ISSN 0386-5878
Technical Memorandum
of PWRI No.3186

THE FIRST CONFERENCE ON PUBLIC WORKS RESEARCH AND DEVELOPMENT IN ASIA

Proceedings

March, 1993

Public Works Research Institute
Ministry of Construction

「Copyright © (1993) by P. W. R. I.

All rights reserved. No part of this book may be reproduced by any means, nor transmitted, nor translated into a machine language without the written permission of the Director General of P. W. R. I.

この報告書は，土木研究所長の承認を得て刊行したものである。したがって，本報告書の全部又は一部の転載，複製は，土木研究所長の文書による承認を得ずしてこれを行ってはならない。」

Technical Memorandum
of PWRI No.3186

THE FIRST CONFERENCE ON PUBLIC WORKS RESEARCH AND DEVELOPMENT IN ASIA

Proceedings

Synopsis

This report is the proceedings of "The First Conference on Public Works Research and Development in Asia" held in February 1993.

Key Words: ASIA, IMPROVEMENT OF INFRASTRUCTURE, DISASTER PREVENTION, ENVIRONMENT, INTERNATIONAL RESEARCH COOPERATION

FOREWORD

The First Conference on Public Works Research and Development in Asia (Executive's Seminar on Public Works Research and Development) was held for five days, February 15 through 19, 1993 at Public Works Research Institute, Ministry of Construction, in Tsukuba. The aim of this Conference is to develop optimum technology of public works for specific natural and socio-economic conditions in Asia nations in an effort to realize efficient utilization of natural and human resources.

The Conference had an attendance of eight executive members in the field of public works research and development representing seven countries that are very close to Japan in many ways, politically, economically and culturally, namely China, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand.

For better understanding of current situations and problems in each country as well as past experiences, the Conference consisted of three keynote lectures, presentations of country reports from each participating country, discussions on river-related and sediment-related disasters and discussions on each specific subject followed by the final synthesis discussion, where it was unanimously agreed that sharing the accumulated experiences is vital for infrastructure development of each country concerned. The significance of this Conference and the importance of its successive development were also recognized. The very first step toward substantial international exchange has been hereby made in the field of public works research and development in Asia. It is expected that this Conference will eventually function as a network creating strong ties among Asian countries through technical exchanges.

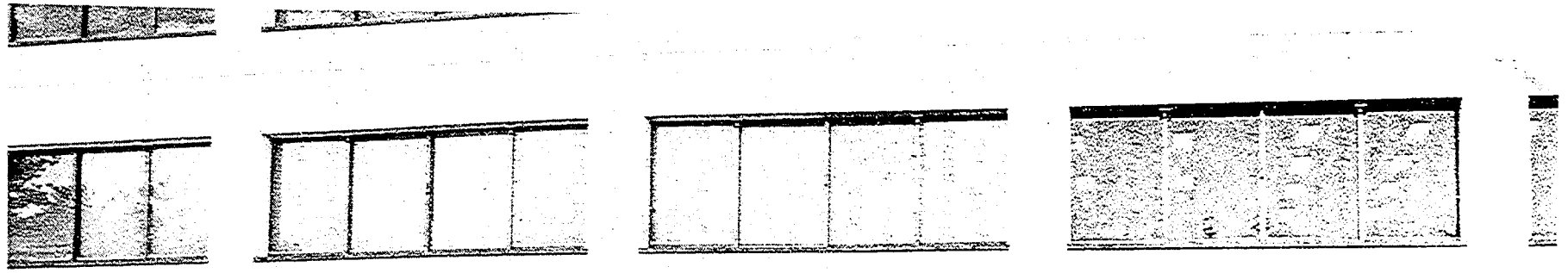
After the closing of the Conference the participants had an inspection tour from February 20 to 26. The tour was mainly in Hokkaido, which had seen a considerable development in infrastructure in no more than a hundred years. During the tour on February 22 the participants attended the Symposium on Public Infrastructure and Civil Engineering Research Institute and Public Works Research Institute.

The proceedings of the Conference has been compiled from the country reports submitted from each participating country, supplementary data, summaries of lectures and discussions including foreign information, which is not easily available. I believe the publication of the minutes of the advancement and then its diffusion will greatly contribute to the advancement and technical improvement of infrastructure development in Asia.

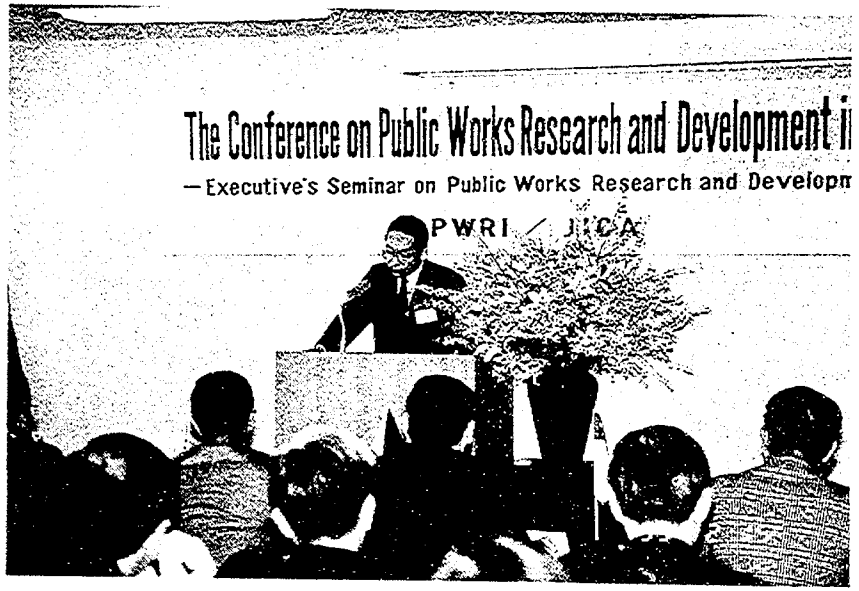
Finally I'd like to express my sincere gratitudes to all those concerned for their support and dedicated efforts for organizing and opening of this Conference, for the further development of which I am determined to do my best, thus to meet the wide expectations.

Yukihiko Sumiyoshi
Chairman,
First Conference on Public Works Research and Development in Asia

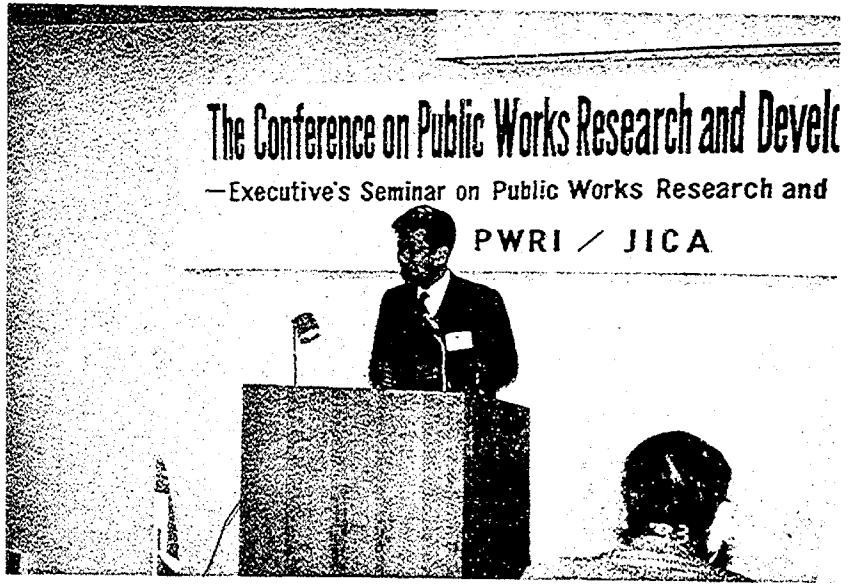
PHOTOGRAPHS



Participants of Opening Ceremony, The First Conference on Public Works Research and Development in Asia
(February 15, 1993)

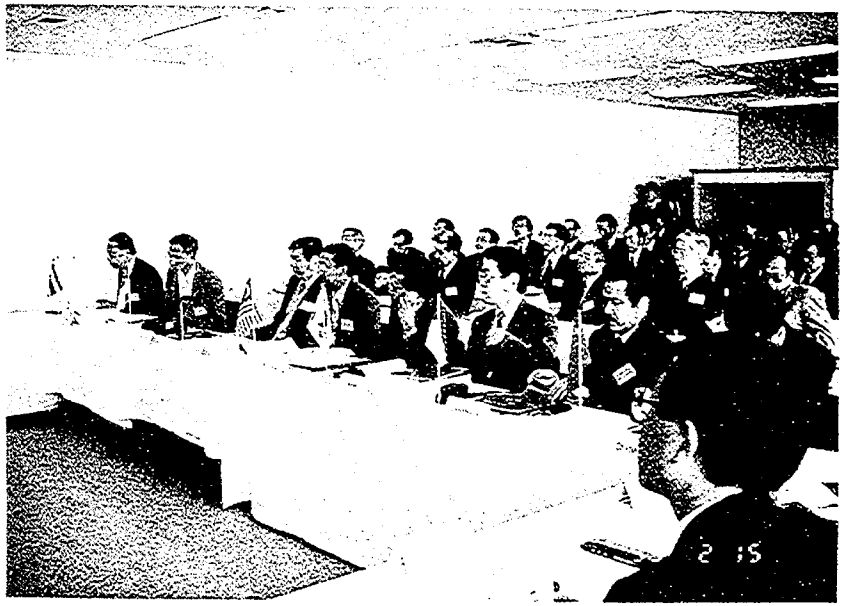


Prof. Fumio Nishino (Keynote Lecture)

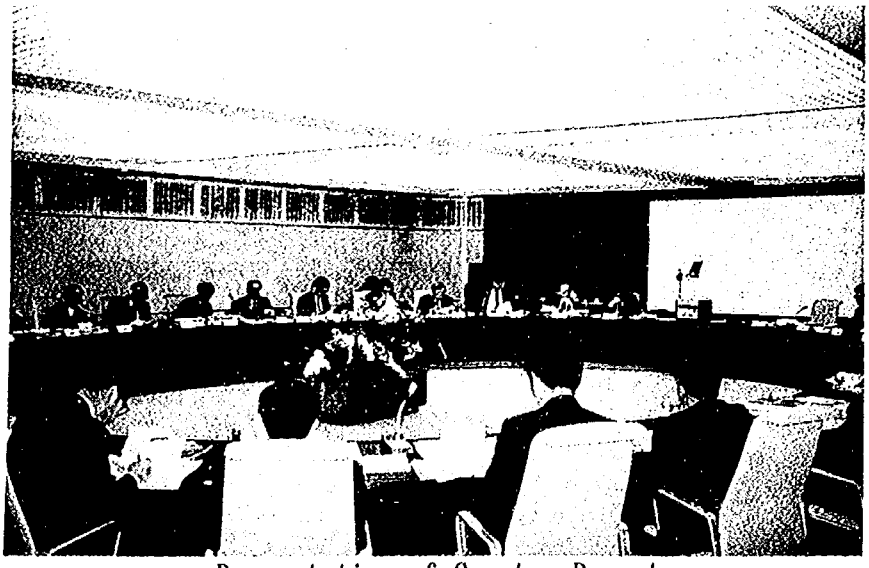


Mr. Hiroaki Tamamitsu (Keynote Lecture)

Keynote Lecture



Participants of Keynote Lecture



Presentation of Country Report

Discussion

Reception

CONTENTS

FOREFORD ---------- i
PHOTOGRAPHS ---------- ii
CONTENTS ---------- v

(A) PROGRAM ---------- PROGRAM - 1

(B) KEYNOTE LECTURE

I. 「Infrastructure Policies for Economic and Social Development of Asian Countries」 ---------- KEYNOTE LECTURE - 1
by Prof. Fumio Nishino, University of Tokyo

II. 「Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan — PWRI's 70 Years and Perspective —」 ------- KEYNOTE LECTURE - 17
by Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute, Ministry of Construction

III. 「The Role of Research and Technology Development in International Technical Cooperation」 ------- KEYNOTE LECTURE - 55
by Mr. Hiroaki Tamamitsu, Vice President, Japan Construction Training Center

(C) COUNTRY REPORT

I. People's Republic of China ---------- COUNTRY REPORT - 1
by Mr. Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research

II. Republic of Indonesia ---------- COUNTRY REPORT - 51
by Dr. Badruddin Machbub, Director, Research Institute for Water Resources Development

III. Republic of Korea ---------- COUNTRY REPORT -107
by Dr. Lee Sang Eun, Vice President, Korea Institute of Construction Technology

IV. Malaysia ---------- COUNTRY REPORT -153
by Mr. Abdul Rahman B. Abdullah, Deputy Director-General, Public Works Department

V. Republic of the Philippines ---------- COUNTRY REPORT -221
by Mr. Manuel M. Bonoan, Assistant Secretary for Planning, Department of Public Works and Highways

VI. Republic of Singapore ---------- COUNTRY REPORT -283
by Mr. Tan Siong Leng, Director, Building Control Division, Public Works Department

VII. Kingdom of Thailand ---------- COUNTRY REPORT -321
by Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways
Mr. Bancha Vadhanasindhu, Chief of Programming Section, Department of Highways

Ⅷ Japan ---------- COUNTRY REPORT -369
by Mr. Tokuji Tomaru, Deputy Director-General, PWRI

Ⅸ. Introduction of PWRI ---------- COUNTRY REPORT -483
by Dr. Takashi Iijima, Assistant Director-General, PWRI
Mr. Masashi Ikemura, Director of Geology and Chemistry Dept., ditto
Dr. Fumio Yoshino, Director of River Dept., ditto
Dr. Kikuo Inaba, Director of Water Quality Control Dept., ditto
Mr. Seizo Takebayashi, Director of Dam Dept., ditto
Mr. Youtaro Asai, Director of Erosion Control Dept., ditto
Mr. Hiroo Kanzaki, Director of Road Dept., ditto
Dr. Yasuyuki Koga, Head of Soil Dynamics Div., Construction Method and Equipment Dept., ditto
Dr. Minoru Fujiwara, Director of Structure and Bridge Dept., ditto
Mr. Yutaka Iida, Director of Earthquake Disaster Prevention Dept., ditto
Mr. Masafumi Fukuda, Research Coordinator for Construction Management Engineering, Construction Management Engineering Center, ditto
Mr. Ryosuke Tsunaki, Head of Niigata Experimental Laboratory, ditto

Ⅹ. Subject of Common Interests ---------- COUNTRY REPORT -559
1. Disaster Prevention and Preparedness in Korea ---------- COUNTRY REPORT -561
2. Problems of Highway Slopes in the Mountainous Region of Malaysia COUNTRY REPORT -577
3. Slope Erosion Control in Granitic Soil Slope, Thailand ---------- COUNTRY REPORT -585
4. The Earthquake and Tsunami in Flores Island, Indonesia ---------- COUNTRY REPORT -601

(D) MINUTES
Ⅰ. Address of Opening Ceremony ---------- MINUTES - 1
Ⅱ. Minutes ---------- MINUTES - 7
1. Keynote Lecture ---------- MINUTES - 9
2. Country Report ---------- MINUTES - 11
3. Subject of Common Interests ---------- MINUTES - 22
4. Discussion on Specific Subjects ---------- MINUTES - 28
Ⅲ. Conclusion ---------- MINUTES - 51
Ⅳ. Address of Closing Ceremony ---------- MINUTES - 57

(E) STUDY TOUR
Ⅰ. Study Tour ---------- STUDY TOUR - 1
Ⅱ. Symposium on Public Infrastructure and Civil Engineering in Asia ---------- STUDY TOUR - 11
1. Keynote Lecture on 「Public Infrastructure Projects in Hokkaido Development」 ---------- STUDY TOUR - 15
by Prof. Hideo Igarashi, Hokkaido University
2. Panel Discussion on 「Public Infrastructure Projects in Each Country and Their Technical Problems」 ---------- STUDY TOUR - 31

(A) PROGRAM

1. Schedule of the Conference
2. Opening Ceremony
3. Session Program of the Conference
4. Closing Ceremony
5. Schedule of the Study Tour
6. List of Participants

1. Schedule of the Conference

February

14 (Sun) : Arrival in Japan

15 (Mon) : Opening Ceremony
Keynote Lecture
Tour of Research Laboratories in PWRI
Reception (Hosted by Mr.Toru Kondo, Vice-Minister of Construction for Engineering Affairs, Ministry of Construction)

16 (Tue) : Presentation of Country Reports
(Japan, China, Indonesia, Korea, Malaysia)

17 (Wed) : Presentation of Country Reports
(Philippines, Singapore, Thailand)
Discussion on Future Perspective for Research and Development of Disaster Prevention Techniques

18 (Thu) : Discussion on Specific Subjects

19 (Fri) : Study Tour in Tsukuba Science City
Synthesis Discussion
Adoption of Final Resolution
Closing Ceremony
Reception (Hosted by Mr. Yukihiko Sumiyoshi, Director-General, PWRI, Ministry of Construction)

20 (Sat) : Study Tour [Tsukuba→Tokyo→Sapporo]

21 (Sun) : Study Tour [Sapporo]

22 (Mon) : Study Tour
Hokkaido Development Bureau
Civil Engineering Research Institute
Symposium on Public Infrastructure and Civil Engineering in Asia

23 (Tue) : Study Tour [Sapporo→Muroran]
Toyohira-River Integrated Dam Group Operation Office
Sapporo River Office, Subway Construction,
Muroran Hakucho Bridge

24 (Wed) : Study Tour [Muroran→Hakodate→Aomori→Tokyo]
Seikan-Tunnel
Aomori Construction Office

25 (Thu) : Study Tour
Courtesy call on Ministry of Construction
Trans-Tokyo Bay Highway
Farewell Party (Hosted by Mr. Yukihiko Sumiyoshi, Director-General, PWRI, Ministry of Construction)

26 (Fri) : Study Tour [Tokyo→Atsugi→Tsukuba]
Miyagase Dam
Courtesy call on Tsukuba International Center, JICA

27 (Sat) : Preparation for Leaving

28 (Sun) : Leaving

2. Opening Ceremony

1.Time : Monday, February 15, 1993 (10:00-10:50)

2.Place : Meeting Room (8th Floor), Public Works Research Institute, Ministry of Construction

3.Program :

Call to order by Mr. Masahide Tamura, Director of Planning and Research Administration Department, Public Works Research Institute, Ministry of Construction

Address by Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute, Ministry of Construction

Address by Mr. Toru Kondo, Vice-Minister of Construction for Engineering Affairs, Ministry of Construction

Address by Mr. Keishi Iimura, Director-General, Tsukuba International Center, Japan International Cooperation Agency

Address by Mr. Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research

Introduction of Executives of Public Works Research Institute, Ministry of Construction

Introduction of Participants from Forign Countries

Closure by Mr. Masahide Tamura

Adjourn

Group Photograph

3. Session Program of the Conference

Monday, February 15

9:00～10:00 Registration

10:00～10:50 Opening Ceremony

10:50～12:00 Keynote Lecture 1

「Infrastructure Policies for Economic and Social Development of Asian Countries」

by Prof. Fumio Nishino, Faculty of Engineering, University of Tokyo

12:00～13:00 Lunch

13:00～13:50 Keynote Lecture 2

「Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan

～PWRI's 70 Years and Perspective ～」

by Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute (PWRI), Ministry of Construction (MOC)

13:50～14:40 Keynote Lecture 3

「The Role of Research and Technology Development in International Technical Cooperation」

by Mr. Hiroaki Tamamitsu, Vice President, Japan Construction Training Center

14:40～15:00 Coffee Break

15:00～17:00 Tour of Research Laboratories in PWRI

18:00～20:00 Reception

(Hosted by Toru Kondo, Vice-Minister of Construction for Engineering Affairs, Ministry of Construction)

(Hotel Sunroute Tsukuba, tel.0298-52-1151)

Tuesday, February 16

9:00～10:00 Presentation of Country Report of Japan
by Mr. Tokuji Tomaru, Deputy Director-General, PWRI, MOC

10:00～12:00 Presentation of Introduction of PWRI
by Dr. Takashi Iijima, Assistant Director-General, PWRI, MOC
Mr. Masashi Ikemura, Director of Geology and Chemistry Dept., ditto
Dr. Fumio Yoshino, Director of River Dept., ditto
Dr. Kikuo Inaba, Director of Water Quality Control Dept., ditto
Mr. Seizo Takebayashi, Director of Dam Dept., ditto
Mr. Youtaro Asai, Director of Erosion Control Dept., ditto
Mr. Hiroo Kanzaki, Director of Road Dept., ditto
Dr. Yasuyuki Koga, Head of Soil Dynamics Div., Construction Method and Equipment Dept., ditto
Dr. Minoru Fujiwara, Director of Structure and Bridge Dept., ditto
Mr. Yutaka Iida, Director of Earthquake Disaster Prevention Dept., ditto
Mr. Masafumi Fukuda, Research Coordinator for Construction Management Engineering, Construction Management Engineering Center, ditto

12:00～13:00 Lunch

13:00～14:00 Presentation of Country Report of China
by Mr. Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research

14:00～15:00 Presentation of Country Report of Indonesia
by Dr. Badruddin Machbub, Director, Research Institute for Water Resources Development

15:00～15:10 Coffee Break

15:10～16:10 Presentation of Country Report of Korea
by Dr. Lee Sang Eun, Vice President, Korean Institute of Construction Technology

16:10～17:10 Presentation of Country Report of Malaysia
by Mr. Abdul Rahman B. Abdullah, Deputy Director-General, Public Works Department

Wednesday, February 17

9:00～10:00 Presentation of Country Report of Philippines
by Mr. Manuel M. Bonoan, Assistant Secretary for Planning, Department of Public Works and Highways

10:00～11:00 Presentation of Country Report of Singapore
by Mr. Tan Siong Leng, Director of Building Control Division, Department of Public Works

11:00～11:10 Coffee Break

11:10～12:10 Presentation of Country Report of Thailand
by Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways

12:10～13:10 Lunch

13:10～17:00 Discussion on Future Perspective for Research and Development of Disaster Prevention Techniques

- 13:10～14:25 Presentation of Topics concerning River-Related Disaster in Each Country (Japan, China, Indonesia, Korea, Singapore)
- 14:25～14:50 Discussion
- 14:50～15:00 Coffee Break
- 15:00～16:00 Presentation of Topics concerning Sediment-Related Disaster in Each Country (Japan, Malaysia, Philippines, Thailand)
- 16:00～16:25 Discussion
- 16:25～17:00 Presentation of Something New Topics (Japan, Indonesia)

Thursday, February 18

9:00～12:00 Discussion on Specific Subject

(1) Sedimentation of Dam Reservoir	(Meeting room 531)
(2) Water Pollution Control	
(3) River Environment	(Meeting room 526)
(4) Soil Improvement	(Meeting room 628)
(5) Tunnel	(Meeting room 8F)
(6) Volcanic Disaster, Debris Flow and Road Disaster Prevention	(Meeting room 629)

12:00～13:00 Lunch

13:00～16:00 Discussion on Specific Subject

(2) Water Pollution Control	
(7) River	(Meeting room 531)
(8) Water Quality	
(9) Soil Mechanics and Foundation Engineerings, Traffic Engineering	(Meeting room 526)
(10) Pavement	(Meeting room 8F)

16:00～17:00 Discuission on Specific Subject

(11) Highway Bridge	(Meeting room 8F)

Program of Discussion on Specific Subjects

	China	Indonesia	Korea	Malaysia	Philippines	Singapore	Thailand	
9:00								
10:00	(1) room 531 Sedimentation of Dam Reservoir	(2) Water Pollution Control	(3) room 526 River Environment	(4) room 628 Soil Improvement	(6) room 629 Volcanic Disaster, Debris Flow and Road Disaster Prevention	(5) room 8F Tunnel	(4) room 628 Soil Improvement	
11:00								
12:00								
13:00								
14:00	(7) room 531 River	(2) Water Pollution Control	(8) Water Quality	(9) room 628 Soil Mechanics and Foundation Engineerings, Traffic Engineering	(10) room 8F Pavement	(10) room 8F Pavement	(10) room 8F Pavement	
15:00								
16:00					(11) room 8F Highway Bridge			
17:00								

Friday, February 19

9:00～12:00 Study Tour in Tsukuba Science City

9:10～10:10 Geographical Survey Institute, Ministry of Construction

10:20～11:00 National Research Institute for Earth Science and Disaster Prevention, Science and Technology Agency

11:10～11:55 Building Research Institute, Ministry of Construction

12:00～13:00 Lunch

13:00～15:00 Synthesis Discussion
Adoption of Final Resolution

15:00～15:10 Coffee Break

15:10～15:30 Closing Ceremony

17:30～20:00 Reception
(Hosted by Mr. Yukihiko Sumiyoshi, Director-General, PWRI, MOC)
(Restaurant Plaza, Tsukuba University Hall 1F, tel.0298-58-0939)

4. Closing Ceremony

1. Time : Friday, February 19, 1993 (15:10～15:30)

2. Place : International Conference Room (8th Floor),
Public Works Research Institute, Ministry of Construction

3.Program :

Call to order by Mr. Hiroaki Kojima, Director of General Affairs Department, Public Works Reserch Institute, Ministry of Construction

Address by Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute, Ministry of Construction

Address by Dr. Lee Sang Eun, Vice President, Korean Institute of Construction Technology

Closure by Mr. Hiroaki Kojima

5. Schedule of the Study Tour

February 20 (Sat) 9:00 Lv. Tsukuba Dai-ichi Hotel (tel.0298-52-1112)
Move (Tsukuba→Haneda, by JR)
13:00 Lv. Haneda Airport (by JAL 513)
14:30 Ar. Shin-Chitose Airport
Inspection on Shin-Chitose Airport
Move (Shin-Chitose Airport→Sapporo, by Bus)
17:30 Ar. Sapporo Grand Hotel
Stay at Sapporo Grand Hotel
(tel.011-261-3311)

21 (Sun) 9:00 Lv. Sapporo Grand Hotel
Move (by Bus)
Inspection in Sapporo City (Micro Bus)
Okura-yama, Sappro Beer Factory
Historical Museum of Hokkaido
17:30 Ar. Sapporo Grand Hotel
Stay at Sapporo Grand Hotel
(tel.011-261-3311)

22 (Mon) 8:15 Lv. Sapporo Grand Hotel
Hokkaido Development Bureau
Civil Engineering Research Institute
13:30 Symposium on Public Infrastructure and Civil Engineering in Asia (at Sapporo Grand Hotel)
19:00 Stay at Sapporo Grand Hotel
(tel.011-261-3311)

23 (Tue) 8:30 Lv. Sappro Grand Hotel
Move (by Bus)
Toyohira-River Integrated Dam Group Operation Office
Sapporo River Office
Sapporo Subway Construction
Muroran Hakucho Bridge
19:00 Ar. Muroran Sunroute Hotel
Stay at Muroran Sunroute Hotel
(tel.0143-43-2333)

24 (Wed)	8:10	Lv. Muroran Sunroute Hotel
		Move (Higashi Muroran→Hakodate, by JR)
		Move (Hakodate→Tappi Kaitei, by JR)
		Inspection on Seikan-Tunnel
		Move (Tappi Kaitei→Aomori, by JR)
		Aomori Construction Office
	16:30	Lv. Aomori Airport (by JAS 216)
	17:45	Ar. Haneda Airport
	19:00	Ar. Tokyo International Center, JICA
		Stay at Tokyo International Center, JICA
		(tel.03-3485-7051)
25 (Thu)	9:00	Lv. Tokyo International Center, JICA
		Move (by Bus)
		Courtesy call on Ministry of Construction
		Inspection on Trans-Tokyo Bay Highway
	18:00	Farewell Party (Hosted by Mr. Yukihiko Sumiyoshi,
		Director-General, PWRI, MOC)
	20:30	Ar. Tokyo International Center, JICA
		Stay at Tokyo International Center, JICA
		(tel.03-3485-7051)
26 (Fri)	7:00	Lv. Tokyo International Center, JICA
		Move (Tokyo→Atsugi, by Bus)
		Inspection on Miyagase dam
		Move (Atsugi→Tsukuba, by Bus)
	16:00	Ar. Tsukuba International Center, JICA
	17:30	Stay at Tsukuba Dai-ichi Hotel
		(tel.0298-52-1112)

6. List of Participants

Foreign Countries

People's Republic of China

Mr. Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research, Chinese Academy of Sciences, Ministry of Water Resources, Ministry of Energy

Republic of Indonesia

Dr. Badruddin Machbub, Director, Research Institute for Water Resources Development, Agency for Research and Development, Ministry of Public Works

Republic of Korea

Dr. Lee Sang Eun, Vice President, Korea Institute of Construction Technology

Malaysia

Mr. Abdul Rahman B. Abdullah, Deputy Director-General, Public Works Department, Ministry of Works

Republic of the Philippines

Mr. Manuel M. Bonoan, Assistant Secretary for Planning, Department of Public Works and Highways

Republic of Singapore

Mr. Tan Siong Leng, Director, Building Control Division, Public Works Department Ministry of National Development

Kingdom of Thailand

Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways, Ministry of Transport and Communication

Mr. Bancha Vadhanasindhu, Chief of Programming Section, Department of Highways, Ministry of Transport and Communication

Japan

Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute (PWRI), Ministry of Construction (MOC)

Mr. Tokuji Tomaru, Deputy Director-General, PWRI, MOC

Dr. Takashi Iijima, Assistant Director-General, PWRI, MOC

Mr. Masahide Tamura, Director, Planning and Research Administration Dept., PWRI, MOC

Mr. Masashi Ikemura, Director of Geology and Chemistry Dept., PWRI, MOC

Dr. Fumio Yoshino, Director of River Dept., PWRI, MOC

Dr. Kikuo Inaba, Director of Water Quality Control Dept., PWRI, MOC

Mr. Seizo Takebayashi, Director of Dam Dept., PWRI, MOC

Mr. Youtaro Asai, Director of Erosion Control Dept., PWRI, MOC

Mr. Hiroo Kanzaki, Director of Road Dept., PWRI, MOC

Dr. Minoru Fujiwara, Director of Structure and Bridge Dept., PWRI, MOC

Mr. Yutaka Iida, Director of Earthquake Disaster Prevention Dept., PWRI, MOC

Mr. Tadahiko Fujisawa, Research Coordinator for Advanced Technology, Planning and Research Administration Dept., PWRI, MOC

Mr. Toshinori Mizutani, Research Coordinator for Underground Development, Planning and Research Administration Dept., PWRI, MOC

Mr. Tadahiko Nakao, Research Coordinator for Hydraulic Structures, River Dept., PWRI, MOC

Mr. Kazuaki Sato, Research Coordinator for Wastewater Treatment, Water Quality Control Dept., PWRI, MOC

Mr. Masafumi Fukuda, Research Coordinator for Construction Management Engineering, Construction Management Engineering Center, PWRI, MOC

Mr. Akira Fujimoto, Coordinator for International Research Cooperation, Planning and Research Administration Dept., PWRI, MOC

Mr. Hirotaka Kawano, Head of Concrete Div., Geology and Chemistry Dept., PWRI, MOC

Mr. Koichi Yamamoto, Head of River Hydraulics Div., River Dept., PWRI, MOC

Mr. Yukihiro Shimatani, Head of Urban River Div., River Dept., PWRI, MOC

Mr. Minoru Kuriki, Head of Flood Disaster Prevention Div., River Dept., PWRI, MOC

Mr. Eiichi Nakamura, Head of Water Quality Div., Water Quality Control Dept., PWRI, MOC

Mr. Shuji Takasu, Head of Dam Hydraulic Engineering Div., Dam Dept., PWRI, MOC

Mr. Kaoru Niwa, Head of Water Resources Engineering Div., Dam Dept., PWRI, MOC

Dr. Yoshiharu Ishikawa, Head of Erosion Control Div., Erosion Control Dept., PWRI, MOC

Mr. Harutoshi Yamada, Head of New Transportation Div., Road Dept., PWRI, MOC

Mr. Toshiyuki Nakamura, Head of Pavement Div., Road Dept., PWRI, MOC

Dr. Akira Inokuma, Head of Tunnel Div., Road Dept., PWRI, MOC

Dr. Yasuyuki Koga, Head of Soil Dynamics Div., Construction Method and Equioment Dept., PWRI, MOC

Dr. Michio Okahara, Head of Foundation Engineering Div., Structure and Bridge Dept., PWRI, MOC

Mr. Ken-ichi Tokida. Head of Ground Vibration Div., Earthquake Disaster Prevention Dept., PWRI, MOC

(B) KEYNOTE LECTURE

I . 「Infrastructure Policies for Economic and Social Development of Asian Countries」

Prof. Fumio Nishino, University of Tokyo

INFRASTRUCTURE POLICIES FOR ECONOMIC AND SOCIAL DEVELOPMENT OF ASIAN COUNTRIES

by Fumio Nishino

Professor of Civil Engineering, University of Tokyo
Professor of Policy Science, Saitama University

I. OECD Conference on Infrastructure Policies for the 1990s.

In spite of the continuous investment in infrastructure development in Japan since the Meiji restoration of 1868, the present Japanese stock of infrastructure would be of the order of one third to one quarter of that of most countries in the Organization for Economic Co-operation and Development, the so-called OECD countries. Despite the large stock of infrastructure available in these countries, the OECD is concerned that their member country's insufficient investment for infrastructure during the coming decade might make it difficult to sustain their economic growth.

Because of this, the OECD held a conference a month ago, in January 1993, with the title "Infrastructure Policies for 1990s". The major focus of the conference was on core physical infrastructure such as road and rail networks, waterways and ports, airports, energy and water utilities, and telecommunications. It is well known that there exist short term impacts of public investment on economic development. The concern of the conference was, however, on long term effects, such as effects of infrastructure provision on growth capacity, international competitiveness of manufactured goods, and living standards.

The conference consisted of four sessions. The first session was to assess recent trends and the current state of infrastructure investment in major regions of the world economy, paying particular attention to the question of the alleged shortfall in investment. The second was to address options for increasing the efficiency of infrastructure provision. The third was to explore problems of decision-making and planning for major infrastructure projects, including the integration of environmental consideration. There followed a concluding session.

Some of the main issues of the conference were:

1. The existing stock of infrastructure may be insufficient to ensure a solid base for the expansion of economic activity eventually expected during the 1990s and the beginning of the next century. Implicit in this concern is the notion that investment in infrastructure is of key importance to economic growth.

Department of Civil Engineering, Graduate School of Engineering, University of Tokyo, Bunkyo-ku, Tokyo 113.
Graduate School of Policy Science, Saitama University, Urawa-shi, Saitama 338.

2. The bulk of investment for infrastructure has to be borne by the public sector. With the increasing indebtedness of governments and needs of funds for education and health and other intangible investments, the margin of manoeuver for governments on spending for infrastructure is being reduced.

3. Many governments of the OECD countries are increasingly considering greater participation by the private sector in the financing of major infrastructure projects. It remains unclear, however, whether in the longer term such private sector involvement results in additional fixed capital formation in infrastructure or whether it merely replaces government expenditure since the available pool of saving is limited. The Euro-tunnel project was quoted as one of these successful privately funded projects. To date, however, private sector funding has been only on a very small scale.

4. One of the items of interest was a suggestion to explore the ways of making more efficient use of existing infrastructure. This subject, however, is not of interest to most Asian countries, where the total stock of infrastructure is much below the minimum level which any economist might assume as necessary.

5. Efficiency in the provision of infrastructure was one of the subjects of major discussion. As the means to attain efficiency in the provision of infrastructure goods and services, privatization, deregulation, and the application of pricing technique were discussed. These are also the subjects of discussion here in Japan and would be the same in many other Asian countries. Japan might be one of the more successful countries in taking advantages of these means.

6. One related subject, which was of significant interest to me with an engineering background, was the issue of initial investment. With the increasing cost of maintenance due to the increasing stock of infrastructure, labor costs, and ageing population, integrating life-cycle maintenance cost projections at the design stage with a particular attention to the future cost increase can generate substantial benefits and hence gain efficiency over the longer term.

7. A number of subjects were discussed similar to the above, which reduce efficiency and hence need improvement. These are the lack of long-term Europe-wide master plan especially for road and rail networks, and the lack of co-ordination among the authorities concerned for the modes of transport and in regions which are key international transit points.

8. The two day conference raised many other issues, which may not be of much interest for the moment for the infrastructure development among Asian countries.

Regarding the other, I wish to report two conclusions drawn as the matters of significant interest. One is that it is now common practice in the OECD countries to consider the environmental impacts when designing major new infrastructure projects, however,

environmental issues are not necessarily enemies of the projects. The other is that, although road pricing is virtually non-existent except for some expressways, bridges, tunnels and a few isolated cases of urban roads among the OECD countries, tolls for expressways could gain wide spread recognition without governments taking a resolute lead. As a matter of fact, I have read a related article in a Japanese news paper only two days ago. The article reported that both the German ruling and opposition parties agreed to charge tolls for all German autobahns starting next year and that the entire autobahn system would be privatized in the near future.

II. Japanese Policies for Infrastructure Development

1. Historical Development

There were many historical infrastructure developments before the beginning of the Meiji restoration, with which Japan opened the country to outside world. Most of this physical infrastructure was construction of cities and roads, river training, irrigation systems and ports as in the other countries. Among the non-physical infrastructure, a mail service was established between all major cities in Japan. Educational institutions of the smallest scale up to the reasonably large scale were established in almost all places in Japan including remote villages.

The oldest large scale construction of cities based on city planning in Japan dates back to the eighth century. The most well known are the Heijokyo in Nara and Heiankyo in Kyoto. Both of them were big cities at the time not only in terms of Japan, but internationally with a palace and zones for administrative offices and for people with different jobs. Most of the present Japanese cities were castle towns built in the 16th century. Presentday Tokyo was also a castle town enlarged into a big city when the Tokugawa regime moved there as its capital.

The large scale construction of physical infrastructure as defined today started with the Meiji restoration in 1868. The early efforts at the beginning of Meiji era were to strengthen military power to prevent colonization and to industrialize with western technology. Construction of railways, modernization of the postal service, establishing a telecommunication system, and elaborating road networks were major aims of these efforts. With the development of needs for domestic and international commodity transportation, major ports such as Yokohama were constructed to meet new demand.

The investment for physical infrastructure development remained at the rate of 3 to 4 percent of the gross national product until 1940, the year when Japan went into World War II. During this period, the annual increase of the gross national product was of the order of 3 to 6 percent.

The construction of railways was started by the efforts of the government at first, but the first private corporation started to operate a rail system in 1883, only 15 years after the

Meiji restoration. Since then construction of railways was continued by the efforts of the private sector, then they were nationalized and the rail network was completed to cover Japanese islands extensively. Similarly, the nationalized telecommunication network was more or less completed, although it was very poor by today's standard. Agricultural land was enlarged through irrigation system.

The first hydraulic power generation plant was planned in Kyoto in 1883 again only 15 years after the beginning of the Meiji era using water at Biwa-lake through a tunnel with a length of 2043 meters. The construction work started two years later in 1885. Five years later in 1890, the project was partially completed with two imported 60 KW electric dynamos. Later the number of electric dynamos was increased to 19. One of the lessons learned from this project was the importance of the domestic capability of manufacturing goods. The price of an electric dynamo per KW was 120 yen at the beginning. When a domestically produced dynamo was available at 40 yen per KW, the price of imported dynamos was cut in half. This lesson, however, is no longer valid because of the presence of a highly competitive international market for almost all industrial goods. Electric power generation was developed by the private sector covering Japan by five power companies. A cartel was established among the existing five power companies to monopolize within each service area in 1931, which the government evaluated as not advantageous to the general public. They were later nationalized and were divided into nine groups to cover nine independent areas which covered the whole of Japan. Later, these nine groups were privatized after World War II and became nine independent private companies.

Data is not immediately available for the 15 years after World War II for public investment for infrastructure. Public investments during the 60s, 70s and 80s in terms of percentage of the gross national product were 8.7, 8.9 and 7.2, respectively. Slightly reduced investment in the 80s is a similar phenomena as observed in other OECD countries, though this reduced investment of 7.2 percent during 80s is much larger than the others. This reduction is mostly due to national budget deficiency. The average annual increases of the gross national product during the three decades were 10.2, 4.6 and 4.2 percent, respectively. For the 1990s, the Japanese national gross product was forecasted to increase with an annual rate of 4.8 percent, with which the infrastructure investment would be increased annually by a rate of 3.5 percent. The Japanese government has decided to invest 430 trillion yen, i.e., roughly three and a half trillion US dollars during the coming decade.

Investment for infrastructure immediately after World War II was concentrated into such areas as restoration of bombed cities, restoration of railways, repair work on ports, and the reclamation of agricultural land. Because of the lack of budget, a gasoline tax system was established with restricted use only for the development of roads during this period. Similarly, a toll system was established for tunnels, bridges, and expressways. Insufficient financial resources for infrastructure development forced the government to establish nine public corporations for specific infrastructure development, and to operate and pay off their investments in the longer term by the income generated by these corporations.

In the ten years following World War II, Japan entered into an era of significant and rapid economic development through industrialization. There was a worry that insufficient economic infrastructure might become a bottle neck of the economic development. Consequently, emphasis was placed on investment in the development of economic infrastructure such as roads, railways, ports and telecommunications. Much less investment was made during this period in the social infrastructure such as urban development for people transmigrating from rural areas, resulting in a sprawling development of major cities without any reasonable city planning. Similarly, investment for sewerage was not significant. Development in quantity rather than quality was emphasized even for economic infrastructure. This policy is now resulting in expensive maintenance and repair works for the economic infrastructure constructed during this period. In the case of roads, the capacity of some of them is not sufficient at present only in 30 years after completion, resulting in huge economic loss caused by the traffic congestion alone. The loss due to traffic congestion in Tokyo is estimated at one billion yen, i.e., roughly 8 million US dollars a day. Expansion of the capacity to solve this congestion is an extremely expensive undertaking because of the huge land acquisition cost.

2. Present Status of Infrastructure

When Japanese per capita gross national product became among the highest in the world, people started to wonder that level. The people in the big cities were experiencing difficulty in commuting to their offices. They were aware for many years that acquiring a decent house or condominium was beyond imagination. A condominium with a total floor area of 80 to 100 square meters within a big city and its suburban area costs more than 10 times the annual income of majority of city dwellers. Land cost in urban areas has become extremely expensive. On the other side, there are many villages where the population is decreasing. Ageing people are remaining , but the younger generation are leaving the villages. This is the situation even in a very small but extremely densely populated country as Japan. Even from a remote village, it takes less than one hour to an urban center in a prefectural level. This fact suggests that people are not satisfied with the life style in these urban cities in prefectural level. One of the reasons is the lack of civic activities available in major cities, which might be due to a certain extent to lack of good infrastructure in these regions.

Japanese government started to emphasize quality of life in addition to economic growth as the major target to attain a decade or so ago, for which investment for social infrastructure was essential. Nevertheless, present Japanese infrastructure is still in a very poor condition. The recent status of the stock of Japanese infrastructure is summarized in Table 1, comparing those with other western industrialized countries.

Though the data in Table 1 is slightly old, a number of situations are clear. Noting the fact that 75 percent of the whole area of Japan can not be used for any activity of the people, and noting that whole area is similar to that of the state of California in the U. S., infrastructure development on a person basis could be attained much cheaper than any

western industrialized countries. The availability of sewerage system to only 34 percent of the total population and the smaller percentage of paved roads indicate less investment in infrastructure not directly related to economic growth. The shortage of urban parks is due partially to the small area of the country itself. However, a greater cause is the lack of good city planning. Good quality tap water is available at all places in Japan. This, however, is not necessarily due to the efforts of investment. Rather it is due to our fortunate natural environment with many mountains and plenty of rainfall. The large number of telephones is evidence of large infrastructure investment for economic growth.

Table 1. International Comparison of Infrastructure Stock*

Type of Infrastructure	Index	Unit	Japan	UK	Germany (W)	France	Italy	U.S.A.
Sewerage	Available People	%	(1984) 34	(1976) 97	(1983) 91	(1975) 65	(1971) 67	(1979) 72
Urban Parks	Area	m^2/person	(1985) Tokyo City 2.2	(1976) London 30.4	(1984) Bonn 37.4	(1984) Paris 12.2	(1973) Rome 11.4	(1976) Washington D. C. 45.7
Roads	Paved Roads	%	(1982) 50.7	(1982) 96.4	(1982) 99	(1982) 95	-	(1981) 85
Rails	Double Trucks	%	(1983) 26.7	(1983) 71.6	(1983) 43.6	(1983) 44.6	(1983) 33.3	-
Tap water supply	Available People	%	(1983) 92.6	(1961) 99.0	(1963) 91.0	(1962) 79.0	-	(1960) 93.0
Telephone	Availability	number/ 100 people	(1982) 49.6	(1982) 50.7	(1982) 48.8	(1982) 49.8	-	(1982) 78.8

* Economic Planning Agency : Infrastructure Development toward 21st Century, Printing Office of Ministry of Finance, 1987.

3. Possible Strategy for Future Infrastructure Development

3.1 Area of Emphasis

A major Japanese concern for the infrastructure development policy has been heavy concentration on infrastructure which contributes to economic growth. A shift to a policy for more investment for social infrastructure, which would be of help in improving the quality of life, is one of the major change in the future infrastructure development policy. It is also recognized that investment for infrastructure development has to be made before the needs arise. Investment made before the needs arose has been the case for economic infrastructure, but this was not the case for social infrastructure, especially in the planning of the expansion of urban development. It is one of the most difficult and expensive tasks to reconstruct these cities to make them reasonably comfortable places in which to live and work. The expansion of the existing road network, together with the

introduction of other modes of transportation is necessary. A zoning system for land use in cities is not well developed nor enforced. Although a big city has many advantages for the people to live and work, it is understood that some major cities are too large to negate these advantages. This is especially so in the Tokyo metropolitan area. For the further development of Japan with the emphasis on an improved quality of life, a well balanced distribution of population is essential. This is possible only through the extensive and concentrated infrastructure investments in a number of regional centers. One typical solution to relieve the disadvantage of an extremely large city is to create satellite cities. This solution, however, could be too late for major Japanese cities.

One distinctive feature of Japan is the presence of a central government with strong leadership for the future direction. Almost all the cores of the central government are located in geographically small area in the central part of Tokyo. No Japanese have seriously thought of relocating some of the government offices. However, it is now being discussed at the parliaments whether it is advantageous to relocate some core parts of the government to other locations to avoid further concentration of already excessive activities of Tokyo and gives large incentive to the development of other regions.

As in other OECD countries, resources for infrastructure development are expected to decrease in the longer term. Effective infrastructure investment was important in the past, but its importance will certainly increase even more in the future. Investment based on good planning is the most important thing. Concentrated investment would be preferable to a number of regions since it generates multiplying benefits in terms of output, employment growth, private investment, productivity and small business creations within the regions rather than scattered thin investment for the whole country. It is believed that a premise for most regional development strategies is public infrastructure investment and that the scale and location of the investment may have an important effect on subsequent investment and the decisions of private firms and households about where to locate.

3.2 Public Versus Private Funding and Operations

Infrastructure has a number of very specific characteristics such as a long and risky amortisation period, a very substantial time-lag between the start of capital formation and the start of financial returns and high sunk costs. These characteristics ensure that only in exceptional cases will large scale infrastructure assets be financed privately. For the balanced development of a country, infrastructure investment could be necessary where short term return is not expected much. The private sector will not fund such infrastructure. If the private sector is given freedom in the selection of infrastructure development, infrastructure development for a country is likely to be distorted.

It is expected that the indebtedness of Japanese government may not improve in the years to come. Economic growth as enjoyed in the past will not be expected with the development of the neighboring dynamic Asian economies. These are items which make governmental attempts to keep the balance of the budget difficult. The increasing

population of ageing people is a reality to be encountered in the near future. Governmental expenditure for pension and health care will certainly increase.

In principle, the major portion of infrastructure investment will have to be borne by the public sector. In reality, however, infrastructure development by both public and private sector funding would be the way in Japan. Japan has already a reasonably well developed mechanism via which private funding is possible.

Among the major infrastructures, railways, telecommunications and the energy sector are already completely privatized. Although these sectors can expect to a certain extent low interest loans from governmental treasury investment, the investment by the privatized companies can be considered essentially private funds.

There are four public corporations involved in achieving a master plan providing limited access expressway networks of 14,000 Km long covering entire Japan. The construction will be continued by the pool system of tolls of existing and expanded portions of the expressway together with governmental treasury investment until its goal is achieved and its investment is paid off. It is fortunate that the busiest portion of the expressway between Tokyo and Osaka was constructed years ago. The construction cost has already been paid off and the portion is earning money to be used for its extension. Interchanges which may not be necessary for the networks and hence not included in the master plan, but of advantage to the local people with negligibly small disturbance to the through traffic are constructed by funds from the private sector and/or local governments when requested by them. From the similar funds and requests, additional stations are constructed on Shin-Kan-Sen railway system.

Pricing for infrastructure services might be most extensively adopted in Japan compared to western industrialized countries. By now almost all major infrastructure services in Japan are charged. Ordinary roads might be the single exception. Privatized corporations poviding infrastructure services naturally charge for their services. Public corporations also charge the users of the infrastructure such as tolls for expressway networks. Local governments also charge for their services. Water supply and sewerage are operated mostly by local governments. A mixture of fixed and volumetric charges is common for water and sewerage, as is the case for electricity and telecommunication. Since the energy crisis, progressive tariffs have been accepted in the energy sector and subsequently for water supply when a shortage of supply has become frequent in big cities. In spite of the congestion of roads, peak hour pricing is not adopted yet for highway tolls. The telecommunication sector, however, charges discount rate at non-peak hours.

Development of housing complexes and construction of houses are a few representative examples where the private sector is playing the leading role throughout the history from the Meiji restoration. The government has established the Housing and Urban Development Cooperation, but its operation is not much compared with the investment by the private sector. One area where private sector is very active is in the development

of resort areas, which at this moment is regarded by the majority of Japanese as luxurious infrastructure and hence public investment is better avoided except funding from local governments for the purpose of regional developments.

3.3 Efficiency

With the expected difficulty of investment for infrastructure, efficiency is one of the items to be improved. Efficient infrastructure maximizes the gap between the benefit to the society and the costs that arise from the construction and the use of that infrastructure, and that to the environment.

Though public funding and ownership are natural for infrastructure, possible efficiency can be gained by privatization, deregulation, and pricing technique. As already mentioned, most of them have been realized in Japan. There is, however, some limitation in the gains unless completely free market competition exists. Some of the corporations providing infrastructure services operate in competitive markets, but at the same time they have monopoly characteristic.

Government and public corporations providing infrastructure services in Japan are trying to contract out as much of their operation as possible to private enterprises to improve their operational efficiency. This tendency is expected to continue and to increase.

The Economic Planning Agency is planning to prepare guidelines for information dissemination of the details of the management, operation and financial situation of all public and private corporations, providing infrastructure goods and services with charges to be approved by the government. The aim is that the transparency of the management, operation and financial situation to general public is one of the best ways to improve efficiency, where a fully competitive market mechanism is not present.

Effort in research and development in construction technology is an area to be encouraged. Possible efficiency gains can be expected by the reduction of construction costs. One discouraging fact is the extremely expensive land acquisition cost. For expressway construction, land acquisition cost in Japan might reach the order of 40 to 60 percent of the total project cost. More important would be an effort for good planning. Efficiency could be attained by an exploration of ways of making more efficient use of infrastructure, for which good planning is essential, especially for new investment.

3.4 Public Investment Policy

In the majority of the OECD countries, governments are more inclined towards infrastructure investment when economic growth is high. In Japan, statistics from 1910 up to now show that the growth rates of investment in infrastructure and the gross national product correlate negatively and moved counter cyclically. However, it has to be understood that the Japanese government invested, on a continuous basis, a certain percentage of the gross national product to increase the insufficient stock of

infrastructure. Further, additional investment was made for infrastructure development as a means to recover economic recession through the short term multiplying effects of the investment on economic activities. Additional budget allocation of 8.6 trillion yen, i.e., roughly 70 billion U.S. dollars was made for public works in the middle of 1992 for this purpose. This amount is roughly two percent of the gross national product. The same is also a subject of discussion at present as the remedy for the present economic recession.

3.5 Necessity of Research to Justify Infrastructure Investment

It is well understood that, if the stock of economic infrastructure is below a certain level, insufficient infrastructure becomes a bottle neck for economic growth. Even when the stock of infrastructure is beyond this level, the link between infrastructure investment and economic growth is generally accepted, but it is not well understood nor easy to quantify. In particular, research has not yet fully explored the relationship between public investment and private sector performance except short term increase of output, private investment, productivity and employment. More important is to explore the link between the stock of infrastructure and long term economic growth.

Since difficulty is expected in increases or even keeping the present level of public infrastructure investment, research output showing the necessity of infrastructure investment for economic growth is essential to convince taxpayers and to raise funds.

3.6 Policy Dialogue with People at the Planning Stage

It is well recognized that the period from the planning stage to implementation for infrastructure development is lengthening. In some cases, even completion of a project becomes difficult. One typical example is the Narita airport project. More than 25 years have passed since the construction of the airport was decided at Narita.

The Japanese government has learned this lesson in a very hard way. It is now the common understanding of the planners that it is essential from the very beginning of the planning stage to have dialogue with all concerned. A process of consultation is necessary, with the involvement of regional and local interests, and particularly local inhabitants.

The assessment of environmental impacts is now also essential for a reasonably large infrastructure project. Assessment is made with reference to checklists and the negative cost to environment is reflected in the cost benefit analysis of a project.

These requirements made infrastructure development much more complex than in the past, especially in densely populated Japan, in addition to the difficulty in fund raising. The situation could be similar in the majority of Asian countries.

III. Lessons Learned and To Be Shared from Japanese Experience

The present state of infrastructure development of each Asian country is similar to the state that Japan has passed in the recent past years. There must be many lessons which could be learned form the Japanese experience in the infrastructure development for most Asian countries.

The Japanese history of infrastructure development, however, has not tended to create a bottle neck of economic growth due to insufficient economic infrastructure within the limited available resources. The investment for social infrastructure was kept to minimum until a decade or so ago. There must have been better resource allocation compared to the allocation made in the past years since the end of World War II. The choices for better allocation, however, seem to have been very little. Resources available in most Asian countries are also limited so that the range of the choice of policy planners may not be wide.

There are many successful infrastructure projects in Japan. Most notable among them are completion of Shin-Kan-Sen between Tokyo and Osaka, limited access expressway between the same two megalopolises, and a number of hydraulic power stations. Most of them are partially funded from the World Bank. The income generated from the Shin-Kan-Sen has been used to support the loss of most of other national railway networks. Privatization of the Japanese National Railway could have been difficult, if the income from the Shin-Kan-Sen had not been available. Similarly, the income from the expressway between Tokyo and Osaka is contributing to the expansion of the modern expressway networks. Hydraulic power stations continued to supply clean energy needed for industrial development, though its present share in power generation is below 20 percent.

Poor preparation of master plans for the development of big cities is probably one of the worst experiences in Japanese infrastructure development. It is regretful that major cities in Japan are the examples of the cities developed without good planning. These cities certainly need extensive reconstruction to make them places where the inhabitants can enjoy a reasonably good quality of life. The reconstruction work seems extremely difficult if not impossible by now, except for minor and localized improvement. This would be one of the most important lessons that Asian countries could learn from the Japanese experience.

Many foreign visitors praise the subway system in Tokyo as exceptionally good. As a person with an engineering background, I am personally very pleased for this sort of acknowledgement. At the same time, I am confident that, with the presence of a better master plan at an early stage, the subway system could have been even better. This is one of the other examples where the presence of a well thought out master plan plays very important role in infrastructure development.

Another weak point of Japanese historical infrastructure development was that the

forecast for the demand of many projects was much less than the real demand which was present when services started, though there were some exceptions such as Sei-Kan-tunnel and the Honshu-Shikoku fixed crossing. The demand far exceeding the forecast was mostly due to the extremely high economic growth rate of the country. Because of this, it is difficult to blame the planners, but we have to accept this underestimate of demand at the planning stages as the facts and reflect on this in the future projects. One of the worst examples of this underestimate of demand is the inner loop of the metropolitan Tokyo expressway network. The construction of the loop was completed in 1964 as a four lane expressway, which is currently jammed for large portion of the day. An increase in the number of lanes is necessary, but there is no possibility to do so without stopping the traffic. At the same time, it is unthinkable to stop the traffic for a year or two because of the resulting huge economic loss. This underestimate of future demand is one of lessons worth considering for Asian countries, where rapid and significant economic growth is expected.

Limited availability of resources forced the construction of the Chuo expressway, which is the second alternative expressway connecting Tokyo and Nagoya, as a two lane expressway at the beginning, though it was planned as a four lane expressway. Soon after the completion of two lanes, the construction of the additional two lanes followed, which resulted in more expenditure compared with construction as a four lane expressway from the beginning except expensive structures such as tunnels at places where traffic was expected to be light. A major portion of the expressway should have been constructed as a four lane expressway from the beginning.

Lack of coordination for a variety of infrastructure development has also caused additional unnecessary expenditure to taxpayers. This is most notable among the authorities in the big cities concerned on roads, subways and utilities such as water, sewerage, electricity, gas and telecommunication. Unfortunately, investment was scarce for the construction of utility conduits. Because of the lack of coordination among the authorities and the lack of utility conduits, city roads are dug and paved on an almost continuous basis, causing direct and indirect economic losses.

Again because of the availability of limited resources, the government did not acquire any land in advance. Limited availability of space combined with rapid economic growth made the rate of increase of the land price in big cities and their suburban areas far exceed the economic growth rate and inflation. A larger share of infrastructure investment is presently spent for the acquisition of land. It is of utmost importance to study and to implement a mechanism to prevent the hike of land prices. The price hike makes not only the infrastructure development difficult but enlarges the disparity between the rich and the poor.

When future economic growth is surely forecasted as is the case at many Asian countries, it is strongly encouraged to allocate as much budget as possible for infrastructure development for which a larger economic return is expected. This is one of the lessons we have learned from the experiences already mentioned, such as the Shin-Kan-Sen, and

the expressway between Tokyo and Osaka.

There are people who insist that the economic growth rate should be lowered by reducing production of unnecessary and/or inefficient goods and services. They are the people who are environmentally conscious. They insist that our society is built so that economic growth is directly resulting in an improved quality of life. By changing the mechanism, even under a reduced growth rate, a good quality of life could be maintained. In practice, it is a difficult task to change our market mechanism. However, the opinion certainly deserves serious study. The same argument may be applicable for the services provided by the infrastructure.

One of the most important lessons we have learned is the necessity of consulting all concerned authorities and inhabitants at the planning stage for infrastructure development. Without this consultation, large scale infrastructure development is very difficult to implement. As already mentioned, the Narita airport project is the most notable example.

I myself have backgrounds in structural mechanics and steel structures. They are the core elements of construction engineering. It is important to study how to construct durable structures cheaply. Presently, however, I feel that it is much more important to devise a good policy and plans to provide efficient infrastructure. The role and responsibility of policy makers are immense for the future infrastructure development among Asian countries, where the present stock of infrastructure is much below the level necessary for economic growth and for a good quality of life and where the available resources are limited.

II. 「Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan —PWRI's 70 Years and Perspective—」

Mr. Yukihiko Sumiyoshi, Director-General,
Public Works Research Institute, Ministry of Construction

Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan - PWRI's 70 Years and Perspective -

by Yukihiko Sumiyoshi
Director-General, Public Works Research Institute,
Ministry of Construction

FOREWORD

It is the great pleasure for me to have a chance of making lecture on a occasion of the conference on Public Works Research and Development in Asia.

SUMMARY

My lecture consists of 4 subjects.

The first subject is the role of infrastructure investment in Japanese economic growth.

Since the Meiji restoration(in 1868), the Japanese economy has been developing rapidly, especially after the world war II. Many economists have analyzed the reason of such a rapid growth had been considered to be that military spending has been kept at low level. And proper economic policy, development of industrial technologies have been successfully done. However, it might be difficult to achieve such rapid growth without proper infrastructure investment.

I would like to explain about the role of infrastructure investment in Japanese economic growth as the 1st subject.

The 2nd subject is the advance in civil engineering technology.

Japanese government kept the three policies to promote the public works and to expand the national power in the modern history.

There are;

- Positive introduction of advanced technology from the West, and promotion of R&D to renovate these technology to Japanese one.
- Promotion of technical education
- Adjustment of special law which supports the infrastructure investment

I would like to explain about the history of 3 items as the 2nd subject.

The 3rd subject is PWRI's 70 years history.

PWRI developed many new technologies and contribute to the renovation of civil engineering since PWRI was established in 1922. I would like to present the growth of the organization, remarkable researches, and the role of PWRI in the development of civil engineering as the 3rd subject.

The 4th subject is the PWRI's perspective.

Leading times is an ideal of PWRI, therefore, prediction of problems in future society is one of the most important work of PWRI. Trends of Japanese society, economic and research subjects which PWRI has to conduct in future will be explained at the end of my lecture.

1ST SUBJECT : ROLE OF INFRASTRUCTURE INVESTMENT IN JAPANESE ECONOMIC GROWTH

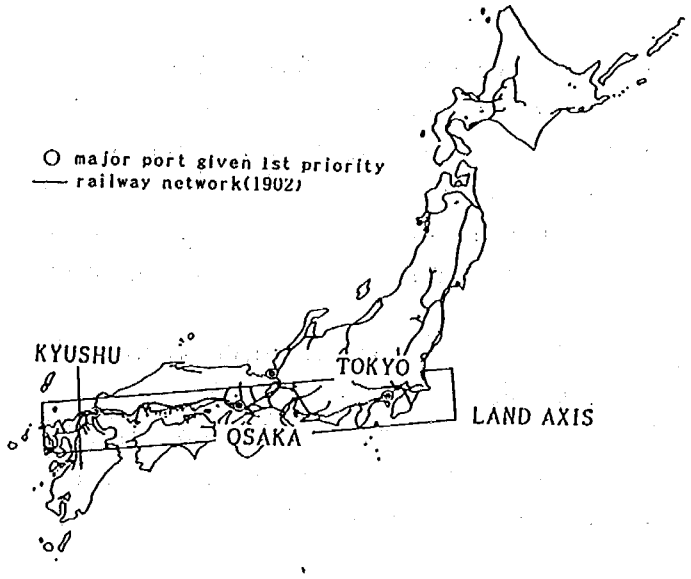
First, I would like to explain about the role of infrastructure investment in Japanese economic growth.

<HISTORY OF JAPANESE ECONOMIC GROWTH AND INFRASTRUCTURE INVESTMENT>

The new government of Meiji Restoration(about 125 years ago) was urged to construct the national traffic and communication system and modernize the industry to centralize administrative power and encounter western countries. For the industrialization of Japan, the government imported western technologies, for example, steel plant, machine, steam engine and so on.

This slide(1) shows the land axis of industry in Meiji era.

Before the Meiji restoration, economic center was in Osaka and political center was in Tokyo in Japan. Therefore, the line from Tokyo to Osaka necessarily became the major traffic and communication system. In addition because the largest coal mine was found out in northern Kyushu Island and the first steel plant was built there, the line of Tokyo-Nagoya-Osaka-Kyushu became the first land axis.

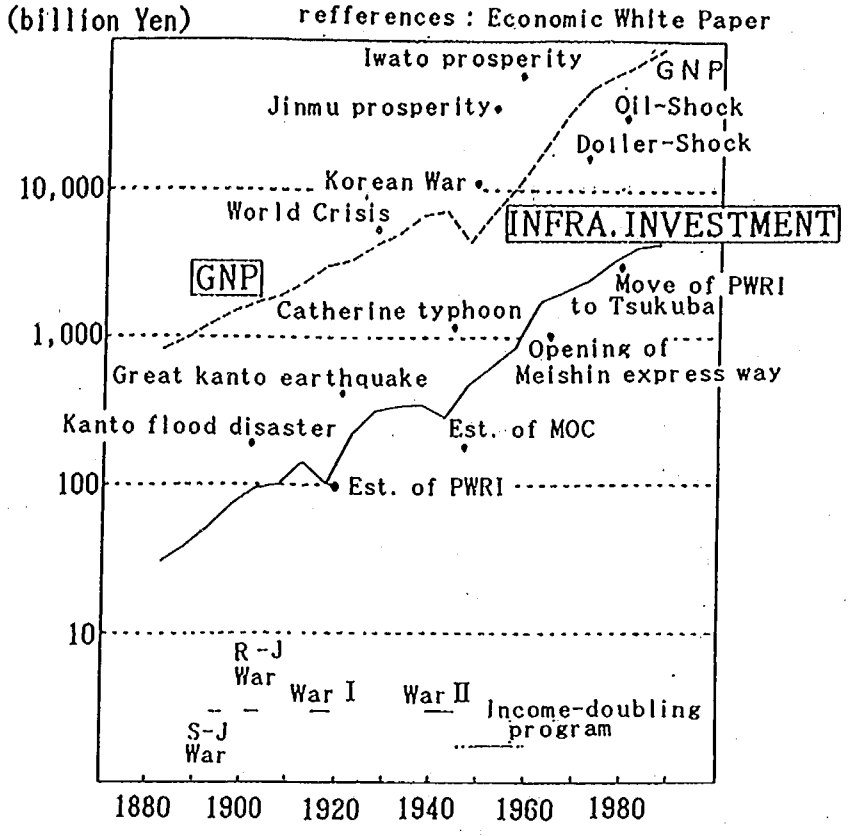


SLIDE 1 LAND AXIS

The land axis had an advantage that pacific ocean could be used as large sea lane connecting Japan to foreign countries through its many natural harbors in Japan's pacific coast.

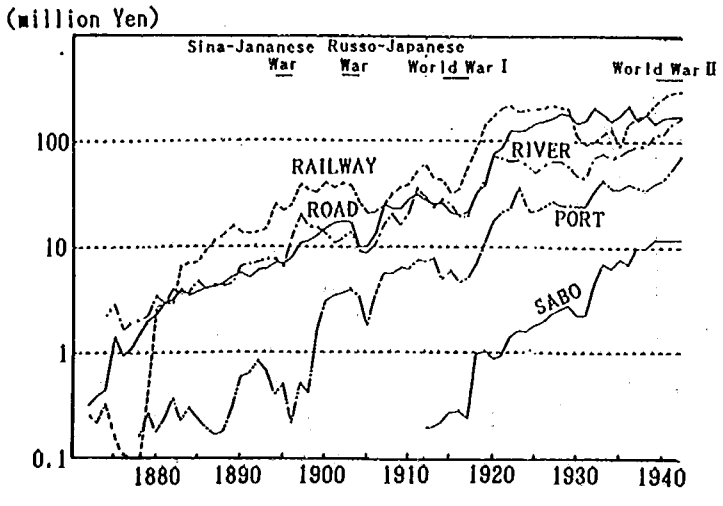
This slide(2) shows the budget of infrastructure investments in laps of time. The Russo-Japanese war reduced the budget for infrastructure investment. This is a typical example of the disadvantage of excessive military spending. Another war influence on infrastructure investment can be seen during World War I. The Japanese economy was thriving because of the large export of war goods to western countries, however, after the war ended in 1918, a reactionary recession hit the Japanese economy for a short time. Also during and after World War II, Japanese economy and infrastructure investment destructively declined.

As a whole, infrastructure investment looks like almost following increase of GNP except resent 10 years of zero-ceiling budget when infrastructure investment was lower increase compared to GNP.



SLIDE 2 GROWTH of GNP and INFRASTRUCTURE INVESTMENT

This slide(3) shows the growth of infrastructure investment before the World War II, in the each field of railway, river, road, port, and sabo.



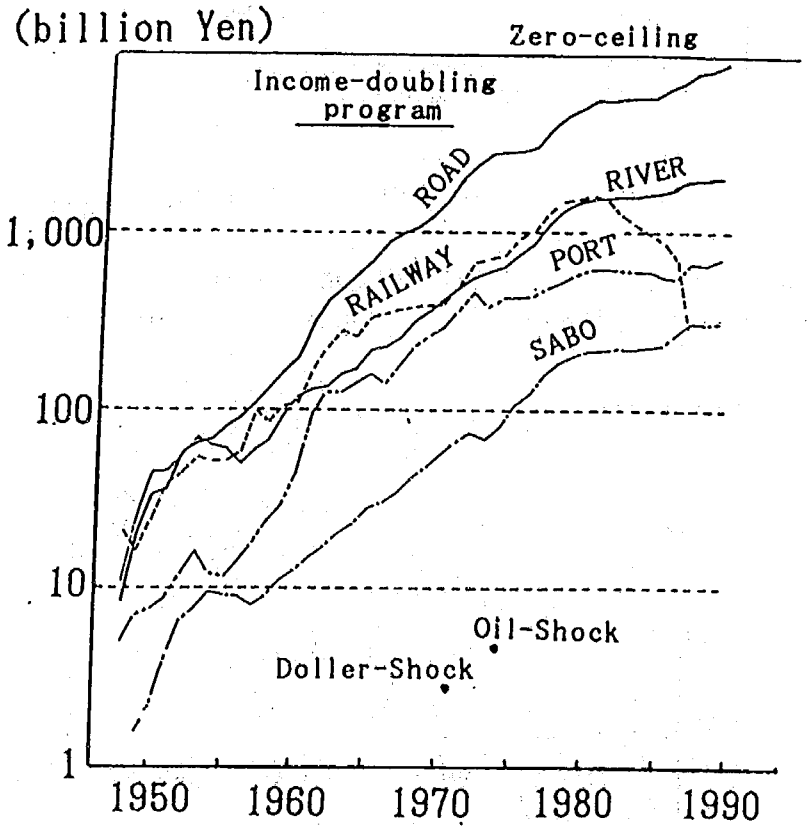
SLIDE 3 GROWTH of INFRASTRUCTURE INVESTMENT
(from Meiji Restoration to the World War II)

Before World War I, the major traffic investment had been concentrated in railway development, however, usefulness of automobile traffic became apparent during the recovery from the Great Kanto Earthquake and World War I urged the formulation. Investment to road became larger than that of railways in 1930s.

The world economy crisis (1932) hit Japanese economy especially in the country side where the major industry was agriculture. National government implemented the road and river improvement works as the countermeasure to unemployment in rural area.

At that time the first Road Law, Second and Third Flood Control Program were epoch-making policies in Japan. However, because those laws or programs were without any financial guarantee, budget of each year easily reduced or discontinued.

This slide(4) shows the growth of infrastructure investment after World War II, in the each field of railway, road, river, port, and sabo.
During World War II, the first priority was given to military budget. The productivity of industry became smaller than that of prewar. As the result of emphasis of military investment Japan often received flood disasters by typhoons after the end of war. Investment on river improvement was temporary increased just after World War II for the recovery of these disasters. Road sector kept the first priority for investment as a whole.



SLIDE 4 GROWTH of INFRASTRUCTURE INVESTMENT(after the World War II)

The turning point for the Japanese economy was "Income-doubling program" formulated in 1960. Five-year program and laws with financial guarantee were formulated in infrastructure investment. You can see the very high increase of infrastructure investment for all sectors until 1975. In this program, the constructions of highways and Shinkansen railway should be noted. Today, in the eleventh five-year road improvement program, it is planed that 14,000 km expressway will be completed in 2010.

In 1972 Japan had the second largest GNP in the world, created by the rapid economic growth. However, a dollar-shock (1971) and an oil-shock (1973) stopped the rapid economic growth. Japanese economy shifted to a status of "stable economic growth". Infrastructure investment came to moderate increase, or rather lower level comparing the increase of GNP in time of Zero-Ceiling Budget. Investment for railway declined after 1980, this is because of privatization of Japan National Railway.

This slide(5) shows the outline of big projects which plans at that time. Big projects such as the Seikan Tunnel, the Honshu-Shikoku Bridges, the New Kansai airport, the Tokyo Metropolitan Ring Roads, the Shinkansen and expressway networks. Some are completed and now in service, and some are still under construction.

SLIDE 5 BIG PROJECT and PROJECT for REGIONAL STIMULATION

N A M E	C O N T E N T S
Ring Roads Around the Tokyo Metropolitan Area	includes Tokyo Bay Road, Trans-Tokyo Bay Road
New Kansai International Airport	at offshore of Osaka bay 24-hour a day
Honshu-Shikoku Bridge	connects Honshu and Shikoku by 3 routes. Akasi bridge is the largest suspension bridge of the world
Seikan Tunnel	connects Hokkaido and Honshu longest undearsea tunnel of the world.
Tohoku Shinkansen	connects Tokyo and Tohoku region.
Joetsu Shinkansen	connects Tokyo and Japan Sea Region across the Honshu island by Shinkansen.
Kan-Etsu Expressway	connects Tokyo and Japan Sea Region across the Honshu island by Expressway.
Tohoku Expressway	connects Tokyo and Tohoku region by Expressway.

In 1990, as one of the result of Japan-US Structure Impediment Initiative(S.I.I.) the infrastructure investment in Japan during the period from 1991 to 2000 was declared to be 430 trillion Yen(about 3.5trillion us$). Focus of this investment is on raising the standard of living by the construction of sewage systems, city parks, road and river improvement projects.

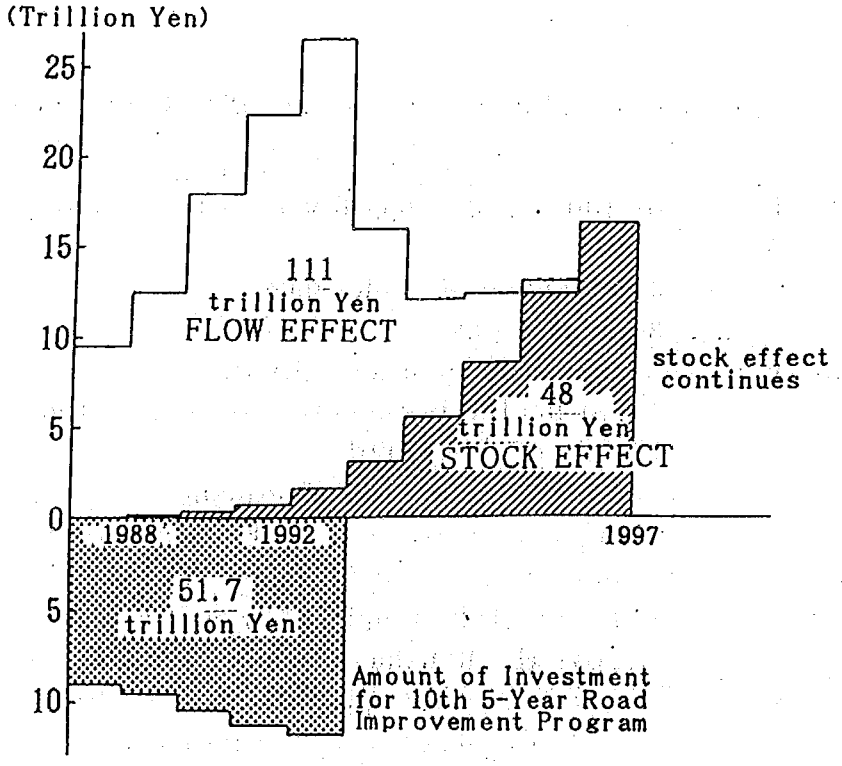
<EFFECT OF INFRASTRUCTURE INVESTMENT ON ECONOMIC GROWTH>

From now on, I would like to explain about the effect of infrastructure investment to economic and social development.

The 1st is the economic effect of infrastructure investment.

As an example, effect of road construction on economy is examined. The slide(6) shows a simulation of the economic effect of Tenth Five-Years Road Construction Project.

The simulated model shows an expectancy of a stock effect of 48 trillion Yen(about 370 billion US$) and a flow effect of 111 trillion Yen(about 850 billion US$) as a creation by 51.8 trillion Yen(about 400 billion US$) investment. It was caused by effects of road construction such as a high mileage for car, a shortening of travel time, an increase in the GNP, an increase in the tax and the employment opportunity, and the low goods value.



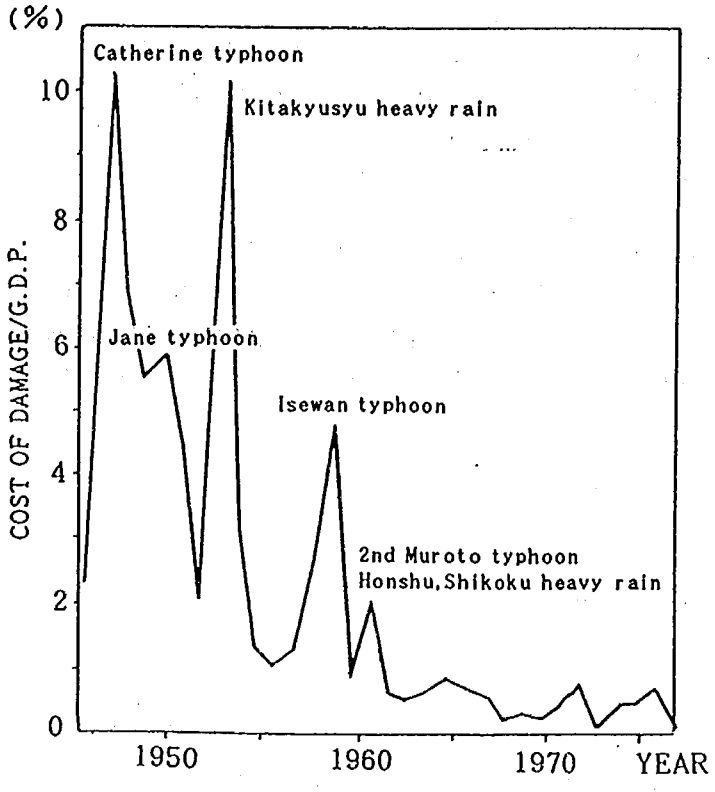
SLIDE 6 GROWTH of GNP by 10th 5-YEAR ROAD IMPROVEMENT PROGRAM

The 2nd is the effect of disaster prevention.

Reducing the losses by flood is one of the most important purposes of river improvement to active economic condition.

This slide(7) shows the ratio between cost of damage due to a disaster and GNP. It is definite that a 10% disaster damage rate just after World War II was

reduced to less than 1% after 1965 as the effect of implementation of disaster prevention facilities such as construction of large size dam and river improvement.



SLIDE 7 EFFECT of DISASTER PREVENTION WORKS

The 3rd is the triggering effect of economic growth.

Iwate prefecture was one of the most underdeveloped prefectures in Japan, till when tohoku highway was completed. This slide(8) shows the comparison of population, customable production, manufactured shipment and retail selling price between these of remote area and adjacent area from highway interchange. Completion of the highway contributed to an increase in these economic indices.

SLIDE 8 EFFECT of SOCIAL and ECONOMIC DEVELOPMENT by OPENING of NEW EXPRESSWAY

	Increase Rate of the Area within 30 minutes from the Interchange of New Expressway	Increase Rate of the Area More Than 30 Minutes from the Interchange of New Expressway
Increase of Population	3.7%	0.9%
Customable Production	44.6%	37.8%
Manufactured Shipment	38.5%	31.0%
Retail Selling Price	48.4%	42.1%

(Location : Iwate Pref., Area along the New Tohoku Expressway opened on Nov. 19, 1977. Total length=680km)

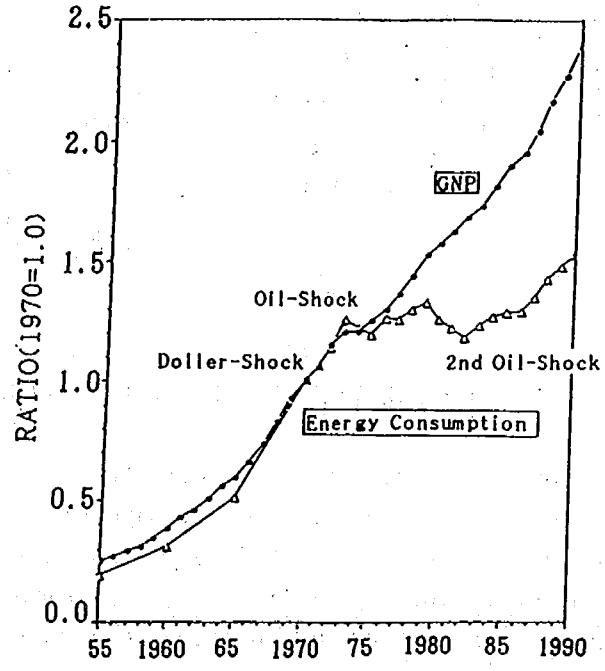
Japan's rate of energy consumption is the most efficient among advanced countries in the world. This slide(9) shows the relation between the growth of GNP and energy consumption in Japan. We can see that energy consumption of Japan does not increase after 1975 except recent 5 years. It can be consider that 3 items are the causes of the decline or level off, such as;

1)Efficiency of plant power sources and production has raised up GNP.

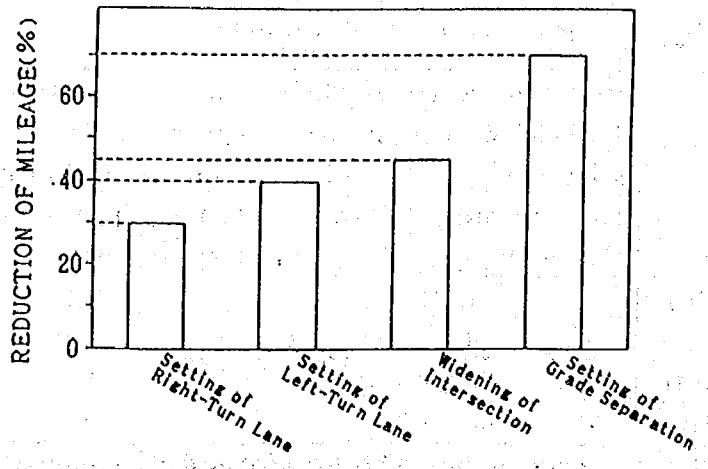
2)Growth of information and communication industry could raise up GNP without increase of energy consumption.

3)Construction of modernized transport facilities like expressway and shinkansen railway reduced the energy consumption.

For example, the effect of improvement of road facilities is examined. This slide(10) shows the reduction of mileage with intersection improvement. It is clear that improvement reduces the energy consumption, according to the type of improvement.



SLIDE 9 GROWTH of ENERGY CONSUMPTION and GNP



SLIDE 10 SUPPOSITIVE DATA on MILEAGE
(using 16 examples of intersection improvement)

2ND SUBJECT : ADVANCE IN CIVIL ENGINEERING

From now on, I would like to present the advance in civil engineering as the 2nd subject.

<HISTORY OF CIVIL ENGINEERING IN JAPAN>

It is thought that there are 3 factors in the development of civil engineering technology. They are the technological development, the engineering education and the tax law and system supporting the investment.

First factor is the technological development.

This slide(11) shows the 5 stages of the advance. I would like to explain about the history of the advance by the each stage.

SLIDE 11 5 STAGES of TECHNOLOGICAL DEVELOPMENT in CIVIL ENGINEERING in JAPAN

*1st Introduction of Foreign Technology(1868～1887)

*Reform of the Introduced Technology by Japanese Engineers(1888～1912)

*Technological Stagnation(1912～1945)

*2nd Introduction of Foreign Technology(1945～1964)

*Development of Original Technology(1965～)

1ST STAGE is the period of "the 1st Introduction of Foreign Technology by Invited Foreign Engineers".

Before the Meiji era, Japan already possessed the technology related to tunnel, bridge, dam, and bank protection work. However, Japanese technology was not designed for large size structures. Therefore, modern public works necessitated to introduce foreign technology by invited foreign engineers with exceptional salary.

This slide(12) shows the invited engineers and their specialities. It can be seen that English was invited for tunnel and bridge, American was invited for dam, and Dutch was invited for river and port. It suggests most progressed technologies of the world were introduced in Japan at that time.

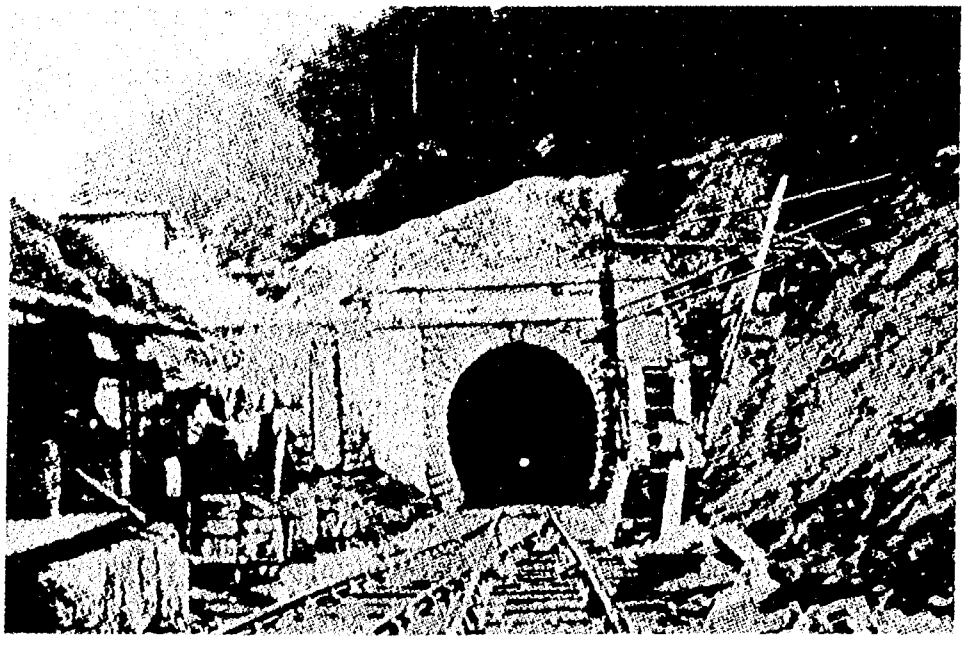
2ND STAGE is the period of "Reform of the Introduced Technology by Japanese Engineers Educated by Invited Foreign Engineer,or Educated in Foreign Countries".

In the 1880's Japanese engineers who were educated in foreign countries began to design and direct the constructions. I would explain about Osakayama tunnel as the representative constructions in this period.

SLIDE 12 INVITED ENGINEER and HIS WORKS in JAPAN

NAME and NATIONALITY of INVITED ENGINEER	MAIN ACHIEVEMENT
J. England(U.K.)	Ishiyagawa Tunnel
ditto	Sumiyoshigawa Tunnel
T.Gray(U.K.)	Ashiyagawa Tunnel
Engineers from Holland	Kuriko Tunnel
Vogel(Holland)	Kurogane bridge
Branton(U.K.)	Yoshida bridge
Holt(U.S.A.)	Toyohira bridge
Paul, White(U.K.)	Mukogawa bridge
Engineers of American company	Ooi Dam(kisogawa river)
Engineers of American company	Komaki Dam(Syokawa river)
C. J. Van Doorn(Holland	Imp. of Tone river, Asaka Canal
J. De·Rijke(Holland)	imp. of Kiso, Yodo river,etc.
H. L. R.(Holland)	Tone Canal
I. A. Lindow(Holland)	Imp. of Shinano river

This slide(13) shows the entrance of Osakayama tunnel. Osakayama Tunnel was the first one built by Japanese engineer. It has 665m length. Japanese original construction method was used for implementation. The tunnel was "handmade" one, because at that time there were many workers in gold mines in Japan. Tunnel floor was made of blocks and powder was used for destroy hard rocks, which was the way of western countries. So it could be said that tunnel was completed by the combination of Japanese traditional method and western technology.



SLIDE 13 OSAKAYAMA TUNNEL

3RD STAGE is the period of "Technical Stagnation".

In the period from Taisho Era to early Showa Era there was technology stagnation. The reason of this stagnation was seen to be the priority given to military spending in the budget and a recession forced not concerns away from new technology in civil engineering.

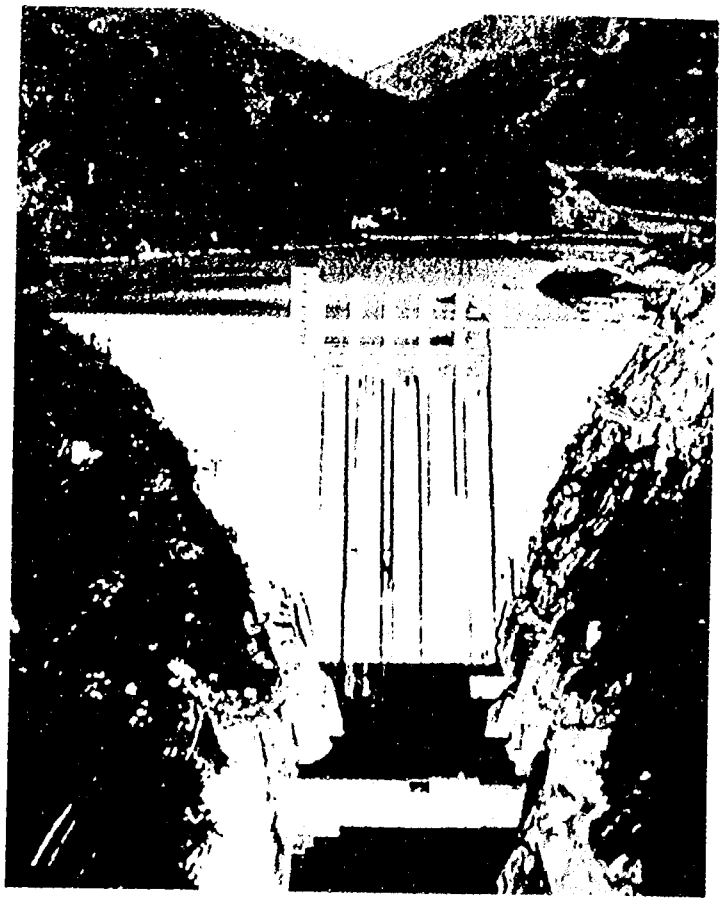
Only the Kanmon tunnel, which connected Honshu Island and Kyusyu Island, is the remarkable project.

4TH STAGE is the period of "2nd Introduction of Foreign Technology".

The rapid economic growth in 1950s necessitated large scale constructions of tunnel, dam and bridges. Introduced foreign technologies (especially from U.S.A) influenced to these large constructions. The rapid economic growth presented the chance for the renovation of introduced technology to Japanese conditions of nature, economy and society. These renovation with the development of original Japanese technology has led Japan to be one of the most advanced nation of the world in civil engineering technology today.

Remarkable works in this period is Sakuma Dam.

This slide(14) shows the view of Sakuma Dam. The American technology using heavy construction machinery changed surprisingly the Japanese construction works. Sakuma Dam 150 m in height, was completed in only 28 months. The term was almost half compared with past experience.

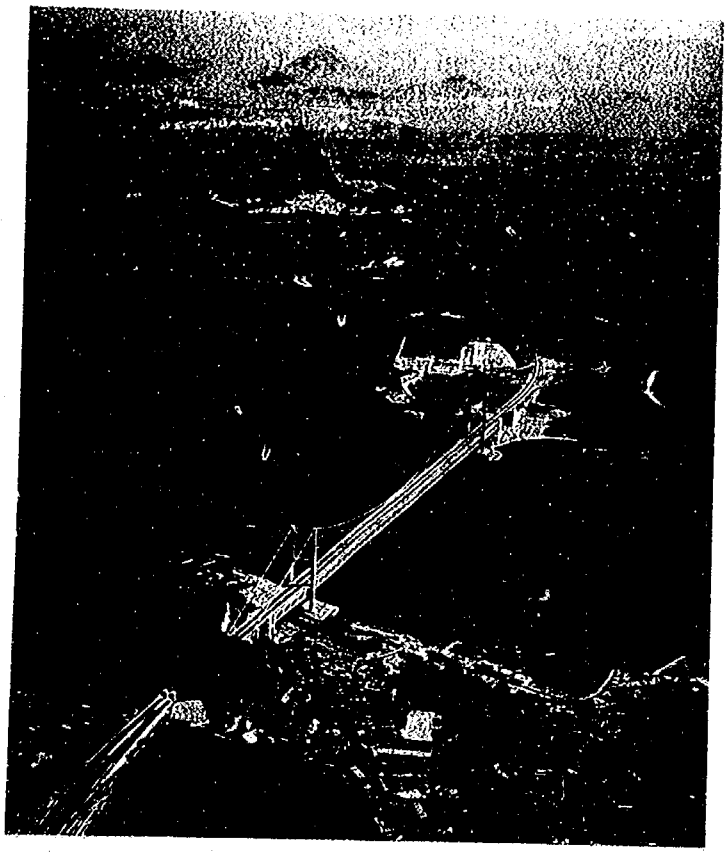


SLIDE 14 SAKUMA DAM

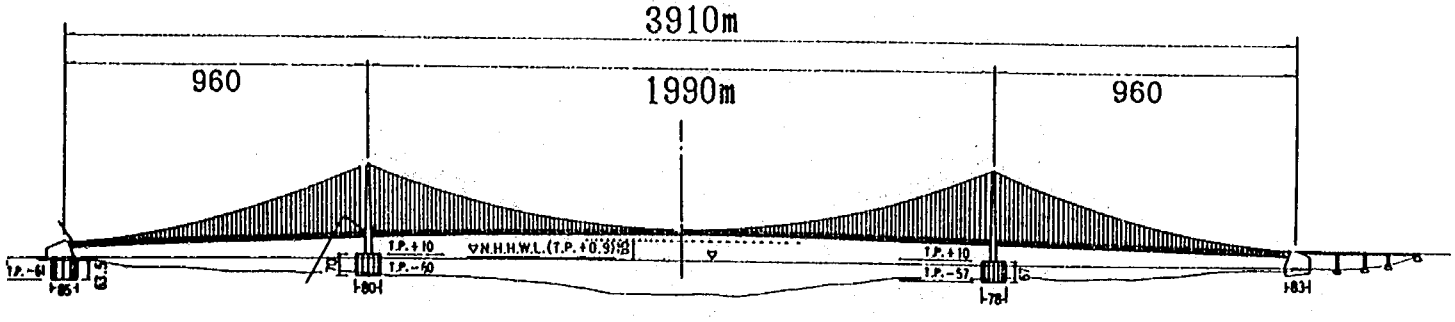
5TH STAGE is the period of "Development of Original Technology".

Japanese original technology for large size structures was developed in the late 1970s. These advance of original technology was supported by the development of other basic industries of steel, machine and computer and others.

The remarkable works are the Honshu-Shikoku Bridges and Seikan Tunnel.



SLIDE 15 HONSHU-SHIKOKU BRIDGE(Kojima-Sakaide Route)



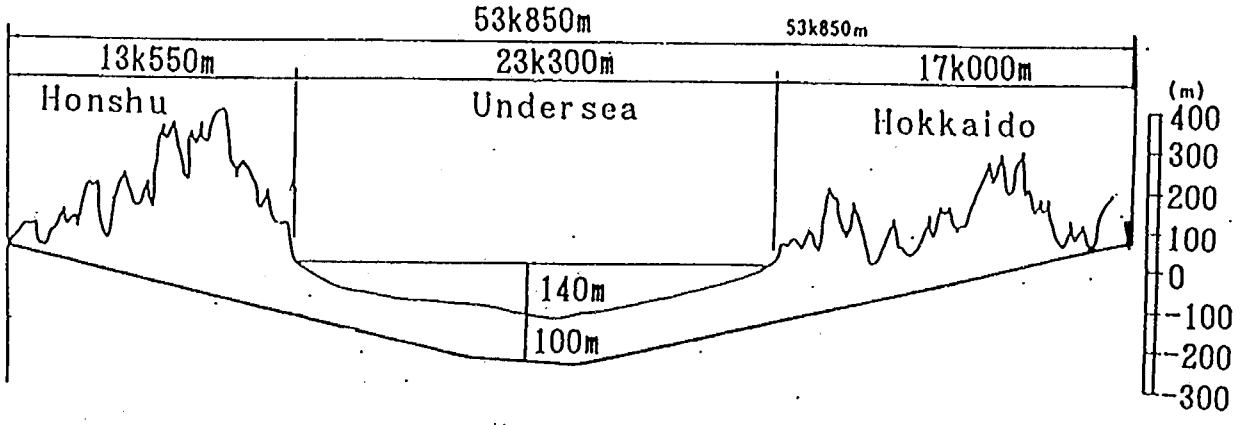
SLIDE 16 PROFILE of AKASHI BRIDGE

Honshu-Shikoku Bridges Project is composed of the construction of three routes. This slide(15) shows Kojima-Sakaide route completed in 1987 as the world

first suspension bridge with expressway and high speed railway. Another routes are under construction now. Designs of these bridges are made by the field survey and analysis about earthquake, typhoon and tide. A lot of new technologies are using in the bridge construction.

This slide(16) shows the profile of Akashi Bridge under construction now. It has a span length of 1990m. Akashi Bridge will be the longest suspension bridge of the world, when it will be completed in 1998.

This slide(17) shows the longitudinal cross section of Seikan Tunnel constructed between Honshu and Hokkaido. Seikan Tunnel which is 54 km in its length is the longest undersea tunnel in the world. The construction was perfected in 1985. Many construction technologies for the tunnel were developed. These new technologies are partially applied to Dover Straight Tunnel. We are going to visit the site of this tunnel within investigation tour of the conference.

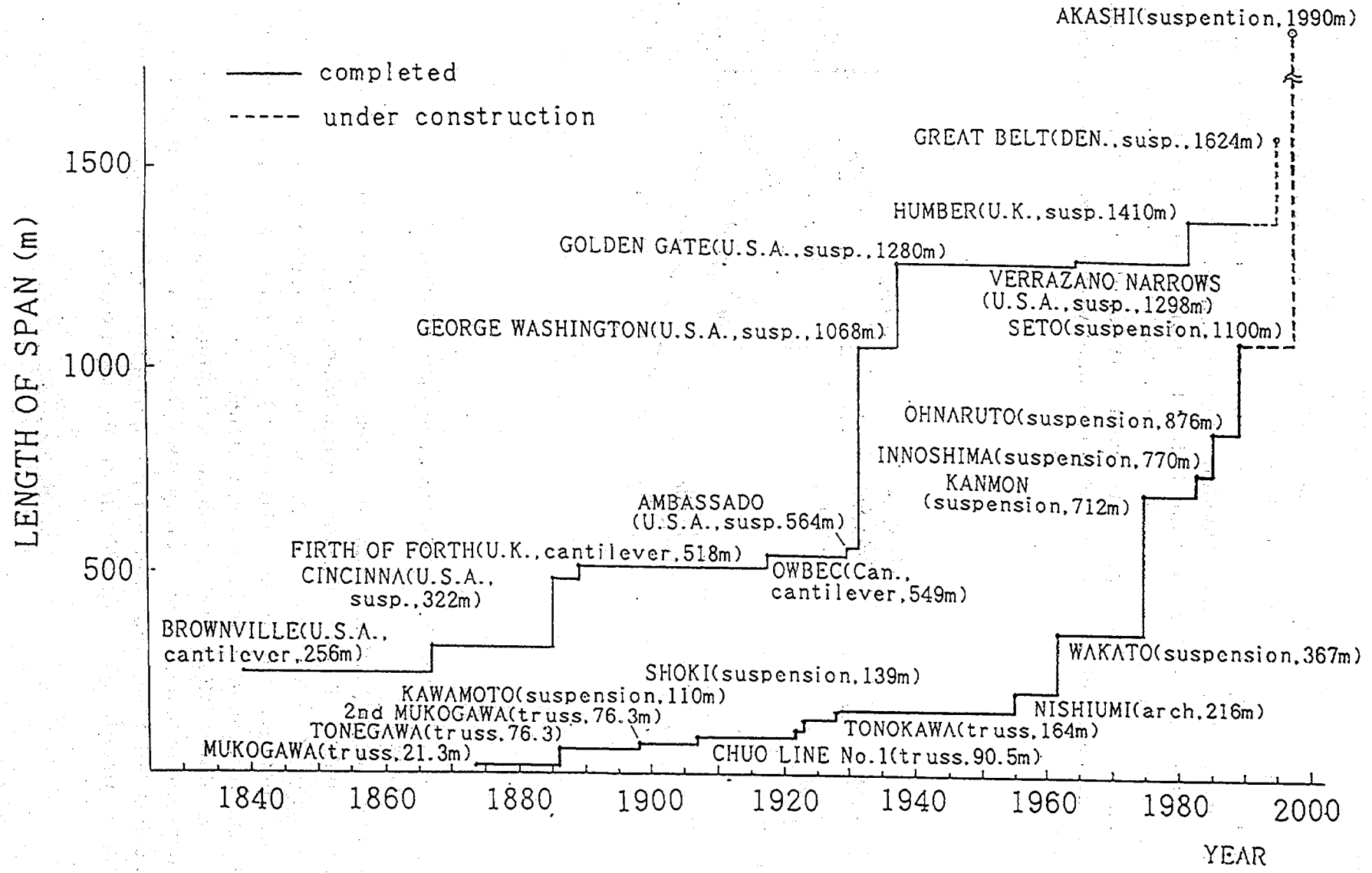


SLIDE 17 PROFILE of SEIKAN TUNNEL

Enlargement of structure can be used as an index of the advance of technologies. Length of span of bridge is explained here.

This slide(18) shows the enlargement of length of bridge span. Longest one of the world and that in Japan at each time are plotted on it. We can see the process that Japan has overtaken in bridge engineering.

It can be considered that factors which contributed to enlargement of center span of suspension bridge were mainly owed by advance of welding technology, high-strength steel wire, and foundation construction technology. Akashi Bridge applied wire of tensile strength 180 kg/mm^2 for main cable.



SLIDE 18 GROWTH OF BRIDGE SPAN LENGTH

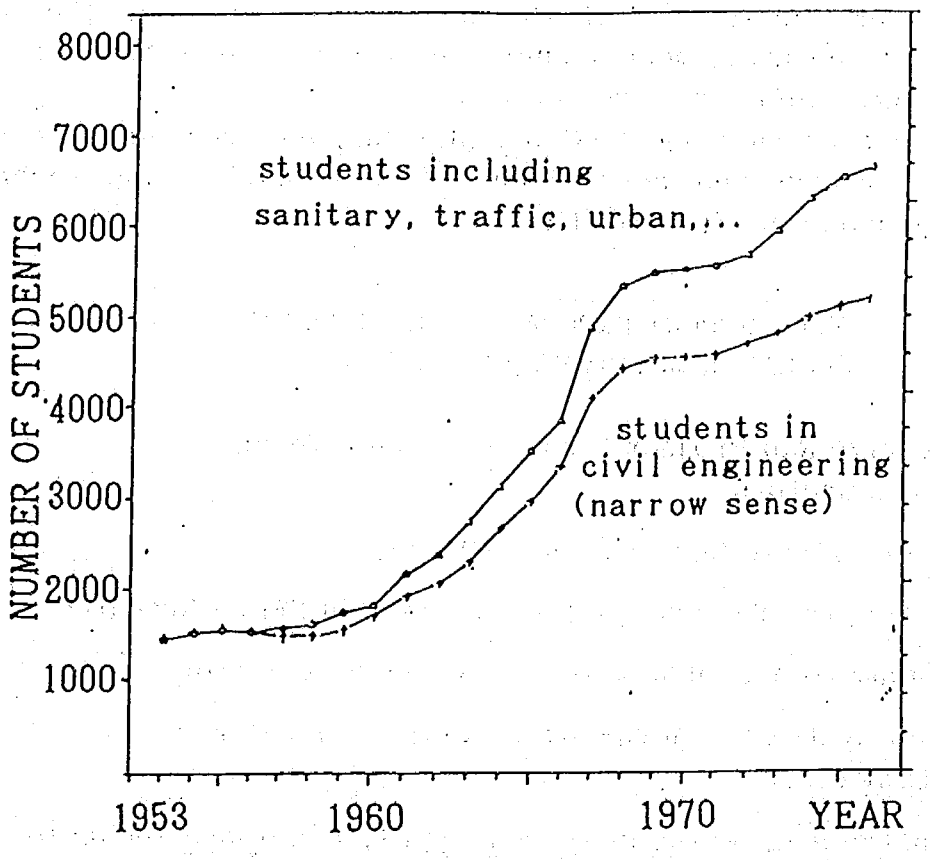
<HISTORY OF CIVIL ENGINEERING EDUCATION>

Next, I would like to explain about the history of civil engineering education, as the 2nd factor of civil engineering development.

In early Meiji era, the first education in civil engineering was begun at the college school of engineering in 1872 at the suggestion of Mr. Morel from England. Ministry Of Education united the high-level schools, and established Tokyo University, Sapporo Agricultural College. At the first, lecturer were foreign engineer. But presentation in english obstructed the understanding of Japanese students. Therefore, Ministry of Education decided Japanese as language for engineering education instead of english in 1884. It increased the skilled engineers at the whole level.

After World War II, many universities were built in Japan. These universities have supplied many engineers, and it contributes to the development of civil engineering.

This slide(19) shows the growth of number of students. Upper line explains the number of students of civil engineering in broad sense. Lower line is that in narrow sense, therefore, the differences indicates number of students of sanitary, traffic, urban, environmental engineering course. As you can see, number of students increased rapidly from 1960 to 1970(it came about 3 times), and the differences grows year by year. It suggests also the education system is changing according to the "needs of times".



SLIDE 19 NUMBER of STUDENTS in CIVIL ENGINEERING

<HISTORY OF FINANCIAL LAWS AND IMPLEMENTING PROGRAMS>

Next, I would like to explain about the history of financial law and improvement programs as the factor of civil engineering development.

Since the Meiji restoration, many national implementing programs were formulated to improve the river, road, port, and railway. But almost all programs had been reduced by financial distress.

Therefore, the government tried to get the financial source system and formulating laws to keep the financial guarantee. The remarkable efforts are System of Toll Road and special gasoline tax dedicated for expenditure of road improvement.

After World War II, 5-years improvement programs with financial guarantee were made in the each fields which were supported by financial systems and laws.

In addition, many public corporation were established as the organization for direct administration under the toll system by the public corporation laws.
Big amount of Government Post Office Banking is financed to public sector's project including infrastructure investment as a stable financial resources.

Next, I would like to explain about the systems for encouraging the R&D of private industries.

Since the end of World War II, some foundations has made and supported the R&D of private companies. Tax system is one of them. Tax deduction for the increase amount of research investment was established in 1962, in which 20% of corporation tax can be deducted in the case that the amount of research investment set over the amount of the preceding year. For the pioneering technologies, 7% of the investment amount can be deducted in the tax system for the promotion of basic pioneering research.

Ministry of Construction and PWRI provide support program for encouraging and promoting research and development of civil engineering technology in private companies shown on this slide(20).

SLIDE 20 MOC SUPPORT PROGRAM for ENCOURAGING RESEARCH in PRIVATE COMPANIES

* Comprehensive R&D Project for Construction Technology with Private Sectors
* Government/Private Sector Joint R&D Project
* PWRI R&D Program for Private Sectors to Join PWRI's Research
* PWRI Program to Accept Researchers of Private Sector
* Evaluation System for Advanced technology Developed by Private Sectors
* Pilot Construction Works Program to Apply Developed Technology

<FACTORS OF ADVANCE IN CIVIL ENGINEERING>

As the conclusion of 2nd subject, I would like to explain about the factors of advance in civil engineering.

It was remarkable that it took only twenty years to master western technologies in early Meiji era. The reasons of this rapid mastering of foreign technologies are on the slide(21).

SLIDE 21 FACTORS of ADVANCE in CIVIL ENGINEERING TECHNOLOGY (in Meiji Era)

1) Aggressive Introduction of Advanced Technology

2) Renovation of Introduced Technologies to Japanese one

3) Volunteer Spirit to Build the New Country

4) Establishment of Engineering Education System

(1)In early Meiji era, Japan had already entered the stage of early capitalism, therefore, it was easy for Japan to accept the system and technology of advanced capitalist countries.
(2)Japanese engineers eagerly made effort to renovate introduced technology to be applied to natural, economic and social conditions of Japan.
(3)Most of engineers of those days had been in samurai class before Meiji restoration. They had flourishing volunteer spirit to build new country.
(4)Invitation of foreign engineers, opening of engineering college school and dispatch of young students to foreign countries were systematically done to absorb advanced technology and to educate engineers.

The rapid growth of economy in 1960s invested large amount of national budget. Financial backing of constructive projects urged development of new technology and originated many big projects such as the Honshu-Shikoku Bridges, the Seikan Tunnel, the Expressway and etc.. This new movement was propelled by the general policies about technology development, which are on the slide(22).

(1)Government recommended and protected the development of technology by private industries. In detail the government legislated for tax deduction in technology development and joint research of government and private industry. The differentiation of construction and engineering consultant shifted private companies to applied research, and shifted government's institutes to basic leading research.
(2)Task committee consisted of university, private industry and governments was organized in each big constructive project. The system of task committee was

very useful on coordination of basic and applied research information.
(3)Establishment of civil engineering division in many national and private universities supplied many highly educated students.
(4)Many companies of steel, machinery and chemical industries developed technology related to civil engineering. This activity together with the development of construction industry presented the new material technology and construction one.
(5)Engineering researchers of universities, government and private industries are often experienced real construction works in construction site in order to get practical way to solve problem.

SLIDE 22 FACTORS of ADVANCE in CIVIL ENGINEERING TECHNOLOGY (after World War II)

1) Promotion of R&D on Private Industry by Government

2) Systematization of Task Committee for Big Project

3) Increase of Civil Engineering Course in Universities

4) Advance of Technologies Related to Civil Engineering

5) Practical Education for Researchers

3RD SUBJECT : HISTORY OF PWRI

From now on, I would like to explain about the history of PWRI as the 3rd subject.

The PWRI is one of the most historic institute in the field of civil engineering. PWRI developed many new technologies in 70 years. Newly developed technologies by PWRI were always characterized as "needs of times". The development of technology in PWRI has been supported by the flexibility of organization. Now PWRI has nine research departments, one center and one branch laboratory. And 472 proper staffs work in comparing 38 staffs when it started.

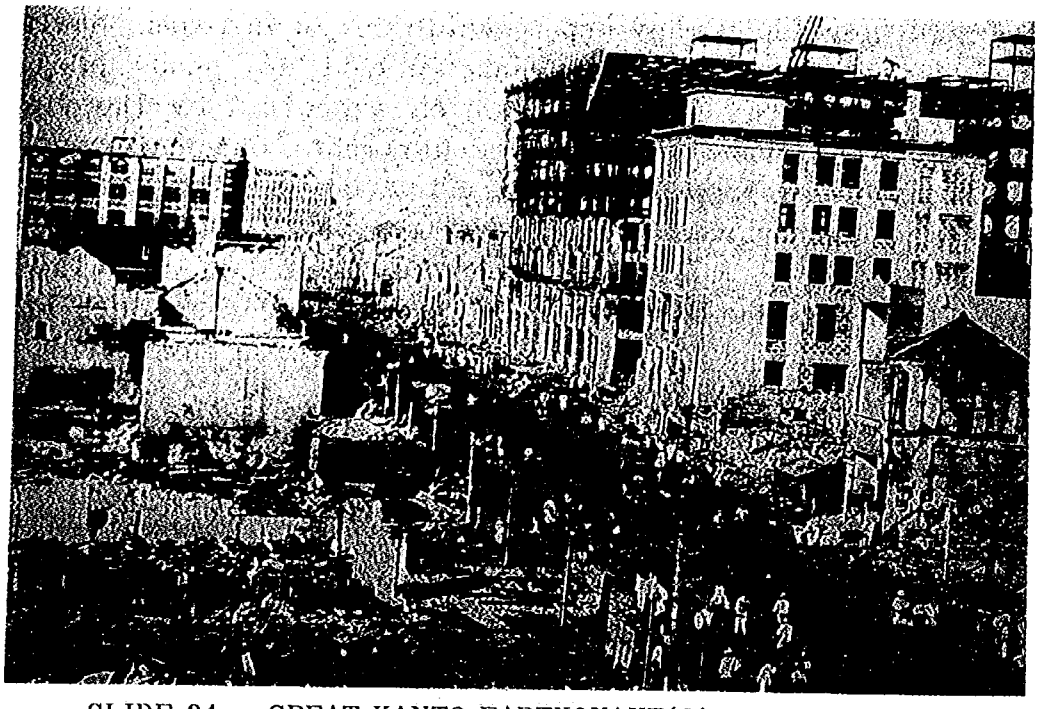
In 1920s, road construction became very important in national traffic system. Road Material Laboratory, Ministry of Interior was built in 1921. The Laboratory became Civil Engineering Laboratory in the next fiscal year which is considered the origin of PWRI. You can see the main building of Civil Engineering Laboratory at Komagome, Tokyo on this slide(23).

SLIDE 23 MAIN BUILDING(Komagome, Tokyo)

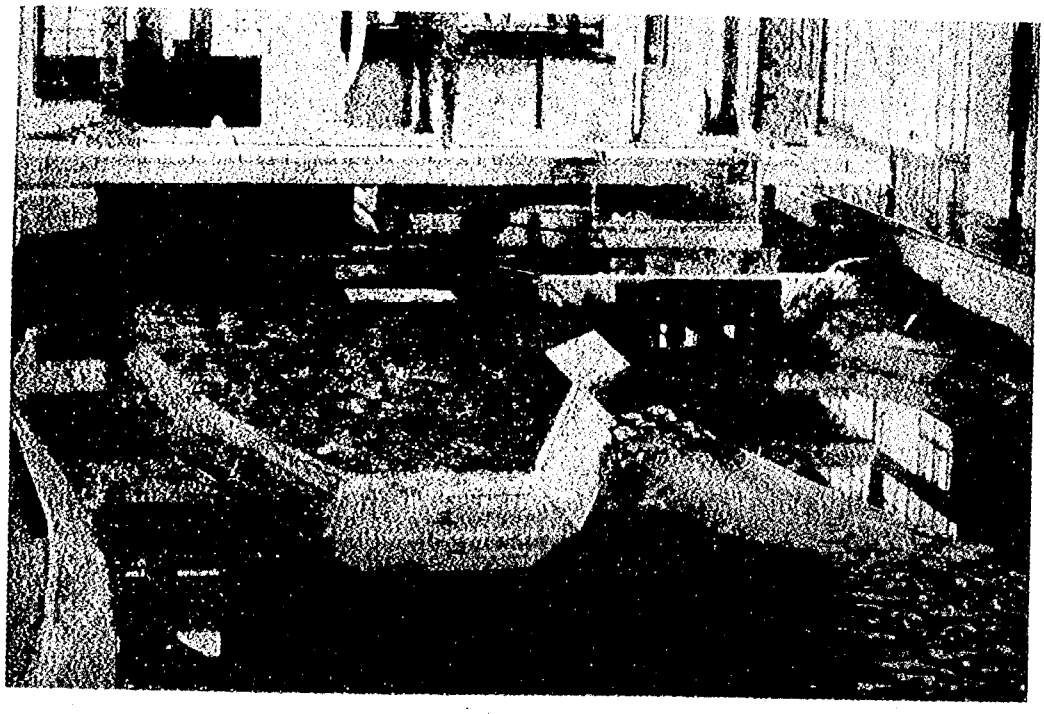
Mid noon, September 1st in 1923, Great Kanto Earthquake occurred with energy level of M 7.9. 100,000 persons were killed, 40,000 persons were missed and 58,000 houses were fired. The slide(24) shows the disastrous scene at Ginza area of Tokyo. Civil Engineering Laboratory conducted the survey of the disaster. As a result of the survey Dr. Mononobe, Director of Civil Engineering Laboratory, emphasized the researches of earthquake engineering. The achievement was published in "EARTHQUAKE STUDY IN CIVIL ENGINEERING", and was the basis of earthquake engineering in Japan.

The movement which makes PWRI more synthetic, produced the Akabane Branch as the hydraulic laboratory. This slide(25) shows the hydraulic experiment of Iwabuchi Water Gate conducted there.

During World War II, PWRI had to conduct military-related researches with reduced budget. The researches conducted in this period were;
(1)Reinforced concrete which used bamboo substituting for steal.
(2)River flashing for clearing mosquito larvas.
(3)Durability of dam for bombing.



SLIDE 24 GREAT KANTO EARTHQUAKE(Ginza, Tokyo)



SLIDE 25 HYDRAULIC EXPERIMENT for IWABUCHI WATERGATE

In 1948, Ministry of construction(M.O.C.) was established and Civil Engineering Laboratory was renamed as Public Works Research Institute as a institute of

M.O.C..

Concentration of military expenditure during the war time was one of the main reason for serious natural disasters after the war. This slide(26) shows the contents of natural disasters at that time. For the prevention of flood damage, Shinozaki research branch of PWRI was established for large scale hydraulic model experiments.

In addition, Numazu branch was established in 1949 for the test of construction machine and snow plow.

SLIDE 26 MAIN NATURAL DISASTERS OCCURRED
in 20 YEARS after THE WAR II

DATE	NAME OF NATURAL DISASTER	NUMBER OF KILLED AND MISSED
1946	Nankai Earthquake	1330
1947	Catherine Typhoon	1930
1948	Fukui Earthquake	3769
1948	Iona Typhoon	838
1958	Kanogawa Typhoon	1269
1959	Isewan Typhoon	5041
1964	Niigata Earthquake	25

In 1960 the government formulated "Income-Doubling Program". This program strengthened the economic growth and increased investment for the public works. This movement produce some branches in PWRI. Kashima laboratory for the advance of hydraulic research in 1952, Chiba research blanch for the advance of road research in 1960, and Niigata laboratory for the study of the land sliding and snow avalanches were established.

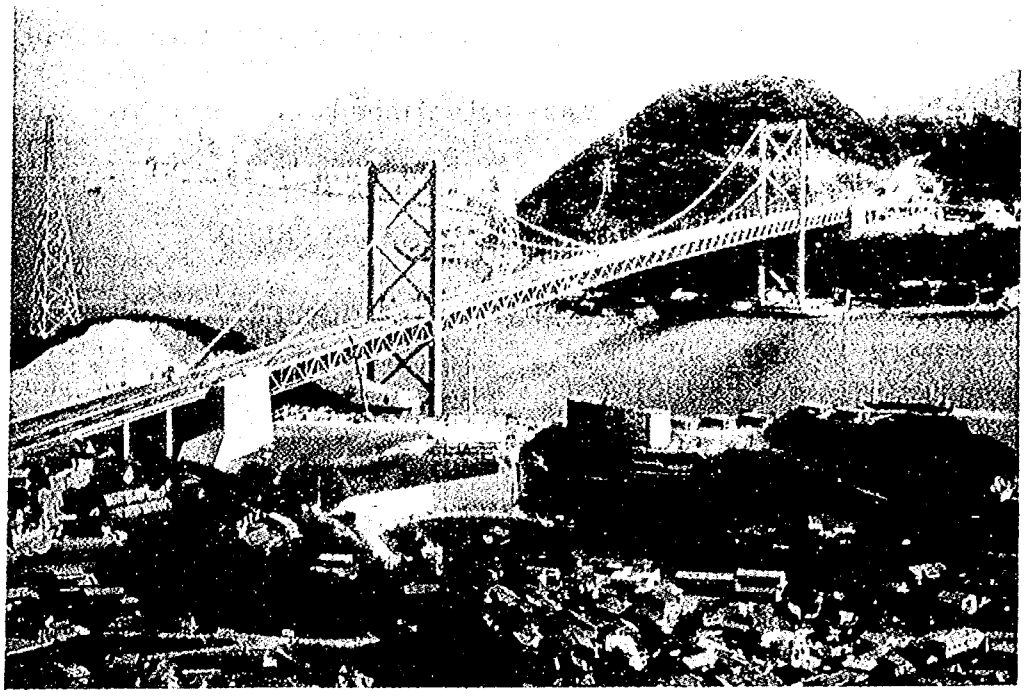
A lot of new technologies began to bring up from this period.

*Testing method of asphalt stability
*Traffic sign
*Application of Clothoid curve in road design
*Wind effect on suspension bridge
*Formula of river bed load transport
*Processing of activated sludge in factory waste water
*Estimating method for sediment yield

Remarkable works are "survey and research for construction of Honshu-Shikoku Bridges", and "Study on liquefaction".

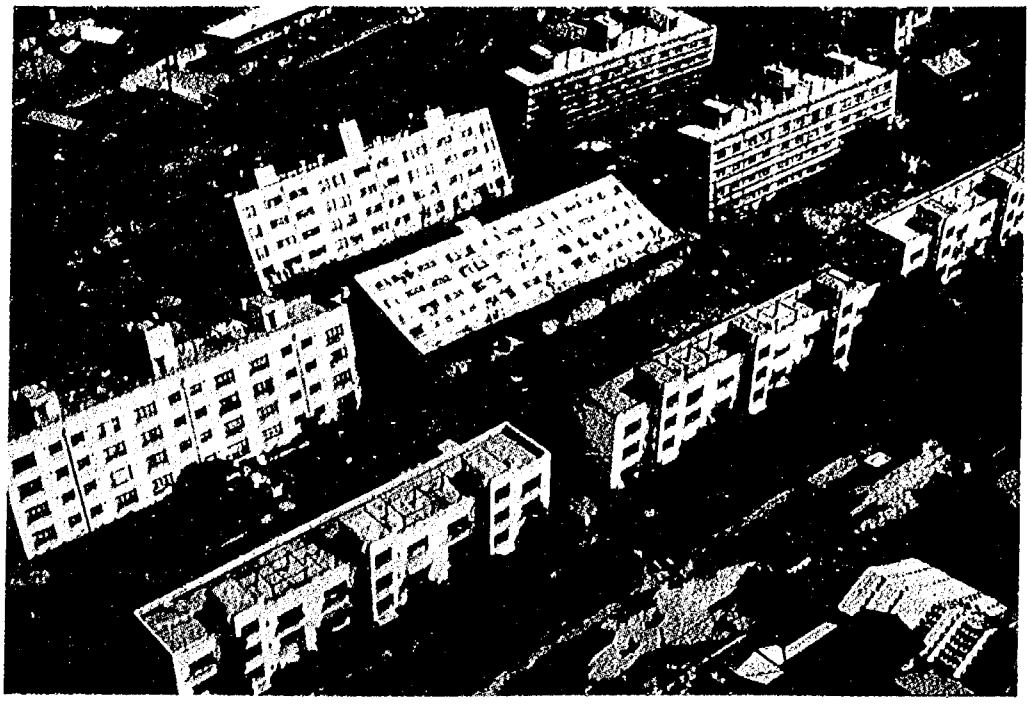
In 1959 PWRI started the geological survey by air photo and sounding on Setouchi sea bottom for constructing Honshu-Shikoku Bridges. Many researches were carried out for the construction of the long span suspension bridge, such as Seismic design of substructure, Rust proof painting, Electric rust proof, Wind effect on suspension bridge.

This slide(27) shows the Kanmon Suspension Bridge, which was built in 1973. Above achievements of research applied to it in construction. The completion convinced the success of Honshu-Shikoku Bridges Project.



SLIDE 27 KANMON SUSPENSION BRIDGE

The reason for severe disaster by Niigata earthquake(1964) was the liquefaction. This slide(28) shows the view of tilted buildings. PWRI started the research on the prevention of liquefaction. Basic characteristics of liquefaction was studied in order to develop the countermeasure.



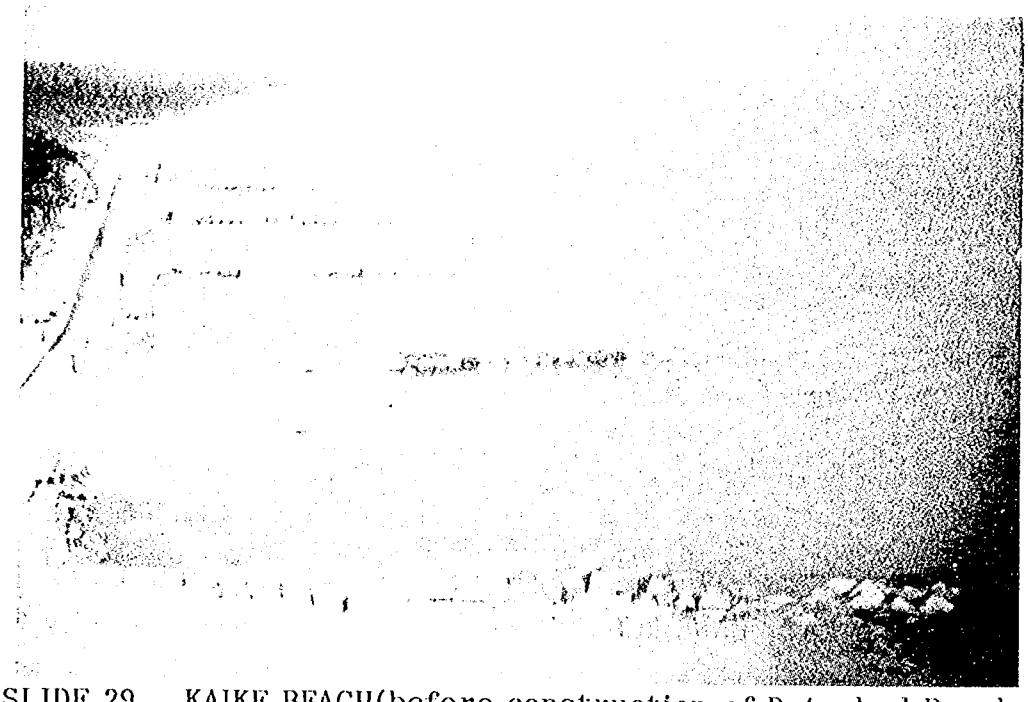
SLIDE 28 NIIGATA EARTHQUAKE

In the latter half of the 1960's, the high economic growth caused many social problems such as the pollution, an increase in traffic accident and so on. These social distortion demanded PWRI to build new research divisions. 12 divisions were set from 1966 to 1975.

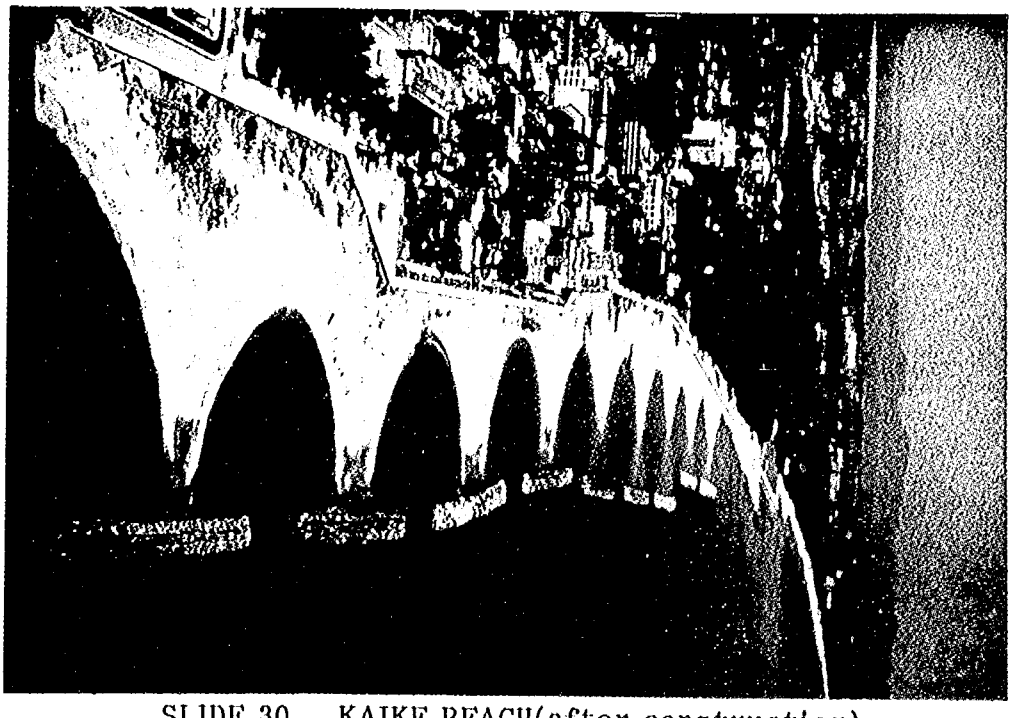
Trend of researches carried during this period, changed more fractionalized.

*Lithological classification of ground rock
*Simulation model for water pollution
*Analysis on traffic accident

are the remarkable works in PWRI. For examples, I would like to explain about "the detached breakwater", "the bank reinforcement against overtopping by flood", and "flat arch dam".



SLIDE 29 KAIKE BEACH(before construction of Detached Breakwater)



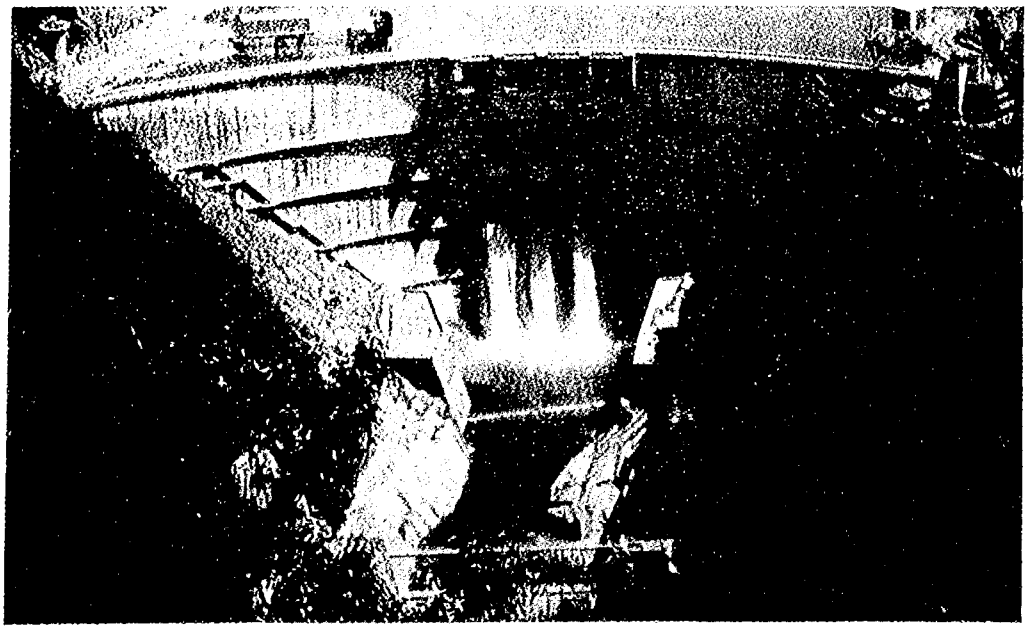
SLIDE 30 KAIKE BEACH(after construction)

In order to prevent the run off sand in seashore, detached breakwater which was built in parallel with seashore was developed. This slide(29) shows the Kaike Beach before building the breakwater. Few beach sands are there.
This slide(30) shows the same site. We can see the revival of beach sands by the breakwater. This success made it a popular protection method of beaches in Japan.

Major reason for the bank destruction is an overtopping by flood. PWRI developed the "Armor levee" in which non woven fabric of high polymer material was laid just beneath the slope of bank. This slide(31) shows the real scale experiment. The work pioneered the recent policy for the protection against unexpected flood.

SLIDE 31 EXPERIMENT for BANK REINFORCEMENT against OVERTOPPING by FLOOD

A collapse of Malpasset Dam in France focused attention on the design of foundation. Flat arch dam developed by PWRI reduced the shear force in rock plate. This slide(32) shows Yahagi Dam which has a typical design of the flat arch dam.



SLIDE 32 YAHAGI DAM

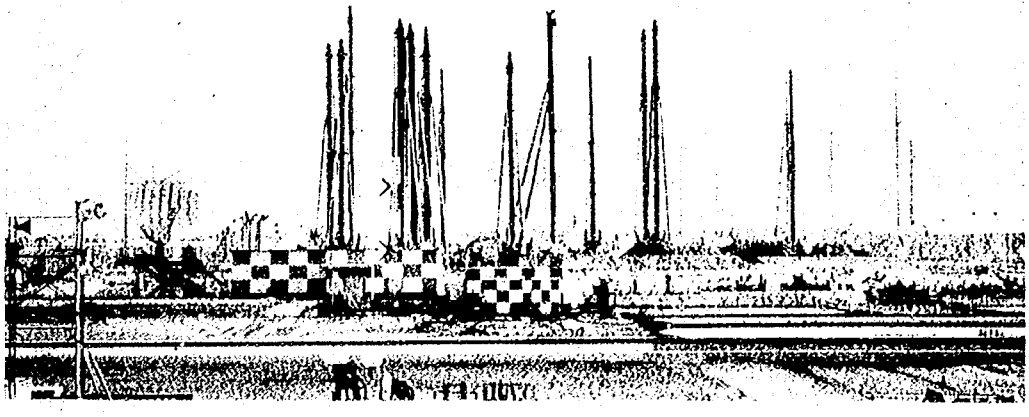
In the first half of 1970's, the Dollar shock(1971) and the Oil shock(1973) discontinued the rapid economic growth in Japan. The stable economic growth has started, and deconcentration of population, particularly from metropolitan area became the most important policy in Japan. It moved PWRI to here in Tsukuba city. Main office and Chiba, Akabane, Shinozaki, Kashima branches were united then.

Remarkable researches in this period were;

*River hydraulic characteristics
*Use of waste sludge in construction material
*Reinforcement of road cut and bank
*Ventilation of road tunnel
*Study of recovery from earthquake disaster

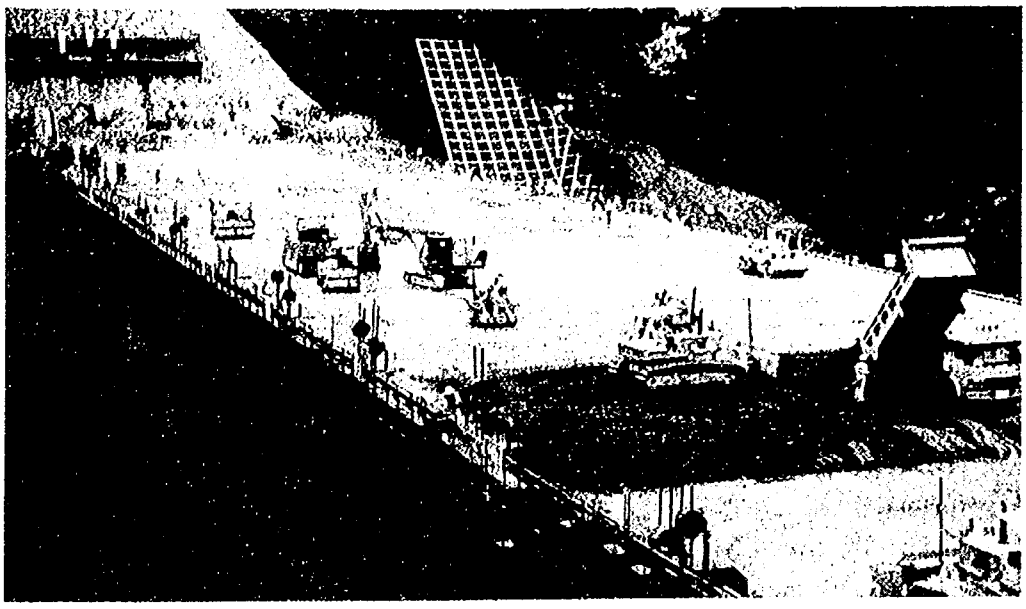
Here, I would like to explain about the contents of remarkable works such as "Dry Jet Mixing(DJM) method for soil improvement", " Roller Compacted Dam concrete(RCD) method", and "Study on alkali aggregate reaction"

Dry Jet Mixing(DJM) method which was developed by PWRI aims to harden soft ground. Dry cement or lime are mixed with soil directly in this method. This slide(33) shows DJM method at Haneda Airport Extension. Many advantage such as firmness, quickness made DJM very popular.



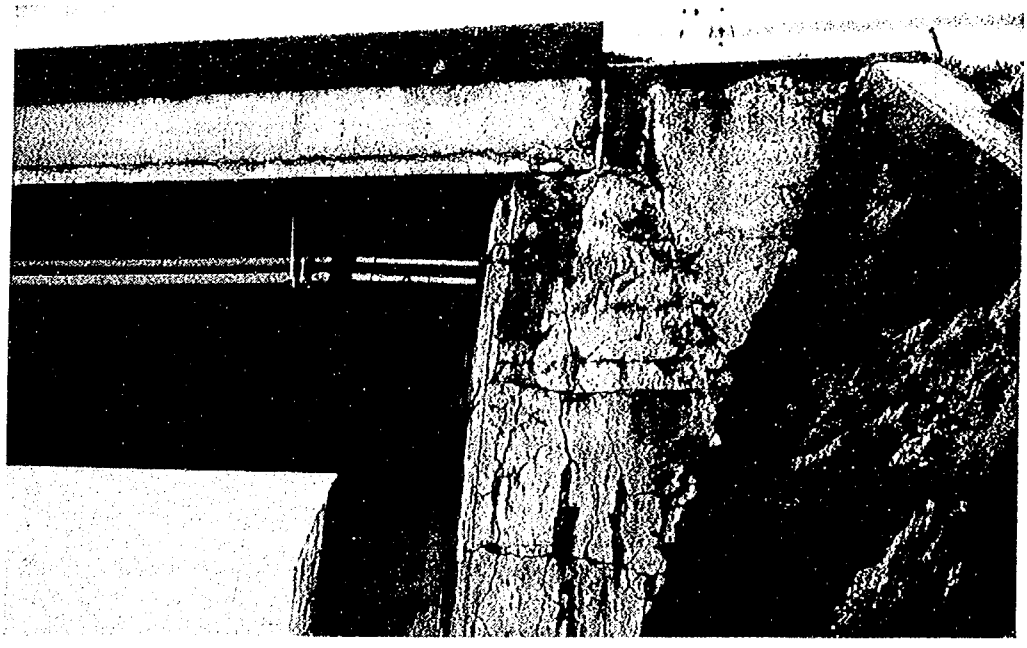
SLIDE 33 DJM at HANEDA EXTENSION

Rising of costs required to economize the construction of gravity dam. PWRI established "Roller Compacted Dam concrete(RCD) method", which is the one of economic, and rapid construction method by compacting lean-concrete by roller. This slide(34) shows the construction site conducting by RCD method. RCD is major in Japan and is exported to foreign countries.



SLIDE 34 RCD METHOD in DAM CONSTRUCTION SITE

The slide(35) shows alkali aggregate reaction on bridge substructure. PWRI standardized testing method of aggregate materials to avoid damage by alkali aggregate reaction.

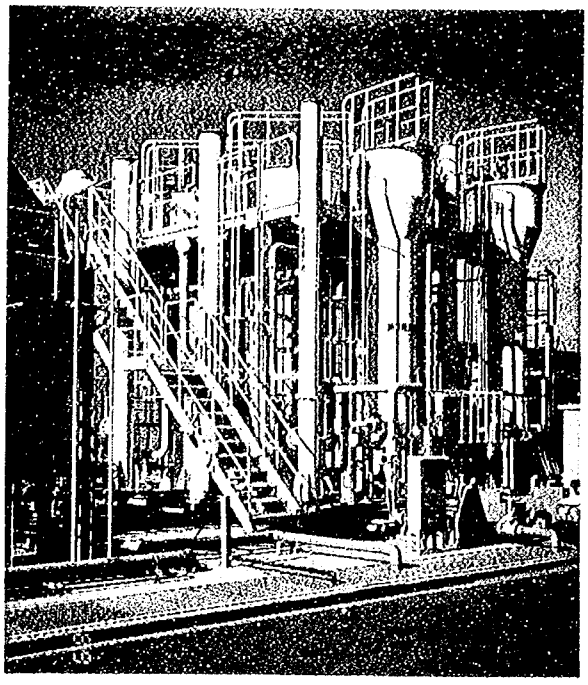


SLIDE 35 ALKALI AGGREGATE REACTION on BRIDGE

In 1991, Construction Management Engineering Center was established in PWRI, aiming to study the ways of construction management for activation of construction industries and the renovation of technology.

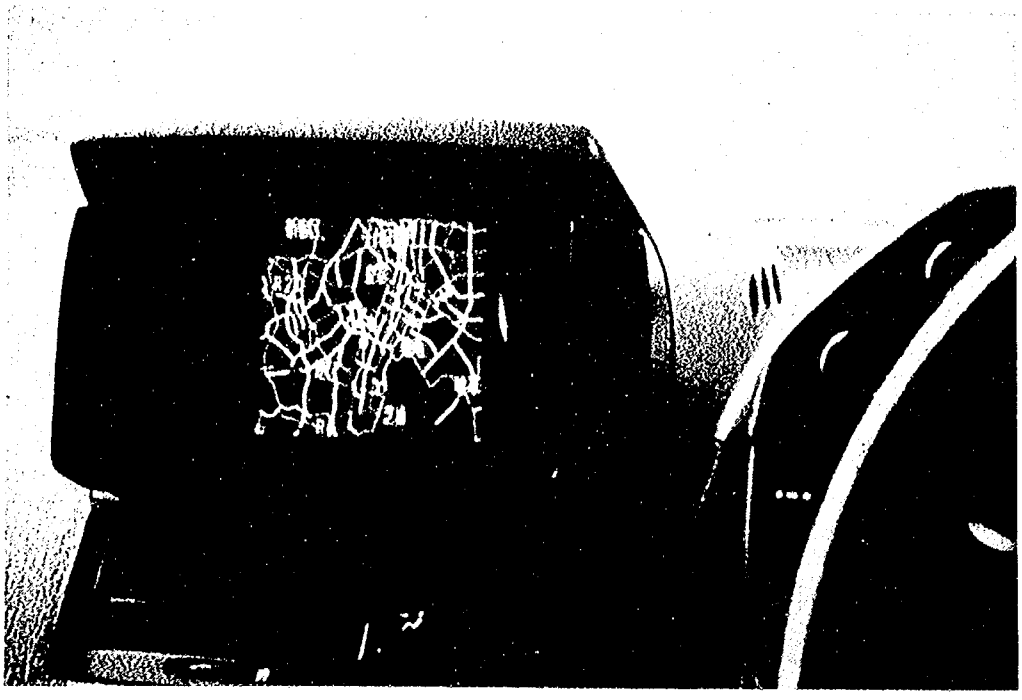
"Biological waste water treatment", "Road/automobile communication system", and "Study on pyroclastic flow" are the some of recent researches conducted in PWRI.

PWRI developed innovative wastewater systems by using the biological technology such as the immobilization of microorganisms. This slide(36) shows the Bio-reactor in pilot plant at Tsuchiura City.



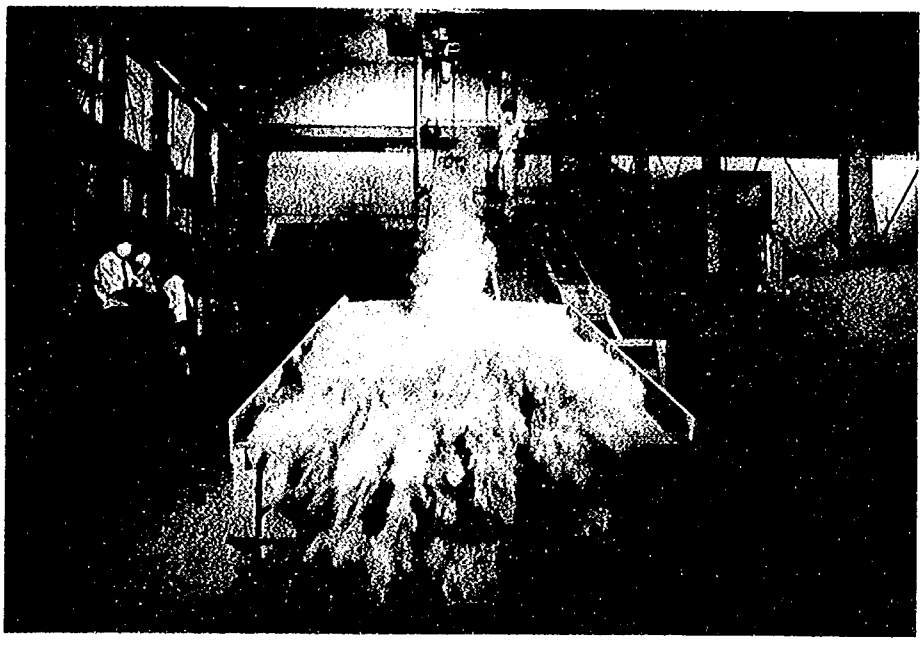
SLIDE 36 BIO-REACTOR in PILOT PLANT(TSUCHIURA CITY)

The road-automobile communication system provides "navigation", "information", and "individual communication" by exchanging information between automobiles(see slide(37)) and beacons installed along the roadside. Research and production of photo-type system was conducted by PWRI collaborated with private companies.



SLIDE 37 ROAD-AUTOMOBILE INFORMATION SYSTEM

Eruption of Unzen-Fugendake volcano in kyusyu Island(1991) focused the research of pyroclastic flow. PWRI investigates the basic characteristics such as the distribution of velocity and density, aiming the design of countermeasure structure. This slide(38) shows the model experiment simulating pyroclastic flow.



SLIDE 38 EXPERIMENT of PYROCLASTIC FLOW

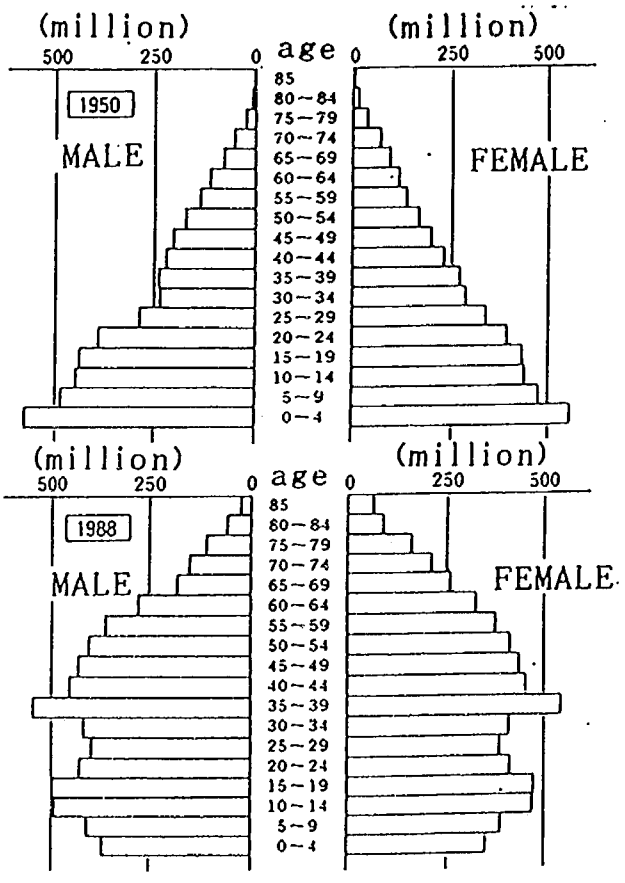
4TH SUBJECT : TREND OF JAPANESE SOCIETY AND ECONOMICS, PERSPECTIVES OF PWRI

The last subject is the trend of Japanese society and economics, and perspectives of PWRI.

<TREND OF JAPANESE SOCIETY>

The prediction of problems in future society is one of the most important work of PWRI. I would like to prospect the trend of society and research subjects.

Serious problems in Japan are aging of society and shortening of the labor. This slide(39) shows the population pyramid of Japan. It is clear that younger generation less than 30 years old is decreasing, and Japanese labor is now getting to be aged. Shortage of 1.6 million labor will occur in 2000 by analysis of the Ministry Of Labor.



SLIDE 39 POPULATION PYRAMID in JAPAN

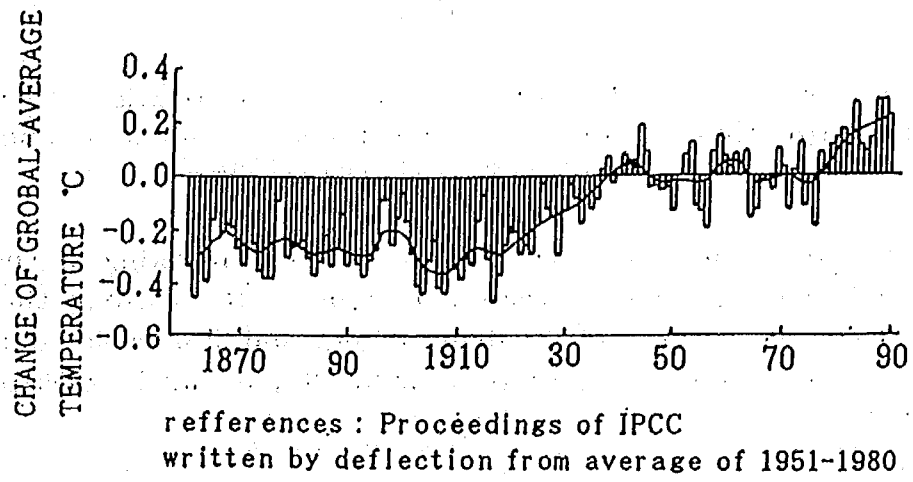
Next is the environmental problem.

This slide(40) shows the change of global temperature in the period from 1961 to 1989. Development of clean energy will required for the countermeasure of Green-House effect.

Disappearance of forest and expansion of desert are one of most serious

problems on the earth. It will make the problems of shortage of rainfall and abnormal climate more worse.

On the other side, environmental conservation and processing urban waste are required for the improvement of quality of life for the people.



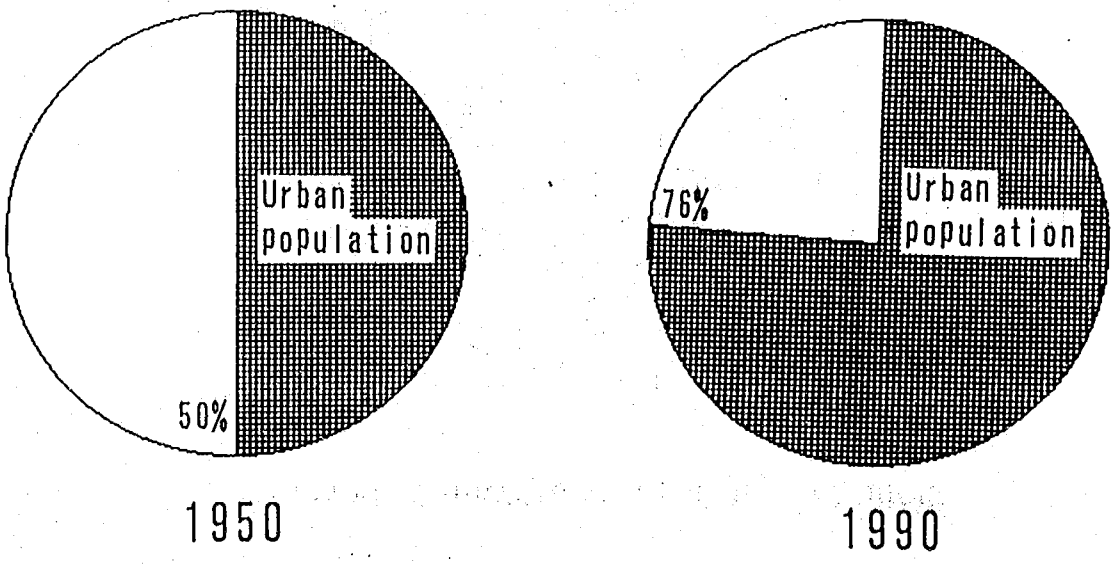
refferences : Proceedings of IPCC
written by deflection from average of 1951-1980

SLIDE 40 FLUCTUATION of GLOBAL TEMPERATURE

Next is the urban problem.

The slide(41) shows the rate of urban population in 1950 and that in 1990. We can recognize that concentration to urban area is progressing.

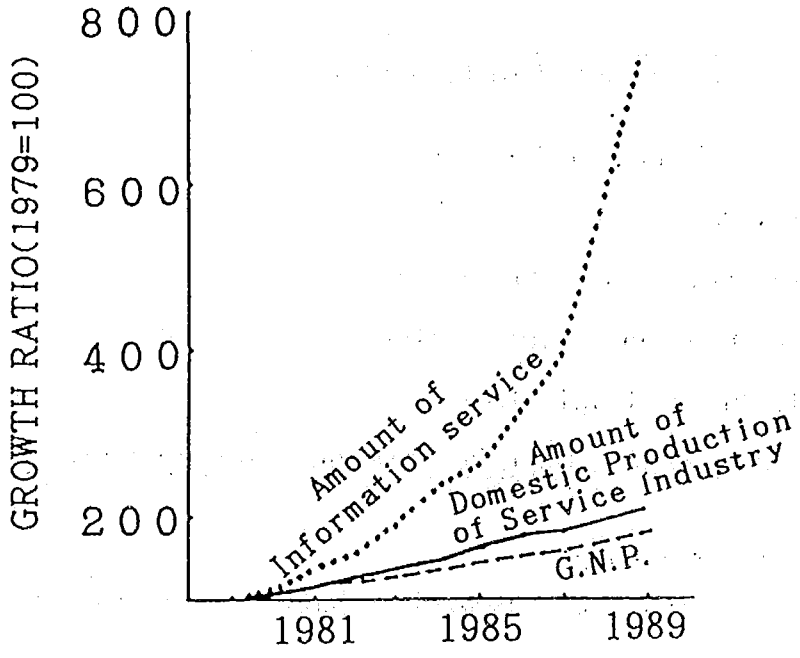
On the other hand, Also high land value is one of most serious problem of infrastructure investment in urban area.



SLIDE 41 URBAN POPULATION

The last trend is the development in information network.

This slide(42) shows the sales amount of information service industry. It shows a rapid growth in the market. The information industry will be more important in future Japanese economy.



SLIDE 42 SALES AMOUNT of INFORMATION SERVICE INDUSTRY

<BASIC CONCEPT OF RESEARCH IN PWRI>

As mentioned before, there are many problems to be solved immediately. PWRI will treat the variable subject. But because of the diversification of problems, it is likely to lose the direction of research subjects. Therefore, I made the 6 basic research concepts in accordance with the "needs of times". These are on this slide(43).

SLIDE 43 BASIC CONCEPT of RESEARCH
1. R&D for Demands Full of Variety
2. R&D for Advance of People's Utility
3. R&D for Environmental Prosperity
4. R&D for International Universality
5. R&D For Technical Originality
6. R&D For Fine Feature, Good Performance, High Durability

1) R&D for demands full of variety

It is indispensable to study research subjects according to the needs of times.

2) R&D for advance of people's utility

It must be noted that infrastructure implementation and R&D should always be in user's side.

3) R&D for environmental prosperity

It must be noted that construction work should use the natural condition on site, then conserve the circumstances after the construction, and create better environment by construction.

4) R&D with international universality

Recently requests from the other countries to PWRI are very often , therefore, it must be noted that the technology developed in PWRI could be used anywhere in all over the world.

5) R&D for technical originality

Under severest condition of natural and social in Japan, such as earthquake, typhoon, dense population etc., original technologies must be strongly required to be developed.

6) R&D for fine feature, good performance, high durability

The structure which has the superior function and durability, can remain to the next generation.

<MAIN RESEARCH FIELD IN FUTURE>

Next, I would like to present the 9 main research fields in PWRI, that would be conducted in priority. These are on this slide(44).

SLIDE 44 MAIN RESEARCH FIELDS
1. Effective Utilization of National Land
2. Disaster Prevention and Safety Life
3. Construction Technology Caring Environment
4. Efficiency and Safety in Construction Work
5. New Construction Materials
6. Infrastructure Management and Maintenance
7. New Frontier of Construction Field
8. Construction Management Engineering
9. International Research Cooperation

The 1st is the "Effective Utilization of National Land".
For obtaining further prosperity and stable society for the people, PWRI has to study the ways for more effective utilization of national land.

The research subjects are;
*Construction method for expressway, long span bridge, and tunnel which cross sea narrows and connect inner islands.
*Utilization of large depth underground space
*Development of new water resources and water supply system

The 2nd is the "Disaster Prevention".

Big cities in Japan must keep durability against the natural disaster because they have the key of economics. PWRI has to study forecasting, prevention, refuge, and recovery from the natural disasters.

Traffic accident is serious problem of modern city too. Traffic safety is the urgent problem to be solved immediately. PWRI has to study for the construction of the road with the function for the traffic weaking such as aged, infant, and handicapped.

The 3rd is the "Construction Technology Caring Environment".

Now, Global environmental problem is the most important one of all over the world. Japan has the responsibility to lead the environmental conservation as the one of the industrial countries. The subjects PWRI has to conduct are;
*Construction and planning method for conservation of energy
*Survey and analysis of the influence of heat island
*Analysis on the impact of green-house on climate and natural disaster
*Preservation of global ecosystem
*Method for reuse, and recycle of construction waste

The 4th is the "Efficiency and Safety in Construction Work".

A lack of skilled worker and a aging of labors will occur the problem of safety in construction work. The R&D which will be necessitated in future are;

*Virtual reality and simulation of construction site before the start of construction work.

*Construction machine and construction method with easy operation.

*Construction machine with energy economizing and reduction of emission gases.

The 5th is the "New Construction Materials".

New materials used for a space station, communication technology and biological technology could be applied for the civil engineering. The new material which will be studied are;

*Utilization of achievement in other field, such as biology, high polymer material, petro-chemistry, electronics etc..

*Material which realizes free maintenance.

*Finding out new material which has much more strength and durability than existent materials such as concrete, steel and rock.

The 6th is the "Infrastructure Management and Maintenance"

The next step of Japanese technology is pursuing the quality of structure. Therefore, administration and maintenance method of them will become important to keep life cycle. The followings will be studied.

*Free maintenance and more durability for infrastructure

*Way of the management and the maintenance for infrastructure

*Reduction of life cycle cost of structure

*Designing and maintenance method of artistic structure

The 7th is the "New Frontier of Construction Field"

Universe and undersea has many unknown space for the development as the "New Frontier". New frontier development will contribute to not only solving the population problem and shortage of food, but also the conversion of military industry to construction one.

The following studies have to be conducted.

*Method for human living

*Designing method of space structure

*Construction work by robotics

*Construction materials

The 8th is the "Construction Management Engineering"

Development of the evaluating system for new technologies is very important to introduce them into construction work. Following researches will be conducted.

*Systematization of construction management

*Evaluation and Information system for newly developed technologies

*Efficiency in whole processes of construction work

The 9th is the "International Research Cooperation".

Recently, promotion of the basic, initiative research whose achievements produce the applied research, are required from the outside. PWRI has to develop much more original technologies, and open them to the world.

World-wide research such as global environmental problem demands the research network extending to all over the world. PWRI will promote to make such a

network.

For the technical cooperation for the country conducting the infrastructure improvement, PWRI promotes to study for the planning and construction method according to the natural condition of each country. Also PWRI should study the method for technical exchange.

<PROMOTION OF SYSTEMATIC RESEARCH IN PWRI>

Finally, I would like to explain about the system of research for the efficiency of R&D activities.

This slide(45) shows the items of systematic research.

SLIDE 45 PROMOTION of SYSTEMATIC RESEARCH
1.Establishment of 5-Years Research Program
2.Promotion of Independent Investigation for Basic Subjects
3.Modification of Systems and Organizations According to "Needs of Times"
4.Expansion of Research Network

The 5-year research program was established for the promotion of premediated research. Of course, a modification is necessarily in the middle of the period.

Also the independent investigation is important. It can be recognized the freedom from the restriction of time and money leads to the great discovery especially in the field of basic research.

Social and economical needs are always changing. It is necessary to modify the system or the organization for the research in conformity with "the needs of time".

The expansion of research network is our strategy. In Japan, private industry study practical subject and university study basic subject mainly. Therefore, PWRI makes the network with the university or private company. Also making network has another merit.. Connection with another research organization is one of effective way against the shortage of budget.

The research network will be expanded all over the world. PWRI will be one of centers for implementation of international cooperation in Public Works Research and Development.

AFTERWORD

This is the end of my lecture. Thank you very much for your attention.

Ⅲ. 「The Role of Research and Technology Development in International Technical Cooperation」

Mr. Hiroaki Tamamitsu, Vice President, Japan Construction Training Center

The role of research and technology development in international technical cooperation

by Hiroaki Tamamitsu
Vice President, Japan Construction Training Center

Foreword

I am very glad and congratulate on the holding of conference of directors of public works research board of Asia, held here for the first time.

I myself was working in JICA as a vice president until July last year, engaged in the operation of international cooperation, especially in technical cooperation.

Before the term of duty in JICA I had been working for 30 year in Ministry of Construction as an expert in flood control and water resources development works in both technical and administrative stand points. During my term of duty in MOC I was also engaged in international cooperation as the director of international affairs and sometime working as a secretary of Japanese embassy.

Today I'd like to explain about outline and future prospect of technical cooperation concerning the social and economic infrastructures, of which development is essential both in developing and advanced countries.

I will also deal with the important role of research and technology development in technical cooperation through my experience so far.

This subject that I'm going to deal with would be of great interest for the participants who are in important position of infrastructure development of their countries.

I thank very much for the organizer of the seminar to have given me a good opportunity to have a speech.

The final objective of technical cooperation for developing countries is to achieve an ability to develop their economy and social welfare by their own hands without any external assistance. For this objective it is essential for the developing countries to continue a sustainable development step by step.

For the sustainable development we need as a basis man power or human resource development and technology development.

Each nation has its most suitable structure of socio-economy, and when education and training of the people to support their structure is achieved the country will be able to take off from developing country through sustainable development. The fundamental basic promoter for such development can be said technology development suitable for their own natural and socio-economical conditions.

Admitting the importance of this seminar I wish this seminar to last for a week will be most fruitful.

1.Significance of technical cooperation

(1)Situation of the technical cooperation in development assistance.

At first I'd like to deal with the significance of technical cooperation.

Among total development assistance to developing counties, the official development assistance (ODA) which is offered on government basis have the most important role.

ODA is separated to 3 categories, bilateral grant, bilateral loan and contribution to multilateral organization such as United Nations.

Bilateral grant is separated to tow parts, grant aid program and technical cooperation. Apart from the contribution to multilateral organization, international cooperation including ODA is also classified to financial assistance and technical assistance.

Financial cooperation, whether reimbursable (loan)or non-reimbursable(grant aid), provide a fund to construct buildings or other infrastructures, and to purchase the equipments.

Technical cooperation is to transfer to developing country advanced technology necessary to build man power and to build the nation.

Experts from Japan are mainly sent to developing countries to be engaged in education or to give assistance in survey, planning and research of the development projects. As the other type of education and training, staff of developing country are invited to Japan as the trainee. As the third type of technical cooperation, equipments or education materials are provided in coordination to the expert's activities or acceptance of trainee.

Above 3 elements; dispatch of experts, acceptance of trainee and provision of equipments, will be effectively combined case by case.We can also provide technical assistance more fruitful by combining with financial assistance.

For example it will be more effective to provide a building such as lecture room or laboratory to the project of human resources development or vocational center where a few Japanese experts are dispatched to execute a center project.

Now, I'd like to look into the outline of ODA of 1990, Japan has contributed 9.2 billion us$, which figure is the largest among development assistance countries (DAC)sharing about 20% of total amount of ODA of the World.

The ratio of Japan's ODA divided by Gross National Product is 0.31%, which value is far less compared to the objective of the world 0.7%.

Japan's ODA should be increased quantitatively in near future.

Content of Japan's ODA shows the figure of 1990 as follows, grant aid 1.38bil$ (15%).technical cooperation 1.65 bil$(18%)and loan 3.92 bil$(42.5%).

Those figure shows ODA of Japan has bigger share for bilateral loan, that is bigger than other counties.

According to the calculation of assistance by OECD, share of grant in Japan's ODA is 43.2%, which ranks in the least among 18 DAC countries, and far less than the world average of 75.6%. Also looking into the rate of technical assistance which is most evaluated because human labor contribution is optimized in its activity, the figure shows the rate value of Japan is only 13%, where as world average is 22%.
Our ODA should be improved qualitatively in near future as well as quantitatively, increasing the share of grant aid and technical cooperation.

(2)Basic concept of international cooperation and technical cooperation.
We often hear a criticism that Japan's ODA has not clear concept or strategy.
However I do not believe that using the assistance for political purpose or for diplomatic purpose to only limited countries as ex-colony area has good incentive or concept.
Japan is not limiting the countries to offer the assistance, still has its own basic philosophy in extending assistance.
Assistance should be extended from the concept of humanism at first. People the world over should enjoy the life equally, for supporting minimum human need, assistance should be given to needy people at least in supplying food and medical service.
Secondly from the view point of coexistence of the world, peace over the world should be achieved through assisting developing countries securing the stability of socio-economy of the countries.
Thirdly assistance will be offered in the line of promoting peace and preserving environment of the world. Japanese government advocating so called 4 principles of foreign assistance.
(1)to promote development in harmony with environmental preservation, (2)to avoid the utilization of assistance for military purpose or for world conflicts, (3)to offer assistance in consideration of the situations of military expense, production of mass destruction arms, import of arms of each countries, (4)to be careful to the situation of promotion of democracy, promotion of market economy and basic human right and freedom.
Final goal of assistance is to make developing countries take off, then assistance for those who make effort to stand up by their own legs is most important concept or policy of foreign assistance.
Self support will be achieved by education and training given to reliable people of the countries, therefore technical cooperation for man power or human skill development is most essential.
Technical cooperation based on human labor contribution is the basis of international cooperation.

2.History of technical cooperation of Japan.

I will now briefly touch on the history of technical cooperation of Japan.
Although Japan is a big country extending technical and financial ODA of this moment, but it was also an assistance receiving country until 40 years ago.
Just after the world war II we needed assistance from foreign countries to obtain food and to reconstruct devastated infrastructures. Technical assistance was also offered to study abroad as well as financial assistance to build road and dams.
It dates back to 1954, when Japan initiated offering assistance to developing countries, then enlisted as one of the member countries of Colonbo Plan. In the same year war compensation program has started with reconstruction of a hydroelectric power station of Burma.
Accepting the trainees to Japan has started in 1954 establishing Asian Association as its cooperation organization. In 1955, expert dispatch scheme was inaugurated, in 1957 development study scheme had started.
Japan obtained the membership of United Nations in 1956. Financial cooperation has started in 1958, then both technical and financial cooperation were systematically combined to make assistance more effective. In 1970 Japan also became a member of development assistance group (DAC) of Organization for Economic Cooperation and Development(OECD).
In the field of technical cooperation, Overseas Technical Cooperation Agency (OTCA) was established in 1962, after merging of Asia Association, Latin America Association, International Engineering consultant Association, and Mekong River Development Association.
Emigration project has started in 1952 as a form of technical cooperation, then in 1963 Japan Emigration Service(JEMIS)was established as implementating semi-government agency.
Meanwhile Overseas Economic Fund (OECF) was set up to manage financial assistance in 1961.
Coming back to the technical cooperation, the equipment supply program was commenced in 1964, medical cooperation project in 1965, agricultural cooperation project and development cooperation project in 1966.Those projects are so called "project type technical cooperation" center projects.
Japan Overseas Cooperation Volunteers scheme has started in 1965, the new office for JOCV was established in OTCA.
Japan International Cooperation Agency (JICA) was established in 1974, by merging of OTCA and JEMIS.
Grant aid program which has close connection with technical cooperation was initiated after completion of war compensation program in 1976.
Preliminary study and promotion of execution of projects of grant aid program are handled by JICA staff. At present 60% of ODA technical cooperation is handled by JICA through Ministry

of Foreign Affairs, and remaining is done by miscellaneous ministries, among them famous project examples are fellowship scheme by Ministry of Education and training scheme of industrial technician by Ministry of International Trade and Industry.

3.Contents of technical cooperation and points to be improved

As I explained before that technical cooperation consists of three elements; accepting of trainee, dispatch of experts and provision of equipments.
Those elements form an independent schemes of course, however combination of elements make the project more effective and stronger. It possibly combined with two of each elements, for instance if dispatch of expert is combined with acceptance of trainee, inviting the counterpart personnel of the expert and showing what is going in Japan will make counterpart personnel easier to understand the expert from Japan and make technical transfer much easier. When the provision of equipments is combined to dispatch of experts, equipment such as personal computer will help both expert and counter part in promoting project or research and make technical cooperation more successfully. When we combine all elements together, in big scale, we call it "project type technical cooperation".
In this case, usually based on governments agreement, we set up a technical cooperation center in developing country, sending a number of experts and considerable amount of equipments which is necessary for research or technology development and training, also inviting counterpart personnel to Japan for additional training. This type of cooperation is most powerful to achieve the aim of technical cooperation.
As another type of technical cooperation we can mention the scheme of "Development Study". Development Study is made for executing survey, planning and design, in rather short term, of the socio-economical infrastructures such as highway, dam, harbor, water supply and sewerage. Those studies also differ in the stages to be executed. Some are finished only in survey, some are studied up to feasibility or master plan study , but some will proceed up to detail design.
The Development Study also includes the scheme to formulate technical standard or manuals of operation after collecting data and analyzing them.
In discussing the research and technology development, above two types of projects;project type technical cooperation and development survey are most nominent works, then I will give more detailed explanation on the two types of projects. Speaking of Project Type of Technical Cooperation, Japan are now running about 200 projects over the world. The projects cover almost all area from medical field, to the field of agriculture, education, skill training, industry and mining and infrastructure.
To mention the examples concerned to public works and civil engineering, we are holding road

construction and equipment center, sabo center, earth quake disaster prevention center, environmental research and training center, railway technical, water supply and sanitary technical center and so on.

In order to cooperate with ASEAN countries in the field of science and technology, anticorrosion research centers for concrete and steel structures were set up in relevant countries.

Those centers are normally operated for 5 years, however when the program is not fully completed in set up term, then extension of cooperation term is also possible depending on negotiations.

The purpose of project type technical cooperation center is to have a research and develop the proper technology suitable to the existing natural and social conditions in each developing country using the economical materials which is available every where in each country, and also the purpose is to give the training to counterpart personnel who will be the lecturers of the institute and leaders of activity for the manpower development of the country.

In case that a new technology was invented, its patents will be shared by both government of donor and recipient countries.

Success in operation of said technical cooperation center depends upon the availability of man, goods and money rudely speaking.

Man means experts from Japan and counterpart personnel.we have to recruit good experts who not only have technical experience but also have a good character to be able to coordinate with people of the country they are dispatched to. And also enough counterpart staff should be supplied to the project. Counterpart personnel will often tend to resign the position and move to other organizations to get better salary , therefore we have to make their work and position more attractive. The student or general trainees should be gathered in projected number to keep the institute active.

Goods means, equipments and materials which is necessary to maintain and operate the technical center, necessary equipment must be sent from donor country just in time when it is needed. Repairing and maintenance of equipments should be done quickly.

And also materials for training or experiment should be supplied timely and in enough amount.

Money means the fund to operate the technical center, electricity, water and telephone should be paid by office maintenance fund, and even salary of counterpart personnel must be paid regularly.

Cost of repair and spare parts of equipments and cost of materials used for training and research are covered by operation fund of the institute.

Those operation costs are paid by recipient government as a rule according to the basic principle of international cooperation that "to assist the nation who endeavor to stand by themselves".

In very special case a part of operation cost of the center may be paid by assisting country.

As above explained three items, man, goods and fund, should be prepared timely and in sufficient amount in order to maintain the project successfully. Especially man power is very important. Experts and counterpart staff such as director and lecturers must be in close relation and make effort to cooperate with each other for the successful operation of the technical center.

Now I'd like to explain about another subject, Development Study.

Main purpose of development study is to survey the project, and after analyzing the survey result make planning and design, and finally to lead the study to construction. Also another type of study is for establishing a technical standard.

In this kind of study collection of data is essential. In most developing countries enough data have not been compiled yet, therefore we sometimes have to start the study from data collection installing measurement station as hydrological study cases that need long term yearly data we have to estimate the long term data from available data which is obtained by the observation for short term period.

As a development study, master plan covering wide area is very useful.

It is recommendable to choose wider area for study area of master plan in case as road or water resources development master plan.

Based on this nation wide master plan, smaller regional development plan, for example the plan for state or city, will be studied more detailedly.

As a target year of the planning, longer term plan as 10 or 20 years at least must be adopted, and on the basis of such longer term plan, detailed executive plan should be studies with short period target.

Long term plan is advisable to be reviewed regularly within a certain period, then the executing plan will not fail to be justified at any time.

Feasibility study which is the most attractive in development study will become a basic data to decide the implementation of the project considering the socio-economical benefit obtained by the study, therefore we must be careful in the estimation of construction and maintenance cost and according benefit. Developing countries will welcome the least cost and to gain most benefit, because most of them are carrying heavy burden of accumulated financial debt.

They prefer stage construction which invest smaller cost in stead of whole completion of a big project. Maintenance and repair works and improvement of management of the facilities with less investment are more stressed to be studied than the study of newly constructing.

Since the development study will be normally carried out in short period concentrating experts manpower to the survey, analysis and planning, consultant engineers are employed more in number than government officials of both donor and recipient countries, then consultant engineers of developing country will find more opportunity to be employed to the study and to get technical transfer from assisting engineers working together with them. This kind of

technology transfer to the consultant engineer as well as to the government official is very appreciable in technical cooperation.

4.Promotion of research and technology development

I have explained about the importance of technical cooperation within the international cooperation. Research and technology development and training are the two main subjects of technical cooperation. Those projects will be executed by the experts or engineers of both developing and developed countries with same purpose and in mutual understanding and in cooperation and coordination. this type of cooperation is most evaluated as so called face to face cooperation or human labor contribution of advanced economies. Training scheme seems to be technical transfer on one way direction, from advanced country to developing country, however in research and technology from advanced country and counterpart engineers of developing country who have sufficient knowledge of local condition in natural and socio-economical matters will cooperate together from equal stand points for the purpose of research and technology development, and then this scheme needs most mutual cooperation of engineers from both countries, consequently could be said as the most valuable type of human contribution.

I have delivered before that Japan's fundamental concept of international cooperation is "to assist self standing of the developing country", that means in other words, to extend cooperation to those who are making their most effort by themselves to achieve social and economical sustainable development in order to stand up by their own will and power.

The social and economical development will be supported by human power of the nation, therefore we need not to say that man power development as the developer of the nation is the most important.

The purpose of research and technology development is to develop a proper technology based on natural condition such as meteorological and geological condition, and also using materials and equipment easily available every where in sites. I'm sure that this kind of technology will contribute to benefit the nation stimulating economical activities all over the country.

At the same time we have to make education and training prevail over the country, therefore it is necessary to grow a number of instructors and leaders who will teach the ordinary people.

Most of the people of developing country like to introduce most high technology for the time being, however we must reconsider and examine what kind of technology may contribute to the sustainable development. Of course there is as certain field which needs urgent application of the most high technology, and it is quite useful to have the knowledge and reconsider about the introducing of it, taking consideration of natural and socio-economical situations of the country.

5.Environmental effects and disaster prevention

We are very much concerned to socio-economical infrastructures such as civil engineering and architectural structures which are requested by the citizen to have a good landscape, without vibration or noise during construction, that is environmental assessment has been carefully done from the past.

The environmental problem in daily life such as water supply, sewerage treatment or waste disposal and water pollution are within the scope of activity of civil engineer, and technical cooperation in these fields has considerable share so far. The most nominent subject in international cooperation is the so called global environmental issues. Prevention of green house effect caused by increasing carbon oxide, preservation of ozone layer by limiting the use of fron gas, preservation of forest against acid rainfall by reducing sulfate oxide in the air, and prevention of water pollution in ocean are the global environmental preservation problems which the world should seriously consider at present.

According to the principle of Japans'policy on extending ODA published June last year, it stipulates as the first clause, "Sustainable development in coordination with environment preservation."

Those environmental issues will be most stressed in our future technical cooperation as well as financial cooperation.

It is the task of civil engineers and those who are engaged in public works that to monitor and compile the data concerned to the global environmental preservation such as data of air pollution, water pollution, desertication and rise of sea water level caused by green house effect.

And most of the counter-measures to preserve the environment, such as water resources preservation in desert area, hydropower development and coastal disaster prevention are also within the scope of those engaged in public works.

Therefore we can say that environmental problems will be the main subjects in research and technology development in the future.

Like environment issue there is another important issue. That is the safety measure of the people over the world against natural disaster.

1990's decade is designated as United Nation's Decade for Natural Disaster Mitigation, and many activities are being carried out by the member countries.

As the anti-earthquake measure, observation and research of prediction of earthquake and antiseismic design of housing and building are carried out in all world. Also international cooperation in the field of flood disaster prevention and volcanic sabo are being carried out.

The counter measures against the natural disaster may differ in its phenomena from country to country, but the basic principle of technology will be same, therefore all countries, advanced and

developing, should globally cooperate with each other to combat against those natural disaster. Environment preservation and natural disaster prevention are the most essential problems of the world as long as human being will exist, and those problems are closely related with those engaged in public works, we have to be more active in near future.

6.Examples of research and technology development in international cooperation.

I have delivered above the importance of research and technology development based on local natural and socio-economical conditions in international cooperation especially in technical cooperation. Even from my short experiences in abroad a lot of differences in those local conditions are recognized. As an example rainfall and discharge in case of planning the water resources development and flood control are much different in tropical area to non-tropical area. Rainfall in tropical area has high intensity with short duration and narrow rain-area as is so called squall, where as in Europe or northern country usually intensity is small and has long duration period.

They have very small amount of rainfall in arid area where mostly drinking water is drawn from underground water, of which hydrological analysis is complicated.

Taking soil again for example, there is a little different type of soil called laterite which was formed by weathering of rocks concentrating ferro-oxide in soil, this soil is often used as road construction material in tropical countries.

In some area of Middle East and South America houses are mainly made of sun dry bricks, this building is quite often destroyed by earthquake.

Anti-earthquake measure of this kind of structure must be studies to help people from the seismic disaster.

Considering above examples we can understand the necessity of research and technology development taking consideration of local conditions , natural and social.

I would like to show more detailed examples of the project which so far have been conducted as the "overseas technology development study" by Ministry of Construction and "project type technical cooperation" by MOC and JICA.

Example of Technology development

Road construction technology development in laterite soil area

Introduction

Laterite soil covers widely over the tropical area in south east Asia, Africa, and South America. The soil contains high rate of iron and consists of fine grade grain of soil. Laterite soil has the characteristics to become fluid natured when the moisture content become higher, and become consolidated when it is dried, so that even heavy construction equipments suffer to excavate the soil.

There are different types of laterite soil, engineeringly useful laterite is suitable as the material for embankment and upper base course of the road, and it is economically acceptable because the soil is found widely and abundantly.

The character of laterite soil is not fully studied, since the soil has variety of natures in engineering as well as in physical character.

By the research employing laboratory test , model test and photo type experimental construction work we will achieve the method of treatment of construction of road dealing with the soil. Those technology development is very useful to construct the road with less expenses.

This kind of technical cooperation for technology development was executed Asia joint project with Thai Highway Authority and Ministry of Construction for 3 years from 1981.

Formation of laterite soil and its utilization

After weathering by high temperature and high humidity in tropical or sub tropical climate rocks will lose silica and base and increase the concentration of ferro-oxide and calcium-oxide. This phenomena is called lateritization.

And this kind of weathered remain is called laterite soil. Literate soils have various type of quality from porous fine grade soil to the solid large grain soil which is called a laterite rock. The color of laterite is red or red-brown due to its high content of iron and aluminum.

To explain about utilization situation in Asia.(1)In Philippines the soil is seldom used for highway construction.(2)In Indonesia laterite soil is used in everywhere, of which most problem is how to control the moisture content.(3)In Malaysia they find this material in limited area, and it is used for road construction.(4)In Thailand good laterite soil is used for lower base-course of road.

For the upper layer of base course, crush run of limestone is ordinary used, but in north east Thailand where less limestone exists, they also use laterite soil for upper layer of base course

treating the soil with cement, lime or asphalt.
This treatment needs high technology which is determined after research and technology development.

Characteristics of laterite and research items

To speak on the physical quality of laterite, specific weight of laterite varies from 2.6 to 3.5. comparing with ordinary Japanese volcanic cohesive soil , of which specific weight is from 2.7 to 2.8, therefore laterite soil can be said quite heavy material.
As for the iron content, some laterite has ferro-oxide content as high as 5%.
The grade distribution of laterite soil differ greatly by the degree of disturbance with water in soil in case of experiment, because grain particles of soil will be separated from each other depending on the degree of disturbance. In case of fine graded soil which contains much silt and clay material, the character of soil is determined by the moisture content, also soil character is defined by the character of mother rocks (granite, shale, sandstone etc.)
Literate soil is classified to three categories from its engineering characters, (1)soil which has mainly friction strength (with good drainage quality)(2)soil that is strong in friction and cohesive strength (sandy soil) (3)soil which is strong in cohesive strength (clay soil with less permeability)
To explain about bearing power, laterite is very much sensitive with the moisture content and length of time in dipping in water.
The permeability of laterite soil differs with the mother rocks, degree of weathering, grain grade distribution and porosity.
As the compaction character, since laterite soil normally contains mica, and have less max. dry density in optimum moisture content.
Need not to say the laterite soil is not suitable for vegetation, therefore in laterite embankment, erosion protection is quite serious problem.
We have learned the general character of laterite soil so far, in order to utilize material especially for base-course of road we have to continue the study for treatment of this material, applying the laboratory test and in site experiment we have to promote research and to develop new technology.
Main items of research will be as follows, (1)development of stabilizing material, (2)determination of mixing ratio for soil with stabilizer, (3)selection of equipment and method for mixing, (4)design of depth of base course and estimation of durability, (5)relation with sub-base course and base embankment,(6)planning of traffic volume and loading conditions.
As delivered already the character of laterite greatly differs from place to place, however we need to develop the technology and establish some technical standard for utilization of laterite.

We need to promote the research of such useful construction material for the benefit of developing countries.

Example of Technology Development

Overseas flood forecasting and warning technology development

Introduction

Rainfalls in tropical area have normally high intensity and short duration, covering rather smaller rain area. Rainfalls in Japan have sometimes high intensity, but most of them have rather long duration and lower intensity, where as in Europe they have rainfalls with small intensity all year round , not specifying rainy seasons.

As delivered above in developing countries the rainfalls have characters of their own, different from that of Japan , therefore we have to study to develop their own technology in flood forecasting and warning.

The natural disaster mitigation especially for flood disaster is very important in all countries of the world as well as environmental preservation.And for technical and financial assistance Japan is adopting quite many of flood forecasting and flood control projects. In this connection this kind of technology development study project was taken up by the Ministry of Construction in 1984, and research study was continued for 3 years. The study area was Indonesia, Philippines and Malaysia, but study was mainly concentrated to Indonesia extending the study to even volcanic mud and debris outflow in cooperation with the government of Indonesia.

The characteristics of flood discharge in different countries

Japan is situated in north east of monsoon affected area, the climate of which is high temperature and high humidity in summer, the topography of which is very steep with back-bone high mountain in the center of long island, attributing to the mountainous area is 75% of all country. Average yearly rainfall of Japan is 1800mm/year with less in north and a little more in southeast of the country. The characteristics of rivers of Japan are, (1)The length of rivers are normally short, slope is steep, and in the out-let point to aluvial plain the gradient of river bed will change drastically and rivers deposit the sand and gravel in this turning point.(2)Peak discharge in flood is high and discharge coefficient is higher than big rivers in continents.(3)Rising and falling of water level in flood occur for short period.(4)Yearly difference of water discharge is large.

Coefficient of yearly maximum and minimum discharge is large as 200 to 400, which value is about 10 times as high as continental large rivers. Therefore many difficult problems will be

encountered in flood control and water resources development and administration. In Indonesia Brantas river is located in the east Java island, where the rainfall season continues from November to April, during which season 80% of annual rainfall is concentrated. The catchment area of Brantas River is 12,000km^2(two thirds of Tone river which is the biggest in Japan) and length of river is 320 km(length of Tone is 300km), therefore Brantas is less steeper than Tone.
Average annual rainfall of catchment area is 2,000mm/year, that is higher than Japan ,but flood causing rainfall will not last longer.
Long term discharge rate is rather high in dry season, and low in rainy season.
Discharge ratio in flood period is 0.3, this value is very small compared with 0.6 - 0.7 of Japanese rivers.
As to the volcanic debris flow prevention, radar rain gauge and other modern system of forecasting and debris reservoirs are employed since many years ago, as the counter-measure for Melapi, Smeer and Galungun volcano.
In Philippines, Panpanga river has also rainy season and dry season clearly separated.
When the north east monsoon is prominent from April to October much rain falls. Typhoon season is also same period as monsoon, around 20 typhoons attack Philippines every year.
The catchment area of Panpanga River is 10,000km^2 and its average rainfall amounts as 2,000mm/year, that seems a little higher than in Japan.
Pangpanga River catchment area is mostly covered by mountainous area as is Japan.
The discharge phenomena is quite similar as in Japan, but most area has so called natural river which is not protected by dike, and they have more debris and timber flow in case of flood than rivers of Japan, that result discharge calculation and estimation is more difficult than in Japan.
Flood disaster is serious in Philippines, forecasting system is already installed in mostly important river basins such as Agno, Bicol, Cagayan and Pangpanga river. In Malaysia they have 2 rainy seasons in a year, with north east monsoon from November to January rainfall covers all over the country, especially heavy in east coast of peninsula, Saba and Sarawak, and with south-west monsoon from April to July rain falls again, but intensity of which is not large as former case. Average annual rainfall is 2,000mm/year in Peninsula, whereas 3,000mm/year in Saba and Sarawak. Most rivers in Peninsula are short and small although mountain area of the catchment is less than rivers in Japan. Hydropower dams are developed every where in peninsula Malaysia, mostly installed with telemetering system of hydraulic data informations.

Subjects of research and technology development

Subjects of technology development in the field of flood forecasting and warning are as follows.(1)Review of existing system;forecasting system, measurement network, predicting

method , transmission system etc.(2)Analysis of tropical rainfall characteristics.(3)Analysis of discharge characteristics in rivers of tropical area. (4)Observation of debris flow (5)Research for reliability of assessing average catchment rainfall.(6)Examination of reliability of water discharge forecasting technology.(7)Preparation of the manual for operation of the system and its maintenance and administration.

Java is volcanic island where nearly 70% of Indonesian population is contained, consequently the land use of this island is much sophisticated with high value, as a result disaster caused by flood or mud flow is very serious. More effective measures against disasters are expected to be established by the development of technology suitable to their own natural and social conditions.

Example of project type technical cooperation

Road Construction Training Center(Thailand)

Introduction

A road construction technical training center was set up by Japanese government in Song khla, south Thailand in 1964. At that time Japan did not have much experience, since the time was only 10 years after Japan's joining as a member of Colombo plan in 1954, when our economic and financial power was not eminent, therefore the scale of cooperation was not enough to supply the equipments needed in the Center.

In 1990's highway construction works were in full swing in Thailand, receiving financial assistance from World Bank, Asin Development Bank etc.

Along with the above financial assistance, road construction technical training center were operated in the central area of Thailand by the governments of Australia and New Zealand.

As the scope of works of RCTC completion of the highway itself was very important as well as training.

We Japanese Government selected the site of cooperation in south Thailand where Japan is very familiar since old time.

For the first cooperation Japan established a center in Songkhla, and second one has started in 1971 in Surat Thani.

Songkhla Road Construction Training Center

Songkhla RCTC was set up November 1964 with coordination of Thai and Japanese

government. The purpose of the center was to train the Thai civil engineers and technicians in the field of survey, planning and design of highway engineering, to train mechanical stuffs in repairing, maintenance and operation of road construction equipments.
At the inception of the center 10 Japanese experts consisting of 3 civil engineers, mechanical engineers and 1 coordinator, were sent to Sougkhla.
We also sent construction equipment of total value of 300 million yen , whereas in the beginning we sent only 100 mil.yen value equipments, because our government considered equipments and apparatus necessary for only training will suffice without considering the execution of highway construction works.
Songkhla RCTC had been operated for 4 year, during the period the Center constructed 52km of highway of 2 lane paved between Songkhla and Natawi, this line was named National High-way No.408, and gave trainings to civil and mechanical engineers and technicians of more than 200 persons.

Surat Thani RCTC

Songkhla RCTC project was not fully appreciated because the project was operated when our government was not much accustomed in the project operation.
Fortunately after the completion of Songkhla project, a request was raised from the Thai Government to iniciate another road technical cooperation project.
After the negotiation of both government Surat Thani site was selected for the second project site, which city located 200km north of former site, but still located in south Thailand.
As to the new technical cooperation for Surat Thani RCTC, Japanese government adopted new policies as follows after the evaluation and recollecting from former Songkhla RCTC.
(1)The completion of construction of 80km highway between Surat Thani city and Sichon will be recognized as a main purpose of the Center as well as the technical training.(2)Cooperation period was set for 5 years as long enough as to complete construction of road.(average period was 3 years then)(3)Supply of equipments as many number of 600 mil. yen in the beginning stage of the project to start road construction smoothly, (finally total amount of equipments became as much as 800mil.yen)(4)Japanese experts will give advice on the survey and design of structures such as bridges and conduits as well as the earth works of road construction from the initial stage of construction.
To review the construction of road in Surat Thani from technical stand point, construction needs higher technology than in the case of Songkhla, because the former is located in hilly area of the height of 120m above sea level, where as the latter located in flat aluvial land.
In constructing highway in Surat Thani we can apply higher technology in the design of

horizontal and vertical alignments and also in construction work method, so that we can get better example as the material for training.

After completion of construction the road between Surat Thani and Nakhornsitamarat where a Japanese Nagamasa Yamada was enrolled as a federal lord in old time became national highway No.401, which will contribute to the regional development in the north east area of south Thailand and serve as the access road to Kosamui and Kopangan Islands that is expected to be developed as a new attractive resorts area.

Cooperation for Surat Thani RCTC was continued until 1978 extending the agreement for one year, giving training to about 300 Thai engineers and technicians in the field of civil and mechanical engineering. Continually 10 Japanese experts and 40 Thai engineers are stationed in the center.Those who were trained in the center have been sent to various Thai road centers of the country and to private companies and are dedicated for the development of Thailand.

The highway was constructed in South Thailand where yearly rainfall is as high as 2000 ~ 2500mm/year, and intensity of rainfall is also very high.

Therefore base-course and pavement should be constructed to be strong enough to bear the heavy rainfall. Twenty years has passed after the completion of the road , and the road and equipments still working very well at this moment, that proves the technical cooperation was very effective so that the maintenance and repair of construction equipment have been carried out by only Thai engineers without any of foreign assistance.

As the appreciation of the project, Japanese government offered a grant aid very lately to donate additional construction equipments and apparatus of repairing factory of the equipments.

Example of project type technical cooperation

Volcanic Sabo Technical Center(Indonesia)

Introduction

Indonesia is world famous country for its volcanic mountains. Especially in Java Island a number of volcano exist in series, actively working over the island. With more than 70% of nation's total population concentrated in the small island, disasters often occur caused by volcanic debris flow. Volcanic debris deposited on out-skirts of the mountain will flow down with heavy rainfall and cause serious disaster destroying houses and lands in down stream.

The technical cooperation from Japan in this field of disaster prevention in volcanic sabo has started in 1970 by continually dispatching experts to public works department, Melapi and Klud work offices, the number of which amounted to 20 up to present.

"Basic study for Sabo works in Melapi volcanic area" has started in 1975, and "Master plan on

disaster prevention measures against volcanic debris flow" has been completed in March 1980. In the line of the recommendation of above master plan, preparation for setting up of Volcanic Sabo Technical Center was made in cooperation with both government of Japan and Indonesia. Record of Discussion (R/D) was signed in October 1982 to start the operation of the center and technical cooperation to the Center continued up to March 1990, extending two and half years over initially set up term of 5 years.

Purpose of the project

Volcanic Sabo Technical Center was established for various purposes.
Long term final purpose is to up-grade technological caperbility of Sabo engineering in Indonesia, to complete Sabo engineering standard and to develop through research, of the characteristic Sabo technology of their own.
As the short term target following are mentioned, the training for the engineers on the general basic technology, the brushing up of the engineers up to the level that engineers are able to conduct feasibility study as well as detail design, development of economical construction work system and development of warning system of volcanic debris flow.

Activity and achievement of the Center

As above mentioned the content of activity of V.S.T.C.consists of two main items, training of engineers and development research of technology.
The training activity consists of three courses, general basic course, advanced course, and integrated course.
In the general basic course aimed to give engineers the orientation and general basic idea of Sabo engineering in short period.
The advanced course is for the engineers in higher position who are taking more responsibilities in executing the Sabo works. The period of training of this course was a little longer, possibly for long term, one or two years, aimed to give a few engineers the education of knowledge of feasibility study and detail design of Sabo works.
The technology development of mud flow (lahar) forecast and warning system, and hydraulic laboratory experiment.
In the first item characteristic methods most suitable for Indonesia was studied in planning and construction of Sabo works, to explain more detaildly, device of adequate concrete for the crest protection of Sabo dam, study of more suitable stone cage structure, use of plant and vegetation for structure reinforcement, development of idea using sabo dam for irrigation purposes.

In the second item, in order to establish mud flow forecasting system, small size radar raingauge, tele-meter system of rain and water level gauges and mud flow watching system were set in two pilot model area. By those observations the center tried to find out the natural situation of mud flow and to establish the warning system as well as the safety evacuation system of the residents.
In the third item is to study the solution to the problems of debris flow causing disasters through model study in laboratory.
3 to 4 experts from Japan stationed in VSTC continually, and total number of 10 experts served to the center during cooperation period. Those experts worked successfully in training and research activities, except some part of development research.
As the follow up of VSTC and to develop all kind of Sabo technology, not only volcanic Sabo, new Center project has started in 1992, including land slide and even slope failure prevention technology. This new center of course contains in its scope of works the further technology development research works for volcanic Sabo.
Office building, training rooms and laboratory were constructed by the grant aid program of Japan, and with the good achievement
of the Center, VSTC project was appreciated as a good example of combination of technical cooperation and financial cooperation.
Further more, gathering engineers from nabour countries, so called third country training courses are held in VSTC, contributing also to the regional development in Asia.

(C) COUNTRY REPORT

I . People's Republic of China

Mr. Chen Bing Xin, Director,
Institute of Water Conservancy and Hydroelectric Power Research

1. THE OUTLINE OF CHINA

1.1 China, located in the east of Asia, has a land area of about 9.6 million square kilometres. Approximately 98 % of China's land area is situated between 20^0 and 50^0 north latitude in climate, the greater part of the country belongs to the temperate zone and subtropical zone, which respectively account for 45.6% and 26.1% of China's land area.

The territory of China extends about 5,200 km from the Pamirs (longitude $73^0$40'E) in western Xinjiang Uygur Autonomous Region to the eastern corner of the boundary marker (longitude $135^0$5' E) at the confluence of the Heilong and Wusuli Rivers. From north to south, it measures some 5500 km,stretching from the borderline in the Heilong River north of the town of Mohe to the Zengmu Reef at the southern most tip of the South China Sea Islands. The length of the land boundary is 22,000 km and the mainland coastline, 18,000 km.

China is bordered by Korea, Soviet Union and Mongolia in the north, Afghanistan, Pakistan, Nepal, Sikkim, Bhutan, and India in the southwest; and Burma, Laos, and Vietnam in the south. Across the seas to the east and southeast it faces Japan, the Philippines, Malaysia, Brunei,and Indonesia.

1.2 One of the major features of China's physical geography is its mountains, plateaus, and hills which accout for about 65 percent of the country's land mass. Generally speaking, the land surface of China descends from west to east in a four-step staircase. At the top of the staircase is the Qinghai-Tibet Plateau, known as the "roof of the world", which towers in the southwest at an average elevation of 4000 m or more, where all major rivers in east Asia and south Asia are originating from these geneses. The second step extends from east of the Qinghai-Tibet Plateau, to the Greater Hinggan-Taihang-Wushan chain and consists mainly of plateaus and basins between 1,000 and 2,000 m. above sea level. These include the Yunnan-Guizhou, Inner Mongolia, and Loess Plateaus

and the Tarim, Junggar, and Sichuan Basins. The third step extends further eastward and reaches the coast, mainly consisting of plains and low hills, 500 to 1,000 m in elevation, such as the Northeast China, North China, and middle-lower Yangtze Plains. The bottom step of the staircase is the vast continental shelf formed by the shallows, middle-lower Yangtze Plains, and the littoral plains, under 50 m in elevation, then finally plus the continental shelf and the islands off the mainland.

1.3 China's climate is characterized by monsoonal winds from the east and distinct seasonal changes, with northerly winds and little rainfall in the winter and southerly winds and plenty of rain in summer. Common climatic phenomena include cold waves, cyclones, intermittent drizzles and typhoons. Another characteristic is a distinct continental climate, with a wide temperature range and variations in rainfall. Temperatures in China are much lower in the winter and higher in the summer than in other countries of the same latitude.

The annual precipitation in China decreases progressively from the southeast coast(where the average is 1,000 to 2,000 mm) to the northwest interior (100 to 200 mm). Eastern Xinjiang is China's most arid region. The average annual precipitation there is less than 50 mm. Toksun County in the Turpan Depression has a mean annual precipitation of only 3.9 mm. China's record high annual precipitation of 8,408 mm was registered in Huoshaoliao, Taiwan Province.

1.4 The natural resources in China is very abundant, having existing agricultural cultivated land of 1.6 billion mu, (1 mu=0,0667 hectare) and grassland of 5.3 billion mu. The forest area amounts to 12.7% of the total land area. The water resources in China is also very rich, embracing 0.68 billion kw of hydropower potential. Biological resources are numerous in variety and great in amount. Mineral resources so far already found amount to 140 kinds more, among which the storage potential of tungsten, tin, molybdenum, antimony, mercury, lead, zinc, iron, coal, sulphur, phosphorus, asbestos, and fluorite-siderite are ranked the front. Petroleum, chromium, nickel, titanium and many

kinds of rare metal and precious metal are also relatively rich in storage. Besides, the internal terrestrial heat potential is abundant as well in China.

1.5 China has a huge population of 1.1 billion at present, among which 80% is of agricultural population, whereas city population is only about 20%. Regions having dense population concentrate in southern east coastal areas, such as Shandong Province in East China area, where the total land area is 150,000 sq. km. has a population about 90 million. The Zhejiang Province embracing a land area of 100,000 sq.km. has a population of 50 million, and Jiangsu Province, having a land area of 100,000 sq.km. has bore a great population pressure of 70 million, which is the province having highest density of population in the whole country. Of particular concern is the Guangdong Province, where the development of economy has grown most rapidly in recent years is also under the strong pressure of dense population of 70 million in the land area of 220,000 sq.km. However, provinces in north western China such as Shaanxi Province where a population of 35 million is living in a land area of 190,000 sq.km., and Qinghai Province embracing a land area of 720,000 sq.km. has a population of only 5 million. The Tibet Autonomous Region holding a vast land area of 1,200,000 sq. km has only a population of 2 million.

In recent 40 years the population distribution in China rapidly tends to cities. From 1949 the number of large and middle cities increased from 132 to 450, and their population increased from 27.41 million to 146 million with 4.3% of annual growth rate. Especially during 1978-1989, the annual growth rate reached as high as 5.7%. The total population in large and middle cities is estimated at 230 million accounting for 17.7% of the total national population in 2000, at 630 million and accounting for 42% of the total national population in 2050.

Shanghai, the largest city in China has the most dense population of 12 million, then Beijing, next to Shanghai, holds a population of 10 million.

1.6 Since the founding of People's Republic of China, in 1949, China's economy has experienced a great advancement and development. Up to 1991, the

annual gross output of national product (GNP) has reached to 1,958 billion yuan (RMB). The total agricultural output was 800. 8 billion yuan, in which the total grain output was 435.24 million ton, and the cotton being 5.663 million ton. In the industrial sector, the total out put was 2822.5 billion yuan. The main output of industrial products are raw coal 1.09 billion ton, ranked the top first in the world, steel 70 million ton ranked the third, in the world and the power generation 670 billion kw-hr., petroleum 130 million ton respectively.

In 1991, the yearly total export has reached to 71.9 billion U.S. $, while the total import value was 63.8 billion U. S. $. Since 1980's, the Chinese government has implemented the policy of reform and open to the outside world, thus making the national economy rapidly developed. The average annual rate of increase was 6%. Recently, during the 14th National Congress of the Communist Party of China(CPC) decision has been made to raise the rate of increase of national economy to 8-9 % in the period from now to the year 2000.

2. PUBLIC WORKS IN CHINA

2.1 In China public works is planned based on the national economy and society development plan, which is formulated by the government and implemented after discussed and approved by the National People's Congress. The departments of the government responsible for construction of public works formulate implementation plans every year according to the development plan.

The national economy and society development plan now under implementation is the Eighth Five Year Plan, geared to the long term plan discussed and approved by the National People's Congress in March, 1991. The 10 year plan also approved by the Congress stipulates that by the year 2000, the gross national product (GNP) will be 3110 billion yuan RMB, two times that in 1990, and the averaged annual economic growth rate will be 6%, the industrial and agricultural output value growth rate 6.1%, in which the rate for agriculture is 3.5%, for industry 6.8%; grain output will be 500 million ton, cotton 5.25 million ton, raw coal output 1.4 billion ton, power generation 1100 billion KWh, copper output 80 million ton; construction of basic industries and basic infrastructure for energy, communication, important raw and processed materials, water resources development will be strengthened, at the same time, processing industries will be reorganized, reformed and promoted so as to solve the long term imbalance between the basin industries and infrastructures and the processing industries thoroughly; a batch of key projects, such as large and medium sized power plants, coal mines, oil fields, trunk railways and highways, harbours, airports, trunk communication lines, water projects and etc. will be either added or expanded or rebuilt. By 1995 the GNP will reach 2325 billion yuan, the agricultural gross output value 878 billion yuan and the industrial gross output value 3270 billion yuan. During the five years from 1990 to 1995 the annual growth rate of investment in fixed assets of the whole society will reach 5.7%, resulting in the total value of 2600 billion yuan, including 1700 billion yuan by state owned enterprises, equivalent to an annual growth rate 5.5%. The latter includes 840 billion yuan for capital construction, with the annual growth

rate 2.1%. In the allocation of the investment for capital construction priority should be given according to the requirement by adjustment of industrial structure to agriculture, water resources development, energy, communication and important raw and processed material production bases.

As is know to all the recently held 14th National Congress of the Communist party of China suggested promoting the annual growth rate of national economy from 6% to 8-9%. With this change other targets, including those concerned with capital construction, will also be promoted.

2.2 The central governmental organization for administration of public works is roughly as follows:

- Ministry of Water Resources
  Responsible for construction of water conservancy projects (including those for irrigation, flood control, urban water supply multi-purpose and soil conservation) and small sized water power stations
- Ministry of Energy
  Responsible for construction of hydroelectric, thermal and nuclear power plants
- Ministry of Communications
  Responsible for construction of water courses, harbours and highways
- Ministry of Construction
  Responsible for construction of cities and infrastructures of cities
- Ministry of Railways
  Responsible for construction of railways
- Ministry of Posts and Telecommunications
  Responsible for construction of post and telecommunication systems.

In addition, there are also construction projects funded by local governments. The funds for extraordinary large projects, such as the Three Gorges project, are specially planned and provided by the central government.

2.3 As the number of major infrastructures is too large to be comprehensive by mentioned, the following only includes several aspects.

Hydropower construction

China is a country rich in hydropower resources. By 1989, the aggregated hydropower installed capacity reached 34,580 MW, 27.3% of the total national installed capacity, 118.5 billion KWh power is generated annually, 20% of the aggregated power generation. Here is the table of different ratios counted for by large, medium and small-sized power houses according to the statistics of 1989.

SIZE OF POWERHOUSE	INSTALLED CAPACITY (10,000 KW)	PROPORTIONS (%)
LARGE (> 250,000 KW)	1590	46
MEDIUM (25,000 -250,000 KW)	720	20.8
SMALL (< 25,000 KW)	1148	33.2

According to the statistics, there are 40 large-sized hydropower houses already built or under construction, with an aggregated installed capacity of 32.88 million KW, which are now forming the hydropower basis in Up and Mid-Yellow River, The Second Songhua River, Middle China, Fujian-Zhejiang and Hongshui River. As for the medium-sized hydropower plants, East China have got the highest development, following after which are the Northeast, Mid-south and North China. Nonetheless, the most concentrated and potential resources of medium-sized hydropower plants lies in Sichuan, Yunnan and Xinjiang. China is also rich in small hydropower resources with a wide layout. At the beginning of 1980s, the State Council put forward a rural electrification program that in the mountainous areas abundant of small hydro, small power plants should be established in 100 counties with Chinese characteristics. This program has been basically accomplished by 1990. Now comes the second program for rural electrification counties.

According to the adjusted development plan, the capacity of hydroelectric power generation will be promoted by 2-5 million KW annually from now to the year 1000, with the corresponding annual power generation finally arriving at 15 million KWh. To the year 2000 total capacity of hydro power plant in China will

be 800 MKW. The ongoing construction involving 30 large and medium sized hydroelectric power stations. Both the Three Gorges (176.8 million KW) on the Yangtze River and the Longtan (4 million KW) in Guangxi will be put into construction within this century.

Water and soil conservation

Water and soil conservation is the key point for the comprehensive development of rural animal husbandry and mountainous economy as well as an important content of river training and disaster prevention. According to the statistics of 1950s, water and soil erosion covered 1.5 million km^2, 1/6 of the total land in China, mainly scattered in the Loess Plateau, hilly areas in the south of the Yangtze, earth-rock hilly regions in the north and black soil regions in the northeast. Among them, the hilly and plateau gullies in Loess Plateau was most serious with about 250,000 km^2 erosive lands, where the soil erosion was 4,000-5,000 tons/ km^2 annually. Following table is a rough division as per water and soil erosion:

REGIONS	EROSION AREA	EROSION CIRCUMSTANCES
LOESS PLATEAU	450,000 km^2 (250,000 km^2 serious erosive areas)	Loose soil, concentrated rainstorm, severe destruction of natural flora; Erosion modulus: 4,000 - 10,000 T/km^2.
HLLY AREA SOUTH YANGTZE	460,000 km^2	Thin subsoil, heavy rain; Erosion modulus: 2,000 - 4,000 T/km^2.
EARTH-ROCK MOUNTAINOUS AREA IN NORTH	540,000 km^2	Chequered with earth & rock; steep slope; frequent rainstorm easy to flush; Modulus: 1,000 - 5,000 T/km^2.
BLACK SOIL AREA IN NORTHEAST	100,000 km^2	Gentle but long slope, water concentrating in rain reason so as to flush the subsoil.

With 40 years' effort, an area of 500,000 km^2 has been harnessed; 0.4 billion mu forest for water and soil conservation been planted; 116 million mu level terrace constructed; 23 million mu reclaimed by warping and dyke building. Among them, in the key harnessing areas in Loess Plateau, 100,000 mu land conserved. In 1982, the State Council approved to establish 8 key harnessing areas of water and soil conservation in the basins of Yellow River, Yangtze River, Haihe River and Liao River. It was adopted to combine water and soil erosion harnessing and poverty alleviation and to combine the benefit of both ecology and economy together, thus achieved very good effect.

The experiences of the farmers of Shanxi Province have been extended to harness the small watershed household and combine harnessing, management and benefit together so as to promote the initiatives of the farmers.

Flood control

China is situated in the east part of Asia and is well known for its complicated topographic and geological conditions. The climate varies greatly from region to region. Affected by the monsoon, the flood disasters caused by the torrential rain become very glaring in the east, where 90% of the national population live and most of the people's economic activities are concentrated. According to an approximate estimation, 1/3 of the total farmland, 2/5 of the total population and 3/5 of the national industrial and agricultural output are threatened by the floods. The frequent-happened floods cause great losses to the social economy every year. There-fore, to strengthen the flood control constructions and reduce the flood-caused losses to a minimum, especially those caused by the destructive floods the will bring about heavy casualties when some section of dyke bursts, is now becoming a most important task to guarantee the social security and national economic development. Based on the characteristics of China's flood control and the common problems on China's major rivers, the following countermeasures will be adopted as China's long-term policies in future.

(1) Carry on the principle of "combining flood storage and discharge". Regulating river course and reinforcing embankments are

the basic measures to raise the flood discharge capacity of the rivers. On the basis of fully utilizing the flood discharge capacity of the river channels in conjunction with the multipurpose capacity of the river channels with the multipurpose water resources utilization programm, river control reservoirs, such as the Three Gorges Project on the Yangtze River and the Xiao Langdi Project on the Yellow River, are to be developed in a bid to effectively control the floods.

(2) Combine the measures of river course regulation, reservoir construction and water and soil conservation tightly in flood control. The job of water and soil conservation and small and medium-sized rivers harnessing should be consistently carried on so as to control the water and soil loss, mitigate the aggradation in river channels, lakes and reservoirs, and alleviate the flood disasters in mountainous areas.

(3) To set up temporary flood diversion and detention areas.

2.4 Cases

1. Three Gorges Project

The Yangtze River (Changjiang) is the largest river in China, with a total length of over 630 km of the main stem, affording 960 billion m^3 of water flowing into the sea every year on average. The total drainage area is 1.8 million km^2, 19% of the total land area of the country. The population of the Yangtze basin is equivalent to 1/3 of the total of the country while its exploitable hydro power potential takes 53% of the country's total and the inland navigable mileage amounts to 70% of the total of the country. The aggregate output value of agriculture and industry equals to about 40% of the total of the country, playing a very important role in the economic development of China.

The stretch from Fengjie to Yichang, about 200 km long, cuts through such three majestic canyons as Qutang Gorge, Wu Gorge and Xiling Gorge-known as the Three Gorges.

Located in Sandouping of the Xiling Gorge, the proposed site of the Three Gorges Dam is 38 km upstream from the Gezhouba Project, installed capacity 2,715 MW, completed in 1980. It is an exceptionally large water

conservancy scheme possessing enormous, comprehensive utilization benefits for flood control, power generation, navigation, breeding of aquatic products and water supply.

The project is to consist of a large dam across a river, hydroelectric power station and navigation structures.

The elevation of the dam crest is 185 metres above sea level. Its normal water storage level is 175 metres and total storage capacity is 39.3 billion cubic metres, with flood-control storage capacity of 22.14 billion cubic metres. The power station would install 26 sets of power generating units, with a total installed capacity of 17680 MW and an annual output of 84 billion kwh. The navigation structure's annual one-way passage capacity would be 50 million tons. About 650 km of channels would be upgraded.

Construction of the project will be divided into three stages. The general construction period for the principal part of the project will last 15 years, including 3 years on construction preparation.

In the ninth year after construction begins, permanent navigation structures will be put into use and the first power generating unit begin generating electricity. Calculated in terms of 1990 price, the total investment, including that for project construction, resettlement of residents and power transmission, could reach 57 billion yuan.

2. Xiaolangdi Project

The dam site of the Xiaolangdi project is located in the trunk Yellow River, 40km north of the City of Luoyang, Henan Province. It is 130 km downstream from Sanmenxia Dam and 115 km upstream from the Zhengzhou bridge of the Beijing-Guangzhou railway, and controls a drainage area of 694000 km^2, 92.3% of the total Yellow River Basin. Located at the outlet of the lowest gorge section of the Yellow, this project to holds a position key to jointly regulating all the reaches and controlling the water and silt, as it is the only one below Samenxia Project which can create a large storage capacity. The Xiaolangdi project is a multipurpose one, mainly aimed at flood control, ice control and sedimentation reduction with secondary consideration to water supply, irrigation and power generation, involving both disaster elimination and

benefit exploitation and holding an important strategic position in the overall layout of the Yellow River's harnessing and development.

The Xiaolangdi Project is composed of the dam, flood spilling and silt discharging structures, intake structures, power house, and etc.. The dam is rock fill type with internal blanketing and an inclined loam core wall, the total storage capacity 12.65 billion m^3, the maximum dam height 154m. There are 15 tunnels for flood and silt discharging and diversion for power generation, which include three plate orifice is spillways three free-flow tunnel spillways is three for silt discharging, six for power generation. The power house is a semi-underground one, located by the dam side with the installed capacity of 156 MW, produce an annual power output of 5.1 billion KWh on the average. Because of the high silt content of Yellow water and the topography and geology at the dam site, all the 15 tunnels are arranged on the left bank with the maximum tunnel diameter being 14.5m. In order to meet the requirements by the purposes and operation mode, i.e. 'to store the clear and discharge the muddy", of the project, the total discharging capacity at the highest pool level is designed to be 17000 m^3/s. The total investment will be 5.2 billion yuan RMB. Construction of the main structures will last 8 years.

3. Ertan Hydroelectric Power Project

This Project is located in Yanpian and Miyi Counties in Sichuan Province, South east of China, and is adjacent to the newly established iron-steel complex at the city of Doukou. Ertan is the first project to be implemented in the cascade development plan of the lower Yalong River.

The River with a total length of 1,500 km, a total heal drop of 3,870m, and a hydropower potential of 25,000 MW, is one of the ten principal hydropower bases in China.

The main purpose of the Project is for power generation, with associated multipurpose benefits. With an installed capacity of 3000 MW, and an average annual generation of 16.2 TWh, the Ertan Project is promising for early development.

The project layout consists of a double-curvature arch dam, spillway tunnels on the right bank, underground powerhouse, and logway at the left bank.

The height of the arch dam is 240m. Six generating units of 500 MW each will be installed in the underground power house.

The project is now under construction. The total investment about five billion yuan.

3. THE INTRODUCTION OF IWHR

3.1 China Institute of Water Conservancy and Hydroelectric Power Research, the (IWHR) under the joint direction of Ministry of Water Resources, Ministry of Energy and the Chinese Academy of Sciences is responsible for the investigation of Scientific and technological problems arising from water conservancy and hydroelectric power construction and development, which is a comprehensive research organization.

The Institute was established in 1958 by merging three organizations, namely, the Institute of Hydraulic Research under the Chinese Academy of Sciences, the Water Conservancy Research Institute under the Ministry of Water Conservancy, and the Hydropower Research Institute under the Ministry of Electric Power Industry. Disbanded in 1969 and reorganized in 1978, it is now the largest and a national research centre in the field of water conservancy and hydropower technology in China.

3.2 The Institute, at present, is composed of 15 research departments (centres), namely:

Department of Water Resources
Department of Sedimentation Engineering
Department of Hydraulics
Department of Structures and Materials
Department of Geotechnical Engineering
Department of Earthquake and Blasting Engineering
Department of Hydraulic Machinery
Department of Automation
Department of Cooling Water Engineering
Department of Instrumentation
Department of Irrigation and Drainage
Department of Water Conservancy History
Research Centre of Disaster Reduction and Environment issues

Water Quality Research Centre

Computer Centre

The Institute is also the seat of International Research and Training Centre on Erosion and Sedimentation, jointly sponsored by the Chinese Government and UNESCO.

Divided into two parts--- the northern and southern compounds, are some 4 km from each other. The Institute covers an area of 281,000 m^2. An affiliated experimental hydropower station is provided for pertinent research on hydraulic machineries.

3.3 50% of the research mission projects of the institute, are commissioned by the Government through the channel of Ministry of Water Resources and the Ministry of Energy. Concurrently, the Institute is also responsible for the research of some fundamental disciplines in the aspects of water conservancy and hydropower technology long-term planning of science and technology development. Another 50% of the mission through contracts signed with local governments as well as design sectors and construction sectors. The main research activities are focused on : engineering measures taken to ensure high agricultural yield; development and utilization of water resources; sedimentation problems of rivers and reservoirs; hydraulics problems of spillways and outlet works in high dams; high dam structures and new materials for construction; geotechnical problems of major hydro-projects; theory and practice of blasting and aseismatic engineering; large hydro turbine and pumps; economics of hydraulic engineering; engineering problems dealing with cooling water for thermal and nuclear power plants; environmental problems related to thermal and hydro projects; water disasters and mitigating measures and so on. Furthermore, the Institute is also provided with a workshop manufacturing instruments for scientific research as well as high efficiency and energy-saving pumps; a workshop for fabricating models.

3.4 The Institute boasts a staff of 1600, among them about 1000 are scientific and technical personnel, including 300 senior engineers and 440 engineers. Among the technical staff 34 have been awarded with Doctor degree of Engineering and 244 with Master degree .

3.5 The annual budget of expense available is 45 million yuan (RMB).

3.6 The Institute has been accredited and authorized by the State Council of the PRC to offer programs of graduate studies for Doctor's and Master,s degrees. A graduate school has been established in cooperation with North China University of Hydropower Engineering. Since 1978, 15 have been awarded Dorctors degree and Doctorate and 300, Master's degree.

3.7 The organizational structures of the Institute are composed of the following parts, namely: three Commissions, i.e. the Academic Commission, the Board of Academic Degree Assessment, and the Board of Professional Title Assessment Commission under the leadership of Director. As regard to the logistic system, there are Secretariat, Personnel Service, Technical Service, Finance Service, Supply Service, and General Management Service. Besides, some companies are available to provide with various labour service as well as living service facing to either the Institute or society.

The highlights of main laboratories and facilities available in the Institute are:

1. Structure Vibration Laboratory---Mainly equipped with 5 × 5 mtriaxial earthquake-simulating shaking table with 6 degree of freedom and fitted out with a whole set of data acquisition and processing system for dynamic parameters.
2. Centrifugal Model Test Laboratory for Geotechnical Engineering---mainly equipped with a rotating arm with 4 m in radius, having the maximum acceleration of 300g, being capable to hold 1.5 ton testing model and basket and completely fitted out with whole set of data acquisition and processing system.

3. Laboratory of Blasting Engineering----mainly equipped with the explosion simulating facility, containing a blasting chamber 9 m in diameter made of closed heavy duty R.C. structures and fitted out with measuring and analyzing system as well as high-speed video tape recorder and camera system.

4. Concrete Laboratory---mainly provided with an servo electro mechanical system of a universal testing machine, concrete calorimeter with a computer, automatic concrete freezing and thawing testing apparatus, high pressure triaxial testing equipment, universal material testing machine, triaxial compression creep testing apparatus and other testing facilities being engaged in the studies on the application of admixtures and fly ash etc. to help enhance the development of concrete dam and roller compacted concrete dam.

5. Structural Model Laboratory---mainly equipped with photo-elastic stress analysis apparatus, holographic and laser speckle interferometric test table and structural model test using facilities brittle materials.

6. Sedimentation Research Laboratory---mainly containing systems being capable to conduct model studies either using clear or sediment-laden flow.

7. Hydraulic Laboratory for High Dams---mainly equipped with a vacuum tank of good performance for testing hydraulic model under scaled ambient atmospheric pressure, a high speed water tunnel with maximum velocity available of 35 m/s for cavitation research, and a variable slope flume for testing air entrainment phenomena of open channel flow.

8. Water Quality Analysis Laboratory---mainly equipped with atomic absorption spectrophotometer, gas chromatography, ion chromatography, polarographic anlayser UV-visible spectrophotometer, liquid chromatography, BOD automatic measuring and recording device etc.

9. Rock Mechanics and Soil Mechanics Laboratory---mainly equipped with a large-sized high pressure triaxial dynamic and static soil

testing machine, a large scale permeameter, a large scale oedometer, an automatic compaction device, a universal consolidometer, a stress paths controlled triaxial testing machine, and a resonance column apparatus etc. being capable to conduct the performance tests of high earth-and rock-filled dams.

10. Hydraulic Machinery Laboratory---mainly equipped with 4 major testing stands, with high precision, among which one stand is capable to conduct silt-laden flow water turbine, taking capability of anti-cavitation damage into consideration.

11. Hydraulic Laboratory for Thermos or Nuclear Power Plant Cooling Water.

12. Laboratory of Computer-Aided Control System Development For Hydropower Station.

13. Remote Communications Laboratory.

14. Hydraulic Turbine Governor Dynamic Emulation Laboratory.

15. Computer Center.

Recently, the Institute has conducted a great amount of research work on related technical problems and has also provided consultation service for the major and important domestic water conservancy and hydropower projects such as the Three-gorge Project, Water Diversion Project from south to north China, Xiao-lang-de Project, and Er-tan Project etc. thus helping solve many problems arising from design, planning and operation of hydro projects. In the meantime, a great amount of academic activities has been carrying out in the form of international cooperation and consulting services.

3.8 Recent achievements

1. Research results for optimizing the planning, design and construction of major water conservancy and hydro power projects in China, including Three Gorges, Xioalangdi and Ertan etc. projects
2. Technology for the building of earth-and rock-filed dams, more than 200m height, and software for design
3. Updating limit equilibrium method for slope stability analysis and its applications

4. Prediction of sedimentation problems in reservoirs and measures for re covering storage capacity
5. New type energy dissipator for high dam spillway
6. Aerated method to mitigate cavitation erosion in high velocity flow channels and tunnels
7. Optimum design of arch dam
8. Optimal regulation of reservoirs of hydro power station-series in power system
9. Application of high content fly ash concrete
10. New additives for concrete
11. New materials for grouting
12. High efficiency hydro turbines and pumps
13. New measures to mitigate silt and cavitation erosion in turbines and pumps
14. New concept for general layout of cooling water engineering structures in thermo or nuclear power plants based on new theories
15. Development utilization and comprehensive regulation of water resources in North China and Hainan Province
16. Instrumentation for dam safety monitoring
17. Development of distributed multi-microcomputer control system in hydropower plant
18. Development of dynamic characteristic test system for hydroturbine governor
19. Development of automatic hydrological data acquisition flood forecasting system
20. New Technology of drilling and installing radical collector wells in Silty-Sandy aquifer
21. Siltation-irrigation by diverting hyper-concentration sediment water
22. Accelerator and surface wave measurement apparatus for rapid evaluations of fill density of earch and rock-fill dam
23. Mathematical model for sedimentation in reservoir and evolution of river bed

4. MAJOR RESEARCH AND DEVELOPMENT PROJECTS IN IWHR

4.1 The major research and development projects in IWHR

The Institute is responsible for the investigation of many problems of vital importance and crucial technicality, arising from water conservancy and hydropower development. About 300 research projects completed annually. The major projects included in the following fields:

- Investigation, assessment, development and utilization of water resources
- Economics for water resources development
- Storm and flood
- System analysis
- Development and application of techniques and equipments for irrigation
- Civil engineering of irrigation and drainage systems
- Sedimentation problems uncounted in the development and regulation of major rivers
- Hydraulic problem arising from water conservancy and hydroelectric power projects
- Problems concerning structures and materials in major water conservancy and hydroelectric projects
- Geotechnical engineering, including rockmechanics, soil mechanics, seepage and foundation treat ment
- Engineering and basic aspects of earthquake resistance of dams and other hydraulic structures
- Construction blasting technique and directional blasting for building rockfill dams and safety control measures
- Technical problems related to hydraulic machinery
- Safety monitoring and comprehensive automation of hydropower plants
- Hydrological data acquisition and flood control of reservoirs and hydropower plants

- Research work related to planning,design and operation of water cooling projects for key thermal and nuclear power stations
- Disaster and disaster reduction
- Environment assessment
- Instrumentation

4.2 Examples

4.2.1 North China Water Management Project

Since the initiation of economic and institutional reform in 1978, the economy of China has seen great progress in industry, agriculture and foreign trade, with which has come increasing demand for water resources.

North China Plain is an important area economically, embracing Beijing, the Capital, Tianjin, an important industrial city, and Shanxi and Hebei Provinces of industries and agricultural importance, etc.. The area covers 300000 km^2 and sustains a population occupying 1/5 of the national total. The average annual precipitation over the area ranges between 400 and 600 mm, and is highly concentrated between June to September. The precipitation varies greatly within the year and from year to year, and has seen a dry span over the last 10 years. In the area, 2/3 of the water supply is used by agriculture, the rest goes to industry and other sectors. With the rapid development of industry and agriculture water shortage is becoming increasingly serious. It is predicted that, by the year 2000, water demand in Tianjin will be increased by 110%, in Beijing by 24%. The water shortage has resulted in overdraft of groundwater in Beijing. The unreasonable existing industrial structures, the rural enterprise boom and the agriculture all result in high water consumption.

The Chinese government has given priority to solving the water shortage in North China and authorized the state Science and Techconology Commission to be responsible for a policy-oriented study for water resources management. This study falls into three stages. The first stage, carried out in conjunction with the Environment and Policy Institute of the East-West Center, USA, established a basic framework. The second stage implements key studies for subareas and cities, such as studies of agricultural water saving, wastewater treatment, etc..

The third stage, during the Eighth Five-Year Plan, will develop a macroeconomic water resources planning model and put this model into use.

This project is funded by the United Nations Development Program. The Institute of Water Conseurancy and Hydroelectric Power Research is responsible for organizing national experts to cooperate with international consultants in carrying out the studies.

The expected outcomes of the project are water management models, including three kinds as follows:

1. A controlling macro-economic model to optimize the benefits of conflicting demands on the limited water resources, balancing economic, environmental and social considerations;
2. Hydrologic and water quality models to give a physical basis to water allocation decisions;
3. Management models of demand and supply which react with 1.

The above models will provide basis for decision making in provincial and central governments.

This project deals with complicated economic, social and environmental issues, etc.. The area covers a large scope, creating a great need for basic data and 30 models will be built up. The project also needs a heavy input of technical staff. Till now initial achievements have been obtained, part of the models have been set up.

4.2.2 Research work for South to North Diversion Project

Northern China (covering the Huaihe, Yellow and Haihe River basins) is an area of serious water shortage. The per capita and per mu farmland water resources are only about 400 m^3, unable to meet the needs by industry and agriculture. The long term studies show that the annual water shortage in the area has reached 10 billion m^3, and will reach 20 to 25 billion m^3 by 2000, 30 to 50 billion m^3 by 2020. The government has planned to transfer 50 billion m^3 of Yangtze River water to this area through three routes from the upper, middle and lower reaches, respectively. At present planning is being carried out, including the super early study of the west route, the feasibility study of the middle route and the preliminary design of the east route. Our institute is undertaking part of

the work for the east and middle routes.

The east route starts at Jiangdo, Nanjing, goes northward through the Grand Canal, involving altogether 16 low-lift and large flow rate pumping stations. The key technical issues are in that the route intercepts the water and pollutant discharging channels in west-east direction in the Yellow, Huaihe and Haihe River basins, thus creating serious pollution of diversion water, and the design of low-lift and large flow rate pumping stations also need to be solved. Our institute has worked out solutions to both the issues.

It is planned that in the near term, the middle route with draws 15 billion m^3 of water annually from Danjiang Reservoir on the Hanjiang River, then delivers the water in gravity flow over 1200 km, along the foots of the Funiu and Taihang Mountains, to Beijing. The key technical issues with this route arise from the fact that the planned diversion water volume occupies about 50% of the Hanjing's flow, thus creating adverse impacts on the local water supply, power generation, navigation, water quality, environment in downstream areas, from the necessity for joint operation of the reservoir and the water projects in the area receiving water and from the route crossing about 200 rivers of all sizes, which brings about many technical issues, such as the expansive soil foudatition problem. The institute is carrying out a study on the transferable water volume, with emphasis on the projection of industrial and agricultural water requirements in the area from which water will be diverted, i.e. the Hanjiang basin, which will serve as a basis for estimation of rational diversion from the local economy, environment and society considerations. An operation model will be established on the basis of the macroeconomic analysis of water resources in the water reception areas of North China to design operation schemes for the South to North Diversion system with consideration to full exploitation of North China's potential water resources. In addition the institute will carry studies of selection of the route line, engineering geology along the route and assessment of environmental impact, etc., with the whole process lasting 5 to 7 years.

For the west route, which starts from the Yalongjiang River, tributary to the upper Yangtze, super early studies are being implemented on route line

selection. The institute will also undertake studies of special issues with the route, such as tunnel excavation, construction in drifted soil areas, water allocation for north west China, and rational operation of the system.

4.2.3 Dynamic Model Tests of Arch Dam Subjected to Earthquakes

A. The arch dam of Ertan Project is located in a "V" shaped canyon. It is a parabolic double curvature arch dam with a height of 240m, and thickness to height ratio of 0.229. The basic intensity of earthquake is 7^0 in the dam site and the intensity of 8^0 is adopted in the design according to the national code.

Since the arch dam is located in the earthquake region, it is quite important of the interaction effects on foundation and reservoir of earthquake responses for the dam. A number of studies on analyses with computer have been done, typically the reservoir interaction has been represented by added mass applied to the upstream face of the dam under the assumption of incompressible fluid, but the mathematic models as well as some fundamental assumption and parameters should be verified and improved by model test. A dam model test with foundation and reservoir has been conducted on the large scale high performance shaking table. Furthermore, the failure test has been carried out for studying the mechanism of fracture during the severe earthquakes.

B. The scale of the model is 1:240. The shaking table is 5mx5m in size, frequency range 0.1-120 HZ, maximum load weight 20^T, maximum horizontal acceleration 1.0 g, maximum vertical acceleration 0.7 g, vibration waveforms include sinusoidal, random and earthquake simulation waves.

The dam model used in experiments is 1.0m in height and 3.0m in width with the extent of the foundation equal to the dam height in all direction from dam contact surface at canyon wall and base. The model reservoir has a length about three times the dam height for avoiding significant interference from the assumed upstream face of the reservoir. The canyon topography has been simulated.

This is the first model test of arch dam with huge foundation and reservoir on a large shaking table when subjected to the actual earthquake waves in China.

In order to study the correlation of analytical and experimental results, the analytical study was performed by using a computer program of ADAP-

CH89. The results of analyses on natural frequencies of vibration and dynamic stresses are rather close with that of model tests.

C. The following results has been obtained:

1. The fragile fracture is possible during the severe earthquake and the cracks will take place at the midlevel or near the top of the dam. Measures should be considered to strengthen the dam.

2. The geometry of the reservoir near the upstream face directly influences the hydrodynamic pressure acting at the dam face.

3. It is apparent that the reservoir has little interaction effect for any vibration mode until water level reaches about sixty percent height of the dam; and the frequency is seem to drop rapidly as the water level rises above sixty percent of the height of the dam. Therefore, the variations of natural frequencies are very sensitive to the variations of water level while full reservoir.

4.2.4 Research on hydraulic problems of flood release structures in high arch dam

A. The Ertan hydropower station is a huge project with a high impounding arch dam, as introduced above. After being put into operation, the project will release a great amount of surplus water in raining seasons. According to the design, the flood release structure of the project consists of 3 parts as follows.

1). Surface spillway-7 outlets, having a discharging capacity of 6600 M^3/s;

2). Mid-level spillway-6 outlets, having a discharging capacity of 6900 M^3/s;

3). Right bank spillway tunnel-2 channels, having a discharging capacity of 7000 M^3/s;

The total discharging capacity is 20600 M^3/s.

The impounding dam is as high as 240 m, and its spillways have to release a very large volume of flood water within a canyon as narrow as 100 m in width. A huge amount of energy carried by the released flood water has to be dissipated, and it unavoidably bring about serious erosion in the downstream valley. Meanwhile, the high velocity of the releasing flow has a great potential to damage the structures which is passed over, so a elaborately well-designed shape for these structures is absolutely important in order to mitigate the potential damage to an extent as much as possible.

On the problems described above, IWHR has conducted a systematic series of investigations by applying hydraulic model tests.

B. A entire undistorted model was built with a scale of 1:120 to investigate energy dissipation for flood releasing through the surface spillway and mid-level spillway. Furthermore, erosion protection at the outlet of the tunnel spillway is also studied with the model.

Section models were built to study the weir crest curve of the surface spillway and to optimize the design of the mid-level spillway outlet.

A 1: 40 model of the radial gate in the tunnel spillway was tested to investigate its dynamic characteristics and possibility of flow induced vibration. Another special model was built to study in details the overflow problems through the top-slit of the radial gate and pertinent cavitation problems.

A mathematical model was applied to simulate flood wave propagation due to a potential dam break and its impact on the downstream area. This model was combined with a physical model to test local flow pattern at river bifurcations downstream.

C. Results

1) The results obtained from the entire model experiment put forward proposals about the optimum elevations for the surface spillway and mid-level spillway and the exit angle in the flip bucket, which makes

the two flow jets coming out of the two outlets impact each other in the air, thus enhancing energy dissipation and reducing local scouring in the downstream river.

2) By means of section model tests on tunnel spillway, a specially designed shape of tunnel spillway structure was suggested in order to prevent cavitation damage. In addition, an optimum design for the outlet of tunnel was adopted to mitigat scouring downstream.

3) Possible impact area due to potential dam break flood was put forward as a reference for the regional planning.

The Ertan project is the highest hydropower project under construction in China at present. The flood releasing problems and the relevant energy dissipation in high and narrow canyon are of typical importance and obviously the experience in this aspect is very useful for designing of other similar projects.

4.2.5 Study on the Construction of High Earth Core Embankment Dams

China's hydropower development in the 1990's requires building a number of high earth core embankment dams that include:

- the 167 meter high rock fill dam with sloping core of loess in the Yellow River;
- the 188 meter high rock fill dam with central core of tilt in the Dadu River, a tributary of the Yangtze River;
- the 190 meter high rock fill dam in the Wujiang River, a tributary of the Yangtze River, the dam type of central core of residual soil being a proposed alternative.

In view of the challenging technical difficulties involved in these projects, as well as the lack of experience of building embankments dams of such height in China, a state major research program entitled *Study on the Construction of high Earth Core Embankment Dams*, was undertaken by our Institute with the collaboration of various research institutions and universities. The research

program is primarily concerned with the following topics:

1. Physical properties of embankment materials and weak seams in the dam foundation.

Extensive studies have been undertaken on the shear strength and stress-strain behaviour of soils under high and complicated stress paths and the softening behaviour of foundation weak seams.

2. Computational methods for designing earth and rock fill dams

We have established a man-machine interactive computer software which allows the evaluations of stresses and displacements at different stages of dams constructions including steady seepage, reservoir impounding and earthquake impact.

3. Quality inspection and control of embankments

A computer database for quality inspection, evaluation and control of the fills has been developed and successfully used in the Lubuge rock-fill dam. The accelerators and a surface wave measurement apparatus were manufactured for rapid evaluations of fill density.

The research program has solved a number of important problems existing in the high embankment dams currently being designed and resulted in considerable savings. The total volume of the embankment of the Xiaolangdi Dam, for example, has been reduced by 1.9 Million cubic metres.

5. INTERNATIONAL RESEARCH EXCHANGE PROGRAMMES

Since China started the policy of reforming and opening to outside , the IWHR has extended the exchange activities with over 70 organizations from more than 30 countries. Each year we receive about 150 foreign visitors and 700 volumes of academic publications from abroad. And the IWHR has undertaken a number of cooperative research projects with the World Bank, Asian Development Bank (ADB), United Nations Development Program (UNDP), United Nations Educational, Scientific and Cultural Organization (UNESCO), Japanese International Cooperation Association (JICA), Canada, Finland, Germany, Iran, Bangladesh, Pakistan, Oman, Thailand and so on. The research exchange programmes in IWHR include consulting, research, physical model test, mathematical models, design, developing new instrument or equipment.

5.1 Present situation

Now the international research exchange programmes in progress or in planning stage mainly are:

(1) North China Water Management Project. It is the biggest research project in China supported by UNDP, starting in July of 1990 and lasting 3 years. Because of some difficulties in implementation, it was decided to shift to the IWHR under the memorandum of understanding signed by UNDP and State Science and Technology Commission (SSTC) of China in May of 1991. The IWHR began to work on the project from July 1991. The project has attracted high technology data base on macroeconomic model and management for water resources, such as expert system, multi-objective decision system, Geographic information system(GIS),

and management model and absorbed several hundreds domestic specialists on water resources, hydrology, water quality, economy, computer and others from over 6 provinces and municipal, and 20 consultants from abroad. A tremendous efforts and progress have been made and all UNDP, Chinese Government and international and national experts are very satisfied with the work have been done. It can be hoped that the project will be successfully completed on schedule, by June, 1993.

(2) The IWHR with Nippon Koei Co. Ltd together win the bid of "North Hainan Water Resources Development Project" from ADB. It began in July of 1991 and lasts about 16 months. A final review meeting was held on October 26 of 1992 and a good evaluation has been paid to it.

(3) Based on the study of flood control and river training project on the Brumaputra River in Bangladesh by IWHR, Yellow River Basin and Pearl River Basin Commissions, some experts of high level in IWHR have been invited as consultants to join the World Bank and German Company in the present Flood Action Plan for Bangladesh. Now we have a representative in Bangladesh to try to obtain more projects.

(4) The IWHR is carrying a cooperative research work of dambreak dynamics with the National Board of Waters and Environment of the Republic of Finland. The project lasts 3 years from 1992 to 1994, including field investigation, physical model experiment and numerical model development. Now the work is going smoothly.

(5) The IWHR send some young engineers to Japan to join the research and technical management activities there.

(6) The Central Research Institute of Electric Power Industry (CRIEPI) of Japan provided us funds and a set of measure equipment and

instrument to study the water quality of rainfall in Beijing Area on the first stage and in South China on the present stage.

(7) The IWHR has signed a contract with the GEC Alsthom Power Plants Limited of England to do maritime study for Shajiao "C" Power plant in China. The contents cover optimum intake and outfall location and field study, physical and mathematical modelling.

(8) Now we are trying to obtain a project titled "Improved Water and Soil Management for Sustainable Agriculture in the Huang-Huai-Hai Rivers Plain" with Portugal and England.

(9) The cooperative research on river ice engineering with Russian engineer is now going on.

5.2 Problems in promotion

The Chinese engineers have high competition capacity on technology, experiences and price. For further cooperation and bid in international markets, we need to improve our foreign language and administration level. On the other hand, we should absorb advanced science and technology from abroad though inviting foreign experts to China or sending Chinese to go abroad for training.

5.3 Necessity for, and problems involved in inter-Asian research exchange

China is a developing country in Asia, so the knowledge and experiences in China may benefit for other Asian developing countries. We would like to strengthen inter-Asian research exchange activities, and have more and more Asian friends to visit China and provide us more information. The market information from abroad is very important to us, so we will try our best to obtain information and also hope more foreign companies know and cooperate with IWHR. It is expected that more Chinese engineers and officials will be employed by the international organizations, such as the Asian Development Bank, United Nations, World Bank and others.

6. ACTIVITIES RELATED TO DISASTER AND DISASTER REDUCTION

6.1 China is a country subject to frequent occunence of natural disasters, mainly floods, water logging and droughts, as well as typhoon, hail, frost and earthquake. The averaged annual disaster induced loss to economy was 8 billion yuan RMB during the 1950s, 41 billion yuan during the 1980s. In 1989 disasters caused a loss of 52.5 billion yuan. Though disaster occurrence in 1990 was moderate and biased to the low side, the direct disaster induced economic loss still amounted to 61.6 billion yuan in the whole country. Every year about 300 counties, 200 to 300 million people and 700 million mu of farmlands are affected by disasters to different degree. The year 1991 saw disasters of different kinds lasting long time and lightly concentrated, which resulted in a heavy loss to economy, therefore, was a year of heavy disasters. In the disasters in 1991 the water related are the most serious, in particular the flood and waterlogging disasters in the Yangtze and Huaihe basins were rarely seen in history. The droughts in 1991 were also more serious than those in a normal year. As checked and ratified by related agencies the affected farmlands were 830 million mu, in which the damaged area was 410 million mu, the crop totally destroyed 84 million mu; and 400 million people affected, in which 280 million heavily affected, with more than 7300 casualties; among which 360 million mu of affected farmlands, 210 million mu of the damaged, 210 million mu of the crop totally destroyed and 5113 casualties were induced by floods or waterlogging, with the total direct economic loss of 77.9 billion yuan.

In order to reduce the loss caused by disasters, the government has adopted many measures and included disaster reaction in the national economy and society development plans. In 1990 the government established the China

National Committee for International Decade of Natural Disasters Reduction. Under the unified arrangement of the government, the related departments of the State Council and local governments have implemented in succession a batch of disaster reduction and study projects. Many reservoirs, embankments, flood diversion and storage projects in China have played a significant role in fighting the extraordinary flood and waterlogging disasters in the Yangtze; Huaihe and other river basins in recent years. After the water disasters in 1991, the government invested several billion yuan in construction of water disaster reduction works for the Huaihe River and Taihu Lake. Construction of the three Gorges Project was already put into the governmental agenda and approved by the National People's Congress. The Three Gorges Project will greatly reduce flood and waterlogging disasters in the middle and lower Yangtze River.

Gratifying progress has also been made in other aspects in disaster reduction with the continuous implementation of all kinds of disaster reduction projects by the governments at all levels, such as earth quake prevention projects, landslide and mud-flow prevention projects, large-scale protective forests, desertization prevention projects, ecologic enhancement projects, etc..

In the scientific aspect of disaster reduction, since 1991 the government has sponsored a large number of disaster reduction scientific study projects involving dozens of thousands experts. For instance a scientific study project of dozens of million yuan investment is being carried out for typhoon and rainstorm disaster reduction. The study projects are also being carried out for reducing marine disasters, earthquake disasters forest fire, desease and insect disasters and for remote sensing techniques to monitor the disasters comprehensively. The implementation of scientific study projects will facilitate the progress of China's scientific disaster reduction undertakings. In 1992 the government also set up the National Management Center for Natural Disaster Reduction to strengthen comprehensive management of natural disasters. The tasks of the center include

forecasting disasters, which involves a seminar to be held from Oct. to Nov. each year for discussion and forecasting of the disasters in the next year, which will yield suggestions for the government on decision making, disseminating disaster reduction knowledge to all the people so as to promote public awareness of disaster reduction and reduce disaster induced losses, thus adapting to the reality that disaster induced loss develops with the growth of national economy. Agencies for study and management of disasters have also been established by related departments of the central government according to the effect of disasters on them, respectively, so as to strengthen the studies.

Because of the geographic conditions which favours concentrated and intensive rainstorms caused by monsoon and locates the major industrially and agriculturally developed areas in the plains along the lower river reaches, China is under serious threatening of floods. In addition, because the precipitation mainly comes from the irregular monsoon, severe droughts occur occasionally. Therefore, priority has long been given to studies of floods and droughts.

6.2 The Institute of Water Conservancy and Hydroelectric Power Research was set up as a center specifically for studies of floods and droughts. In the recent more than 30 years the institute has undertaken a lot of work with the main items as follows:

(1) Comprehensive collection and evaluation of basic data on the history and current status of floods and droughts for instance, compilation of the disaster conditions for the last 500 years involving the Ming and Qing Dynasties, evaluation of China's water utilizations, etc.;

(2) On-site investigation and evaluation of the effects of floods, droughts and others on water resources projects along with formulation of suggestions on the disaster reduction. For example, the Institute already made investigations into the large floods in the Haihe River basin

in 1963, the effect of Xingtai, Hebei Province, earthquake on water resources projects in 1966, the loss caused by dam failure during the floods in Henan Province in 1975, the damage to water resources projects caused by the Tangshan earthquake in 1976, the damage caused by the landslide induced close of the Bailongjiang River, tributary to the Yangtze, Gansu Province in June, 1991, the mud-rock flow induced damage in Beijing's suburbs in June, 1991, the conditions of the floods in the Yangtze and Huaihe rivers in August to October, 1991, the landslide in the Zhaotong district, Yunnan Province in May, 1992, etc.. As a national study center of floods and droughts, this institute is ready at all times send chief consultants to conduct on-site investigations, involving evaluation of the current status, forecasting of the development, and suggestion on the planning for the future. The long term activities show that the institute is the main consultation unit of the government in this regard.

(3) Systematic studies of disasters and disaster prevention. Under the jurisdiction of the Ministry of Water Resources (MWR) the preparatory office for the Research Center of Disaster Reduction, MWR was established in the Institute in 1989. This office worked out a plan for research activities on Disaster Reduction for the Decade, involving four aspects: strategic planning of disaster reduction (including organization, education, etc..), disaster reduction policies (including standards, Laws and regulations, warning system, emergency measures, etc. for urban and rural flood, waterlogging and drought disasters), disaster reduction technologies (including those for dam safty and reduction of loss due to dam failure, flood control expert system, flood regulation, utilization of excess flood water, etc.) and fundermental studies (including data bases for floods, water logging and droughts, evaluation methods of disaster

induced loss, etc.). This office is currently organizing related agencies over the country to carry out scientific studies on disaster reduction. The important study projects implemented by the Institute in the recent five years include: the disaster risk maps for China's major rivers, such as the Yongdinghe River in the vicinity of Beijing City, the Liaohe River in the vicinity of Shenyang City, the Dongpinghu Lake and Jintihe flood diversion and detention district adjacent to the Yellow River, etc.; dam-break floods and their impacts; forecasting of reservoir's local flow and operation of reservoirs; disaster reduction measures for the flood diversion and detention districts in the middle and lower Huaihe River; regulation and eutrophication of the Taihu lake; disaster reduction measures for the lower Yellow River; impact of reservoir sedimentation on flood prevention regulation; and flood prevention and disaster reduction measures for urban areas. In addition the Institute is also implementing some fundamental studies, such as the studies of drought standard, economic models for water resources development, risk standard for flood prevention, etc..

(4) Studies of structural disaster prevention measures. Good tools are available for the studies in the institute, as it has a number of advanced experimental facilities, such as large scale shaking table, high-velocity flow and vacuum tank, large scale geotechnical centrifugal machine, etc.. With those facilities, a lot of scientific information has been obtained on earthquake prevention measures for various kinds of water resources projects and civil structures, geotechnical characteristics and liquefaction failure of earth embankments and dams, design of spillways, etc., thus contributing to improving the design of disaster prevention structures to promote their capacity against disasters. In 1992 the Disaster Research Center was established. In order to facilitate the progress in the above

mentioned studies, the center is conducting exchange and cooperations with foreign counterparts in the following regards:

(1) Exchanging basic data and methodologies of disaster studies;

(2) Cooperating to survey and study typical disaster damages;

(3) Cooperating to study specific disaster reduction issues;

(4) Developing advanced experimental equipment and new disaster-resistant hydraulic structures.

In recent years, the institute has conducted or is conducting the projects in cooperation with foreign counterparts in the following items: study of flood control, study of dam-break floods, study of reservoir induced earthquake, study of dam safety evaluation.

6.3 Further Research Topics for Disaster Reduction

1. Natural disaster information management system

It is to set up a information management system for the gathering of existed data of natural hazards such as occured time, effected range, process, damage, causes and background, and for the collection, transmission and treatment of real time natural disaster information from disaster prone areas.

2. Real time monitoring techniques for natural hazards

It is to monitor the natural hazard on a large scale, such as flood, draught, forest fire, earthquake, tropical cyclone, and environmental pollution, by means of radar system, telemeters, as well as satellite and air borne remote sensing equipments, so as to keep informed on how the disaster is progressing, its scope and tendency. What should be studied are monitoring techniques, on line image processing and transmission techniques, as well as quantitative analysis methods.

3. Risk analysis of natural hazards

The risk of the living area exposed to natural hazard is different. If the probability and effected degree of natural hazard for different regions can be

estimated beforehand, it will be significant for the rational land use and mitigation of losses during disasters. The researches involve to set up risk assessment models and to apply them to disaster prone areas.

4. Evaluation of economic losses caused by natural hazards

The economic losses caused by natural hazards are quite different in different regions. It's also difficult to evaluate damage exactly. The research is focused on the establishment of estimation models of natural hazard damages related to different areas, so as to evaluate the losses that may caused by natural hazard more exactly.

5. Non-structural measures for natural disasters reduction

Some new techniques will be developed, such as disaster forecasting and warning systems, evacuation system for inhabitants, expert system for disaster prevention decision making, command system for dealing with emergency, rescue and relief affairs, by which decision makers may improve their emergency ability and avoid unnecessary losses through decision faults.

7. HARMONY BETWEEN THE ENVIRONMENT AND IMPROVEMENT OF INFRA STRUCTURE

7.1 The current situation and possible problems in China

China is a developing country with vast territory, complex geomorphology and much variable climate. As the rainfall is much affected by the south-east storm, in most part of China not only the spatial distribution of rainfall and runoff is very uneven from the east to the west, their seasonal and over-year distributions are also very uneven. Historically, frequent floods, droughts and unstable agricultural production are traditional concern for all the dynasties. Through thousands of years of history, people came to understand the extreme significance of water conservancy with regard to the economic and cultural development of China. Water resource is the life line not only of agriculture, but also of the whole national economy. Therefore, in order to achieve sustainable development of China in the 21st century, the seriousness of water resources problem should be dealt with from a strategic level.

During the past 40 years since the establishment of the new China, China has earned tremendous achievement with world-wide renown. Large number of hydro-projects have been constructed for irrigation, power generation, water supply, navigation, etc.. The water storage, water diversion, water transfer, and water delivery engineering works have accelerated the development of national economy and improved the peoples' livelihood. By the end of 1988, we have constructed more than 80,000 reservoirs of various sizes, with total storage volume of 450 billion m^3, developed irrigation area of 48 million ha, constructed 2.9 million tube wells both for irrigation and for drainage, with 64,370 MW of power in total, and supplied drinking water to 40 million rural people and 21 million cattles. In the field of hydropower, total installed capacity reached

32,700 MW, total annual power gensation reached 109,000 GWh.

In the field of industrial and urban water supply, the total water supply capacity reached 129 million m^3/day for 450 cities. The construction of these hydro-infrastructures greatly accelerated the social and economic development of China.

For the sustainable development of China in the 21st century, water conservancy, as the foundation of national economy, will undergo large scale development. First of all, in order to satisfy food sufficiency, the irrigation area will be expanded from the existing 48 million ha to 60 million ha. The water supply capacity of the whole country through storage, diversion, pumping etc. will be enlarged from the present 500 billion m^3 to 800~1,000 billion m^3. Thirdly, in order to satisfy the power demand from various sectors of national economy, the development of hydro-power will reach a much higher level.

As is widely known, the construction of hydro-projects will have significant impacts on the natural and social environments. Particular attentions should be given to the gigantic hydro-projects, such as the Three Gorges Project and the Project of Water Transfer from the South to the North.

The main environmental impacts include:

(1) Natural environmental impacts:

- Hydrology and meteorology,
- Water temperature and water quality,
- Sedimentation,
- Reservoir induced earthquake,
- Terrestrial and aquatic fauna and flora,
- Siltation and ecology of estuaries,
- Deformation of river bed.

(2) Social and economic impacts:

- Resettlement,

- Transportation and communication,
- Historic relics and recreation,
- Community culture,
- Diseases and hygienic condition,
- Job opportunities and poverty alleviation,
- Economic development.

The Chinese government has paid appropriate attentions to the study of environmental impacts hydro-infrastructures prior to the implementation, during the implementation and during O& M period. Emphasis is being given to the pre-implementation studies or the Environmental Impacts Assessment (EIA). Some regulations and specifications have been promulgated in these aspects by the Government. For some gigantic projects, such as the Sanmenxia Project on the Yellow River, the "Feedback Assessment" has been carried out.

7.2. Activities in the Institute of Water Conservancy and Hydro-electric Power Research (IWHR)

The main activities carried out by IWHR in the field of harmony between the environment and improvement of hydro-infrastructures are as follows:

- EIA of hydro-projects both in theoretical study and in practical study,
- EIA of thermal and nuclear power stations,
- Water quality monitoring and modelling,
- Prevention and amelioration of secondary salinization and alkalization,
- Engineering measures to alleviate the environmental impacts,
- River sedimentation problems and their control,
- The mechanism of reservoir induced earthquake,
- The eutrophication of reservoirs,
- Stability of reservoir bank slopes.

7.3. Technical tasks necessary for the promotion of "Harmony between the Environment and Improvement of Hydro-infrastructure"

- Approaches and methodology for the EIA of inter-basin water transfer projects,
- Approaches and methodology for the assessment of economic and social impacts of hydro-projects,
- Theoretical study on the development-oriented involuntary resettlement,
- Engineering and technical measures to alleviate the negative environmental impacts,
- Study on the siltation and ecology of estuaries,
- Research on the eutrophication of reservoirs.

8. PROPOSALS FOR FURTHER DISCUSSION

8.1 The problems on sedimentation in reservoirs

In China there are numerous rivers and rich water conservancy resources. Because of serious water and soil losses, the river sedimentation problems are serious. For instance, the Yellow River well-known in the world carries about 1.7 billion tons of sediment to the downstream in each year, its average sediment concentration during flood season is 37 kg/m^3, the maximum concentration can be 911 kg/m^3 in the mainstream. The Yangtze River, the largest river in China, and its numbers of tributaries in the upper reaches carry a lot of sediment too. The mainstream of Yangtze River sluices about 500 million tons of sediment annully. Therefore the reservoir sedimentation problems are common when dams are built in China. In recent 40 years China has built 87,000 dams which have played huge roles in developing irrigation and hydro power, reducing natural disasters and supplying water for cities. However the reservoir sedimentation problem is a hard topic faced by Chinese engineers. According to investigation of 231 large and middle reservoirs in 1989, 14.3% of storage volume are occupied by sediment, the deposit rate is 2.3% per year. Series of problems emerged from the reservoir sedimentation are as follows:

(1) The storage capacity and service life of reservoirs decrease due to sand deposit in reservoirs.

(2) As the sand deposit extends to upstream, the channel bed at the upper end of reservoir will rise, which impacts city flood control and agricultural production.

(3) The reservoir sedimentation impacts navigation in inland water way.

(4) The sediment in front area of dam impacts safe operation of

structures, even blocks the intake of hydro power station.

(5) The scouring of dam downstream. Because most of sediment deposits in reservoirs, the sediment concentration flushed from reservoirs will be tremendously decreased, which changes the natural river characteristics largely. The downstream, channel bed will be scoured down and river pattern will change. It causes a series of problems in navigation, irrigation and water supply.

(6) The reservoir sedimentation impacts on river mouth.

(7) Water Pollution problem. The sand deposited in reservoir will absorpt numbers of toxic particles, deteriorate water quality, and impact fish and drinking water.

(8) The sediment abrasion of hydraulic turbine.

China has accumulated some experiences in reservoir sedimentation control, these are succefull for middle and small reservoirs partially. However lot of difficult topics for large reservoirs are still to be resolved due to the complex problems.

The Sanmenxia Hydro Project built in 1960 is the controlling construction in the middle reaches of the Yellow River. Because of inconsiderate design in sediment, very serious sedimentation problems appeared after the reservoir was impounded. To 1964 the storage capacity lost 43% in 4 years, the annual sediment deposition was 1 billion m^3. The dammed water level rose which brought salinity and alkalinity to the important crop base in the upstream area, and large land was inundated, even threatened the safety of Xian, the capital of Shanxi Province. Hence the hydro power station had to stop operation, the hydro turbines already installed had to be removed. In the following over 20 years, a series of reconstructions have to be conducted in order to flush flood flow and sediment to downstream Two sluice tunnels have been added in the left bank and 12 blocked bottom outlets have been reopened. It makes most sediment in flood

season flush to the downstream. Meanwhile a new operation plan has adopted, i.e. during flood season the reservoir does not storage flow, so the water with high sediment concentration can directly go through the dam to downstream, but in dry season, it storage the flow water with low sediment concentration and operates the hydro power station. This operation way is called "to store the clear and discharge the muddy water".

Since the Sammenxia project has been rebuilt and run in new operation way for more than 10 years, it goes smoothly, and keeps a certain storage capacity. The deposition volume in the reservoir no longer increases. After the hydraulic turbines restalled the hydro power station generates electricity in dry season according to the new operation way.

The succeful experience on the Sanmenxia Project may apply to other large reservoirs. It is required to monitor the sediment deposition situation in reservoirs continuously and study new problems.

The Xiaolangdi Hydro Project downstream the Sanmenxia Project is under construction. Its sedimentation problems are even more complex than the Sanmenxia Dam. In 2000 China will construct the Three Gorges Hydro Project on the Yangtze River and some knotty sedimentation problems must to be resolved. China would like to share the experiences with international experts and study together to solved the difficult problems.

8.2 Environmental Problems of the Interbasin Water Transfer and Water Quality Protection

Owing to the unfavourable characteristics of very uneven regional and time distribution of water resources and the pollution of the existing water resources and rapid increase of water demand, a serious water shortage is already happened in some places, especially in the northern part and coastal areas of China. For example, more than 180 cities are faced with water shortages, and

at least 40 of them, the situation is critical. In order to meet the needs for the economic and social development and to satisfy the water demand, several interbasin water transfer project had been built, for example, Luan He-Tianjin water transfer project, Biliu He-Dalian water transfer project, and Yellow River-Qing Dao water transfer project. Also quite a few are in planning, main of these are South-to-North water transfer project. This huge project transfers water from Yangtze River to North China, including Beijing and Tianjin.

Since China's water exporting, transfer and importing regions of these projects are almost in the densely populated industrial and agricultural areas, great attention must be paid to the environment impact assessments. The construction of inter-basin water transfer projects might affect the physical, economic and social environment. The main environment problems are:

i. Impact on the environment of the water exporting region. Diversion from exporting region must affect the balance of water supply and demand, therefore may bring impact on socioeconomic development for exporting region, on the lower river navigation channel, seawater intrusion in the river estuary, silting of lower river and coastal ecology. In the feasibility study of the East Route of South-to-North water transfer project plans, the seawater intrusion has been extremely concerned, because of the guarantee of fresh water supply to Shanghai is most important. Owing to the high sediment loads carried by the Yellow river, the sedimentation associated environment problems in inter-basin water transfers become a special serious problems in China, such as the siltation of estuaries and river channels.

ii. Impact on the environment of the transfer region sediment loads of China's river are high. During the water transferring the treatment of sediment and silting of canal is important. After passing through the desilting basin the transferred water enter main canal with definite

sediment thus silt-up of canal. Besides, the possibility of the spreading of local deseases, for example malaria and schistosomiasis, must be studied.

iii. Impact on Environment of water importing region. The benefits to the importing regions are clear. In general, the environment of importing regions will improve markedly after water is imported into water deficient cities and industrial or mining centres. But some problems, just like salinity of the soil will take place.

The transfer water quality is of vital important. Great attention must be pay to the quality of the transfer water, which may be polluted by:

1. polluted water sources at intakes.
2. industrial and domestic waste and solid from the point pollution sources along the routes.
3. non-point pollution sources.
4. eutrophication of associated reservoirs and lakes.
5. polluted flow from the intersected rivers and lakes, etc.

In the East-route of South-to-North water transfer project planning, the waste water discharge from 29 cities, situated along main canal, amounts to 1.2 million ton per day. Most of 17 intercepted rivers have been polluted. Thus, the treatment of waste water is unavoidable, though it is very expensive. Therefore the protection of water quality must seriously considered in the planning of a transfer project.

The environment problems of interbasin water transfer is very complicated, a lot of problems are pending to be solved. The exchange of experiences in various region and different countries is necessary.

II. Republic of Indonesia

Dr. Badruddin Machbub, Director,
Research Institute for Water Resources Development

RESEARCH AND DEVELOPMENT OF PUBLIC WORKS IN INDONESIA

List of Contents

I. THE OUTLINE OF INDONESIA
   1. Description of The Land
   2. Climate
   3. Demographics
   4. Economy and Society

II. THE PUBLIC WORKS SYSTEM IN INDONESIA
   1. Master Plan of National Land Development
      1.1.Agricultural development
      1.2.Development of urban and industrial areas
   2. Budget for Investment in Construction
   3. Organization Concerned with Public Works
      3.1.Organization scheme of the Ministry of Public Works
      3.2.Secretariat General
      3.3.Inspectorate General
      3.4.Directorate General of Water Resources Development
      3.5.Directorate General of Highway and Bridges
      3.6.Directorate General of Human Settlement
      3.7.Agency for Public Works Research and Development
   4. History, Progress, and Problems of Major Infrastructure
      4.1.Water resources development
      4.2.Roads and transportation
      4.3.Water supply network
   5. Major Project in Progress or Under Planning
      5.1.Water Resources
      5.2.Roads
      5.3.Housing and Human Settlement

III. RESEARCH AND DEVELOPMENT OF PUBLIC WORKS

1. Name of the Organization
2. History
3. Organization Chart
4. Number of Staff Members
5. Budget
6. Management System
7. Major Research Facilities
   7.1. Research facilities of the Ministry of Public Works
   7.2. Research Institute for Water Resources Development
   7.3. Research Institute for Roads
   7.4. Research Institute for Human Settlement
8. Recent Achievements

IV. MAJOR RESEARCH AND DEVELOPMENT PROJECTS IN AGENCY OF RESEARCH AND DEVELOPMENT OF THE MINISTRY OF PUBLIC WORKS
1. Name of the major Research and Development Projects
   1.1. Science, Technology and Research Sector
   1.2. Human Settlement Sector
   1.3. Natural Resources and the Environment
2. Research and Development in Progress in ARD-MPW
   2.1. Small Reservoir as Water Storage in Dry Land
   2.2. Underground Water Reservoir
   2.3. Microhydro Electric Plant in Irrigation Channels
   2.4. Prototype Water Pollution Control Project
3. Problems in Promoting Research and Development

V. INTERNATIONAL RESEARCH EXCHANGE PROGRAMME IN ARD MPW
1. Present situation
2. Problems in Promotion
3. Necessity for and Problems Involved in Inter-Asian

Research Exchange

VI. AVTIVITIES RELATED TO DISASTER AND DISASTER PREVENTION

1. Present Situation and Problems in Indonesia
   1.1. Flood Problems
   1.2. Volcanic Eruptions
   1.3. Beach Erosion
2. Activities in Agency Research and Development of the Ministry of Public Works
3. Technical Tasks Required for Disaster Prevention
   3.1. Flood Control
   3.2. Volcanic Debris Control with Sabo Dam
   3.3. Coastal Protection

VII. ACTIVITIES CONCERNING HARMONY BETWEEN THE ENVIRONMENT AND IMPROVEMENT OF INFRA STRUCTURE

1. The Current Situation and Possible Problems
2. Activities in ARD-MPW
   2.1. Environment impact Assessment (EIA)
   2.2. Water resources and environmental management
3. Technical Tasks Necessary for The Promotion of Harmony Between The Environment and Improvement of Infra Structure
   3.1. Water resources conservation
   3.2. River and Coastal Protection
   3.3. Flood prevention to protect residential and agricultural areas
   3.4. Lava flood prevention to protect residential area, rivers, roads and bridges
   3.5. Water pollution control

VIII. PROPOSAL FOR FURTHER DISCUSSION

1. Name of topic
2. Background
3. Current Activities and Technical Tasks for Problems Solving
   3.1. Water Quality Management Studies
   3.2. Water Pollution Control Studies

I. THE OUTLINE OF INDONESIA

1. Description of The Land

Indonesia spreaded between 95-141 Meridian for along 5,110 km and 6 to 11 North Latitude for 1,888 km has a total area of 5,193,252 square kilometers comprising 1,904,569 sq.km of land and 3,288,683 sq.km sea. This archipelago with 13,579 islands such as Kalimantan (539.460 sq.km), Sumatera (473,600 sq.km), Irian Jaya (422,981 sq.km), Sulawesi (189,216 sq.km), Java and Madura (132,187 sq.km). The 80,000 km coastline of Indonesia is second longest of the world next to Canada.

The forest land covers an area of about 1,193,810 sq.km (63% of the total land area) spreaded unevenly over the area and being the third largest next to Brazil and Zaire. Large forest land is found in Kalimantan namely 436,700 sq.km (36.58 % of the total forest area), and in Irian Jaya 335,000 sq.km (28.06%). Rice fields in Indonesia cover an area of 9,630,000 ha of which 1,600,000 ha are irigated and the remaining area rain catch area, tidal land, polderland and rice fields in swamp area. About 2,000,000 ha of land is cultivated for productive or non-productive hard crop.

2. Climate

The climate and weather of Indonesia are characterized by two tropical seasons which vary with the equatorial air circulation and the meridian air circulation. The displacement of the latter follows the north-south movement of the sun and its relative position from the earth, in particular from the continents of Asia and Australia, at certain periods of the year.

These factors contribute to the displacement and intensity of the Inter-Tropical Confergense Zone which is an equatorial trough of low pressure that produces rain. Thus, the west and east monsoons or the rainy and dry season are a prevalent feature of the

tropical climate. The dry seasons (June to September) is influenced by the Australian continental air masses, while the rainy seasons (December to March) is the result of Asian and Pasific ocean air masses. The air contains vapour which precipitates and produces rain in the country. Tropical areas have rains almost the whole year through. However, the climate of Central Maluku is an exception. The rainy season is from June to September and the dry seasons is from December to March. The transitional periods between the two seasons are April to May and October to November. Annual rainfall is in the range of 1,500 mm-4,800 mm. In the lowland plain of Java, where the bulk of rice is grown, total annual rainfall varies from about 1,500 mm up to 2,500 mm.

Due to the large number of islands and mauntains in the country, average temperatures may be classified as follows : coastal plains : 27 centigrade inland ang mountains areas: 25 centigrade, and higher mountain area : 22 centrigrade , varying with the altitude. Indonesia being in a tropical zone, average relative humidity varies between 75% and 85% with a minimum of 50% and a maximum of 100%.

3. Demographics

The population of Indonesia in 1990 has reached 179,2 million people of which 110,3 million are living on Java and Bali showing a population density of 800 people/sq.km and being one of the most populated areas of the world.

Indonesia has actually shown impressive decrease of population growth during the last decades from 3.6% in 1970, 2.3% in mid 1980, and 2.08% in mid 1990. According to 1990 population census, around 69.1% of Indonesia's population live in the rural area. About 51,9 million people are living in the big cities showing a population growth of 4.16%/year or 2.5 times the national population growth. Also is assumed that population growth in cities will increase from 29-30% to 40.5-52.2% in coming 20 years. It is presumed that in the year 2020 the national

population growth will reach 278,7 million with 146,9 million living on Java only.

4. Economy and Society

Indonesia giving much attention to the agricultural sector produces rice, cassava, peanut, soy bean, tobacco, coffee, pepper, kapok coconut, palm oil, tea, sugar and many others. It has also an abundant source of mining material such as petroleum, natural gas, nickel, coal, banxite, manganese and copper. However during last decades, Indonesia has also given much interest to the development of textile, cement, fertilizer, petrochemicals, small and agro industries.

The employment survey of 1985 showed that about about 55.3% of the labour force were engaged in activities of the primary sectors. Moreover most of Indonesia's rural population earned their living from activities in agriculture, in particular outside the modern sub-sector of estate crops and forestry.

By 1989 the role of primary sectors to the gross domestic products (GDP) is 36.2 %, agriculture 20.6 % and mining 15.6%. At the start of the first Five Year Development Plan (FYDP 1), the Indonesia Gross National Income per capita had only been US $ 50 but increased to US $ 600 at the end of FYDP 5 , and by the year 2000 is aimed to reach US $ 1000.

Exports in 1990/1991 was $ 28.1 billion, consists of oil and gas exports $ 12.6 billion and non-oil exports $ 15.5 billion. Non oil export is showing an increase so that by 1990/1991 the role of oil and gas was reduced to a level of 44.8% of total exports; and that of agricultural commodities to 13.8%. At this time 36.8% of Indonesia's exports already consisted of manufactured exports, although exports of the resource-based plywood and textile and garments predominated.

Table 1. Forest Area in Indonesia

Island	Land area sq km	Forest area sq.km	Percentage from land total area	forest area
Sumatera	473,600	242,200	57	20.28
Jawa	132,187	29,060	22	2.43
Bali / Nusa Tenggara	61,875	14,850	24	1.24
Kalimantan	539,460	436,700	68	36.58
Sulawesi	189,216	63,000	32	5.28
Maluku	84,507	60,000	71	5.03
Irian Jaya	422,981	335,000	78	28.06
INDONESIA	1,904,569	1,193,810	63	100.00

Table 2. Production of Minerals,1988

Petroleum	484.7 m bb/s
Tin	30.6 tons
Copper	294.7 tons
Nickel	1,733.2 tons
Bauxite	505.8 tons
Coal	2,854.5 tons
Iron Sand	202.8 tons
Gold	4,730.9 kg
Silver	61,538.0 kg
Natural gas	1,852.6 mcf

Source: Central Bureu of Statistics, Government of Indonesia

Table 3. Principal Agriculture Products. 1988
(in thousands of tons)

Food crops :		**Cash crops :**	
Rice	41,769	Rubber	1,170
Corn	6,806	Palm Oil	1,690
Cassava	15,280	Copra	2,105
Sweet potato	2,066	Coffee	398
Soya beans	1,254	Tea	156
Groundnuts	565	Cloves	60
		Pepper	52
Fisheries :		Tobacco	119
Saltwater fish	2,166	Sugar	2,202
Freshwater fish	715	Cotton	78
Meat and dairy :		**Forestry :**	
Meat	928	Teakwood	725
Eggs	446	Other timber	22,860
Milk	262		

Source: Central Bureu of Statistics, Government of Indonesia

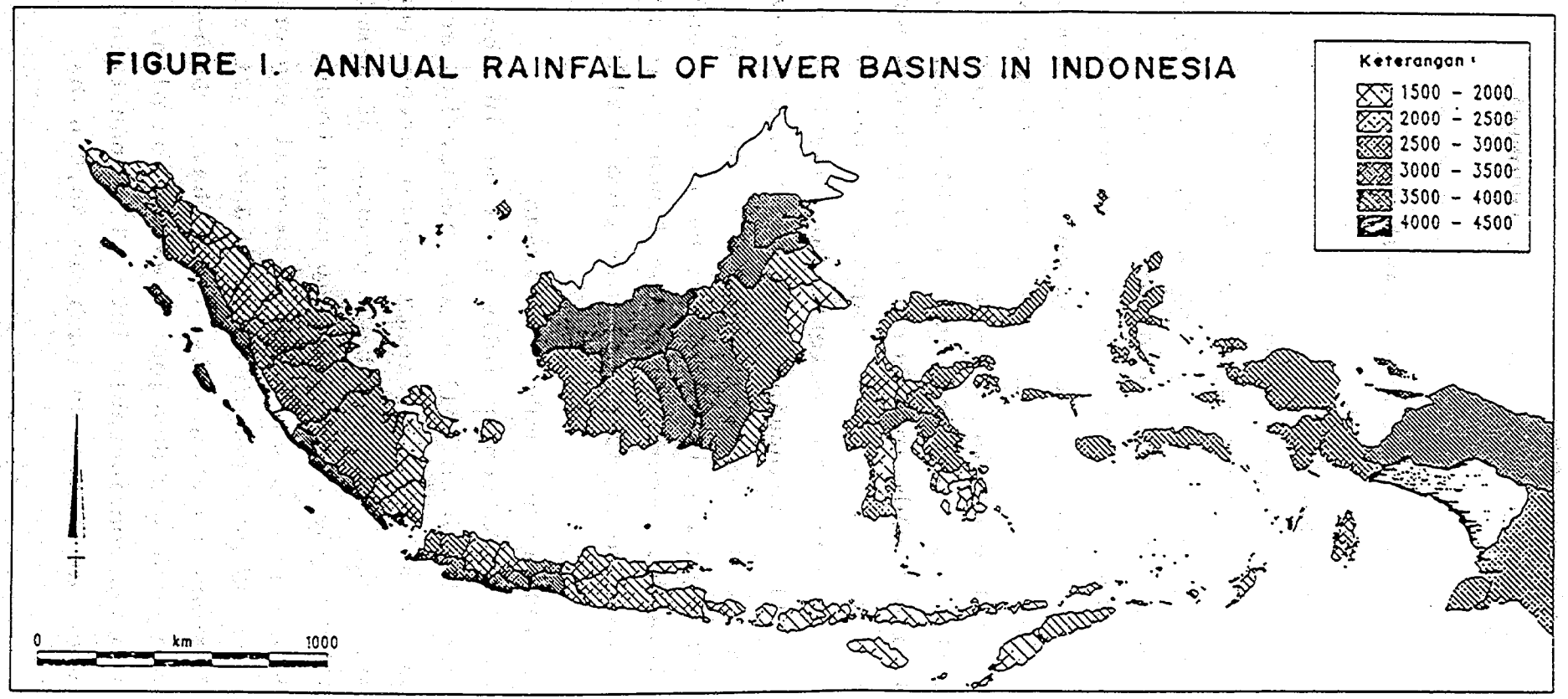


FIGURE I. ANNUAL RAINFALL OF RIVER BASINS IN INDONESIA
Keterangan :
1500 - 2000
2000 - 2500
2500 - 3000
3000 - 3500
3500 - 4000
4000 - 4500
0
km
1000

II. THE PUBLIC WORKS SYSTEM IN INDONESIA

1. Master Plan of National Land Development

1.1. Agricultural development

The Java island which covers about only 7% of the total land area of Indonesia produces more than 60% of the food crop commodities (rice, sugar, corn, soy bean, cassava) and this segment has been relatively constant for the last twenty years. At the same time, considerable agricultural land has been converted into non-agricultural one, namely about 15,000 ha anually. We are all aware that this figure will not decrease, it will even increase with the rapid growth of industry and other sectors in Java. Beside that, conversion of irrigated rice fields into horticultural crops which have higher market value is also in progress. In spite of this limited land resources, the efforts to develop new rice fields will still be maintained. In FYDP 5, the development target for new rice fields is 375,000 ha. At present, 169,719 ha have been realized, 30,464 ha in Java, and 135,255 ha in other islands. Whereas for the fiscal year 1993/1994, it is planned to develop 50,000 ha new rice fields.

1.2. Development of urban and industrial areas

The urban area, has been rapidly growing in the last 25 years, both the cities as well as the industrial areas. At present, there are 612 fungsional urban areas (each with population more than 10,000) which consist of 6 metropolis, 12 cities, 84 mid-size towns, and 510 small towns.

Industrial zones are spread out in several regions in the vicinity of the towns, especially in Java. At first, the industrial regions covered only 1,775 ha. However, since 1989, the Government has develop an extension plan. In three years it has grown considerably into 134 industrial estates which consume an area as much as 38,000 ha. From the

growth of the existing industrial estates, it can be seen that the main interest of the business world in developing industrial estates follows the market trend, and the chosen areas are those with relatively complete facilities (such as highways). It is proved, both from the number of industrial estates as well as from the area reserved for this purpose, that Java draws the highest interest for industrial development.

Especially in order to take advantage of the global market momentum, the Government of Indonesia in agreement with the Governments of Singapore and Malaysia pioneer an economic cooperation to develop a concept which is known as "Growth Triangle", namely the plan to develop the regions of Riau, Singapore, and Johor into production, business/trade, and tourism centres in Southeast Asia. To anticipate the growth, nine industrial estates are being developed currently in Batam covering an area of 2,760 ha, and also in Bintan (4,000 ha).

2. Budget for Investment in Construction

The budget of the Ministry of Public Works for the fiscal year 1992/1993 is Rp. 2,308 billion, comprising of Rp. 648 billion (28.07 %) for water resources development, Rp. 1,351 billion (58.53 %) for road/highway construction, and Rp. 271 billion (11.74 %) for public settlement and housing.

3. Organization Concerned with Public Works

3.1. Organization scheme of the Ministry of Public Works

As shown on the following scheme, the Ministry of Public Works consists of the Secretariat General, Inspectorate General, Directorate General of Water Resources Development, Directorate General of Highway and Bridges (Bina Marga), Directorate General of Housing and Human Settlement (Cipta Karya), and Agency for Public Works Research and Development.

3.2.Secretariat General

The main responsibility of the Secretariat General is to establish the administration, organization, and standard practices for all element of the Ministry of Public Works, and provide administrative and technical services to the Minister, Inspectorate General, Directorate General, and other Public Works units.

3.3.Inspectorate General

The main responsibility of the Inspectorate General is to supervise the implementation of the work in all elements of the Ministry, both routine and development, to ensure their compliance with the plan and prevailing regulations.

3.4.Directorate General of Water Resources Development

The Directorate General of Water Resources Development has the main responsibility of developing water resources, such as :

a. formulation of technical policy and issue permits and regulations,
b. enforcement of rules, maintenance and development of water resources,
c. technical supervision on the implementation of the main responsibility of the Directorate General.

3.5.Directorate General of Highway and Bridges

This Directorate Generalo is mainly responsible for maintenance of roads/highways and bridges, as follows :

a. formulate technical policies, establish and issue permits and regulation,
b. implementation of rules, maintenance and development of road which include development of long- and mid-term general plans and programmes, provision and maintenance of public road network and the appurtenant structures,
c. technical supervision of the implementation of the main

responsibility of the Directorate Generale.

3.6. Directorate General of Human Settlement

This Directorate General is mainly responsible for maintenance of housing and human settlement, as follows:

a. formulate technical policies, establish and issue permits at the human settlement,
b. implementation of rules, maintenance and development of human settlement which include development of long and mid-term general plans and programmes, provision and maintenance of public building network and the appurtenant structures,
c. technical supervision of the implementation of the main responsibility of the Directorate General.

3.7. Agency for Public Works Research and Development

This Agency is the executing agency for the Public Works research and development. In carrying out its tasks, the Agency has the following functions :

a. formulate plans, process and coordinate the formulation of research and development policies within the Ministry,
b. guide and coordinate the development of research and development programmes and their implementation,
c. conduct public works research and development in order to support the Ministry in carrying out its main tasks,
d. investigate the implementation of research and development.
e. tests of equipment, material, and implements.
f. disseminate and publish the results of public works research and development
g. prepare technical standard and guidelines in the field of public works.

4. History, Progress, and Problems of Major Infrastructure

4.1. Water resources development

Development of new irrigation network for rice fields in

order to increase food production is a highly important work and it has been successfully completed so that Indonesia becomes self supporting. While at the end of FYDP 1, there were only 191,000 ha irrigated rice fields, at the end of FYDP 5 , it has become 1,693,000 ha. The total existing irrigation area is 3,877,470 ha

4.2.Roads and transportation

Land transportation in Indonesia is highly depends on roads which connect cities in the provincies in each island. The current length of roads is 170,703 km, out of which 10,000 km was constructed in the beginning of FYDP 1. The total road construction (accumulation) become 52,400 km at the end of FYDP 5.

Railway is also an important communication facility, especially in Java. Transport through rivers and canals are vital in areas outside Java, especially in Kalimantan and Sumatera. Since Indonesia is an archipelago, marine transportation also plays highly important role. Railway transportation, marine transportation and air transportation facilities are under the competency of the Ministry of Transportation.

4.3.Water supply network

Water for domestic and industrial purposes are supplied independently and also by the Government. At the beginning of FYDP 1 the capacity of water supply is 15,366 l/s and at the end of FYDP 2 it has increased to 57,269 l/s. However, most of the network is available in urban areas.

5. Major Project in Progress or Under Planning

5.1.Water Resources

During the fivth Five Year Development Plan (FYDP 5), the Directorate General for Watar Resources Development had among others implemented development programs for new irrigation

networks, swamp area for new agriculture land, river and coastal zone protection, and flood control.

The construction of new irrigation networks aims to irrigate 500,000 ha of rice fields, whereas consolidation projects and maintenance of existing irrigation networks irrigate about 1,924,103 ha.

Development of lowland comprises the improvement of the swamp area for lowland ricefields (444,200 ha), tambak for fishery (60,000 ha) and new tambaks (10,000 ha).

Flood control has the objective to save 450,000 ha area threaten by floods and coast-line protection intends to prevent 20 km of coastal zone from wave erosion.

5.2.Roads

In the Five Year Development Plan, Directorate Generale of Roads is assigned with the construction of new roads and bridge (1,782 km), rehabilitation and road and bridge maintenance (164,194 km), betterment of road condition (40.651 km) and reconstruction of roads and bridges (1,782).

5.3.Housing and Human Settlement

Main objective of the Directorate General of Human Settlemetn or Cipta Karya is to build simple houses (450,000 units) and apartments (20,000 units). Restoration (300,000 units) and improvement of village environment (20,000). Restoration also includes the improvement of kampongs (47.217 ha) and market places (6.182 ha).

Provision of clean water during the Five Year Development Plan intends to incase capacity with 14,000 ltr/sec. Whereas the sanitation program is aiming at the improvement of waste water treatment (294 cities and 5,000 villages) and garbage disposal (450 cities).

Arrangement if lay-out in the Five Year Development Plan consists of 1 National Region, 7 Regions, 26 Provincies, 200 kabupatens, 567 cities, 176 strategic zones and 746 villages.

III. RESEARCH AND DEVELOPMENT OF PUBLIC WORKS

1. Name of the Organization

The Indonesian name for this organization is Badan Penelitian dan Pengembangan Pekerjaan Umum, Departemen Pekerjaan Umum whereas in English it can probably be translated into the Agency for Research and Development, Ministry of Public Works (ARD-MPW).

2. History

Research activities and development of public works has been carried out since a long time, namely before the II World War. At that time it still had the name Dienst van Verkeer en Waterstaat and being located in Bandung, West Java. Consisting only of several laboratories, that is a hydraulic, construction material and road soil laboratory, this organization was mainly concerned with investigations to support the solutions of problems occuring in the field. With the time, these laboratories developed their respective function and became a research institute with parent organization the former Ministry of Public Works and Energy.
In 1957, this agency was appointed by UNESCO as the Regional Housing Centre for Southeast Asia. When the Directorate General was established in 1958, each institute was operationally placed under the authority of this organization. To coordinate its programs, in 1970 the Minister of Public Works and Energy set-up a research board having as members the Directors of each lesearch Institute being ex-office organized by the Head of the Bureau for Science and Technology of the Secretariat General of the Ministry of Public Works and Energy.
In general these institutes are providing technical support for projects within the Directorate General and are assumed to find solution for construction as well as design problems encountered during field survey and conducted little research work except the Research Institute for Housing which was doing study on housing material to improve the quality of local construction material.

In 1975, these institutes rechange their function into Directorates under each Directorate General, whereas respective Ministry established new organizations known later on as the Institute for Research and Development of the Ministry of Public Works being assigned with the coordination and implementation of research activities particularly in management.
The re-organization in 1984 stated that each Directorate has to be managed by the Agency for Research and Development, Ministry of Public Works and change the name of organization into respectively the Research Institute for Water Resources Development (RIWRD), Research Institute for Human Settlements (RIHS) and Research Institute for Roads (RIR) countenction and should still be located in Bandung, whereas the Secretariat of the Agency for Research and Development in Jakarta.

3. Organization Chart

In line with the Ministerial Decree of Public Works on the organization and flow chart of the Ministy of Public Works, in 1984 structure of the Agency for Research and Development and task of implementation was changed into the following chart.

4. Number of Staff Members

On March 31, 1990 the Agency for Research and Development had recorded 1770 personnel comprising 1398 Civil Servants and 472 daily paid labour. The number of staff personnel are 372 persons who undertake research work in the research institute and support administrative work in the Secretatriat.

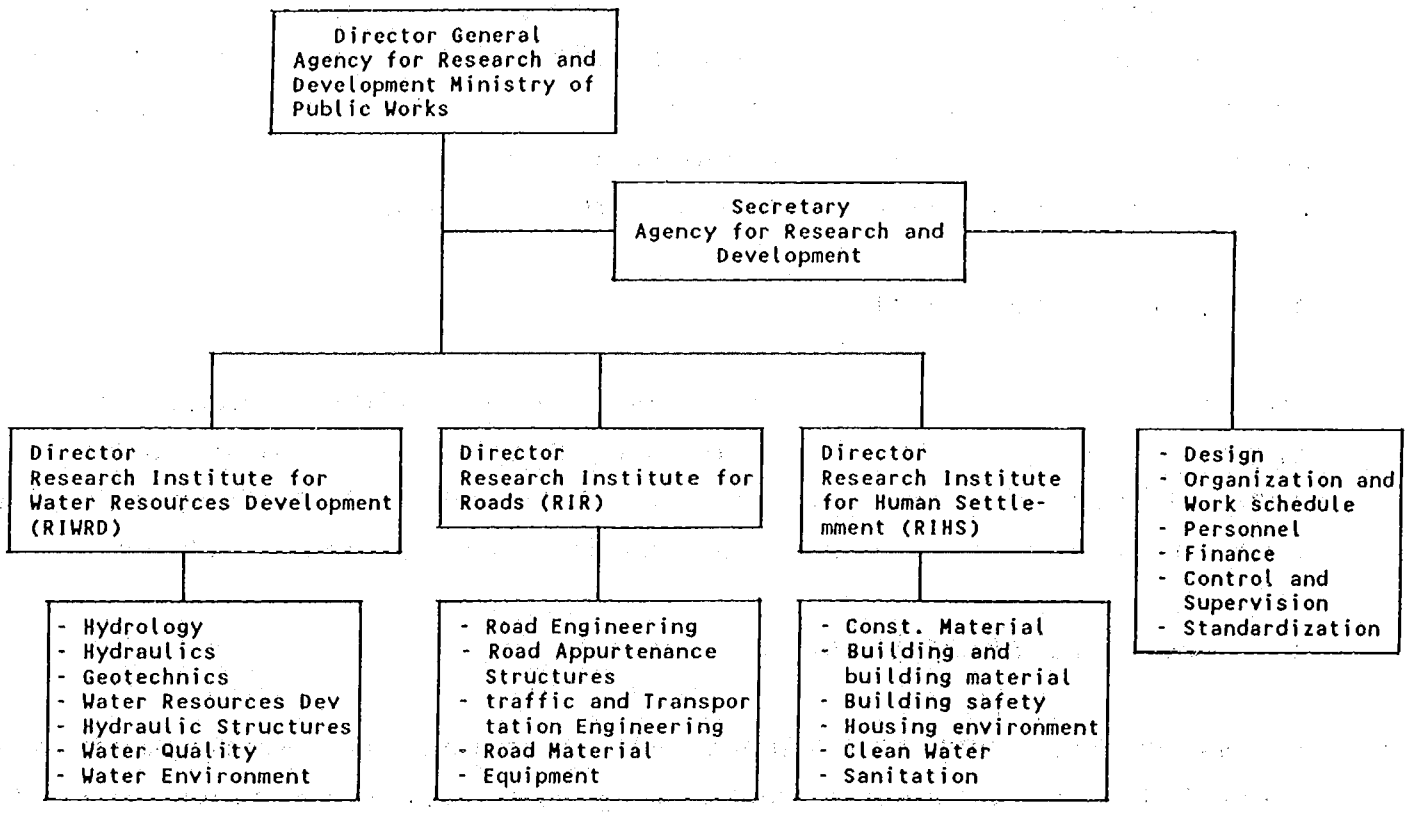
5. Budget

The budget of ARD-MPW for F.Y 1992/1993 amounted 16,29 trilyun rupiahs or 0.71% of the total budget allocated to MPW which is about 2,308 trilyun rupiahs. Whereas each institute has been allocated respectively RIWRD 8.3 trilyun rupiah, or 1,28% of the

total construction budget for water resources development, RIRC 3,5 trilyun rupiah or 0.26% of the road construction budget, and RIHS 1,79 trilyun rupiah or 0.66% of the total construction budget for housing and settlement.

Figure 2.

Organization Structure of
The Agency for Research and Development
and Task of Implementation



6. Management System

The Agency for Research and Development, Ministry of Public Works as the centre of research has to carry out research and become the scientific backbone as well as managerial support for other Directorates, the Inspectorate General and Secretariat General. The results of the implementation of these tasks should provide technical as well as managerial input for improvement of system, support and development of public works for long and short term

according to the policy set by the Minister.
In order to realize above objective, the Agency for Research and Development should carry out research, and become the scientific backbone in water resources development, road construction, sanitation, housing and building construction in general sense. To gain this aim, all three institutes should work together and support the management implemented by the Secretariat of the Agency for Research and Development.

Main products expected from the Agency for Research and Development are :

a. Research and Development products :
   - Standards on Method of Implementation, Specification and Method of Testing
   - Study of new techniques

b. Scientific supports products :
   - Technical Advice for projects
   - Technical Certificates
   - Calibration
   - Technical Arbitration

c. Dissemination products :
   - Seminars
   - Trainings
   - Information (included a list of all research and scientific backbone results.

7. Major Research Facilities

7.1.Research facilities of the Ministry of Public Works

Research and development conducted by the Agency for Research and Development, Ministry of Public Works has to provide technical input for the improvement of quality of study and development of public works. Mastering of techniques can only

be made possible because of the provision of complete research facilites. To support this condition, the Agency for Research and Development has set-up laboratories in the Experimental Stations of each research institute.
Besides being used as a research facility, laboratories at the research institutes are also used for public service in quality testing particularly the laboratories within the Regional Offices of Public Works of the 27 Provincies.

7.2. Research Institute for Water Resources Development

a. Experimental Station for Hydrology is assigned with the implementation of survey and testing, preparation of technical advice and the development of hydrological methods.
b. Experimental Station for Hydraulics should conduct survey and testing, prepare technical advice and developing hydraulic techniques.
c. Experimental Station for Geo-techniques is assigned with the implementation of survey and testing, preparation of technical advice and development of water resources development.
d. Experimental Station for Sediment Control Structures in Yogyakarta has to implement survey and testing, prepare, technical advice and develop sediment control structure methods.
e. Experimental Station for River Engineering in Solo has to conduct survey and testing, prepare technical advice and develop river control techniques.
f. Experimental Station for Hydraulic Structures in Bekasi is assigned with the conduct of survey and testing, prepare technical advice and develop hydraulic structure techniques.

7.3.Research Institute for Roads

a. Experimental Station for Road Construction has to implement survey and testing, prepare technical advice

and develop road construction methods.

b. Experimental Station for Soil Material for Road Construction also has to implement survey and testing, prepare technical advice and develop soil techniques for road construction.

7.4. Research Institute for Human Settlement

a. Experimental Station for Buildings and Housing is assigned with the implementation of survey, and testing, prepare technical advice and develop new methods of building and housing construction.

b. Experimental Station for Sanitation has to implement survey and testing, prepare technical advice and develop new sanitation methods.

8. Recent Achievements

Various research results have been applied for the development of public works and been beneficial for the public, and a few to mention are :

a. Labyrinth dams which should be constructed at river mouthss to facilitate impeding of the flood discharge.
b. Bottom controller constructed in rivers to prevent damage of river structures due to degradation of river bed.
c. Undersluice structure to prevent sediment transport into the channels.
d. Waste water treatment system to decrease water pollution caused by industries.
e. Drinking water treatment system with simple process.
f. Purification system for coloured waste caused by peat with clay filter.
g. Construction material for low price housing.
h. Application of natural asphalt for road construction.
i. Re-cycling of road construction material by dredging and re-processing road material.

Table 4. Number of Staff Members

No.	Working Unit	Staff	Total
1.	Secretariat	30	89
2.	Research Institute for Humman Settlement	68	280
3.	Research Institute for Water Resources Development	196	597
4.	Research Institute for Roads	78	432
	Total	372	1398

Table 5. Annual Budget of The Ministry of Public Works 1992/1993

	thousands Rp
MPW	**2.308.441.660**
Water resources	648.492.868
Roads	1.350.984.882
Housing	271.598.689
ARD-MPW	**16.294.462**
Water research	8.305.663
Road research	3.505.724
Housing research	1.790.228

IV. MAJOR RESEARCH AND DEVELOPMENT PROJECTS IN AGENCY OF RESEARCH AND DEVELOPMENT OF THE MINISTRY OF PUBLIC WORKS

1. Name of the major Research and Development Projects

1.1. Science, Technology and Research Sector

1.1.1. Development of Science and Technology

Development of Science and Technology Programs

1) Study of the application of public works management and technology
2) Study and application of water resources science and technology
3) Research and development of the betterment of the road maintenance system
4) Research of building safety in densely populated cities and hazardous areas
5) Application of Standards and Technology of public works
6) Compilation of Standards and water resources science and technology
7) Compilation and dessemination of Road standards and technology for the betterment of road quality
8) Study and dissemination of research and development results to increase housing quality.

1.1.2. Research

1) Research of agriculture and water resources:
   a. Research and development of water resources in public works
   b. Research of sediment control
   c. Research of hydraulic structure construction
   d. Research of Rivers
   e. Research and Development of Hydrology
2) Research of Transportation and Tourism:

a. Research and Development of Road Betterment
b. Research and Development of the use of local material for road construction
c. Research of road maintenance quality
d. Research and Development of traffic load handling
e. Research of soil problems

3) Research of Human Settlement:
a. Research of human settlement to improve housing quality in densely populated areas
b. Research of housing and buildings for low income people

1.2. Human Settlement Sector

1.2.1. Human Settlement

1) Housing for low income people:
Research of the development of local construction material
2) Clean water supply:
Research of clean water supply for low income people
3) Sanitation of housing environment :
Research of clean water and treatment of waste to improve the domestic waste quality.

1.3 Natural Resources and the Environment

1.3.1. Natural Resources and the Environment

Management of Natural Resources and the Environment :
1) Environmental impact assesstment of public works projects
2) Research on the environmental aspects of water resources
3) Research and development of water pollution control
4) Research of water quality at the East Java Clean Water Project
5) Research of water quality at the West Java Clean Water

Project

6) Research and development of the River Environment
7) Research of the housing and the environment.

2. Research and Development in Progress in ARD-MPW

2.1. Small Reservoir as Water Storage in Dry Land

2.1.1. Background and admnistration need

In Indonesia, dry areas especially strecth out from the Lesser Sunda Islands to the Aru Islands, covering the provinces of Bali, Nusa Tenggara Barat, Nusa Tenggara Timur, Timor Timur, and south eastern part of Maluku. This region comprises groups ef small-medium size islands extending from wet to east in the south-eastern part of the Indonesian archipelago.

The rainy seasons last only 3 - 4 monthos (December to March) so that the dry seasons extends 8 - 9 months, longer than in any other part of Indonesia. Heavy rainfall that makes the largest portion of the rainfall depth occurs losses. Therefore, this region needs water-retaining structures in order to maintain the supply of water in dry seasons.

According to the topographical and geological conditions of the region, small water retaining structures (embungs) are the most suitable ones. Hills dominate the topography of each island, while the plains are very norrow.

The regional geology is characterized by low capabiity for retaining groundwater. Embungs, which require simple technology, low cost, short construction times, and also quick yielding, are suitable and potential to be developed extensively in this entire region. Beside storing water, embung gives other benefit of land and water conservation.

The Research Institute for Water Resources Development

(RIWRD) is currently preparing the design standar, construktion prosedures, and O & M of embung specifically for the south of Timor island, eastern part of Sumba Island, and east of Flores island in Response to the request of Dinas Pengairan Dati I Nusa Tenggara Timur. With the financial support of CIDA (Canadian International Decelopment Agency) and cooperation with the Provincial Government of East Nusatenggara. The Project is in line with the Technical Assistance of Canadian Governmant(CIDA).

2.1.2.Time Period

The Project is scheduled for 18 months, starting from May 1992 to Oktober 1993. While the preparation of standar for other dry areas (if required), from Bali to the Aru islands, will take an approximate period of three years.

2.1.3.Methodology

As the standar will be improved for the local technical staff, it has to be presented in the simplest way, without including too many analyses and evaluation. Therefore, it is necessary to find some standar parameters through various tests, in the field as well as in the laboratory, especially hydrology and local materials so that it will be economical and quick to construct. Depending in the geological characteristics of the sites, there are many types of embungs to be selected, such as homogeneous embankment, zoned embankment, mansory gravity, and composite.

2.1.4.Possible results

Embung is expected to supply water to the community, livestock, and farm in a village during dry seasons which last for about 9 months annually. A village, such as one in NTT province, is occupied by 350 families which own as many as 2,000 goats and cows, and yards covering a total area of 3 hectares. Based on these data and restricted

technology to be applied, then the maximum dimension of an embung for a village will be limited to the height of 10 m, storage capacity of 76,000 m3, and the maximum catchment is 100 ha. There are also spesific requirements for selection the sites of embungs, namely :

a. it has to be closed to a village/settlement
b. it has no other source of water for dry season
c. it has to be the possible closest location to the road

The outputs of the project are design criteria, technical index of selected embung sites, and training for local technical staff.

2.1.5. Problems of Implementation

In the implementation of the research for the preparation of the standard and in the future development, verious constraints will be ancountered, such as :

a. difficulty in obtaining basic and spesific data,
b. remote R & D locations, scarce and expensive transport facilities,
c. lack of qualified local staff which give rise to the need for training, espescially on contruction procedures,
d. unfamiliarity of the water users the applied technology; guidance on the use of the facilities will be appropriate.

2.2. Underground Water Reservoir

2.2.1. Background and Administrative Needs

Some areas in Indonesia have difficulties to obtain surface water resources, in addition ground water resources are found in lower parts so that the local people have difficulty in obtaining water for house hold purposes. One of the methods to obtain water is by building underground water reservoirs which are able to reserve water in the ground and raise its water surface. This kind of prototype

technology is being studied in east Bali by installing subsurface dam using the cement grouting technology. The location of the study is situated at Desa Bunutan, Kecamatan Abang, Kabupaten Karang Asem, Bali.

2.2.2.Time Period

The study commenced in 1991 lasted for 5 years and covered survey, investigation and construction as well as operation.

2.2.3.Methodology

Underground water reservoir development study covers the following :

a. groundwater characteristic study
b. detailed technical geological mapping
c. technical geological studies covering soil layer characteristics and its ability to absorb cement
d. study of ground water logging, core drilling and grouting
e. monitoring height of ground water layesr before and after installing the sub-surface dam.

2.2.4.Possible Results

The prototype underground water reservoir concerned will be utilized as ground water resources for the local people. In addition, these study results can be developed into groundwater supply for dry areas having difficulties with water.

2.2.5.Problems of Implementation

Since this is the first study in Indonesia, input of technology and experiences from other countries are badly required.

2.3. Microhydro Electric Plant in Irrigation Channels

2.3.1.Background and Administrative Needs

Electric power in Indonesia is mostley generated by hydropower i.e. hydro electric power plants constructed in reservoirs. Although electric power has been distributed to rural areas, its distribution has not reached remote areas. Rice fields irrigated by the irrigation network has high potency to generate electric power to rural areas. The irrigation channels have a water fall height of about 1,0 to 20 m and water dischange of 0,2 to 10 cubic meters/second. Studies and development on microhydro electric power are thus badly required to be applied in agricultural areas having water resources or channels with low water discharge and head.

2.3.2.Time Period

This study started in 1992 and will need 3 years covering laboratorial and field work.

2.3.3.Methodology

a. hydraulic model study and test in laboratory to analyze electric turbin system for low water head
b. development of microhydro electric protopype in the field and study of hydraulic characteristics as well as electric supply
c. micro hydro electric application for people in remote areas.

2.3.4.Possible Results

This study will produce a microhydro electric prototype to be introduced to people living as farmers in vast irrigation areas throughout Indonesia particularly areas having no electric network.

2.3.5.Problems of Implementation

Microhydro electric power which is recently generated or sold in Indonesia needs a waterhead (head air) more than 4

m, whereas the greater part of irrigation channels have waterheads less than 4 m so that studies of the existing technological modification are required.

2.4. Prototype Water Pollution Control Project

2.4.1. Background and administrative needs

In pursuit of sustainable development, the government of Indonesia accords high priority to water pollution control, focusing initially on control of indutrial wastewater discharges. RIWRD provided study on a Water Pollution Control . This study recommended that, for clusters of existing industries in Indonesia, centralised wastewater collection and tratment schemes (CWCTSs) would be more efficient and cost-effective than individual on-site treatment schemes.

The Study further recommended that the Goverment should initiate a Prototype CWCTS Project at the South Bandung in the Citarum River Basin in order to demonstrate to industries the advantage on the CWCTS approach and to gain experience in all aspects of the CWCTS approach, prior to initiating a number of major CWCTS projects.

2.4.2. Time period

The studies will last for 5 years, and were started in 1990. This study needs a long time considering that in previous study a very rapid industrial development had recured in South Bandung. If at the start, water waste treatment cluster covered 70 industries, in the middle of the study, capacity of each industry increased likelycausing wereas of capacity of waste water.

2.4.3. Methodology

Project methodology involves:

a. conducting surveys and studies within the South Bandung Cluster, including in-plant surveys, in order to

determine volume and characteristics of wastewater.

b. laboratory works on water quality analysis of wastewater and treatment processes.
c. design works on the treatment plant
d. construction of the treatment plant
e. trial operation of the treatment plant
f. institusional and economic or tariff structure studies for the management of the plant

2.4.4. Possible results

The main technical result anticipated from this Project is that the industrial effluent discharged from the entire cluster will be treated to the National Effluent Standards. These include BOD5 of 50 mg/I and COD of 100 mg/I. Present average discharges have been measured at the following values : BOD5 of 555 mg/I and COD of 1029 mg/I. This will contribute to a considerable improvement in the level of pollution in the Citarum River Basine.

The project will also ensure that the necessary is established in order that the system can be effectively operated and managed on a sound financial basis once it is completed. Furthermore, as a true "PROTOTYPE" the Project will provide a sound demontration of the CWCTS system.

2.4.5. Problems During Implementation

Initial problems during implementation have been :

a. Rapid rise in the project's overall dimensions:
This has been caused by an increase, during the last two years, in the number of factories in the cluster (70 to 85) in the numbers of omployees (21,799 to 37,000) and in the volume of wastewater produced (15,000 to 35,000 + cubic metres per day).
b. Uncertainties regarding design flows:
Discrepaincies were found between water consumption, "declared" waste water discharges and "measured" discharged. Problems also arose in forecasting future

growth over the next 10 years. These problems heve been overcome, in cooperation with the Industrial Society and the Individual Industries concerned, using "DISCHARGES QUOTAS", whereby each Industry was invited to state, for themselves, the amount of discharge they wished the Project to accpet up to the year 2003.

3. Problems in Promoting Research and Development

The role of research and development in national development is unquestionable. However, to sucessfully play its role, R&D needs to be supported by several factors, among others are :

a. human resources which are interested in research, in this case, it concerns with its quantity, quality, and distribution,
b. equipment and other research facilities,
c. sufficient funds

National development oriented research and development in general, and development of public works facilities and infrastructures especially, require sufficient number of qualified researchers. Additionally, development of public works needs the contribution of various disciplines other than civil engineering, since public works support the national programmes which involve many development sectors. At present, research personnel are still limited due to lack of interest in such activities. This problem is more crucial in regional offices especially in reaching full autonomy. The researchers have to upgrade their quality, they need education and training programmes, in Indonesia as well as abroad. The Government has implemented the programmes through bilateral as well as multilateral cooperation.

Research facilities have been considerably developed by the Ministry of Public Works, in the Ministry as well as in 27 provincial offices.

V. INTERNATIONAL RESEARCH EXCHANGE PROGRAMME IN ARD MPW

1. Present situation

International cooperation in R&D has been realized during PJPT1, among others are :

a. International agencies under the UN, namely UNDP, UNESCO, WMO, WHO, UNEP, and FAO.
b. International financial agencies, such as World Bank and Asian Development Bank
c. Foreign countries, namely Japan, Canada, USA, the Netherlands, France, Germany, and Finland.

2. Problems in Promotion

The results of research and development for public works development needs to be promoted and disseminated both to Government projects as well as to private sectors. The problem concerning promotion activities need to be solved is the lack of understanding on the importance of R&D, among others are concerning the following :

a. R&D activities can provide correction to the currently applied technology, and also give cheaper and more suitable alternatives.
b. R&D requires funds which, in short term, becomes a project liability, but in long term, will result in project efficiecy and effectiveness.

Therefore, the promotion activities have to be intensified through seminars, workshop and training programs for Government staff and technicians, and also for private parties who carry out Public Works construction work or projects.

3. Necessity for and Problems Involved in Inter-Asian Research Exchange

ARD-MPW Indonesia needs regional cooperation in carrying out

the R&D activities, such as :

a. low cost construction materials and housing technology
b. water supply and sanitation technology
c. road construction technology, especially recycling of road material
d. water-efficient irrigation technology
e. water conservation technology
f. water pollution control technology
g. micro hydro electric plant in low head irrigation channel
h. ground water conservation technology

Beside in R&D activities, cooperation also needed in preparation of various standards concerning design and construction of public works structures. Although these standards are mostly for national use, some of them are also regionally and internationally applicable.

VI. AVTIVITIES RELATED TO DISASTER AND DISASTER PREVENTION

1. Present Situation and Problems in Indonesia

1.1. Flood Problems

Flood may cause river water level increasing rapidly and water will spill over the river bank and furtherly it may break it and inundate low land areas surrounding the river. In general the most tremendous flood takes place in the very down stream area and it will be more serious should a high tide comes at the same time.

Flood disaster may also cause the loss of human life, properties and crop damages, communication interference, pests and some indirect disadvantages. Flooded rice field in 1990/1991 was 40,638 hectares, therefore about 4,335 hectares of the area gave no yield. Flooded arable land crop area which was not able to harvest was about 2,324 hectares.

1.2. Volcanic Eruptions

Indonesia has more than 128 active colcanoes which have located along three volcanic zones. The first volcanic zone runs along the entire length of Sumatra island, passes Krakatau, Jawa, Bali, Lombok islands until Banda Sea. The seconds zone begins from the northern part of Sulawesi islands, runs to Sangir island. The third zone runs through Halmahera, Ternate and Makian islnads. More than 1000 eruptions had been recorded since 1000 A.C, killed more than 175,000 people. The eurptions of Mt. Tambora (1815) and Mt. Krakatau (1883), were reported had killed 90,000 and 36,000 people. These eruptions produce volcanic ash, nuee ardante, lahar flow, etc, which could be disatrous, but also believed to bring vertility to the land in the surrounding area. Therefore, the agrarian people prefer to live in the volcanic highland rather that migrate elsewhere. They are living in harmony with the nature, the promissing fertile and disaster prone land. There are 2,399,000 (1974) people living in

16,620 km square volcanic hazard area.

The volcanic eruption may cause either primary or secondary disaster. Primary disaster occurs due to nuee ardante, pyroclastic fall or pyrocalstic flow. There erupted material partly deposited in the volcanic highland. Heavy rainfall will erode these deposition and cause debris flow, which is known as secondary disaster.

One of the active volcanous is Mt. Merapi and what so called Merapi Type eruption is the eruption which is followed with very hot cloud, reaching the temperature of 900 - 1,200 centigrade. From 1984 up to 1991 a creater of about 7,000,000 m3 was formed and it consists of unstable loose material and easily to slide.

Mt. Merapi surrounding area is very fertile, so a very densely populated villages (1,290 people/km2) and agricultural area existed. In addition, lava flow direction is to urban area such as Magelang and Muntilan.

1.3.Beach Erosion

Coastal areas are essentially natural resources with high potential for development, and require conservation, maintenance, and quality improvement. In Indonesia, coastal areas have been developed into tourist, business areas, cultivation areas, ports, etc.

There are some coastal areas which have been severely damaged, so that need coastal protection actions.

a. Kuala Raja - Aceh
b. Padang - Sumatera Barat
c. Anyer Carita - Jawa Barat
d. Marunda - DKI Jaya
e. Nusa Dua - Bali
f. Sanur - Bali
g. Panimbangan - Bali

The damages resultes in change of coastal morphology due to

erosion, abrasion, and intensive sedimentation. The cause are among others: quarrying of river and coastal materials, damaged coastal habitat, pollution of coastal waters which destroy coral reefs and coastal vegetation, construction of reservoir in the upstreams, weathering of rocks, unproper coastal protection structures and natural disasters.

2. Activities in Agency Research and Development of the Ministry of Public Works

Disaster Prevention Research Institute, Kyoto University of Japan (DPRI) commenced the joint research on Disaters Caused by Volcanic Debris Flows, Floods and Beach Erosion and Their Mitigation with the Research Institute of Water Resources Development, Agency for Research and Development, Ministry of Public Works, Indonesia (RIWRD) as a part of international research project on natural disaster and their mitigation that is related to the International Decade For Natural Diasater Reduction (IDNDR).

The objective of this joint research is to conduct studies as a cooperative work in IDNDR on the hazards caused by the volcanic debris flows, floods and coastal erosion to get more reliable assessing and mitigating methods and also to anhance the research capabilities and manpower development in the field of the natural disaster science through exchange of scientists and engineers.

Under this theme four subthemes are assigned as follows:

a. Prediction of debris flow in volcanic areas, i.e. at the foot of Mt. Merapi in Central java and Mt. Kelud in East Java.
b. assessment of rain-water and sediment runoffs from volcanic areas and research on flood hazards, i.e. in the Brantas River Basin
c. Beach erosion in coral reef beaches in Bali and its control,
d. Research on warning and refuge systems.

3. Technical Tasks Required for Disaster Prevention

3.1.Flood Control

All efforts or activities including either physical or non-physical facilities provided to prevent flood or to reduce damages, lost of human life and properties caused by flood is called flood meligation or river water level control. Since there is a possibility even very slightly of extremely tremendous flood takes place, so a fully controlled flood where no damage occurred based on physical or economic feasibility point of view, is impossible to carry out.

It is understandable that every river will have its own flood characteristics, therefore every river requires different flood control method. Nevertheles, there are several methods of flood control which are considered as general principal and applicable partialy or completely for every river.

Several methods classified as physical and non-physical flood controls are :

a. Structural Method or Physical Facility
   1). upstream dam and other retention/detention area as water parking area.
   2). levee, embankment and dike
   3). channel improvement/river training
   4). floodway/river diversion
   5). upstream soil conservation

b. Non-structural Method
   1). flood area zoning
   2). warning and evacuation

Implementation in flood project, such as :

- Citanduy Project, facilitated with : levee, retention area of Rawa Wanareja and Cipanggang, channel improvement and Nusawuluh - Sagara Anakan floodway.
- Cimanuk Project, facilitated with : levee, floodway, channel improvement and Jatigede Dam Plan.

- Brantas Project, facilitated with dam, levee and channel improvement.
- Sei Ular Project, facilitated with levee and channel improvement.
- Krueng Aceh, facilitated with levee, channel improvement and floodway.

3.2.Volcanic Debris Control with Sabo Dam

Primary hazard of direct volcanic eruption is hardly to be overcome but by people evacuation. Secondary hazard such as cold lava flood which is flowing down with very huge energy in wet season, is overcome by directing the flow by means of Sabo dam. When the volume of sediment is so tremendous, that a series of sabo dam is required to be constructed like in Mt. Merapi, Galunggung and Semeru.

To prevent people from the volcanic disaster, the Government developed some volcanic Debris Control Projects. There are five projects, i.e.:

a. Mt. Merapi Volcanic Debris control Projents in Yogyakarta. Mt. Merapi (1291) is located in the border between central Jawa Province and Yogyakarta special Province. This project was development in 1969, soon after the eruption. The last eruption as in 1984.
b. Mt. Kelud Volcanic Debris Control Project in Kediri, East Jawa Province. The crater lake of Mt. Kelud (1731 m) contains wwater. The more water in the crater, the larger the lahar spreads. In order to reduce the danger, the water in tahe crater lake is kept to a maximum amount about 2,000,000 cubic meters by means of drainage tunnel.
c. Mt. Semeru Volcanic Debris Control Projects in Lumajang, East Jawa Province. Mt. Semeru or Mahameru is the highest volcano in Jawa. Minor eruptions usually occur several times a day.
d. Mt. Agung Volcanic Debris Control Project in Denpasar, Bali Province. He eruptions in 1963 produced more that

829,000,000 cubic meters material and killed 1,148 people.

e. Mt. Galunggung Volcanic Debris Control Project Tasikmalaya, West Java. During the eruption period from April 5, 1982 to January 1983, there were 35 big eruptions and 300 small eruptions. After these eruptions a crater was from and filled with water. A drainage tunnel is being considered to be constructed.

Apart from those five projects, a Volcanic Sabo Technical Center was also developed since 1982 in Yogyakarta. This center is to conduct training in Volcanic Sabo Technology and to make experiment Sabo Engineering.

3.3.Coastal Protection

Coastal protection efforts are implemented by several ways, such as :

a. Coastal protection by civil construction, implemented especially in urban area or recreation resort such as in Jakarta Bay, Bali, West Sumatera and Menado.

b. Coastal protection by ecosystem approach, such as mangrove reforestation in rural area like in north coastal area of Java island. The approach will strengthen the coast in addition to support coastal fishery ecosystem.

c. Degraded coastal protection, such as atoll degradation due to lime mining as local construction material. This problem was overcome by not allowing people to treat atoll as a lime resources.

Bali and Banten beach in western part of west java.

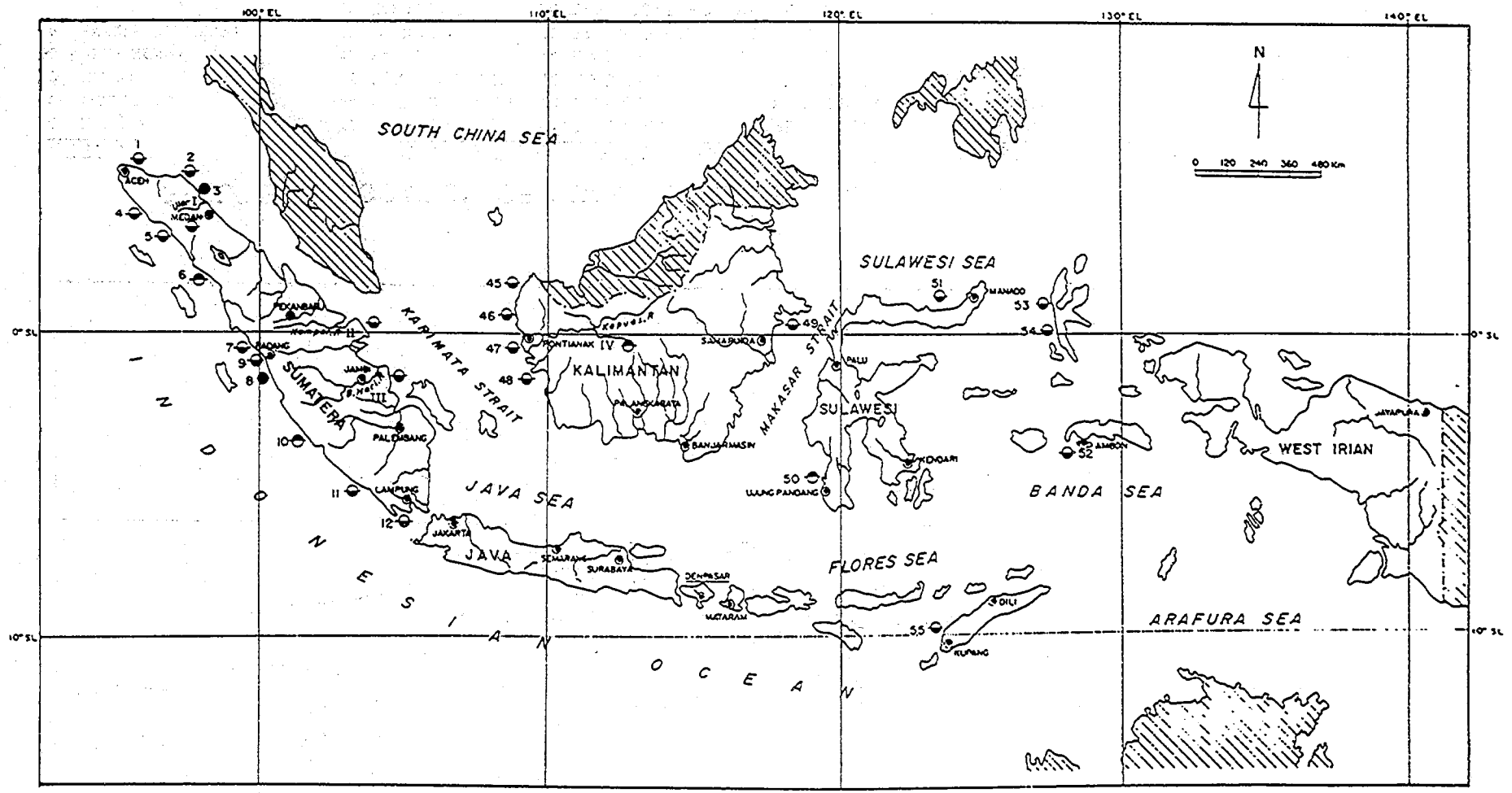


FIGURE 3. LOCATION OF COASTAL AND FLOOD PROBLEMS IN INDONESIA

LEGEND

- O : LIGHT
- ⊖ : MODERATE
- ⊖ : HEAVY
- ⊖ : VERY HEAVY
- ● : EXTREMELY HEAVY

COASTAL PROBLEMS

1	ULE LHEU	7	PARIAMAN	45	SINAM	51	MANADO
2	SIGLI	8	PADANG	46	SEI DURI	52	AMBON
3	KUALA RAJA	9	SINGKARAK	47	TANJUNG DURI	53	TERNATE
4	MEULABOH	10	LAIS KETAHUN	48	KAMPUNG BUGIS	54	TIDORE
5	TAPAK TUAN	11	PANJANG/P.BAAY	49	SEPINGGAN	55	KUPANG
6	BARUS	12	PASIR PUTIH	50	DUAN PANUA		

FLOOD PROBLEMS

I. ULAR R.
II. KAMPAR R.
III. BATANG HARI R.
IV. KAPUAS R.

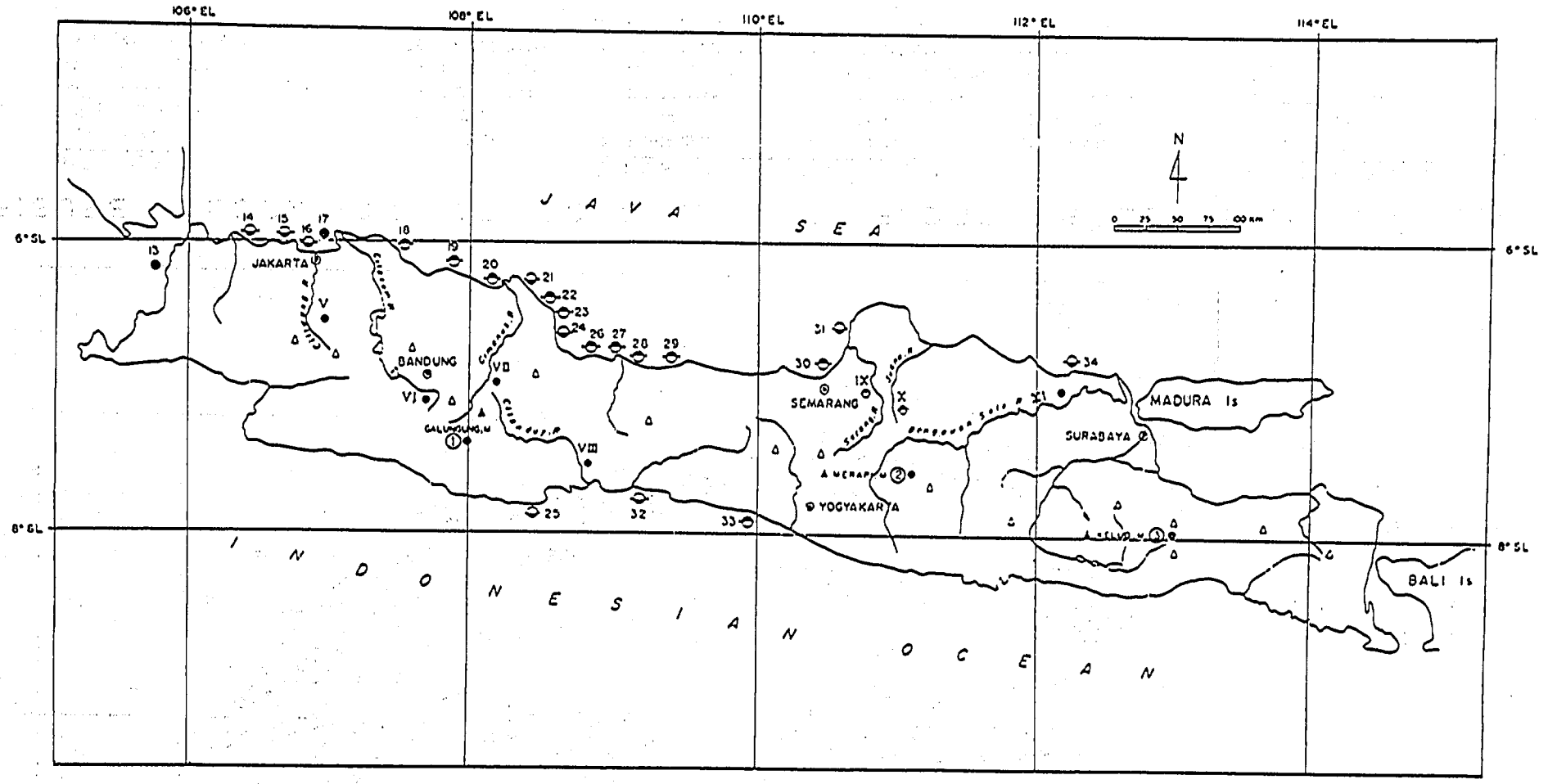


FIGURE 4. LOCATION OF COASTAL, FLOOD AND VOLCANIC PROBLEMS IN JAVA

LEGEND

- ○ : LIGHT
- ⊖ : MODERATE
- ⊖ : HEAVY
- ⊖ : VERY HEAVY
- ● : EXTREMELY HEAVY

COASTAL PROBLEMS

13 CARITA	21 BALONGAN	29 PEKALONGAN
14 KARANG SERANG	22 GLAYEM	30 MORODEMAK
15 TANJUNG PASIR	23 GABUS	31 KEDUNG SEMAT
16 KALI BARU	24 DADAP	32 TIPAR
17 MARUNDA	25 PANGANDARAN	33 WAWAR
18 KARAWANG	26 CASANGGARUNG	34 TUBAN
19 CIASEM	27 KABUYUTAN	
20 ERETAN	28 TEGAL	

VOLCANIC PROBLEMS

① GALUNGGUNG M.
② MERAPI M.
③ KELUD M.

FLOOD PROBLEMS

V. CILIWUNG R.
VI. UPPER CITARUM R.
VII. CIMANUK R.
VIII. CITANDUY R.
IX. SERANG R.
X. JUANA R.
XI. BENGAWAN SOLO R.

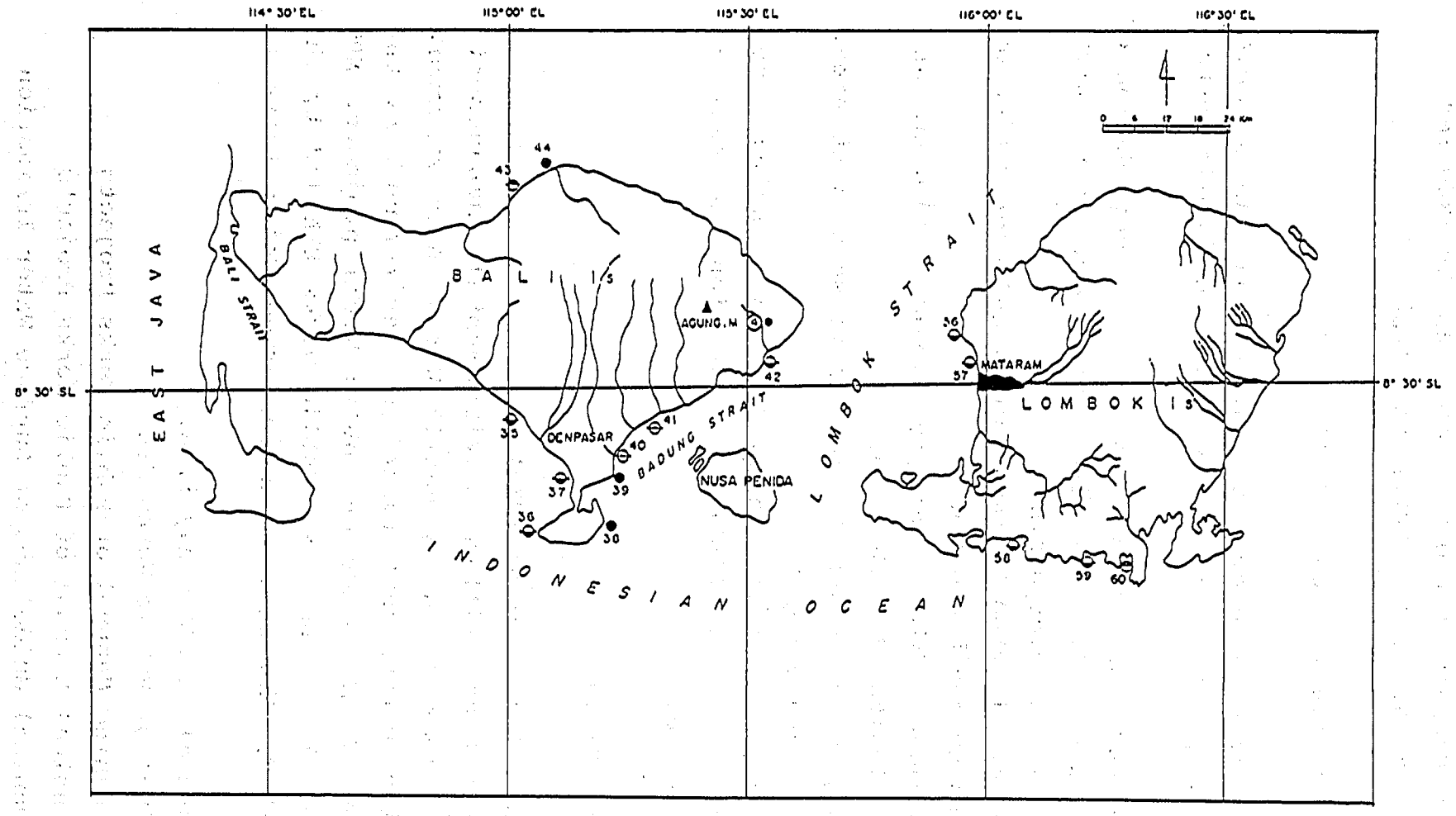


FIGURE 5. LOCATION OF COASTAL AND VOLCANIC PROBLEMS IN BALI AND LOMBOK

LEGEND

- O : LIGHT
- ⊖ : MODERATE
- ⊖ : HEAVY
- ⊖ : VERY HEAVY
- ● : EXTREMELY HEAVY

COASTAL PROBLEMS

35	TANAH LOT	40	GUMICIK	56	SENGGIGI
36	ULUWATU	41	SIYUT, LEBIH	57	SETANGGI
37	K U T A	42	CANDI DASA	58	KUTA LOMBOK
38	NUSA DUA	43	BULELENG	59	PUTRI NYALE
39	S A N U R	44	PANIMBANGAN	60	S E G E R

VOLCANIC PROBLEM

④ AGUNG M.

VII. ACTIVITIES CONCERNING HARMONY BETWEEN THE ENVIRONMENT AND IMPROVEMENT OF INFRA STRUCTURE

1. The Current Situation and Possible Problems

Various environmental problems relating to sustainable development and operation of infra structure of Public Works are as follows :

a. Water resources conservation problems i.e. degradation of river basin due to the excessive erosion and ground water problems caused by overpumping.
b. Degradation of riverbed by sand mining and degradation of coastal area by beach erosion.
c. Flood problems which destroy human settlement and decrease agricultural production.
d. Lava flood problems which destroy human settlement area, rivers, roads and bridges
e. Water pollution problems which disturb drinking water supply and decrease fishery production as well as ecosystem damage.

2. Activities in ARD-MPW

2.1. Environment impact Assessment (EIA)

ARD-MPW activities within environmental management, particularly things caused by Public Works infra structure and facilities development impact on environment is the implementation of EIA study on Public Works projects. MPW organizes central commission of Public Works EIA led by the head of ARD-MPW. The commission concerned doing tasks as follows :

a. Produce Mannual of EIA Study i. e. :
   1). Guidelines of Public Works EIA
   2). EIA Screening Mannual of Public Works Projects
   3). EIA Technical Mannual of Public Works Projects
   4). EIA Technical Guidelines of Surface Water Irrigation

Projects

5). EIA Technical Guidelines of Swamp Irrigation Projects

6). EIA Technical Guidelines of Groundwater Irrigation Projects

7). EIA Technical Guidelines of Flood Control and River Arrangement

8). EIA Technical Guidelines of Road and Bridge Projects

9). EIA Technical Guidelines of Urban Drainage Projects

10). EIA Technical Guidelines of Fresh Water Projects

11). EIA Technical Guidelines of Waste Water Projects

12). EIA Technical Guidelines of Garbage Projects

b. Screening of irrigation, roads, settlement developmnet projects or activities which are obliged to implement the EIA study, i.e. activities or projects having important impacts on environment.

c. Investigation and evaluation on environmental impact analysis study and the continuity of project implementation.

d. Monitoring and supervision, in order that the project implements management of living environment being in line with recommendation.

2.2. Water resources and environmental management

Research on sustainable of water resources development has been implemented by ARD-MPW are as follows.

a. Introducing land cover crop and constructing check dam prototype to support water and soil conservation program.

b. Mapping of river segments which are permissible or forbidden for sand mining

c. Development of bottom controller to protect the riverbed and hydraulic structure from river degradation

d. Development of coastal protection prototypes to protect the beach from erosion which is damaging building and road

e. Constructing of the prototypes of artificial ground water

recharge by collecting the rainfall from roofs of housing to ground water table layer.

f. Constructing of pilot plant installations for water pollution control

3. Technical Tasks Necessary for The Promotion of Harmony Between The Environment and Improvement of Infra Structure

3.1.Water resources conservation

Availability of water sources is greatly affected by hydrological cycle which depends on forest existence which has hydro-orological function. Due to such reality, water conservation efforts should be implemented simultaneously with watershed conservation, especially to conserve the role of forest and other species of plant which protects watershed.

In addition, continuity of ground water availablility is also necessary, especially in human settlement and industrial areas, so that ground water recharge technology should be developed especially in the area where surface water is difficult to obtain.

3.2.River and Coastal Protection

The function of river as surface water discharge and distribution is very obvious that such important function should be developed and maintained from time to time. Sand mining activity was increasing rapidly during the last period of physical construction , therefore no more such activity permitted should it may degrade the fucntion of river. Furtherly, sand mining control regulation which is followed with physical plan for river conservation, is required.

Coastal area is quite important, since it has various uses such as fishery, residential area, industry and recreation

resort. Because of such situation, it should be protected namely to maintain either its social or economic function. A proper land use planning plan for coastal area, in which environmental aspect is taken into account as well, is required.

3.3. Flood prevention to protect residential and agricultural areas

Most of down stream inhabitant suffers from flood danger. In addition to residential area, flood also threatens thousands of hectares of rice field. It will significantly reduce the yield of rice. Flood prevention is required namely by constructing levee and dam and river catchment conservation.

3.4. Lava flood prevention to protect residential area, rivers, roads and bridges

Surrounding area of an active volcano is subject to continuation danger, when eruption has happened. Cooled lava lying on the volcano peak and slope will be brought down by surface run off, threatening residential area and entering rivers. Such cooled lava flow may endanger residential environment or make river bed shallow. Should flood happens in such shallow river, bridge and its surrounding area may be damaged. Therefore sabo dam (sediment control) construction is definitely required in volcanic area.

3.5. Water pollution control

Water resources development program, to cope with increasingly water demand, is facing water pollution problems. Efforts to increase water availability, will give nothing, since water quality degrades beyond specified qualification. Due to such condition, water pollution control obviously should be improved, especially in urban and industrial area.

VIII. PROPOSAL FOR FURTHER DISCUSSION

1. Name of topic

Water Quality Management and Water Pollution Control

2. Background

Water quality monitoring data is very essential to evaluate water quality changes and water pollution interference to several type of water use of the river. In the Clean Water Program which include water pollution programs in eleven provinces, the data is required to evaluate the achievement of the activity of pollution control including industrial waste water teratment.

Number of observed rivers and channels in eleven provinces are 41 which had been monitored at 112 stations. Most of them have been extremly heavily polluted as indicated in the table (IPPA index 1s 5).

3. Current Activities and Technical Tasks for Problems Solving

3.1.Water Quality Management Studies

Water quality management studies have been executing at some river basins in Indonesia such as Brantas river, Citarum river, Sunter river and Cisadane river.

The studies covering :

a).water pollution sources inventory

b).water supply and other usage inventory

c).the assessment of water quality objectives

d).the required water pollution control level to conserve the river water quality agree with the stream standards for various beneficial usage.

The studies had been executing by the Ministry of Public

Works supported by bilateral technical assisstance.:

a) Brantas river assissted by France Government

b).Citarum River assissted by German Government

c).Sunter River assisted by British Government

d).Cisadane River assisted by France Government.

3.2.Water Pollution Control Studies

Water pollution control study in Java island was prepared by the Agency for Research and Development of Public Works and the study was conducted by the Research Institute for water Resources Development for which technical aid as a grant was provided by Asian Development Bank. Study was intended to arrange technical design of integrated industrial waste water control at the area of highly density of industry. Studied area for the first stage is Java island which is consisting of some important river catchment areas.

The result of study is very useful either for Government or Regional Government, it will carry out the estabilishment and operation of integrated waste water purification installation

The main objective of this study was preparing a program for cleaning up the rivers by controlling industrial wastewater discharges in order to upgrade and maintain water quality in the Java study area.

The study is focused on industrial wastewater treatment, in particular the management of wastewater by collection and treatment in centralized systems. Broadly stated, the objectives were to

a).inventory and characterize the industries in the study area

b).determine the feasibility of centralized systems in terms of technology, financial and institutional

factors

c). estimate the investment needed for industrial control, using centralized systems where they are appropriate and having individual industrial systems where centralization cannot be used

d). evaluate the feasibility of an industrial pollition control loan program

e). develop an investment plan and specify a follow-up priority project

Java presently has about 10,100 large to medium-sized industries, half of which are believed to involve wet processes that generate polluted wastewater. This project inventoried and characterized 2,051 of these to establish a basis for estimating the industrial waste tratment investment needs. It is estimated that about 70 percent of the existing industries in Java can be served by centralized systems and 30 percent will need individual on-side treatment plants. By the year 2000 these proportions will be 80 percent and 20 percent, respectively.

A projection was prepared of the investment needed to provide pollution controll for all industries by the year 2000, assuming a 6.5 percent yearly increase in the number of industries and a 5 percent annual cost inflation. Table 1 shows the projected number of industries served, and the cumulative and annual investment required. The costs are for secondary treatment systems (contingency not included).

An estimated 9,473 industries need to be equipped with pollution control facilities, either on-site or centralized, by the year 2000. The cumulative cost, including inflation, is $3,980 million. The 1991 annual investment requirement is $254 million; this grows to

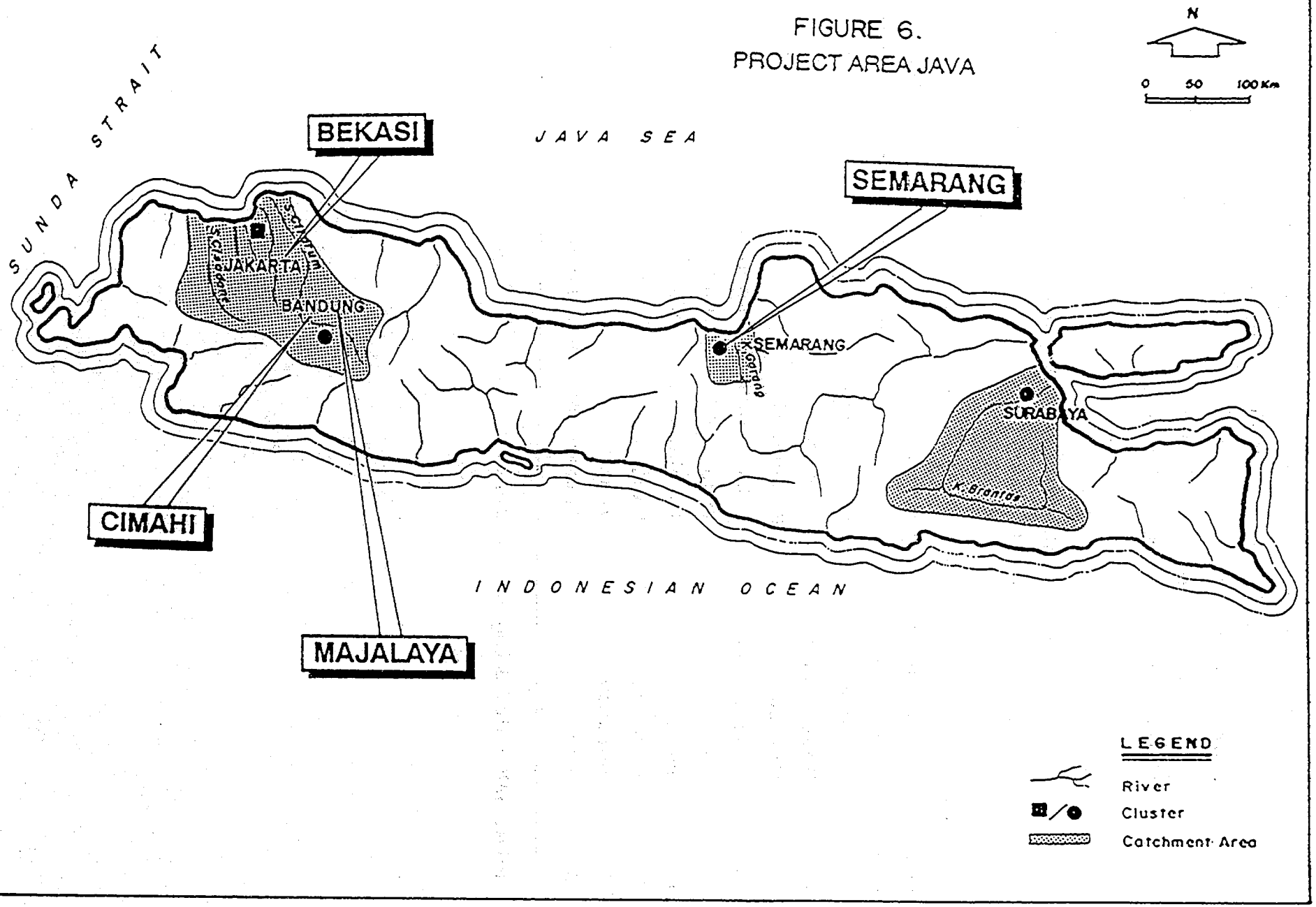
$583 million by the year 2000. This provides polllution control facilities for roughly 500 to 600 industries each year. Approximately one-third of the investment would be in government initiated centralized facilities (collection systems with primary treatment).

Table 6. Water Pollution Level of Some Rivers in Indonesia
(Based on Evaluation System on IPPA Indexes)

No.	River/channel	Station	IPPA
1.	Cisadane	Tanggerang	5
2.	Mookervaart	Tangerang	5
3.	Ciliwung	Manggarai	5
4.	Banjir Kanal	Intake DWS Pejompongan	5
5.	Sunter	Intake DWS Pulogadung	5
6.	Bekasi	Intake DWS Bekasi	3
7.	Citarum	Nanjung	5
8.	Surabaya	Jagir	5
9.	Musi	Intake DWS Palembang	1

Note: DWS- drinking water supply

FIGURE 6.
PROJECT AREA JAVA



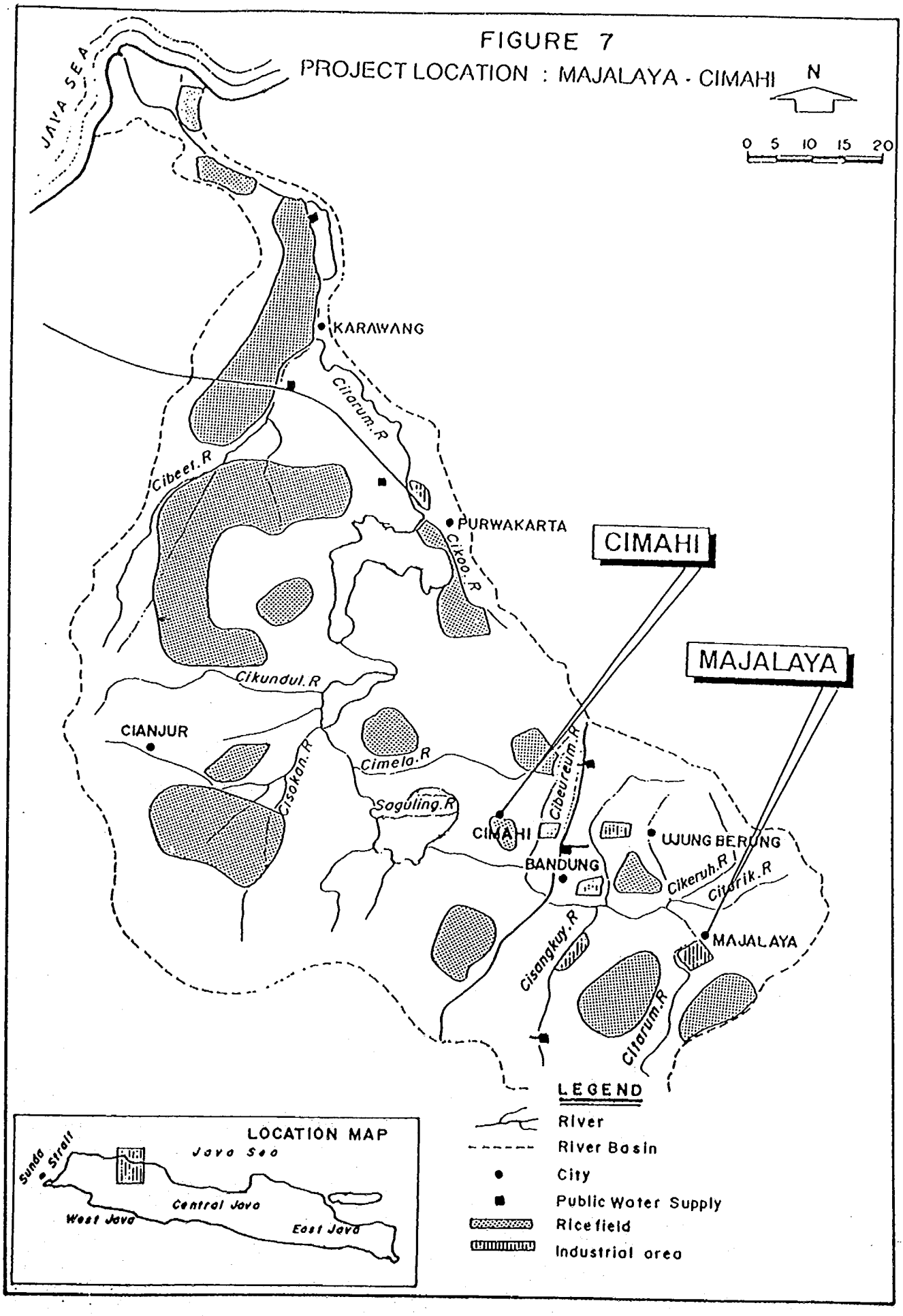


FIGURE 7
PROJECT LOCATION : MAJALAYA - CIMAHI
N
0 5 10 15 20
JAVA SEA
KARAWANG
Citarum.R
Cibeet.R
PURWAKARTA
Cikoo.R
CIMAHI
MAJALAYA
Cikundul.R
CIANJUR
Cisokan.R
Cimela.R
Sogüling.R
Cibeureum.R
CIMAHI
BANDUNG
WUNG BERUNG
Cikeruh.R
Citarik.R
Cisangkuy.R
MAJALAYA
Citarum.R
LEGEND
River
River Basin
City
Public Water Supply
Ricefield
Industrial area
LOCATION MAP
Sunda Strait
Java Sea
Central Java
West Java
East Java

III. Republic of Korea

Dr. Lee Sang Eun, Vice President,
Korea Institute of Construction Technology

C O N T E N T S

1. The Outline of Korea

2. National Development and Public Works

3. R & D Activities in Public Works

4. Major Research and Development Projects

5. International Cooperation

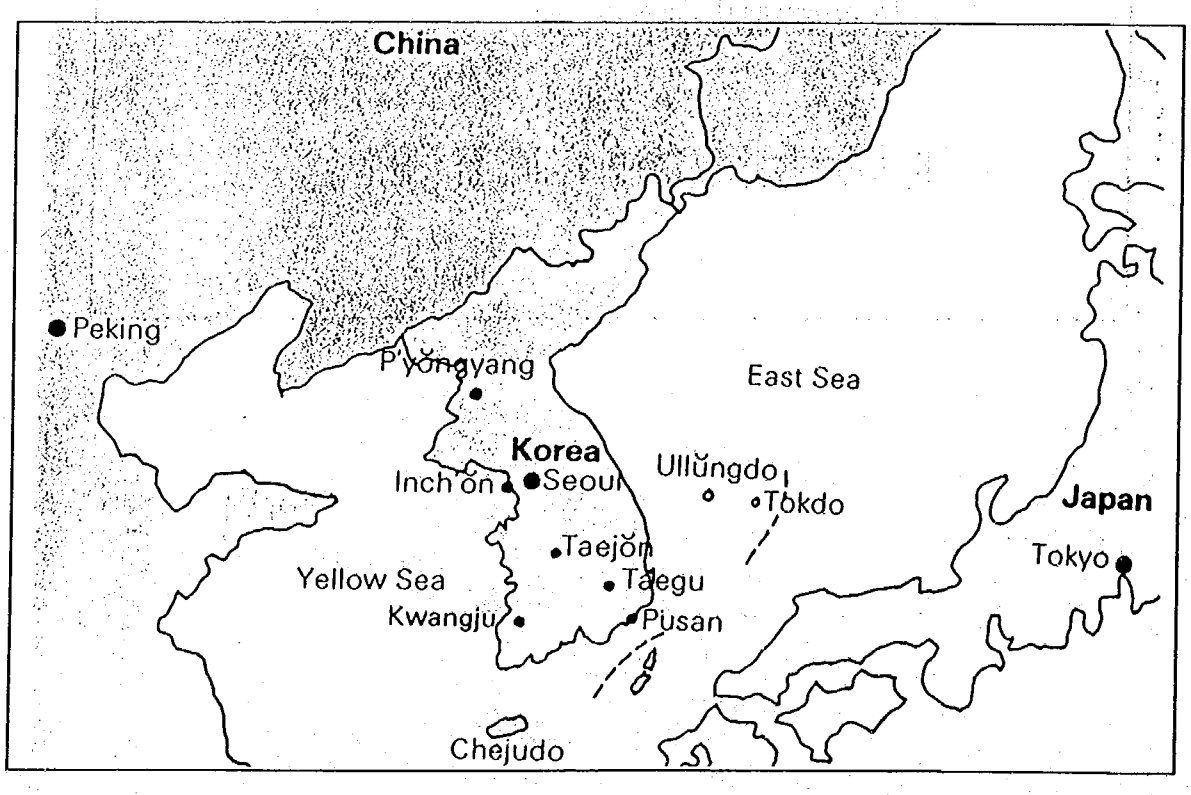
6. Water Quality Conservation in KOREA

1. The Outline of Korea

1. 1 Description of the land

The Korean peninsula extends southward from the northeastern section of the vast Asian continent. Spanning 1,000 kilomiters north to south, the size of the peninsular is about 221,000km². It shares most of its northern border with People's Republic of China and touches the Republic of Russia. And three sides are surrounded with the East Sea, Yellow Sea and South Sea.

Since 1948, the peninsula has been divided into two parts, the Republic of Korea in the south and Democratic People's Replic of Korea in the north. Korea has a varied terrai, which is largely mountainous(70%), with small valleys, and narrow coastal plains. The spectacular Taeback Sanmeak(mountains) runs the full length of the east coast, where the lashing tides of the East Sea have carved out sheer cliffs and rocky islets. Principal rivers, such as Han, Kum and Nakdong, all have their sources in the Taeback Mountains, and they flow between the ranges. The western and southern slopes are very gentle, forming plains and many offshore islands honeycombed with inlets. The irregular shoreline is dotted with over 3,000 islands.



1. 2 Climate

Because the Korean peninsula is located in latitude 33° -43° North and Taeback -Sanmeak extends in a north-south direction, the temperature difference among east, west, south and north is marginally. Because of the Temperate Zone and continental influences, change of season is clear in Korea. It has hot, humid summer and long, dry and cold winter. Spring and autumn are rather short, but very pleasant with crisp weather and many days of sunshine.

Temparatures range from as low as -12° C(10° F) in winter to as high as 37° C(98° F) in summer. The three months of June, July and August have the heaviest rains, with July usually the wettest month of the year. Winter starts in late November and lasts until early March. It is dominated by a high pressure zone caused by cold blasts of air from Siberia. There is little precipitation and the sky is usually clear. Winter in South Korea is generally not as severe as North Korea.

Belonged to zone of moisture climate, Korea get a lot of rain. A rainfall range 1,400 - 1,500mm in south coast, 1,200mm in middle and 800 - 900mm in north region. The seasonal variation is also remarkable with 70 percent of annual rainfall is concentrated from June to Sempember.

A rainfall of rainy season and typoon in August decide total precipitation duriong Summer. Snow generally becomes major precipitation from November to February.

1. 3 Population

The Republic of Korea had a population of 43.3 million in 1991, registering a density of 437 persons per square kilometer. The population of North Korea was about 21 million in 1991.

Rapid population growth was once a serious social problem in the Republic as in most other developing nations. Owing to successful family planning campaigns and changing attitudes, however, population growth has been curbed remarkably in recent years, though still not quite low enough. The annual growth rate was 0.92 percent in 1991.

A notable trend in the population structure is that it is getting increasingly younger. The 1985 census showed that 55.7 percent of the total population was

under 25. The number of people of productive age, namely 14 and above, rose from 20,918,000 in 1975 to 29,648,000 in 1991.

Another distinction, but unwelcome phenomenon, is the continuing migration of rural residents to cities. It causes high urbanization rate. Currently, one fourth of Koreans live in Seoul. By the year 2,000, specialists predict that the urbanization rate will increase to 77 percent from the present 69.9 percent. To cope with the growing urban problems caused by such an imbalance, the government has prepared a long-term manpower development plan. The plan aims at dispersing population to provincial areas through the relocation of economic activities and balanced land development.

Minority groups are almost not exist in Korea, apart from some 30,000 Chinese, who are mostly long-term residents in the capital area.

AREA AND POPULATION(South Korea)

Area km^2, Population in thousand

YEAR	WHOLE AREA	ESTIMATES OF MID-YEAR POPULATION			RATE OF INCREASE
		Total	Male	Female	
1989	99,262.63	42,380	21,359	21,021	0.97
1990	99,273.70	42,869	21,568	21,301	0.93
1991	99,299.80	43,268	21,775	21,493	0.92

1.4 History

Korea remained a "hermit kingdom" with 5,000 years of history adamantly closed against the Western demands for diplomatic and trade relations in the 19th century. Korea adhered to its alliance with China, which was fighting for its own life against Western encroachment and could not help Korea. Japan, which had risen as a new industrial power, eventually stepped in to the power vacuum and annexed Korea. The Choson Kongdom(Yi Dynasty) fell in 1910.

Before the end of the World War II, the allies at Yalta had secretly decided that Korea, like Germany, would become a trustee of the allied victors. In accordance with this exclusive pact, the United States and the Soviet Union occupied Korea after the war and brought with them the cold war rivalry, which later divided the peninsula.

In 1948, general election were held in the southern half of the peninsula to

found the Republic of Korea with Sungman Rhee as President. In North Korea, a communist regime was established under Kim Il-sung.

Most Koreans were enraged with the division of their country which brought on the tragic Korean War(1950-53). The entire land was devastated and millions of people were left homeless and separated from their families during war. A cease-fire was signed in July 1953, and both sides have since gone through enormous changes in their efforts at rehabilitation.

Reunification remains a sacred goal for people on both sides of the vigilantly guarded Military Demarcation Line. Nevertheless, the entangled superpower interests surrounding the peninsula and the deep ideological differences among Koreans themselves conspire to keep the fortified boundary as impenetrable as ever.

1.5 Economy

Over the last quarter century, the Republic of Korea has achieved what is widely acclaimed as "the economic miracle of the century." Since Korea embarked on economic development in earnest in 1962, its economy has grown at one of the fastest paces in the world. As a result, Korea, for long one of the world's poorest agrarian societies, has emerged as an upper middle-income, fast-industrializing country.

During only three decades from 1962 to 1991, Korea's gross national product increased from US $2.3 billion to US $207.5 billion, with per capita GNP soaring from US $87 to US $6,498. The key to this success was the adoption of an outward-looking development strategy making exports the engine of growth. This strategy reflected Korea's insufficient natural endowments, its limited domestic market, and its abundant, well-educated, industrious manpower.

The economic structure was radically trasnsformed as a result of the successful execution of several phases of 5 years socio-economic development plans, during these years. The manufacturing sector increased its share of GNP from 14.5 percent to over 39.3 percent in 1991. The domestic savings rate rose to 36.1 percent from 3.3 percent during the same period. After Korea marked a surplus in international trade in 1986 for the first time in history, its economy progressed rapidly in the manufacturing and mining sectors. Export-oriented manufacturing, which received strong governmental support was particularly successful, and the country's balance of payments improved in

recent years.

Of course there are several thorny problems that need to tackle. One is rising labor costs that threaten to erode the competitiveness of Korean products. Another is mounting protectionism of the industrialized countries, especially in Korea's major trading partners. But those ploblems can be overcome by accelerating industrial adjustment toward high value-added technology and knowledge intensive products, combined with greater market diversification. The governmental support for technology development is rising step by step. And Korea has been continuously putting many efforts to enter the ranks of the industrialized countries and assume an increasing role in international endeavors for progress and prosperity.

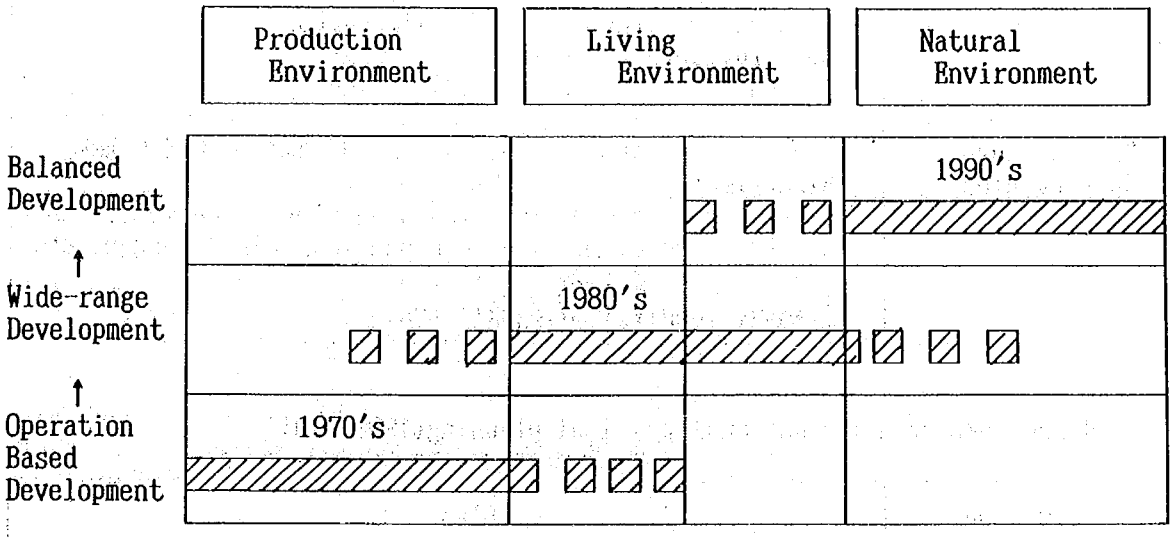
2. National Development and Public Works

2. 1 The comprehensive national physical planning

○ Basis of the planning

- Promulgate the law of in 1963
- Establish the basic plan in 1968
- UNDP/SF team investigated the plan for 2 years
- A Presidential Decree No. 26(1971.10.26) to execute the 1st plan

○ Phase of the plan



A. 1st the comprehensive national physical planning(1972-1981)

Division	Achievements
Industrial Complex	• Industrial area 102km² → 332km² • Industrial water facility 648,000m³/day→1,903,000m³/day • Construction of the industrial complex - Pohang, Ulsan, Changwon, Yucheon (whole country level) - 24 provinces including Chungju, Kunsan, Kwangju, etc.
Traffic	• Traffic capacity - passenger : 32billion/km → 86.7bil./km - freight : 16billion ton/km → 23.2bil. ton/km • Construction of highway : 7 lines including Seoul-Pusan, etc. • Construction and pavement of national road : 3,250 km
Water Resources & Land Use	• Soyang-dam, Andong-dam, Dacheong-dam, etc.(4.1bil.m³) • Setting up 'Green Belt' for environment conservation

B. 2nd The comprehensive national physical planning(1982-1991)

Division	Achievements
Population Dis-perse Policy	• Assignment of specific regions (Jeju Island, Taebaek Mt. etc) • Setting up agricultural industry area (24.3 km²) • Working out a master plan for arrangement of metropo-litan region
Traffic, the Use of National Land	• Expansion of six highways including 88 Olympic Highway : 491.3 km - Completed, 679.7 km - to be started • Construction and pavement of national road : 589 km • Reclamation of land by drainage • Setting up large scale industrial areas
Citizen's Welfare	• Water supply capacity 15.7 mil. ton/day ratio of diffusion : 78%, area, 524 cities • Housing construction : 2.2 mil. units • Construction of new towns • Telephone expansion : 11.7mil. lines
Environment Conservation	• Expansion of national parks : 2,794 km² → 6,440 km² • River improvement : 30.6% → 54.1% • Setting up conservation area of national land:52,138km² • Construction of multipurpose dam including Chungju, etc. [Water demand : 29.4 bil. ton [Water supply : 27.6 bil. ton

C. 3rd The comprehensive national physical planning(1992-2001)

Division	Plan
Assignment of New Industrial Area	• - Asan Bay, Daejeon, Cheongju - Kunsan, Janghang, Iri, Junju - Kwangju, Kwangyang Bay] 3 Areas are intensively industrialized in con-nection the west sea area development • Setting up small industrial complex • Setting up high tech industrial areas
Traffic	• Construct X shape road net • Construct highway (1,500km) • Double track railroad (27% → 54%) • Railway electrification (17% → 50%) • Construct new airports in Yongjondo, Chongju, etc.
Preparation for National Unifica-tion between North and South Koreas	• Development of DMZ area • Restoration of railway and national road • Joint development of economic co-operation complex in demilitarized zone

Division	Plan
Environment Conservation	• Strangthening the standards of environment conservation • Investment for environment : 0.15%→1.5% of GNP by 2001
Housing Construction	• Construct 5.4 mil. housing units : supply ratio up to 92.8% • Construct 2.15 mil. rental house(40% of the newly built)
Water Supply and Sewage	• Construct 18 wide range water supply system • Construct 180 sewage disposal plants • Construct 10 multipurpose Dams
Financial Resources	• Total investment : 320-370 tril. won('85 fixed price) or 16-18% of GNP • - Central government : 27% - Local government : 19% - Nongovernmental : 50% - Others : 4%

2. 2 Budget for Construction Investment

unit : bil. won

Year	GNP	Increase Rate(%)	Budget for Constrution	Increase Rate(%)
1973	32273.8		3331.4	
1974	34903.6	8.2	4001.0	20.1
1975	37143.3	6.4	4251.7	6.3
1976	42001.6	13.1	4789.6	12.7
1977	46135.4	9.8	5969.8	24.6
1978	50645.6	9.8	7591.4	27.2
1979	54289.5	7.2	8093.6	6.6
1980	52260.8	-3.7	7793.5	-3.7
1981	55354.3	5.9	7035.6	-9.7
1982	59322.2	7.2	8443.1	20.0
1983	66803.0	12.6	10657.7	26.2
1984	73004.0	9.3	11436.4	7.3
1985	78088.4	6.9	12011.1	5.1
1986	88173.5	12.9	12338.2	2.7
1987	99611.6	13.0	13761.8	11.5
1988	111979.9	12.4	16106.5	17.0
1989	119534.8	6.8	19429.1	20.6
1990	130373.5	9.1	25199.4	29.7

note) 1985 fixed price

2. 3 Organizations Concerned with Public Works

Project owner	Names of organizations
Center Government	· central government and its affiliated organization, the legislature, the judicature, military units, national schools, etc.
Local Government	· Seoul metropolitan government, Pusan and four cities, each province and districts, Board of education in provinceial districts, Public shcools, etc.
Government-invested corporation	· national banks, corporations, etc.
- Special bank	· the Bank of Korea, Industrial bank of Korea, etc.
- Corporation	· Korea power corporation, Korea Highway Corp., Korea Petroleum Development Corp., Korea Broadcasting Corp.,etc.
- Stock company	· Pohang Steel and Iron Copmany, etc.
Other public organization	
- Government supported institution	· Korea Advanced Institute of Science and Technology, Korea Korea Standards Research Institute, etc.
- Local government invested institution	· Seoul Kangnam Hospital, etc.

2. 4 Major Infrastructures and Public Works

2. 4. 1 the Present Status of Social Overhead Capital(SOC)

- SOC Stock of 1987 was 70.2 tril. won which is four times higher than 1977's. But the ratio of industrial total capital stock has decreased to 22% from 24% during some period.
- The stock of water resources and telecommunication increased 20% annually, while traffic and living facility 11-14% only.
- Traffic facilitiy of highway, railroad, harbor, etc. increased 11.9% annually while the ratio of stock has decreased to 38% in '87from 49% in '77.

the Social Overhead Capital Stock

(Unit : bil. won, %)

	1977		1987		increase '77-'87	
	amount	ratio of GNP	amount	ratio of GNP		annual increase rate
· Traffic	3,594 (48.8)	20.2	26,697 (38.1)	25.2	3.1	11.9
Highway	2,163 (29.4)	12.1	15,119 (21.5)	14.3	2.9	11.3
Railroad	1,286 (17.4)	7.2	9,859 (14.1)	9.3	3.2	12.3
Harbor	125 (1.7)	0.7	1,376 (2.0)	1.3	4.6	16.4
Airport	20 (0.3)	0.1	343 (0.5)	0.3	7.1	21.7
· Living Facilities	2,020 (27.4)	11.3	18,225 (26.0)	17.2	3.8	14.1
Water Supply and Sewage Treatment	374 (5.1)	2.1	2,971 (4.2)	2.8	3.3	12.7
Electricity and Gas	1,646 (22.3)	9.2	15,254 (21.8)	14.4	3.9	14.4
· Telecommunication	745 (10.1)	4.2	10,545 (15.0)	9.9	5.9	19.4
· Water Resources and Flood Control	1,005 (13.7)	5.6	14,697 (20.9)	13.9	6.1	19.8
Social Overhead Capital(A)	7,364 (100.0)	40.4	70,164 (100.0)	66.1	4.0	14.8
Industrial Total Stock (B)	30,314		312,412		4.3	15.7
(A/B)	(24.3)		(22.4)			

* Notes : fixed price

2. 4. 2 Highway

- Total road length : 56,715 km as of '90
  - Automobile increased 2.6 times while road construction 1.2 times after '86
  - Unpaved road is 16,170 km (28.5% of total length)
- Economic loss is seriously caused by heavy traffic congestion.

2. 4. 3 Railroad

- Total railroad length is 3,091.3 km as of '90
  - the ratio of railway electrification : 17%
  - the ratio of double lines : 27.4%

2. 4. 4 Habor and Sea transport

- 346 million tons of cargo is handled at harbor in 1990 with annual increase rate of 10.2% .
  - Container with 2,393 TEU in 1990, increases 15% annually.
  - Present capacity of cargo handling is 189.9 million tons and increases 9.7% annually.

2. 4. 5 Airport

- Domestic passenger is 110 mil. in '90 and has been increase 13.3% annually. Domestic cargo reaches 182 thousand ton with annual increase of 20.1%.
- International passenger is about 9,360 thousand
  - Kimpo Airport is expected to surpass its capacity in 1995 and Kimhae Airport in 1993 or thereafter.

2. 4. 6 Electric Power

- Power Consumption is 94,383 GWH in 1990 with average increase rate of 14.9%.
  - Max power in 1990 was 17,251 thousand KWH.
- Power demand is expected to increase on more large scale.

2. 4. 7 Water Resources

- Water Resource has balanced demand and supply at present with exceptions at Ulsan, Chungju, etc.
- Wide range water supply network is focused in metropolitan area (75% of total supply).
- The price of water supply is relatively low, which results in financial constraints to construct water facilities.
- 3.9 trillion won is supposed to be invested during 1992-2001.

Stock of Major Social Overhead Capital

Unit : km, thousand ton/day

Year	Highway	Railway	Harbor Capacity	Water Supply	Sewage Treatment Capacity
1982	53,936	6,113.4	87,423	8,076	822
1983	54,600	6,128.7	95,512	8,386	822
1984	51,004	6,168.1	100,317	9,498	822
1985	52,264	6,299.0	112,778	10,214	822
1986	53,654	6,323.6	118,413	11,505	973
1987	54,689	6,339.9	150,676	12,613	4,262.5
1988	55,778	6,456.2	168,774	14,442	4,644.5
1989	56,481	6,436.6	184,739	15,725	4,945
1990	56,719	6,434.6	189,926	16,274	5,097

2. 5 Major Project in Progress or in Planning

Unit : trillion won

Section	Main Works	Investment		
		Total	1992-1996	1997-2001
Highway	· highway [new construction 1,500km [extension 700km · national road [new construction 1,100km [extension 5,500km	39.3	18.5	20.8
Railway	· rapid-transit railroad 915.7km	18.9	6.092	5.588
	· metropolitan area electric railway 269.4km		1.737	0.159
	· subway in large city 536.4km		1.71	1.043
Harbor	· container, freight	7.5	3.088	4.401
Airport	· new airport	3.2	2.725	0.489
Distribution	· construction of complex terminal	0.7	0.434	0.3
Water Supply	· multipurpose-dam, wide range water supply, industrial water, etc.	3.9	2.826	1.045
Total		73.5		

* Notes : Nongovernmental 2.5 trillion won was excluded in habor project.

3. R & D Activities in Public Works

3. 1 Status of construction technology

The Korean construction industry has executed many types of construction projects successfully, and has become the major industry with contribution to GNP of higher than 9%, however, this growth was mainly through labor intensive construction works and thus the level of construction technology is still fell behind comparing with that of advanced countries.

The level of construction technology of Korea was assessed for various of types of project and for various stages of construction activity by comparing with those of advanced countries. The results are quantitatively expressed in Table-1 for representative construction works by assuming the present technology level of the advanced countries as 100.

As appeared in this table, although the technology level of simple construction is fairly high for most types of project, level of technology intensive stages, such as planning, operation & maintenance and supervision, and also that of technology intensive construction works are still low.

The construction industry is willing to put every effort and to utilize the best technology in execution of many construction projects, such as expressway, main roads and other facilities of social overhead capital to leave artistic construction products as the legacy to our descendants.

Level of construction technology
(Index : level of advanced country = 100)

Facility	Stage of construction activity				
	Planning Investigation	Design	Construction	Supervision	Maintenance
Bridge	66	68	73	62	62
Nuclear Power Plant	45	45	60	45	55
Road & Airport	72	75	85	75	80
Railway	68	70	85	70	75

Facility	Stage of construction activity				
	Planning Investigation	Design	Construction	Supervision	Maintenance
Tunnel	65	68	83	65	68
Dam	64	62	77	62	65
Building	59	78	73	61	60
Highrise Building	58	60	73	58	58
Water and Sewerage Facilities	57	57	67	58	56
Hydroelectric Power Plant	71	69	72	53	45
Building Facilities	73	63	76	56	63

3. 2 Policy and strategy to improve construction technology

To improve the construction technology of Korea to the level of advanced countries and thus for the Korean construction firms to become more competitive, the Government of Korea has set up long term plans for R & D and technology development.

In 1987, the Korea Institute of Construction Technology (KICT) carried out a research project to propose Long Term Direction of Research and Development of Construction Technology with a sponsorship of the Ministry of Construction. Although the project was carried out by KICT, about four hundred experts from university, industry and government were involved in the project to share their experiences.

Many aspects of construction technology were reviewed in this project and the followings were the major contents of the proposed long term plan.

1) The demands for construction technology in 21st century to meet the upgraded demand for construction product were projected and the goals and directions of R & D were proposed to fullfill these projected demands.
2) Policies and systems to promote the development of construciton technology were proposed.
3) The directions of long-term and short-term plan for research and development by determining neccessary research subject, for various sub-research field in construction technology were set up.

4) The appropriate mechanisms and strategies to secure neccessary resources including facilities, manpower for R & D and financial resources were investigated.

5) The long term plan for development of information management system of construction technology was established.

The Construction Technology Management Law which was promulgated in 1987 and become effective 1988 covers many aspects of technology development including protection mechanism of new innovative construction technology and establishment of KICT as well as construction technology information center.

According to this law and also on the basis of the Long Term Direction of Research and Development of Construction Technology, 10 years basic plan was established in April, 1991. This plan consists of various policies and basic technology development plan for various area ; the various policies include 1) supporting system for technology development 2) management of technologist 3) supporting of research institutions 4) expansion of investment for thechnology development 5) establishment of technical information management system, and 6) extention of international technical cooperation. The technology development includes defining the major area of technology development, basic plan of R & D for each area and determining the amount of financial resources required.

The following step of 10 years' plan for promotion of construction technology is establishment of detailed implementation plans for the items mentioned in it. The 5 years' implementation plan for R & D of construction technology has just been announced by Ministry of Construction in January, 1993 and include all R & D activities related with construction technology which should be conducted by university, research institute, private sector and also government.

3. 3 Public R & D institutes in construction field

Unit : million won, %

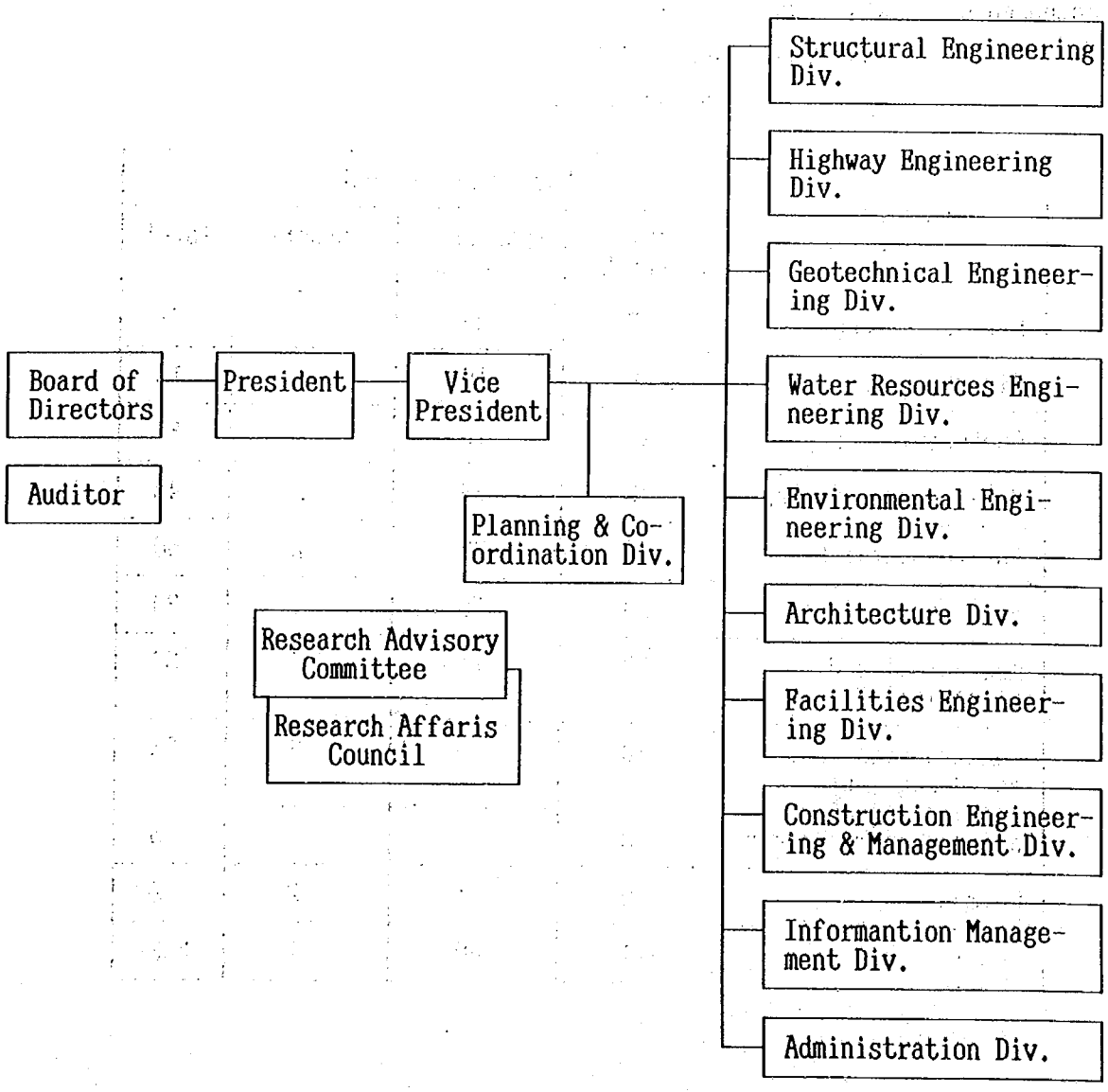
	Foundation Date	Number of R&D Staff	Net Scale	R&D Exp.	Ratio of R&D Exp.
Korea Highway Corp.	'69. 2.15	41	4,274.7	34.2	0.80
Korea Water Resources Corp.	'67.11.16	42	2,131.1	55.7	2.63
Korea National Housing Corp.	'62. 7	121	27,266.2	132.1	2.23
Korea Land Development Corp.	'79. 3.27	44	11,825.6	26.0	0.10

3. 4 Korea Institute of Construction Technology (KICT)

3. 4. 1. History

- May. 17. 1983 Inauguration of Board of Directors and enactment of the Articles of Association
  Elected Dr. Ahn, Kyung Mo as the first president of KICT
- Jun. 11. 1983 Opening of KICT as an incorporated foundation
- Sep. 1. 1986 Inaugurated Dr. Yoon, YongNam as the second president of KICT
- Jan. 8. 1988 Transformed to the government-supported institution, based on "Construction Technology Management Law". Article 7.
- Jan. 24. 1989 Inaugurated Lee, Yun Sik as the third president of KICT

3. 4. 2 Organization Chart



3. 4. 3 Number of staff member

· Regular staff

Executive	Research Technical Staff	Administrative Staff	Technician	Total
2	142	21	30	195

· Temporary staff : about 70 persons

3. 4. 4 Budget(1992) : 7,848 million

· Pesonnel Expenses : 2,510 mil. won

· Research Activities : 2,360 mil. won

· Management Expenses : 2,278 mil. won

· Construction Expenses of Laboratory : 700 mil. won

3. 4. 5 Recent achievements

KICT has completed 302 research projects during 1983 - 1992, which are composed of · KICT research 141

· Sponsored research 140

· Basic research and others

Research Field	Number of Project			
	KICT research	sponsered research	others	Total
Structural Eng.	17	23	1	41
Highway Eng.	8	10		18
Geotechnical Eng.	17	15	3	35
Water Resources Eng.	16	24	2	42
Environmental Eng.	16	32	2	50
Arcjotectire	23	15	1	39
Mechanical and Electrical Eng.	23	11	2	36
Construction Eng. and Management	13	5	8	26
Information Management	2	4		6
Common	6	1	2	9
Total	141	140	21	302

4. Major Research and Development Projects in KICT

4. 1 Title of the major research and development projects in 1993

- A study on chemical reaction of crushed aggregates
- Rehabilitation of earthquake-damaged structures
- A study on design and construction methods for long span bridges
- Early-age behavior and crack patterns of continuously reinforced concrete pavements(C.R.C.P) in Korea
- A study on automatic traffic identifications
- The evaluation of engineering characteristics for domestic marine clay
- A study on fiber-reinforced soil
- A study on property of frozen soil and pile foundation in permafrost
- A study for the groundwater management and conservation in Korea
- A study on assessment of hydrologic models
-
- A study on the improvements of sewer materials
- A study on the reuse and reclamation of treated wastewater
- A study on the use of aeration tank and soil filter adsorber for odor control in sewage treatment plants
- Development of energy conservation method for apartment housing
- Guidelines for maintenance and modernization of existing buildings
- A study on the heating system for residential building using low temperature waste heat
- A study on the power demand control system in office buildings
- A preliminary study on application of geographic information system for national facilities

4. 2 Project Summary

■ Structural Engineering Division

1. Research Projects

   A Study on Design and Construction Methods for Long Span Bridges

2. Period : 1993. 1. 1 ~ 1995. 12. 31

3. Background and Research Needs

   Nowadays, a number of long span Bridges (cable - stayed bridge, suspension bridge) are consturcted in our country. But the technology of the design and construction method about such type bridges remains in the underdeveloped stage in Korea. Therefore, research concerning the design as well as construction method is necessary to upgrade the technology of long span bridges.

4. Objectives

   - 1st step (1993) :
     - Investigation and analysis of research materials
     - Study on the design load
     - Study on the analysis method
   - 2nd step (1994) :
     - Study on the wind tunnel test and its standard
     - Study on the wind resistant design
     - Study on the earthquake resistant design
   - 3rd step (1995) :
     - Analysis of the construction method
     - Development of the anaylsis computer program
     - Development of computer program for the wind and earthquake resistant design
     - Development of pre and post processing system

5. Methodology

   - Design data and experience from designers
   - Constitution of an advisory committee
   - Analysis of the developed program
   - Investigation and use of the data base system

6. Anticipated Results

   - Application as a raw material of the design standard about long span bridge
   - Propagation of the long span bridge technology in Korea
   - Propagation of the useful software package for the long span bridge
   - Overall improvement of the long span bridge technology of our country

■ Highway Division

1. Research Project

   Early-Age Behavior and Crack Patterns of Continuously Reinforced Concrete Pavements(C.R.C.P) in Korea.

2. Period : 1993. 1. 1.~1993. 12. 31.

3. Background and Research Needs

   In order to use C.R.C.P. widely in Korea, it is needed to ascertain whether C.R.C.P. in Korea performs in accordance with the design and to compare the performances of Korean C.R.C.P. with those of other countries.

4. Objectives

   The objects of this study are to review the construction procedure and design standard of C.R.C.P. in Korea, and provide recommendations for the suitable construction.

5. Methodology

   - Construction and monitoring of a test section.
   - Analysis and evaluation of the data collected from the test section
   - Comparison of the results with those from other countries.

6. Anticipated Results

   - Provide recommendations as to design and construction of C.R.C.P. in Korea
   - Establishment of initial data-base for the performance of C.R.C.P.
   - Provision of basic data for the performance of C.R.C.P. in Korea.

■ Geotechnical Engineering Division

1. Research Project

   Evaluation of Engineering Characteristics for Domestic Marine Clay

2. Period : 1993. 1. 1 ~ 1994. 12. 31

3. Background and Research Needs

   As a strategic domestic land development plan for coming 21st century, a systematic land utilization of coastal belt area along the west and south coasts of Korean Peninsula has been undertaken as one of the major program in the Third National Land Development Plan.

   Since this program includes the construction of diverse and massive infrastructures, such as new city, industrial complexes, airfields, harbors, and waste disposal site, on weak marine clay formations in the near coast areas, a comprehensive study on geotechnical characteristics of domestic marine clays is a prerequisite to provide appropriate and effective schemes for design, construction, and maintenance of structures to be built in the coastal area of weak marine clay.

4. Objectives

   The purpose of this research is to establish a systematic Data Bases on engineering properties of the domestic marine clays.

5. Methodology

   - Theoretical research on fundamental behaviour of marine clay soils and provision of the method to evaluate engineering properties of the marine clay.
   - Construction of Data Bases and study on the correlations between various engineering properties of the marine clay.

6. Anticipated Results

   - Provision of the systematic Data Bases for evaluation of engineering characteristics of the domestic marine clay.
   - Optimum design and construction scheme for the embankment and foundation.
   - Development of the method for the failure prediction and stability analyses.

■ Water Resources Engineering Division

1. Research Projects

   Development of a Method for Determination of Equilibrium River Profiles

2. Period : 1993. 1. 1 ~ 1993. 12. 31

3. Background and Research Needs

   - Existing methods for determining equilibrium river profiles lack a credibility and justification of their formulations.
   - These methods are being used for river maintenance works and planning.
   - Serious problems, such as excessive scours and depositions of the river, may occur due to the use of these uncertain methods.
   - Development of a new method for determining equilibrium river profiles, therefore, is necessary.

4. Objectives

   - Developing a new method for equilibrium river bed slope

5. Methodology

   - Investigation of the methods which have been used in calculating the equilibrium river bed slope in river engineering practice.
   - State of the art review
   - Analyzing the existing methods in its structural and logical viewpoint
   - Collecting and arranging the geometric and hydraulic data
   - Developing a new method for equilibrium river bed slope
   - Comparing with the result of some mathematical models

6. Anticipated Results

   - Developing a new method for equilibrium river bed slope, which will replace the existing ones.
   - Suggesting a reliable method for estimating equilibrium river bed slope for channel improvement or river planning.

■ Environmental Engineering Division

1. Research Projects

   A Study on the Use of Aeration Tank and Soil Filter Adsorber for Odor Control in Sewage Treatment Plants

2. Period : 1992. 1. 1 ~ 1993. 12. 31

3. Background and Research Needs

   - Sewage treatment plants are necessary facilities for water quality management but are regarded as disgusting ones
   - The odor problems at the existing plants threaten workers health and safety, cause lower laud value, declinig environmental quality, and other social problems.
   - Lack of basic data for design and operation of odor control facility
   - From the preliminary research for the odor problems at the existing sewage treatment plants, it was proposed that the best alternative for the odor control is the use of aeration tank and the soil filter adsorber
   - Therefore, it is necessary to make research on establishing an odor control in detail by using the aeration tank & the soil filter adsorber.

4. Objectives

   - Proving odor causing substances according to the processes at a sewage treatment plant
   - Feasibility study for the employment of microbial odor control technique
   - Find design & operation factors for the odor control facility by employing aeration tank and soil filter adsorber supply
   - Develop odor-control process for the design of odor-control facility at a sewage treatment plant

5. Methodology

   - Literature search
   - Investigate the reality by surveying field facilities
   - Laboratory analysis by Bench-Scale & Pilot-Plant operation

6. Anticipated Results

   - Improvement of work condition & health environment for the operators at STP
   - Eliminate public discontent, improve living environment, and restore amenity value around the treatment plant
   - Use the results as basic data for odor-control facility design
   - Propagation of odor-control facility in conjunction with economical control process development.

■ Architecture Division

1. Research Project

   Guidelines for Maintenance and Modernization of Existing Buildings

2. Period : 1993. 1. 1 - 1995. 12. 31

3. Backgrounds and Research Needs

   There has been growing recognition that existing buildings represent sizeable economic resources and thus should be managed and maintained in the way to extend their usable life. This has led to greater attention on building maintenance and modernization activities. Despite this growing recognition and increasing amount of current building stocks, only a few research works have been reported regarding this subject.

4. Objectives

   This research project aims mainly at three objectives as follows.

   - Part A - Standards for the evaluation of building deterioration
   - Part B - Technical skills for building repair
   - Part C - Development of a maintenance program

5. Methodology

   In order to meet the above mentioned objectives and to establish maintenance computerization, related data will be collected using survey methods as follows.

   - Survey 1 will focus on current practices regarding building repairs, maintenance, and management.
   - Survey 2 will be a case survey about prior developments of repair, computerization and maintenance operations.

6. Anticipated Results

   - Practical guidelines for the evaluation of building deterioration
   - Skills and methods for building maintenance and modernization.

■ Machanical & Electrical Engineering Division

1. Research Projects

   A study on the Heating System for Residential Building Using Low Temperature Waste Heat

2. Period : 1993. 1. 1 ~ 1993. 12. 31

3. Background and Research Needs

   The conventional waste heat utilization has been the use of high temperature waste heat in the industrial fields.

   However, a huge amount of the low temperature waste heat is actually exhausted from urban facilities, office and residential buildings.

   According as the ratio of energy demand for urban living is highly increasing, it in urgently required to study the technology to recover the low temperature waste heat.

4. Objectives

   It becomes a ultimate goal to seize the amount of the low temperature wast heat, which has been unused energy source in urban areas, and to purse the possibility of utilization.

   Eventually, the results of this project will assist in developing innovative energy saving system for residential buildings.

5. Methodology

   A small residential building model will be constructed to simulate the expected heating energy consumption on the various selected systems and strategies.

6. Anticipated Results

   This project is intended to be used as a general guide for designers, consultants, and building owners or operators who desire to retrofit or install new heating systems for energy saving in residential building.

■ Construction Engineering & Management Division

1. Research Projects

   A Preliminary Study on Application of Geographic Information System for National Facilities

2. Period : 1993. 1. 1 ~ 1993. 12. 31

3. Background and Research Needs

   - Efficient maintenance and management of national facilities by utilizing Geographic Information System
   - Necessity of integrating national facility information
   - Minimizing environmental and traffic impact of national facilities

4. Objectives

   - Search for the fundamental list of national facilities management information
   - Preliminary study on the maintenance and management of national facilities by utilizng Geographic Information System
   - Preliminary study on the application of Geographic Information System for environmental and traffic impact assessment

5. Methodology

   - Investigating foreign cases
   - Analizing national facility management operation
   - Building a pilot system

6. Anticipated Results

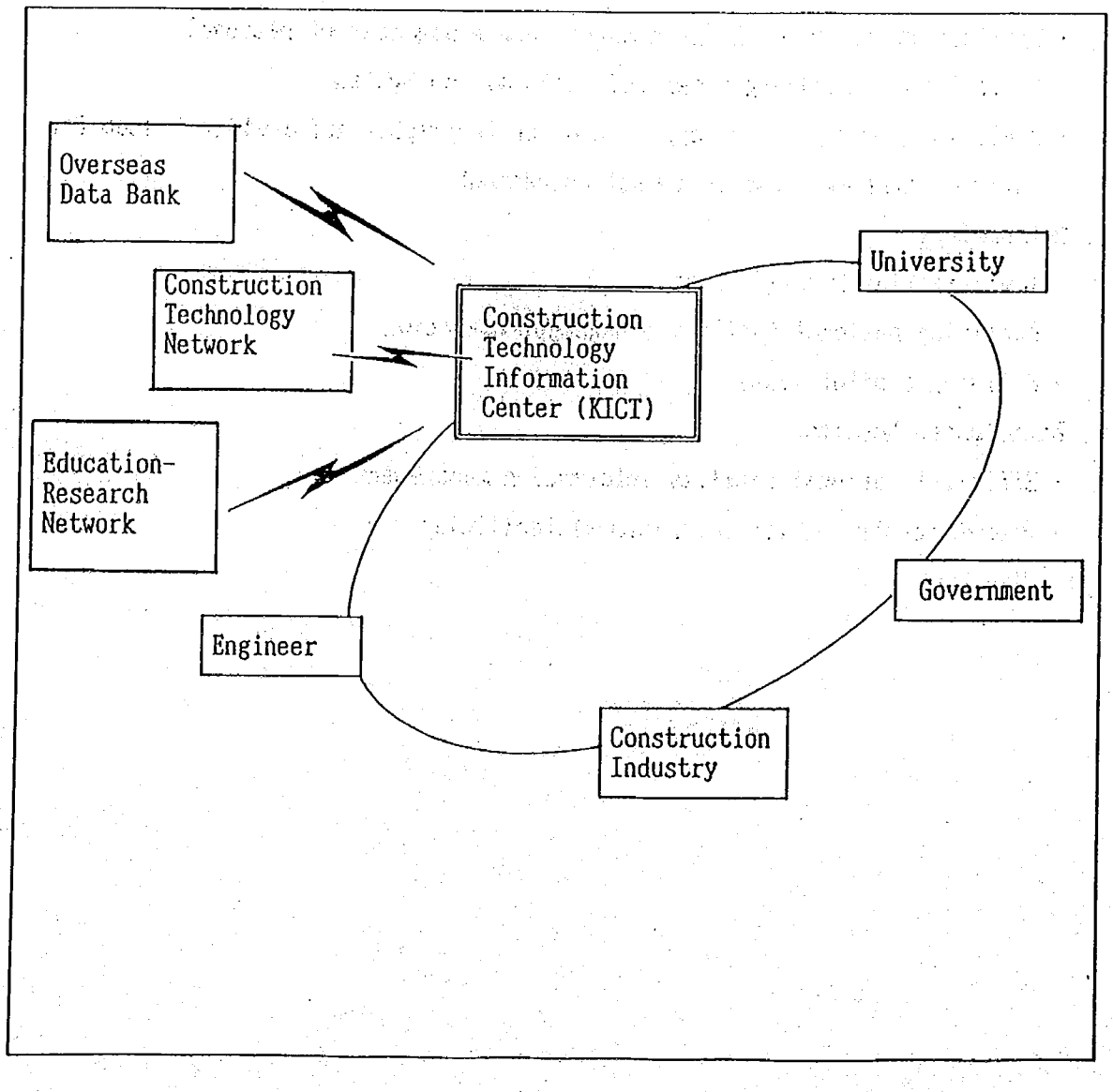
   - Efficient national facility information management
   - Prompt repair service for national facilities

4. 3 Construction Technology Information Center

1. Objectives

In order to improve the quality of construction products and to improve the international competitiveness toward the 21st century, the construction industry requires to have well-defined information system for construction technologies which would collect the information of Korea as well as abroad. The information system is mainly composed of the following ; · Data collection & Management, · Database Establishment, · Information Dissemination & Circulation and · Computer system management.

2. Basic strategy for information management



3. Plan for development of technology information system

The development of the information management system will be accomplished in 3 phases as shown in the Table-2 with a target year of 2001.

Table-2 : Development of technology information system

Phase I Preparation phase ('88 -'91)	Phase II Establishment of information center ('92 - '96)	Phase III Operation and further development ('97 - 2001)
• Investigate the sources of construction technology information	• Systematic management scheme for informations	• Establishment of On-line service system through information communication network
• Internationa cooperation & Exchange	• Development and expansion of D/B system	• Commencement of full service
• Extablishment of joint exchange and utilization between related organization	• Commencement of information service to government, construction industry and other related organization	
• Development of D/B system	• Participate in international information Service Network and test run	

5. International Cooperation

5. 1 Present Situation

KICT has maintained cooperation relationships with 58 major organizations in advanced countries related to construction technology.

KICT will continue to promote a series of cooperation programs, i.e., information and personal exchange, joint research, international seminar, etc. in the fields of mutual concern by keeping a close line of communication with these organizations.

- International seminars on construction technology
  - 1st seminar : 1983. 11. 22, Seoul, Korea
  - 2nd seminar : 1984. 1. 27, Seoul
  - 3rd seminar : 1984. 6. 22, Seoul
  - 4th seminar : 1984. 10. 30-31, Seoul
- Joint research with NIST
  - Agreement in cooperation relationship : 1984. 10. 4, USA
  - joint research : 1984-1988
- KICT/MIT joint workshop
  - Agreement in research exchange : 1984. 10. 5, USA
  - KICT/MIT joint workshop : 1985. 8. 27-28, Seoul
- International symposium on special problems of alluvial rivers
  - 1991. 9. 16-19, Seoul

5. 2 JICE (Japan Institute of Construction Engineering, Japan)

- 1989. 6. 3 KICT, JICE have a mutual agreement in research exchange.
- 1990. 9. 5 1st Korea-Japan Construction Technology Seminar in Seoul
- 1991. 8. 27 2nd Korea-Japan Construction Technology Seminar in Tokyo
- 1992. 9.2-3 3rd Korea-Japan Construction Technology Seminar in Seoul
- 1993. 8. 31 - 9. 1 4th Korea-Japan Construction Technology Seminar (scheduled in Tokyo)

5. 3 PI (Permafrost Institute, Russia)

- 1990. 2. 21 Holding international seminar on 'Construction Technology for Cold Regins'(Seoul)
- 1990. 9. 25 Cooperation Agreement between KICT and PI

- 1991. 9.-1992. 9. KICT dispatched a researcher to PI for joint research
- 1992. 11.17 Holding a seminar 'Problems of Construction in the Permafrost Area'(Seoul)

5. 4 VTT (Techniclal Research of Finland, Filand)

- 1991. 12. Minister of Construction(Korea) visited to Finland, agreed technical cooperation between two contries.
- 1992. 9. President of KICT visited to VTT, discussed the technical cooperation.

5. 5 PWRI (Public Works Research Institute, Japan)

- 1987. 12.20 Ministry of Construction(Korea) and PWRI discussed technical exchange between Japan and Korea.
- 1989. 12. KICT dispatched a researcher to PWRI for one month.(the field of environment)
- 1990. 8. The Vice President of KICT visited to PWRI, discussed the technical cooperation
- 1990. 9. KICT dispatched a researcher to PWRI for one month.(the field of highway)

5. 6 Other organizations in contact with KICT

Organization	Country	Field of cooperation
·Reunion Internatioale das Laboratoires Dessais dt Recherches Sur les Materiau et Les Constructions	France	Architecture
·International Council for Building Research, Studies and Documentation	Netherland	Architecture
·International Water Resources Association	USA	Water Resources
·Americal Society of Civil Engineers	USA	Construction
·American Geophysical Union	USA	Water Resources
·American Water Works Association	USA	Water Resources
·Instrument Society of America	USA	Architecture

Organization	Country	Field of cooperation
·American Concrete Inst.	USA	Architecture
·American Society of Heating, Refrigerating and Air-Conditioning Eng.	USA	Civil Engineering
·International Association on Water Pollution Research and Control	UK	Environment
·Water Research Centre	UK	Water Resources
·Japan Society of Civil Engineers	Japan	Civil Engineering, Architecture & Building
·Building Research Inst., Ministry of Construction	Japan	Architecture & Building
·Japanese Society of Soil Mechanics and Foundation Eng.	Japan	Geotechnical Engineering
·Hydrologic Eng. Center	USA	Water Resources
·Water Eng. Research Lab.	USA	Environment
·Construciton Industry Inst.	USA	Construction
·Water Resouces Research Center	USA	Water Resources
·Construction Eng. Research Lab.	USA	Construction
·Argicultural Research Service	USA	Water Resources
·Soil Conservation Service	USA	Geotechnical Engineering
·National Building Technology Centre	USA	Construction
·Transportation Research Board	USA	Highway Engineering
·Massachusetts Inst. of Technology	USA	Civil Engineering
·Texas A & M Univ.	USA	Civil Engineering
·Univ. of Texas at Austin	USA	Civil Engineering
·Research Inst. of Shimizu Construction Co. Ltd.	Japan	Construction
·Research Center Daisei Corporation	Japan	Construction
·Kajima Inst. of Construction Technology	Japan	Construciton
·Inst. of Construction Eng	Japan	Construction
·Disaster Prevention Research Inst.(Kyoto Univ.)	Japan	Construction
·Inst. of Hudrology	UK	Water Resources
·Transport and Road Research Lab.	UK	Highway Engineering
·Federal Inst. for Materials Testing	Germany	Architecture & Materials
·Federal Highway Research Inst.	Germany	Highway Engineering
·Federal Inst.of Hydrology	Germany	Water Resources

Organization	Country	Field of cooperation
•Statens Byggeforsknings Inst.	Germany	Architecture
•Centre National de La Recherche Scientifique	France	Construction
•International Tranining Centre for Water Resources Management	France	Water Resources
•Centre Scientifique et Technique du Batiment	France	Architecture
•International Commission on Large Dams	France	Water Resources
•Danish Building Research Inst.	Denmark	Construction
•Centrl Building Research Inst.	India	Architecture
•National Council for Cement and Building Materials	India	Architecture
•Ret-Ser Eng. Agency	Taiwan	Construction Management
•Houstin & Development Board	Singapore	Architecture
•Hungarian Inat. for Building Science	Hungarry	Architecture
•Technical Univ. of Buda pest	Hungary	Civil Engineering
•Inst. for Research in Construction	Canada	Construction

6. Water Quality Conservation

6. 1 Water pollution problem

Korea has limited water resouces. The average annual rainfall exceeds world average, however, since about two-thirds of annual rainfall is concentratad in only about four months, the water pollution becomes more serious during dry season while the surface water run off during rainy season is being discharged into sea with flood.

To deal with this problem, large and numerous dams have been constructed to provide storge reservoirs, flood control and for energy production. However, due to long hydraulic retention time of the artificial lakes, water quality is deteriorated even farther and eutrophication of water supply reservoir would soon become of major concern. The serious water pollution problem had been experienced mainly at the waterbodies near large cities and industrial complexes, however, the problem is now experienced everywhere and they become nation-wide problem.

Recently Korea has experienced sewage episodes of drinking water contamiation which, in turn, has made the environmental problem to get major attention from the government and also from the public. Concerning these, this paper has been prepared to review the current situation of water pollution in Korea and to suggest strategic plan for improvement of water quality.

6. 2 Rivers and Lakes

Under the River Act, rivers in Korea are classified as three Classes(Ministry of Environment(1992)) : Class A rivers are directly administered by the Ministry of Construction while Class B rivers are administered by local government. Class C rivers are also administered by local government but are indirectly governed by the water Act.

Total number of rivers which are designated by the Act, including 62 Class A rivers, 55 Class B rivers and 3,847 Class C rivers is 3,964 with total extension of 30,426km as shown in Table-1. There are also 34,958 tributaires and small rivers with total extention of 39,110km which are not designated by the Act.

Table-1 : Rivers in Korea by River basin

river basin	basic area (km^2)	extension(km)							
		Total		Class A		Class B		Class C	
		No.	ext.	No.	ext.	No.	ext.	No.	ext.
Total	88,747.5	3,964	30,416	62	2,858	55	1,320	3,847	26,238
Han	26,018.0	705	7,257	15	814	12	553	678	5,890
Nakdong	23,817.3	825	7,460	10	830	10	191	805	6,440
Keum	9,810.4	503	3,742	11	402	20	362	472	2,998
Yongsan	3,371.3	185	1,472	5	197	2	46	178	1,229
Sumjin	4,896.5	284	2,071	3	237	1	22	280	1,812
others	20,834.0	1,462	8,414	18	379	10	146	1,434	789

Table-2 summarizes the pertinent dimensions of the major lakes in Korea. While there are 207 lakes in Korea, the most major lakes are artificial lake. If the lake has hydraulic retention time of longer than 3.6 days with enough concentrations of nitrogen and phosphorus, the lake is considered to be readily become eutrophic lake. (Japan study group of water quality regulation(1996). Therefore it can be said that the most artifical lakes in Korea are prone to become eutrophic since Table-2 indicates that hydraulic retention times of the major lakes are fairly long.

Table-2 : Pertinent Data of Major Lakes

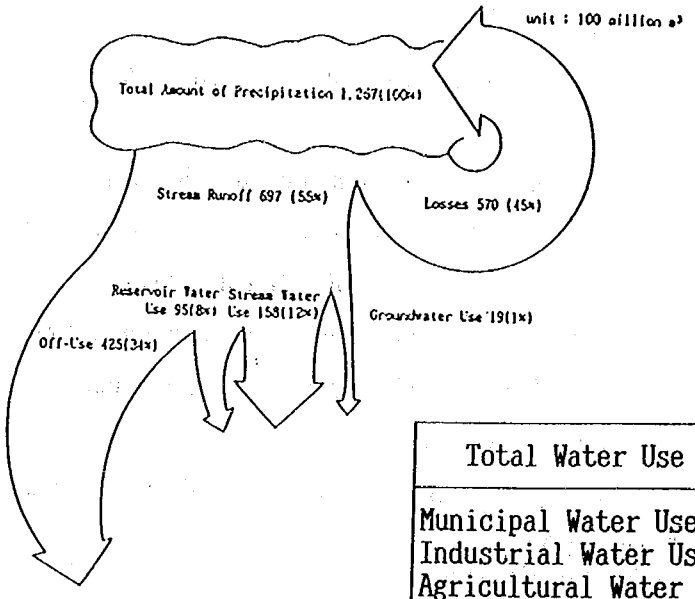
Lake	Inflow ($10^6m^3/yr$)	Total storage (10^6m^3)	catchment area (km^2)	Aug depth (m)	HRT (days)	surface area (km^2)
Soyang	1,874.5	2,900	2,703	41.4	562	70.0
Paldang	16,505.2	244	23,800	6.7	5	36.5
chungju	4,610.3	2,750	6,648	28.4	217	97.0
Andong	1,098.5	1,230	1,584	23.9	410	51.5
Namgang	1,584.6	136	2,285	5.8	31	23.7
Hapcheon	641.4	794	925	28.8	435	27.6
Imka	852.9	1,060	1,230	22.1	456	48.6
Seomjingang	592.1	466	763	17.6	287	26.5
Juam	700.4	860	1,010	14.0	451	61.3
Daechung	2,864.8	1,490	4,134	20.5	190	72.8

6.3 Water Resources and Water Use

The average annual rainfall of Korea is about 1,274mm which is 1.3 times of the world average of 973mm, however, annual runoff per capita in Korea is only

3,000m³ which is only one eleventh of the world average of 34,000m³. About 65% of annual rainfall is concentrated in four months, June to Semptember, and thus the most rainfalls during this season are lost with flood.

Figure-1 shows the water balance of Korea. Among total annual precipitation of 126.7 billion tons, 45% are lost through evaporation and/or infiltration, and the rest 55%(69.7 billion tons) become surface runoff. However, since 42.5 billion tons are directly discharged into the seas mainly due to flood, the available annual surface runoff becomes only 25.3 billion tons.



Total Water Use	272(100%)
Municipal Water Use	47(17%)
Industrial Water Use	25(9%)
Agricultural Water Use	150(55%)
Environmental Water Use	50(19%)

Figure 1. Water supply and Use (1990)

It is now belived that there are at least 1.3 trillion tons of ground water, however, technical and economic feasibility of groundwater development is fairly limited consideriag the soil and ground conditions.

6. 4 Pollution of Rivers and Lakes

6. 4. 1 Sources of pollution

The major source of pollution are domestic sewage and industrial wastewater. Besides these major sources, various livestock wastes also make some contribution due to its high strength although the quantity is not very significant.

As of the end of 1991, the daily sewage generation was 10.217 million tons while the industrial wastewater discharge was 7.28 million tons/day. The number

of industrial wastewater discharger had been increased from 4,000 in 1980 to 13,500 in 1990 as shown in Table-3. The rate of livestock wastewater generation has also been increased as more meats are now being consumed than before. Table-4 shows that the manures of cattles and pigs are the major components of liveslock wastes generated.

However, the soures of liveslock wastes are so scattered that the control of these wastes is very difficult and thus the most of these wastes are discharged without being properly treated.

Table-3 : Indrestrial Wastewater Dischare by Year

Year	No. of Indrestry	Wastewater (10^3m^3/day)
'80	3,984	1,962
'81	4,920	2,209
'82	5,671	2,760
'83	5,924	2,538
'84	6,422	2,729
'85	7,375	3,109
'86	7,900	4,489
'87	8,570	4,603
'88	9,522	5,983
'89	11,203	6,499
'90	13,504	7,280

Table-4 : Geveration of Livestock Wastewatr ('87)

	No. of Livestock	Wastewater(ton/day)
Cattle	2,386	71,580
Horse	3	120
Pig	4,281	21,415
Poultry	59,910	8,987

6. 4. 2 Water pollution levels

Table-5 summarizes the BOD levels of upstream, midstream and downstream of 4 major rivers, i.e. Han River, Nakdong River, Keum River and Youngsan River.

Water qualitiy of upstream and midstream of Han River are fairly good, however, it becomes poor at downstream as several heavily polluted tributaries, are joined with Han River.

Table-5 : Current and Projected BOD levels of mainstream of major rivers

River	'89	'91	'96
Han (Noryangjin)	3.4	3.9	4.9
Nakdong (Mulgeum)	3.6	4.0	5.0
Keum (Buyeo)	3.5	3.0	5.4
Yungsan (Naju)	6.6	7.0	7.6

Water quality of upstream Nakdong River is also good showing 0.8mg BOD/L at Bongwha, however, as the river receives Keumho River which is heavily polluted with wastewater from City of Daegu and tremendous amount of various industrial wastewaters, the water quality is deteriorated. The water quality is slightly improved at downstream mainly by self purification of the river while there are no major pollution sources between midstream and downstream.

The water quality of Daecheong Reservoir, which is located at upstream of Keum River and is the major source of public water supply for Central Korea, does not meet the First-Grade grade I water quality standard while those of midstream and downstream become even worse as sewage and industrial wastewater from various sources including City of Daejeon and Cheongju City are discharged to the river.

The length of Youngsan River is shortest among 4 major rivers and the river basin area is not very large, however, several reservoirs including Naju, Changsung and Kwangju reservoirs with total storage capacity of 26 million tons are located at upstream mainly for agricultural purpose. Because of the reservoirs, the average flow rate of the river becomes rather low and thus BOD at the junction of the river and Kwangju Chun is very high i.e. about 10.6 mg/L since Kwangju Chun is heavily polluted with sewage and industrial westewater from City of Kwangju. Table-5, however, shows that the water quality is again improved at downstream.

Table-6 shows representative BOD levels of tributaries which have been considered as typical heavily polluted streams with BOD level close to sewage. As several sewage treatment plants and industrial wastewater treatment plants are being operated, the water quality of these tributaries have been improved, however, BOD levels are still very high.

Table-6 : BOD level of heavily polluted tributaries

Tribuary	'87	'88	'89	'90
Keumhogang	69.8	98.7	47.5	36.9
Chungryangcheon	37.5	36.5	30.0	31.6
Kwangjucheon	31.7	35.8	38.3	25.0
Kapcheon	17.2	31.9	28.2	15.5

6. 4. 3 Water pollution control facilities

The domestic sewage and some industrial wastewater are being treated primarily with approx 14,000 septic tanks and 1,300 small scale treatment facilities. As of the end of 1991, 22 sewage treatment plant are in operation treating approx 5.4 million tons of sewage per day which is equivalent to 33% of total daily sewage generation in Korea.

Table-7 summarizes the type of treatment methods currently employed in Korea to treat industrial wastewater. Although there are many industries which employ very simple treatment mothods, such as sedimentation, filtration or neutralization, some industries employ rather advaned technologies, such as A/C adsorption, ion exchange or membrane processes. However, many industries employ combined wastewater treatment system or joint treatment system consisting of physial, chemical and biological treatment processes.

Countrywide, the percentage of flush toilets is 43% and the rest of approx 43,600m^3/day nightsoils are being treated by several means before disposal. The large portion of nightsoils, approx 15,000m^3/day, is treated at nightsoil treatment plants in urban area. About 3% of nightsoils are decomposed in tanks with long retention time, while the rest 19% are being handled in some other means, such as composting or ocean dumping.

Livestock farms which grow more than 1,000 pigs or more than 100 cattles or horses with the farm area larger than 1,400m^2 or 1,200m^2, respectively, should treat the wastewater to meet the effluent BOD and SS standards of 150mg/L. The wastewater discharged froms the smaller farms with the area of 150~1,400m^2 for pig farms and 350~1,200m^2 for cattle or horse farms should meet the BOD standard of 1,500mg/L. However, the most livestock farms are rather small scale, only 30% of the livestock are regulated by the laws and thus wastewater generated form 70% of livestocks are not properly treated before disposal.

Table-7 : Type of treatment method for industrial wastewater

Type	Number	Capaiety(10^3m^3/day)
physical	1,338	120
physical + chemical	7,742	1,487
physical+biological	877	335
combined	708	5,093
Joint treatment	632	227
others	1,704	19

6. 4. 4 Projection of Water Quality

Domestic sewage and various industrial wastewater will still be the major source of water pollution. The total population will be 47 million in the year 2001 as the population increases at consistent rate of 0.8% per year. Urbanization will be accelerated to reach 86.2% of urbanization rate by the year 2001.

Table-8 shows the projection of industrial production of four representalive industries. During the last decade, the index of industrial production of Korea has been tripled and this remarkable rate will be continued with average incremental rate of over 9% per year as shown in Table-8. Although it is expected for the industries to employ pollution prevention technology (or clean technology), the industrial wastewater dischage will still be increased.

The current Seventh Five-Year Economic and Social Development Plan (92-97) projects that sewage generation will be increased by 4% while industrial wastewater will be increased by 28% during this period and thus industrial wastewater will become the most significant pollution source since 1993 as appeared in Table-9

Talbe-8 : Projection of industrial productor for selectal industices

	'91	'96	2001
petrochemical (10^3ton)	4,230	5,757	7,071
steal (10^3ton)	25,000	29,000	33,500
VTR ($x10^3$)	10,990	12,090	12,700

Table-9 : Projection of wastewater generation

	'91	'93	'95
Domestic sewage	10,217	11,855	12,291
Industrial wastewater	9,356	13,472	17,400
Livestock wastewater	89	92	96

6. 5 Strategic Plan for Water Quality Conservation

6. 5. 1 Five-year plan for improvement of environmental quality

The Ministry of Environment has established a Five-year ('92-'96) plan to improve environmental quality. The plan includes the following five strategies to improve water quality of major water bodies ; a) Strongly implement the strategy to protect the water quality of areas designated as Conservation Area for. b) Determine rational target of water quality for each river and lake and also establish the monitoring systems., c) Strengthen the control of wastewater dischargrs considering the water quality target. d) Implement the systematic treatment methodology of sewage and industrial wastewater, and e) Rehabilitate the rivers to recover the self-purification capacity of rivers and lakes and also to improve water quality.

The more details of the plan are follows ; Firstly to protect the water qualities of Paldang Reservoir and Daecheong Reservoir, which are the major sources of water supply of Seoul area and Central Korea, the area around these two reservoirs have been designated as special conservation region. Any development works in these areas are limited and the limits for wastewater discharge are strongly enforced and the construction of water pollution control facilities including sewage treatment plant in these areas has the highest priority in the Nation. This concept of special conservation region will be gradually applied to area around other important reservoirs.

Secondly the water quality control plans for each major river basin have been established. The strategies in the plan will be strongly implemented to achieve the water quality target by expanding the water pollution control facilities including sewage treatment plant and combined treatment facilities of livestock wastewaters.

Thirdly more stringent but more rational discharge permit will be gradually established. For example trichloroethylene and tetrachloroethylene will be regulated from January 1, 1993 and discharge limits of Nitrogen and phosphorus will be also applied to the treatment plants which discharge the effluent to the lakes designated by the Minister of Environment

During this period, it is planned to invest 3,873 billion wons to construct 100 sewage treatment plants for large cities and 152 small scale treatment plants for smaller cities(Eup's) as shown in Table-10 so that the sewage treatment rate will be raised to 65% by 1996. The plan for construction of

other treatment facilities are also included in this Table

Table-10 : Construction plan of various wastewater treatment plants for 1996

Type	Number	Capacity(10^3m^3/day)
• sewage treatment plant	76(18)	9,307 1,098
• Combined Industrial Wastewater Treatment plant	10(2)	934
• Combined wastewater treatment plant for agro-industrial complex	128 181	41.2
• Livestock waste treatment plant	32	4.73
• Niphtsoil treatment plant	34(50) 79	4.17

The investment plan also include the excavation of bottom sediment of polluted rivers also and the institutional and regulatory improvement plan so that the water quality of major rivers will be improved to maintain at least 2nd Grade level. After accomplishing this plan, the percentage of drinking water intake for First Grade sources will be increaced from 34% to 70%

6. 5. 2 **Long term strategy for water quality conservation**

It is now almost impossible to maintain water quality of all waterbodies to the level of drinkable water and it is not economical even in the advanced conuntries. Therefore it is very important to maintain water quality clean enough to protect beneficial uses and ecosystems of the waterbodies. For this porpose, the environmental capacity of the waterbody should be determined and all the dischargers should be regulated to discharge the polluants load which will not over this capacity. The long term plan, therefore, should be developed on the basis of the following essential idea.

a. Determine the environmental capacity of each river basin and develop the economically achievable and stepwise target for reduction of pollutant load. For this propose, not only environmental data but also many hydraulic data such as flowrate and pollutant emission rate should be accumulated.

b. Systematic plans should be developed and implemented to rehabilitate and construct sewers to make sure all the wastewater generated are properly collected and transported to treatment plant

c. Wastewater reclamation technology should be employed to conserve the

limited water resources by increasing reuse rate and also to reduce waste load to natural waterbodies. The standard for wastewater reclamation should be prepared and some incentives for reclamatan, such as tax benefit, should be considered.

d. To minimize the eutrophication of artifical lakes, which is the major water resources of Korea, the wastewater treatment should include the removal of nitrogen and phosphorus. It is believed that the effluent limit for T-N and T-P which will be applied in 1996 are too loose and thus much more stringent limit should be applied considering the local conditions.
e. It may be more economical to have small scale wastewater treatment plant rather than constructing sewers to scattered area.
f. In addition to improvement works of rivers, the riverside area can be used to construct in situ treatment facilities to lower the pollution level.
g. It would be more economical and effective to use pollution prevention technology (or clean technology) rather than employing end of pipe treatment which has been the major approach for pollution control. For this purpose, highly advanced technologies should be developed and/or introduced to the area of pollution control.
h. Long term plan for technology development of environmental control should be established and steadily carried out. It is fortunate that environmental control technology has been included in the category of the Highly Advanced Nationl Project for science and technology development(G7 project). For this year only, 4 billion wons of governmental fund is invested to 7 technical resersh projects in environmental field.

6.6 Conclusions

Due to rapid industrialization and unbanization of Korea, the sewage and industrial wastewater generation has been increased remarkably to increase pollution load to natrual waterbodies. Furthermore, the socio-economic and natural conditions of Korea, such as high population density, limited water resources and rapid conversion rate of traditional toilet to flugh toilet had worsen the water quality of rivers and reservoirs.

The Five-year plan for improvement of environmetal quality('92-'96) include rather inteusive strategy to improve water quality by investing 3,900 billion wons during 5 years and it is expected that the water quality will be improved

remarkably with completion of this plan.

However, for more effective water quality conservation, several other aspects should be considersl, such as rehabilitation and construction of sewers, removal of nitrogen and phosphorus with advanced treatment technolgy to prevent the lakes from eutrophication, and also introduction of small scale treatment facilities for unbarninged area and for livestock waste treatment.

It is also very important to convert the concept of pollution control from end-of-pipe treatment to pollution prevention technology to reduce the pollution load from various dischargers.

The Government, Industry and public should realize that they are not just victims of pollution but also the major polluters and should do their best for water quality conservation.

Ⅳ. Malaysia

Mr. Abdul Rahman B. Abdullah, Deputy Director-General,
Public Works Department

CONTENTS

Part I	:	The Outline of Malaysia
Part II	:	Public Works System in Malaysia
Part III	:	Research and Development Projects in Public Works Department Malaysia
Part IV	:	Disaster and Disaster Prevention
Part V	:	Harmony Between The Environment and Improvement of Infrastructure
Part VI	:	Proposals for Further Discussion

PART I : THE OUTLINE OF MALAYSIA

THE OUTLINE OF MALAYSIA

1.1 Topography

Malaysia comprises the Malay Peninsula, Sabah and Sarawak. The coountry has a total land area of around 330,433 sq. kms. (125,565 sq.miles) while Sabah and Sarawak are separated from the Peninsula by about 530 kms (330 miles) of the South China Sea. Peninsular Malaysia extends 740 km (460 miles) from Perlis in the north to the Straits of Johor (Selat Tebrau) in the south. It consists of the states of Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Pulau Pinang (Pinang), Selangor, Terengganu and the Federal Territory (Wilayah Persekutuan) of Kuala Lumpur. The Peninsula's coastline extends for some 1930 km (1,200 miles). Sabah dan Sarawak stretch some 1120 km (700 miles) from Tanjung Datu (Sarawak) in the west to Hog Point (Sabah) in the east, and have a coastline of around 2253 km (1,400 miles.)

In Peninsular Malaysia a mountainous spine known as the Main range or Barisan Titiwangsa runs from the Thai border southwards to Negeri Sembilan, effectively separating the eastern part of the peninsula from the western. A considerable part of the interior of Kelantan, Terengganu and Pahang is also mountainous and contains the highest peak in the Peninsula, Gunung Tahan (2187 m or 7,186 ft). As a result of the configuration of the country and of the heavy rainfall, there are many rivers which until just over one hundred years ago formed the main arteries for trade and travel and whose historical importance is underlined by the fact that nearly all of the states of the Peninsula take their names form the principal river in each. The longest of these rivers is the Sungai Pahang (475km/297 miles), followed by the Sungai Perak (400km/250 miles) and the Sungai Kelantan.

The rivers of Sarawak and Sabah are longer than those of the Peninsula.

The longest of them all is the Rajang of Sarawak (563 km)/350 miles) which is navigable for small coastal steamers as far as Kapit, 160 km (100 miles) upstream. The other principal rivers in Sarawak are the Baram (400 km/250 miles), the Batang Lupar (228 km/142 miles), the Limbang (196 km/120 miles) and the Sarawak (113 km/70 miles). In Sabah the four main streams are the Kinabatang (563 km/350 miles), the Labuk, the Segama (100 km/63 miles) and the Sugut, all of which flow eastwards to the Sulu Sea.

The interior of Sabah is criss-crossed by a series of mountain ranges and hills, the most prominent of which is the Crocker Range with an average of 762 to 914 m (2,500 to 3,000 ft), which separates the narrow lowland of the north-west coast from the interior. The Crocker Range culminates in Gunung Kinabalu (4,100 m/13,450 ft), the highest mountain in Malaysia and in Southeast Asia. Malaysia's third highest mountain, G.Tambuyukon 2597 m/8,462 ft), is close by, while the country's second highest peak, G.Trus Madi (2597 m/8,520 ft) is in the same range. In Sarawak the interior is generally mountainous, with the highest range lining the border with Indonesia. The two highest peaks in Sarawak are G.Murud (2425 m/7,960 ft) and G.Mulu (2371 m/7,779 ft) which also boasts one of the largest natural caves in the world.

About four-fifths of Malaysia (i.e., including Sabah and Sarawak) are covered by tropical rain forest. Rice cultivation is practised throught the Peninsula but the main and traditional centres are the states of Perlis, Kedah and mainland Pulau Pinang (Province Wellesley). Newer areas for large-scale rice cultivaion are also to be found in Perak, Selangor and Kelantan. Most of the larger rubber and oil-palm estates are located on the West Coast of the Peninsula, as are also the nation's main tin deposits. The eastern side of the Peninsula is generally speaking far less developed agriculturally while its coast-line consists of long stretches of fine, sandy beaches in contrast to the dark groves of mangrove on the western shore. In Sabah and Sarawak an alluvial coastal plain, much of which is also fringed by mangrove swamps, lies between

the sea and the mountainous interior.

1.2 Climate

Malaysia lies entirely in the equatorial zone. The climate is governed by the regime of the north-east and south-west monsoons which blow alternately during the course of the year and whose existence in the days of sailing ships made the country the natural meeting and exchange point for traders from East and West. The north-east monsoon blows from approximately October till March, and the south-west monsoon between May and September, the periods of change between the two monsoons being marked by heavy rainfall. The north-east monsoon coming from across the open South China Sea is responsible for the heavy rains which hit the east coast of the Peninsula and frequently cause widespread floods, particularly between December and February, and likewise cause the wettest season in Sabah and Sarawak. Only Kedah and Perlis lying too far north to be properly affected go through a dry spell during this period. On the other hand the period of the south-west monsoon is a drier period for the whole country, particularly for the other states of the west coast of the Peninsula, sheltered by the land mass of Sumatra. Being in the tropics the average temperature throughout the year is constantly high (26°C or 80°F). The diurnal temperature range is about 7°C/12°F and the annual temperature range is less than 1°C/2°F. Regional variation in temperature and rainfall is mainly due to relief, e.g. Cameron Highlands has a mean temperature of 18°C/65°F and an annual rainfall of over 2500 mm/100 inches compared to Kuala Lumpur's 27°C/81°F and 2410 mm/95 inches. Near the coasts land and sea breezes modify the temperature, while being surrounded on virtually all sides by sea results in the Peninsula's rather equable climate. Mornings are generally fine and conventional rainfalls in the late afternoons are often accompanied by lightning and thunder. The humidity is high (about 80%) due to the high temperature and high rate of evaporation, and the rainfall heavy (more than 2500mm/100 inches). In general, Sabah and Sarawak experience a greater rainfall than the Peninsula.

1.3 Demography

The outstanding characteristic of Malaysia's population today is its highly variegated ethnic mix which makes it one of the prime examples of a multi-racial society in the whole world. The multi-ethnic character of Malaysia's population has come into being over the course of the last 150 years. Broadly speaking Malaysia's ethnic groups fall into two main categories; those with cultural affinities indigenous to the region and to one another, who are classified as bumiputera; and those whose cultural affinities lie outside.

Bumiputera Groups

The bumiputera groups themselves are highly differentiated. There are three broad categories: (1) the aborigines (orang Asli); (2) the Malays; (3) Malay-related. The aborigines represent the oldest element in the population but survive in only small numbers and in scattered groups, mainly in the Malay Paninsula.

The Malays form the predominant ethnic group in the Malay Peninsula, a substantial minority in Sarawak and a smaller group in Sabah. A distinction may be drawn between those Malays long settled in the country especially the Malays of the East Coast of the Peninsula, in Sarawak, Sabah (and Brunei), and those who crossed the Straits of Melaka from Sumatra and settled in considerable numbers during the latter part of the nineteenth and in the twentieth centuries. Other ethnic groups regarded for practical purposes as Malays, and most of whom have settled in the country (mainly in the Malay Peninsula) since 1850, include the Javanese - especially on the western coasts of Johor, Selangor and Lower Perak, the Banjarese, Boyanese, Bugis and Minangkabau. Into the same category also fall the Bajau of Sabah. The quick assimilation of these groups into the Malay community is a result of common cultural traits and, above all, the bond of Islam.

The third or non-Malay bumiputera category consists of ethnic groups

found in Sarawak and Sabah. In Sarawak the largest of these are the Iban who also form the largest ethnic group in the state, while others include the Bidayuh (formerly known as Land Dayaks), the Melanau, Kenyah, Kayan and Bisayah. In Sabah the Kadazan (Dusun) form the largest single ethnic group, with the Murut, Kelabit and Kedayan forming significant minorities. These groups represent peoples of the same basic stock who entered the country during the period of early migration. They followed a shifting mode of agriculture, and have acquired their present identities and characteristics in a process of separation and refusion over centuries.

Non-Bumiputera Groups

These consist primarily of the Chinese and the Indians, with much smaller communities made up of Arabs, Sinhalese, Eurasians and Europeans. Chinese and Indian contacts with Malaysia go back to the dawn of history but there was no substantial permanent settlement in the country by these two groups until the nineteenth century - with the exception of the Chinese baba community of Melaka who can trace their ancestry to sixteenth century Melaka. The reason for the massive immigration of Chinese and Indians that started to take place in the nineteenth century was the rapid economic development which began under the impact of the forces of the Industrial Revolution and the *laissez-faire* policies followed by the new British colonial administration in the Straits Settlements. The Chinese found opportunities for investment and labour in the expanding tin mining industry and the Indians primatily as agricultural labour on coffee and later rubber estates.

Immigration into the Malay Peninsula and into the Borneo territories remained unrestricted until 1931 when the impact of the Great Depression forced the imposition of controls. However, up till this point the nature of Chinese and Indian immigration was essentially transitory and the number of local-born Chinese and Indians was low in proportion to the total number of immigrants in the country. The imposition of immigration controls reduced the

number of immigrants drastically, rapidly normalized the sex ratio, and resulted in predominantly local-born Chinese and Indian communities. The outbreak of the Second World War and the Japanese Occupation effectively ended Chinese and Indian immigration altogether.

The Chinese population of Malaysia is largely derived from South China, with the Cantonese and Hokkien forming the largest dialect groups. Amongst the Indians the largest group are the Tamils from South India and Sri Lanka, with significant Sikh and Malayalee minorities.

Until the 1980s it was official policy to encourage a slow growth rate in the population. This policy has now been reversed, and based on a growth rate of 3.2 per cent per annum the aim now is to achieve a target population of 70 million. Based on the growth rate just quoted this should be achieved by the year 2095.

1.4 Economy and Society

Overview

On Independence this country inherited from the British an economy which bore all the characteristics of a classical colonial one. In 1957 Peninsular Malaysia was the world's largest producer of tin and the second largest producer of natural rubber, while Sabah depended largely on its timber and Sarawak on its petroleum, rubber and pepper for their prosperity. The country's commanding position over these commodities was the source of the prosperity which it enjoyed and placed it well to the fore amongst Third World nations; at the same time the nation was dangerously placed at the mercy of the fluctuations of the world market, particularly in tin and rubber. The main aim of successive administration since Independence has been to end this dangerous reliance on two or three major commodities by diversifying the economy in the agricultural sector and by promoting industrialization in selected areas. The trend towards substantial industrialization has become particularly

marked in the present decade.

In the development of the national economy the Government plays a leading role, directly and indirectly. The general path of economic evoluation has been mapped out in a series of five-year plans and since 1971 guided by the philosophy of the New Economic Policy (NEP). The NEP was launched with the introduction of the Second Malaysia Plan (1971-75) with an avowed two-prong strategy 'to reduce and eventually eradicate poverty, by raising income levels and increasing employment opportunities, irrespective of race', and by 'accelerating the process of restructuring Malaysian society to correct economic imbalance, so as to reduce and eventually eliminate the identification of race with economic function'. The original target date for the achievement of these goals was scheduled for 1990, but it is now clear that the concepts behind the NEP will continue to be applied in economic planning and development after that date.

In line with the expected sluggish recovery in the major industrial countries, overall output growth in the domestic economy is expected to moderate in 1992. After four consecutive years of strong economic expansion since 1988, real gross domestic product (GDP) for 1992 is expected to grow by 8.5 per cent, compared with the 8.7 per cent achieved in 1991. The gross national product (GNP) in current prices is expected to rise at a faster rate of 13.8 per cent in 1992 in line with the price increases, compared with 11.8 per cent in 1991.

The stimulus to growth is expected to come from both the domestic and external sectors. In contrast to 1991, the external sector is expected to contribute positively to overall growth in 1992 as imports are expected to slow down substantially while exports continue to grow.

Domestic aggregate demand is projected to expand at a rate of 9.5 per

cent in current prices in 1993 (1992 : 9.1 per cent). The growth is envisaged to emanate from both the public and the private sectors, with the increase in public sector demand growth projected at 8.1 per cent. The private sector expenditure is projected to expand at a slightly higher rate of 9.7 per cent in 1993.

PART II : PUBLIC WORKS SYSTEM IN MALAYSIA

PUBLIC WORKS SYSTEM IN MALAYSIA

1.0 National Development Policy (NDP)

1.1 The objective of NDP is to attain balanced development in order to create a more united and just society. NDP which emphasizes growth with equity will enable all Malaysians to participate in the mainstream of economic activities, thereby ensuring political stability and national unity. Building upon the ongoing thrust of National Economic Policy (NEP) in eradicating poverty and restructuring society, NDP will encompass the following critical aspects :

- striking an optimum balance between the goals of economic growth and equity
- ensuring a balanced development of the major sectors of the economy so as to increase their mutual complementaries to optimize growth
- reducing and ultimately eliminating the social and economics inequalities and imbalances in the country to promote a fair and more equitable sharing of the benefits of economic growth by all Malaysians
- promoting and strengthening national integration by reducing the wide disparities in economic development between states and between urban and rural areas in the country
- developing a progressive society in which all citizens enjoy greater material welfare, while simultaneously imbued with positive social and spiritual values, and an increased sense of national pride and consciousness
- promoting human resource development including creating a productive and disciplined labour force and developing the necessary skills to meet the challenges in industrial development through a culture of merit and excellence without jeorpadising the restructuring objectives
- making science and technology an integral component of socio-economic planning and development, which entails building

competence in strategic and knowledge-based technologies, and promoting a science and technology culture in the process of building a modern industrial economy

- ensuring that in the pursuit of economic development, adequate attention will be given to the protection of the environment and ecology so as to maintain the long-term sustainability of the country's development.

2.0 Budget For Investment in Construction

2.1 The transport and communications sector will be allocated a sum of MR10,832 million or 19.7 percent of the total Federal Government allocation, in line with the objective to provide better infrastructure networks to meet the increased demand for the infrastructural facilities. Of this allocation, MR7,585 million will be for the expansion and upgrading of roads, including a sum of MR1,286 million for rural roads outside the Regional Development Authority areas. In addition, MR1,386 million will be allocated for the Malayan Railways, mainly for the purchase of rolling stocks, construction of double tracking system and modernization of the signalling and communications system. The development and improvement of new and existing airports will amount to MR997 million, of which MR176 million will be allocated for upgrading and improving the Subang International Airport while the development of ports will amount to MR758 million.

2.2 The energy and water resources subsectors will be allocated a sum of MR4,752 million. Priority will be given to the development and improvement of water supply schemes which will be provided a sum ofMR2,854 million. This includes an allocation of MR1,048 million for the rural water supply programme which involves the installation of reticulation systems in rural areas. The allocation also includes the construction of dams to conserve water resources as well as meet inter-state and inter-basin water transfers. To further improve the quality of water and the environment, some MR551 million will be allocated for the development of

sewerage facilities. A new financing system for sewerage projects is being considered in order to assist local authorities to expand these facilities.

2.3 In the energy sector, the bulk of the proposed development expenditure of PETRONAS and the electricity authorities will be financed from their internal funds. However, the Federal Government will allocate a sum of MR979 million to this sector, of which MR765 million will be for rural electrification. The rural electrification programme will enable the attainment of 100 per cent coverage for Peninsular Malaysia, 73 per cent for Sabah and 77 per cent for Sarawak, by the end of the Plan period. PETRONAS will spend about MR10,800 million for projects in the petroleum and gas sector. Investment allocations for major projects will include MR4,260 million for refinery projects in Melaka, MR1,650 million for the expansion of the LNG plant in Bintulu and MR1,480 million for petrochemical projects. Tenaga Nasional Berhad will spend about MR11,000 million during the Sixth Plan, mainly for power generation, transmission and distribution networks.

2.4 The allocation for the water resources sector during the Sixth Malaysia Plan period will be MR3,773 million. The major proportion of this allocation, amounting to MR2,855 million will be for water supply development. Of this, MR1,717 million will be for source development works, MR350 million for the upgrading of existing treatment plants and rehabilitation of distribution systems and MR787 million for reticulation systems development. As for sewerage development, the allocation will be increased substantially to MR551 million. The urban drainage programme will be allocated MR368 million.

3.0 Organizations Related To Public Works Department

3.1 Economic Planning Unit,
Prime Ministers Department,
Jalan Dato' Onn,
50502 Kuala Lumpur.

3.2 Implementation Coordination Unit,
Prime Ministers Department,
Jalan Dato' Onn,
50502 Kuala Lumpur.

3.3 Ministry of Finance,
Jalan Duta,
50592 Kuala Lumpur.

3.4 Ministry of Transport,
Wisma Perdana,
Jalan Dungun, Damansara Heights,
50616 Kuala Lumpur.

3.5 Ministry of Defence,
Jalan Padang Tembak,
50634 Kuala Lumpur.

3.6 Ministry of Health,
Blok C, Kompleks Pejabat-pejabat Kerajaan,
Jalan Dungun, Damansara Heights,
50590 Kuala Lumpur.

3.7 Ministry of Education,
Blok J, Pusat Bandar Damansara,
50604 Kuala Lumpur.

3.8 Ministry of Home Affairs,
Jalan Dato' Onn,
50546 Kuala Lumpur.

4.0 Major Projects In Progress

4.1 The New Kuala Lumpur International Airport

Construction Period - 5 years

Planned Completion Year - 1997

Cost of Construction - Not available

4.2 The North - South Toll Expressway

Planned Completion Year - 1994

Cost of Construction - MR5 Billion

5.0 History, Progress And Problems Of Major Infrastructures

- **Road Development**

Refer to the document attached

PART III : RESEARCH AND DEVELOPMENT PROJECTS IN PUBLIC WORKS DEPARTMENT MALAYSIA

EXECUTIVE SEMINAR ON PWD RESEARCH & DEVELOPMENT IN TOKYO

1. RESEARCH AND DEVELOPMENT PROJECTS IN JKR MALAYSIA

1.1 Introduction

Research and development in JKR (PWD) Malaysia is carried out by the Public Works Institute Malaysia (IKRAM), a training and research institute under JKR Malaysia.

Research activities in JKR Malaysia prior to 1988 has been on an ad-hoc basis carried out individually by the respective JKR Branches. In 1988, the JKR Research Centre was established and became responsible for coordinating and carrying out all research activities within JKR Malaysia. It was amalgated with the existing Training Centre to form the JKR Training and Research Institute. To better reflect its expanding role, the Institute's name was changed to Public Works Institute Malaysia in December 1991.

1.2 Major research programmes

The main thrust of the current research programmes are in two areas, namely pavement and geotechnical engineering. However under the 6th Malaysia Plan (1991-1995), it will be expanded to include traffic engineering, road safety, water supply engineering and building technology.

Appendix 1 give details of the various research programmes and their sub-programmes.

1.3 Research Management Structure and Process

1.3.1 The research management structure at IKRAM is implemented following a 4 level structure, i.e:

- Research Advisory Committee
- Research Management Committee
- Research Technical Committees
- Research Teams

The **Research Advisory Committee** (RAC) is chaired by the Director General of Public Works and has wide representations from central agencies such as Treasury, Economic Planning Unit, relevant Government Departments and local institutions of higher learning. It is the overall guiding body for the direction and research programmes at the Institute to ensure that it meets the need of the country. It also functions to prevent any duplication of research efforts with local universities and other research bodies.

The **Research Management Committee** (RMC) is the highest departmental committee and is responsible to coordinate the research programmes and resolve management problems. It also acts as a link between JKR and the RAC and ensures that decisions of the RAC are followed and carried out. The Committee is chaired by the Director of Management, JKR Headquarters.

The various **Research Technical Committees** at the IKRAM is responsible to ensure that each individual research project is carried out properly and achieve its objective. The Committee is opened to invited members from academicians or lower JKR officers who possess the experience or expertise relevant to a specific research project. The Committee is chaired by the Director of the Institute.

The **Research Teams** comprises of the research engineers who are carrying out the research work.

1.3.2 The research process at IKRAM follows a 5 stage structure, i.e.

Stage 1	-	Project Initiation
Stage 2	-	Feasibility Study
Stage 3	-	Project Approval
Stage 4	-	Project Implementation
Stage 5	-	Dissemination of Information

The attached Figure 1 gives the flow chart for the research process adopted by IKRAM.

1.4 Research and development in progress at IKRAM

Within the research programmes and sub-programmes, there are many projects or studies. Appendix 2 gives the details of 5 research projects that are currently undertaken by IKRAM.

1.5 Problems in promoting research and development

The Malaysian Government recognises the importance of R & D in increasing productivity, efficiency and the competitive edge that is required for Malaysia to achieve its vision of becoming a developed nation by the year 2020. This is reflected by the fact that an allocation of M$ 600 million for R & D projects was allowed for under the 6th Malaysia Plan.

At the same time, the Government is asking the private sector to play a bigger role in R & D, as at the present time most of the R & D activities are carried out mostly by the public sector organisations.

The main problem that is being faced by R & D organisations is the shortage of experienced research personnel. This is due in part to the vibrant economy of the country which has resulted in a general shortage of professionals, especially engineers.

2. INTERNATIONAL JOINT RESEARCH PROGRAMMES

2.1 Joint Research Programme with TRL

IKRAM's major international joint research programme is with the Transport Research Laboratory (TRL) of U.K. This joint research programme started in 1987 with the signing of a Memorandum of Understanding between PWD and TRL. It covers the two thrust areas of pavement and geotechnical engineering and was the driving force behind the research activities of IKRAM.

Through this joint research programme, TRL assigned two of its Senior Scientific Officers at IKRAM (one for 3 years & the other 4 years) in addition to periodic visits by other TRL personnel to assist IKRAM in the implementation and coordination of the various research programmes.

Through this joint research programme, further links was established with the University of Birmingham and University of Bristol in U.K. whereby the research work carried out by the research engineers at IKRAM is accepted as partial fulfillment of the Masters in Philosophy (M.Phil) Degree. So far, 4 research engineers have been awarded M.Phil degrees and 1 the Ph.D. degree under this programme.

This joint research programme with TRL will be extended in 1993 to include road safety. One TRL Senior Scientific Officer is to be assigned to IKRAM for a period of 2 years.

2.2 Other Joint Research Programmes

Other joint research prgrammes have also been established with overseas institutions on specific research projects. They include the following institutions:

a) University of Strathclyde, U.K.

The research project is entitled "A study of Malaysian Sedimentary Soft Clay" and includes research into factors that influence engineering properties of soft marine clays in tropical areas.

b) City University, U.K.

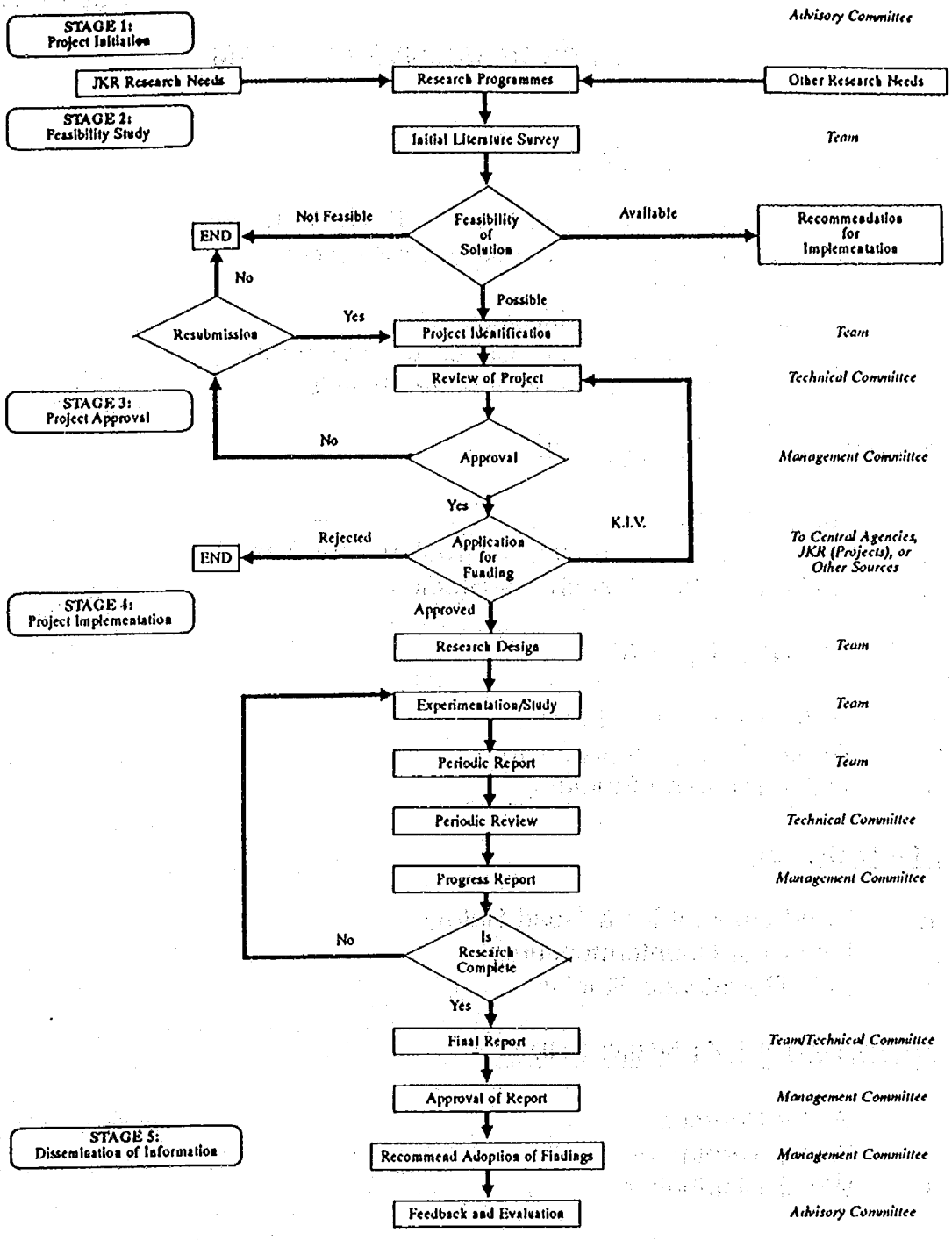
The research project with City University is on the usage of aerial photography and photogrametry to investigate erosional aspects influencing cut slope stability.

c) Bristol University, U.K.

The research project together with Bristol University is the extension of the research project "Highway cut slope instability problems in Peninsular Malaysia". It investigates the influence of vegetation on the stability of cut slopes.

2.3 Problems

So far, IKRAM has not faced any problems regarding their joint research programmes.



Research Process

FIGURE 1

APPENDIX 1

RESEARCH PROGRAMMES AT IKRAM

A. PAVEMENT ENGINEERING

1. Design & Performance of Flexible Pavements
2. Rehabilitation & Maintenance of Pavements
3. Aggregate Mixtures
4. Bitumen & Bitumen Additives
5. Design & Performance of Concrete Pavements
6. Design & Performance of Unpaved Roads

B. GEOTECHNICAL ENGINEERING

1. Soil Usage Studies
2. Foundation & Geotechnical Structures Studies
3. Environmental Geotechnics Studies

C. TRAFFIC ENGINEERING

1. Traffic Congestion Studies
2. Traffic Management Studies
3. Traffic Planning Studies

D. ROAD SAFETY

1. Road Geometrics & Road Safety
2. Low Cost Countermeasures
3. Skid Resistance Studies

E. WATER SUPPLY ENGINEERING

1. Water Sources
2. Water Treatment
3. Water Distribution

F. BUILDING TECHNOLOGY

1. Planning & Architectural Design
2. New Construction Systems & Technology
3. Conservation & Maintenance

APPENDIX 2

CURRENT RESEARCH PROJECTS AT IKRAM

PROJECT 1: METHODS AND ANALYSIS OF PILE LOAD TESTS

(a) Background and Administrative Needs

Pile load tests are carried out to verify the load carrying capacity and to develop criteria for the design and installation of piles. The JKR Standard Specification for Building Works provides two alternatives - the Maintained Load (ML) Test and the Constant Rate of Penetration (CRP) test. In JKR works, the ML test is normally carried out as it is familiar to many engineers, the interpretation of the test results is simple and it does not require any special equipment or skill to perform.

The ML test takes 48 hours to complete and it involves substantial resources of manpower and time to ensure the integrity and reliability of the test data. In the interpretation of the test results, the effect of the elastic shortening of the pile is not taken into account in the failure definition of the pile. The residual settlement criterion in the failure definition also requires validation.

The objective of this research is to review the existing practice of load testing of piles in JKR and develop appropriate acceptance criteria for test piles. It also aims to back-calculate the parameters required in the design of pile foundations for local soil conditions.

(b) Time Period

A three year program is planned so that the testing work shall cover the soft clay and residual soils.

(c) Methodology

Full scale comparative testing of single piles using the quick and slow options of the ML test are undertaken in the field. The load-settlement behaviour of the piles from both methods are compared to study the similarities and differences.

(d) Possible Results

The research works have been undertaken in the soft clays for one year. The preliminary results show that the load-settlement behaviour of the piles tested using the quick and slow versions of the ML test show close agreement. This indicates a possibility of replacing the slow ML test with the quick version. However, further testing ie required to study this agreement over other soft clay regions in Malaysia.

(e) Problems in Implementation

No problems in implementation is envisaged.

PROJECT 2: HYDROLOGICAL DESIGN OF SLOPES IN MALAYSIA

(a) Background and Administrative Needs

Available slope design techniques have been shown to be inadequate. Frequent landslides still occur during or after prolonged rainfall although sophisticated techniques had been used in the slope design. Extensive surveys and statistical studies carried out by IKRAM on the Kuala Lumpur-Karak Highway in 1987 showed that the available techniques had a maximum of only 54% success in slope design.

In 1988, IKRAM embarked on a joint research program with the University of Bristol, U.K. to develop a numerical model for slope stability which is more suited to the geological and hydrological conditions in Malaysia. From subsequent statistical studies, this model provided greater design reliability than other currently available models.

The objective of this research is to prepare a hydrological design manual for slopes to assist engineers in the design of cut slopes which will take into account the dynamic hydrological conditions.

(b) Time Period

A four year program is planned to establish a slope inventory, to assess the performance of the slope stability model and to study the use of a local species of vegetation on slope stability and erosion.

(c) Methodology

The application of the slope hydrology-stability model to produce an effective design for the improvement of the Kuala Kangsar - Grik road is being assessed . A review of the slope forms and the range of design charts will be investigated for this road. The model will be used to quantify the influence of the local species of vegetation on erosion and stability.

(d) Possible Results

A complete and comprehensive set of slope stability design charts for Malaysia that account for the dynamic hydrological conditions in the analysis. The charts will allow identification of slopes that are prone to erosion and the application of natural and artificial slope covers to improve stability and minimise erosion.

(e) Problems in Implementation

No problems in implementation is envisaged.

PROJECT 3: SOIL-CEMENT STABILISATION FOR RURAL ROADS

(a) Background and Administrative Needs

Most of the rural roads in Malaysia are not paved due to the fact that the traffic volumes are relatively low. Their locations at remote areas, sometimes also makes it difficult to carry out proper and regular maintenance as required. Thus, these roads become dusty in the dry season and muddy in the wet season. The dust and mud poses problems to road users and the people living around the areas. To upgrade these roads with normal paving material such as bituminous macadam is uneconomical. As such ways to upgrade them with appropriate and cheaper methods should be studied.

Soil-cement stabilisation has been used in many countries to upgrade the subgrade and road bases. This method is also applied to low volume roads and is found to be suitable and can reduce construction costs. In Malaysia, soil-cement stabilization is not widely used for such roads even though cement is locally produced. This research project is to study the suitability and performance of soil-cement stabilisation when subjected to the local environment and traffic conditions.

(b) Time Period

This research is being carried out continuously and is expected to have valuable data within five years. The research started in 1990 and early findings of its performance are promising.

(c) Methodology

Two studies are being carried out under this research. They include :

i. to establish the percentage of cement required to stabilise different types of local soils adequately. Preliminarily, the study was carried out on one particular soil and stabilised with different amount of cement content. The assessment was made based on the Unconfined Compressive Strength, durability and conditions of each stabilised road.

ii. to assess the performance of soil-cement which has been mixed with a special additive for use as road base. To carry out this study, cement that has been mixed with the additive is used to stabilise the soil for use as a road base. As a control, a conventional road base (crushed rock aggregate) is constructed along the same stretch of road so that both will experience the same traffic and environmental conditions.

(d) Possible Results

From these studies, it is hope that a specification or guideline on soil-cement stabilisation for rural roads in Malaysia can be produced. The specification will comprise of the design method, construction and maintenance techniques.

(e) Problems in Implementation

No real problems are anticipated.

PROJECT 4: HIGH COMPACTION MIX (HCM) FOR HIGH STRESSED AREAS

(a) Background and Administrative Needs

Pavement failure in the form of heavy rutting and heaving occurs in high stressed areas in Malaysia. The rutted surface reduce the serviceability and safety levels of the pavement. This problem is undesirable to traffic operations and is costing the road authorities millions of ringgit in rehabilitating them.

A full scale trial on a climbing lane along a major highway was undertaken by IKRAM in an attempt to mitigate bituminous mix problems at these highly stressed climbing lanes. In this attempt an inovative mix, HCM, was used as the prime solution, being cheap and easily produced. The design of the mix is based on achieving a mix with a minimum void content of 2-3 per cent at refusal state (a state of maximum compaction).

(b) Time period.

The trial was constructed in September 1990 and was monitored periodically after the construction. It is expected to be fully completed when the main parameters monitored (deformations (rutting) and cracks propagation) have reached unacceptable serviceability and safety levels.

(c) Methodology

To test out its performance, the HCM Bituminous Mix was constructed along side other bituminous surfacings fortified with various bitumen additives. A section was constructed of the normal Asphaltic Concrete Wearing Course as a control. The test sections were as follows:

Table 1: Details of Trial

Sections	Description
A	ACWC + Chemcrete (a liquid additive)
B	ACWC + Gilsonite (a natural asphalt in powder form)
C	ACWC + Caribit (SBS modified Bitumen)
D	HCM Bituminous Mix
E	ACWC as a Control

The control was an Asphaltic Concrete mix following the JKR's Standard Specifications for Roadworks (JKR/SPJ/88). The suppliers of the additive were requested to bring in their experts so that proper blending and construction procedures were adopted. For this purpose the Chemcrete supplier brought in their experts from USA, the Gilsonite supplier from Singapore and the Caribit supplier (Shell) brought in their experts from Denmark.

(d) Possible results

The HCM bituminous mix has performed on par with the other modified mixes. The rate of rutting and cracking of the mix is lower then the others after about 600 days of monitoring. The normal ACWC mix rutted to a critical level after only 200 days. Apart from being able to withstand the shearing effects of the heavy loads, the mix should be durable enough to prevent rupture causing cracks. The mix should be a viable and economical solution to the problems of excessive deformations along high stressed roads.

Considering the many kilometres of road pavements experiencing the same high stress conditions which are unsuitable for the normal asphaltic concrete mix, the HCM Bituminous Mix should be able to save the Malaysian Government millions of ringgit. At the present time, the usage of the mix has been enlarged to cover a few more areas. All of these sites are being monitored by IKRAM.

(e) Problems in implementation

Inexperienced contractor poses the main problems in the implementation of this research. Other specific problems relate to the quality control of construction and material preparation.

PROJECT 5: MITIGATION OF REFLECTIVE CRACKS

(a) Background and Administrative Needs

Bituminous overlays in Malaysia fails in the form of reflective cracking, especially if the existing pavement was not treated prior to being overlaid. The rate for the cracks to appear on the surface depends on traffic loading, existing pavement conditions and the thickness of the overlay. The cracked surface allows water ingress and thereby increases the rate of deterioration resulting in premature failure. This problem remains undesirable unless mitigated or solved.

A pilot trial was carried out where interlayers were used and compared to a conventional bituminous overlay. Another trial is in progress where three strategies of mitigating reflective cracking will be employed. The strategies are to use Stress Absorbing Membrane (SAM), Stress Absorbing Membrane Interlayer(s) (SAMI) and Crushed Aggregate Overlays.

(b) Time Period.

The trial will be constructed in January 1993 and will be monitored periodically after the construction. It is expected to be fully completed in five years when the cracks propagation is expected to have reached unacceptable serviceability and safety levels.

(d) Methodology

The following methods will be constructed next to another as follows :-

Section	Method
A	Geosynthetic grid fabric interlayer
B	Geosynthetic needlepunch fabric interlayer
C	Control
D	Single surface dressing interlayer using MC3000
E	Single, rubberised surface dressing
F	Cut and patch
G	Asphaltic concrete binder course interlayer
H	Pervious macadam interlayer
I	Crushed stone overlay.

(d) Possible Results

It is expected that one or more of the strategies to mitigate reflective cracking will show convincing results. Further evaluation will be made with respect to their construction cost and life cycle cost. Since this type of failure is common, an economical solution will have tremendous impact.

(e) Problems in Implementation

To construct the above trial, an experienced contractor is required which can handle the various different types of construction methods over a relatively short length of road.

PART IV : DISASTER AND DISASTER PREVENTATION

1. DISASTER AND DISASTER PREVENTION

1.1 Present Situation And Problems In The Country.

It is fortunate that Malaysia is situated relatively far away from any active volcanic or earthquake zone and has so far not experienced any major disaster resulting from these activities. Though occassionally, some earth tremors were felt, they have not caused any serious damage.

However Malaysia with annual mean rainfall of 2500mm do experience one form of natural disaster in a more moderate scale by way of floods.

1.1.1 Floods

Flood is the only main natural disaster in Malaysia. It is an annual occurrence and usually occurs during North-East monsoon seasons in the month of October to February.

The flood magnitude vary from year to year and the most affected area is the Eastern seaboard of Malaysia which are directly exposed to the North-East monsoon.

In 1969 Malaysia experienced one of the worst floods in history which resulted in loss of properties and lives. The destruction with respect to road are damages to the road pavement, road furniture, washout bridges or culverts, landslips and roads unpassable.

In 1991, the death toll in Malaysia due to loss of lives was ten (10) and loss of properties which amounted to millions of ringgit. For example Kelantan, one of the states in Malaysia which was worst hit by flood lost millions of ringgit due to loss of properties:-

Loss Of Properties.

a)	Damages to roads and structures	-	M$1,500,000.00
b)	Damages to crops	-	M$ 201,960.00
c)	Loss to Goverment Departments and other Agencies	-	M$1,179,468.00
d)	Other damages	-	M$ 46,713.00
	Total	-	M$2,928,141.00
	Loss Of Lives	-	6

1.1.2 Landslides

There are no major landslides in Malaysia and most of the landslides that occurred in Malaysia were only minor landslips which occurred during the months of monsoon or after a prolonged torrential rain.

Most of the mountainous/hilly roads such as East-West Highway, Karak Highway and Ranau-Tamparuli road are common examples which experienced landslips during monsoon or after prolonged rain.

1.2 Activities In Disaster Prevention

There is no specific major activity carried out by PWD (Roads Branch) in preventing disasters such as landslips and floods.

However Roads Branch has incorporated certain measures in preventing landslips and floods under its maintenance activities and also in their designs.

Under road maintenance activities:-

a) Routine maintenance will be carried out to ensure that all drainages, culverts and bridges are free from any debris thus preventing flash flood during rainy season.

b) By improving the existing flood prone area such as :-

   i) Improving the existing drainage system and laying additional number of culverts.

   ii) Raise up the existing road level.

c) Providing adequate drainage system and slope protection on man made slopes.

d) Provide preventive maintenance especially on slopes which are likely to fail during rainy season.

Under road design activities:-

a) Design pertaining to slope stability and slope protection.

b) By increasing the capacity of the drainage system, size of culvert and the clearance height/waterway of the bridge based on certain design period.

PWD Roads Branch does not have specific major activities in preventing disasters other Government departments such as:-

a) Drainage and Irrigation Department (DID).

b) PWD Water Supply Branch/National Energy Board (TNB).

c) Agriculture Development Authority.

do have some specific activities either directly or indirectly in dealing with the prevention of natural disasters particularly in floods.

1.2.1 River Improvement

For example in Drainage and Irrigation Department various flood mitigation schemes have been introduced to reduce the risk of flooding. Example of these schemes are:-

a) Deepening and widening of the existing rivers.

b) Realignment or channeling the existing river.

c) Building earth bunk on both sides of the river bank.

d) Providing sluice gate.

1.2.2 Dam Construction

Construction of dams at various catchment area by the PWD Water Supply Branch and National Energy Board apart from supplying water and electricity also indirectly forms part of national flood mitigation scheme.

With the construction of these dams, the down streams will benefit the most in minimizing the loss of properties and lives.

1.2.3 Irrigation Schemes

Irrigation schemes under various Agricultural Department Authorities such as Muda Irrigation Scheme, Kemubu Irrigation Scheme also have an important role in minimizing the risk of flooding thus cultivation of crops can be carried out throughout the year.

1.3 Technical Tasks For Disaster Prevention

PWD Roads Branch do not have special technical task for disaster prevention.

1.3.1 Landslips

In the event of a landslips and bridge collapse, the Roads Branch of PWD will take immediate action as to ensure the stretch of road is passable and safe for the road users or if in need to provide alternative route or road diversion.

This is done under emergency work where the work is carried without delay in view of the safety and convenience of the road users. It can either be carried out departmentally (depends on the availability of the work force, plant and equipment) or by direct appointment of qualified and experienced contractor with a good track record in that particular field.

Under emergency work, the work are carried out without following the normal contract procedure however PWD will inform the Treasury Department the reasons of carried out the emergency work, its cost estimate and also the reasons of appointing the specific contractor.

In the case where the job was given to the contractor, upon receiving the appointment letter, the contractor should start mobilising the plants and equipment, clearing the site, provide diversion and signages where necessary and proceed with the remedial work under the supervision of PWD representive.

1.3.2 Floods

As mentioned earlier there is no special technical task for disaster prevention. Since flood is main natural disaster in Malaysia a special commitee at national level has been set up to monitor the flood situation, evacuate flood victims and providing food, temporary shelters, medication, logistics, technical aid and emergency works where necessary.

This special committee at national level is headed by the National Safety Council under the Prime Minister Department which will only operate when there is a major and critical flood situation throughout the whole country.

Various departments such as:-

a) Ministry of Information.
b) Public Works Department.
c) Police.
d) Meteorological Department.

e) Drainage and Irrigation Department.
f) Ministry of Trade.
g) Ministry of Health.
h) Army.
i) Civil Defence Department.
j) Ministry of Education.
k) Welfare Department.

will play their own roles according to their function and are under the directive of National Safety Council.

Under normal flood situation these various departments will operate independently according to their function. (i.e when National Safety Council is not in operation).

The Public Works Department Flood Operation Room at national level will be on alert and standby position from the month of October to February i.e. when the monsoon season starts.

The function of this flood operation room is to:-

a) Monitor the flood situation throughout the country and at the same time inform the public through the mass media which of the roads are unpassable.

b) Assist in terms of logistics, technical aid and carried out emergency works such as clearing of landslides and fallen trees from the road, provide road diversions and setting up Bailey bridges etc.

c) Assist National Safety Council.

The Flood Operation Room will be in operation depending on the severity of floods. Monitoring of the flood will be carried in three stages:-

Stage 1 - Under normal condition (i.e. only one state is affected) the flood operation room will not be in operation. However it will be monitored by Road Branch during office hours i.e from 8.00 a.m to 4.15 p.m.

Stage 2 - When more than two states are affected, the operation room will be in operation from 8.00 a.m to 6.00 p.m.

Stage 3 - When more states are affected and the conditon is severe, the operation room will be in operation for 24 hours.

Apart from operating the Flood Operation Room at national level, the States PWD at states level will also operate its flood operation room (having almost similar function to that of the national level)and conduct a routine inspection and take up certain measures before, during and after the flood. Example of these inspection and measures are:-

i) Before the Floods.

a) Ensure that all the road pavement are in good condition.

b) Ensure all drainages, culverts and bridges are free from any debris.

c) Ensure all culverts and bridges are structurally sound to withstand the floods.

d) Cut down trees which are likely to fall during heavy rains.

e) Placing timber markers (to indicate the edge of the road) along both sides of the road in flood prone area.

f) Placing warning signs and flood information notices at strategic places.

g) To ensure enough supply of fuel, construction materials, water tanks, machinery and equipment.

h) To ensure impounding reservoirs are structurally sound.

ii) During the Floods.

a) Patrolling and reporting to State PWD flood operation room.

b) Providing logistics, technical aid and emergency works when and where required.

iii) After the Floods.

a) To reinstate any road failures.

b) To ensure all culverts and bridges are structurally sound or to repair any damages due to flood.

c) To ensure all drainage, culverts and bridges are clear from any debris.

d) To ensure impounding reservoirs are structurally sound.

PART V : HARMONY BETWEEN THE ENVIRONMENT AND IMPROVEMENT OF INFRASTRUCTURE

" Harmony Between The Environment And Improvement of Infrastructure "

1.0 Introduction

1.1 As efficient management of the environment and natural resources is an essential condition for ensuring balanced development, the Government during its Sixth Malaysia Plan period (1991-1995) develops better techniques of integrating environmental considerations in the formulation of programmes and projects. Effective implementations of environmental programmes ensures that the poor are not adversely affected by environmental degradation since they are the most vulnerable and least capable of protecting themselves. In addition, to sustain development of scarce and depletable natural resources, the Government will progressively control pollution and enhance the natural beauty of national landscapes and physical surroundings through the conservation of natural resources and the preservation of the environment.

1.2 Malaysia continues to play a visible role since the Langkawi Declaration on Environment which we initiated at the Commonwealth Heads of Government Meeting (CHOGM) in October 1989. The declaration epitomised our continued commitment to the global plan of action aimed at arresting possible environmental degradation and promoting environmentally sound and sustainable development.

2.0 Progress In Fifth Malaysia Plan (1986-1990)

State of the Environment

2.1 Water Quality

2.1.1 The quality of water in Malaysian rivers has improved slightly during the Fifth Plan period. Despite this overall improvement, water quality trends, in terms of the following three water quality parameters, namely biological oxygen demand (BOD), suspended solids and ammoniacal-nitrogen, showed a deterioration. Organic pollution, also expressed as BOD, has deteriorated at the rate of 0.37 per cent whilst the levels of ammoniacal-nitrogen and suspended solids deteriorated at 10.17 per cent and 1.89 per cent respectively. These data indicate the prevalence of heavy and uncontrolled loadings of organic wastes and silt into the water courses. Industrial and domestic discharges accounted for major components of the organic load while intensive land clearings, unregulated development, mining and logging activities in the catchment areas were responsible for sedimentation and siltation problems. Untreated domestic sewage and animal wastes continued to pose a major problem in the country as indicated by the highest deterioration rate of 10.17 per cent for ammoniacal-nitrogen.

2.1.2 Rivers on the west coast of Peninsular Malaysia were more polluted with heavy metals such as mercury than other rivers in Malaysia. This was due to a more extensive land use and increased industrialisation that result in increased wastewater discharges containing heavy metals. Small and service type industries which were established without proper and adequate wastewater treatment facilities were the principal sources of pollution.

2.1.3 Sewage contamination mainly from both domestic and animal wastes, as indicated by faecal coliform, were found in the states of Sarawak, Perak, Pulau Pinang and Pahang. A number of river estuaries in the states of Kedah, Pulau Pinang, Selangor, Johor, Terengganu, Kelantan and Perak were also contaminated with faecal coliform due to high population density, increased urbanization and lack of adequate facilities for sewerage treatment.

However, the coastal waters of recreational beaches of Malaysia are not contaminated with faecal coliform except in few isolated locations. Therefore, beaches in Malaysia were still safe for recreational and water sport activities. Nevertheless, the degree of contamination by suspended solids continued to prevail as a result of continued extensive land development activities carried out in the upland and adjacent areas. Some parts of the coastal areas were found to have traces of oil and grease.

Control of Pollution

2.2 Water Pollution

2.2.1 Water pollution from industrial origin continued to be concentrated on the west coast of Peninsular Malaysia accounting for almost 50 per cent. The principal industries responsible for pollution included manufacturing of textile, rubber, paper, food and beverage.

2.2.2 Non-industrial wastes, which continued to be the most significant contributor of organic pollution in inland waters, showed little improvement during the Fifth Plan. Sewage and wastes from animal husbandry increased over the period; sewage, increasing from 6.28 million population equivalent in 1986 to 7.56 million population

equivalent in 1990, and animal husbandry, from 1.1 million population equivalent to 1.3 million equivalent in 1990. Overall, being three times more than the combined loads from industries and animal husbandry, sewage remains the main contributor of organic pollution.

2.2.3 Pollution load discharges from two major agro-based industries; namely, crude palm oil and natural rubber processing, which were significantly reduced during the Fourth Malaysia Plan period (1981-1985), were within control during the Fifth Plan despite increases in the number of processing facilities.

2.2.4 The control of pollution from animal husbandry has not been resolved as some states are still without specific enactments to control animal waste. Despite a number of research projects on finding a practicable system for treating animal wastes, for example by Malaysian Agricultural Research Development Institution (MARDI), no system has been found to be economically viable as most of the pig farms are managed as cottage industries. The "Pig Farming Area" (PFA) concept contained in the National Agriculture Policy has not been fully implemented except in the state of Negeri Sembilan.

2.2.5 Other than control of water pollution from animal husbandry, no specific programme has been implemented to control pollution arising from the use of chemical fertilizers, pesticides and herbicides in agriculture. Indiscriminate use of such chemicals has resulted in substantial reduction of freshwater fishes which used to thrive in some locations. However, there were no systematic studies done to determine the effects of pollution from these chemicals.

3.0 Conservation of National Resources

3.1 Malaysia is endowed with rich and varied natural resources particularly natural forests, rivers, coastlines and fertile soil. Despite development encroaching upon virgin forest areas, 12.70 million hectares of permanent forest accounting for 38 per cent of the total area of land in the country is still being maintained. Of this, 29 per cent is protected or maintained as amenity forest, which also covers the Taman Negara. In addition, 1.27 million hectares are being maintained as national parks and wildlife reserves, and 5.12 million hectares as stateland forests. Some 1.65 millon hectares of permanent forest estate have been rehabilitated and annually programmes are also ongoing to rehabilitate the logged-over areas.

3.2 During the Fifth Plan, the Government continued monitoring development that have tendencies to further encroach upon these natural preserves. This is because excessive forest harvestings and extensive land-based development can lead to deforestation, massive erosion, diminution of catchment areas and consequential effects on weather, atmospheric temperature, water sources and soil quality as well as coastal pollution. Lowland forests, mangrove and peat swamps areas were also closely monitored in order to prevent further the destruction of spawning and nursery areas of many species of fish and other seafoods. The marine ecosystem is vital in sustaining bio-organism on which fishes thrive. Hence, large-scale mangrove and peat swamp clearing, aquaculture and cage culture are been closely monitored.

3.3 In line with spirit of the Langkawi Declaration on Environment and the concern of the Government on the preservation of a clean environment and sustainable development, the implementation of sectoral programmes and projects will continue to focus on the necessity of maintaining a balance between the demands of growth and sustainable development. Amongst

these programmes and Strategies are :

3.3.1 Firstly, designating additional forested areas as forest reserves, animal sanctuaries and, national recreational parks which will ensure that the required ecological balance is maintained, occurrences of environmental degradation are minimized and essential habitats and bio-diversity are preserved.

In support of this strategy of conservation of natural heritage, nine states have taken the initiative to formulate conservation strategies. These are Selangor, Terengganu, Kelantan, Negeri Sembilan, Perlis, Melaka, Kedah, Wilayah Persekutuan and Sarawak. The intial focus is on the conservation of natural environment.

3.3.2 Secondly, large scale reforestation programmes supported by agro-forestry programmes are carried out to balance the needs for economic growth and the needs for promoting ecological balance. Greater priority are given to efforts at providing the required budget for R&D for reforestation, studies on determining fees for licences, and as well as more strict enforcement.

3.3.3 Thirdly, tree cover is expanded to preserve habitats, safeguard soil quality, to reduce siltation and erosion, sustain climatic balance and also to absorb excessive carbon dioxide released into the atmosphere. This programme is anticipated to moderate soil losses, droughts and floods, and to reduce disruption of water supplies and to replenish the natural productivity of land.

3.3.4 Fourthly, projects in watershed areas e.g. dam construction, and other major infrastructural projects which are likely to affect adversely

the environment will be carefully planned and implemented. The preservation of unique flora and fauna and bio-diversity which may be endangered by such projects will be given due attention.

With regards to this too, environmentel impact assessment or EIA is carried out and it is mandatory according to the Environment Quality Order 1987, for any dam construction having more than 200 ha of impounded water.

4.0 Technical Tasks Necessary For The Promotion of "Harmony Between the Environment and Improvement of Infrastructure"

4.1 Research and Development

4.1.1 Research and development programmes have been carried out to develop more effective preventive measures towards pollution control and abatement. Towards this end, a set of criteria and standards for water quality has been formulated. Consistent monitoring of the environment and studies will continue to be conducted to enable the Government to take corrective measures.

4.2 Integrated Project Planning

4.2.1 Under the integrated project planning approach, aside from EIA, environmental considerations will continue to be integrated into project planning and implementation. EIA mandated under the Environmental Quality (Amendment) Act 1985 and Environment Quality (Prescribed Activities, Environment Impact Assessment) Order 1987, specified 19 categories of 'prescribed activities'. Preliminary studies have shown that costs of incorporating EIA are only marginal to the project overall costs.

4.2.2 The peparation of development and structure plans, infrastructure and conservation projects and sectoral programmes, and urban development, will continue to incorporate environment considerations. With regard to projects not subject to EIA, the siting of potentially polluting projects will be away from environmentally sensitive areas such as residential areas, schools, hospitals and water catchment areas especially if those areas are without sufficient buffers. Furthermore, mitigation and control measures to prevent and reduce the possibility of environment pollution will also be given special consideration in implementing such projects.

4.3 International Cooperation and Transboundary Pollution

4.3.1 Malaysia had played an important role in promoting environmental consciousness in world forum. This was exemplified by Malaysia in obtaining the consensus of the Commonwealth Heads of State in the Langkawi Declaration on the Environment. In addition, under the umbrella of the ASEAN committee on Science and Technology (COST), projects under the ASEAN Environment Programme (ASEP) II (1983-1987) and ASEP III (1988-1991) will be continued. Further, the ASEAN Senior Officials on Environment (ASOEN) would focus on firstly, strengthening of ASEAN co-operation in the exchange of information, technology, resources and manpower in dealing with international environmental concern; and secondly, ensuring the integration of environmental dimensions in the decision of other ASEAN Committees.

4.4. Environmental Awareness

4.4.1 Environmental education, as a tool for creating environmental awareness and informed the citizens of Malaysia has been

introduced in the curriculum since 1986 in the form of the subject "Man And His Environment" for upper primary schools. The subject is intended to provide knowledge, perception and positive attitudes towards the environment as a holistic approach. At the tertiary level, both the University of Agriculture Malaysia (UPM) and the University Technology Malaysia (UTM) offer formal degree courses which cover environmental topics such as pollution control and environmental management as well as environmental control technology. Environmental education and awareness programmes on a non-formal basis are conducted by various Government agencies, voluntary organisations and by the private sector.

5.0 CONCLUSION

5.1 Consistent with the spirit of the Langkawi Declaration on the Environment the policy of promoting sustainable development will be given priority. This policy will cover strategies affecting sectoral growth and equitable distribution in particular the optimum utilization of national depletable and renewable resources. The focus is to give due importance to conservation, clean environment and ecological balance within the context of sustainable economic development; and to ensure harmony between infrastructural development and the environment.

JKR

RMT/fs

PART VI : PROPOSALS FOR FURTHER DISCUSSION

SUGGESTED RESEARCH IN GEOTECHNICAL ENGINEERING IN COLLABORATIONS WITH PWRI,JAPAN

1.0 A CLASSIFICATION SYSTEM TO DETERMINE EXCAVATION CLASSES OF NATURAL MATERIALS IN MALAYSIA

Civil engineering works often involve excavation in natural materials for various purposes such as for pad and strip footings, road or highway cuttings and quarries. Deep cuttings very often expose the full weathering profile from incompetent soils to fresh rock. Equipments normally used for excavation works vary from simple hand picks and spades to powerful excavators and explosives.

Disputes often arise during construction as guidelines or specifications provided for are not very well defined and often misinterpreted. Without ripping trials during site exploration, the design engineer has a difficult task of identifying the volumes of materials involved in different classes of excavation. Such a problem leads to miscalculation of project cost and duration. The contractor or tenderer on the other hand probably has his own idea of ripping and hence, different classes of excavation for these materials. Thus, the magnitude of potential disputes which can arise out of this situation is evident.

In Malaysia, there is a need to review the current single demarcation line separating excavation classes of rippable and non-rippable materials based on a particular machine size, e.g. Caterpillar D7/D8 etc. It may also be necessary to introduce an excavation class to include 'soft rock' of grades III and IV where material rippability may fall in between these two classes. In addition to this empirical classification based on machine sizes, it is also proposed that a scientific quantitative classification system is established where this can be used in the event of any disputes. Provisions must also be made to determine the parameters required for the scientific classification using standard tests.

2.0 PERFORMANCE IMPROVEMENT OF DISTINCTIVE MALAYSIAN CLAYS

Malaysian coastal clays have been found to contain high organic matter, pyrites and active clay minerals, i.e. montmorillonite. These features may be the key influence to their fundamental engineering characteristics which make the behaviour of Malaysian clays distinct from other clays. Anomalous behaviour has been observed in a number of well documented field trials. Amongst the unique behaviour observed are;

i) Slow or non-dissipation of excess pore water pressure after embankment construction, and

ii) Significant magnitude of primary consolidation and secondary compression.

Current research effort being undertaken at the Public Works Research Institute of Malaysia (IKRAM) concentrates on the engineering properties of Malaysian clays and performance of embankment constructed on soft clays. Preliminary findings indicate that the aspects of high organic content, pyrites and active clay minerals warrant further research in order to understand fully the distinctive behaviour of Malaysian clays.

The potential research areas related to this aspect are as follows;

i) Further evaluation of distinctive engineering characteristics.

ii) Study the effective methods to improve the engineering performance of distinctive Malaysian clays.

iii) Physical and computational modelling with specific emphasis on the use of centrifuge testing and formulations of constitutive equations.

With the expertise and facilities available at the PWRI, it is hope that the research collaborations, if materialised, will enable IKRAM to accomplish the study successfully on Malaysian clays especially on the aspects mentioned in paragraph 2.0 above.

Suggested research collaborations can be in the forms of:

i) Regular expert advice from PWRI personnel.

ii) Use of testing and computing facilities at PWRI

iii) Training of IKRAM engineers.

3.0 FOUNDATIONS AND EARTH RETAINIG STRUCTURES STUDIES

3.1 Shallow foundations in compacted fills

Shallow foundations are normally constructed on natural ground or cut areas where both the bearing capacity and settlement criteria can be satisfied easily. Shallow foundations in compacted fill can be most cost-effective especially for low rise buildings where column loads are not high. However, engineers are reluctant to adopt this mode of construction due to low quality compaction resulting in low bearing capacity and high compressibility. The problem can be overcome by detailing specifications for earthwork used as a structural fill and by tighter field compaction controls.

To propagate the use of shallow foundations in compacted ground, an overall understanding of the effects of compaction on soils, the design considerations and compaction criteria is required. The research work is targetted towards realising the potential of this mode of construction in Malaysia.

3.2 The environmental aspects of foundations construction methods in built-up areas.

The rapid development in Kuala Lumpur is reflected in the many constructions of high rise office blocks and condominiums in the city and in the surrounding suburbs. The foundation construction methods employed vary from pad footings and rafts to bored and driven piles. Some of the methods have undesirable effects on the environment such as noise and air pollution.

This is an area of research where some guidelines can be formulated to control the pollution. At present, there is no strict controls over the use of any specific method.

3.3 The design of piled foundations in residual soils.

The design of piled foundations in soft clays is currently under investigation in IKRAM. In residual soils, the driveability of the piles are of importance as it is directly related to the capacity. The Standard Penetration Test (SPT) is widely used in the soil investigation methods and its values are often used as the criteria to predict the pile driveability.

Wave equation programs may used effectively to research and provide correlations with the SPT values on pile driveabilities and capacities of different types of piles in residual soils.

Proposed Joint Research in Traffic Engineering Between JKR and PWRI, Japan.

Contents

A. Traffic Engineering Parameters

1. Traffic Study Methodologies
2. Urban Traffic Capacity
3. Rural Traffic Capacity
4. Expressway Traffic Capacity

B. Traffic Planning

1. Estimating Travel Demands
2. Urban Area Traffic Planning
3. Rural Area Traffic Planning

C. Traffic Management and Control

1. Urban Traffic Management Techniques
2. Rural Traffic Management
3. Environmental Management
4. Traffic Control Techniques

Proposed Joint Research in Traffic Engineering Between JKR and PWRI, Japan.

A. Traffic Engineering Parameters

There is a need to look at highway capacity-related parameters which suit local conditions and not to adopt parameters that were researched in foreign countries, as these might not fit local conditions. Rather, to carry out studies to determine the extent foreign adopted parameters are applicable and if need be, develop new parameters for Malaysian conditions.

Presently, local traffic engineering and design guidelines have come from a variety of sources, including Britain, Australia and the USA without knowing the extent to which these foreign-based capacity models apply to Malaysian conditions. This may lead to misleading results.

1. Traffic Study Methodologies

By adopting and adapting existing and advanced study methods of researching in the field of traffic engineering. This will ensure that the collection of data are relevant to the solution of the needs of the situation.

2. Urban Traffic Capacity

There is a need to identify the capacity characteristics of urban traffic which serves the major centers of activities in a city area. To study parameters affecting speed-flow relationships, weaving sections, signalized and unsignalised junctions.

3. Rural Traffic Capacity

Most JKR roads generally cater to rural traffic as such there is a need to classify capacity characteristics for traffic in rural roads which reflect the lower intensity and nature of development in rural areas. Also to study the parameters pertaining to speed-flow relationships, passenger car units (P.C.U.) and junction design.

4. Expressway Traffic Capacity

Similarly there is a need to distinguish capacity factors for the design of expressways traffic which allows high operating speed for vehicles. Again parameters relating to weaving sections, road links, speed-flow relationships and passenger car units (P.C.U.) requires to be studied.

B. Traffic Planning

For this activity there is a need to look at methods and techniques in traffic planning to cater to the movement of people and goods. Further, there is a need to study traffic planning research methods from the view of predicting the occurrence of, say, traffic congestion and which assists in planning of traffic in small towns and residential areas, or rural and urban roads.

1. Estimating Travel Demands

Estimating the demand for travel is a highly important part of traffic planning process as existing and future travel demands will have a major influence on the provision of transport facilities and policies. As such there is a need to develop models of land use and prediction models of travel demand.

Efforts should be directed to produce a travel demand modelling in order to increase the nation's capability in predicting travel demand and land use forecasting.

An analysis of this model building will assist in not only prediction of future traffic pattern but also in formulating:-

a. Future Planning Parameters,
b. Future Transport Facilities,
c. Future Policies.

2. Urban Area Traffic Planning

To look at assessing the performance of existing facilities, in terms of the incidence of accidents, traffic conditions (eg. congestion, delays, queues, operating costs), particular conflicts which may exist (eg. in shopping streets between pedestrians, and through traffic). Also study techniques for traffic planning in urban areas.

3. Rural Area Traffic Planning

There is a need to cater to high volume traffic during national festive seasons when most urbanites will "balik kampung". Very often these peak periods of traffic can cause congestion in rural towns and delays to passing traffic. At the same time the planning must cater to the basic travel demand of the localised rural area. One way is to look at modelling of interurban planning for rural areas.

C. Traffic Management and Control

Traffic management and control involves adjusting and adapting the use of an existing road system to meet specified objectives without resorting to substantial new road construction. Traffic management and control can be undertaken on a small or large scale either to improve conditions in an area where new transport infrastructure is not envisaged, as a short-term measure pending new construction, or as a temporary arrangement to accommodate short-term demands. Also to look at ways of making the current road networks more efficient in terms of capacity, safety, accessibility and by improving the environment.

1. Urban Traffic Management Techniques

The study of various traffic management techniques like traffic restrictions, traffic restraints, upgrading of road system, traffic control, flow regulation, etc. The most recent technique being much publicized in the media now is the collective usage of private vehicles or simply called as "carpooling".

A selection of the various traffic management techniques can be packaged to help solve or mitigate specific areas of congestion or improving traffic flows in urban areas.

Research should be focussed on studying the salient features and the benefits and drawbacks of these measures.

2. Rural Traffic Management

There is a need to mitigate effects of fast "through traffic" in rural towns. This is particularly true for high volume rural traffic roads with its peak occurring during festive seasons. This has to be tempered with a balance on safety of both local

commuters and passing traffic.

In order to enhance safety aspects of rural area traffic, studies can be carried out to ascertain appropriate short-term and long-term measures at mitigating effects of fast "through traffic" in rural towns.

3. Environmental Management

To study ways of improving and maintaining minimum environmental standards for particular areas which relate to pollution from exhaust fumes, noise, vibration, severance, visual intrusion, etc.

Current problems like the smog hanging over Kuala Lumpur city have been frequently highlighted in the media. Other adverse effects of traffic movements on the environment are noise, vibration, pollution from exhaust fumes, dust and dirt, visual intrusion, severance, and nuisance from parked vehicles.

These issues need to be addressed and measures which improve or protect the environment must be found and considered.

Research efforts can focus on studying possible specific environmental improvement measures and looking at the benefits and drawbacks of each measure.

4. Traffic Control Techniques

To study salient features of traffic control techniques and look at better ways of using them. Control techniques such as traffic signals, parking should be studied in detail.

By studying traffic control techniques and using them, it may make the best use of existing network capacity and reduce journey times without creating adverse environmental effects, possibly reduce congestion and delay.

Research studies can focus on salient features of variable message signs, traffic signals and parking.

V. Republic of the Philippines

Mr. Manuel M. Bonoan, Assistant Secretary for Planning,
Department of Public Works and Highways

TABLE OF CONTENTS

1.0 Country Outline

2.0 The Public Works System in the Philippines

3.0 DPWH Office in Charge of Research and Development

4.0 Major Research and Development Projects

5.0 International Research Assistance/Exchange Programme

6.0 Disaster and Disaster Prevention in the Philippines

7.0 Infrastructure, the Environment, and Sustainable Development

8.0 Proposals for Further Discussion

Figures

Tables

Appendix: DPWH Organization

EXECUTIVE SEMINAR ON PUBLIC WORKS RESEARCH AND DEVELOPMENT
COUNTRY REPORT: PHILIPPINES

by:

Manuel M. Bonoan
Assistant Secretary for Planning
Department of Public Works and Highways

1.0 COUNTRY OUTLINE

1.1 Topography and Geology

The Philippines is composed of about 7,100 islands occuring between two trenches the Philippine on th east and Manila on the west. It is one of the largest island groups in the world. It lies 966 kilometers off the southern coast of Asia between latitude 4° 23′ N and 21° 25′ N and between longitude 116° E and 127° E.

The greatest length north to south of the archipelago is about 1,851 kilometers, and the greatest breath east to west of the archipelago is about 1,107 kilometers. It is bounded on the west by the South China Sea, Pacific Ocean on the east, Sulu and Celebes Seas in the south, and the Bashi Channel in the north (Please refer to Figure 1). Its northernmost islands are approximately 240 kilometers south of Taiwan, and the southernmost islands are about 24 kilometers from Borneo.

The Philippines is situated on the eastern rim of the Asiatic Meditteranean: the warm and shallow waters between the Pacific and Indian Oceans and between Australia and the Asia mainland. This location finds the Philippines at the crossroads of international travel lanes.

The total land area of the country is approximately 300,000 square kilometers, 92,30 percent of which is contained within the 11 largest islands. The Philippines is divided into three major island groups: Luzon, with an area of about 141,395 square kilometers; Visayas, with an area of about 56,606 square kilometers; and Mindanao with an area of about 101,999 square kilometers. These three groups are further divided into regions, regions into provinces, provinces into cities and municipalities, and cities and municipalities into barangays. Its capital is Manila.

The Philippines has a varied topography with lofty highlands and numerous valleys. It has four major lowland plains: the Central Plain and Cagayan Valley in Luzon, and the Agusan Valley and the Cotabato Valley in Mindanao. These lowlands contrast sharply with the adjacent high mountain ranges. The diversity of topography is further contributed by the existence of plateaus, such as the Bukidnon and Lanao Plateaus in Mindanao.

The Philippines has the longest discontinuos coastline in the world. Its extensive sea coasts are indented with good harbors, navigable rivers and lakes. There are about 61 natural harbors and about 132 rives found in 73 provinces, aside from small streams that expand up to three times their size during the rainy season.

The Philippines is believed by historians to be a remnant of a vast continent in the Pacific that sank beneath

the waters in prehistoric times. Some geologists, however, assert that the Philippines was of volcanic origin whose eruptions have caused the emergence of the islands above water. Structurally, the archipelago may be considered as the crumpled edge of the Asian continental platform. Ranges by folding, waste-filled valleys at cyncline, block mountains, and volcanic belts make-up the islands of the Philippines.

Allmost all principal types of rocks are found in the Philippines. On a basement complex of igneous rocks there are many thousand meters of sediment, mainly Tertiary Age, with some small outcrops of mizoic rocks, which are succeeded by lava of the andesitic type, with great accumulations of more recent tufts and considerable areas of coral limestones. Deep-seated rocks are naturally not widely distributed to the surface and are usually found in canyons of mountain ranges, whenever streams have cut through the overlying recent formations.

In all parts of the islands there are large amounts of extrusive materials found around volcanic areas. The sedimentary formations generally consist of shells, limestone, sandstone, and conglomerates. The rocks in abundance are andesite, pyroclastics, quartz, diorite, and small amounts of alluvium and limestone.

The Philippine Fault, created by the second orogenic movement, traverses the Philippines north to south. Secondary faults and holds resulted from the major fault and are present in all its regions. It is about 89 kilometers northeast of Mindanao and is the second deepest known part of the Pacific Ocean.

The Philippines is prone to earthquakes, and is rocked on the average by one perceptible earthquake every two days that are too weak for people to feel but are strong enough to be recorded by seismograph. Not all parts of the country are vulnerable to destructive earthquakes which could be explained that while the country is crisscrossed by large fractures along which any dislocation can cause a tectonic earthquake, these fractures are not of the same stability.

1.2 Climate

The climatic conditions of the country are varied due to the existence of mountains and plateaus in various parts. The differences in climatic conditions depend mainly on the local air currents, which are the result of the general air stream, the position of the islands, and the most usual storm tracks.

The principal air streams affecting the Philippines are: (i) the Northeast Monsoon which streams along the easterly and southeasterly side of the great Asiatic high pressure area, (ii) the Southwest Monsoon or equitorial air which pushes its way from the equator from the high pressure area of the Pacific, and (iii) the North Pacific Trades which comes from a easterly direction from the tropical high pressure area of the Pacific.

The general direction of the winds from these three sources are as follows: (i) northeast monsoon and trade winds from north to east from October to January, (ii) the trade winds from east to southeast from February to April; and (iii) southeast monsoon from a southerly direction for the rest of the year.

The basis for climate classification of the country are the type of rainfall, the presence or absence of a dry season and the maximum rain period. Climate is classified into four types:

First Type: There are two pronounced seasons: dry from November to April, and wet the rest of the year.

Second Type: There is no dry season, and the maximum rain period is from November to January.

Third Type: The seasons are not very pronounced: relatively dry from November to April and wet the rest of the year. The maximum rain periods are not very pronounced, but the short dry season lasts from one to three months.

Fourth Type: Rainfall is more or less evenly distributed throughout the year.

The Philippines is located in a region which is recognized as having the greatest frequency of tropical cyclones in the world. Tropical cyclones are classified into the following three categories: (i) Tropical depression - maximum wind speed within the disturbance up to 63 kilometers per hour; (ii) Tropical storm - maximum wind speed within the disturbance ranges from 64 to 118 kilometers per hour; and (iii) typhoon-maximum wind speed within the disturbance exceeds 188 kilometers per hour.

Average annual frequency of tropical storms is about 19.9 (36 year period basis) of which 4 are tropical depressions, 5.1 are tropical storms, and 10.8 typhoons. The tropical cyclone season lasts from June to December, although the other months are not entirely free of these cyclones. The period June to December accounts for 88 percent of the mean annual total number of tropical cyclones. Tropical cyclones follow widely variable tracks in the vicinity of the country.

The annual average rainfall in the Philippines is about 2,533.4 mm. Luzon has an annual average of 2,724.4 mm, Visayas has 2,391.7 mm, and Mindanao has 2,349.8 mm. The month of August has the highes average monthly rainfall with 304 mm, while April has the smallest with about 100 mm.

The mean annual temperature of the Philippines is 27 ^{o}C. The average annual temperature of Luzon is 26.8 ^{o}C, 27.3 ^{o}C in Visayas, and 26.9 ^{o}C in Mindanao. For the whole country in general, the hottest months are May with 28.2 ^{o}C, June with 27.9 ^{o}C and April with 27.2 ^{o}C. The coldest months are January with 25.6 ^{o}C, February with 25.9 ^{o}C, and December with 25.9 ^{o}C.

1.3 Demographics

From a total population of 48.3 million persons in 1980, the total population has increased to 60.670 million in 1990 and is projected to grow to 66.415 million in 1995. Based on the 1989 population level of 60.10 million, Filipino males numbered 30.18 million while females were counted at 29.92 million, thereby placing the sex ratio at 100.9. Nearly half of the population were aged 19 and below. By population size, the Philippines ranked eight in Asia and seventeenth largest in the world.

Bulk of the population was concentrated in Southern Tagalog and Metropolitan Manila Area with 12.72 percent and 12.32 percent of the total population. In terms of annual growth rates, six regions exceeded the national rate of 2.71 percent as follows: Western Mindanao (4.31), Southern Mindanao (4.28), Northern Mindanao (3.58), Metropolitan Manila Area (3.58), Southern Tagalog (3.25), and Cagayan Valley (2.76). High growth rates in most of these areas are mainly due to high in-migration rates. In contrast, one of the most depressed regions in the country, Eastern Visayas, registered the least growth rate at 1.49 percent.

The population of the country's 60 cities in 1980 constituted 21.17 percent of the country's population or about 10.18 million for a 1.45 million increase (16.68 percent) increase over the 1975 figure. According to the 1980 Philippine population census,the country had a national density of 160.3 persons per square kilometer for an increase by 20.1 persons per square kilometer or 14.34 percent over the 1975 level. The Metropolitan Manila Area posted the highest density of of about 9,317 persons per square kilometer, followed by Central Luzon with 263.4 persons per square kilometer.

The Philippines is predominantly rural with approximately 37.23 percent of the population living in urban areas in 1980 compared to only 31.63 percent in 1975. Much of the population growth may be attributed to the influx of rural migrants to the more urbanized areas to gain access to relatively better employment opporunities. Metropolitan Manila, the most urbanized area in the country, held 33.09 percent of the total urban population as of 1980. Cebu constituted 5.17 percent and Negros Occidental, about 3.96 percent.

The Philippines has a relatively young population considering that its population below 15 years old accounted for about 42 percent of the total population. The median age increased (in years) increased to 17.6 in 1980 from roughly 16.9 in 1970 and 17.1 in 1960.

The Philippines had a daily average of 4,093.1 live births in 1989 and has showed a generally declining trend during the period 1980-1989. In terms of mortality, the Philippines has continously exhibited a stable death rate. In 1983, national death rate was recorded at 6.3 which declined to 5.8 in 1987 and went down further to 5.2 in 1988.

There are about 87 languages and dialects in the country based on the 1980 Census of Population and Housing. Tagalog is spoken in 29.66 percent of the households, Cebuano by about 24.2 percent, Ilocano by 10.30 percent, Ilongo by 9.16 percent and Bicol by about 5.57 percent.

In terms of religion, About 85 percent of the total population are Catholics, 4.32 percent are Islam, 3.91 percent are Aglipayans, 1.3 percent Iglesia Ni Kristo, .9 percent Buddhist.

1.4 Economy and Society

The growth of the Philippine economy over the twenty-one year period 1971 to 1990 was deemed modest averaging only about 4.1 percent annually. The whole period can be roughly divided into two phases: the debt-driven phase (1971-1980) when growth averaged 6.4 percent and the debt-

constrained phase (1981-90) when growth averaged a mere 1.8 percent.

The debt-driven phase was characterized by heavy borrowings contracted to support the Government's development projects and ease the country's balance of payments difficulties. Growth during this period was driven largely by investments financed by foreign debt. Industry accounted largely for the growth of real GNP during this period with a 2.7 percent contribution compared to 2.2 percent of services and 1.4 percent of agriculture.

The debt-constrained phase was a period characterized by severe strains on the economy's capacity to develop, occasioned by the need to service a huge foreign debt. Servicing of the debt led to the diversion of resources away from much needed infrastructure developments and social services. Growth was further constrained by high interest rates brought about by the Government's huge budgetary deficits partly incurred through debt servicing.

The period 1971 to 1991 witnessed a notable shift of exports towards non-traditional agricultural and natural resource exports like garments, footwear, furniture and fixtures, and microelectronics. For the 1971-1975 sub-period, the traditional exports of mainly forestry, mineral, sugar, abd coconut products accounted for 85.2 percent of total exports. These declined dramatically to 22.2 percent in the 1986-1990 sub-period. Correspondingly, non-traditional exports increased from 14.1 percent to 76.3 percent of total exports for the same sub-period.

Agriculture, including fishery and forestry, remains one of the largest single contributor to the national economy. During the last two decades, agriculture has contributed a yearly average of P 24 Billion in Gross Value Added to the national economy. The agricultural sector contributed a yearly average share of about $ 1.65 Billion to export revenue from 1970 to 1990 for an annual average growth rate of 3.5 percent. Fishing also provides a substantial contribution to the country's economy with the value of production increasing markedly from about P 14 Billion in 1981 to over P 46 Billion in 1989.

Since the early 1970's the pace of industrial development has been accelerated through various Government incentives and reforms. Industry dispersal was pursued, complemented by the continued encouragement of foreign investments in selected industries. Export processing zones and industrial estates were established in selected sites throughout the country. As a result, the share of the industry sector to the GNP grew to 33.5 percent and is forecasted to reach 40.1 percent and 42.6 percent in 1995 and 2000, respectively.

Compared with other developing countries, especially those is the ASEAN region, the Philippines economic performance has been below par. The country's GNP per capita in dollar terms ($ 730) in 1990 is only about half that of Thailand, about 1/4 of Malaysia, and about 1/8 of Singapore. It exceeded only Indonesia ($ 570) but is in real danger of being overtaken since the country's average annual growth rate of GNP per capita from 1965 to 1990 is the slowest in the ASEAN region at 1.3 percent.

Economic development has also not been broadly based. Inequities in income generation and distribution persisted as more than half of the country's income continue to be controlled by the richest 20 percent of the population. The bottom half accounted for only about 1/5 of the total income generated in 1985 and 1988. Though poverty incidence was brought down from 58.9 percent in 1985 to 55.2 percent in 1988, there were 17,000 more families falling below the poverty line because income and employment in the lower income strata grew too slow to cope with the pace of population growth and household size. Moreover, in spite of the reduction in poverty incidence, more than half of the households in the country continued to be poor.

The inequality of income distribution is the most difficult economic problem that appears to defy solution. The rapid population growth continues to be a constraint to raising the standard of living of the average Filipino. This is also putting pressure on the limited resources of the country and that existing resources going to production and productivity upgrading such as investments in infrastructure, equipment modernization, skills upgrading/training, and the like continue to be spread thin.

To stimulate economic recovery, the Government is implementing the 1993-1998 Medium Term Development Plan with three basic objectives: (i) sustained and broad-based growth of output and employment; (ii) price stability; and (iii) sound balance of payments position. This shall be pursued through: people empowerment, human development, international competitiveness, sustainable development, and enhanced role for the private sector to propel the economy and society. Selected macroeconomic information for the Philippines are presented in Tables 1-1 to 1-3.

2.0 THE PUBLIC WORKS SYSTEM IN THE PHILIPPINES

2.1 The DPWH Medium Term Infrastructure Program

In addressing the country's development concerns, the DPWH through its medium term infrastructure development program for 1993-1998, seeks to provide the physical foundation needed to support the national development goals of: (a) poverty alleviation, (b) reduction of inequality, (c) generation of productive employment opportunities, (d) comprehensive human development, and (e) attainment of sustainable growth, in accordance with the Medium-Term Philippine Development Plan. These objectives shall be achieved through the pursuit of world competitiveness and people empowerment which shall serve as the springboard for the attainment of a more resolute economic recovery and sustained growth that will, in turn, ensure the protection of human welfare in the process of development. Concretely, the people empowerment strategy is envisaged to ensure the equal participation of women and men in relevant infrastructure development activities from project formulation to project monitoring.

Consequently, the medium-term DPWH infrastructure program has a "bias" for the folowing infrastructure sectors:

a. Pro-poor infrastructure which includes basic transport, sanitation, and other essential facilities that will help especially those in the bottom 30 percent of the population, particularly those in the "survival" and "subsistence" levels.

b. Rural-based and production supportive infrastructure, such as countryside highways, and flood control and drainage, to link rural production and consumption areas with the national and international economies.

c. Basic urban infrastructure, like roads, flood control and drainage to help the poor and make these centers viable markets or service areas for their rural hinterlands.

The DPWH infrastructure program includes the following special concerns:

a. Establishing a well-built and maintained national arterial road network comprising the north-south backbone, east-west laterals and other roads of strategic importance to ensure continous and efficient flow of people, goods , and services among regions and between major production and consumption areas.

b. Providing sufficient national secondary roads to complement the national arterial road network to link resource areas to the national mainstream.

c. Providing adequate infrastructure support to tourism and agro-industrial areas to harmonize with the Government's goal of increasing productivity in the countryside.

d. Addressing the infrastructure needs of the designated regional industrial centers.

e. Providing alternate access in cases of national and regional emergencies through the development of strategic roads.

f. Mitigating flooding to induce intensive production, especially in the major river basins.

g. Providing essential infrastructure to the fast-growing urban centers including Metro Manila.

h. Adopting the following general order of project priorities: maintenance, rehabilitation, improvement, and construction.

i. Involving women and cultural minorities in relevant infrastructure development activities.

The medium-term DPWH infrastructure program aims to attain the following scenario by 1998:

a. In highways, 100 percent of the 15,798 kilometer national arterial road network consisting of a north-south backbone, east-west laterals, and other roads of strategic importance will have been constructed and improved to all weather standard, and about 93 percent of these will have been paved (compared to 89 percent and 58 percent, respectively, as of the end of 1991). Of the 10,706 kilometers national secondary roads, about 96 percent will have been constructed and improved to all-weather standard and about 82 percent of these will have been paved. One hundred percent of the 240,200 lineal meters of bridges along national roads will have been made permanent (compared to 82 percent as of the end of 1991).

b. Flooding will have been mitigated to tolerable levels in Metro Manila and the major river basins.

2.2 Overall Investment Levels

The 1993-1998 infrastructure program entails a total investment of P 178,193.2 Million, or about P 29,698.9 Million a year, as shown in the summary of investments by project category in Table 2. The infrastructure outlays will increase at an average rate of around 28.3 percent per annum from P 13,155.1 Million in 1993 to P 45,749.7 Million in 1998.

As shown in Table 2, the highways sector will account for the bulk of the total investment from 1993 to 1998 absorbing an average of P 25,987.75 Million per annum or 87.5 percent of the total. Flood control and drainage follows with an average yearly outlay of P 2,495.8 Million or about 10.5 percent of the total. Rural water supply comes next with an average annual outlay of P 790.8 Million constituting 2.7 percent of the total geared at continuing tbe on-going foreign-assisted projects which DPWH has started. This is followed by urban infrastructure with an average yearly investment of P 414.9 Million or 1.8 percent.

2.3 Organizations Concerned With Public Works

The infrastructure program of Government consist of the provision of physical facilities needed to prop-up the productive sector of the economy. It embraces the following:

transportation, covering highways, railways, airports, ports, and urban transport; water resources, consisting of water supply, sewerage, sanitation and flood control and drainage; social infrastructure, covering school buildings, health facilities, national buildings, and urban community infrastructure; energy, involving energy resource development, power and rural electrification; and communications, consisting of telecommunications and postal communications.

The Government agencies concerned with public works and Infrastructure, among others, are the following:

1. Department of Public Works and Highways
2. Metropolitan Waterworks and Sewerage System
3. Local Water Utilities Administration
4. National Water Resources Board
5. National Irrigation Administration

6. Department of Transportation and Communication
7. Air Transportation Office
8. Land Transportation Office
9. National Telecommunications Commission
10. Philippine Postal Service
11. Philippine National Lines
12. Philippine Ports Authority
13. Toll Regulatory Board
14. Ninoy Aquino International Airport Authority
15. Metro Manila Transit Corporation
16. Philippine National Railrways
17. Philippine Aerospace Development Corporation
18. Light Rail Transit Authority
19. Maritime Industry Authority
20. Civil Aeronautics Board

21. Department of Energy (newly created)
22. National Electrification Administration
23. Office of Energy Affairs
24. National Power Corporation
25. Energy Regulatory Board

26. Department of Interior and Local Government
27. Department of Health
28. Department of Education and Culture
29. National Housing Authority

2.4 History, Progress, and Problems of Major Infrastructures

During the period 1987 to 1991, the infrastructure sector of the Philippines focused on strengthening basic and support facilities for improved quality of life and sustained economic growth. Priority was given to small scale, rural-based projects, and rehabilitation and maintenance of existing facilities. The Government instituted several policy measures to improve funds utilization and project administration and implementation. These included the involvement of local government units (LGUs) and non-governmental organizations (NGOs) in program/project implementation and monitoring, respectively. Active private sector participation in infrastructure development, specifically through Build-Operate-Transfer (BOT) and related schemes, was also encouraged.

In pursuing reforms to generate efficiency in the infrastructure sector, significant accomplishments were registered in the policy areas involving privatization, liberalization and decentralization, particularly in the

transportation and communication sub-sectors. The sector was also tasked to effect more concrete improvements, which called for fast-tracking the construction/completion of on-going and new high priority projects.

In general, development efforts in the infrastructure sector have been hampered by some major problems which at present remain unresolved, as follows:

- Insufficient coordination among agencies/units in the implementation of infrastructure plans, policies, programs, and projects. This resulted among others in the perceived below-satisfactory performance in the implementation, and operation and maintenance (O & M) of projects and existing facilities;

- Budgetary constraints in the provision of funding for capital investments and O & M expenditures;

- Inadequate project preparation and lack of clear procedures on the resolution of environmental and community-related issues which affect project implementation; and

- Extensive damages upon infrastructure facilities caused by natural calamities.

2.5 Major Projects in Progress or in Planning

Some of the major foreign-assisted projects being implemented and pipelined by the DPWH in 1993-1998 with special assistance from the Government of Japan through its Overseas Economic Cooperation Fund (OECF) are the following:

1. Laoag-Allacapan Road Improvement Project (150 kms, P 627 M)
2. Special Rehabilitation Project: Allacapan-Aritao Road (P 391 Million)
3. Special Rehabilitation Project: Sta. Rita-Aritao Road (48 kms P 565,9 M)
4. Special Rehabilitation Project: Calamba-Calauag Road (61 kms,P 265 M)
5. Special Rehabilitation: Lipata Ferry Terminal (port works, P 28 M)
6. Rehabilitation and Maintenance of Bridges Along Arterial Roads (Manila North Road and Philippine-Japan Road; 37 bridges, P 154 M)
7. Rehabilitation and Maintenance of Bridges Along Arterial Roads Phase II (4 bridges, P 123.8 M)
8. PJHL and Related Roads Improvement Project (900 kms, P 7.4 Billion)
9. Rosario-Pugo-Baguio Rehabilitation and Disaster Prevention Project (46 km, P 795 M)
10. Naguillian Road, Allen-Calbayog, and Calauag-Matnog Section Rehabilitation and Disaster Prevention Project (P 360.275 M)
11. West Leyte and Northwest Roads Project (116 kms, 32 bridge replacements, P 934 M)
12. Carmona-Tarnate-Nasugbu Roads and Bridges Project (P 212.8)M)
13. Nabas-Caticlan Road (P 44.069 M)
14. Rural Roads Development Project Phase I (P 377 M)
15. Metro-Manila Urban Transport Project, Phase II (Urban Roads, P 1.054 Billion)
16. Metro Manila Interchange Construction Project I: EDSA-Ayala-Pasay Road (P 389 M)
17. Circumferential Road C-5 and Radial Road R-4 to Manila South Expressway Upgrading Project, P 409 M)

18. Radial Road 10 and Related Road Project (12 km, bridges and reclamation works, P 481 M)
19. Metro Manila Circumferential Road C-3 Project (P 193.7 M)
20. Metro Manila Pavement Rehabilitation Project (P 105.27 M)
21. South Luzon Expressway Construction (21 km, P 384.8 M)

3.0 DPWH OFFICE IN CHARGE OF RESEARCH AND DEVELOPMENT OF PUBLIC WORKS

3.1 The DPWH office in charge of research and development of public works is the Bureau of Research and Standards (BRS).

3.2 It was created in 1987 when the DPWH (then called the Ministry of Public Works and Highways) was reorganized under Executive Order Number 124. The BRS was formerly called the Bureau of Materials and Quality Control. Its main function then was the testing of construction materials to be incorporated in DPWH projects. The research activities were mainly related to soils and their improvement as foundation for road pavements.

3.3 The organizational chart is shown in Figure 3.

3.4 Personnel of the BRS

The distribution of personnel of the BRS is as follows:

Personnel Complement of BRS

Division/Office	No. of Positions
Office of the Director	17
Systems & Standards Division	29
Research and Development Division	38
Technical Services & Evaluation Division	23
Materials Testing Division	28
Quality Control Division	25
Technical Training & Publication Division	16
Total	176

3.5 The BRS Budget for 1992 is presented as follows:

BRS Budget for 1992

Per General Appropriations Act (RA 7180)	
Personnel Services	P 14,351,000
Maintenance and Other Operating Expenses (MOOE)	5,727,000
Research Fund	4,000,000
Total	P 24,078,000

3.6 In the management of research and development activities of the DPWH, the BRS initially conducts a research needs survey covering all DPWH field units and technical support units. The long list of research proposals are then prioritized considering the following criteria:

1. Urgency/Necessity of the Project

   This should address problem/s relative to DPWH operations as well as the construction industry.

2. Probability of success (risk factor) in attaining the desired output/s concerning the following:

   a. Availability of competent manpower
   b. Availability of appropriate equipment and facilities
   c. Funding requirement
   d. Completion time
   e. Availability of necessary technical information

3. Benefits derived from the project

   a. Countryside development
   b. Labor-intensive/Use of indigenous materials
   c. Cost reduction
   d. Economic benefit-cost ratio

4. Innovation

   a. New/necessary technological development to support the infrastructure program of the DPWH
   b. Utilization of waste materials/by-products

The ensuing prioritized list of research projects is then submitted to the DPWH Secretary for approval. Upon approval, funds sources for the projects are negotiated and secured from Government and external sources. Projects are subsequently carried out and monitored for their impact. Results are desseminated to various DPWH offices in the form of guidelines, Department Orders, and other communications.

3.7 The research facilities of the BRS are located at its new building along EDSA, Diliman, Quezon City. it is equipped with the necessary testing equipment for almost all kinds of construction materials - soil, cement, asphalt, steel, concrete, etc. It recently acquired new equipment through a grant from the Japan International Cooperation Agency (JICA) and office equipment such as computers from the Transport Research Laboratory (TRL) of the United Kingdom.

3.8 Recent Achievements

Consistent with the Bureau's mandate to engage in research and development on all major areas pertinent to infrastructure, the BRS had accomplished the folowing achievements:

a. Its research on the use of Fly Ash in Concrete Pavement Construction resulted to the issuance of a Department Order authorizing the use of fly ash as mineral admixture and as 20 percent replacement of Portland cement in concrete pavement construction. This was based on an extensive literature review, laboratory studies and long term performance testing. This maximized the use of fly ash which is locally available and results to savings in Portland cement construction work.

b. Use of locally manufactured Portland Pozzolan Cement Type IP in concrete construction. This alleviated the problems on shortage and high cost of Portland cement during the peak period of construction. A Department Order was issued authorizing the use of said cement in DPWH projects.

c. Establishment of cold mix design for emulsified asphalt-aggregate paving mixture for potholes patching.

A Department Order was issued authorizing the use of bituminous cold-mix for potholes patching during the rainy/wet period wherein, during such period, the use of hot asphalt mix is generally not effective.

d. Use of ordinary soil types stabilized with cement/lime as substitute for aggregate subbase and base course materials. This alleviated the problem of scarcity/non-availability of conventional subbase and base course materials in some areas of the country and maximized the use of abundant local soil. A Department Order was issued authorizing the use of said materials.

e. Utilization of weathered limestone (Anapog) as road base material. This maximized the use of locally available and good quality weathered limestone and avoided delays in road construction arising from scarcity/non-availability of conventional base course materials in some areas of the country. A Department Order was issued authorizing the use of blended anapog and granular materials in DPWH road projects.

f. Use of volcanic ash/sand in concrete hollow blocks (CHB) making. This identified application of volcanic ash/sand as useful construction materials considering that said material is presently very abundant in the country due to the Mt. Pinatubo eruption.

g. Establishment of effective asphalt content for bituminous mixes. This determined an economical proportion of aggregates and asphalt as well as blending and gradation of aggregates (within the limits of specification) to obtain a stable, workable, and durable mix.

h. Establishment of tie-ups with foreign organizations such as the JICA and TRL. JICA road pavement experts were dispatched to the Philippines to provide technical assistance on road researches/studies. A colloborative research with TRL on the most cost-effective method to rehabilitate deteriorated concrete pavement is currently on-going.

4.0 MAJOR RESEARCH AND DEVELOPMENT PROJECTS

4.1 The DPWH Research and Development programs are geared towards developing/improving indigenous materials for infrastructure projects. It also intends to adopt foreign technologies and modify them to suit the local conditions. At the same time, new technologies, based on existing knowledge and materials are being developed to further improve the efficiency of implementation of infrastructure projects. To date, the Bureau of Research and Standards has completed various researches/technical studies mostly centered on construction materials, and is presently undertaking a number of researches aside from the programmed activities.

4.2 On-going Researches/technical Studies

1. Use of Locally Manufactured Portland Pozzolan Cement Type P in Concrete Pavement and Structure

   The study aims to determine the feasibility of utilizing the locally manufactured cement as an alternative material for Portland Cement Type I. A series of strength determination of control specimens were already completed. Monitoring and evaluation of the constructed first pilot project along the Tabe Barangay Road at Guiguinto, Bulacan is on-going. A second pilot along Osmena St., Pag-asa, Obando, Bulacan is proposed to be constructed by December, 1992.

2. Use of Ordinary Soil Types in Regions I, IX and X Stabilized with Cement/Lime as Substitute for Aggregate Subbase and Base Course Materials

   Quality testing of abundant ordinary soil types from Regions IX and X with and without cement/lime are on-going. The study area covers the provinces where subbase and base course materials are scarce. The objective of the research is to find the utilization for inferior quality/ordinary soil as suitable subbase or base course materials where said soil types are available extensively and the sources of the conventional materials are scarce. The research is projected to be completed by the end of December, 1992.

3. Pavement Maintenance/Flexible Pavement Mixture Design Using Recycled Asphalt Concrete

   The objective of the research is to encourage effective use of industrial waste product, one of which is the asphalt pavement waste, that will lessen the construction and maintenance costs of road projects. Literature survey and review were already completed. Laboratory equipment to be used in the study was installed by Japanese technicians in March 1991. Marshall test on recovered asphalt materials from thirty (30) sources is completed. The research is envisaged to be completed by the end of December, 1992.

4. Study on the Causes of Pavement Failures and Different Methods of Rehabilitating Concrete Pavement (Joint Study with TRL)

   The study aims to determine the most cost-effective method of rehabilitating deteriorated concrete pavement. Mr. John D. Parry, pavement expert, heads the research together with BRS engineers. Investigation

of the project site in Teresa, Rizal was started and completed in November, 1992. Completion date for Phase I activities is targetted to be completed by the end of December, 1993.

5. Use of Lightweight Aggregates in Concrete Structures

The study aims to identify and explore the possibility of utilizing lightweight aggregates, which are available in various parts of the country, in concrete structures construction. Literature survey and review were completed. Identification and selection of sources including sampling of aggregates are on-going. The research is expected to be completed by the end of March, 1993.

6. Study on the Use of Volcanic Ash/Sand as follows:

a. Multipurpose Blocks - Preparation and quality testing of volcanic ash/sand from various sources had been completed. Additional strength test of mortars is currently on-going. It is expected to be completed by the end of December, 1992.

b. Fine Aggregates in Concrete Mixes - Preparation and strength determination of trial mixes with different cement factors for strength test at ages 28 days are on-going. The study wull be completed by end of December, 1992.

7. Study to Mitigate the Hazards of Lahar and Mud Flows

A technical working group (TWG) composed of representatives from the Department of Public Works and Highways (DPWH), Department of Science and Technology (DOST), Department of Natural Reources (DENR) and the Department of Agriculture (DA) was created for the said study, with the BRS as the overall coordinator. Data gathering activities were completed while evaluation/analysis of subject data is currently on-going. In line with this, a scientific study on lahar flows and factors that affect its behavioral characteristics will be conducted by the BRS with Dr. Kelvin S. Rodolfo, Lahar Expert from the University of Illinois, Chicago. The National Hydraulic Research Center and Mines and Geosciences Bureau will also be involved in the Study.

8. Curing Concrete Pavement Using Indigenous Materials

It was observed in the constructed pilot sections that rice hull is the most effective curing material followed by earth, ponding, sawdust and straw. Continous sprinkling of the concrete pavement for seven days will ensure a strong and durable concrete as most of the hydration takes place in this period. Other experimental sections are proposed tp be constructed to validate the above findings/observations.

9. Flexurial-Compressive Strength Relationship of Paving Concrete

The initial study showed that for a cement factor of 10 bags per cubic meter of concrete using crushed coarse aggregates and porac sand, the relationship ranges from 0.182 (1/5) to 0.234 (1/4) at 14 days and 0.139 (1/7) to 0.238 (1/4) at 28 days. The initial results are

still being validated by the BRS.

10. Programmed Researches/Technical Studies

Listed hereunder are the programmed research projects prioritized based on the needs survey conducted by the Department in terms of necessary technological developments to support the infrastructure program of the country. Most of these are classified into short and long term research.

	PROJECT TITLE	CATEGORY
1.	Use of Sulfur as Asphalt Additive and Extender	Long-Term
2.	Effect of River Flow on Bridge Sub-structure	Short-Term
3.	Fatigue Resistance of Bituminous Pavement	Short-Term
4.	Use of Roller Compacted Concrete in Pavement Construction	Long-Term
5.	Drainage Characteristics of Base Course Materials Pavement, Graded and Compacted in Accordance with Approved Specifications	Short-Term
6.	Development of Technique for Hydrologic Analysis of Ungauged Rivers	Short-Term
7.	Use of Beach Sand in Concreting Works	Long-Term
8.	Action/Effects of Sea Water in Concrete	Long-Term
9.	An Investigation of Cracking in Soil-Cement Bases for Roads	Short-Term
10.	Use of Sand-Bitumen for Road Bases	Long-Term
11.	Skid Resistance of Concrete	Long-Term

A survey and review of literature and preparation of project proposals for the aforementioned researches are currently on-going.

11. Project Evaluation

To benefit from new construction materials in terms of quality and economy, the Bureau is also evaluating new products for possible use in DPWH projects which are not yet covered by the generally accepted existing standards and/or not yet adopted in DPWH projects, upon the request of their respective proponents. These products include additives in asphalt, steel fibers, soil stabilizers, reflectorized traffic paints, and and other products on infrastructures.

4.3 Problems in Promoting Research and Development

1. Government Policy Support and Commitment

Research and Development programs as well as development programs, in general, should be carried-out within the context of national development objectives and policies. Government commitment, political will, and policies that support the attainment of program and project objectives are critical to these activities.

Development projects should relate to appropriate national objectives and not political, regional, ethnic, and individual desires of decision makers and political leaders. Correspondingly, national objectives should form the basis of sectoral objectives to ensure consistency in direction; coordination, integration, and synchronization of projects; that proper linkages are defined in implementation; and that sustainability are phased with institutional redundancy/duplicated efforts minimized.

National objectives are often broad and sometimes conflict - i.e. short term versus long term considerations, points of view of decision-makers, and implementability in view of limited resources. There is a need for an agreement on objectives; and appropriate support and resources for responsible organizations (financial/budgetary, logistic, managerial, administrative and legislative).

Government policies on budgets, foreign exchange stability, foreign debt, prices and subsidies, interest rates, personnel and hiring practices, private sector participation, centralization/decentralization, sector priorities, procurement, organization for the delivery of Government services, training, etc. affect research and development activities. In order to promote sustainability, policy reforms may be necessary for the greater good of the country.

It is also a fact that Government commitment and support may vary over time. In a political process characterized by instability, there are frequent changes in its policy package or environment which hinder sustainability of projects. Policy statements in the image of long term strategy may only be adaptive responses by Government to short term internal pressures from vested interest groups

Frequent changes in Government leadership and organizational set-up result in a deemphasis of existing programs and therefore their sustainability. Changes of Government or of policy can also lead to sudden reductions of budgets, conflicts on operational areas of concern, more difficult access of resources, and possible loss of key staff.

2. Management, Organization, and Participation

Sustainability of research and development activites is affected by management leadership and support, administrative and logistic processes, training, management information support, feedback mechanisms, decentralization, and a participative approach or the involvement of end-users in the planning, implementation, and monitoring of programs/projects.

Program and project management should include the responsibility for shaping policy and technological applications, setting goals, and mobilizing political support, and coordinating with complementary organizations and project end-users. Project objectives should be well matched with an implementing organization's administrative capability - with appropriate administrative systems for hiring and

personnel, human resource development and training, research and development facilities, logistics and maintenance, management information and feedback systems, budget and financial management systems.

Currently, the organization structure and level of professionalism requires continuing improvement. Currently, a low priority is being accorded long term institutional development objectives geared at improving overall service delivery, increasing technical and financial assistance to strengthen research and development sub-organizations at the central, regional, and district level; and giving adequate basic testing and facilities as well as equipment support.

Managerial leadership is a crucial factor in developing sustainable programs. It is a fact that management skills and good leadership are among the scarcest of human resources required for development and subsequently sustainability. Sustainability can also be equated with effective program management. Competent managerial leadership and technically capable staff are also important to ensure the success and sustainability of projects.

3. Finance

Sustainability in this area requires sufficient cash flow to cover implementation, operations, maintenance, and depreciation of investments. Financial assessments showing sourcing via cost-recovery, commercial sale and revenue recipts, direct appropriations of funds, and, where there may be shortages, donor or external financing are important in establishing sustainable research and development programs.

With the reality of scarce resources, competing demands from increasingly politicized groups, resource allocation has often been influenced by political expediency vis-a-vis economic rationality. Often, a major impediment to research and development programs has been the lack/insufficiency of funds for operations, maintenance, facilities, and depreciation.

The predominant use of Economic Rate of Return (ERR) as a measure of viability and in the allocation of resources via the capital budgeting process affects the decsion to invest and sustain infrastructure projects as: (i) it encourages a short term focus as benefits and costs as benefits produced during the early years of a research project implementation are more highly valued than those generated later; (ii) it pays almost no attention to long term environmental impacts outside of the project area (e.g. lowering of water table from a concentration of dug wells, long term ecological effects of high income crops/trees which are financially viable on the ecosystem, downstream effects of irrigation systems and high yield agricultural practives, etc.); (iii) difficulties in quantifying all costs and benefits in monetary terms; and (iv) methodological difficulties in utilizing ERR as a monitoring base. For many infrastructure projects as well as research and development activities in this field, the major flow of benefits usually begin until after an extended period of investment. The nature of

the flow and duration of benefits need to be considered in economic viability assessments.

More pertinent methodologies for assessing overall program/project viability and sustainability need to be developed, piloted, and tested for applicability. Examples of such parameters are: socio-economic welfare indicators environmental impact, cost-effectiveness, technological advance and parity, network development considerations from an overall system's efficiency point of view and given relative priority in terms of a development planning and resource allocation. .

Opportunities to use/tap the private sector and enterprises as co-partners in the development process also need to be explored and developed in order to conserve limited Government funds and to minimize external debt.

4. Technological Factors

Technologies should be selected to fit the country's financial and institutional capabilities as well as meet program goals. The costs of providing and maintaining these technologies must not be excessive relative to the benefits generated.

The development and application of "soft" technologies - i.e. organizational structure and management, personnel and training practices, and extension services are important in facilitating the assimilation of "hard" technologies.

The capability to develop and adapt new technology as well as technological renewal in relation to changing environments need to be addressed under research and development and sustainability thrusts. Technology need to be examined, tested, and adapted (applied research) together with research and development (R & D) suited to our country's setting need to be pursued. Furthermore, Indigenous labor, skills, materials, and technology are not fully used.

State of the art technology are not properly acquired, tested, and piloted due to lack of training/retraining opportunities, research and development facilities both Government and private, non-availability of specialized education/training in the country and even in the academe, testing equipment, and lack of financial support. Also bulk of these technologies are available only from developed countries and are very expensive for the country to acquire.

5. External Factors

Research and development programs and projects operate within the context of existing political, economic, and socio-cultural circumstances which are oftentimes beyond their influence and control.

Political and economic instability often disrupt research and development program sustainability. Frequent political turn-over in political leadership, implementing agency leadership and organization; together with the negative impacts of inflation and escalation on budgets, foreign exchange instability,

difficulties in the availability of capital equipment and spare parts, and fluctuations in foreign and domestic prices often result.

5.0 INTERNATIONAL RESEARCH ASSISTANCE/EXCHANGE PROGRAMME

5.1 Presently, the DPWH through the BRS is the recipient of research and development assistance from the Government of Japan through its Japan International Cooperation Agency (JICA) and the British Government through its Transport Research Laboratory (TRL) of its Overseas Unit.

1. JICA's Mini-Project Type Technical Cooperation

The objective of this technical cooperation is to develop the technological capabilities of the BRS in the design, construction and maintenance of road pavements as well as on research and development. Pavement experts were dispatched by the Government of Japan to the BRS. Likewise, BRS counterpart staff involved in the project will be trained in Japan to enhance their technical know-how. In order to support the research activities of the Bureau, several equipment/apparatus on soil, asphalt and concrete were also donated under the grant-aid program.

2. Collaborative Research Between TRL and BRS, DPWH

The objective of the collaborative research is to determine the most cost-effective method of rehabilitating deteriorated concrete pavements. The project is headed by Mr. John D. Parry, a pavement expert of TRL, with BRS personnel as members. The study involves the identification and assessment of the causes of failures on concrete road pavements. Different rehabilitation methods will be tried on experimental pavements and monitored to evaluate their effectiveness. A comparative cost analysis will also be made to evaluate its economic viability. A number of research equipment including a computer were also donated to the BRS.

3. Exchange Programme of Technical Publications

In line with the BRS' research and standards-setting activities and promotion and dissemination of technical publications thrusts, it continously engages in the exchange programme of technical publications with foreign organizations. These include the American Association of State Highway and Transportation Officials (AASHTO), American Society for Testing Materials (ASTM), American Concrete Institute (ACI) and other organizations involved in research and public works.

5.2 Problems in Promotion

1. Need to Capitalize on the the Current State of Communications and Information Systems/Networks

There is a need to avail, capitalize on, and integrate the continuing improvements in world communication networks and information systems in the promotion of research and development and scientific research as these become more sophiscated and advanced. A key feature of making cooperation possible is usually the much more developed state of development and communications.

The Philippines has very limited resources concerning information and communication systems needed

to maximize promotion of research and development endeavors. A centralized network to coordinate the overall research and development effort need to be established. Linkages to academe, research facilities, donor institutions, etc. need to be established considering all potential and interested users, both local and foreign. A decentralized promotion network with approppriate information processes to promote research and information gathered and produced need to be established, say regional and provincial centers which will make information truly a free good and to promote interest in the field of scientific processes and research in relation to sustainable development.

Government should be the natural coordinator of this network. It must compel its agencies to search for, acquire and supply the maximum of information. It must initiate rules, procedures, and methods that will make technology and information cheaper, more accessible, and easier to use. Contacts and linkages with other countries, information agencies, research organizations both local and foreign, and international agencies need to be continously pursued, developed, and updated.

2. Need to Properly Identify Areas of Assistance

There is a need to address the question of how to optimally identify the need for aid. This requires an enlightened economic planning and administration for a developing country which should appropriately address questions which are political and value judgemental in nature. The nature of development in general should concern calculating how much aid should the country employ as well as its timing. Thus, it is necessary for these government agencies to properly assess and state its objectives taking into account futuristic value judgement and sustainable levels of development. It is a fact that politicians have limited span of decision which is more on the short and medium term, and not much on the long term. To exemplify this fact, some very worthwhile research and pilot projects on grant basis proposed for the Philippines had to be deferred to date because of other sectoral priorities of Government at macro level.

Government commitment, political will, and policies that support the attainment of program and project objectives are critical to these activities. Also, management leadership and support, administrative and logistic processes, training, information system support, feedback mechanisms, decentralization, and a participative approach will also play a crucial role in promoting and maximizing the impact of research and exchange activities.

3. Need for Effective Assistance

Another major issue concerns the effectiveness of the assistance. Often, the effectiveness of the assistance is dependent upon the suitability of the goods, services, and technology being made available and considering also the alternative sources of supply for these. The effectiveness of the aid will also be dependent on the terms and conditions set in making these available such as the financial cost, repayment and interest on the financial aspects of the program.

Donor countries at times make it a practice to attach conditions to aid, assistance, and exchange programmes. This is characterized by the phenomenon of "tying" whereby donors make available the assistance under certain conditions. Examples of these are: (i) project tying - whereby funds and/or assistance can only be spent or used for specific items of expenditure or areas of endeavor; and (ii) procurement tying - limiting the funds or assistance to goods and services that are supplied by a particular country, usually the donor country.

Research and development projects and exchange programs need to consider cost-effective local industry supplies, indigenous materials and resources, local social customs and practices, as well as labor and current levels of expertise.

4. Political Aspects of Assistance

The decision to grant aid to another country is fundamentally a political decision. It may be important to understand the political and other bases for assistance giving. Political considerations, or the existence of old links between countries arising from linguistic, political or circumstances very largely determine the allocation of developed countries aid. Donor countries are often the richer countries of the world.

Oftentimes, self-interest is the basic motivation for making foreign aid and assistance available. It will be best if the assistance and exchange will be considered from the point of view and best interests of the recipient country. The continous contact between nations is needed to establish confidence and close working relations.

There is a need to promote a development-oriented science and a science-based development engineering approach which shall apply the research method and the world's accumulation of scientific knowledge to problems impeding technical, economic, and environmental harmony; to evaluate the feasibilities of transferring science-based technology; and to adapt science-based technologies for assimilation. This should also be set up on a holistic and programmatic approach and be dedicated to the greater good and sustainable future of mankind.

5. Limited Finances

It is also a fact that as developing countries receive more and more assistance in the form of loans, rather than grants, the burden to service these charges on the country's balance of payments also become larger and larger. Developing countries often find the debt problem a very acute and real problem.

Assistance and the basis of exchange should be made on the best terms possible such as grants and soft concessionary loans. The essence of grants that leaves no liability and obligations behind for repayment and other conditionalities need to be maximized. Technology for overall sustainabe growth on a global basis should be promoted to override solely financial and self

interest considerations.

6. Maximizing Available Sources of Assistance

The ultimate source of assistance will be the income, wealth, and technology of the richer and more developed countries of the world. Sources of these will be twofold: (i) private actions involving direct investment, loans, and support to multilateral agencies; and (ii) public actions involving bilateral transfers/assistance to multilateral agencies. There is a need to maximize assistance from these sources for a viable research exchange and other assistance programs.

7. Technology

State of the art technology are not properly acquired, tested, and piloted due to lack of: information on these developments per se, training/retraining opportunities, research and development facilities both Government and private, non-availability of specialized education/training in the country and even in the academe, testing equipment and facilities, and lack of financial support. This greatly affecfs the capacity to absorb, assimilate, and promote the fruits of the research and development and promotion endeavors.

Also bulk of these technologies are available only from developed countries and are very expensive for the country to acquire. The system of patents, system of keeping trade secrets, security constraints, increasingly rapid rate of obsolescence of technical and industrial equipment are also problems in the promotion of technology and exchange programs. The patent system typically grants a system of monopoly priveleges to those who succeed in making technical progress of special kind in particular fields. These pose a conflict between the best allocation of resources under existing conditions and the desire for improvement and sustainable growth on a global basis. Systems, legislation, and special arrangements need to be established to truly promote the best and most appropriate technology possible as well as promote the further conduct of secondary and tertiary research on inventions and advanced technology and processes.

The development and application of "soft" technologies, the capability to develop and adapt new technology, technological renewal aspects, and adaptability and suitability of the incoming technology need to be considerd in research and development and their adaptation to the developing countries.

5.3 Necessity for, and Problems Involved in Inter-Asian Research Exchange

Proposals for greater international cooperation and reforms (liberalization) of licensing and system and patent provisions are needed to truly address sustainable and more equitable development. These are envisaged to effect a lower overall research expenditure as well as the ability to recoup heavy research expenditure.

Exchange and flows will not optimally take place without the intervention of special machinery and procedures. Also, the terms and conditions under which such

flows or exchanges take place need to be administered. A Coordinating body for inter-Asian research need to be established.

The coordinating body will be needed to unify objectives, policies, programs, and make them more effective; to coordinate the activities of various research and development and information dissemination organizations of participating countries; to stimulate reforms and new initiatives in this field; and to transfer the results of scientific research undertaken under its authority.

It must prepare a five-year and long range strategic program, including a set of technical assistance measures and joint research and development ventures that will encourage economic and environmentally-sound growth of the Asian region. It can be tasked to develop, coordinate and administer the annual aid programs within the Asian region allocating these to countries, research institutions, and universities, etc.

It will also establish its appropriate information policy covering functions such as: (a) Documentation - consisting of collecting the maximum intelligence from local and external sources; and (b) Information - the transfer of that intelligence to its users. It will also concern itself with: the main information media and the nature of participating governments intervention; information processing; the training and qualification of specialized research and development, technical, and information personnel; nature and number of specialized information establishments; use of modern equipment (computers, information processing, and communications); promotion; and international problems.

It should also address the issue of standardization of technology, specifications and test parameters, information, and reports. Examples would be the standardization of technical reports on microfilm, computer media (tapes, diskettes, portable disks, optical devices, and data communications), and videotape format in order to create a new and very large market with considerable consequential savings in costs and rapid promotion. Uniform methods of identifying reports will also facilitate their retrieval and classification, cut down publication time, minimize the failure of having researches not publicized, and assist in organizing teaching in methods of expression for scientists and engineers. Furthermore, translation facilities for these reports and information can be facilitated as it is common knowledge that costs of translation are unquestionably very high.

The exchange program must consider the experience, results, and methods of the American and European countries aiming at the similar goals and to establish appropriate linkages with all institutions specialized in the dissemination of scientific, engineering, and technical information in order to benefit from them.

6.0 DISASTER AND DISASTER PREVENTION IN THE PHILIPPINES

6.1 Present Situation And Problems In The Philippines

Road Disaster Prevention

The Philippines has long been emphasizing the development of trunk roads in view of the overall socio-economic development program of the country and that a quantitative expansion has been realized. Despite the achievements made, some of most important roads suffer many deficiencies including, among others, disasters due to slope failures, fall, landslide, debris flow, and the like which impair the efficiency of the road transport system. Road disasters were classified into five types:

a. Cut Slope Failure which is further sub-classified into surface and deep failures. Surface failures are generally caused by erosion, weathering and structural weakness while deep failures are caused by scouring, rotational and translation failures.

b. Embankment Slope Failure which is sub-classified into surface failure due to erosion and deep failure due to scouring and saturation.

c. Fall which is sub-classified into rock and debris falls. The former is the free fall of rocks detached from bedrocks, while the latter concerns unsupported pebbles, cobbles, and boulders on a slope.

d. Landslide which is caused by the loss of balance between shear strength of materials and movement force along a specific slide plane. This is sub-classified into rock and soil landslides.

e. Debris Flow which is induced by a force of flow caused by floods where there exists deposits on torrent or riverbed. This is sub-classifed into debris and mud flows.

Eruption of Mt. Pinatubo and its Lahar Threat

The eruptions of Mt. Pinatubo in Central Luzon, Philippines, during the period June 12-15, 1991 and the subsequent onslaught of typhoons and lahar flows resulted in extensive damage to public infrastructure and private properties. This natural calamity caused almost the total destruction of several low-lying communities, laid waste to large areas of very productive agricultural lands, and considerably affected commerce and industry.

Based on preliminary estimates of the US Geologic Survey (USGS) and the Philippine Institute of Volcanology and Seismology (PHILVOCS), the 15 June 1991 eruption ejected approximately seven billion cubic meters of pyroclastic materials, most of which were deposited on the highland slopes sorrounding the volcano (See Figure 2). So far, fifteen percent of these materials have eroded resulting in the siltation of all eight major river systems sorrounding the volcano and inundation of a significant land area. Up to 25 percent of pyroclastic deposits is expected to erode in the first three years, and up to 50 percent within ten years, which could cause extensive damages unless appropriate measures are put in place.

The extent of damage to infrastructure is estimated, in

terms of rehabilitation and reconstruction requirements, at P 8,215 Million. Flood control, including lahar, accounts for a about 42.8 percent of the total damage at P 3,514 Million. Existing roads and bridges suffered heavy damage at P 1,525 Million and new alternate roads needed call for for an additional P 2,194 Million for a total P 3,719 Million or 45.3 percent of the total. Damage to schoolbuildings was also extensive at P 748 Million (9.1 percent), while damage to other public buildings amounted to P 234 Million (2.8 percent).

About 489 kilometers of major national and 163 kilometers of municipal roads were covered with volcanic fall ranging from 5 to 30 centimeters in thickness. Six major bridges collapsed immediately after the eruptions. Subsequent lahar flows destroyed bridges as well as approaches of several other bridges were damaged.

Damage to river control facilities included silted rivers, breached dikes, eroded waterways, clogged drains, and destroyed spur dikes within the immediate influence area of the eigth major river systems affected by the eruptions.

Some 4,665 classrooms were totally and partially destroyed mainly due to ashfalls. The eruptions caused the displacement of an estimated 236,686 pupils and 7,009 teachers. Ashfalls likewise caused total damage to 98 hospitals and health centers, 18 public markerts, 13 municipal buildings. and 70 other Government buildings.

About 645 persons were reported dead, 195 injured and 23 missing. The majority of these casualties were victims of collapsing residential houses due to ashfalls, drowning in the ensuing floods, and diseases in the evacuation centers. A total of 40,809 houses were totally destroyed while 67,395 houses were partially damaged.

Agricultural land area affected reached some 86,000 hectares while damage to crops, livestock, and fisheries is estimated at P 604.9 Million. About 18,000 hectares of forest land had been buried in ashfalls of approximately 25 centimeters. Nearly 19,799 hectares of newly forested areas were destroyed and some P 125 Million worth of tree seedlings were lost. Damaged natural forest covers and reforested areas extend to 43,801 hectares.

An estimated 651,000 employed persons have lost their sources of income either permanently or temporarily which is rougly 28 percent of the total employment level in Region III registered in April 1991. Heavily hit was the manufacturing sector and consequently the exporting sub-sector, affecting a total of 599 firms with total assets of P 850.6 Million.

6.2 Disaster Prevention Activities In The DPWH

Road Disaster Prevention Program

In recognition to the importance of road disaster prevention, the Government of the Philippines has planned the formulation of a long term program for road disaster prevention with the kind and benevolent assistance of the Government of Japan through the Japan International Cooperation Agency (JICA).

Two disaster prevention feasiblity projects were undertaken in 1983 (Stage I) and 1985 (Stage II). The Stage

I has identified disaster spots and prioritized disaster sections along four national roads: (i) the Maharlika Highway (Luzon to Leyte Section), (ii) Kennon Road, (iii) Agoo-Baguio City Road, and (iv) Naguillian Road. Feasibility studies were also undertaken for three sections: (i) Dalton Pass, (ii) Mahaplag-Sogod, and (iii) Kennon Road. The Stage II study covered the folowing sections: (i) Lucena-Calauag, (ii) Allen-Calbayog Section, and (iii) Naguillian Road.

The typical countermeasures adopted in these projects are as follows:

a. Surface Drain - The main cause of cut slope and embankment slope failures is surface water. Various kinds of ditches were applied in many sections. Top slope ditches were placed were running water from adjacent hinterland area was expected and berm ditches were adopted everytime berms were proposed. Side ditches were applied as a prerequisite in all disaster spot because of the non-existence of drainage facilities.

b. Subsurface drains - Horizontal drain hole and closed conduit were applied to check debris flow where the level of groundwater seems to be high and seepage water was observed.

c. Slope Protection - Except on slopes composed of hard rock not susceptible to erosion and scouring, protection works were generally applied for all kinds of slope. Slope protection with vegetation was applied for slopes with soil and weathered rocks where vegetation can grow. For other slopes, concrete spraying was applied.

d. Anchoring - Unstable rocks susceptible to fall on slopes were proposed to be fixed to the bedrocks by anchoring with rockbolts. This measure was applied on slopes where big size with a few number of rocks exist.

e. Anchor Wire Net - For slopes where small size with many unstable materials exist, anchor wire net was applied. Since this type cannot provide complete protection for the prevention of erosion and scouring of slope surface, this was adopted mainly on slopes composed of hard rocks.

f. Stone Masonry Retaining Wall - For steep embankment slopes where the slope gradient cannot be improved, stone masonry retaining wall with re-filling was applied. It should be noted that side ditches were invariably provided at these spots.

g. Realignment with Catch Wall - Re-alignment was applied at spots where there is enough flat space to allow shifting of the existing road. This is almost always more economical than the slope protections applied directly on slope. The maximum shift adopted was about six meters. Catch walls were always used to prevent spreading of damage due to falling rocks.

DPWH Rehabilitation Plan for Mt. Pinatubo Affected Areas

Immediately, after the eruptions, emergency actions particularly on rescue, evacuation, and relief operations were implemented through various Government agencies at all levels, with the participation of non-government

organizations and the private sector. The emergency operations were immediately followed by a comprehensive rehabilitation and restoration of damaged infrastructure, the continuing provision of needed social services, the establishment of resettlement areas for evacuees who have lost their properties, and the restoration of jobs and creation of new livelihood activities.

The infrastructure plan and program has been made an integral part of the overall master plan for the Pinatubo-affected area and considers a 5-10 year scenario. The DPWH rehabilitation and reconstruction plan is focused on the following priorities and activities:

a. Keeping transport systems open and lahar free, particularly major roads and river crossings, to provide for uninterrupted movement of people goods, and services to enhance speedy recovery and rehabilitation.

1. As part of its emergency operations, the DPWH cleared the roadways of some 652 kilometers of road ashfalls within a week after the eruption thereby considerably enhancing the effectiveness of the rescue, evacuation and relief operations done during the first two to three weeks following the eruptions. Disposal of ash and other volcanic debris from the roadsides, however, became a repetitive and extended operation because of the continous dumping of spoils on the roadsides by residents abutting the roads.

2. Declogging and clearing of road drainage likewise have become a continous operation due to the effect of subsequent rains and road floodings.

3. Road sections which have become prone to inundations and traffic closures during heavy rains have been raised to an average of two meters to preclude traffic interruption.

4. A total of 31 graders, 86 loaders, and 279 dumptrucks were mobilized and used in DPWH operations.

5. As to bridge operations, because of the ever-changing conditions particularly relating to lahar action and its destructive effects on river channels, the following are being undertaken:

- o The reconstruction of permanent bridges has, in general, been initiated only where the conditions have stabilized;
- o Activities on bridges have been and will continue to be mostly limited to emergency repairs on damaged approaches and providing detours by fording and temporary structures with DPWH crews continously monitoring these detour crossings to ensure their continous passability;
- o Other bridges are being kept open thru continous desilting on the bridge sites and their environs; and
- o River control works immediately upstream and downstream of bridges are included.

6. Under consideration as long term measures, are the construction of new alternate roads that are envisaged to provide undisrupted passage of people, goods, and services.

b. Protection of life, communities, agricultural and fishpond areas, and infrastructure from further destruction, and mitigation of the effects of potential damages, especially from lahar and floodwaters.

Based on studies made by the PHILVOCS which categorized different areas and communities as follows, the corresponding strategies are being pursued:

1. High Risk or Group I Areas: These are areas which are likely to be buried by lahar, even with infrastructure works, because of their location directly to the path of lahar, their low lying topography, and the enormous volume of potential lahar flow. Thus, these areas cannot be saved even by on-going interventions.

   Strategies:

   a. Basically, let nature take its own course without any engineering intervention works.

   b. Evacuate the residents in the high risk area and resettle them in safe new communities.

   c. Protect what can be reasonably protected, such as town centers near the periphery of high risk areas in consultation with the people affected. This can be achieved thru strong engineering structures, such as concrete-lined dikes and drainage systems. As may be needed, the channels should be maintained to allow continous flow of water.

2. Medium-Risk or Group II Areas: These are areas which are likely to be affected by lahar and can be protected by normal engineering works.

   Strategies:

   a. Stop the sediment at its source. This is being done by building "sabo" or check dams in the upper reaches of the river at or near the pyroclastic deposits. The structures are designed to retain as much of the deposits as feasible and reduce their velocity to minimize their destructive effects downstream.

   b. Convey the materials directly to the sea. This is being done through channel deepening, widening, and dredging.

   c. Control the sediment as it moves from the mountain to the alluvial fans. Measures being undertaken include restoration, desilting, and dredging of channels; raising, rehabilitation and strengthening of dikes; construction of river training works, such as spur dikes, hurdles, traverse sills and consolidation dams; provision of sediment retention basins, sand pockets, and ring

dikes.

3. Low Risk or Group III Areas: These are areas at very little chance of being affected by lahar flow and may need only minimal engineering works. The strategies to be undertaken are the same measures for Group II but to a lesser extent as needed.

c. Reconstruction and rehabilitation of schools and other public buildings (with upgraded designs) located outside areas affected by mudflows to restore the educational program and essential administrative services.

Emphasis has been given to the immediate repair and restoration of damaged/collapsed school buildings, mostly on sites which are free from lahar attack. To date, the building rehabilitation program has been completed, except for a few two-storey buildings scheduled for completion this 1992 to early 1993. The schoolbuildings have been redesigned to provide steeper roofs with no gutters and closer spacing of purlins for more damage resistance.

Equally given priority is the reconstruction of heavily damaged or totally destroyed municipal buildings, public markets, slaughterhouses, etc. As in the school building program, the design features steeper, gutterless roofs, closer purlin spacings, and reconstruction will be at lahar-free sites.

d. Support to other rehabilitation activities of other agencies by providing assistance to relief and social services and infrastructure support to resettlement and livelihood programs.

The DPWH has provided vehicles and heavy equipment support in the relief, evacuation and rescue operations in various affected areas. The immediate clearing of roadways of ashfall deposits made possible the speedy and timely evacuations and delivery of relief services.

Equally meaningful is the role of the DPWH in providing infrastructure support to the resettlement program partially for the displaced or affected residents in the high risk areas. The infrastructure component of this program involves the clearing and site development, construction of access roads and road network within settlement areas, construction of schools, toilet and health facilities, shallow and deep wells, and recreational facilities. It also includes the construction of productivity and various community centers.

6.3 Technical Tasks Required for Disaster Prevention

Drawn from the experience and results and recommendations from the Stage I and II studies, the related problems had been shown and their immediate solutions emphasized so that further deterioration and/or eventual disaster were avoided and minimized. The Government of the Philippines is, therefore, more determined to pursue the immediate implementation of road disaster prevention program along its major trunk roads nationwide as well as to continue the conduct of feasibility studies for other identified and to be identified disaster potential sections nationwide.

Disasters from typhoons, earthquakes, volcanic eruptions and other natural causes result in destruction of infrastructure facilities, destruction to the environment, death and displacement as well as inconvenience to people and their socio-economic activites. The costs of disaster prevention and rehabilitation/reconstruction will be deemed very difficult to bear for the primarily affected country alone especially if it is a developing country like the Philippines with meager and stretched financial resources. This requires a global response and international cooperation and assistance. Grants, scientific and technical know-how, special studies and monitoring, and concessionary loans for disaster prevention, rehabilitation and reconstruction should be made available by developed countries, development institutions, and benevolent donor countries so that the disruptive effects of these can be minimized and prevented. Activities in this area can serve as a platform for research, prevention, and mitigation on a global scale so that occurences of similar events in other countries can be immediately resolved at a minimum of human pain and suffering.

7.0 INFRASTRUCTURE, THE ENVIRONMENT, AND SUSTAINABLE DEVELOPMENT

7.1 The Current Situation In The Philippines

The Philippine terrestial ecosystem is characterized by a high level of biological diversity and endemism. However, population pressure, poverty, and survival needs, as well as multifarious economic activities have resulted in rapidly decreasing forest cover; diminishing number of species of flora and fauna; increasing cultivation of fragile upland areas; urban encroachment on prime agricultural lands; decreasing soil productivity due to erosion; salinization and misuse of agricultural chemicals; and gradually decreasing pasture, grasslands, and rangelands. In 1972, the country had about 10.4 million hectares of natural forest cover. By 1990, there were only 6.16 million hectares or approximately 20.50 percent of total land area.

The increasing land requirements of ever increasing population has led to intensified utilization of the country's limited productive lands and the exploitation of vulnerable ecosystems. This has generated environmental problems like soil erosion, pollution, decreasing soil fertility and loss of genetic resources. The land in at least 22 of the country's provinces are already badly eroded. The resulting destruction of forests has caused adverse economic impacts involving, among others, displacement of cultural communities and economic losses from foregone benefits and damages to life and property. Roughly 3.5 to 6.6 million inhabitants belonging to cultural communities reside in the uplands.

Agricultural lands have also been subjected to growing pressure from various sectors. Erosion, salinization and misuse of chemicals have combined to degrade some of the country's best soils. Conversion to non-agricultural uses has likewise caused the loss of the most productive agricultural lands. In 1983, about 45 percent of the 5.78 million hectares classified as suitable for crop production were found susceptible to erosion in varying degrees. In 1985, 50 percent of the country's seasonally cropped areas were believed to be subject to soil erosion.

As to the country's coastal and marine environment, the major problems currently encountered are the degradation of mangrove forests and their conversion to other uses, the destruction of coral reefs due to pollution and destructive fishing practices, overfishing beyond sustainable yields, and the occurence of red tides (bloom of toxic floating phytoplankton). Destructive fishing practices like blast fishing, cyanide fishing, and muro-ami fishing (driving fish towards a bag or grill net by using vertical scare lines festooned with streamers which break-up brittle hard coral as these impact on the sea bottom).

The increasing siltation and pollution of surface waters and the salinization of groundwater are the main problems confronting the country's freshwater resources. These are very pronounced in rivers and lakes near urban areas. Only about 15 percent of Metropolitan Manila's population is served by a sewerage system. Domestic wastes account for 70 percent of the pollution load in rivers of the country's capital. Industrial wastes account for the balance of the pollution load.

In other parts of the country, the rivers are heavily silted with mine tailings. Sugar mills, fermentation alcohol

plants, coconut oil mills and desiccated coconut factories contribute heavily to the pollution of the country's rivers and lake since conventional technologies have proved to be inadequate to handle the pollution problem. More advanced technologies, on the other hand, have proved to be too costly requiring huge outlays and operating costs. Numerous small and medium scale industries, like electroplating and tanneries, which have no or grossly inadequate treatment facilities contribute significantly to the amount of toxic and hazardous wastes reaching the country's waterways. Also, siltation from sorrounding denuded areas and eroded banks of river tributaries have resulted to shallow rivers and lakes.

Sustaining the basic needs for an increasing population is a problem of national proportion. Any headway in productivity is easily negated by increasing population pressures on land and natural resources. It is straining the Government's capability to provide the basic services such as education, health care, and shelter. Balancing the size of the population and the rate of growth with available resources in relation to the capacity of the economy to provide the basic needs of the population is currently one of the major concerns of Government.

In many areas, the pattern of human settlements in high lowland-to-upland migration are resulting to conflicts between the migrants from the lowlands with the upland farmers, loggers, and pasture leaseholders as well as tribal communities. The increasing dominance of migrants over indigenous groups has created negative environmental, economic, and social impacts.

Since the 1950's, the pattern of human settlements has been characterized by growing urbanization. The country's premiere cities continued to be the most populated resulting in serious strains on both physical and social infrastructures. Traffic noise and congestion, inadequate sewerage system, poor garbage collection and disposal, heavily polluted rivers, and air pollution pervade the major urban centers.

The country faces a two-pronged housing problem. First, there is the problem of quantity, which means that there is a need for new housing stock. Second, there is the problem of quality meaning that there is need to upgrade the existing stock of dilapidated, makeshift and light material housing. In 1980, an estimated 0.857 million persons comprised Metro Manila's squatter population. By 1987, it had grown to 2.5 million or about one-third of the total population of the capital region.

Proliferating slums and squatter settlements have posed various negative environmental impacts. The low-lying poorly drained sections of these areas render the residents extremely vulnerable to health and safety hazards. The settlements which are often situated along and within rivers and waterways are contributory causes of water pollution, flooding and drainage problems. They also present a physical obstacle to the successful implementation of environmental improvement projects.

Air and noise pollution and traffic congestions are problems associated with urbanization. Air pollution is due mainly to the presence of large numbers of motor vehicles and manufacturing plants with inadequate control systems. Due to the country's tight economic situation, proper maintenance of vehicles is seldom a priority. Most public

utility vehicles in use are generally second-hand imports or rejects from other countries.

Poor sanitation and grossly inadequate garbage collection and disposal are highly visible problems in the country's cities particularly in Metro Manila which generates nearly 4,000 tons of solid wastes per day. The country's urban centers share the same problems: limited budgets for new facilities to handle expansion of the communities served; low service fees which prevent effective improvement of existing facilities; lack of technological know-how to improve collection efficiency and to operate modern sewerage facilities, sanitary landfills or incenerators; and inadequate public cooperation regarding proper disposal of sewerage and solid wastes.

The Philippines is also prone to natural disasters which have seriously constrained economic growth and resulted in widespread environmental damage. The country is visited by an average of 19 typhoons annually. Between 1980 and 1990, a total of 213 typhoons crossed the country affecting over 25 million people and resulting in 5,952 deaths, about 14,000 missing or injured and environmental and property damages of about P 45 Billion. Floods due to excessive rainfall usually accompanying typhoons have also caused widespread damage. In 1989 alone, floods damaged property and crops worth over P 390 Million.

Drought has also adversely affected several parts of the country. Between 1982 and 1990, three major droughts affected the country which appears to be strongly correlated with the global phenomenon called "El Nino". A total of 287,000 hectares of agricultural lands were damaged affecting over 27,000 farmers and caused production losses of over P 763 Million.

Earthquakes have also struck the country. The strongest and most devastating earthquake hit Luzon Island on July 16, 1990 causing thousands of fatalities and injuries, widespread destruction of buildings and physical infrastructures, and near complete devastation of the premiere northern city and summer capital of the Philippines, Baguio. The cost of rehabilitation alone was placed at over P 20 Billion.

The eruption of Mt. Pinatubo in June 1991 after being dormant for 600 years was the latest and probably most environmentally destructive natural disaster of the country. The Pinatubo eruption forced more than 250,000 people to abandon their homes, caused 650,000 people to lose their jobs after their workplaces were destroyed, and permanently devastated over 80,000 hectares of the country's most productive lands. The resulting lahar and mudflows practically obliterated the sorrounding flood plains causing widespread floodings and destruction of roads and bridges as well as severe damage to sorrounding ecosystems.

7.2 Government and DPWH Activities for Sustainable Development

The Philippine response to environment and development issues is basically embodied inthe Philippine Strategy for Sustainable Development (PSSD) which was formally approved by the Government in November 1989. The PSSD aims to achieve, maintain and disperse economic growth without depleting the stock of natural resources and degrading environmental quality. It has basically ten basic principles and policy directives to guide the country's programmes,

projects, and activities for environmentally sustainable development.

a. Integration of Environmental Considertions In Decision Making. Development planning objectives will be realigned to enable the merger of environmental and economic considerations in decision making. Analytical tools and methodologies such as natural resource accounting to emphasize the productive role of natural resources in the economic systems, environmental impact assessment system to evaluate the environmental consequences of major projects and land use planning to determine optimum land use allocation based on environmental quality perspectives will be utilized to ensure that environmental considerations are integrated in decision making.

b. Proper Pricing of Natural Resources. Resource management will be improved by properly pricing natural resources based on the cost of replenishing and increasing their supply and providing appropriate substitutes. The question of who pays for damages to the environment will be defined. The question of who pays will be defined with emphasis on the "polluters pay principle" and proper valuation of underpriced resources. The ultimate objective is to have a self-regulating system where resource users make choices in a way that does not impair the quality of the resource base.

c. Property Rights Reform. At the heart of the strategy is giving security of tenure to small-holder farmers and occupants over primary resources. This is envisioned to result in self-regulation by the concerned community or individuals in the exploitation of the natural resource. However, proper management of such resources must be demonstrated by recipient individuals or communities as a basis for obtaining resource rights.

d. Conservation of Bio-diversity. The preservation of wild species and genetic diversity will be emphasized to provide increased capacities for future questions on survival and development in the face of rapidly changing local and global environments. Protected areas will be established for the conservation of wildlife and unique ecosystems and the preservation of their scientific, educational, cultural and historical values. Accordingly, existing national parks and reserves will be protected, rehabilitative strategies will be developed for degraded parks, and new areas for conservation will be identified.

e. Rehabilitation of Degraded Ecosystems. Since massive destruction has already occurred and nature's regenerative capacity is not enough, projects will be implemented to rehabilitate degraded ecosystems. As pressures caused by increasing demands for both raw materials and products that come from natural resources intensify, so must the country's commitment and capability for rehabilitative action. Accordingly, programmes involving reforestation, denuded watersheds, mangrove planting, clean-up and control of pollution including revival of biologically-dead rivers, and seagrass transportation will be vigorously undertaken. These rehabilitation programmes, will be linked to ecosystems protection programmes, policy reforms and institutional strengthening in order to deal decisively

with the socio-economic roots of ecosystem degradation.

f. Strengthening of Residuals Management. The problem of pollution will be addressed within a more comprehensive framework of materials policy which includes resource recovery, recycling, and appropriate product design that saves materials and energy. Rather than focusing on "end of pipe" control systems, the strategy will concentrate on adopting recent innovations in industrial process designs which are aimed at reducing waste streams. Reformulating products, developing saleable by-products from residuals, and redesigning or combining processes are some of the measures that will be implemented to reduce wastes and costs as well. Likewise, enforcement of appropriate pollution controls will be strengthened and supplemented by policy instruments such as economic incentives to encourage industries to install pollution control facilities.

g. Control of Population Growth and Development of Human Resources. The country's programme to control rapid population growth will not be limited to controlling numbers but will include health, education, and rural development projects. It will be implemented as part of a comprehensive socio-economic programme at the regional and community levels. The programme will be based on methods consistent with the cultural and religious norms of the population.

h. Inducing Growth in the Rural Areas. Since economic recovery and long-term stability depend on increasing incomes and employment in the rural areas where majority of the people reside, special attention will be given to rural development. The economic, social and political potentials of the countryside will be harnessed in order to alleviate poverty and uplift the conditions of the rural poor. This rural development strategy will be characterized by: (a) empowerment of the rural poor through greater participation in policy making and project implementation; (b) accelerated implementation of land reform to achieve equity in the distribution of wealth and boosting producer incentives; (d) removal of economic policy and public investment biases against the rural sector; (e) provision of infrastructure and support services to increase rural productivity and expand markets; (f) establishment and reinforcement of growth centers to serve as bases for industrial and commercial activities; and (g) strengthening of social services such as education, health and nutrition.

i. Promotion of Environmental Education. Environmental education will be promoted to enable citizens to understand and appreciate the complex nature of the environment as well as the role played by a properly managed environment in economic development. The specific aims are: to develop social values that are strongly supportive of environmental protection; to create the commitment and political will to deal with difficult issues; and to develop a rational basis for the study of the environment by equipping people with the basic capability to make the best choices.

j. Strengthening of Citizen's participation. Non-governmental organizations (NGOs) will be mobilized and networks among NGOs and Government organizations will be formed to assist in organizing communities, public

information campaigns, research/situation assessment, environmental surveillance and monitoring, and promotion of environmentally sound technologies.

7.3 Necessary Tasks for Sustainable Development

Holistic environmental management covers not only the protection of the environment per se, but more importantly, the management of human activities which have significant impacts on the environment. The notion of development should include the enhancement of environmental quality alongside development on a sustainable basis.

Resource depletion, environmental degradation, and pervasive poverty, aggravated by rapid population growth and heavy debt burden, are the pressing environment-development problems in the Philippines. There are also problems of know-how and technology. It also concerns the assurance of social equity and adaptation to existing cultural norms and practices.

The resolution of these complex environmental-developmental issues in a Philippine situation of rapidly increasing population, frequently occuring natural disasters, and continously contracting financial resources will be difficult. It will require strong political will, rapid transfer of technology, enhanced international cooperation, and massive financial and technical assistance.

1. Debt Relief, Poverty Alleviation and Environment

In the Philippines, widespread poverty is the biggest problem. The situation is not only intolerable in human terms, but also has adverse environmental consequences. The destruction of forests and erosion of soil due to marginal farming practices of the very poor; the loss of productivity due to disease and malnutrition; and the disruption of fragile ecosystems due to ignorance and hunger are manifestations of poverty as an environmental problem.

An estimated 35 million people in the Philippines live in poverty representing 50 percent of the urban population and 64 percent of the rural population. At the same time, the country is burdened with a $ 29.6 Billion foreign debt. Foreign debt servicing eats up 40 percent of the country's net export earnings. Meanwhile, forests and natural resources are being rapidly depleted to earn much needed foreign exchange, environmental and sanitation infrastructures are not provided nor maintained, and land, water and coastal resources are degraded by industrial and domestic wastes for lack of adequate pollution control facilities.

For as long as much of the country's financial resources are diverted to the repayment of foreign debt, the Philippines cannot hope to halt and reverse the degradation of its environment and the depletion of its natural resources, nor alleviate the pervasive poverty resulting from lack of development. There is need for an international effort to provide relief to heavily-indebted nations like the Philippines through, among others, expanded "debt-for-nature swaps" programmes, condonation of selected debts, particularly those incurred for past projects which had adverse environmental impacts, and refinancing of

existing debts under better and more concessionary terms.

2. Natural Disasters and Environmental Rehabilitation

Typhoons, earthquakes, and volcanic eruptions result in massive destruction of the environment and the death and displacement of large numbers of people. The cost of environmental rehabilitation and the scientific and technical needs for monitoring and prediction cannot be borne by the primarily affected country alone. It would need global response and international cooperation. The proposed international environmental fund should therefore have a special window to provide grants for scientific and technical studies and monitoring, and concessionary loans for environmental rehabilitation.

3. Transfer of Environmentally Sound Technology

The long term solution to industrial pollution is the development and use of technologies that produce little or no residuals. However, 90 percent of all technological know-how is in developed countries. Developing countries can not leapfrog in their environmental protection programmes unless these technologies are made available and affordable to them. The provision of new additional financial resources would, by itself, not be sufficient to solve the multifarious environmental problems of developing countries like the Philippines. They would also need to acquire environmentally sound technologies. Newly developed clean manufacturing technologies which prevent or minimize production of residuals, as well as technologies for the treatment of domestic and industrial wastes should be made available to developing countries on concessionary terms if they are to become effective partners in the global effort to clean the environment.

8.0 PROPOSAL FOR FURTHER DISCUSSION

1. Establishment of an ASEAN Public Works Research Institute

This is proposed to have collaborative research undertakings among ASEAN countries on common technologies related to infrastructures that can be adopted by participating countries. It will promote joint research ventures and avoid duplication of research efforts. Eventually, this will lead to the development of neighboring ASEAN countries and the Philippines. These is likewise envisaged to effect a lower overall research expenditure as well as the ability to recoup heavy research expenditures.

A Coordinating body for ASEAN and/or inter-Asian research need to be established with the proposed institute serving the function. It is envisaged to: (a) unify objectives, policies, programs, and make them more effective; (b) coodinate the activities of various research and development and information dissemenation organizations of participating countries; (c) to stimulate reforms and new initiatives in the ASEAN region; and (d) to transfer the results of scientific research undertaken under its authority.

The institute is envisaged to prepare a five-year and long range strategic program of research and development and technical information dissemination activities particularly a set of technical assistance measures and joint research and development ventures that will encourage economic and environmentally-sound growth of the ASEAN region and Asia in general. It will also establish its appropriate information policy to answer crucial questions such as:

a. How can the research and development activities in infrastructure and construction be coordinated among various ASEAN countries?

b. How information networks and data banks will be set up for the ASEAN region and the rest of the world linked and information shared?

c. How can the obstacles created by monopolistic patents, industrial or commercial trade secrets, and security restrictions be further reduced?

d. How can new and more advanced technology in the field of construction and engineering be assimilated by ASEAN countries considering their existing conditions and unique environments?

e. How can the necessary personnel be trained and the pursuit of sustainable development, harmonious-environment, and science-based engineering be promoted and pursued in the ASEAN Region?

f. What is the foreseeable return on completely automating this field and linking it to the recent developments in the communication and information processing fields?

g. How can the impact of the institute's activities be monitored in terms of country impact and industrial applications?

It should also address the issue for the need of standardization of technology, specifications and test parameters, guidelines, information, and reports as well as the provision of translation facilities considering the diversity of ASEAN cultures and languages.

For the long term success of the institute, it must study and innovate upon the experience, results, and methods of the American and European countries as well as Japan in the field of reseach and development, design, application, and promotion.

2. Project to Promote the Use of Indigenous Materials in Construction and Public Works

It is common knowledge that novelties emerge within the limits of possible changes in conditions in a technological process. Research and development efforts in the Philippines need to be improved and adapted to use new or more advanced technology suitable to local conditions; shifted to make use of available abundant indigenous materials (which saves foreign exchange and does not aggravate the balance of payments position of the country) or shifted to use materials with new or differing properties; and assess newer modes of implementation and work relationships (say, labor-intensive equipment supported methods). In this manner, acts of further insight on the invention or primary invention/process are achieved to test the universal applicability of a technoligical process and pave the way for secondary and tertiary inventions as well as research characterized by critical revision and development of the primary process. The latter supplementary revisions often lead to improved efficiency of the invention and furthers technological change and human progress.

Furthermore, testing equipment will be deemed necessary in carrying out such assessments and will be of vital importance together with skills upgrading activities for technicians, engineers, and scientists undertaking these. Pilotworks and experimental designs or test projects will also be important. External assistance on grant or concessionary basis will be crucial in this area.

3. Public Works and Construction Information Network Improvement Project

There is an urgent need for the DPWH to avail and integrate its research and information network with the improving world communication network and information systems which are becoming more sophiscated and advanced. A key feature of making bilateral and multilateral cooperation possible is usually the much more developed state of development and communications together with coordinating mechanisms.

The proposed project shall seek to establish two main objectives. First, establish a centralized DPWH network, say at BRS, to coordinate this effort and to establish more optimized linkages to major academic institutions, research facilities, donor institutions, engineering information agencies, etc. considering all potential and interested users, both local and foreign.

Increased potentials for continuing and sustained exchange programmes will be pursued.

Second, it also seeks to establish a decentralized pilot public works and construction information and promotion network similar to the BRS central network except that its operations will be on a more localized level collecting and promoting data from regional or provincial sub-centers. This shall further be tasked at promulgating interest in the field of scientific processes and research in relation to sustainable development.

The proposed Study, in general, will establish procedures and methods nationwide that will make public works and construction related technology and information cheaper, more accessible, and easier to use.

Contacts and linkages between other countries, information agencies, research and professional organizations, and international agencies will be established, upgraded, and continously updated. It will also seek to establish the collection of maximum intelligence from local and external sources and effect the transfer of that intelligence to its users (e.g. abstracts, periodic journals, and seminars).

It should also address the issue of standardization of technology, specifications and test parameters, information, and reports in the country. Examples would be the standardization of technical reports on microfilm, computer media (tapes, diskettes, optical devices, and data communications), and videotape format in order to create a new and very large market and promote technological advance.

It will also seek to establish uniform methods of identifying and preparing reports in order to facilitate their retrieval and classification, cut down publication time, prevent the failure of having researches not publicized, and make recommendations as to how scientific and engineering education can avail and be integrated into the system.

The project will provide the pilot hardware needed to operationalize the system as well as establish the pilot regional centers say one for North and Central Luzon (e.g. Baguio), one for Visayas (Cebu), one for Mindanao (e.g. Davao City).

The Project could be a supplementary adjunct to the proposed ASEAN Public Works Research Institute's activities in the Philippines.

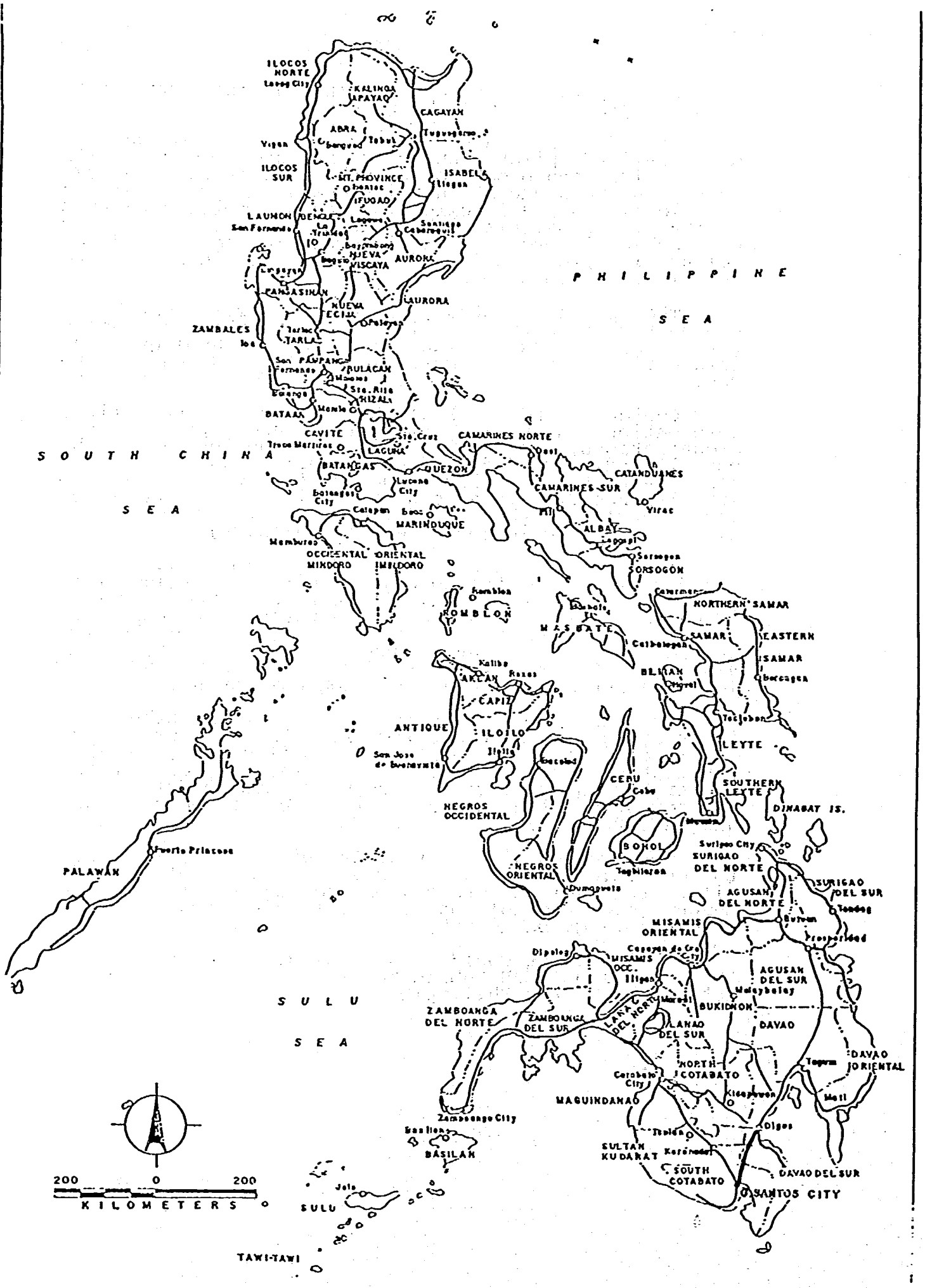

PHILIPPINE SEA
SOUTH CHINA SEA
SULU SEA
ILOCOS NORTE
KALINGA APAYAO
CAGAYAN
ABRA
ILOCOS SUR
MT. PROVINCE
ISABELA
IFUGAO
LAUNION
BENGUET
NUEVA VISCAYA
AURORA
PANGASINAN
NUEVA ECIJA
LAURORA
ZAMBALES
TARLAC
PAMPANGA
BULACAN
RIZAL
BATAAN
CAVITE
LAGUNA
CAMARINES NORTE
BATANGAS
QUEZON
CATANDUANES
CAMARINES SUR
MARINDUQUE
ALBAY
OCCIDENTAL MINDORO
ORIENTAL MINDORO
SORSOGON
ROMBLON
NORTHERN SAMAR
MASBATE
SAMAR
EASTERN SAMAR
BILIRAN
AKLAN
CAPIZ
ANTIQUE
ILOILO
LEYTE
CEBU
SOUTHERN LEYTE
NEGROS OCCIDENTAL
DINAGAT IS.
BOHOL
SURIGAO DEL NORTE
NEGROS ORIENTAL
SURIGAO DEL SUR
PALAWAN
AGUSAN DEL NORTE
MISAMIS ORIENTAL
MISAMIS OCC.
AGUSAN DEL SUR
ZAMBOANGA DEL NORTE
ZAMBOANGA DEL SUR
LANAO DEL NORTE
BUKIDNON
LANAO DEL SUR
DAVAO
NORTH COTABATO
DAVAO ORIENTAL
MAGUINDANAO
SULTAN KUDARAT
SOUTH COTABATO
DAVAO DEL SUR
SANTOS CITY
BASILAN
SULU
TAWI-TAWI
200 0 200
KILOMETERS

FIG. 1

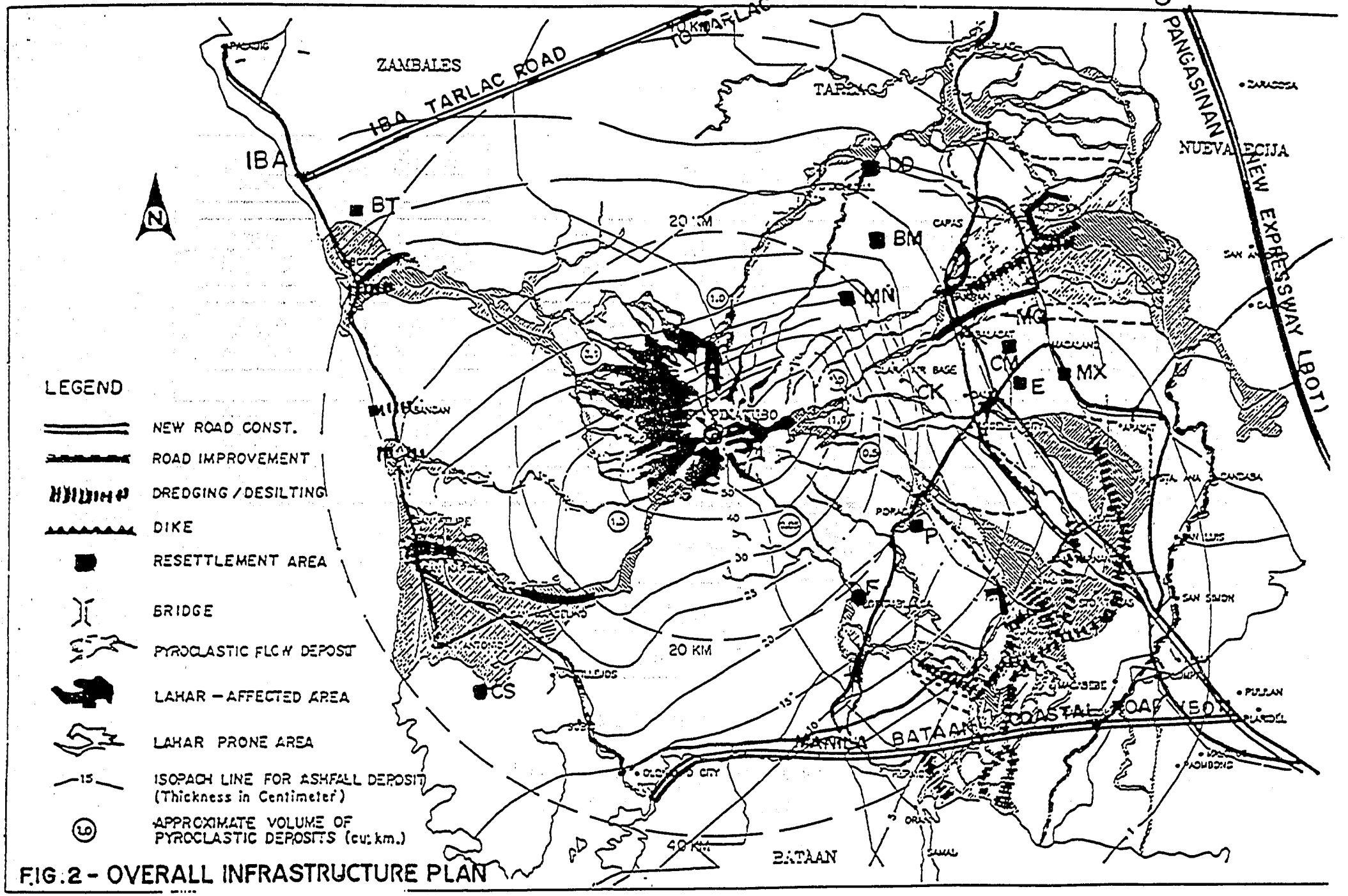


FIG. 2 - OVERALL INFRASTRUCTURE PLAN

BUREAU OF RESEARCH AND STANDARDS
Department of Public Works and Highways

ORGANIZATION CHART

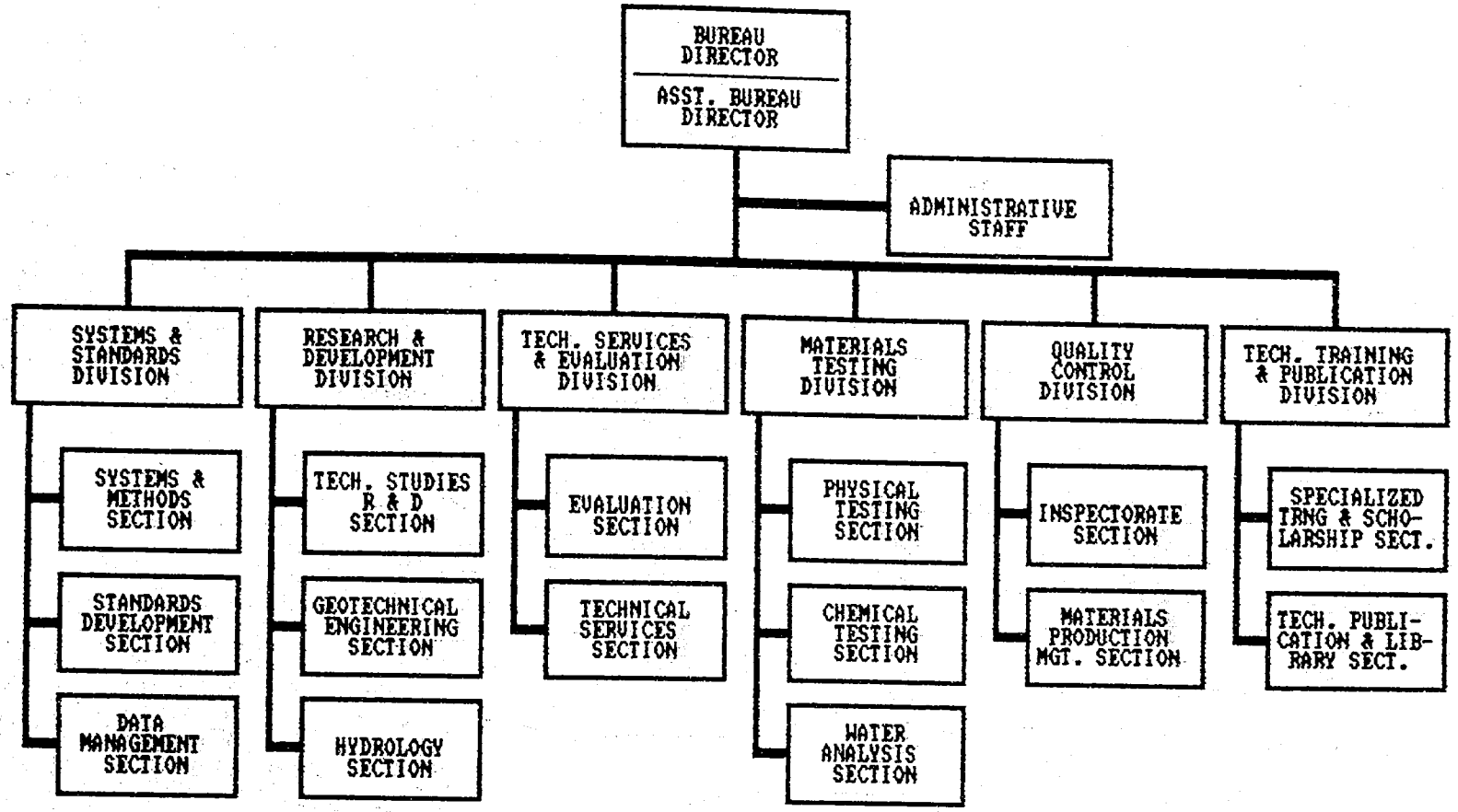


FIGURE 3

Table 1-1

MAJOR MACROECONOMIC INDICATORS
1987-1991

	1987	1988	1989	1990	1991	Average 1987-91
Real GNP Growth	5.1	7.2	5.7	4.2	-0.1	4.4
Personal Consumption	4.0	6.2	5.0	5.4	2.2	4.6
Government Consumption	4.9	9.1	5.6	8.1	-6.0	4.3
Investments	17.6	11.6	23.6	5.7	-13.6	9.0
Exports	6.5	14.7	10.7	1.3	5.5	7.7
Imports	28.6	19.6	15.2	10.0	-1.6	14.4
Real GDP Growth	4.8	6.3	6.1	2.7	-0.9	3.8
Agriculture	3.2	3.2	3.0	0.5	0.7	2.1
Industry	5.4	7.6	8.2	1.8	-2.3	4.1
services	5.2	6.9	6.0	4.0	0.0	4.4
Inflation Rate	3.0	8.9	12.2	14.2	18.7	11.4
Current Account Deficit (% of GDP)	1.3	1.0	3.4	6.1	2.3	2.8
National Government Deficit (% of GDP)	2.7	2.9	2.2	3.5	2.1	2.7

Source: NSCB, CB, DBM, DOF

Table 1-2
GROSS NATIONAL PRODUCT AND PER CAPITA GNP, 1991-98

	Annual Ave. 1987-1991	Actual 1991	Projected 1992	Targets 1993	1994	1995	1996	1997	1998	Annual Average 1993-1998
Gross National Product (In P B, at constant 1985 prices)		718.5	732.9	765.8	815.6	876.8	946.9	1,027.4	1,130.2	
Growth Rate (%)	4.4	(0.1)	2.0	4.5	6.5	7.5	8.0	8.5	10.0	7.5
Gross National Product (In P B, at current prices)		1,253.2	1,393.2	1,565.4	1,783.6	2,042.0	2,337.7	2,675.9	3,105.4	
Inflation Rate (%)	11.4	18.7	9.0	7.5	7.0	6.5	6.0	5.5	5.5	6.3
Per Capita GNP (In Pesos at constant 85 prices)	11,251.0	11,429.0	11,405.0	11,666.0	12,167.0	12,814.0	13,566.0	14,435.0	15,581.0	13,371.0
Growth Rate (%)	2.0	(2.3)	(0.2)	2.3	4.3	5.3	5.9	6.4	7.9	5.4
Per Capita GNP (In Pesos at current 85 prices)	15,583.0	19,933.0	21,683.0	23,842.0	26,606.0	29,844.0	33,490.0	37,597.0	42,812.0	32,365.0
Per Capita GNP (In U.S. dollars, at current prices)	671.0	725.0	849.0	902.0	977.0	1,066.0	1,161.0	1,268.0	1,399.0	1,129.0

Sources: NSCB, NEDA, and NSO

Table 1-3
GOVERNMENT EXPENDITURES PROGRAM, 1993-98
(In Billion Pesos, except percent)

	Ave. Annual Growth Rate (%) 1987-1991	Estimate 1992	Targets 1993	1994	1995	1996	1997	1998	Ave. Annual Growth Rate (%) 1993-1998
TOTAL DISBURSEMENTS	14.4	273.9	298.9	335.3	390.2	453.4	530.1	627.3	14.9
(% of GNP)		19.7	19.1	18.8	19.1	19.4	19.8	20.2	
Current Operating Expenditures	24.0	221.0	232.5	255.3	289.2	315.6	344.9	388.1	9.9
Personal Services	23.7	76.2	70.7	80.4	91.6	104.0	117.4	132.6	10.0
Maintenance and Other Operating Expenses	19.2	35.7	40.9	46.3	57.3	65.8	76.8	86.0	15.8
Subsidy	19.9	4.1	6.3	4.9	4.9	4.9	4.6	5.0	5.7
Tax Expenditure	17.3	5.0	5.0	6.0	6.6	7.6	8.6	9.8	12.0
Allotment to LGUs	13.2	16.9	29.1	37.8	45.2	55.5	61.0	71.7	28.7
Interest Payments	28.2	83.0	80.6	79.9	83.6	77.8	76.5	83.0	0.1
Capital Outlays	8.4	49.6	58.6	71.5	88.2	121.3	165.0	198.8	26.3
Infrastructure	17.5	21.9	24.1	28.0	38.5	55.7	79.9	98.7	29.2
Other Capital Outlays	39.1	20.8	21.2	30.1	34.6	48.5	66.3	79.2	25.3
Equity	(45.0)	2.7	3.0	3.9	3.8	3.2	3.5	3.0	3.0
Capital Transfers to LGUs	19.6	4.2	7.3	9.5	11.3	13.9	15.2	17.9	28.8
CARP Land Acquisition & Credit	41.7	1.0	5.6	8.5	12.2	15.9	19.6	39.8	118.7
Net Lending	21.4	2.3	2.2	0.0	0.6	0.6	0.6	0.6	

Table 2-1

1993–1998 MEDIUM-TERM PUBLIC INVESTMENT PROGRAM
SUMMARY OF INVESTMENT, BY CATEGORY
(In Million Pesos, Current Prices)

CATEGORY	1993	1994	1995	1996	1997	1998	TOTAL 1993–1998
1. HIGHWAYS	10,438.2	18,102.9	24,006.1	29,390.4	32,377.8	41,611.1	155,926.5
2. FLOOD CONTROL AND DRAINAGE	1,493.7	2,073.0	2,336.0	2,490.0	3,045.0	3,537.0	14,974.7
3. RURAL WATER SUPPLY	562.3	1,000.0	1,021.5	1,040.0	800.0	321.0	4,744.8
4. URBAN INFRASTRUCTURE	602.9	428.0	391.6	419.0	367.1	280.6	2,489.2
5. PRELIMINARY/DETAILED ENGINEERING/ NATIONAL BUILDINGS	58.0	0.0	0.0	0.0	0.0	0.0	58.0
TOTAL	13,155.1	21,603.9	27,755.2	33,339.4	36,589.9	45,749.7	178,193.2

Source: DPWH

TABLE 2-2

SECTORAL DISTRIBUTION OF DPWH INVESTMENTS

CATEGORY	1993-1998 TOTAL AMOUNT (P Million)	1993-1998 PERCENT TO TOTAL (%)
1. HIGHWAYS	155,926.5	87.53
2. FLOOD CONTROL AND DRAINAGE	14,974.7	8.41
3. RURAL WATER SUPPLY	4,744.8	2.66
4. URBAN INFRASTRUCTURE	2,489.2	1.40
TOTAL	178,135.2	100.00

APPENDIX:
THE DPWH ORGANIZATION

THE DPWH ORGANIZATION

The Department of Public Works and Highways (DPWH), as established under Executive Order No. 124 in 1987, functions as the engineering and construction arm of the Government tasked to continously develop its technology for the purposes of ensuring the safety of all infrastructure facilities and securing for all public works and highways the highest efficiency and the most quality in construction. The DPWH is responsible for the planning, design, construction and maintenance of infrastructure, especially national highways, flood control and water resources development systems, and other public works in accordance with national development objectives.

The DPWH, as of 1991, has on the average an annual budget of about P 19 B of which the infrastructure budget component comprise about P 15 B (79 per cent) while the operation and maintenance budget component comprise about P 4 B (21 percent). It implements an annual average of about 63,800 infrastructure projects nationwide and maintains about 160,000 kilometers of roads nationwide.

The DPWH is composed of an Office of the Secretary; six technical, financial, and administrative support services, namely: Planning Service, Internal Audit Service, Monitoring and Information Service, Comptrollership and Financial Management Service, Legal Service, and Manpower and Administration Service; five staff bureaus, namely: the Bureau of Design, Bureau of Construction, Bureau of Maintenance, Bureau of Equipment, and Bureau of Research and Standards; fifteen regional offices; about 109 district offices; and 25 project management offices. It previously had 58 city engineering offices which it has turned over to individual local government units as provided as the devolution and decentralization act of Government in 1991. Figure A-1 presents the DPWH organization chart as established under Executive Order 124. Figure A-2 presents the current functional chart of the DPWH as of May 1991 per Department Order 130.

The DPWH has a total personnel complement of about 46,786 of which 17,159 (37 percent) are permanent personnel, 5,866 (12 percent) are temporary road maintenannce personnel, and 23,761 (51 percent) are casual and project-hired contractual personnel. About 13.4 percent (2,658) of its personnel is in the central office (Office of the Secretary, services, bureaus, pool of project managers, etc.); 14.6 percent (2,900) in regional offices and 44.1 percent (8,700) in district engineering offices for a total of 86.6 percent of the total DPWH staff; and the rest distributed in other offices.

The DPWH is headed by a Secretary, four Undersecretaries, four Assistant Secretaries, five staff bureau directors, 15 Regional Directors, 112 project managers and engineers, and other middle-level executives.

The personnel complement is currently being streamlined with the devolution of local infrastructure activities to local government units as well as the current Government thrusts for more cost-effective and efficient government operations and fiscal reforms.

Figure A-1

DEPARTMENT OF PUBLIC WORKS & HIGHWAYS
ORGANIZATION DIAGRAM

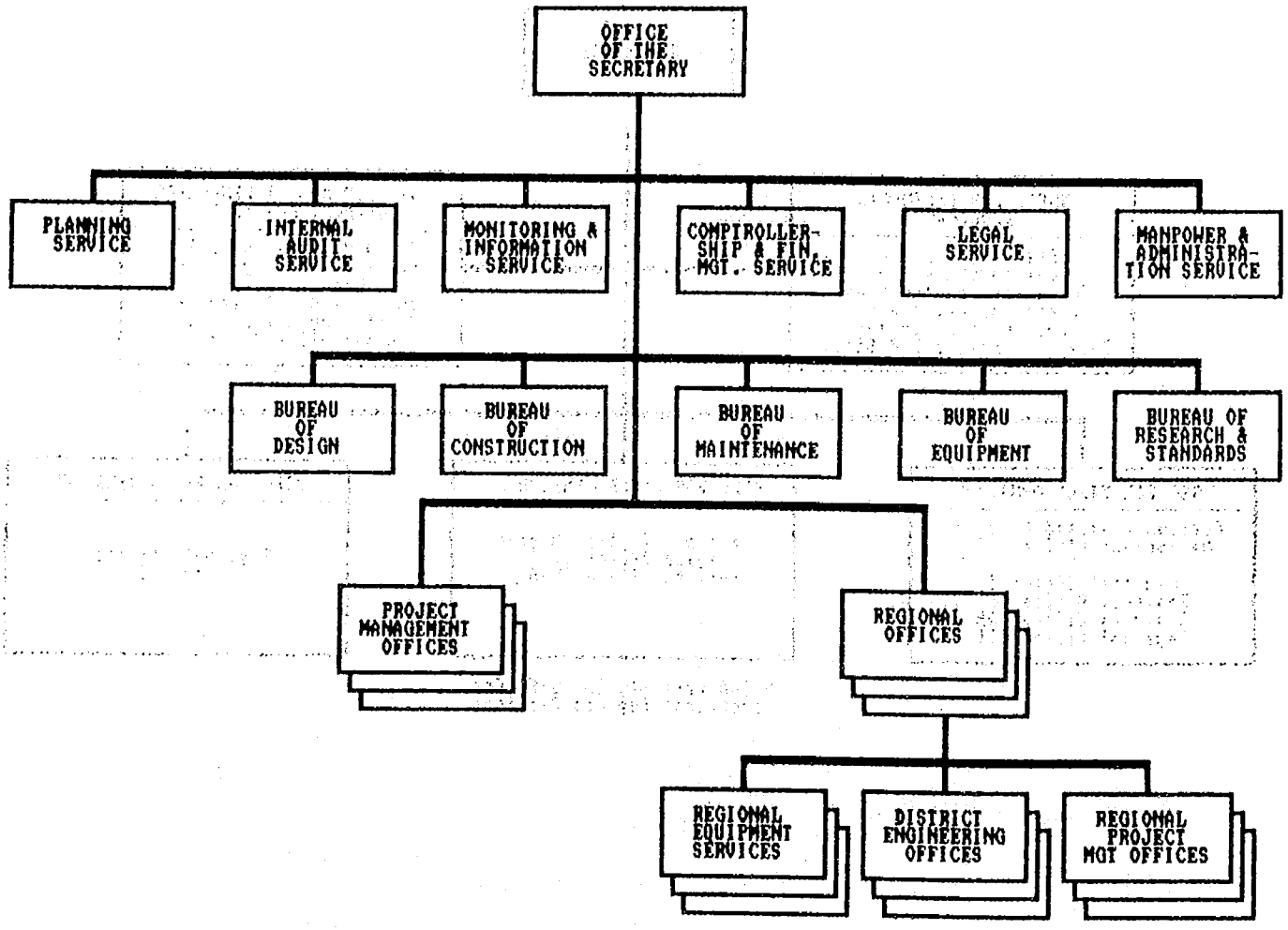
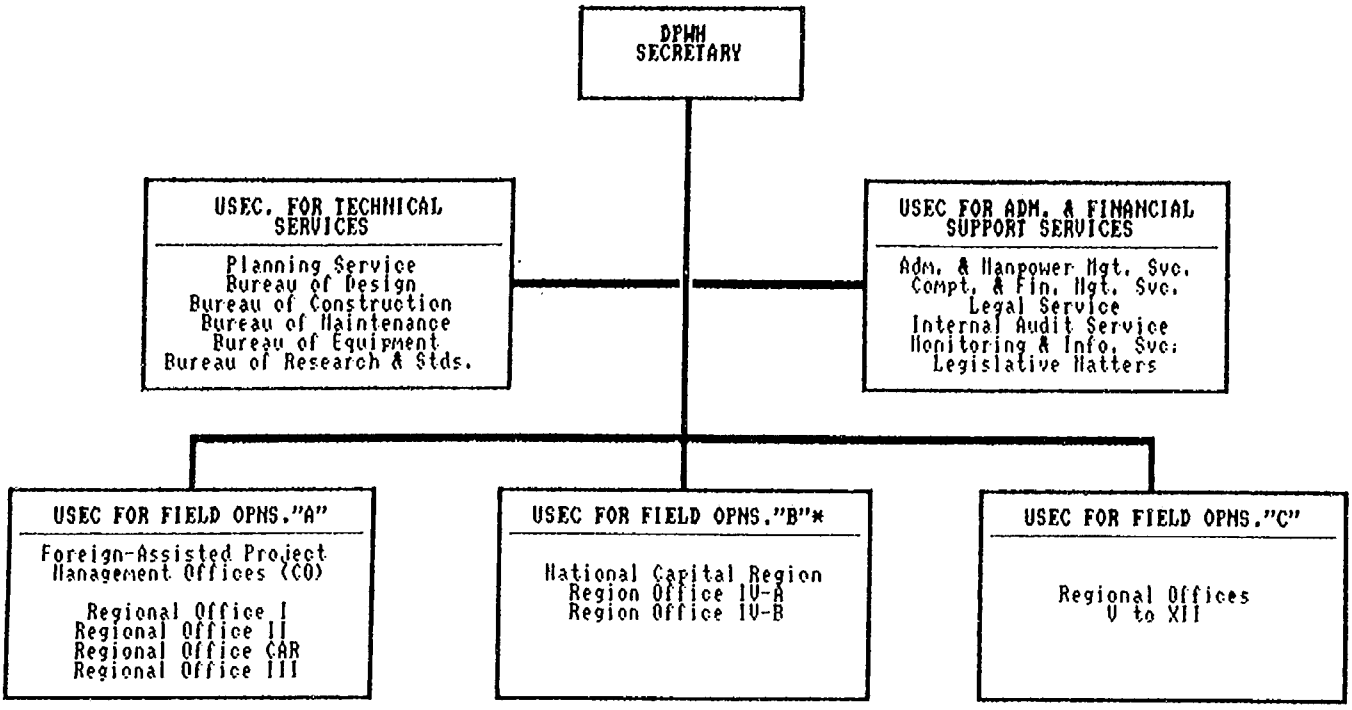


Figure A-2

DEPARTMENT OF PUBLIC WORKS & HIGHWAYS

OPERATIONAL SET-UP



* Concurrently the USEC for Technical Support Services

Ⅵ. Republic of Singapore

Mr. Tan Siong Leng, Director, Building Control Division,
Public Works Department

Table of Contents

1 Outline of Singapore

1.1 Description of the country

1.2 Climate

1.3 Demographics

1.4 Economy and Society

2 Public Works System in Singapore

2.1 Master Plan for National Development

2.2 PWD Budget for investment in construction 6

2.3 Organisations concerned with public works

2.4 History, progress and problems of the development of major infrastructure

2.5 Major projects in progress

3 Research and Development in Public Works Department

3.1 History of Public Works Department, Singapore

3.2 Organization Chart

3.3 Budget

3.4 Major research facilities

4 Major research and development projects in PWD

4.1 Names of research & development projects

4.2 Research & development in progress

4.3 Problems in promoting research & development

5 International research programmes

5.1 Present situation

5.2 Problems in promotion

6 Activities concerning Disasters and Disaster Prevention

6.1 Present situation and problems in Singapore

6.2 Activities concerned with prevention of national disasters

6.3 Technical tasks required for disaster prevention

7 Proposals for further discussion

COUNTRY REPORT FOR THE EXECUTIVE SEMINAR ON PUBLIC WORKS RESEARCH AND DEVELOPMENT

1 The Outline of Singapore

1.1 Description of the country

Singapore consists of the island of Singapore and some 58 islets within its territorial waters. It is situated between latitudes 1° 09' N and 1° 29' N, and longitudes 103° 38' E and 104° 06' E approximately 136.8 km north of the Equator. The main island is about 42 km in length and 23 km in breadth. Including the offshore islets, the total land area of Singapore is about 633 sq km.

Singapore's immediate neighbours are Malaysia to the north and Indonesia to the south. Singapore is linked with Peninsular Malaysia by a 1,056 m long causeway, which carries a road, a railway and a water pipeline across the Strait of Johor.

The main island of Singapore can roughly be divided into three regions: the central hilly region of igneous rock formation in Bukit Timah, Bukit Gombak, Bukit Panjang and Bukit Mandai; the western region of sedimentary rocks, which form a succession of northwest-trending hills and valleys; and relatively flat eastern region of sand gravel depots which extends from Katong to Changi. The highest peak is the Bukit Timah Hill which measures 176m situated roughly in the centre of the main Singapore island.

The land utilization is summarised in the following table.

Table I

	Area in sq km
Total land area (main island and offshore islets)	633.0
Built-up areas (including new industrial sites)	311.6
Farm holding areas (of licensed farms, excluding land occupied by pure rubber and coconut plantations)	10.8
Forest	28.6
Marsh and tidal waste	15.7

Others (inland waters, open spaces, public gardens, cemeteries, non-built-up areas in military establishments, quarries, rubber and coconut plantations, and unused land)	266.4

1.2 Climate

The main features of Singapore climate are relatively uniform temperature, high humidity and abundant rainfall due to the maritime exposure of the island and its close proximity to the Equator.

The average daily temperature is 26.7° C. The mean maximum temperature of 30.8°C occurs in the afternoon, and the mean minimum of 23.8°C just before dawn. It is generally cooler during the Northeast Monsoon from November to January.

Relative humidity often exceeds 90% at night and in the early hours of the morning shortly before sunrise. On dry afternoons, it is usually between 65% and 70%. The average daily relative humidity is 84.5%.

Surface wind direction generally blows from north or northeast during the Northeast Monsoon season (Dec to Mar) and from southeast during the Southeast Monsoon season (Jun to Sep). Mean wind speeds are usually light, below 5 m/s, although mean speeds up the 10 m/s can occur during the Northeast Monsoon surge.

Rain, falling all the year round, is most abundant from November to January. Much of the rain falls in sudden showers with rainfall of more than 50mm a day occurring about 9 times a year. The annual rainfall is 2,363mm.

Thunderstorms are frequent during the inter-monsoon months of April-May and October-November. The highest recorded wind speed during a squall is 144 km/hr.

The climatological statistics are shown in Table II.

Table II Climatological Statistics

Mean daily temperature	26.7°C
Mean daily maximum temperature	30.8°C
Mean daily minimum temperature	23.8°C
Highest maximum temperature	35.8°C
Lowest minimum temperature	19.4°C

Mean daily relative humidity	84.5%
Mean daily maximum relative humidity	96.3%
Mean daily minimum relative humidity	64.2%
Mean annual rainfall	2,362.8mm
Highest annual rainfall	3,452.4mm
Lowest annual rainfall	1,483.9mm
Highest rainfall in 24 hours	512.4mm

1.3 Demographics

The total population living in Singapore on Census Day, Jun 90, was 3,002,800. Of this total population, Singapore residents (citizens and permanent residents) comprised 89.6% and numbered 2,690,100. The resident population grew by an average annual rate of 1.7% during 1980-1990. The foreign population, which numbered 312,700, included foreigners who were working, studying or living in Singapore but excluded foreign tourists residing in hotels and ships' crew and passengers in Singapore waters.

The resident population comprised 2,089,400 Chinese, 380,600 Malays, 191,000 Indians and 29,200 persons of other ethnic groups. The Chinese constituted 77.7% of the population and Malays 14.1%, the Indians 7.1% and others the remaining 1.1%.

There were 1,360,500 resident males and 1,329,600 resident females, giving a sex ratio of 1,023 males to every 1,000 females. Residents below 15 years of age formed 23.3% of the population while those 60 years and over formed 9.1%. The median age of the resident population in 1990 is 29.8 years.

Singapore is a city state with highly urbanised society. Since 1960, the Government started a massive low-cost public housing construction programme with the establishment of Housing & Development Board. Under the various phases public housing development programme, a number of new towns had been constructed. Today, about 87% of the Singapore's population live in public housing.

1.4 Economy and Society

From an entrepot depending on trading, the Singapore's economy has been transformed into a broad based one with Manufacturing, Financial & Business Services, Commerce and Transport & Communications forming the major sectors.

The economic transformation of Singapore began in 1961, two years after the country attained independence. With the establishment of the Economic Development Board to implement Singapore's industrialization programme, the economy went through several stages of development leading to its present status as a global, cosmopolitan city with total business capabilities.

In the 1960s, labour-intensive industries were encouraged as the priority was job creation. By the early 1970s, when full employment was achieved, the emphasis was shifted to the generation of higher-skill jobs and the production of quality products. To stimulate the growth of capital-intensive industries, new financial assistance scheme were introduced and existing tax incentives improved. Industrial manpower training was intensified.

With better trained workforce and higher industrial capabilities in Singapore, companies in the late 1970s began to bring in more sophisticated processes to manufacture higher-skilled and capital-intensive products. Companies also started to undertake knowledge-intensive activities, including research & development, engineering design and computer software development. By the early 1980s, a substantial and vibrant base of manufacturing capabilities had been established.

Today, the economic development strategy of Singapore has been broadened, so that promotional emphasis is placed on both manufacturing and services as the twin engines of growth. In addition, local enterprises are encourage to diversify their operations into regional growth areas, upgrade their skills and develop into strong export-oriented companies.

The 1990s will see the Asia-Pacific region grow in strategic importance to global businesses. Singapore aims to build on its capabilities and continue to provide a pro-business and competitive environment. The emphasis will be on partnerships with international businesses to develop and implement global and regional strategies.

Since the starting of the industrialization programme in the 1960s, Singapore has been experiencing high

growth for its economy. The Growth Domestic Product (GDP) grew at an average rate of 9.45% from 1969 to 1984. However, in 1985 the economy plunged into negative growth due largely to recession in the world economy to which the Singapore economy is closely linked.

Swift recovery was made in subsequent years due in part to the various cost cutting measures introduced by the Government and recovery in the world economy. Presently, the annual GDP is growing at a rate of about 6%. The projected growth rate for the rest of the decade is 4% - 6%.

2 Public Works System in Singapore

2.1 Master Plan for National Development

In the 1960s, the task that confronted Singapore was one of immediate urban renewal - clearing slums and revitalising the city centre so that it could support and encourage economic growth. The urgency then was on improving the living environment and to meet the housing demands of a booming post-war population. The Master Plan drawn up to chart the physical growth was modelled on traditional British planning concepts. It was not geared to the rapid development and expansion that Singapore put into effect.

A new and more flexible plan was designed in 1971 leading to the formulation of the Concept Plan. It was a long range land use and transportation plan devised to guide our new development. It did so by forming a "Ring Plan" to structure high density residential areas, industries and urban centres in a ring formation around the central catchment, linked together by a high capacity and efficient transportation network.

"Corridors" of urbanised areas stretched along the southern portion of the island with the Central Area (which encompasses the Central Business District) as the focus. With development over time, two additional corridors were added - to Tampines and to Hougang.

The existing New Towns, the airport, expressways, main roads and the MRT were shaped by the 1971 Concept Plan. However, there have been many significant social and economic changes since the formulation of the Concept Plan. From 1967 to 1988, the population had increased by ½. The resident population is expected to increase to about 3.7 millions by the Year 2030. Singapore economy has been steadily growing over the years. The projected rate of growth is from 4% to 6% up the year 2000 and thereafter the annual economic

growth rate will be between 2.5% to 3%. Sufficient land and resources must be allocated to cater for such growth and new industries such as those in the high-tech and information-based fields. With economic growth, there has also been a significant growth in the per capita income of Singaporeans from S$1600 to S$19,500 in the last 25 years.

With increasing population, affluence and continuing economic growth, there was a need to review the Concept Plan to meet the changing needs and to bring about a better quality of life to Singaporeans. A revised Concept Plan was drawn up recently taking into consideration our land supply, our ultimate holding capacity and the needs of different sectors of the community. The broad objective of the revised Concept Plan is to plan for the physical development of Singapore into a Tropical City of Excellence, an exotic island and an international hub. It will meet the objective by:

i) Safeguarding and providing land for development to meet all future needs.

ii) Encouraging sustained economic growth and co-ordinating infrastructure development.

iii) improving the quality of living and working environments.

iv) enhancing the quality of life.

v) projecting our Asian city and tropical island image.

To realise these goals, the Concept Plan will be implemented in phases to take Singapore to Year X, the year the population will reach an ultimate level of 4 million. Staging the development will enable Singapore to adapt to changing circumstances as planning is a dynamic process, ever subject to change. The Concept Plans for year 2000, year 2010 and year X are shown in Figures 1, 2 and 3 respectively.

2.2 PWD Budget for investment in construction

The Public Works Department (PWD) is responsible for developing and managing public works infrastructure such as roads, schools, airport, hospitals, polyclinics, public libraries, government office buildings, arts centre etc. The annual Budget is broadly divided into two groups: one for roads programme and the other for building programme. Based on past records, the annual development expenditures for roads programme and building programme handled by the PWD averages about S$200,000,000/- and

$300,000,000/- respectively. In the next few years, the project expenditures in these two programmes are expected to rise due to several major road infrastructure and public building projects that are being planned. The projected expenditures are shown in the Figures 4, 5 and 6.

2.3 Organizations concerned with public works

The are a number of public agencies involved with the implementation of infrastructure projects in Singapore. These agencies and their functions are listed below:

Agency	Ministry	Functions
Public Works Department	Ministry of National Development	Develop and manage public works such as roads, airport, schools, hospitals, government office buildings, prisons and other government buildings; carpark planning and building control functions
Housing & Development Board	Ministry of National Development	Develop and manage public housing; resettlement of people affected by public schemes
Urban Redevelopment Authority	Ministry of National Development	Planning authority responsible for master planning of physical development and development control in Singapore
Parks & Recreation Department	Ministry of National Development	Develop and manage public parks and open spaces
Drainage Department	Ministry of Environment	Develop and manage public drainage works; control of private drainage works
Sewerage Department	Ministry of Environment	Development and manage public sewerage projects

Agency	Ministry	Functions
Port of Singapore Authority	Ministry of Communication	Develop and manage port including control of sea navigation
Mass Rapid Transit Corporation	Ministry of Communication	Develop and manage mass rapid transit system
Telecommunication Authority of Singapore	Ministry of Communication	Develop and manage telecommunication system
Public Utilities Board	Ministry of Trade and Industry	Develop and manage public utilities ie. electricity, water and gas
Jurong Town Corporation	Ministry of Trade and Industry	Develop and manage industrial estates and provide related industrial facilities and infrastructure
Singapore Tourist Promotion Board	Ministry of Trade and Industry	Promote tourism and tourist development projects
Sentosa Development Corporation	Ministry of Trade and Industry	Develop, market and manage Sentosa as a holiday resort and manage 11 other offshore islands.

2.4 History, progress and problems of the development of major infrastructure

In the following paragraphs, the roads development programme will be described.

The development of roads infrastructure forms the main stay of the work carried out by PWD. The planning and construction of roads was undertaken by PWD since colonial days when Singapore was under the rule of the British. Many roads and bridges in the city which were constructed during the colonial era are still being used now, although these roads had been improved and bridges restored.

Major roads construction programmes were undertaken by the PWD after independence to serve the new housing

estates that were developed to provide cheap public housing for the growing population, and industrial estates developed to spearhead the Republic's industrialization programme. These included the construction of new road as well as upgrading of existing roads. Many city roads were upgraded and converted to one-way streets to improve traffic flow. Roads radiating from the city were widened to a minimum of 3 lanes each direction and upgrading of some of the existing roads to form an inner and an outer ring road to bypass the city area was effected. In addition, flyovers and grade separated intersections were erected at critical junctions to relieve congestion.

The most important road project implemented from the late 60s onwards was the weaving of the expressway network, which saw many tree-lined highways with impressive flyovers and interchanges dramatically altering Singapore's landscape and radically changing the whole concept of motor traffic. The expressway network measuring 141km in length to be completed before the end of this decade, links the city, the satellite towns and industrial estates to each other with tributaries leading vehicles on and off the main expressway network. Figure 7 shows the expressway network under implementation. The first expressway, namely the Pan-Island Expressway (PIE) which was completed over a 13 years period (from 1969-1981) has attracted so much traffic that it is fast reaching its saturation point especially during the peak hours. Widening of the PIE is now being carried out to increase its capacity and to relieve traffic congestion. Elsewhere, upgrading of some interchanges at the intersection of these expressways is being undertaken to improve traffic flow.

The main problems encountered in road and expressway construction pertain to shortage of land, resettlement of affected people and poor soil conditions. Being a small, land scarce, densely populated and highly urbanised city state, major roads development and improvement programmes in Singapore cannot help but affect many people whose lands have to be acquired to make way for roads development. Due to the political implication and sensitive nature of land acquisition, delays in the construction were often unavoidable. Little time is generally available for site preparation and soil improvement. This is aggravated by the fact that about 30% of Singapore's land surface is covered by soft soils which are highly compressible. As a result, roads constructed on reclaimed land and areas with poor subsoils were often faced with settlement problems during and after construction. The problem was most acute at the approaches to bridges/flyovers where the unsuspended

at grade roads meet the pile supported bridges or flyovers. The PWD has carried out soil improvement at critical sections of the roads during construction wherever time permits. Unfortunately, settlement could not be totally eliminated during the construction stage. Some residual settlement persists affecting the road riding quality and necessitating repair and resurfacing during the operation of the roads.

The shortage of land means that construction of new roads and widening of existing roads will often lead to traffic noise problem when the roads pass through or by residential estates. Current planning guidelines require a noise buffer zone of 30m to be provided between residential development and expressway. However, for existing residential estates, this requirement could not be easily met. PWD has carried out noise surveys to study the problems of traffic noise. Several solutions are available. However, it is doubtful whether these solutions are practicable and effective in Singapore context.

Currently, about 10% of the Singapore land area is taken up by road space. There is a limit to the amount of land that can be used for further expansion of road network. Underground road is being considered as the solution to the shortage of land for road construction.

2.5 Major projects in progress

As the public works authority in Singapore, the PWD is responsible for the planning and implementation of major public infrastructure projects. It has been projected that the PWD will be spending about S$5 billion on roads development projects and S$7.5 billion on building development projects within this decade. In addition, the annual expenditure on maintenance activities for road and building is estimated to increase from the current value of about S$65 million to more than S$100 million within the next five years.

Current major building programmes under implementation and in the pipeline include the following:

Project	Estimated cost (S$ mil)
Secondary school building programme involving building 34 new secondary schools and upgrade 17 existing sec schools	873
Redevelopment of K K Hospital	277

Project	Estimated Cost (S$ mil)
Central Ministries Building	138
New Immigration Building	121
Institute of Health & National Dental Centre Building	168
New Parliament Complex	100
Changi Airport Terminal I Refurbishment	170
Changi Airport Terminal II Extension	300
Singapore Arts Centre	780
New National Library	80
New Ministry of Education HQ	180
Changi Airport Phase III	1000
Redevelopment of Changi Prison	645
Redevelopment of Tan Tock Seng Hospital	323
Eastern General Hospital	248
Temasek Polytechnic	340

The road construction programme will not lag behind the building construction programme. The construction of the expressway network in Singapore was started in the late 60s. Figure 7 shows the planned expressway network with a total length of 141 km. Presently, about 78% of the expressway network has been completed including 2.4km of underground road tunnel forming part of the Central Expressway, The whole expressway network is planned to be completed before the end of this century.

Besides the expressway construction programme, the PWD is now planning another massive road development programme involving the construction of about 90 lane-km of underground road. The Singapore Underground Road System (SURS) will be planned as a ring road system to follow the inner ring road of Singapore and cross the water from Marina South to Marina East (see Figure 8 for the preliminary proposed alignment). The ring road will be a high capacity network of underground roads which is designed to provide safe and efficient movement of goods and people in Singapore. It will

increase the total road capacity in the Central Business District (CBD) and immediate surrounding area by a minimum of 40% as compared with the capacity of the existing main roads and it will help to relieve traffic congestion along the major road corridors and traffic intersections. The SURS will cater for traffic demands in the CBD up to the year 2030. The estimated cost of the SURS is $4 billion. It will be implemented in phases and is planned to be completed within the next 10 years. The feasibility study has just been completed. Construction is expected to start in 1994.

In addition to the underground road system, there is also a long term plan to upgrade the present arterial roads and construct new roads to form a semi-expressway system to cater for the traffic demands in the whole island in the next century.

While new roads development programmes will further enhance Singapore road capacity, the PWD is also actively looking into ways and means to increasing road capacity by improving the efficiency of our traffic management system. The Area Licensing Scheme (ALS) is one of the most unique and well-known measures that PWD has introduced in 1975 to control congestion in the CBD. Under the scheme, motorists will be required to pay to enter, during the morning and evening peak hours, the Restricted Zone (RZ) which covers an area of 725 hectares in the CBD. In a sense, the ALS is a form of road pricing and is operated manually. In the next few years, the ALS scheme will give way to an Electronic Road Pricing (ERP) system. The ERP is the new technology which PWD will introduce to replace the existing ALS and Weekend Car Registration Scheme. When implemented in the next few years, Singapore will have one of the most sophisticated electronic traffic management systems in the world. Eventually, the ERP will be extended to the outlying area and future regional centres. Besides ALS, the PWD has also introduced another traffic management measure called the Green Link Determining System (GLIDE). The GLIDE is a computerised traffic light control system which allows for the traffic light timings to be centrally monitored and continuously adjusted to suit changing traffic conditions. The system maximises the use of the existing road capacity and ensures smooth traffic flow. The GLIDE was introduced for the CBD in 1988 and is being extended to other parts of the island.

3 Research & Development in Public Works Department

3.1 History of Public Works Department, Singapore

The history of Public Works Department (PWD) dates back to 1833 when the first Superintendent of Public Works was appointed for the island. During that time, the Straits Settlements (to which Singapore belongs) came under the control of the colonial administration of British-ruled India.

With progress and pressure from local commercial community, the British decided to create a Crown Colony in 1867 to transfer the control of the Straits Settlements directly under the Colonial Office in London. With further development, the first Public Works Department, Straits Settlements was formed in 1872. By the ends of 1930s, the PWD had grown to a size of 45 staff headed by the Director of Public Works. The headquarter was housed in Singapore.

After the Second World War, Singapore gained self-government from the British and the Public Works Department, Singapore finally came into being. The 1950s saw the PWD working hard to establish the essential amenities for a growing population and thriving city.

In 1954 a new Assembly House (now the Parliament House) was renovated. The next year, Paya Lebar Airport was completed and so was a new ward built at Tan Tock Seng Hospital in 1956. It was also the year the Merdeka (Malay for 'Freedom and Independence') Bridge was completed. Independence came in May 1959, when the People's Action Party was swept into power and a new era began for PWD. With full internal self-government, the new leaders abolished local authorities like Municipality and appointed the first local Director of Public Works in November that year.

The task of nation building began in earnest and the PWD played an important role in it. The 1960s were a decade of many 'firsts'. The first library, the National Library was completed in 1960. The year of 1964 saw the first multi-storey car park, the first pedestrian overhead bridge and first pedestrian underpass. In 1966, the first permanent television studio was completed. The first junior college came in 1968.

By the time Singapore moved into the 1970s, the political situation had stabilised. The children of baby-boomers were reaching the school age and the first school building programme was launched in 1973. The year also saw the National Stadium completed in time for the Southeast Asia Peninsular Games.

The 1970s were also years of change within the PWD. In 1972, building control function was transferred to PWD. The drainage and sewerage functions were transferred to the Ministry of Environment and the Parks and Recreation function was taken out to form a separate Department. By that time, important foundation has already been laid to make Singapore a garden city.

Cruising into 1980s, the PWD went into high gear and the fast lane to keep up with an affluent car-loving population. Although more roads were built and existing ones expanded, the 1980s were really the decade of the Expressway, with the Pan-Island Expressway, the East Coast Parkway and Benjamin Sheares Bridge ready in 1981. In 1985, the Bukit Timah Expressway joined the network, followed by the Ayer Rajah Expressway in 1988. The Central Expressway (CTE) tunnel system was opened in Sep 1991, taking Singaporeans into a new era of road travel.

1980s also saw the completion and opening of Phase I of Changi Airport in 1981. The second runway was completed in 1984 and by 1991, the Changi Airport Terminal 2 went operational only ten years after Terminal I.

In the coming decades, the PWD will embark on more challenging undertakings and build Singapore into a tropical city of excellence.

3.2 Organization chart

The PWD is headed by the Director-General of Public Works assisted by a Deputy Director-General. The Department is made up of five divisions, each of which is headed by a director. The five divisions and their function are as follows:

i) Corporate Services Division - provide financial, personnel, administration, public relation and computerisation services for the Department

ii) Building Control Division - Regulate private building works to ensure building safety; ensure private buildings are well-maintained by their owners; safeguard the interest of private house buyers.

iii) Specialist Services Division - Planning, design and supervision of construction of government buildings including schools, junior colleges, fire stations, prisons, office buildings etc.

iv) Development & Management Services Division - consultancy business development which includes

project development services, project management services, property estate management services.

v) Roads & Transportation Division - Planning, Design, construction and maintenance of public roads, flyovers, bridges and pedestrian walkways; maximising the use of road network and implementation of road safety measures; administration of car parking policies.

The organisation chart of the PWD is shown in Figure 9. The PWD has a staff strength of 1594 officers comprising of 314 professional staff, 832 technical staff, 345 administrative staff and 103 daily rated employees.

3.3 Budget

As a full government department, the budget for the operation of PWD is fully provided by the Government. The annual budget is divided mainly into two components ie. current expenditure and development expenditure. The current expenditure consists mainly of the manpower cost and other operating expenditure such as utilities, office stationery, travel expenses, office equipment purchase & maintenance, maintenance of government buildings and roads etc. The development expenditure comprises of annual development budgets for roads construction and building construction.

In Financial Year 92 (from 1 Arp 29 to 31 Mar 93), PWD's annual budgets for various items of expenditure are as follows:

Item	Annual Expenditure (S$ million)
Manpower Cost	60
Other operating expenditure (including maintenance of government buildings and roads)	100
Roads development	300
Building development	650

3.4 Major research facilities

Because of shortage of manpower, no full-time research unit is set up in PWD to carry out research work. Traditionally in PWD, the PWD Engineering Laboratory has been playing a leading role in conducting research & development work in PWD. The PWD Engineering Laboratory also provides day-to-day quality control testing for construction materials such as soil,

concrete, steel, road pavement materials etc. It is the oldest and also the one of the largest civil engineering material testing laboratory in Singapore.

A number of organisations in Singapore are involved in R&D activities. The two universities in Singapore namely, the National University of Singapore (NUS) and the Nanyang Technological University (NTU) possess good laboratory facilities to carry out building and civil engineering related R&D work. The PWD has been collaborating with both the NUS and NTU in jointly conducting R&D projects. These joint R&D collaboration not only provide opportunities for PWD to tap the good research facilities in the universities but also enable PWD's engineer to share their practical experience and problems with the academics for the universities.

4 Major research and development projects in PWD

4.1 Names of research & development projects

In the last few years, some of the R&D projects completed by PWD include the following:

i) Pile instrumentation to study the behaviour of bored-pile and driven piles in local soil conditions and to develop design concept for piles appropriate for local soil conditions including the prediction of Negative Skin Friction.

ii) Development of Expert System to assist in the analysis and interpretation of stresswave measurements on piles using Pile Driving Analyser.

iii) Study into properties of local bitumen with an aim to improve the performance of bituminous pavement.

iv) Development of tree aeration system for road side trees.

v) Traffic-Speed-Flow study for Central Area

vi) Study on Accident Cost

vii) Investigation on the use of bitumen additives to improve pavement performance.

4.2 Research and Development in progress

Currently, PWD is conducting a number of R&D projects. A few of these are highlighted below:

i) Study on the feasibilities of creating underground caverns in the Bukit Timah Granite Rock for various uses.

This is a joint study between PWD and the Nanyang Technological University (NTU) aimed at investigating the feasibility and potential of constructing underground spaces in the Bukit Timah Granite Rock body for various uses. Due to shortage of land in Singapore, there is a need to make use of underground spaces. The project was commissioned to explore the potential of Bukit Timah Granite Rock in central and northern Singapore for this purpose.

This project is funded by the government with a budget of S$1.5 million. The project commenced in Jan 89 and is scheduled to be completed in Mar 93.

The project involves the following activities:

a) Desk study and mapping the Bukit Timah Granite deposit.

b) Geophysical survey using seismic and resistivity method to establish a geological model for the Bukit Timah Granite

c) rock coring using both vertical and inclined boreholes to verify the geological model and obtain samples for engineering testing and analysis. Down hole logging using various geophysical methods.

d) Assessment of the suitability of the rock for various uses; preliminary design and economic analysis.

From this investigation, the weathering pattern of the Bukit Timah Granite can also be established in addition to the potential of the rock for underground space construction.

The main problems of implementation is the lack of local expertise to carry out the highly specialised site investigation and survey work. As a result, expertise has to be imported from foreign countries namely, Norway for the seismic survey and Japan for the in-situ geophysical logging. Another problem is the difficult terrain

of the study site which is not easily accessible. The presence of military training activities in the study site also affected the progress of the work.

ii) Community noise study of Singapore with specific reference to the preparation of planning and design guides

This is a joint project between PWD and National University of Singapore (NUS). The aim is to survey the noise problems in various building types so as to evaluate the response of Singaporeans to acoustical environment and determine the noise criteria for the various building types. The study will cover buildings like schools, hospitals, office buildings, hotels & libraries and places of public resort.

The project commenced on Oct 89 and is targeted for completion in early 1993. The estimated cost is S$310,000/-.

The project entails conducting noise survey in various building types, subjective survey of the occupants with respect to the noise environment in these buildings, analysing the data to establish correlation between user response and measured noise data, establishing design guidelines and methods of noise reduction.

The main difficulties encountered during the study are high turnover of the research personnel causing disruption to the work, difficulty in recruiting technicians to conduct site measurement and difficulty experienced by the research staff in gaining access to certain buildings to conduct noise survey because of non-cooperation from the building owners.

iii) A scientific study of building defects

This is another joint study between the PWD and NUS. The project aims at a comprehensive survey and development of a knowledge base for building defects and the study of factors causing cracking and deterioration of reinforced concrete in Singapore.

The project commenced on Jun 92 and is targeted to be completed in mid 93. The estimated cost is S$410,000/-.

In this study, extensive survey on the common defects various concrete elements such as flat

roofs, walls, columns and beams are carried out. Laboratory testing and field measurement on concrete deterioration are in progress. An Expert System on defects of concrete flat roofs was also developed. This Expert System will provide the building maintenance personnel a useful tool for diagnosing defects of flat roofs and recommending appropriate repairs methods. The Expert System is being extended to cover other defects.

The main difficulties encountered with this project are high turn over of the research personnel, difficulty in recruiting research staff and difficulty is getting domain experts on building defects to spend more time in providing the necessary knowledge base due to the experts' heavy work commitments.

iv) Survey on Traffic Loadings in Singapore

This is a joint study undertaken by PWD and NUS Centre for Transportation Research. The aim is to study the characteristics of traffic loadings on Singapore roads. Hitherto, road design in Singapore is based on design criteria established in foreign countries, notably U.K. The project will provide information on the levels of traffic loading which are useful for road planning and design.

The project started in Dec 91 and will completed in two years. Its total budget is S$195,000/-.

In this study, an island-wide evaluation of the patterns of traffic loading on different classes of roads, including expressways, major arterials, collectors and local roads will be carried out. Engineers for PWD and academic staff from NUS are closely involved in the planning and monitoring of field survey of traffic loading as well as the compilation and analysis of traffic count data.

4.3 Problems in promoting research and development

The following problems have been encountered in the promotion of R&D activities in building & civil engineering in Singapore.

i) Lack of manpower

There is a general lack of personnel trained in conducting R&D work in building and civil engineering. This is especially so in a tight labour market situation currently experienced in Singapore due to the booming construction

industry. Most of the building & civil engineering professionals in Singapore are engaged in planning, design and construction of new projects and maintenance of existing building infrastructure. There are difficulties in attracting good personnel to conduct R&D work in building & civil engineering. This explains the high turn over in the research staff for several joint research projects undertaken by PWD and local universities.

ii) Lack of research facilities

Singapore is a small country with a modest local construction market. This constraint places a limit on the size of local construction companies. Most local construction companies, except a few larger ones, do not have the technical capability and financial capacity to carry out R&D work. The cyclical boom and bust nature of the construction industry also does not encourage local construction companies to make long term planning and commitment on research & development. As a result, R&D work in building & civil engineering is mainly carried out by large state organisations and the academic institutions.

iii) Presently, most of the R&D activities supported by the Government are channelled through the National Science and Technology Board (NSTB) which was a statutory body set up by the Government to promote R&D work in Singapore. Up to now, the emphasis of the NSTB is on promoting R&D activities which will increase the competitiveness of the high-tech, manufacturing and service industries. The construction industry is lower down in priority because of its limited export potential and smaller contribution to the economy. There is therefore greater difficulty in securing government funding support for building and civil engineering related R&D activities as compared with other industries.

5 International research programmes

5.1 Present situation

The PWD has been involved in a few international research exchange programmes in the last few years. These are:

i) Japan-Asean Cooperation Programme on Materials Science and Technology.

The Singapore project under this programme was on the prevention of corrosion in structures. The direct participating organisations this Singapore project were JICA, Ministry of Construction of Japan, Ministry of Transport of Japan, BRI of Japan, PHRI of Japan, Singapore Science Council, Housing Development Board, Port of Singapore Authority, National University of Singapore and Singapore Institute of Standards and Industrial Research. The PWD was not directly involved in the project. However, PWD has been involved in discussions and seminars organised for the project.

The Singapore project was started in Aug 87. It covered the study of corrosion prevention in drinking water storage tanks and corrosion prevention in concrete structures at port and harbour. The project was completed in 1990 and a seminar was held in Sep 90 at Singapore to present the results of various joint Japan-Asean R&D projects carried out. For the Singapore project on the study on Prevention of Corrosion in Port and Harbour Structures, it was decided that the technical cooperation be extended for another two years (from Sep 90) to continue the research activities and finalise the manuals for corrosion prevention.

ii) Coordinating Committee on Offshore Prospecting (CCOP) programme.

Singapore is a member of CCOP. It was previously represented by PWD. However, for administrative reason, the representation was transferred to the Economic Development Board (EDB). Although, Singapore is now represented by EDB in the CCOP, the PWD continues to play an active role in CCOP activities in advising EDB and participating in the training programmes and activities organised by the CCOP. Between 23 Jul and 4 Aug 90, CCOP organised a workshop on "Introductory Training on Land and Marine Engineering and Environmental Geophysical Techniques" in Singapore and the workshop was hosted by PWD. PWD's officers had also participated in workshops organised by CCOP in Hawaii and China in 1991. Presently, PWD provided some limestone core samples retrieved in one of the deep borehole sunk in western part of Singapore for petrological and palaeotological analyses by experts from the CCOP.

iii) International Atomic Energy Agency (IAEA)

The PWD has also participated in some discussions and training programmes organised by the IAEA. Singapore was represented by the Singapore Science Council (now National Science and Technology Board) in the IAEA activities. So far, PWD has not been directly involved in any project on the application of radioactivity in civil engineering. However, PWD has together with the Singapore Science Council discussed with Japanese experts from IAEA on the possibility of applying radioactive techniques in civil engineering construction. PWD's officers had also participated in workshop on "Non-Destructive Testing of Non-Metallic Materials" organised by UNDP/IAEA/RCA in Japan.

5.2 Problems in Promotion

The shortage of manpower is a constraint not only to promotion of R&D within the PWD but also to the promotion of international R&D research exchange programmes. The current exchange programmes are concentrated more on training and development. For instance, PWD regularly sends its professionals to overseas for academic courses, practical training and study visits through various programmes such as the JICA Group Training Scheme, Colombo Plan Scholarship, Commonwealth Scholarship etc. In return, PWD is also providing training schemes for applicants from its counterparts in ASEAN under the Colombo Plan Training Scheme.

The are a number of agencies in Singapore conducting building & civil engineering related R&D work. Overseas organisations intending to collaborate with Singapore on R&D work may encounter some difficulties in approaching and choosing the right agency.

6 Activities concerning "Disasters and Disaster Prevention"

6.1 Present situation and problems in Singapore

Natural disasters that have wreaked havoc and brought destruction to civilization include earthquakes, floods, cyclones, drought, landslides etc. Singapore lies at the fringe of one of the most active seismic belts in the world. The nearest distance from Singapore to the Sumatran Fault Zone is about 400km. Although at this distance the earthquake effects are generally negligible, there had been unique cases in the past where major damages had been inflicted on other cities situated at about 400 km from the epicentre of major earthquakes. The most recent

example is the magnitude 8.1 Mexican earthquake which occurred on 19 Sep 85 at an epicentre about 400 km west-southwest of the Mexico City. The earthquake caused extensive damage in the centre of the city area, primarily to modern buildings between 6 to 20 storeys high. The destructive effects of the earthquake were due mainly to the long period effect and soil amplification.

So far, Singapore has not been struck by any major tremor in its short history of 173 years. However, minor tremors had been felt time and again in Singapore. These minor tremors were mainly due to long period waves generated by distant earthquakes. Because of the long distance, the intensity of the seismic waves reaching Singapore is usually very low. However, these low intensity waves could still be amplified by the soft foundation soils and building structures through resonance effect. Resonance effects are most pronounced on tall buildings and these effects are generally called long-period effects.

Other natural hazards faced by Singapore include floods and landslides. The incidence of drought and cyclone in Singapore is rare or practically nil. Flooding problems in Singapore have diminished with the completion of major drainage schemes in recent years although minor and localised flooding still occur during the Northeast Monsoon period. Singapore drainage system is still being further improved.

Landslides in Singapore are often induced by heavy rain. They normally occur in steep cut or filled slopes and natural hill slopes. However, as Singapore is generally low lying and less hilly as compared to other countries such as Malaysia, Hong Kong, Japan etc, the scale of landslide problems in Singapore is considered to be minor when compared with other countries. Nonetheless, fairly large landslides had occurred in the past. However, the risk caused by landslide is considered low and no casualty due to landslides has been reported so far.

6.2 Activities concerned with prevention of natural disasters

As described in para 6.1, Singapore is fortunate to be spared of major natural disasters that have brought untold damages and casualties to other disaster prone countries. Nevertheless, the authorities in Singapore are not complacent of Singapore's fortunate position.

Although Singapore has not been affected by major earthquakes, the Building Authority is concerned about the possible damages caused by long period effects especially if magnitude 8 and above earthquakes occur

along the Sumatran Fault in the future. The PWD is proposing to carry out a study on earthquake effects on high rise buildings in collaboration with the Nanyang Technological University.

The Government is also devoting more funds for the improvement of country's drainage system to further minimise the flooding problems.

The Government has also formulated and implemented an emergency plan to deal with both natural and man-made disasters. Training and exercises are being conducted to prepare the people against disasters.

6.3 Technical tasks required for disaster prevention

As mentioned earlier, the PWD & NTU are contemplating to investigate into earthquake risk in Singapore with particular reference to long period effects on tall buildings. The aim is to determine possible earthquake risk and the resistance of existing buildings against earthquake forces and to recommend design criteria against earthquake.

PWD is also considering introducing more stringent building control measures to minimise the risk and occurrence of landslides.

7 Proposals for further discussion

As PWD will be embarking in a massive construction of an underground road system within the highly developed urban city area, the Department is particularly concerned with the impact of road tunnel construction on adjoining properties. The impact will include noise and vibration generated during the construction, ground movement caused by the excavation works, noise and air pollution at tunnel portals during the operation of the tunnels. We are also experiencing water leakage in the recently completed road tunnels for the Central Expressway. Ventilation, lighting, safety and fire in the tunnels are also of concern to PWD.

The PWD has been concerned with the performance of road pavement. Several studies had been carried out in the past leading to the development of better mixes. Road maintenance programme has also been stepped up to ensure that road riding quality is kept up to an acceptable standard. Recently, the PWD has also developed and implemented a Pavement Management System through the help a consultant in order to improve our road maintenance programme. However, there are still several areas to be addressed. These relate to the resistance of pavement against stripping, ravelling and cracking, skid resistance and reduction of noise generated by the friction between tires and pavement.

Because of shortage of land, Singapore will have to seriously look into the possibility of making more use of her underground space. Besides the utilization of underground space in the city area which is generally underlain by soft soils, the sound granite rock in the Bukit Timah area also shows a high potential for the creation of underground spaces for a variety of uses. A joint feasibility study is being conducted by PWD and NTU.

Recently, the Building Authority in Singapore is also worried about the threats caused by tiles and curtain walls falling from external facades of building. The Building Regulations are being amended to provide for compulsory inspection of the building facades in addition to the existing requirements on periodic structural inspection. In addition to building facades, the Building Authority is also concerned with earthquake effects especially with respect to long period effects on tall buildings. Also, the Building Authority is exploring the application of Artificial Intelligence and Expert System Technology in building control processes.

With the above background, I wish to propose the following topics for further discussions with the relevant Japanese experts.

i) Construction of road tunnels using cut and cover methods

ii) Effects of cut and cover construction for road tunnels in soft ground on adjoining structures such as MRT tunnels, building foundations, services etc and their prediction.

iii) Underpinning of structures affected by adjoining deep excavation work in soft ground.

iv) Performance of pavement materials: Resistance against stripping, ravelling and cracking, skid resistance and reduction of noise due to friction between tires and pavement.

v) Ventilation, lighting, fire and safety in road tunnels

vi) Utilization of underground space in rock

vii) Waterproofing in building and underground space development.

viii) Application of thermography in building and civil engineering construction and building maintenance

ix) Application of Artificial Intelligence and Expert System Technology in building control functions

x) Earthquake effects with specific references to long period effects on tall buildings.

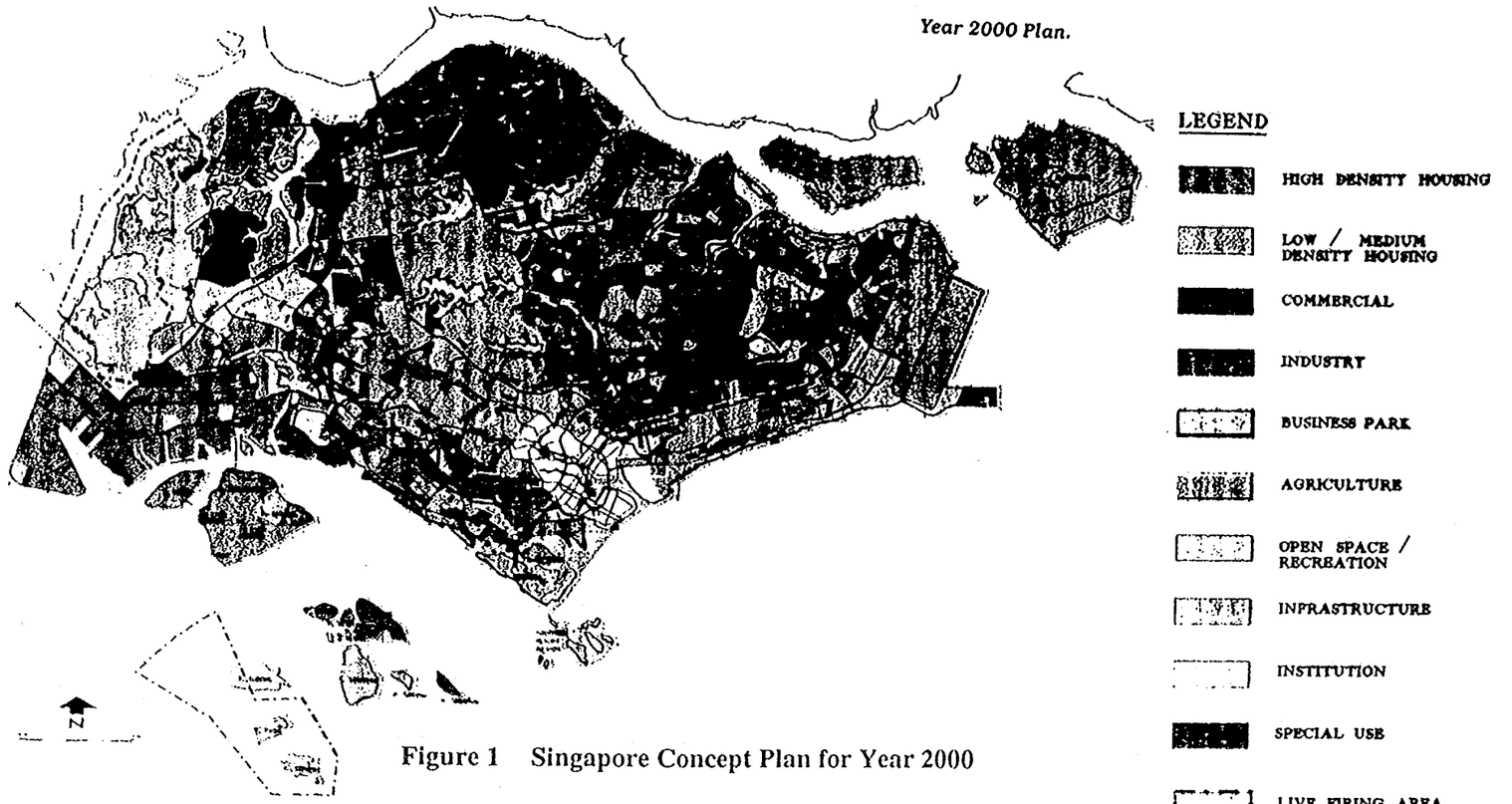


Figure 1 Singapore Concept Plan for Year 2000

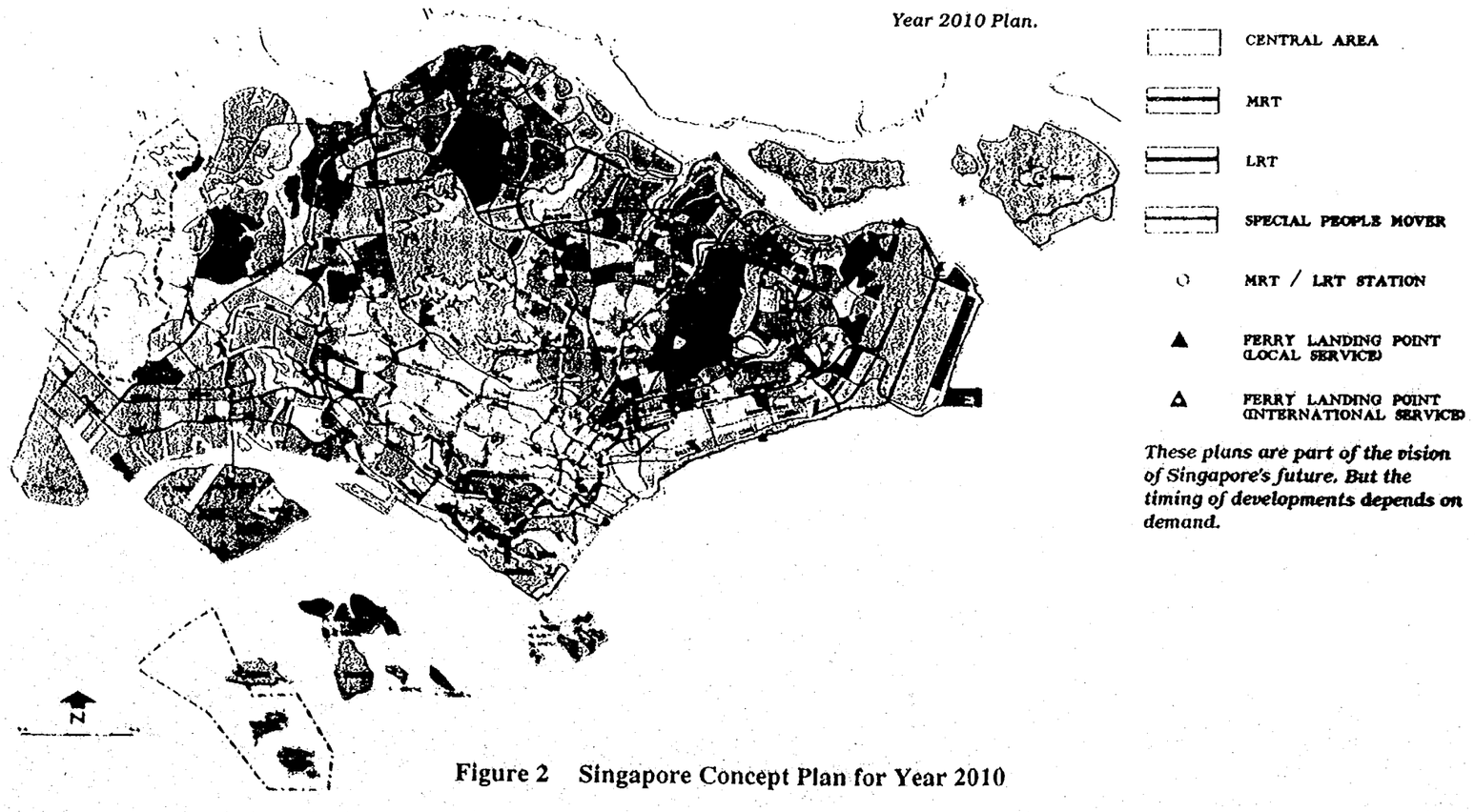


Figure 2 Singapore Concept Plan for Year 2010

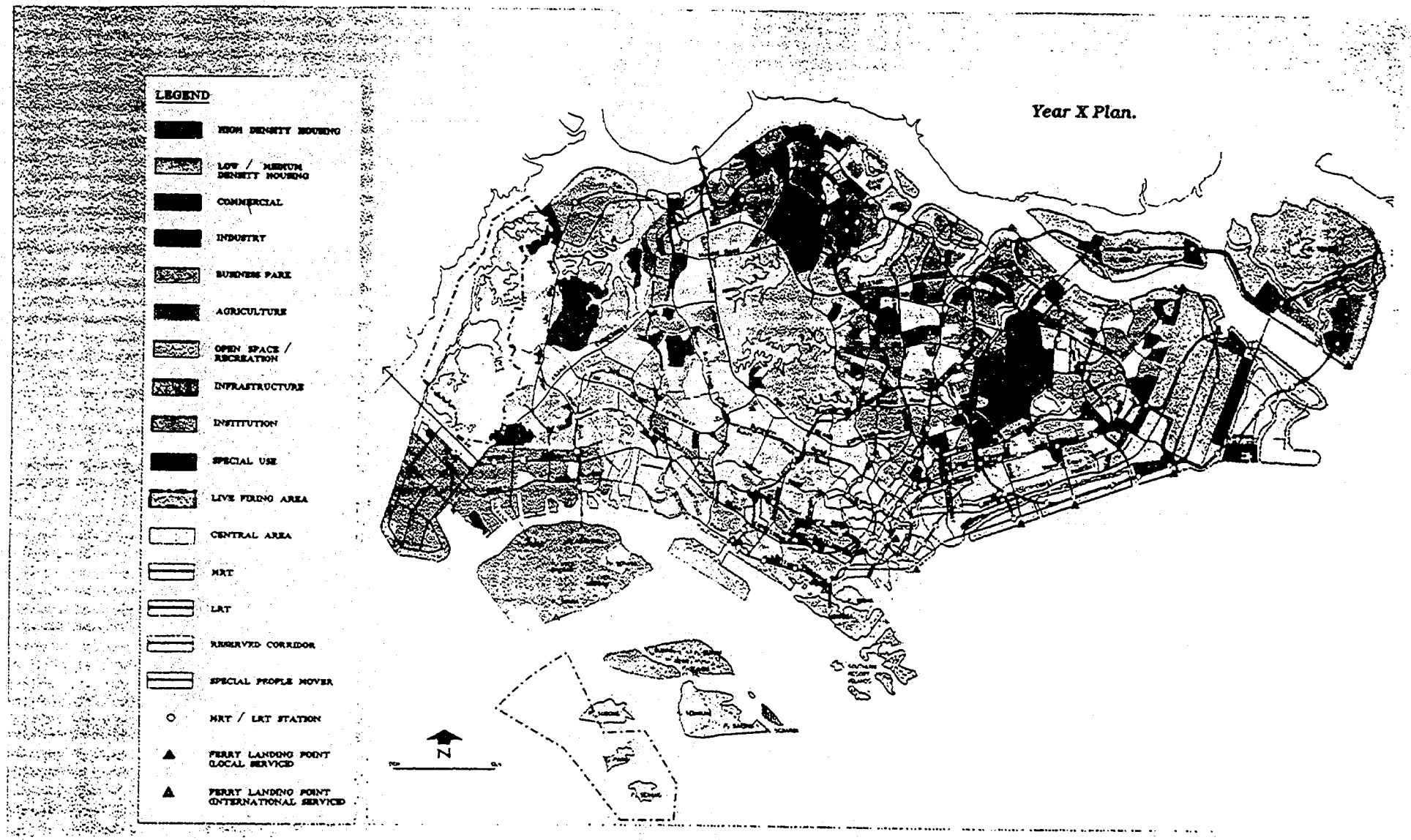


Figure 3 Singapore Concept Plan for Year X

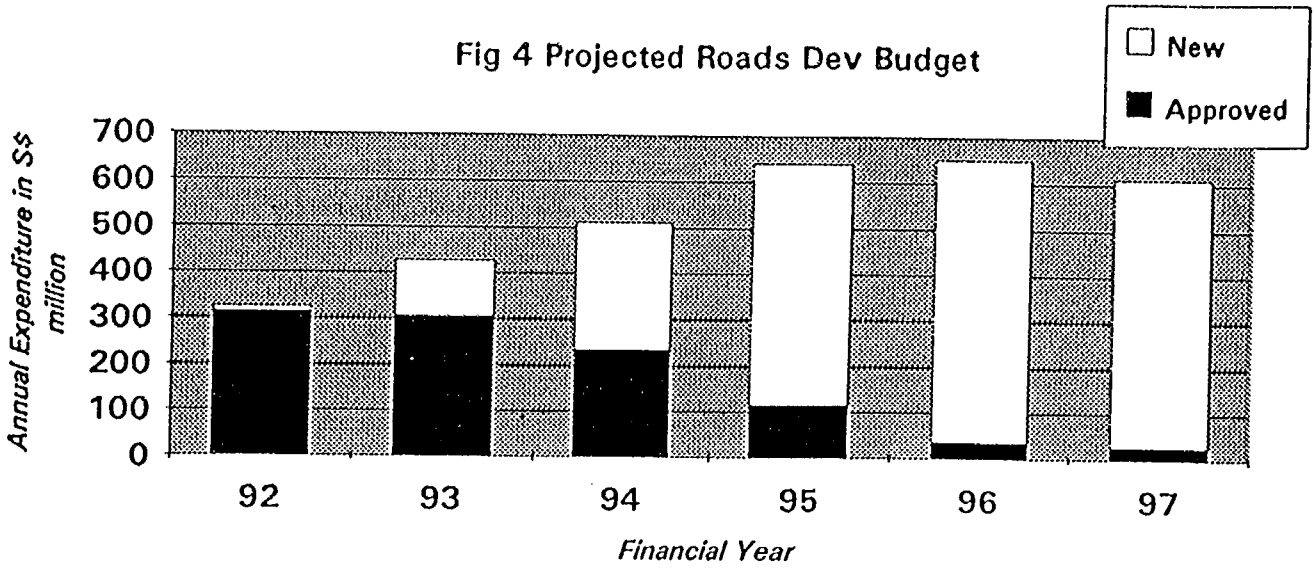


Fig 4 Projected Roads Dev Budget
New
Approved
Annual Expenditure in S$ million
700
600
500
400
300
200
100
0
92
93
94
95
96
97
Financial Year

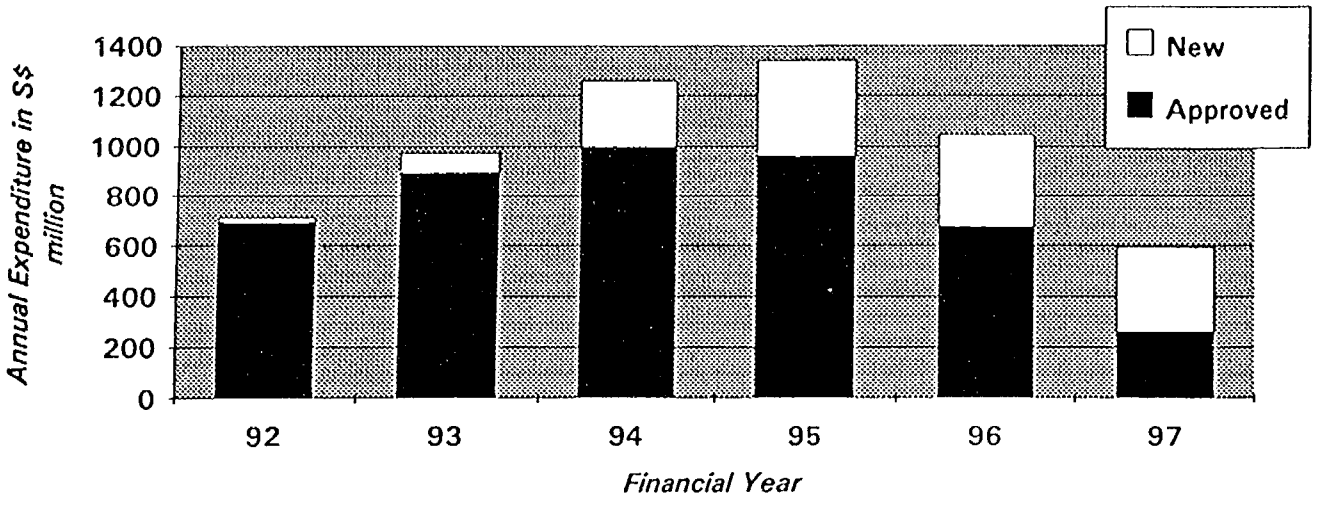


Fig 5 Projected Building Dev Budget
New
Approved
Annual Expenditure in S$ million
1400
1200
1000
800
600
400
200
0
92
93
94
95
96
97
Financial Year

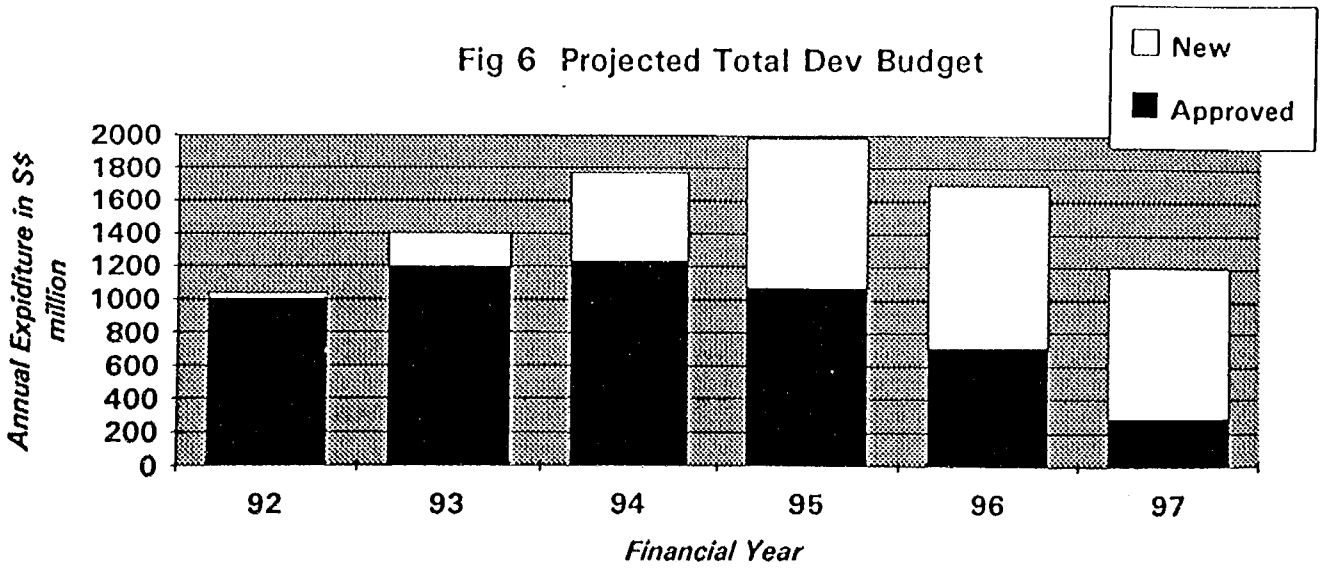
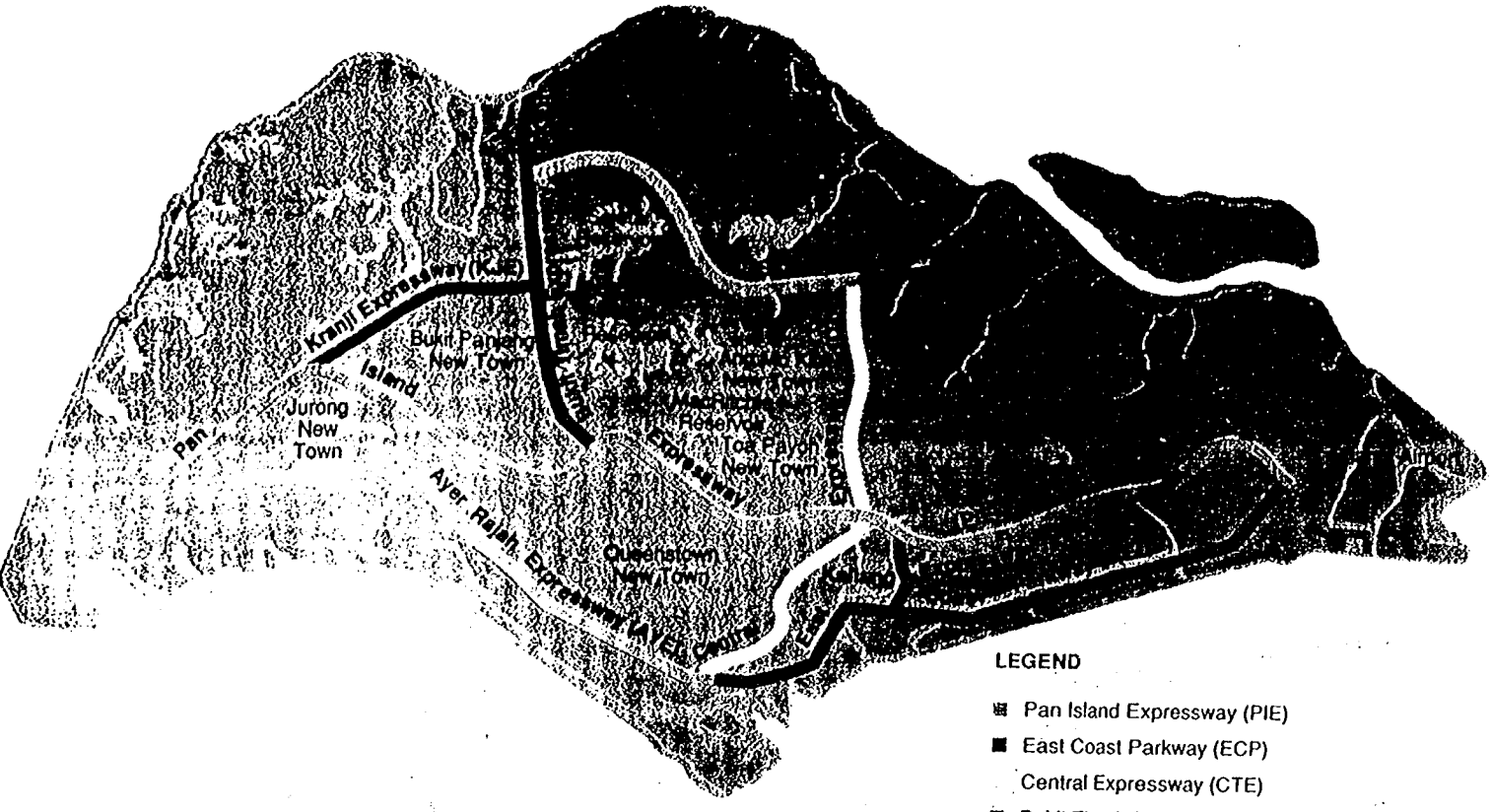


Fig 6 Projected Total Dev Budget
New
Approved
Annual Expidifure in S$ million
2000
1800
1600
1400
1200
1000
800
600
400
200
0
92
93
94
95
96
97
Financial Year



By the end of the 1990s nine expressways will cross the island

Figure 7 Singapore Expressway Network

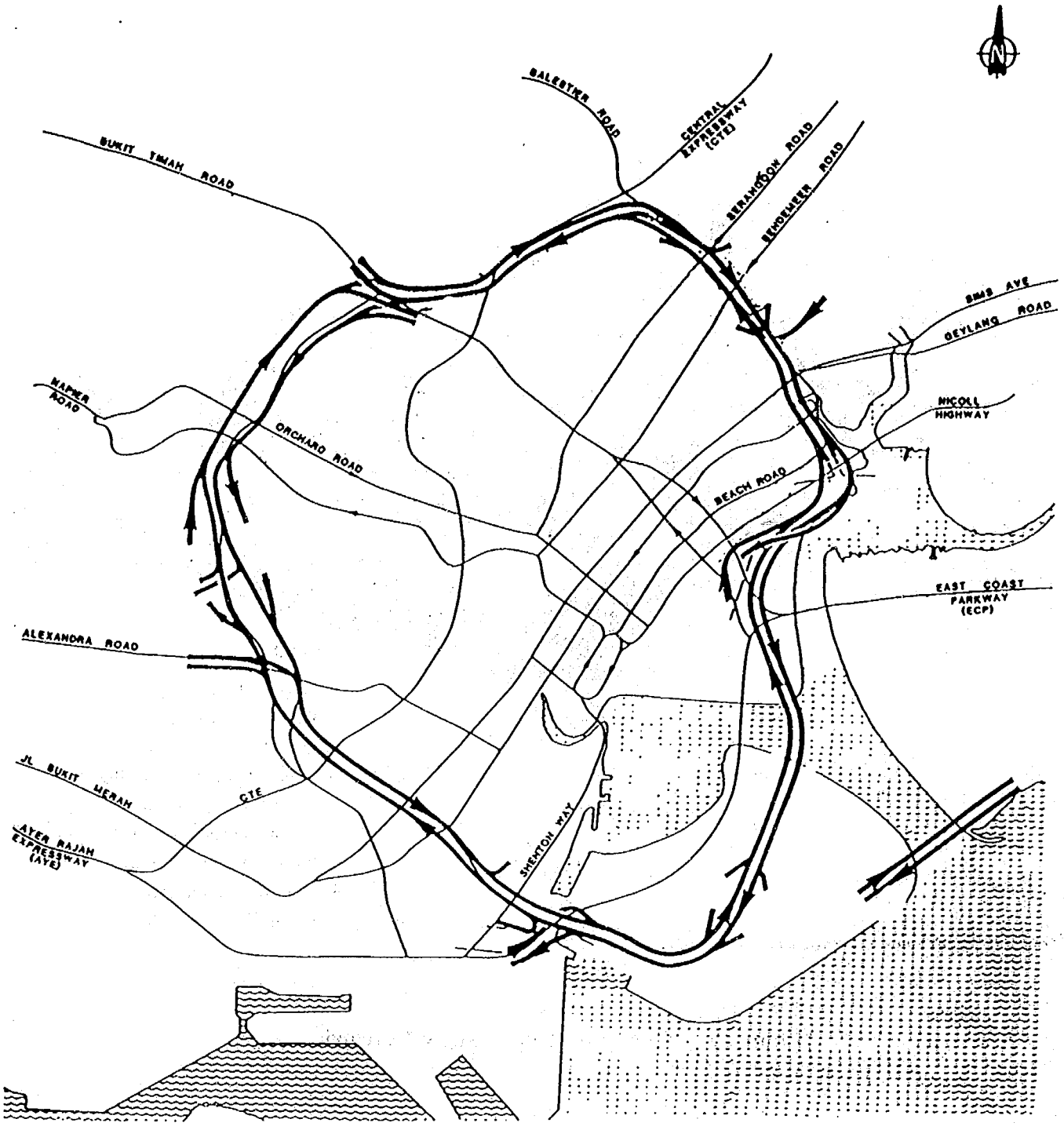


Figure 8 Proposed Singapore Underground Road System (SURS)

ORGANISATION STRUCTURE OF THE PUBLIC WORKS DEPARTMENT

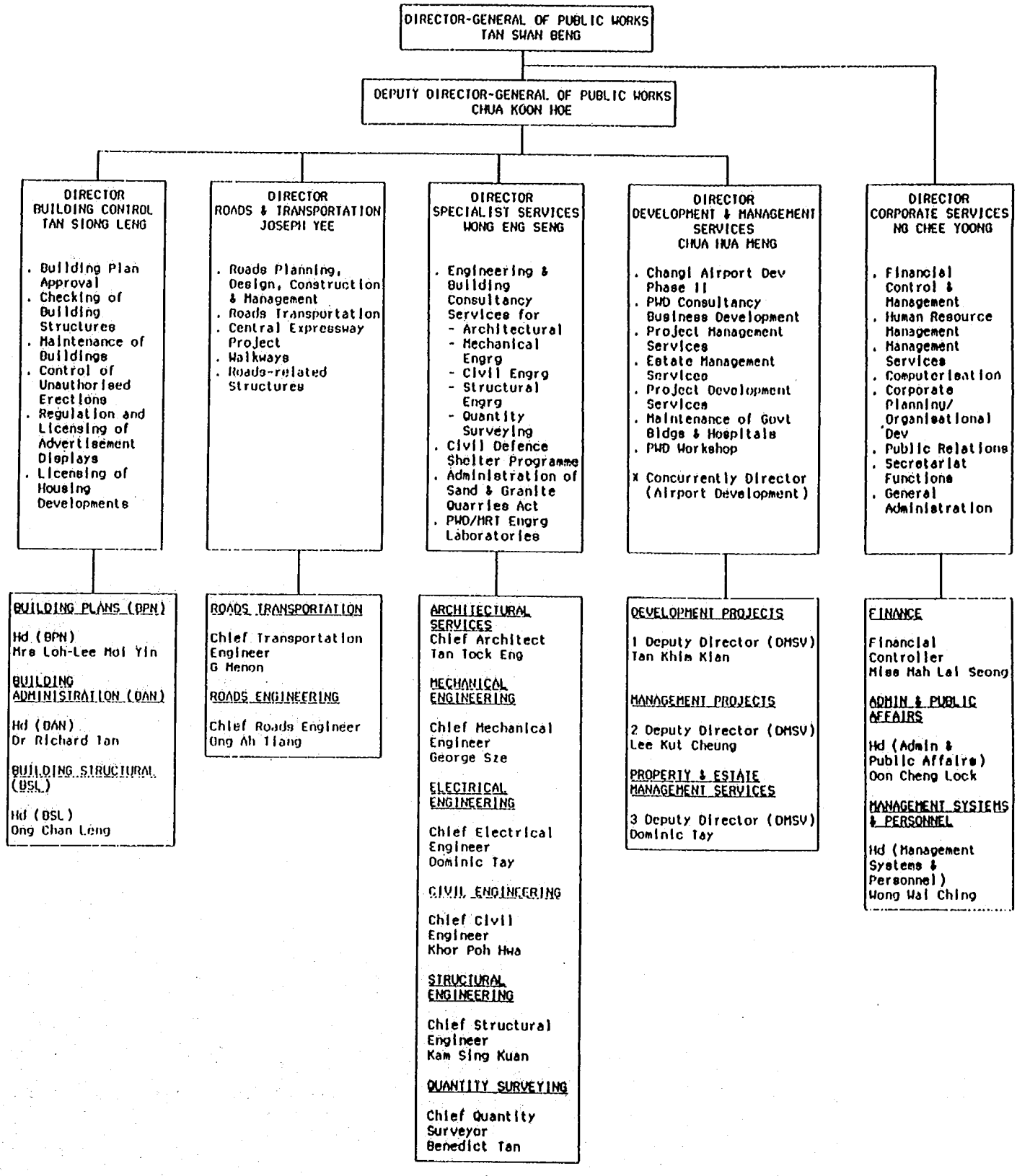


Figure 9 Organization Chart of Public works Department, Singapore

Ⅶ. Kingdom of Thailand

Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center,
Department of Highways

Mr. Bancha Vadhanasindhu, Chief of Programming Section,
Department of Highways

CONTENTS

1. The Outline of Thailand

2. A Description of the Highway Work System in Thailand

3. The Department in charge of Research and Development in DOH

4. Major Research and Development Project in DOH

5. International Research Exchange Programmes in DOH

6. Activities Related to Disaster and Disaster Prevention

7. Activities Concerning "Harmony between the Environment and Improvement of Infrastructure"

8. Proposals for Further Discussion

1. The Outline of Thailand

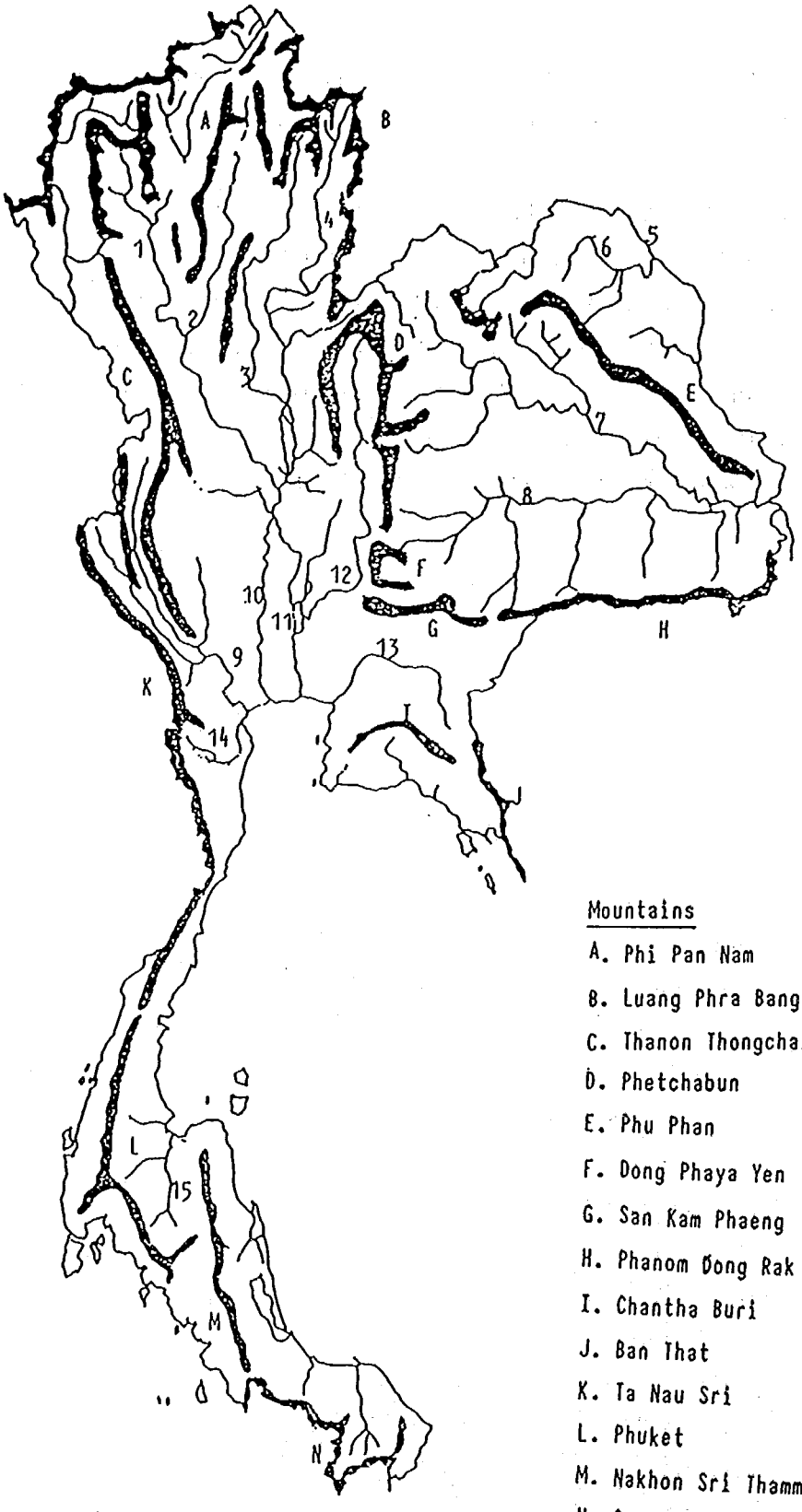
1.1 Description of the Land

The Kingdom of Thailand with an area of some region of Southeast Asia known as Indochina. The country lies entirely between the Equator and the Tropic of Cancer.

As may be expected in a country of its size, Thailand possesses varied types of terrain. The far north and western areas are rugged and mountainous, the east consists of the gently undulating topography of the Korat plateau; the central area contains the flat alluvial plain of the Chao Phaya, one of the region's principal rivers whilst the southern peninsula comprises coastal plains with rolling and hilly areas of hinterland.

The major rivers and mountains in Thailand are shown in Fig. 1-1.

Fig. 1-1 Major Rivers and Mountains in Thailand



Rivers

1. Ping R.
2. Wang R.
3. Yom R.
4. Nan R.
5. Khong R.
6. SongKhram R.
7. Chi R.
8. Mun R.
9. Mae Klong R.
10. Tha Chin R.
11. Chao Phra Ya R.
12. Pa Sak R.
13. Bang Pa Kong R.
14. Pran Buri R.
15. Tapi R.

Mountains

A. Phi Pan Nam
B. Luang Phra Bang
C. Thanon Thongchai
D. Phetchabun
E. Phu Phan
F. Dong Phaya Yen
G. San Kam Phaeng
H. Phanom Dong Rak
I. Chantha Buri
J. Ban That
K. Ta Nau Sri
L. Phuket
M. Nakhon Sri Thammarat
N. San Kala Khiri

1.2 Climate

The country is in a tropical zone which enjoys a warm and generally humid climate almost all year round, with abundant rainfall resulting from the seasonal monsoon.

The country's average annual temperature are about 27°C whilst in Bangkok are about 39.2°C maximum (in April) and 16.9°C minimum (in December). As a result, most parts of Thailand are very fertile and the economy is dominated by agriculture, especially the cultivation of rice, which is the country's staple food and a principal export.

There are two seasons, namely the dry season and the rainy season. The rainy season starts in May and ends in October. In September, we have the largest amount of rain. Some meteorological data in major cities are shown in Table 1-1.

Table 1-1 Meteorological Data in major cities in 1989

City	Temperature			Rainfall (mm.)	Mean relative humidity (%)
	Mean Max.	Mean.	Mean Min.		
Bangkok	32.9	28.2	24.4	1,496.4	82.0
Chiang Mai	32.1	25.5	19.9	1,190.4	69.3
Phuket	32.2	28.8	25.0	1,899.0	74.8

(Source) Meteorological Department

1.3 Demographics

The transition of a population in Thailand and in Bangkok is shown in Table 1-2. In 1989, the total population is about 56 million, while the population of Bangkok is 5.8 million. The density of populatin is 109 persons/

Km^2 in the whole country and 3,727 persons/Km^2 in Bangkok.

The percentage of a population of Bangkok in the total population increased from 8.6% in 1970 to 10.4% in 1989 as economic function concentrated in Bangkok.

Table 1-2 Population Growth in Thailand

(unit: million)

Year	1970	1980	1985	1986	1987	1988	1989
Total	35,550	46,961	51,796	52,969	53,873	54,961	55,888
Bangkok	3,077	4,349	5,363	5,469	5,609	5,717	5,833

(Source) Registration Division, Local Administration Department

1.4 Economy and Society

Major economic data are shown in Table 1-3.

1.4.1 Economic Growth

The Thai economy has grown rapidly and has become increasingly internationalized. During the Sixth Plan period (1987-1991), the Thai economic growth has skyrocketed with gross domestic product (GDP) expanding at an average of 10.5 percent per year, twice the Plan target, representing the highest average growth rate of the past twenty five years. Furthermore, the economic structure has become more outward-oriented and internationalized, as indicated by the increase in the proportion of international trade to GDP from 60 percent in 1986 to 80 percent by 1991.

1.4.2 Major Industries

Most of the population are farmers. The important agricultural commodities produced for export are rice, corn, coconut, tapioca and rubber. Furthermore, Thailand also exports industrial products such as processed food, garments and textiles, gems and jewelry etc.

Recently, the development of manufacturing is remarkable. The percentage of manufacturing product in GDP increased from 16% in 1970 to 25% in 1989, while in the same period that of agricultural product in GDP decreased from 26% in 1970 to 15% in 1989.

1.4.3 Trade and Financial Affairs

(1) Trade

The Thai economy has become more open and internationalized and has been increasingly dependent on the foreign trade sector. During 1986-1989, the value of foreign trade had increased from 475 billion baht in 1986 to 1.18 trillion baht in 1989. Value of exports had increased about 2.2 times from 233 billion to 516 billion baht while value of imports had increased about 2.8 times from 241 billion baht to 663 billion baht.

(2) Finance

During the Sixth Plan period (1987-1991), the fiscal position continues to be secure with high stability. Government revenue collection had been significantly higher than targets, having increased from 15.1 percent of GDP in 1986 to 19.7 percent of GDP by 1990. Although the government has significantly increased investment spending in infrastructure projects facing bottlenecks, government cash balance is in substantial surplus. During this period, the foreign debt burden had been declining constantly. In addition, the amount of international reserves increased from 5.2 billion U.S.dollars in 1987 to 17 billion U.S.dollars by mid-1991. Nevertheless, household savings continue to be at a low level although the government has implemented a number of fiscal policies to stimulate savings.

Table 1-3 Major Economic Data

Year		1986	1987	1988	1989
GDP (billion Bt.)[a]		1,095	1,253	1,507	1,791
Growth Rate of GDP (%)[a]		4.9	9.5	13.2	12.2
Per Capita GNP ($)		776	893	1,076	1,225
	Bangkok	2,336	2,784	-	-
Percentage of GDP by Industrial Origin[a]	Agriculture	16.3	16.4	16.6	15.2
	Manufacturing	23.6	23.9	24.8	25.4
	Others	60.1	59.7	58.6	59.4
International Trade[b] (billion Bt.)					
	Export	233.4	299.9	403.6	516.3
	Import	241.4	334.2	513.1	662.7
	Balance	-8.0	-34.3	-109.5.	-146.4
Government Fiscal Cash Balance (billion Bt.)[c]		-34.2	-8.9	36.1	65.3
Increasing Rate of the Consumer Price (%)[d]		1.9	2.5	3.8	5.4
Foreign Debt (billion $)[e]		11.0	12.9	12.4	11.7
International Reserves (billion $)[e]		3,776	5,212	7,112	10,509

(Source) a. National Income of Thailand, 1989. NESDB.
b. Foreign Trade Statistics of Thailand. Department of Customs
c. The Comptroller's Generals Department
d. Department of Business Economics
e. Bank of Thailand

2. A Description of the Highway Work System in Thailand.

2.1 Master Plan of National Land Development

In 1962, Thai government established the National Economic and Social Development Board (NESDB) which plays an essential role in formulating National Economic and Social Development plans, 5-year plans for every section of investment and development. Since then the Department of Highways (DOH) has been formulating 5-year plans for Highway development in concurrence with them.

2.1.1 The Five-Year National Economic and Social Development Plan

The major objectives of the Seventh Plan (1992-1996) as stated in the Summary are, to:

- sustain economic growth rates at an appropriate level to ensure sustainability and stability
- redistribute income and decentralize development to the regions and rural areas more widely
- accelerate the development human resources, and upgrading quality of life, the environment and natural resource management.

Having critically reviewed the current situation, transport sector targets for the Seventh Plan are set in section 2. These are, to:

- provide convenient, rapid, safe services at lower cost
- utilise transport to catalyse and accelerate development
- emphasise safety and quality.

The general guidelines for infrastructural development given in section 3 are:

- to support private sector investment by: amending legislation which restrict it; designating and organisation etc. to ensure implementation; encouraging sub-contracting of public services
- to improve fund mobilisation by: emphasising equity over debt financing; converting some state enterprises into limited companies; raising capital through bond issues; supporting joint ventures
- to improve operating efficiency through: more business orientated organisation and administration; emphasising information system and investment and corporate plan; streamlining project approval; monitoring and evaluation
- to organize long term planning and coordination by: requiring public

agencies to prepare 10 to 20 year plans as their principal framework for development; and designating an agency to be responsible for long term planning to ensure consistency

- to improve pricing procedures by: setting up a permanent, independent body to supervise and determine prices to reflect actual costs; and setting special prices for the poor

- to prevent pollution and protect the environment by: building environmental protection into projects

- to develop personnel by: supporting educational and training institutes in the public and private sectors.

The guidelines for transport are:

- to solve traffic congestion and organize the urban transport system by: accelerating construction of ring roads and bypasses; speeding up secondary road construction in outer Bangkok; construction a central intermodal passenger complex; accelerating construction of megaprojects and facilitating use of expressways by buses; reducing use of private vehicles by enforcing restrictions; constructing truck terminals at appropriate locations; encouraging passenger transport by river and canal; improving organization of traffic problems; promoting private-public sector cooperation on traffic related environmental problems.

The specific guidelines for land transport are:

- to develop a network of controlled access inter-urban expressways or special highways

- to meet the needs of new economic zone development

- to development road and rail networks to facilitate trade between sectors

The Seventh Plan lays down environmental guidelines, to:

- enforce the "polluter pays" principle of pollution control

- improve the basis for environment administration

- mobilize investment in pollution control, through Government subsidies, joint ventures or private sector concessions

- set up tripartite organizations (Government, private enterprise and the community) for environmental control, supervision and conservation to international standards; in particular for urban, industrial and tourist areas.

2.1.2 7th Five-Year Plan for Highway Development (Draft)

Now, DOH has made the draft of the 7th Five Year Plan for Highway Development. The guideline and objectives of the plan is as follows.

1. Direction of Development

1) To develop "Inter-city Motorway" in order to increase the efficiency on highway system.

2) To increase the highway structure standard by widening traffic lanes in highways connecting the Bangkok Metropolis with other regions, major cities and some special areas to reduce traffic congestion on highways.

3) To emphasize reconstruction and rehabilitation of existing highways to function effectively.

4) To take the important role in traffic accident prevention to reduce the accidents on highways.

2. Objectives

1) To increase the highway transportation efficiency.

2) To raise the quality of life to the people in the rural area.

3) To render safety to road users.

Under these policies, this highway development plan is composed of 667 projects with the total length of 14,681 Km. The total construction cost is 95,833 million baht. The detail of projects in the plan is shown in Table 2-1.

Table 2.1 Highway Construction and Rehabilitation Plan between 1992-1996 (Only New Projects)

Projects	Number	Distance (km.)	Construction cost (million baht)	Amount of each Fiscal year (million baht)					Under Construction between 1992-1996		Carry Forward to 8 th Plan (million baht)
				1992	1993	1994	1995	1996	km	Million baht	
1. Inter-city Motorway	5	198	14,800	-	-	700	2,800	5,700	122	9,200	5,600
2. Widening Project	98	2,394	30,036	935	3,177	6,176	7,330	7,070	1,891	24,688	5,348
3. Interchanges and Flyovers construction Project	38	14	6,004	-	362	1,124	1,703	1,613	15	4,802	1,202
4. New Alignment Construction Project	61	987	6,882	75	743	1,600	1,674	1,583	790	5,675	1,207
5. Paved Road Construction Project	215	5,086	15,221	89	1,200	2,832	3,552	4,235	4,002	11,908	3,313
6. Flyovers Across the Railway	15	7	627	-	-	60	199	230	6	489	138
7. Reconstruction and Rehabilitation Highway Project	235	5,995	22,263	-	1,472	4,517	6,444	5,557	4,793	17,990	4,273
Total	667	14,681	95,833	1,099	6,954	17,009	23,702	25,988	11,620	74,752	21,081

2.2 Budget for Investment in Highway Development

The Department of Highways annual budget allocation covers appropriation for administration, construction and maintenance for the following plan:

1. Land Transportation Administration
2. Special Highways Construction,
3. National Highways Construction,
4. Highways and Bridges Maintenance,
5. National Security Highways Construction

The detail of DOH budget in 1992 is shown in Fig. 2-1

2.3 Organization Concerned with Public Works

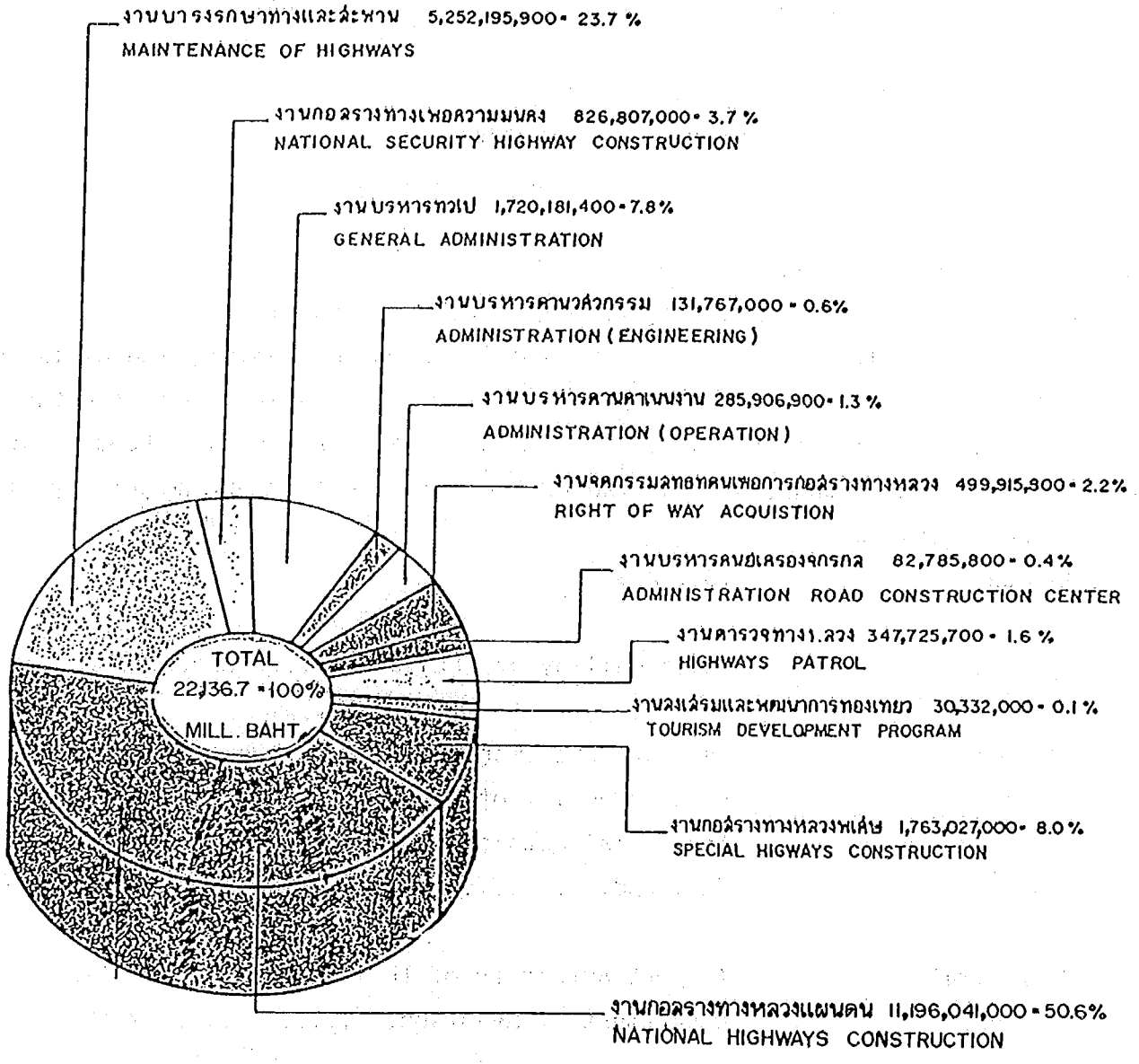
2.3.1 Organization Concerned with Major Infrastructures.

In Thailand, Ministry of Transport and Communications (MOTC) and Ministry of Interior (MOI) are mainly in charge of development of major infrastructures except agricultural infrastructures. These ministries have several Departments and Authorities which construct and manage these infrastructures. Major organizations are as follows:

1) Road	(See 2.3.2)
2) Railway	State Railway of Thailand.....MOTC.
3) Port	Harbour Department.....MOTC. Port Authority of Thailand.....MOTC. Industrial Estate Authority of Thailand.....MOIN.[1] etc.
4) Airport	Airport Authority of Thailand.....MOTC. Department of Aviation.....MOTC.
5) Tele-Communication	Telephone Organization of Thailand.....MOTC. Communication Authority of Thailand....MOTC.
6) Waterworks	Metropolitan Waterworks Authority.....MOI. Provincial Waterworks Authority.....MOI.
7) Drainage & Sewerage System	Department of Drainage and Sewerage....BMA.[2] Department of Public Works.....MOI.

Fig 2.1 งบประมาณกรมทางหลวง ปี 2535

DEPARTMENT OF HIGHWAYS BUDGET IN 1992



หมายเหตุ * ข้อมูลเมื่อเดือนตุลาคม พ.ศ. 2534

Remark * The information is based on the one received in October 1991

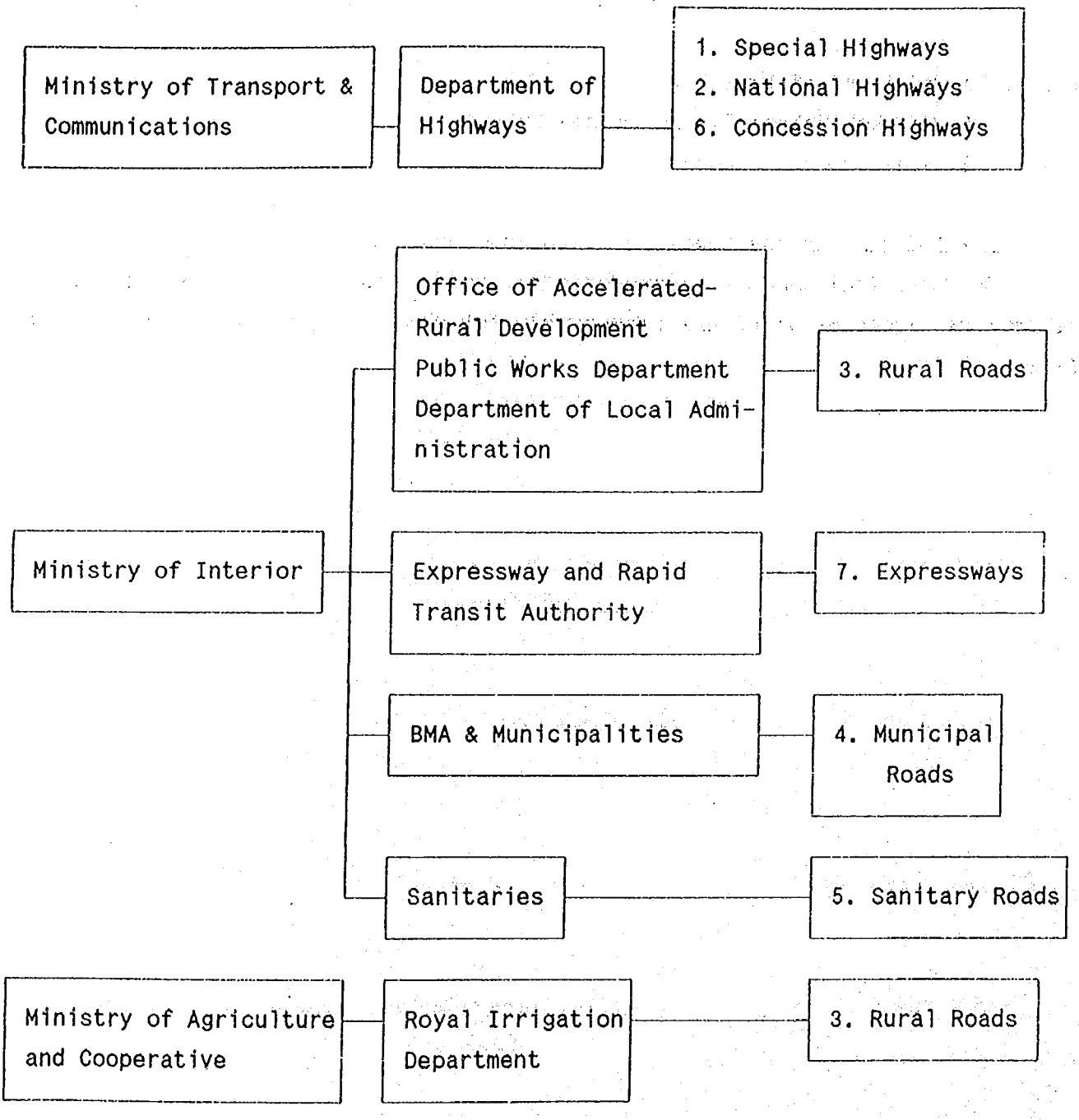
8) Housing	National Housing Authority.....MOI.	
	Government Housing Bank.....MOF.[3]	
9) Electricity	Metropolitan Electricity Authority.....MOI.	
	Provincial Electricity Authority.....MOI.	

Notice: 1. Ministry of Industry
2. Bangkok Metropolitan Administration
3. Ministry of Finance

2.3.2 Organizations Concerned with Road Development.

In 1992, Thailand has 7 categories of roads. DOH is respondsible for 3 categories. Agencies which are responsible for each category are shown in Fig. 2-2.

Fig. 2-2 AGENCIES RESPONSIBLE FOR ROADS



2.4 History, Progress and Problems of Roads in Thailand

2.4.1 History and Progress

The first road to be constructed in Thailand for the purpose of transportation was begun in 1862 during the reign of King Rama IV. This road was divided into 2 sections: Section I began in Songkla province and ran to the border of Saiburi, Section II ran from the end of the first section into the town of Saiburi itself. The road was financed by taxes from these two provinces and its first use was in welcoming King Rama V, on his return trip from India, it was, them, called "Rajdamnoen or Thanon Rubsadej" (a welcome to the King).

In the reign of King Rama V. there was no agency that was really responsible for road construction. Most roads were built in the provinces by the Governors. In the period 1871-1916, a total length of 775 km. of roads were constructed in provinces throughout the Kingdom.

In 1933, in order to improve all highways in accordance with both the government policy and economic requirements, the government approved a plan for the construction of highway to all provinces, a total length of 14,900 km. was to be completed within 18 years. The Highway Division implemented its first five-year plan by constructing highways according to the original standard, i.e. macadam or lateritic surfacing of 5 meters width, and overall 8 meters. At the end of the plan, 2,215 km. of highways were open to traffic.

Owing to the "Indo-China Affair" and World War II, the constrution of highways made no substantial progress during the years 1941-52. After World War II, there were a big change in both the highways construction and the vehicles. The vehicles have become bigger, the weight of vehicles is heavier and they travel at higher speeds.

Highway construction, on the basis of Highway Engineering, had first come into Thailand during 1953-1955. At that time, the International Cooperation Administration (I.C.A.) of the United States of America had extended its assistance in the Friendship Highway construction (Saraburi-Nakhon Rajasima) by using new technology and international standards of construction. Since then, the Department of Highways has adopted new technology in road construction.

In the period 1956-1962, all working plans primarily emphasised construction of both primary and secondary national highways. During this period, the Department of Highways was capable of constructing an additioned total of 1,850 km.

The Government established the National Economic and Social Development Board (NESDB) in 1962. It played an essential role in formulating 5-year plans for every section of investment and development. Since then, the Department of Highways has proceeded to implement plans for the development of highways in concurrence with the National Economic and Social Development Plan.

2.4.2 Problems of Road

Highways in Thailand have been developed and improved systemmatically over the past 30 years. Nevertheless highways still face substantial problems:

1) The Damage of Highway

At present, advanced vehicular technology enables trucks to carry heavier and heavier loads which causes considerable damage to the road network. A rough survey of national highways found that 62% of highwayis in good condition, 20% is fair and 18% is bad or worse. The percentage ofhighway in bad condition is higher than the international target standard of between 0-1%. Those highways at present in fair condition will deteriorate unless reconstructed. This will have a direct impact on the efficiency of the highway system and overloaded trucks will also cause more damage to the highway so it needs reconstruction immediately.

2) Traffic Congestion

Highways in the Central Plains especially the areas in Bangkok and its peripheries are facing widespread traffic congestion due to the very high growth. The main roads linking the regional centres and Bangkok as well as roads linking Bangkok to specific areas, for example, the Eastern Seaboard Development Project also face this problem. Apart from budget limitations due to needs in other development areas, another important cause is due to the rapid economic expansion which results in the shortage of construction materials and contractors. This slows down the construction projects and reconstruction of many highways under the plan specified. Owing to the budget restriction, the road construction planning by department of Highways needs a stage-construction method which is suitable to the implementation of work under the plan and schedule. Anyhow, the construction work cannot catch up with the demand of road-using. This causes a heavy traffic congestion on several main roads.

3) Traffic Accident

Almost all highways in Thailand, except the expressways of the Expressway & Rapid Transit Authority of Thailand, are toll-free roads. Lack of knowledge in car-use, in discipline, in road-use and less enforcement of laws causes a lot of accidents each year. The accident statistic reports by the Traffic Engineering Division, Department of Highways 1981- 1989, show that accidents rose from 16,361 cases in 1981 to 42,537 cases in 1989, an increase of over two times, with casualties increasing from 12,157 cases to 17,773 cases

From the data on accidents and casualties on the roads under the responsibility of Department of Highways from 1981-1989, the increasing rate of accidents nationwide is not clearly related to the number of registered vehicles or population. The population increased in Bangkok has a direct impact on the increasing rate of registered vehicles. A three-stage approach to traffic safety is to be implemented:

1. Improvement of the highway system;
2. Educate road-users in the correct use of roads;
3. To take decisive action over the control of responsible agencies.

2.5 Major Project in Progress in Planning and Construction

2.5.1 Nationwide Motorway Network in Thailand

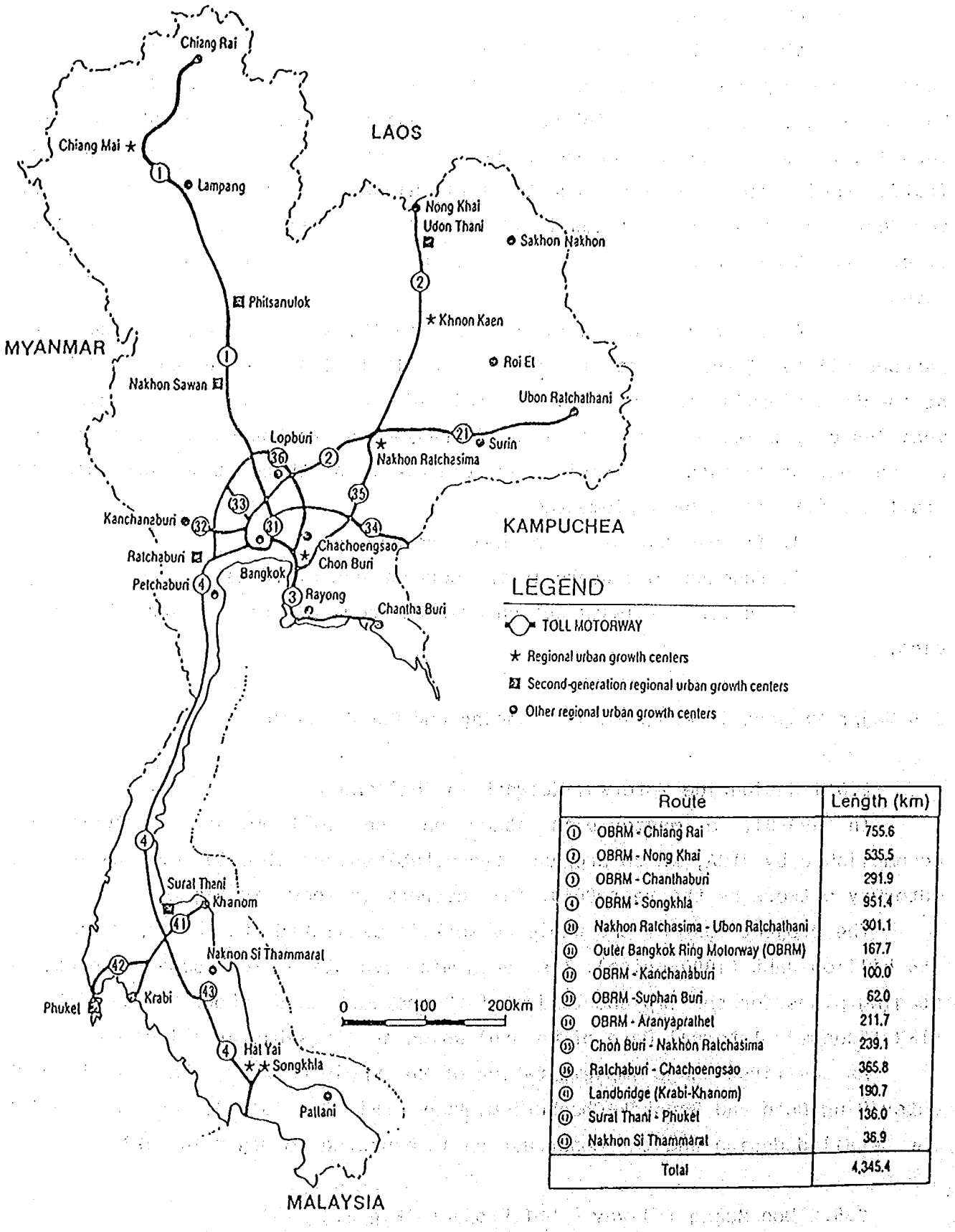
In 1990-91, a master-plan study on the toll motorway network was accomplished by JICA, which proposes the establishment of 4,300 km. nationwide motorway network by the year 2010. This network is shown in Fig 2-3.

The project cost of the whole network is estimated to be approximately 356 billion Baht (1990 price). The economic evalution for some alternative staging plans for the implenentation of the network shows about 23% to 35% in EIRR (Economic Internal Rate of Return) which are feasible in all cases.

As the first stage implementation of the whole network, Eastern Bangkok Outer Ring Road and Bangkok-Chonburi Highway (Fig.2.4-(5)(6)) are now under the detailed design and the construction is expected to begin in 1993.

2.5.2 Don Muang Tollway - BOT Project (Fig.2.4-(1))

This new highway which is already under construction, has 6 traffic lanes elevated on a concrete viaduct 14 meters above the existing Vibhavadi-Rangsit



Route	Length (km)
① OBRM - Chiang Rai	755.6
② OBRM - Nong Khai	535.5
③ OBRM - Chanthaburi	291.9
④ OBRM - Songkhla	951.4
⑩ Nakhon Ratchasima - Ubon Ratchathani	301.1
⑪ Outer Bangkok Ring Motorway (OBRM)	167.7
⑫ OBRM - Kanchanaburi	100.0
⑬ OBRM -Suphan Buri	62.0
⑭ OBRM - Aranyaprathet	211.7
⑮ Chon Buri - Nakhon Ratchasima	239.1
⑯ Ratchaburi - Chachoengsao	365.8
⑰ Landbridge (Krabi-Khanom)	190.7
⑱ Surat Thani - Phuket	136.0
⑲ Nakhon Si Thammarat	36.9
Total	4,345.4

Figure 2.3 PROPOSED MOTORWAY NETWORK

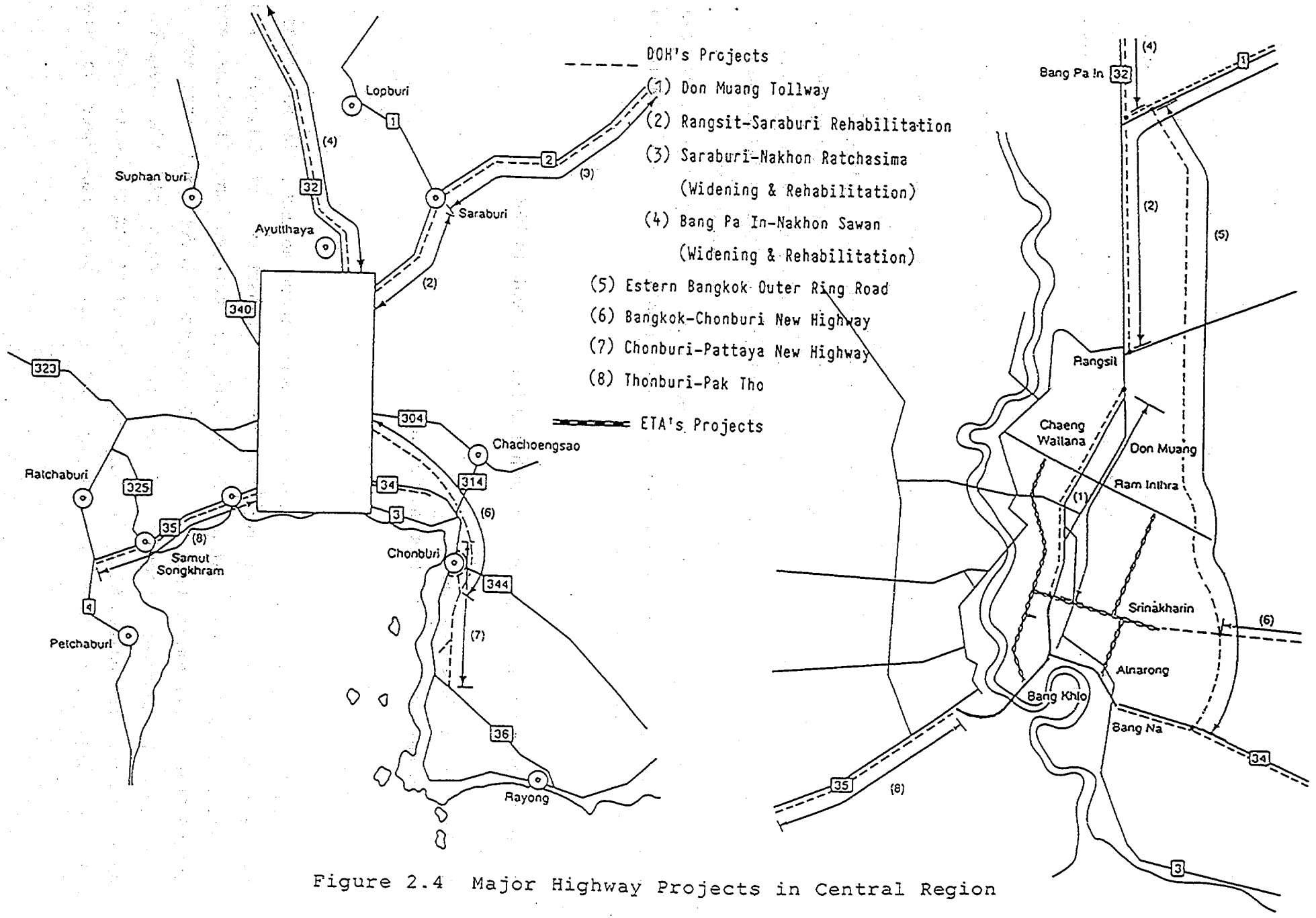


Figure 2.4 Major Highway Projects in Central Region

road. The total width of the highways is 25.30 meters and the viaduct piers are located within the central median of the existing road. The total construction cost is about 10,000 million baht. The Don Muang Tollway Company is the concessionaire for the whole project which is expected to be completed during 1993. Once the elevated highway is opened it will relieve the chronic traffic congestion on the existing Vibhavadi-Rangsit road where the present traffic volume is about 200,000 vehicles per day and, is increasing at an annual rate of more than 8 percent.

2.5.3 Bang Pa In-Nakhon Sawan Widening and Rehabilitation Project (Fig.2. 4-(4))

This section of Highway No.32 which is the major access to the Northern Region of Thailand, is already being widened into a 4-lane divided highway. The existing heavily congested 2-lane asphalt road is being rehabilitated with a concrete road pavement and, a new carriageway is being built alongside the existing. Both directions will have 7 meters wide carriageways with 2.5 meters wide asphalt surfaced shoulders. In addition, there are eight interchanges to be constructed. The total length of the project is 182.6 km. The total construction cost is about 7,940 million baht. Some sections will be completed in 1993 but the whole project will not be finished until 1994. Upon completion it will be operated as a toll highway.

3. The Department in Charge of Research and Development in DOH.

3.1 Name of the Organization

Road Research and Development Center

3.2 History

During the past time, road researches were conducted under the Materials and Research Division. Road research of the Department of Highways was initiated probably around 1967 by the cooperation between the Thailand and United States Governments under the USAID project. Under this contract a research work committee composing of the Thai engineers and the research engineers from the United States cooperated in investigating the properties of lateritic soils in Thailand. Results of the study were published in two

technical reports.

During the same period of time, there were a number of special projects under investigation in more detail than the conventional practice. Some of them are the design and construction of soil-cement road, and design and construction of road embankment on soft clay. There are some related reports published in the regional journal and the proceedings of the technical seminars.

In 1972 The Office of the Civil Service Commission approved the initial set-up of the road research section in the Materials and Research Division. There were 3 active sectors in the road research section namely, highway materials, soil foundation and traffic engineering. Later in 1977 the Office of the Civil Service Commission approved 2 more sectors namely, road maintenance and building structure, to cover more extensive road research.

The Department of Highways, realizes about the aforementioned problems very well, so it established the Road Research and Development Center in the framework of the Department in 1992. The objective of the Road Research and Development Center Establishment is to conduct detailed studies on the stated problems technically and systemmatically in order that the appropriate solutions could be drawn on the basis of the Thailand conditions. As a consequence, the Department of Highways could utilize the results of the research studies to improve the works.

3.3 Organization Chart

The Organization of the Center is shown in Fig. 3-1

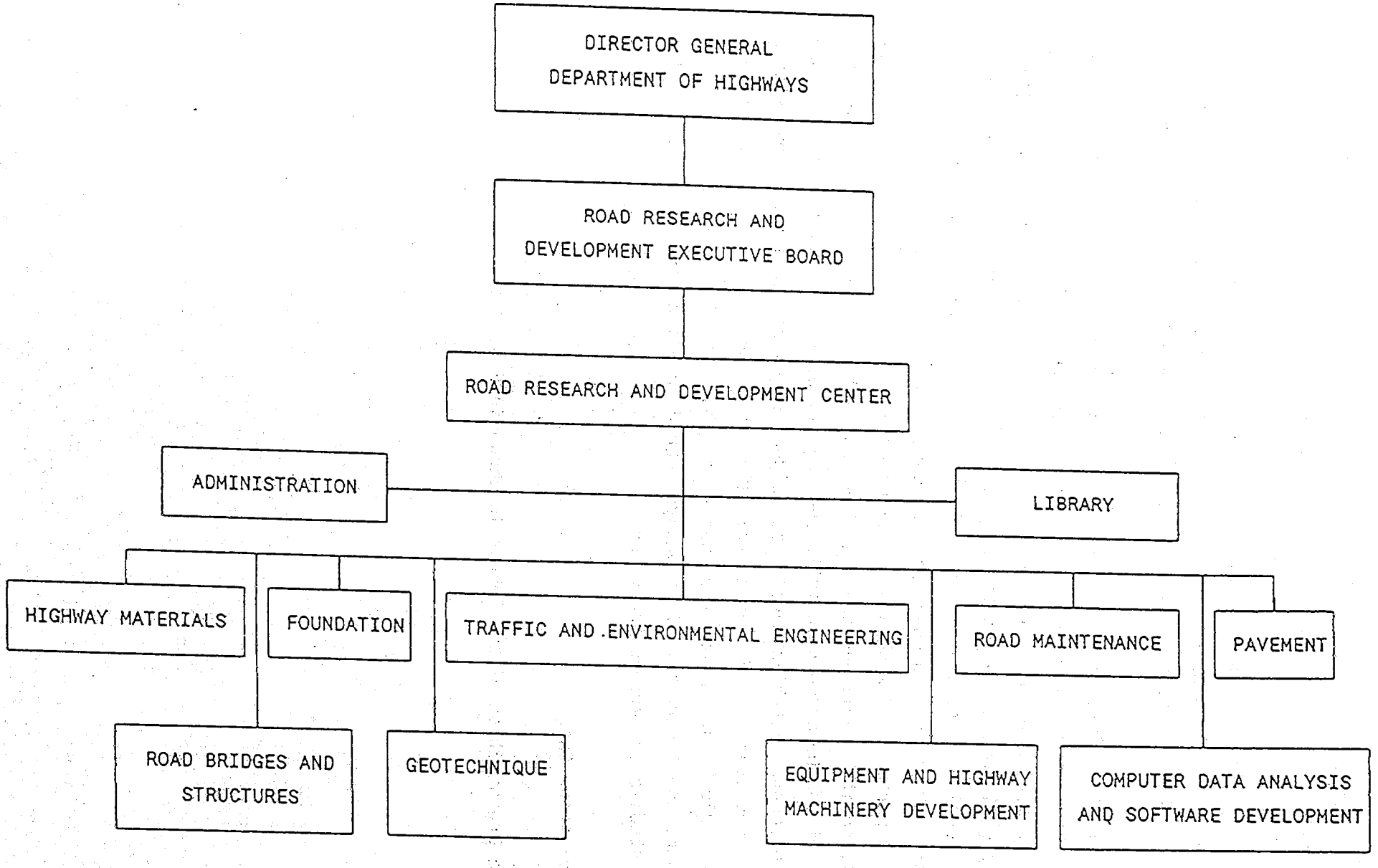


Fig. 3-1. ORGANIZATION OF THE ROAD RESEARCH AND DEVELOPMENT CENTER

3.4 Number of Staff

Road Research and Development Center has the manpower of 24 engineers associated with a few number of supporting staff such as typists, foreign affair officers, librarian, messengers and unskilled labours, etc.

3.5 Budget

The budget of the Road Research and Development Center in these fiscal year (1993) is approximately 7 million Baht. Most of the budget is for the establishment of the basic facilities for research development.

3.6 Management Systems

Road Research and Development Center will be directed by the Director under the Executive Board appointed by the Director-General of the Department of Highways. The Executive Board is chaired by the Deputy Derector-General for Engineering. Members of the Executive Board are from different divisions related to research activities. The Director of the Road Research and Development Center serves as a Member and a Secretary of the Executive Board.

As a result of the Road Research and Development Center establishment, the Department of Highways assigned following policies for effective research development.

1. Plan of developing the Center should be divided into 2-3 stages according to the manpower, equipment and working offices in order that efficient progress could be made associated with some gained experience that will take time to fully develop.

2. First stage road research should be principally created from all available information and resources by developing them to be in a form of research projects.

3. Increase of the manpower and other research facilities could be appropriately made to induce an initial efficiency in research operation, and to serve as a base for the future expansion.

4. Positioning the personnel for research works will be made on the selective basis by considering the academic background, readiness for research, and other status.

5. Trying to make the Road Research and Development Center physically operated for the benefit of the Department of Highways, and the country.

6. Both institutional and international cooperation for research works are strongly promoted.

3.7 Major Research Facilities

1. Basic properties test equipment for soil
2. Unconfined compression test for soil
3. Triaxial compression test for soil
4. Convertional consolidation test
5. Laboratory vane shear test
6. Automatic compaction machine
7. Oven, balance
8. CBR test set
9. Slake durability test
10. Aggregate impact value test
11. Aggregate crushing value test
13. Iowa borehole shear device
14. Dynamic soil tester
15. Polish stone value tester
16. Micro-computer and software

3.8 Recent Achievements

The major research and development achievements which have been accomplished by DOH are as follows.

1. Research on Embankment on Soft Clay

This project is focussed to the techniques of soft soil foundation improvement for supporting the road embankment to prevent an excessive settlement. In 1991 the Department of Highways introduced geogrid and geocell mattress to reinforce the embankment foundation constructed on soft clay for the Thon Buri-Pak Tho Highway. In addition the road section of 12 kilometers with an embankment supported by the pile foundation was constructed along this highway.

2. Case Study of Using the Geogrid Reinforcing the Earth Embankment in the Mountainous Terrain.

This project initiated the system of reinforced earth structure to improve the stability of the high filled embankment in the mountainous terrain for the first time in Thailand. Results of the study tend to enable the geo-technical engineer of the Department of Highways making more efficient design of the earth structure in the mountainous terrain.

3. Road Maintenance Study Project

This is a study project that the Department of Highways obtained the technical assistance from the Asian Development Bank. The duration of the project is 3 years. The objective of the project is to study the road maintenance and to improve the road data base for administration. Results of this project will enable the Department of Highways to make more efficient planning, operating and evaluating the road maintenance. In addition the criteria and appropriate levels of road maintenance could be assigned to the roads conforming to the fluctuated economic conditions of the country.

4. Road Pavement Research

This research project studies about the methods of flexible pavement design and the pavement structures appropriated for the heavily trafficked road with a number of overloaded trucks for the Thailand conditions. It is composed of a number of sub-projects as follows.

- Structural evaluation of the asphalt pavement.
- Structural evaluation of the semi-rigid pavement.
- Structural evaluation of the asphalt pavement subjecting to overloaded truck.
- Comparison evaluation between the asphalt pavement structures designed by empirical and analytical methods.
- Other related projects.

4. Major Research and Development Project in DOH

4.1 Name of Major Research and Evelopment Projects

4.1.1 Highway Materials Research Projects

(1) Stabilization of soil aggregates with silica cement (active)
(2) Improvement of clay with ionic soil stabilizer (active)
(3) Properties of asphalt cements in Thailand (active)
(4) Stabilization fo silty sand with cement
(5) Stabilization of subgrade soils
(6) Stress-strain characteristics of the cemented materials
(7) Stress-strain characteristics of concrete
(8) Evaluation of the elastic modulus of asphalt concrete
(9) Evaluation of the elastic modulus of modified asphalt concrete
(10) Evaluation of the elastic modulus of cemented materials
(11) Evaluation of the elastic modulus of subgrade materials
(12) Permanent deformation characteristics of asphalt concrete
(13) Permanent deformation characteristecs of unbound granular materials and subgrade soils
(14) Fatigue characteristics of asphalt concrete
(15) Fatigue characteristics of cemented materials
(16) Fatigue characteristics of subgrade soils

4.1.2 Soft Clay Foundation Research Projects

(1) Analysis and design of embankment piles (active)
(2) Analysis and design of bridge approach bearing unit (active)
(3) Instrumentation for the road embankment of the Thonburi-Pak Tho Highway (active)
(4) Analysis for stability and settlement of the Thonburi-Pak Tho Highway (active)
(5) Analysis for stability and settlement of the Bang Pakong-Chachoengsao Highway
(6) Analysis for stability and settlement of the Minburi-Chachoengsao Highway
(7) Performance of the road embankment and the bridge approaches of the Rangsit-Ongkarak-Nakorn Nayok Highway

(8) Settlement analysis of the Bang Na-Bang Pakong Highway

(9) Analysis and remedial design of the road embankment failure in Central Thailand

(10) Development of the geotechnical data base for the outskirts of Bangkok

(11) Consolidation characteristics of the Bangkok subsoil along some selected roads

(12) Shear strength characteristics of the Bangkok subsoil along some selected roads

(13) Installation of the bench marks along some selected roads around Bangkok

(14) Settlement characteristics of the Bangkok-Chonburi (New Route)

(15) Settlement characteristics of the Outer Bound Ring Road (East Side)

(16) Research projects on soft clay foundation improvement

(17) Development of the foundation design manual for the Bangkok areas

4.1.3 Road Pavement Research Projects

(1) Performance of soil-cement roads for phase 2 (active)

(2) Asphalt pavement design by the Asphalt Institute Method (active)

(3) Dowel stress analysis in concrete roads (active)

(4) Flexible pavement analysis by using the PSAD2A program (active)

(5) Review of flexible pavement design methods (active)

(6) Flexible pavement analysis and design by using the DAMA program (active)

(7) Flexible pavement analysis and design by using the BISAR program (active)

(8) Flexible pavement analysis and design by using the ELSYM5 program

(9) Evaluation of the pavement strength by Dynamic Cone Penetrometer (DCP) (active)

(10) Investigation of road surface roughness of the asphalt pavement in Thailand (active)

(11) Analysis of the capacity of concrete roads in Thailand to resist the load repetitions

(12) Investigation of the concrete road damage in Thailand

(13) Determination of the elastic modulus of the pavement layers from Benkelman Beam Deflection and Falling Weight Deflectometer

(14) Determination of truck factor for each type of heavy vehicles

(15) Study of pavement temperature in Thailand

(16) Evaluation of service life of the Thonburi-Pak Tho Highway, sections 3 and 4

(17) Development of pavement design manual for Thailand

(18) Chonburi test road project

- Degradation of asphalt concrete in Thailand
- Service life of the joint sealing compound for concrete pavement
- Field evaluation of strength development and crack of cemented materials

(19) Research projects related to asphalt paving technology

(20) Research projects to study the service life of asphalt roads and concrete roads in Thailand

(21) Other projects in the form of test sections and case studies

4.1.4 Road Maintenance Research Projects

(1) Maintenance techniques for concrete road repair

(2) Strength of the bonding layer in the thin bond patching

(3) Properties of the in-service joint sealing compound

(4) Use of micro-silica for the concrete road repair

(5) Study of special concrete for emergency concrete road repair

(6) Advanced technology for asphalt surface maintenance and overlay

4.1.5 Geotechnique Research Projects

(1) Survey of area expansion and locating the sources of construction materials with the use of remote sensing and air-photo

(2) Survey of soft areas with the use of remote sensing and air-photo

4.1.6 Traffic and Environmental Engineering Research Projects

(1) Skid resistance of the chip asphalt concrete

(2) Driver behaviors

(3) Development of the highway capacity manual

(4) Relationship between the traffic accidents and physical conditions of roads

4.1.7 Road Bridges and Structures Research Projects

(1) Service life and load carrying capacity of old bridge by non-destructive test

(2) Analysis, design and manufacture of prefabricated concrete slab for concrete road repairs

(3) Study on methods of reinforcing to increase the load carrying capacity of the existing bridges

4.2 Reseach and Development in Progress at Thailand Department of Highways

4.2.1 Stabilization of soil aggregates with silica cement

Soil-cement road has been used in Thailand for more than 25 years. Portland cement type I is generally employed as an additive to mix with the natural soil aggregate at the percentage amount of 3-5 percent by weight. However the short setting time sometimes causes trouble to the construction. It is expected that silica cement might be more suitable for some particular conditions. So this project is undertaken for the sake of solving the stated problems. The project is expected to be taken for 2-3 years for the laboratory investigation. In addition some test roads have to be constructed to evaluate the result of the field performance. It is expected that the setting time of the soil-cement mixture could be prolonged, and the amount of the reflected crack could be reduced as compared to type I Portland cement. At present the project is still going on with no serious problems.

4.2.2 Improvement of plastic clay with ionic soil stabilizer

Plastic clays, both alluvial clay and tropical red clay, are generally found in Thailand. Study to improve the bearing capacity of this type of clay will be useful for designing the pavement structure. Increasing the bearing value of the tropical plastic clay by mixing with ionic soil stabilizer of surface active agent tends to increase the service life of the road pavements, especially the ones carrying very heavy traffic. Studies will be conducted both in the laboratory and in the field. This project is expected to take for about 3 years.

4.2.3 Analysis and design of embankment pile

Soft deltaic clay covers most of the Central part of Thailand. Road construction in this region encounters with the problems of stability and settlement. Stability can be solved by different methods such as berm, stage construction, preloading, and etc. But settlement could not be avoided. Considerable settlement of the road embankment tends to shorten its service life by intermittent flooding. Some important roads are designed by using the embankment pile supporting the road following the Swedish technique. Road construction associated with embankment pile seems to function properly. The pile tip will be located in the deeper soft or medium clay layer, thus settlement still occurs, but at much slower rate. It is expected that embankment pile could solve the settlement problem of road embankment on soft clay by lengthening its service life. The duration of this project will last for 5-10 years for continuous observation of the settlement of the road.

4.2.4 Performance of soil-cement road (phase2)

Research project on soil-cement road has been studied for more than 25 years. Studying in phase 1 the appropriated specifications for soil-cement road construction has been developed for Thailand conditions. Studying in phase 2 the soil-cement roads being constructed following the stated specifications will be evaluated for their performance. Duration of the project will be about 10 years. In evaluating the road performance some pertinent tests will be conducted from time to time, such as the strength development of the soil-cement cored samples, Benkelman Beam Deflection test, surface roughness, crack formation, records of surface maintenance associated with the basic data at the construction time. Results of the phase 2 research project will enable the Department of Highways to improve the construction specifications obtained from phase 1.

4.2.5 Flexible pavement analysis by using the PSAD2A Program

PSAD2A program was developed by the University of California, Berkeley, U.S.A. for analysing the pavement layer system. The original PSAD2A program was modified to be used with the micro-computer for making the flexible pavement analysis. Truck loads used in the analysis are 21, 23, 25, 30, 35 and 40 T. The project is divided into a number of sub-projects for different pavement layer systems and types of bases and subbase courses that might be granular or cemented materials. Results of the project will be served as a

basis for analytical pavement design in future. Up to the present time the project has been started for about 5 years. It is expected that the project will take about 5 more years to cover the scope of the proposed works. Most of the analysis will be made by micro-computer associated with some manual works, especially for comparing the effect of each truck load and pavement layer system.

4.3 Problems in Promoting Research and Development

There are a number of problems in promoting research and development in the developing countries. Some of them are as follows.

4.3.1 Major works of all highway departments are design, construction and maintenance, so most of the technical men (especially engineers) will be allocated to all these types of works. Only minor portion will be concerned with research.

4.3.2 Most highway departments lack of the well trained research engineers as well as the sophisticated research equipment. In addition, sometimes the availability of both does not match for each other at the same period of time.

4.3.3 There is low incentive for research development at the highway departments because most officers will concentrate over design, construction and maintenance works for the sake of these types of works can be easily shown out to the public in short time.

4.3.4 Most research engineers in the developing countries could not get adequate compensation (in the form of salary and honorarium) as compared to the engineers who works in other positions.

4.3.5 Research works is an elaborate job, and requires highly educated engineers to conduct the works to obtain the beneficial result for the future development of the countries.

4.3.6 In conclusion there are four basic factors for human being to be alive , namely, housing, food, clothing and medicine. There are also four basic

factors for researcher to work for development as follows.

(1) good and convenient working space

(2) adequate salary and honorarium

(3) modern equipment for research, and

(4) high incentive for research works

All above factors tend to attract more qualified engineers to work for research.

5. International Research Exchange Programmes in DOH

5.1 Present Situation

It is the policy of the Department of Highways and the Road Research and Development Center to cooperate with the institutes in the country and in other countries for research works. At present the Center is contacting with the institutions in Belgium, Denmark, Sweden and Japan for getting some research equipment and experts to work in Thailand. More technical assistance is expected from others.

During the past time, the Department of Highways has cooperated and exchanged the reports with many research institutes in the foreign countries. Some of them are Transport and Road Research Laboratory (TRRL) in the United Kingdom, Belgian Road Research Center (BRRC) in Belgiam, Australian Road Research Board (ARRB) in Arstralia, Central Road Research Institute (CRRI) in India, Laboratoire Central des Ponts-et-Chaussees (LCPC) in France and others.

Concerning to the foreign activities, the Department of Highways regularly sent the technical officers participating and presenting the papers in the international conferences continuously for a long time. Some important conferences are IRF World Meeting, PIARC World Road Congress, REAAA Conference and Southeast Asian Geotechnical Conference. In addition the Department of Highways has become the Government Member of PIARC officially since 1991.

5.2 Problem in Promotion

The major problem in promotion the international research exchange programmes seems to be the shortage of the financial support for the expert to

work in Thailand. The fields in which DOH needs technical cooperation from other countries now are as follows;

1. Highway Materials
2. Foundation Improvement
3. Road Pavement
4. Master Plan for the Development of Road Research Center

5.3 Necessity for, and Problems Involved in Inter-Asian Research Exchange

In future there will be numerous international conferences, seminars, symposiums and meetings, especially in the technical point of view, it will be good if the highway engineers or research engineers from different countries in Asia could participate these conferences. It might be a good idea for the host organizer to reduce the registration fee, cost of accommodation or provide other extra rights for the participants from Asian countries that most of them are developing and have the problem of finance, especially the international currency such as U.S.$, Yen, Sterling Pound, etc.

6. Activities Related to Disaster and Disaster Prevention

6.1 Present Situation and Problem in Thailand

The major cause of disaster in Thailand initiates from typhoon. Every year Thailand will be hit by typhoon 3-5 times between June and October. Typhoon tends to cause flooding in the effective areas, especially in the low area like Bangkok that has the average elevation about +2.0 meters above the mean sea level. In addition flooding, typhoon tends to cause landslide and soil erotion in the mountainous areas of Northern and Southern Thailand. According to the record of the Meteorological Department, typhoon in Thailand usually initiates in the South China Sea and Gulf of Thailand. The one induced in the South China Sea generally hit the Northern part of Thailand, while the one in the Gulf of Thailand tends to affect the Southern part including Bangkok.

In addition to typhoon, earthquake is another cause of disaster affected Thailand, especially in the Northern part. However, the epicenter of the

earthquake inducing vibration in Thailand is in Burma, about 200-300 kilometres from the Thailand-Burma border. So the intensity of vibration is not so strong and the maximum measured value is about 6 following the Richter scale. The vibration generally causes minor crack to the building in Northern areas. In Bangkok which is nearly 1,000 kilometers from the epicenter, the people will feel about this unusual vibration, but no severe damage to the building is record. The duration of the vibration is in the range of 30-60 seconds. In conclusion at present earthquake is not so severe in Thailand. However, for the high-rise building the design engineer will provide the safety factor for the intermittent earthquake following the recommendations of the Engineering Institute of Thailand (EIT).

The Meteorological Department has installed the modern equipment to detect both typhoon formation and earthquake triggering in Bangkok and in the country and to warn the people all the time. So a number of systemmatic data regarding both typhoon and earthquake are available upon request.

The most severe disaster occurred in Thailand seems to be the flood of November 1988 in the South of Thailand. From November 18 to 23, 1988 up to 1,000 mm. rainfall was recorded in some areas in the South of Thailand, which caused large scale flooding in 14 provinces and 356 people were killed. The worst hit provinces were Nakhon Sri Thammarat and Surat Thani which are located about 1,000 kilometers south of Bangkok (See Fig. 6-1). Altogether 1560 bridges and 5694 kilometers of road were damaged. In the districts of Ban Nasan, Phibun and Lan Saka debris flows consisting of water, sand, stones and trees cause heavy damage along rivers and in the flood plain of the Khao Luang mountain range area. The debris flows were often obstructed by bridge piers, abutments and approach embankments. The uprooted trees formed barriers which led to clogging of the rivers at several bridges. This caused either overtopping of bridges, severe erosion of abutments, approach embankments and pier foundations or even complete destruction of modern reinforced concrete bridges. Six highway bridges were either washed away or suffered partial collapse. In Ban Nasan and Phibun the clogged rivers created new river beds at bridge locations. Three weeks after the floods, all main roads to the South could be repaired and open to traffic.

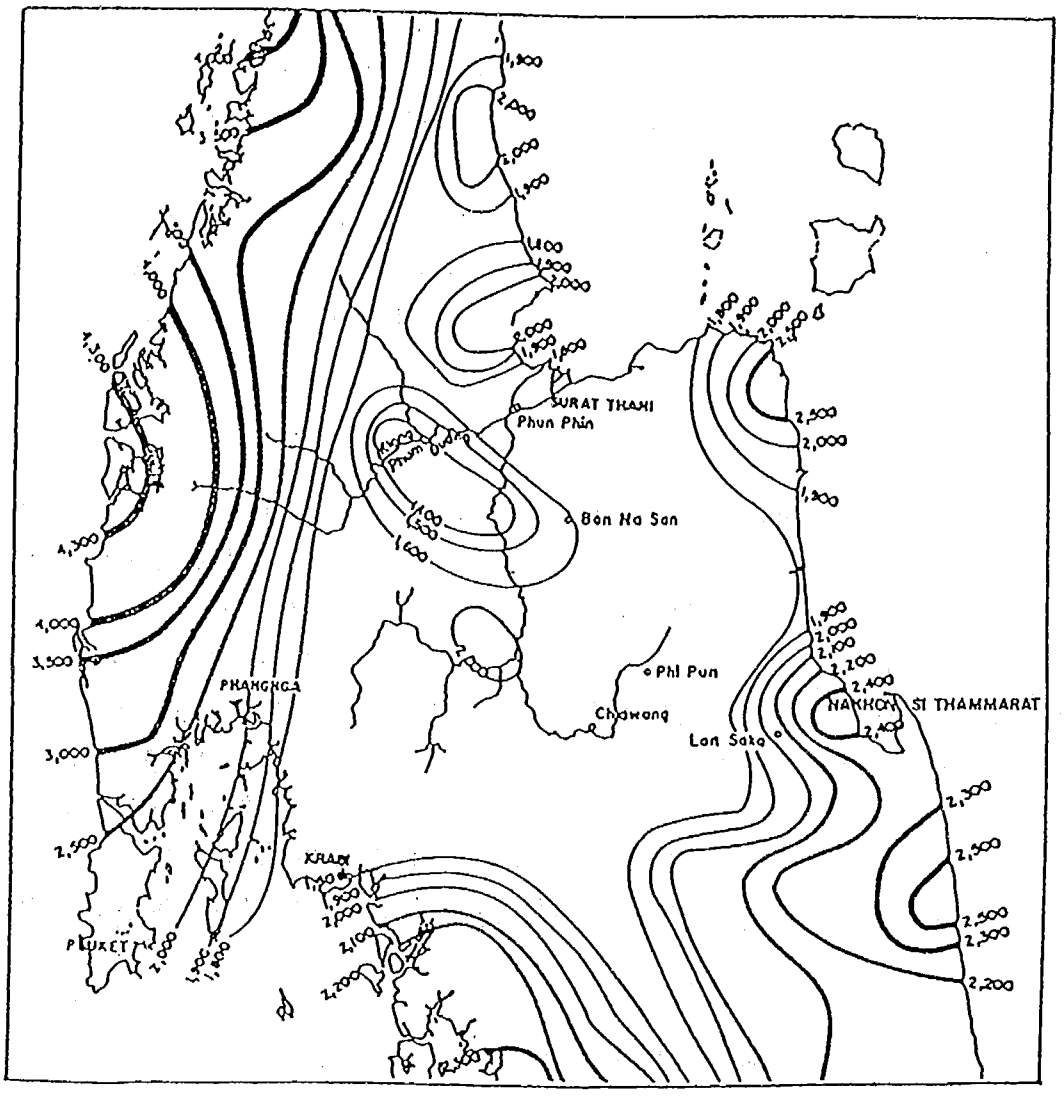


Fig. 6 - 1 Mean annual rainfalls in Khao Luang mountain range (ESCAP, 1989)

Besides highway bridges, the effect of the heavy rainfall and floods on the two largest dams in the South of Thailand were investigated. These are Ratchaprabha dam (formerly called Chiew Larn dam) in Surat Thani Province and Bang Lang dam (formerly called Pattani dam) in Yala Province. In the first dam, the water level in the reservoir was below the operating level of the spillway, whereas in the latter, 49.4 x 10^6 $m.^3$ was released by the spillway from December 2-7, 1988, which has contributed to the flooding along the Pattani river.

The most affected areas in Nakorn Sri Thammarat and Surat Thani were observed by the experts from some institutes in Bangkok. It was found that reconstruction and clean up works in the worst hit areas were progressing at a rather slow pace, despite the fact that substantial funds have been approved by the Thai government for flood relief.

Due to changes in land use, fast economic growth and increase in population density, the flood risk in southern Thailand has been increasing exponentially in recent years, and it can be expected that without proper measures floods will become more destructive in the future. One major cause of this catastrophe is due to the deforestration in many local areas. At present, there are some government departments being established to look after all the environment problems including the deforestration. Activities of these departments tends to reduce the disaster and improve the environment in general of the country. These departments are under the Ministry of Science, Technology and Environment.

6.2 Activites of the Department of Highways

Disasters relating to highways are landslide, slope erosion, waterway diversion, flooding and deforestration. At present the laws regarding the environment control has been released by the government and all departments have to follow this laws. In locating and designing the new roads, the Department of Highways and/or the consultant have to study the environmental impacts due to the new road construction.

For the existing highways in the mountainous terrain, the Department of Highways tries to prevent the landslide by using the technique of an earth

reinforcement employing geotextile/geogrid. The technique of ferro-cement covering the surface of the cut slope has been successfully used for slope erosion in many highways in the North and the South of Thailand. In addition at the moment the Department of Highways is using a type of deep rooted grass, locally called Yah Faek to be grown onto the side slope and back slope of the erosive soil. The roots of this particular type of grass tend to hold the soil from being washed down to the nearby streams and waterways. As a consequence the problem of flooding in the lower area as well as the problem of soil slope erosion could be cut down.

In addition, other geotechnical techniques are investigated and introduced to prevent the disaster due to the road construction in the mountainous terrain. For the road embankment on soft clay, a number of techniques have been successfully employed to solve the stability and settlement problems. Some of them are the use of the embankment pile, bearing unit system, berm counterweight, light weight material and geotextile. In designing the Bangkok-Chonburi New Route and Outer Bound Ring Road, the technique of prefabricated vertical drain (PVD) will be tried for the first time in Thailand.

DOH is now planning to do a study on road structure disaster prevention plan which includes the following items;

- Basic survey (Natural conditions, etc.)
- Development of a plan for road disaster prevention
- Proposal for road and bridge materials deposit and type of equipments for disaster restoration
- Proposal for road disaster prevention projects (case study)

For the highway bridge design and construction, special provisions to prevent the damage due to earthquake, subsurface erosion under the bridge piers and the means to protect the timber floating along the waterway from being hit to the bridge columns are also provided. It is hoping that all the tehnical preventions tend to reduce the disaster of road network of the Department of Highways.

6.3 Technical Tasks Required for Disaster Prevention

As stated in section 6.2 the technical task used to prevent disaster for

the highways in Thailand could be summarized as follows.

6.3.1 For roads in mountainous terrain

- Use of reinforced earth to improve stability of high fill
- Use of ferro-cement to prevent soil slope erosion
- Use of special deep rooted grass, locally called Yah Faek to be grown on the soil slope and to prevent the soil erosion.
- Use of the deep hole lime stabilization to stabilize the loosely compacted clay filled embankment.
- Use of curb and gutter system to control the flow of surface water to be drained out the some suitable locations along the road.
- Use of earth ditch to drain the surface water from the upper part of the back slope to reduce the potential failure due to landslide.

6.3.2 For roads on soft clay foundation

- Use of lightweight material
- Use of berm counterweight
- Use of embankment pile
- Use of bearing unit system at the bridge approach
- Use of geotextile/geogrid to reinforce the embankment
- Use of the preloading technique
- Use of prefabricated vertical drain (PVD) to accelerate the construction settlement
- Use of lime column for soft clay improvement
- Use of jet mixing for hardening the soft clay foundation

7. Activities Concerning "Harmony between the Environment and Improvement of Infrastructure

7.1 The Current Situation and Possible Problems in Thailand

The environment situation in Thailand seems to be critical at the moment. Many major rivers such as the Chao Phraya River has been contaminated by the waste water released from the factories along both sides of it. This will make

the inhabitant along both sides of the river fall in bad situation. Few months ago a large quantity of the waste water from one sugar cane factory was released into the major rivers in Northeastern Thailand, and the waste water killed all types of plant and animal in the river. These are examples of environment destruction by river. Many rivers and waterways in Thailand, especially the ones near to the main cities, are generally contaminated by the factory owners who are not responsible for the things that they have done to the community and to the country.

In addition to the contamination by water as stated, pollution by air is also critical now, especially in Bangkok and other major cities, due to the traffic congestion. Travelling in Bangkok from one place to another will take much more time than ever. Air pollution due to traffic congestion generally derives from smoke, dust, smell and noise.

The government realizes about the problems of river and air contamination that affect to the environment, people and everything in the effective area. Some counter measures are released by the government by laws associated with the private sectors by persuation as follows.

7.1.1 All factories that use plenty of water have to install the waste water treatment plant before flushing to the public waterways.

7.1.2 Bangkok Metropolitan provides a number of motor boats to collect the garbages from the houses of the inhabitants living near to the Chao Phraya River and other major canals.

7.1.3 Some private companies produce the green garbage bag and cheaply sell to the people to collect the garbage type of plastic, glass, foam and metal separately from the garbage derived from plant and animals. The separation of garbage by type like this can reduce the quantity of the garbage considerably, because the first type of garbage could not be easily destroyed.

7.1.4 Smoking is limited only in the specified smoking areas, violation will be fined for 2,000 Baht. The policeman will be in charge for this violation.

7.1.5 Unleaded gasoline was introduced into Thailand some years ago to reduce the unpleasant smoke and smell from the car engine.

7.1.6 In 1993 all types of motor car have to install the filter in the engine to catch up the black smoke and fine carbon from the exhausted gas before being released to the air.

7.1.7 The government will be more stringent to the business regarding timbering from the forest to reduce the deforestration in the country.

7.1.8 The government in association with the private society will promote growing the plants and trees in the cities, along the highways and in the areas that used to be forest but being destroyed by deforestration.

7.1.9 Periodic check of the amount of smoke from the heavy trucks and motorcycles by the policeman associated with the other government officers as well as the engineering students to catch up the vehicles that released too much black smoke.

7.1.10 The government in association with the private sectors persuades the people avoid using foam in all celebrating ceremonies such as the Loi Kratong Festival in November of every year.

7.2 Activities of the Department of Highways

The Department of Highways does not get involve much with the environmental problem in the past, but about five years ago the Department considers environment is a major factor to be considered associatedly with road design and construction. Some major activities deserved to be mentioned are as follows.

7.2.1 Decorating the space in the interchange area with flowers and plant to keep beautiful landscape and sight seeing.

7.2.2 Use of the noise barrier along the motorway/main highways passing through the residential areas.

7.2.3 Use the deep rooted grass (Yah Faek) to reduce soil slope erosion in place of ferro-cement.

7.2.4 The Department of Highways hired Chulalongkorn University to study about the environment impacts of the road around Phuket Island which is a major sight seeing spot in the South of Thailand. Foreigner named this island as Pearl of Andaman to reflect the scenic landscape of this island. This study includes the following items;

Physical Resources
- Surface Water Hydrology
- Water Quality
- Ground Water
- Air Quality
- Noise
- Ecology

Human Use Value
- Transportation
- Land Use
- Agriculture

Quality of Life Values
- Social Aspect
- Economic Aspect
- Tourism
- Landscape

7.2.5 The Department of Highways tries to avoid the deforestration from road construction by keeping the narrow right of way for the mountain roads.

7.2.6 The Department of Highways tries to reduce the amount of earthworks by introducing the reinforced earth system for road construction in the mountainous terrain.

7.2.7 At present the Department of Highways makes a request to the Government of Japan through JICA to conduct the joint research project on disaster and disaster prevention. This project will be emphasized over the soil slope erosion prevention and stability of the high fill embankment in the

mountainous terrain. It is expected that results of this study tend to enable highway engineers in Thailand make a proper design to harmonize between the stable road and the beautiful landscape.

7.3 Indicate Technical Tasks Necessary for the Promotion of "Harmony between the Environment and Improvement of Infrastructure"

7.3.1 At the moment the Technical Committee of PIARC (Permanent International Association of Road Congresses) is preparing the guideline correlating between environment and road, it will be good to contact with the PIARC Technical Committee regarding this topic. This is because this Technical Committee will collect a number of data and information from all country members.

7.3.2 The Department of Highways from all Asian countries should exchange document or technical information regarding environment and infrastructure harmonization.

7.3.3 The Department of Highways from all Asian countries should try to make the systemmatic design manual for different situation and distributed to their neighboring countries for reference.

8. Proposals for Further Discussion

8.1 Research on Pavement Analysis and Design

It is generally accepted that conventional pavement design by the empirical method, such as The Asphalt Institute (1970) and Road Note 29 (1970), could not be properly used to design the motorway and very heavy traffic volume road with the number of repetitions in excess of 10 MSA (million single axle). So, analytical pavement design method should be developed for the tropical and Asian countries. In order to design the pavement structure following the analytical design method, it is necessary to know the appropriate values of the elastic modulus (E) of all materials layers being employed in the pavement structures. However, the equipment used to determine the elastic modulus of the pavement materials is generally elaborated and require the well-trained engi-

neer to operate. From the 7th REAAA Conference in Singapore just finished in 1992, most papers in pavement discussed about the analytical design. The theory used in analytical pavement design is mostly linear elastic theory. So it will be good for the Department of Highways in the Asian and other tropical countries conduct researches on elastic modulus of the pavement materials and exchange these technical data. It is clear that in the near future the analytical pavement design methods will supersede the old ones. So, highway engineers in the Asian countries should aware of this trend.

8.2 Research on Soft Ground Improvement

Bangkok Clay is one of the worst clay deposits in the world because of its high plasticity index, high water content (greater than 100%), high compressibility, and low shear strength. Surface deflection on the road pavement for 70-90 percent occurs in the soft soil layer, and the rest in the pavement structure. If the subgrade is strong, surface deflection will be low and the pavement is safe from fatigue crack. So, soft ground improvement is necessary for the main highway constructed on the soft clay foundation. This is the important topic for research in the near future. At present different methods of soft ground improvement are available, namely, embankment pile, lime column, vertical drain, jet mixing and others. It is necessary to know which improvement technique will be most suitable for the soft plastic clay like the Bangkok Clay.

8.3 Research on Modified Asphalt Concrete

As the weight of the heavy trucks passing along the main highways and motorways in Thailand is generally over the legal load limit. The quality of the upper pavement layers such as surface and base courses should be very good. Modified asphalt concrete has been used in the European countries and the United Stated for many years. It is good if the research project on modified asphalt could be initiated for motorway design in the near future. It is necessary to know the effectiveness of each type of modifiers generally used in road construction in different parts of the world, especially in the tropical area with high rainfall and humidity.

8.4 Further Topics for Discussion

8.4.1 The possibility of the technical assistance and cooperation from the developed countries.

8.4.2 The technology transfer between the developing and developed countries.

8.4.3 The possibility of exchange researcher between Asian countries.

8.4.4 The fee reduction for the international conference for the Asian countries (host organizer is also Asian country).

Ⅷ. Japan

Mr. Tokuji Tomaru, Deputy Director-General, PWRI

TABLE OF CONTENTS

1. Outline of Japan
1.1 Description of the Land
1.2 Climate
1.3 Population
1.4 Economy and Society

2. A Description of Public Works
2.1 Master plan of national land development (laws, plans, etc.)
2.2 Budget for investment in construction
2.3 Institutions and organizations (main Ministries) concerned with public specially in civil engineering field
2.4 History of significant developments in infrastructure, the progress and problems of development
2.5 Major projects under in progressing or planning

3. Outline of Public Works Research Institute, Ministry of Construction
3.1 Name of organization
3.2 History
3.3 Organization
3.4 Staff capacity
3.5 Trends in the budget
3.6 Management systems
3.7 Outline of major research facilities
3.8 Recent achievements

4. Major Research and Development projects in the Public Works Research Institute, Ministry of Construction
4.1 Major research and development projects
4.2 Current research and development at the Public Works Research Institute
4.3 Research and Development Issues

5. International Research Exchange Programmes in the Public Works Research Institute
5.1 The present situation of international research exchange programmes in the Public Works Research Institute
5.2 Problems in implementation
5.3 The necessity for and problems involved in implementing international research exchanges in the Asian region

6. Disaster and Disaster Prevention
6.1 River Disasters
6.2 Coastal Problems
6.3 Droughts
6.4 Sediment-Related Disasters
6.5 Earthquakes

7. Harmony between the Environments and Improvement of Infrastructures
7.1 Rivers
7.2 Sewerage and Water Quality Control
7.3 Dams
7.4 Urban Environments
7.5 Roads

1. Outline of Japan

1.1 Description of the Land

1) Location and size

Japan is a country of islands arranged in an arc-like formation extending over a total of 3,000 kilometers (1,860 miles) to the east of the Asian continent.

Apart from the four main islands of Honshu, Shikoku, Kyushu, and Hokkaido, the country is made up of more than 4,000 scattered islands. These are referred to collectively as the Japanese Archipelago.

The capital, Tokyo, stands at east longitude 140° (roughly the same as New Guinea and Australia) and north latitude 36° (roughly the same as Shingtao in China, Tehran in Iran, Malta in the Mediterranean, the Straits of Gibraltar, and the Grand Canyon in America).

2)Topography

The Japanese Archipelago is surrounded by seas including the Pacific Ocean and The Japan Sea; the Pacific Ocean side features the extremely deep Japan Sound and Izu Ogasawara Sound. Since a number of volcanic chains traverse Japan, the topography is varied. Rivers are short but fast-flowing, while deep ravines are formed between mountains, and the coastline is highly complex. There are many sights of scenic beauty as well as several hot-spring spa resorts dotted around the country.

The Japanese Archipelago lies on the Circum-Pacific Volcanic Belt, and it is one of the world's most prominent areas of seismic occurrences, with a great deal of volcanic activity. The Great Kanto Earthquake of 1923, which registered a magnitude of 7.9, caused great damage in Tokyo and the southern part of the Kanto region.

67% of the land is made up of mountains, many of which are covered with forests. Farmland takes up 15%, housing land 3%, and industrial land a mere 0.4%.

3) The mountains, rivers, and lakes of Japan

While 67% of Japan is made up of mountains, in the central part of Honshu in particular there are the three mountain chains of Hida, Kiso, and Akaishi, featuring mountains which rise to heights in excess of 3,000 meters (9,840 feet). These are known individually as the northern, central, and southern Alps, or collectively as the Japan Alps. They were given this name in 1896 by an Englishman named Weston.

Mount Fuji, at 3,776 meters (12,388 feet) above sea level, is the highest mountain in Japan, and is a classic example of a conical dormant volcano with beautiful sweeping plains at its foot (although there was a major eruption in 1707, in more than two-and-a half centuries since then there has been no volcanic activity). In winter it is covered with snow down to its middle reaches, thus adding further to its beauty.

At present, there are about 60 active volcanoes in Japan, including Mounts Asama, Aso, Sakurajima, and Mihara.

There are numerous short but fast-flowing rivers, the longest being the River Shinano at only 367 kilometers (228 miles). Fast-flowing rivers with large headwaters are used for hydraulic power generation as well as creating beautiful ravines, but are hardly used at all for transport while also presenting the risk of flooding.

There are lakes amongst the mountains, and many of them make fine sights with their clear waters. However, they are only on a small scale, the largest being Lake Biwa with an area of 674km² (260 square miles). Meanwhile, the deepest lake is Lake Tazawa, which reaches a depth of 423m (1,388 feet). Apart from this, there is Kasumigaura, with an area of 168km² (65 square miles), a lagoon which has been separated from the open sea by sand dunes, sand banks, and such like.

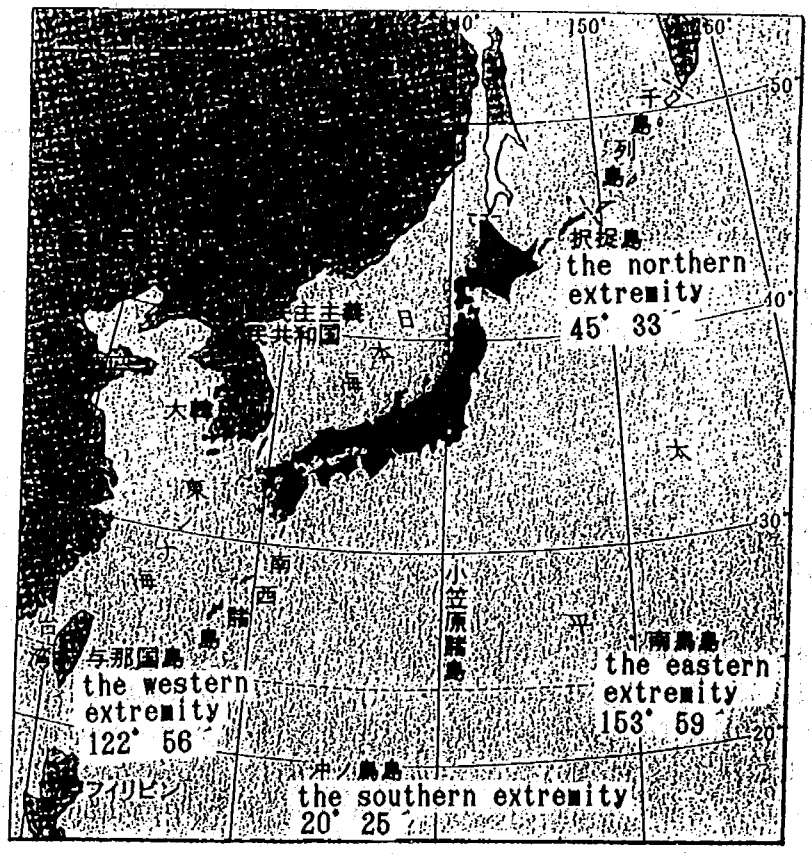


Fig.1.1.1 Location of Japan

1.2 Climate

Japan is spread over about 31 degrees of longitude and about 25 degrees of latitude, thus there is a large difference in climate from north to south. The Ogasawara, Ryukyu, and other islands in the south belong to a semi-tropical climate, while Hokkaido, the northern Tohoku region, and the inland plateaus of central Japan have a subarctic climate. However, for the most part the country falls within a temperate climate zone, with large amounts of precipitation and high humidity overall. There are great seasonal and regional variations in climate which result from the geographical characteristic of being wedged between the Asian continent and the Pacific Ocean, as well as the topographical characteristics mentioned above.

Annual rainfall in Japan as a whole is about 1,800mm, which is much higher than the world average of 800mm. As shown in Fig.1.2.1, this varies greatly from region to region, for while Setouchi (Takamatsu) and eastern Hokkaido (Asahigawa) have around 1,000mm, in certain areas on the Pacific side of southwest Japan it reaches almost 4,000mm. In terms of monthly variations in rainfall, the tendency is for the greatest rainfall to come in the "tsuyu" rainy season in Kyushu and Shikoku, in the winter in heavy snowfall areas on the Japan Sea (Joetsu), and in other areas in autumn, when typhoons are frequent.

Conversely, on the Pacific side in general there is little rainfall in winter, while in midsummer, beset by high atmospheric pressure from the Pacific, if there are no typhoons there is hardly any rainfall except for thunderstorms, making this a semi-dry season. The characteristics of precipitation in Japan are marked by the three elements of snow, "tsuyu" rainy season, and typhoons.

In winter, the northwest seasonal winds that blow in from the chilly Siberian air mass on the Asian continent bring large amounts of snowfall to the Japan Sea side, and the majority of regions from Hokuriku northwards have snowfalls in excess of one meter. From early June to mid-July every year, the so-called "tsuyu (rainy season) front" is formed at the meeting point between a high-temperature high-humidity tropical air mass over the Pacific Ocean and a cool air mass over the Okhotsk Sea. It accumulates in the vicinity of Japan and brings concentrated and sometimes violent rainstorms. Furthermore, from summer to autumn, tropical low pressure over the Pacific Ocean builds up and forms typhoons, three or four of which score direct hits on Japan every year and deposit large amounts of rainfall over a wide area. The amount of rainfall brought to the Japanese mainland by one typhoon is said to be as much as 5 to 40 billion tons, with major typhoons reaching up to 80 billion tons. And in terms of Japan as a whole one-quarter to one-third of annual precipitation is said to be brought by typhoons.

The record for the maximum amount of rainfall in Japan in the past shows a considerably large figure which can rival worldwide maximum records. Rainstorms of this sort, caused by fronts and typhoons, frequently lead to large-scale flooding and disasters across the nation.

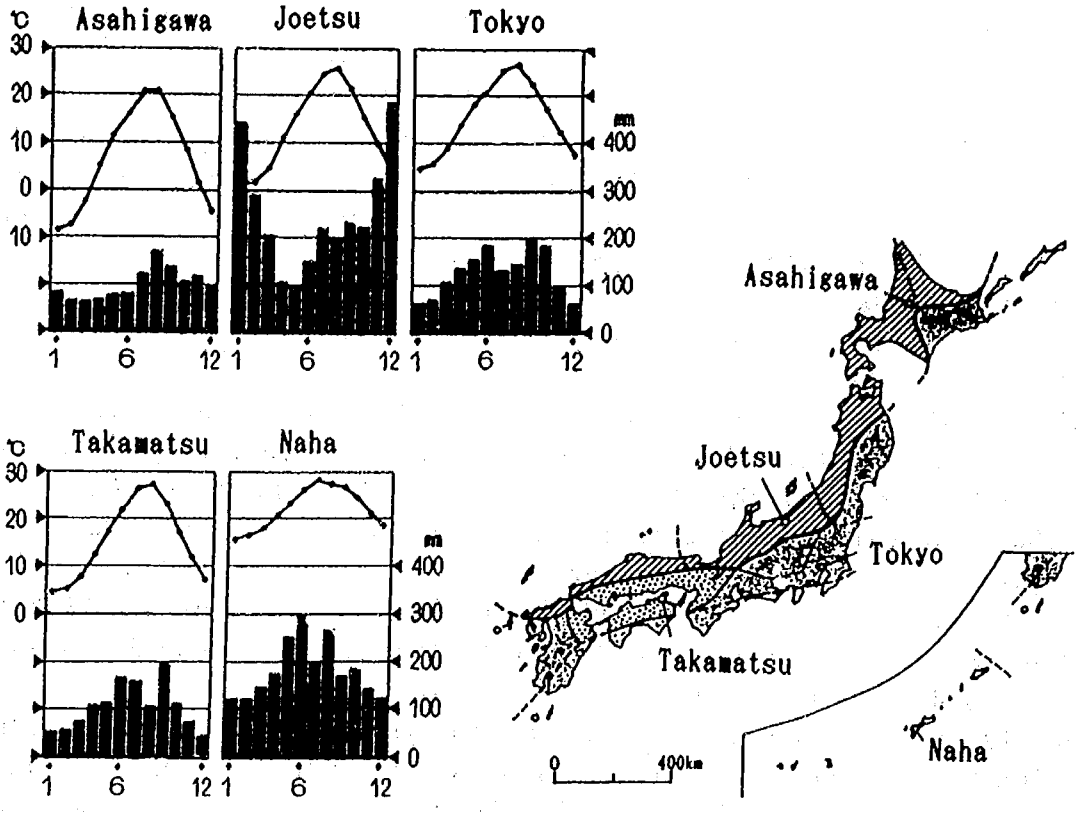


Fig.1.2.1 Climate of Japan

1.3 Population

The population of Japan has increased dramatically in line with the development of industry since the Meiji Reformation (in the second half of the 19th century), until at present it numbers around 120 million people. The population density per square kilometer is about 320 people. Countries which have a higher population density than Japan include Bangladesh, South Korea, the Netherlands, and Belgium. However, the majority of Japan is made up of mountains. For this reason, if we were to compare population densities in relation to flat land area suitable for human habitation, the population density in Japan turns out to be extremely high, rivalling that of South Korea.

The distribution of population in Japan shows large regional disparity. The population is concentrated in particular in coastal areas from Kitakyushu to the Seto Inland Sea, the central part of the Kinki region, and the flat lands on the Pacific coast stretching from the Tokai region to southern Kanto. These form an overpopulated zone which is known as the Pacific Ocean Belt. In particular, there is an outstanding concentration of population in major cities such as Tokyo and Osaka as well as in cities peripheral to these.

In the population census of 1983 it became clear that about 40% of Japan's total population was concentrated within spheres with diameters of 50 kilometers centering on the Tokyo Metropolitan Government Offices, the Osaka City Offices, and the Nagoya City Offices, respectively. On the other hand, the land area inside these spheres is only about 6% of the total national land area.

In contrast to this, there are low population concentrations in Hokkaido, in southern Kyushu and the Pacific side of Shikoku, in mountainous areas in the interior of Honshu and on its Pacific side, and depopulated areas are spreading.

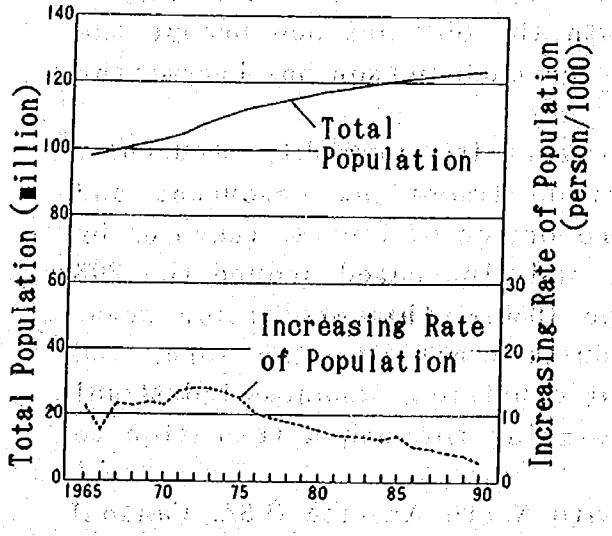


Fig.1.3.1 Growth of Population in Japan

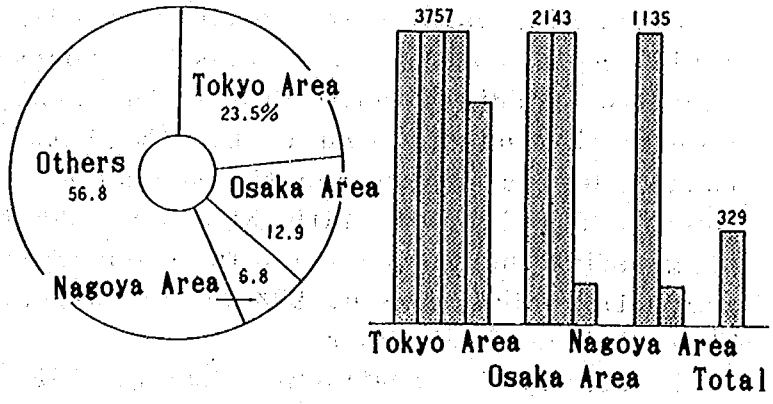


Fig.1.3.2 Population and population density in three major cities

1.4 Economy and Society

The Japanese economy grew to a postwar revival from the period of extreme disorder at the end of the Second World War in 1945. Subsequently, in the space of about 19 years from around 1955 to 1973 (the year of the oil crisis) the actual economic growth of GNP recorded an annual growth rate of about 10%. This rapid growth was three times the pre-war rate and twice the average rate of growth by industrially advanced countries after the war.

First half (1955-65): In this period, a vigorous level of capital equipment investment was achieved, under conditions of a rising world economy and an export boom. This period saw expansion notably in steel, shipbuilding, and electric power, but also in petrochemical and household electrical industries, and there was an ongoing conversion to heavy chemical industries.

The labour force for secondary and tertiary industries was filled by a decline in the farming population.

Second half (1966-73): In the second half, the foreign technology that had been introduced in the first half bore fruit, and the international competitiveness of industries such as steel, automobiles, and electric appliances was strengthened.

It was around this time that the "internationalization of the Japanese economy" began to be advocated (such as through a liberalization of international trade and exchange markets and a transition to an IMF article 8 nation), and there was a spate of major domestic mergers which touted the principle of improving international competitiveness. In this period, the surplus in the balance of payments increased due to the export-led nature of Japanese trade, but this also signalled the start of trade friction.

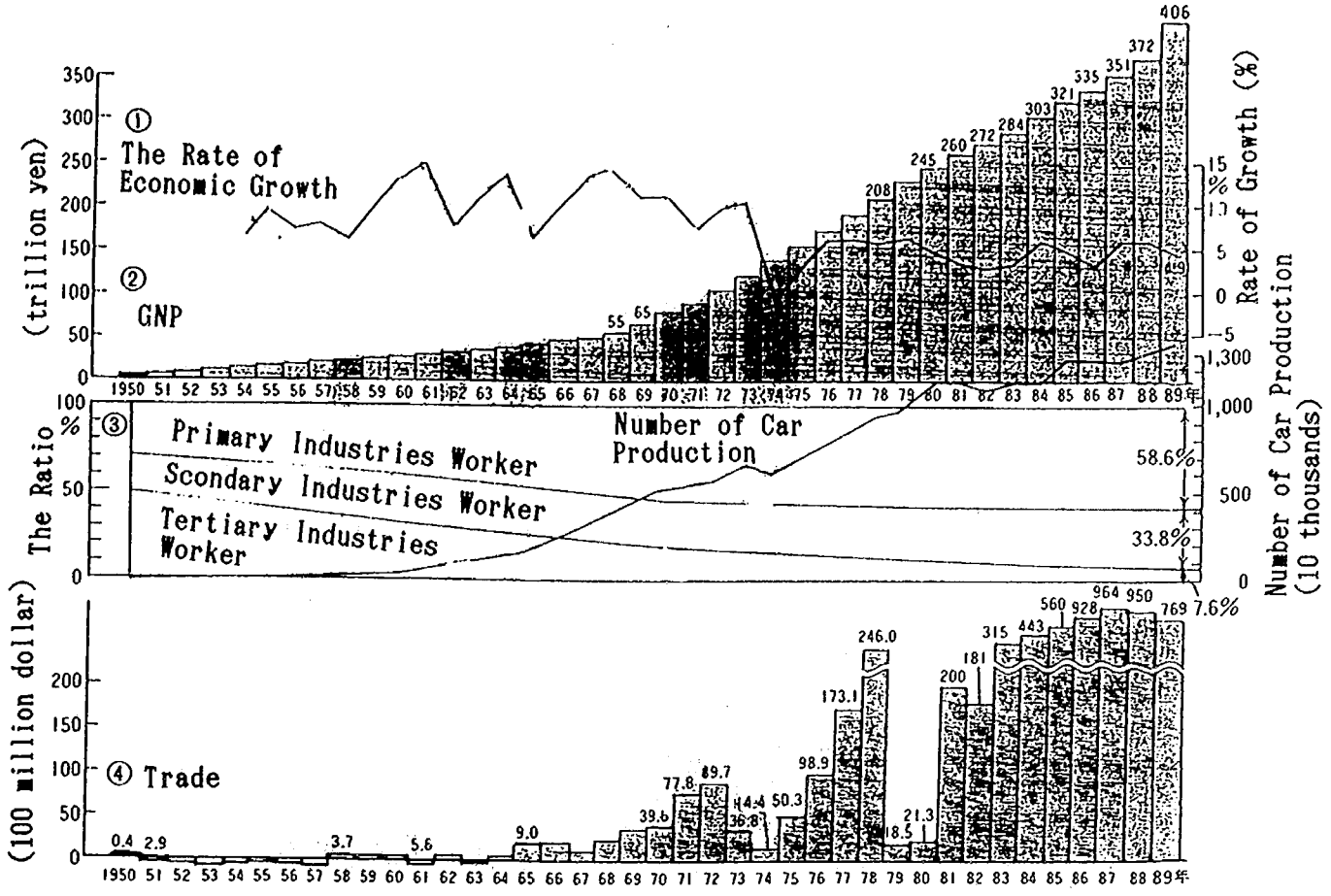
The Japanese economy experienced four recessions within its period of high-level growth. In particular, that of 1965, caused by a surplus of capital equipment, was the most serious, and the government attempted to revive the economy by issuing deficit-covering national bonds. In spite of these recessions, at the end of the extended period of economic growth the GNP has now become the world's second highest, while the national income for each person has become the highest in the world.

Meanwhile, Japan's international trade, in terms of its commodity structure, could be described as a classic processing trade (importing resources and exporting products) until 1970. In the past, the proportion of imports taken up by industrial products used to be 30% at the most, and fluctuated around the 20% range. But as we entered the second half of the 1980's, this proportion grew, topping 50% in 1990. With NIES and ASEAN products coming to the fore, and progressive industrialization in resource-exporting countries, Japanese industrial products, which take up 99% of her exports, are going through a transition to higher added value goods.

Of Japan's international trade in 1991, that with North America (USA, Canada) totalled $159.8 billion, that with Southeast Asia totalled $155 billion, and that with the EC totalled $91 billion, these three regions together amounting to $405.8 billion in total and taking up three-quarters (74%) of the overall sum. In terms of individual trade partners, that with the United States of America is overwhelmingly

large, amounting to $144.9 billion (26% of the overall total). South Korea in second place with $32.4 billion (6% of the total), followed by Germany ($31.3 billion, 6%), and Taiwan ($27.7 billion, 5%) (see Fig.1.4.1).

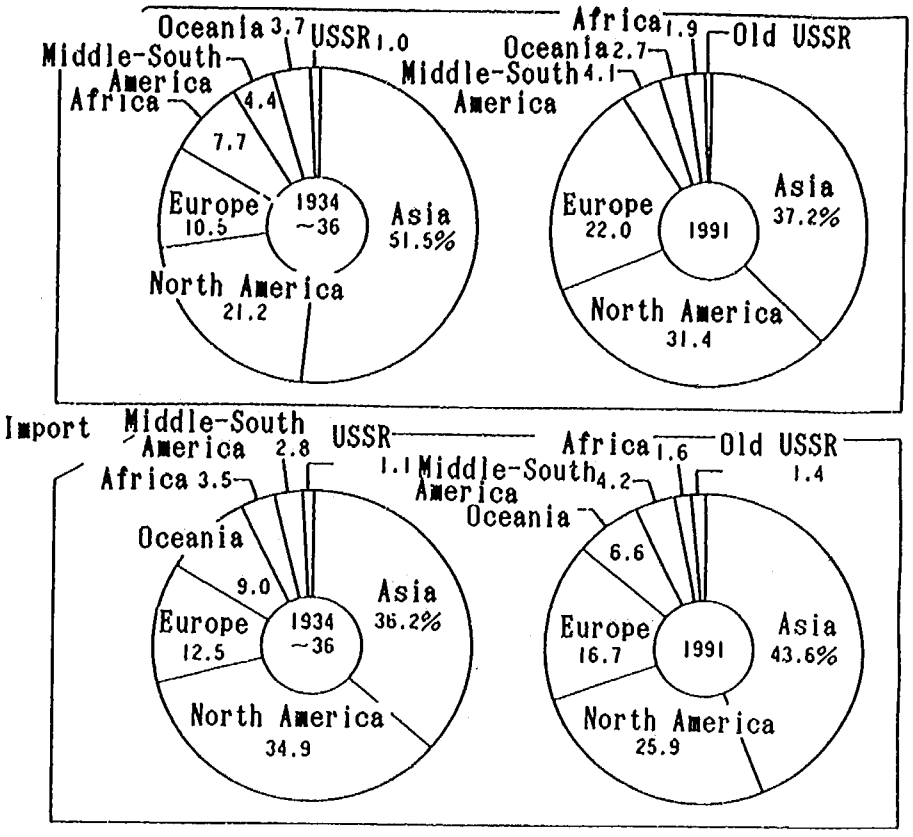
The trade surplus (a surplus of exports over imports) with the USA increased slightly by 0.7%, but that with the EC saw a dramatic increase of 48%, and that with Southeast Asia also grew by 33%.



	Nation	G N P		National Income / person	
		100 million dollar	No.	dollar	No.
1960	U.S.A.	5, 038	1	2, 294	1
	(West Germany)	742	2	1, 079	10
	U.K.	719	3	1, 117	9
	France	604	4	1, 014	11
	Japan	430	5	358	23
1989	U.S.A.	52, 008	1	18, 630	2
	Japan	28, 337	2	20, 001	1
	(West Germany)	12, 029	3	17, 314	4
	France	9, 564	4	–	–
	Italy	8, 543	5	6, 805	19

Fig.1.4.1 Growth of Japanese economy

Export



Export

Fig.1.4.2 Trade Partner

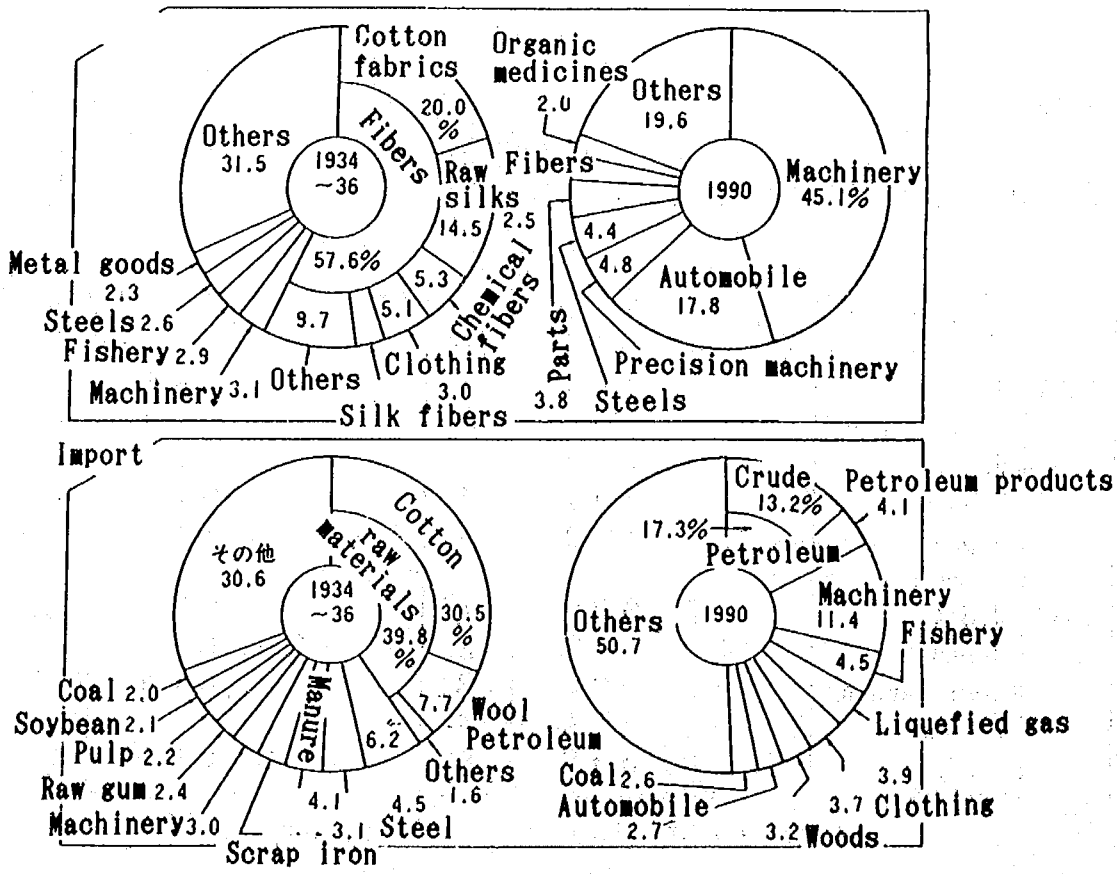


Fig.1.4.3 Items of Trade

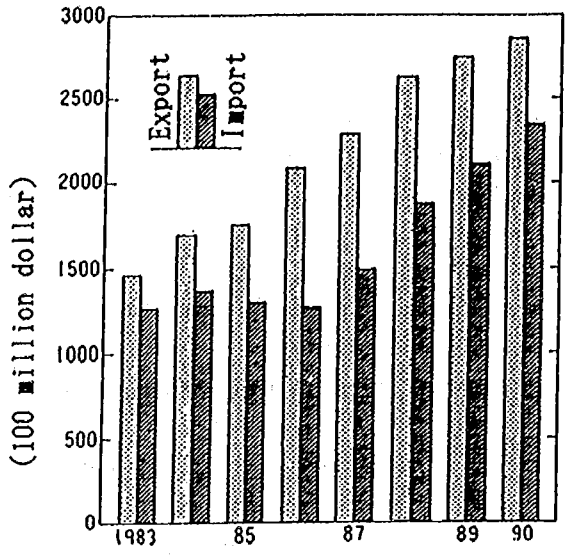


Fig.1.4.4 Amount of trade in Japan

2. A Description of Public Works

2.1 Master plan of national land development (laws, plans, etc.)

Laws relating to national land development in Japan comprise key laws such as the Comprehensive National Land Development Law, the Land Basic Law, the National Land Utilization Planning Law, and other laws peripheral to these; the National Capital Region Development Law and Regional Development Promotion Laws in order to promote the development of these respective areas, laws such as the Law for Advancement of Outlying Islands, and related laws such as the Electric Power Development Law.

Table. 2.1.1 Laws concerning national land development

(1) Basic Law : Comprehensive National Land Development Law (1950)
Land Basic Law (1989)
National Land Utilization Planning Law (1974)
(2) Block laws: National capital Region Development Law (1956) and others
(3) Special area laws: Law for Promoting Construction of New Industrial Cities (1962) and others
(4) Others:
Specific Utilities:
Law for Comprehensive Development of Lake Biwa(1972)
Water Resources Development Promotion Law (1961)
Electric Power Development Promotion Law (1952)
Law for Construction of Arterial Motorways for National Land Development (1957)
National Expressway Law (1957)
Law concerning Emergency Measures for Highway Construction(1956)
Ports & Harbour Development Emergency Measures Law (1961)
Fishing Ports Law (1950)
Housing Construction Planning Law (1966)
Emergency Measures Law for Construction of Urban Parks etc.(1972)
Emergency Measures Law for Sewerage Construction (1967)
Waste Disposal Facilities Emergency Measures Law (1972)
Erosion and Flood Control Emergency Measures Law (1960)
Land Development Law (1949)
Special Measures Law concerning Upstream Area Development (1974)
Law for Improvement of the Surrounding Area of Power Generation Facilities(1974)
Nationwide New Trunk Line Railway Development Law (1970)
Ports and Harbours Law (1950)
Airport Development Law (1956)

National Land Preservation:

Rivers Law (1964)
Sand Control Law (1955)
Seacoast Law (1956)
Landslide Prevention Law (1958)
Law for Prevention of Disasters Due to Collapse of Steep Slopes (1969)

While planning at every stage is formulated on the basis of these various laws, plans relating to the development of national land are largely based on the Nationwide Comprehensive Development Plans. At present the fourth such Plan is under way; this will provide for the development of about 8,000-9,000 kilometers of high-grade trunk highways (of a total plan for 14,000km) to be achieved by the year 2000. Other development targets that have been set involve enabling large rivers to control at least the largest flood since the Second World War ; enabling small and medium rivers to control a rainfall intensity of 50mm per hour in catchment area; increasing the area of urban parks to double the figure of 4.9m² for each person recorded in 1985; for sewerage, overall establishment in urban areas; for housing, increasing the floorspace per unit to 100m²; constructing about 19 million units of new housing; and developing about 180,000ha of land available for housing. Moreover, for each project there are five-year plans in which more concrete medium- and long-term development objectives are stipulated, and thus development is being promoted in a systematic manner.

Table 2.1.2 The 5-year plans under the jurisdiction of the Ministry of Construction, and their objectives

---

① 1) Fifth 5-Year Plan for Development of Urban Parks etc.
2) FY1991 - 1995
3) 50,000
4) The area of urban parks etc. for each person of the population covered by the Plan to be increased from about 5.8m² to about 7.0m², etc.

② 1) Seventh 5-Year Plan for Sewerage Development
2) FY1991 - 1995
3) 165,000
4) The diffusion rate of sewerage system to be raised from 44% to 54%.

③ 1) Fifth 5-Year Plan for Coastal Works
2) FY1991 - 1995
3) 13,000
4) The improvement rate of coastal areas requiring protection to be raised from about 44% to about 54%.

④ 1) Fifth 5-Year Plan for Development Works on Designated Traffic Safety Facilities
2) FY1991 - 1995
3) 18,500
4) About 135,000km of roads needed for the extension of footpaths etc. to be established overall.

⑤ 1) Sixth 5-Year Plan for Housing Construction
2) FY1991 - 1995
3) Public Funded Housing (200,000 units); 3.7 million units; Total 7.5 million units constructed
4) While seeking as soon as possible to eradicate habitation that fails to meet minimum standards, efforts will be made to raise habitation standards towards a new induced standard with a view towards the 21st century.

⑥ 1) Eighth 5-Year Plan for Flood Control Works
2) FY1992 - 1996
3) 175,000
4) The flood control rate to be raised from 45% to about 55%.

⑦ 1) Eleventh 5-Year Plan for Highway Development (Draft)
2) FY1993 - 1997
3) 760,000
4) Rush-hour traffic flow speed to be increased from 18km/h to 20km/h within the DID of the three major conurbations and from 22km/h to 24km/h in regional cities.

⑧ 1) Third 5-Year Plan for Anti-Landslide Works on Steeply Sloping Land (Draft)
2) FY1993 - 1997
3) 13,000
4) The development rate of facilities for the prevention of landslides on steeply sloping land to be raised from 22% to about 34%

---

*:1)Name of the Plan
2)Period covered by the Plan
3)Total sum invested (hundred million Yen)
4)Objective levels etc.

2.2 Budget for investment in construction

Although, as can be seen in Fig.2.2.1, total investments in construction have been moving briskly in comparison with the growth in GNP, as far as the budget for public works is concerned there has been no growth owing to the stringent policy of restraint since 1982. As a result, a disparity has arisen in the growth in construction investments including the private sector, and this has led to a delay in the development of housing and social capital.

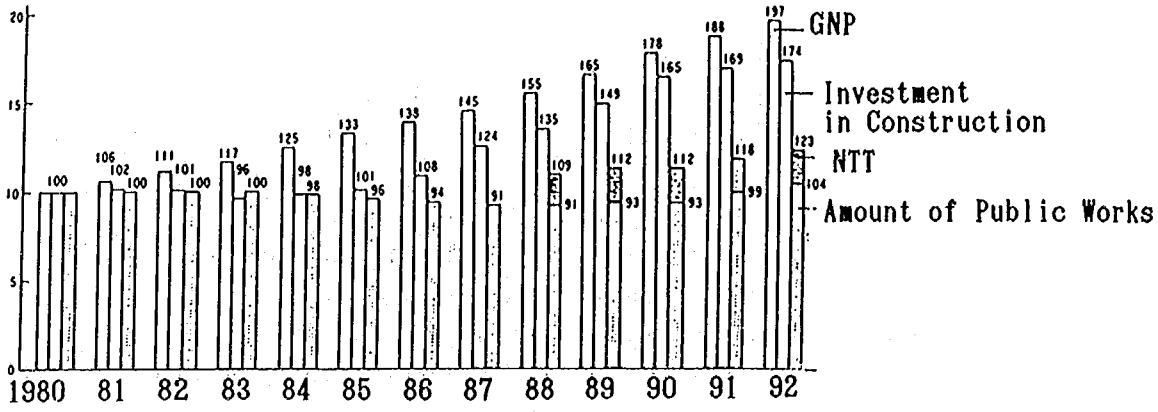


Fig.2.2.1 Growth of Budget for investment in construction

However, in the Master Plan for Public Works Investment (authorized in 1990), which shows the keynote for public works over the next ten years and was compiled in response to USA demands in the Japan-US Structural Agreement that Japan should expand her public works investment, it would appear that public works investment is to be boosted. The details are (1) an approximate sum of 430 trillion yen, (2) a period from FY1991 to FY2000, and (3) a basic rationale of (i) greater emphasis on areas which are closely related to the daily lives of the people, (ii) the formation of a multipolar, dispersal-type national land, and (iii) construction of a safe and beneficial national land.

2.3 Institutions and organizations (main Ministries) concerned with public specially in civil engineering field

Ministry of Construction : Improvement of rivers, dams, coasts
Erosion control
Improvement of highway
Improvement of housing land
Improvement of sewerage
Improvement of parks and green

Ministry of Agriculture, Forestry, and Fisheries:
Improvement of the industrial foundation for agriculture, forestry, and fisheries (farm roads, fishing ports, etc.)

Ministry of Transport : Improvement of of railways
Improvement of ports and harbours
Improvement of airports

Ministry of International Trade and Industry :
Improvement of industrial water supply
Improvement of electric power facilities

Ministry of Health and Welfare :
Improvement of water services

National Land Agency : Plan of national land

Hokkaido Development Agency : Public works in Hokkaido

Okinawa Development Agency : Public works in Okinawa

2.4 History of significant developments in infrastructure, the progress and problems of development

1) River works etc. (Ministry of Construction)

Japan was devastated during the Second World War, and after the war was struck several times by large typhoons and heavy rainfall. Flood disasters occurring in 1945, 1947, and 1948 caused human casualties as well as flood damage in financial terms far in excess of pre-war levels, leading to an increased necessity for flood control works. Indeed, the repeated occurrence of flood in 1953 spurred the formulation of the "Outline of Key Measures for Flood Control" followed by the Erosion and Flood Control Emergency Measures Law and the Flood Control Special Account Law in 1960, with which the foundations for the present flood control system were laid.

In addition, in order to control flood while coping with factors such as increases in the demand for electric power and the demand for municipal water services which accompanied the revival in the economy after the war, the Designated Multi-Purpose Dam Law was enacted in 1956 to enable multi-purpose dams to be constructed efficiently. Furthermore, the Water Resources Development Promotion Law was enacted in 1960 with the aim of promoting the rationalization of

comprehensive development and use of water resources. At the same time, a Water Resource Development Public Corporation was established, and attempts were made to promote works such as the comprehensive development of water resources in major river systems.

The excessive concentration of population in major cities during the period of rapid growth in the economy gave rise in urban areas to (1) a brake on the progress of river conservation works due to spiralling land prices, (2) a decline in water holding and retarding functions due to the development of river basins, and (3) rapid transformations in river basins such as the concentration of population and properties in the vicinity of rivers. Thus the occurrence of chronic flood became a new problem. Therefore, in 1976 the River Council issued a report on promotional policies for comprehensive flood control measures, including (1) vigorously promoting river conservation works, (2) appropriately securing water holding and retarding functions in river basins, and (3) official notification of inundation areas.

Moreover, because of the concentration of population and properties in the cramped national land of Japan, there is a high level of land use in comparison with other countries, thus preventing the occurrence of landslide disasters and protecting coastlines are important works. In 1957 landslide disasters occurred in many parts of the country and the need for radical countermeasures increased. Thus in 1958 the Landslide Prevention Law was enacted. In addition, the Seacoasts Law was enacted in 1956 after the occurrence of a series of tidal wave disasters after the war.

In this way, since the war, development based on legislation has led a positive drive towards the preservation of the national land. Nevertheless, every year disasters still occur today in various regions, and there is a need for continued progress from now on towards guaranteeing safety from disasters.

In addition, with an increased orientation towards nature, there has been a considerable increase in people's needs for the recreational functions of rivers, and there is a desire for positive policies to be promoted.

2) Highway works (Ministry of Construction)

Immediately after the war, roads were left in a state of considerable devastation. On the request of the Allied Command in 1948 a 5-year plan for maintenance and repairs to roads was formulated, and highway development work was started with the primary objective of restoring dilapidated roads.

Subsequently, as the Japanese economy pulled away from its period of disorder and economic growth started to be anticipated, the need for highway development was recognized. The demand for motorized conveyance also grew by about 3.05 times in terms of traveller conveyance (persons/km) and about 1.75 times in terms of freight conveyance (tons/km) between the years of 1950 and 1955.

This state of affairs led to the enactment in 1952 of both the New Road Law, which stipulated a system of management of existing roads, and the Former Law concerning Emergency Measures for Highway Construction, which stipulated a system of toll roads. Furthermore, in 1953 it was determined that gasoline tax would

become a designated source of revenue and that five-year plans for highway development would be formulated. As a result, in 1954 the First 5-Year Plan for Highway Development was formulated with support from revenue resources. In 1956 the Japan Highways Public Corporation was established as a body that would undertake comprehensive management of toll roads.

In order to support the socio-economic activities of the nation as a whole while safely and efficiently processing a diversifying and growing traffic demand, there was a greater need for the development of an expressway network which would form a framework for the structure of the national land. Thus in 1957 the National Land Development Long-Distance Highway Construction Law (later to become the Law for Construction of Arterial Motorways for National Land Development) was enacted, and work on developing expressways was started. In 1965 the full 190km length of the Meishin (Nagoya-Kobe) Expressway was opened to traffic, followed by the 346km Tomei (Tokyo-Nagoya) Expressway in 1969. Also, in order to smooth traffic in major conurbations, the construction of the Capital Expressway in Tokyo was started in 1960 and that of the Hanshin (Osaka-Kobe) Expressway in 1962.

As a result of the high level of growth in Japan and the transformation of the industrial structure from the mid-1950's onwards as well as the mass popularization of the automobile from the mid-1970's onwards, the growing demand for conveyance and the increasing size of vehicles continued at a pace exceeding that of the progress of highway development. This gave rise to chronic problems such as traffic congestion in and around cities. Moreover, the rapid increase in the number of automobiles also led to a dramatic rise in traffic accidents and gave birth to the phrase "traffic war". Consequently, as a radical measure for dealing with traffic accidents, the Emergency Measures Law concerning Construction of Traffic Safety Facilities etc. and other Facilities was enacted in 1966. This enabled support to be given in connection with the development of road safety facilities and the expansion of road safety measures to be sought. Meanwhile, in 1956 the Special Measures Law for Securing Road Traffic in Special Snowy and Cold Areas was enacted. This specified implementation and support to be given for snow and cold works such as snow removal on specific in snowy and cold regions routes. Through this, a guarantee of smooth traffic was sought in the winter season in snowy and cold districts, and this is contributing to local development and the improvement of standards of living.

Thereafter, the enactment of the Law for Construction of Arterial Motorways for National land Development in 1966 stipulated 32 planned routes for national trunk highways covering about 7,200km.

These developments helped to take the share of highway conveyance within domestic freight conveyance (tons/km) and domestic traveller conveyance (persons/km) to considerable proportions of 47.4% and 57.0% respectively in 1985. This leads one to deduce that the steady development of highways since the end of the war has supported the Japanese economy. Although Japanese road networks are gradually being improved, nevertheless the steps taken to deal with the ever burgeoning traffic demand and the increasingly diversified and sophisticated mobility can still hardly be said to be adequate. Thus increasingly positive

development will be needed in future.

3) Housing (Ministry of Construction)

Housing after the war was in a state of absolute shortage of supply, and so as an emergency stop-gap measure the government developed 43,000 units of temporary prefabricated housing for disaster-hit cities. Indeed, emergency measures continued to be undertaken for an extended period of several years.

Moreover, housing construction by the private sector was stagnant after the war due to factors such as spiralling construction costs caused by fierce inflation, while, in terms of funding, private sector finance was pressurized by the provision of funds for industrial promotion and did not have the surplus capital strength to be able to offer long-term low-interest housing loans. So in 1950 the Housing Loan Public Corporation was established, offering long-term and low-interest loans for housing construction with the aim of promoting the construction of housing. Furthermore, in 1951 the Public-Operated Housing Law, which was aimed at the development of public-Operated housing, was enacted, while in 1955 the Japan Housing Public Corporation, which undertakes such work as large-scale supplies of multiple-unit housing as well as land for housing, was established. Thus the main schemes within housing policy were established.

In the first half of the 1960's there was a marked lag in standards of habitation in contrast to the healthy increase in the national level of consumption. Therefore the New Residential Built-Up Area Development Law was enacted in 1963 with the aim of offering large-scale supplies of housing, while in 1966 the Housing Construction Planning Law, which formulates comprehensive and long-term plans for housing, was enacted.

In the First 5-Year Plan for Housing Construction, which was decided by the Cabinet in July 1966 on the basis of the above, the eradication of housing problems was set as a target, under the principle of "one home for one household". Thereafter the systematic development of housing continued to be promoted, and in a housing census in 1968 the number of houses exceeded the number of households across the nation as a whole. Meanwhile, in the same census in 1973 the same result was achieved in all prefectures, and the eradication of the absolute shortage of housing was in sight.

However, even though the eradication of housing problems was achieved to a degree, Japanese housing was still cramped and low in quality in comparison with other advanced countries of Europe and America. In order to attempt an improvement in quality, the Third 5-Year Plan (FY1976-80) set targets for minimum and average habitation standards, while the Fifth 5-Year Plan (FY1986-90) set a target for improved habitation standards. Thus policies are being developed towards a systematic improvement in the quality of housing.

4) Sewerage (Ministry of Construction)

The development of sewerage has only a short history in Japan, for while this was carried out to a certain degree even in the Meiji, Taisho, and pre-Second World War periods, it was not undertaken as one of the country's primary utilities.

However, rapid economic growth based around the development of heavy chemical industries after 1955 promoted an expansion of industrial production and a concentration of population in major cities. These factors were accompanied by a marked deterioration in urban environments, such as an increase in poor drainage areas due to land foundation subsidence, and advancing contamination of water quality in public water areas such as rivers and lakes. Thus there was a rapid increase in the number of cities which took up sewerage works.

As the need for and importance of sewerage development increased, five-year plans for sewerage development have been formulated since 1963, and efforts are being exerted towards promoting the development of sewerage. However, since historically Japan lags behind other advanced countries in this respect, the diffusion of sewerage is still at a low level.

5) Parks (Ministry of Construction)

It was only comparatively recently that park development was taken up as a serious issue in Japan. The dramatic advance of urbanization in the era of high-level growth in economy has had the effect of depriving cities of greenery and open spaces, and a deterioration of living and urban environments has come to the fore. As a result, this has increased the nation's requirements for improved urban environments through the development of urban parks, and in 1972 the First 5-Year Plan for the Development of Urban Parks etc. was formulated. Since then there has been a rapid development of parks in cities.

Furthermore, since 1976 there has also been development in government-managed parks thanks to revisions to the system of urban parks, and there is now ongoing development of parks on a large scale and over a broad area.

However, the area of urban parks for each person is still at a low level compared to other advanced countries, and so in future continued positive development will be needed.

6) Agriculture, forestry, and fisheries (Ministry of Agriculture, Forestry and Fisheries)

As a result of the devastation of the country and the sharp increase in population immediately after the end of the second World War, Japan was hit by an unprecedented shortage of food provisions, and increasing the production of food became a national task. Furthermore, as this had the added effect of a means of fighting unemployment, its weight at one point even outstripped investments in national railways to take up a share of nearly 30% in total state investment.

However, from the mid-1950's, the improvement in agricultural productivity slowed down while there was at the same time an ongoing population outflow away from farming villages and towards cities, as well as a conversion of agriculture into a side business. Furthermore, because the Japanese economy has gone through a period of high-level growth, the position of agriculture within the domestic economy has fallen sharply. As a result, the weight of public works investment in connection with agriculture, forestry, and fisheries investment will also gradually decrease.

7) Railway facilities (Ministry of Transport)

The sharp growth of the Japanese economy after the war brought with it an increase in conveyance volumes of both freight and passengers, and the Tokaido Main Line, in particular, was already virtually stretched to its limits by the first half of the 1950's. Therefore, the construction of the Tokaido Express Line (Shinkansen) was started in 1959. The line was completed in 1964. The vast reduction in the time taken to travel between different regions thanks to the development of the Shinkansen has had a large effect on political, economic, and cultural progress in Japan. Since then there has been ongoing development of high speed railways such as the San'yo Shinkansen, the Tohoku Shinkansen, and the Joetsu Shinkansen.

Meanwhile, the Railways Construction Public Corporation was created in 1964 (the year in which the Tokaido Shinkansen was completed), since when it has taken steps towards expanding railway service networks. But the case for privatization was argued on grounds such as increasing deficits, so it has now been divided into six controlling parent organizations, and privatized.

8) Development of ports and harbours (Ministry of Transport)

While immediately after the end of the war development was carried out with an emphasis on restoring ports and harbours ravaged by the war, more thoroughgoing development was undertaken subsequently in line with the revival of the economy. The era of high-level growth in economy from the mid-1950's was marked by a sharp increase in cargoes handled by ports and harbours and the underequipped state of port and harbour facilities to cope with the increasing size of ships. There was thus concern that this would form a bottleneck in the growth of the economy. Therefore, the Ports and Harbours Development Emergency Measures Law was enacted in March 1961, and on the basis of this Law the First 5-Year Plan for Ports and Harbours Development was formulated in 1962.

In addition, in the Nationwide Comprehensive Development Plan for fiscal 1962 a system of key base development came to the fore as a means of regional development, and on the basis of this there was a series of development of enclosed ports and harbours in places such as Kagoshima. Indeed, marine industrial zones progressed in Tokyo, Nagoya, Sakai and elsewhere, and development proceeded on ports and harbours which could accept large ships such as oil tankers.

However, in conjunction with the gradual conversion in Japan from a structure that consumed large quantities of energy to one that concentrates on saving energy following the double oil crisis in 1973 and 1978, a transformation is under way from "big-and-heavy" to "light-and-compact" type industries. Thus the weight of merchant shipping, a means of large-volume transportation, is decreasing. As a result, the emphasis on port and harbour development has also declined in recent years.

9) Airport development (Ministry of Transport)

The high-level growth in economy after the war has meant that the requirements for airborne transportation have increased, and since the opening of the Tokyo

International Airport in 1959 positive steps have been taken to develop airport.

Improved income standards and more energetic industrial activity resulting from the high-level growth in economy have raised the value placed on time, which has led in turn to an increase in the demands made of air conveyance with its great time-saving effects. In terms of air passenger conveyance figures (person-kilometres conveyed), these rocketed from 218 million person-kilometres in fiscal year 1955 to 2,939 million person-kilometres in fiscal year 1965.

For this reason, as well as developing a new airport from 1975, moves to increase the scale of existing airports and to equip them to receive jets have been promoted. By 1986 about 50% of all airports had been converted for use by jets.

Furthermore, recently there has been an increased need for transportation by light aircraft running between highly specific locations, and there are expectations for the development of a commuter airport.

2.5 Major projects under in progressing or planning

The ten years leading up to the 21st century form a period which will see spectacular projects jostling for prominence, incorporating visions such as the Tokyo Bay Loop Highway, Control Business Cities, the Kansai Culture, Science, and Research City, the Kansai International Airport, and the Honshu-Shikoku Bridges.

In addition, these large-scale projects will be accompanied by regional promotion projects which abound with individuality and appeal, and which are being designed and implemented with a view to forming a multipolar, dispersal-type national land.

Representative examples of these are outlined in Table 2.5.1 .

Table 2.5.1 Examples of large-scale and regional development projects

① 1) Tokyo Bay Loop Highway (Tokyo, Kanagawa, Chiba)
2)Includes the Trans-Tokyo Bay Highway which will cross the central part of the bay to link up with the about 160km Tokyo Bay Highway running around the perimeter.
3) ·Will ease traffic congestion in the center and outskirts of the Tokyo region.
·Will create direct traffic linking mainly Chiba and Kanagawa but bypassing Tokyo.

② 1) Central Business cities
2)e.g. the development mainly of business-related activities centering on Chiba or the Makuhari New Metropolitan Center
3)Will encourage the dispersal of business functions of the Tokyo 23-ward area and contribute to a balanced development of the Tokyo region.

③ 1) Kansai Culture, Science, and Research City (Kyoto, Osaka, Nara)
2)Centralized development of cultural, scientific, and research facilities, public facilities, housing, and other facilities in a 15,000-hectare area in hills between Kyoto, Osaka, and Nara.
3)Will contribute to the progress of Japanese and world culture as well as to the growth of the national economy by forming a focal point for new developments in culture, science, and research.

④ 1)Kansai International Airport (Osaka)
2)Aiming at the development of a new international airport which can be used round-the-clock, located in 318.4 hectares of reclaimed land in Senshu-oki, Osaka Bay.
3)·Activation of overseas connections which bypass Narita.
·The birth of a new aerial gateway which meets the round-the-clock requirements of urban activity.

⑤ 1) Honshu-Shikoku Bridges (Hyogo, Tokushima, Okayama, Kagawa, Hiroshima, Ehime)
2)In addition to the Kojima-Sakaide route, these will link Honshu and Shikoku by means of bridges over the Kobe-Naruto and Onomichi-Imabari routes.
3)The birth of a major cultural and economic sphere on either side of the Seto Inland Sea. Will extend ranges for commuting, school attendance, and commercial distribution.

⑥ 1)Comprehensive Development of Lake Biwa
2) Large-scale development for water utilization in the Kinki region.
3) Will help to correct chronic water shortages.

⑦ 1) Erosion Control on Fugendake Volcano, Mount Unzen
2) Measures to control lava flow and earth flow on Fugendake volcano.
3) Will guarantee the safety of the region.

⑧ 1) Regional activation by upgrading and accumulating industry etc.
2) a)Technopolis (The Law for Promoting the Development of Regions through the Accumulation of Advanced Technology Industries)
e.g. Hamamatsu: developing a base for the formation of "the Future City of Light, Sound, and Colour"
b)Areas for promotion of accumulation (laws relating to promoting the accumulation of designated industries which contribute to the upgrading of regional industry)
e.g. the familiarly-named Brains Location Law; Toyama: developing new industrial fields by accumulating information bases, research institutions
3)·Vitalizing regions by accumulating and upgrading industry
·A balanced development of the national land
·Employment-creating effects, settlement of young people

⑨ 1)Regional promotion through the accumulation of functions which have industrial, cultural, and other characteristics corresponding to special regional features
2)Focal regions for promotion (the Law for Promoting the Formation of a Multipolar and Dispersal-Type National Land)
e.g. Mie; accumulating and expanding research, development and other functions centering on the Suzuka-Sanroku Science City
3)·promotion and development of regions by accumulating characteristic functions
·Promoting the formation of a multipolar dispersal-type national land

⑩ 1)Regional promotion via resort development (the Comprehensive Recreational Area Development Law)
2)e.g. Nagasaki: resort development making use of a variegated natural setting and unique culture
3)·Will realize a rich national way of life
·Regional activation

---

*: 1) Name/Place
2) Details
3) Anticipated effects

3. Outline of Public Works Research Institute, Ministry of Construction

3.1 Name of organization

Public Works Research Institute, Ministry of Construction

3.2 History

The Public Works research Institute, Ministry of Construction was launched on September 30th 1922 as the Civil Engineering Laboratory, the Ministry of Internal Affairs. Subsequently its name was changed to the Public Works Research Institute, Ministry of Construction in line with the creation of the Ministry of Construction on July 10th 1948, and in March 1979 all of its branch offices and Laboratories(except those of the Niigata Experimental Laboratory) were moved to new Tsukuba Science City. The main historical developments over these 70 years are shown in Table 3.2.1.

Over the 70 years since its establishment, the Public Works Research Institute has undertaken research from experimental to applied stages and technological development with the aim of solving problems of technology in connection with a wide range of construction projects. These include rivers, sewerage, dams, erosion control, roads, bridges, construction method and equipment, materials, earthquake disaster prevention, and construction management engineering. The role of the Public Works Institute is to take care of research and development in civil engineering technology as a core institution within the Ministry of Construction, in preparing an infrastructure that will form a foundation for the balanced development of the national land and the creation of a comfortable living environment. At the same time it also contributes to the development of civil engineering technology in Japan as well as in the rest of the world.

Table 3.2.1 The History of the Public Works Research Institute

1921	: Established in 1921 as the Road Materials Testing Department (Komagome, Tokyo).
1922	: Renamed as the Civil Engineering Laboratory, Ministry of Internal Affairs.
1926	: Hydraulic Laboratory in Shimomachi, 3-chome, Kita-ku (Akabane Branch Office) established.
1947	: Renamed as the First Technical Research Institute of the Construction Bureau, Prime Minister's Office.
1948	: Renamed as the Public Works Research Institute, Ministry of Construction.
1949	: The Numazu branch is established through the merger of the Engineering Staff Training School of the Ministry of Transportation and the Institute.
1952	: Hydraulic experimental station for rivers and dams established in Higashi Shinozaki-cho, Edogawa-ku (Shinozaki Branch Office).
1960	: Establishment of the Chiba Branch in Anagawa-cho, Chiba City, and the Niigata Experimental Laboratory in Arai City, Niigata Prefecture. Numazu Branch shut down.
1961	: The Kashima Hydraulics Laboratory is established in Kamisu-machi, Kashima-gun, Ibaraki Prefecture.
1967	: The Akabane Branch (formerly the Akabane Branch Office) and Shinozaki Experimental Laboratory (formerly the Shinozaki Branch Office) established.
1979	: All facilities moved to the new Tsukuba Science City, with the exception of those at the Niigata Experimental Laboratory.
1992	: 70th anniversay

3.3 Organization

The Public Works Research Institute, with the Director-General of Public Works Research Institute at its head, is composed of a Research Support Department (comprising a General Affairs Department,and a Planning and Research Administration Department), nine Research Departments, the Construction Management Engineering Research Center, and the Niigata Experimental Laboratory. There are 35 research divisions under the jurisdiction of the nine Research Departments, forming a structure which is able to handle research and development of civil engineering technology over a wide range of fields.

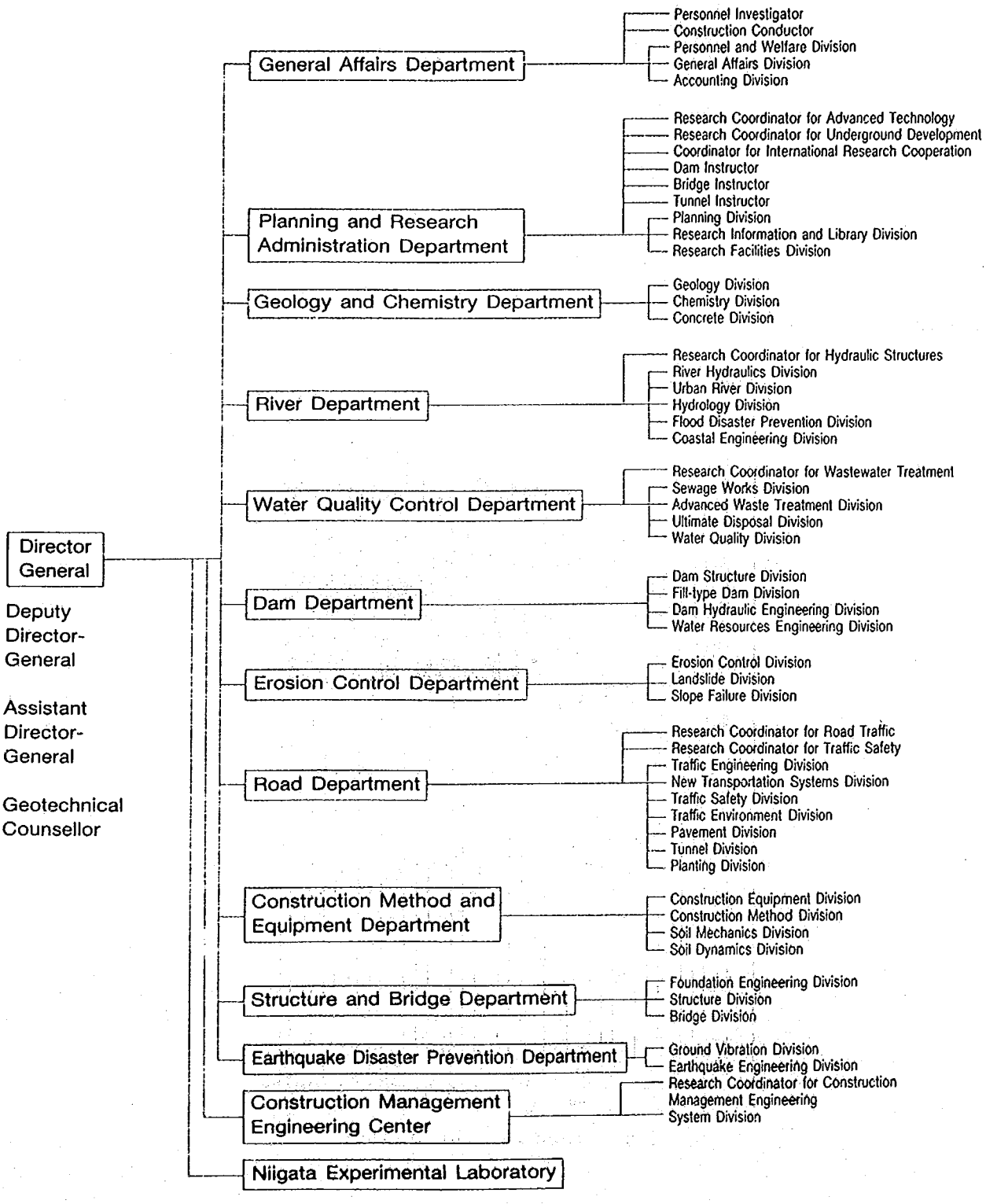


Fig.3.3.1 Organisation of Public Works Research Institute

3.4 Staff capacity

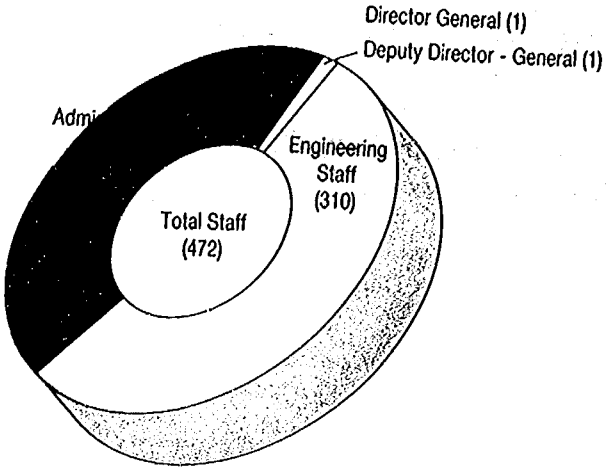


Fig.3.4.1 Staff composition

3.5 Trends in the budget

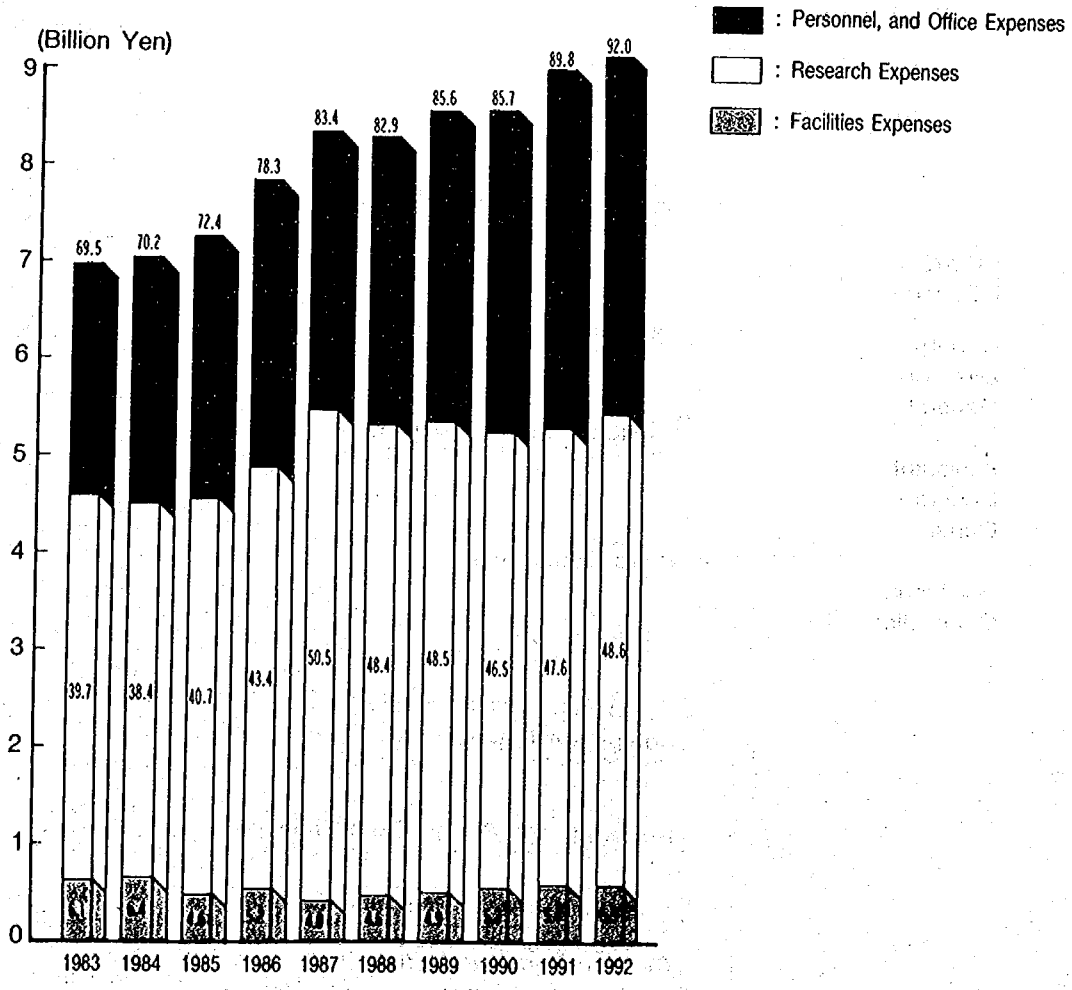


Fig.3.5.1 Trends in the budget

3.6 Management systems

Since its launch, the Public Works Research Institute, as the only state research organization related to comprehensive civil engineering technology, has conducted research over the whole range of construction projects such as rivers, dams, erosion control, roads, sewerage and so on. It contributes to the upgrading and integration of civil engineering technology by, for example, carrying out research and development aimed at the materialization of big projects such as the Honshu-Shikoku Bridges or the Trans-Tokyo Bay Highway, and is in the process of becoming a center of excellence (COE) for research in civil engineering fields.

In order to promote effective and efficient research activities when undertaking this research and development, it makes practical use of comprehensive R&D projects and joint research systems with research taken on by a combination of industrial, academic, and governmental interests. It has also set up a system of accepting researchers for a period of months to year from universities and private enterprises.

The research activities of the Public Works Research Institute are currently being undertaken in the nine research departments, and the Construction Management Engineering Center and the Niigata Experimental Laboratory. There are various methods of proceeding with research for each research subject, depending on the content of the subject. These include cases where one research laboratory, one section, or one test laboratory carry out research independently, cases where research is carried out compositely with the participation of test laboratories, or cases where research is carried out jointly with public corporations, the private sector, and so on. Fig.3.6.1 shows the trends in the number of research subjects per fiscal year.

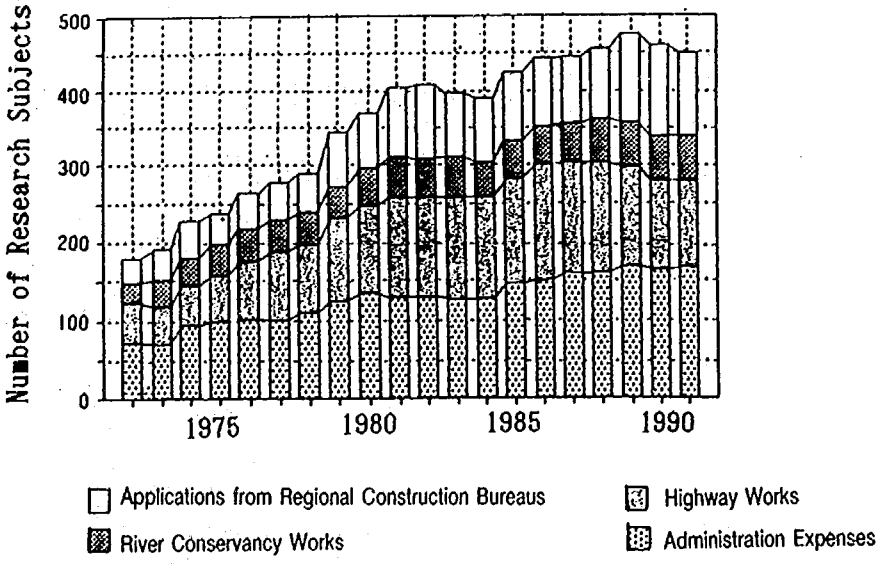
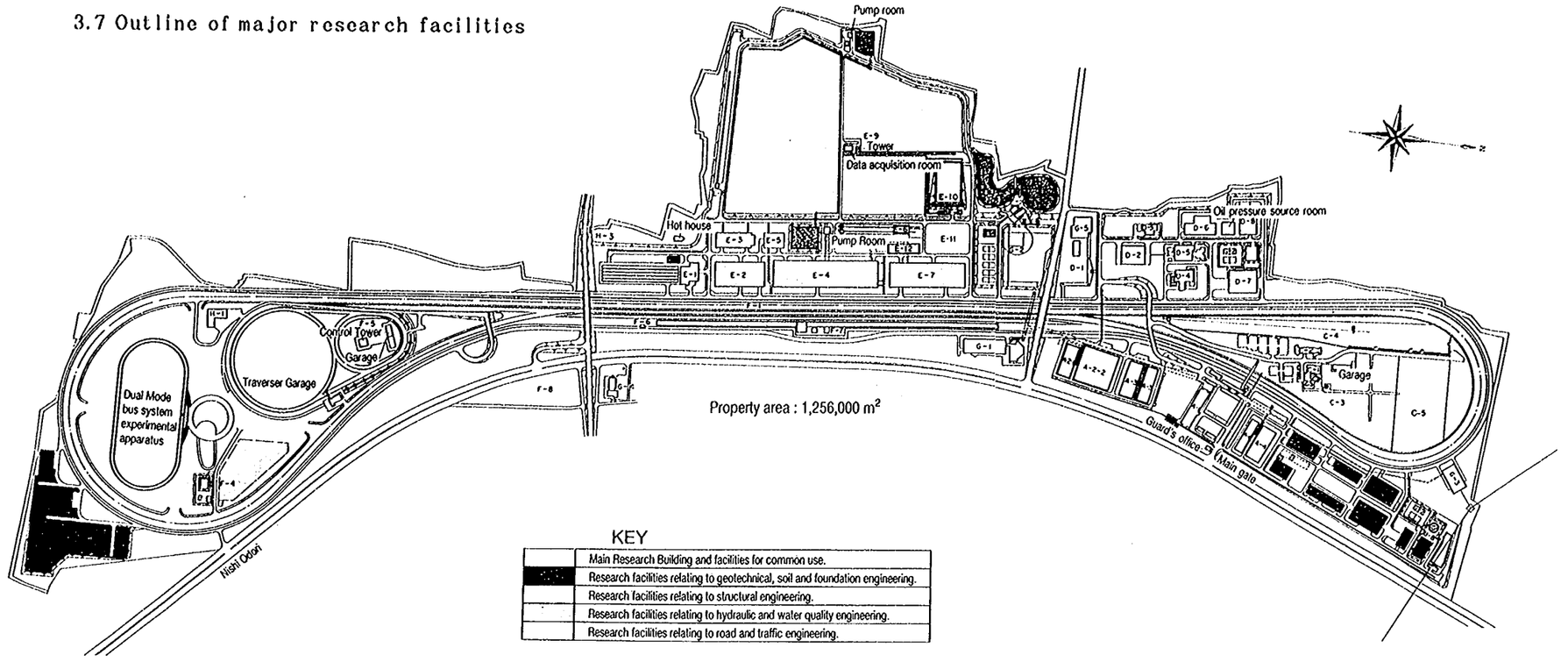


Fig.3.6.1 Trends in the number of research subjects

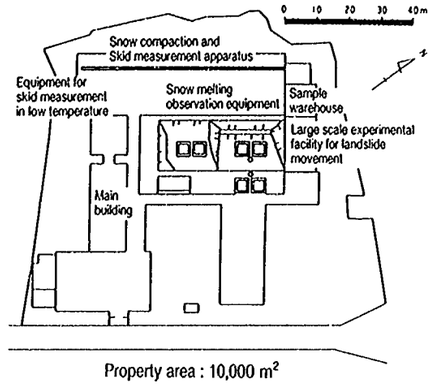
3.7 Outline of major research facilities



KEY

	Main Research Building and facilities for common use.
	Research facilities relating to geotechnical, soil and foundation engineering.
	Research facilities relating to structural engineering.
	Research facilities relating to hydraulic and water quality engineering.
	Research facilities relating to road and traffic engineering.

● NIIGATA EXPERIMENTAL LABORATORY



Property area : 10,000 m²

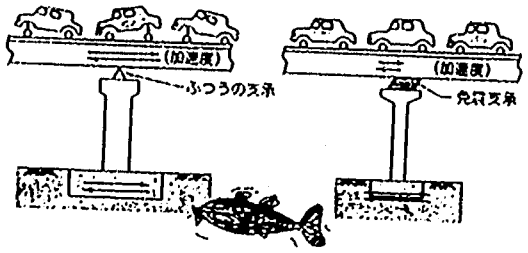
A-1	Main research building	Common facilities of management and research departments: conference room, computer room, welfare facilities, etc.
A-2-1	Sanitary engineering and hydrology laboratory	Analytical and experimental equipment for sewage and sludge treatment, hydrological simulator, flood runoff, resefvoir operation simulator.
A-2-2	Hydraulics laboratory	Experimental channels and wave generators for hydraulic experiments.
A-3	Material and structural engineering laboratory complex	Material and structural experimental equipment for concrete, steel polymers, submarine tunnel materials and dam structure, ground vibration, traffic engineering, etc.
A-4	Geotechnical engineering laboratory complex	Experimental equipment for rock dynamics, soil mechanics, soil dynamics, soil work management, erosion control, construction machines.
G-1	Wastewater treatment plant	General experiments on physical, organic and inorganic systems; cement-contained, oil-contained and salt-contained treatment equipment.
G-2	Sport facilities	Soft baseball ground, tennis court, swimming pool, welfare building
G-3	Transformer house	Capacity 26000 KVA (including 6000 KVA for geographical survey institute).
G-4	Research communication and training center	
G-5	Gym:	Basketball court or 2 volleyball courts
	Exhibition hall	Exhibitions of many panels, models and samples
	Seepage laboratory	Secondary permeation test tank, tertiary permeation test tank, rainfall apparatus, water level regulating apparatus, observatory platform cars.
	Excavation laboratory	Soft rock excavation experimental tank, soft rock excavation apparatus, rock excavating bit testing machine.
	Landslide model test laboratory	Landslide, mudflow experimental slope, failure experimental slope, permeation test tanks, rainfall apparatus, poxe water pressure gauge.
	Foundation engineering laboratory	Test pits experimental tank, material testing yard, loading apparatus.
	Earth works laboratory	Test pit for soft ground stabilizing treatment, retaining wall experimental facilities, retaining wall experimental apparatus, rainfall apparatus; measuring station, water circulation type excavator.
	Earth structure laboratory	Banking experimental tank, rainfall apparatus, water level regulating apparatus, observatory gondola equipment.
	Geological engineering laboratory	Large experimental water tank, grouting test yard, submarine boring machine, microwave rock breaking test apparatus.
	Underwater machinery test pit	Experimental water tank (deep), experimental water tank (shallow).
	Earthworks test field	Outdoor test field.
	Garage of field testing devices	Rotary wheel sampler, boring machines.
C-3	Strong motion earthquake observation station	Strong-motion seismographs, 8 accelerographs on ground and 5 accelerographs under-ground, earthquake intensity measurement apparatus.
C-5	Construction machine test field	
D-1	Strong motion earthquake observation station	Strong-motion seismographs, 1 unit on ground and 5 units underground, earthquake intensity measurement apparatus.
D-2	Structural mechanics laboratory	Stiffener test pit equipment, bridge dynamics testing unit, tunnel support work loading equipment.
D-3	Dam model vibration test laboratory	Vibrating table, vibration/loading equipment.
D-4	Structural aerodynamics laboratory	Flutter wind tunnel, non-steady air force wind tunnel, smoke wind tunnel.
D-6	Vibration laboratory	Shaking table (6m×8m), vibration/loading equipment.
D-7	Structural engineering laboratory	3000 ton large structural member universal testing machine, test bed equipment, large structure low-cycle testing machine.
D-8	Earthquake engineering laboratory	Test tank, vibration/loading equipment.
E-11	Boundary layer wind tunnel laboratory	Large wind tunnel
F-8	Experiment of material exposure	Weather measuring room, exposure racks.
E-1	Sanitary engineering laboratory	Aeration tanks, experimental channel for ecological studies, and small scale pilot facilities for various unit processes of wastewater treatment.
E-2	Dam hydraulics laboratory	Three-dimensional dam hydraulic model experiment equipment, water supply equipment.
E-3	Dam hydraulics laboratory annex	High speed flow experimental equipment, high pressure water tank equipment.
E-4	River hydraulics laboratory	River hydraulics model experiment field, water supply equipment, density-current plane water tank.
E-5	Groundwater laboratory	Ground water recharge test apparatus, ground water model experiment equipment.
E-6	Wave channels	Littoral drift experimental channel equipment, irregular wave generator, irregular wave experimental channel equipment, irregular wave generator.
E-7	Coastal hydraulics laboratory	Large plane water tank equipment, tide generating equipment, plane wave generator, irregular wave generating water tank equipment, irregular wave generator.
E-8	Current meter calibration channel	Current meter rating flume, current meter rating ruck.
E-9	River model test yard	Experimental water supply equipment, high water tank, guage tank, low water tank equipment, large structure testing channel equipment.
E-10	Torrent channel model test field	Hydraulic model test yard for channel works water supply equipment.
E-12	River ecosystem laboratory	Model test channel, pump station and water purification pool.
F-4	Hydrological experiment field	Hydrological observation experimental equipmen, large scale lysimter.
C-1	Noise control laboratory	1st reverberation room, 2nd reverberation room, 3rd reverberation room.
C-2	Traffic sign laboratory	Movable sign mounting apparatus, artificial weather conditioning apparatus, projecting equipment, illumination equipment.
C-4	Traffic collision test field	Guide rail, observation tower, winch equipment (tracting equipment), test barrier.
D-5	Boundary layer wind tunnel	Diffusion wind tunnel equipment.
F-1	Test track	Movable signs and illumination equipment.
F-5	Pavement test field	Test circuit (large and small loops), load vehicles, rotary wearing testing machine, road repeated compressive fatigue testing machine.
F-6	Skid resistance test field	Skid test circuit, Freezing equipment, sprinkling apparatus, underground observation room.
F-7	Full-scale test tunnel	Full-scale tunnel equipment, (overall length 700 m), underground duct equipment, sprinkling equipment, ventilation equipment.
H-1	Dual mode bus system test field	Guideway about 1 km, experimental bus, 2 units, central control equipment, driving simulator.
H-2	Dual mode bus system test facility	Approx. 1 km guideway, 2 test buses, 1 test truck, central control system.
H-3	Greenery test field	Living environment control device, indoor greenhouse, outdoor greenhouse.

3.8 Recent achievements

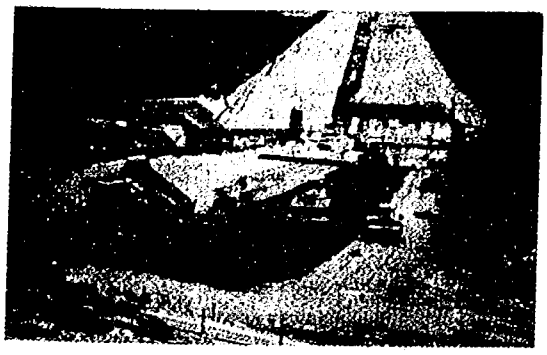
The role of the Public Works Research Institute is to elucidate technical problems in projects under the jurisdiction of the Ministry of Construction, and, by means of model experiments and so on, to solve technical problems faced on site by regional construction bureaus in areas such as planning, design, and implementation. The outcome of this research goes to create new technology, new construction methods, new standards and new directions. Table 3.8.1 shows the flow of achievements in some leading cases of technological development in chart form, from investigative research, through the development of new construction methods, to application on-site. Many cases of technological development have been taken on, including Menshin bridges, the RCD construction method, and the EPS construction method.

Table 3.8.1 Major achievements in technological development

Name of Research Subjects	→	New Construction Method New Guideline etc.	→	Representative Construction Site
① Development of Menshin Highway Bridges	→	Menshin Bridges	→	Miyagawa Bridge (Shizuoka Pref.) etc.
② Research on Improvement of the Dam Design Method	→	RCD Construction Method	→	Miyagase Dam (Kanto Regional Construction Bureau) etc.
③ Development of Ultra-lightweight Filling Materials	→	EPS Construction Method	→	R1 of National Highway (Shizuoka Pref.), R9 of National Highway (Tottori Pref.), R13 of National Highway (Yamagata Pref.)
④ Survey on Wind and Seismic Effects of Honshu-Shikoku Bridge	→	Wind and Seismic Effects of Long Span Bridges	→	Wind and Seismic Design of Akashi Kaikyo Bridge
⑤ Development of New Transportation Systems	→	Guide-way Bus System	→	Nagoya City etc.
⑥ Research and Development to Enhance Durability of Concrete	→	Guideline of Design against chloride attack and alkali aggregate reaction	→	Application of Design of Concrete Structure
⑦ Research on Utilization of Coastal Zones	→	New-type Offshore Breakwater	→	Under Selection of Model Area of MMZ (Marine Multi Zone)
⑧ Development of Counter-measures against Debris Flows	→	Debris Flow Draining Braker	→	Sakura-Jima, Mt.Fuji etc.
⑨ Development of Alternative Sewer Systems	→	Vacuum Sewer System	→	Saijo City (Ehime Pref.), Hamamatsu City (Shizuoka Pref.)

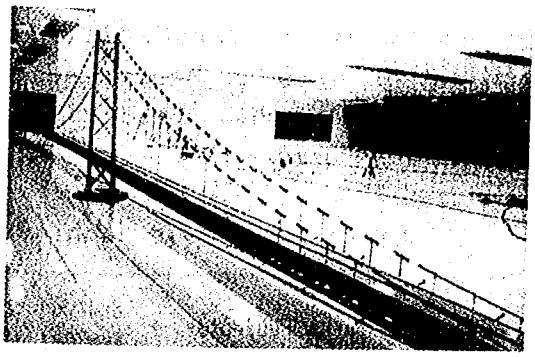


① Design of Menshin Highway Bridges



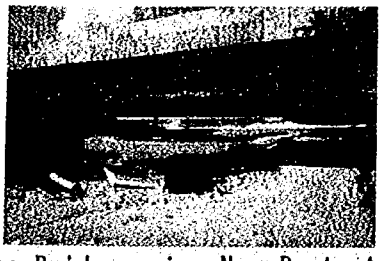
② RCD Construction Method

③ EPS Construction Method



④ Full Model Wind Tunnel Test
of the Akashi Kaikyo Bridge (1/100)

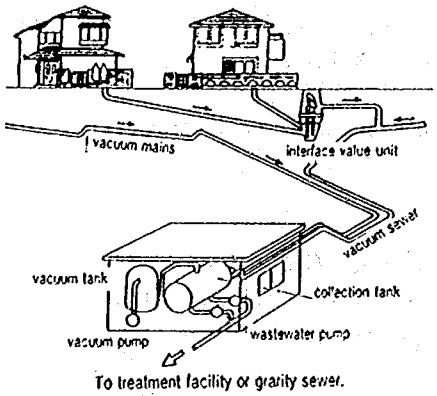
⑤ Guide-way Bus System



⑥ Concrete Bridge using New Protection Technology

⑦ Image of Marine Multi Zone

⑧ Debris Flow Draining Braker



⑨ Vacuum Sewer System

4. Major research and development projects at the Public Works Research Institute, Ministry of Construction

4.1 Major research and development subjects

The Public Works Research Institute, the backbone of national land construction technology in this country, develops and disseminate construction technology in response ever-diversifying public and administrative needs. Moreover, the Institute investigates new construction technology from an environmental viewpoint and promotes research and development subjects to enhance Japan's international contribution. At present, the Public Works Research Institute is carrying out approximately 460 different types of research and development subjects in response to diversifying needs, with particular emphasis of the following:

1) Promotion of research and development into construction technology pursuing better environment

Research and development into the impact of construction on the earth and living environment and the use of infrastructure according to changes in environment greatly in demand. Moreover, there is a demand for technology capable of maintaining better relation between humans and nature, and of creating a environment.

The Public Works Research Institute is carrying out research and development on the following:

- Research on comprehensive national land conservation technology corresponding to global warming
- Research and development of resource-saving and energy-saving national land construction technology
- Research and development on controlling the generation of construction by products and utilization of recycled materials.
- Development of technology for creating pleasant scenery
- Research on the conservation and utilization of water environment
- Research on alternative sewer transport systems
- Development of basic technology to create spaces for flowers and green
- The evaluation of environmental conservation methods
- Research on noise characteristics in road traffic

2) Promotion of minimum impact construction technology

In terms of the use of infrastructure, what is required now is construction technology which does not have a major impact on the ecosystem. There is thus a significant need for construction technology (minimum impact construction technology) to reduce the under on the natural environment and produce a better environment even after construction.

The Public Works Research Institute is carrying out research and development on the following:

- Research on environmental facility zone
- Research on the impact of low-pollution cars on the environment
- Research on water quality conservation technology in reservoirs
- Research on slope greening works.
- Survey on the effects of fish pass and fish nest blocks.

3) Technology for creating a social base to assure safety

The principal task of the Ministry of Construction protection of lives and property from disasters such as earthquake, flood, tsunami, debris flow, pyroclastic flow. Moreover, the number of traffic accidents has increased due to the increase in the ratio of vehicles owned, and strategies for reducing traffic accidents and other traffic safety measures are urgently required. Because of this, research and development into creating a social base to ensure safety is required.

The Public Works Research Institute is carrying out research and development on the following:

- Research and development on earthquake disaster prevention technology in urban districts
- Research on the methods for determining the flow behavior of floods
- Research and development on sediment disaster prevention systems
- Research on disaster prevention technology in volcanic zones
- Research on design and planning methods for snow avalanche protection facilities
- Research and development on new technology for improvement and renewal of social resources
- Research on a higher standards and intelligence for road structures
- Development of new freight transport system
- Research on design and construction methods for superlong span bridges
- Research on the rationalization of road bridge design system
- Research on the development of road traffic safety facilities for the disadvantaged in traffic
- Research on prediction and countermeasures for traffic congestion
- Testing and investigation into the creation and use of a comprehensive traffic accident data base.

4) Promotion of research and development on safety in construction

Aging and the low skill level of construction workers greatly affect the safety of construction work. Also, the size of construction projects has increased, and if accidents in city construction projects these days have a much greater social impact. There is therefore an urgent need to further enhance safety. The Institute is carrying out research and development on techniques for accurately determining conditions of a site and reflecting these process in the construction design and execution as well as in labor-saving automation.

The Public Works Research Institute is carrying out research and development on the following:

- Research on information oriented construction works by advanced instrumentation technology.
- Research on AI control system for construction machinery
- Development of new technique for subsurface exploration
- Research on safety measures in construction technology
- Research on construction site management system using IC cards

4.2 Current research and development at the Public Works Research Institute

Among the approximately 450 types of research currently being carried out at the Public Works Research Institute, six leading examples are presented here.

4.2.1 Development of technology for utilization of advanced materials in public works

1) Background and administrative needs

Public works projects mainly use steel, concrete, sand and soil as basic materials. However, more sophisticated social needs of recent years sometimes demand higher performing materials. For example, the progress of aging, decrease in labor force and increase in social overhead capital stock demand easiness of execution, more special performance and/or higher durability of materials, of which characteristics consequently bring less total cost of construction and maintenance of public works projects. In this research project, therefore, the feasibility of use of various advanced materials as well as the technology of utilization of particular materials is being studied.

2) Period of the research project

Five years from 1988 to 1992 fiscal year.

3) Methodology

The scope of research covers a very wide range from physical and/or chemical material science through to general civil engineering. We are therefore out the research at PWRI with the cooperation of universities and private sectors.

Principal research themes are as following:

(1) Research on the feasibility of utilization

First of all, the institute conducted a survey on the present state of utilization of advanced materials in the field of public works. Then it surveyed the needs to advanced materials from the field and collected wide information on newly developed materials.

From those survey result, feasible applicable field and characteristics to be improved of advanced materials was suggested.

(2) New ground grouting materials

Some new types of grouting materials with high permeability, strength, durability and safety has been developed. In this research estimating methods for characteristics of those materials, especially on durability, are developed. In addition, a suitable survey method of geological ground condition and maintenance method for grouted are developed.

(3) High durability coating materials

The Institute is developing and improving painting and coating materials with specially high durability such as fluorine resin and silicon resin paints. In addition, execution methods utilizing the characteristics of those materials are being developed and methods for evaluating durability are being reviewed.

(4) High-performance concrete

We conducted research and development for one-day concrete and studies evaluation methods for high-strength low-heat concrete.

(5) Ultra-lightweight filling materials

For applying Expanded-poly styrene (ESP) to filling material, design and construction methods were studied, and corresponding manuals were produced.

(6) New bridge cable materials

For applying FRP with corrosion-free high-tech fibers such as carbon fibers to bride cable, mainly PC tendon, physical testing and durability evaluating methods were reviewed. And new design method and construction methods suitable for new FRP cable are under developing.

(7) Evaluation system for newly developed materials

There is no systematic evaluating methods for newly developed materials on its physical and chemical properties, durability, safety and suitable constructing methods. The institute is trying to establish the evaluating system for those materials for future.

Especially, establishment of evaluating methods of durability is an urgent subject, because its test usually takes a long period. For polymer materials and metal materials, the particular evaluating systems considering the environments where public works structures are located are being studied.

4) Possible outputs

Results obtained in this research are to be summarized in the form of a Manual for Utilization Techniques of Advanced Materials in order to facilitate their use in actual construction projects.

The institute is collecting data on the reliability and durability various advanced materials by performing in-door and out-door test as well as pilot construction project.

5) Problems with implementation

The advanced materials were used to be not quickly adopted in public works due to the following reasons:

In many cases, advanced materials are higher in cost than conventional materials. And it was difficult to prove the benefits corresponding to the higher cost when adopting them, because of lack of evaluating system. We have to establish new concept for adopting suitable materials.

Also, despite of its excellent performance, advanced materials, being only recently developed, are not accompanied by enough engineering data. Particularly for public works structures demanding long-term reliability, durability data is very strictly required. Even durability testing methods are established, it may take a long-term to obtain enough data. Therefore, in order to accelerate the adoption of advanced materials in public works we have to carry out trial actual construction as well as tests.

4.2.2. Development of rationalized construction technology of concrete dams

1) Background and administrative needs

Modern dam construction in about the 1900's in Japan and many big dams begun to be constructed in the 1940's. Concrete gravity dams were the most popular type of the dams at that time because of their simple design theory. Then, concrete arch dams and concrete hollow gravity dams flourished in the last half of the 1950's due to the advance in structural analysis techniques. The construction economy of these dams was achieved by reducing the volume of the dams.

However, in 1970's, this construction economy became declined as a result of increasing labor cost. In addition, the number of damsites with good geological conditions decreased. So, attention turned to the rock fill dam construction and many big rock fill dams were constructed. The construction economy of rock fill dams was achieved by using large-scale machinery.

Rock fill dams, however, had low resistance against overflow of floods on the dam bodies and required a larger spillway than concrete dams. Since the spillway was not allowed to be built on the rock fill dams because of the lack of its structural stability, rock fill dams were not always advantageous in Japan where the topography of the damsites is steep. There was therefore a strong demand for developing the new construction technology of concrete dams using large-scale machinery as adopted in the rock fill dam construction. The RCD construction method was thus developed.

The first test was conducted at the cofferdam of the Ohkawa River in 1977. The efficiency of the RCD construction method was proved in the test and high quality of RCD concrete was confirmed. The RCD construction method was subsequently adopted at Shimajigawa dam (height of dam: 89 m, volume of dam: 317,000 m^3). The world first RCD dam was completed in 1981. The RCD construction method has been adopted in 26 dams since then and its technology has been significantly improved. At present, the method can be adopted to such a big dam as Miyagase dam (height of dam: 155 m, volume of dam: 2,000,000 m^3) where concrete of high quality is required.

2) Methodology

The RCD construction method was developed in order to meet the following requirement:

(1) Enhancement of mechanization and reduction of labor cost in the dam construction
(2) Use of the construction machinery most suited to the damsite in order to achieve the construction efficiency
(3) Development of the optimal construction system corresponding to the topography of the damsite and the size of the dam

In the RCD construction method, lean concrete mix of extremely stiff consistency is spread out by bulldozers and is compacted by vibrating rollers. The Public Works Research Institute played a leading role in developing the RCD construction method through many laboratory and field tests. The contribution included the establishment of the mix design of RCD concrete, the design and

construction techniques of the RCD dams, and the construction management of the RCD dams.

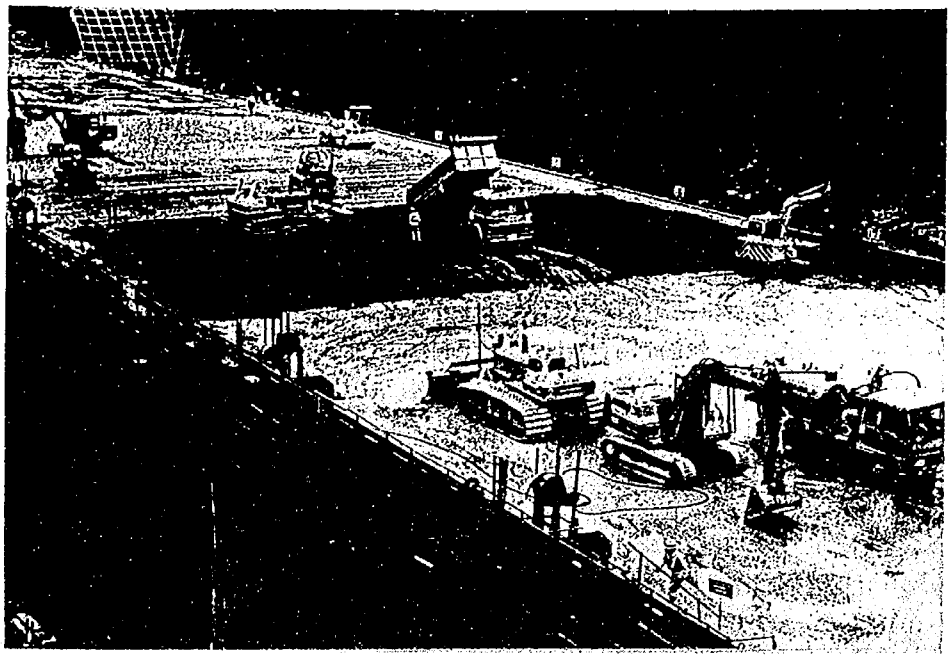


Photo.4.2.1 RCD construction method

3) Research

Research on the RCD construction method is in many fields including materials, design and construction. Studies on materials, in which the Public Works Research Institute has played a leading role, are described here.

(1) Mix design method of RCD concrete

RCD concrete should be of lean mix in order to prevent temperature cracks due to heat of hydration of cement. The concrete should be of extremely stiff consistency so that dump trucks and vibrating rollers can travel on it, and of consistency to be compacted well by vibrating rollers. The concrete should also have required density and strength. The design procedure of RCD concrete mix was developed to satisfy these requirements.

The mechanical properties of RCD concrete are determined not only by its mix proportion but also by its compaction density. The compaction density of RCD concrete is then affected by its consistency and applied compaction energy on it. The testing method of RCD concrete should be developed so that the consistency of RCD concrete mix can be evaluated precisely and that the compaction energy can be controlled accurately during testing. RCD concrete mix used to be determined in the field tests using actual vibrating rollers. However, at present, the large-scale specimen producing equipment has been developed and RCD concrete mix can be determined using the large-scale specimens in the laboratory. The design procedures of RCD concrete mix with

large-scale specimens comprise: (a) the test to determine unit water content, (b) the test to determine unit cement content, (c) the test to determine sand aggregate ratio and (d) the test to evaluate the change of the VC value with time.

The representative RCD concrete mix is as follows: The maximum size of aggregate is 80 mm. The unit cement content is 120 to 130 kg/m^3, 30 % of which is replaced by flyash. The unit water content is 95 to 105 kg/m3. The sand aggregate ratio is 30 to 32 %.

(2) Measurement of the consistency of RCD concrete

Compaction density of RCD concrete is affected by its consistency. The VC value is used as the index of consistency of RCD concrete mix. The VC value is defined the time in second until the paste comes up to the surface of the RCD concrete specimen under 1 mm of vibration and 20 kg of overburden. The test was developed during the development of the RCD construction method and many improvements were added thereafter. The standard testing procedure is now established. The adequate VC VALUE OF RCD concrete is 20 seconds.

(3) Quality control of RCD concrete

The properties of RCD concrete is affected by its consistency and its compaction density. The quality control of concrete is therefore more important in the RCD construction method than in the conventional construction methods. The quality control of RCD concrete comprises :(a) measurement of consistency by the VC value, (b) measurement of compaction density by the number of passes of vibrating rollers on RCD concrete, settlement of the RCD concrete surface during compaction and the RI density, and (c) measurement of compressive strength of standard specimens. In producing the standard specimens, compaction energy should be controlled accurately. The standard specimen producing equipment has been developed in order to control compaction energy.

4) Results of research

The benefits of the RCD construction method are:

(1) Improvement of construction efficiency and construction economy: In the RCD construction method, the possibility of temperature cracking caused by heat of hydration of cement can be significantly reduced by using lean concrete mix. This enables the placement of large amount of concrete without contraction joints (This placing procedure is called the flat placing method) and contributes to the construction efficiency and the construction economy.

(2) Enhancement of safety in construction work: The flat placing method without lift difference can provide a flat and wide working area and can eliminate the dead angle in the working area. It contributes to enhancing construction safety.

(3) Less impact on surrounding environment: The various ways of concrete transportation can be used in the RCD construction method because of the flat placing method. They include dump trucks, inclines, belt conveyers and so on. As a result, the large slope excavation of both abutment for the travelling cable way, which is usually necessary in the conventional construction method, can be avoided. It contributes to the minimal influence to the surrounding

environment.

5) Research in the future

In order to enhance the reliability and the economy of the RCD construction method, further research is required.

(1) Establishment of surface water control of fine aggregate: Consistency of RCD concrete is sensitive to the unit water content. The surface water of fine aggregate should be controlled strictly. The method should be established.

(2) Improvement of construction efficiency in the narrow working area: The efficiency of the RCD construction method is maximized in the big dams with wide working area, but is not fully realized in the small dams nor at the top of the dams because of the narrow working area. The effective construction technology for small dams should be developed.

(3) Effective use of aggregate: The production cost of aggregate has a large influence on the concrete price. The effective use of aggregate should be studied and the production efficiency of aggregate should be enhanced. The concrete mix design for aggregate of low quality and the design technology of dams using such concrete should be also established.

4.2.3 Research and Development on Road／Automobile Communication System (RACS) and Advanced Road Traffic Systems

1) Background and administrative needs

The dependency of lifestyles and economic activity upon road vehicles is ever increasing in Japan, but road development has kept pace with the increase in traffic. Increased traffic congestion has so far been seen as a social problem. Moreover, the number of deaths from traffic accidents has exceeded 10,000 per year recently, and is likely to increase further. The socioeconomic environment is going to change significantly in the 21st century, due to factors such as shortening of labor hours, increasing leisure time and aging of society. Requirements for roads, such as acquisition of constant-time traveling and supply of various information, will become more diversified and sophisticated.

In response to this, various kinds of Road Vehicle Communication Systems are being developed utilizing up-to-date telecommunication and information processing technology.

2) Time period

The Ministry of Construction developed Road/Automobile Communication System during a four-year program from fiscal 1986. Moreover, to respond to the need for more diversification and sophistication, research and development work on Advanced Road Traffic Systems was begun in fiscal 1989.

3) Methodology

Developing on Road / Automobile Communication System and Advanced Road Traffic Systems required broad based knowledge. Not only the knowledge related to road traffic but also to automobile engineering and telecommunication engineering is necessary. Therefore, both the systems are being developed by joint research system with electric and automobile manufacturers involved.

4) Progress of research and potential results

(1) Road / Automobile Communication System (RACS)

a) Outline of development system

An overall image of Road Automobile Communication System is shown in Fig. 4.2.1. The system consists of communication equipment (beacons) installed at the side of the road, on-board equipment and central processing equipment (system center); communication between motor vehicles and beacons is by radio, and between beacons and system center by cable network, supplying and collecting information. Various types of radio communication are possible, depending on directivity, communication region and the form of communication. In this system, however, monodirectional and bidirectional narrow range digital communication is used, supplemented with the following functions:

① Navigation

The navigation function allows the driver to recognize the present location and guides the driver to the destination by means of on-board sensors and a

digital road map displayed in the car. Positional information supplied from the beacon can correct errors from the on-board sensors.

② Information service

The information service function receives road traffic information and parking area information from beacons. The driver can select and display the desired information on the on-board equipment.

③ Individual communication

Functions of ① and ② use one-way communication from the beacon. The individual communication function enables two-way message communication and vehicle operation control via bidirectional communication between vehicles and beacons.

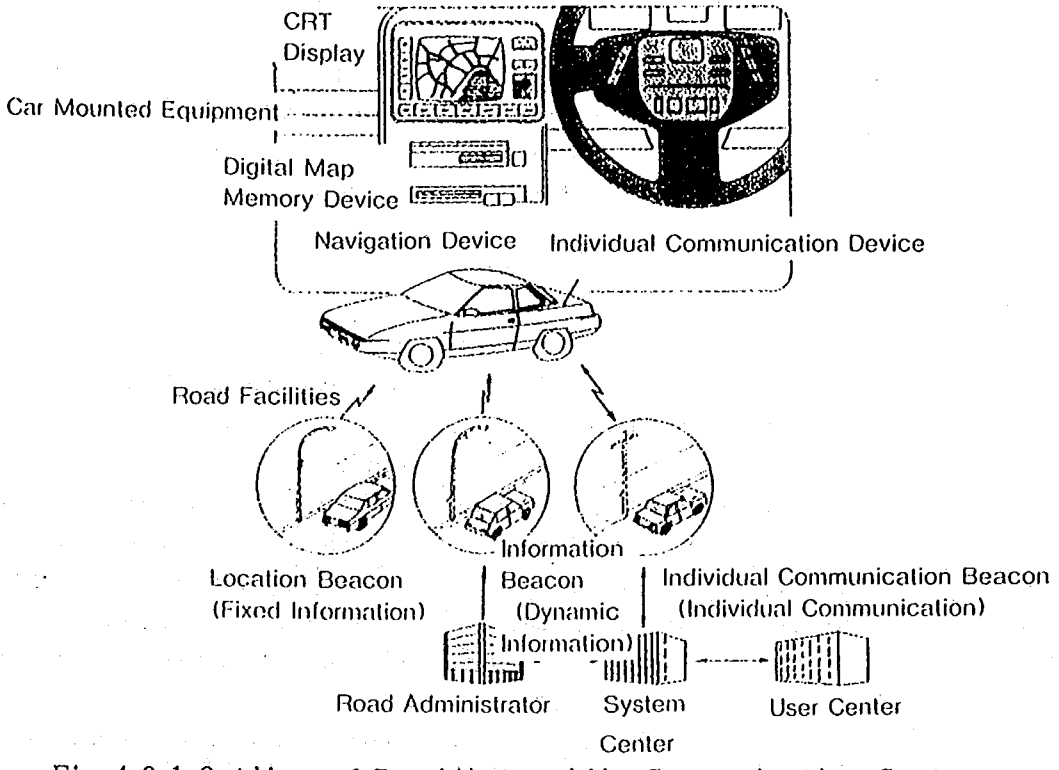


Fig.4.2.1 Outline of Road/Automobile Communication System

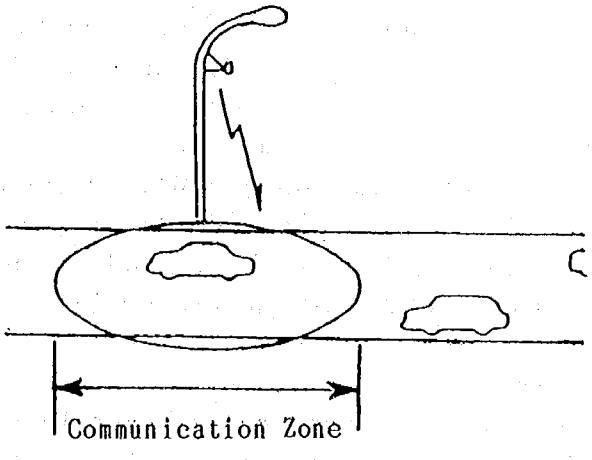


Fig.4.2.2 Intermittent Minimum Zone Method

b) Stage of development

Producing the basic functions and carrying out checks and tests was conducted up to fiscal 1989. Experiments included digital road map and on-board navigation functions; the verification of basic communication functions and position assessment of the beacon under quasi-microwave; dynamic information supply from the beacon; and two-way communication between vehicles and base stations via the beacons. Based on the results of these experiments, a scheme for beacon installation intervals an important element when putting the system to practical use, a standard format scheme for digital maps, and a scheme for the contents of dynamic information were developed. It is expected that this system will lead to smooth road traffic and the realization of advanced information services within cars.

This system was first reviewed in 1989 and is now being subjected to a final review as Vehicle Information Communication System (VICS system) for practical use in coordination with relevant Ministries and Agencies (National Police Agency, Ministry of Posts and Telecommunications).

(2) Advanced Road Traffic Systems (ARTS)

a) Outline of the system

Information density within the road space has markedly increased with the development of the Road / Automobile Communication System. However, drivers' needs on roads have been further diversified and sophisticated, and construction of a new road system is required in response to the above. Therefore, PWRI began research and development on Advanced Road Traffic Systems in fiscal 1989. This research intends to investigate an ideal approach to road traffic with higher safety and higher transport efficiency treating the road and cars as one united body, in anticipation of social needs for the coming generation.

An outline of some of the systems currently being developed is given below.

① Automatic tool collection system

This system identifies vehicle IDs at the tollbooth and automatically collects tool. This system would eliminate the need to stop motor vehicle and issue magnetic cards at the tollbooth and is thus expected to ; (1) eliminate traffic jams, (2) prevent rear-end collision and squeezing between cars, (3) decrease exhaust gas and noise from stopping and starting, and (4) save labor costs through unmanned tollbooth operation. (Fig. 4.2.3)

② Road surface condition detection

This system detects road surface conditions such as freezing on road surface and rainfall via weather sensors installed in roads, and supplies in real time this road information to drivers from roadside beacons. This system makes it possible to transmit road condition information accurately to the drivers. (Fig. 4.2.4)

③ Guidelight system

This system transmits the presence of a car in the opposite lane via luminous bands installed at curves in mountains where the view is obstructed. By the introduction of this system, the accidents of head-on collisions at the curves

can be reduced. (Fig. 4.2.5)

④ Headway and lateral control system

This system supports the running control of motor vehicles from roadside and controls the distances (intervals) from other motor vehicles traveling at the front and rear, and right and left, as well as the lateral distances between the car and road. Such a system can be used for automatic driving in the future. This system will supplement driver recognition, judgment and operation or even substitute for the driver. Effects of this system are to enhance the safety by preventing errors in driving operation and to improve transport efficiency by maintaining uniform, appropriate running conditions. Also, a number of variations can be considered in the controlled items and in systems. (Fig. 4.2.6)

b) Stage of development at present

For building various systems described in Par. a), various research and development themes must be reviewed. Therefore, as the first stage, basic research and development themes are being selected and reviewed. A fundamental research and development theme is that of communication technology for moving bodies. Communications for the Advanced Road Traffic Systems require (1) real time, (2) continuous all-time connection and (3) high reliability. As a communication method for fulfilling the requirements, a method of forming radio zones by leakage coaxial cables laid along a road has been proposed. For this purpose, testing is now under way on communication via leakage coaxial cables under quasi-microwave.

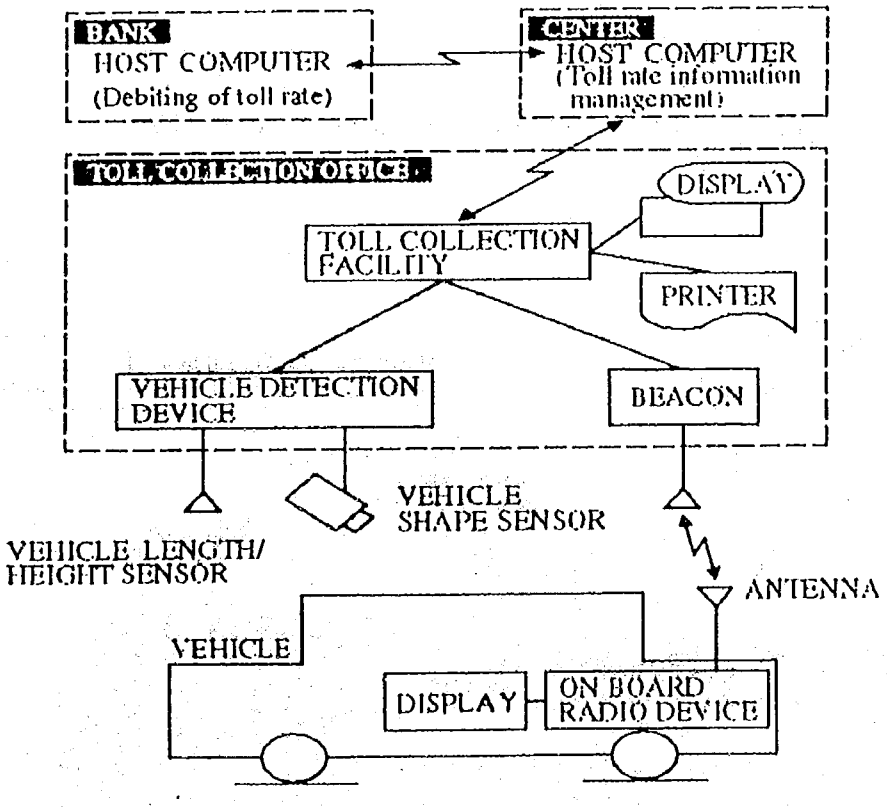


Fig.4.2.3 Automatic tool collection system

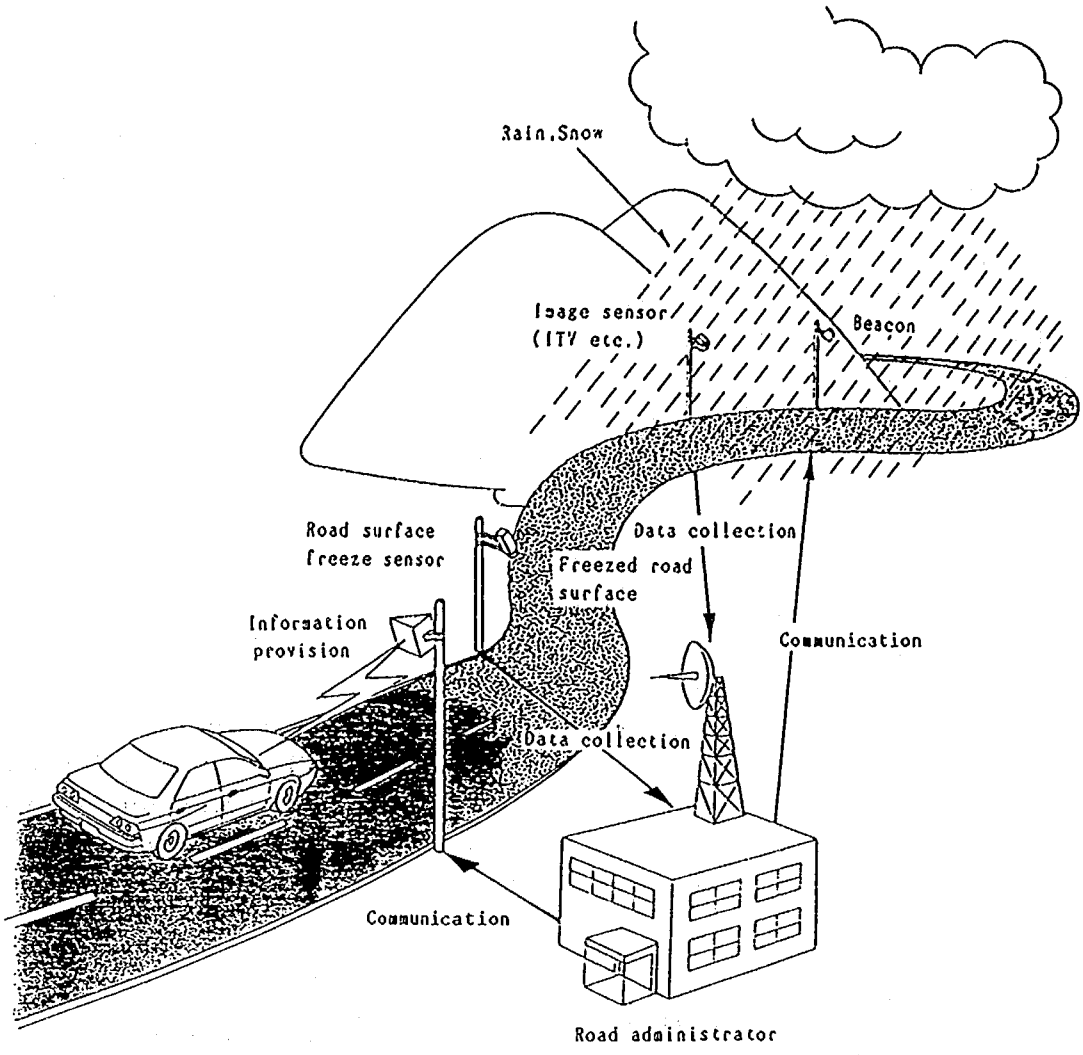


Fig.4.2.4 Road surface condition detection

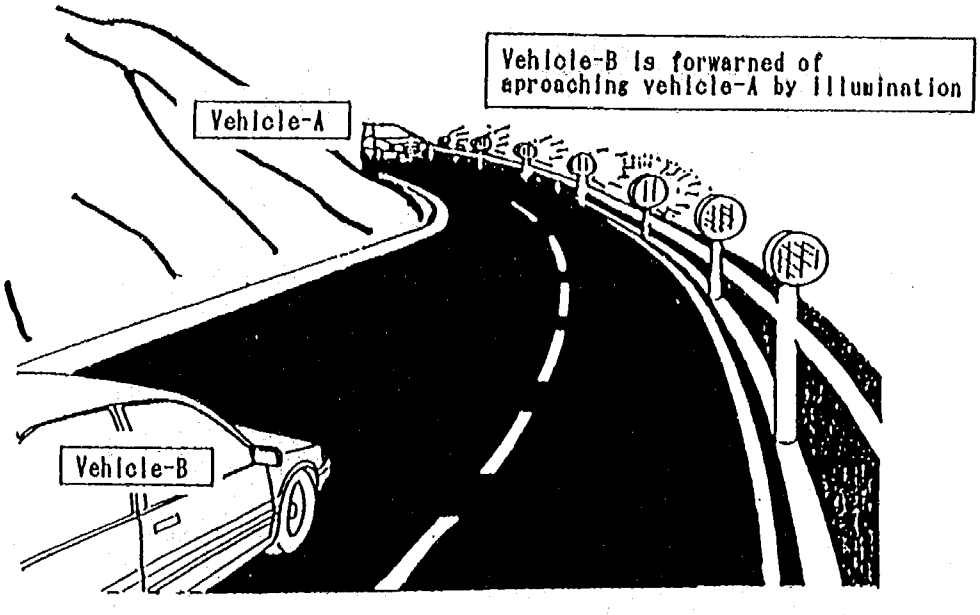


Fig.4.2.5 Guidelight system

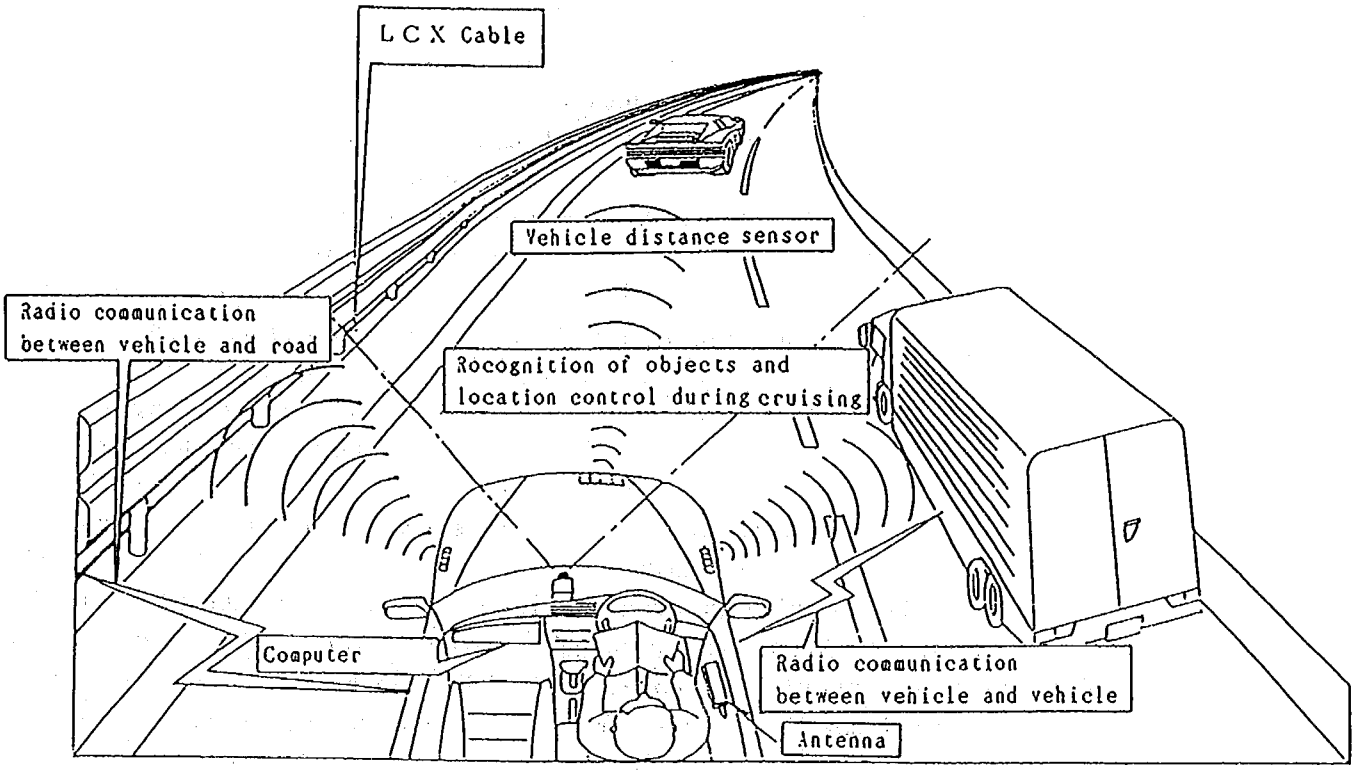


Fig.4.2.6 Headway and lateral control system

5) Problems in implementation

Both the Road / Automobile Communication System and Advanced Road Traffic Systems are comprehensive traffic systems, and in addition to the road technology various possible problems related to car technology and traffic operation technology must be examined. Coordination with the relevant bodies is thus considered an important issue.

4.2.4 Development of new construction technology in construction projects

1) Background and administrative needs

Investment in public projects in Japan is expected to play an important role in the business upswing and the expansion of domestic demand. However, the situation surrounding today's construction business is not bright. For instance, low labor productivity in construction business has long been a problem, and the aging of construction workers and a shortage of expert engineers and skilled workers is predicted for the future. These problems need to be solved quickly. In addition, working time is long, wages are low, and many tasks are dangerous, so that improvements in labor conditions and general working environment have been delayed, creating a major problem of young workers leaving the construction industry. Besides, before the arrival of the full-scale aging society expected at the beginning of the 21st century, the issue of housing and social overhead capital needs to be solved urgently. While dealing with existing problems within the construction industry, the construction business must also practice natural resources conservation and energy saving measures which are kind to the environment, must contribute to international society, and must create high quality living spaces corresponding to increasingly diversified life styles and individuality. This is an important role to be played by the construction industry.

To deal with these problems, the development of construction technology must be encouraged. The development of new technology for the automation and sophistication of construction works is now required in order to promote higher efficiency in construction projects by encouraging use of new technology at construction sites, and to promote labor saving, high-quality construction, higher safety and improved working environments.

2) Time period

From fiscal 1990 to fiscal 1994

3) Methodology

The Public Works Research Institute is developing automation technology such as robot-based construction and prefabrication technology in cooperation with researchers and engineers from universities and the private sector. Eight specific themes are set out as follows: (Refer to Fig. 4.2.7)

① Concrete structures and construction methods suited to automation, ② Automation technology in tunneling works, ③ Automation technology in the construction of bridge foundations, ④ Automated earthwork system, ⑤ Integration of automation technology in dam construction work, ⑥ Rationalization of paving machines, ⑦ Rationalization of work through use of secondary products and robotization, and ⑧ Development of rationalization technology utilizing precast form members. ①,③,④ and ⑧ are explained in detail below.

4) Research themes and results expected

(1) Research on design method and construction method of concrete structures suited to automation

Concrete products are characterized by one-by-one production specified for each structure because of special field conditions. Thus rationalization such as automated construction work has been delayed compared to other industries such as vehicles and household appliances, and many manual labor and skilled workers are required in all kinds of work, from the assembly of reinforcing bars to concrete placement.

In this research, therefore, the element technologies corresponding to the automated construction work is examined; the shape of structures is simplified; members are standardized; shape of reinforcing bars is simplified; reinforcing bars are bonded and assembled by welding; a prefabricated reinforcing bars system is adopted; concrete materials requiring no compaction are developed; and a new quality control method is established. Also, to enable the achievements of this research to reach construction sites quickly, the design and construction standards for reinforced concrete are reviewed, and standard designs of civil engineering structures corresponding to the construction rationalization are produced. By these achievements, a series of concrete operations can be rationalized, saving labor, reducing, hard work, and enabling low skilled workers to do the job. Also, automated construction work and work by robots in the future will be accelerated. All of these are expected to be useful strategies in response to the aging of workers and the shortage of skilled workers, problems become more serious every year.

(2) Research on automatic technology on construction work for bridge foundations

In recent years, construction conditions for bridge construction works have become more severe and the scale of bridges has greatly increased. Required conditions on construction are the reduction in workers, smaller construction yards, faster construction work and higher quality. To respond to these, a new method introducing precast construction of structural body of caisson and its automatic excavation and sinking system is being studied. Features of this method are shortened period of work and reduced number of workers on site, although the cost increases slightly in the existing estimation system. Its merit seems to be greatest however when considering the future.

(3) Research on automated earthwork systems

Earthwork is strongly influenced by natural conditions such as weather, topography and geology, and it was various natural materials such as sediments and rocks. The quality of the finished work is thus very much dependant on the execution plan and management. To improve execution plans and management, an integrated system capable of quickly collecting and processing the execution information, and of managing and controlling from a stage of the execution plan to that of execution management is now being developed. This integrated system has a design and execution data base where it records and arranges the construction work information collected on site and develops a program for the next step such as requirements for input of workers, materials and equipment

which determines the progress of work and performs computation and simulation, and also includes the development of equipments for collecting the information about completed work and quality control as well as centrally controlled automated earthwork machines. This system reduces the time and labor previously required for making execution plan such as filling and conveying on site, measurement of the work completed and work management for compaction control, thereby making construction planning easier and enabling the use of advanced construction management.

(4) Development of streamlined technology using precast concrete forms

In construction rationalization technology using precast concrete forms, the precast concrete forms are assembled on the site, secondary concrete is poured into the forms, and the forms are removed after construction work but are used as exterior walls. This rationalizes construction work by large-scale prefabrication method with mechanized work as prerequisite.

5) Problems in implementation

(1) Research on design method and execution method of concrete structures suited to automation

Conventional design concept in which initial construction cost is reduced by minimization of materials according to the most suitable design for each structure tends to prevent rationalization of construction work. To accelerate the rationalization, design concept must be shifted to new one in which, for example, a minimum man-hour is top priority and more simple designed section, more standardized sizes and prefabricated reinforcing-bar system are acceptable. Definitive strategies for the rationalization of construction work found in the present research will be reflected in various current criteria related to design and construction management for concrete structures without losing durability or functions required for conventional structures. Estimate criteria corresponding to the above then become increasingly important.

(2) Research on automatic technology in the construction of bridge foundations

Connecting joints for members required when producing the caisson body by precast method greatly affect the rigidity of the completed body. Reliability (such as durability) must therefore be high. Thus, the required rigidity and yield strength of the joints are almost the same as those of structure without joints, but usually fulfilling these requirements is very difficult. A design method which uses decreased rigidity at the joints is required.

Also, such a new construction method tends to have increased costs, thus it may be avoid to introduce in public projects. To solve this problem it is necessary to shorten the construction period for roads, thereby putting structures in service quickly to eliminate traffic snarl and to re-examine economic and social merits such as the response to the shortage of workers and aging of workers which paid little attention in conventional estimation systems, and to create a new system with which the new technology can be more easily utilized.

(3) Research on automated earthwork systems

In developing a program for supporting efficient on-site operation by collecting and processing construction work information, it is required to standardize the input/output information to enable general-purpose applications. This requires unification of specifications, widely different between orderers at present. In case people in charge of sites may not be familiar with keyboard operation, it is necessary to develop a system which permits the use of mouses or the like. With respect to equipments used for determining work completed and quality control, and automated earthwork machines, it is necessary to develop basic technology for improving the reliability of measured values and for instantly processing the measured values. Particularly, since the positioning technique for machines or moving equipment is vital for realizing the automation and sophistication of construction work, as is research and development of it is needed subject to accuracy measuring range and measuring speed required.

(4) Development of rationalized technology using the precast concrete forms

One problem with research on the precast concrete form method is to create one united body between the precast concrete forms and secondary concrete. Another is bondability between the concrete forms. Bonding between the forms and secondary concrete in the united body is also being studied, as is bondability between forms with respect to the structure of bonding portions; and shear box tests and beam bending tests have been conducted.

Further more in the area of construction management and materials research is being carried out for the concrete forms and secondary concrete materials, weight, strength, durability, filing control for secondary concrete. In the area of workability, forms producing method and carrying and assembling method are being reviewed, and the method of placing reinforcing bars is being studied.

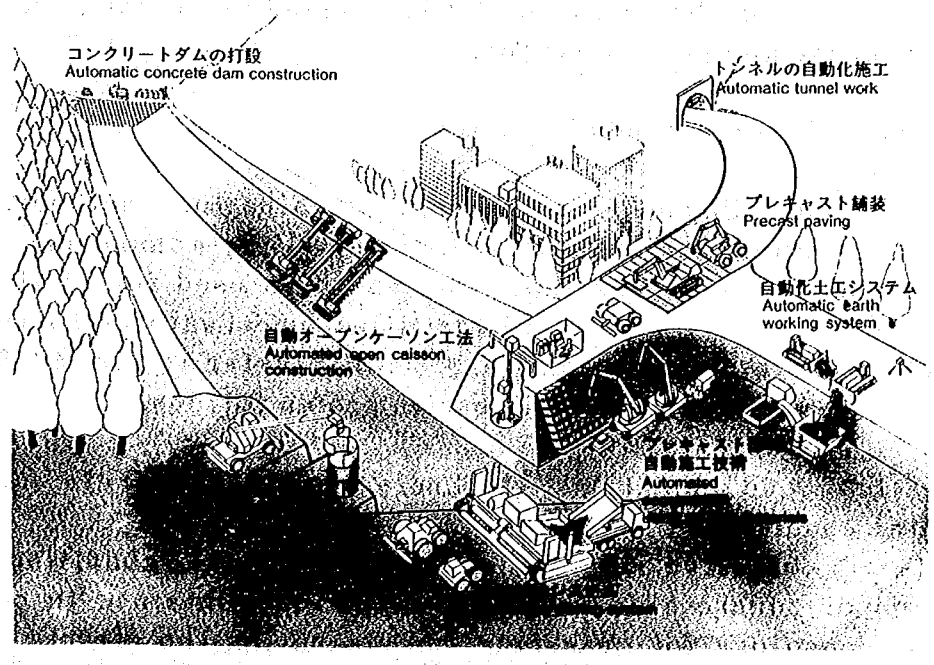


Fig.4.2.7 Development of construction technologies in civil engineering field

4.2.5 New Technologies for Improvement and Renewal of Social Resources.

1) Background and administrative needs

Public facilities and buildings which Japan's social and economic activities are based upon, have been steadily increasing and now Japan holds an enomous amount of stock. In order to maintain the good condition of these facilities and improve facilities in accordance with the development of society, the research on stodk technology such as evaluation method for value of these social resources and counter-measures against deterioration has become important themes at present. From this reson, and viewpoint of efficient investments, it is necessary to develop the technologies capable of adequately maintaining, managing and preserving the existing stodk and utilizing the stock to a maximum limit.

The intension of the present researchis, in response to the increase in social resources such as public facilities and buildings, to develop evaluation technology, and elemental technology for renewing and improving the functions and management systems for adequate maintenance, and to upgrade the quality of social resources.

Research is conducted by to both the Public Works Research Institute and the Building Research Institute, and the former is carrying out research on civil engineering structures among the social resources.

2) Time period

From fiscal 1991 to fiscal 1995

3) Methodology

The research and development will be conducted by the public Works Research Institute of the Ministry of construction cooperation with the researchers and engineers from universities and the private sector. For this purpose, a Council of scholars will be set up and the research will be carried out through joint research between the Government and private sector.

4) Contents of research and potential results

(1) Outline of research

Measurement and diagnosis technology, evaluation methods, elemental technology for renewing and improving functions, and management systems for adequate maintenance will be developed for concrete used for civil engineering structures, covered concrete, sewerage facilities, underwater structures such as water gate and drainage pump stations, and bridges (refer to Fig. 4.2.8). Detailed descriptions of research and potential results are as follows.

(2) Concrete

a)Instrumentation and diagnosis technology for concrete affected by environmental conditions

Concrete is affected by various environmental conditions including neutralization of concrete and corrosion of steel contained in concrete. We will develop technology for measuring and diagnosing the effects of the above by non-destructive measures.

b) Durability prediction for concrete

In order to adequately maintain concrete structures, it is necessary to judge the extent of deterioration based on a survey of the impact of environmental conditions on the concrete. The rate of deterioration of concrete is evaluated and the results are used in developing a method for predicting the durability of concrete.

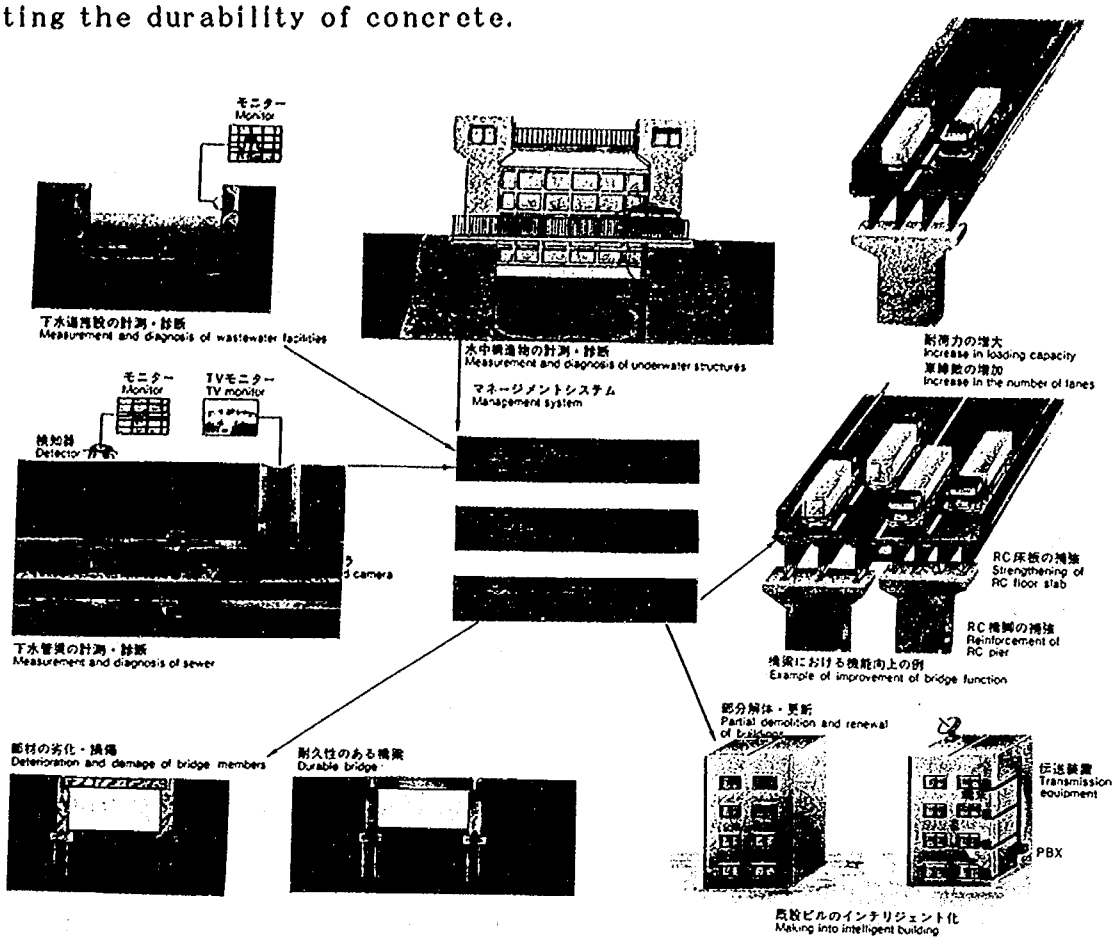


Fig. 4.2.8 Management System

c) Development of materials and methods for upgrading and improving concrete

Deterioration and control levels seem to vary depending on concrete structures, such as structures with the durability reduced after being affected by the environmental conditions, or structures currently being held relatively sound but this soundness is required also in the future. here, repairing and reinforcing methods suited to the control level and the degree of deterioration of concrete will be developed.

(3) Covered structures

a) Development of measurement and diagnosis technology for covered structures

We will develop techniques for measuring and diagnosing via non-destructive methods the effects of repair by covering on concrete structures deteriorated by alkaliaggregate reaction.

b) Development of materials and methods for upgrading and improvements by covering

We will develop new materials for scenery enhancement by covering and labor saving methods.

(4) Sewerage facilities

a) Development of measurement and diagnosis techniques for sewerage facilities

An investigation into the current status of maintenance and rehabilitation of sewerage facilities will be conducted, important elements for rehabilitation will be selected for wastewater collection and treatment facilities, and the measurement and diagnosis techniques for the deterioration and the degree of damage in the respective facilities will be developed.

(5) Underwater structures such as floodgates and drainage pump stations

a)Development of measurement and disgnosis techniques for underwater structures

With respect to the measurement and diagnosis of the conditions of members in water when maintaining or upgrading underwater structures, problems in existing technology will be reviewed and the diagnosis criteria review method will be systematized, and techniques for measuring and diagnosing the degree of deterioration will be developed.

b) Development of materials and methods for upgrading and enhancing underwater structures

For the upgrading and enhancement of structures in rivers, techniques for disassembling structures including underwater portions and functional enhancment must be developed. For this purpose, disassembly techniques will be developed for concrete and steel structures, as will enhancement techniques for replacing equipment and reinforcing members.

c) Management systems for underwater structures

In order to effectively and economically carry out maintenance and upgrading for underwater structures in watergates and drainage pump station facilities, elementary techniques for measurement, diagnosis and disassembly will be developed in a systematized and integrated management system.

(6) Bridges

a) Measurement and diagnosis technology for bridge

The increase in the number of bridges has seen more corrosion problems in steel contained in concrete due to salt damage as well as deterioration to substructures and reinforced concrete slabs. As diagnosis methods for such deterioration non-destructive (infrared, impact and electrical) methods will be reviewed and these measurement and diagnosis techniques will be established.

b) Development of soundness evaluation for bridges

Evaluation techniques for bridges are required for checking fatigue damage, deterioration to reinforced concrete slabs, and corrosion and deterioration of reinforced concrete slabs and concrete members. Fatigue tests and deterioration accelerated tests of members will be carried out with respect to the deteriorated damages, and evaluation techniques will be developed.

c) Materials and methods for bridge upgrading and functional enhancement

In order to renew and improve bridges, it is necessary to improve the load-withstanding forces of reinforced concrete slabs, girders and

substructures designed for small design loads. Use of precast members and repairing and reinforcing method utilizing outcables or the like increasingly viewed as a suitable technology for the above, will be upgraded.

d) Bridge management systems

In order to carry out maintenance and renewal for bridges effectively and economically, the elemental techniques such as measuring, diagnosing, evaluating and repairing will be systematized and integrated into a management system.

5) Anticipated Results

- Technologies for measurement and diagnosis manuals for evaluation methods, and manuals for maintenance, repair, and renewal of civil engineering structures.
- Management system for civil engineering structures.

4.2.6 Earthquake Protective Technology for Highway Bridges through Passive, Active and Hybrid Control

1) Background and needs

Since Japan is one of the most earthquake disastrous countries in the world, and earthquake tolerance is an important consideration in facilities design.

In particular, roads require necessary safety to enable efficient restoration and rescue activities after an earthquake. Among the road facilities, highway bridges, when damaged, require enormous amounts of time and labor for the restoration. Since the damage to highway bridges significantly affects on the community thus these bridges must have adequate earthquake resistance.

In recent years, "Menshin (base isolation) design," "active control design" and their combination, "hybrid control technology," have been put to practical use or are being developed as earthquake protective technology instead of conventional "earthquake-resistant design." Menshin (Base isolation) design is a design method to elongate the natural period of a structure and increase its energy absorbing performance, thereby reduce earthquake response of the structure. It is anticipated that bridges can be so designed that damages would be minimal even during a large-scale earthquake. The active control design method is to actively, control the response of a structure by special mechanisms or devices with external energy supply which are attached to the structure. In active control design, a bridge can be so designed that no response occurs at all. However, enormous amounts of energy are required to control the response of a structure during a large-scale earthquake, and so this method has not yet been put to practical use against earthquakes. For this reason hybrid control was conceived for effectively controlling the response of a structure within a practical amount of external energy. In hybrid control, the response reduced by base isolation design is further decreased by active control design.

In the present research, the development of menshin (base isolation)devices Menshin (base isolation) design methods, and the applicatablity has been carried out. At the same time, equipments and devices for active and hybrid control as well as control algorithin and design methods are being developed.

2) Time period

(1) Development of Menshin (Base Isolation) systems for highway bridge (fiscal 1989 to fiscal 1991)

(2) Japan-U.S. cooperating research on the hybrid control of seismic response to highway bridges (fiscal 1990 to fiscal 1994)

3) Methodology

(1) Development of Menshin (Base Isolation) systems for highway bridges

This research and development has been carried out jointly between the Public Works Research Institute and 28 private firms.

(2) Japan-U.S. joint research on the hybrid control of seismic response of highway bridges.

This research and development is being carried out jointly between Japan and the U.S.A. The Public Works Research Institute is carrying out the research activities in Japan and the National Center for Earthquake Engineering Research Center, the National Institute for Standard Technology, the Federal Highway Administration, and the University of California at Irvine are executing the research and development activities in the U.S.A.

4) Progress of research and potential results

(1) Development of Menshin (base isolation) systems for highway bridges

The objectives of the research is to develop Menshin devices and Menshin design method suitable for highway bridges in Japan.

This research was divided into four areas: ①development of Menshin devices for bridges, ②development of expansion joints and falling-off prevention devices for Menshin bridges, ③development of Menshin design methods, and ④application of Menshin design methods.

The following results are obtained from this research:

①Highway bridges with superior earthquake resistance will become possible to construct with earthquake-free design Menshin design.

②Results of research over three years was compiled "Manual for Menshin Design Methods for Highway Bridges (draft)" and passed on field engineers.

③A new Menshin device, "High Damping Laminated Rubber Bearings", was developed from an almalymation of domestic technologies (Fig. 4.2.9).

④By the adoption of the Menshin design, not only enhanced earthquake resistance but also super-multi-span continuous bridges with bridge length of 1 km class with better drivability and maintainability can be realized. (Fig. 4.2.10).

⑤30 Menshin bridges, designed by applying the results of the above research, are under construction or planning (four are already completed, see Photos 4.2.2 and 4.2.3).

(2) Japan-U.S. joint research on hybrid control of seismic response of highway bridges

In this research, active structural elements (active mass dampers) and passive structural elements (variable dampers) are being developed, and appropriate combination of the two are being studied.

Potential results from this research are:

①Significant improvement to earthquake resistance using hybrid control can be made (Fig. 4.2.11).

②Variable dampers in which the damping characteristic is variable dependent on the response of a structure, is being developed. The variable damper has functions as damper stopper, energy absorber and stopper for preventing excessive response with, buffer (Photo 4.2.4).

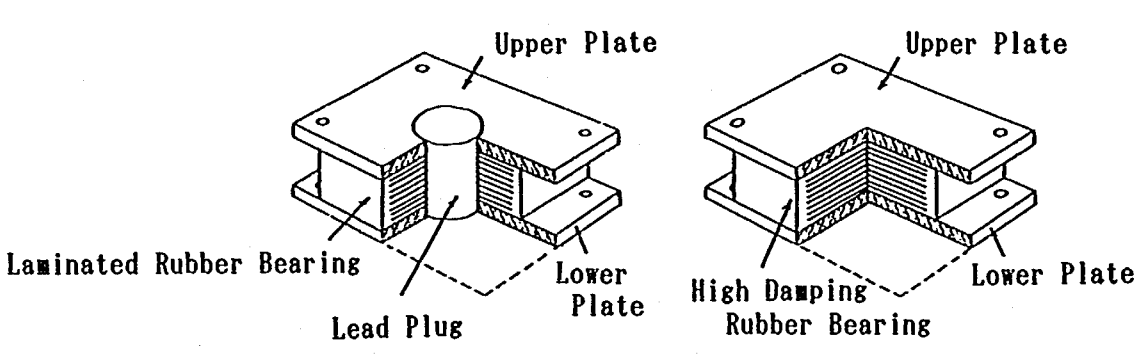


Fig. 4.2.9 Menshin bearings

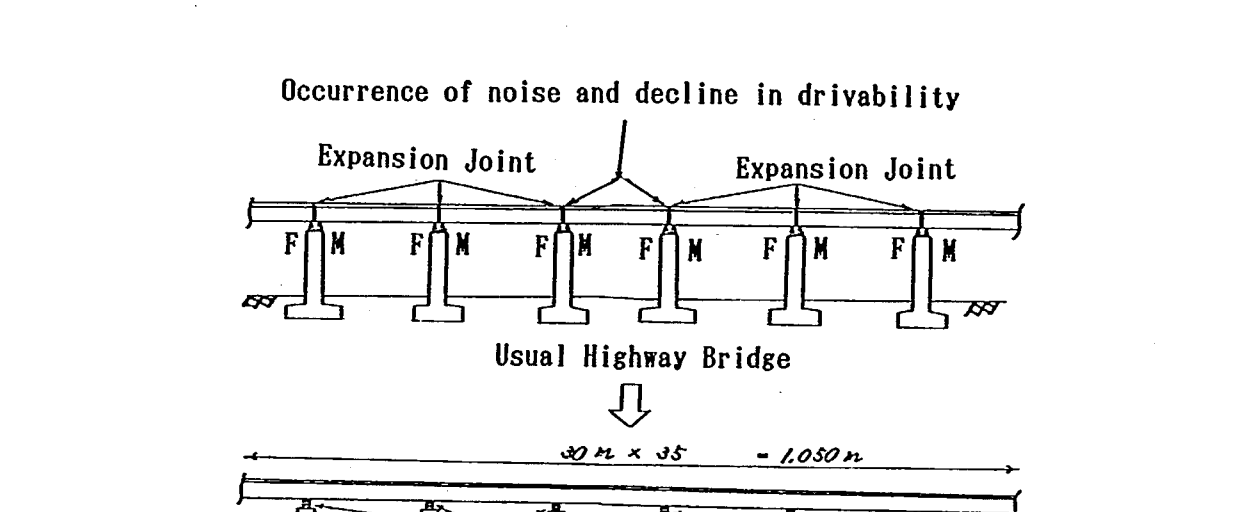


Fig. 4.2.10 Super-multi-span continuous bridge using Menshin bearings

Photo 4.2.2 Menshin bridge
(Miyakawa Bridge in Shizuoka Prefecture)

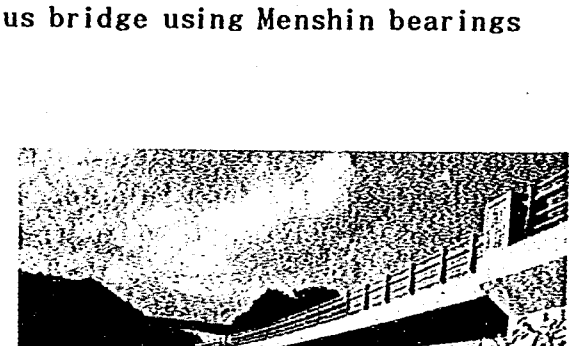


Photo 4.2.3 Menshin bridge
(Marukibashi-Oohashi Bridge in, Iwate Prefecture)

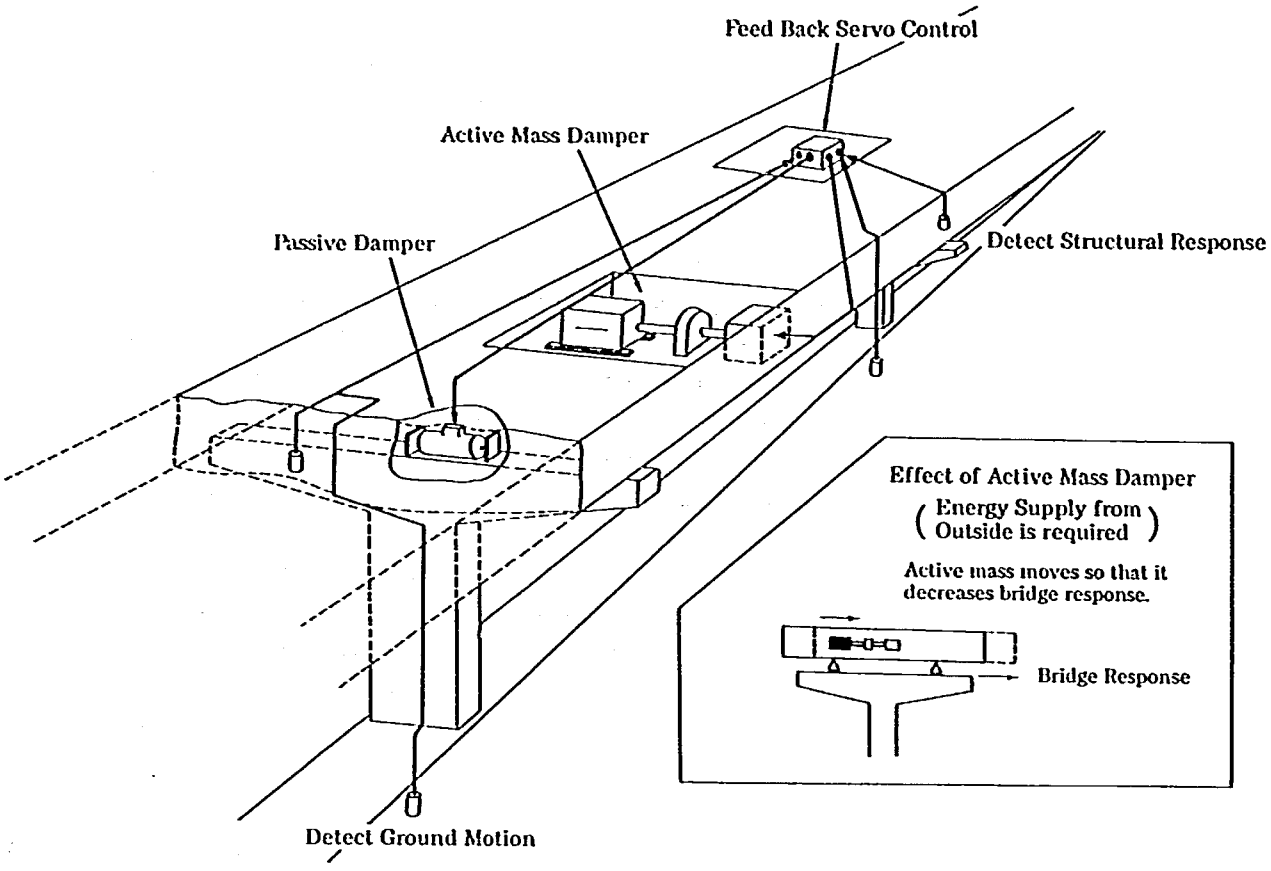


Fig. 4.2.11 Earthquake protective technology by hybrid control

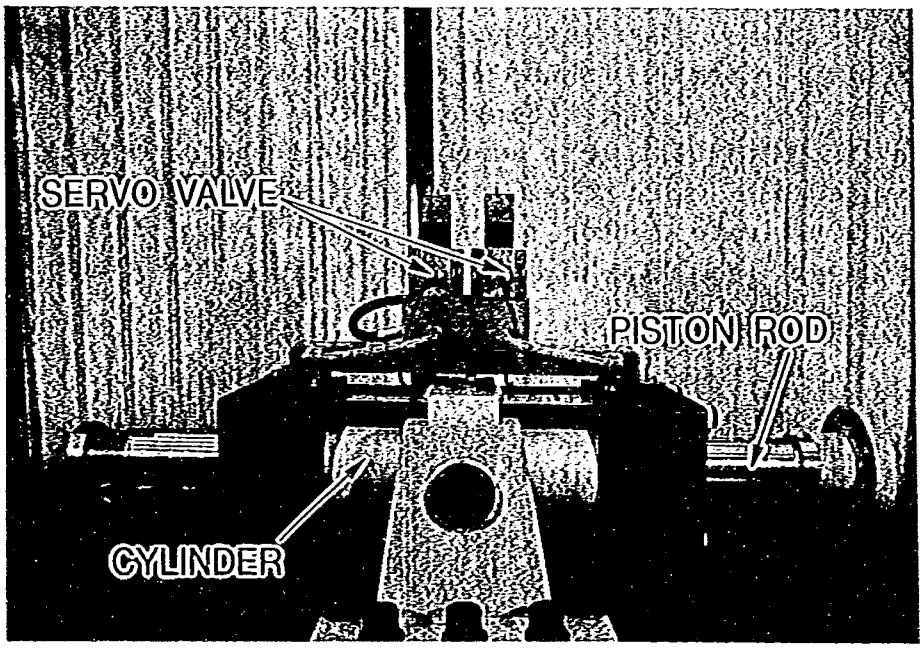


Photo 4.2.4 Variable damper

4.3 Research and Development Issues

Today, close to the 21st century, Japan has entered an age of stable economic growth. However various changes are taking place in society, including aging, internationalization, information intensification and others. In the Improvement of infrastructure, it is now necessary to promote research and development in construction technology in terms of the needs of citizens seeking fulfilment and amenities in line with the economic power of Japan. For this purpose, Japan needs to develop comprehensive disaster prevention systems, from the prediction and forecast of floods, sediment disasters and earthquakes to restoration technology, and also construction robots for safe, labor-saving work, future road technology, regional scenery design technology harmonized with the natural environment, and social overhead capital useage technology for cities, industries and living in new frontiers such as outer space, oceans and underground, which will program further through civil engineering technology and other advanced technology in the future.

Social overhead capital useage technology will provide better lives for people not only in Japan but also in developing countries. Civil engineering technology is the foundation of industries and is necessary for all countries for realizing safe, full lives, for freeing people from hard labor and for building comfortable traffic space International cooperation through researches, together with the passing on of advanced technology and technical guidance will become increasingly necessary.

The Public Works Research Institute has carried out many research and development projects in civil engineering technology, but people's needs and administrative needs are always diversifying. In order to respond to these needs, the Institute has to further promote the research system and make efforts to systematically maintain and upgrade some of the research equipment and facilities that have significantly deteriorated or become-dated. In the future, interdisciplinary research systems incorporating science in other areas such as biology, chemistry, information engineering and human engineering surpassing the conventional framework of civil engineering will become increasingly important. Moreover, it is vitally important to combine basic research in research divisions of universities with the specialized applied technological power of research divisions in the private sector, thereby organizing interindustrial research systems based a flexible linking of industrial, academic and governmental powers.

5. International Research Exchange Programmes in the Public Works Research Institute

5.1 The present situation of international research exchange programmes in the Public Works Research Institute

The Public Works Research Institute, a comprehensive national research organization concerned with technology aimed at developing infrastructure, has made great advances in its international research exchange programmes in recent years.

The international research exchange programmes promoted by the Public Works Research Institute include
1) research cooperation (exchanges of information via multilateral or bilateral cooperation; carrying out international joint research), 2) holding international conferences, 3) sending researchers/experts overseas, and 4) accepting overseas researchers/experts, students and visitors.

1) Research cooperation

Multilateral research cooperation has been carried out through the four organizations and on the six cooperating committees shown in Table 5.1.1. Apart from these, bilateral research cooperation has been carried out on 32 subjects with a total of ten countries in North America, Europe, and Asia within the framework of agreements for cooperation in science and technology. The cooperation includes participation in conferences, exchanges of documented information, human exchanges, joint research, and so on.

Table 5.1 International Research Cooperation by the Public Works Research Institute

(a)Multilateral cooperation

Name of organization	Names of cooperating committees
OECD	Road Transport Research Programme Steering Committee Road Transport Research Programme Expert Committee Road Transport Research Programme International Road Research Documentation (IRRD)
PIARC	International Road Conference
ESCAP	Economic and Social Commission for Asia and the Pacific
RILEM	International Union of Construction Testing and Research Laboratories for Materials and Structures

(b)Bilateral cooperation

Countries (No.of Subjects)			
Australia	(4)	Norway	(2)
Canada	(4)	Sweden	(2)
China	(6)	UK	(1)
Germany	(1)	USA	(8)
Italy	(2)		
South Korea	(2)		

Within the framework outlined above, about ten projects for joint research have been carried out every year since the Joint Research on Paving in Cold Area started with Canada in 1982. Joint research in fiscal 1992 is duly under way implemented in ten projects in fields such as the global environment, coasts, erosion control, roads, and earthquakes, with five partner countries (Australia, Germany, Indonesia, Thailand, and the USA).

2) International conferences

The main international conferences hosted by the Public Works Research Institute are shown in Table 5.1.2.

Table 5.1.2 Main international conferences hosted by the Public Works Research Institute

① 1) **The Conference on Public Works Research and Development in Asia**
2) 1992 ; research institutes and authorities in charge of public works in the Asian region
3) Has the objective of promoting exchanges in technological research and establishing a permanent network among the authorities concerned in order to contribute to proper social development and encouraging technology and researches in the countries of Asia, including Japan.

② 1) **The US-Japan Conference on the Development and Utilization of Natural Resources (UJNR) -- Panel on Wind and Seismic Effects**
2) 1969; the US National Institute for Standard Technology Research [NIST] and others
3) Has the aim of contributing to the advance of wind- and earthquake-proof technology in civil engineering and architectural structures. Has a long history of nearly a quarter of a century.

③ 1) **The Japan-US Committee on Hydrology, Water Resources and Global Climate Change**
2) 1991; the US Geological Survey [USGS] and others
3) Aims at exchanges of technological research and outcomes in surveys, understanding, and methods of assessment of the effects of changes in the global environment on hydrology and water resources at river valley level. This conference was launched in February 1992.

④ 1) **The Japan-US Workshop on Advanced Technology in Highway Engineering**
2) 1992; the US Federal Highway Administration [FHWA]
3) Aims at exchanges of technological research and development in all fields relating to highways. This conference was newly launched in November 1992.

⑤ 1) **The Japan-US Conference on Sewage Treatment Technology**
2)1971; the US Environment Protection Agency and others
3)Has the aim of solving issues such as preventing water contamination, high-grade processing of sewage, and improving convergence-type sewerage systems.

⑥ 1) **The Japan-Germany Workshop on Waste Water and Sludge Treatment**
2) 1982; the Karlsruhe Nuclear Research Institute and others
3) Aims at exchanges of technological research on waste water and sludge processing, with workshops held every other year in Japan and Germany alternately.

⑦ 1) **The Japan-Canada Conference on Paving in Cold Areas**
2)1982; the Ontario State Traffic Department and others
3) Aims at exchanges of technological research on road surface maintenance and management, new materials, and new construction methods for cold regions.

* : 1)Conference Name
2)Year of commencement; names of partner organizations
3)Outline

3) Sending researchers/experts overseas

Every year about 100 researchers/experts are sent overseas to attend events such as conferences and research meetings based on multilateral, bilateral, and other forms of cooperation, or to provide technological assistance via organizations such as the Japan International Cooperation Agency.

Apart from this, every year two or three researchers are sent to overseas universities and research organizations for a long-term research .

4) Accepting overseas researchers/experts, students and visitors

- Every year about 5-10 foreign researchers/experts are accepted, making use of the schemes of various countries, the Science and Technology Agency's fellowship scheme, and others, on the basis of multilateral and bilateral cooperation.
- Every year about 250 foreign trainees are accepted.
- Every year about 200 foreign visitors are accepted.

5.2 Problems in implementation

1) Research cooperation

Starting research cooperation depends on the availability of adequate technological research information relating to mutual research needs. However, it could hardly be said that there is any system yet in existence so as to enable an effective exchange of information. Thus, such a system needs to be created.

2) International conferences

The travel expense budget for invitations from abroad is inadequate. Effects should be made to increase invitation opportunities by making better use of the various schemes of the Science and Technology Agency, the training programs of the Japan International Cooperation Agency, and others.

3) Sending researchers/experts

The travel expense budget for overseas posting is inadequate. Attempts need to be made to increase the overseas travel expense budgets of the Construction Ministry and the Science and Technology Agency, as well as to utilize dispatch requests from public organizations at home and abroad such as the International Cooperation Agency, and so on.

4) Accepting overseas researchers/experts, students and visitors

Advance information on technology research, which is vital for successful acceptance program, is insufficient.

5.3 The necessity for and problems involved in implementing international research exchanges in the Asian region

- In recent years, problems which cannot be solved by one country alone have proliferated, and there is a growing need for fellow Asian countries to

cooperate with one another.

- Until now, the majority of research exchanges between Japan and other Asian countries has involved sending experts and receiving foreign trainees under the auspices of the Japan International Cooperation Agency. From now on, there will be an increasing need to intensify information networks on technological research, and to promote exchanges in fields of technological research and development on a broader basis.
- An adequate system for the exchange of technology research information needs to be created.

6. Disaster and Disaster Prevention

Japan is in a monsoon zone, and has high precipitation. So that it suffers from frequent flood damage and sediment-related disasters. Then, the islands of Japan are located on the edge of the Eurasian plate, where the Pacific Ocean plate and the Philippine Sea plate slip into the Eurasian Continent. As the result, Japan also suffers very frequently from volcanic eruptions and earthquakes. Moreover, as it is surrounded by the sea, it also suffers from many coastal disasters such as tsunami, storm tides and coastal erosion. In addition, as water demand has increased recently due to rapid population concentration and improved standard of living, serious drought problems occur when rainfalls is low. Therefore, the Ministry of Construction is actively tackling disasters related to river, coast, drought and sediment flow as well as earthquakes. More details on the measures being taken are given below.

6.1. River Disasters

6.1.1 River Disasters - Major Issues

Land conditions and meteorological conditions in Japan are characterized by steep topography, narrow plains, monsoon type rainfall and typhoons. Those will easily cause flooding. The country suffered from flood damage almost every year since ancient times. The numbers of dead and missing and the extent of damage were particularly big for the 15 years after 1945. Thereafter, flood damage steadily decreased because of flood control investment and fewer big typhoons on the mainland. Recently flooding of large area seldom occurs and the number of dead and wounded has fallen rapidly. However, the number and grade of flood control facilities are still not enough. After the 1960's, the Japanese economy showed very rapid growth. As the result, population and properties were concentrated in urban areas, especially in flood prone areas, and the form of flood runoff changed. The amount of properties damage caused by the flood of same size greatly increased. Although the annual flooded area is decreasing, the extent of damage to properties other than public works tends to increase slightly. (Refer to Fig. 6.1.1)

According to 1990 statistics, 86 people were killed and two missing as a result of floods damage during the year. Here floods include floods, high tides, tsunami, debris flows, landslides, and failure of steep slope. Approximately 160,000 houses were damaged and damage to properties other than public works amounted to 300 billion yen.

6.1.2 River Disasters and Disaster Prevention Technology at the Public Works Research Institute

1) Research on river hydraulics (Fig. 6.1.2)

Strategies for prevention of inundation in Japan include (1)the enhancement of river channel capacity through embankment, construction of floodway, dredging, etc., and (2)the reduction of peak flood discharge by retarding basins, construction of dams and reservoirs. A minimum safety degree of flood control is being achieved, though present status is still far from the ideal. At present on top of the old and

eternal problems, research emphasis is on the points shown in Table 6.1.1. The latest technologies aim to raise safety level and restore the charms possessed originally by the natural rivers themselves.

First is research on formulating river channel plans. Investigation is focused on a method of achieving a desired shape of river and a method for making a river which is stable for many years.

Second is research on river bank protection strategies. The Institute is studying the best approach to river bank protection which is both safe and harmonized with the environment.

Third is research on strategies against floods discharge of which is larger than planned floods. Development of design criteria on armor levees (overflow-resistant levee) to prevent levee collapse by withstanding overtopping of flood water has been established. Design criteria for super levees (high standard levee against abnormally large floods) is now being developed.

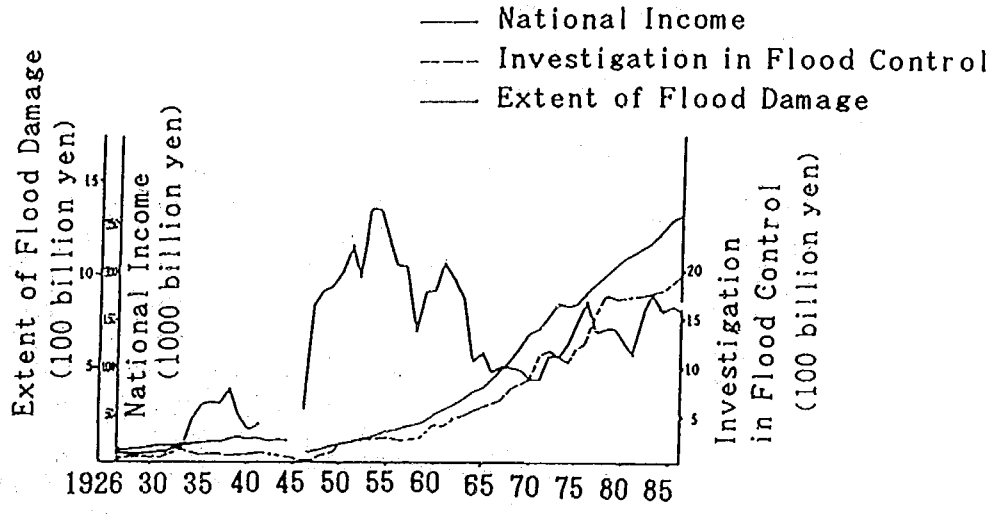


Fig. 6.1.1

Table 6.1.1 Research on river disaster prevention

Ploblems	Researches to clear problems
River channel design	Research on river channel improvement plan Research on estimation method longitudinal bed profile change Research on formation and erosion process of river bank Research on characteristics of river channel Research on measuring method for floods Research on arrangement method of river data
Protection of bank erosion	Research on design of bank revetment and foot protection Research on design of groyne works Research on strength of soil and bank against erosion Research on vane works and ripraps
Countermeasures against extraordinary flood control	Research on design of Armon Levee Research on design of Super Levee

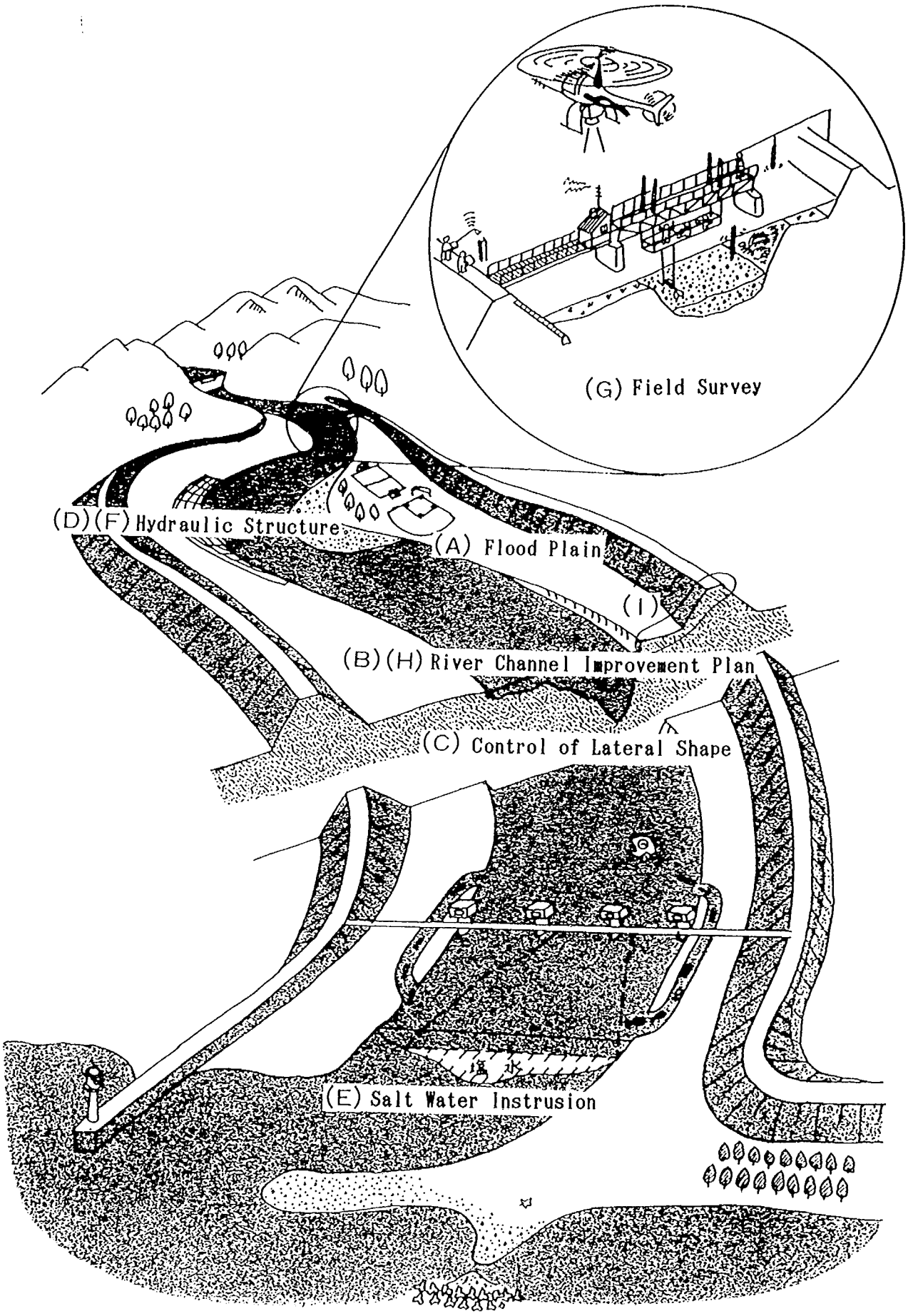


Fig. 6.1.2 Outline of research on river hydraulics

2)Research on hydrological process

In order to create safe and environmentally sound society by preventing flood disasters and securing water resources, it is necessary to study the water circulation in the natural world and to control water via engineering. The Institute has conducted three main types of hydrological research: (1) development of hydrological observation technology; (2) investigation and research into the river runoff; and (3) investigation and research into the influence of global environmental changes on river in catchment scale.

The most basic requirement for the prevention of river disasters is the development of hydrological observation technology for accurate measurement of discharge of rivers and rainfall in river basins. The Institute is now carrying out research and development work on (1) a precipitation observation system using a special radar (orthogonal two-polarized wave Doppler radar, Photo 6.1.1). The radar is hopefully to respond to specialized needs such as the enhancement of observation accuracy of rain and snow and the use of results in rainfall prediction. And (2) development of electromagnetic flow meter for open channels is also nearing to the completion.

Research and development is being carried out for a runoff model with distributed parameters. The model is capable of rational evaluation of model parameters from short-term hydrological data. The aimed model will be able to respond quickly to changes in the hydrological conditions in a river basin due to urbanization or climatological changes. Also, intensive hydrological observation is underway continuously. An atmospheric numerical model is being developed in order to enhance the accuracy of short-term prediction of precipitation.

Moreover, in order to predict the influence of climate changes upon river disasters and runoff forms of river basins, research into remote sensing technology using artificial satellites is being carried out. This technology will enable us to monitor the changes in hydrological conditions in global scales. Also the survey and research into estimation of changes in precipitation in river basin scale in Japan are being carried out.

3) Comprehensive flood control measures (Fig. 6.1.3)

In order to deal with flood control problems in urban rivers and basins, it is necessary to carry out ordinary river improvement work as well as various structural and non-structural measures within basins. The Institute is researching evaluation and plan formulation methodology of comprehensive flood control plan. River channel improvement, flood control facilities in the basin, flood relief measures and the zoning based on flood flow analysis are organically united in the comprehensive plan.

The Institute is conducting various experiments for verifying the regulating capacity of storage type runoff-control facilities in dealing with increased runoff. The Institute developed infiltration type runoff-control facilities. They are widely applied on the fields. It is also developing a runoff model capable of clearly establishing the effect of runoff-control facilities dispersed throughout the basins, for a small basin unit.

Moreover, the Institute is researching evaluation of the degree of danger of inundation using the results of inundation calculations, and has developed an

inundation simulation technology by two-dimensional unsteady flow model. Also, for the purpose of making an accurate prediction of flood flow behavior by numerical simulation, the Institute is now researching to revise modeling methods for flood flow and methods to set boundary conditions. It also is conducting model experiments to that target.

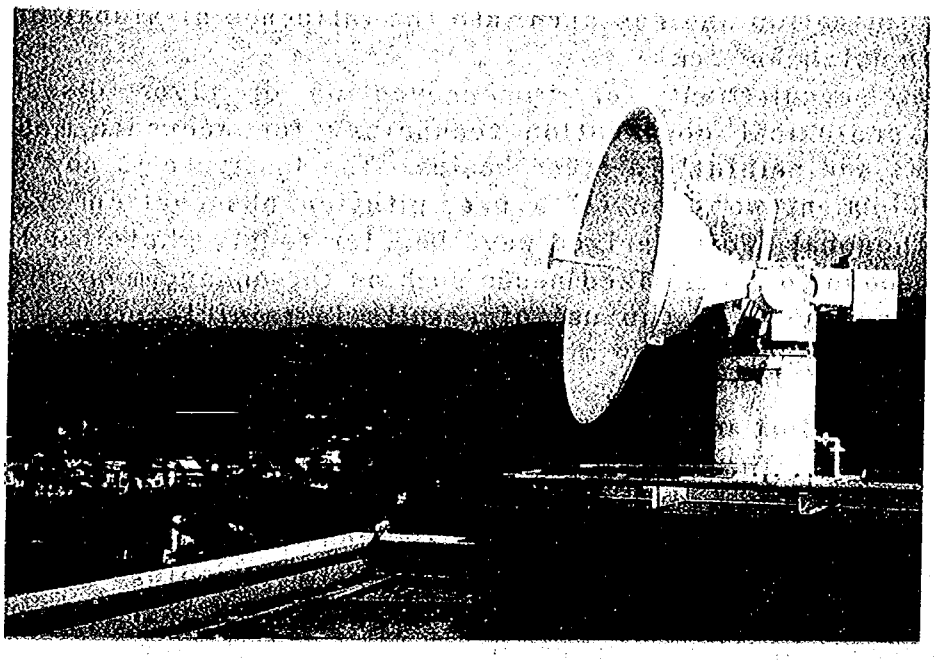


Photo 6.1.1 Orthogonal two-polarized wave Doppler radar

Fig. 6.1.3 Comprehensive flood control measures

4) Flood control plan by dam and the operation of reservoir

Flood hydrograph clearly shows the runoff characteristics of a river. Since the flood hydrograph is extremely sharp for Japan, flood control by dam should be very effective in principle. The Public Works Research Institute is researching various technical problems related to whole dam and reservoir construction works. Among these, the following points related to flood control planning and reservoir operation are being examined:

(1) Flood control techniques

We have reviewed flood control methods from the view point of effective utilization of completed dams. We reviewed the rationalization of dam operation and flood control effect in terms of the increasing number of dams and the decreasing number of skilled dam operators in the future. We are now studying flood control methods to make planning of dams and reservoirs that can be easily managed. We are also studying effective and manpower-saving dam management scheme.

(2)Freshet (Snowmelt flood) characteristics

Snowmelt flood tend to last a long time in heavy snow districts. This is a problem in dam management. Therefore, the Institute reviewed the characteristics of snowmelt and developed a snowcover - snowmelt flood model for continuous analysis from snow cover through to snowmelt flood. We also studied methods for applying the results of the model to the actual dam operation.

(3)Introduction of expert system into reservoir operation

In order to solve problems in dam operation due to the increased number of dams and the decreased number of skilled dam operators, the experience of skilled operators is currently being recorded. Construction of an expert system for aiding dam and reservoir operation is now under way.

6.1.3 Future Technical Issues Regarding River Disaster and Disaster Prevention Strategies

The current environment concerning river administration in Japan is changing significantly. Due to urbanization in river basins, water retention in basins has dropped, flood runoff volume increased, the time lag between rainfall and flood peak decreased, and river morphology changed rapidly. In addition to these rather technical problems, public demands on rivers have diversified: river area is considered as scarce open space; ecology and scenery in and around rivers are more and more esteemed. The public sense of value attached to these has grown higher in recent years.

Future technical issues will thus concern the more rational and efficient implementation of river channel improvement, river structure plans and flood control plans. Because of this, the Institute is required to research river channel plans, rivermouth plans, behavior of flood flows and evaluation of infiltration facilities.

Also, research will be carried out into techniques for designing lateral shape of river channel, river bank treatment using vegetation, and high standard levees. They are to be used to develop evaluation and design criteria for river structures harmonized with the surrounding environment. Moreover, with respect to prediction of river disasters and disaster prevention systems during floods, disaster prevention measures using minimal structures should be established. It will be achieved through researches on the application of rainfall and runoff forecasting and flood analysis.

Again, with respect to future problems in flood control by dams, research and development into efficient and simple operation of dams and reservoirs through the expert system is very important.

6.2 Coastal Problems

6.2.1 Coastal Problems and Related Issues

Japan's coast into has been repeatedly damaged by storm surges and tsunamis in the past. Typical storm surges include the Muroto Typhoon, which attacked Osaka Bay in 1934, and the Isewan Typhoon, which shuck Ise Bay in 1959. The Isewan Typhoon, in which tide level rose 1 m above the top of the sea wall along the coast between Nagoya City and Kuwana City, account for some 5,000 dead and missing. Tsunamis have also caused great damage, such as the Sanriku Tsunami in 1896 and 1933, the Chilean earthquake tsunami of May 25, 1960, and the tsunami caused by the Nihonkai-chubu earthquake on May 26, 1983. In recent years, there have been fewer incidents of this kind of disaster due to construction of breakwaters and sea walls. But on the other hand, beach erosion is progressing nationwide and beaches are rapidly disappearing. Loss of the beaches, which have wave dissipation effect may damage to sea walls and revetments during storm surge. This is highly in desirable. The causes of this beach erosion can be classified as follows: ① A structure such as a breakwater constructed in a coastal zone where the littoral sand transport is prevailing in one direction then blocks the sandtransport, and the beach down driftside of the structure is eroded because of the continuity condition of sand volume, ② A large-scale breakwater extended in to a sea area, forms a wave sheltering area behind, and leading to erosion and accretion in the vicinity, and ③ sediment supply from the rivermouth decreases as a result of construction of dam or river course improvement, thereby erosion occurs in the vicinity of the rivermouth.

The coast line has been eroded at many places throughout Japan mainly by the causes stated above, and countermeasures against beach-erosion is urgently required.

6.2.2 Coastal Problems and Disaster Prevention Technology at the Public Works Research Institute

The main coastal problems in Japan are beach erosion and storm surges. Counter measures against coastal erosion include the headland method, a technique for forming stable beaches, and the artificial reef method which attenuates the waves during storm surges. In the headland method, artificial headlands in a group are constructed at intervals on a long sand beach. Sandtransport is limited between headlands be sandvolume is conserved and coastline, stabilizing the coastline. This method was used on the and beach is stabilized Ohno Kashima Coast (Fig. 6.2.1). In the artificial reef method, rubble or concrete blocks are placed on the offshore sea bed to form a shallow sea area, and waves are dissipated by breaking and dissipating, thereby creating a calm area at the shore. Unlike detached breakwaters, artificial reefs are completely sunk under water so as not to spoil

the scenery. This method has been adopted on the Niigata coast and Itoigawa coast where its usefulness has been proved (Fig.6.2.2).

6.2.3 Future Technical Issues regarding Coastal problems and Disaster Prevention strategies

Living standards have risen significantly in Japan in recent years, and the Japanese people are now more interested in leisure and have greater awareness of environmental protection. Because of this, high quality planning considering the natural environment and usage characteristics are required, even in the shore protection works plans rather than merely emphasizing disaster prevention. In respond to these demands technical development for the purpose of harmonizing with shore protection and the coastal environment is now required. Examples are the development of new shore protection facilities such as artificial reef or gentle slope levees which take into consideration scenery and the use of coastline, and the development of the shore protection facilities which take into account the coastal ecosystem.

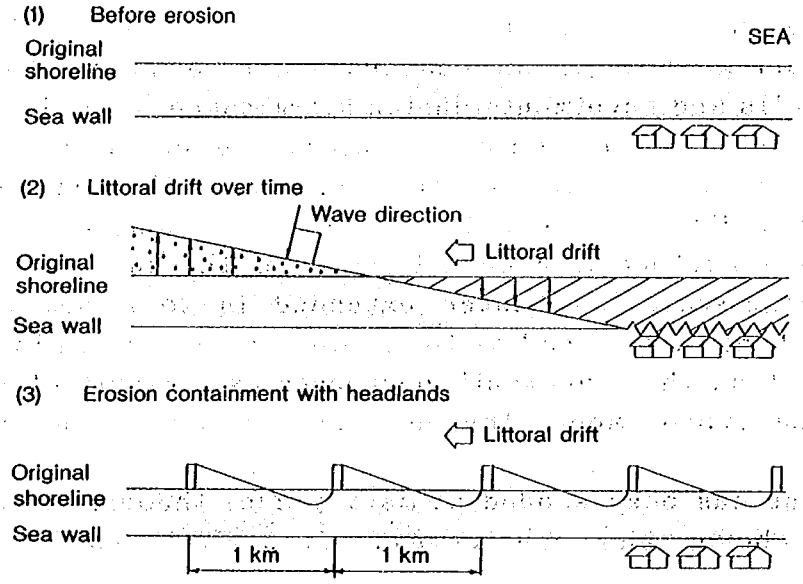


Fig. 6.2.1 Style of headland

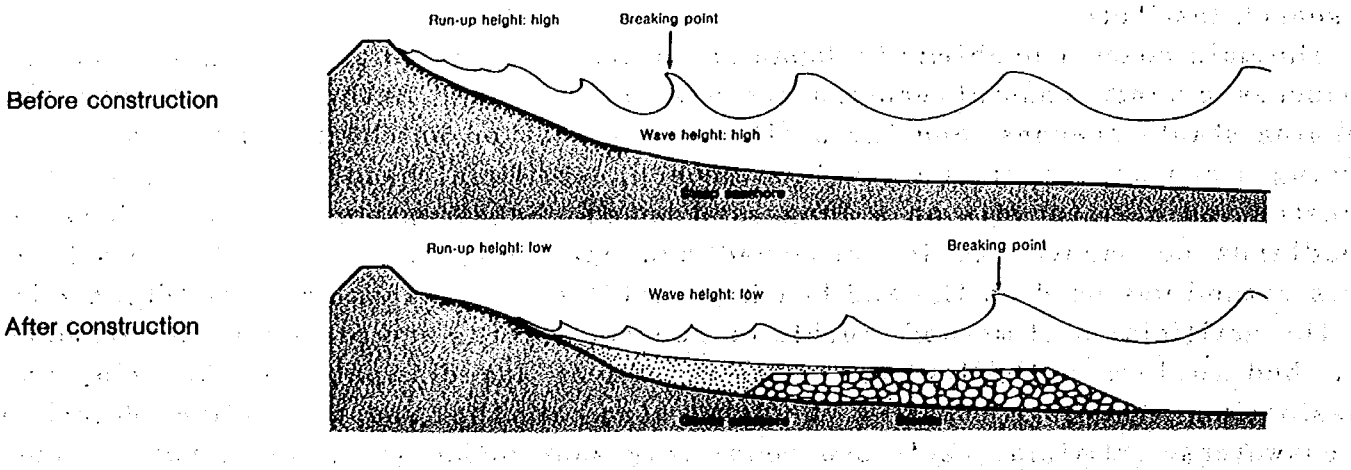


Fig. 6.2.2 Sectional shape of artificial reef method

6.3 Droughts

6.3.1 Droughts and Related Issues

The annual mean precipitation in Japan is a relatively large 1,750 mm, about twice the world average. However, the precipitation per head from the viewpoint of water use is only about one-sixth of the world average, and thus water resources in Japan are not necessarily plentiful. The breakdown by district reveals, significant differentials in the precipitation per head. Fir instance in the Kanto District, which its extremely concentrated population, precipitation is about one-quarter of the national average. Therefore there is a marked regional imbalance between the presence of water resources and water demand. In addition, rivers in Japan are steep and their flow behaviour fluctuates considerably, so that disadvantageous conditions exist from the aspect of water use.

According to secular changes in the mean annual precipitation observations at 46 stations across the Japan, the country has been in a rainfall phase since 1960 and very low rainfall has been seen in the last few years. The annual precipitation was below 1,500 mm in 1967, 1973, 1977, 1978, 1984, 1986 and 1987; in 1984 it was only 1,239 mm, the lowest for the past 90 years.

In recent years, drought have occurred very frequently, such as in Western Japan in autumn and winter 1984 and 1986, and over a wide area in 1987. Normally major droughts occurred during the summer season when water demand is high. But those in 1984, 1986 and 1987 had a quite different character, occurring in autumn and winter, over a wide area and for a long time. This clearly indicated an extreme weakness against drought, under scoring the importance of drought strategies. According to trend in water demand for the future, the water demand in 1995 is estimated to be about 105.6 billion cubic meters per year according to "National Comprehensive Water Resource Plan" formulated in 1987 by the National Land Agency. An increase in water demand of about 16.4 billion cubic meters per year from 1983 was estimated. To cope with this the Ministry of Construction formulated the "Water Resource Development Plan toward the 21st Century" in January 1988. This plan sets out about 340 water resource development projects such as dams which will secure about 49 million cubic meters per day of water resource development.

The Ministry of Construction has built multipurpose dams for flood regulation and maintenance of normal running water in addition to the supply of irrigation water. Together with dams in mountaineous regions, the Ministry is carrying out Comprehensive River Development Projects for retarding basins, lakes and swamps, middle stream weirs, rivermouth weirs and flow regulating rivers which connect several rivers together.

6.3.2 Drought Strategies at the Public Works Research Institute

Construction projects for dams as water resource development facilities are based on the widest technological range among other civil engineering projects. Construction technology has both software and hardware aspects. The Public Works Research Institute is researching the following technical issues related to the

overall construction of water resource development facilities.

1) Planning the water resource facilities
① Evaluating social and economic damages drought of in river basins
② Establishment of water use safety index
③ Evaluating water volume and water quality improvements
④ Planning drought facilities
⑤ Preparing ground surface water and underground circulation models in river basins

2) Operation of water resource development facilities
① Reservoir optimum operation method by evaluating probabilistic water use safety.

3) Influence of global warming on the water resources
① Influence of change in water circulation due to global warming upon water use safety at water resource development facilities

4) Design methods for dams and foundations
① Design method for dam body of concrete dam
② Streamlined earthquake resistance design for filldam
③ Design method for foundation bedrock
④Determining hydraulic characteristics and infiltration flow of filldam foundation

5) Rationalization of dam materials and construction methods
① Rationalization of concrete dam construction materials and methods
② Effective utilization of filldam materials

6) Hydraulic structures
① Design standardization for dam outlet
② Studies on high velocity flow
③ Development of new gate and valve technology
④ Research on water currents and vibration

7) Safety management of dam
① Safety management of concrete dams
② Measured behavior analysis for filldam

8) Sedimentation measurement
① Surveying the progress of sedimentation
② Development of design methods for sand removal facilities

6.3.3 Future technical tasks required for promoting drought strategies

Construction of the above must be carried out with a definitive vision for creating water resource development facilities for the next generation. For this purpose, the following technical problems must be solved:

1) Establishing planning and design methods for diversifying water resource development facilities

① Establishing planning and design methods for drought dams as abnormal drought measures and for underground dams and small-scale dams as local water resource measures

② Comprehensive evaluation methods for water volume, water quality improvement and recreation effects

2) Increasing complexity of operating methods for water resource development facilities

① Establishing comprehensive operation methods for the groups of water resource development facilities during abnormal drought

② Establishing an optimum operation method for evaluating water volume and water quality

③ Establishing an optimum operation method for reservoir considering water circulation in the lower reach of the dam

3) Overcoming dam foundation bedrock conditions

① Development of a method for changing the foundation bedrock to a physical condition suitable for dam foundation

4) Rationalization of levee construction materials

① Development of concrete dam design method which fully utilizes available construction materials

6.4 Sediment-Related Disasters

6.4.1 Sediment-Related Disasters and Related Issues

In Japan the topography is steep and geology is weak, and natural phenomena such as torrential rain, typhoon, earthquake and volcanic eruption are common. Mountainous areas are developed, which many people living on slopes and near mountains, and thus sediment-related disasters (Table 6.4.1), such as debris flow, landslide and slope failure, are common. Also, slope surfaces and slope failures, rock falls, landslides and debris flows occur easily along mountain roads, disrupting road traffic. Because of this, sediment-related disasters occur often, accounting for approximately 60% of total deaths and where abowts unknown due to natural disasters (Fig. 6.4.1).

In order to reduce and prevent sediment-related disasters the Ministry of Construction and prefectural governments are carrying out various measures in accordance with Sabo Law, Landslide Prevention Law and the Law concerning prevention of disaster due to collespse of steep slope land.

In sabo (erosion control) projects, hillside work for greening an devastated area in the upper reach of river is carried out to prevent lage great volumes of outflow of sediment from devastated mountains, and sabo dams and channel works are constructed in devastated torrents. Also, in order to prevent debris flow disasters, both active measures such as sabo dams, retarding basins and channel works for installing debris flow measure facilities, and passive measures such as the establishment of warning and evacuation systems are being carried out.

Also, the measures for preventing the sediment-related disasters accompanying volcanic eruption (such as volcanic mudflow, pyroclastic flow and lava flow) and sediment-related disasters due to rainfalls in volcanic areas are being carried out.

In order to prevent disasters due to landslides, landslide countermeasure projects are being carried out in areas where the landslide hazard areas are concentrated and the degree of danger is high. Also in recent years, landslide prevention works are being carried out in urban areas, where the degree of danger is increasing. Moreover, comprehensive landslide stategies, including passive measures such as monitoring landslides, establishing warning and evacuation systems as well as effective use of slope space and removed groundwater, are being carried out.

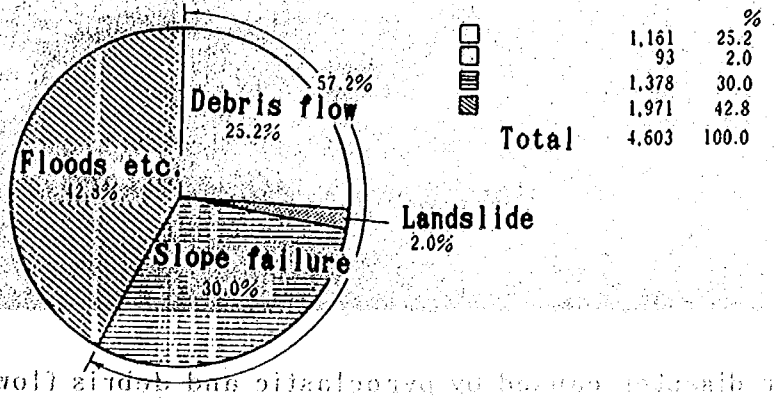
In dealing with slope failures, work to prevent the collapse of steeply sloped land is carried out, as is restriction of harmful acts that may invoke or trigger collapses, recommendations to more house from dangerous areas, establishment of warning and evacuation systems, designation of disaster hazard areas, and works to prevent collapse of steeply sloped land. This last work is carried out by prefectural governments with the support of Government subsidies.

To prevent sediment-related disasters on roads, disaster prevention inspections have been carried out throughout the nation, and disaster prevention works are carried out in areas requiring work. Moreover, in areas containing mamy dangerous to cations, a reference rainfall depth is established and traffic restrictions

brought in when danger is anticipated. The "Road Earthwork Guide" and "Rock Fall Measure Handbook" are produced as technical guides for designing road structures which can cope with sediment-related disasters.

Table 6.4.1 Difference between debris flow, landslide and slope failure

	Debris flow	Landslide	Slope failure
Outline	Debris flows generate in steep streams with more than 15° river bed gradient in general. Those velosities are very high. Most of them deposit at the river bed or grand with 2-3°	Mass of soil on gentle slope moves down very slowly.	Slopes with more than 30° collapse suddenly and the soil fall down quickly.
Occurrence	Outbreak	Continuance, Recurrence	Outbreak
Movement of soil	Large boulders are concentrated in front part, and mud flow follow it.	Masses of soil move down with original shape without disturbance	Collapsed soil is strongly disturbed
Volume :average	About 30,000m³	About 1,000,000m³	About 400m³
Dangerous sites	70,434 streams	10,288 slopes	81,850 slopes
Standard of assessment on dangerous sites	Streams which originates at the first-order stream and ends at the stream gradient with 3° . Moreover, there is either more than five residential houses or governmental offices, a school, a hospital, a railroad station, a hotel, or an electric power station.	Slope which is in danger of landslide	Steep slope with more than 30° and 5 m in hight , including manmade slope. Moreover, there is either more than five residential houses or governmental offices, a school, a hospital, a railroad station, a hotel in hazardous area.
Law Year enacted	Sabo law 1897	Landslide prevention law 1958	Law concerning prevention of disaster due to collapse of steep slope land 1969
Project	Sabo works	Landslide prevention works	Slope failure prevention works



		%
	1,161	25.2
	93	2.0
	1,378	30.0
	1,971	42.8
Total	4,603	100.0

Fig.6.4.1 Number of deaths and where abowts unknown due to natural disasters

6.4.2 Sediment-Related Disasters and Disaster Prevention Technologies at the Public Works Research Institute

With respect to the debris flow measures, debris flow observations are being carried out at tge sites, and the occurrence, flow-down and deposition mechanism of the debris flows is being studied. Also, new debris flow facilities such as bottom water draining screens have been developed. Recently, the debris flow flood area prediction technique using numerical analysis method (simulation) by computer is being studied. In addition, the movement of flowting logs, which magnifies the damage wrought by sediment is being studied. On the other hand, slit sabo dams, sabo dams with large culvert, sabo dams with gates and other new structures are being considered as potential new methods for increasing sediment regulating and sediment capturing by the sabo dams. Based on the importance of the prediction of sediment yield by collapse, hydrological observation and infiltration experiments on slopes are being carried out.

As to sediment-related disasters in volcanic regions, the importance of volcano monitoring systems was seen in the sediment-related disasters accompanying with the eruption of Mt. Unzen in 1991 and 1992, and the surveys of the pyroclastic flows are now being carried out. (Photo 6.4.1)

Photo 6.4.1 Major disaster caused by pyroclastic and debris flows at Mt. Unzen in 1991-1992

6.4.3 Future Technical Issues regarding Sediment-Related Disaster Prevention strategies

In order to clarify movement during landslides field surveys, laboratory tests and fundamental research is being carried out. Also, research into landslide strategies accompanying factors such as road construction and dam filling is being carried out. Moreover, to establish landslide survey and prevention works corresponding to topographical and geological conditions, landslide surveys are being carried out in model areas. Based on these, guidance on the landslide survey method and prevention works is being given at sites owned by the Ministry of Construction and local public bodies.

With respect to slope failure, new works such as the steel bar insertion method are being developed in order to promote consideration of the surrounding environment in steep slope land work. For warning and evacuation systems, surveys are being carried out to develop collapse prediction techniques, setting methods for collapsed sediment, and the establishment of warning and evacuation criteria.

To deal with sediment-related disasters on roads, the improvement in accuracy of slope stability evaluation is being studied, a rational design approach for rock fall protection works is being reviewed, and new slope disaster prevention works such as the steel bar insertion method are being developed.

Technical Problems in Issues regarding Sediment-Related Disaster Prevention Strategies

To conserve the environment of torrents, it is necessary to review sabo facilities taking account of the environment. Also, it is necessary to improve techniques for using hillside works while natural land is being lost and turned into desert on a global scale. It is necessary to develop new debris flow facilities and a more accurate debris flow prediction method. New countermeasures be developed for preventing or reducing volcanic mudflow, pyroclastic flow, and lava flow accompanying volcanic activities. Monitoring equipment for these should be developed together with a system for accurately and quickly transferring the data to the persons in charge.

In the landslide research, clarification of the mechanism of the sliding surface formation has become an important issue. With respect to the slope along roads in mountains, it is necessary to review the stability of rocks prone to cracking, long-term prediction of slope instabilization and long-term instabilization of landslide slopes due to earth cutting. With respect to slopes near reservoirs, it is necessary to deal with the issue of design methods for anchor works and techniques for judging landslide hazard areas. Also in order to determine the distribution of landslide hazard areas, the accuracy of landslide hazard evaluation method needs to be improved. Recent research has to cussed on the development of methods for judging sliding surfaces in model areas, and the evaluation of global climatic changes on landslides.

Accuracy of slope failure prediction must also be improved in the future. Also, improvement of accuracy of setting hazard area is required. Also, strategies for preserving and regenerating natural land should be encouraged particularly in urban areas.

As to sediment-related disasters on roads, it is necessary in the future to improve the accuracy of prediction techniques for hazard areas, to develop a method of evaluation of countermeasure works and to develop a method for establishing traffic restriction criteria based on the relationship between rainfall and disaster occurrence. It is necessary to develop new countermeasure works which are safer, economical and for environmentally sensitive.

6.5 Earthquakes

6.5.1 Earthquakes and Related Issues

Japan is located where the Pacific Ocean and Philippine Sea plates slip under the Eurasian Continent, and is thus subject to frequent earthquakes. Japan has one of the highest rates of occurrence of earthquakes in the world. Fig. 6.5.1 shows the distribution of earthquakes in Japan and the vicinity for the past 100 years. However Japan has not had an earthquake causing dead or missing persons since the 1987 Chiba Tohooki Earthquake, the Kushiro Oki Earthquake (M=7.8) has occurred in January 1987. Therefore, earthquakes of M8 class occur once every 10 years, M7 class once every six months and M6 class earthquake once per month on the average, so the situation is not optimistic. Recently, tremendous damages have been caused by earthquakes in the United States, Turkey, Philippines, Indonesia, Costarica and elsewhere, and this is seen as a warning to Japan.

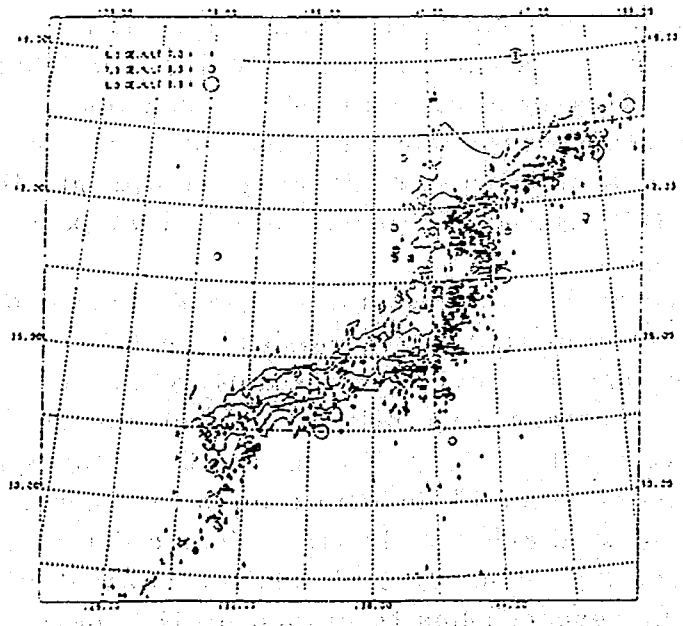


Fig. 6.5.1 Recent earthquakes in Japan
(1985 to 1988, depth of hypocenter 60 km)

Table 6.5.1 Major earthquakes in Japan

Name of Earthquakes	Date of Occurrence	Magnitude	Deaths
Kanto Earthquake	9/ 1/1923	7.9	142,807
Tonankai Earthquake	12/ 7/1944	7.9	1,223
Nankai Earthquake	12/ 21/1946	8.0	1,432
Fukui Earthquake	6/28/1948	7.1	3,895
Tokachi Oki Earthquake	3/ 4/1952	8.2	33
Chile Earthquake Tsunami	5/23/1960	9.5	139
Niigata Earthquake	6/16/1964	7.5	26
Tokachi Oki Earthquake	5/16/1968	7.9	52
Izu-Hanto Oki Earthquake	5/ 9/1974	6.9	30
Izu-Oshima Kinkai Earthquake	1/14/1978	7.0	25
Miyagiken Oki Earthquake	6/12/1978	7.4	28
Nihonkai Chubu Earthquake	5/26/1983	7.7	104
Naganoken Seibu Earthquake	9/14/1984	6.8	29
Chiba Tohooki Earthquake	12/17/1987	6.7	2
Kushiro Oki Earthquake	1/15/1993	7.8	2

More than 100 years has passed since the Nomi Earthquake (1881, M=8.1), 70 since the Kanto Earthquake (1923, M=7.9) and 30 since the Niigata Earthquake (1964, M=7.5). At present, people fear a Tokai Earthquake and the also an earthquake directly under the Kanto District. Earthquake measures are being under taken by the Government. Table 6.5.1 shows major earthquakes in Japan. It should be noticed that the type of earthquake varies depending on the location and social situation at the time. For instance, in the 1976 Izu-Oshima Kinkai Earthquake in 1976 and the 1984 Naganoken Seibu Earthquake in 1984, the characteristics of slope failures in mountain regions were similar to the 1990 Philippine Earthquake in 1990; the 1978 Miyagiken Oki Earthquake in 1978 was an urban disaster similar the 1989 Roma Prita Earthquake, 1989, U.S.A.; and in the 1983 Nihonkai Chubu Earthquake in 1983, the tsunami were the same as in the 1992 Nicaragua Earthquake and the 1992 Indonesia Earthquake. As stated above, the nature of the disaster depends on the location of the earthquake and on land use in the area. Thus, earthquake disaster prevention is required for every possible scenario. In this country where population and infrastructures are densely concentrated, earthquake disaster prevention measures are urgently required in urban areas. The 1923 Kanto Earthquake occurred on September 1, 1923. September 1 was later established as "Disaster Prevention Day" and earthquake disasters prevention drill involving inhabitants held every year in order to be prepared for earthquakes.

6.5.2 Earthquakes and Research and Development at the Public Works Research Institute

As part of the comprehensive research and development for integrating Ministry

of Construction earthquake disaster prevention, "Development of new earthquake resistance design methods" (fiscal 1972 to 1976), "Development of earthquake restoration technology" (fiscal 1981 to 1985) and "Development of disaster information systems" (fiscal 1981 to 1985) were carried out.

Table 6.5.2 Main earthquake resistance design criteria for civil engineering structures in Japan

Name / Year of Establishment, Revision
Specifications for Earthquake-Resistant Design of Honshu-Shikoku Bridges/1967
Specifications for Earthquake-Resistant Design of Highway Bridges/1971, 1980, 1990
Specifications for Earthquake-Resistant Design of Submerged Tunnels/1975
A proposal for Earthquake-Resistant Design Methods/1977
Guidelines of Earthquake Resistant Design for Water Supply Facilities/1979
Guidelines of Earthquake Countermeasures for Sewage Facilities/1981
Technical Standards of River and Erosion Control Facilities (Proposal)/1986
Manual for Repair Methods of Civil Engineering Structures Damaged by Earthquakes (Proposal)/1986
Design Guidelines for Common Utility Ducts (Proposal)/1986
Manual for Retrofit, and Post-earthquake Methods of Road Facilities/1988
Guidelines for Earthquake-Resistant Design of Akashi Kaikyo Bridge(Proposal)/1988
Specifications for Earthquake-Resistant Design of Fill-type Dam (Proposal)/1991
Manual for Menshin Design of Highway Bridges (Proposal)/1992
Specifications for Design and Construction of Parking Garage/1992
Guidelines for Disaster Information System (Proposal) /1992

Also from fiscal 1992, "Development of earthquake disasters prevention technology in large urban areas" was begun, and the research and development on earthquake disaster prevention technology on soft ground will be carried out for the next five years.

Research on earthquake resistance design criteria is being carried out to developing earthquake resistance design techniques for civil engineering structures such as highway bridges and common utility ducts, and these achievements are reflected in earthquake resistance design criteria. Table 6.5.2 shows the main earthquake resistance design criteria in Japan. Research findings by the Public Works Research Institute are used as the basis of these criteria.

Recently, we have been carrying out research and development on new technology such as the characteristics of earthquake motions, ground flow due to liquefaction, Mention Design Method and Active Control for bridges, and have made many achievements.

6.5.3 Future technical Issues regarding Implementation of Earthquake and Disaster Prevention strategies

The principal technical problems to be investigated in carrying out the earthquake countermeasure works in the future are as follows:

1) Expansion of strong motion observation system and development of technology to apply its for restoration

Strong earthquake observation is the basis of the development of earthquake countermeasure techniques such as the earthquake resistance design method. It is required that such earthquake observation networks should be maintained and expanded. Table 6.5.3 shows the present situation of the strong earthquake observation in the facilities under the jurisdiction of the Ministry of Construction; strong motion seismographs must be newly installed and old seismographs have to be replaced. In this case, an online observation network will be provided, so that strong motions can be utilized even for restoration activities after an earthquake, thereby enabling multipurpose use.

2) Development of earthquake resistance evaluation techniques for soft ground and countermeasure techniques

Since the soil liquefaction is closely related to damage, a method for predicting potential and countermeasures must be developed.

Table 6.5.3 Situation of Strong Motion Accelerograph Installation for Public Works Facilities (As of March 31, 1992)

Facility	Number of Site	Accelerograph Type		
		SMAC Type Number of Site (Number of Accelerograph)	Electromagnetic Type Number of Site (Number of Component)	Newly Developed MOC Type Number of Site (Number of Accelerograph)
Road Facility (Brige, Tunnel, Ground where Construction is arranged)	176	126 (251)	30 (389)	20 (108)
River Facility (Embankment, Weir, Flood Gate)	49	25 (51)	6 (40)	18 (43)
Dam Facility	121	25 (54)	55 (508)	41 (102)
Severage Facility (Pipe, Disposition Facility)	6	6 (13)	0 (0)	0 (0)
Total	352	182 (369)	91 (937)	79 (253)

Display of maximum ground acceleration and seismic intensity around Tokyo Bay against a given earthquake (Scale of Map: 158km × 130km)

Photo 6.5.1 An example of zoning of seismic ground motions

In Japan, judging methods for liquefaction are already being used in the design method for highway bridges. In the future, research is required for a liquefaction potantial judging method which takes into consideration the deformation characteristics of a structure from liquefaction as well as the development of design techniques for countermeasure.

Also to be developed are techniques for evaluating the earthquake hazard of a structure due to liquefaction and micro-zoning techniques. The results can be utilized for earthquake disaster prevention planning.

3) Development of earthquake countermeasures for sloped

In the mountaineous zones, earthquake damage to the slope surfaces and slope body are specially significant, and it must be reviewed for the earthquake disaster measures. At the present, disaster prevention due to rainfall is mainly considered for slopes. However it is necessary to study and develop the earthquake technology by considering the characteristics during earthquakes.

4)Improvements to verification method for seismic retained horizontal bearing force during earthquake in earthquake resistance design of bridge

At present, in the earthquake resistance bridge design the basic procedure is to check seismic stabiliby by seismic cootliclant methods and the allowable stress method. However, presuming an external seismic external force of the Kanto Earthquake class, it is necessary to further improve the verification method for seismic retained horizontal bearing capacigy by considering the actual yield strength and deformation performance of structural members. Use of this method enables a design where seismic external force, structural calculations and checking earthquake resistance are well balanced with each other.

5) Development of earthquake resistance design techniques for large, long span bridges

Large bridge construction projects following the success of the Honshu-Shikoku Bridges are now being carried out in Japan. One is the Tokyo Baymouth Highway and another one is the Ise Baymouth Highway. These two roads are located along the coast of the Pacific Ocean and are very closely located to many hypocenters. Also,

the ground conditions are poor compared to the Honshu-Shikoku Bridges. Therefore, for these large, long span bridges, is earthquake resistance design technology is required from a new viewpoint, with more severe earthquake and ground conditions than for conventional bridges in the seismic input earthquake motion setting method and earthquake stability verification method.

6) Development of Menshin Design method and Active Control

The Public Works Research Institute has researched Menshin Design method of bridges for the purpose of enhancing dissipating and attenuating performance of seismic forces. It is now at the stage of putting this research to practical use. Five Menshin bridges planned in the pilot project, and three bridges are already in service. In the future, the Menshin Design Method concept will be applied to ultra-multispan continuous bridges, and broad reviews are required for the Menshin Disign method.

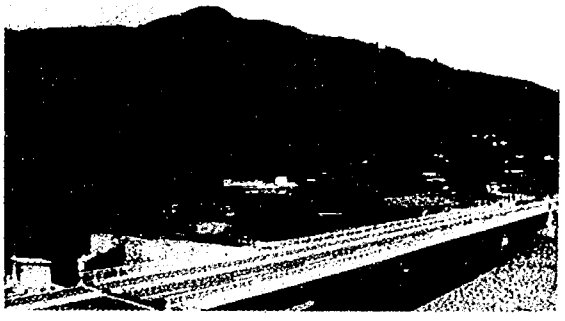


Photo 6.5.2 Example of Menshin designed

7) Rationalization of earthquake resistance design method for shield tunnels

An underground structure in soft ground must be fully checked for earthquake resistance. The earthquake resistance of shield tunnels is being reviewed for the Tokyo Bay Highway; based on this, more general-purpose earthquake resistance design technology must be developed in the future.

8) Rationalization of the earthquake resistance design method for dams

Most dams in Japan are built in mountainous regions, so that the design method must be able to cope with complex changing topography and geological characteristics in response to earthquake. In the future, the earthquake motion characteristics of topographic conditions of dam sites will be clarified. The establishment of earthquake resistance design methods considering the strength characteristics and seismic response characteristics of dam body materials for filldams and concrete dams are also required.

9) Development of earthquake resistance inspection and reinforcement technology

Earthquake resistance is required not only for new bridges but also for existing bridges designed according to old standards. In Japan, earthquake disaster inspection is already conducted four times for roads; in the future, improvements to earthquake resistance inspection techniques for structures are needed, as is a review of evaluation of the earthquake resistance required for facilities. Moreover, with respect to earthquake resistance reinforcement based on the results of inspection, it is important to develop reinforcing techniques for foundations in addition to the conventional bridge falling prevention technology and bridge pier reinforcing technology.

10) Development of earthquake spreading evaluation techniques

When considering earthquake prevention and restoration, the estimation of indirect losses and the formulation of effective disaster measures before and after earthquake can be made possible by considering spreading characteristics of damage. Thus, together with earthquake resistance technology for structures, it is necessary to study the evaluation of earthquake spreading characteristics and its application.

7. Harmony between the Environment and Improvement of Infrastructure

In Japan, people's lives have become more stable as the economy develops, and they are increasingly pursuing spiritual rather than materialistic ends. As a result environmental problems become people's strong concerns. Improvement of infrastructure in Japan has traditionally had the emphasis on the accomplishment of targets. Little attention was paid to the environment. Because of this, efforts are now needed toward rearranging improvement of infrastructure to maintain harmony between the environment and to preserve the environment.

The Public Works Research Institute is actively pursuing the preservation and restoration of the environment. Here follows details on the Institute's work on rivers, sewerage and water quality preservation, dams, urban areas and roads.

7.1 Rivers

7.1.1 River Work and Related Issues

1) General

As a result of the progress of urbanization in river basins in recent years, the river environments have changed, water quality has worsened and hydrophilic properties fallen. Public demand for the improvement of water quality, and preservation of rivers have increased and diversified.

Watersides are considered valuable open spaces with water and natural land, supporting natural conservation, disaster prevention and recreation. The role of such spaces in the formation of regional environment has been re-evaluated.

For instance, according to the national census on River Environment by the Ministry of Construction in fiscal 1990 to 1991, about 130 million people visit rivers under the ministerial jurisdiction throughout the country. This means that each citizen visits a river about once a year for walking, fishing or sports, illustrating the recreational role of rivers.

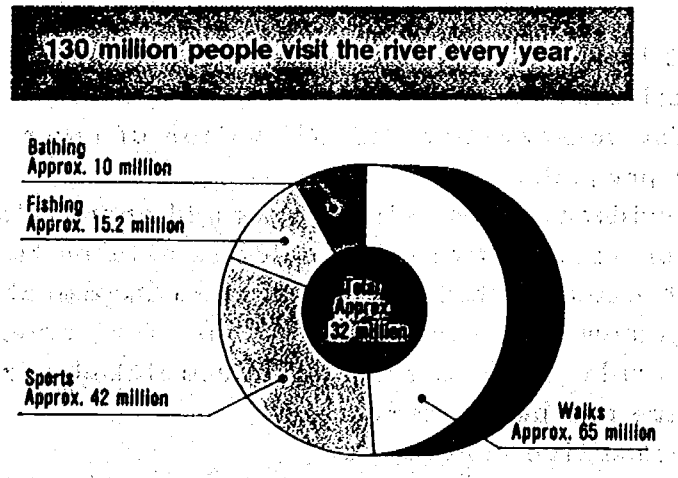


Fig. 7.1.1

2) Policies

Principal policies on river environment taken by the Ministry of Construction are as follows:

(1) National on river environments census

This is a survey on inhabitation by fish, birds, insects, small animals and plants in rivers, and on utilization of river space. The nationwide survey is carried out periodically for rivers under ministerial jurisdiction, and in the future will also be conducted for rivers managed by prefectural governments. This survey is one of the basic surveys used to know the current situation of rivers, and the results are reflected on various plans.

(2) River Management Basic Plan

Recommendations entitled "Approach to River Environment Management" were submitted by the River Council in December 1981, which noted that "river management is extremely important for the people's daily lives, together with flood control and water use." people's life together with the flood control and water use management."

In response to this, the Ministry of Construction intends to formulate a master plan for river management carrying out comprehensive policies on conservation and creation, coordinating and harmonizing with the flood control and water use plans and local characteristics, based on the long-term, broad-based perspectives.

The master plan for river management plan will establish the following:

a) Water management

① Basic concept for comprehensive management of supply and quality of water
② Plans for monitoring of supply and quality of water
③ Policies for operation of river management
④ Policies for management approved structures
⑤ Basic policies for implementation of projects for water improvement environment
⑥ Policies for coordination with other projects and policies related to water environment
⑦ Other important items related to water environment management

b) River spatial environment

① Basic concept for conservation and utilization of river space
② Plans for river projects
③ Policies for considerations of river works and approvals for occupancy
④ Policies for coordination with other policies related to river management
⑤ Other important items related to river space management

River satial environment management plans for rivers under ministerial jurisdiction nationwide have been almost completed, and water environment management plans are now being formulated.

(3) Environmentally-sensitive river works

a) River improvement projects

Various works are being carried out, such as the conservation and creation of

scenery, conservation of natural environment and various schemes to enhance hydrophilic properties.

These include the creation of multiple-nature rivers, natural hilly levees and rivers where fish can easily swim upstream, as well as home town river model projects and model project for levees planted with cherry trees.

Porous materials are used for river banks, shoals and pools, installation and improvement of fish channels, installation of levees with gentle slopes and undulations, river work coordinated with town planning, expansion of levees and planting cherry trees.

b) River purification projects

Dredging of deposited sludge is being carried out in rivers, lakes and swamps.

Introduction of purified water is performed by taking in fresh water from other rivers to a river where water quality is poor. This was done in many rivers such as the Uchi River in Wakayama City and the Furu River in Neyagawa City.

In addition, river purification can be performed by direct purification such as intergravel contact oxidation, where river water is taken into a gravel tank, and pollutants are absorbed, settled and oxidized by gravel and organic matter on the gravel.

Purifying facilities described above were installed at inlets to the Tama River, and water was taken in from its tributaries, the No and Hirase Rivers.

3) Problems with implementation

River works were conventionally carried out for flood control and water utilization purposes. These days, river works must also take into account the river environment, a major change in thinking.

Concepts such as living things and scenery have hardly been touched on in river planning, so that the basic survey, planning and facilities design methods have not been established technically, and this problem must quickly be solved in establishing new methods.

7.1.2 River Conservation, Restoration and Design Technology at the Public Works Research Institute

The Public Works Research Institute is carrying out research as required for implementation of these administrative policies and for development of new policies.

1) Research on the value of rivers

Research to clarify the value of rivers, basic to river environment administration, is now underway, and includes "Degree of Possible investment in Projects Considering the Environment," "Aspects of the Environment which should be Emphasized," and "Aspects of Rivers Unique to Japan."

For example, surveys are conducted on "The Historical Relationship between the Japanese People and Water," "Volume of Water Space in a Typical Japanese City," and "Public Utilization of Rivers," the value sections are examined and the river

value quantified.

2) Research on the conservation of river ecosystems

In order to preserve birds and fish living in rivers, various researches are underway.

(1) Survey techniques

Especially for fish, survey techniques are being established by introducing or improving advanced technology or traditional techniques.

(2) Inhabitable conditions for living things

Inhabitable conditions for common species of birds, fish and plants are being studied in terms of river management by examining existing papers, field surveys and experiments. For instance, the cruising speed, dashing speed and danger of harmful substances for fish are being studied via experiments.

(3) Preservation techniques for living things

Research and development is being looked at ways to create fish channels, nests, shoals, pools and plants mainly through field experiments and hydraulic tests. (Photo 7.1.1)

3) Preservation of river water qualities

Research is being carried out on "discharge of pollutants in to rivers," "development of direct river purifying methods" and "a new index for water quality," the last being in response to public demand for pleasant scenery, preservation of the ecosystem, and supply of safe, drinkable water.

With respect to water quality preservation in closed water areas, new water purifying methods are being studied, such as vertical counter-current type charcoal purifying methods and vegetation purifying method using floating islands. (Figure 7.1.2)

4) River scenery and hydrophilic utilization

In order to create pleasant river sceneries, research is being conducted on the color and design of river structures. Also, in response to requests for hydrophilic utilization of rivers, case studies of hydrophilic use and facilities are being collected and basic research carried out into the use of hydrophilic facilities. (Photo 7.1.2)

5) Effective use of river water heat

Research into effective use of heat energy in river water will help create resources-saving and energy-saving type national land. (Photo 7.1.3)

(1) Creation of pleasant river climates

The effect of rivers on weather in urban areas will be clarified through observation and simulation. The acquisition of water areas to prevent heat islands in cities and the technique of guiding cool air from a river to a city are being studies.

(2) Development of urban cooling systems utilizing water

Heat island prevention by water-spraying, water permeation or water storage

cities are being studied with simulation models and field experiments for establishing an urban cooling system.

7.1.3 Future Technological Issues Regarding Environment Technology

Present research has limited limited targets, such as scenery or water quality. However, the whole system exists first and respective items occur as part of the whole system. Therefore, in the future, research on systematization for handling water circulation, river space structure or social structure as one of the systems is required.

Also, in river improvement in the future, a plan will be formulated while seeking opinions of residents on environmental issues. It is now required to study a form of system for the formation of agreement.

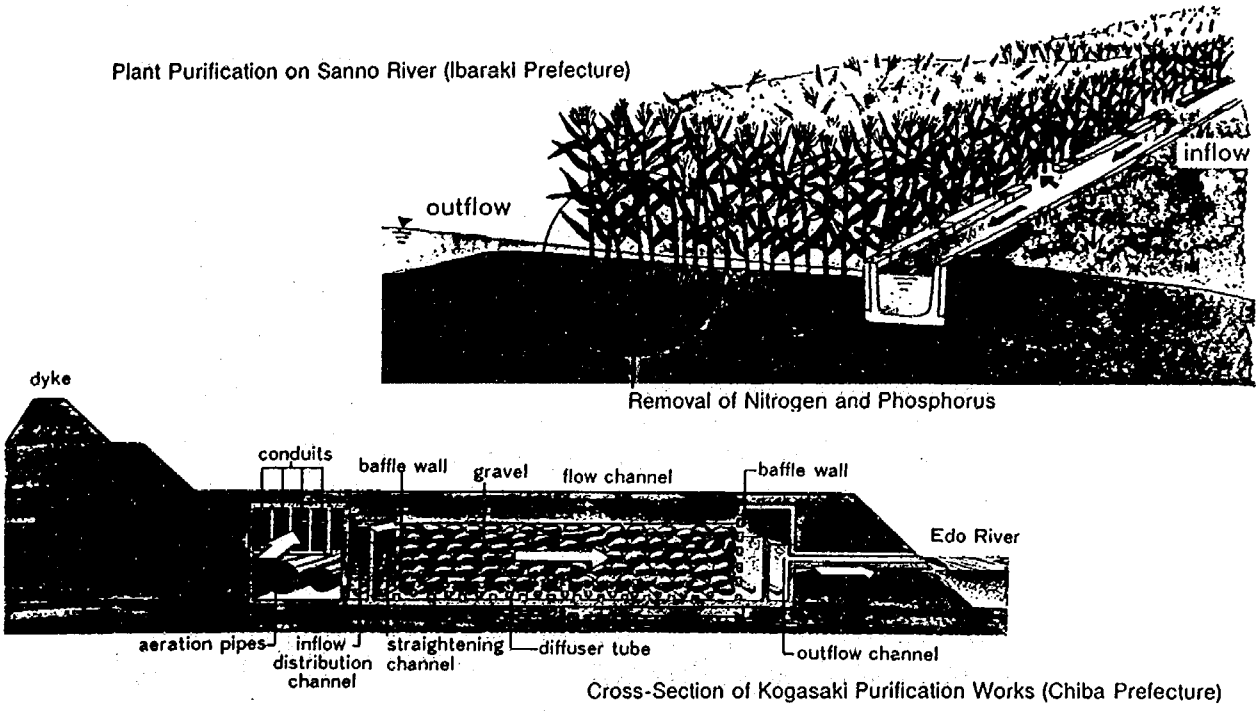


Fig. 7.1.2

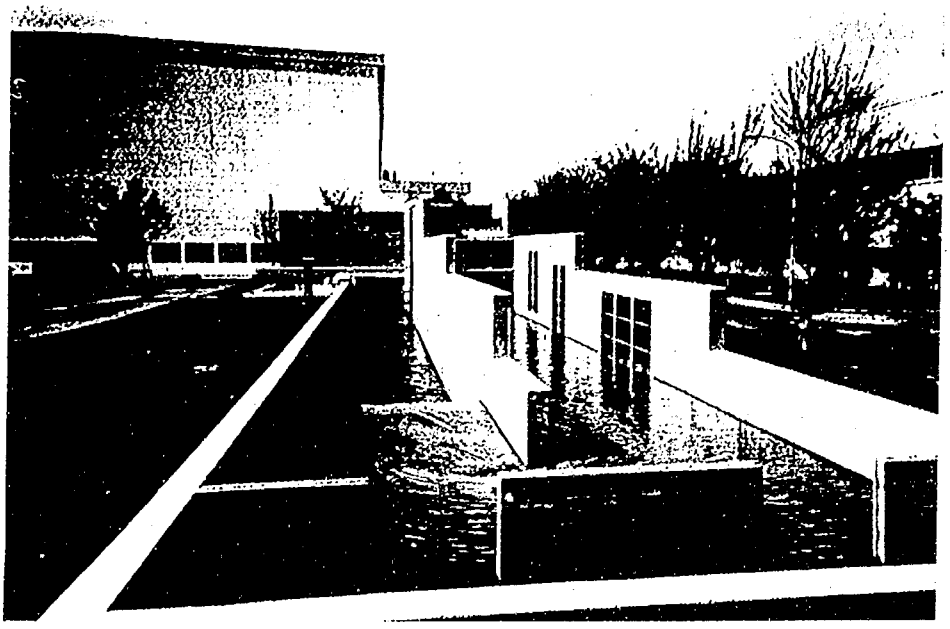


Photo 7.1.1

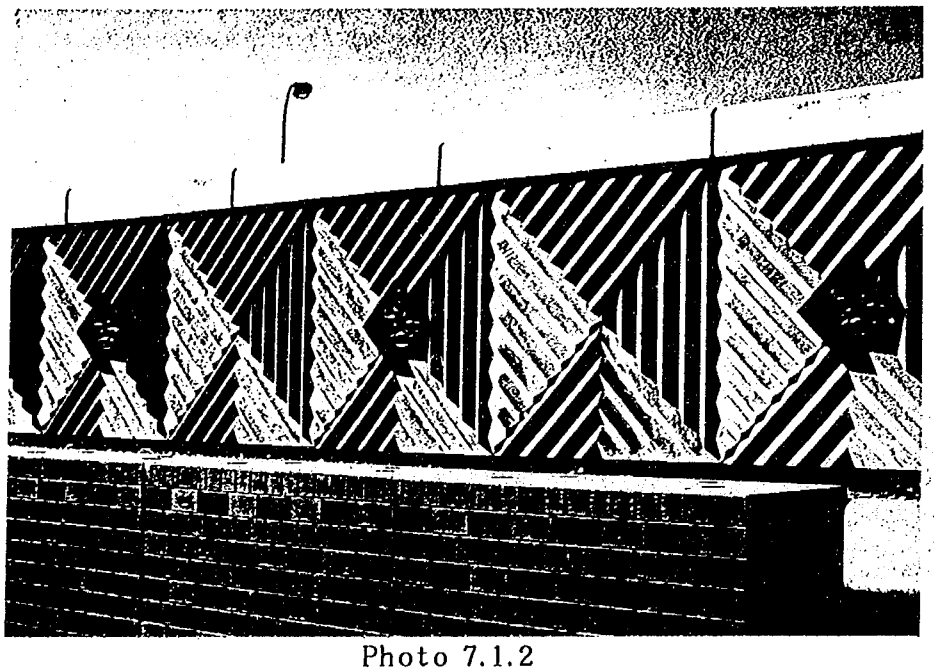


Photo 7.1.2

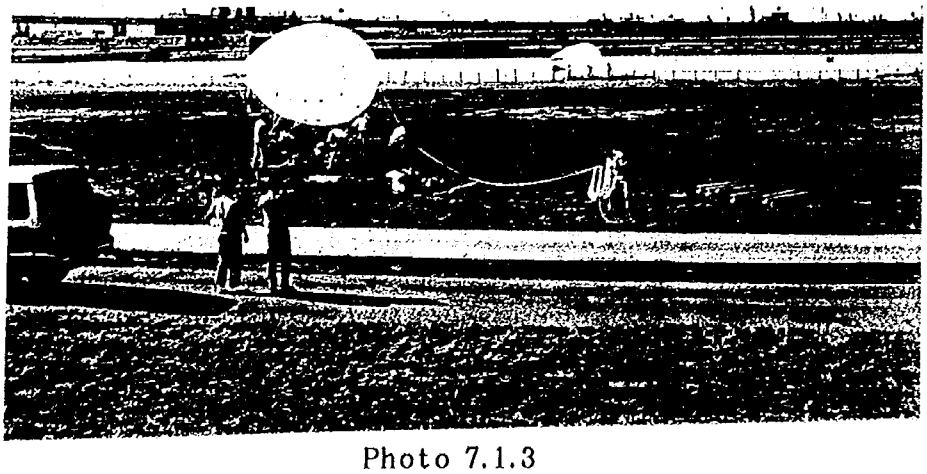


Photo 7.1.3

7.2 Sewerage and Water Quality Control

7.2.1 Current Issues Surrounding Sewerage Works in Japan

Construction and management of sewerage facilities in Japan are carried out to create modern urban living environment and to control water pollution. The number of sewerage works completed is shown in Fig. 7.2.1. At the time of start of sewerage works in this country, combined sewerage systems were build mainly in large cities. Construction of urban drainege channels for draining only storm water was also been carried out. At present, separate sewerage systems are primarily constructed to collect wastewater causing water pollution.

In municipalities and small villages, Specific Environment Conservation Public Sewerage, Basin Sewerage Class 2 or "Simplified Public Sewerage" projects are carried out for domestic wastewater treatment.

Collected wastewater is treated at wastewater treatment plants, which in Japan mainly use the biological treatment method. This method can be classified into suspended growth method and biofilm method. In the suspanded growth method, masses of microorganisms (activated sludge) are formed in sewage and they decompose the organic matter. In the biofilm method, films of organisms are created on the surfaces of solid bodies, and sewage is brought into contact with the organisms to decompose the organic matter. Principal biological treatment methods are shown in Table 7.2.1.

Table 7.2.2 shows the treatment methods adopted in publily owned treatment works in Japan by size of plant. While the conventional activated sludge method is mostly used when the treatment capacity is larger than 10,000 m3/day, oxidation ditch and batch type activated sludge methods are often used in small-scale treatment plants (less than 10,000 m3/day), the number of which is increasing recently.

In secondary wastewater treatment, BOD (Biological Oxygen Demand) of effluent can be reduced to below 20 mg/liter, but the use of advanced treatment methods capable of providing better effluent are increasingly used to reduce water pollution at the public water bodies or to enhance the reuse of treated water.

In fiscal 1990, about 1.41 million tons of sewage sludge (converted to dry solid) were generated in Japan, of which 81% was disposed of by land filling. However, finding of new disposal land has become more difficult from year to year. Because of this, the volume of sewage sludge is reduced in treatment plants to utilize the existing disposal land longer, and 61% of sewage sludge is incinerated.

Sewage sludge can be converted into resources instead of merely being waste, and research and development work for reuse of sewage sludge in lawn areas, farmland or as construction materials is actively farmland or as construction materials is out. In Japan, about 13% of sewage sludge generated each year is now utilized for lawn areas and farmland, and 3% is used as construction materials. In the future, the percentage of reuse of the sewage sludge is expected to increase.

As stated above, as a result of advance in sewerage facilities, wastewater preciously discharged from houses and factories directly in to the public water bodies is now collected and transported to treatment plants. Therefore, water

quality preservation in rivers and the sea has been significant. Rivers in the areas, where the sewerage treatment is advanced, are now able to maintain good water quality.

After the war, Tokyo became highly developed as a result of population and industrial concentration. Water quality in the Sumida River, which runs through downtown Tokyo, rapidly deferiorated due to the increase in wastewater discharge from houses and factories. But sewerage facilities installed thereafter have brought about gradual improvement in water quality (Fig. 7.2.2).

7.2.2 Studies on Water Quality Preservation, and Restoration by the Public Works Research Institute

Sewerage facilities are composed of pipeline for the collection and transport of wastewater, and of a treatment plant. The treatment process generates sludge, thus necessitating sludge treatment and disposal.

Research and development work is carried out into pressure and vacuum facilities sewage, as a new conveying systems for collecting sewage. This will enable the construction of sewage facilities in areas where laying of pipeline is difficult by conventional methods.

Preservation of the environment is now desired by the general public, and advanced chemical or biochemical treatment technology is developed to preserve public water bodies and promote the effective utilization of treated water.

In Japan, where land prices are very high, disposal land for sewage sludge is very hard to find. Because of this, rather than the disposal of sludge, research is being carried out into techniques such as compost and melging, to produce sludge which can be used in lawn areas, farmland and as construction materials.

Water pollution in public water bodies such as rivers and the sea has only been partially revealed, and more complete complehension on water pollution is being made by research into effective water quality preservation strategies. Also strategies to counter the toxicity and environmental impact of microchemical substances, which has become problematic recently, are now investigated.

7.2.3 Future Technical Issues Related to Water Quality

In cities where sewerage works have been performed since long ago, combined sewerage system has usually been adopted whereby both storm water and sewage are collected through the same pipeline. With sanitary this combined system, untreated sewage is discharged to rivers together with storm water during high intensity rainfall. This problem must be addressed. Also, facilities in such cities are in poor condition and in need of upgrading. Since contains eutrophication is sometimes caused by nutrient salts such as nitrogen and phosphorns particularly in lakes and swamps, nitrogen and phosphorns removal technology is required. Also, the development of treatment techniques for microchemical substances becomes increasingly important. Sewage sludge tends to thicken heavy metals in water, preventing the use of sludge in farmland. Therefore, heavy metal treatment for sludge is important.

In parallel with the progress of sewage, treated water is mixed with river water

and reused as drinking water. Conventionally treated water was made safe by treating only pathogens. In the future, however, the safety of treated water will be viewed in terms of virus and microchemical substances. Thus, new indices for safety are required.

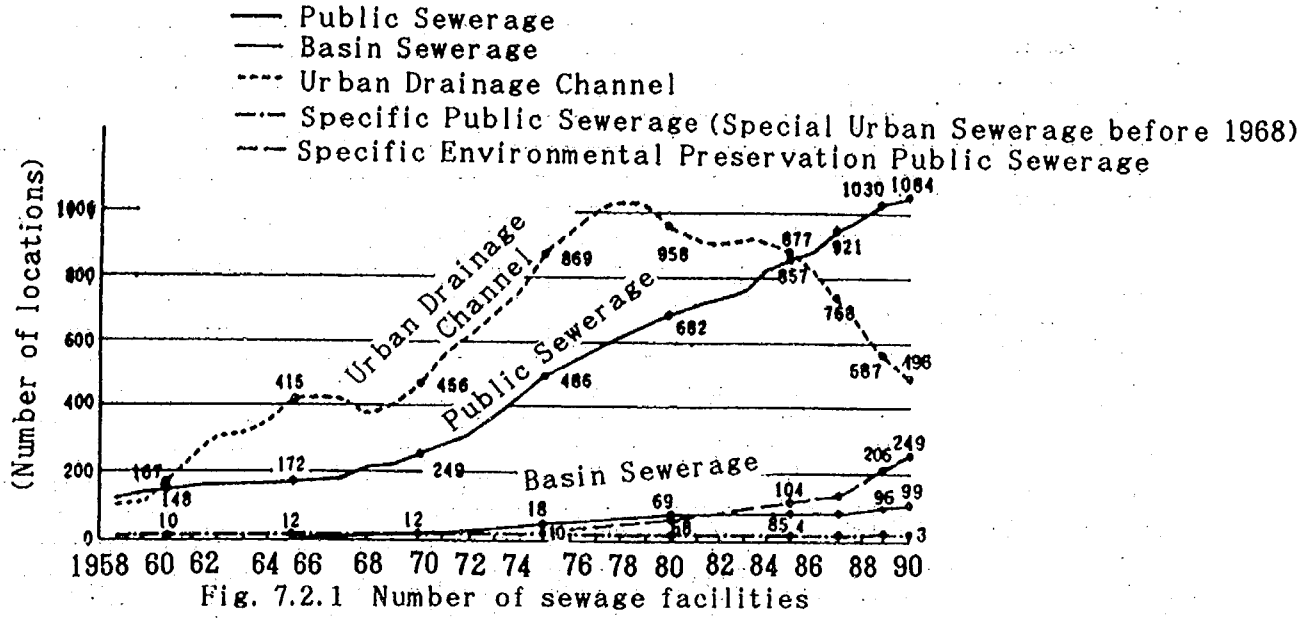


Fig. 7.2.1 Number of sewage facilities

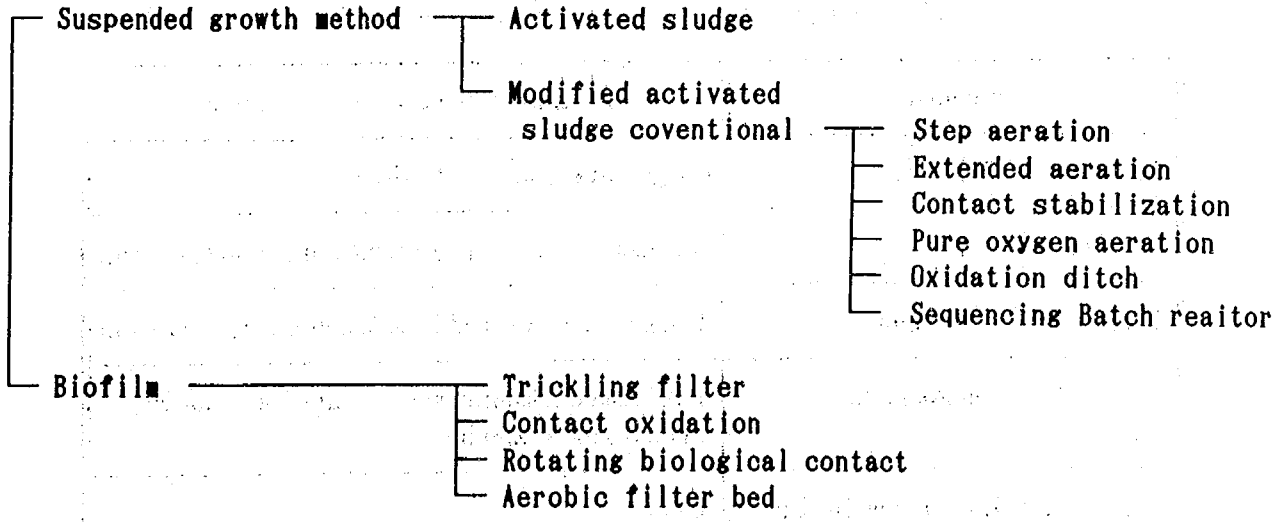


Table 7.2.2 Number of treatment plants by treatment method

Table 7.2.2 Number of treatment plants by treatment method

Design daily maximum (×1000 cubic meters per day) / Treatment method	~5	5~10	10~50	50~100	100~500	500~	Total
Secondary							
Serrling basin			1				1
Medium							
High rate trickling filter	2	2	1				8
High rate activated sludge	2		8	2	1		13
Primary							
Activated sludge method							
Conventional	55	63	228	96	126	13	581
Step	3	3	16	17	8	7	54
Extended	11	3	2				16
Contact stabilization							
Pure Oxygen		1	3	1	2		7
Aroxic/Oxic		1		3	1		5
SBR	11	1					12
Oxidation ditch	16	11	2				29
RBC	13	4	6	1			24
Contact aeration	2		2				4
Anaerobic & aerobic filter	1						1
Others	1						1
Advanced	(10)	(9)	(2)	(9)	(8)	(2)	(40)
Total	147	89	275	119	138	20	788

Note: When treatment plant uses two or more treatment methods, the treatment method with the larger water volume is used.

Table 7.2.3 Advanced treatment in Japan

Purpose	Advanced treatment in Japan
Removal of BOD, SS	High rate sandfiltation
Removal of COD	Activated carbon adsorption, coagulation
Removal of nitrogen	Biological vitrification denitrification
Removal of phosphorus	Activated sludge with coagulant doring Aroxic/oxic method
Sterilization, discoloring	Ozone

Table 7.2.4 Disposal and reuse of sewage sludge in Japan
(Fiscal 1990)

Sludge Treatment		Disposal and Reuse					Total	
		Landfill Reclamation	Agricultural Use	Construction Material	Ocean Disposal	Others	DS-t/y	%
Thickened Sludge		2	0	0	6,954	0	6,956	0.5
Dewatered Cake		327,443	45,476	0	4,731	937	378,587	26.8
Compost		0	121,414	0	0	1,096	122,510	8.7
Dried Sludge		3,111	7,697	0	0	456	11,264	0.8
Incinerated Ash		806,423	7,133	42,756	0	6,672	862,986	61.0
Melted Slag		1,566	0	2,078	0	27,071	30,715	2.2
Total	DS-t/y	1,138,545	181,720	44,836	11,685	36,232	1,413,018	
	%	80.6	12.9	3.2	0.8	2.6		100.0

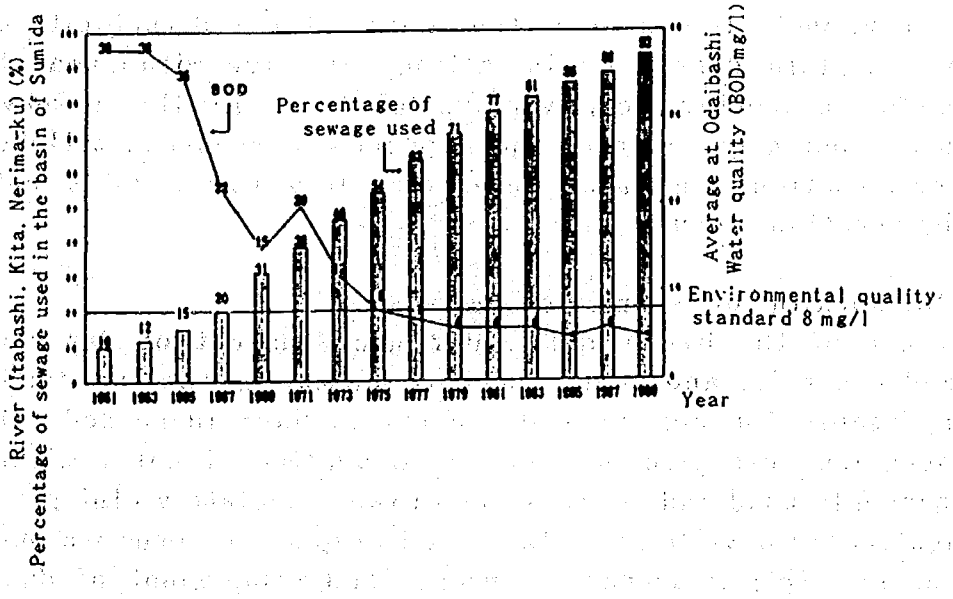


Fig. 7.2.2 Percentage of sewage used and BOD in the Sumida River

7.3 Dams

7.3.1 Dam Strategies

Dam reservoirs provide "flood control function" called flood regulation and "water use function" for developing water resources or hydropower energy, as well as the pleasant scenery of newly formed lake water mixed with the surrounding natural environment, used for fishing, playing with water, picnics and sports. Recently, the styles and behavior have diversified, and the public pays special attention to the assets of dams described above, and seeks the use of dam reservoirs as recreation fields.

In order to tackle environmental issues in dam construction, one of the water quality preservation measures for dam reservoirs themselves and rivers in the lower reaches are carried out by building facilities such as selective withdrawal facilities. Also, the Government is working on the environment surrounding dams and reservoirs, providing resting fields and open spaces filled with water and natural scenery.

1) Water quality preservation measures for dam and reservoir

When a large reservoir is constructed in a natural river course after building a dam, water quality sometimes changes due to the retention of running water. Three types of water quality problem that occur in a dam reservoir; decrease in water temperature of discharged water, prolonged turbidity of discharged water after flood, and eutrophication. These water quality problems of the reservoir affect the environment; cold water affects agriculture; and turbid water and eutrophication have the potential to affect a broad sector* * Researches is underway into all three problems i.e. cold water, prolonged turbidity and eutrophication. The water quality changes have been almost completely clarified and strategies reviewed. It was found that cold water and turbidity problems can be solved to a certain degree by installing selective withdrawal facilities as required. As for eutrophication, various measures in the reservoir and an upstream area are being considered, and appropriate measures will be adopted in response to the situation in each dam reservoir. In dam reservoirs, eutrophication is combatted by aeration circulation.

2) Environmental work in the vicinity of dams

The importance of the hydrophilic environment aspect of dam reservoirs has been recognized recently, and public demands for making the surrounding areas of dam reservoirs usable for resting and recreation have increased. On the other hand, dam reservoirs must also preserve good quality of water without allowing adverse or disorderly used and development in the immediate vicinity.

Dam environment works have been systematized in order to promote public interest in rivers, such as safety measures for users good management of dam reservoirs, and water quality preservation for reservoir. Environmental work such as site arrangements and greening measflood discharge by constructing levees, retarding basins, and dams and reservoirs. A minimum safety degree of flood control is being

establish. At present, research emphasis is on the points shown in Table 6.1.1, designed to enhance safety and restore the charms possessed originally by the natural rivers themselves.

First is research on formulating river course plans, whereby a desired shape of river and a method for makifore, in recent years, the installation of fish ways is being carried out in line with "Dam Torrent Fish way Installation Works."

7.3.2 Preservation, Restoration and Design Technology for Dams at the Public Works Research Institute

One of the most important feature of dam reservoirs is water quality, and techniques for water quality preservation have been a top priority. Also, there is strong public demand to improve the environmental features with a large water surfaces, and to utilize reservoirs as the core of the development of water resources. Research is being carried out into preservation and creation of ecosystems and scenery at dam reservoirs.

1) Preservation of water quality

There are several important issues related to the water quality of dam reservoirs, such as prolonged turbidity for a long time in downstream rivers after a floods and eutrophication, whereby water bloom and fresh water red tide occurs in the reservoir. These are problems not only for water use but also for scenery in some cases. In order to deal with these problems, water quality prediction models were developed, and the evaluation and formulation of water quality preservation strategies such as selective withdrawal have been reviewed. Also, the causes of prolonged turbidity and eutrophication were analyzed; and the possibility of occurrence of these phenomena in dam-reserviors under construction or at the planning stage is being reviewed. Also, the effects of anti-eutrophication are being reviewed via yield observations and laboratory tests.

"Dam reservoir water quality prediction analysis models" developed here are used for water quality prediction, environment impact assessment and planning of water quality preservation steps in each reservoir. "Dam reservoir water quality surveying" is being used in water quality surveys at dam reservoirs throughout the nation. Also, "Guide to dam reservoir eutrophication strategies (draft)" is used for eutrophication strategies.

2) Ecosystems

Dam reservoirs created by dam construction, with their large water volume and a wide water surface, become a new place of inhabitation for fish and birds. The Public Works Research Institute is developing fish ways for high levee dams and is studying the hydraulic characteristics of various kinds of fish ways, swimming power of fishes and ecology of aquatic live. Findings thus far are summarized in "Design of Fish ways," already used for planning in many places.

3) Scenery

To improve dams and their hydrophilic characteristics, it is necessary not only

to design facilities in the immediate vicinity of the dam reservoir but also to conserve and design the entire area. With respect to the entire area surrounding the reservoir, the body of dam levee, lake coast line and road diversion occupy the largest proportion of the space and thus are the important points.

The body of dam levee becomes the center in size and function and thus it is important, in the planning and design stage, to give consideration to predicting the type of scenery which will appear in the future.

Research findings thus far are summarized in "Scenery Design for Dams," already in use for scenery design of dams.

7.3.3 Future Technological Issues Surrounding Dam Environments

Research into dam construction for the next generation is focussed on the following themes;

1) Preservation and design of dam reservoir ecosystem
2) Overall control of water volume and water quality of dam reservoir
3) Use of dam reservoir (improvement of hydrophilic aspects)
4) Development of dam reservoir scenery design method
5) Developing the region with the dam reservoir as the centre

7.4 Urban Environments

7.4.1 Current Urban Environmental Issues and Strategies Measures

After the war, the high economic growth of Japan led to expanded economic activity, sudden concentration of population and industry in large cities and changes in the life styles. This brought about environmental problems such as mass consumption and disposal of energy and resources, and shrinking natural land. Since Japan has had only a short history of modern urban development, this urbanization was relatively sudden. The natural environment in cities deteriorated, and attention to the living environment was considerably delayed. It is now necessary to work on urban environments via the use of social overhead capital and the encouragement of appropriate land use. Public awareness has shifted from an emphasis on materialistic richness to an emphasis on spiritual richness. Therefore, important aspects of town planning are the creation of cities with individuality, effectively utilizing the nature, history, culture and scenery unique to the region, the formation of pleasant urban landscapes and the formation of pleasant and agreeable urban environments through greening.

The Ministry of Construction put out "Urban scenery model city system" in 1987 and "Amenities, nature and landscapes model town creation" in 1990, and is encouraging the formation of model urban sceneries. Also in other cities, town planning is being promoted by considering the formation of good urban sceneries. However, there is only a short history of the formation of modern sceneries in Japan, so technical knowledge is not yet sufficient, and we must now objectively evaluate scenerarios which would otherwise be too easily governed by subjectivity.

A "The five-year program for the planting of trees, etc. for urban green space development" was formulated in fiscal 1977, and greening is being promoted in

public facilities and elsewhere. Also, the Ministry issued "Guide for formulation of general structure plan of parks and open spaces in urban areas" in 1977 and "Urban greening promotion plan formulating procedure" in 1985. Also, every city formulates a master plan and urban greening, including private sector land. In order to further promote urban greening in the future, we must now develop greening techniques for shaded land below elevated highways, roof tops, wall surfaces and indoor spaces where greening was previously considered too difficult. It is also necessary to establish a proper system and management method to encourage greening in land owned by the private sector. Moreover, in order to deal with global environmental issues, which are now receiving a great deal of attention, research is needed on greening techniques to ease the heat island phenomenon of cities, techniques to reduce CO2 concentration thereby arresting global warming, and techniques to preserve and create an environment for the preservation of biota, such as preservation and creation of biotopes (living spaces for small animals).

Future urban planning will be required to formulate land use plans based on pleasant urban environments with many amenities, while maintaining the continuous growth of cities. Important themes are: comprehensive "Urban environment plans" related to the preservation and
creation of fresh water environments; greening; small traffic systems with a smaller environmental burden; energy-saving recycling urban systems; open spaces; and ecological projects, especially "Eco-city."

7.4.2 Preservation, Restoration and Design Technology for Urban Environments at the Public Works Research Institute

For forming urban environments with amenities and pleasantness, research is required on environmental preservation and creation technology, such as urban greening techniques and techniques for creating for urban scenery. The Public Works Research Institute has conducted research on greening techniques, creating scenery, and designing and managing parks and green spaces.

With respect to the greening technology, the Institute has established the effects of greening such as purification of atmosphere (absorption of CO2, capturing dust), sound absorption, easing micrometeorology and formation of sceneries. It has also conducted research, e.g. on improving planted environments of sea beaches, sloped surfaces and shaded land; on the properties of greening trees such as tide resistance, cold weather resistance and shade resistance; on soil improvements using water retaining materials and sewage sludge; on planting trees cultured in containers; and on maintenance of grasses and trees. In addition, techniques such as planting units for use in places where planting was previously not possible, are being developed. Moreover, systems are being summarized into documents such as "Road greening technical guide" and "Guide for slope works and slope stabilization work."

A guide to forming good scenery, the "Road sceneries arrangement manual (draft)" will be produced. Also, the research into objectively evaluating scenery is being performed; this is necessary because the evaluation of scenery is easily

governed by subjectivity. Locations being considered are internal and external sceneries of mountain roads, scenic roads, national highway bypass roads, streets and river parks; overall scenery public projects is also being considered. In addition, simulation technology using computer graphics is also being developed (Photo 7.4.1).

For the arrangement and management techniques for park areas, we are performing research in all areas of planning, design and management. For the planning, we are surveying and studying planning approaches to green buffer areas, urban forests, open spaces and ocean resorts. We are studying a staged design method for large-scale parks, amenity design for sodded open of jogging tracks. We are also surveying management issues such as user analysis in large-scale parkes and grassland restoration in sodded open spaces.

7.4.3 Future Technical Issues Regarding Urgan Environmental Strategies

Among the technical issues related to the urban environment, the following are considered urgent:

1) Park planning: Park planning neds to be established for the creation of urban environments taking into account micrometeorology and the preservation of the ecosystem.

2) Biotope: Techniques creating biotopes need to be established in to preserve ecosystems and produce "ecosystem" (city coexisting with environment) harmonized with nature. (Fig.7.4.1).

3) Scenery: It is necessary to establish methods for objectively evaluating scenery and to develop simulation software for scenery which can be easily used on-site. Also, techniques for forming the scenery in town planning should have individuality, with local flavor, and be harmonized with nature.

4) Urban greening: It is necessary to develop basic technology for creating greening space and to develop more land where greening is possible. (Fig. 7.4.2)

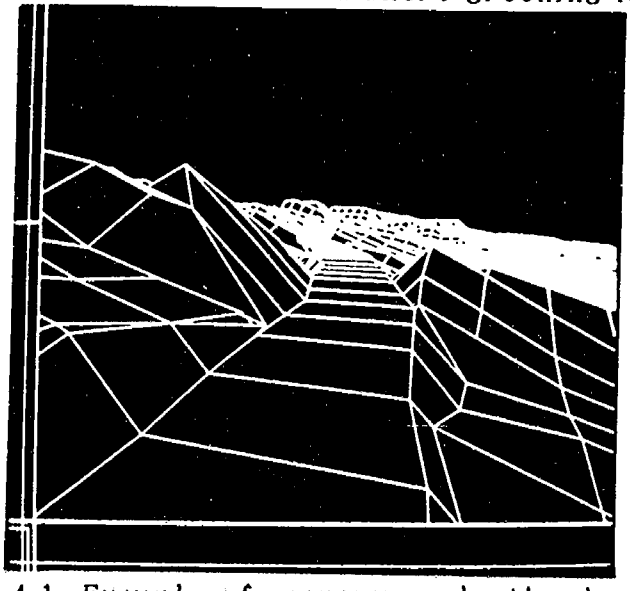


Photo 7.4.1 Example of scenery evaluation by simulation
(reviewing the internal scenery of a road)

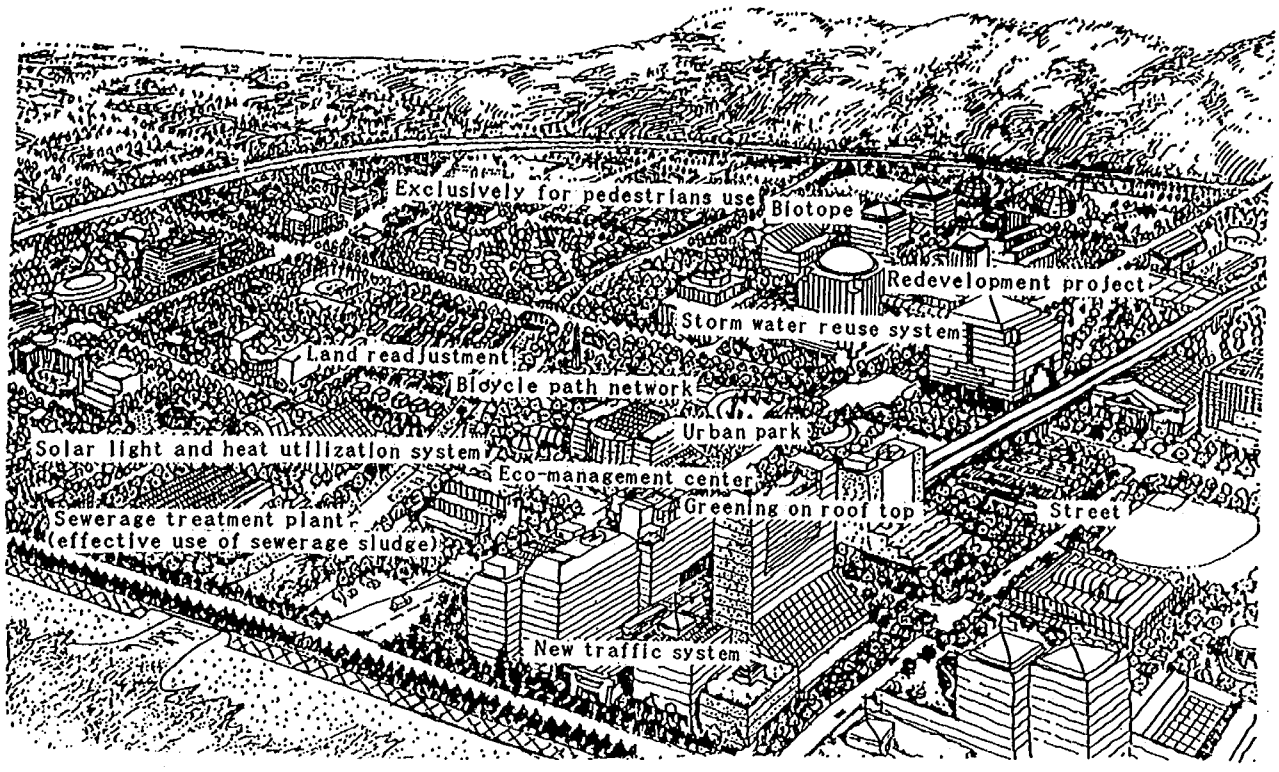


Fig. 7.4.1 An image of an "Eco-city" (city coexisting with environment)

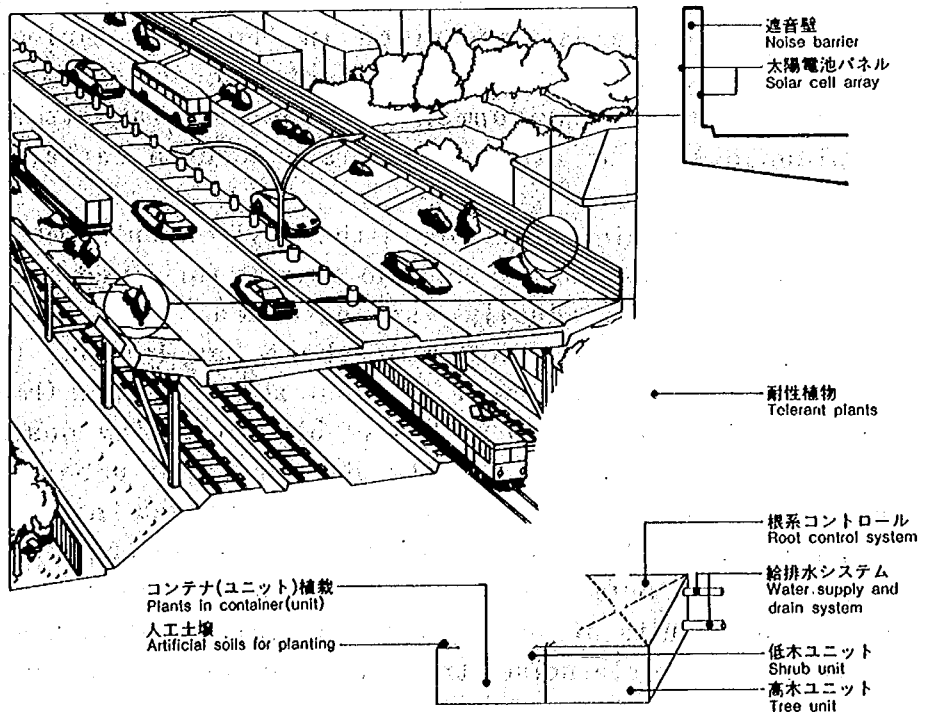


Fig. 7.4.2 An image of the development of fundamental technology for creating greening space

7.5 Roads

7.5.1 Current Road Enviroment Issues

Since roads in Japan are indispensable to the improvement of living standards and the development of economic society, they have been developed so much and have played a great role in Japan. However, population concentration in urban areas and the unexpectedly rapid progress of motorization has caused environmental problems such as vehicle noise and air pollution in cities and roadside areas since the second half of the 1960's. Various countermeasures have since been taken by various sectors, and the pollution problem has improved to a certain degree, but unimproved areas still remain.

The "Basic Law for Environmental Pollution Control" was enacted in 1967 to promote comprehensive pollution control measures including industrial pollution and to conserve the living environment. "Environmental Quality Standards (Tables 7.5.1 and 7.5.2)" were established to protect the health of humans and preserve the living environment, and measurement and monitoring of the environment are carried out based on this law. Also the "Air Pollution Regulation Law," "Noise Regulation Law," and "Vibration Control Law" were established individually. Also the "Natural Environment Preservation Law" was established to preservenatural environment.

In addition to these laws and standards, cabinet passed a resolution "For the implementation of the environmental impact assessment system (1984)" prevent pollution and preserve the natural environment, and environmental impact assessments became obligatory for certain works carried out by the Government and others. The concrete procedure is prescribed in "For the implementation of environmental impact assessment system of projects under addministration of Ministry of Construction (1985)". Environmental impact assessments are required when the scale of planned road or other projects exceeds a certain limit. (Fig. 7.5.1).

Due to the present level of air pollution in the environment, emission control was brought in for passenger cars and trucks, the same as for fixed sources such as factories, and control was gradually strengthened. As a result, the concentrations of SO2, CO and HC in the atmosphere has fallen. However, the concentration of NO2 has not improved ever the last several years (Fig. 7.5.2). In 1990, the concentration of NO2 measured at 36% of air monitoring posts of vehicle exhaust gas exceeded the Environmental Quality Standard. For urban areas such as Tokyo, Knagawa Pref. and Osaka, the concentration 77% exceeded the Standard.

A maximum allowable noise limit for vehicle was established and gradually strengthened. However, noise levels still exceed the Standards at many measuring points. According to the results of measurement at 4,585 locations, most of which are problematic in terns of vihicle noise, the Standards were satisfied only at 13% (Fig. 7.5.3).

7.5.2 Preservation, Restoration and Design Technology for Road Environment at the Public Works Research Institute

It is the most important to harmonize the roads with their environment, and we

must encourage research to create roads which protect humans, nature and the earth.

Much research has been carried out up to now with the emphasis on the prediction and strategies for air pollution and noise due to road traffic. In environment prediction, the diffusion forecast method for exhaust gases from vehicles and roadside noise distribution forecast method have been established for roads with ordinary structures such as plane, fill, elevated and cut. These are being used in environmental impact assessments.

In recent years, the second Tomei and Meishin Expressways were planned on a high travelling speed never used before, and thus surveys and experiments were conducted on exhaust gases from high travelling speed (140 km/h). The results were used in environmental impact assessments air pollution and noise on the said routes. With respect to unusual structures such as trench roads, tunnel portals and interchanges, highly accurate prediction methods for air diffusion and noise distribution were developed.

Air purification by trees in environmental facilities zones were also surveyed (Photo 7.5.1). The degree of absorption of NOx was measured, and the air diffusion effect of planted tree zones determined. With respect to noise, the reduction in noise by noise barriers, sound absorptive panels on the rear face of elevated roads (Photo 7.5.1) drainage pavements and noise abatement measures for vihicles was tested.

7.5.3 Future Issues Surrounding Road Environment Countermeasure Technology

With respect to road environment, the above prediction and measures were summarized for basic road structures up to now. However, various structures such as complicated trench type and multi-layer roads for large-scale highways are planned for the future. Because of this, research is required into improving accuracy of air diffusion and noise prediction through the development of simulation methods and model experiments using air diffusion wind tunnels (Photo 7.5.3) and anechoic rooms (Photo 7.5.4).

Moreover, further efforts have to be made to develop new technology for the preservation of the roadside environment. The development of noise barriers, research on low-noise pavements and utilization of effective environment facilities zones (Photo 7.5.5) are under consideration.

Also, car manufactures must study lower noise and clean exhaust gas protecting both global and regional environments.

Measures to protect the natural environment were taken only for valuable species in the past. However, in the future, techniques must be developed which can preserve and help to recover both ecosystems containing animals and plants and natural scenery.

Table 7.5.1 Environmental Quality Standards on Ambient Air

Substance	Sulfur dioxides	Carbon monoxide	Suspended[1] particulate matter	Nitrogen dioxides	Photochemical[2] oxidants
Environmental conditions	Daily average of hourly values shall not exceed 0.04 ppm. and hourly values shall not exceed 0.1 ppm	Daily average of hourly values shall not exceed 10 ppm. and average of hourly values in eight consecutive hours shall not exceed 20 ppm.	Daily average of hourly values shall not exceed 0.10 mg/m^3, and hourly values shall not exceed 0.20 mg/m^3.	Daily average of hourly values shall be within the range between 0.04 ppm. and 0.06 ppm. or below.	Hourly values shall not exceed 0.06 ppm.

Note: 1. Suspended particulate matter shall mean airborne particles of 10 microns or less in diameter.
2. Photochemical oxidants are oxidizing substances such as ozone and paroxiacetyl nitrate produced by photochemical reactions (only those capable of isolating iodine from neutral potassium iodide, excluding nitrogen dioxides).

Table 7.5.2 Environmental Quality Standards on Noise

(Unit dB(A))

Category of area	Division of hours		
	Daytime	Morning & evening	Night time
	Not more than	Not more than	Not more than
Type A areas bordering on a two-lane road	55	50	45
Type A areas bordering on a more than two-lane road	60	55	50
Type B areas bordering on a not more than two-lane road	65	60	55
Type B areas bordering on a more than two-lane road	65	65	60

Note: A–Primarily residential areas
B–Areas where a substantial number of residence are located among shops and factories

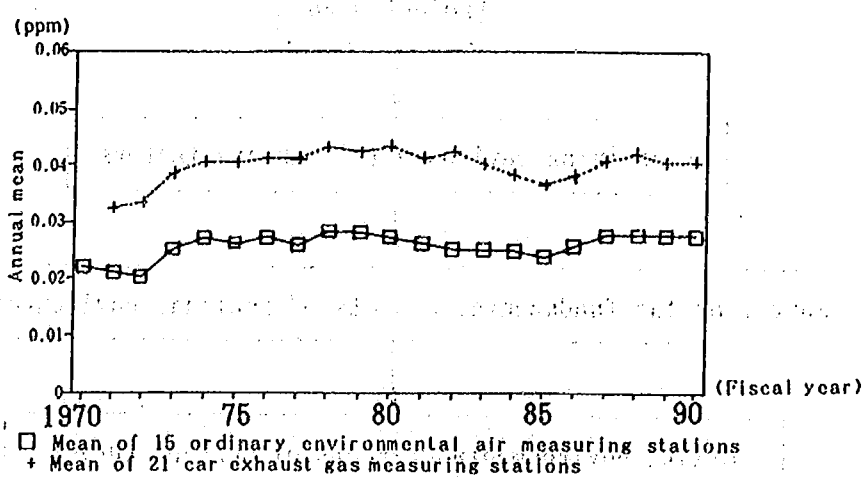


Fig. 7.5.2 Secular change in mean value of the concentration of NO2 (mean at continuous measuring station)

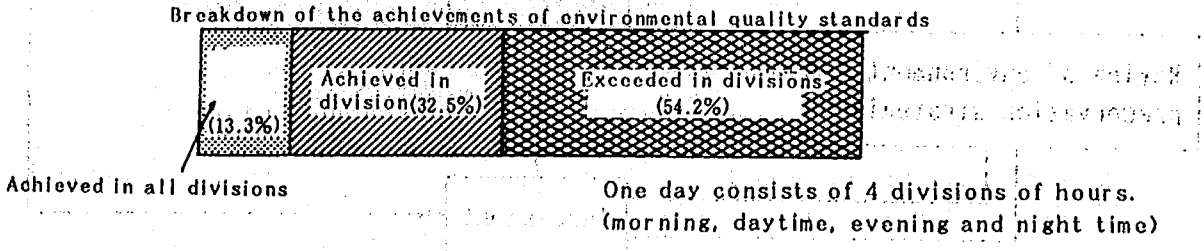


Fig. 7.5.3 Achieving environmental quality standards for automobile noise

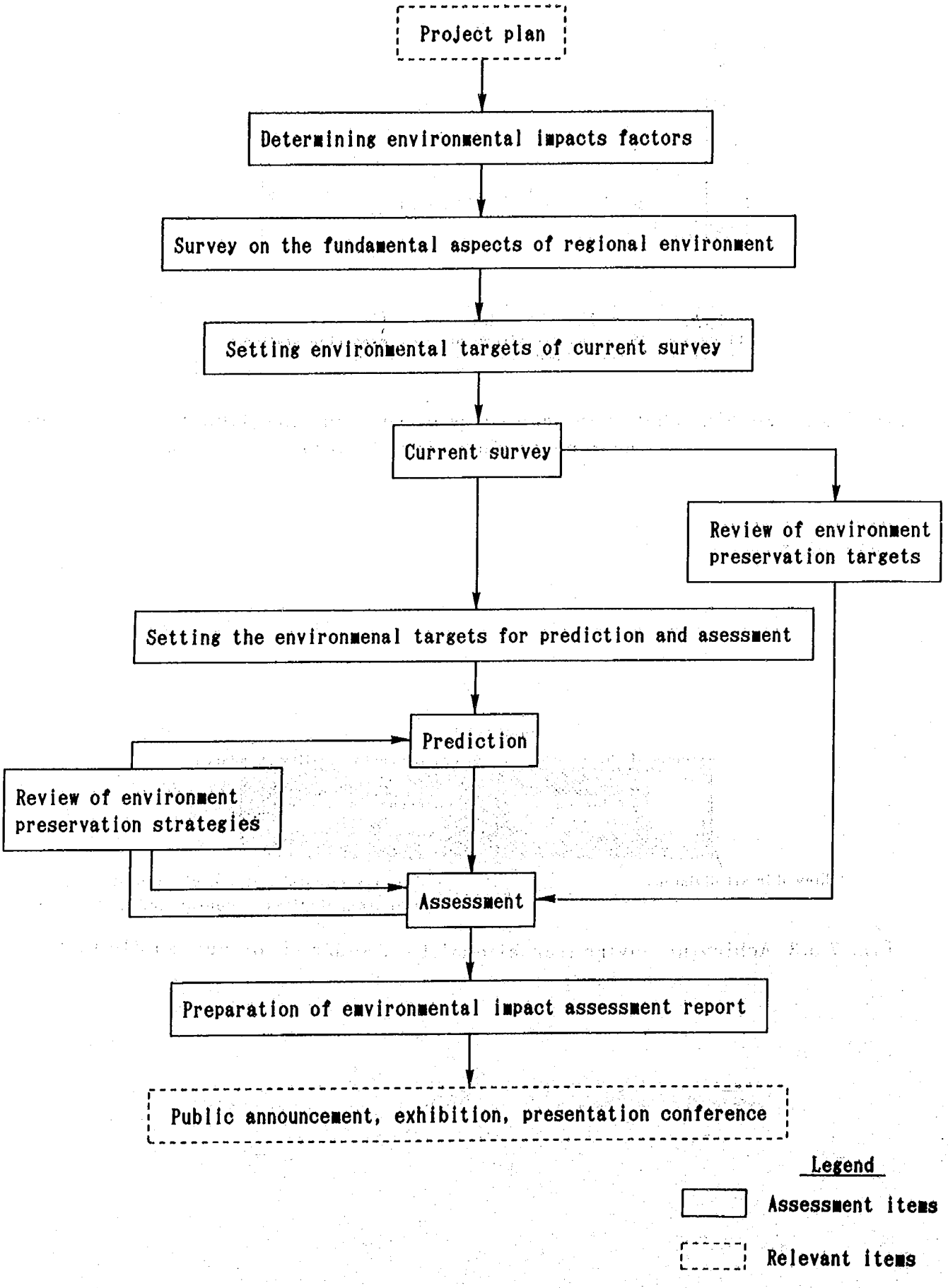


Fig. 7.5.1 Environmental impact assessment

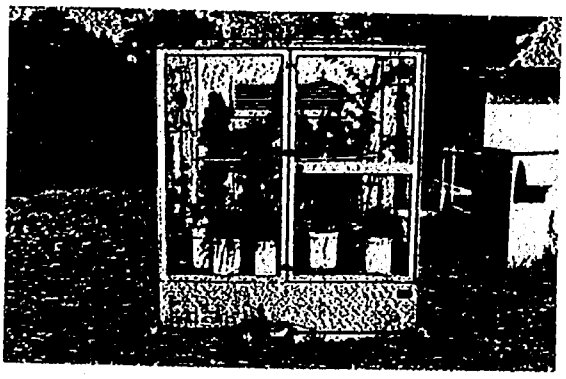


Photo 7.5.1 NOx absorption by plants experiment

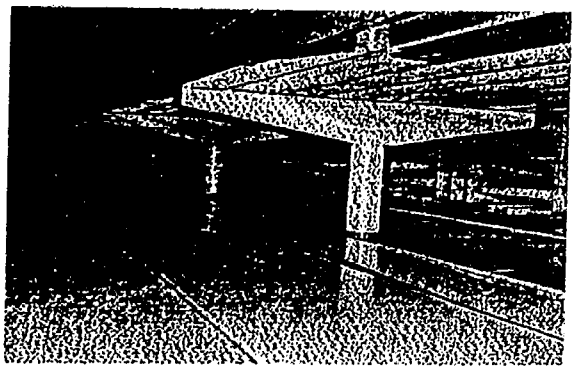


Photo 7.5.2 Model experiment of noise abatement measures against the reflected noise on the rear face of elevated roads

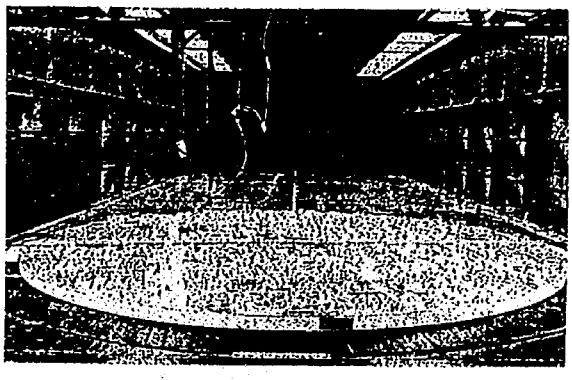


Photo 7.5.3 Air diffusion model experiment using wind tunnel

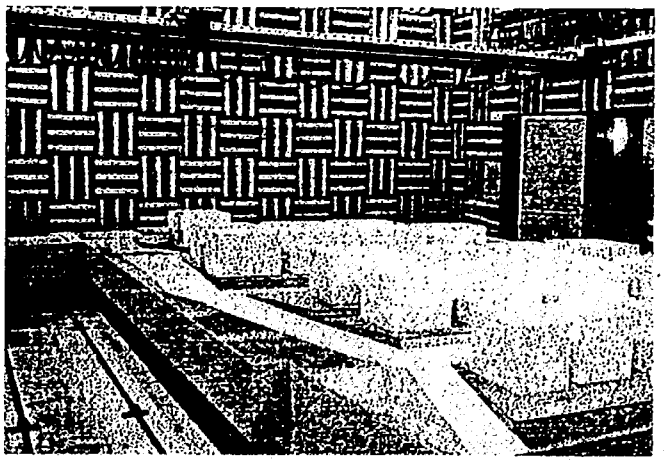


Photo 7.5.4 Anechoic room

環境施設帯の例

Photo 7.5.5 Example of environmental facilities zone

Ⅸ. Introduction of PWRI

1. Research System of PWRI
   Dr. Takashi Iijima, Assistant Director-General, PWRI
2. Geology and Chemistry Department
   Mr. Masashi Ikemura, Director of Geology and Chemistry Dept., ditto
3. River Department
   Dr. Fumio Yoshino, Director of River Dept., ditto
4. Water Quality Control Department
   Dr. Kikuo Inaba, Director of Water Quality Control Dept., ditto
5. Dam Department
   Mr. Seizo Takebayashi, Director of Dam Dept., ditto
6. Erosion Control Department
   Mr. Youtaro Asai, Director of Erosion Control Dept., ditto
7. Road Department
   Mr. Hiroo Kanzaki, Director of Road Dept., ditto
8. Construction Method and Equipment Department
   Dr. Yasuyuki Koga, Head of Soil Dynamics Div., of Construction Method and Equipment Dept., ditto
9. Structure and Bridge Department
   Dr. Minoru Fujiwara, Director of Structure and Bridge Dept., ditto
10. Earthquake Disaster Prevention Department
    Mr. Yutaka Iida, Director of Earthquake Disaster Prevention Dept., ditto
11. Construction Managment Engineering Center
    Mr. Masafumi Fukuda, Research Coordinator for Construction Management Engineering, Construction Management Engineering Center, ditto
12. Niigata Experimental Laboratory
    Mr. Ryosuke Tsunaki, Head of Niigata Experimental Laboratory, ditto

RESEARCH SYSTEM OF PUBLIC WORKS RESEARCH INSTITUTE

1. Research system

Since its inception 70 years ago, the Public Works Research Institute (PWRI) has been playing a leading role in Japanese civil engineering research and development for solving various technical problems associated with maintaining rivers, dams, roads, bridges, sewerage systems, sedimentation control, earthquake safety, construction materials, and so on. The PWRI, in accordance with its long-term research program implemented in April 1982, has drafted several five-year programs to aid in the timely development of this research.

Recent social and economic developments in Japan have effected major changes at the Institute, while new demands for construction management to more efficiently use public funds have risen. In response, the Ministry of Construction drafted its "Long-term Perspective for Research and Development in Construction Technology" in 1988. Two years later, PWRI drafted "Investigation Reports Regarding Future Civil Engineering Technology" after conducting investigations to clarify the roles to be played by construction techniques and the direction of future research plans, based on the discussions on projected future of national lands. This complements the current "Long-term program for PWRI". These two reports have formed the basis for the current third five-year program, which was formulated in 1992 to expedite the systematic administration of research and development at the Institute.

The Ministry of Construction is currently drafting its "Vision of Research and Development in Construction Technology for the coming 21st Century"(tentative title), which is scheduled to be completed by the end of 1993. In addition, the Ministry is also planning to draw up a "Five-Year program for Research and Development in Construction Technology" which will start in 1994. This program will determine the most important research topics and development objectives such as maintenance-free techniques, energy-saving techniques, and techniques for unattended construction sites. At the same time, it will provide for the funding and allocation of research duties among industry, university, and government. The PWRI will use PWRI five-year program to promote research and development to meet various administrative and public needs.

In the 1992 fiscal year, approximately 460 research subjects at are ongoing the Institute. The operating budget was 4.9 billion yen, with about 10 million yen

available for individual subjects. Research divisions, which are usually staffed by fewer than 10 researchers each, are responsible for an average of twelve subjects which may be determined by the relevant five-year program.

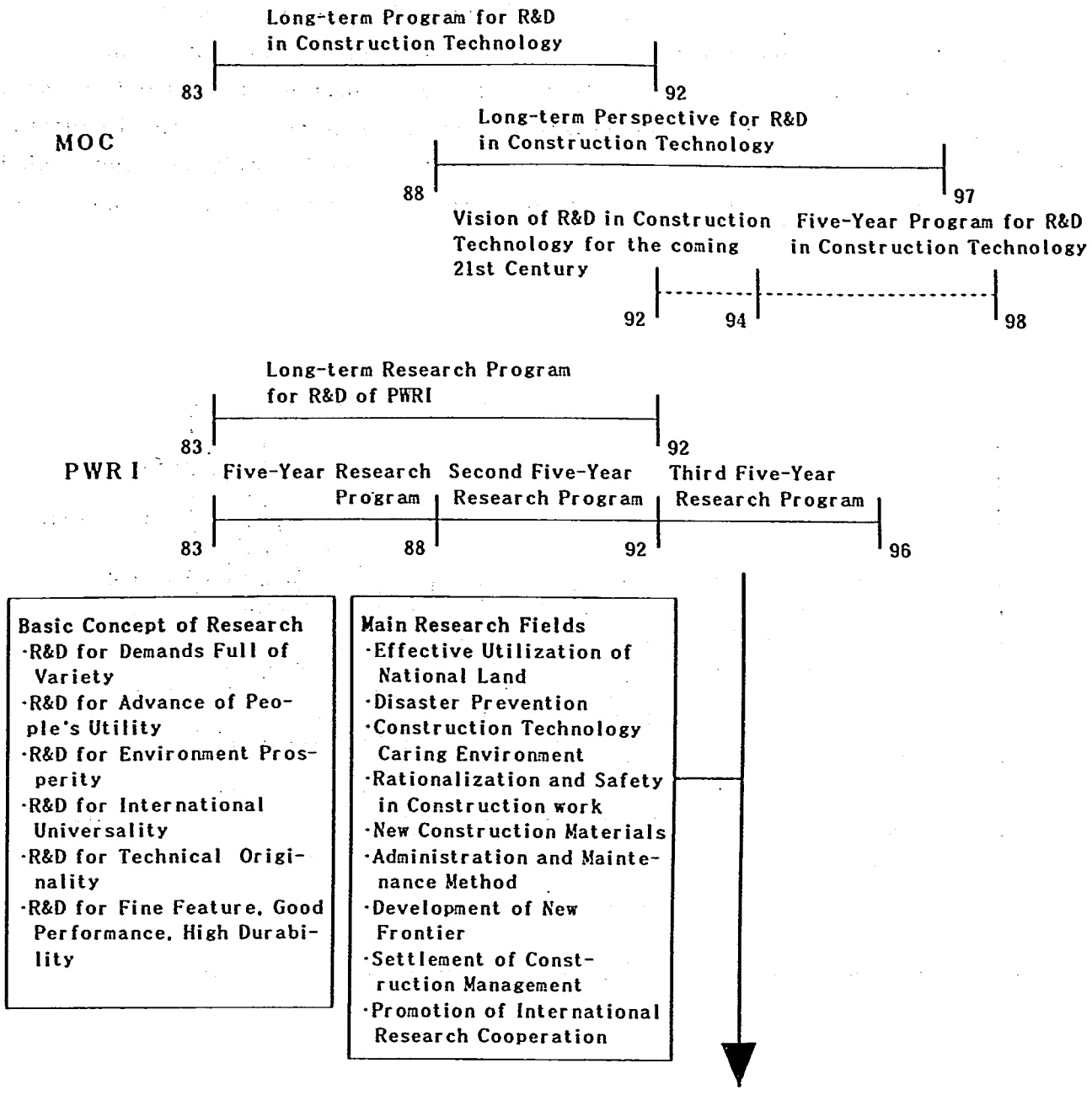
In addition, the concept of research, progress and target are discussed and screened in the meetings, consisted of Director-General, and managing staff of PWRI, administrators, specialists outside, to obtain advice, instruction, and ideas. (Fig. 1)

Subjects of overriding importance for administration, or which encompass a variety of fields, may be undertaken as project by several divisions or, if necessary, in cooperation with university and the private sector. This can be very conducive for technical development, since university is entrusted with fundamental research, and the private sector is usually responsible for developing applied techniques.

For general research, funding priority is given to those subjects which require considerable outlays for experiments, and those which are expected to have demonstrable success in the near future. Especially, attention focuses on the global environment and a better quality of life at present. The number of research topics relevant to environment such as global environmental problem, improvement of our immediate life space, better sight, preservation of ecosystem, energy-saving, and so, on is increasing (Fig. 2). It is also important to consider recent social changes and future outlooks of the PWRI when managing research.

To insure the success of research and development, it is necessary to nurture and improve the abilities of the researchers themselves through exchanges of information and knowledge. Therefore, accepting researcher system has been put in place to improve exchanges between public and private sectors.

Nowadays, private research institutions have been gaining in effectiveness, and the number of universities with civil engineering departments has been increasing. It is the responsibility of the PWRI, as a center for excellence in Japanese civil engineering, to conduct its own research by utilizing its considerable experience, and also act as a sort of moderator between universities, and private enterprises. PWRI should chart the course for Japanese civil engineering research and development, as well as mediate changes in role distribution among the various organization concerned.



Research type	Item of research expensive	Number of subjects
Based research	General account	75
Applied research	Special account (Flood control,Road improvement)	308
Developmental research	Comprehensive R&D project Govt./Private sector joint research	79
	Total number	462

Fig. 1 Research Program

Joint research systems between public and private sectors are improving year by year, allowing for greater opportunity for exchange. Moreover, it has become common practice for researchers from private companies to attend academic conferences. It will become increasingly important to participate in discussions which attract researchers from a wide range of academic, private, and public organizations to aid in the improvement of civil engineering research and development.

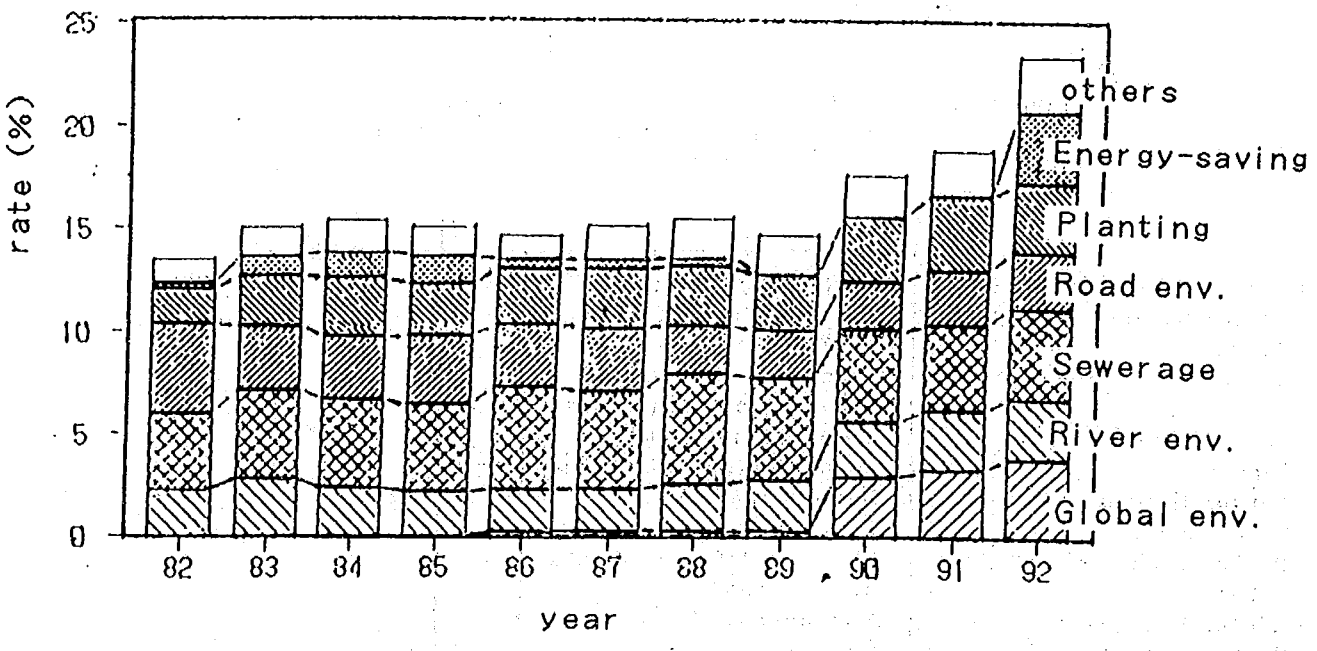


Fig.2 Trends in the rate of subjects related environment

2. Cooperation among academic, private, and public organization

① Comprehensive R&D Technology Development Project (established 1972)

In 1972 the Ministry of Construction inaugurated the Comprehensive R&D Project. Its purpose is to encourage research and development to meet increasingly diverse and stringent public demands, making use of the unique characteristics of the different fields of industrial, academic and government technology. The Public Works Research Institute is actively involved in the project as one of its main participants.

The Comprehensive R&D Project, with government bodies such as the Public Works Research Institute at the centre, closely coordinates with university and private bodies to create an organized system of research and development on a diverse range of issues of special importance and urgency. At present research is being carried out at a number of laboratories and sites and in a variety of different forms, such as joint ventures with public and private enterprises and specially commissioned research. The Project has also set up councils at institutions involved in research in which the intelligentsia of both universities and the private sector play an important role.

By coordinating the efforts of the three sectors, private, public and academic, the Project accelerates the overall process of research and development.

The fruits of the Project are spread to the Ministry of Construction and regional public organizations so that they may be passed down and come into general use by all of society. The Public Works Research Institute had investigated nineteen different research topics as of the end of the 1991 financial year, with a further seven in progress at the present.

② Government/private sector joint R&D (established 1986)

The Government/private sector joint R&D was formally established in 1986 to assist in putting a wide range of advanced technologies developed by private industry into practical use in the construction industry. Research proposals are screened, and those considered most applicable to the administrations needs are developed jointly by the relevant organization and the Public Works Research Institute. The Fig-3 shows an outline of the joint research system.

The joint R&D minimizes the investment risk to private companies,

stimulating the development of publicly useful technology. The ability of private industry is utilized efficiently in developing advanced construction technologies.

③ Joint research system (established 1980)

Research and development of advanced construction technologies is essential for the efficient utilization of infrastructure, and for dealing with the increasingly diverse and stringent needs of the people. Such research must cross the traditional boundaries between academic disciplines and between fields of industry, and make effective use of the unique aspects of industrial, academic and public technology.

Joint research is governed by Ministry of Construction regulations. Before 1985 this applied to research conducted jointly by national government bodies, public corporations and public-interest corporations, with the emphasis on the public role of such works. With the upsurge in research activity in the private sector, its rising interest in areas relevant to public administrations, and the growing realization of the necessity for joint work for effective and efficient research and development, the regulations were revised in 1985 to allow participation by private enterprise.

The number of joint research projects, (shown in the Fig-5), has subsequently seen a dramatic increase, illustrating the demand for joint research. One hundred and forty-six projects had been completed at the end of the 1991 financial year, with another 41 presently underway.

The results of this research, reflected in the work of a variety of different enterprises, contribute enormously to the future growth and development of the Public Works Research Institute.

Table.1 Comprehensive R&D Projects at PWRI

Area of research	Name of project
1) Conservation, safety, and disaster prevention on public land	• Development of new seismic resistant design method ('72-'76) • Development of comprehensive countermeasure for post-earthquake urban fire ('77-'81) • Development of repair methods of civil engineering structures damaged by earthquakes ('81-'85) • R&D of the comprehensive technologies to make snow resistible city ('82-'86) • Information systems for disaster mitigation ('87-'91) • R&D on earthquake disaster prevention technology in urban districts ('92-'96) • Sediment disaster prevention system R&D ('92-'96)
2) Advanced use of space	
3) New frontiers	• Development of construction technology of offshore structures ('72-'76) • Development of offshore technology for creation of marine multi-purpose zone ('86-'90) • Underground space use technology R&D ('87-'91)
4) Effective use of natural energy resources	• Development of artificial recharge of groundwater ('76-'80) • Development of new techniques to recycle waste disposal material on construction works ('81-'85) • R&D to increase the durability of concrete structures('85-'87) • R&D on new technologies for planning and construction of sustainble society ('91-'95) • R&D on controlling the generation of construction by products and utilization of recycled materials ('91-'95)
5) Maintaining effective use of social capital	• R&D on new technologies for improvement and renewal of social resources ('91-'95)
6) Boosting production efficiency in the construction industry	• Development of new soil improvement techniques ('75-'79) • Advanced construction technology R&D ('90-'94)
7) Utilization of advanced technology in a wide range of areas	• Electronics systems for advancing construction technology ('83-'87) • Development of new wastewater treatment systems employing biotechnology ('85-'89) • R&D on the application of new materials to construction industries ('88-'92)
8) Living environments	• Development of the technique on improving the living environment alongside the road ('78-'82)
9) Conservation, harmony, creativity of the environment	• R&D of technique which improve construction environment('77-'81) • Development of synthetic control system for quality of water on lake ('82-'86)
10) Comprehensive improvement of traffic systems	• R&D of new transportation system ('73-'76) • R&D of new urban freight transport system ('76-'80)
11) Advanced land information system	
12) Participation in international project	

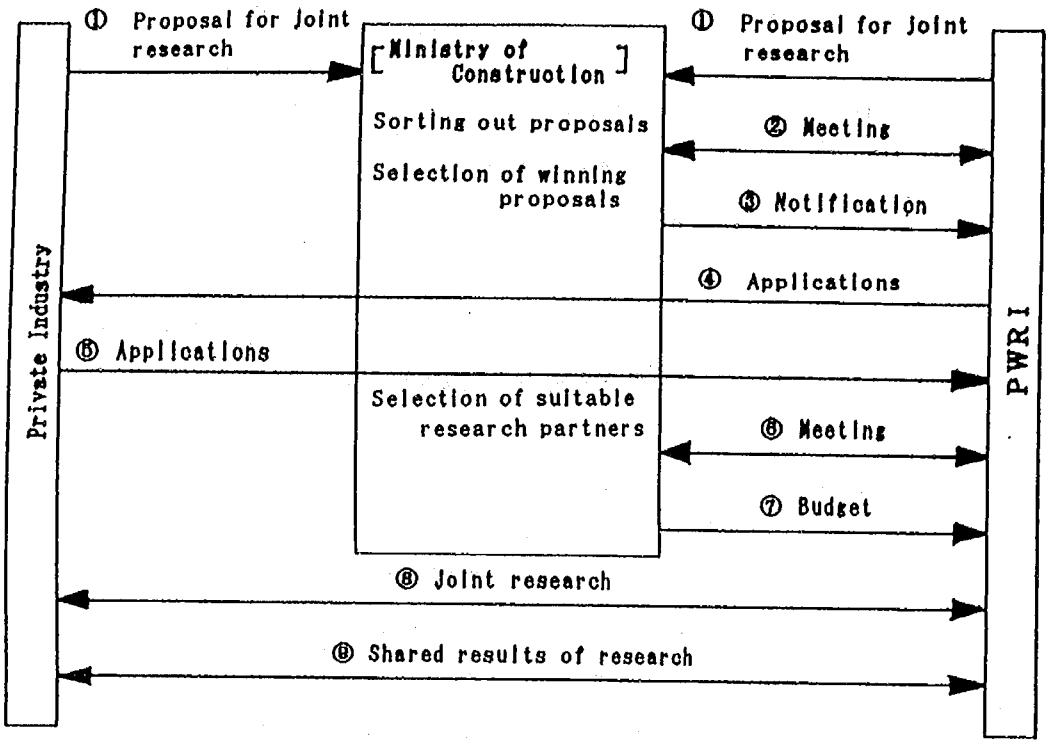


Fig. 3 Outline of Government/private sector joint R&D

Table 2 Government/private sector joint R&D

Research Subject	Division	Period
Research and development of Road/automobile communication system (RACS)	Traffic Eng. Div.	1986~1988
Development of inspection and repair system for existing construction	Bridge Div.	1987~1989
Development of small-bore tunnelling operation controlling systems	Sewage Works Div. Construction Equipment Div. Construction Method Div.	1988~1991
Base isolation system research and development for highway bridges	Earthquake Eng. Div.	1989~1991
Development of basic technique to create spaces for flowers and greens	Planting Div.	1991~1993
Development of new soil improvement techniques	Geology Div. Fill-type Dam Div. Soil Mechanics Div	1992~1994
Construction site management system using IC card	Construction Equipment Div.	1992~1994

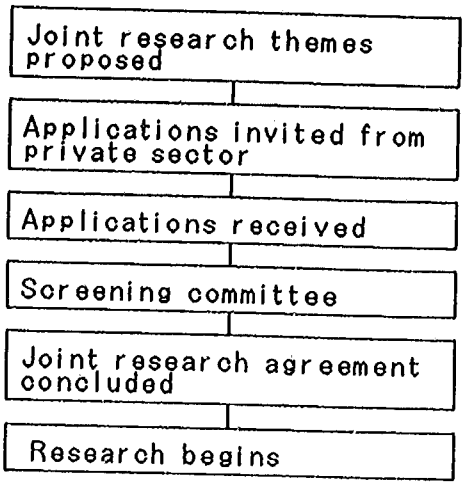


Fig. 4 Joint research flowchart

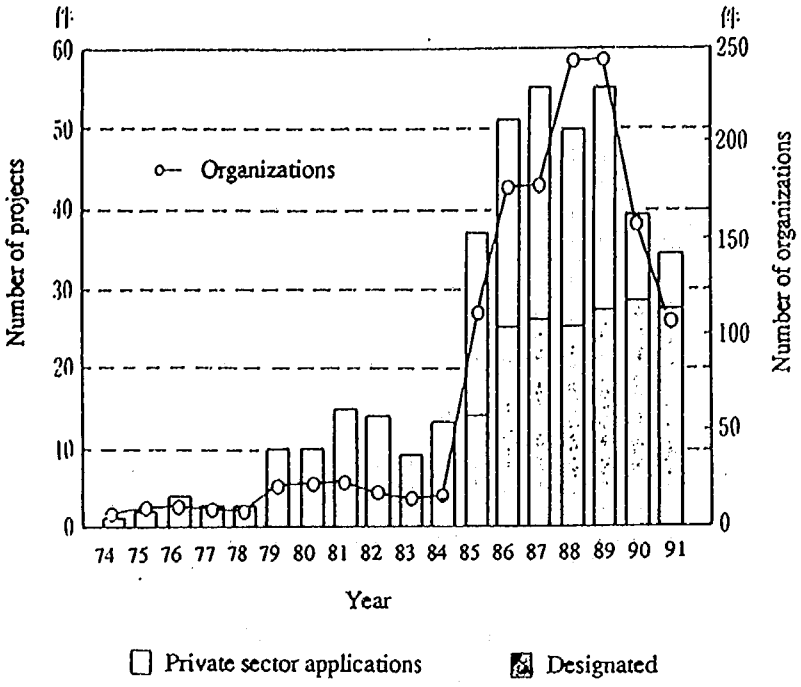


Fig. 5 Number of joint research projects and organizations

Table 3 Major joint research projects before 1992

Joint Research Themes	Division	Period
Study on the dual mode bus system	New Transportation systems Div. Traffic Environment Div. Pavement Div. Structure Div. Bridge Div.	1974～1978
Development of chemical grouting method not to cause environmental pollution	Construction Method Div.	1980
Research on development of rubberized asphalt for plastic flow and wear resistance pavement	Chemistry Div. Pavement Div.	1981～1983
Long term exposure tests of weathering of steel for road bridge	Chemistry Div. Bridge Div.	1981～1991
Development of new-type offshore breakwaters	Coastal Eng. Div.	1986～1991
Development of the automatic earth-moving machine	Construction Equipment Div.	1985～1987
Development of Biosensors	Water Quality Div.	1985～1989
Studies on the reasonable methods for design of geotextile reinforced soil	Construction Method Div. Soil Mechanics Div Soil Dynamics Div.	1988～1990

Table.4 Major joint research projects during 1992

Joint Research Themes	Division	Period
Study on geotechnical properties of Zeolitesbearing rocks	Geology Div.	1991~1993
Improving durability techniques of maritime structure	Chemistry Div.	1987~1994
Design for public structure in urban applied with new materials	Chemistry Div.	1992~1995
Cooperative research on the development of dual-linear doppler radar for quantitative observations of precipitation	Hydrology Div.	1985~1995
Study on seepage control for rock foundation by dry grouting method	Fill-type Dam Div.	1992~1994
Research on the planning and design methods of protection structures for snow avalanches	Slope Failure Div. Niigata Experimental Lab.	1992~1994
Research on highway driving simulator	Traffic Eng. Div.	1990~1992
Research of advanced road traffic systems (ARTS) toward 21th century	Traffic Eng. Div.	1992~1996
Research and Development of new urban freight transport system	New Transportation systems Div.	1990~1993
Research on improving the noise reduction effect of the drainage pavement	Traffic Environment Div.	1992~1993
Research and Development on new technologies for improvement and renewal of underwater Structures.	Construction Equipment Div.	1991~1994
Studies on the development of new techniques of reinforced soils	Soil Mechanics Div	1990~1992
Research of the countermeasures against earthquakes occurring on soft ground	Soil Dynamics Div.	1992~1996
Study on design for precast segmental prestressed concrete bridge	Bridge div.	1991~1993
Research & Development on the nondestructive measurement techniques for estimating soundness of existing concrete structures	Concrete Div.	1992~1995
Study on the landslide countermeasures by using materials for rainfall seepage prevention	Landslide Div. Soil Mechanics Div	1992~1994
Research of lighting in road tunnels	Tunnel Div.	1992
Study on wind induced vibration control of parallel stay cables	Structure Div.	1992~1994
Development of measurement and diagnosis technologies for bridge substructures	Foundation Eng. Div.	1992~1995
Research on limit state design methods during earthquakes for highway bridge piers	Earthquake Eng. Div.	1992~1993
Research on rigid barrier	Traffic Safety Div.	1992~1993

④ Accepting of researchers

(1) Accepting researchers from outside (from 1980)

The Public Works Research Institute receives many requests from regional public bodies, public corporations and private organizations who wish to study construction technology research with the benefit of the Institute's technology and facilities. To comply these requests, the Ministry of Construction established a system for the admission of outside, non-Ministry researchers for the period of around 1 year . The purpose of this system is to nurture young researchers, and to help diffuse the results of the Institute's research and exchange ideas. Around fifty outside researchers are admitted every year.

(2) Inviting researchers from outside (from 1980)

In order to progress research ability to meet increasingly diverse and complex problems, the Ministry requires highly specialized knowledge in a variety of different fields. Such knowledge can be obtained from specialists working at public research institutions, universities and private organizations. The Ministry of Construction therefore decided to implement such a system, and invitations are made regularly to outside researchers.

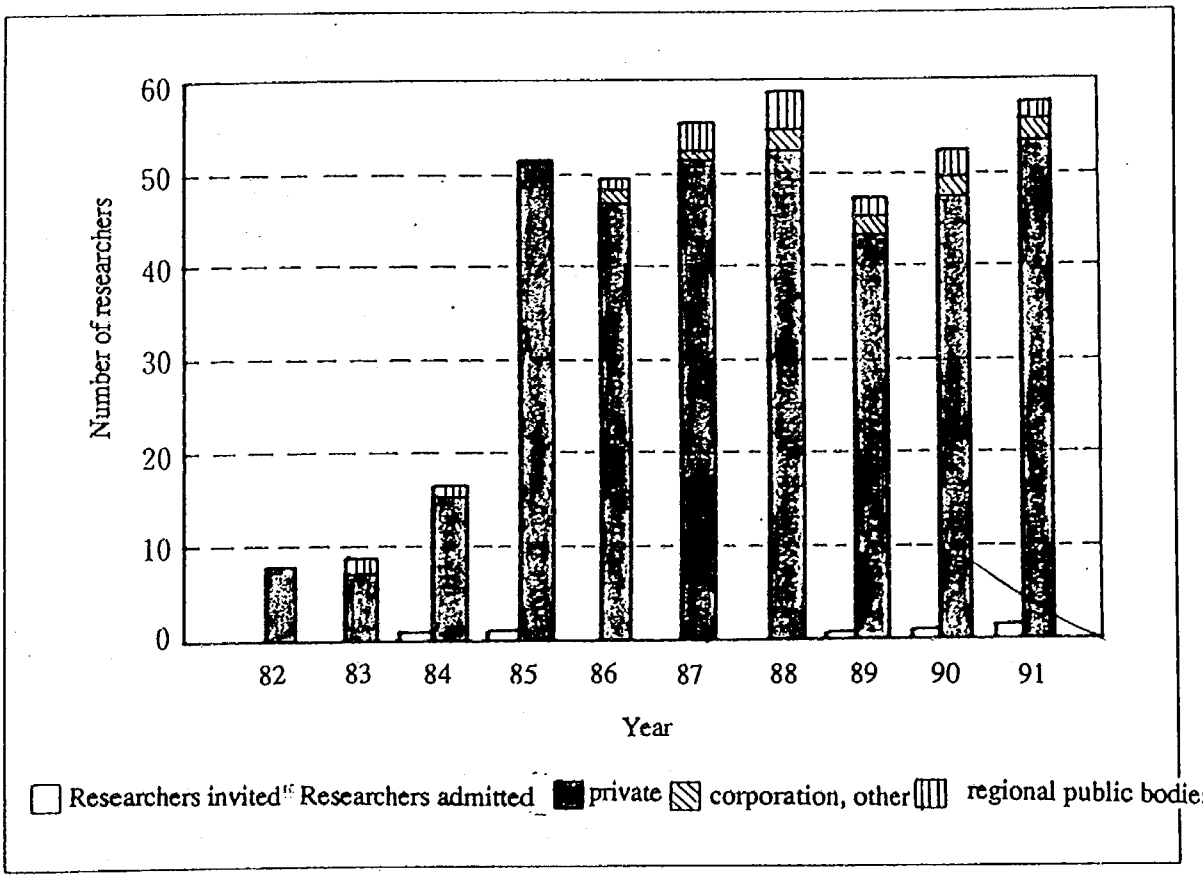


Fig. 6 Number of outside researchers at the Institute

3. Presentation of Research Active

Publications of research outcome latest studies and researches are compiled and introduced to the public in the following reports;

• Report of PWRI

This is a collection of selected papers considered scientifically and technologically excellent among the works done at PWRI.

• Journal of Research (Occasional)

This is a collection of selected papers from "Report of PWRI" cosseting important for overseas public as well as valuable for exchange.

• Technical Note of PWRI (Occasional/English)

This is compiled from research data obtained through studies, test and researches at PWRI and considered indispensable for further researches.

• Civil Engineering Journal (Monthly)

This is compiled from the latest research results and civil engineering topics in and out of Japan as well as research data attained through studies, test and researches at PWRI.

• PWRI News Letter (Quarterly/English)

This is to introduce main research activities at PWRI for promoting international friendship and scientific exchanges.

We also host Lecture Meetings and Study Meeting where researchers of PWRI present the latest topics and trends in civil engineering. In addition, we promote Technical Meeting of MOC, dispatch of lecturers, technical instructions and activities with academic societies. Through these activities, we disseminate the civil engineering technology to the public.

GEOLOGY AND CHEMISTRY DEPARTMENT

The Ministry of Construction has been making earnest efforts to promote the development of infrastructure in order to build a country in which the people are given a sense of affluence. In order to realize this policy efficiently it has become important to improve construction technology and to establish rational methods for using various construction materials.

The Geology and Chemistry Department, which comprises three divisions, the Geology Division, Chemistry Division, and Concrete Division, is engaged in research and development on construction materials and technologies.

The Geology and Chemistry Department applies the results of research into geology, chemistry, and construction materials such as concrete, and participates in developing technology for the use of new materials as well as research on standardizing methods of use. It is also engaged in research of improving methods of maintenance of the big volume of infrastructure, i.e. roads, dams, and bridges, that has been constructed hitherto.

In recent years, there has been growing concern of the Japanese people for problems of saving energy and resources from a view of improving the global scale environment. The Geology and Chemistry Department aims to continue research of construction materials, while paying greater attention to these problems.

1. Geology Division

In executing the construction of dams, roads, tunnels, bridges, as well as hazard protection measures against landslides, slope failure, debris flow, and so on, it is important to have a precise understanding of topography, geological history, lithology, geological structure, geotechnical properties of ground such as strength, deformability, and permeability, as well as the properties of rocks and gravel as construction materials at construction site in question. In this division, we carry out the following investigative research into various problems relating to civil engineering geology, and attempt to solve them.

(1) Topographical, geological, and geotechnical research relating to deterioration of rock and foundations, and stability of slopes
(2) Developing and improving geotechnical survey methods and test methods in order to gain a precise understanding of the physical and dynamic properties of foundations and rock
(3) Preparing geological survey guides to rationalize the design and construction of dams, roads, tunnels, bridges, disaster protection facilities, and so on.

In addition to these research, we also carry out technical instruction on problems of civil engineering geology in projects such as dams, roads, and disaster protection facilities undertaken by the Ministry of Construction and related organizations.

Next, I shall describe the history of research until the present.

In 1938, elastic wave exploration and electric exploration were carried out for bridge foundations and underlying rock foundations of dams. Taking this as the

first step, we started applying various geophysical exploration over a broad range of civil engineering fields, continuing until the present day. Also in 1938, engineering geological surveys for the Koanmon road tunnel were started. This not only signalled a major era for geological surveys into road tunnels, but also was the first step in the organized involvement of civil engineering geology in large-scale projects.

In the first half of the 1950's the construction of high-dams flourished, and in conjunction with this, research into dam geology was positively promoted. From the mid-1950's the construction of arch dams was started, and, with the establishment of bedrock dynamics, dam geology developed rapidly. Meanwhile, geological surveys were started on two major highway projects, namely the Chuo Highway in 1958 and the Honshu-Shikoku Link Bridge in 1963. At the same time, technology was developed for assessments based on aerial photography and for marine engineering geological surveys.

Accompanying a dramatic increase in dam construction and deteriorating geological foundations from the mid-1960's, proposals were made for schematic surveys, engineering classification methods, and evaluation methods for bedrock foundations. Apart from this, geological surveys in shallow sea areas and surveys/tests on soft rock were energetically promoted in connection with the Trans-Tokyo Bay Highway. Finally, research was also promoted into disaster-related geology, such as coastal erosion and sediment disasters in the outskirts of major cities.

From the mid-1970's bedrock foundations of structures increasingly diversified and deteriorated, such that more finely detailed and precise geological surveys were needed. This situation has continued up to the present day. In particular, accompanying the move to Tsukuba in March 1979, various updated instruments were used to carry out research with a focus on the strength and permeability properties of soft rock, methods of rock mass classification, methods of surveying Quaternary faults, and others. As well as these, research on the durability and effective use of rock materials also become an important theme.

Since the mid-1980's, geophysical explorations have posted notable progress, and new geological survey methods such as geotomography have been developed. Furthermore, we are tackling the development of advanced foundation data processing technology through which effective use can be made of foundation data.

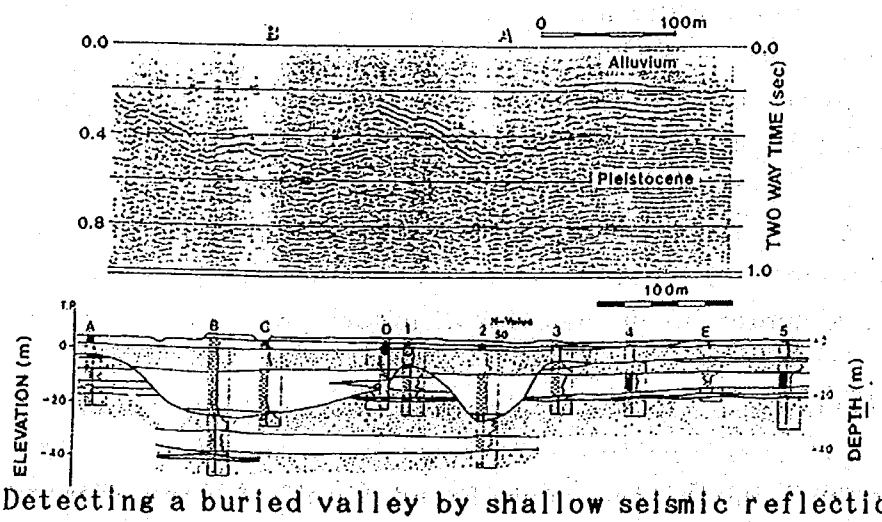


Fig.1 Detecting a buried valley by shallow seismic reflection method

2. Chemistry Division

Since chemistry has a large part to play in the field of civil engineering, the Chemistry Division undertakes positive research activities including research in aspects such as the durability and maintenance of civil engineering structures, and research on environmental analysis making use of advanced analytical technology, with a focus on that relating to civil engineering materials including new materials. The results of this research are compiled in the form of technical guides. Meanwhile, on an international level, we publish technical data in the form of bilateral research exchanges.

Next, I shall describe the history of research until the present.

Since the improvement of roads was a matter of pressing urgency when the Division was first established, it launched itself energetically into the work of testing and researching applications for materials such as bitumen (asphalt), tar, and cement, as well as to civil engineering chemistry.

In order to satisfy the rapidly growing demand for road surfacing from the mid-1920's due to the diffusion of motor cars as well as for military reasons, research was undertaken into a wide range of paving materials, including bitumen permeated blocks, asphalt emulsion, composite tar or tar paving materials, and so on.

On the other hand, as civil engineering works came to flourish in a number of areas such as bridge supports, dikes, sluice gates, or tunnels, research was conducted on erosion aging caused by acidic water, permeating water, or salt-containing water, in relation to the durability of cement concrete, and surveys were carried out on erosive environments. Various special types of cement were manufactured, including moderate heat Portland cement, high-early-strength Portland cement, silicon compound cement, and blast-furnace cement, and research into their use was promoted.

Once the post-war confusion had settled in 1951-2, surveys and research over a wide range were started up again to respond to the full reconstruction of the national land.

Research was conducted in areas such as in clay minerals from inland waters and landslide areas, related to countermeasures against natural disasters such as landslides, or research into various types of cement for dams in connection with the flourishing construction of the latter. Further, to accompany the expansion and development of the national highway network based on the formulation of the five-year plan for highway development from fiscal 1954, research was conducted on asphalt as a road-surfacing material and on chemical stabilizing treatment of road beds and road foundations from the new standpoint of upgrading road construction technology. On the other hand, from 1956 the use of tracers in connection with the application of radio-isotopes in the civil engineering field was widely implemented as one peaceful way of using nuclear energy.

From the mid-1960's investments in the infrastructure came to fulfil an even more important role in order to support the high level of growth. At the same time major changes were made to construction materials.

Steel materials came to be used in large volumes in all types of civil

engineering structures, and research was undertaken into rustproof paint in connection with the construction of the Wakato Bridge. Furthermore, construction plans for projects on a scale not previously experienced in our country, namely the Honshu-Shikoku Link Bridge and the Tokyo Bay Loop Highway, gradually took shape, and research was started into corrosion and corrosion-prevention for steel materials in a marine environment. Thereafter, these evolved into development towards maintenance technology to accompany the massive accumulation of infrastructure. As a new arrangement, a system of joint research with private companies was organized, as a result of which various materials were developed and verification tests were carried out in actual environments.

In addition, in order to deal rapidly with problems of the early aging of concrete which arose from the start of the 1980's, we participated in a comprehensive research project on technology for improving the durability of concrete, as a result of which comprehensive technology was developed and standardized to cope with new phenomena which had not previously been witnessed in Japan, such as salt corrosion and alkaline aggregate reaction.

In terms of increasing the stock of infrastructure, we are also participating in a new comprehensive research project, "Developing Technology for Renewing and Maintaining the Infrastructure and Improving its Functions".

As concerns the utilization of ocean space, we are participating in the comprehensive research project "Developing Technology for Creating and Preserving Ocean Utilization Space", which was started on the basis of the MMZ Plan (Ministry of Construction), and have had a hand in the planning of technical development in aspects such as ocean product surveys, ocean materials, checks, and so on.

From the mid-1980's we entered the era of new materials. The pursuit of new materials in manufacturing fields started, and the results of this started to have repercussions through utilization in the construction sector. Meanwhile, new technology is also required for the construction industry, in view of the labour shortage, high durability, high functionality, and changes in the social environment such as social amenities.

By virtue of the fact that these materials are new, they have short track-records of utilization, and so we need to establish evaluation procedures and practical applications. To this end, we have decided to undertake research and development systematically in accordance with the comprehensive research project "Developing Technology for Utilizing New Materials in Construction Projects".

Major Research Achievements

1) Development of technology for the use of new materials in civil engineering structures
2) Development of anti-corrosive technology in oceanic structures
3) Development of maintenance technology for coating and lining civil engineering structures
4) Development of new paving materials and road surface recycling technology

5) Development of technology for improving the durability of concrete

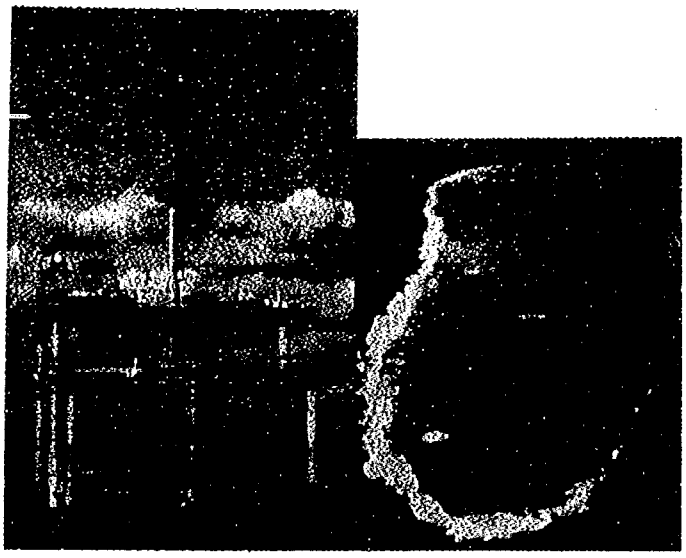


Photo.1 Oceanic civil engineering materials (Maritime Technology Research Station and Okinotori Island)

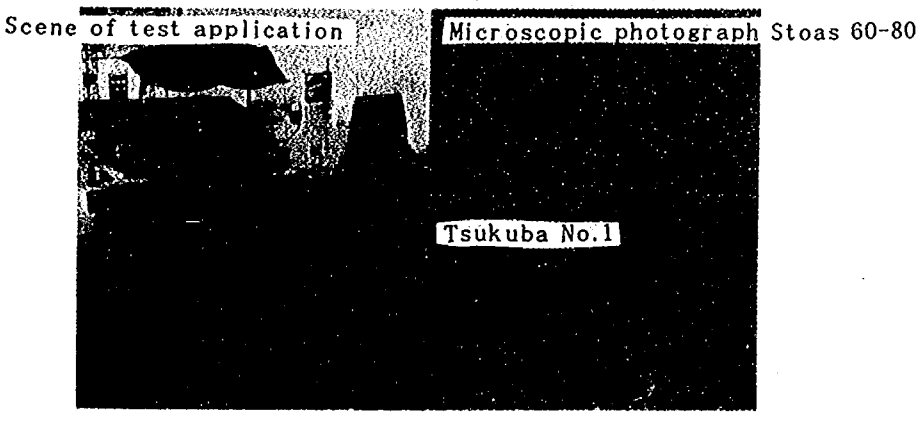


Photo.2 Application and quality of "Tsukuba No.1"

3. Concrete Division

Together with soil and steel materials, concrete is one of the most fundamental materials used in construction works, and so technical development aimed at improving the properties of this material, increasing its easiness of application, and guaranteeing the durability of concrete structures has a very big effect on construction projects. Indeed, there are hopes that a variety of new materials can be incorporated in concrete used in structures which are built under rigorous environments or specialized conditions.

In view of this, in the Concrete Division we carry out surveys and research from a number of angles on materials and structures relating to concrete.

Next, I shall describe the history of research until the present.

Along with the increasing construction of dams in locations where the rock foundations are not always favorable, there has also been an increase in cases where effective use has to be made of aggregate that does not altogether comply with conventional standards. Because of this, we have conducted research to clarify the physical properties needed by aggregate to be used for concrete in

ordinary dams, while considering the properties of dam concrete. The results of this allowed us to indicate quality regulations for the practical application of base aggregate for dam concrete.

We are conducting research into underwater and high-strength concrete, as research aimed at developing new fields of application for concrete. Regarding the former, we have studied underwater concrete using concrete mixed with high-performance water-reduction agent or blast-furnace slag powder, as an improvement of conventional methods of application. But more recently we have surveyed the properties of concrete using newly developed anti-washable admixture for use in concrete, and have studied ways in which it can be used. High-strength concrete is a never-ending theme, and our other activities include studies on raising the strength of concrete by incorporating new admixtures and short fibres, and studies on concrete structures such as those using ferro-cement frames.

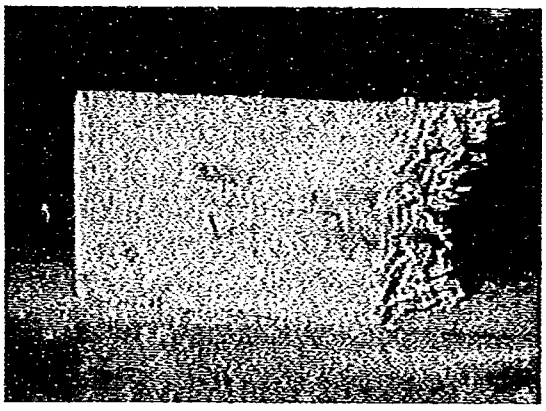


Photo. 3 Fibre-reinforced concrete

After the oil crisis in 1973, we conducted research on the effective use of blast furnace slag and fly ash, by-products of industry, as research into economizing on energy and resources in the field of construction. While at first our studies on the former concentrated on its use as an aggregate, since then we have shifted towards the use of ground granulated blast-furnace slag as a admixture. We are currently studying this powder from different angles, such as a countermeasure against alkali aggregate reaction or for the control of heat generation in mass concrete.

We are also studying the use of new materials in concrete.

For example, we have studied problems of adhesion to concrete and fatigue characteristics when resin-coated steel reinforcing bars are adopted, as a material for use in concrete free from corrosion in areas such as those which are susceptible to chloride damage; we have also made decisions on issues such as tolerable degrees of adhesion stress. Next, we developed One-day concrete with the objectives of reducing the normally long time required from casting the concrete until putting it into use, and enabling its prompt use in works such as repairs and road pavement. In this issue we carried out cooperative research with private sector cement manufacturers with the objective of achieving a one-day strength of 300kgf/cm^2 or more, and taking off more than one hour from the handling time

needed from mixing to casting. We thus achieved an One-day concrete for practical use, and are now undertaking investigative surveys for structures such as road pavement.

As for surveys into methods of construction, we are conducting surveys and research into roller-compacted concrete, a type of concrete which is of an extremely dry and stiff consistency compared to ordinary concrete, but which cannot be handled by conventional mixing design or quality control methods.

Quality control of concrete is carried out in slump tests prior to casting, air volume tests, and 28-day strength tests on compression strength test samples which have been thus prepared. But in order to judge the 28-day strength within a few days we have developed an accelerated curing method via warm water curing (1976). This involves curing a pre-cured compression strength test sample in warm water. As a proposal for test methods we have settled on the method of curing for 24 hours in warm water at 70°C, as conditions under which a high strength can be achieved in a short time in relatively low-hazard conditions. With this method, after mixing, results can be obtained two days after the application, with one day for pre-curing and one day for warm water curing.

Apart from this, recently we have also been studying quick methods of measuring unit water volumes in fresh concrete, using heating and specific gravity measurement.

For cases where alkali aggregate reaction has become a problem, we have studied ways of improving conventional chemical or mortar bar methods so that they match aggregate available in Japan, as well as methods of making even faster assessments using auto-clave, or methods of simplifying assessment, without recourse to special devices or capabilities.

Reinforced concrete used to enjoy an almost legendary reputation for being maintenance-free and durable. But between the mid-fifties and the mid-seventies production volumes of concrete leapt upwards, and this was accompanied by outstanding progress in quick construction technology. Along with a shift in attention from the construction of concrete to one of mass production, in terms of quality itself as well as of quality management it became difficult to maintain standards at the legendary level that they had enjoyed until then. Apart from this, there were also increasing cases in which the environments for constructing structures became more rigorous.

As a result of this situation, various phenomena of early deterioration of concrete structures came to the surface from the mid-1970's onwards.

The first problem to emerge was chloride damage. Corrosion was discovered in steel reinforcements in civil engineering structures in the Kansai region which incorporated sea sand, while deterioration accompanying the rusting of steel reinforcing bars, likewise regarded as being due to the effect of salt, was also discovered sporadically in superstructure sections of bridges in coastal regions. Similar deterioration also became visible in buildings, and these deterioration phenomena were widely taken up by the mass media as problems which could unsettle the infrastructure, the very foundation of the country; in other words, as a "concrete crisis".

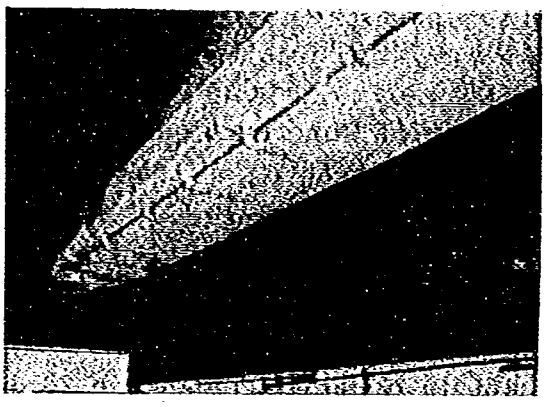


Photo.4 A bridge girder which has deteriorated due to chloride attack

While chloride damage became a problem, at the same time deterioration of concrete marked by a considerable and previously unwitnessed degree of cracking was recognized in structures in the Kansai area. This was the phenomenon known as alkali aggregate reaction (referred to below as ASR), which is thought not to have existed in Japan until then.

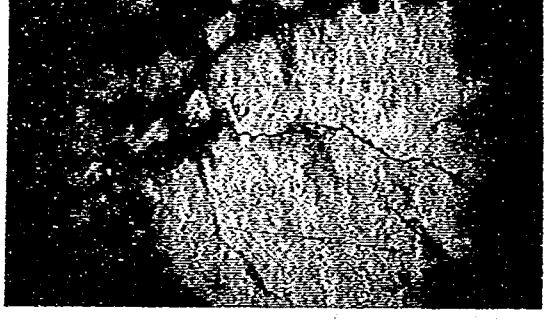


Photo.5 Deterioration due to alkali aggregate reaction

Indeed, since early deterioration was also blamed on a general mistakes of construction work, we launched the comprehensive research project "Developing Technology to Improve the Durability of Concrete", in order to seek solutions to such problems relating to durability.

As part of this research, a whole series of research and development of technology was carried out, including field surveys of structures which had deteriorated due to chloride attack and ASR, elucidating the mechanism whereby deterioration occurred, revising quality criteria for concrete, and developing diagnostic and repair technology for deteriorated structures.

As regards the design of concrete members, we conducted various tests in order to establish design standards for steel frame and steel reinforced concrete, and drew up "Guidelines for the Design of Steel Framed Steel Reinforced Structures (Draft)", indicating basic design concepts and structural details.

In order to rationalize the construction of concrete, we carried out research aimed at establishing design methods for joining precast members together, and for joining concrete cast on-site to pre-cast sections.

In order to establish earthquake-resistant design methods for pier footing joints in substructure sections of road bridges and the like, we compared seismic design methods at domestic and abroad, studied critical condition design methods, and studied methods of dynamic analysis as well as carrying out experimental studies. In consequence we drew up "Earthquake-Resistant Design Methods for Concrete Structures (Draft)" in 1977. We gained a grasp of the behaviour of road bridge substructures at times of repeated load imposition caused by earthquakes, and studied earthquake-resistant design methods, paying attention to the effect of rotation deformation of columns caused by slip-out of anchored reinforcements in joints.

Furthermore, in order to increase ductility and improve earthquake resistance in concrete structures, we carried out studies on ductility concrete sections. In particular, in cases using fibre-reinforced concrete, for which there has conventionally been a lack of design methods that suitably evaluate its characteristics, we studied design methods such as would effectively reflect the properties of fibre-reinforced concrete, gleaned from tests, in ductility designs for concrete sections.

As the use of spot-welding in reinforcing bar assembly is thought to be one way of rationalizing the application process, we tested the static strength and fatigue strength of spot-welded reinforcing bar and studied the suitable range of use and allowable stress levels of spot-welding.

We compiled "Standard Designs for Girder Base Widening (Revised Draft)" in compliance with new clauses in the earthquake-resistance edition of the 1980 Guidelines on Road Bridges, which stipulate the length of girders which should be secured for bridge abutments and bridge columns in order to prevent the beams from collapsing.

In order to repair bridge supports and others that have suffered damage or deterioration or have been subjected to earthquake damage, we studied a method of repair by means of resin injection, for cases where the deterioration is not too severe and which mainly involves cracking. For cases where the deterioration is severe, we studied repair methods involving face restoration using putty, splicing additional steel for damaged reinforcing bars, or RC lining. These are reflected in the "Technical Manual for Earthquake Damage Restoration of Civil Engineering Structures (Draft)".

Photo.6 Load experiments on model road bridge piers repaired after earthquake damage

RIVER DEPARTMENT

Geomorphological and meteorological conditions in Japan inflict severe river-related disasters on intensive socio-economical activities on flood plains. To make these lands more secure against flooding, the River Department studies techniques to predict river discharges using radar observations of rainfall, methods for improving the course of rivers, rainwater runoff control using infiltration-and-storage type facilities, and simulation of overland flows.

In order to create good qualities of life preservation and utilization of natural river environments, methods for improving water quality and scenery, design of fish ladders and river promenades are under investigation.

On the other hand, coastal areas suffer from violent waves, high tides, tsunamis and beach erosion. Therefore,the development of measures for breaking water and stabilizing beaches,especially offshore control structures,which can create a multi-purpose space, is studied.

With regard to sea level rises and other hydrological effects due to global changes, the continuation of accurate observations and the development of an analytical model of rainfall are carried out.

In addition, large scale physical model tests and field observing facilities are used to confirm the effects of river improvement works, preventive measures for beach erosion.

1.. River Hydraulics Division
- 1)Development of armored levee.
- 2)Method for estimating the scouring depth around a pier.
- 3)Observation of flood flow and development of measuring devices.
- 4)Development of vene work.

2. Urban River Division
- 1)A study of the most desirable river scape in an urban region.
- 2)A study of a synthetic management technique of lake water.
- 3)Improvement of land-scapes using sheet piles with designed panels.

3. Hydrology Division
- 1)Development of runoff analysis.
- 2)Development of hydrological observation systems.
- 3)Development of groundwater management.
- 4)Study on global climate change.

4. Flood Disaster Prevention Division
- 1)Research on evaluation of flood loss prevention projects and planning methods.
- 2)Hydraulic and hydrologic analyses of the effects of various run-off control facilities, identification of economic and social problems and presentation of solutions.
- 3)Research on flood risk maps.
- 4)Water-related disaster prevention.

5. Coastal Engineering Division
- 1)Experimental study on shore protection facilities.
- 2)R&D of new-type offshore breakwater.
- 3)R&D of headland systems.

Research Activities

Flooding of Kokai River, Aug., 1986 (Landsat)
The Kokai River was flooded by localized torrential rain and the neighboring area inundated.

Japan has suffered from many disasters such as flooding and storm surges due to the country's natural and social conditions.

In order to prevent these disasters, the River Department researches rain and snowfall observation by multiparameter radar system, flood forecasting improvement of river facilities, measures for reducing flood runoff and inundation, and measures for preventing storm surges and coastal erosion.

Research on water quality improvement and landscape design is carried out to improve river environments. Investigations of global warming effects on the characteristics of flood, drought, and coastal disasters are also made. Research related to river improvement and coastal erosion prevention is also carried out through large scale hydraulic model experiments and field observations.

Model Experiments on River Channel Improvement Works

For better river channel improvement planning, the characteristics of river channels, that is flood flow patterns, velocity, channel bed variation, bank erosion, influence of river structure on river channels etc., should be investigated in detail. River model experiments are one of the most effective ways of obtaining the above information.

Many model experiments have been carried out in the station for river model experiments.

Investigations through these experiments are put to practical use in river improvement works.

Hydraulic model experiment for improvement of the river mouth of the Naka River

Riverside Scenery Improvement

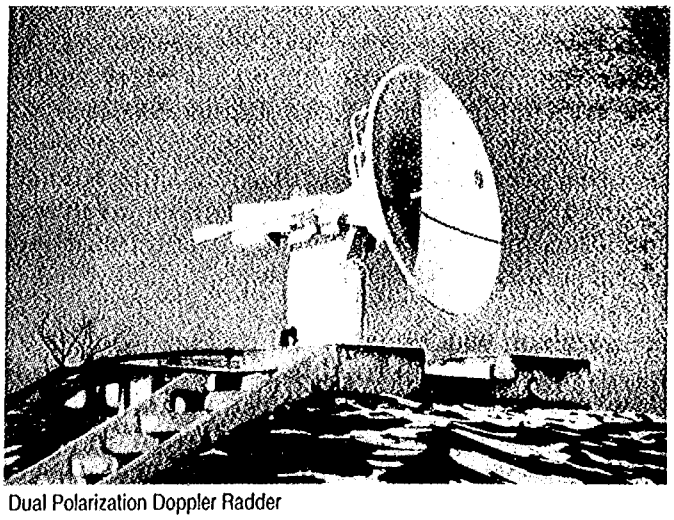
Rivers and wide flood channels are generally used for sports (boating, yachting, base-ball and gateball), fishing, birdwatching, etc. In cities, open spaces along rivers offer relaxation to residents. In the countryside, rivers are important tourism resources. In order to carry out scenic improvement, the following subjects are being researched:

I. Conservation and development of riverscapes.
II. River improvement in harmony with amenities.

Playing with water in Oh-yodo River (Miyazaki City)

Observation of Rainfall and Snowfall by the DND Radar

DND radar if the first dual-polarized doppler radar in Japan. The optimum method for rainfall observation, methods for distinguishing the phase, size and shape of hydrometers, and methods for estimating drop size distribution are studied with the DND radar. Research on the mechanism of precipitation and methods of rainfall forecasting by the simultaneous use of conventional radar data and satellite data are also conducted.

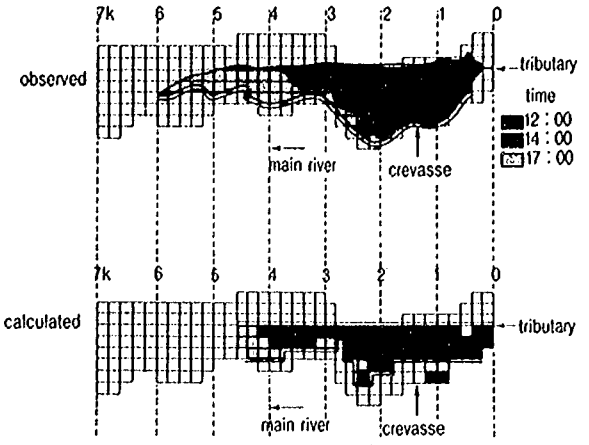


Dual Polarization Doppler Radder

Flood Prediction Model and Its Application

Flood control projects such as river improvement and dam construction are being carried out for the purpose of preventing floods, which cause serious damage to lives and property. To evaluate their effects, to verify their usefulness, and to implement the rehabilitation of levees and evacuation of people properly during times of flooding, it is important to predict the propagation of floodwater, and provide the information in a readily understandable manner combined with other flood-related information.

This research is carried out to improve the accuracy and application of the prediction.



(Kokai River, Aug.1986)

Temporal propagation of inundated areas

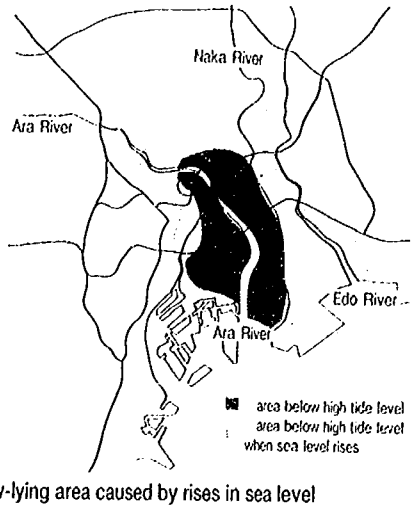
Coastal Protection and the Creation of Good Coastal Environment

In Japan typhoons and earthquakes have greatly influenced human activities along coasts, as they cause high tides, high waves and tsunamis. Furthermore, coastal erosion has also come to be a severe problem. Under these circumstances, countermeasures against these disasters have been studied by means of physical model experiments, numerical analyses and field observations. Recently, according to changes in life style, leisure time is increasing and coastal zones must be good water fronts. Coastal planning methods are studied in order to create a comfortable coastal environment as well as to construct shore protection facilities.

Wave overtopping at Sizuoka Coast in 1979

Estimation of the Greenhouse Effect

It is expected that the greenhouse effect will cause expansion of low-lying areas through rises in seal level, and that many more frequent floods and droughts will occur due to changes in water balance. Research is being carried out on monitoring evapotranspi ration and water storage in mountainous areas by microwave remote sensing and monitoring of rises in sea level, coupling the use of a hydrological model and an atmospheric model and mechanisms accelerating coastal erosion.



Expansion of low-lying area caused by rises in sea level

WATER QUALITY CONTROL DEPARTMENT

The construction of sewerage system was launched in Japan in the early 1960's after formulating the 1st Five-year Program for Sewerage Construction in 1963. Sewerage systems have been constructed steadily in accordance with the past six Programs and the current Five-year Program since then.

The percentage of households connected to a sewer reached 44% at the end of FY 1990. However this number is still too low compared to the target of 90%. In this regard, emphasis is placed on increasing this proportion particularly in small communities. Another concern is the upgrading of sewerage systems in large cities where this proportion is considerably higher. This includes: multiplication of measures to conserve water quality such as the implementation of advanced wastewater treatments and the improvement of combined sewer systems, the promotion of urban flood prevention measures and the renewal of sewerage systems.

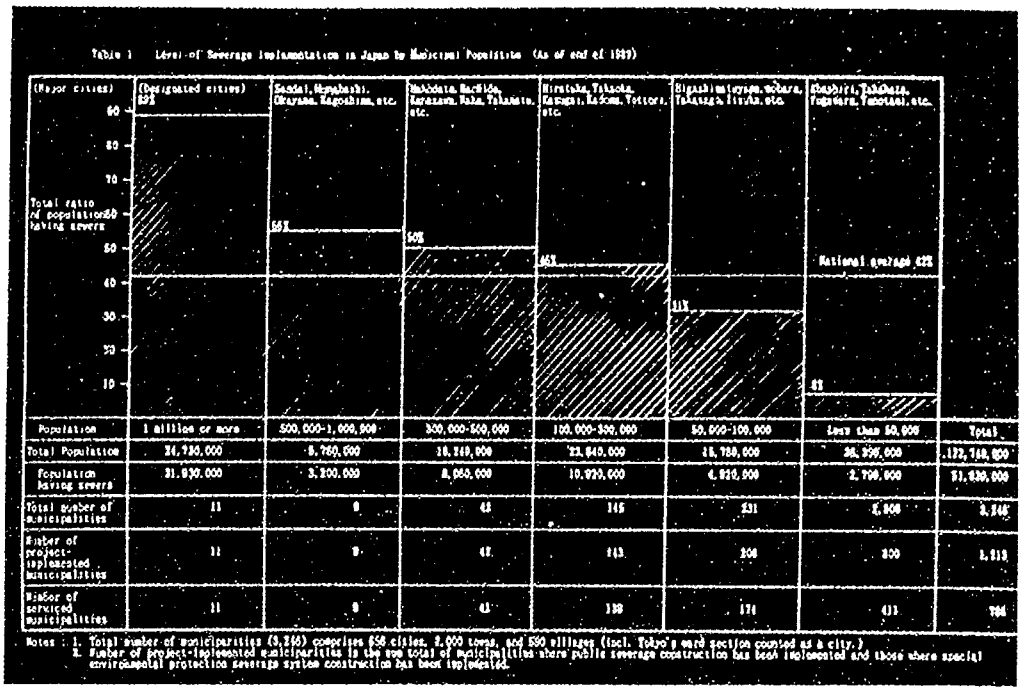
The Water Quality Control Department consists of 4 divisions, are Sewage Works Division, Advanced Waste Treatment Division, Sludge Management Division and water Quality Division. These divisions conducts studies in a broad range of fields to water pollution control, including the analysis of pollution mechanisms, the development of wastewater and sludge treatments, and the improvement of the planning, design, operation and maintenance of sewerage systems.

The development of alternative collection systems, wastewater reuse, the use of sewage sludge as resource and the determination of specific chemicals in biological wastewater treatment are topics on which emphasis is being placed.

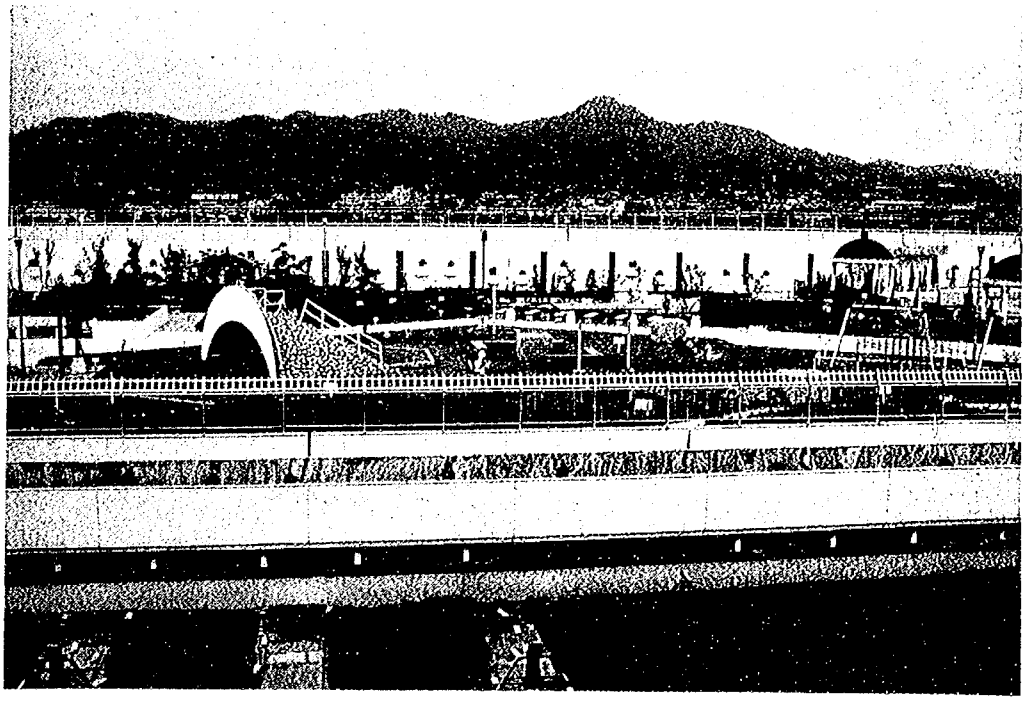
Related surveys and experiments are carried out either at the laboratories in the campus or at the pilot plant facilities located in the wastewater treatment plants.

Research Activities of the Department are shown in the following slides.

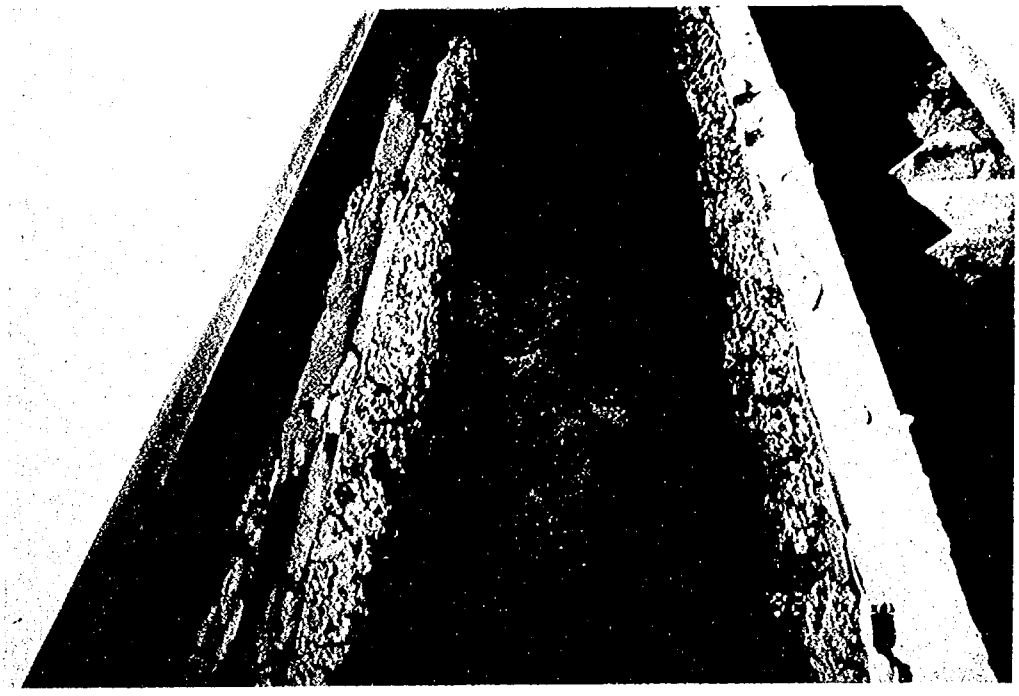
Slide 1 : the level of sewerage implementation in Japan by municipal population.
Slide 2 : one example of the wastewater treatment plant opened to the public.
Slide 3 : the deterioration of wastewater facilities.
Slide 4 : the urban stormwater control facilities.
Slide 5 : the Kohoku Pilot Plant.
Slide 6 : an urban stormwater control facilities.
Slide 7 : the melted sludge slag.
Slide 8 : the experimental equipment of measurement concerning sludge.
Slide 9 : the development of the Biosensor.
Slide 10 : the analysis equipment of specific chemicals on biological wastewater treatment.



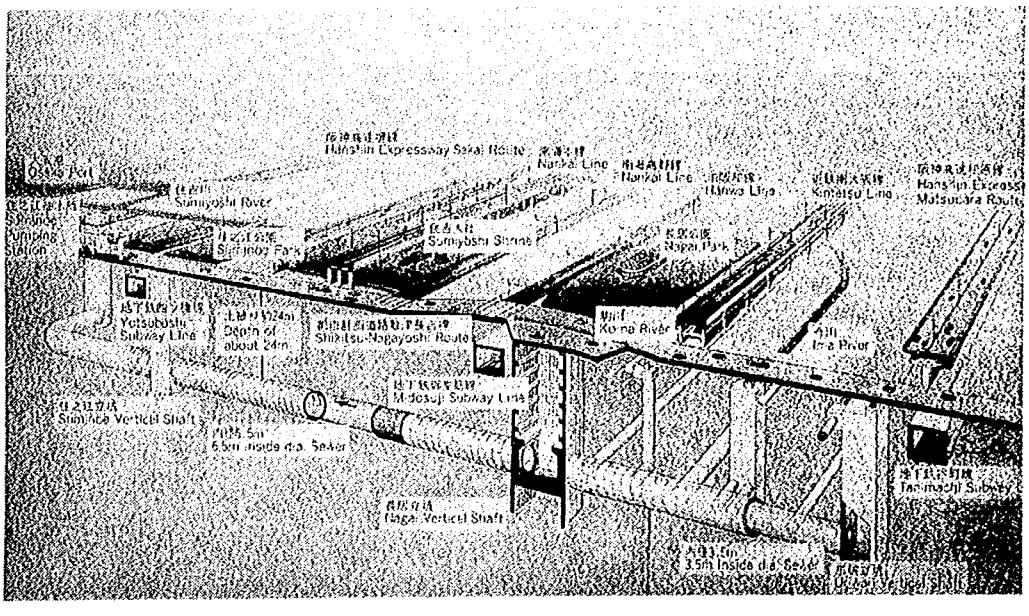
Slide 1 : the level of sewerage implementation in Japan by municipal population



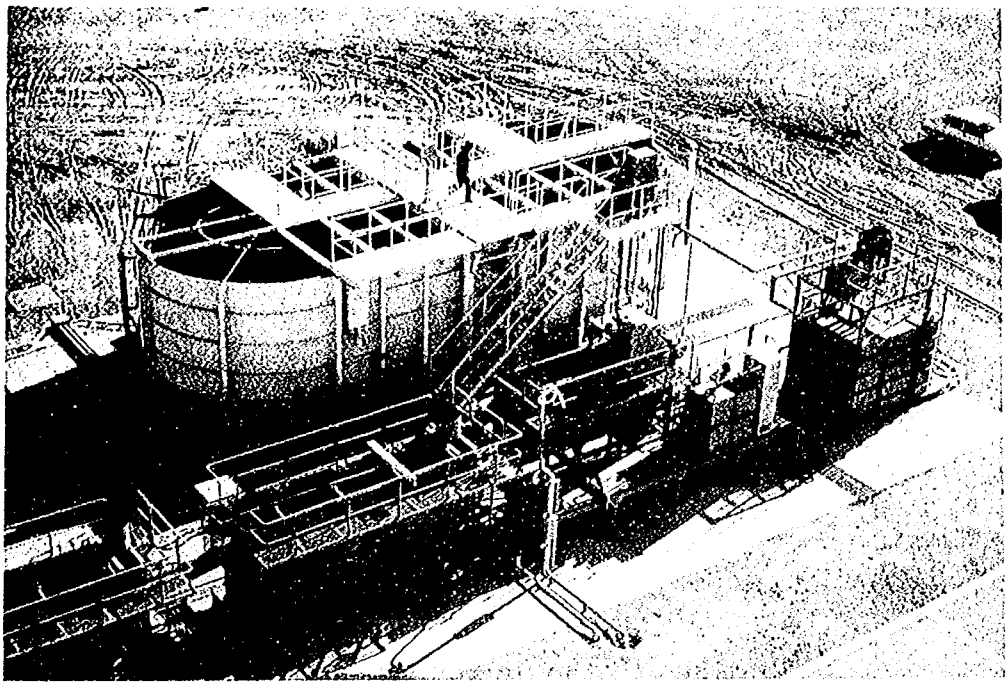
Slide 2 : one example of the wastewater treatment plant opened to the public



Slide 3 : the deterioration of wastewater facilities

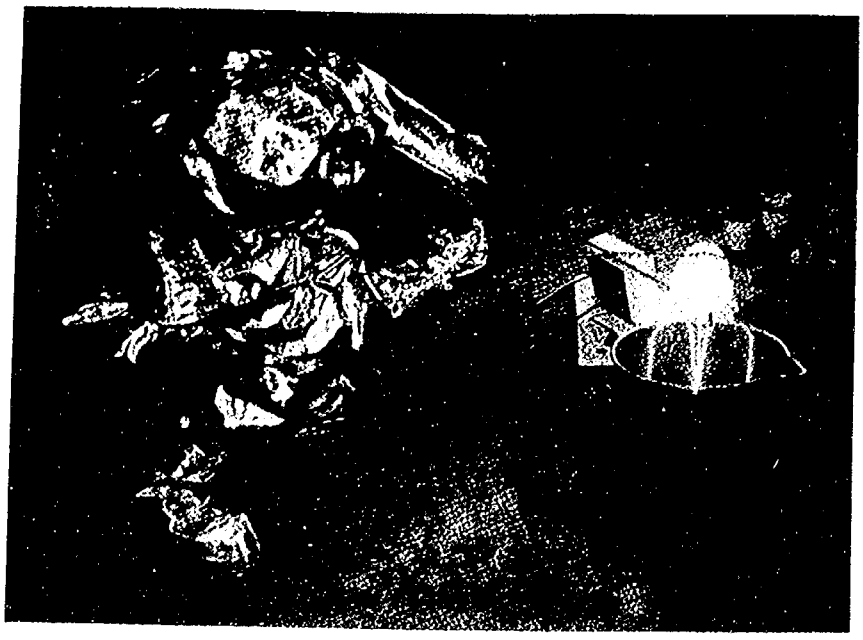


Slide 4 : the urban stormwater control facilities

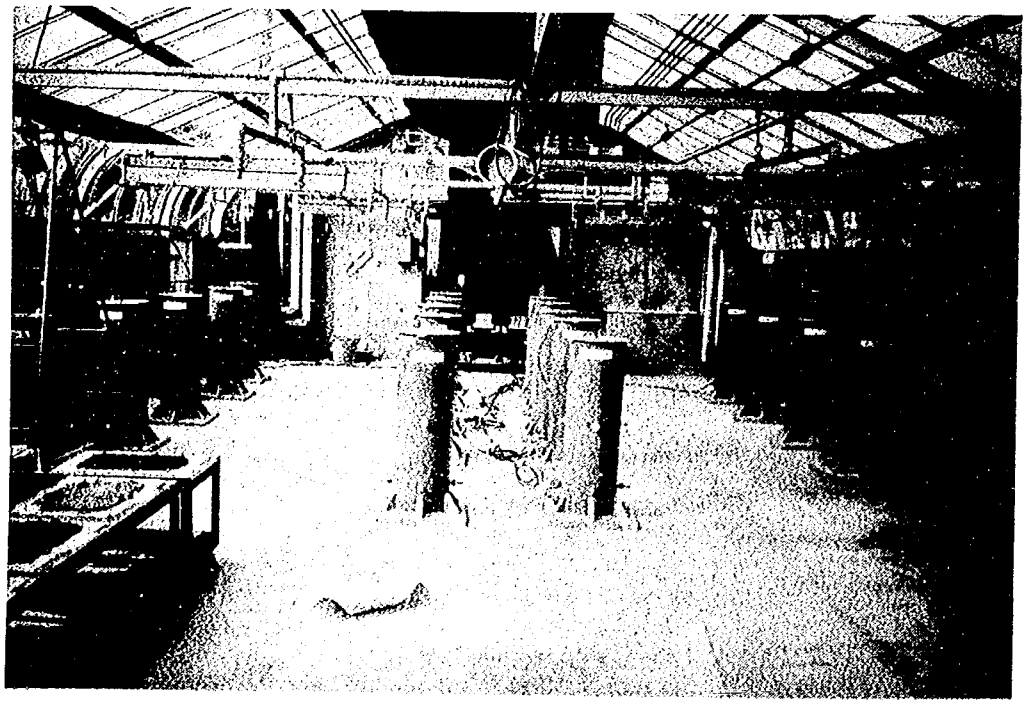


Slide 5 : the Kohoku Pilot Plant

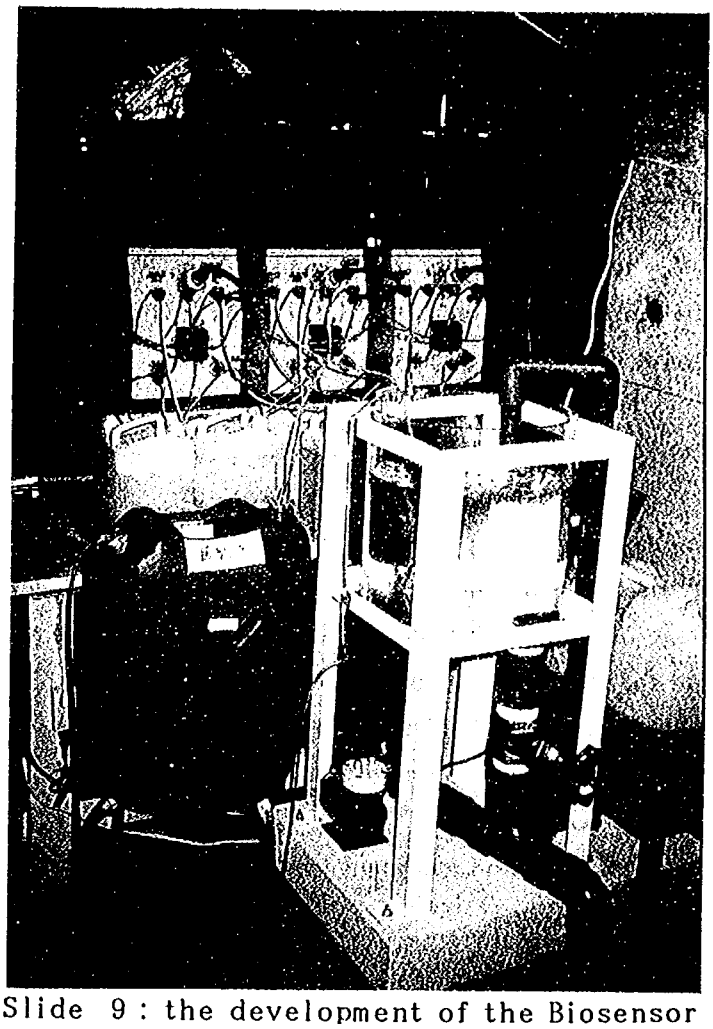
Slide 6 : an urban stormwater control facilities



Slide 7 : the melted sludge slag



Slide 8 : the experimental equipment of measurement concerning sludge



Slide 9 : the development of the Biosensor

Slide 10 : the analysis equipment of specific chemicals on biological wastewater treatment

DAM DEPARTMENT

INTRODUCTION

Flood prevention as well as stable water supply is necessary to our comfortable daily life. Providing open spaces with water is also necessary to enrich our life in the coming 21th Century. The Ministry of Construction plays a key role to address these needs and has constructed 327 dams for flood control, water supply and so on. 400 additional dams will still have to be constructed in the near future.

The Dam Department of the PWRI is carrying out extensive research in fundamental and applied dam engineering to solve various technological problems related to the planning, design, construction and operation of dams in cooperation with other Departments.

The research and development done by the Dam Department includes studies on design technologies to construct safe and economical dams in difficult topographical and geological conditions, new construction technologies to meet the shortage of labour, technologies to preserve the natural environment during the dam construction and operation, and the effective usage of reservoirs.

Technical assistance to the engineers in the field is one of the important roles of the Dam Department. The Dam Department provides useful technical advice on various problems of planning, survey and testing, design, construction, operation and management of dams. These advisors contribute to the smooth progress of dam construction projects and the efficient operation and management of dams.

MAJOR RESEARCH SUBJECTS

■ Dam Structure Division

Major Research Subjects	Major Research Results
• Study on Stability of Foundation Rock for Concrete Dams • Study on Foundation Grouting for Concrete Dams • Study on Seismic Resistant Design for Concrete Dams • Study on Concrete for Dams • Study on Automation Technology for Dam Construction • Study on Safety Evaluation of Existing Concrete Dams	• Development of a structural model test of an arch dams. • Development of parabolic arch dams. • Development of 3-dimensional structural analysis for arch dams. • Development of concrete gravity dam with fillet or base mat. • Development of in-situ deformation test using a flat-jack. • Development of the design concept of local safety factor of shear friction. • Development of a foundation treatment by transmitting wall and prestressed rock anchors. • Development of efficient grout injection by taking into account critical injection pressure. • Development of temperature stress analysis using restraint matrix. • Development of Mix Design for RCD Concrete.

■ Fill-Type Dam Division

Major Research Subjects	Major Research Results
• Study on the dynamic strength of rock-fill materials • Study on the resistivity of seepage failure in foundations • Study on the seepage flow of bedrock • Study on the effective usage of materials from quarry sites • Study on analyses of observed behaviors of embankment dams • Study on earthquake-proof design of embankment dams	• Establishment of earthquake-proof design methods for embankment dams (1991). • Establishment of testing methods for the dynamic deformation characteristics of banking materials. • Development of a multiple groundwater level measuring system. • Standardization of the method for effective utilization of quarry sites. • Proposal of a new type of embankment dam.

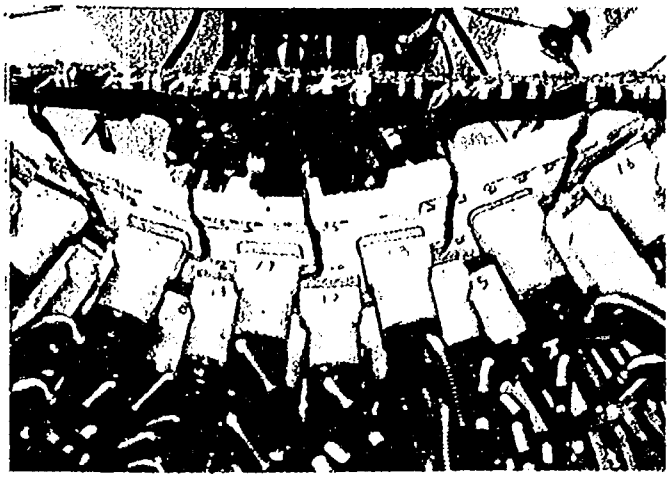
■ Dam Hydraulic Engineering Division

Major Research Subjects	Major Research Results
• Effects of surface tension on hydraulic model testing • Hydraulic characteristics and structural design of spillways and outlet works • Ecological and environmental improvement around dam reservoirs • Design and operation of fishways • Design and operation of sediment flushing facilities • Erosion control for spillways and outlet works	• Study on density currents (Study on selective withdrawal works). • Study on high volocity flows. • Study on sediment flushing facilities. • Study on fishways. • Development of new types of dam hydraulic structurs.

■ Water Resources Engineering Division

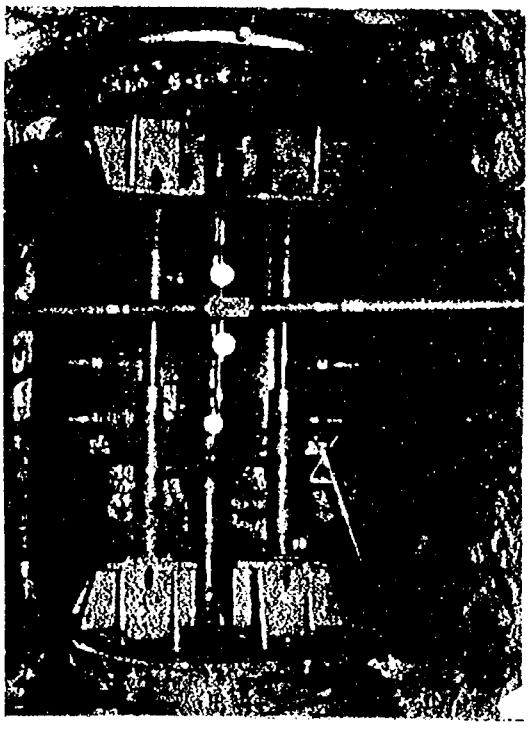
Major Research Subjects	Major Research Results
• Study on planning of flood control and methods of dam-reservoir control • Study on methods of planning for water resources development • Study on improvement of environmental function of dam-reservoirs • Study on utilization of dam-reservoirs and activation of reservoir area • Study on the effect of global warming on water resources • Study on the utilization of thermal energy in reservoirs	• Planning of flood control and the methods of dam-reservoir control. • Methods of planning for water resources development. • Improvement of the environmental function of dam-reservoirs. • Utilization of dam-reservoirs and the activation of reservoir areas.

Major Research Facilities

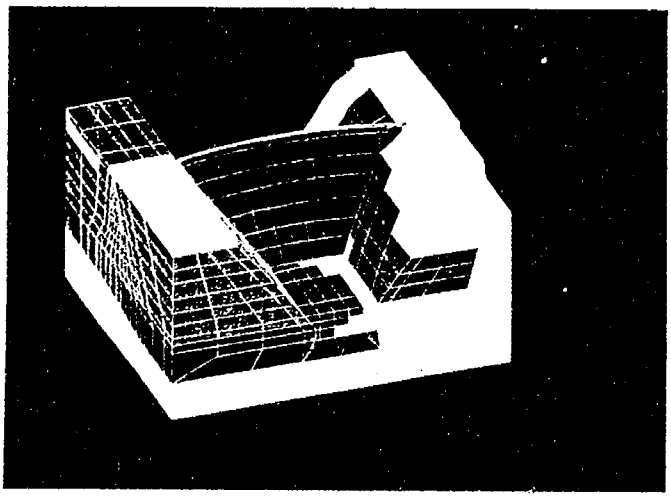


Structural Model Testing Apparatus for Arch Dams

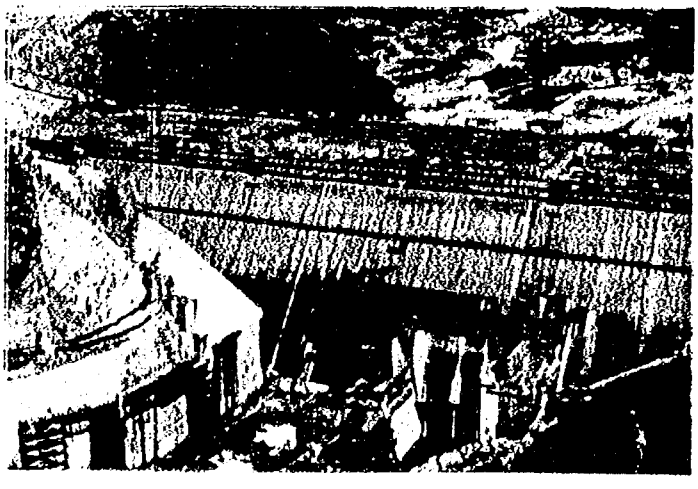
Major Research Results



In-situ Deformation Test using a Flat-jack

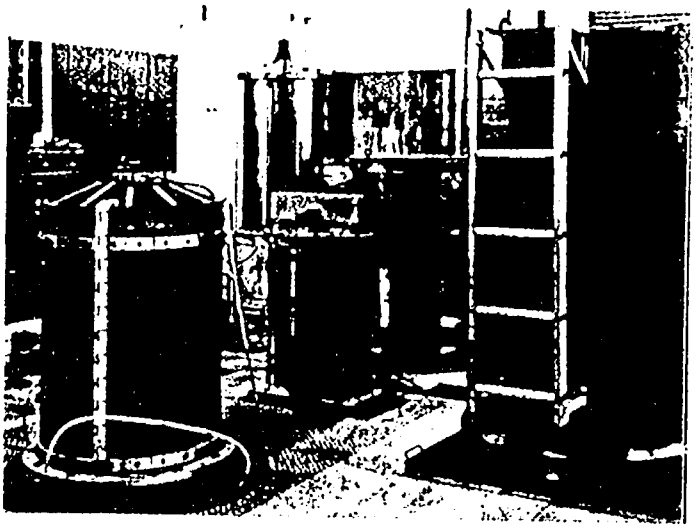


3-Dimensional Structural Analysis of a Curved Gravity Dam



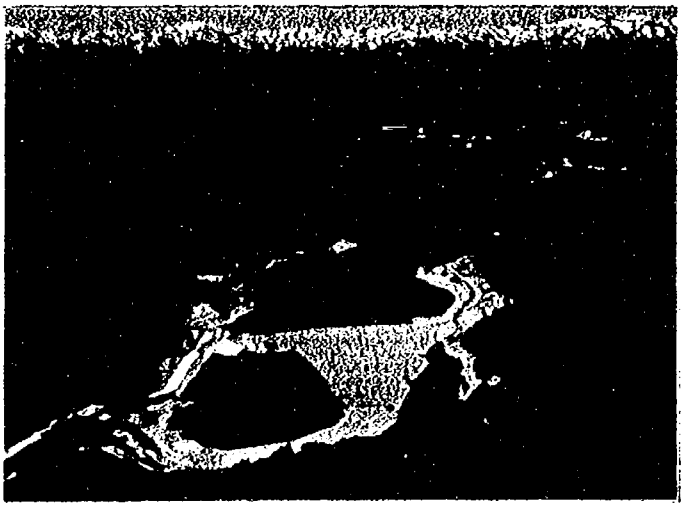
RCD Construction Method

Major Research Facilities

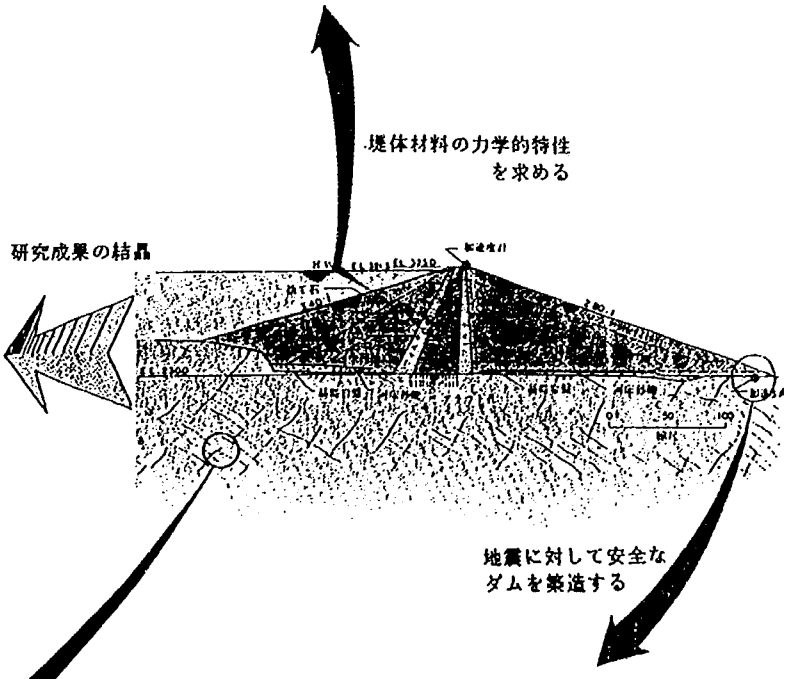


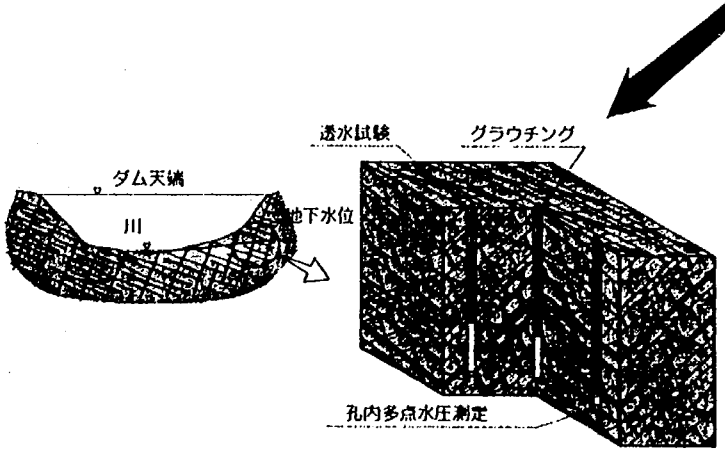
Large-scale Torsional Simple Shear Testing Apparatus
(The Largest in the World)

Major Research Results

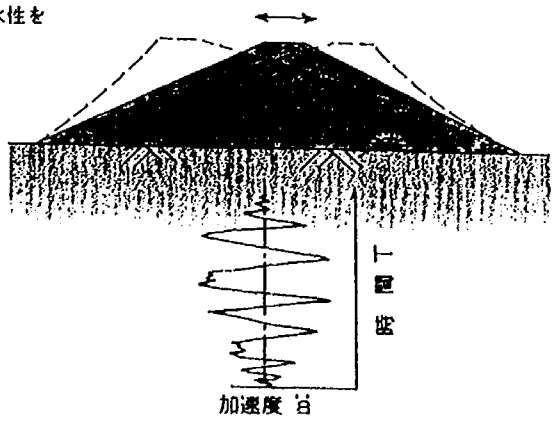


Rockfill Dam (Sagae Dam)



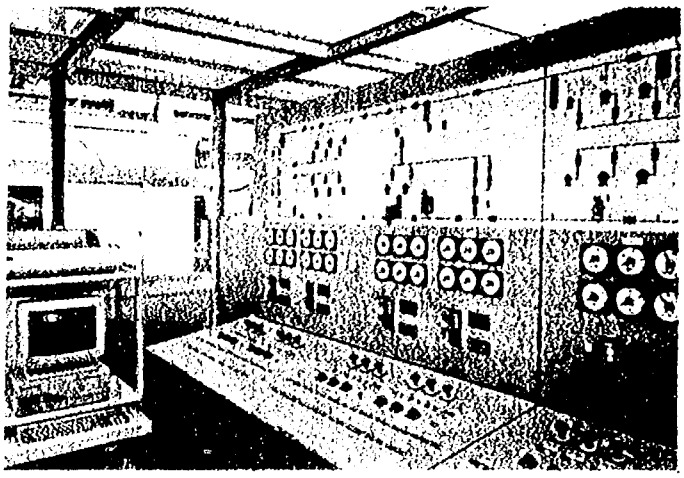


Development of MGL Systems



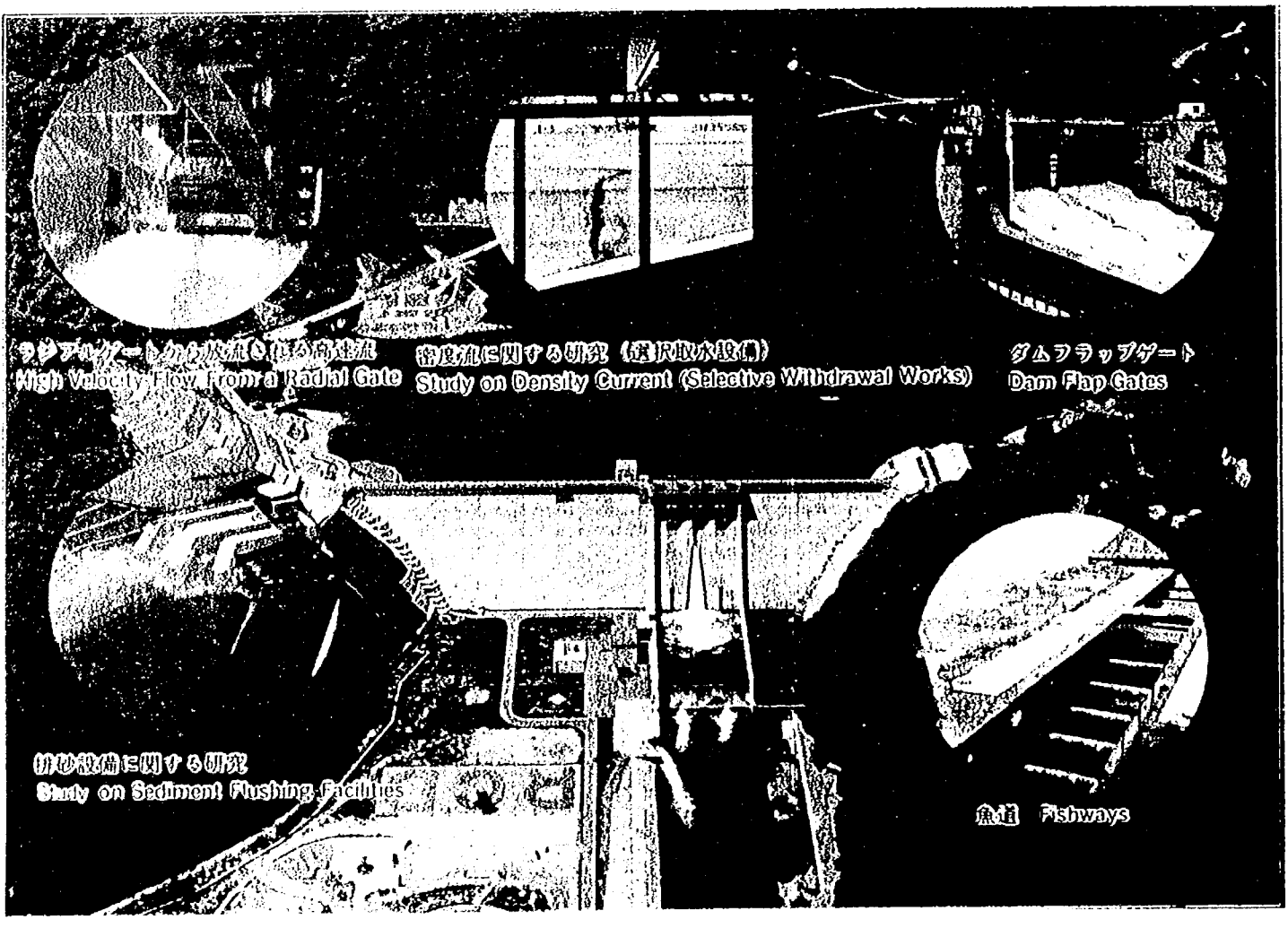
Establishment of Earthquake-proof Design Method

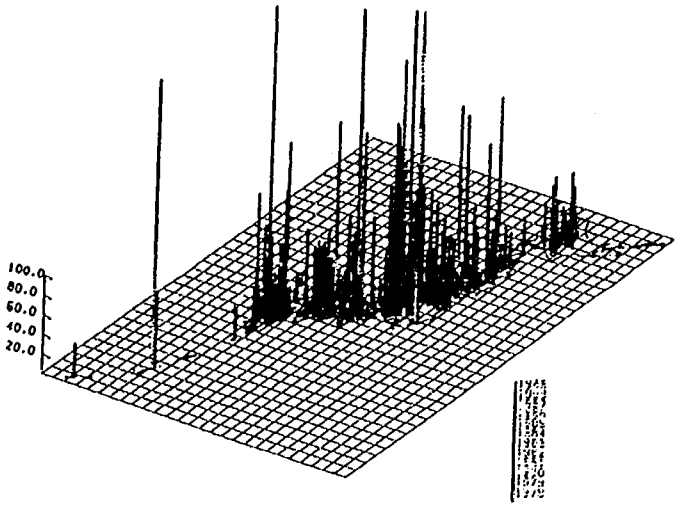
Major Research Facilities



The Central Operating Room (Water Supply System)

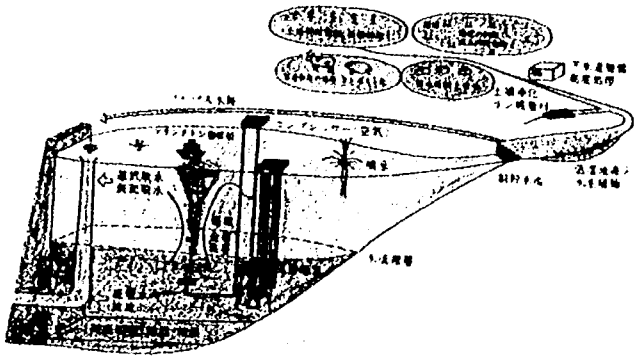
Major Research Results



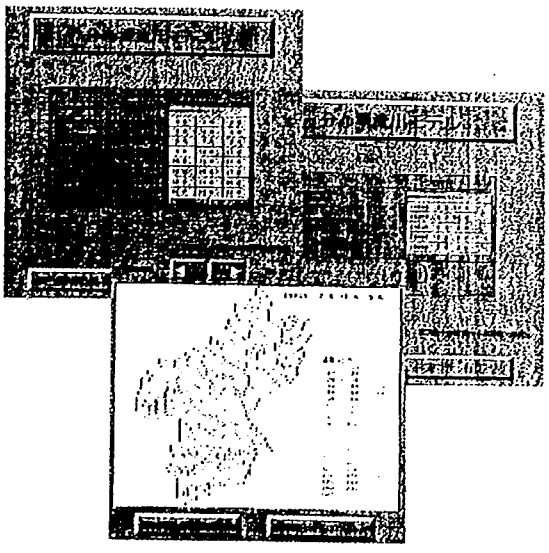


Prediction of Amount and Shape of Sedimentation in Dam-Reservoirs

Development of Methods for Evaluation and Improvement of the Environmental Function of Dam-Reservoirs



Development of an Effective Reservoir for Water Quality Enhancement Techniques and Evaluation Methods



Expert System for Flood Control and Water Resources Management

New Prospects of Dam Construction of Next Generation

Introduction

With a progressive concentration of assets in valley areas, we are seeing a steady increase in various requirements such as demands for improvements in the flood control functions of dams in order to preserve a safer national land, demands for the development of water resources which are indispensable for a more comfortable social lifestyle, and demands for hydro-thermal power generation as a domestically-produced form of "clean energy". Furthermore, as the leisure time of the Japanese people increases, dam reservoirs are being re-appraised as places for recreation, and as places where relaxation and peace of mind can be sought. Meanwhile, as the sense of values of the Japanese people become more diverse, they are treating harmony with the environment as an increasingly important issue. In view of these various circumstances, it is vitally important that we forge ahead with dam construction equipped with a clear vision of the creation of dams for the next generation. Below, I shall raise some points concerning the prospects for solutions to various issues which relate to dams.

1)Research on creating dam reservoirs as places abounding with nature

Water is the root substance from which all things have come into being; no form of life could possibly exist without it. Living things gather wherever there is water. Most artificial lakes have already become havens for wild birds. As well as this, lake water provides habitation for fish and other aquatic life forms. And there are already many types of fish that repeat cycles of preservation and reproduction of their species by using dam reservoirs to take the place of a sea which nurtures them to growth, and the rivers flowing into them as places for producing eggs. In addition, colonies of all types of marsh plants grow prolifically at the edges of lakes, while insects such as dragonflies that make their homes here proclaim the coming of spring to our world. Meanwhile, at high water levels the grasses which provide sustenance for butterflies grow in abundance and there are fields of plants with pollen-bearing flowers. Dam reservoirs in such places provide habitats for beautiful multi-coloured butterflies to flutter about. Our minutely discerning, attentive care and efforts will be indispensable in order to nurture these various eco-systems to a fullness of life, and various forms of technological research are underway to this end. The day is almost upon us when dam reservoirs, as well as forming havens for wild life, will become places where we will be able to see the workings of nature and feel a contentedness of spirit.

2) Research aimed at overcoming various geological conditions of dam foundations

Land foundations in our country really are widely divergent, with a great variety of geological types from Paleozoic strata to the Quaternary period, featuring many faults, misalignments, folds, and so on. Dam construction technology has the prime concern of somehow discovering geological weak points at dam sites, as well as how to add devices to, or change the dam axis, its scale or format; in other words, how to make the design of the dam structure compatible with the

geological conditions of its foundations. A revolution in ideas is needed in discovering how to make rational improvements to foundation bedrock to give it physical properties compatible with the dam wall, which forms the principle vision of dam technology for the next generation. Steady progress is being made in research aimed at overcoming geological foundation conditions using an approach developed still further from conventional ones, starting from the fact that demands such as for small-scale sustenance dams have been increasing more and more in the development of water resources which respond to special regional characteristics. Thus the day is near when the vision will be achieved.

3) Research aimed at rationalizing the materials used in constructing dam walls

Of the system of designs currently in use, the RCD construction method used hitherto is primarily a matter of dam wall design, with its main attention on how to create concrete of a quality that will satisfy the design conditions. From now on, research will be promoted in order to specify a concrete which has optimum evaluation as an aggregate and to establish technology for concrete from an opposite conceptual approach; that is, how to create a rational system for dam wall design which corresponds to the physical properties of concrete produced by making the maximum possible use of the dam wall construction materials available on site. Needless to say, this also applies to fill-type dam wall materials.

4) Research aimed at creating dams which are easy to manage

We are promoting research which takes the creation of a total system based on various software and hardware designs as its priority task, starting with the design of dams aimed at solving these issues once and for all.

5) Issues in the creation of lake fronts, the cores of water-based culture

Ever since ancient times people have gathered near water; this is where the flowers of civilization opened. In our country, with its cramped land space, the open stretches of water and greenery provided by dam reservoirs are extremely precious regional assets. Many municipalities are tackling town revival and village creation by taking dam reservoirs as the central focus for their vitalization. From the standpoint of managing dams, research is being promoted into various aid policies which will let the flower of water-based culture open up around a core of dam reservoirs.

Conclusion

In order to make still greater advances in the history of dam technology in our country, which has led the world's dam technology in forms such as earthquake-proof design methods and the RCD construction method, we are boldly challenging difficult as well as new broad-ranging themes, and we are steadily promoting research aimed at solving these.

Concrete from optimum evaluation aggregate
- The CODA construction method -
(Concrete of Optimum Design for Aggregate)

Concrete dams made by conventional construction methods and the RCD construction method

↓

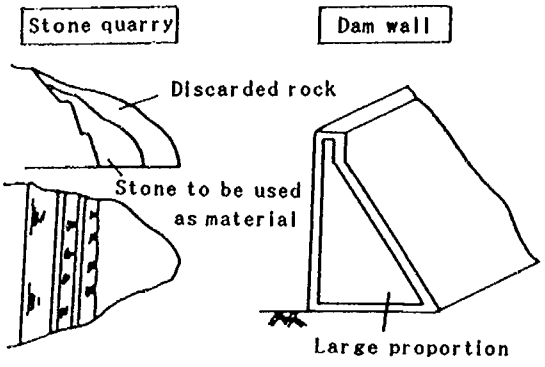
Dam wall designed regardless of the conditions of the stone quarry

↓

Concrete which complies with the design is used

↓

Aggregate which does not comply with use is discarded



Concrete dams made by the CODA construction method

↓

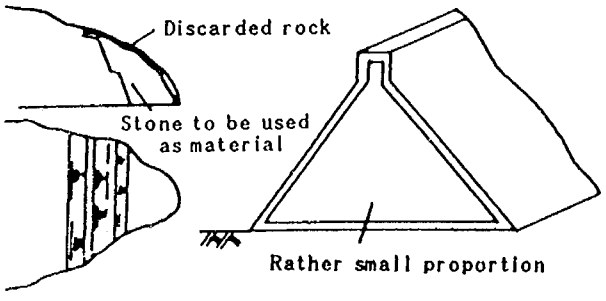
As far as possible, aggregate available at the stone quarry is not discarded

↓

The best concrete formation that can be achieved using this aggregate is found

↓

Dam wall design is carried out in compliance with the physical properties of this concrete



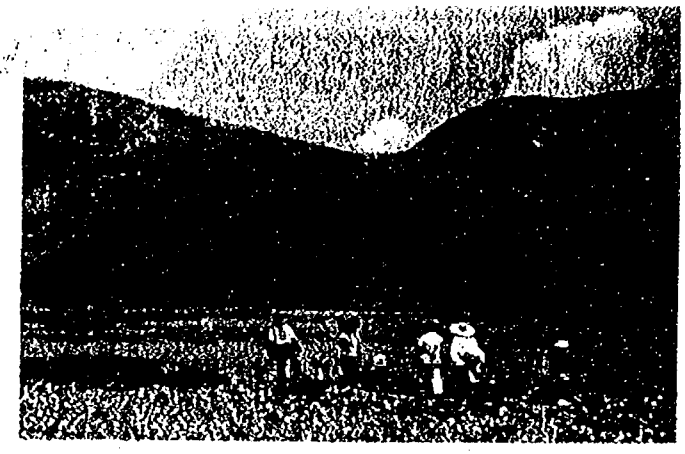


Photo.1 View of a dam reservoir

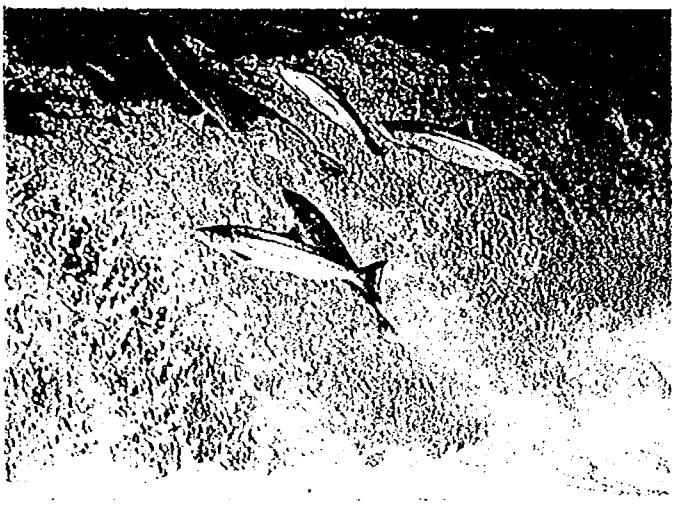


Photo.2 Freshwater trout migrating upstream

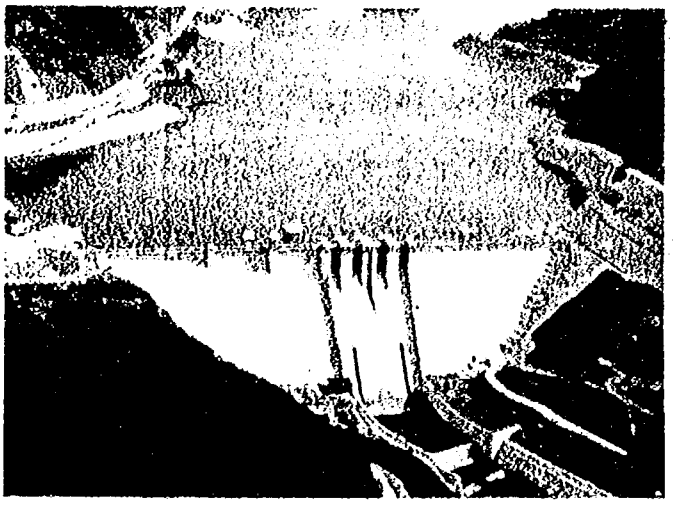


Photo.3 Completed dam

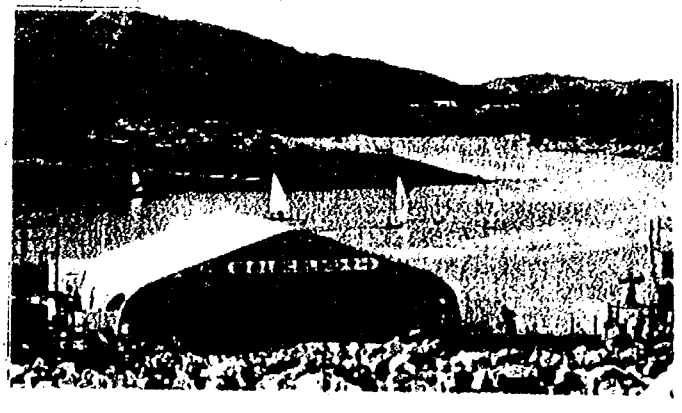


Photo.4 An event at a dam reservoir

EROSION CONTROL DEPARTMENT

Research on Development of Sediment-related Disaster Prevention Systems and Prospects for the 21st Century from the Viewpoint of Preventing Topographical Disasters

Introduction

From the point of view of topographical disasters, and particularly sediment disasters, neither the situation in Japan nor that in the world in general is at all encouraging. Burgeoning populations, uneven distri butions of wealth, technology, and resources, conflicts caused by the la ck of an established order for controlling regions and countries: due to an increase in such problems prior to disaster prevention, it is highly likely that resources which ought to be parcelled out for disaster prev ention will become relatively scarce.

On the other hand, in order to raise standards of living, we have to promote developments of land and natural resources and improvements in infrastructure. The difficulties facing present and future societies at home and abroad lie in the fact that such unfavorable conditions cannot be allowed to stay as they are. The human environment will become increa singly vulnerable to nature's propensity for c sing disasters. Here we have the much-discussed vicious circle of poverty. The situation in Japa n used to be considered extremely favorable. However, the eruption disas ter at Mt.Unzen-Fugendake once again made us aware of our country's vuln erability to sediment disasters.

1. Research on Development of Sediment-related Disaster Prevention

Systems

Houses and public facilities have frequently been damaged and lives have been lost by the catastrophic movement of soil masses(pyroclastic flows, failures of natural dams, large landslides, and collapse of gigantic slopes)in Japan. In this project of research and study, we will make an effort to develop techniques, as described below, necessary for preventing or mitigating the effects of sediment-related disasters.

First, we will develop methods for making high quality hazardous area maps, suitable for the purpose of improving warning and evacuation system for residents in hazardous areas. Next we will develop new monitoring techniques that are necessary for executing warning, evacuations, or providing emergency measures, and will develop highstandard methods of predicting the occurrence of sediment-related disasters. We will also develop new techniques for emergency measures and emergency measure selection systems to properly execute emergency measures without delay.

■ Erosion Control Division

- Study on Momentum Mechanism of Multiphase Liquid Flows
- Research on Preventing Methods against Debris Flows in Upper Watersheds
- Research for Planning and Design of Erosion Control Facilities, Taking into Consideration the Environment
- Research on Mechanism of Sediment-related Disasters Measures in Volcanic Areas
- Research on Technical Development for Prevention of Desertification
- Research on Development of Sediment-related Disaster Prevention

Systems

■ Landslide Division

- Research on the formation and development of slip surafce due to softening
- Tests and surveys on anti-slide retaining walls
- A survey on the design of anchor works in landslide areas in reservoirs
- Estimation of degree of danger and survey about appropriate land utilization of landslide area
- Survey on the frequent occurrence of landslide disaster due to global warming
- Survey on storm rainfall-type landslides

■ Slope Failure Division

- Research on mechanisms of sedimentation of debris derived from slope failure
- Evaluation of slope stability under rainfall and earthquake conditions
- Avalanche prevention measures
- Countermeasures for slope failures
- Technology for slope greenery
- Investigation of rockfall

2. Prospects for the 21st Century from the Viewpoint of Preventing Topographical Disasters

2.1 Slope Movement disasters

The collapse of rock slopes on National Highway No.305 in Fukui Prefecture and National Highway No.158 in Azumimura, Nagano Prefecture, were incidents which made us realize how difficult it is to maintain man-made slopes The landslide disaster at Jitsukiyama occurred behind new forms of housing which are supposed to be safer than any. The large scale landslide of Mt. Ontake and the slope collapse on the Japan-Philippine Friendship Highway on Luzon Island are still fresh in the memory as cases of slope movement disasters caused by earthquakes.

Regardless of the whys and wherefores of objectives and formats, development must inevitably be accompanied by a reformation of slope topography. Various forces work on reformed slopes and attempt to push the slope backwards. However, there are still many aspects of this mechanism that we have yet to understand. The technology concerned with forming and maintaining artificial topography stands as one of the decisive factors in development and growth. And when the development of cold-zone regions becomes a fully-fledged reality, the stability of frozen soil slopes will also become an issue.

2.2 Disasters in alluvial fan

It has been known since fairly ancient times that disasters in alluvial fans are caused by the generation and transportation of sediments from upper mountain areas. However, much time has been required before selecting countermeasures and converting these into action. This is due to the fact that countermeasures against sediment disasters in alluvial fans have been dependent on society's political and social maturity and on the reinforcement of its economic strength. A society which lacks any one of these conditions could be seen as facing a dilemma of either avoidi

ng danger by refraining from intrusion, or giving the survivors a fresh start whenever a disaster occurs. The use and reformation of topography are economic acts, and if as a result they are taken to have created causative factors for disasters, these cannot be prevented unless disaster prevention is planned in such a way that it can internalize the external economic liability which forms causative factors for disasters. In preparing such plans, the technology for erosion control planning, works, and maintenance has made a big contribution. However, our technology is somewhat biased towards concrete, and has been criticized for not harmonizing diverse regional eco-systems. This fact runs contrary to the technology whose aim is to erase causative factors which are difficult to control. To counter this, we need to establish minutely detailed monitoring as well as technology and systems for maintenance. In developing countries there is a widespread lack of such awareness or plans. At the same time as developing and furnishing a simple and inexpensive system of technology, efforts are needed to cooperate in creating plans whereby external economic liability is internalized. In this respect, self-awareness and study is needed to overcome the element of specialism for it's own sake, to which disaster prevention technologists are prone.

2.3 Volcanoes

Research into aspects such as lava, pyroclastic flow, and mudflow is underway. However, volcanic disasters are not so simple that prevention can be achieved merely by applying the results of this research. There is a need for interpretation of the processes of topographical formation, and, on the basis of this, fundamental technological proposals for promoting land use in moderation. This is something which will be of value on a global scale.

Photo.1 Pyroclastic flow occurring on Mount Merapi, Indonesia, on June 15th, 1984.

(Photo: Volcanic Sabo Technical Center (VSTC))

Photo.2 Experiment on fishway structures using white spotted chars

Photo.3 Pyroclastic and debris flows accompanying the eruption of Fugendake on Mount Unzen

Photo.4 Natural dam caused by the landslide of Mt. Ontake

ROAD DEPARTMENT

1. Organization and Budget

The Road Department consists of a director, two coordinators for road traffic engineering in general and traffic safety, and seven research divisions (Figure-1). In fiscal 1992, the research budget of Road Department is 1.1 billion yen except personnel expenses.

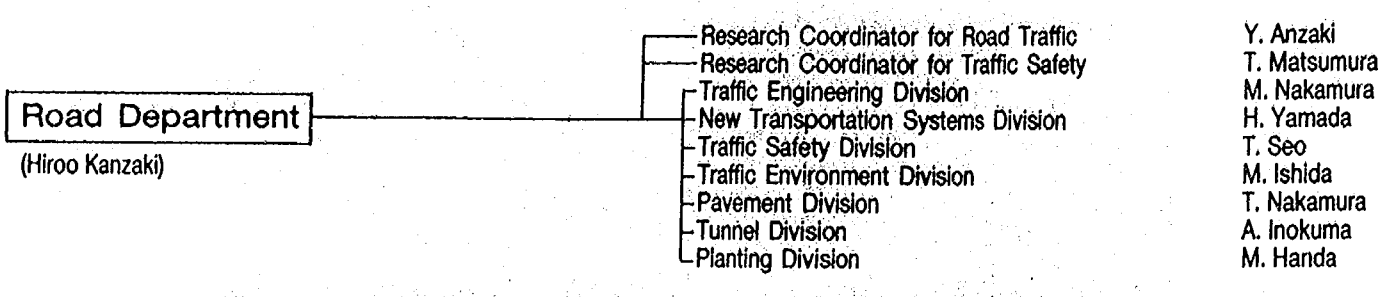


Figure. 1 Organization of Road Department

2. Overview of Research Themes of Each Division

Traffic demand has been increasing because of development of industry and life. In particular, automobile traffic has become so accessible and available that it has been highly evaluated as an indispensable traffic means supporting both industry activities and life development. As a result, the number of registered automobiles has exceeded 60 million. The diversification of life-styles and values demands for high-quality road traffic services such as high speed, safety and comfortable driving, harmony with surroundings and fulfillment of various road functions.

Under these circumstances the Road Department does research on road geometric design, traffic information systems, new transportation systems, coutermeasures against traffic congestion, traffic safety for the aged, design of safety facilities, planning of footpaths, planning of traffic environments, planning of planting and landscapes, rational design of pavements and tunnels, ventilation and lighting in tunnels, etc. through cooperation of seven divisions.

Table-1 shows the main research themes of each Research Division.

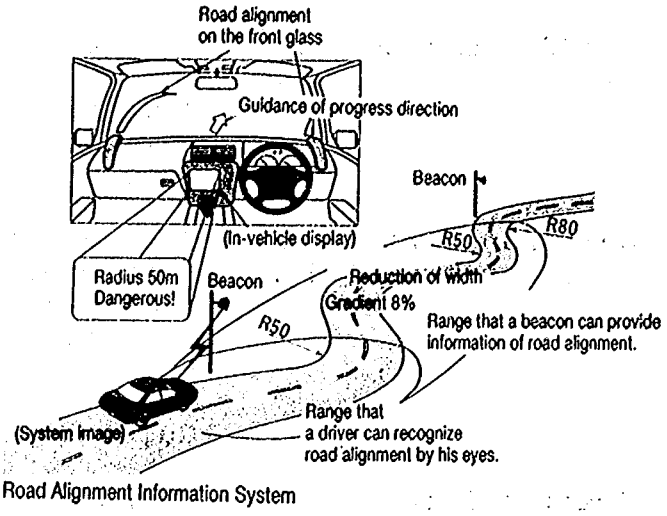
Table. 1 Research Themes

Traffic Engineering Division	Geometric design and road traffic capacity Skid resistance and drivability Road traffic information systems Advanced road traffic systems Snow disaster prevention
New Transportation Systems Division	Methods of evaluating the economic effects of road improvements Prediction of and remedial measures for traffic congestion Estimation of holiday and recreation traffic New freight transport systems Guide-way Bus System
Traffic Safety Division	Computer-aided systems for traffic accident data analysis Safety measures for specific accidents (single accidents, accidents related to right turning, etc.) Safety evaluation by analyzing drivers' maneuvers and reactions Warrants for safety facilities Guidance of traffic flow
Traffic Environment Division	Estimation of coutermeasure methods Road traffic noise Influence on roadside environment caused by road traffic Diffusion of air pollutants along large roads Characteristic of traffic noise measured in the particular structure road section
Pavement Division	Design and construction of asphalt pavement Design and construction of cement concrete pavement Maintenance of pavement Development of new pavement materials and construction methods
Tunnel Division	Technology for use of underground space Mountain tunneling methods Sield tunneling methods Techniques for maintaining road tunnels Ventilation, lighting and safety in road tunnels
Planting Division	Landscape and planting Guidelines for planning and designing parks and open spaces Improvement of green environment around roads Prediction and improvement of landscapes Environment impact assessment

3. Summary of Principal Researches

3.1 Advanced Road Traffic Systems

In order to alleviate traffic congestions, it is necessary to provide drivers adequate information quickly. The Highway Advisory Information Radio (HAIR) and Road/Automobile Communication Systems (RACS) have been developed so far.



Road Alignment Information System

Applying the knowledge and technology established in the research of RACS, researches on an "Advanced Road Traffic Systems (ARTS)" in 21st century began in fiscal 1989, the systems of which are aimed to develop much safer and much more efficient ones.

The system includes "Guide-Light System," "Vehicle Headway Control System" and "Road Alignment Information System," etc.

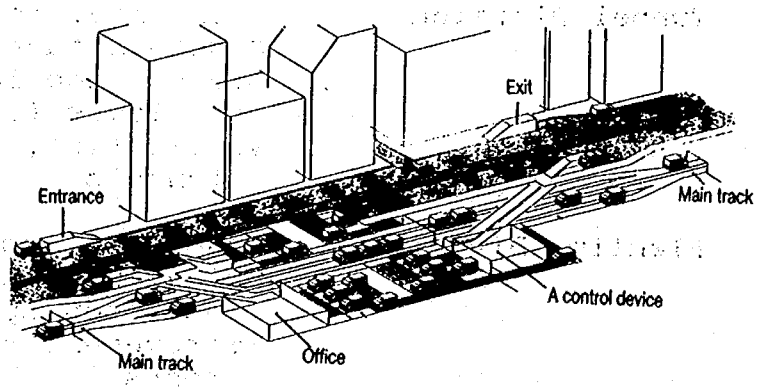
3.2 Guide-way Bus System

One of the measures for solving the problems of urban road traffic such as road congestion, noise, air pollution, etc., is to develop a new transit system. The Guide-way Bus System which can be introduced more economically than ordinary new transit systems, has been developed. A Guide-way bus is able to travel on both exclusive guideways and ordinary roads, and thus the system has a dual-mode function.

The Guidway-Bus System at the Asian-Pacific Exposition

3.3 New Urban Freight Transport System

Freight transport in Japan is shared by roads, railways, shippings and airplanes, and the share by roads has increased year by year. In particular, most goods in urban areas are transported by trucks. However, there are serious problems regarding the urban freight transport. The problems are as follows: (1) traffic congestion, (2) environment problems like noise and air pollution, and (3)



shortage of truck drivers and increase of their average age.

The new urban freight transport system is studied for reducing a large number of truck traffic in urban roads and substantially solving the traffic problems. This system is supposed to have densely located depots, loading/unloading machines and automated vehicles which carry freights, etc. Thus this system can provide a higher level of services to trucking companies.

3.4 Road Traffic Safety

A system for traffic accident analysis is being developed, the system of which unifies and computerizes the databases of accident reports, road censuses, and road facility data. Field investigations at accident locations and measurements of optical reaction through driving test are carried out in order to analyze some factors which can not be determined from accident statistics.

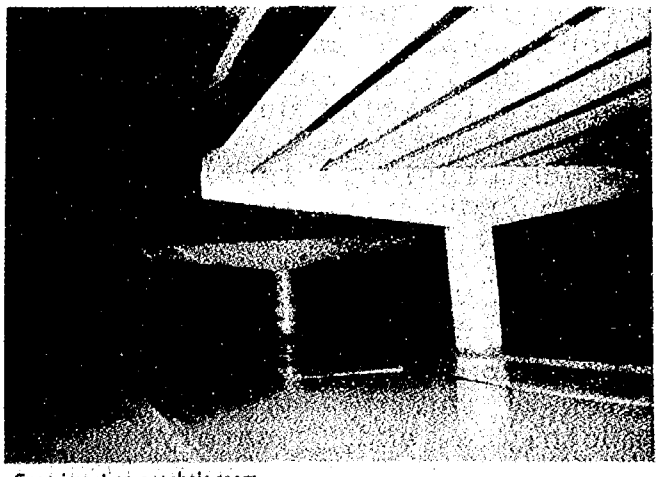
Full-scale collision test

Concerning traffic guide, a computerized system for selecting a destination name displayed on a traffic sign and a research on displaying method of guide signs at complex intersections and in tunnels are being studied.

Regarding to the researches on rational design of traffic safety facilities, design methods of crash barriers which can correct the direction of a large vehicle colliding with them at high speed are being developed, through computer simulation and full-scale collision test.

3.5 Prediction and Countermeasures for Road Traffic Noise

It is important for road improvement to evaluate the influence of road traffic noise and take effective countermeasures. Therefore the acoustic model experiments and field surveys are carried out to estimate characteristics of noise propagation depending on the various types of road structure and roadside configuration and effects of countermeasures (i.e. noise barrier and environmental protection zone). In addition to these studies, researches on developing materials used for

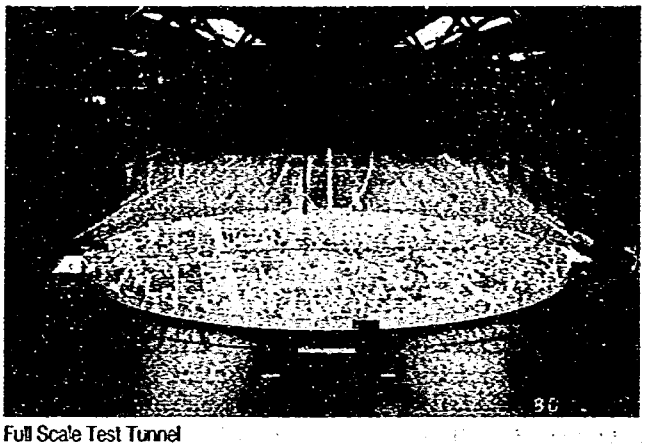


Experiment on anechoic room

noise barriers are also conducted through measuring characteristics in the reverberation chambers.

3.6 Diffusion of Air Pollutants from Vehicles

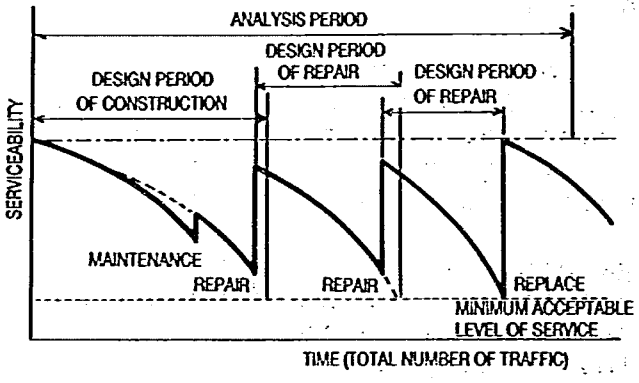
When predicting and taking countermeasures for roadside air pollution, we have to know the amount of air-pollutants from vehicles and the characteristic of their diffusion. The amount of air-pollutants is measured through the chassis dynamometer test according to the vehicle operating conditions. As the characteristics of diffusion differ with structures and roadside configurations, tracer gas diffusion tests are carried out in the field or in a diffusion wind tunnel to analyze the characteristics.



Full Scale Test Tunnel

3.7 Pavement Management System

Pavement surface which is badly damaged and in the low performance affects on the amount of gas consumption as well as the riding comfort. Therefore road surfaces must be maintained or repaired in order to rehabilitate their performance.

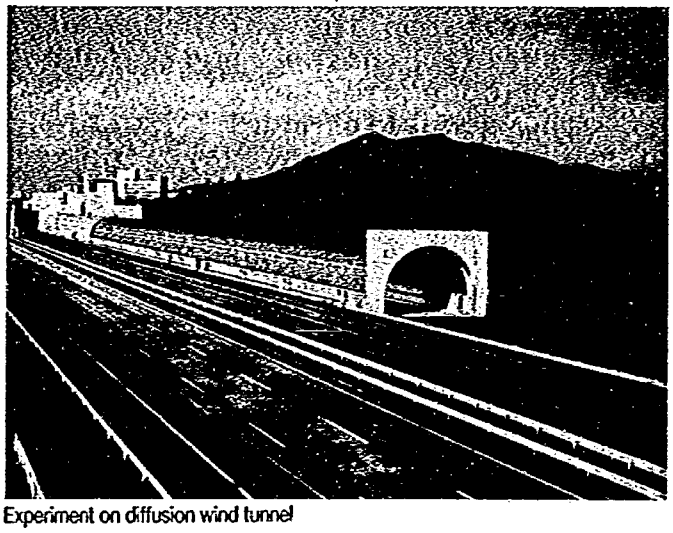


Life-cycle of Pavement

Periodical measurements of pavement performance should be conducted in order to establish a "Pavement Data Bank." Using this data bank, a rational and economical repair plan should be made in consideration of a concept of "Pavement Life-Cycle Costs." Therefore an expert system which makes the same decision as a skilled engineer is being developed.

3.8 Ventilation, Lighting and Disaster Prevention in Road Tunnels

Recently, projects of long road tunnels are to be carried out in megalopolitan areas. For inter-urban tunnels there is a need to allow faster traffic more smoothly and safely. In consideration of these trends, such experiments as ventilation

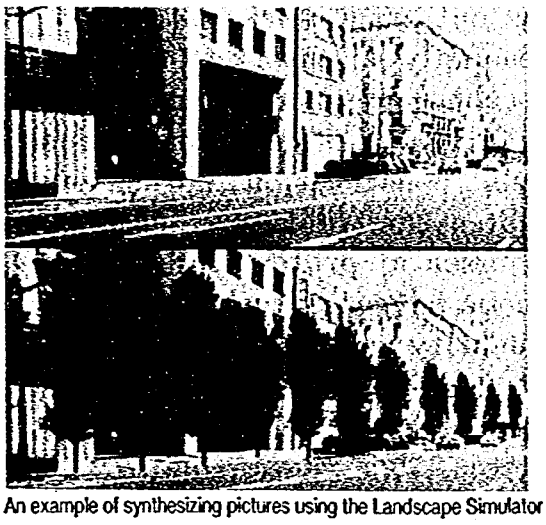


Experiment on diffusion wind tunnel

for faster traffic or an effective counter-beam lighting are performed in the Full-Scale-Test Tunnel. In the field of disaster fighting, the smoke behavior in case of fire on the rectangular-dug road are investigated and computer program to simulate the smoke behavior is also being developed.

3.9 Prediction and Improvement of Landscapes

It is important to create and maintain beautiful landscapes. When constructing facilities such as parks, roads, green zones, bridges, buildings, etc., landscape change should be considered. Technology of predicting and evaluating the landscape change is studied using the Landscape Simulator which has a computer graphic system.



An example of synthesizing pictures using the Landscape Simulator

CONSTRUCTION METHOD AND EQUIPMENT DEPARTMENT

Introduction

With a view towards the 21st century, the Japanese construction industry is placing emphasis on further development of infrastructure, as well as creating a land that is affluent and safe, and has a good vitality. In order to carry out such work rationally and efficiently, from now on it will be increasingly necessary to upgrade earthwork technology as well as developing new technology, as outlined below.

With the remarkable economical growth and the change in public demand, today's construction works have to fit larger-scale, more varied and sophistcated structures than ever experienced before. On the other hand, environmental protection and pollution controls are becoming more stringent and some advanced technologies are needed to cope with these tasks, in terms of quantity and quality. To facilitate operation efficiency and safety on construction works, further rationalization of construction methods and further automatization of construction equipments are becoming more in demand.

Therefore, in many areas such as roads, rivers, dams, sewage systems, the Construction Method and Equipment Department is conducting research and investigations to enhance the quality of structures such as embankments, cut slopes, retaining walls, slope protection works, rockfall protection works, buried pipes and culverts. The department is also doing research on the improvement of reinforcing methods for soils, the establishment of evaluation methods for the safety of existing structures and method to reinforce them.

The automatization and robotization of construction equipments, the reduction of noise and vibrations, the enhancement of new construction methods and the rationalization of construction control techniques are also important research themes in the department.

Further, the department is engaged in research on the application of new materials and new technologies to construction works, the improvement of ground inspection techniques, the development of methods to reuse construction waste.

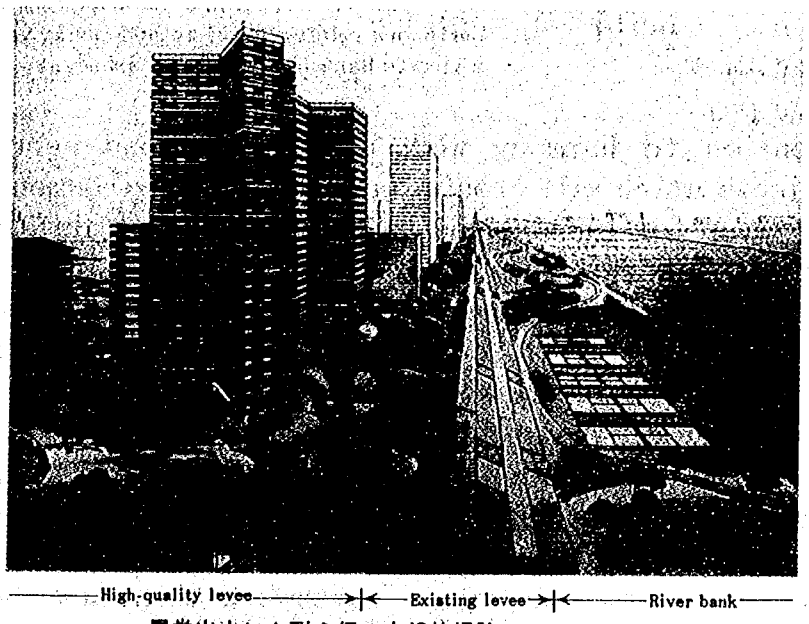
The results of the research and developments outlined above are reflected in many kinds of guidelines and manuals for earthworks and structures for roads and rivers.

The department greatly contributes to the construction field through its educational effects aimed at the site engineers about newly developed technologies.

1) Raising the quality and standard of earthwork structures

With regard to civil engineering structures which are to be built as part of the development of infrastructure from now on, there are greater expectations that high-quality structures to be built will be safely usable and durable to last over several generations. In particular, because earthwork structures such as road embankments, riverbank levees, cut slopes, earth-retaining structures, and foundation treatment works have conventionally been easy to repair, there is a strong lobby of thought towards economizing on initial construction costs and gradually increasing their functions through maintenance and repair.

道路における切土の安定化をはかる各種ののり面保護工
Various forms of slope protection designed to enhance slope stability for roads



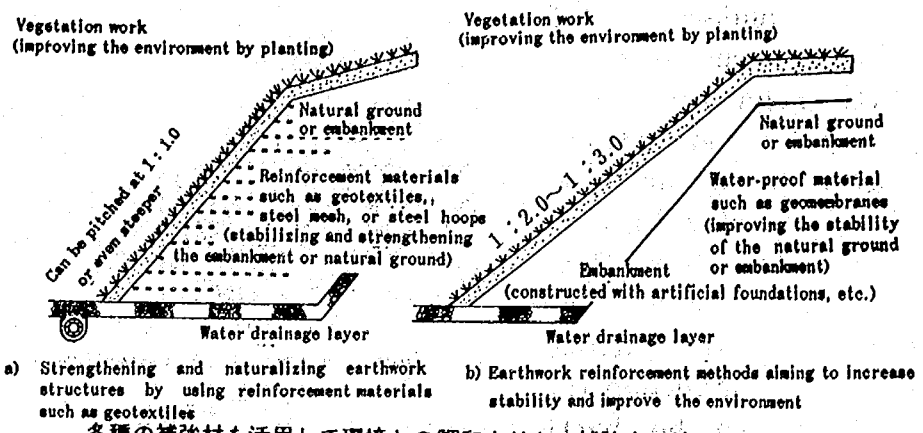
異常出水にも耐え得る高規格堤防
A high-quality levee which can withstand excessive flooding

But, looking towards the future, the expectation is that earthwork structures which need hardly any maintenance or repair will be created, and will be passed down to future generations strong and maintenance-free.

Also to this end, so-called upgraded technology should be established in order to create earthwork structures with a high degree of stability against heavy rains, excessive flooding, earthquakes and the like, by positively introducing new ways of thinking and new construction methods.

2) Developing new civil engineering technology aimed at harmony with the environment

In view of the fact that environmental protection will be taken up as an increasingly important issue in future, it is essential that we push ahead to build structures which pay attention to harmony with the natural and surrounding environment, and projects which will create a new, better environment. In construction work, it is common for foundations to be excavated or cut slopes or embankments to be formed. But recently development has been in progress on technology for using new materials and new construction methods in ways such as hardening foundations, reinforcing earthworks, increasing water-retentive or water-proof properties, or returning underground water into the ground after it has been drawn up.



a) Strengthening and naturalizing earthwork structures by using reinforcement materials such as geotextiles

b) Earthwork reinforcement methods aiming to increase stability and improve the environment

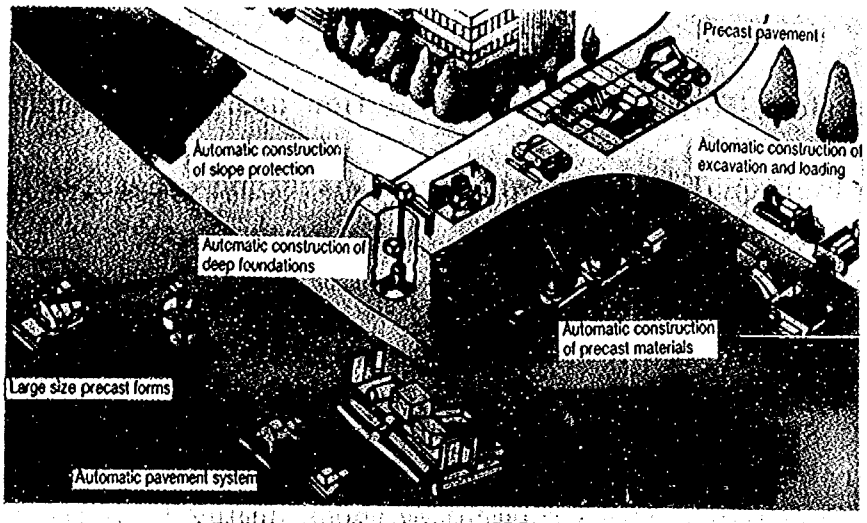
各種の補強材を活用して環境との調和をはかる補強土工法

Earthwork reinforcement methods using various reinforcement materials with a view to harmony with the environment

At the same time as developing these forms of technology further and promoting technology for hardening or reinforcing foundations and thus reducing excavation or slope-formation, it is also important on the other hand to attempt to create earthwork structures which have new shapes or structures using reinforcement, hardening, water-proof and other materials, to achieve harmony with the surrounding environment. In particular, by for example utilizing a combination of reinforced earthwork or various kinds of material together with a covering topsoil, we will be able to create a new format for earthwork structures and man-made foundations which will be in tune with topographical and foundational conditions as well as with eco-systems; thus there are further expectations for the progress of such earth work technology.

Moreover, we also need to improve construction technology to alleviate noise pollution, vibration, disturbance to underground water and surrounding foundations, subsidence, and other effects such as those on the surrounding environment which occur during construction, and to create new construction methods.

3) Developing new technology for construction



自動化等による施工新技術の開発
Development of new construction technology via automation and other means

While construction projects have been increasing along with the development of infrastructure, in recent years there have been increasing cases of construction being carried out in places where conditions are rigorous, such as building civil engineering structures on foundations with complex geological strata compositions or on extremely weak foundations, incrampedurban locations or in locations close to buildings and the like.Apart from this, the environment surrounding recent construction projects is characterized, on the one hand, by an increasingly serious shortage of skilled labour and advancing age, but also by strong hopes such as for raised productivity in construction projects and improvements in working environments. Indeed, as regards improving the quality of construction projects and the degree of safety of construction work, still greater levels of attention are required. Therefore, in order to implement such construction works smoothly as well as efficiently, we will need to go that much further in undertaking technological research such as in recent electronic and sensor technology, rationalizing construction technology such as improvements to construction techniques or new construction technology making use of AI and others, as well as automating construction machinery and converting to the use of robots. At the same time, while promoting the safe and reliable execution of works it is also important to continue to promote the upgrading of foundation survey technology through means such as non-destructive probes, whereby information can be gathered speedily and precisely, and the rationalization of construction technology by increasing information to provide feedback to the construction site on foundation movements and works management information.

Apart from these, we also need to establish techniques for evaluating the safety of existing structures and to develop technology such as measures for reinforcing and strengthening them. Whatever the case, while contributing to the promotion of construction projects which respond to on-site needs through the development of new technology, these technical developments are expected to be extremely useful on an international scale.

(A)Various forms of slope protection designed to enhance slope stability for roads

(B)A high-quality levee which can withstand excessive flooding

a. High-quality levee

b. Existing levee

c. River bank

(C)Earthwork reinforcement methods using various reinforcement materials with a view to harmony with the environment

a) Strengthening and naturalizing earthwork structures by using reinforcement materials such as geotextiles

b) Earthwork reinforcement methods aiming to increase stability and improve the environment

1. Vegetation work (improving the environment by planting)
2. Can be pitched at 1 : 1.0 or even steeper
3. Water drainage layer
4. Natural ground or embankment
5. Reinforcement materials such as geotextiles, steel mesh, or steel hoops (stabilizing and strengthening the embankment or natural ground)
6. Water-proof material such as geomembranes (improving the stability of the natural ground or embankment)
7. Embankment (constructed with artificial foundations, etc.)

(D)Development of new construction technology via automation and other means

STRUCTURE AND BRIDGE DEPARTMENT

The Structure and Bridge Department conducts extensive research in the fields of survey, design, construction, maintenance and management of civil engineering structures. In order to construct safe and economical public facilities, such as highway bridges, river structures and marine structures, the Department is engaged in the investigation of various subjects such as: 1) rational method for evaluating soil properties for foundation design, 2) design method for foundations in deep water or in mountain areas, 3) appropriate design method for structures when variations in applied load and structural strength are probable, 4) method for analysing the aerodynamic stability of structures and subsequent countermeasures for suppressing vibrations caused by high wind. The Department has also carried out comprehensive study for the construction of large-scale structures such as the Honshu-Shikoku Bridges and the Trans-Tokyo Bay Highway. And the Department has made efforts to develop technology utilizing underground space and coastal areas.

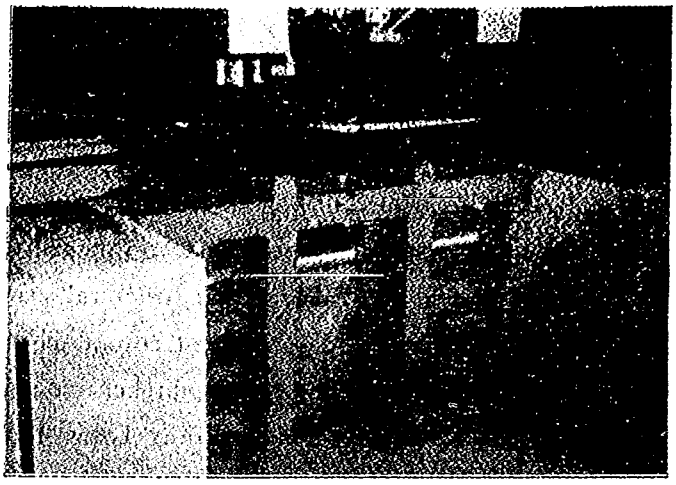
With the increase in number of highway bridges, maintenance of the existing bridges has become more important. The Department has developed the support system of bridge maintenance and retrofitting technique of bridge members, and also has doing researches on the design method of the durable bridges. The Department is making an effort for the utilization of new material for civil engineering structures and for the automatization of their construction. The outcomes of the above research have been reflected in the publication of various technical standards such as the Specifications for Highway Bridges, and have contributed to the promotion of projects related to the Ministry of Construction.

1. Foundation Division

【Major Research Subjects】

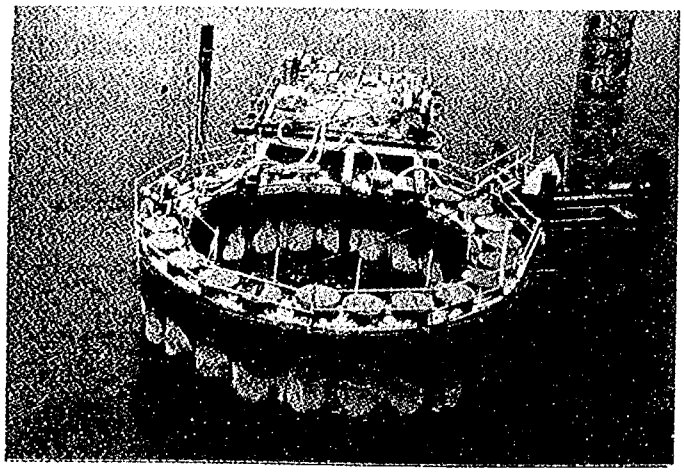
1) Research on design methods for shallow foundations.
2) Research on design methods for pile foundations.
3) Development of new types of foundations (multicolumn foundations, steel pipe sheet pile foundations, continuous diaphragm wall foundations).
4) Research on design methods for pier bodies and abutments.
5) Development of technology utilizing coastal areas and underground spaces.

【Major Research Facilities】

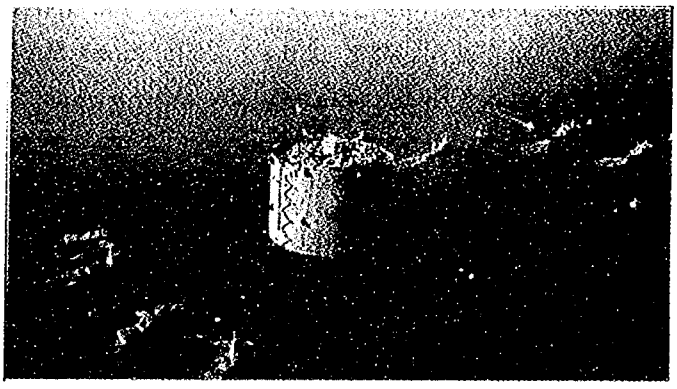


Large-Scale Test Pit

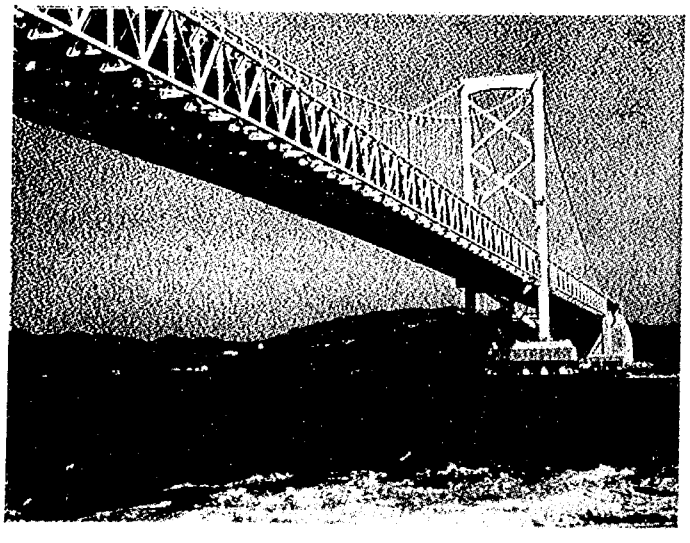
【Major Research Results】



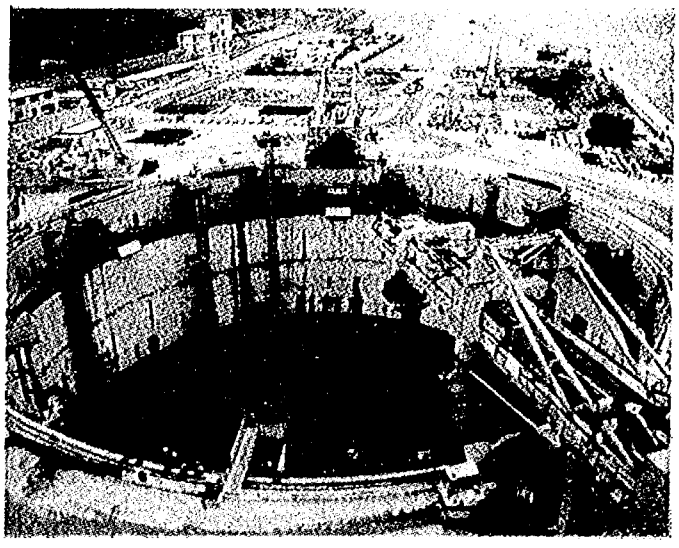
Construction of Steel Pipe Sheet Pile Foundation



Design Method for Shallow Foundations (Towing of the Caisson for the Constiuction of the Akashi Kaikyo Bridge)



Multi Column Foundation (Ohnaruto Bridge)



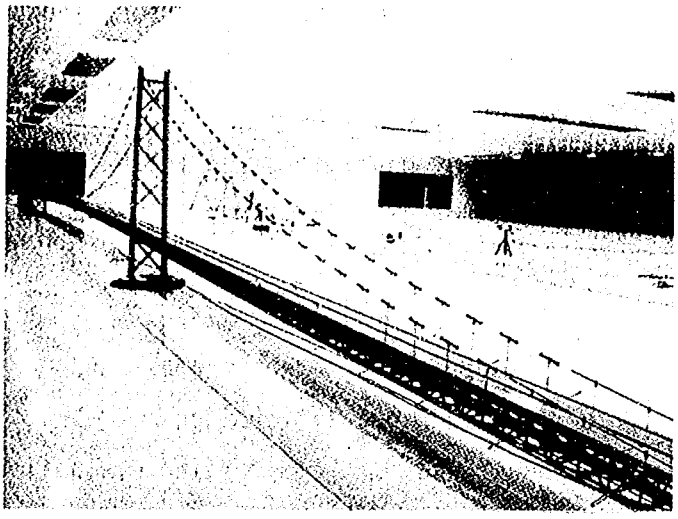
Design and Construction Technology for Continuous Diaphragm Wall (Akashi Kaikyo Bridge)

2. Structure Division

【Major Research Subjects】

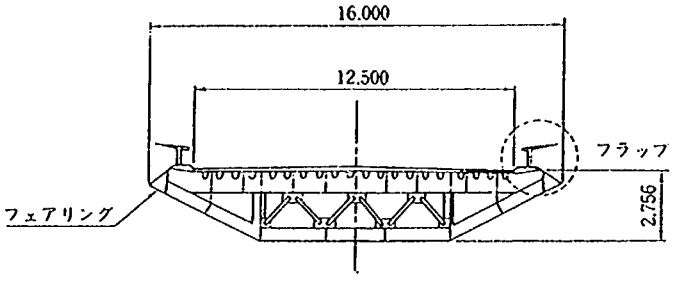
1) Research on wind resistant design for long span bridges.
2) Research on the dynamic response of highway bridges due to moving vehicles.
3) Development of an Expert System for bridge type selection.
4) Research on the reliability of the design strength of super-structures.
5) Research on design methods for structures other than bridges.

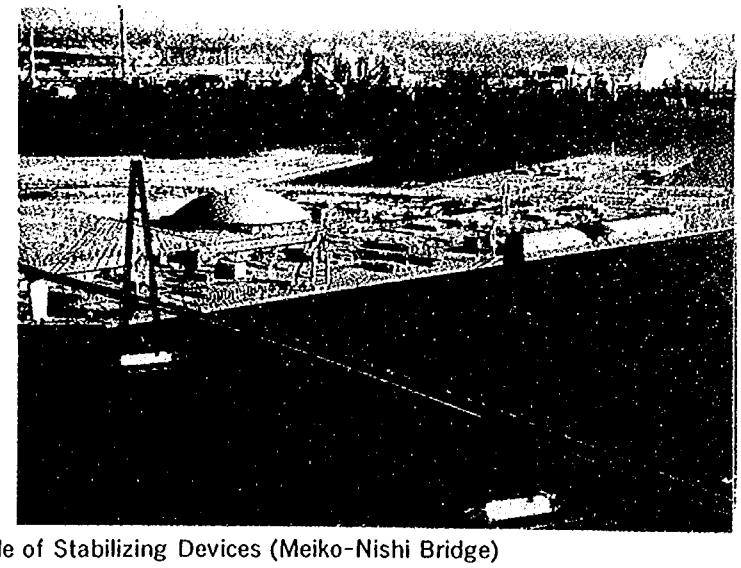
【Major Research Facilities】



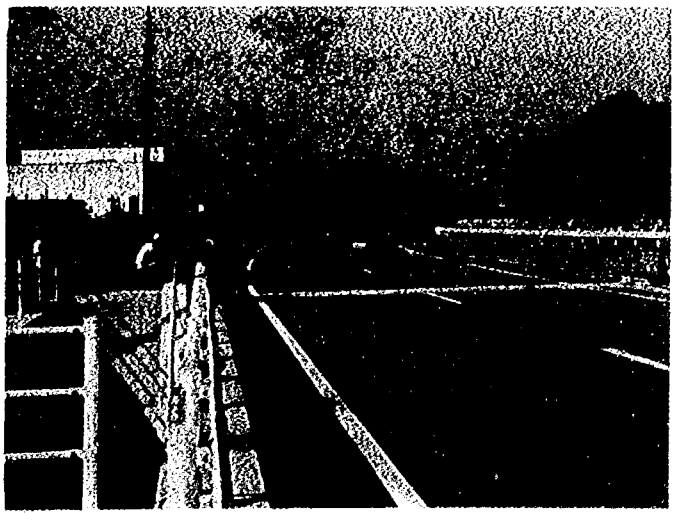
Big Boundary Layer Wind Tunnel

【Major Research Results】

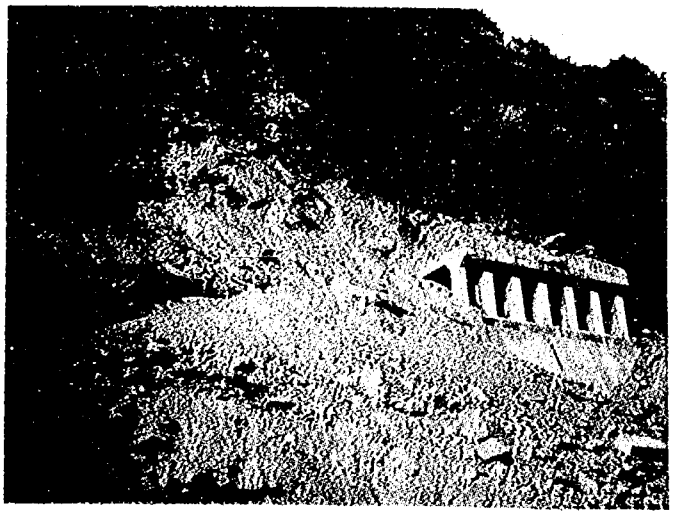




Example of Stabilizing Devices (Meiko-Nishi Bridge)



Reduction of Traffic Induced Vibrations



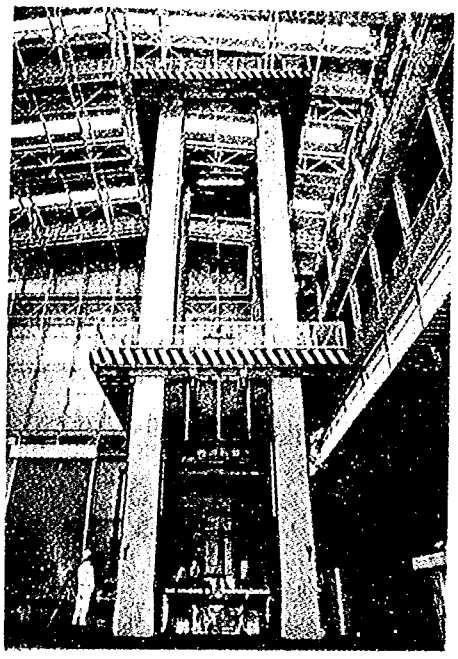
Improvement of Design Methods for Rockshed

3. Bridge Division

【Major Research Subjects】

1) Research on design methods for highway bridges.
2) Research on the design live load.
3) Research on ultimate and fatigue limit state for structural members.
4) Research on the application of advanced materials to highway bridges.
5) Research on methods to repair and strengthen existing bridges.
6) Research on methods for the evaluation of bridge load carrying capacity.

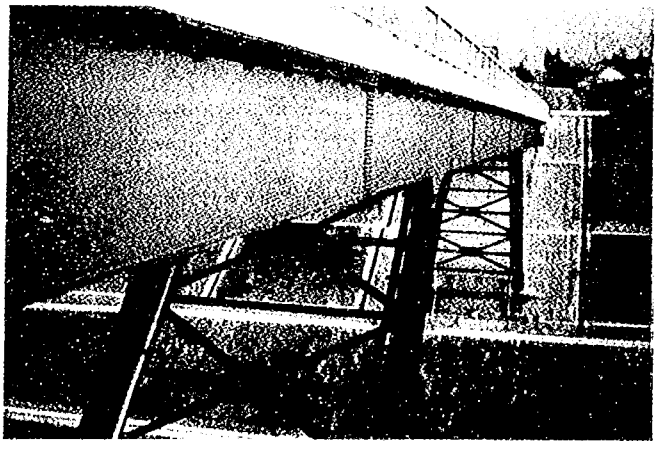
【Major Research Facilities】



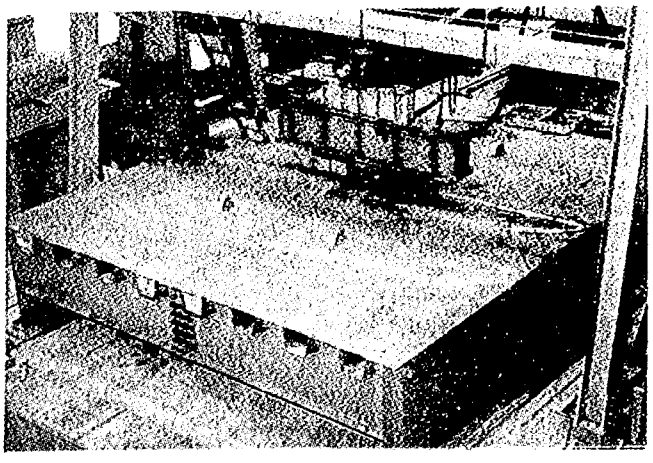
30MN Universal Testing Machine

【Major Research Results】

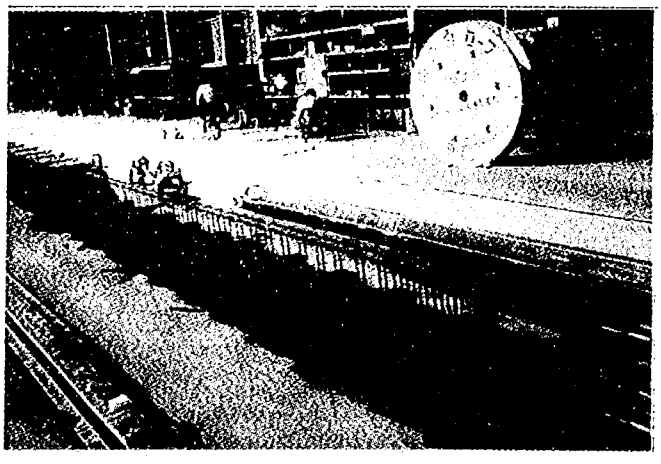
Repair Work of Deteriorated Bridges due to Chloride Ions



An Unpainted Weathering Steel Bridge



Fatigue Tests of Steel Plate Deck



Fabrication of PC Girders using FRP Cables as Tendons

EARTHQUAKE DISASTER PREVENTION DEPARTMENT

Introduction

Because Japan is located in an area of intense seismic activity along the Rim of the Pacific Ocean, one should always take earthquake effects into account when planning for or constructing public facilities in Japan. For example, on January 15 of this year, Off Kushiro Earthquake of Magnitude 7.8 and on February 7, Off Noto Peninsular Earthquake of Magnitude 6.6 occurred.

Since it's establishment , the Public Works Research Institute has conducted research in the field of earthquake engineering. In the late 1950's , as the Honshu-Shikoku Bridge project became a realistic undertaking, further improvement of the earthquake resistant design of the Bridge and related technology became essential. Severe damage that was sustained when a newly constructed bridge in Niigata collapsed because of soil liquefaction in the 1964 Niigata Earthquake triggered the upgrading of the earthquake engineering for public works facilities. The Ground Vibration Division was established in 1968 and the Earthquake Engineering Division in 1975. The Earthquake Disaster Prevention Department was established in 1976 based on the two divisions.

The Department has studied the input motion in earthquake resistant designs, liquefaction problems, refinement of earthquake resistant design for various structures such as highway bridges and underground structures, retrofitting technology for existing structures, and new technologies such as seismic isolation and hybrid control, namely, Menshin design.

Results of the research have contributed to promote the technologies in earthquake engineering and have been applied in various projects such as the Honshu-Shikoku Bridges and the Trans-Tokyo Bay Highway.

1) Strong motion observation and ground vibration characteristics

The Public Works Research Institute conducts observations of strong earthquake ground motions at 350 public facilities such as roads, river dikes and dams administered by the Ministry of Construction. The purpose of these observations is to study ground motion and structural behavior during earthquakes and to determine a rational seismic load for earthquake resistant design of structures. Further more, dense instrument array observations are conducted at 4 sites along Suruga Bay in Shizuoka Prefecture and at the PWRI in order to investigate the effects of local topography and ground conditions on ground motion during earthquakes.

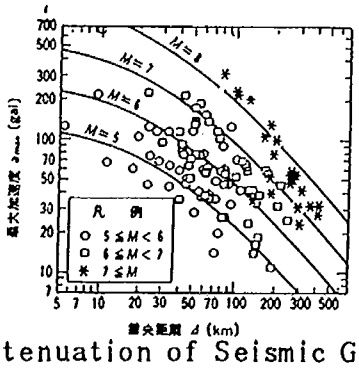


Fig.1 Attenuation of Seismic Ground Motion

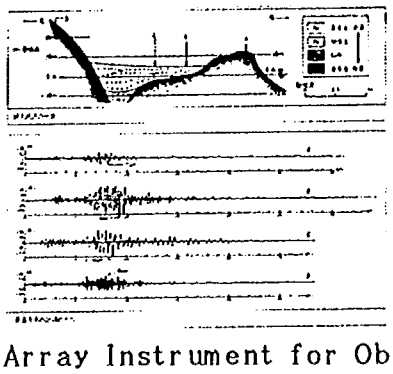


Fig.2 Dence Array Instrument for Observation of Strong Earthquake Motions

2) Prediction of Seismic Ground Hazard and Its Applications

Because most lifeline facilities are installed underground and have the potential to be damaged by ground hazards during earthquakes, seismic ground hazard zoning is very effective for estimating the damage of underground structures over a large region. A system which is capable of assessing the ground hazard due to an any earthquake which might affect the area is very useful for making a rapid inspection and for implementing urgent restoration measures in case of damage to structures. A dynamic visual information system for prediction of seismic ground hazards and its practical applications have been developed.

F_L; Liquefaction Resistance Factor
R; Resistance of Soil Elements to Dynamic Load
L; Dynamic Load Applied to Soil Element s

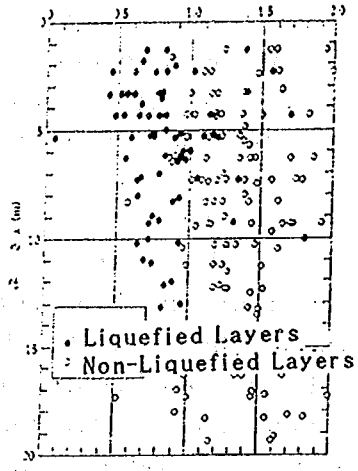


Fig.3 Produce for Estimating Liquefaction Potential (F_L Method)

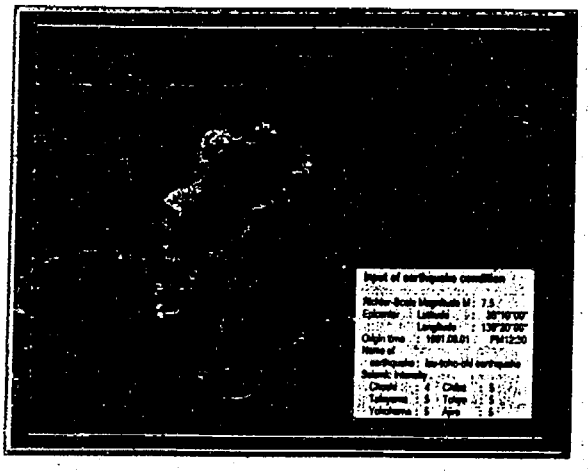


Fig.4 Display of Maximum Ground Acceleration and Seismic Intensity Around Tokyo Bay Against a Given Earthquake (Scale of Map; 158km x 130km)

3) Seismic Design Method for Civil Engineering Structures

The safety of urban civil engineering facilities has to be ensured against earthquakes as huge population and investments are concentrated in city areas. Therefore, for the purpose of developing rational seismic design methods for civil engineering structures, such as highway bridges and urban underground tunnels, their strength and deformation properties are investigated thought computer simulation and large-scale dynamic loading tests. Research and development of seismic strengthening methods for various older existing structures are also

conducted in order that they may service as long as possible. Furthermore, new technology using Menshin design method and hybrid control systems is under development.

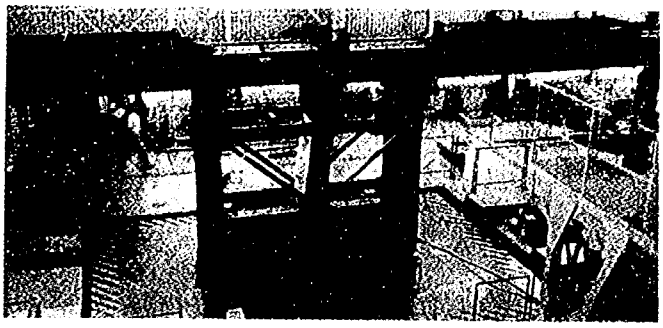


Fig.5 Development of Seismic Design Method for Reinforced Concrete Bridge Piers

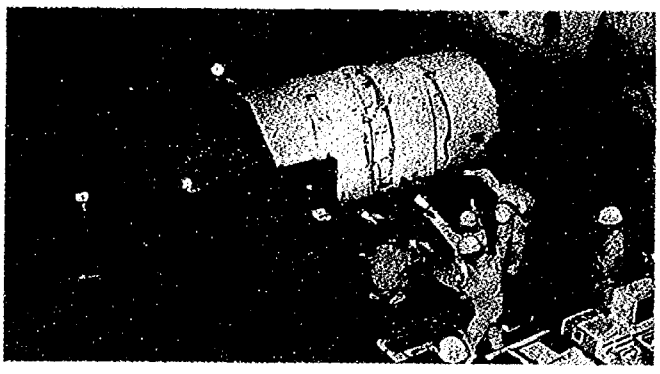


Fig.6 Development of Seismic Design Method for Reinforced Concrete Shield Tunnels in the Trans-Tokyo Bay Highway

4) Prediction of Earthquake Damage to Civil Engineering Structures and Restoration

It is essential to develop appropriate measures against earthquakes for the whole road network system as well as individual structures in order to improve the seismic safety of complex road networks in urban areas. Therefore, research is being conducted on prediction methods of seismic damage to the whole road network and the socio-economic influence of direct and indirect damage. Furthermore, information systems for efficiently gathering, transmitting and processing disaster and restoration information after an earthquake are developed in order to support quick and appropriate restoration services.

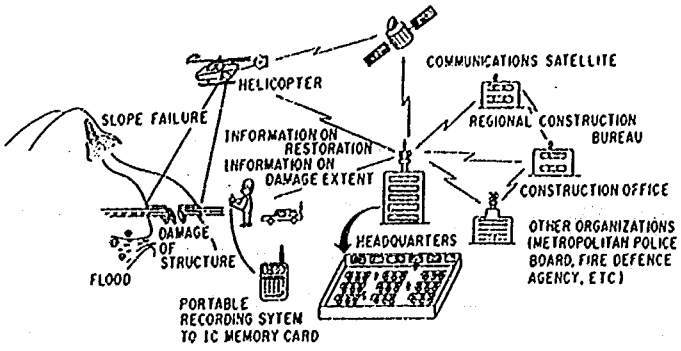


Fig.7 Development of Information Processing Systems for Earthquake Disaster Mitigation

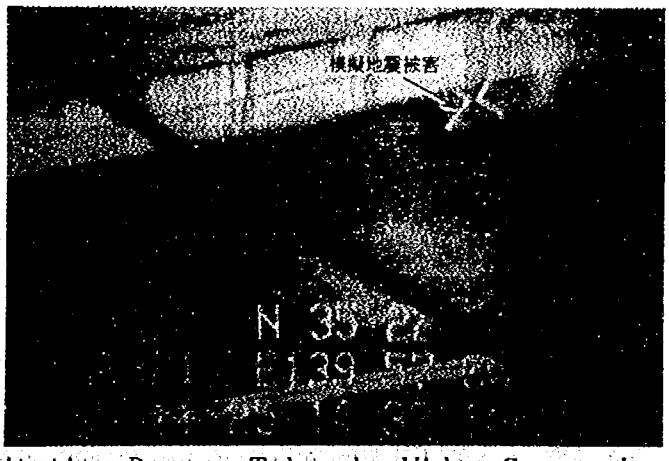


Fig.8 Picture of Imitation Damage Taken by Video Camera Loaded on a Helicopter

The Earthquake Disaster Prevention Department conducts joint research with the USA in the earthquake resistant design of lifeline facilities, chiefly in the form of the UJNR exchanges which have undertaken cooperative activities continuously for 24 years now.

It also carries out research exchanges in US-Japan joint research on hybrid control, utilizing both Menshin design and hybrid control systems. In addition, apart from international conferences and workshops, it is also characterized by an increase in international exchanges recently, as proved by the number of research engineer from countries such as New Zealand, Canada, and the USA who have spent time here.

CONSTRUCTION MANAGEMENT ENGINEERING CENTER

1. Foreword

These days social and economic conditions surrounding public works have changed remarkably through internationalization, increasing ratio of older generation and diversification of the sense of values. In order to perform the construction project smoothly and effectively under such circumstances, the Construction Management Engineering Center is in charge of carrying out comprehensive research and investigation from a standpoint of rationalization and systematization of a series of processes for public works, which include preliminary studies, project planning, structural design, cost estimation, contract with construction firms, execution control and maintenance.

Now for the coming 21st century, the establishment and development of infrastructure is indispensable for creation of amenities and better living environment at national, regional as well as municipal level. To this end further development of construction management system is also necessary. It should always be prepared for flexible and prompt responding to the socio-economic changes, such as sharp fluctuations in material prices and labor cost, changes in construction conditions mainly in urban areas, diversification of subcontractors, increasing use of construction machinery by lease system and changes in construction method brought about by the development of new technology.

In the execution of public works, enhancement of safety, rationalization and labor saving techniques to cope with a shortage of labor force are the subjects to be elaborated. Also our task is to encourage the construction industry to purpose technological improvement including better quality control and rationalization by providing incentives. At the same time for promoting adoption of new technology, efforts should be made to give solutions to problems of cost/merit evaluations and such.

The Center, newly established in April, 1991, is engaged, among others, in contributing to the overall improvement of construction management techniques such as reexamination of the existing cost estimation method. The Center is also in charge of the management and maintenance of the Institute's computer system.

2. Investigation and Researches related to construction management engineering

Construction management engineering covers a wide area of construction work in general, including planning, investigation, design, cost estimation, contract,

and execution control. This should be effectively linked with a series of processes involved. To facilitate a smooth and an efficient process, problems need to be clarified and then to be solved. The current researches at the center are classified into three major categories;

(1) Researches for improvement of cost estimation system

In Japan a competitive bidding is a common practice in public works projects. The bidding is based on ceiling price estimated by the organs which place an order. Therefore establishment of ceiling price based on appropriate cost estimation is very important.

The centre's role is to reexamine the existing cost estimation methods and improve them from the standpoint of simplification, labor savings to cope with an increase in public works projects, flexibility vis-a-vis social and economic changes such as sharp fluctuations of material prices and labor cost. Some of the subjects to be studied are as follows:

- identification and understanding of the problems of the existing cost estimation system
- examination of cost estimation improvement ideas so as to adjust to the current situation of construction
- study of flexible cost estimation system so as to be able to respond to changes in situations of construction
- researches for reconstruction of cost estimation system
- researches for labor saving method of cost estimation

(2) Comparison of the domestic construction management system with the foreign ones

Construction management system involves a series of processes, planning, design, cost estimation, execution control and such. Through a comparison with and an analysis of the techniques and systems with those of foreign countries, we aim at collecting necessary information for e improvement of domestic systems concerned. Researches are being made in the following subjects;

- history of cost estimation systems in Japan
- analysis of cost estimation systems in foreign countries and comparison with the ones in Japan

(3) Researches for design, cost estimation and execution control method of new technology and construction techniques

The Center provides cost estimation criteria and technological guidelines in an effort to establish a systematic method of design, cost estimation and execution control for each newly developed technique and technology so as to make its prompt application to the construction sites. As a first step, utilizing the specific technology pilot project, we offer, in good cooperation with the other sections of PWRI, technical support and instruction by establishment of cost estimation criteria and evaluation of constrcution feasibility of the technology in question.

3. Standardization of Designs and Automated Design System

We have been engaged in developing standard design for civil engineering structures and automated design systems to save labor in creating structural designs as well as to enhance precision in structures. Standard design systems are sets of drawings which contain major items of structural information for techniques most frequently applied for design and construction. Once the design conditions on the construction site are decided, corresponding data on the structure, shape, size, reinforcement, materials and such can be promptly obtained. Publication has been successfully completed for drawings of earth-work structures like culvert and retaining walls, and also of substructure and superstructure of concrete and metal bridges including abutment, pier and Posttensioned T girder bridge.

They are widely used not only in the Ministry of Construction but also in many public organizations throughout the country. In case of different conditions from those of standard design or under conditions too complicated to be registered within standard design system, automated design systems provide computer programs which automatically calculate, design and draw.

4. Development of Information and Communication system supporting construction administration

To promote further development, efficiency and better quality in services efforts are being made to install advanced Information and Communication systems to various administrative fields. Some of the examples of such efforts are; River Structures Management System by multi-media Data Base, Disaster Integrated Information System based on combined use of radio and computer, Road and Traffic

Information System to collect and to provide road, weather and traffic information, River and Basin Integrated Information System to collect and provide rainfall and water level, water quality, etc. Studies and researches are under way for improvement of Information and Communication System in an effort to support and facilitate administrative works in the field of construction.

5. Researches for Regional Planning

Infrastructure formed by construction project has a great influence on regional life and activities. It is necessary to develop infrastructure properly to cope with the problems Japan has faced, for example, excessive concentration in Tokyo and depopulation in rural areas. We have been engaged in researches to support effective regional planning such as the way to to predict the effects the construction of roads may have on the distribution of population and the location of industry and to procure resources of money in construction project.

NIIGATA EXPERIMENTAL LABORATORY

Due to its climatic, topographic, and geologic conditions, Japan isannually plagued by landslides, earthflows, and similar disasters. In addition, its geographic setting, particularly along the Sea of Japan, is conducive to heavy snowfall activity in winter which can easily lead to snow avalanches. Not only are such disasters costly in economic terms, but their menace is a constant source of anxiety for local residents. This urgent and pressing problem led to intense public outcry for the establishment of anti-disaster planning and policy.

In response this outcry, the Niigata Experimental Laboratory was established in Arai City, the site of numerous landslides and snow avalanches. Since its inception in 1960, the Niigata Experimental Laboratory has sought to elucidate the causes and effects of naturaldisasters, as well as develop more efficient ways of preventing them. Although the Public Works Research Institute were consolidated and moved to Tsukuba Science City in 1979, the Niigata Experimental Laboratory has continued its on-going research at various local test areas due to its unique character.

The work presently being undertaken by the 13 employees of the Experimental Laboratory can be divided into two main fields: landslides and snow damage. A description of each follows.

The region in which the Niigata Experimental Laboratory is located consists of a widely-distributed Tertiary layer, making it an area of high occurrence of landslides, even in Japan. Therefore, efforts are being made to examine the distribution of hazard zone, condition of slip surface and geotechnical characteristics of clay sampled from slip surface in this landslide belt. In addition, research is currently being conducted at landslide areas such as Saru Kuyoji, where properties of movement and occurrence of landslides caused by snowmelt are being studied.This research includes examining the effect of snowmelt on hillslope stability, as well as the horizontal and vertical landslide movement on the one hand, and the relationship between landslide movement and pore water pressure on the other. Moreover, prevention works, such as design methods for steel pile construction, are being drafted and proposed, and effective methods for water catchment are being examined.

Snow avalanches are major field of interest among snow damages. Causes of avalanches and methods for their prevention are currently being researched through in site observations and low temperature laboratory experiments. In addition, great strides have been madein designing methods for countermeasures against avalanche, discerning relationships between weather conditions and avalanche occurrence, examining characteristics of snow layers and how they are weakened, and developing movement simulation methods for predicting avalanches and mapping avalanche-prone areas.

Another important sub-field of snow damage research concerns ensuring smooth traffic flow during the winter. This entails elucidatingproperties of friction between automobile tires and icy or snow-packedroad surfaces by utilizing snow disaster observation vehicles and cryogenic sliding experiments. Moreover, on site

observations have helpedto explain conditions conducive to blizzard occurrence, while three-dimensional models have been developed for simulating snowdrift formation. Methods for predicting snowfall are being devised which can aid in establishing guidelines for winter traffic control and snow removal.

In conclusion, the Niigata Experimental Laboratory is chacterized by its use of neighboring test areas which may profit from its research. We believe its mission, now and in the future, will be to further use its research and spatial attributes for the benefit not only of Japan, but of the international community as well.

X. Subject of Common Interests

1. Disaster Prevention and Preparedness in Korea

   Dr. Lee Sang Eun, Vice President,
   Korea Institute of Construction Technology

2. Problems of Highway Slopes in the Mountainous Region of Malaysia

   Mr. Abdul Rahman B. Abdullah, Deputy Director-General,
   Public Works Department

3. Slope Erosion Control in Granitic Soil Slope, Thailand

   Dr. Teeracharti Ruenkrairergsa, Director,
   Road Research Development Center, Department of Highways

   Mr. Bancha Vadhanasindhu, Chief of Programming Section,
   Department of Highways

4. The Earthquake and Tsunami in Flores Island, Indonesia

   Dr. Badruddin Machbub, Director,
   Research Institute for Water Resources Development

1. Disaster Prevention and Preparedness in Korea

Dr. Lee Sang Eun, Vice President,
Korea Institute of Construction Technology

CONTENTS

I. Introduction

1. Geographical Features
2. Weather and Climate
3. Natural Disasters and Relief Efforts

II. Natural Disasters

1. Hydrological Circumstances
2. Socio-Economical Backgrounds
3. Direct Causes of Disasters
4. Statistics in Natural Disasters

III. Natural Disaster Prevention and Preparedness

1. Institutional Framework
2. Long-term Countermeasures for Disaster Prevention
3. Short-term Disaster Planning and Mitigation Programmes

IV. Natural Disaster Restoration

1. Classification of Disaster Restoration
2. Emergency restoration
3. Improving Restoration Works
4. Government Financial Role on Disasters

V. Natural Disasters in 1991

I. Introduction

1. Geographical Features

Korea, which covers the area of 99,200 sq.km (38,301 sq. miles) in the Korean Peninsula, is one of the most mountainous countries in the world - more than 70 percent of the country is dominated by mountains and hills. Geographical features can be characterized by the Korean expression "east-high-west-low". The mountains near the east coast plunge steeply into the sea. On the contrary, the western or southern slopes descend gradually down to the coastal plains, where often be flooded.

2. Weather and Climate

Korea enjoys four distinct seasons and a variety of weather types. As Korea located in the east Asia monsoon belt, the country has a rainy season during summer. In June, daily average temperature rises up to above 20°C (68°F), and in the end of the month the rainy season usually begins and lasts about a month. In winter, it is extremely cold and dry. In January, daily mean temperature is usually below 0°C (32°F), but cold and less cold weathers normally alternate for three and four days, respectively.

3. Natural Disasters and Relief Efforts

Major natural disasters are caused by floods. Since extremely heavy rainfalls frequently occur during the rainy season, plains often are flooded. Typhoons also strike the peninsula usually two or three times a year and cause severe damages. In addition, this country is occasionally striked by heavy snowfalls, hails, tidal waves, thunderstorms, earthquakes and others.

The central and local governments support various disaster prevention and preparedness activities: weather and flood forecasting; improvement of rivers; construction of embankment and drainage facilities for lowlands; and implementation of many educational programmes for inhabitants and related staffs. In spite of such efforts, numer of losses in human lives and amounts of property damages have increased significantly in recent years. Annually, during the recent ten-year period, losses of 283 human lives and about 550 million U.S. dollars worth of property damages occurred, and 450 million U.S. dollars were spent for the disaster relief and restoration works.

II. Natural Disasters

1. Hydrological Circumstances

a. The average annual precipitation is 1,274 mm (50.2 inches).

b. About two-thirds of the annual precipitation occurs during the summer season (June, July and August) because of monsoonal rainfalls.

c. Regional flash floods frequently occur in recent years.

d. Rain storms rush into rivers due to the geographical characteristics of the peninsula, and subsequent floods often occur in low areas.

2. Socio-Economical Backgrounds

a. Population growth and urban development increased the use of flood - liable lowlands and landslide-liable hillsides in the outskirts of cities and created potential severe problems.

b. Rapid urbanization and forest developments increased the volume and velocity of runoff and produced higher peaks in flood discharges than lever occurred in the past.

c. Embankment and improvement works for rivers have not been done sufficiently.

d. Many tributaries do not have sufficient flood control structures/ facilities.

3. Direct Causes of Disasters

More than half of the disasters are caused by heavy rainfalls and typhoons. Major causes of disasters are briefly discussed as follows.

a. Floods

Korean rivers are relatively short and steep that the velocity of river flow is high, and as a result the shape of flood hydrograph is extremely sharp.

b. Typhoons

Tropical depression which originates in the West Pacific around 5 to 15 degrees of North Latitude with maximun wind speed of 17m/sec, is referred to as a typhoon. Typhoons usually occur 30 times an year, and 70 percent of them from July to October. The typhoons occurring from July and October could approach the Korean Peninsular. Two or three times every year the typhoons bring direct rainstorms, rain front and heavy precipitation.

c. Debris Flows and Landslides

The Korean peninsula has many areas of brittle soils. Futhermore, as developments are pursued even in the mountain areas or hillsides, numer of disasters caused by debris flows are increased continuously. The debris flows are subsequent results of landslides and collapse of steep slopes.

d. High Tides and Tsunamies

The shoreline of Korea is very long, and considerable property is concentrated along the shoreline. Thus damages are likely to occur by high waves in a rather great extended areas. The waves which wreak such damage are classified into swells by typhoons, tsunamies by volcano activities, high tides and others.

4. Statistics in Natural Disasters

Table 1 shows number of natural disasters occurred for the different types of causes during the period from 1904 to 1991. The annual damages caused by the natural disasters in recent 10 years are summerized in Table 2.

Table 1. Numer of natural disasters occurred in Korea (1904-1991).

Cause	total	typhoon	heavy rain	heavy snow	hail	tidal waves	storm	earth-quake
No. of strike	1,568	263	429	224	89	49	435	79
Annual average	17.8	3	4.9	2.5	1	0.6	4.9	0.9
Percent (%)	100	17	27	14	6	3	28	5

Table 2. Damages occurred from natural disasters (1981-1990).

Year	Loss of Life (person)	Sufferers (person)	Inundated Area (ha)	Property Damage (in million U.S dollars)					
				Building	Farmland	Crops	Public Facilities	Others	Total
1981	216	18306	149583	5.29	17.67	26.74	130.26	18.93	198.89
1982	121	6609	37008	1.25	6.85	42.32	62.69	14.03	127.14
1983	91	1355	24851	3.21	0.14	15.44	6.61	4.73	30.13
1984	265	364236	140199	13.67	28.39	96.80	186.21	54.82	379.89
1985	250	72257	126291	1.83	2.42	109.12	67.45	28.67	209.49
1986	156	99114	86701	2.99	2.55	268.47	60.81	31.08	365.90
1987	1022	272277	300453	21.29	104.70	350.08	836.69	327.34	1640.10
1988	143	5053	17988	0.89	15.95	20.48	124.93	21.81	184.06
1989	307	92593	121060	8.80	21.76	342.68	303.80	141.34	818.38
1990	257	203314	124276	13.17	64.19	829.02	394.66	246.46	1547.50
Total	2828	1135114	112841	72.39	264.62	2101.2	2174.1	889.2	5501.5
Arithmatic Mean	283	113511	112841	7.24	26.46	210.12	217.41	88.92	550.15

Note: The property damage does not cover the losses of materials for production, products and household goods.

III. Natural Disaster Prevention and Preparedness

1. Institutional Framework

The National Disaster Prevention and Countermeasures Headquarters, which is now under the Ministry of Home Affairs but under the Ministry of Construction before April 23, 1991, is the central organization tasked for national natural disaster prevention and preparedness. This headquarters has responsibilities for government-level plans and activities against natural disasters, and for international co-operations. In addition, the headquarters formulates and carries out mid-and-long term national disaster mitigation programmes.

Figure 1 shows the disaster prevention organization systems in Korea. The National Disater Prevention and Countermasures Headquarters is supported by the National Disaster Prevention and Countermeasures Committee, of which Chairman is the Minister of Home Affairs (MOHA) and Vice Chairman is the Vice Minister of the MOHA. This committee is composed of 17 ministerial officials and 8 other specialists.

In addition, as a supreme executive council in working level, the Headquarters Committee is constituted under the National Disaster Prevention and Countermeasures Committee. The Headquarters Committee is chaired by the Minister of Home Affairs and assisted by two vice chairmen, the Vice Minister of MOHA and the Vice Minister of MOC. The members include 24 director-generals from 17 ministries and the Korea Meteorological Administration. Once a major disaster occurs, the headquarters is activated and coordinates the activities of the ministries/agencies and their supporting units concerned to the disasters.

At the provincial, municipal and county levels, similar organizations are established with the same composition and responsibilities as the Disaster Prevention and Countermeasures Headquarters have.

2. Long-Term Countermeasures for Disaster Prevention

Measures, which prevent or mitigate adverse effects of the nation's land, human lives and properties caused by various disasters, are classified into follows : preventative measures ; urgent countermeasures when a disaster has occurred ; restoration and rehabilitation after disasters ; and research for development of preventative science and technology.

a. River Improvement

In order to prevent inundation caused by floods, the government has carried out river improvement works including widening of rivers, strengthening of river banks, and construction of flood channels, retarding basins and pumping stations.

The government has invested about 330 million U.S. dollars for the river improvement works in recent five years, and as a result the ratio of improved length (19,690 km) to the total length (30,222 km) of rivers reaches 55 percent. Table 3 shows investments for the river improvements in recent 5 years.

Table 3. Government's investment for river improvement in recent 5 years
(In million U.S. dollars)

Fiscal Years	Average	1986	1987	1988	1989	1990
Length of rivers improved in kilometers	204	230	202	189	201	200
Investment in million U.S. dollars	66.0	59.4	51.2	62.1	70.2	86.9

b. Construction of Multi-purpose Dams

The multi-purpose dams take the great role of flood control in Korea. These dams are usually located in the headwaters of rivers and have several other purposes such as water supply for various uses, hydropower generation and others. The current status and future plans about the multi-purpose dams are as follows:

- Operated : 8 sites (1.7 billion cubic meters of flood control capability)

- Under construction : 2 sites (350 million cubic meters of flood control capability)

- Planned: 7 sites

After the year 2011, the total number of multi-purpose dams will be 17 sites with flood control capability of 2.7 billion cubic meters.

c. Preventive Works for Steep Slope Failures

To prevent the failure of steep slopes in urban or densely built-up areas, the construction of retaining walls and other means of slope protection are being carried out.

d. Improving Restoration Works

Improving restoration works are carried out in order to prevent similar disasters which would be occurred at the same place again if restoration works are made to recover the original damages only.

3. Short-Term Disaster Planning and Mitigation Programmes

a. Short-term Plans/Progrmmes

Various short-term disaster mitigation plans and programmes are prepared and carried out for the rainy season. They include:

- Repair of hazardous facilities and designation of their responsible personnel.

- Removal of obstructive materials in rivers.

- Designation of observers for flood-liable rivers.

- Designation of superintendents for important hydraulic facilities and structures.

- Education on advanced skills and knowledges about natural disaster prevention for the related staffs.

- Planning and education of evacuation for disaster-vulnerable communities.

- Various media coverages for public awareness on the vulnerability.

- Enforcing the pre-exercises for natural disasters.

b. Temporary Actions to Reduce Disasters.

In response to the existence of a known hazard, and especially in response to prediction and/or warning of impeding events, many emergency measures are usually planned and performed. These measures include:

- 24-hour nation-wide TV networks coverage.

- Evacuation of people and properties in disater-vulnerable areas.

- Preparatory releases of stored water from reservoirs.

- Embargo on fishery boats and ocean-going ships.

- Stand-bys of flood-fighters, civil defence corps and staffs in the national, provincial, municipal and county disaster prevention and countermeasures headquarters.

IV. Natural Disaster Restoration

1. Classification of Disaster Restoration

- Emergency restoration
- Perpetual restoration
  - Restoration of the original condition
  - Improved restoration

2. Emergency restoration

To prevent the additional loss of human lives and property damages from the disasters occurred, special emergency countermeasures are carried out for improvement of rivers and landslide prevention.

3. Improving Restoration Works

The fundamental aim of disaster restoration works is to recover the damaged facilities to their original conditions. However in the case that the damage is so serious, the effectiveness of recovery could be limited. Therefore an improving restoration work is necessary in order to prevent recursive disasters with additional expense.

4. Government Financial Role on Disasters

a. Disaster Prevention Measures

In Korea, responsibilites for disaster prevention and management are shared by the various levels of governments. At the national level, the

principal concern is concentrated on broader issues such as allocation of funds to the provincial and local governments for the construction works. The national governments also directly involved with the formulation and implementation of national-level policies and programmes.

At the lower levels, regional or local governments have their own policies and programmes. When the associated expenses to implement these policies and programmes are too costly for the lower-level government, the national government also takes part in funding in order to stimulate the efforts of provincinal and local governments.

b. Arrangements for Disaster Restoration and Relief Activities

Government assistance for relief is provided according to the natural disaster relief arragement standard called "Codes on the Government's Support on Disaster Restoration and Relief Actvities". The codes provide basis for financial assistance to help the local authorities and people faced with financial difficulties because of the unexpected and/or sometimes high expenses of providing disaster relief.

The major objectives of the codes are twofold. One is to allocate the necessary costs to various-level of governments and the relevant people, and the other is to provide for the immediate assistance to overcome presonal hardship and distress including indispensable repairs of various levels of public structures and facilities.

Even though it is not uncommon for national government to give funds to rehabilitate community services or individuals affected by disasters, the government's share of the funds should be restricted at a certain level. Otherwise it will be a permanent financial burden on the national government and will weaken disaster mitigation efforts of local governments and individuals.

c. Damage Assessment and Rehabilitation Plan

The National Disaster Prevention and Countermeasures Headquarters sets up a guideline every year in order to support the local authorities in assessing damages at the national level so that informed estimates can be properly evaluated. When a disaster occurs, total damage is estimated by the relevant local government personnel in accordance with the guideline. The local government takes responsibility for disasters with relatively light casualties. In the case of the disaster with a serious damage, the national government takes part in the field survey for the restoration plan

after the emergency actions are taken. The field survey team, teamed with technical staffs from concerning ministries, finalizes damage assessments and sets up a restoration plan for each of the damaged area. After the survey completed, the costs needed to carry out the plan will be shared in accordance with the codes.

d. On "Codes on Government's Support for Disaster Restoration and Relief Activities"

When a disaster occurs, total damage is estimated by the local government. In case of the disaster with a serious damage, the national government is supposed to take part in the field survey for the restoration plan. Otherwise the local authorities take responsibilities for the works. According to the codes, when the damage estimated by local governments exceeds one million U.S. dollars, the national government takes share of the recovery costs. The expenses required for the restoration and disaster relief works are shared by various levels of governments and private sectors. Table 3 shows some examples of cost sharing shown on the code.

Table-3 Examples on the cost sharing shown in the "Government's Support on Disaster Restoration and Relief Activities"

Classification	Government		Contri-butions or donations	Pri-vate	Low in-terest loan
	National	Local			
Disaster relief for sufferes			$ 4,500		
Victim's Family					
Food & clothing(per person, up to 3 mo.)	$ 7/day	$ 3/day			
Temporary shelter		100 %			
Poor family support	$ 1,000		$ 100		
Tax and education fee exemption for suferers reduction	100 %				
Public facilities/structures					
National Gov't belongings	100 %				
Local Gov't belongings	50 %	50 %			
Private school		50 %		50 %	
Private forest	60 %		40 %		
Private facilities/structures					
House Repair/resettlimant	6 %	6 %	8 %	10 %	70 %
Public works for resettlement	100 %				
Inundated House	$ 700				
Farmland Recovery/Crops	70 %			30 %	
Farmland Purchase	50 %	50 %			
Boats/ships	30 %			10 %	60 %
Grassland/barns/fishing nets	0-20 %			20 %	60-80%
Fisheries	70 %			30 %	
Livestocks	20 %			20 %	60 %

V. Natural Disasters in 1991

As of 30 September 1991, twenty-four various disasters have struck the country in 1991. These disaters have resulted 226 people dead or missing and total damages of 900 million U.S. dollars. The casualties caused by natural disasters in 1991 are summerized as follows.

1. Human Life Casualties
   - killed: 169
   - missing: 59
   - injured: 181

2. Sufferers: 29,573 persons in 7,468 families.

3. The Losses of Farmlands
   - inundated: 61,173 hectares
   - lost: 38,362 hectares

4. The Damages of Houses
   - inundated: 24,097 units
   - destroyed: 3,841 units

5. Total amount of property damages: 900 million U.S. dollars.

6. Total Expenses for Disaster Relief and Rebuilding Activities : 926 million U.S. dollars.

2. Problems of Highway Slopes in the Mountainous Region of Malaysia

Mr. Abdul Rahman B. Abdullah, Deputy Director-General,
Public Works Department

PROBLEMS OF HIGHWAY SLOPES IN THE MOUNTAINOUS REGION OF MALAYSIA.

1.0 Introduction

Many of todays modern roads are designed to take high volumes of traffic. This is achieved by allowing for relatively high vehicle speeds and limiting all sources of possible congestion. It implies wide roads with modest gradients and a geometry which provides large radius bends. In contrast to narrow roads, which can follow contours, meeting the design conditions for such roads in mountainous terrain obviously presents some difficulties. It either involves extremely high investment in order to provide engineering solutions in the form of tunnels, bridges and anchored retaining structures or more modest investment in the form of extensive earthwork changes to the terrain. Many developing countries choose the latter course of action in order to spread investment and meet growing needs for new roads.

In many cases the effect of constructing roads with a high design geometry in mountainous terrain, using very large scale earthwork operations, has led to extremely high levels of maintenance and resulted in roads which may have a short life unless expensive rehabilitation work is carried out at frequent intervals. This reflects the terrains response to the large earthwork changes which have occurred both in terms of exposing sensitive soils and rocks and altering drainage patterns.

One of the most serious problems affecting Malaysia's roads is connected with earthwork and natural slope failure. Physically the country is divided by steep mountainous terrain and in recent years there has been a tendency to construct new or widen existing roads in these regions which has resulted in considerable earthwork activity. The outcome has been a spate of slope failures and the need for considerable maintenance effort and in some cases large scale rehabilitation programmes.

The success of any slope stability methods in the tropics depends largely on the level to which the instability problems is understood. In Malaysia and also in many other tropical and subtropical countries, landslides are normally associated with heavy and prolonged rainfall, and they are increasingly getting more and more difficult to arrest. This is due to the increasing demand for better roads and highways, cutting deeper and deeper into residual soils.

2.0 Geotechnical Related Problems of the East-West Highway

The East-West Highway extends from Grik in Perak to Jeli in Kelantan, a distance of 116km. It traverses through mountainous terrain amidst densely grown rain forest. The highway alignment rises from approximately Elevation 100m to reach an Elevation 1050m at the highest point on the Main Range at about midway along the route. Such unique features of geographical position with forested mountain barrier at high altitudes creates an ideal situation for heavy and frequent precipitation from rainfall, resulting in annual rainfall record of 3600mm or 50% over the Peninsular Malaysia average.

During each monsoon season, a number of cuttings and embankments failed. To date, assessment of remedial work priority has been carried out on an *ad hoc* basis. Every year the Federal Government spends millions of ringgit on rehabilitation works of the East-West Highway. A large proportion is expended on the repair of cutting and embankment slopes and on routine and preventive maintenance. From 1981 to 1992, a sum of RM 454.11 million has been expended on remedial stabilisation and routine

maintenance to satisfy the primary objective of keeping the highway open at all times. This sum has been expended on 151 numbers of cuttings and embankments.

As a result there has been significant effort aimed at overcoming such problems in terms of improving the design and construction of earthworks and using more sophisticated engineering methods to build roads. Whilst both solutions might lead to reductions in the cost of maintaining roads they would certainly result in significant increases in the cost of constructing such roads.
A long stability plan is required to ensure that Federal funds are only allocated to slopes having high risk ratings and that the remedial works are implemented in a most cost effective manner.

2.1 Aspects of Surface Water Concentration.

In addition to recognizing the influence of geology on stability, it is important to provide a link between slope hydrology and stability analysis for successful design of these slopes.

From the analysis carried out so far it is clear that surface water is the main factor influencing slope stability along many of the road.

a. Culverts: These have caused extensive damage to side slope embankments along much of the road line on the East-West Highway.

b. Road gradient: Along sectors with a shallow gradient considerable amounts of water accumulate as flow. When rainfall is very heavy such flow exceed the capacity of side drains and will flow over the side of the road embankment causing erosion.

c. Natural drainage channels. Some channels may only be active, in terms of flow, during periods of exceptional heavy rainfall. Perhaps those connected with 5 to 10 year rainfall events.

d. New drainage gullies. Disturbances have resulted in surface water concentrations. The formation of gullies leads to further concentration until the surface flow has sufficient energy to do considerable damage to lower slopes.

e. Mans activities. Aerial photographs show a considerable amount of ribbon development along roads in Malaysia. Some of this may influence groundwater concentration.

f. Springs and groundwater. Aerial photographs generally provide little evidence of the emergence of groundwater on slopes. However it is a factor which should be born in mind and attempts made to recognise where it occurs.

2.2 Other Factors that are common problems to many highways in Malysia as well as in the region are:

a. Oversteep/high slopes. It is apparent that many of the slopes analysed so far were cut at relatively steep angles of 1:1 to 0.5:1, length to height ratio, in spite of the poor strength and variability of the soils. As a guide Table 1 shows a range of recommended slope angle to height values that could be used for weak soils in Malaysia.

TYPE OF MATERIAL	(RECOMMENDED HORIZONTAL TO VERTICAL RATIO)			
	Up to 5m	5 to 10m	10 to 15m	> 15m
Silty sand and uncompacted silt	1:1	1:1	1.25:1	up to 1.5:1
Soft compressible clay	1:1	1.25:1	1.5:1	1.5:1
Fully weathered granite	0.75:1	0.75:1/1:1	1:1	1:1

Table 1

b. Slope angles/shape. Many slopes were provided with deep unprotected benches that appeared to more than the nominal six metres apart (In Malaysia it is common practice to incorporate berms at approximately 6m vertical intervals on slopes). This might impose some drainage problems.

c. Slope bedding angles. The bedding angle of slope deposits differed widely and in some locations was vertical. Such bedding was clearly at an unsympathetic angle to the road and cut slope in many instances.

d. Alignments in Gullies. In places where slopes enter a gully re-entrant between two ridges there has been a tendency, it is understood, to use fill, to obtain sufficient road width, rather than cut back the re-entrant slopes. This is acceptable providing sufficient allowance is made for drainage.

e. Loose rock falls. Some slopes on the East-West Highway consist of very fragmented deposits of rock which stem from the folding and metamorphic processes that have occurred in the region.

3.0 Methodology

In response to such problems in Malaysia there has been research into improving slope stability on such roads by 1) minimising environmental disturbance, 2) using slope protection, 3) slope equilibrium design and 4) statistical evaluation methods. However all of these techniques, even when proven, rely on making significant changes to construction methods which is not easy to achieve in most instances. Also changes once made are often costly and may not always be beneficial.

An alternative now being considered is to continue to construct such roads at the minimal cost and subsequently use an earthwork monitoring and management approach in order to minimise subsequent maintenance requirements and improve rehabilitation methods.

As the present problems are connected with repair costs it is proposed to seek savings by improving the overall efficiency of maintenance methods by implementing an earthwork management system. Additional benefits of such a system would be that rehabilitation and widening schemes could be improved by providing better information and planning at the investigation stages of such schemes. Also the continuous monitoring of slopes would allow priorities to be determined and maintenance resources allocated accordingly.

The most effective allocation of remedial works funding depends on the stability assessment of cutting and embankment slopes and their prioritisation for repair. This requires the establishment of an extensive database inventory of slopes for stability assessment. Hazard rating maps can be produced from time to time as an engineering quantification of remedial work priority.

A comprehensive desk study should be carried out on old and new maps, aerial photographs, historical records on instability, as built drawings and reports on past remedial works.

On completion of the desk study, there should be a programme of site collection by geotechnical inspection, geological mapping, site investigation, instrumentation, monitoring and aerial surveys to determine all factors which may be affecting the stability of cuttings and embankments. This information should be incorporated into a database for stability assessment.

Hazard ratings and maps should then be produced using "state of the art" analytical methods based on engineering, geological, hydrological and geomorphological studies along the highway.

A Geographic Information System (GIS) or equivalent may be the most appropriate method of gathering, manipulating, analyzing and updating data for a number of specific reasons:

1. As a data gathering tool the approach offers flexibility. It allows integration of many forms of data (e.g. site specfic point data and spatial information such as soil and geology map data). Many levels of information can be held, information can be added for any location as it becomes available, and information can be manipulated and altered as the project progresses. The approach also allows complete flexibility in the output product where this can be tailored to specific requirements of the end user.

2. The approach also allows updating of any data at any time. A mapping approach results in information becoming obsolete and outdated from the moment it is recorded.

In addition to the hazard ratings and maps produced, such a system also provides readily available information for the purpose of designing further investigation and instrumentation to obtain the most cost effective remedial works.

4.0 Conclusion:

Geotechnical engineering, a specialise area of the civil engineering, deals with the soils and its application in roads and buildings constructions. Research into the advancement of certain geotechnical engineering aspects have always been towards better economics of solving or preventing problems relating to infrastructure development, which at present are costing the government huge sum of money to remedy or rehabilitate as and when they occurred. These problems, if continue to be left to chance to happen without addressing the root causes, will continue to drain the financial resources of the country, not counting the disruptions on the goods and services required for the industrial sectors. It is certainly not very efficient in promoting healthy advancement of competitive knowledge, which may have an ultimate goal of doing the best at the cheapest cost. However, economic comparisons are abstracts at best as cost evaluations cannot be predicted in monetary figures since many comparative factors will have heavy influences on the estimate.

The method is based on obtaining 'engineering' quality aerial photography of all hilly and mountainous roads in Malaysia at frequent intervals, analysing the photographs using semi-automated techniques and storing information in data-base systems which allow ready access for a range of engineering applications.

There are three benefits which can be gained from implementing an effective monitoring and engineering management technique. These are;

1. In many instances if slope problems can be identified quickly enough the cost of dealing with them is low and they seldom re-occur.

2. Classifying the more serious problems and implementing appropriate investigation and remedial action is a method of making the most effective use of maintenance resources.

3. Providing contractors with design guidelines and realistic cost criteria is a means of reducing overall costs.

The categories of information which can be obtained from an earthwork management system include the following.

a. Detailed planning for site investigations in connection with highway rehabilitation programmes.

b. Listing of remedial and inspection tasks required in terms of planning road maintenance schedules.

c. Preliminary costing of remedial work at a planning level in connection with road maintenance and rehabilitation programmes.

d. Long-term monitoring of earthwork and slope degradation on highways.

e. Design recommendations and initial cost estimations for construction work.

f. Overall allocations of regional maintenance funding based on an assessment of priorities.

g. Environmental assessment of highway earthwork and ribbon development disturbance.

3. Slope Erosion Control in Granitic Soil Slope, Thailand

Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center,
Department of Highways

Mr. Bancha Vadhanasindhu, Chief of Programming Section,
Department of Highways

SLOPE EROSION CONTROL IN GRANITIC SOIL SLOPE*

SONGSAWASDI DUANGRATANA
Deputy Director-General
Department of Highways
Thailand

TEERACHARTI RUENKRAIRERGSA
Director, Road Research and
Development Center
Department of Highways, Thailand

SUPOJE HUALTHANOM
Chief, Soil Foundation Research
Road Research and Development Center
Department of Highways
Thailand

SURAPOL SANGUANKAEW
Engineering Geologist 6
Materials and Research Division
Department of Highways
Thailand

1. INTRODUCTION

Granitic soil is a residual soil derived from in-situ weathering of granite and gneiss. Major minerals in granite and gneiss are quartz and feldspar with biotite, muscovite and hornblende are associated ones. In the process of chemical weathering, feldspar will be transformed into kaolinite which is a stable clay mineral of relatively low plasticity. Quartz is more resistant and not altered. After weathering to some particular stage, the products obtained are the mixture of quartzitic sand, decomposed feldspar and fine sand and silt (non-plastic fines), as well as kaolinite clay (plastic fines). The texture of granitic soil in the undisturbed state tends to reflect that of the parent rock. Granite soil could be easily taken out with hand tool or mechanical equipment. It is a well graded soil consisting of coarse sand and fines. Grain size of the sand particles varies from fine to coarse depending on the cooling rate of lava at the time of crystallization. From the evidence found in the field investigation, grain size

---

* This paper is presented at the Executive's Seminar on Public Works Research and Development, Tsukuba, Japan, 14-28 February 1993.

distribution and other index properties of granitic soil taken from the same mountain tends to be consistent. Probable areas of granitic soil formation are shown in Fig.1 Profile of granitic soil forming over the granite or gneiss parent rocks is shown in Fig.2 (LITTLE, 1969). Basic properties of granitic soils in Northern Thailand and Peninsula of Thailand are shown in TABLES IA and IB. It will be seen that most granitic soils in Thailand are non-plastic materials.

2. SLOPE EROSION CONTROL BY FERRO-CEMENT

Slope erosion is one of the major problems of road construction in the mountainous terrain in the North and the Peninsula of Thailand where formations of residual granitic soils are widely distributed. Most granitic soils in Thailand are non-plastic, so it has a high tendency to be washed away from the slope surface where the rainwater flows through. Road construction in the formative area of granitic soil encounters with the slope erosion problem. Slope erosion tends to cause difficulties to road engineers, and the local inhabitants near to the waterways close to the erosive slope. Slope sodding could not effectively prevent the slope erosion, especially for the high cut section and particularly for the granitic soil. Slope will be eroded and a large quantity of soils will be washed down and deposited along the bed of the waterway nearby, thus reducing its hydraulic capacity. The reduction of the hydraulic capacity of the waterway tends to cause flood in the following years. Few years ago, a ferro-cement blanket was tried to protect the granitic soil slope from the surface erosion. Its function is generallly found to be satisfactory for most slopes. Ferro-cement can solve the engineering problem, as well as an environmental effect at the same time.

Before discussing about the ferro-cement construction in more details, it is instructive to understand the process of granitic soil formation

in the tropical regions. The humid environment associated with high temperature is the principal agent of the weathering processes. Chemical weathering occurs by reactions between the minerals forming the rock and different aqueous solution. Water from the rainfall generally contains dissolved gases, such as oxygen and carbon dioxide from the atmosphere. When infiltrating into the soil, the water also dissolves and carries several organic and inorganic substances, thus inducing the process of weathering. As a result of the chemical weathering, kaolinite will be the most dominant clay mineral in the residual soil derived from granite and gneiss. According to the research studies in Thailand, most granitic soils are well graded with the maximum particle size of about 9 mm. The percent passing No.200 U.S. sieve is 10-50 depending on the stage of weathering. The plasticity index of most granitic soils is found to be non-plastic. This is presumably due to the considerable amount of the non-clay mineral in the fine fraction of the granitic soil. The lack of the plastic property of the fine fraction makes the granitic soil having no resistance to water erosion. As a result granitic soil in Thailand has a property of an erosive soil. The surface water flowing on the slope tends to wash out the non-plastic fines from the mass of the granitic soil. The initial damage caused by the surface erosion is shown in Fig.3. If the washed out materials are from the embankement slope, they tend to deposit along the natural waterways, or else on the land of the local inhabitants nearby. Deposition along the natural waterways tends to reduce their hydraulic capacity that might cause flood in the rainy season. Deposition on the land of the people will make the land could not be used for plantation because of the lack of fertility and the acid nature of the fines of granitic soil. So slope erosion will cause damage to the infrastructue, and have the environmental and social effects to the local people living near to the problem areas.

Sodding is a conventional method for the slope erosion control being employed for road construction and maintenance in both the flat and mountainous terrains for a long time. But it is

generally found that the result is not satisfactory, especially for the high slope and particularly for the erosive soil like the granitic soil. Few years ago ferro-cement was introduced to place over the face of the slope composing of granitic soil along some highways in Northern and Southern Thailand. Fig.4 shows a typical ferro-cement slope protection for a back slope of a highway in Thailand.

The constuction of the ferro-cement on the earth back slope is diagrammatically shown in Fig.5. There are some different steps of ferro-cement construction for the erosion control of the back slope as follows.

(1) Before construction the ferro-cement, the face of the back slope has to be improved, refilled with the soil and compacted, to get a more or less regular slope conforming to the original design.

(2) Shoot the cement mortar which is mixed at the proportion of cement : sand = 1:1.75 by weight with a water/cement ratio of 0.40 onto the surface of the slope. This layer thickness of the cement mortar blanket covering the soil is about 1-2 cm.

(3) Place the mat of the steel wire mesh onto the blanket of the cement mortar freshly laid. Install the anchorage rod to tie the steel wire mesh to be in a proper position on the soil slope. The diameter of the steel for making the wire mesh is about 2 mm. The one for the anchorage rod is 9 mm.

(4) Shoot the second layer of the cement mortar onto the first layer being laid over by the wire mesh. Apply the hand finishing on the surface of the sprayed cement mortar as necessary. The total thickness of the ferro-cement will be about 3-5 cm as shown in Fig. 6.

(5) As ferro-cement has to be shot on the slope face having a relatively wide area so construction joint has to be provided as shown in Fig. 4.

(6) Coarse gravel filter has to be provided at different elevations of the slope in order to drain the seeping water out of the slope, as well as to trap the fine particles from being washed away from the slope.

Ferro-cement blanket covering the erosive soil slope can solve the problem of the surface erosion in the high cut areas of many highways in the North and the Peninsular of Thailand. Ferro-cement slope protection is found to be an effective method of preventing the soil erosion in the high cut areas with high rainfall. It also solves the environmental problems due to the deposition of the washed-down soil along the nearby waterways where their hydraulic capacities are lowered, and inducing floods in the following years. Since the first initiation of the ferro-cement for the back slope protection in Thailand for about 5 years, its function seems to be satisfactory even though some of the ferro-cement blankets failed due to excessive pore pressur in the back-slope soils.

3. RESEARCH ON SLOPE EROSION CONTROL BY HYDROSEEDING

Even though ferro-cement blanket has proved to effectively prevent the soil erosion in the mountainous terrain, but somebody argues about the contrast between the light color of the ferro-cement and the surrounding. So the technique of hydroseeding was tried on some selected slopes and the result is quite impressive. It is expected in the near future this technique will be used more and more to control the slope erosion in granitic soil.

4. RESEARCH ON SLOPE EROSION CONTROL BY DEEP ROOTED GRASS (VETIVERIA ZIZANIOIDES NASH.)

In Thailand there is one species of grass. Its name is Yah Faek. This type of grass has the long and strong roots that can penetrate into the erosive soil. This type of grass has a system of fibrous root. In Northern Thailand this special grass has been successfully used to control the erosion of the surficial soil in the hill slope that has been subjected to deforestration. The Department of Highways, under the sponsorship of the National Research Board, launched the research project to use this deep rooted grass to prevent the slope erosion for both cut slope and embankment slope. The project is still going on.

5. CONCLUSIONS

5.1 Slope erosion causes both engineering and environmental problems to the Department of Highways and local inhabitants

5.2 Slope erosion control could be made by different techniques as follows.

(1) Ferro-cement

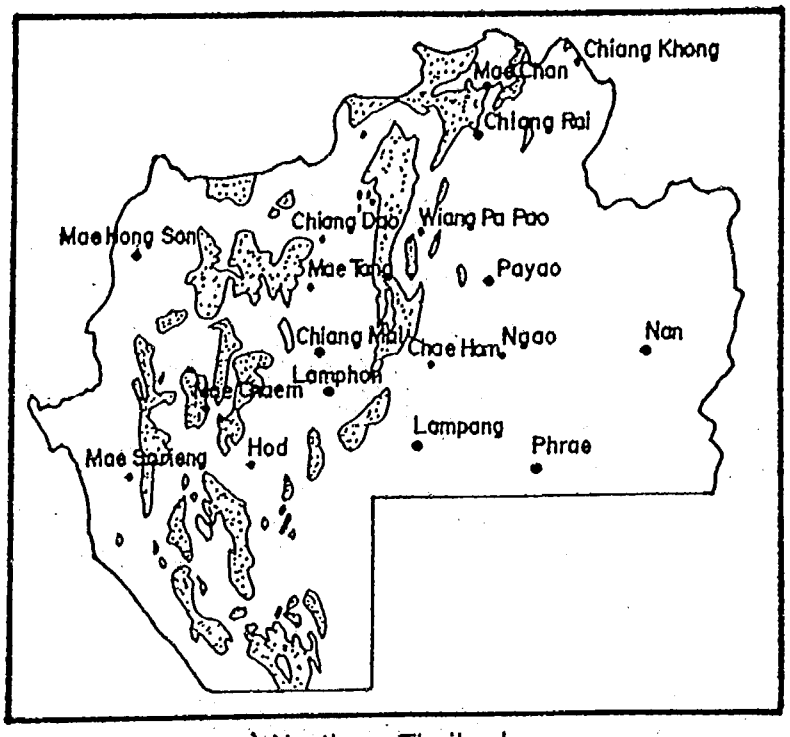
(2) Hydroseeding

(3) Growing deep rooted grass

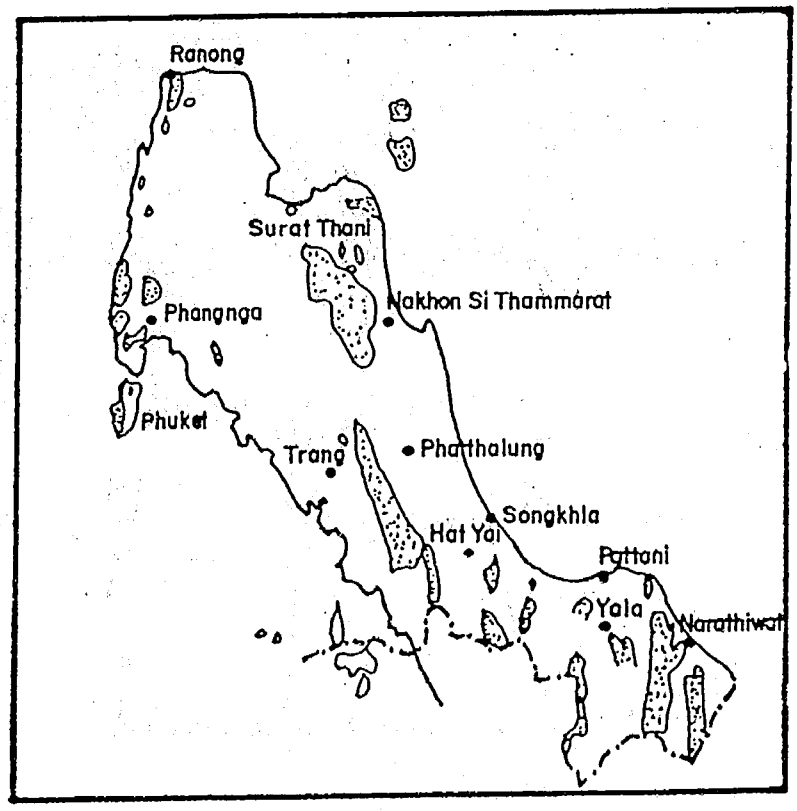
6. REFERENCES

LITTLE, A.L.(1969), The Engineering Classification of Residual Tropical Soils, Proc. Specialty Session on Engineering Properties of Lateritic Soils, Proc. VII ICSMFE, Asian Institute of Technology, Bangkok, Thailand, pp. 1-10.

RUENKRAIRERGSA, T. and CHANGSUWAN, S. (1978), Some Sources and Basic Properties of Granitic Soils in Thailand, Proc. Materials of Construction for Developing Countries, Vol. II, pp. 613-644.



a) Northern Thailand



b) Peninsula of Thailand

Fig. 1 Granitic Soil in Thailand

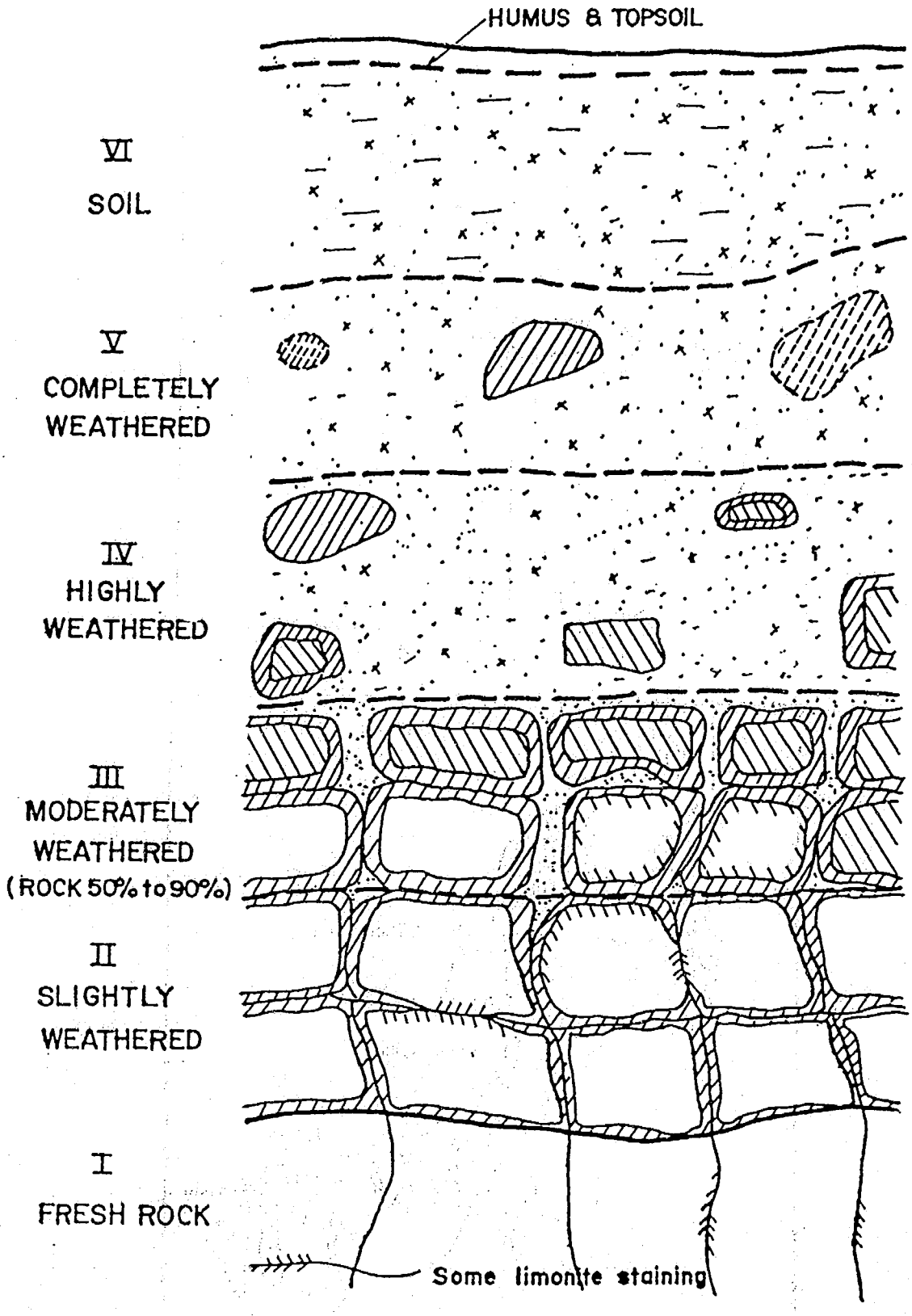


Fig. 2 Profile of Granitic Soil Formed Over Granite
(LITTLE, 1969)

Fig. 3 - Slope Erosion in Decomposed Granite Mountains

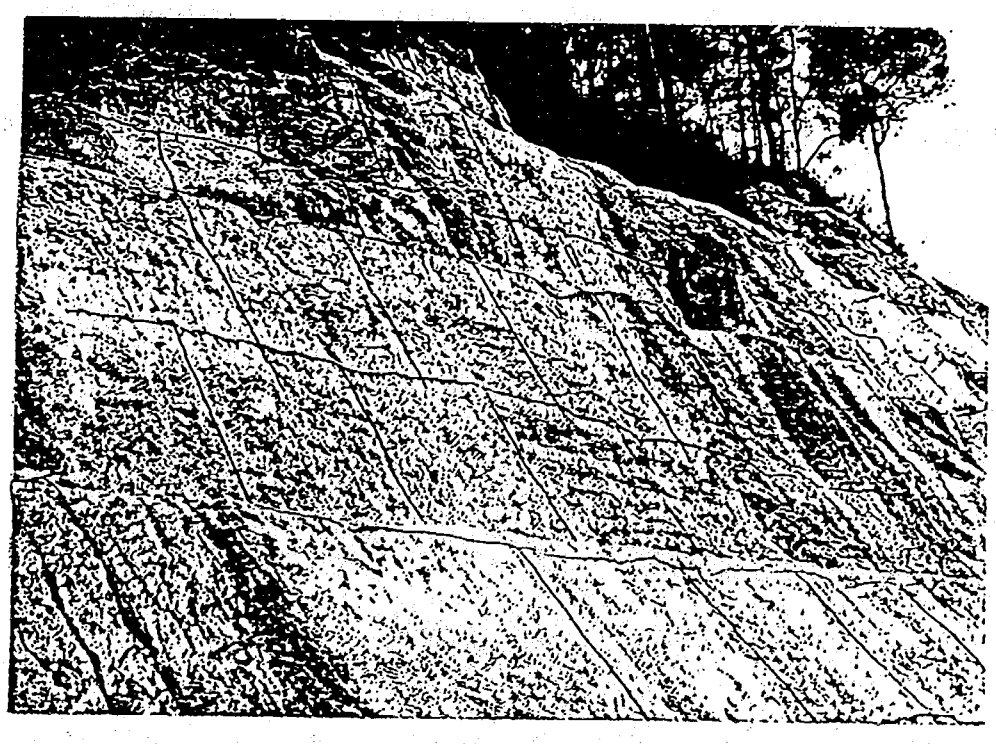


Fig. 4 - Typical Ferro-Cement Slope Protection

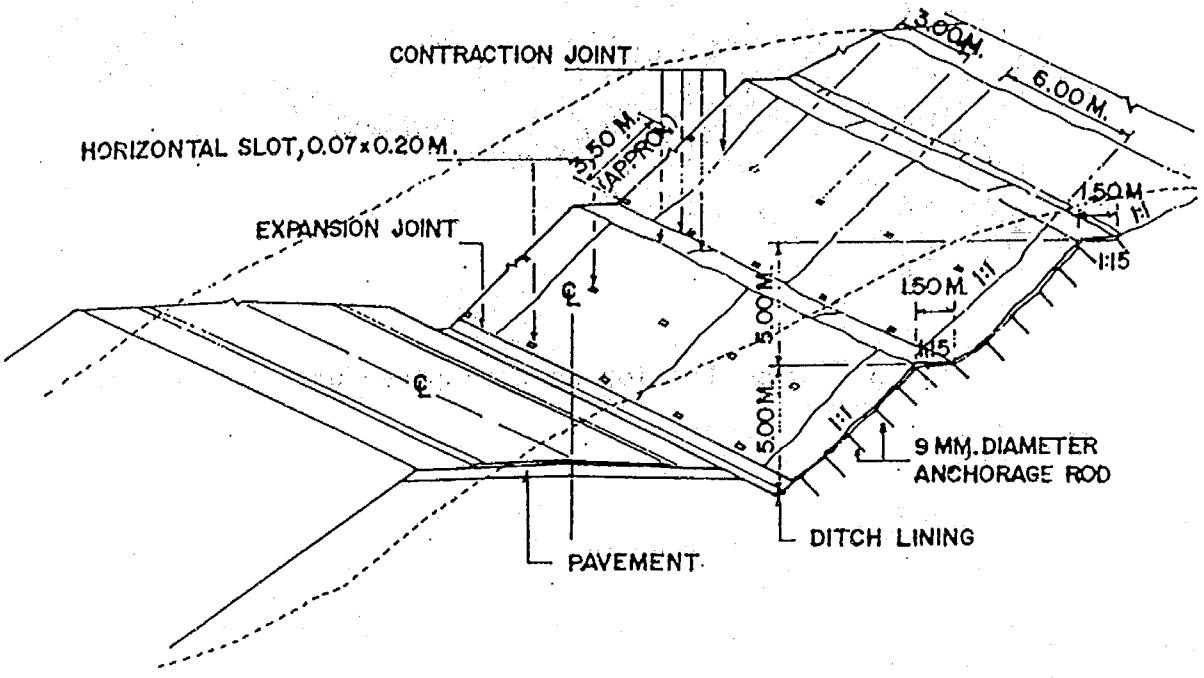


Fig. 5 Diagram Showing a Ferro - Cement Protection on Earth Back Slope

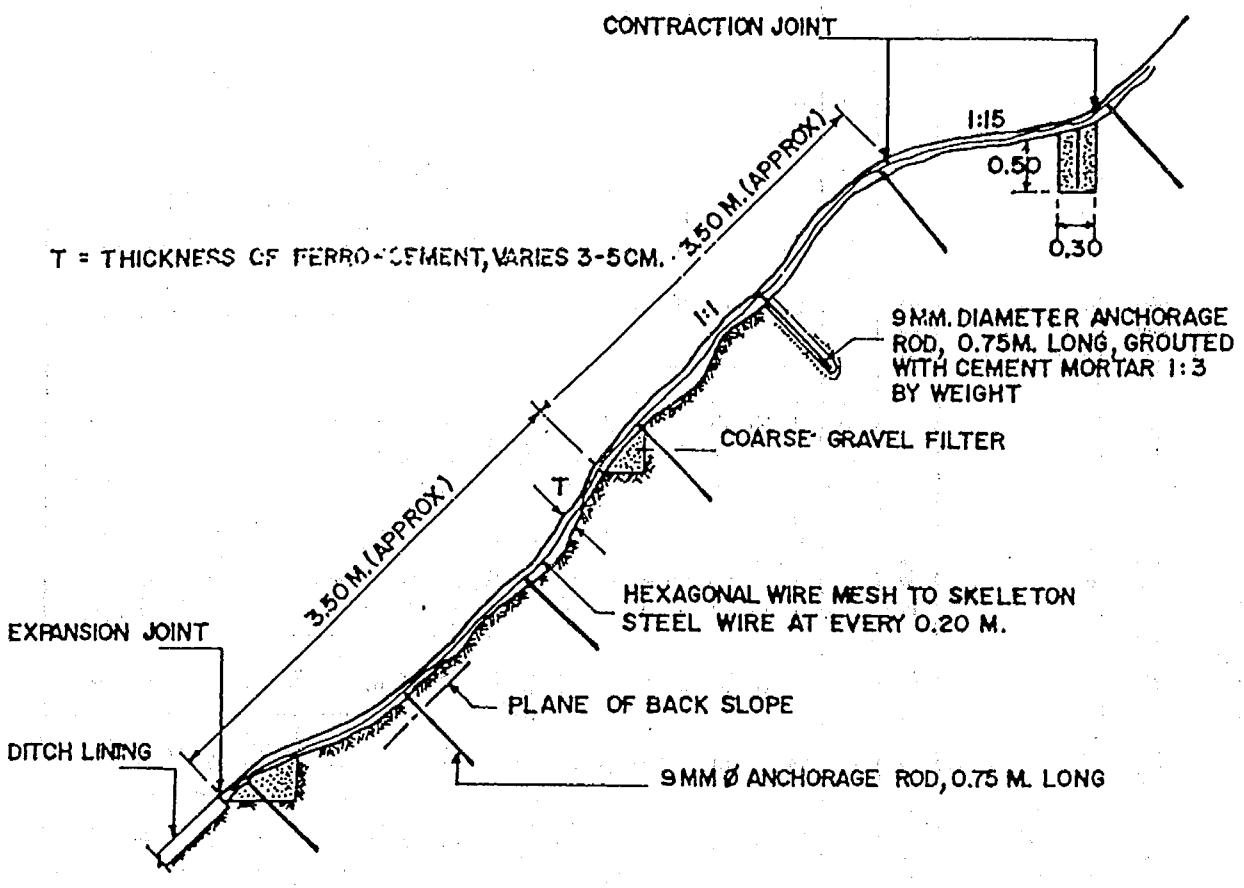


Fig. 6 Cross Section Ferro – Cement Slope Protection

TABLE IA

BASIC PROPERTIES OF SOME SELECTED GRANITIC SOIL SAMPLES FROM NORTHERN THAILAND (RUENKRAIRERGSA and CHANGSUWARN , 1978)

Sample	Grain Size Distribution , %						Textural Composition[1], %				Plasticity		Classification			Mod. Proctor		C.B.R.	
	1"	3/4"	3/8"	#10	#40	#200	Gravel	Sand	Silt	Clay	L.L.	P.I.	AASHO	Unified	U.S.B.S.[2]	$(\gamma_d)^3_{max}$	O.M.C. %	95 % C.B.R.	Swell %
N1		100	98	43	23	14	57	27	9	7	–N	P–	A-1-a	SM	Sand	2.04	3.9	45	0.7
N4		100	99	62	25	14	37	45	9	9	30	8	A-2-b	SC	"	2.01	9.8	13	0.6
N6	100	96	96	46	23	15	54	29	9	8	30	7	A-2-b	SC	"	2.03	7.6	14	0.7
N10			100	67	19	17	32	56	6	6	–N	P–	A-1-b	SM	Sand	2.00	9.0	32	0.2
N11		100	99	49	20	11	51	35	3	11	–N	P–	A-1-a	SM	"	1.87	11.2	10	0.4
N21		100	98	60	27	13	41	43	10	6	–N	P–	A-1-b	SM	Sand	2.04	8.9	17	0.6
N32			100	89	58	46	11	36	43	10	–N	P–	A-4	SM	Loam	1.89	11.0	10	1.8
N39			100	92	51	33	8	55	21	16	–N	P–	A-4	SM	Sandy loam	1.92	12.4	19	0.7
N48			100	91	58	34	18	58	27	7	–N	P–	A-2-4	SM	"	1.89	12.4	8	1.4
N52			100	81	66	41	19	30	37	14	48	16	A-7	SC	Loam	1.82	12.0	12	1.2
N54			100	75	56	39	25	40	20	15	–N	P–	A-4	SM	Sandy loam	1.82	14.4	4	3.8
N57			100	82	70	55	18	34	17	31	51	17	A-7	MH	Sandy clay loam	1.76	16.6	11	2.4
N58			100	80	68	53	20	15	40	25	–N	P–	A-4	CL	Clay loam	1.76	15.4	5	2.6
N59			100	77	48	39	22	13	47	18	58	20	A-7	MH	Loam	1.82	13.6	7	1.6
Special			100	91	42	19	9	70	11	10	–N	P–	A-1-b	SM	Sandy loam	1.97	10.0	33	–
N66			100	96	77	52	4	41	38	17	–N	P–	A-4	SM	Loam	1.76	15.9	11	0.1
N67			100	93	46	19	7	69	13	11	–N	P–	A-1-b	SM	Sandy loam	1.89	12.0	28	0.1
N71		100	98	82	50	24	17	59	15	9	–N	P–	A-1-b	SM	"	1.83	15.0	23	0.1
N72		100	99	78	59	48	23	24	8	45	–N	P–	A-4	SM	Clay	1.76	15.4	24	0.4

1. Based on AASHO System, amount in percent
2 U.S.B.S = United States Bureau of Soils
3. Maximum dry density in gm./cc.

TABLE IB

BASIC PROPERTIES OF SOME SELECTED GRANITIC SOIL SAMPLES FROM THE PENINSULA OF THAILAND (RUENKRAIRERGSA and CHANGSUWARN, 1978)

Sample	Grain Size Distribution, %						Textural Composition,%[1]				Plasticity		Classification			Mod. Proctor		C.B.R.	
	1"	3/4"	3/8"	#10	#40	#200	Gravel	Sand	Silt	Clay	L.L.	P.I.	AASHO	Unified	U.S.B.S[2]	(ld)max[3]	O.M.C %	95 % C.B.R.	Swell %
S1		100	100	85	53	32	15	54	15	16	— N	P—	A-2-4	SM	Sandy loam	1.84	14.8	25	0.7
S4		100	100	81	60	49	19	32	(49)[4]		62	21	A-7	SC	—	1.76	17.4	7	2.0
S5	100	98	92	70	43	26	29	45	12	14	—N	P—	A-2-4	SM	Sandy loam	1.91	13.0	32	1.1
S7		100	100	83	52	28	16	49	20	15	—N	P—	A-2-4	SM	"	1.99	11.4	22	0.9
S13		100	99	67	49	37	32	31	(37)		—N	P—	A-4	SM	—	1.90	12.8	22	0.6
S20	100	97	97	71	39	22	28	45	11	16	—N	P—	A-1-b	SM	Sandy loam	2.02	9.8	23	0.4
S21		100	99	73	41	19	24	48	14	14	—N	P—	A-1-b	SM	"	1.94	11.5	9	1.34
S23		100	96	64	46	34	35	31	(34)		54	17	A-7	SC	—	1.84	15.0	20	1.2
S27		100	100	80	43	22	20	57	7	16	—N	P—	A-1-b	SM	Sandy loam	2.03	9.2	23	0.3
S38			100	80	38	20	20	50	11	19	—N	P—	A-1-b	SM	"	1.91	9.4	24	0.4
S40			100	86	51	24	15	52	11	22	—N	P—	A-2-4	SM	Sandy clay loam	2.07	8.3	—	—
S41		100	100	69	33	21	31	47	11	11	—N	P—	A-1-b	SM	Sandy loam	2.00	11.0	39	0.5
S42		100	99	59	28	19	42	40	10	8	—N	P—	A-1-b	SM	"	2.00	8.6	17	0.4
S45		100	98	80	42	33	20	52	15	13	39	7	A-2-4	SC	"	1.97	10.5	12	0.2
S48	100	96	67	47	39	35	54	11	18	17	72	27	A-2-7	SC	"	1.70	18.4	12	2.9
S50		100	99	75	57	50	24	27	16	33	77	35	A-7	SC	Sandy clay	1.81	16.6	13	1.8
S53			100	56	28	20	43	37	10	10	—N	P—	A-1-b	SM	Sandy loam	2.02	10.0	32	0.2
S55			100	77	49	41	24	35	19	22	45	10	A-5	SC	Sandy clay loam	1.97	10.5	10	2.1
S61			100	77	46	26	24	40	21	15	35	10	A-2-4	SC	" "	2.00	10.0	50	0.9
S65		100	99	60	33	26	40	29	24	7	46	18	A-2-7	SC	Sandy loam	1.91	13.9	76	0.1
S69		100	99	78	43	36	22	43	11	24	59	14	A-7	SC	Sandy clay loam	1.86	14.0	50	0.3

1. Based on AASHO System , amount in percent
2. U.S.B.S = United States Bureau of Soils
3. Maximum dry density in gm./cc.
4. Silt + Clay

4. The Earthquake and Tsunami in Flores Island, Indonesia

Dr. Badruddin Machbub, Director,
Research Institute for Water Resources Development

THE EARTHQUAKE AND TSUNAMI IN FLORES ISLAND

1. Introduction

Flores island was struck by earthquakes and Tsunami storm, and the Government has declared it national disaster. The epicentrum was under the sea and the earthquake was a tectonic. The first areas affected were those on the fault lineaments of Flores Island; the rocks became the media of the seismic waves which was followed by Tsunami storms, the media of seismic waves through the sea.

The earthquake was then followed by others of smaller magnitudes and relatively longer periods as the rock/soil elasticity eventurally returned to their normal conditions, following the law of nature.

The earthquake occurred on the fault lineaments which generally strikes southwest - southeast and northeast - northwest. The return period of such earthquake is 30 years.

2. The Epicentrum

The epicentrum of the earthquake which struck Flores on 12 December 1992 located between 8.4^{o} SL and 122° EL its depth was 34 km, and the earthquake magnitude was 7 Richter scale. The earthquake was presume to occur on the thrust fault found in the north of Flores. The form of energy released by this earthquake were earthquake shocks which was felt on the earth surface and tidal waves which destroyed the buildings on the coast of Flores.The north of Flores was found to suffer the hardest impact of the earthquake.

3. Areas struck by earthquake and tsunami

The areas struck by the earthquake were the islands of Flores, Besar, Babi, and Permaan; while those hit by the Tsunami waves were the north coast of Flores, the coasts and inland of Babi and Besar islands. Those areas covered four regencies of Ngada, Flores Timur, Ende, and Sikka, the measurements made on the trace of Tsunami waves showed the heights between 1.9 - 26.2 m.

4. Damage to soil/rock from the geological point of view

The existing geological structures of Flores are folds, faults, and lineaments. The geological structures generally strike Northeast - Southwest, some of them strike Northwest - Southeast. The sufficiently strong folds have rock layers which dip between 25° - 50°, and the fold axis strikes Southwest - Northeast. The considerably strong folding was presumed to occur from the Upper Pliocene to Lower Pleistocene. The faults strike Northwest - Southeast and Northeast - Southwest.

The natural disaster hitting Flores on 12 December 1992 was earthquake which was followed by landslides and Tsunami storms along the north coast of Maumere. The damages caused by Tsunami waves were seen along the north coast of Flores. The waves with the height of about 2 meters reached about 200 m inland.

In areas whose surface were covered by loose sand and silt (alluvium), liquefaction process occurred. It is the process of decreasing shear strength of the soil which consequently reducing its bearing capacity. Such areas are generally found in the north coast of Flores. The damages due to changes of soil layer structure were settlement and liquefaction process along the coast of

solid material into liquid; it is especially occurred to Maumere.

The information specifically indicate the occurrence of liquefaction. The exact deph of the layer undergoing liquefaction was not known, but it was estimated to reach approximately 15.00 m. The Maumere harbour became about 10.00 to 15.00 deeper so that big ships could now be moored at the harbour.The same indication was also found in several coastal areas in the east and west of Maumere.

5. Damages suffered by water resources and irrigation facilities

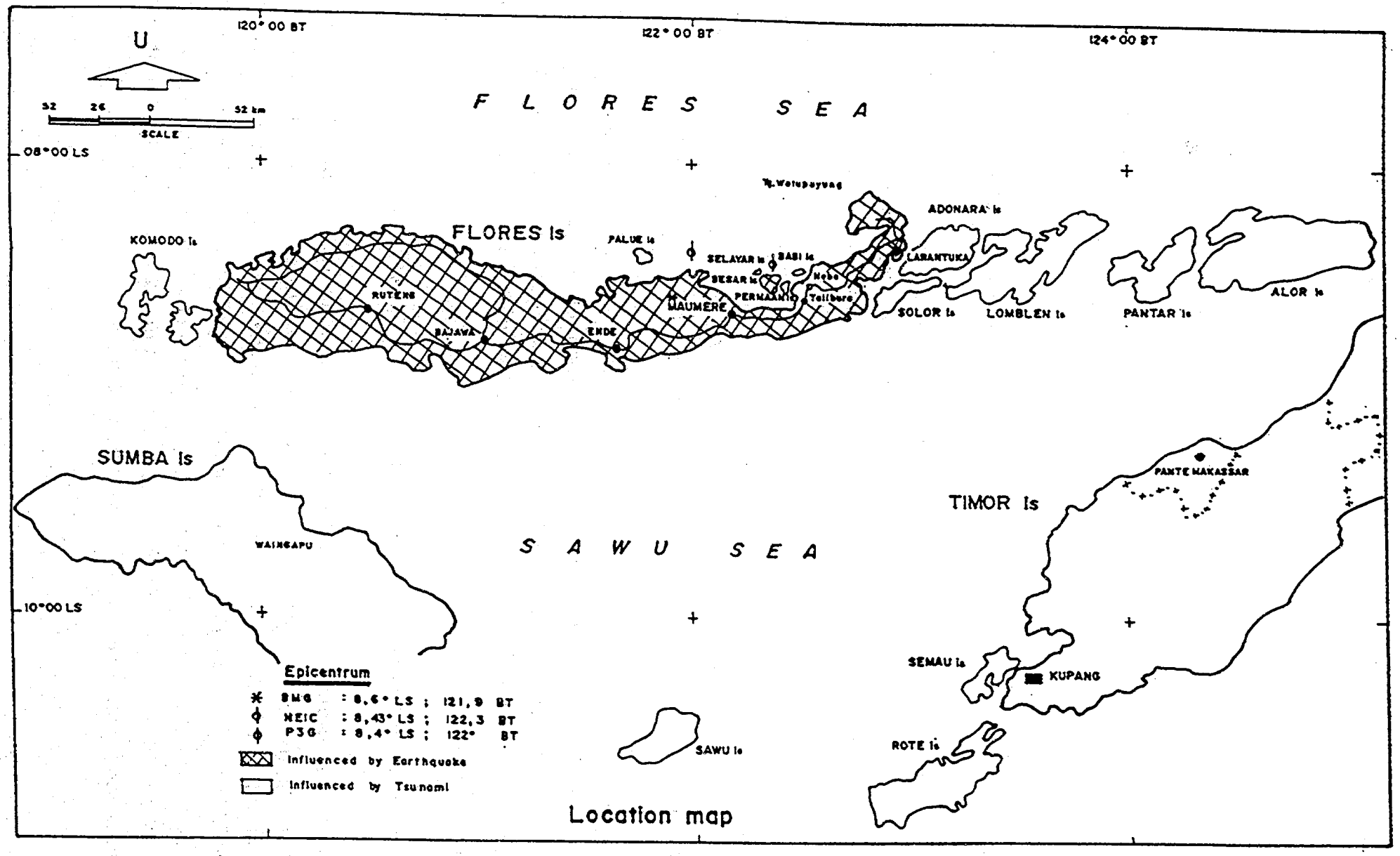
The earthquake has caused the surface water, groundwater, and spring water to became turbid, dirty, and mixed with sludge (muddy), especially on the fault lineaments.

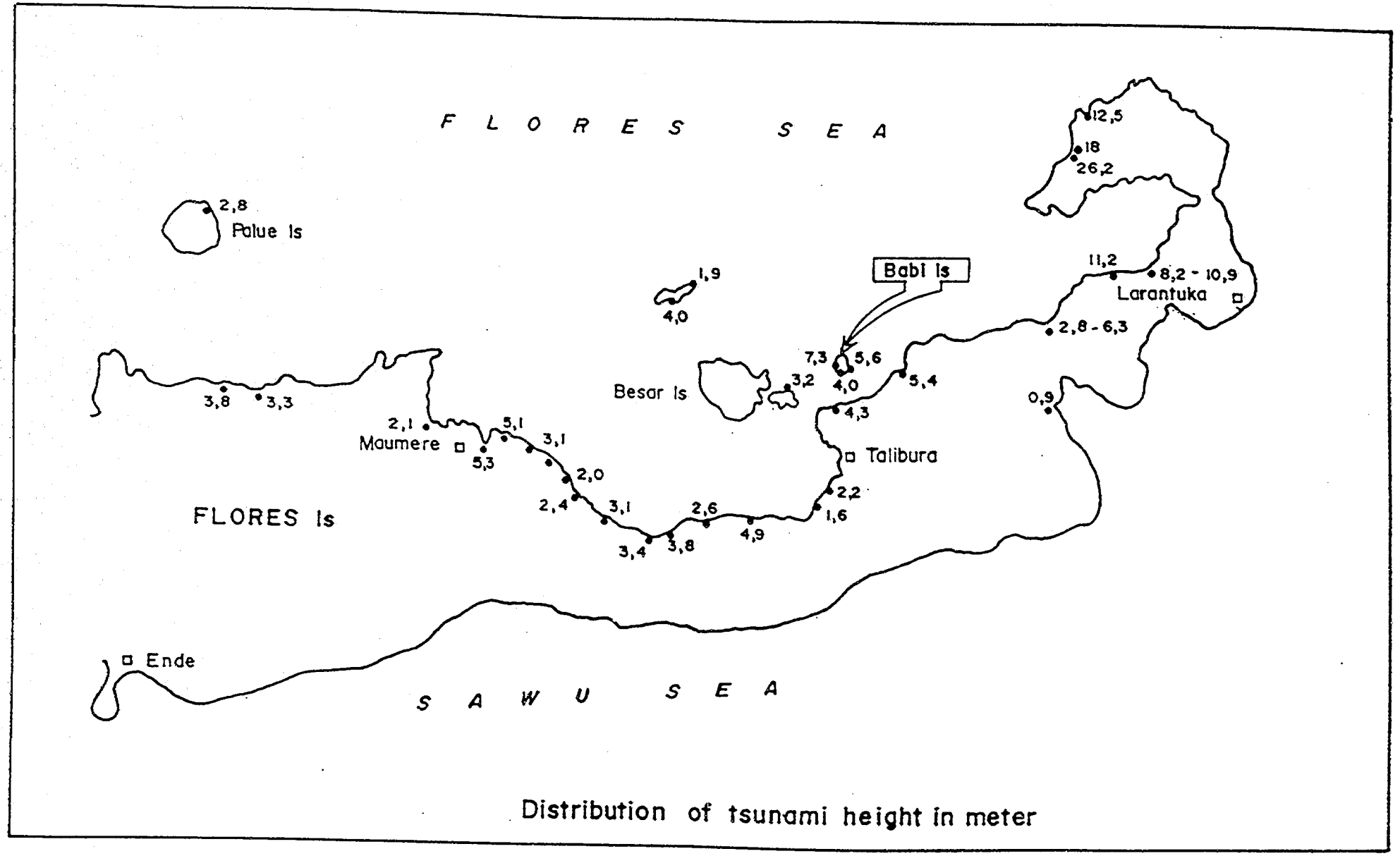
Landslides on river banks resulted in damages of irrigation networks and change of river discharge. Such change was found in Batik Wair River. The river discharged is estimated to become less after the occurrence of landslides and new cracks.

Before the earthquake, a dug well at the Kantor Proyek KSU in Liba had a groundwater surface of 2.5 m and the well depth was 3 m. After the earthquake the groundwater level and the depth of the well became 5.5 m and 6.0 m, respectively.

6. Damaged settlement, road , and other facilities

Damaged settlements were found in Maumere town 128 km of roads (cracked roads, collapsed bridges, or landslides blocking the inland transports) was destroyed by the earthquake. Record on 29 December 1992 showed the following damages : 1,047 office buildings, 370 places of worship, 817 houses, 32,000 schools. The above record included the 244 totally destoryed houses and other buildings in Babi Island.


U
120° 00 BT
122° 00 BT
124° 00 BT
32 26 0 52 km
SCALE
08°00 LS
10°00 LS
F L O R E S S E A
S A W U S E A
FLORES Is
KOMODO Is
PALUE Is
SELAYAR Is
BESAR Is
BASI Is
Mt. Watupayung
ADONARA Is
LARANTUKA
RUTENG
BAJAWA
ENDE
MAUMERE
PERMANAK
Tellbere
SOLOR Is
LOMBLEN Is
PANTAR Is
ALOR Is
SUMBA Is
WAINGAPU
TIMOR Is
PANTE MAKASSAR
SEMAU Is
KUPANG
ROTE Is
SAWU Is
Epicentrum
BMG : 8,6° LS ; 121,9 BT
NEIC : 8,43° LS ; 122,3 BT
PSG : 8,4° LS ; 122° BT
Influenced by Earthquake
Influenced by Tsunami
Location map



Distribution of tsunami height in meter

(D) MINUTES

I . Address of Opening Ceremony

Address of Opening Ceremony

Mr.Yukihiko Sumiyoshi, Director-General, PWRI, MOC

It is our greatest honor and pleasure to have you here in the Public Works Research Institute for the opening ceremony of the First Conference on Public Works Research and Development in Asia.

Our Institute celebrated its 70th Anniversary last year. During all those years as an important research Institute of the Ministry of Construction, being in charge of about 70% of the national public works, we have constantly and widely contributed to the national development of infrastructure in the field of research and development of technology.

Under the increasing internationalization we have been actively engaged in and promoting various exchange programs with foreign countries. We host regularly about ten international meetings such as US-Japan Conference on Development and Utilization of Natural Resources - Panel on Wind and Seismic Effects -, which has a history of a quarter of a century. With our Asian partners exchanges have been promoted through technical cooperation by our staff, acceptance of researchers and visits of investigation team. And here as a first attempt in Asia for initiating a regular meeting we have proposed the opening of this Conference on Public Works Research and Development in Asia as a place where those in responsible positions in the field of public works research and development meet and discuss the need and the importance of establishment of infrastructure as a base of social and economic development for each Asian country.

The aim of the Conference is to promote research and development exchange for a creation of public works technology suitable for natural and socio-economic conditions in Asian nations and also an effective utilization of natural and human resources in each country. We hope this conference will eventually function as a close network for public works projects all through Asia. We believe that cooperation among Asian nations will be activated by 5-day sessions starting with keynote lectures today and then presentations of country reports and discussions on specific subjects. We sincerely hope this conference will be successfully continued with a kind cooperation from our Asian partners and from all of you present here today.

Finally I'd like to express my utmost gratitudes to all of you for your dedicated efforts for the opening of this Conference. Thank you very much for your kind attention.

Mr.Toru Kondo, Vice-Minister of Construction for Engineering Affairs, MOC (read by Mr.Kazuhiko Ono, Assistant Vice-Minister for Engineering Affairs of Minister's Secretariat, MOC)

First of all I'd like to offer my sincere congratulations for the opening of the First Conference on Public Works Research and Development in Asia. I feel greatly honored by this opportunity to say a few words and also by the presence of eight highly responsible persons in the field of public works research and development from seven countries, China, Indonesia, Korea, Malaysia, Philippines, Singapore and Thailand, countries politically, economically as well as culturally in close and long relation with Japan.

As you may very well know, infrastructure is the most important basis for socio-economic activities, thus a basis for national prosperity. To meet the growing demand for an establishment of social infrastructure, the Ministry of Construction is promoting research and development efforts by well defining the course of its development. It is the Public Works Research Institute that importantly leads the public works research and development in Japan and it has always played a major role in the public works throughout its 70 years' history. Globally there is an increasing need for international exchange and cooperation to strengthen each other in tackling the problems of social development, disaster prevention and environment as well as in developing the optimum public works technology for each country under different natural and socio-economic conditions.

I believe that this Conference will provide a valuable opportunity for mutual understanding and cooperation in the field of public works, indispensable for infrastructure development, among Asian countries through exchanges of experiences in reports and discussions of the present situations in each country. Cooperation among us is urgently needed. Therefore the opening of this kind of conference, the first in the field of public works, is very pertinent and significant for Japan, too.

Now we are in the middle of the coldest month. Some of you come from warmer countries, so please do take good care of yourselves not to catch cold.
Finally wishing you a successful conference with valuable discussions and exchange of information and a nice trip after the conference, I hope mutual understanding and friendship among us will make the conference even more meaningful. Thank you for your kind attention.

Mr.Keiji Iimura, Management Director, Tsukuba International Centre, JICA

It is my great pleasure and honor to say a few words, on behalf of the Japan International Cooperation Agency, at this opening ceremony of the Conference.

As you may know, the Japan International Cooperation Agency was established in 1974 for the purpose of implementing Official Bilateral Cooperation through technical cooperation, grant aid cooperation and so on. As a part of this cooperation, this Conference has been organized through close cooperation with JICA and the Public Works Research Institute to efficiently and properly contribute to implementation of infrastructure and public works for the

development of each country through the introduction and analysis of the current situation and problems of the public works in each country and Japan, as well as discussions among personnel concerned in the public works and yourselves.

You will be staying in Japan for only two weeks, during this time you may encounter some difficulties such as the unfamiliar climate, different living conditions and so on. Particularly this month is the coldest of the year, so be careful of your health and make sure you don't catch cold.

And I hope that you will enjoy and obtain successful results during your short stay in Japan and also hope this Seminar will help further strengthen the mutual understanding and friendship between Japan and your esteemed countries.

Finally, I would like to express again my deepest appreciation to the honourable guests present here today and also to all the staff of Public Works Research Institute and the ministries concerned for their excellent contributions to realization of this Conference.

Mr.Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research

The Conference on Public Works Research and Development in Asia, initiated by the Government of Japan is open ceremoniously today. It is a great honor to have the opportunity to attend such a grand ceremony. Let me take the pleasure to extend my hearty congratulation.

The development of public infrastructure is a sound foundation for national economy and social development in all countries. It plays an important role and has been put in a very significant and cardinal position.

The regional area of Asia has been esteemed as an area where development of economy has grown more rapidly. A great amount of investment has been input for public infrastructures, thus ensuring the smooth development of national economy. Many public works were constructed and fruitful experiences were thus accumulated Numerous technical problems were solved in the process of implementation of public works. We are well informed that much more successful experiences are available in Japan on such aspects.

Information concerning the current activities and experiences will be fully exchanged in this Conference among eight countries. It will be very helpful to facilitate development of economy in Asia.

I would like to express my sincere thanks to the Government of Japan, Ministry of Construction, Public Works Research Institute, and the Japan International Cooperation Agency (JICA) for their great efforts for organization of this conference. I have an opportunity to exchange experiences of mutual interest from different countries.

Furthermore, I heartily hope that such kind of exchange of knowledge and information will help to build a rigid foundation as well as to pave an excellent free way leading to better and more extensive cooperation among various countries in the aspects of public works research and development in days to come.

To conclude, I wish the conference will be a great success.

II. Minutes

1. Keynote Lecture

2. Country Report

3. Subject of Common Interests

4. Discussion on Specific Subjects

1. Keynote Lecture

(1) Infrastructure Policies for Economic and Social Development of Asian Countries

by Dr.Fumio Nishino, Professor of Civil Engineering, University of Tokyo
Professor of Policy Science, Saitama University

Following content was presented according to the proceeding paper.

1. OECD conference on infrastructure policies for the 1990s ; theme, main issues and conclusions.
2. The policies of Japan for infrastructure development; history, current status and possible strategy for future development.
3. Lessons learned and to be shared from the experiences of Japan; successful projects, unsuccessful examples, and importance of well planned policy and master plans.

There was no discussion.

(2) Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan - PWRI's 70 Years and Perspective -

by Mr.Yukihiko Sumiyoshi, Director-General, PWRI, MOC

Following content was presented according to the proceeding paper.

1. Economic Growth in Japan and Infrastructure Investment
   - ·Economic Growth in Japan and Infrastructure Investment
   - ·The role of Infrastructure Investment
2. Advanced in Civil Engineering Technology
   - ·Advance of Civil Engineering Technology
   - ·History of Education in Civil Engineering
   - ·History of Financial Act and Program
   - ·Factors of Advance in Civil Engineering Technology in Japan
3. 70 Years of the Public Works Research Institute
   - ·History of PWRI
   - ·The Role of PWRI in Advance of Civil Engineering Technology
4. Perspective
   - ·Trend of Society
   - ·Concept of Basic Research
   - ·Fields to be Studied in Future
   - ·Promotion of Systematic Research

There was no discussion.

(3) The Role of Research and Technology Development in International Technical Cooperation

by Mr.Hiroaki Tamamitsu, Vice President, Japan Construction Training Center

Following content was presented according to the proceeding paper.

1. Significance of Technical Cooperation
   - Situation of Technical Cooperation in Development Assistance
     Situation and Problems of ODA
   - Basic Concept of International Cooperation and Technical Cooperation
     4 Concept in extending assistance
2. History of Technical Cooperation of Japan
   Award and Organization for Effective Assistance
3. Contents of Technical Cooperation and Points to be Improved
   Outline of Project Type Technical Cooperation
   Outline of Development Study
4. Promotion of Research and Technology Development
   Importance of Technical Cooperation, R&D, and Training, Aiming to assist self-standing of Development Country
5. Environmental Effects and Disaster Prevention
   Necessity of Consideration for Environmental Effects and Disaster Prevention in Assistance
6. Examples of Research and Technology Development in International Cooperation

<Research>
- Road Construction Technology Development in Laterite Soil Area
- Overseas Flood Forecasting and Warning Technology Development

<Project Type Technical Cooperation>
- Road Construction Training Center (Thailand)
- Volcanic Sabo Technical Center (Indonesia)

There was no discussion.

2. Country Report

The country reports of all participating countries were presented for one and a half days from 9:00 a.m. to 5:00 p.m., February 16, from 9:00 a.m. to the noon, February 17 in the order of Japan, China, Indonesia, Korea, Malaysia, Philippines, Singapore, and Thailand. The outline of the each country, current status of public works, research institute related of public works, disaster prevention policies, and environmental issues were presented and discussed.

Reports are summarized as follows:

1) It was well recognized that research and development on public works is a key factor to pursue development of a nation, social infrastructure such as road, river, dam, erosion control and torrential improvement, and sewage works are contributing factors for the growth of the countries.

2) Natural disasters such as volcanic eruption and flood cause failure of existing infrastructures instantry, which results in great economicloss. Prevention measures against natural disaster are quite important.

3) Environmental issues are concerns of all participating countries. Water quality preservation and air pollution were discussed intensively. The current problem and implementation method of environment impact assessment of each country were discussed in earnest.

4) As to how the construction and improvement of the infrastructures in urban area should be, an example of utilization of underground space was introduced, and many questions were raised.

5) In addition, several interesting reports were presented on the specific topic that each country is currently facing.

SUMMARY OF DISCUSSIONS:

(1) Japan

Outline on Japan, current situation of public works, outline of PWRI environment, and infrastructure improvement were reported. Environmental issues were highlighted in particular in the presentation. In conjunction with this, "How the environmental standards are forced to observe" was queried. The answer was as follows: As far as the Basic Law for Environmental Pollution Control is concerned, the environmental standards are treated as the target for attainment. In case of the new undertakings, various possible measures are attempted to clear the standards.

(2) China

Reports on outline of China, current situation of public civil works, outline of IWHR, environmental issues were made. Especially, Three Gorges Project and introduction of IWHR were highlighted in the presentation.
Questions were raised regarding to the target year for long-term water demand plan and the countermeasures for sand sedimentation. Answers for these were, "Year 2020 is the target for long term, and 2010 is for mid-term," and, "Storing the clean water and releasing the muddy water quickly is the basic solution".

(3) Indonesia

Outline on Indonesia, current situations of public works, outline of Development & Research Agency of Public Works Ministry, harmonization between environment and social capital improvement were reported, and particular emphasis were placed on the environmental issues and environmental assessment.
Execution organization of environmental measures (measures against water quality degradation), timing and method of the assessment were the points of questions, and explanations of the status of environmental measures being taken and its assessments were made.

(4) Korea

Outline on Korea, development of Korea and public works, status quo of constructions technology, international cooperation, and preservation of water quality were presented, and mechanism of infrastructure improvement and disaster prevention organization were emphasized in particular.
Questions were raised in relation with the reliability of private sector finance in improvement planning and the contents of data-base of construction area.
"Funds from public corporation are transferred to the private finance, and various types of incentive measures are available to promote the investments from private sectors." "Construction information data-bases include the design standards and actual construction records (items which became obstacles to the expected performance, etc.) and made available for actual construction works" were the answers.

(5) Malaysia

Outline on Malaysia, current situation of public works, research and technology development in Public Works Department, environment and social capital improvement were reported, and particular stress was placed on the law related with environment.
Question was made on the effects of public works execution upon the environmental law.
The answers were, "All projects more than 200 ha are compulsorily subject to environmental assessment, so the documents have to pass through the

Ministry of Environment before arriving to the Ministry of Public Works."

(6) Philippines

Outline of Philippines, current situation of public works, outline of DPWH, disaster prevention and environmental issues were reported, and debris flow disaster caused by eruption of Mt. Pinatubo was particularly emphasized.

Presence of policy to impose any limitation as regards to the disaster hazardous area was asked. The answer was, "There exists such policy, however, as a matter of practice, it is very hard to persuade residents to evacuate prior to the actual occurrence of disaster."

(7) Singapore

Outline of Singapore, current works of public works, research and development in Public Works Department, outline of P.W.D. was presented, and emphasis was placed on specific big project (4-million population scheme, underground tunnel network).

Questions were raised on technical subjects of large scale under-ground tunnel, details of road-works budget, and water supply plan in 4-million population scheme. Replies were, "Ventilation technology is still to be solved," "Road constructions are covered by general budget. High tariffs are charged on cars," and "As far as the water supply is concerned, international cooperation is required. For our own effort, storage of water in the underground caves is one of the alternatives."

(8) Thailand

Outline of Thailand and high-way project system, outline of D.O.H. were reported, and road administration, research organization and international cooperation in research were specifically emphasized.

Questions raised were related with the research period in Road Research Center, co-operation with universities, and present situation in air pollution by car.

"Research periods on specific subjects in collaboration with universities are usually 2 to 4 years duration. Total research period will last 10 to 15 years. In case of collaboration with universities, final decision is made after full internal discussion and prior hearings with universities."

"Unleaded gasoline was commercially made available last year and environmental regulations are applied to the newly registered cars. This does not apply to the older models."

In conjunction with this, an example in Singapore was introduced to show that the renewal to the pollution-controlled new models are in progress by imposing punitive high tax upon the more than 10 years old cars.

Discussions of Country Reports are following ; (Q : Question, A: Answer, C: Coment)

(1-1) **J a p a n**, by Mr.Tokuji Tomaru, Deputy Director-General, PWRI, MOC
[9:00～10:00, Feb.16th (Tue)]

(Q) Mr. Tan (Singapore) : How do you enforce standards concerning noise and air pollutions?

(A) Mr.Kanzaki: Environment Agency sets the standard, and Ministry of Construction enforces it. Noise barriers and environmental facilities zones are constructed. However, they have not been widely used due to high cost.

(Q) Mr. Tan (Singapore) : If there is any violation, do you take measurements and take measures to enforce the standard ? For example, if there is any complaint at construction site, do you dispatch an inspector or leave it to the contractor ?

(A)Mr.Sumiyoshi: The environmental standard is a target to be met. Actually a complete plan of a new facility is thoroughly explained to neighbors before its construction. In some cases under an environmentally severe condition, regular measurement is made after construction. For example, when road noise exceeds the standard, a countermeasure is performed. If it is impossible, an alternative road may be constructed.

(C) Mr.Tomaru : There is no penalty in the standard.

(1-2) Introduction of PWRI
by Dr.Takashi Iijima, Assistant Director-General, PWRI, MOC
Mr.Masashi Ikemura, Director of Geology and Chemistry Dept., ditto
Dr. Fumio Yoshino, Director of River Dept., ditto
Dr. Kikuo Inaba, Director of Water Quality Control Dept., ditto
Mr. Seizo Takebayashi, Director of Dam Dept., ditto
Mr. Youtaro Asai, Director of Erosion Control Dept., ditto
Mr. Hiroo Kanzaki, Director of Road Dept., ditto
Dr. Yasuyuki Koga, Head of Soil Dynamics Div., Construction Method and Equipment Dept., ditto
Dr. Minoru Fujiwara, Structure and Bridge Dept., ditto
Mr. Yutaka Iida, Earthquake Disaster Prevention Dept., ditto
Mr. Masafumi Fukuda, Research Coordinator for Construction Management Engineering, Construction Management Engineering Center, ditto
[10:00～12:00, Feb.16th (Tue)]

(Q) Dr. Lee (Korea) : How do you evaluate the results of the studies.

(A) Dr.Iijima : They are evaluated by the following three methods:
1. To report to the Ministry of Construction.
2. To present them to the journals of scientific societies,

including international conferences.
3. To present them to other journals.
One of the most important evaluations of the results is to be used in guidelines.

(Q)Dr.Badruddin: 1. Countermeasures against global warming effects.
(Indonesia) 2. Can the sands in sea be used in building material?
3. Countermeasures against water pollution.

(A)Dr.Yoshino : 1. We investigate and research about global warming effects with U.S., and about water cycle and so on with Thailand.

(A)Mr.Ikemura : 2. Since the amount of salt in sand material is regulated, sand in sea is not used recently.

(A)Dr.Yoshino : As for the cleaning of river water, Urban River Division is investigating and researching, each cleaning method is on experimental stage.

(C)Mr.Tomaru : Environment Department will be established in order to cope with environmental problems widely in the next fiscal year.

(C)Dr.Iijima : Twenty percent of research subjects carried out in PWRI is on environmental problem.

(C)Dr.Lee : As for global environmental problem, five countries in
(Korea) North-Eastern Asia, such as Japan, Korea, China, Russia and Mongol, have formed the cooperation network after the UN Conference on Environment and Development.

(Q)Mr.Bonoan : I would like to obtain informations on the direction of the
(Philippines) research in progress on the debris flows and pyroclastic flows, because the disaster caused by them are very serious in our country.

(A)Mr.Asai : We have the technology of precise prediction of debris flows flowing and sedimentation area by using the numerical simulation method, however little is known about the mechanism of pyroclastic flows so far. A dynamic model of pyroclastic flows and its numerical simulation method should be established as soon as possible.

(C)Mr.Sumiyoshi: Any techniques which can be useful the Philippines in mitigating sediment-related disaster should be notified.

(Q)Mr.Tan : Has your Institute been conducting the comparable research
(Singapore) on the methods of estimation ?
Most of the Japanese contractors presented higher bids than local contractors in foreign countries (such as Malaysia).

(A)Mr.Fukuda : The competitive bid system which is different from foreign countries has been practiced in our country. We will study the actual situation of the bid system in foreign countries and improve it if necessary.

(Q)Mr.Chen : Please let me know the research activity on the structure and
(China) durability of old dams.

(A)Mr.Takebayashi : We have the experience of 100 years concerning the concrete

dam building. As for the filldam, we have the experience of 1000 years. We inspect and repair old dams because of sedimentation and deterioration of concrete. The methods for inspection and repair vary in each dam type. We conducted the comprehensive study on the above-mentioned topics with Chinese Resource of Science, Ministry of Water Resource during 9 - 20, January, 1993 in Beijing.

(2) **China**, by Mr.Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research

[13:00~14:00, Feb.16th (Tue)]

(Q)Mr.Niwa : How many years do you see ahead when you make a long-term water resources plan ?

(A)Mr.Chen (China) : 2010 for mid-term plan, 2020 for long-term plan

(Q)Mr.Tomaru : What kind of countermeasures against the sedimentation do you use in China?

(A)Mr.Chen (China) : Sedimentation of reservoir is a serious problem in China. After about 40-year operation of reservoirs, we have accumulated much experience and data. Effective storage for reservoirs is now maintained. We store clear water and release the muddy water as the operation strategy. We have a very famous reservoir, San Men Xia, in the middle of the Yellow River. Effective storage is being operated smoothly. We can discuss this problem after this meeting.

(3) **Indonesia**, by Dr.Badruddin Machbub, Director, Research Institute for Water Resources Development

[14:00~15:00, Feb.16th (Tue)]

(Q)Mr.Tomaru : I heard cases of severe water pollution in Jakarta Area. In prevention of water pollution, what kind of roles should be allocated among Ministry of Public Works, Ministry of Industry, and Ministry of Health? In particular, what is the role of Ministry of Construction?

(A)Dr.Badruddin: (Indonesia) Cooperation from Ministry of Environment (ME) is required to solve the problem. ME has a right of law enforcement and control and monitoring the implementation of the water quality standards. Therefore, cooperation between Ministry of Industry which is concerned with industrial activities and several agencies, not only one ministry, which promote physical works to prevent pollution, is necessary. The cooperation has been done also on a case-by-case basis. For example, the project in Bandung area is under MPW and the project in western Jagotabeck area is promoted by Jagotabeck corporation under cooperation between MPW and MI, but those activities are directed by a Steering Committee which consists of

representatives of several agencies. In Jakarta, a project of a wastewater treatment plant is promoted under MPW (Directorate General of Housing & Human Settlement). The sewage plant will adopt combined treatment of industrial wastewater with domestic waste water because of cost effectiveness.

(Q)Dr.Lee (Korea) : At what stage is your environmental impact assessment (EIA) made for public works projects? Planning stage or design stage?

(A)Dr.Badruddin (Indonesia) : We have two stages in EIA. The first stage is to collect information on environmental impact as pre-study. Each project has to present reliable environmental impact statement (EIS) to the Government. The head of the environmental impact committee discuss all EIS. After screening, the committee decides which EIS should be improved to environmental impact study. No matter whether new or existing planning, they are, had to do in last year. EIS should be implemented even for the projects under feasibility study. For the projects already in progress, the Environmental Impact Study, has to be conducted, too.

(Q)Dr.Lee (Korea) : Do you have public hearing?

(A)Dr.Badruddin (Indonesia): Yes, we have limited public hearing for representatives of other sectors. For instance, if the MI wants to discuss the MPW, the committee invites MPW.

(Q)Dr.Iijima : Is Buton asphalt popularly used in Indonesia? When the Buton asphalt is used, what kind of problem?

(A)Dr.Badruddin (Indonesia): Buton asphalt is mixed with natural aggregate. Buton asphalt contains of asphalt and agregades. Problem is that transportation from Sulawasi to Java is very expensive, so the usage near Sulawasi is recommended. Research on lining is promoted for improvement of impoundment for small reservoirs in Eastern Indonesia.

(4)Korea, by Dr.Lee Sang Eun, Vice President, Korea Institute of Construction Technology

[15:10~16:10, Feb.16th (Tue)]

(Q)Mr.Bonoan (Philippines) : How do you ensure that your (long term) development framework plan be sustained and implemented by the same administrative organizations that have established the plan even if there would be any change in administration?

(A)Dr.Lee (Korea) : Actually, the plan was set up not only by Ministry of Construction, but the plan was worked out by thousands of specialists together. It was initiated by another research organization under MOC (Korea research institute of human settlement). Therefore, even though the function of Ministry would change, the plan would be continuously implemented.

(Q)Mr.Bonoan: Have you ever had any problems in implementing expressway

(Philippines) in Korea ; particularly with regard to acquiring the necessary road-right-of-way?

(A)Dr.Lee (Korea) : Most problems associated with infrastructure is related with highways. The traffic jam in the highway is getting very severe, for example, congestion on Inchon-Seoul Highway affects industrial development. In the future, the investment for infrastructure development will be put mostly to resolve the traffic problem.

(Q)Mr.Tomaru: Concerning the 3rd comprehensive national physical planning, could you tell us more precisely about the non-governmental financial resources, which amounts to 50% of total investment?

(A)Dr.Lee (Korea) : Non-governmental fund means that it comes from private sector such as Hyundai Corporation, but includes investment made by government invested corporations.

(Q)Mr.Tomaru: Don't you think that the non-governmental fund involves uncertainties in financial planning?

(A)Dr.Lee (Korea) : We cannot guarantee that the fund or investment is reliable. But, recently the government has been granting some kind of benefits for the private sectors to invest more in the infrastructure. That is one method to enhance and ensure their investment in the infrastructure.

(Q)Mr.Tan (Singapore) : I would like to know some more detail of the construction technology information system. Does it contain only textured based on information or more?

(A)Dr.Lee (Korea) : The construction technology information system involves databases not only for literatures or articles but also for the record of construction project, some design standards and guides, and how to get construction materials. It also includes information concerning the new technology and the design of major construction projects reviewed by Ministry of Construction. The emphasis will be put on the improvement of the databases which include the record of construction project, some design standards and guidelines rather than articles and literatures.

(Q)Mr.Tan (Singapore) : Does the construction record also include graphic information such as building plans and detailed drawing?

(A)Dr.Lee (Korea) : It also includes information on problems during the construction and on the construction time. They are all stored in the database. We first tried to include graphic information, but it has been very difficult. Eventually we will include the graphic information.

(5)M a l a y s i a, by Mr.Abdul Rahman B. Abdullah, Deputy Director General, Public Works Department

[16:10~17:10, Feb.16th (Tue)]

(Q)Mr.Tomaru : How the EIA is implemented in Malaysia?

(A)Mr.A.Rahman: All development plannings over 200 ha must meet the EIA criteria (Malaysia) before implementation of projects, a master plan must be submitted,

which delays the implementation of projects.

(Q)Mr.Sumiyoshi : Do you have any delay case of 1 or 2 years due to the EIA?

(A)Mr.A.Rahman (Malaysia) : Yes. The project owners must visit the Environment Agency, which is another reason of delay.

(Q)Dr.Lee (Korea) : Referring to Figure 1 of your report, stage 2 is the feasibility study and stage 3 is project approved. If the originally planned project is found to be not feasible, what do you do? Also will you explain how JKR does the survey stage for research project?

(A)Mr.A.Rahman (Malaysia) : When the problems occur during the construction, we try to solve the problem during construction. When investigated and it is not possible to solve, the projects would be suspended.

(6)Philippines, by Mr. Manuel M. Bonoan, Assistant Secretary for Planning, Department of Public Works and Highways

[9:00~10:00, Feb. 17th (Wed)]

(Q)Mr.Tomaru : Has your country been taking any non-physical countermeasures such as designation of a risk area against natural hazards?

(A)Mr.Bonoan (Philippines) : Yes. We identify and delineate the risk areas. However, in reality this measure is not effective unless the people who are at risk are physically taken out from such areas, because the people are not willing to voluntarily leave the hazard area until the last minute when they can already see the threat and the danger coming. We also have a National Disaster Coordinating Council whose main function is to mobilize and coordinate immediate relief operations in times of calamities. However, it does not have a function of disaster mitigation.

(7)Singapore, by Mr. Tan Siong Leng, Director, Building Control Division, Public Works Department

[10:00~11:00, Feb.17th (Thu)]

(Q)Dr.Badruddin (Indonesia) : At present Singapore buys water from Malaysia. When the population reaches the planned maximum of 4 million is water supply ensured? Any considerations given to a water agreement between Singapore and Malaysia or to any other technology development project?

(A)Mr.Tan (Singapore) : Water is currently being imported from Malaysia. Water supply to 4 million people will be a big issue. Cooperation with Indonesia will be also considered as well as development of a new technology such as construction of underground tunnels for water storage use. The problem is the cost and environmental impacts.

(Q)Mr.Kanzaki : Is ventilation taken into consideration in underground road system project? Will the road be toll-free?

(A)Mr.Tan : Toll-free. High import tariff (200%) (>200%) imposed on

(Singapore) cars & high road tax will cover the expenses for road development. High tariff is designed for controlling the number of cars.
Ventilation is at the design stage. Transverse-ventilation with ventilation stacks are being considered other possibilities are also under study.

(Q)Mr.Kanzaki : Where will the ventilation facility be installed?

(A)Mr.Tan (Singapore) : Exact locations and height of the ventilation stacks will be decided in the detailed investigation and design stag

(Q)Mr.Bonoan (Philippines) : Any special budget allocation for road construction?

(A)Mr.Tan (Singapore) : Presently S$300 mil (or US$180 mil) allocated annually and it is on the rise.

(Q)Mr.Bonoan (Philippines) : Any revenu from special highway tax, for instance?

(A)Mr.Tan (Singapore) : Not special tax, as high tariff on imported registration of cars and road tax have been imposed. Also, with the recent introduction of vehicle quote system, substantial revenue has also been generated through the sale of certifications of entitlement for purchasing new cars.

(Q)Dr.Lee (Korea) : How is PWD introduced in the various building projects it implements ?

(A)Mr.Tan (Singapore) : PWD does the planning, designing and construction supervision of government building projects. Its implementation, physical construction work is done by contractors.

(Q)Dr.Lee (Korea) : Underground road, being under the sea level, does it not pose some psychological problems?

(A)Mr.Tan (Singapore) : Yes, this is one of the concerns in planning and design of the underground road system. Simulation study on this aspect is under consideration.

(Q)Mr.Tomaru: In Japan trading of water among prefectures is difficult. Water supply issue is being considered in parallel with the national growth project?

(A)Mr.Tan (Singapore) : Yes. We have long term water supply agreement with Malaysia. Currently Singapore Government is also cooperating with Indonesia Government in jointly developing water resources in Sumatra.

(8) Thailand, by Dr.Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways

[11:10～12:10, Feb.17th (Wed)]

(Q)Mr.Kanzaki : When does the research in the 7 field start in the Road Research Development Center?

(A)Dr.Teeracharti (Thailand) : The Research is done by the graduate students and will be continued 2 or 4 years. The research plan will be determined after the research of the university has been finished. It will

take about 10 or 15 years as a whole.

(Q)Dr.Iijima : Do you conduct the research on reducing traffic accidents?

(A)Dr.Teeracharti: Such research is not conducted actively.
(Thailand) The traffic accidents could be reduced by widening 2 lane highways to 4 lane highways. And also, they will be reduced by the regulation which requires the motorcycle drivers wear a helmet.

(Q)Mr.Bonoan : How is the pollution (air pollution) caused by vehicles in
(Philippines) Thailand? Have the measures been implemented to reduce the pollution?

(A)Dr.Teeracharti: The unleaded gasoline has been used since last year.
(Thailand) For the new vehicles, the emission control using filter is enforced. For old vehicles, this is not applied. Regulation of the two-cylindered engine is considered but not yet materialized.

(C)Mr.Tan : In Singapore, there is a government policy to encourage
(Singapore) scrapping of a car once it reaches 10 years old. This is done by allowing a car to be a given a high scrap value if it is scrapped before it reaches and of 10 years of usage from new. A car loses its scrap value completely after 10 years. Also, a higher road tax is imposed on cars older than 10 years. Older cars are also subjected to stringent and more frequent compulsory vehicle inspection to ensure their road worthiness. In this way, there will be fewer old cars on the roads and air pollution due to old and inefficient engines will be reduced. Also lead free petrol has been introduced. In Singapore in 1991, from July 92, all newly imported cars are required to be fitted with catalytic converters to ensure 100% combustion. More stringent emission testing criterion has also been introduced for older cars.

(Q)Mr.Tan : How is the joint research of DOH and the university funded ?
(Singapore)

(A)Dr.Teeracharti: The fund for the research is financed by DOH. Before starting
(Thailand) the project, we discuss to determine the suitable university or institute and person.

(Q)Mr.Tan : A lot of experiment facilities belong to the university. Do you
(Singapore) use facilities belonging to university, DOH or both ?

(A)Dr.Teeracarti: Both facilities are used.
(Thailand)

3. Subject of Common Interests

Discussion on "Future Perspective for Research and Development of Disaster Prevention Techniques against Disaster caused by Rainfall" was held from 13:00 to 17:30 on February 17, with all the participants from eight countries.

The discussion issues were selected based on contents of the country reports prepared by the participants. The discussion was divided into following three sessions:

1) River-Related Disaster
2) Sediment-Related Disaster
3) Topics on Recent Disasters

The first session was chaired by Dr.Yoshino, Director of River Department, PWRI and the second session on was chaired by Mr.Asai, Director of Erosion Control Department PWRI. Each session considered of brief country presentations on the issue and a short discussion period.

Country presentations were made based mainly on the country reports. Documents distributed during the sessions were to be attached as appendices to the country reports.

(1) River - Related Disaster

1) Presentation of Topics

Japan (Mr. Nakao)

1. History of flood damage
2. Research on river disaster prevention in PWRI
3. Future technical issues

China (Mr. Chen)

1. Flood disaster and its background
2. Research on river disaster prevention in the Institute of Water Conservancy and Hydroelectric Power Research
3. Further research topics for disaster prevention
4. Research on drought

Indonesia (Dr. Badruddin)

1. Flood prone area and damage
2. Flood control measures
3. Topics concerning erosion of river and coast

Korea (Dr. Lee)

1. Meteorological and hydrological aspects
2. Disaster prevention and rehabilitation measures
3. Governmental policy and program

4. Research topics of KICT regarding disaster prevention

Singapore (Mr. Tan)

1. Flood prone area and damage
2. Cause of river-related disasters
3. Mitigation measures taken

2) Discussion

Followed of the presentations of the above speakers, questions and answers relating to river-related disasters were exchanged among the participants. Issue that were discussed included the follows:

1. Non-structural measures against flooding, including soil conservation, forestation, watershed management, and warming systems;
2. Return period for designing structures;
3. Estimation of economic losses due to floods;
4. Structural measures, including dams; and
5. Groundwater recharge.

With respect to structural and non-structural measures against river-related disasters, in particular, the importance was pointed out of the comprehensive approach that well-combine these two types of measure, as well as promotion of research and development on this issue.

In addition, the importance of the research for drought was emphasized.

(2) Sediment-Related Disaster

1) Presentation

Japan (Dr.Ishikawa)

1. Current situation of sediment-related disaster (debris flow, landslide, slope failure, slope erosion)
2. Outline of structural active measures and non-structural passive measures
3. Outline of the research works of PWRI on sediment-related disaster

Malaysia (Mr.Abdul Rahman)

1. Present situation of highway slope failure in sandy soil or clay
2. Countermeasure works against highway slope failure
3. Outline of investigation and research works on highway slope failure

Philippines (Mr.Bonoan)

1. Highway slope failure and bridge damage caused by earthquakes
2. Damage of bridges, roads caused by lahar of Mt. Pinatubo
3. Rehabilitation policy for the damages caused by Mt. Pinatubo eruption and debris flow after the eruption

Thailand (Dr.Teeracharti, Mr.Bancha)

1. Highway slope erosion in granite area
2. Concrete blanket as a countermeasure against highway slope failure
3. Research on Hydroceeding
4. Research on deep-rooted grass vegetation

2) Discussion

After the presentations the following were discussed.

1. Design of highway in mountainous area
2. Investigation on the area prone to sediment-related disaster
3. Effectiveness, reliability and applicability of the countermeasures against the erosion of slopes

(3) Topics on Recent Disasters

1)Japan (Dr.Ishikawa) presented pyroclastic flow and debris flow caused by eruption of Mt. Fugen, Unzen

2) Indonesia (Dr.Badruddin) presented the earthquake and tsunami in Flores Island area in December, 1992

(4) Conclusion

Through the presentations and discussions, we reached the following conclusions.

1) The participants deepened their understanding of the present situation of disasters, and the countermeasures and policies to avoid disasters in participating countries. At the same time, it is well recognized that they are diversified due to the differences of natural and socio-economic conditions.

2) Regarding river-related disaster, comprehensive flood mitigation measures including both structural measures and non-structural measures should be taken, and it is important and essential to promote research and development in that direction, It is agreed to promote exchange of Information on this regard.

3) As for sediment-related disaster, it is recognized that disaster caused by slope failure and its countermeasure in each country are extremely diverse. With regard to this issue, it is agreed to promote exchange of information for mutual understandings. It is suggested that uniform format should be made for date exchange of slope failure , especially concerning highways.

4) It is quite fruitful to have discussion focusing on the common interests of all participating countries. It was pointed out that such discussions on common interests should be continued at coming conference. It is proposed and agreed that environmental issues such as water quality conservation and urban environment (noise, air pollution) should be discussed in the future.

Discussions are shown as follows; (Q: Question, A: Answer, C: Coment)

(1) River-Related Disasters

[13:00～15:00, Feb.17th (Thu)]

(Q)Dr.Yoshino : Mr. Chen introduced 5 aspects as the future research and development field in China. In that connection, please tell us the detail of non-structural countermeasures?

(A)Mr.Chen (China) : In our Institute, higher priority is being placed on the study of non-structural measures.

(Q)Dr.Yoshino : How is the situation on this subject in other participating countries ?

(A)Dr.Badruddin: (Indonesia) As non-civil engineering measures, what we have implemented to reduce erosion is forestation and soil conservation. In addition, soil management done by farmers will be effective in the long term.

(Q)Dr.Yoshino : Are there any other comments? I welcome comments on any subject.

(C)Dr.Lee (Korea) : I often found out that many structures such as sewage installation are designed to deal with rainfalls that have 10 - 20 years return period. In reality, Korea has been often experiencing 100-year or 200-year return period rainfalls. However, I think it is practically impossible to change the design of many infrastructures on the basis of 50-years and more. How do you deal with this in Japan?

(C)Mr.Tan (Singapore) : The design level of drainage networks cannot be enhanced because of the limited budget. It's not reasonable to change the current design level to cope with floods with low recurrence probability. Floodings are probably caused by uncontrolled deforestation. Developing countries should take measures to control such illegal activities rather than invest in the structural measures.

(C)Dr. Lee (Korea) : I agree with you. The best way is to provide non-structural measures such as warning systems, forecasting of the damage of floods. We have started the researches on the utilization of GPS and remote sensing technology to get better forecast and earlier warning.

(Q)Dr.Yoshino : The country report of China introduces a study theme on the estimation of economic losses due to floods. I think this study area is very important and contributes to solving the problem described by Mr. Tan, from the viewpoint of investment and its benefits. How are the losses due to floods investigated and estimated?

(A)Mr.Chen (China) : We evaluate the economic losses according to statistics and on-site investigation.

(C)Dr.Yoshino : The reason I have questioned about the economic losses is that a large investment necessary for the revision of the design level must be in balance with the return. Are there any suggestions for the collaboration concerning the subject discussed among participating countries?

(C)Mr.A.Rahman (Malaysia) : We are now beginning to build dams in major rivers. Those dams will contribute to flood disaster reduction and water resources conservation.

(Q)Mr.Kuriki : I would like to get some information about underground drainage tunnels from Singapore and the recharge of groundwater from Indonesia.

(A)Dr.Badruddin (Indonesia) : We have calculated the effect of groundwater recharge with a numerical model. The measure was found to be effective in reducing the erosion and also is beneficial in terms of water resources development.

(A)Mr.Tan (Singapore) : Underground tunnels are built in the shallow underground region. The construction of the tunnels ensure the high utilization of land and conservation of mangroves.

(C)Mr.Tomaru : The important aspect would be how to decide the balance between structural and non-structural measures. This would be one of the subjects of collaboration.

(C)Dr.Inaba : I would like to add a comment. The design level of storm sewage installation in Tokyo metropolitan area has been revised from 50 mm/hr to 75 mm/hr in terms of rainfall intensity.

(C)Dr.Yoshino : The following is my own personal draft plan of the resolution. It'll be discussed with you wether you will adopt or not. "There are diversities of natural and socio-economic conditions and river-related disasters in the participating nations. Therefore, we have to encourage the information exchange among participating nations."

(2) Sediment-Related Disasters

[15:10～17:00, Feb.17th (Thu)]

(Q)Mr.Tan (Singapore) : Which kind of design method is used for grading works accompanying with mountain roads in Malaysia? Which kind of prevention method is the most effective from a long-term viewpoint among the erosion prevention methods of slope in Thailand?

(A)Mr.A.Rahman (Malaysia) : The design method is based on the past experience. A book published by a study committee of highway is referred.

(A)Dr.Teeracharti (Thailand) : The hydroseeding method seems to be the best. However, the further field experiment will be necessary.

(Q)Dr.Iijima : Is the place in danger of sedimentation-related disaster investigated?

(A)Mr.Bonoan (Philippines) : The investigation assisted by JICA is going.

(A)Mr.A.Rahman (Malaysia) : The dangerous places and the economic loss owing to disaster are not estimated. The cost of recovery is calculated.

(A)Dr.Teeracharti (Thailand) : A foresight calculation of slope erosion is carried out, based on understanding the pattern of erosion.

(A)Dr.Lee : The hydroseeding method is adopted in Korea mainly for

(Korea) landscaping and erosion control purpose, too. However,there are controversies regarding stability of the slope.

(A)Dr.Teeracharti (Thailand) : The effectiveness of the hydroseeding method depends on the kind of plant used. The deeproot plants are used in Thailand. But they die after 1.5 - 2 years.

(C)Mr.A.Rahman (Malaysia) : As for the hydroseeding method, the plant can grow on suitable ground and not on unsuitable one such as granite.

(C)Dr.Ishikawa : I propose the long-term plan of exchange of information especially real data, about the research and experiment which have been done and are now proceeding in every country, because almost all the paraticipants have interest in the stability of slope.

(C)Mr.Tan (Singapore) : I support his proposal wholeheartedly. The information about the stability of slope must be exchanged, based on the experience and technology accumulated in ever country. Especially, Japan has a lot of experience and technology in this field, so Japan has to supply his information actively.

(C)Mr.Sumiyoshi : The successful example is necessary, but the failed one also important. It is necessary to study the reason why that project failed. I propose that Dr. Ishikawa, Japan, make a format to exchange information.

(C)Dr.Lee (Korea) : I'd like to investigate how to distinguish the origine of disaster, caused by mankind or by nature.

(C)Mr.Asai : I propose the conclusion of the session as follows;

(1) The present situation and problems of sedimentation related disaster in each country were presented to be clarified fairly well.

(2) The information about stabilization of slope along mountain road should be exchanged closely in future.

At last, a topic for the next meeting was discussed. The participants from Philippines and Thailand emphasized the necessity of concreting. As next topics, Indonesia proposed "Environmental Control and Pollution Prevention", Japan "Management of Water Quality, and Environment and Noise of Urban District, etc." as a subject of the next meeting.

4. Discussion on Specific Subjects

For each specific subject in public works, participants who have the similar problems in public works met and discussed, taking a full day from 9:00 - 17:30 on Feb. 18.

Summary of discussion in each subject are as follows;

(1) Sedimentation of Dam Reservoir — China, Japan (Dam Dept.)

Both sides presented and discussed serious situation on reservoir sedimentation and its countermeasure. It is clearly recognized that the research cooperation is very important for effective studies on countermeasure against reservoir sedimentation, in order to solve the problem both in China and Japan.

(2) Water Pollution Control — Indonesia, Japan (Water Quality Control Dept.)

Both sides made a field study of industrial wastewater treatment system at Kasima Littoral Industrial Region in Ibaraki Prefecture, and discussed the basic policy of industrial wastewater control in Japan including the basic concept of sharing the construction costs. Both side agreed to exchange research achievement and other related information about water pollution control.

Also Indonesian side requested to dispatch Japanese experts in the field of water pollution control.

(3) River Environment — Korea, Japan (River Dept.)

Korean side presented the river environmental improvement project of Han Kang(Han river), the organization and legal system concerned with the river environmental improvement project in general. Japanese side presented the current research activity on river environment, such as "ecosystem and conservation of natural environment of river".

Both sides agreed upon several research subjects in river environment, which they will tackle cooperatively in future.

(4) Soil Improvement — Thailand, Japan (Construction Method and Equipment Dept.)

Thailand side presented countermeasure taken in low soft ground area near

sea shore. Japan side presented summary of Japanese manual for countermeasure of road construction on soft ground and newly developed techniques. Thailand side requested to dispatch Japanese experts in the field of ground improvement technology.

(5) Tunnel — Singapore, Thailand, Japan (Geology and Chemistry Dept., Road Dept., Structure and Bridge Dept.)

Singapore side presented the expressway road tunnel and underground road system. Japanese side presented the design standards for road tunnel including ventilation facilities, lighting facilities, emergency facilities, and also newly-developed tunneling technologies and foundations.
All of them agreed to exchange technical information.

(6) Volcanic Disaster, Debris Flow and Road Disaster Prevention — Malaysia, Philippines, Japan(Erosion Control Dept., Construction Method and Equipment Dept., Earthquake Disaster Prevention Dept.)

Each side exchanged information concerning planning and design of countermeasures against volcanic and debris flow disasters by model experiments.

Concerning slope protection measures for road, all of them discussed on characteristics of soil liquefaction, and status of damage by earthquake, cases of earthquake-durable structure, prediction method for liquefaction-susceptible area with geo-hazard map which shows geological information including faults, and on construction method of anchor against landslide and countermeasure against surface erosion around anchor.

It is recognized that the exchange of technical information on survey, planning and design for countermeasures against sediment-related disaster caused by volcanic eruption, such as pyroclastic flow, lahar, and slope protection measure for road is very important to renovate technology.

(7) River — China, Japan (River Dept.)

Both sides presented and discussed on target, process, system of research on sediment problems in river.

Both sides agreed on regular exchange of research achievements and technical information.

(8) Water Quality — Korea, Japan (Water Quality Control Dept.)

Both sides exchanged the information on the present situation of water quality control strategy, the progress and technological development of sewage works, and confirmed research cooperation in the same manner as it has been done.

(9) Soil Mechanics and Foundation Engineerings, Traffic Engineering — Malaysia, Thailand, Japan (Road Dept., Construction Method and Equipment Dept., Structure and Bridge Dept., Earthquake Disaster Prevention Dept.)

With regard to the issue of soil mechanics and foundation, they presented foundation work measures etc, and both side exchanged thier opinions about researches on it in Japan. It was agreed that they mutually exchange information on these subjects from now on. And Malaysia made a request for technical cooperation.

In Traffic Engineering Session, participants discussed traffic capacity of roads, transportation planning, traffic management and control, traffic safety, and environmental management. It was recognized that it is important to exchange technical information mutually.

(10) Pavement — Philippines, Singapore, Thailand, Japan (Geology and Chemistry Dept., Road Dept.)

Each side presented and discussed the current situation and problems of pavement in their countries. All of them agreed to conduct cooperative research activities such as exchange of information on theoretical design method, use of local materials, and research on new pavement technology.

(11) Highway Bridge — Philippines, Japan (River Dept., Erosion Control Dept., Bridge and Structure Dept., Earthquake Disaster Prevention Dept.)

Philippines side presented the potential danger of bridge collapse due to

aggradation of river bed with volcanic lahar,and discussed its countermeasure with Japanese side.

It was decided that furter discussion and information exchange will be made on hydraulic analysis method and protection of bridge structure.

There was a request for technical cooperation from Philippine.

Through the above discussions we could have a better mutual understanding on relevant and current research activities in each participating country. At the same time necessity for future cooperation including exchange of details and accurate information in each public works field was recognized once again.

(1) SUMMARY OF DISCUSSION (SEDIMENTATION OF DAM RESERVOIR)

DATE February 18, 1993 (Thu) 9:00 - 12:00

PLACE Public Works Research Institute Rm 531

PARTICIPANTS

China

CHEN Bingxin	Directer of Institute of Water Conservancy and Hydroelectric Power Research

Japan (Public Works Research Institute, Ministry of Construction)

TAKEBAYASH Seizo	Directer of Dam Department
TAKASU Shuji	Head of Dam Hydraulic Engeneering Division
NIWA Kaoru	Head of Water Resources Development Division
SHINYASHIKI Takashi	Senior Researcher of Dam Hydraulic Engeneering Division
HAKOISHI Noriaki	Researcher of Dam Hydraulic Engeneering Division
YAMAGUCH Yoshikazu	Researcher of Fill Type Dam Division
HIROSE Masayoshi	Researcher of Water Resources Development Division

1. CONTENTS OF DISCUSSION

China(IWHR) and Japan(PWRI) sides introduced sedimentation problems of dam reservoirs of their own countries and countermeasures against them and discussed about them. Through the discussion, it is clearly recognized that sedimentation of reservoir is a very important problem to be solved for each country in order to improve water resources development, and that research activities of each institute will be improved through exchange of experience and products of research.

Next, based on this discussion, we discussed about outline of future joint research activities and reached the conclusion as the following 3.

2. FUTURE RESEARCH TOPICS

"Research on countermeasures against sedimentation of dam reservoirs"

This will be carried out in order to reduce sedimentation problems in dam reservoirs.

3. AGREEMENTS

Since the problem concerning sedimentation in dam reservoirs is very serious both in China and Japan, research cooperation between China Institute of Water Conservancy and Hydroelectric Power Research (IWHR) and Public Works Research Institute (PWRI), Ministry of Construction of Japan, is very important for effective studies about this subject. Therefore, we should establish the cooperation system about research on sedimentation problems in consideration of restriction in fund. The first step may be :

1) Exchange of Information

   Exchange of publications and observed data should be done.

2) Exchange of Researchers

   Endeavor should be made to dispatch researchers each other.

(2) SUMMARY OF DISCUSSION(WATER POLLUTION CONTROL)

DATE February 18 , 1993(Thu) 9:00 - 16:00
PLACE Kashima Specific Industrial Waste Control Sewerage System and Kashima factory of Dainippon Ink & Chemicals, INC.

PARTICIPANTS

INDONESIA Dr. Badruddin Machbub
Director, Research Institute for Water Resources Development

JAPAN Mr. Eiich Nakamura
Head, Water Quality Division
Mr. Katsuhisa Shioji
Sewage Works Division

1. CONTENTS OF DISCUSSION

We made a field trip to the treatment plant of Kashima Specific Industrial Waste Control Sewerage System and to the pretreatment facility at Kashima factory of Dainippon Ink & Chemicals, INC. which discharges its wastewater into the sewerage system stated above.

At the treatment plant, we had a discussion about the kind of sources and their shares of construction costs for this sewerage system,including the basic idea of private industries' share. Also, we studied the user charge system for industrial wastewater.

At the factory, we made a detailed study on the pretreatment process and its O&M costs.

2. FUTURE RESEARCH TOPICS

(1) Study on combined treatment of industrial wastewater and domestic wastewater
(2) Study on separate treatment of industrial wastewater

3. WAYS OF FUTURE RESEARCH COOPERATION

(1) Exchange of reports
(2) Indonesian side wants Japan to dispatch its engineer(s) on the field of water pollution control to Indonesia.

4. AGREEMENTS

Both countries agreed to exchange reports and other related information about the subjects stated above in the section of 2.

(3) Summary of Discussion(River Environment)

DATA :Febrary 18, 1993(Thu) 9:00～11:45

PLACE :Public Works Research Institute, Rm 526

PERTICIPANTS

Republic of Korea

Lee Sang Eun	Vice President, Korea Institute of Construction Techonology

Japan(Public Works Reserach Institute, Ministry of Construction)

Fumio Yoshino	Director of River Department
Tadahiko Nakao	Reserach Coordinator for Hydraulic structures
Minoru Kuriki	Head of Flood Disaster Prevention Division
Yukihoro Shimatani	Head of Urban River Division
Okimiti Suzuki	Senior Reseracher of Urban River Division
Yuichi Kayaba	Reseracher of Urban River Division

1. CONTENTS OF DISCUUSION

"On River Enviroment 1992", Korean side explained recent topics for Korean river enviroment. Main subjects are shown as follows.

1. The river environment improvement project of Han Kang(Han River) and the impact of the project.
2. The organization and law system on river enviroment improvement project, especially the relation between Ministry of Construction and Ministry of Environment.

Japan side explained the situation of river environmental project in Japan and the research on river environment in PWRI. Main subjects are shown as follows.

1. Evaluation of river environmental value
2. Landscape of river
3. Conservation of natural environment of rivers
4. Conservation of water quality
5. Conservation of water quantity
6. Grobal environmental problem

On each research being operated by Japan mentioned above, Korean side explained thier present stiuation, interest and importance.

2. FUTURE RESERACH TOPICS

Among the items mentioned above, taking into consideration the situation of progress and importance of reserach in Japan and Korea, Both parties agreed to cooperate and tackle the themes as follows ; ①Landscapes of river(especially, Forecast of Landscapes using computer graphics), ②Conservation of water quality, ③Conservation of water quantity.

3. WAYS OF FUTURE RESERACH COOPERATION

1) Infomation exchange

Both sides shall exchange the results of the research carried out by PWRI and KICT.

2) Interchange of engineers

From 1993 / 5 / 17 to 12 / 18, Japan side will receive Lee Jin Won, the reserach engineer from KICT through the JICA , and Both sides are going to exchange Japanese and Korean techniques of river environment.

4. AGREEMENTS

From 2. and 3. mentioned above, Both sides agreed that they promote the cooperation of reserach in future.

5. OTHERS

On "conservation of water quality " and "conservation of water quantity" in the content of 1, for the time being the exchange of information will be carried out. In future if the project " The development of the system of water improvement" is commenced under the Scientific Technology Cooperation Committe of Science and Technology Agency Japan, these themes will be carried out under the project. Both sides will decide the strategy of cooperation in the issue of "conservation of natural environment of rivers" after further considerations.

(4) SUMMARY OF DISCUSSION (SOIL IMPROVEMENT)

DATE: February 18, 1993 (Thu) 9:00～12:00
PLACE: Public Works Research Institute, Rm 628
PARTICIPANTS:

1) Kingdom of THAILAND
   Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways, Ministry of Transport and Communcation
2) JAPAN (Public Works Research Institute, Ministry of Construction)
   Yasuyuki Koga, Head of Soil Dynamics Division
   Shouzo Naemura, Head of Construction Method Division
   Hiroshi Miki, Head of Soil Mechanics Division
   Nobuyoshi Ogawa, Senior Researcher of Construction Method Division
   Nobuyuki Tsuneoka, Senior Researcher of Construction Method Division
   Hidetoshi Kohashi, Researcher of Soil Mechanics Division
   Junichi Koseki, Researcher of Soil Dynamics Division

1. CONTENTS OF DISCUSSION

1) Presentation of "Research Associated with Foundation Improvement for Road Construction on Soft Bangkok Clay"
2) Presentation of "Soft Ground Improvement Techniques in Japan"
3) Discussion on Future Cooperation

Thailand side presented countermeasures taken in low soft ground area near sea shore. Japan side presented summary of manual for soft ground countermeasure of road construction in Japan and techniques newly developed.
Thailand side requested to dispatch Japanese specialists in the field of ground improvement technology.

2. FUTURE RESEARCH TOPICS

Ground improvement methods (especially jet grouting and vertical drain)

3. WAYS OF FUTURE RESEARCH COOPERATION

1) Exchange of Information
   Information of research topics listed above will be exchanged.
2) Dispatch of Technical Person
   By the request of Thailand, the possibility of dispatch of technical persons will be considered.

4. AGREEMENTS

Japanese side will try to translate case histories of ground improvements and manuals for highway earthworks into English and exchange written information with Thailand.

(5) SUMMARY OF DISCUSSION (Tunnel)

DATE Rebruary 18.1993 (Thu) 9:00～12:00,17:00～17:30
PLACE Public Works Reseach Institute Rm 8F
PARTICIPANTS

Singapore

TAN Siong Leng	Director of Building Control Division, Public Works Department, Ministry of National Development

Thailand

BANCHA Vadhanasindhu	Chief of Programming Section, Department of Highways, Ministry of Transport and Communication

Japan (Public Works Reseach Institute, Ministry of Construction)

KANZAKI Hiroo	Director of Road Department
MIZUTANI Toshinori	Reseach Coordinator for Underground Development
KAWANO Hirotaka	Head of Concrete Division
OKAHARA Michio	Head of Foundation Engineering Division
INOKUMA Akira	Head of Tunnel Division
KADOYU Katsunori	Reseacher of Tunnel Division

1.CONTENTS OF DISCUSSION

The subjects Singapore side explains are the Expressway Road Tunnel. Singapore side explains the background, investigation, design, execution, and maintenance problem of expressway underground road tunnel. As for maintenance problem, Singapore side explains that waterproofing is very important, but perfect waterproofing is very difficult, and it is a major problem that has yet to be resolved. As for Singapore Underground Road System, the general concept and feasibility study are explained.

Next Japan side explains the technical standards for road tunnels. The explained subjects are structure design, ventilation facilities, lighting facilities and emergency facilities.

Japan side explains that supports such as shotcrete, rock bolts, and steel arch combined (known as NATM) have become the standard in Japan. Then Japan side explains design concentrations of soot and carbon monoxide which are necessary to insure the safety and comfort of traffic. The purpose of tunnel lighting is to insure safety and smoothness of traffic inside the tunnel, and suitable lighting facilities are designed by the standard to give a certain road luminance. The way to set emergency facilities is decided in relation to the tunnel length and the traffic flow volume.

And next Japan side introduces several newly developed and developing technologies regarding to tunnel engineering. And then Japan side introduces newly developed foundations, Continuous diaphram wall foundation, soil cement composite steel pipe pile, precast caisson, foundations in deep water,

and methods of ground improvement.

2.FUTURE RESEARCH TOPICS

After discussions we have both decided to cooperate in the following themes.

· As for the planning, design, and execution of road tunnel in urban area, we are often faced with problems due to the presence of soft ground and adjoining buildings which may be damaged during construction of tunnels. In the future we both aim at establishment of tunnel design and execution method, taking paticular urban conditions into consideration.

· As for the design of ventilation, lighting, emergency facilities of road tunnels,it is important to establish the rational planning of facilities and operation system. Because the demand of road tunnel is more and more increasing in the future, we both should cooperate to pursue the establishment of rational planning and design standards and collect the field data for exchange.

3.WAYS OF FUTURE RESEACH COOPERATION

In the future we will cooperate through the following ways.

1) Information exchange

We exchange the fruits of the reseach and occasionally offer the presentation place of reseach fruits.

2) Exchange of engineers

We both dispath the reseach engineer to each country with the help of the organization like JICA if necessary.

4.AGREEMENTS

· Information exchange of technical standards of each country

We exchange the technical standards to help us to grasp the present development of urban tunnel engineering in each country.

· Offer of reseach fruits

We offer to exchange the reseach fruits obtained by each countries.

5.OTHERS

· There is also a need to translate technical papers in this area for the benefits of both countries.

· Such system as to translate papers easily is needed.

(6) SUMMARY OF DISCUSSION (Volcanic Disaster, Debris Flow and Road Disaster Prevention)

DATE: February 18.1993(Thu) 9:00~12:00
PLACE: Public Works Research Institute Rm 629
PARTICIPANTS:

Philippine

Manuel M.Bonoan	Assistant Secretary for Planning,Department of Public Works and Highways

Malaysia

Abdul Rahman B.Abdullah	Deputy Director General,Public Works Department Ministry of Works

Japan(Public Works Research Institute)

Youtaro Asai	Director of Erosion Control Department
Yutaka Iida	Director of Earthquake Disaster Prevention Department
Yoshiharu Ishikawa	Head of Erosion Control Division,Erosion Control Department
Kenichi Tokida	Head of Ground Vibration Division,Earthquake Disaster Prevention Department
Yoshimitsu Nakamura	Head of Slope Failure Division,Erosion Control Department
Daisuke Higaki	Senior Researcher of Landslide Division,Erosion Control Department
Shuzo Washida	Researcher of Soil Dynamics Division,Construction Method and Equipment Department
Takashi Yamada	Researcher of Erosion Control Division, Erosion Control Department

1. CONTENTS OF DISCUSSION

The following were presented by the Japanese participants. The results of the studies were introduced concerning liquefaction of grounds caused by earthquake: countermeasures for express highways: damages to bridge; slope failure in mountainous area; mechanism of grounds liquefaction prediction methods for enginnering structures with consideration of liquefaction, checking of existing structures for liquefaction; and countermeasures for liquefaction.

Next, the following results of the studies were introduced concerning distribution of landslide areas in Japan, form of landslide, status-quo of landslide disaster, examples of landslide prevention measures with anchor, effective implementation methods of anchor, and countermeasure against slope surface erosion between anchor heads, examples of practical use of landslide areas as an open-space, occurence of landslides caused by gloval warming.

Slope failure was taken up as a main issue of slope disaster in Japan and the following were introduced on this matter; status-quo of slope failure disaster; the mechanism of collapse; the study on the flow formura of granular flow; efficient measures, designation methods of collapse dangerous area using numerical simulation.

Furthermore, information was exchanged on how to reproduce debris flows by hydraulic model tests while visiting hydraulic model tests which is currently being carried out as an experimental study to prevent debris flows disaster like the one which took place at Unzen Volcano.

To these exchanges of information, specific example of implementation of engineering structure with consideration of earthquake magnitude data which causes grounds liquefaction.

How to try to predict the liquefaction-dangerous area in the country on the basis of geo-hazard map was also introduced.

2. FUTURE RESEARCH TOPICS

- The method of survey, plan and design of disaster prevention of slope failure along road.
- Sediment-related disaster accompanied with volcanic eruption(pyroclastic flows and debris flows)

3. WAYS OF FUTURE RESEARCH COOPERATION

- Exchange of information

  Research results will be mutually exchanged and the meeting place as the occasion demands will be offered

4. AGREEMENTS

Several problems and present state of research in the Phillipines, Malaysia and Japan and the situation of participant country in each field were understood mutually.

Moreover, the necessity of the further cooperation, such as future exchange of technological information about sediment-related disaster in volcano such as lahars and disaster prevention of road, is acknowledged mutually.

Information should be mutually exchanged and the improvement of technology from both side, should be planned about the survey, plan, design guide and examples of disaster concerned with slope failure on road occure with rainfall and earthquake.

The results of survey related to pyroclastic flows and lahars at Mt. Pinatubo and Unzen Volcano will be exchanged. Moreover, the information about plan and design methods for countermeasures will be exchanged.

Finally, the improvement of technology of disaster prevention related to sedimentation by volcanic eruption will be planned.

5. OTHERS

(7) SUMMARY OF DISCUSSION (RIVER)

DATE February 18,1993(Thu) 13:00~16:00

PLACE Public Works Research Institute Rm.531

PARTICIPANTS

China

CHEN Bingxin	Director of Institute of Water Conservancy and Hydroelectric Power Research

Japan (Public Works Research Institute,Ministry of Construction)

Fumio YOSHINO	Director of River Department
Tadahiko NAKAO	Research Coordinator for Hydraulic Structures,River Dapartment
Kouichi YAMAMOTO	Head of River Hydraulics Division
Koh-ichi FUJITA	Senior Research Engineer of River Hydraulics Division

1.CONTENTS OF DISCUSSION

The Pubilic Works Research Institute (herein after to as PWRI) and Institute of Water Conservancy and Hydroelectric Power Research (herein after to as IWHR) discussed eagerly to promote cooperative activities aimed at mutually supportive research activities to understanding of sediment problems in rivers.

The PWRI explained the research activities related river sedimentation conducted by River Hydraulics Division. The topics are as follows

1) Study on bank erosion and bank formation

2) River improvement planning aimed at low cost maintenance

3) Study on layout and design of bank erosion protection works (vane works, bank revetment and foot protection)

4)Investigation on soil strength against water flow

In addition to them, the PWRI presented and explained some papers on the characteristics of alluvial river channels and channel changes due to human activities in Japan.

The IWHR explained the research activities concerning sediment problems and river works.The main topics are as follows

1)Research organization related to fluvial sedimentation

2)Status of research activities concerning sediment problems of the Yellow river and the Yangtze river

3)Study on hydraulic characteristics of hyper-concentrated flow

4)Operation system of river model experiments

2.FUTURE RESEARCH TOPICS

The sediment problem in rivers is worth taking up as a subject for cooperative research. This poblem includes the development of methods for

controling river courses, related to river-bed variation near a dam, a hyper-concentrated flow and bank erosion. It also covers the improvement of fundamental techniques such as the hydraulic model test and the calculation of river-bed variation.

3.WAYS OF FUTURE RESEARCH COOPERATION

1)Exchange of information on the sediment problem of rivers

2)Determination of specific subjects to be studied through the above exchange of information

3)Dispatching researchers each other if necessary and within fund available.

4.AGREEMENTS

Both sides will start to exchange research output and related material concerning the sediment problem, at least abstract of which will be written in English.

(8) SUMMARY OF DISCUSSION (WATER QUALITY)

DATE : February 18,1993 (THU) 13:00 - 16:00

PLACE : Public Works Research Institute

PARTICIPANTS : Republic of Korea

Dr.Lee,Sang Eun , Vice President , Korea Institute of Construction Technology

Japan

Mr.Kazuaki Sato , Research Coordinator for Wastewater Treatment , PWRI

1.CONTENTS OF DISCUSSION

Mr.Sato introduced the state of practical use of technology developed in comprehensive development project of MOC "Biofocus". Then, he explained the proceeding of recent administration of water quality maintenance, especially discussion about removal of nitrogen and phosphorus in drainage dischanged into sea.

Referring to the problems difficult for actual use of developed technology, Dr.Lee introduced the prospect of development sewerage system in Korea and the outline of the reduction plan of pollution load in the whole water area of Korea.Korea has Highly Advanced National Project aimed at 2000. One of 14 fields is the technology of environmental control. This field of technology consists of 15 items and one of them is advanced water treatment project, which will be handled by KICT.

2.WAYS OF FUTURE RESEARCH COOPERATION

Dr.Lee asked the favor of PWRI to accept some researchers of KICT in order to collect the information about the technology of reuse of wastewater, relating with the above-mentioned project carried out in KICT.

(9－1) SUMMARY OF DISCUSSION (SOIL MECHANICS AND FOUNDATION ENGINEERINGS)

DATE February 18, 1993 (Thu) 13:30 - 14:45
PLACE Public Works Research Institute Rm628
PARTICIPANTS

Malaysia

Abdul Rahman B. Abdullah Deputy Director General, Public Works Department, Ministry of Works

Kingdom of Thailand

Bancha Vadhanasindhu Chief of Programming Section, Dept. of Highways, Ministry of Transport and Communication

Japan (Public Works Research Institute, Ministry of Construction)

IIDA Yutaka Directer of Earthquake Disaster Prevention Dept.
OKAHARA Michio Head of Foundation Engineering Division
MIKI Hiroshi Head of Soil Mechanics Division
KIMURA Yoshitomi Researcher of Foundation Engineering Division

1. CONTENTS OF DISCUSSION

1) Mr.Abdullah introduced a state of excavating natural materials and the necessity of establishing their classifications by way of the capacity of the excavating machine and requested technical assistance to PWRI on this matter.
The Japan side said: A guide-line of selecting excavating machine is now in use in Japan, which seems to be useful for Malaysia. The English translation of this guide-line will be presented to Malaysia.

2) Mr.Abdullah asked PWRI to accept Malaysian trainee through the JICA technical cooperation in order to conduct study on the soil improvement of Malaysian clay.
The Japan side said: Further consideration is necessary for acceptance of Malaysian trainee.

3) Mr.Abdullah explained that the shallow foundation (spread foundation) is economical to construct small structures such as building structures in Malaysia and in order to use this type of foundation, it is planned to investigate the soil compaction method and set up a guideline through technical assistance of PWRI.
The Japan side said: PWRI has been conducting a research on bearing power of shallow foundation. The information concerned can be offered.

4) Mr. Abdullah explained a state of pollution problems caused by construction of foundations in urban areas, such as noise and air pollution and requested technical assistance to develop new construction methods and establish a guideline.
The Japan side explained a state of low polluted construction methods and presented a translation copy of Japanese Specifications and said it is possible to give information concerning this matter.

5) Mr. Abdullah requested technical assistance regarding to the design method and estimation method(wave equation method) of bearing capacity of friction piles executed in thick deposit of residual soil.
The Japan side said : PWRI is conducting a study on wave equation method and friction pile test data were collected. It is possible to provide these data.

2. FUTURE RESEARCH TOPICS

(1) A Classification system to determine excavation classes on natural materials in Malaysia
(2) Performance improvement of distinctive Malaysian clays
(3) Shallow foundations in compacted fills
(4) The environmental aspects of foundations construction methods in built-up areas
(5) The design of piled foundations in residual soils

3. WAYS OF FUTURE RESEARCH COOPERATION

1) Exchange of information
Exchange of research result
2) Dispatch of experts
Dispatch of experts through JICA is considered.

4. AGREEMENTS

Provision of research result
Mutual provision of research result obtained in participating countries

(9-2) Summary of Discussion(Traffic Engineering)

Date: February 18, 1993(Thu) 13:00~16:00
Place: Public Works Research Institute Room 628
Participants:

Malaysia		
	Abdul Rahman B. Abdullah	Deputy Director General Public Works Department, Ministry of Works
Thailand		
	Bancha Vandhanasindhu	Chief of Programming Section Department of Highways Ministry of Transport and Communication
Japan		
	Yamada Harutoshi	Head, New Transportation Systems Division
	Ishida Minoru	Head, Traffic Environment Division
	Kijima Ken	Researcher, Traffic Environment Division
	Muranishi Masami	Senior Researcher Traffic Engineering Division

1. CONTENTS OF DISCUSSION

In the Traffic Engineering Session, participants discussed traffic capacity of roads, transportation planning, traffic management and control, traffic safety, and environmental management. It was recognized that it is important to exchange technical information mutually.

2. FUTURE RESEARCH TOPICS

- Formulation of traffic capacity of roads in Malaysia in relation to Malaysian traffic and road conditions
- Future transportation demand forecasting methodology and data collection for forecasting
- Measures to improve road environments, especially urban road environments
- Traffic safety management

3. WAYS OF FUTURE RESEARCH COOPERATION

Cooperative study will be carried out through
1) mutual exchange of information on research results
and
2) mutual exchange of researchers through JICA projects and other relevant projects.

4. AGREEMENTS

Participants agreed that references and technical information related to the research topics listed above should be exchanged mutually.

(10) SUMMARY OF DISCUSSION (PAVEMENT)

DATE February 18, 1993 (Thu.) 13:00～16:00
PLACE Public Works Research Institute
PARTICIPANTS

Philippines	Manuel M. Bonoan	Assistant Secretary for Planning, Department of Public Works and Highways
Singapore	Tan Siong Leng	Director of Building Control Division, Public Works Department, Ministry of National Development
Thailand	Teeracharti Ruenkrairergsa	Director, Road Research Development Center, Department of Highways, Ministry of Transport and Communication
Japan(Public Works Research Institute, Ministry of Construction)		
	H. Kanzaki	Director of Road Department
	H. Kawano	Head of Concrete Division
	K. Sakamoto	Senior Researcher of Chemistry Division
	T. Nakamura	Head of Pavement Division
	T. Kiriyama	Researcher of Pavement Division
	K. Kubo	Researcher of Pavement Division

1. Contents of Discussion

Each country representative reported on the present situation and problems of pavement development & research in their respective countries. After the presentations, the following subject matters were discussed;

- Standardization of pavement materials and use of local materials;
- Pavement Management System (PMS);
- Direction for conducting pavement research in Asia including technical cooperation between coutries.

2. Future Research Topics

- New pavement design methods (for example, theoretical design method)
- Pavement materials including use of asphalt modifiers, additives and local materials
- New pavement technology (for example, RCCP, drainage asphalt pavement, modified asphalt concrete etc.)

3. Ways of Future Research Cooperation

- Exchange of research information among countries
- Dispatch of Experts (for example, JICA)

4. Agreements

We agree that the research of durable pavement is socioeconomically very important for each country. It was, therefore, agreed that cooperative research activities such as exchange of information shall be continued.

(11) SUMMARY OF DISCUSSION (HIGHWAY BRIDGE)

DATE February 18, 1993 (Thu) 16:00 - 17:00

PLACE Public Works Research Institute Rm 8F

PARTICIPANTS

Republic of the Philippines

Manuel M. Bonoan Assistant Secretary for Planning, Department of Public Works and Highways

Japan (Public Works Research Institute, Ministry of Construction)

IIDA Yutaka	Directer of Earthquake Disaster Prevention Dept.
KURIKI Minoru	Head of Flood Disaster Prevention Division
ISHIKAWA Yoshiharu	Head of Erosion Control Division
OKAHARA Michio	Head of Foundation Engineering Division
KIMURA Yoshitomi	Researcher of Foundation Engineering Division

1. CONTENTS OF DISCUSSION

1) Mr.Bonoan explained a situation of damages to highway bridges in the Philippines and its policies on how to cope with it.
River beds are still rising rapidly because of the accumulation of debris flow deposits and concern has emerged that bridges might be washed away. It is considered to dig down river beds or to extend the length of bridges as countermeasures. He asked technical assistance to PWRI on this matter.

2) Discussion
The following items should be considered for the future study:
(1)Design method considering riverbed fluctuation
(2)Prediction method of river channel fluctuation by hydraulic analysis
(3)Emergency countermeasures
However,emergency countermeasures is given high priority.
It is necessary to predict change in river beds in order to choose an appropriate location for constructing bridges and their forms.

2. FUTURE RESEARCH TOPICS

The hydraulic analysis and countermeasure for bridge structures

3. WAYS OF FUTURE RESEARCH COOPERATION

1)Exchange of information

The results of researches will be exchanged mutually.

2)Request of the Philippine to the cooperation of JICA should be considered.

4. AGREEMENTS

Hydraulic analysis and disaster prevention method should be investigated further more and its information should be interchanged occasionally

III. Conclusion

The Conclusion of
The First Conference on Public Works Research and Development in Asia

The First Conference on Public Works Research and Development in Asia was held in Public Works Research Institute, Ministry of Construction, Japan from Feb. 15 (Mon), 1993 to Feb. 19 (Fri), 1993. The participants of this Conference were officials from government agencies in Asia responsible for infrastructure research and development and its promotion, including those from China, Indonesia, Korea, Malaysia, Philippines, Singapore, Thailand and Japan. Based on the country reports prepared by participants each country, presentations and discussions were carried out with a common interest for better understanding of problems facing each country as well as making the best use of experience in every country.
The results of the Conference are as follows.

1. Keynote Lecture

Preceding country report and discussion, three keynote speeches were given. The first lecture, "Infrastructure Polices for Economic and Social Development of Asian Countries", was given by Dr. Fumio Nishino, Professor of Civil Engineering, University of Tokyo. It focused on the lesson learned from Japanese policies for infrastructure development and Japan's experience.

Second lecture entitled "Progress of Civil Engineering and Its Contribution to Economic and Social Development in Modern Japan — PWRI'S 70 Years and Perspective —" was given by Mr. Yukihiko Sumiyoshi, Director-General, PWRI, MOC. The main theme was the PWRI's role which is to contribute to civil engineering research development as basis of infrastructure development.

And the third lecture, "The Role of Research and Technology Development in International Technical Cooperation" was delivered by Mr. Hiroaki Tamamitsu, Vice President, Japan Construction Training Center. It refers to the philosophy of international cooperation, the factors and problems of technical cooperation and introduction of the instances of research and technology developed by technical cooperation.

2. Country Report

The outline of each country, current status of public works, research institute of public works, disaster prevention policies, and environmental issues were presented and discussed.
Reports are summarized as follows :

1) It was well recognized that research and development on public works is a key factor to pursue a nation's development, since social infrastructure such as road, river, dam, erosion control, and sewage contributes to the economic and social growth of countries.

2) Natural disasters such as volcanic eruption and flood cause failure of existing infrastructure instantly, which results in great economic loss. Prevention measures against natural disaster are quite important.
3) Environmental issues are concerns of all participating countries. Water quality preservation and air pollution were discussed intensively. The current problems and implementation method of environment impact assessment of each country were discussed in earnest.
4) As to the construction and improvement of the infrastructures in urban area, an example of utilization of underground space was introduced, and many questions were raised.
5) In addition, several informative topics were presented on the specific issues each country is currently facing.

3. Subjects of Common Interests of All Countries

Issues on Future Perspective for Research and Development of Disaster Prevention Techniques against Disaster caused by Rainfall were discussed.

1) The participants deepened their understanding of the present situation of disasters, and the countermeasures and policies to avoid disasters in participating countries. At the same time, it is well recognized that they are diversified due to the difference of natural and socio-economic conditions.
2) Regarding river-related disaster, comprehensive flood mitigation measures including both structural measures and non-structural measures should be taken, and it is important and essential to promote research and development in that direction. It is agreed to promote exchange of information on this regard.
3) As for sediment-related disaster, it is recognized that disaster caused by slope failure and its countermeasure in each country are extremely diverse. With regard to this issue, it is agreed to promote exchange of information for mutual understandings. It is suggested that uniform format should be made for data exchange of slope failure, especially concerning highways.
4) It is quite fruitful to have discussion focusing on the common interests of all participating countries. It was pointed out that such discussions on common interests should be continued at coming conference. It is proposed and agreed that environmental issues such as water quality conservation and urban environment (noise, air pollution) should be discussed in the future.

4. Specific Subjects

The concerned participants gathered to discuss the specific subjects of public works. At the present meeting, the following eleven subjects were selected according to the interest of the participants among the many fields of construction technology and discussed separately :
Sedimentation of Dam Reservoir (China and Japan), Water Pollution Control (Indonesia and Japan), River Environment (Korea and Japan), Soil Improvement (Thailand and Japan), Tunnel (Singapore, Thailand and Japan), Volcanic Disaster, Debris flow and Road Disaster Prevention (Malaysia, Philippines and Japan), River (China and Japan), Water Quality (Korea and Japan), Soil Mechanics and Foundation Engineerings, Traffic Engineering (Malaysia, Thailand and Japan), Pavement (Philippines, Singapore, Thailand and Japan), Highway Bridges (Philippines and Japan). Several problems of each country in the individual field of civil engineering technology and situation of research were understood mutually by participants through this discussion. Moreover the necessity of further technical cooperation, such as future exchange of detailed information, in specific field of civil engineering was recognized.

5. Conclusion

1) Through the presentation of the country reports, the participants deepened their understanding on current situations, their problems, perspectives etc. of other participating countries.
2) Through the discussion on subjects of common interest in all countries, it is agreed to promote the exchange of information in order to pursue research and development on comprehensive prevention measures against river-related disasters and sediment-related disasters.
3) It is suggested that environmental issues in relation with public works such as water pollution, air pollution and noise be discussed in the future should be discussed in the future, taking into account of diversity of natural and socio-economic conditions of each country.
4) Through the discussion on specific subjects, each participating country deepened in detail the mutual understanding of the present situation of the technical problems and current research activities of of each country. Many views were exchanged on the importance of technical cooperation including the further exchange of information and human resources among the countries.
5) Recognizing the importance of sharing the accumulated experiences and the efforts of research and development among the countries to promote and ensure further development of social infrastructures, It was unanimously agreed through the discussion that this conference was productive, and it would be important to continue and develop the conference.

Ⅳ. Address of Closing Ceremony

Address of Closing Ceremony

Mr. Yukihiko Sumiyoshi, Director-General, PWRI, MOC

This conference has been the first attempt for an international meeting for an exchange of informations and opinions among executive members from East Asian countries in the field of Public Works Research and Development. We just conclude the session with the adoption of the final resolution. We could agree once again on the necessity of international cooperations.

In the bright future, we could just confirm not only in the field of Public Works Research and Development but field beyond it, we are finally realizing a more fruitful international cooperation.

Thanks for persons concerned.

Dr. Lee Sang Eun, Vice President,
Korea Institute of Construction Technology

I am sure that the conference has been very fruitful. We have been very fortunate during last 5 days to be involved in in-depth discussions on various aspects of Public Works Research and Development and also to get acquainted with actual situation of each country. We all realize that technology development is essential for consistent economic and social development and that the cooperation among Asian countries is important.

We all know this is only a beginning and, we all wish the cooperation among Asian countries will be continued and become more active through this conference here after.

(E) STUDY TOUR

I . Study Tour

1. Study Tour

Outline

The program of the First Conference on Public Works Research and Development in Asia included a one-week tour from February 20 (Sat) through February 26 (Fri) to inspect and study the development of major infrastructure in Hokkaido and Kanto Area.

The itinerary is as follows:

20 (Sat) : Move [Tsukuba → Tokyo → Chitose → Sapporo]
Inspection on Shin-Chitose Airport

21 (Sun) : Inspection in Sapporo City
Okura-yama
Sapporo Beer Factory
Historical Museum of Hokkaido

22 (Mon) : Hokkaido Development Bureau
Civil Engineering Research Institute
Symposium on Public Infrastructure and Civil Engineering in Asia

23 (Tue) : Move [Sapporo → Muroran]
Toyohira River Integrated Dam Group Operation Office
Sapporo River Office
Sapporo Subway Construction
Muroran Hakucho Bridge

24 (Wed) : Move [Muroran → Hakodate → Aomori → Tokyo]
Inspection on Seikan-Tunnel
Aomori Construction Office

25 (Thu) : Courtesy call on Ministry of Construction
Inspection on Trans-Tokyo Bay Highway
Farewell Party (Hosted by Mr. Yukihiko Sumiyoshi, Director-General, PWRI, MOC)

26 (Fri) : Move [Tokyo → Atsugi → Tsukuba]
Inspection on Miyagase Dam
Courtesy call on Tsukuba International Center, JICA

Acknowledgement

The tour was made possible through the dedicated efforts and kind cooperation of Hokkaido Development Bureau, Civil Engineering Research Institute, Shin-Chitose Airport Management Center, Toyohira River Integrated Dam Group Operation Office, Sapporo River Office, Sapporo City, Muroran

City, Muroran Road Office, Japan Highway Public Corporation, Trans-Tokyo Bay Highway Corporation, Miyagase-Dam Construction Office and Japan International Cooperation Agency. We'd like to express our sincere thanks to them all.

February 20 (Sat) Shin-Chitose Airport Terminal

Leaving Tsukuba Dai-ichi Hotel by bus at 8:40 and by taking JR trains and Monorail. The party arrived at Haneda Airport in time for lunch and for the 13:00 Flight JAL #513 for Shin-Chitose Airport.

Upon arrival at the Shin-Chitose Airport was met by Mr.Mori, Deputy Director General and Mr.Ogasawara, Director of Research Planning and Coordination Section, of Civil Engineering Research Institute, Hokkaido Development Bureau and then led to the Shin-Chitose Airport Terminal, which started operation on July 1, 1992. Mr.Fujita, Manager of Shin-Chitose Airport Management Center explained, among others, the outline of the new terminal building, future perspective, and runway management including snow removal works.

After the inspection of the airport facilities, the bus took us to Sapporo via Hokkaido Chuo Expressway and then to Sapporo Grand Hotel around 18:30.

February 21 (Sun) Inspection in Sapporo City

At 9:00 the party headed toward Okura-yama, wellknown as the ski jump site of Sapporo Olympic Games 1972. Second stop later in the morning was at Sapporo Beer Museum, where historical background of beer brewery along with the development of Hokkaido was explained.

The visit to the Historical Museum of Hokkaido in the afternoon offered the members a very good insight into the nature, history and culture of Hokkaido. The bus brought us back to the Hotel around 16:00.

February 22 (Mon) Symposium on Public Infrastructure and Civil Engineering in Asia

After leaving the Hotel at 8:15 the first stop was at Hokkaido Development Bureau for a meeting with the Director-General, Mr.Yanagawa.

The visit to Civil Engineering Research Institute was given by Dr.Ota, Director-General and Mr.Mori, Deputy Director-General, followed by the explanation of current situations of public works development in cold region and visits to the laboratories and the experiment facilities.

Back to the Hotel for the preparations of the Symposium, starting at 13:00.

This Symposium on Public Infrastructure and Civil Engineering in Asia was held under the Joint auspices of Civil Engineering Research Institute, Hokkaido Development Bureau and Public Works Research Institute, Ministry of Construction supported by Hokkaido Government and Sapporo Municipal Government and others. The Symposium attracted a large audience including the press of about 200 people from governmental and private organizations as well as universities.

The Symposium consists of two sessions. One is Keynote Lecture "Public Infrastructure Projects in Hokkaido Develpment" by Dr.Hideo Igarashi, Professor of Civil Engineering, University of Hokkaido. The other, Panel Discussion, is made with theme "Public Infrastructure Projects in Each Country and Their Technical Problems" of Coordinate by Dr.Ota, Director-General, CERI, and 8 Panelists from each countries.

The Symposium session was concluded at 17:30 ending with the reception hosted by Hokkaido Development Bureau.

February 23 (Tue) Inspection in Sapporo City and Muroran City

Leaving the Hotel at 8:30, the first visit was Toyohira River Integrated Dam Group Operation Office. Sapporo River Office, where its river training works and of information management system of Ishikari River were explained.

Next the tour took us to the construction site of subway (extension work of Toho Line), an important transportation means in Sapporo City, Outline of the whole project and a new tunnelling method were explained.

Leaving Sapporo for Muroran by bus in the afternoon, the party visited the Hakucho Bridge, which upon completion is going to be the longest suspension bridge in Eastern Japan. Mr.Konagai, Director of Muroran Road Office, Muroran Development and Construction Department explained the construction works in progress.

The bus arrived at Muroran Sunroute Hotel at 18:00.

February 24 (Wed) Seikan Tunnel

The 8:27 train Hokuto #2 leaving Higashi-Muroran Station at 8:27 took the party to Aomori via Hakodate and Seikan Undersea Tunnel. For one hour from 12:20 to 13:20 Mr. Tomine of JR Hokkaido guided the party all through Tappi undersea station with explanations of the Seikan Tunnel, the longest in the world, and its management system.

Before proceeding to Aomori Airport, we made a brief stop at Aomori Work Office, Tohoku Regional Construction Bureau, welcomed by Mr.Ikeda, Director.

JAS Flight #216 left Aomori Airport at 16:30 for Haneda Airport, from where the party directly headed for Tokyo International Center.

February 25 (Thu) Trans-Tokyo Bay Highway

A report on the Conference was given to Mr. Mitani, Vice-Minister of Construction at the occasion of courtesy call on Ministry of Construction in the morning.

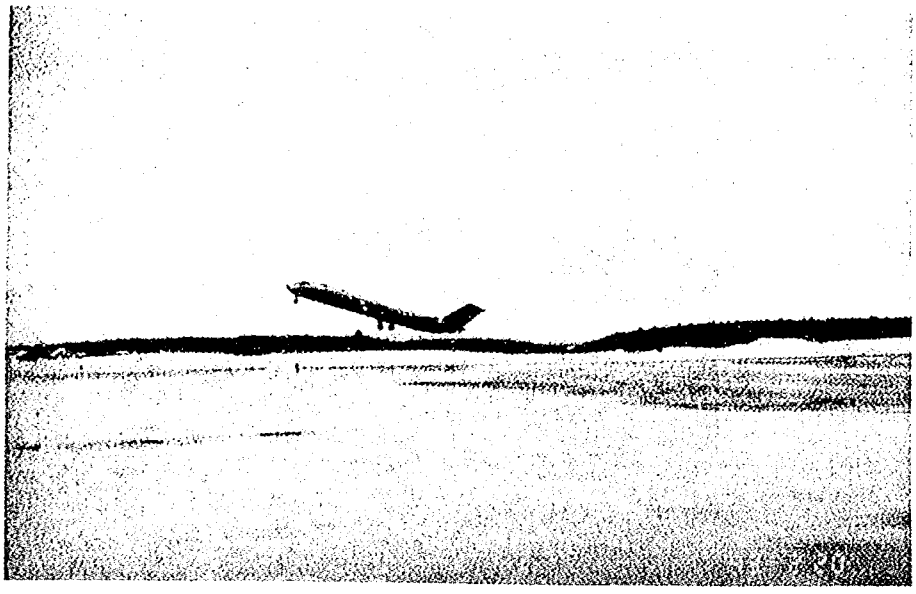
Later Mr.Ikeda, director of Works Coordination Dept., Japan Highway Public Corporation, was the guide to Kawasaki. During the boat ride from Kawasaki to Kawasaki Man-made Island the whole picture of the bridge construction work was presented by Mr.Shioi, Director of Technology Department of Trans-Tokyo Bay Highway Corporation.

A Farewell party hosted by Mr.Sumiyoshi, Director-General of Public Works Research Institute was held at Pastoral, Toranomon.

February 26 (Fri) Miyagase Dam

The bus left Tokyo International Centre at 7:30 for Miyagase, Atsugi City, Kanagawa Prefecture via Chuo Expressway. Upon arrival at Miyagase-Dam Construction Office, Kanto Regional Construction Bureau, the party was briefed on the Miyagase Dam project. one of the largest dams in Japan, as well as RCD method by Mr. Adachi, Director of Miyagase-Dam Construction Office.

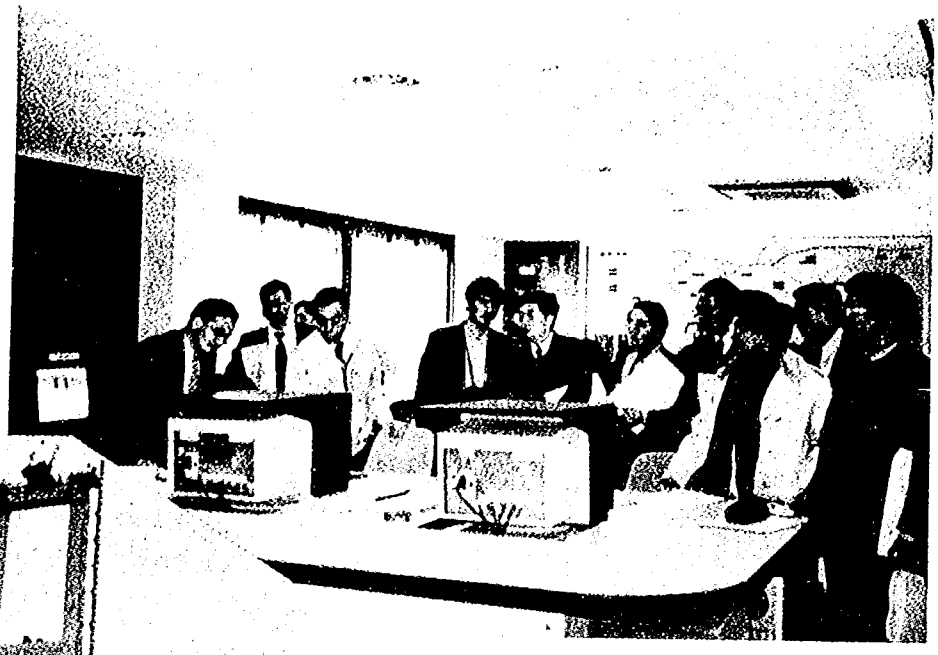
Leaving Miyagase at 13:00 the bus arrived at Tsukuba International Centre, Japan International Cooperation Agency at 16:30. Special thanks for their full support to the Conference were offered to Mr.Iimura Director of Tsukuba International Centre along with a report of successful conclusion of the Conference.



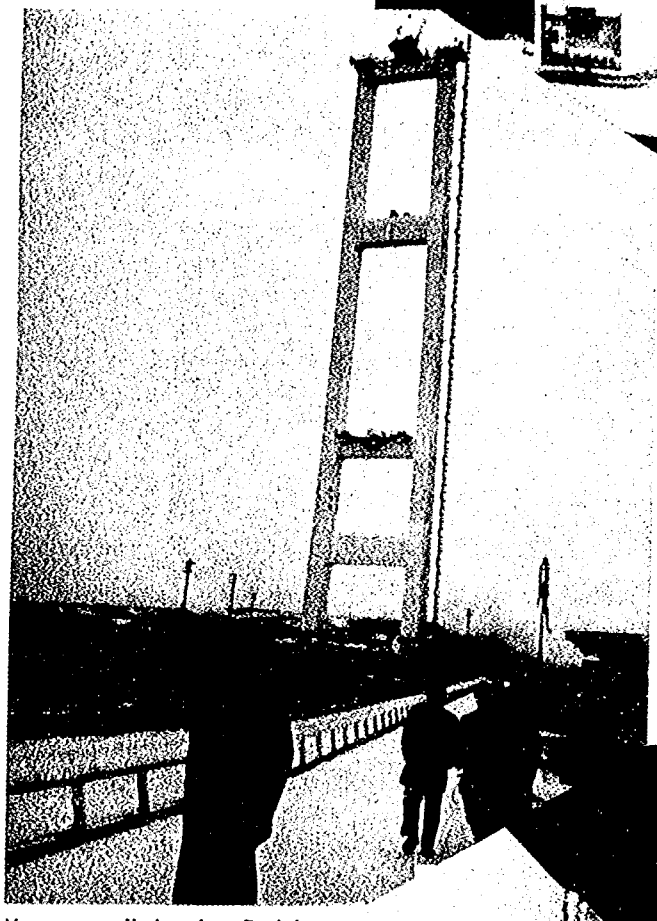
Shin-Chitose Airport (Feb. 20th)

Hokkaido Development Bureau (Feb. 22th)

Symposium on Public Infrastructure and Civil Engineering in Asia
(Feb. 22th)

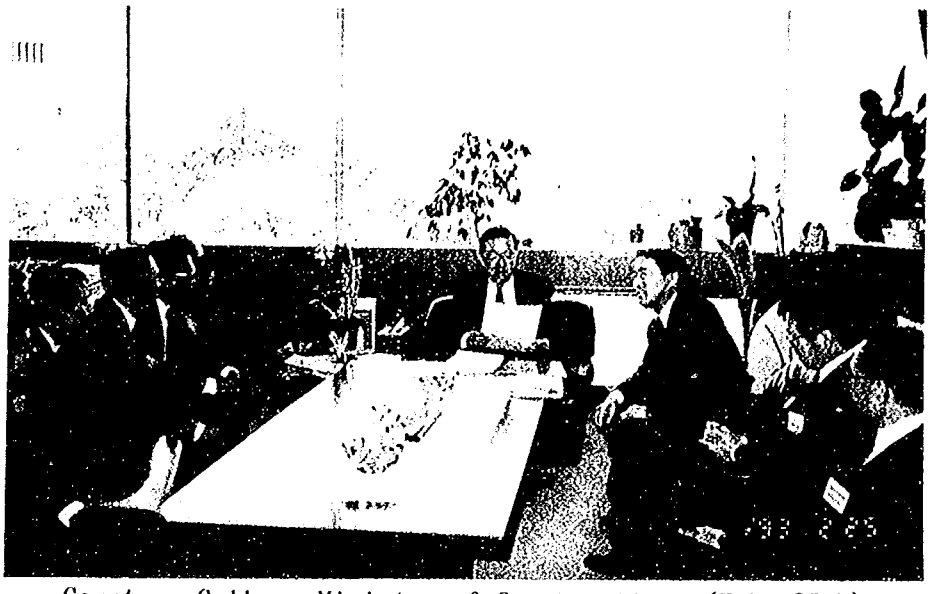


Toyohira River Integrated Dam Group Operation Office / Sapporo River Office (Feb. 23th)



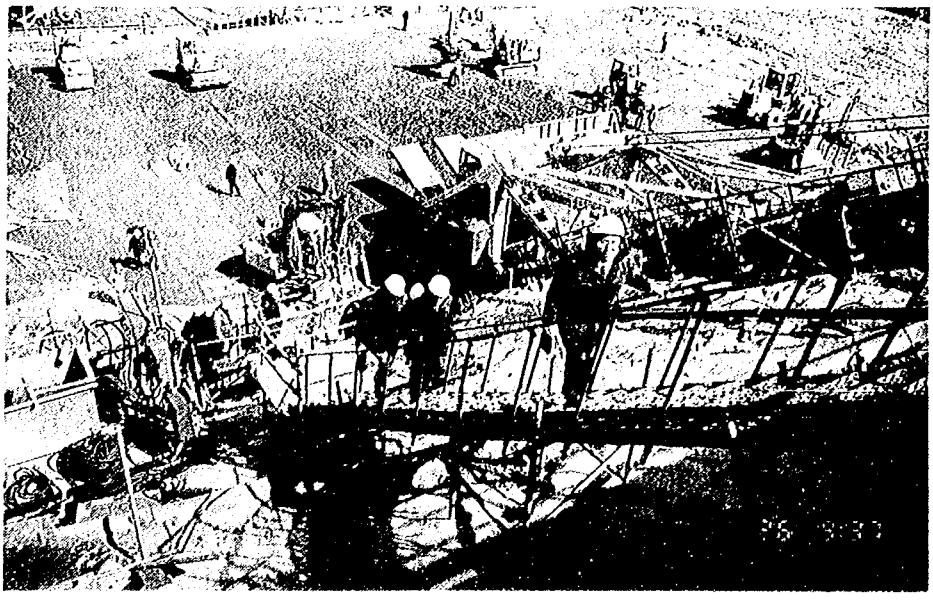
Muroran Hakucho Bridge (Feb. 23th)

Seikan Tunnel (Feb. 24th)



Courtesy Call on Ministry of Construction (Feb. 25th)

Trans-Tokyo Bay Highway (Feb. 25th)



Miyagase Dam (Feb. 26th)

II. Symposium on Public Infrastructure and Civil Engineering in Asia

1. Keynote Lecture on 「Public Infrastructure Projects in Hokkaido Development」
   Prof. Hideo Igarashi, Hokkaido University

2. Panel Discussion on 「Public Infrastructure Projects in Each Country and Their Technical Problems」

PROGRAM

13:30~13:45 Opening address: Toshitaka Ohta
Director General, Civil Engineering Research Institute,
Hokkaido Development Bureau

Address: Yukihiko Sumiyoshi
Director General, Public Works Research Institute, Ministry of Construction

13:45~14:45 Keynote lecture: "Development and Infrastructure of Hokkaido"
Hideo Igarashi
Professor, Faculty of Engineering, Hokkaido University

14:45~15:55 (recess)

14:55~16:25 Panel discussion
Theme: Public Infrastructure Projects in Each Country and Their Technical Problems
Coordinator: Toshitaka Ohta
Director General, Civil Engineering Research Institute,
Hokkaido Development Bureau

Panelists
Japan
Yukihiko Sumiyoshi, Director General, Public Works Research Institute,
Ministry of Construction

People's Republic of China
Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research, Chinese Academy of Sciences, Ministry of Water Resources, Ministry of Energy

Republic of Indonesia
Badruddin Machbub, Director, Research Institute for Water Resources Development, Agency for Research and Development, Ministry of Public Works

Republic of Korea
Lee Sang Eun, Vice President, Korea Institute of Construction Technology

Malaysia
Abdul Rahman B. Abdullah, Deputy Director General, Public Works Department, Ministry of Works

Republic of the Philippines
Manuel M. Bonoan, Assistant Secretary for Planning,
Department of Public Works and Highways

Republic of Singapore
Tan Siong Leng, Director, Building Control Division, Public Works Department, Ministry of National Development

Kingdom of Thailand
Teeracharti Ruenkrairergsa, Director General, Road Research Development Center, Department of Highways, Ministry of Transport and Communication

16:25~16:30 Closing address: Yasuo Mori
Assistant Director General, Civil Engineering Research Institute,
Hokkaido Development Bureau

1. Keynote Lecture on 「Public Infrastructure Projects in Hokkaido Development」

Prof. Hideo Igarashi, Hokkaido University

Development and Infrastructure of Hokkaido

- Reasons for Success and Typical Results -

Hideo Igarashi
Professor, Faculty of Engineering, Hokkaido University

1. Beginning of Development and Frontier Spirit

1-1 Turning point of development

Hokkaido has been a front for the defense of the country and a frontier for the advance of its civilization.

In 1856, Hokkaido, then called "Yezo," served as a front to prevent Imperial Russia from advancing southward in the Far East. Russia advanced beyond the Urals to Kamchatka and watched for a chance to advance southwards.

In order to prevent a southward advance by the Russians, the Tokugawa shogunate ordered six feudal clans of the Ohu area (the Tsugaru, Nambu, Akita, Sendai, Shonai and Aizu clans) to defend Yezo. The samurai warriors of the Akita clan assumed responsibility for defending the Soya district, which was the northernmost part of Western Yezo. Records show that they drank coffee, not as a treat but as a beverage to resist the severe cold of the northernmost area of Japan and to prevent edema, which resulted from insufficient vegetable intake.

According to 1982 statistics, the annual coffee consumption per capita of major countries in the world is as follows: Finland (12.77 kg), Sweden (11.73 kg), Denmark (11.46 kg), Norway (10.51 kg), France (5.94 kg) and US (4.77 kg). Cold Northern European countries consume much more coffee.

The benefits of coffee were outlined on coffee bags, as follows: "Dutch coffee beans, which prevent chills and rheumatism. Use as follows: 1 coffee bag can be used repeatedly to make coffee, until it loses flavor." The directions resemble today's directions for tea bags. Coffee was probably brought to Yezo by foreign vessels which arrived at Hakodate. Coffee was brought to Yezo 20 years before coffee shops opened in Tokyo.

As mentioned above, foreign civilization was making inroads into Hokkaido even before Japan opened the door to foreign countries after the Meiji Restoration. In this way, Hokkaido was the frontier of Japanese civilization.

After the Meiji Restoration, the Meiji government also emphasized the defense of Hokkaido, for the same reasons as the Tokugawa shogunate. At the same time the Meiji government considered the development of Hokkaido important. In order to execute the development of Hokkaido systematically as an important, large-scale, national project, the Mission of Hokkaido Development, a special government office to develop Hokkaido, was established in 1869. Furthermore, the Colonial Troops System was introduced to develop and defend Hokkaido. The farmers-soldiers were given houses, land, farm implements and other necessary goods by the government. They lived in Hokkaido and engaged in farming in peacetime, but they were required to undergo the same military training as regular soldiers when not engaged in farming.

In Kotoniheison, farmers-soldiers got up at 4 a.m., started work at 6 a.m. (they jointly cultivated the land during the first year.), had a 1-hour lunch break, and went home at 6 p.m. in the summer (April-September). Military training was conducted mainly during the off season. The agriculture of that time emphasized sericulture and hemp spinning. The names of places in Sapporo today indicate this emphasis. Soen means mulberry garden, and Asabu is so named because it's the former site of flax factories.

Large-scale development of Hokkaido started in the Meiji era. The early development was conducted in accordance with Japanese traditional development methods. After the Mission of Hokkaido Development was established, development methods which were more suitable for Hokkaido's climate and natural features were adopted. It was decided that the development of Hokkaido would benefit from the help of experienced foreign advisors, and a chief foreign advisor was sought after in U.S. Horace Capron, who at that time was the Commissioner of the U.S. Department of Agriculture, was selected as the leader. The Meiji government had already employed foreign specialists in various fields to accelerate the modernization of Japan. Most of them were from European countries, including Britain, France

and Germany. Only the Mission of Hokkaido Development employed mainly Americans, because the vision of Hokkaido's future paralleled the history of American development in which America vigorously expanded its frontier westwards from the east coast.

During the short period from 1871 to 1881 the Mission of Hokkaido Development employed 78 foreigners in total, of which 45 were American. Furthermore, many foreigners employed by the Mission of Hokkaido Development worked in Hokkaido, not in Tokyo, unlike foreigners employed by other central government offices.

Hokkaido people are characterized by their freedom and broad-mindedness, and their lifestyle is said to resemble the American lifestyle. These characteristics may have come from the contact Hokkaido pioneers had with foreigners employed by the Mission of Hokkaido Development.

According to the contract between the Mission of Hokkaido Development and Capron, who was the commissioner and advisor, his job involved: (1) surveying Hokkaido's topography and strata and inspecting mines and other facilities; (2) improving access to all areas by construction of roads and waterways and zoning of hamlet, village and town lots; (3) studying forestry, stock farming, mining, fishing and hunting methods; (4) estimating costs of these works and establishing their objectives; (5) presenting the cost estimates and objectives to the Japanese government and executing these works; (6) assisting the Director General of the Mission of Hokkaido Development and conferring with him regarding administrative affairs.

The contract specified that Capron would: (1) receive an annual salary of $10,000 (¥10,000 in Japanese yen at that time; (2) be reimbursed all his expenses, including those for traveling and food; (3) be accommodated in a proper house and have policemen and waiters available; (4) be assisted by foreign scholars well-versed in various fields.

Capron's annual salary of $10,000 was the second highest among foreigners employed by the Japanese government, after that of Thomas W. Kinder's annual salary of $12,540. Kinder was British and employed as Director of the Mint Bureau, Ministry of Finance. The Prime Minister received an annual salary of ¥9,600 (about $9,600: ¥1 = about $1), the highest among high-ranking Japanese officials. The Ministers of the Left and Right received ¥7,200. Cabinet Councilors and Ministers (who resembled present-day ministers) received ¥6,000. Vice-ministers, like Kiyotaka Kuroda, who was in charge of the Mission of Hokkaido Development, received ¥4,800. Capron's annual salary indicates the Japanese government's dedication to the development of Hokkaido.

As mentioned above, the Meiji government engaged wholeheartedly in the development of Hokkaido. The Japanese government paid foreign advisors high salaries, over twice as much as that of the person in charge of Hokkaido development and more than that of even the Prime Minister, the highest-ranking official of the central government, in order to develop Hokkaido, a remote region of Japan.

Hokkaido's population was about 50,000 in the early days of development (1869). As a result of these efforts, Hokkaido's population grew to be more than 5,680,000, about 110 times that of the early days of development, within 120 years. Hokkaido's population is now larger than that of Denmark (5,130,000).

1-2 Work ethics of colonists

Isami Hiroi (1862-1928) has been hailed by many civil engineers as one of the great pioneers who established the foundation of Japan's civil engineering.

In July 1881, Hiroi graduated with the second group to graduate from Sapporo Agricultural College, an educational institution founded by the Mission of Hokkaido Development. He became a world-famous authority on harbor and bridge construction technology in the early 20th century. He greatly contributed to railroad and bridge construction, river mouth and harbor improvement, and other construction work in Hokkaido.

One day when Hiroi was the head of the Otaru Chikko Office, Soichiro Asano, who was the founder of a "sangyo zaibatsu" (industrial group of companies) which monopolized the cement industry, visited a construction site near Otaru port to see how his company's cement was used there. He encountered a man who was diligently mixing cement on the site. Asano told the man about the object of his visit and asked the man to show him the way to Hiroi's office. The man stopped mixing cement and said, "I am Isami Hiroi, head of Otaru Chikko Office. What is the object of your visit?" Asano was very surprised at Hiroi's remark, but he admired Hiroi's character and realized that Hiroi would be a great man some day. It is said that Asano's respect for Hiroi never died. Hiroi went to the sites earlier than ordinary laborers and worked in his office past midnight. He never assumed an arrogant attitude toward anybody, even though he was an employer and high-ranking official.

Such devotion of the Japanese toward work is based on a work ethic which differs from that of Western countries. That is to say, the Japanese don't despise work. To be more precise, the Japanese regard doing a job well as sacred duty, similar to that of the gods who were the an-

cestors of the Japanese, as part of the process of self-discipline to become Buddha, and as the esteemed activity of human beings. Therefore, "work" is usually called "vocation" in Japanese and has the connotation of devotion to divinity and mankind.

This Japanese philosophy resembles Puritan Protestantism. In Western countries, work has usually been regarded as labor, an attitude which may stem from a verse in the Old Testament. When God expelled Adam and Eve from the Garden of Eden, He said, "With the hard work of your hands you will get your bread..." (Genesis 3:19).

On the other hand, gods of Japanese mythology worked daily in Takamagahara (the Plain of High Heaven), where they lived. According to the Kojiki, which was completed in 712 and is the oldest record of ancient matters, Ama-terasu-oho-mi-kami (Heavenly Shining Great August Deity), the highest-ranking deity, was a goddess who wove alone in a weaving house. Gods also cultivated fields and engaged in agriculture. This tradition continues with today's emperor, who plants rice seedlings in a paddy field in spring, harvests the rice in autumn, and offers the harvest to gods. Therefore, we Japanese don't despise work in the least, since apparently the emperor also works.

After Buddhism was introduced into Japan, it was transformed into Japanese Buddhism with a changed doctrine. Shosan Suzuki (1579-1655), a Zen scholar in the early Edo period, explained the work ethic of samurai warriors, farmers, craftsmen and merchants in his book, "Banmin Tokuyo (Economy for All the People)." He stated that all work which is well done contributes to society and benefits mankind. When the laity works hard, with faith in a sense of gratitude to Buddha, they serve Buddha just as priests do. For example, when they diligently engaged in farming, with their firm faith in Buddha, farming was not simply work but the noble religious discipline of Buddhist saints who sought to become Buddha.

Such a philosophy is also found in the Sekimon Shingaku school, which was founded by Baigan Ishida (1685-1774). The work ethic of Sekimon Shingaku school is as follows: "The way of merchants is to pursue reasonable profits. However, the merchants who profit through inhumanity will fail and bring ruin to their families. When merchants learn about how to conduct business humanely, their families prosper because they are free from unjust greed and can work humanely. Therefore, even merchants must keep in mind that they should help the poor." (Tohi Mondo by Baigan Ishida)

Not only farmers and merchants but also samurai warriors had such a work ethic.

Kanzo Uchimura, who was Japan's leader of Christianity during the Meiji and Taisho eras, published a book, "Japan and the Japanese" (translated by Toshiro Suzuki, Iwanami Bunko, 1941). In the book, he praised Uesugi Yozan Harunori (1751-1822), a feudal lord, as being a typical Japanese. Harunori had the same work ethic as the modern Japanese. He encouraged the military, agricultural, industrial and merchant classes in the Yonezawa clan to work diligently and harmoniously to rebuild the clan economy. At one time, Yozan himself cultivated the fields and planted mulberries in the castle to breed silkworms, and encouraged his subjects to plant mulberries in their houses. Uesugi Yozan respected work and issued the Denkoku-no-ji Advice. The advice was given to his son, Haruhiro, when he succeeded the Uesugi family. It consisted of the following three articles as rules for feudal lords.

February 7, 1785

Mr. Haruhiro:

1. Nation (the Yonezawa clan) should be passed on to descendants and should not be private property of the feudal lord.
2. The people are citizens of the state and should not be private property of the feudal lord.
3. The feudal lord exists for the state and the people; the people do not exist for the feudal lord.

Harunori

(Translated into modern Japanese by the author)

Such a philosophy continues in modern Japan and forms the foundation of the administrative philosophy of Japanese companies. In other words, today's Japanese companies resemble the Yonezawa clan of the feudal times. Companies are considered to be owned not only by stockholders, creditors and management but also by employees, though employees have no actual say in the

administration of the companies. Therefore, the crises of a company result not only in crises for the management but also for employees. Therefore, employees demand only modest wage increases and work diligently to overcome crises. Discharge of employees by the management is a last resort.

Furthermore, there is no discontinuity between supervisors and workers in Japan's employment relationships. Most workers who have worked for 20 years or more are promoted to junior supervisors. Junior supervisors can be promoted to senior supervisors. When college graduates and postgraduates join companies, they first have to engage in regular work like ordinary workers. Some engineers are assigned to financial affairs or sales. They obtained a wide range of experience and are promoted from lower positions to higher positions. In some cases, they become executives or presidents.

The Japanese regard work as a chance to be recognized by colleagues and something to live for. Work is respected activity. Through work, workers can be evaluated by their peers, obtain chances to be promoted, and get satisfaction from doing good works. This philosophy can be seen as both a strong and weak point of Japan. When it has positive effects, regional development work develops rapidly due to the devoted cooperation of all concerned. When it has a negative effect, regional development work, which is a measure to enrich our lives and bring us happiness, becomes an aim in itself. All concerned make meaningless efforts to accomplish the false aim and become exhausted.

1-3 Education of Colonists and Sapporo Agricultural College

The Mission of Hokkaido Development thought that Hokkaido's development should be based on technology and regarded the education of human resources as an urgent matter. The Mission of Hokkaido Development established the Colonization Commission School (provisional) in Tokyo in 1872. A girls' high school was established as an annex to the school to educate wives of Hokkaido colonists in September of the same year.

The aims of large-scale regional development involve not only development of land and natural resources but also social development and education. The Mission of Hokkaido Development realized that regional development would succeed only if it was based on cooperation between men and women. This philosophy can be applied to current regional development and must not be forgotten.

Horace Capron served as an advisor to the Mission of Hokkaido Development. He was the Commissioner of the U.S. Department of Agriculture before assuming his position as an advisor, and was knowledgeable and experienced in terms of colonization. Before assuming the position of advisor, Capron regarded an agricultural school as an essential element of regional development. He therefore proposed the establishment of an agricultural college. This proposal was agreed to by Kiyotaka Kuroda, who was in charge of the Mission of Hokkaido Development. The Mission of Hokkaido Development accepted the proposal and promptly requested the U.S. government, through the Japanese minister to the U.S. Kiyonari Yoshida, to recommend a qualified person who could organize an agricultural college. William Smith Clark, who was then the president of the Massachusetts Agricultural College, was invited to Hokkaido. Clark accepted the invitation and came to Sapporo in July 1876 on one-year contract, accompanied by Prof. William Wheeler and Prof. David P. Penhallow. As soon as he came to Sapporo, Clark immediately prepared a curriculum for Sapporo Agricultural College, organized subjects of study, and established a four-year course. Graduates were granted bachelor's degrees. The students of Colonization Commission Sapporo School, which had already been established, took tests given by Clark, and 12 students passed the tests. Eleven students took tests in Tokyo and were admitted to Sapporo Agricultural School. The 23 students were admitted to the school as government students of regular courses to the school. A three-year preparatory course in the liberal arts was established along with a regular course which government students took.

Hirotake Zusho was the principal of Sapporo Agricultural College, and Clark was vice-principal. Wheeler was the head of the farm and a professor of mathematics and civil engineering. Penhallow was a professor of botany and chemistry.

The school name was "Noh Gakko," which was translated from the English name, Agricultural College. Colonization Commission Sapporo School was closed, and Sapporo Agricultural College was opened on August 14, 1876. It developed into the current Hokkaido University. The anniversary of the founding of Hokkaido University is August 14, and it celebrates the 117th anniversary of its founding this year.

2. 10-Year Hokkaido Development Plan to Fifth Hokkaido Comprehensive Development Plan

2-1 Days of Mission of Hokkaido Development

In 1872, the Mission of Hokkaido Development drew up the 10-year Hokkaido Development Plan, the first development plan for Hokkaido. Based on this plan, acceptance of colonists was promoted, land and sea routes were constructed, coal mines were developed, railroads were constructed, the Colonial Troops System was established to relieve the difficult situation of the former samurai class and defend Hokkaido, the purchasing system of agricultural products was established, and government-run processing factories, including a brewery, were constructed.

2-2 Days of three prefectures and one bureau

The Mission of Hokkaido Development was abolished in February 1882, when the 10-year Hokkaido Development Plan ended, and governments were established in 3 new prefectures: Hakodate, Sapporo and Nemuro. Colonization, forests, Sapporo Agricultural College, and so on, which had been under the jurisdiction of the Mission of Hokkaido Development, were transferred to the Ministry of Agriculture and Commerce. Factories, coal mines and railroads were transferred to the Ministry of Engineering. The Colonial Troops System was transferred to the Ministry of Army. In 1883, Hokkaido Administrative Management Bureau was established in the Ministry of Agriculture and Commerce to centrally administer agricultural and industrial works again. However, the abolishment of the Mission of Hokkaido Development, which had unified development works of Hokkaido, was a hard blow to Hokkaido, which had just started large-scale development, to carry out development works. Therefore, no outstanding development works were conducted during the days of three prefectures and one bureau.

This fact shows the necessity of a strong organization, such as the Commission of Hokkaido Development, to unify all the development works and to develop a remote region.

2-3 Days of Hokkaido Development Board

The national government was worried about the sluggish development of Hokkaido and dispatched Chief Cabinet Secretary Kentaro Kaneko to Hokkaido to investigate the state of colonization there. In his report to the government, he stated that administrative reform was necessary to carry out large-scale colonization. The national government therefore abolished the three prefectures and the Hokkaido Administrative Management Bureau, and established the Hokkaido Administrative Development Board in January 1886.

The Director General of the Hokkaido Development Board, who resembled the present day ministers of state, administered colonization affairs. Development of Hokkaido was promoted under the jurisdiction of the national central administrative organization for about 60 years until the Local Autonomy Law was enacted in May 1947.

(1) Early days of Hokkaido Development Board

There were no specific development plans during the early days of the Hokkaido Development Board (from 1886, when Hokkaido Development Board was established, to 1901). The basic development policy of Hokkaido was converted from one of direct protective policy to colonists, which was conducted by the Mission of Hokkaido Development, to one of indirect protective policy to colonists, which aimed primarily to improve the basic conditions of colonization. With Japan's economy growing, the basic development policy of Hokkaido changed drastically to invite capital.

Government factories and mines were sold off to private interests. Furthermore, vast areas of land were disposed in accordance with the Hokkaido Land Disposal Regulation and the Hokkaido National Undeveloped Land Disposal Law. Selection work of land to be colonized started, and large landowners came into being as land division for agriculture and livestock farming was promoted.

Furthermore, Otaru, Muroran, Kushiro and other ports opened, and the Hokkaido Colonial Bank was established in 1900. Basic conditions of colonization were gradually improved.

(2) Days of 10-Year Hokkaido Development Plan

Rapid development of Japan's economy started with the Sino-Japanese War, and resulted in the rapid increase of the population and the birth of poor farmers. The development of Hokkaido was increasingly emphasized as a solution to the aforementioned problems. In 1901, the 10-Year Hokkaido Development Plan and the Hokkaido Local Expenses Law were enacted. Hokkaido's administrative expenses had been paid by the National Treasury until that time, but an "Autonomous System" was introduced and the administrative expenses were divided into national and local expenses.

In 1901, the 10-Year Hokkaido Development Plan began with a budget of ¥21,610,000. The development plan aimed to conduct colonization work, construct and repair roads and bridges, construct Otaru and Kushiro ports, extend postal and ferry services, dredge rivers, including the Ishikari River, subsidize sea routes, and conduct other works in various fields. However, expenses were covered as planned for only the first 2 or 3 years, after which payments were reduced due to the Russo-Japanese War in 1904. Even after the war ended, the 10-Year Hokkaido Development Plan did not advance as planned due to fiscal constraints, and was discontinued after 9 years, after which a new plan was drawn up. Hokkaido's population totaled 1,540,000 in 1909.

(3) Days of First-term Colonization Plan

In 1910, the national government started a new 15-year plan, "First-term Colonization Plan," because they realized the necessity of national power development after the Russo-Japanese War. The plan aimed to survey the land, select and zone land for colonies, dispose of undeveloped national land by sale, promote industry, conduct research and experiments to establish a foundation for agriculture and fisheries, construct and improve roads and bridges, develop paddy fields, conduct Ishikari River improvement work, survey and repair harbors, including Otaru harbor, and conduct other works. The plan was revised several times due to the recession during the early period of the plan, to the economic boom during World War I and to the recession in reaction after the war. However, colonization expenses increased yearly during the later period of the plan, and colonization works advanced rapidly. Many new works which had not been planned were incorporated into the plan.

During the period of the plan, fisheries, agriculture and the manufacturing industry developed rapidly. Many private enterprises entered the manufacturing industry in particular, and the manufacturing industry became Hokkaido's major industry, exceeding agriculture in output in 1920.

The aims of the First-term Colonization Plan were to increase the population to 3 million and distribute 1,650,000 chobu (about 1,636,000 ha) of undeveloped land. The plan was carried out in 1910-1927. In March 1927, the plan ended with the actual results of a population of 2,430,000 and 1,350,000 chobu (about 1,339,000) in undeveloped land transferred.

(4) Days of Second-term Colonization Plan

The First-term Colonization Plan ended successfully. However, new problems, including improper policies to stabilize production, also occurred because resources were exploited primarily during the 60-year colonization of Hokkaido.

The end of the First-term Colonization Plan was a turning point to solve these problems and the Second-term Colonization Plan was drawn up as an important national policy.

The Second-term Colonization Plan started in 1927 and unprecedented financial measures were taken, with total expenses of ¥960,000,000 for the 20-year period. In accordance with the plan, the government exploited undeveloped land, developed paddy fields, and administered facilities of transport, industry and civil engineering which were necessary for population movement. The plan aimed to turn 1,580,000 chobu (about 1,567,000 ha) of land into farmland, have one million head of cattle and horses, have a total population of 6 million, including about 1,970,000 colonists, and conduct other works.

In the early part of the Second-term Colonization Plan, a shortage of financial resources for colonization occurred due to the recession, and funds had to be appropriated from the national general accounts to pay the expenses of the plan. Furthermore, the national government followed a policy of retrenchment in 1929. As Japan's economy came to be influenced by the Great Depression, Japan's depression worsened and continued.

The Manchurian Incident occurred in 1931, and the emphasis of Japan's colonization policy gradually shifted from Hokkaido to China. Hokkaido colonization did not continue as planned. Furthermore, Hokkaido suffered cold-weather damage and poor harvests every year after 1931. Colonization activities had to be reduced or postponed.

In the late part of the Second-term Colonization Plan, the Sino-Japanese War and the Pacific War broke out, and the emphasis of the plan was shifted to increased production of lumber and food. Colonization and civil engineering works, which were the original aims of the plan, came to be treated lightly in the plan. The plan

ended incomplete in 1946.

The plan ended with the actual results of 780,000 chobu (about 774,000 ha) of farmland, 400,000 head of cattle and horses, and a population of 3.5 million. The results indicate that the plan was less than 50% successful.

2-4 Chaotic days after World War II

Japan surrendered on August 15, 1945, ending World War II and bringing chaos. Japan's industrial activities were severely restricted due to reduced territory and war damage. Food was in short supply, and the population grew rapidly due to the return of repatriates and demobilized soldiers.

The aforementioned situation emphasized development of Hokkaido's rich resources as an important national task to build the national economy, increase food production, and absorb population.

The national government enacted the Outline of Emergent Colonization Execution as the first step of domestic development. Land cultivation of 700,000 chobu (about 694,000 ha) and settlement of 200,000 families were planned for Hokkaido. The goals equaled the results of the past 80 years, and were planned to be accomplished within 5 years. However, the plan was carried out without sufficient research and resulted in the settlement of only 9,122 families from 1945 to 1948.

The prefectural system was drastically revised and the former development system abolished with the dissolution of the Ministry of Home Affairs and the reorganization of the Hokkaido Development Board into a local government. Furthermore, there was a growing tendency toward the establishment of a new administrative organization which centrally administered all development affairs in order to promote development of Hokkaido, which played a great role in overcoming Japan's crisis.

In 1950, the Hokkaido Development Law was enacted and the Hokkaido Development Agency was established after certain complications were overcome. The basic postwar guidelines to develop Hokkaido comprehensively as part of national policy were then established after several postwar years of no policy.

2-5 Days of Hokkaido Development Agency

The Hokkaido Development Law was enacted in 1950 and the law was partially revised in 1951. The Hokkaido Development Agency was established to draw up overall development plans. Hokkaido Development Bureau was established to carry out Hokkaido development works comprehensively under the direct supervision of the national government. A new development system was established and Hokkaido's development was carried out organically, systematically and powerfully in accordance with the Hokkaido Comprehensive Development Plan under the aforementioned system.

The First to Fifth Hokkaido Comprehensive Plans were enacted under the consistent development principle that Hokkaido's development greatly contributes to the development of Japan's economy and society.

Hokkaido's development has been conducted in accordance with the goals of these development plans and has effectively dealt with Japan's various postwar problems.

3. Stage for Hokkaido Comprehensive Development Plan

Hokkaido's regional characteristics, the bases for the current Hokkaido Comprehensive Development Plan, are as follows.

3-1 Vast land area

Hokkaido has an area of 83,158 km^2, accounting for about 22.1% of Japan's total area of 377,780 km^2 (including the Russian-held Habomai islets, Shikotan, Kunashiri and Etorofu). Hokkaido is larger than the Netherlands (41,000 km^2), Belgium (31,000 km^2) and Luxembourg (2,600 km^2) combined.

It takes 4 and a half hours to travel from Sapporo to Kitami by limited express. Furthermore, only 4 limited express train - Okhotsk No.1, No.3, No.5 and No.7 - run this route per day. It takes 4 and a half hours to travel from Tokyo to Hiroshima by Shinkansen (bullet train). It takes about 6 and a half hours from Sapporo to Wakkanai (1990 pop. 48,000), the northernmost city of Japan by express, as limited expresses are not available north of Asahikawa. It takes about 5 hours from Asahikawa (1990 pop. 359,000) to Wakkanai by express train. The citizens of Wakkanai cannot make day trips to larger cities. When a Wakkanai citizen is seriously sick and must see a doctor in a large city, he or she has to make a two-day trip to a large city.

The only measures to solve this inconvenience and provide the citizens of Wakkanai with urban services like other prefectures are improvement of access measures by high-speed railroad service and construction of high-grade roads, and construction of facilities and institutions, including Wakkanai hospitals, with proper equipment, as in those of larger cities, which can offer high-level urban services to the citizens of Wakkanai. The citizens of Wakkanai cannot rely on airlines when the arrival and departure times are so inconvenient and the fares are so expensive.

3-2 Island in lozenge

From Rumoi on the coast of the Sea of Japan to Kushiro on the Pacific coast is about 250 km. From Wakkanai, the northernmost point in Hokkaido, to Urakawa, the southernmost, is 400 km. The ratio of the width to the length is 0.62. As for Honshu, along the Chuo Mountains from Aomori to Shimonoseki is 1,300 km, and from Niigata to Onahama is 200 km. The ratio of the width to the length is 0.15.

The shape of Hokkaido is circular, as opposed to Honshu, in terms of the ratio of the width and the length. The fact suggests that linear transportation such as railroads is suitable for Honshu and multidirectional transportation such as automobiles is suitable for Hokkaido. In other words, railroads are efficient in Honshu because they travel through large cities which border each other and are situated in rows; roads are efficient in Hokkaido because they link cities scattered throughout vast Hokkaido.

Hokkaido's large cities, including Sapporo, Asahikawa, Obihiro and Kitami, are situated far apart from each other in the inland area. Therefore, land transportation is suitable for freight transportation in Hokkaido because land transportation links port cities to inland cities, and coastal shipping is inconvenient.

3-3 Sparse population

Hokkaido's population totaled 5,680,000, accounting for 4.6% of Japan's total population (123,610,000) in 1992. Hokkaido's land area accounts for 22.1% of the total area of Japan. As a result, Hokkaido's population density is only 68 people/km², much lower than the national total. Hokkaido's population density is about 1/5 (1/4 when the Northern Territories are excluded) Japan's overall population density of 325 people/km². Therefore, when cities and villages are classified in terms of relative population, an autonomous community outside Hokkaido with a population of over 50,000 can be defined as a city while an autonomous community with a population in Hokkaido of over 10,000 can be defined as a city. Therefore, the towns of Esashi (pop. 12,000) and Urakawa (pop. 18,000) have to offer their surrounding regions urban services, including administrative, educational, cultural and medical services, as they are central "cities" of the Hiyama and Hidaka subprefectures. Local communities would collapse without the services. From the viewpoint of urban geography (Shinzo Kiuchi, urban geographer), the population to divide cities and villages is 2,000 in the U.S., whose population density is 1/13 that of Japan, and 10,000 in Europe, whose population density is 1/3 that of Japan. A "City" is defined as an urban center with a population of 50,000, in accordance with the eighth article of the Local Autonomy Law. However, when mergers of towns and villages were promoted, there were special cases in which autonomous communities with populations of 30,000 were treated cities.

The distinction between a city and a village depends on whether or not the autonomous community offers urban services to its surrounding region. When an autonomous community with a small population offers urban services and serves as the core of the region, the autonomous community has hegemony as an important city and can be classified as a city.

In fact, Esashi and Urakawa, Hokkaido towns with populations of 10,000-20,000, serve as core cities similar to cities with populations of over 50,000 in other parts of Japan.

For example, the town of Nakashibetsu, with a population of 22,000 (1990), offers urban services to regions around it, including Rausu, Shibetsu and Bekkai, which cover about 3,000 km², more than the area of Kanagawa prefecture (24,000 km²). Urban services offered by Nakashibetsu now depend on only road traffic, since the Shibetsu Railroad Line was closed on April 30, 1988. Therefore, insufficient road construction will result in the collapse of the region.

3-4 Snowy and cold weather

Sapporo is located at 41°03' north latitude, about the same latitude as Marseilles in Southern France. Marseilles is located in the Mediterranean climate. Marseilles' average temperature in January is 6.7°C, similar to the climate around Miyazaki, in the southern Japanese island of Kyushu.

Sapporo has a cold climate. Monthly average temperatures range from 21.3°C, the highest, in August, to -4.9°C, the lowest, in January. The average annual temperature is 8°C. The total precipitation is 1,158 mm. Precipitation comes in the form of snow from December to late March because temperatures are below zero. The

total amount of snowfall during that period reaches 617 mm. The greatest amount of snowfall in precipiction in one day was 169 cm on February 13, 1939, and average amount of snowfall per day exceeds 100 cm per year. Sapporo is not as cold as Edmonton, Canada (average January temperatures -14.7°C and 40 cm of snowfall), or that of Harbin, China (average January temperature -12.7°C and 21 cm of snowfall). However, Sapporo's amount of snowfall far exceeds those of these cities.

Snow is a big obstacle to traffic. Unless snow is cleared in winter, roads became completely covered and daily life collapses. Therefore, complete snow removal is conducted in winter, and construction of roads on which drivers can travel just as easily as in summer, that is, construction of expressways, is emphasized much more than in other parts of Japan.

Furthermore, the Okhotsk coast from Wakkanai to Nemuro is closed due to drift ice from January to early April and harbors cannot be used.

3-5 Industrial structure and accumulation

Primary industry has a higher share of those working in industry in Hokkaido than of those working in industry in Japan. When we look at the composition of Hokkaido's working population by industry in October 1990, we see that primary industry accounts for 10.9%, secondary industry 23.7% and tertiary industry 65.4%. Of the national working population, on the other hand, primary industry accounts for 7.2%, secondary industry 33.9% and tertiary industry 58.9%. Hokkaido's primary industry has a 3.7% higher share and secondary industry has a 10.2% lower share than the national industries. This suggests that Hokkaido's primary industry produces more freight and has less ability to pay freight fares. Furthermore, transport demand for agricultural products concentrates in autumn, the harvest season.

Comparing the composition ratios of Hokkaido's industrial production totals with those of national industrial production totals, we learn about Hokkaido's industrial accumulation. Industries whose share of production totals greatly exceed Hokkaido's share of population (4.7%) are the mining industry (14.5%) and agriculture, forestry and fisheries (12.1%) in 1982. Industries whose share of production totals slightly exceed Hokkaido's share of population (4.7%) are the construction industry (5.9%) and the public sector (5.5%). On the other hand, the share of production totals of the manufacturing industry exceeds Hokkaido's share of population by only 1.9%.

The aforementioned fact influences the per capita income of Hokkaido. The per capita income of Hokkaido is ¥2,376,000 ($18,100), or about 91.5% of the average national per capita income (¥2,596,000 = $19,800) in 1989.

3-6 Overpopulation and underpopulation

Sapporo has a population of 1,717,955 (December 1, 1992) and is the largest city in Hokkaido. There is no megacity with a population of 2,000,000 in Hokkaido. Therefore, there is no serious problem with overpopulation in Hokkaido. On the other hand, underpopulated cities, towns and villages account for 70% of all municipalities. The percentage is more than 2 times the national average (34%). This suggests that roads are superior as a major means of transport in the countryside. National surveys show that per capita car ownership in the country is greater than that in the cities. People in villages drive cars more frequently than people in cities because people in villages cannot live without cars. Therefore, construction of roads in Hokkaido is as important as construction of infrastructure such as waterworks and drains.

The percentage of senior citizens (65 years or older) is generally higher in underpopulated areas. In 1985, the national percentage of senior citizens is 10% and the percentage of senior citizens in underpopulated areas is 17%. This is because the population exodus is mostly caused by younger people. This also suggests that people in underpopulated areas cannot depend only on cars as a means of transportation. Even if senior citizens have cars, they generally cannot drive cars freely and safely, and they belong to a limited mobility group. Therefore, improvement of public transportation, particularly bus service, is essential for underpopulated areas.

4. Typical Results of Civil Engineering Works

The Hokkaido Development Agency was established in 1951 as a comprehensive administrative organ to carry out development works of Hokkaido under the direct supervision of the national government. Various works have been completed over the past 42 years. I would like to introduce the following results of several typical civil engineering works from a subjective viewpoint.

4-1 Route 36 (Sapporo- Chitose), "Bullet Road"

Hokkaido's road technology established a good reputation due to construction of Route 36 in Japan's postwar road construction history. The road covers 34.5 km and was completed at a cost of ¥870,000,000 in about one year. Fourteen leading improvement and pavement companies from Hokkaido and other parts of Japan par-

ticipated in the construction. Three machinery groups under the direct supervision of the Hokkaido Development Bureau were assigned to sections which required large quantities of earthworks and completed the construction of these sections with high-tech equipment.

Construction of Route 36 required large quantities of earthworks, including excavated soil (295,300 m^3) and banks (376,700 m^3). Furthermore, 2 new bridges were constructed and 10 bridges were remodeled and improved. Paved area covered 263,500 m^2. The following materials were used for the construction: roadbed soil (291,900 m^3), cement (7,090 tons), asphalt (3,200 tons), and steel (450 tons). Up to 339,000 workers were employed. The following machines were used for the construction: 42 bulldozers (7 large bulldozers, 16 medium-sized bulldozers and 19 small bulldozers), 13 carryall scrapers, 53 macadam and tandem rollers, 2 tire rollers and 6 asphalt plants.

Effective measures against frost heaving, pavement abrasion and snow and for road maintenance deserve special mention for Route 36, which was constructed with ground-breaking countermeasures and construction methods as a test road in snowy and cold regions. One of the important results is that construction of Route 36 played a great role in changeover from concrete pavement to asphalt pavement. The major benefit of the construction of Route 36 is the fact that asphalt pavement was adopted nationwide as a high-grade pavement after the success of its use of Route 36.

A newspaper at that time said, "Route 36 was completed with Japan's best civil engineering technology and with various machines in a single year. Construction of the road proved to be a monumental achievement in the history of Japanese road construction. The road is expected to offer much convenience to Hokkaido's industry and economy."

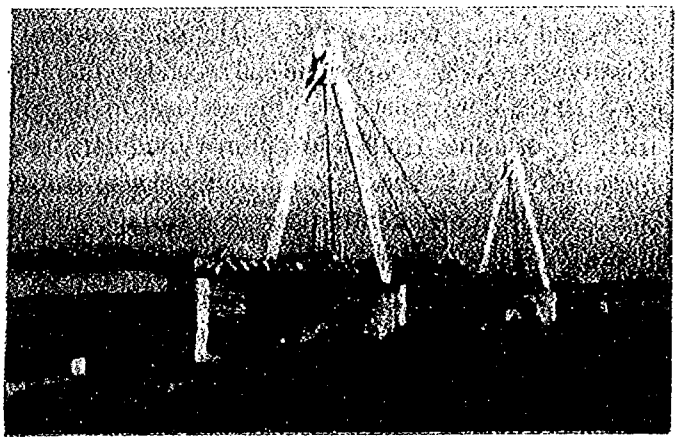
Road construction completed near Shimamatsuzawa

4-2 Ishikari Kako Bridge

The second stage of construction on the Ishikari Kako Bridge, about 6 km upstream from the mouth of the Ishikari River, was completed in November 1976, and the bridge was completed in about 10 years. The bridge is 1,412.7 m long and the maximum span length is 160 m. The bridge was the largest river bridge in Hokkaido. The bridge has the following characteristics:

(1) The Steel Pipe Pile Well Curb Method was first adopted in Japan as a bridge foundation construction method in weak ground for the construction of the main span foundation, and the structure analytic method of bridge foundation construction was proposed.
(2) For the design of the upper-part of the main span and cable-stayed bridge, "intermittent-type wind-proof stability flaring" made of reinforced plastic was developed to control Karman's vortex, based on Hokkaido's first experiments on dynamic wind-proof stability, and limited vibration was successfully controlled in low winds.
(3) The Axial Shock-Proof Experiment Method at low temperatures regarding by-line cable strands (hardly used in Japan at the time), which were adopted for main cables of main span and cable-stayed bridge, was first developed in Japan. Absorbed energy at various levels ranging from -60°C to +20°C was measured.

The steel pipe pile foundation construction in (1) aims to transmit vertical pressure to diluvium about 50 m below sea level and have weak riverbeds share horizontal force in accordance with K values. The foundation construction method came to be widely adopted as a bridge foundation construction method for weak grounds in Japan also because of its safety.



Ishikari Kako Bridge

4-3 West Tomakomai Port

Construction of Tomakomai Industrial Port was regarded as an important aspect of the First 5-Year Hokkaido Comprehensive Development Plan. Construction of Tomakomai Industrial Port, Japan's first inland dredged port, started in 1931. The construction of the port was vigorously promoted. The coal pier in the commercial and industrial district was completed in 1963

and Tomakomai Industrial Port started operation as an industrial port with the arrival of the long-awaited first vessel.

Tomakomai Industrial Port has been used more frequently every year since the start of its operation, and improvement of the port facilities has been steadily promoted. The port has grown to be the core of one of Hokkaido's large-scale industrial areas and plays an important role as a center of distribution in stable development of the economies of Hokkaido and Japan.

The port handled 69.5 million tons of freight (including that of East Tomakomai Port) in 1990. The port has handled more freight than any other Hokkaido port for the past 13 years (It handled 35% of Hokkaido freight, clearly indicating the advantage of the port.)

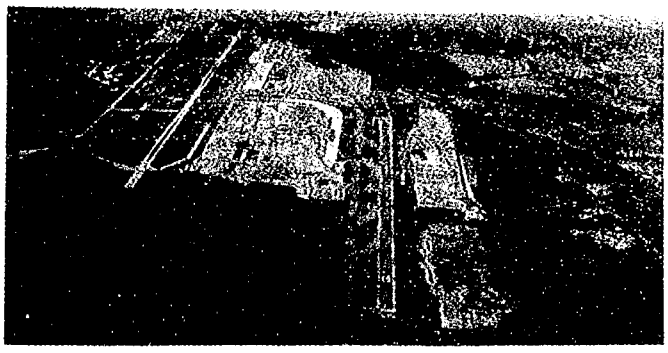
Construction of West Tomakomai Port greatly influenced not only society and economy but also technology. The success of the grand project, in which a large dredged port was constructed on a sandy beach with much quicksand, was based on Japan's first quicksand tracking survey by radio isotope and steadfast efforts and enthusiasm, including various surveys and studies and technological development. These results were then applied to construction of other ports, including Kashima Port and New Niigata Port, and to the construction of Tomakomai Tohbu Industrial Base.

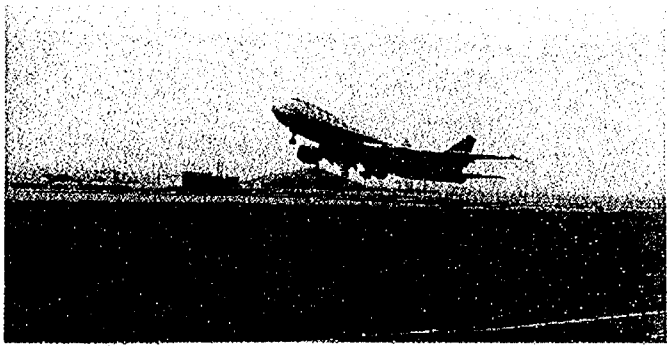
Regular container routes to North America inaugurated at Tomakomai West Port

4-4 New Chitose Airport

New Chitose Airport, for exclusive use by civilian airplanes, aims to deal with the increasing demand for air freight and internationalization. The airport is located adjacent to and southeast of Chitose Airport, and is the 4th largest airport in Japan, with an area of 719 ha. The 3,000-meter Runway A was completed in 1988 and the 3,000-meter Runway B is being constructed.

Construction of New Chitose Airport started in 1975. The 1st stage of construction was completed at a total cost of ¥46.8 billion (part of the funds were used for the 2nd stage of construction), after various problems, including slow progress of land acquisition, were overcome. New Chitose Airport started operation with the old terminal facilities on July 20, 1988. In 1992, new terminal buildings were completed and JR Hokkaido extended a railroad line into the basement of the airport. New Chitose Airport is known as Japan's gateway to the north, as it can handle an increased number of flights, an expansion of flight routes, the arrival of foreign airplanes and direct international flights. Furthermore, the opening of New Chitose Airport instigated research of various related projects. Various projects are expected to be realized, including the following: the establishment of an aircraft repair base, by using the vast area around the airport, the International Air Cargo Base Project, as the center of international air cargo distribution, and the introduction of a magnetically levitated train (linear motor car) between New Chitose Airport and Sapporo.





New Chitose Airport, open for exclusive commercial use and expected to become an international air cargo base

4-5 Ishikari River improvement work

After the early Meiji era when Yezo was renamed Hokkaido, the development of the Ishikari River basin started and Japanese people began to settle there. The history of the development in the basin is new and the history of Ishikari River improvement work is not as long as that of Japan's other river improvement works. However, Ishikari River improvement work is unique from other river improvement works in that Ishikari River improvement work was planned and surveyed with the cream of technology from the beginning and

was promoted as part of the colonization plan, along with the development of the Ishikari River basin which was systematically promoted by the government.

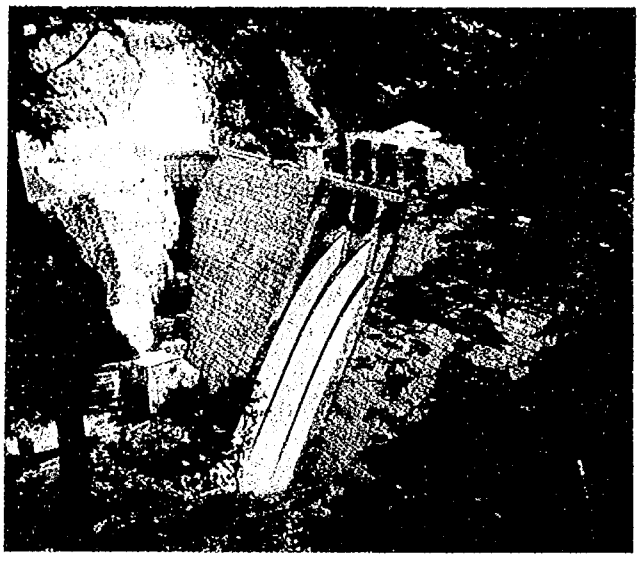
The name of the Ishikari River is said to stem from the Ainu words, "I Shikara Betsu (extremely winding river)." On old maps, the Ishikari River meanders across the Ishikari Plain and many traces of the past can be seen in such aspects as the many crescent lakes. The emphasis in the early river improvement works was placed on straightening the winding river. Twenty nine points of the Ishikari River were straightened from 1918, when construction of the New Oyafuru Waterway started in the Barato River, to 1969. The total length of the Ishikari River was shortened by about 60 km. The Ishikari River ran about 370 km in the late Meiji era, but the total length of the river is now about 270 km, about 100 km shorter, due in part to natural straightening.

The ability of the Ishikari River to drain flood water increased greatly, and the flood control of the basin was improved due to the shortened length and steep riverbed inclination. Furthermore, the normal water level of the Ishikari River was lowered and the water level of marshes around the river was also lowered. Marshes dried and were transformed into prospective farmland. Furthermore, banking work and construction of dams started in the 1950's. The current area of farmland is 5 times that of the late Meiji era, due to farmland development conducted along with banking work and construction of dams.

Oxbow Like In the Ishikari River created by short-cutting

4-6 Kanayama Dam

Construction of Kanayama Dam as the 2nd multipurpose dam in Hokkaido was begun in 1959, after the completion in 1957 of Katsurasawa Dam. The construction of Kanayama Dam was based on social and economic requirements such as flood control, irrigation water, hydraulic power generation and relief work for the unemployed. A plan to construct Kanayama Dam existed before World War II, but only in 1961 were full-scale surveys and studies conducted by the Hokkaido Development Bureau to plan the construction of a hydraulic power generation dam. The plan to construct the dam was promoted not only for power generation but also for flood control and irrigation. More than 10 km of railroad on the Nemuro Main Line of Japanese National Railways and more than 200 houses had been flooded before the completion of the dam, and the construction cost of the dam was enormous. The Electric Power Development Promotion Law was enacted in 1952 and the Specific Multipurpose Law was enacted in 1957. The size of the dam was to be balanced against investment effect in accordance with laws regarding the construction of multipurpose dams. This delayed the decision to include power generation and irrigation plans and to start the construction of dams.



Kanayama Dam

The construction of Kanayama Dam required 13 km of relocation work for railroad, 10 km of relocation work for prefectural and village roads each and a large amount of general compensation. Southern Furano Village was greatly affected by the construction of the dam. The area to be flooded was 1,185 ha, accounting for 27% of the farmland of the Kanayama District of the village. Two hundred sixty nine house lots were flooded, accounting for 24% of all farmhouse lots. Furthermore, the village was divided by a lake. People who lost houses due to the construction of the dam organized the Committee on Kanayama Dam to negotiate with the national government. The Village Council submitted 67 requests, including those for compensation and life reconstruction measures for people who lost houses due to the construction of the dam and also submitted the report on "Village Planning in Great Stride" to the national and prefectural institutions concerned. The Hokkaido government established a committee chaired by the vice-governor, and dealt with the problem jointly with the Hokkaido Development Bureau. Compensation measures for riv-

erhead areas, which are now indispensable for the construction of a dam, were taken for the construction of Kanayama Dam.

The Japanese economy was sluggish at that time, with low wages and expensive materials such as cement. Therefore, dams with reduced bank volume and construction costs were greatly attractive for Japan. Hollow gravity concrete dams, such as Kanayama Dam, were popular because they reduced bank volume by about 30% of that of gravity dams.

5. Future Development Plans
- Proposal of holonic network -

5-1 Holonic network harmonizing and developing organizations

When several organizations are tightly linked physically and consciously by network in a melting state, an organization also exists in all the other organization which are linked by the network. All organizations are highly interdependent. The functions of organizations have a strong synergetic effect by compensating and emphasizing each other, so that the total effect is greater than the sum of each organization's functions.

Such a network resembles that of a healthy human body which adapts to changes in the environment by maintaining dynamic stability. The organs of the human body are regarded as single units, but they are constantly working together, freely changing their relative positions within a range, circulating body fluid and activating the metabolism. Such a harmonized network of organizations is called a holonic network. The human body is a complete system which consists of many linked tissues and organs. An unexpected synergetic effect occurs due to the holonic network. Similarly, when several organizations are linked and united by a network but do not fuse, they form only a combined network. When organizations are linked by external forces but repel each other, an offsetting effect, not a synergetic effect, occurs.

5-2 New large-scale projects in Central Hokkaido

New Chitose Airport opened with the dream of internationalization on July 20, 1988. Chitose Airport was also called Chitose Airfield, and was used by military and civilian airplanes. Strict restrictions were imposed on takeoffs and landings of civilian planes at the airport. With the construction of runways exclusively for civilian use at the airport, Hokkaido people's various hopes, such as separation of runways for military and civilian airplanes and the International Air Cargo Base Project,

were fulfilled. The International Air Cargo Base is being constructed and is scheduled to be completed in the year 2000. The original aim of the International Air Cargo Base Project was to promote the internationalization of New Chitose Airport in terms of international air cargo transportation and to use the full-scale international airport as stimulus for Hokkaido's development.

New Chitose Airport is located 600-700 kilometers closer to North America and European countries than New Tokyo International Airport (Narita). Therefore, the advantages of the airport are shorter transportation time and less fuel consumption. When the airport operates around the clock, air cargo and passengers that cannot be handled at Narita will move to Chitose, and large amount of transit cargo to Southeast Asian countries will most likely be transported via Chitose. However, these estimates will be hard to realize unless the current air cargo base project is upgraded.

The reason for this is that traffic is not necessarily a physical phenomenon but mainly an economic phenomenon. In other words, cargo transportation occurs due to the demand of cargo, just as transportation does. Therefore, constructing an airport and cargo base facilities alone will not ensure the arrival and departure of airplanes at the airport. Airports in regions which have no demand from international passengers or for air cargo cannot fully become international airports without special air fare policies or creation of transportation demand. For example, a regular international air flight (Chitose-Honolulu via Narita) started operation on March 23, 1981, and ceased its operation due to a shortage of passengers on December 30, 1987.

How do we create transportation demand? I would like to introduce my ideas frankly.

The construction of HIMEX (Hokkaido International Medical and Industrial Complex City) is planned by the Hokkaido government in the vicinity of New Chitose Airport near Sapporo. HIMEX is a magnificent project which aims to construct an advanced medical and industrial city (pop. 100,0000) with advanced medical facilities grouped at its center. The HIMEX Project is being carried out in cooperation with the Cleveland

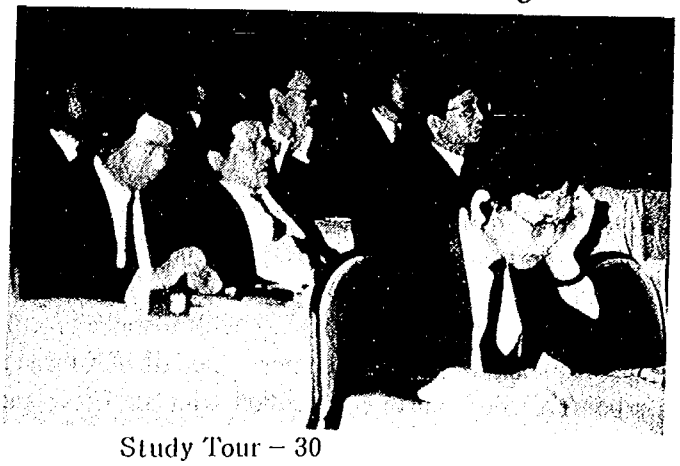
Clinic Foundation, an advanced medical research institute in Ohio. The project includes the following plans: invitation of a National Artificial Organ Development Center (tentative name); accumulation of various research and medical institutions which develop and transplant artificial organs; accumulation of universities with postgraduate courses in science, engineering and medicine and accumulation of medical companies; construction of International Silver Town to suit the needs of an aged society; and development of a high-grade residential area for foreign researchers, engineers and their families to live comfortably and settle in Hokkaido.

The Cleveland Clinic is visited by 700,000 patients annually. When HIMEX is completed, many patients will come on supersonic aircraft from all over the world. Therefore, international aircraft will continuously take off from and land at New Chitose Airport, and the aircraft will be filled with passengers and international air cargo.

Both ends of Runway A of New Chitose Airport are located in the area of Tomakomai. Tomakomai has Tomakomai Tohbu Industrial Base (11,250 ha in area), which was developed as a national project. Although the industrial base has a large dredged port, the new east port facilities and vast industrial sites, few large factories were constructed besides Isuzu Motors' car engine factory, which started operation in June 1984, and most industrial sites were not used. Three years ago, the construction of Toyota Motor Corporation's factory was finally decided.

Tomakomai is also a mecca of ice hockey and is a center of winter sports. Tomakomai has little snow in winter and low temperatures. The average temperature in August does not exceed 20°C even in summer. I would like to propose the construction of low temperature stockpile silos in Tomakomai.

The Low Temperature Stockpile System consists of grain silos, natural ice-making equipment and ventilation fans. The natural ice-making equipment consists of a stainless steel container which contains salt water. The salt water freezes in the cold air of winter. In summer, air is sent around the container containing frozen salt water by ventilation fan. The cooled air is circulated in the grain silo to keep the temperature inside the silo around 1°C. In winter, temperatures are kept around 0°C by adjusting the inflow of open air by opening and closing valves and using respiration heat from the grain. Grain can be stored with no loss of quality by keeping it in a state of hibernation through the year. It is said that grain can be stored with this system with almost no loss of quality for several years.



One low-temperature insulated grain stockpile silo can store 12,000 tons of grain. According to calculations made by Prof. Hiroshi Saeki at the Faculty of Technology, Hokkaido University, one silo can be constructed for ¥0.6 billion in 1987 yen. According to his calculations, the storage cost is less than 10% that of storage by electric power.

If imported grains were stored in the silos, the grains would be useful to ensure safe food. If this entire region were a free trade zone and some silos were entrusted to the U.N. World Food Stock Center (tentative name), an international institution, New Chitose Airport would immediately become one of the most important international airports in the world. Tomakomai port would also be active due to the arrival of vessels coming to the storage base.

If Sapporo, a central city among northern region countries, HIMEX, New Chitose Airport, the U.N. World Food Stock Center and Tomakomai Port were all linked by magnetic levitation trains and the operations of traffic facilities in these areas were all administered comprehensively by the Transportation Authority of Hokkaido Metropolitan Area (tentative name), a supervisory institution by third sector system.

These big projects of Hokkaido will form a holonic network and will have a great synergetic effect. As a result, Hokkaido's development will be rapidly promoted and Hokkaido will promote development of other parts of Japan. Furthermore, when disasters occur somewhere in the world and emergency aids such as food and medicine is required, grains in the Food Stock Center and medicine and medical equipment produced in HIMEX will be immediately transported to the disaster areas through New Chitose Airport and Tomakomai Port. Hokkaido will help the world by conducting such activities. In other words, Hokkaido's development works will result in Hokkaido's contribution not only to Japan, but also to world peace and the prosperity of human beings by realizing big projects and promoting their development effects.

2. Panel Discussion on 「Public Infrastructure Projects in Each Country and Their Technical Problems」

Coordinator:

Dr. Toshitaka Ohta, Director General, Civil Engineering Research Institute, Hokkaido Development Bureau

Panelists :

Mr. Yukihiko Sumiyoshi, Director-General, Public Works Research Institute, Ministry of Construction, Japan

Mr. Chen Bing Xin, Director, Institute of Water Conservancy and Hydroelectric Power Research, China

Dr. Badruddin Machbub, Director, Research Institute for Water Resources Development, Indonesia

Dr. Lee Sang Eun, Vice President, Korea Institute of Construction Technology, Korea

Mr. Abdul Rahman B. Abdullah, Deputy Director-General, Public Works Department, Malaysia

Mr. Manuel M. Bonoan, Assistant Secretary for Planning, Department of Public Works and Highways, Philippines

Mr. Tan Siong Leng, Director, Building Control Division, Public Works Department, Singapore

Dr. Teeracharti Ruenkrairergsa, Director, Road Research Development Center, Department of Highways, Thailand

Panel discussion

"Public Infrastructure Projects in Each Country and Their Technical Problems"

Toshitaka Ohta
Director General, Civil Engineering Research Institute, Hokkaido Development Bureau

Coordinator:

Before we start the panel discussion, I would like to introduce the 8 panelists.

Starting from this side, Mr. Yukihiko Sumiyoshi, Director General of the Public Works Research Institute, Ministry of Construction of Japan. Mr. Chen Bing Xin, Director of the Institute of Water Conservancy and Hydroelectric Power Research, Chinese Academy of Sciences, Ministry of Water Resources, Ministry of Energy, the People's Republic of China. Mr. Badruddin Machbub, Director of the Research Institute for Water Resources Development, Agency for Research and Development, Ministry of Public Works, the Republic of Indonesia. Mr. Lee Sang Eun, Vice President of the Korean Institute of Construction Technology, the Republic of Korea. Mr Abdul Rahman B. Abdullah, Deputy Director General of the Public Works Department, Ministry of Works, Malaysia. Mr. Manuel M. Bonoan, Assistant Secretary for Planning, the Department of Public Works and Highways, the Republic of the Philippines. Mr. Tan Siong Leng, Director of the Building Control Division, Public Works Department, Ministry of National Development, the Republic of Singapore. Mr. Teeracharti Ruenkrairergsa, Director General of the Road Research Development Center, Department of Highways, Ministry of Transport and Communication, the Kingdom of Thailand.

As Professor Igarashi mentioned in his keynote lecture, it has become clear that improvement of public infrastructure plays a very important role in regional development, and that improvement of public infrastructure, induced by new technology, is the driving force behind great regional development. Furthermore, we confirmed that investments to drastic public infrastructure improvement have proven to be truly fruitful for regional development. On the other hand, the efficiency of projects must be promoted due to the limited budget.

There will be some large-scale public infrastructure improvement projects, for which the current techniques will not be efficient enough, and which can be effected only by technical breakthrough. On the other hand, new techniques which are studied and developed in the process of some large scale projects, such as the Honshu-Shikoku Bridge and Seikan Tunnel, may make other difficult projects possible.

Therefore, in the first place, I would like the panelists to introduce public infrastructure improvements in large scale regional development projects in their respective countries and explain how they deal with the technical challenges facing them, so that we can discuss the future direction of research and development for civil engineering.

Panelists: (Summaries of Panelists' Speeches on Following Pages)

Coordinator:

I was impressed by the facts that Asian nations are actively promoting large-scale projects on their own to improve public infrastructure and, in order to realize the projects, are extensively doing research and promoting technological development. As time is running out, I would like to summarize the discussion.

Natural and socioeconomic conditions differ according to each nation, but I think that the technology already developed or that to be developed, for expressways, super-long bridges or large dams which require high technology, is illuminating and useful to every nation. Moreover, I think that such technology can result in new ideas and technology.

Last April, the Japanese government announced a basic policy regarding scientific technology, which it aimed to realize during the coming ten years. There are three goals; the first one is to work in harmony with the environment, the second to enlarge and enrich intellectual stock, and the third to realize a lifestyle in which all can feel that they are truly "well-off."

It would be ideal if the civil engineering technology developed by each nation could be utilized as common intellectual stock of the Asian region to improve civil engineering technology. In order to realize this, I think it is necessary to strengthen the information and exchange network.

I can understand that, particularly for large-scale local developments, we must pay strict attention to environmental problems as well as to socioeconomic conditions. I think that it is necessary in the future for us to wrestle with environmental problems not only locally but also globally.

With the above summary, I would like to end this panel discussion. Thank you very much for your cooperation.

Trend of Public Works Implementation and Research Subjects in Japan

Yukihiko Sumiyoshi
Director General,
Public Works Research Institute,
Ministry of Construction

1. FOREWORD

Recently, the advance of socio-economics in Japan diversified the social demands to the infrastructure improvement. All of current public works projects have the role to solve the problems such as balanced distribution of population to the national land, urban problem with high land value and concentration, environmental problem including global environmental preservation, human living problem desiring the quality of life, besides the proper mission as the infrastructure of economics.

These movements requires diversified R&D. This paper describes the outline of projects now in planning or implementing, the lines of the projects, trend of public works in Japan, and R&D activities in the PWRI.

2. CONTENTS OF PUBLIC WORKS IN JAPAN AND TECHNICAL SUBJECTS TO BE SOLVED

2-1 PUBLIC WORKS FOR EFFECTIVE UTILIZATION OF NATIONAL LAND AND R&D SUBJECTS

(1) 2nd Tomei-Meishin Expressway

Tomei-Meishin Expressway is the most important land axis connecting the Tokyo, Nagoya, and Osaka, where are three biggest cities in Japan. However, the resent increase in transportation has pressing the capacity of the road. Figure 1 shows the view of current traffic jam. The 2nd Tomei-Meishin Expressway is planned as the road which locates in parallel with the existing Tomei-Meishin Expressway, and have some junction with it. Design speed is set up at 140 km/h, which is larger than the ordinal one (100 km/h - 120 km/h), aiming to get greater transportation capacity.

Because the site which is suitable for construction has already been deprived by existing Tomei-Meishin Expressway, 2nd Tomei-Meishin Expressway has to be routed on the site with difficulty. In addition, as the increase of design speed (140 km/h) is the first trial in Japan, the Road Structure Ordinance has to be renewed. PWRI conducts the following researches to realize 2nd Tomei-Meishin Expressway.

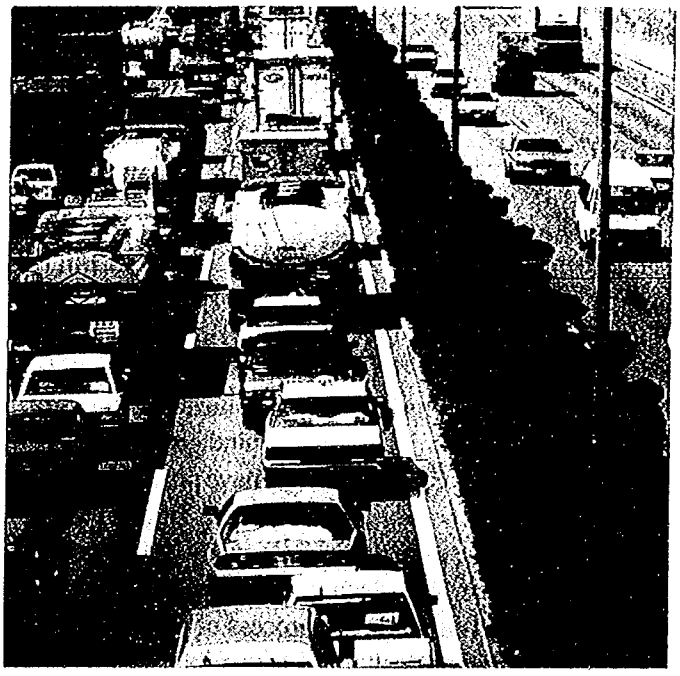


Figure 1 Recent Traffic Jam on Expressway

1) Geometrical planning method for lighting, and traffic safety facilities covering the design speed of 140 km/h
2) Prevention method for traffic noise, and exhaust fumes
3) Connection method with existing road including Tomei-Meishin Expressway
4) Construction technology for long tunnel and road in hilly and mountainous area

(2) High-Graded Trunk Road and Regional High-Graded Road

Recently, the concentration of population, information, economics to urban area is getting to disturb the urban performance. The 4th Comprehensive National Land Development Program, which settles the target of land improvement in Japan, demands the "balanced distribution of population to the national land" by formulation of

regional socio-economic sphere centerized to polar city.

High-Graded Trunk Road Network Plan is for construction of the road to be able to ride on it within 1 hour from the regional cities and rural area. The Network would reach up at 14,000 km in 2010. Figure 2 shows the High-Graded Trunk Road Network Plan.

Regional High-Graded Road Plan now under planning is for development of regional economics. The road would be radiated from the regional city. Social and cultural access would be increased and settlement of population would be implemented to the regional city by the network of two types of High-Graded Trunk Road. The following subjects will have to be studied.

1) Characterization of high-graded trunk road and investigation of the performance to be required
2) Connection method between high-graded trunk road, regional high-graded road, and existing road
3) Impact on national/regional economics

(3) Super Long Span Bridge and Undersea Tunnel

In Japan locates many main cities at the inner bay. The location is useful for sea transportation, but sometimes not useful for regional land transportation. It is considered that the construction of bridge connecting the both edge of the bay or crossing the channel is indispensable to formulate the new national land axis.

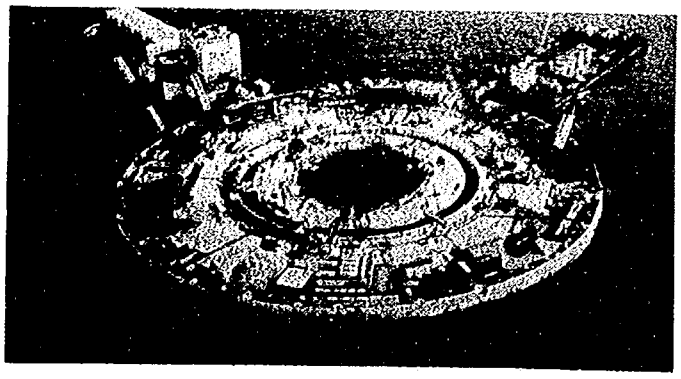


Figure 3 Man-made Island under Construction

Trans-Tokyo Bay Highway is constructed for connection between Kanagawa Pref. and Chiba Pref. across the center of the Tokyo Bay, which is composed of a 10km undersea tunnel and a 5km bridge. Figure 3 shows the view of man-made island now under construction.

Honshu-Shikoku Bridge is made for connection between Honshu and Shikoku. Kojima-Sakaide route completed in 1988 and another 2 routes are under construction. Figure 4 shows the bird's-eye view of Kojima-Sakaide route. Akashi bridge, which has the span length of 1990 m, is now under construction, would become the largest suspension bridge of all over the world. Figure 5 shows the bridge under construction.

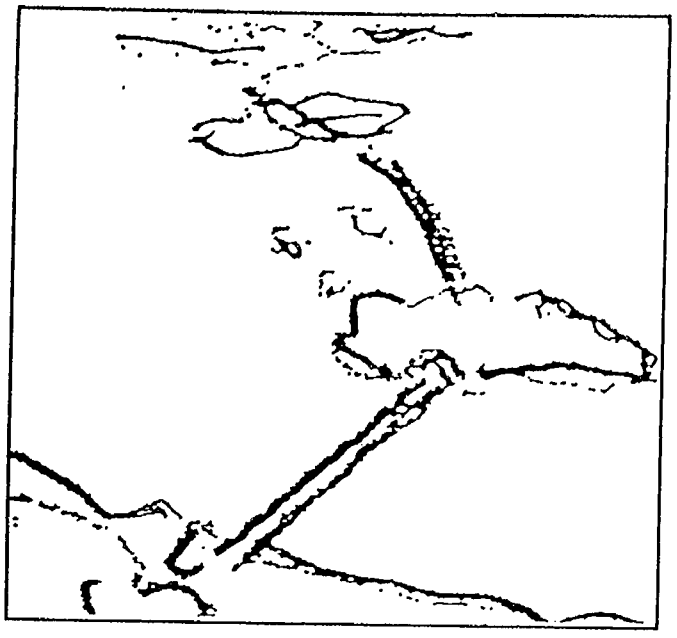


Figure 4 Kojima-Sakaide Route of Honshu-Shikoku Bridge

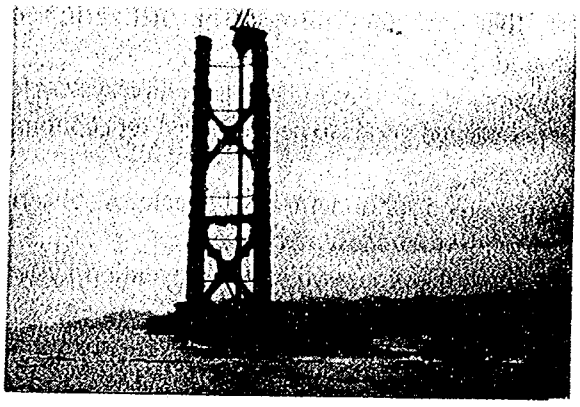


Figure 5 Construction of Akashi Strait Bridge Main Tower

Furthermore, construction of bridge at the mouth of Tokyo Bay, and Ise Bay near Nagoya city, construction of road over narrows, would be required near future. PWRI conducts the R&D for construction of super long span bridges, and undersea tunnel. The subjects are as follows;

1) Sounding and investigating method to the topography and geology of under sea ground in busy line
2) Design and construction method of substructure for very deep water
3) Seismic design and aerodynamic stability for bridge, foundation, etc...
4) Investigation to new material such as rusting paint, high tension steel

(4) Utilization of Underground

Underground space is regarded as a valuable resource in view of development of metropolitan area and regional center city. It is considered that underground space can be used for the traffic system, storage space for human and goods, space for disaster prevention, and housing.

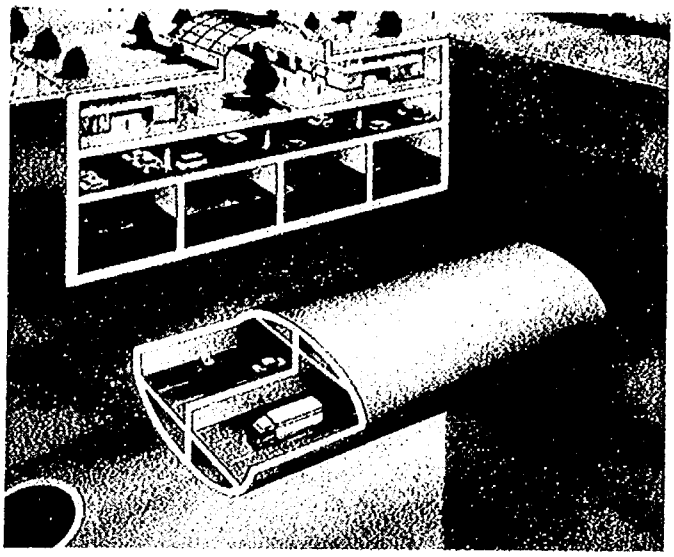


Figure 6 Conceptual View of Underground Use

Figure 6 shows the conceptual view of underground use. PWRI would conducts following research subjects to develop the new technology for utilization of underground.

1) Study for new underground transportation system for both people and goods to be facilitated for economic activity
2) Design method for underground structures concerning earthquakes, underground water
3) Study for utilization as disaster prevention system such as underground river and dam.
4) Study for living, such as ventilation, energy supply system, temperature control system.

2-2 PUBLIC WORKS FOR DISASTER PREVENTION AND R&D SUBJECTS

(1) Super Levee

In 1947, Catherine typhoon caused terrible floods around Kanto region. Overtopping of flood destroyed the levee of Tone River, which is the largest river in Japan, and accumulated water had stopped the functions of Tokyo for several days. This example suggests that river bank are considered not to be durable against overtopping flow.

High-durability river bank, which is so called "Super Levee," has the width over 200 m. It aims to prevent the collapse of bank perfectly against the overtopping flow. Figure 7 shows the conceptual view of it. Utilization of wide space at the top of the bank for the housing or urban park would solve the high land value problem, and progress the land readjustment simultaneously. PWRI recognizes the following researches has to be conducted.

1) Development of method for structure design of super levee concerning earthquake, ground substance, and water intrusion
2) Study on method for reinforcement
3) Utilization of the wide space at the top of the levee

(2) Earthquake Disaster Prevention in Urban Area

In Japan, earthquakes occur frequently. Especially in urban area, it is important to promote the construction of high-durable infrastructure, and making plural preparation for rapid refuge and recovery in disaster. Following researches are required.

1) Advance of seismic design method including the public facilities such as gas, electric, and water supply
2) Planning method for network of high durable road
3) Development of earthquake prediction method and zoning method for evaluation of danger
4) Relationship between the progress of road construction and efficiency in recovery

2-3 PUBLIC WORKS CONCERNING ENVIRONMENT AND R&D SUBJECTS

(1) Public Works Caring Global Environment

Now, global environment is the most focused problem of all over the world. Also in Japan, public works taking care of both human and global environment are demanded. Figure 8 shows the "Eco-Road" by which beast pass is preserved. PWRI conducts R&D activities with caring the environment. These are as follows;

1) Comprehensive land preservation method against the green-house effect, including river, sabo, dam, and high tide

Figure 8 Eco-Road

2) Study on construction machine with energy economizing and reduction of exhaust fume and noise

(2) Public Works for Better Quality of Life

According to an increase in demand for better quality of life, many public works for advance of life circum-

stances such as sewerage improvement, planting, river environmental works, pollution prevention work with priority. The following R&D are conducted in PWRI.

1) Advanced treatment of sewage water by using bio-technology
2) Disposal or recycle of construction waste
3) Study on countermeasure to traffic pollution
4) Planting in urban area, around road, and on river
5) Environmental preservation or environmental creation on dam lake and in river

3. TARGET OF INFRASTRUCTURE IMPROVEMENT IN FUTURE

3-1 WITH USEFULNESS

Fig-9 shows the conceptional idea for future direction of research and development of Ministry of Construction as a whole. Both of the trends, desire for comfortable life and aging, demand the usefulness of infrastructure.

3-2 WITH FINE FEATURE, HIGH DURABILITY, AND EASY ADMINISTRATION

Extension of infrastructure's life-cycle is indispensable, because shortage of labor will occur near future.

3-3 WITH ENVIRONMENT

It is important that construction work should use the natural condition on site, preserve the environment and ecology, create the beauty, and then conserve the circumstances after the construction.

3-4 WITH EFFICIENCY AND SAFETY

Lack of skilled worker and aging of labors will demands the efficient, unattended, and safe construction technology.

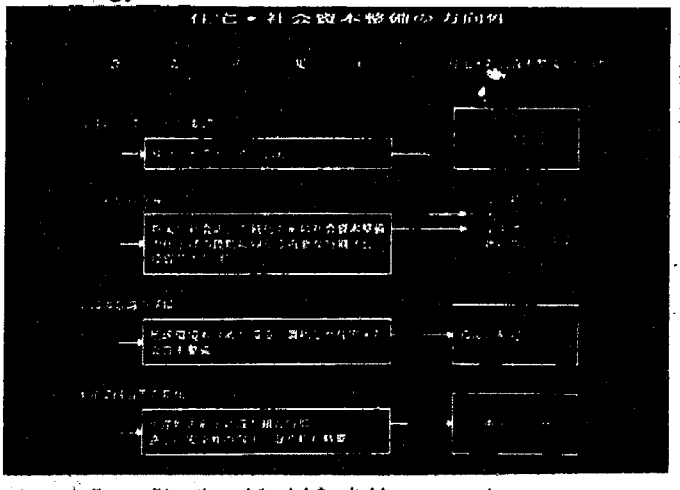
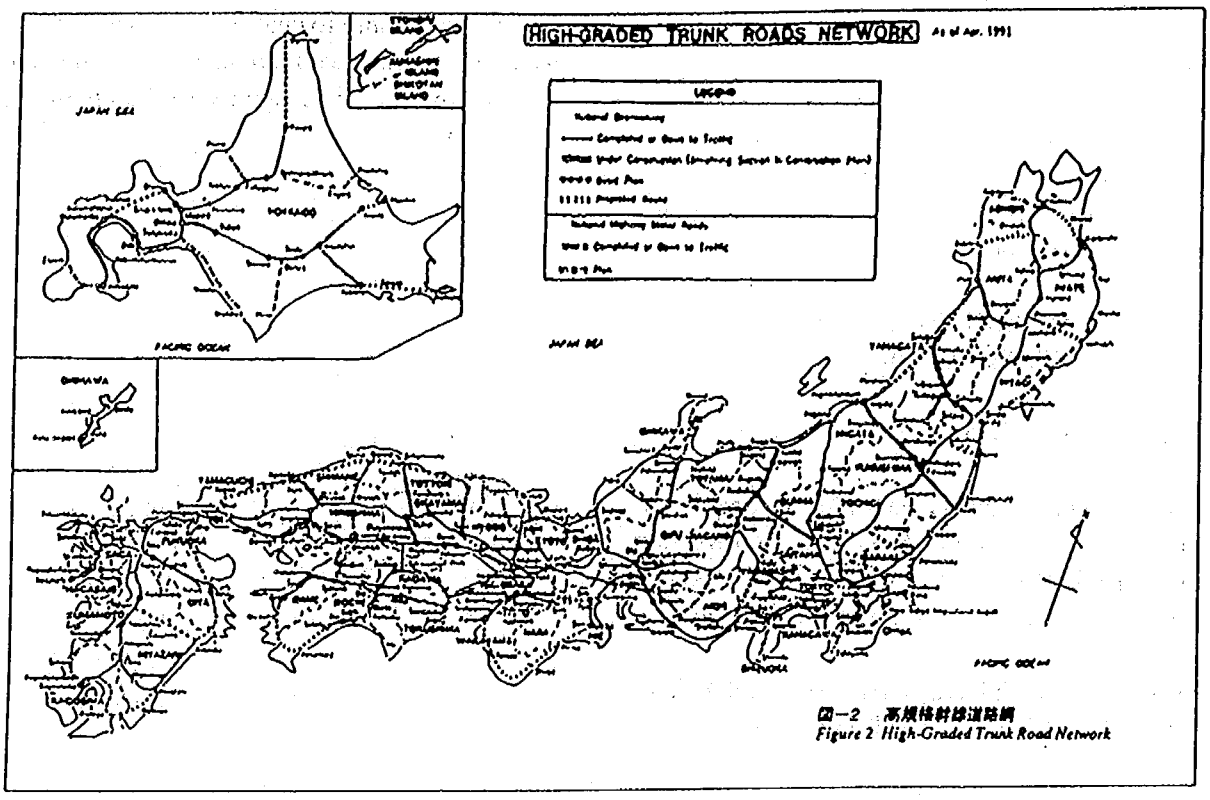


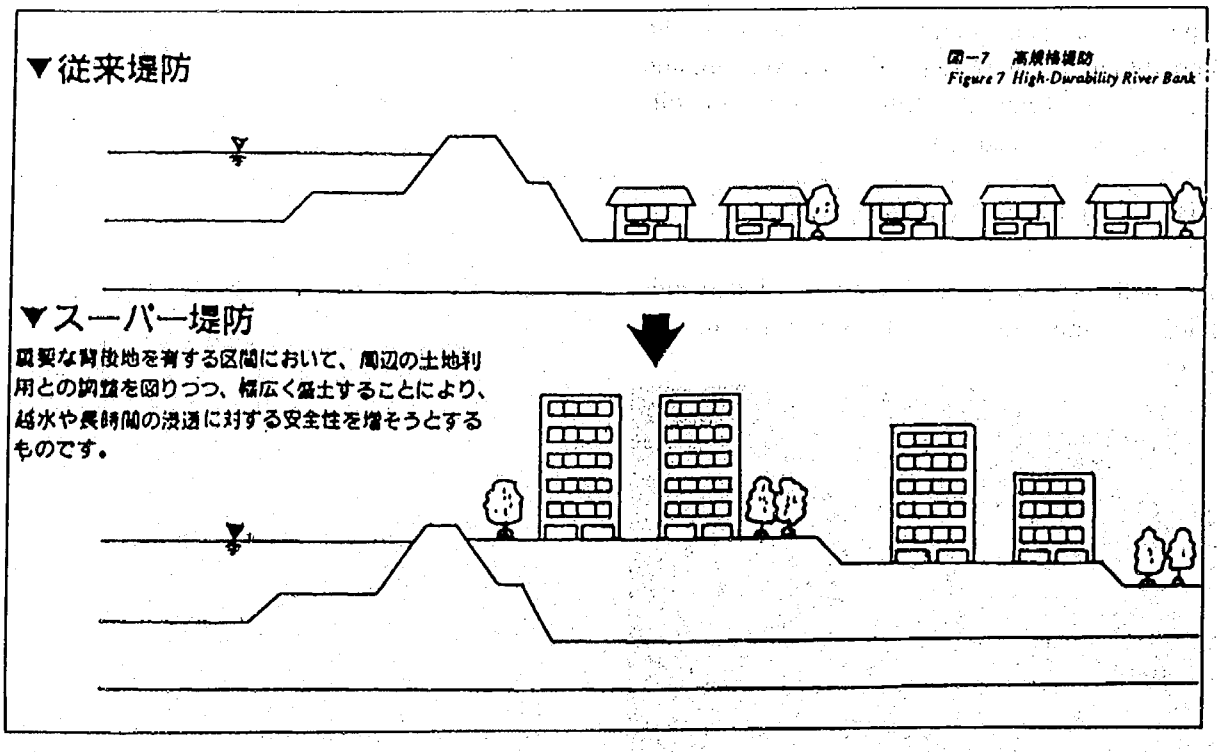
Figure 9 Future Direction of Social Capital Improvement

4. AFTERWORD

Demands for infrastructure improvement are getting to shift from quantity to quality. It is considered that R&D have to be conducted more actively for the construction of infrastructure, in response to the changing request everlastingly.



図－2　高規格幹線道路網
Figure 2 High-Graded Trunk Road Network



図－7　高規格堤防
Figure 7 High-Durability River Bank

Presentation on The Symposium on Public Infrastructure and Civil Engineering in Asia

Chen Bing Xin,
Director, Institute of Water Conservancy and Hydroelectric Power Research, Chinese Academy of Sciences, Ministry of Water Resources, Ministry of Energy

Public infrastructure plays an important role in the economic and social development in every country. In China, public works are being planned based on the national economic and social development plan, which is formulated by the govemment and implemented after discussed and approved by the National People's congress. The departments of the government responsible for construction of public works according to the development plan.

The national economy and society development plan now under implementation is the Eighth Five Year Plan, geared to the long term plan approved by the Congress. The annual growth rate of GNP is 8 - 9%, and the rate of investment in fixed assets of the whole society will reach 5.7%, including the annual 5.5% growth of the state owned enterprises. The later includes 840 billion yuan for capital construction in 1991, with the annual growth rate of 2.1%. In the allocation of the investment for capital construction, priority should be given according to the requirement by adjustment of industrial structure to agriculture, water resources development, energy, communication and important row and processed material production bases.

Now, I would like to give the introduction of a large scale public work, representing the regional development activities of China.

Three Gorges Project
Key to Development of Yangtze River

1. Introduction

The Yangtze River is the largest river in China, with a total length of over 6300 km of the main stem, affording 960 billion m 3 of water flowing into the sea every year on average. The total drainage area is 18 million km2, 19% of the total land area of the country. The population of the Yangtze basin is equivalent to 1/3 of the total of the country, while its exploitable hydro potential takes 53% of the country's total and in land navigable mileage amounts to 70% of the total of the country. The aggregate output value of agriculture and industry equals about 40% of the total of the country, playing a very important role in the economic development of China.

The river cuts through three majestic canyons as Qutang Gorge, Wu Gorge and Xiling Gorge, known as the three gorges, in its midstream. Located in the Xiling Gorge, the last one of the three gorges, the proposed site of the Three Gorges Dam is 38 km upstream from the Gezhouba Project (completed in 1980). It is an exceptionally large scheme possessing enormous, comprehensive utilization benefits for flood control, power generation, navigation, breeding of aquatic products and water supply.

The project consists of a large dam across the river, a hydroelectric power station and a navigation structure. The elevation of the dam crest is 185 metres above sea level. Its normal water storage level is 175 metres and total storage capacity is 39.3 billion cubic metres, with flood-control storage capacity of 22.14 billion cubic metres. The power station would install 26 sets of power generating units, with a total installed capacity of 1768 MW and an annual output of 84 billion Kwh.
The navigation structure's annual one-way passage capacity would be 50 million tons, about 650 km of channels would be upgraged.

The general construction period for the principal part of the project will last 15 years, including 3 years of construction preparation. In the ninth year after construction begins, permanent navigation structures

will be put into use and the first power generating unit will begin generating electricity. Calculated in terms of 1990 price, the total investment, including that for construction, resettlement of residents and power transmission, could reach 57 billion yuan.

The Three Gorges Project is the largest public works project in China in the near future. The benefit of the project will greatly promote not only the economic development of the river basin but also the whole country. The project was ascertained and listed in the national 10 year programme (1991-2000) for economic and social development by the National People's Congress in April, 1992. The preparation of the construction was begun at the beginning of 1993.

2. The Comprehensive Benefits of the Project

a. Flood Control

The Yangtze valley, the river's middle and lower reaches in particular, is vulnerable to serious flood disasters. Historical records show that during the 2000 years from 206 B.C. to 1911, serious flooding swept the Yangtze 214 times. This century has so far seen three immense floods, two of which, one in 1931 and the other in 1935, submerged 3,393,000 and 1,509,000 hectares of farm land and killed 145,000 and 142,000 people respectively.

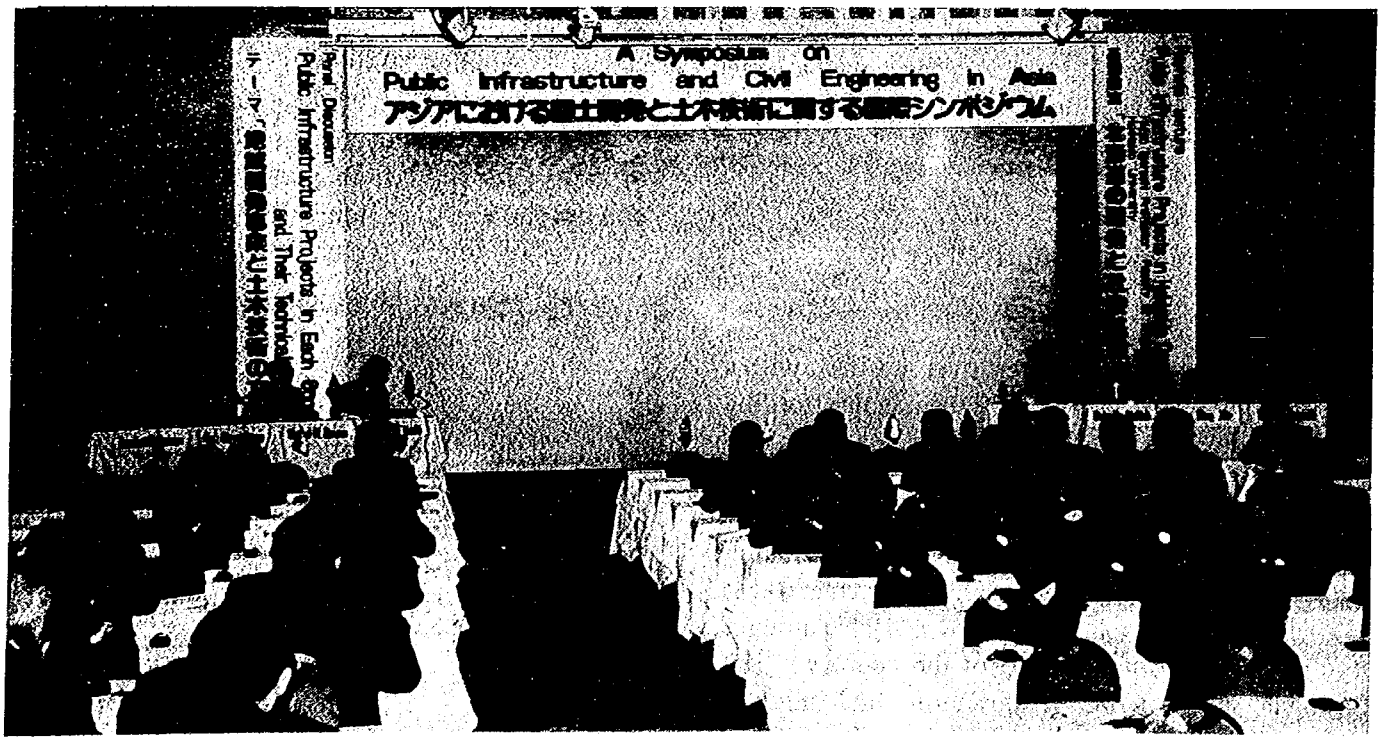
The main reason behind the serious flood threatening the middle and lower reaches of the Yangtze River is the high peak and large volume of the floodwater from torrential rainfall in the upper reaches when it exceeds the safe discharge capacity of the river. Currently the safety limit in flow capacity along the Jingjang section, the most dangerous river section downstream of the Three Gorges Project, is smaller than the peak flow from upstream.

This problem cannot be resolved by expanding the flow capacity of the river courses. The aforementioned safety flow capacity can only allow the flow of 10 or 20 year frequency flood.

The two banks of the Jingjang River, where 15 million people live and 1.53 million-ha area of cultivated land lies, are important bases of commercial crops of grain and cotton, plus the existence of large and medium sized cities, factories, communication facilities and oil fields. But due to the fact that the ground levels on both banks are several to ten plus meters lower than the flood water level if the bank was breached, the flood water would bring about serious consequences and have far-reaching socio-economic impacts.

Based on the research and evidence for many years, it is necessary to adopt over all harnessing measures to solve the above serious flood control issue. Such measures include the heightening and reinforcement of dykes, arrangement and setting up of flood diversion and detention areas, building of reservoirs in main stream and tributaries, water and soil conservation in the upper reaches, and rectification of rivers, as well as strengthening of flood control management and non-engineering flood control measures. The most crucial of these is the building of the Three Gorges Project.

The Three Gorges Project is to be sited at the place, where the Yangtze River's middle and upper reaches meet. Its unique geographical location would enable it to control 95% of the flood volume of the Jingjang river section and 2/3 of the flood volume of Wuhan. The



reservoir, once completed, can raise flood control capacity from the present 10-year frequency to 100-year frequency in case of a flood larger than the 100-year frequency occurred, it could, in coordination with temporary flood diversion works, prevent breaches of the Jingjang dyke and devastating destruction.

b. Electricity Generation

The central and eastern regions of China are economically developed but the main factor limiting their progress is insufficient supplies of power. The coal resources of these two regions are very meagre, accounting for 3.2% and 3.6% respectively of nation-wide reserves. Unexploited water resources in eastern China have been used up while 70% of these resources in the central region are concentrated in the Three Gorges.

Under the electricity development plan for these two regions, in the years from 1986 to 2015, there will be the need for an installation of generators with 170,000 MW capacity. Even if the hydroelectric station of the Three Gorges is built and other hydroelectric and nuclear power stations are developed as far as possible, in 2015 the amount of coal taken from the northern coal base will come to 285 million tons every year. Coal mining and particularly its transport will face a grim situation.

Coal resources along the Yangtze river are insufficient but water resources are rich. However, 80 percent of the water resources of the Yangtze River are concentrated in the mainstream and tributaries on the upper reaches. A hydroelectric station of the Three Groges, close to the power consumption and supply center, from which the distance for transmitting electricity to central China is under 500 km and no more than 1,000 km to east China, would be the best solution to the problems of supplying electricity to these two regions.

In addition, the replacement of a thermal power station by the Three Gorges Project will generate great social benefits and good environmental effect. It will reduce the consumption of coal by 40 million or 50 million tons every year, and also greatly reduce the amount of industrial liquid waste and play an important role in cutting sources of environmental pollution, such as acid rain.

c. Shipping Benefits

The Yangtze River has always been China's main transport artery linking its eastern, central and western regions. However, the 660 km-long section of the river, which runs through hills, high mountains and gorges, has a 120 m drop and a swift current. It causes a low towing capacity and high freight cost.

The Three Gorges Project, if constructed, a 10,000 - ton tow boat will be able to sail right up to Chongqing because shoals will be eliminated, shipping lanes will become deeper and wider, and the river current will slow down. The annual shipping capacity will increase to 5 times of that at present and transport costs will be cut by 35%.

d. Other Benefits

In dry seasons the minimum river flow will increase about 2,000 m3/s due to regulation by the reservoir. It will not only facilitate shipping on the downstream, but will also help city water supplies along the river and transfer of water from the south to the north to alleviate water shortage in north China. It will provide

comprehensive benefits including irrigation, fish breeding, recreation and economic development of the reservoir area.

3. Technical Problems to be solved

The design and investigation of the Three Gorges Project have been conducted on the basis of complete, accurate and reliable hydrological and geological data. It is verified that the Three Groges Dam is to be built on the base of intact solid granite. Both Chinese and foreign engineers and geologists rate the site as an excellent one for a high concrete dam.

a. Design and Construction

The Three Gorges Dam will be built of a conventional concrete gravity type and be 175 metres high. With the rich experience accumulated and favourable geological conditions of the Dam, China is more certain of its ability in mastering the necessary design and construction technology.

Although the hydroelectric station of the Project will be huge and its total installed capacity will rank number one in the world, its shape, layout and size will resemble other large powerhouses in both China and overseas, so there are no special difficult technological problems to be solved.

The permanent navigation structures will consist of a double line of five-step continuous shiplocks, the chamber size of all the locks will be the same as that of Gezhouba. The maximum water head of operation and maximum discharging capacity of the locks are higher than similar ones constructed both in and outside China, but the technological problems can be resolved after the studies and experiments of many years.

The maximum water head and maximum navigation tonnage projects for shiplift will be higher than those completed projects in other domestic and overseas projects. The recommended scheme, based on conventional technology was drawn from many years of design work and scientific research plus experiences learnt from examining the operations of shiplifts in other countries.

The most striking feature of the Three Gorges Project is its gargantuan scale. The civil engineering work will be 2.5 times that of the Gezhouba scheme. Construction will entail some difficulties, but the technical problems are not insoluble. Large amount of high performances modern facilities for construction are needed.

b. Turbogenerator and High-tension Transmission Technology

The unit capacity of the turbogenerator of the project hydroelectric station is to be 680 MW, and the power will be transmitted with AC 500 KV and DC±500 KV. The manufacture and installation technology for these turbogenerator and ultra-high tension electric facilities have matured in the world.

c. Reservoirs Induced Earthquakes and Landslides

The Three Gorges Project is located in an area where the earth's crust is relatively stable, ruling out the possibility of any regional major ruptures or other abnormal geological features that might trigger strong earthquakes. This is an area where earthquakes are relatively weak in the mainland of China.

There are 22 large slopes that are unstable or may become unstable once the reservoir is filled with water, but they are all 26 km away the dam site. Calculations and model testing presage that any surging waves generated by large unstable slopes would not threaten the safety of the dam or other structures. The total mass of the 22 unstable slopes is only 380 million M^3. Even if the entire bulk slid into the reservoir, it would only fill up 2.2% of the reservoir of the 145-metre water level and would not threaten either the reservoir's enormous storage capacity or its service life.

d. The Problem of Sedimentation

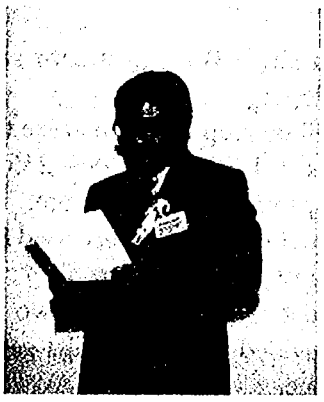
The reservoir is designated to have a normal pool level of 175 metres. The flood control level is 145 metres, while the flood storage capacity is 22.15 billion M^3. Studies show that if the operational method of "retaining clear water and releasing muddy water" is applied, after a century of operation, the reservoir's storage capacity would remain at 86% for flood control, and 92% for power generation. Sediment Deposit will not threaten Chongqing city.

e. Resettlement

A total of 19 counties and cities, 13 county towns, 140 towns and 4,500 villages would be affected by inundation. The total population to be moved, including natural growth, would reach 1,1318 million up to the year 2008.

f. Environmental Impact of the Project

Impact on local climate
Impact on water temperature and quality
Impact on land flora and fauna
Impact on aquatic life
Impact on public health
Impact on the plains and lakes of the middle reaches
Impact on the river's estuary and surrounding sea
Inundations impact on environment
Affect on scenery.



Citarum River Basin Development Scheme

Badruddin Machbub,
Director, Research Institute for Water Resources Development,
Agency for Research and Development, Ministry of Public Works

1. General Plan of Citarum River Basin

The Citarum river rises from the foothills of Wayang mountain near Bandung, flows northward and discharges into the Java Sea through the coastal plains of West Java. Its catchment area is some 6,000 km² and is the largest among the rivers in West Java. The length of the main stream is about 350 km.

The development of the Citarum river for purpose of irrigation, flood control and hydro power has been identified since the 1940's.

The initial step was realized by the Jatiluhur multipurpose project comprising a 100 m high rockfill dam with a reservoir of 3,000 x 10 6 m³ capacity.

Its main purpose is the irrigation in dry-season of the vast rice-fields of the northern coastal plain of 240,000 ha besides flood control, municipal water supply and power generation (150 MW).

The Feasibility Study of the Citarum Hydro Power Development was further carried out in the period from 1973 to 1978, whereas major hydro power potentials were identified at Saguling site and Cirata site, with a possible output capacity of 700 MW and 500 MW respectively.

The main features of Saguling site are a maximum discharge of 224 m3/sec, a flood discharge of 5,195 m³/sec corresponding to the 1,000 year return period and an effective storage capacity of 609 x 106 m³. The dam is of the rockfill type of 99 m high with a volume of 2,750 x 10 3 m³.

The dam embankment was completed on November 9, 1984, filling of the reservoir started on February 15, 1985 and water level raised to the high water level on May 13, 1985.

The commercial operation of generator unit No. 1 with a capacity of 175 MW was carried out on October 12, 1985, whereas the commercial operation of No. 4 as the last unit was on August 1, 1986.

The Saguling project has a mean annual energy output of 2,156 GWh to be supplied to the 500 KV Java grid system.

In parallel with the development of the Saguling site, another hydro power scheme along the Citarum river, namely the Cirata site, has been developed to meet the generation expansion program.

The Cirata site is located just upstream of the Jatiluhur reservoir and down stream of the Saguling site. The project is scheduled for completion in 1988 and will have a mean annual energy output of 1,428 GWh.

The Cirata site features a maximum discharge of 540 m³/sec, probable flood discharge (after Saguling) of 5,900 m³/sec and an effective storage capacity of 796 x 10 6 m³. The dam is of a concrete faced rockfill type of 125 m high with a volume of 3,600 x 10 3 m³.

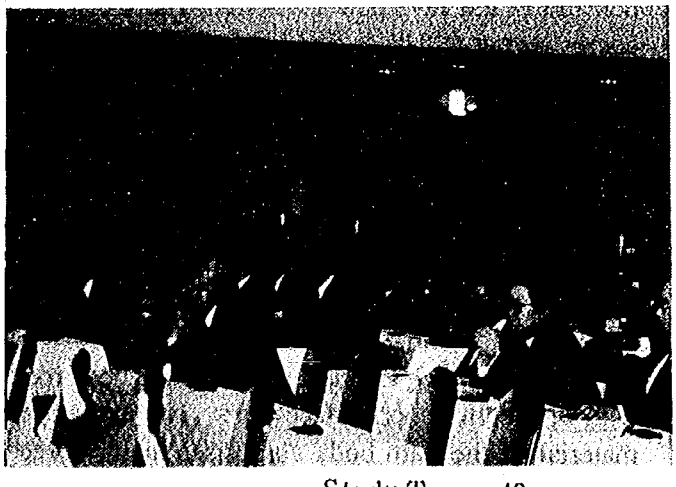
2. JATILUHUR/JUANDA DAM

The Jatiluhur dam, a rockfill dam 100 m high and 1,200 m in crest length, required about 9.1 x 10 6 m³ of embankment material.

The dam body is founded on claystone with sandstone layers.

A concrete tower 105 m high and 90 m in diameter concentrates the hydraulic functions of the scheme, which are:

- Routing of floods, capable of spilling 3,000 m³/sec.
- Providing water for irrigation by means of two intakes regulated by hollow-jet valves.
- Housing the hydropower-station with six 31,000 KVa sets.



The water passes under the dam through two concrete tunnels (tailraces) with a capacity of 1,500 m^3/sec each.

Since there were some low points around the perimeter of the reservoir, they were closed by auxiliary embankment with a total volume of about 2.5 x 10 6 m^3 and a total length of 3 km.

The Ubrug embankment on the right bank has an auxiliary spillway with a capacity of 2,000 m^3/sec.

3. SAGULING DAM

The Saguling dam completed by the end of 1984 is located approx. 30 km west of Bandung.

The powerstation has an installed capacity of 700 MW to serve the peak demand in the power system. The mean annual energy will be around 2,156 GWh. The 99 m high dam is a zoned rockfill dam of vertical center core type. Its upstream and downstream surfaces are sloping at 1 to 2.6 and 1 to 1.9 respectively.

The embankment of the dam body comprises mainly andesite rock quarried some 8 km away from the damsite. The clay material for the impervious core was borrowed 1 km away from the dam site.

The dam body is founded on a rock foundation consisting of agglomerate, conglomerate and claystone layers dipping upstream at 15° to 20°.

The dam is provided with a grouting gallery beneath its impervious core which is also used for the purpose of instrumentation monitoring.

A chute spillway is constructed at the left side of the dam, with a discharge capacity of 2,400 m^3/sec.

4. CIRATA DAM

The Cirata dam is planned downstream of Saguling dam approx. 60 km north west of Bandung. The dam was constructed in 1989.

The powerstation has an ultimate capacity of 1,000 MW with a first stage of 500 MW to serve the peak demand in the Java power system. The mean annual energy output will be around 1,428 GWh.

Water will be conveyed through two 8.4 m diameter power tunnels to the four generating units of 125 MW each (first stage) which will be located in a 35 m wide and 49 m high underground powerhouse. The length will be 256 m for the total 8 units, including the second stage of 4 x 125 MW units.

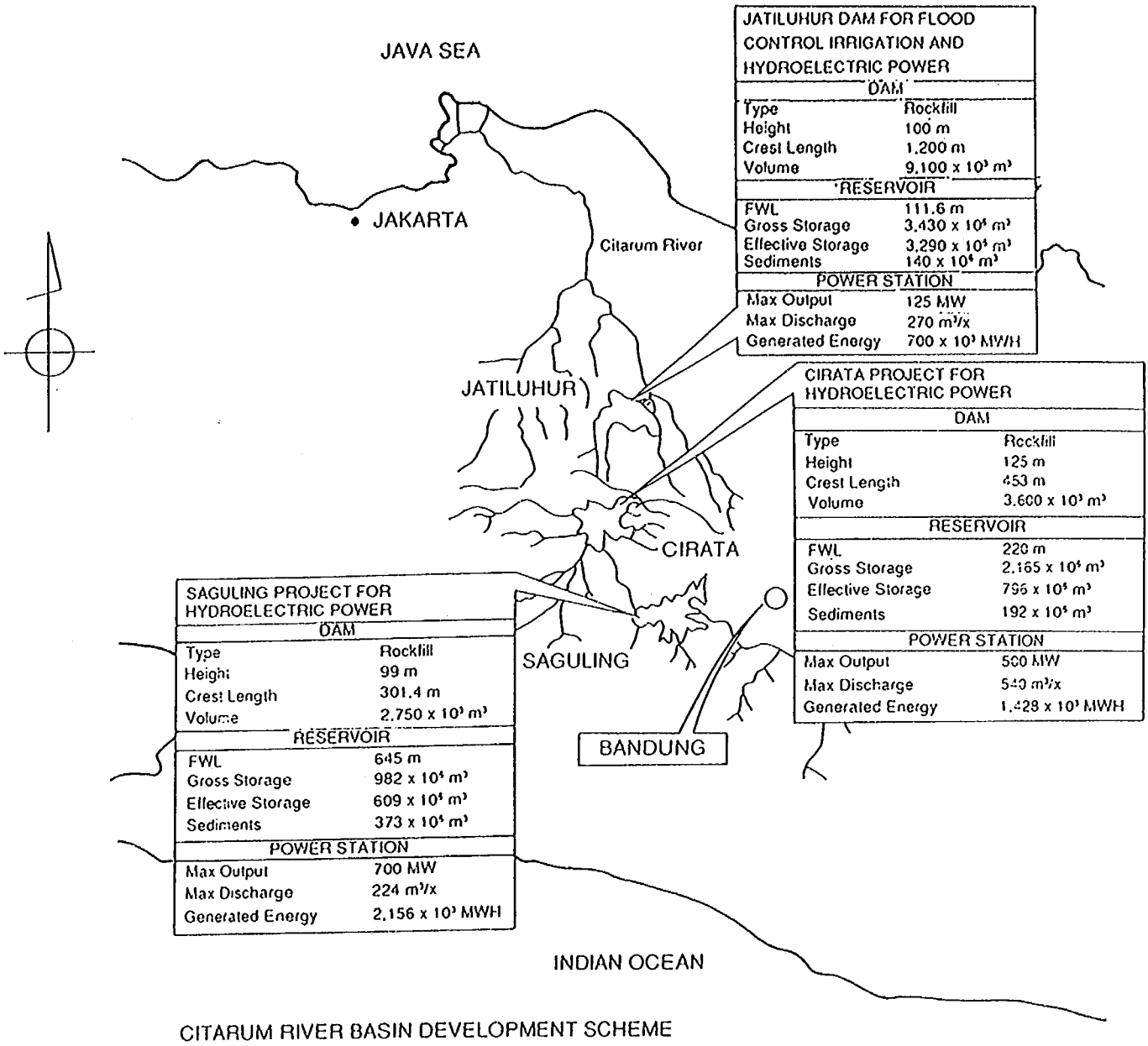
A 35 m wide span so far is the largest man made cavern in the world.

The 125 m high Cirata dam will be of zoned rockfill with upstream concrete face type. The embankment material of the dam body comprises mainly breccia, quarried nearby the dam site. Both upstream and downstream surfaces are sloping at 1 to 1.5.

The dam foundation will be prepared to increase the dam height from elevation + 221 m to elevation + 235 m to increase the water supply to Jakarta in the future.

A grouting gallery is provided which is also used for the purpose of monitoring instruments.

The spillway is of a tunnel type. There are two 10 meter diameter tunnels provided with two radial gates for each tunnel at its entrance.



CITARUM RIVER BASIN DEVELOPMENT SCHEME

Public Infrastructure Projects in Korea and Technical Problems

Lee Sang Eun, Vice President
Korea Institute of Construction Technology

Korea is now in the stage of implementation of the 3rd Phase of Comprehensive National Physical Planning (1992-2001) which consists of the most major public works, to be carried out in the next 10 years.

Through successful execution of two phases of Comprehensive National Physical Planning, many infrastructures have been developed. However, Korea is still suffering from a shortage of many types of infrastructures, such as harbors, expressways, water pollution control facilities etc., due to its rapid economic development.

With recognition of the importance of infrastructures development to support continuous economic development, a special planning Board for Social Overhead Capital (SOC) was founded in the Presidential Office since 1991.

There are many types of large scale infrastructures in the planning and/or execution stages. These include construction of a new airport (Yong Jong Do), a Seoul-Pusan rapid-transit railway, reclamation of seashore, multipurpose dams, apartments etc.

Although the Korean construction industry has capability for successful execution of various types of both domestic and overseas large scale construction projects, the level of construction technology is not very high, since the construction industry has been grown through rather labor-intensive type projects. Accordingly, Korean construction industry rely the technology intensive part of the projects on the technology of the advanced countries.

Recently, the efforts of governmental sector and private sector for construction technology development have become extensive.

The Korean Government has recently finalized the 10 year basic plan for construction technology development (1992 - 2001) and 5 years implementation plan for R&D of Construction Technology ('93 - '97).

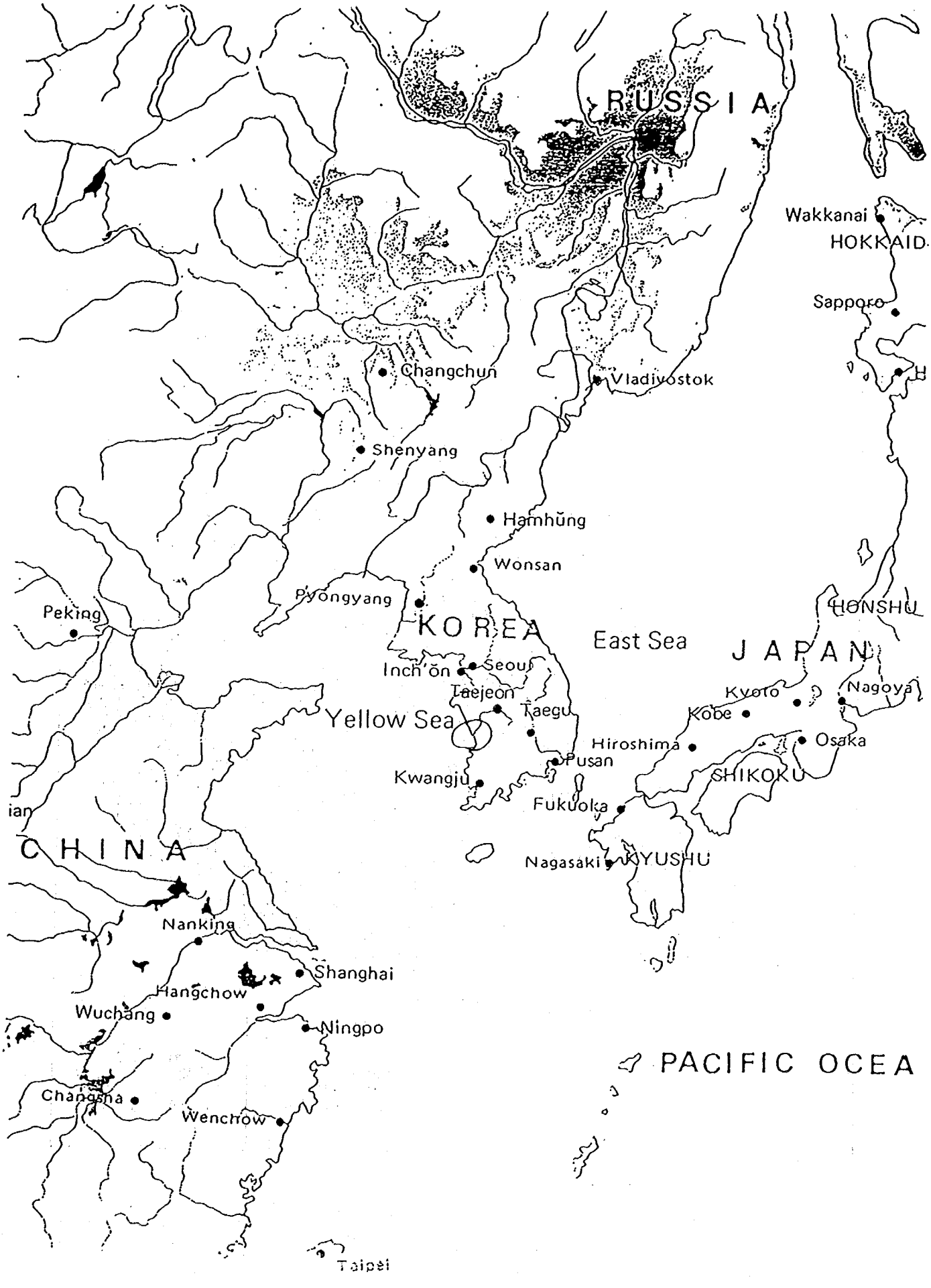
The Government is also trying to improve the institutional and regulatory systems which have somehow discouraged the construction industry to become more active in R&D of construction technology development.

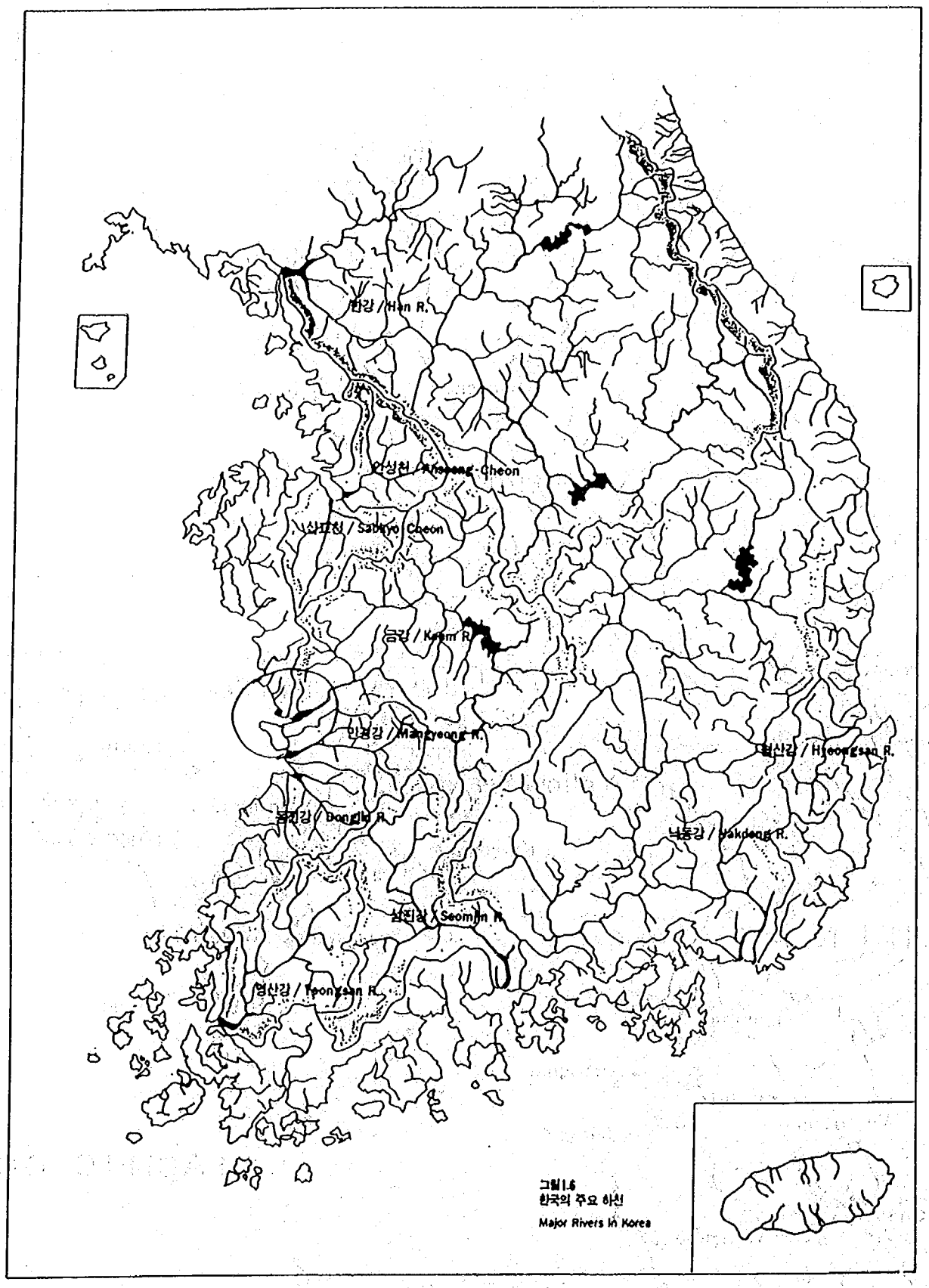
Since a tremendous amount of investment is required for infrastructure construction, the priority should be determined in the most rational way. However, it is a very difficult subject, although the priority determination is the major function of the SOC planning Board.

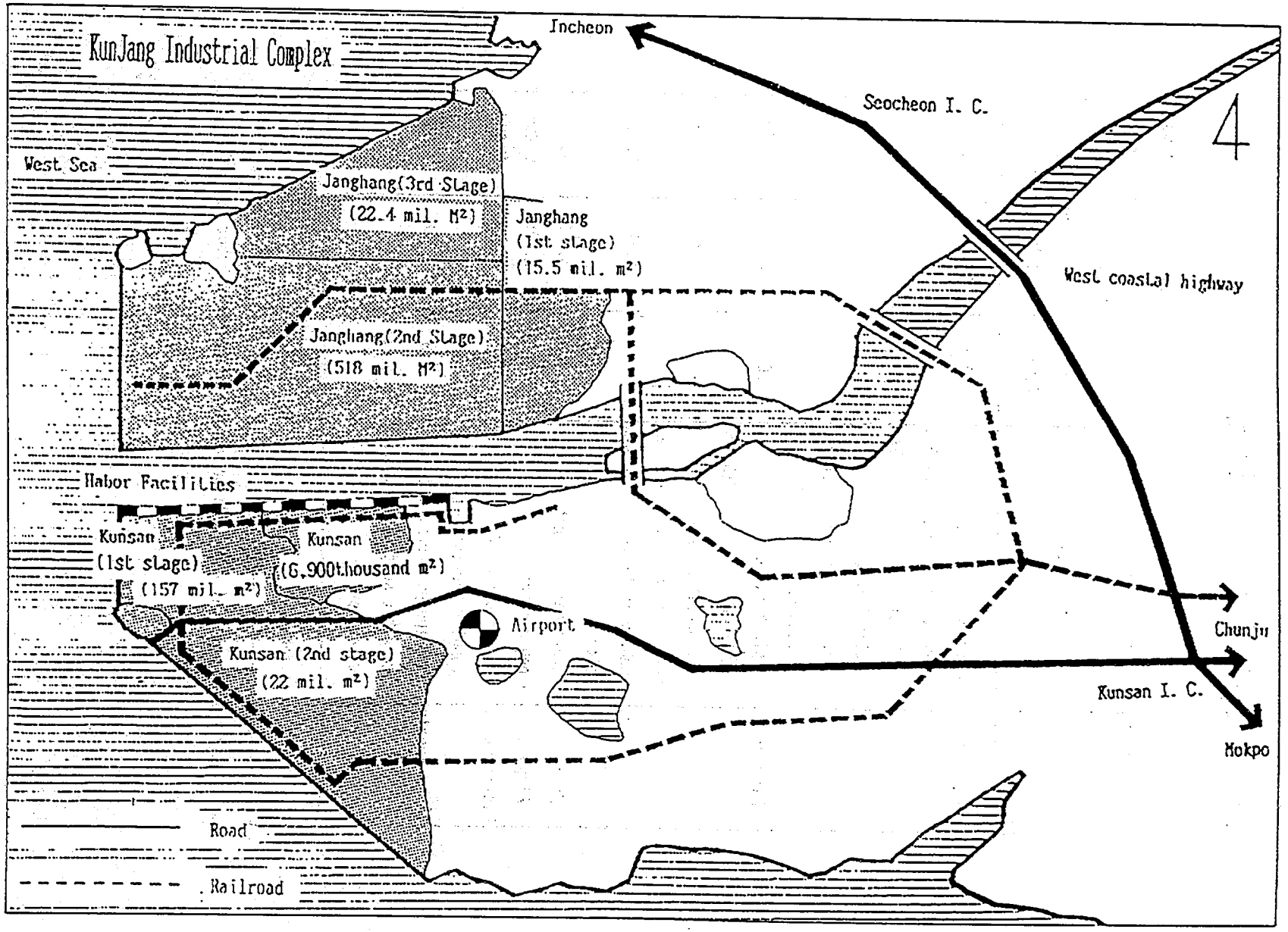
Another problem is lack of accumulation of construction technology information. KICT established the Construction Technology Information Center in 1992. However, the information available in this center is still limited. For efficient implementation of public works and infrastructure projects, in addition to the technology development, establishment of construction technology information service network is essential.

The largest scale infrastructure projects have to assess environmental impact and thus many projects, such as the new airport project and rapid-transit railway project, are facing the strong movement which are against the projects due to their possible adverse environmental impacts.

The technology development to satisfy both the need for infrastructure development as well as environmental conservation will play a key role for future infrastructure projects in an environmentally sound and sustainable society.


RUSSIA
Wakkanai
HOKKAID
Sapporo
Changchun
Vladivostok
Shenyang
Hamhŭng
Wonsan
Pyongyang
Peking
KOREA
East Sea
JAPAN
HONSHU
Inch'ŏn
Seoul
Taejeon
Taegu
Kyoto
Nagoya
Kobe
Yellow Sea
Hiroshima
Osaka
Pusan
Kwangju
SHIKOKU
Fukuoka
CHINA
Nagasaki
KYUSHU
Nanking
Shanghai
Hangchow
Wuchang
Ningpo
PACIFIC OCEA
Changsha
Wenchow
Taipei


한강 / Han R.
안성천 / Anseong-Cheon
삽교천 / Sabkyo Cheon
금강 / Keum R.
만경강 / Mangyeong R.
섬진강 / Seomjin R.
영산강 / Yeongsan R.
그림1.6
한국의 주요 하천
Major Rivers in Korea

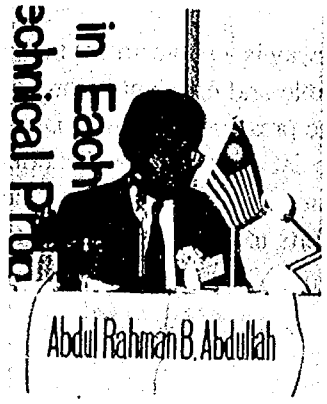

KunJang Industrial Complex
Incheon
Seocheon I. C.
West Sea
Janghang(3rd Stage)
(22.4 mil. M²)
Janghang
(1st stage)
(15.5 mil. m²)
West coastal highway
Janghang(2nd Stage)
(518 mil. M²)
Habor Facilities
Kunsan
(1st stage)
(157 mil. m²)
Kunsan
(6,900thousand m²)
Airport
Chunju
Kunsan (2nd stage)
(22 mil. m²)
Kunsan I. C.
Mokpo
Road
Railroad

2. 5 Major Project in Progress or in Planning

Unit : trillion won

Section	Main Works	Investment		
		Total	1992-1996	1997-2001
Highway	· highway [new construction 1,500km [extension 700km · national road [new construction 1,100km [extension 5,500km	39.3	18.5	20.8
Railway	· rapid-transit railroad 915.7km · metropolitan area electric railway 269.4km · subway in large city 536.4km	18.9	6.092 1.737 1.71	5.588 0.159 1.043
Harbor	· container, freight	7.5	3.088	4.401
Airport	· new airport	3.2	2.725	0.489
Distribution	· construction of complex terminal	0.7	0.434	0.3
Water Supply	· multipurpose-dam, wide range water supply, industrial water, etc.	3.9	2.826	1.045
Total		73.5		

* Notes : Nongovernmental 2.5 trillion won was excluded in habor project.



The Malaysian North - South Expressway

Abdul Rahman B. Abdullah,
Deputy Director General, Public Works Department,
Ministry of Works

Roads have always played a vital role in the history of Malaysia's development.

Along with railways, roads were used to bring the bounty of resource-rich Malaysia - its tin, rubber, palm oil and timber - to towns and to ports for export.

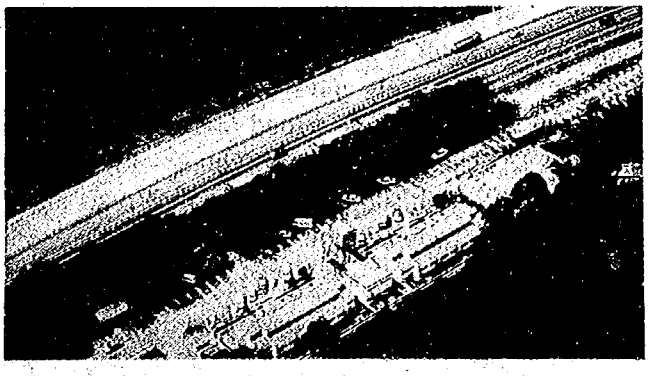
Roads held the country together, allowing motorists to drive from one corner to the other, traversing north and south, east and west.

By 1994 Malaysia will have an over-900 km expressway running the entire length of the west coast of peninsular Malaysia from Bukit Kayu Hitam in the north to Johor Bharu in the south. With a total projected cost of $6 billion, it is Malaysia's largest current infrastructural project as well as being the country single largest privatised venture.

The highway will enable motorists to travel southwards from the Thai border to the causeway Johor Bharu with Singapore. It is a journey along Peninsula Malaysia's western corridor on a dual-carriageway expressway which would take less than 10 hours – almost half the current time taken. Such speed and efficiency will boost industrial growth and tourism while dramatically redefining travel in the country and bring together the west coast of Peninsular Malaysia into a bigger common market.

Under a concession agreement signed in 1988 between the Malaysian Government and a public company known as PLUS, the company mapped out a three-phase program to build 513 km of expressway consisting of the remaining 462 km of the North-South expressway and over 35 km of the New Klang Valley Expressway – a vital artery linking the capital Kuala Lumpur, Subang International Airport and Port Klang, Malaysia's main seaport and container terminal. Apart from this, the company is also responsible to manage, improve and operate the 310 km of the existing portion of the expressway, which had been previously completed under the management of the Malaysian Highway Authority (MHA) of the Ministry of Works Malaysia.

When completed, the expressway will have over 300 bridges and overpasses and two tunnels. There will be over 20 service areas with petrol stations and food facilities and over 40 rest areas. There will be a total of 46 interchanges which will be served by over 400 toll booths where motorists will have the distance traveled checked by computer as they pay at their final exit at the end of the journey. The journey from the north to the south will present a sweeping panorama of Malaysia natural beauty. It is a journey past paddy field, tin mines, rubber and oil palm estates, made against a scenic backdrop of limestone hills and Malaysia's lush tropical forests.



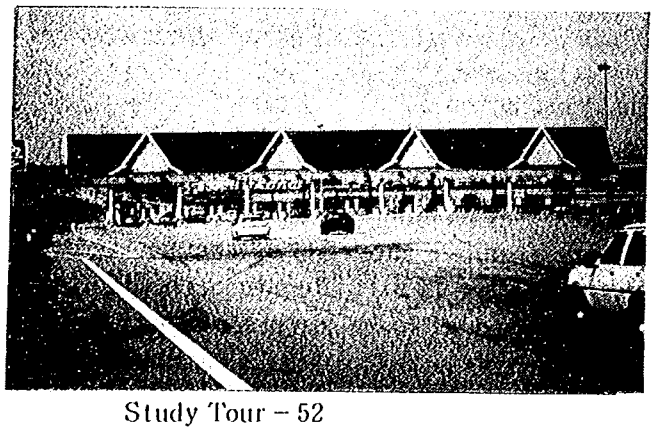
The Construction

The bulk of the construction activity was carried out simultaneously on different sections of the expressway system. There are altogether 47 contract packages. Advanced earthwork and trial embankment construction were completed before the start of the main civil works. The major civil works included the construction of the

main-line carriageways of the expressways, the interchanges and the associated link roads. Supply of concrete products and other construction materials was crucial, as was the installation of sign and gantries, guardrails and street lighting, as well as the telecommunications equipment. The expressways predominantly run in two lanes in each direction, with adequate hard shoulders to enable vehicles to pull off the carriageway in an emergency.

Designed for safety and efficiency, dual three-lane carriageways are also provided in areas where traffic flow studies forecast they are needed. There are also wind socks along the route to warn motorists of crosswinds. Subsoil improvements had to be carried out before advanced earthwork could start. Rock stabilization works as well as soft ground treatments were essential in some areas with underlying marine clay or high water tables. Slope protection measures were put in place while piled embankments and retaining walls were constructed and telecommunication infrastructure installed.

Over 154 km of the expressway is built with Continuously Reinforced Concrete Pavement (CRCP). With emphasis on safety and security, the expressways have been equipped with a road monitoring system, numerous signage and halogen lighting. Emergency telephones will be installed at two-km intervals along the entire expressway system.



The North-South Expressway is an investment in the future. It is a fast, comfortable and efficient means of transportation. It relieves the pressures of traffic jams. Beyond this are intangible social and economic benefits which are not so easy to quantify. It demonstrates the government's continuing efforts to improve the quality of life for all Malaysians.

Infrastructure for Development of Metro Manila and its Suburban Area

Manuel M. Bonoan
Assistant Secretary for Planning,
Department of Public Works and Highways

1. Development of Metro Manila

The Metropolitan Manila area of the Philippines, called the national Capital Region or Metro Manila, comprises cities and thirteen municipalities, encompassing an area of 636 square kilometers. The development of Metro Manila can be traced from the center of the city of Manila. As the years passed, Manila evolved into a major urban center. Metro Manila's present population of 8 million has triggered the rapid growth of urbanization. During the recent 10 years, population of about 2 million has been increased in Metro Manila area. With the growth of urbanization, the number of vehicles is also increasing rapidly. Then recently traffic congestion and air pollution of Metro Manila became serious problems every year. In order to solve traffic congestion, the Philippine Government carries out a lot of projects of infrastructure, which consists of not only rehabilitation of road pavement and bridges but also new-construction of structures such as interchanges, flyover and underpass. Though infrastructure of Metro Manila is progressing every year, there are still some kinds of problems such as concentration of population in the city center and right-of-way acquisition caused by escalation of land price.

On the other hand, the Philippine Government aims at the utility and equal development of our country.

Therefore, the Philippine Government emphasizes development of rural areas with modernized agriculture, industry and tourism in the three main regions of Luzon, Visayas and Mindanao.

One of the famous projects in Luzon area is the following CALABARZON Project.

2. Development of the suburbs Metro Manila (CALABARZON Project)

The CALABARZON region consists of the five Provincial Governments of Cavite, Laguna, Batangas, Rizal and Quezon, with a land area of 16,229 square kilometers and a total population of 8.3 million. It is located on the Philippine island of Luzon, contiguous to Metropolitan Manila.

The Philippine Government has recognized the CALABARZON region's resources and outstanding potential as a center for high industrialization, attracting foreign export-processing type industries with substantial capital investment. The CALABARZON Project is a large scale, multi-sectoral program designed to convert the traditional, agro-based rural economies of the region into vigorous, agro-industrial urban economies.

The massive scale of the project demands a systematic, fully integrated approach, in which the industrial sector is developed simultaneously with the economic and social sector, as well as infrastructures and services such as transport, telecommunications, energy, water, utilities, and environmental management. There are some main transportation facilities such as the Manila International Airport, Batangas Port and Lucena Port which are international ports and connect the region to other island. The Philippine Government is particularly implementing the rehabilitation of existing highways and road, and links between the urban transport system of Metro Manila and the industrial region's transport system.

This area is also Metro Manila's resort area, as beautiful seasides dotted with leisure communities such as executive golf courses and country club facilities.

Therefore, the Philippine Government emphasizes rehabilitation of road network in this area, and some rehabilitation project are now implementing.

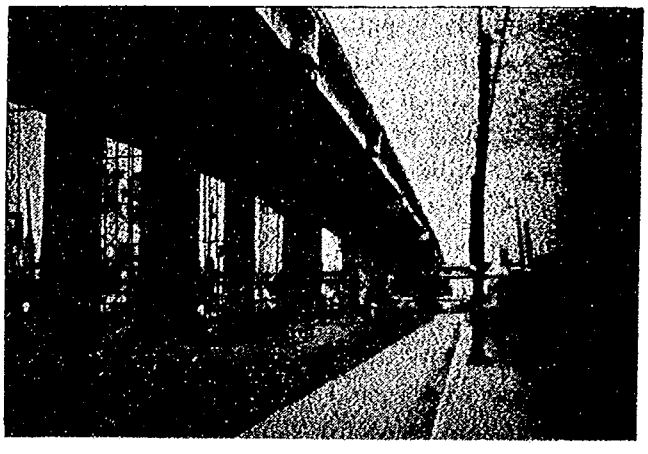
3. Problems of infrastructure development

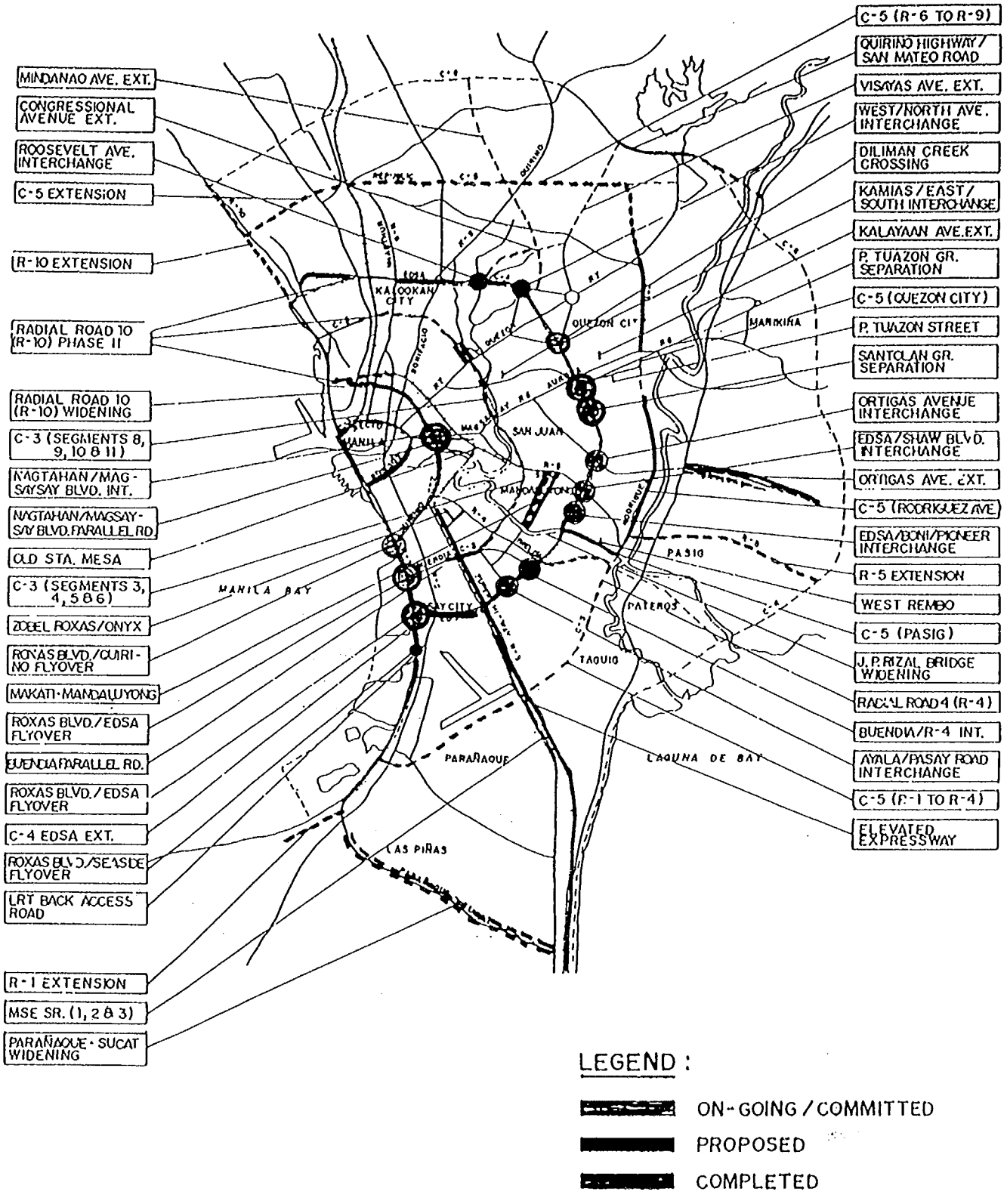
Though for infrastructure development projects such as the above CALABARZON , disasters or calamities are serious obstacles.

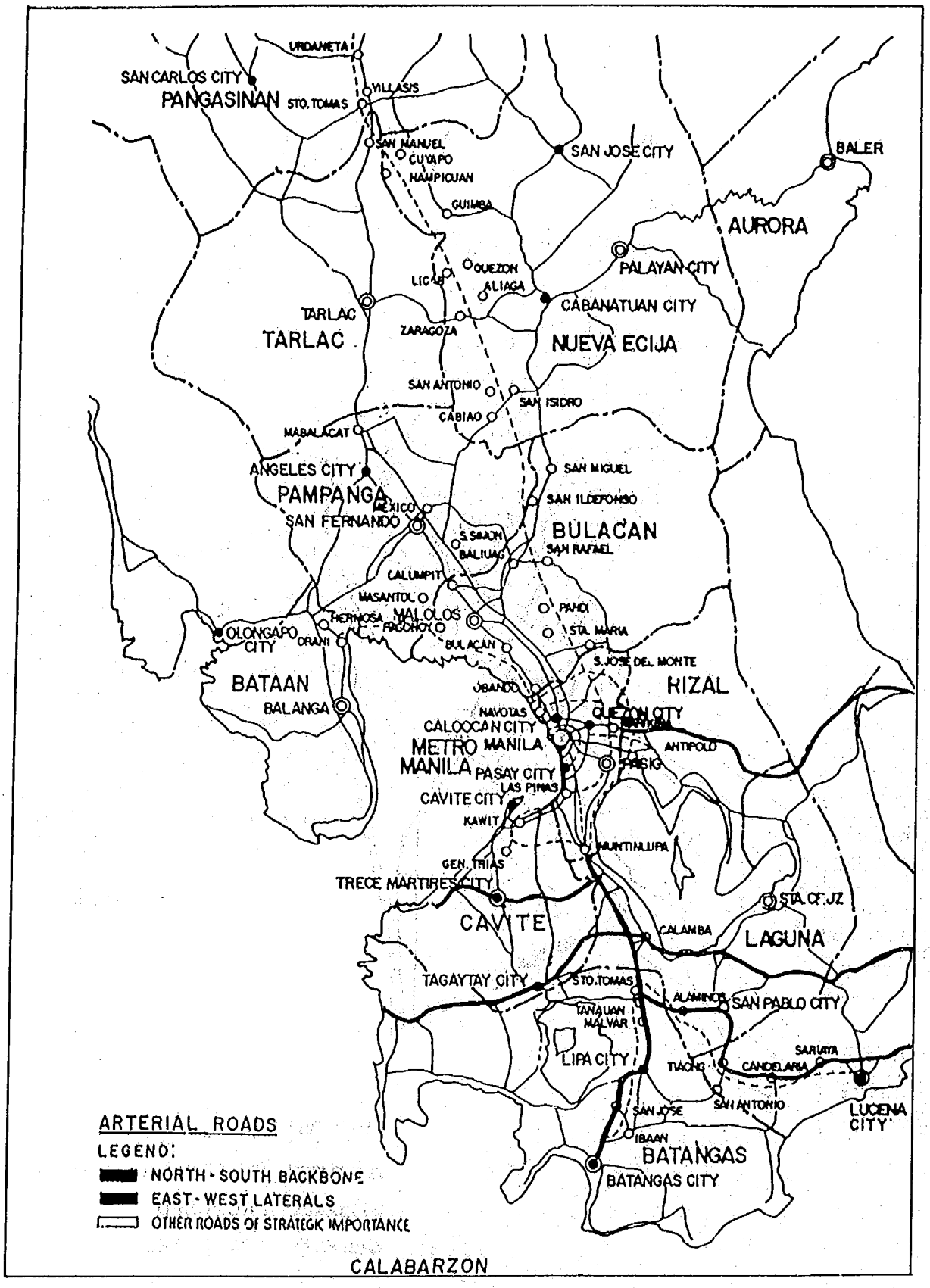
The Philippines is located in a region which is recognized as having the greatest frequency of typhoon, earthquakes and volcanic eruptions. Various national calamities cause serious damage to the social infrastructures every year. For example,
1) an earthquake of magnitude 7.7 devastated central Luzon in June 1990, 2) a killer typhoon with the maximum instantaneous wind speed of 70 m/second attacked Cebu in November 1990, 3) eruption of Mt. Pinatubo, the greatest eruption in history, damaged a large area in June 1991 and lahar damaged not only infrastructure such as bridges but also towns during the rainy season in 1992, 4) typhoon "Uring" hit West Leyte and approximately 10,000 people were killed in November 1991.

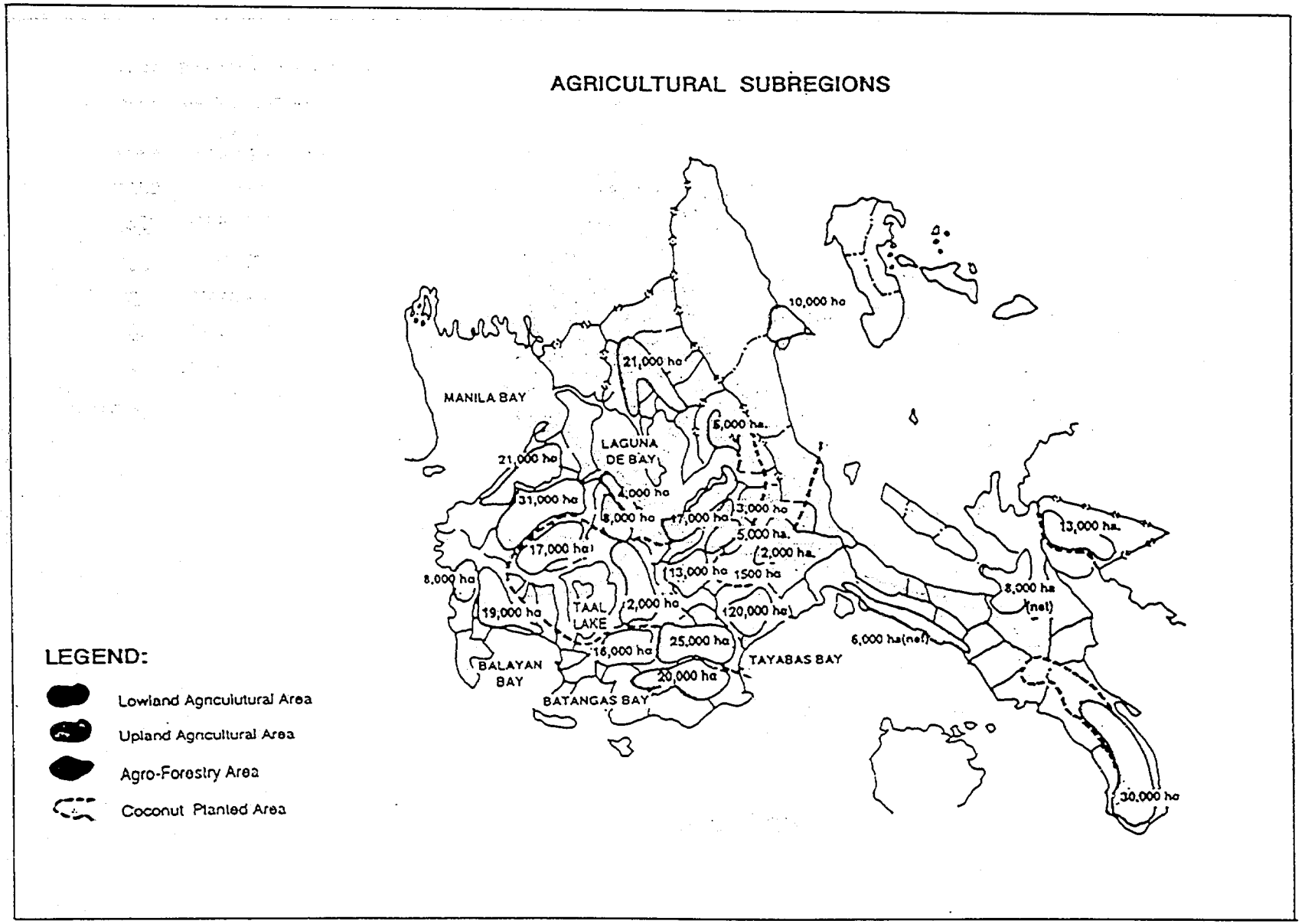
The calamities caused serious damages to the social infrastructure, especially roads and bridges, and closed the public transportation for a long period, therefore the calamities caused difficulty in terms of not only human life but also socio-economic development.
Therefore, we have to establish a financial system and disaster prevention and maintenance techniques in order to construct infrastructures to develop our country steadily.

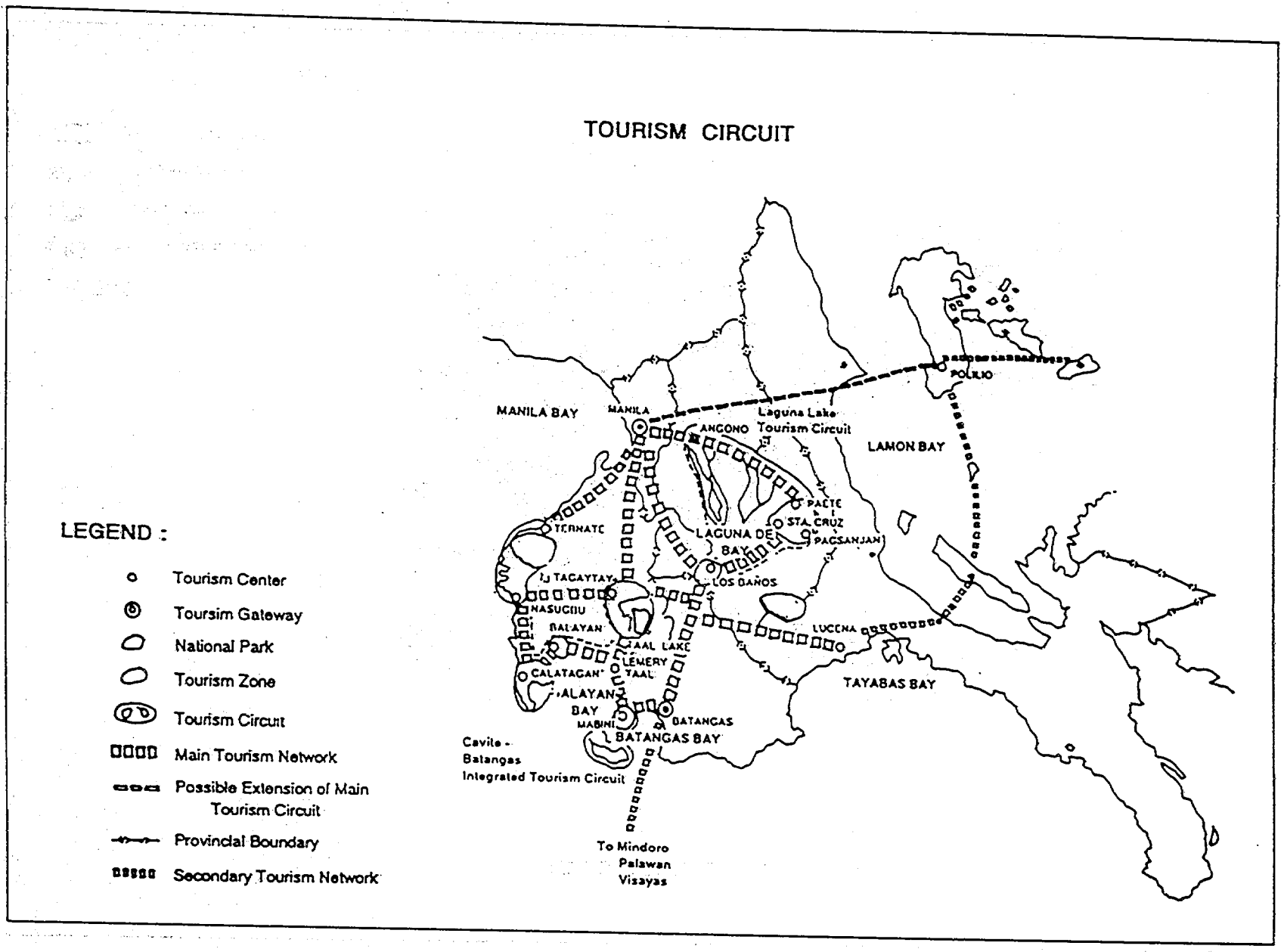
In the symposium, I would like to use three (3) or four (4) slides and three (3) or four (4) OHP sheets.



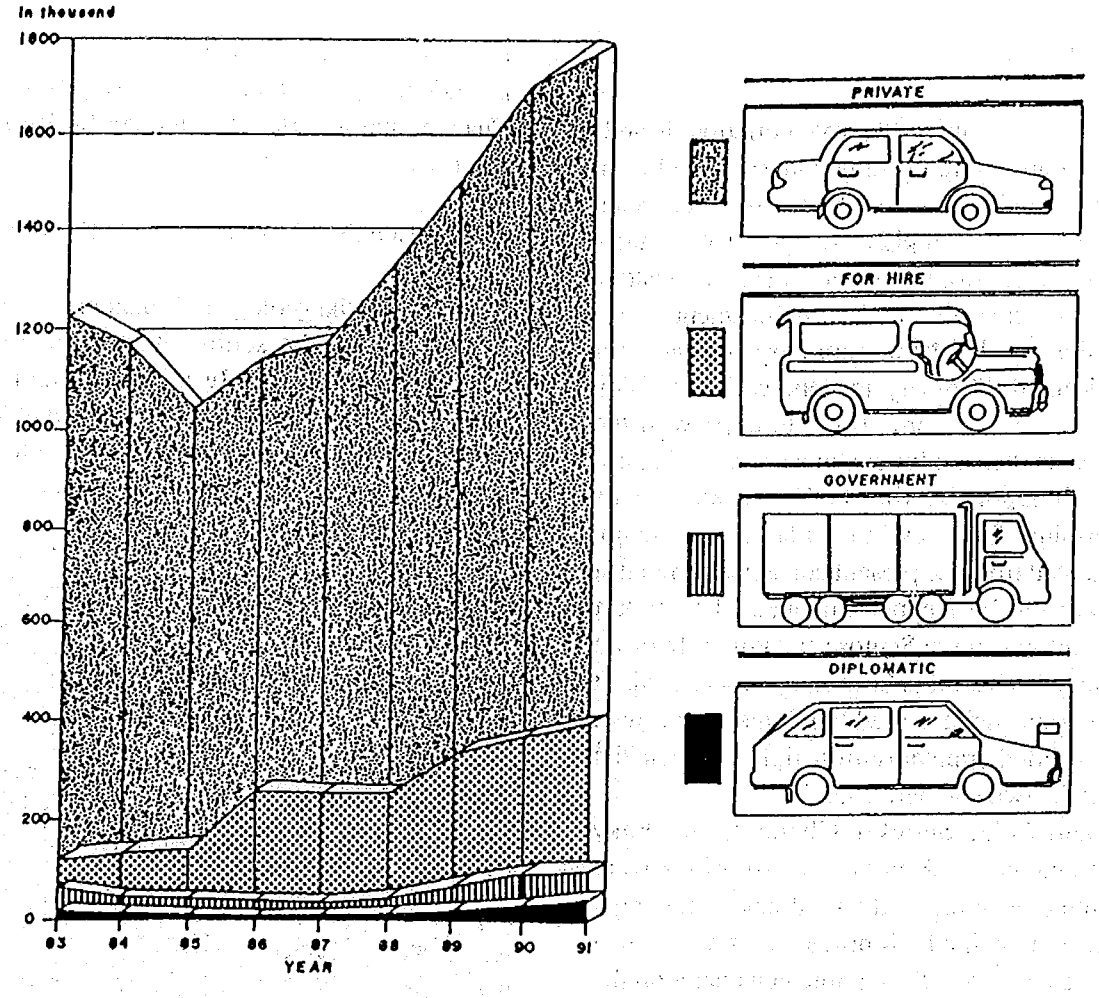

MINDANAO AVE. EXT.
CONGRESSIONAL AVENUE EXT.
ROOSEVELT AVE. INTERCHANGE
C-5 EXTENSION
R-10 EXTENSION
RADIAL ROAD 10 (R-10) PHASE II
RADIAL ROAD 10 (R-10) WIDENING
C-3 (SEGMENTS 8, 9, 10 & 11)
NAGTAHAN/MAG-SAYSAY BLVD. INT.
NAGTAHAN/MAGSAY-SAY BLVD. PARALLEL RD.
OLD STA. MESA
C-3 (SEGMENTS 3, 4, 5 & 6)
ZOBEL ROXAS/ONYX
ROXAS BLVD./QUIRI-NO FLYOVER
MAKATI-MANDALUYONG
ROXAS BLVD./EDSA FLYOVER
BUENDIA PARALLEL RD.
ROXAS BLVD./EDSA FLYOVER
C-4 EDSA EXT.
ROXAS BLVD./SEASIDE FLYOVER
LRT BACK ACCESS ROAD
R-1 EXTENSION
MSE SR. (1, 2 & 3)
PARAÑAQUE-SUCAT WIDENING
C-5 (R-6 TO R-9)
QUIRINO HIGHWAY/ SAN MATEO ROAD
VISAYAS AVE. EXT.
WEST/NORTH AVE. INTERCHANGE
DILIMAN CREEK CROSSING
KAMIAS/EAST/ SOUTH INTERCHANGE
KALAYAAN AVE.EXT.
P. TUAZON GR. SEPARATION
C-5 (QUEZON CITY)
P. TUAZON STREET
SANTOLAN GR. SEPARATION
ORTIGAS AVENUE INTERCHANGE
EDSA/SHAW BLVD. INTERCHANGE
ORTIGAS AVE. EXT.
C-5 (RODRIGUEZ AVE.)
EDSA/BONI/PIONEER INTERCHANGE
R-5 EXTENSION
WEST REMBO
C-5 (PASIG)
J.P.RIZAL BRIDGE WIDENING
RADIAL ROAD 4 (R-4)
BUENDIA/R-4 INT.
AYALA/PASAY ROAD INTERCHANGE
C-5 (R-1 TO R-4)
ELEVATED EXPRESSWAY
KALOOKAN CITY
QUEZON CITY
MANDALUYONG
SAN JUAN
MANILA
MANILA BAY
PASIG
PATEROS
TAGUIG
PARAÑAQUE
LAGUNA DE BAY
LAS PIÑAS
LEGEND :
ON-GOING / COMMITTED
PROPOSED
COMPLETED


URDANETA
SAN CARLOS CITY
PANGASINAN
STO. TOMAS
VILLASIS
SAN MANUEL
CUYAPO
NAMPICUAN
GUIMBA
SAN JOSE CITY
BALER
AURORA
PALAYAN CITY
QUEZON
LICAB
ALIAGA
CABANATUAN CITY
TARLAC
TARLAC
ZARAGOZA
NUEVA ECIJA
SAN ANTONIO
SAN ISIDRO
CABIAO
MABALACAT
ANGELES CITY
PAMPANGA
MEXICO
SAN FERNANDO
SAN MIGUEL
SAN ILDEFONSO
BULACAN
S. SIMON
BALIUAG
SAN RAFAEL
CALUMPIT
MASANTOL
HERMOSA
MALOLOS
PAGONOY
PANDI
STA. MARIA
OLONGAPO CITY
ORANI
BULACAN
S. JOSE DEL MONTE
BATAAN
RIZAL
BALANGA
NAVOTAS
QUEZON CITY
CALOOCAN CITY
METRO MANILA
MANILA
ANTIPOLO
PASIG
PASAY CITY
LAS PINAS
CAVITE CITY
KAWIT
MUNTINLUPA
GEN. TRIAS
TRECE MARTIRES CITY
CAVITE
CALAMBA
LAGUNA
TAGAYTAY CITY
STO. TOMAS
ALAMINOS
SAN PABLO CITY
TANAUAN
MALVAR
LIPA CITY
TIAONG
CANDELARIA
SARIAYA
SAN JOSE
SAN ANTONIO
LUCENA CITY
IBAAN
BATANGAS
BATANGAS CITY
ARTERIAL ROADS
LEGEND:
NORTH - SOUTH BACKBONE
EAST - WEST LATERALS
OTHER ROADS OF STRATEGIC IMPORTANCE
CALABARZON


AGRICULTURAL SUBREGIONS
MANILA BAY
LAGUNA DE BAY
TAAL LAKE
BALAYAN BAY
BATANGAS BAY
TAYABAS BAY
10,000 ha
21,000 ha
5,000 ha.
21,000 ha
4,000 ha
31,000 ha
8,000 ha
17,000 ha
3,000 ha
5,000 ha.
2,000 ha.
17,000 ha
13,000 ha
1500 ha
8,000 ha
19,000 ha
2,000 ha
120,000 ha
25,000 ha
16,000 ha
20,000 ha
6,000 ha(net)
13,000 ha.
8,000 ha (net)
30,000 ha
LEGEND:
Lowland Agriculutural Area
Upland Agricultural Area
Agro-Forestry Area
Coconut Planted Area


TOURISM CIRCUIT
LEGEND :
Tourism Center
Toursim Gateway
National Park
Tourism Zone
Tourism Circuit
Main Tourism Network
Possible Extension of Main Tourism Circuit
Provincial Boundary
Secondary Tourism Network
MANILA BAY
MANILA
ANGONO
Laguna Lake Tourism Circuit
LAMON BAY
POLILLO
PAETE
STA. CRUZ
PAGSANJAN
TERNATE
LAGUNA DE BAY
TAGAYTAY
LOS BAÑOS
NASUGBU
BALAYAN
TAAL LAKE
LEMERY
TAAL
CALATAGAN
LUCENA
TAYABAS BAY
BALAYAN BAY
MABINI
BATANGAS
BATANGAS BAY
Cavite - Batangas Integrated Tourism Circuit
To Mindoro
Palawan
Visayas

NUMBER OF MOTOR VEHICLES REGISTERED BY TYPE OF VEHICLE 1983 TO 1991



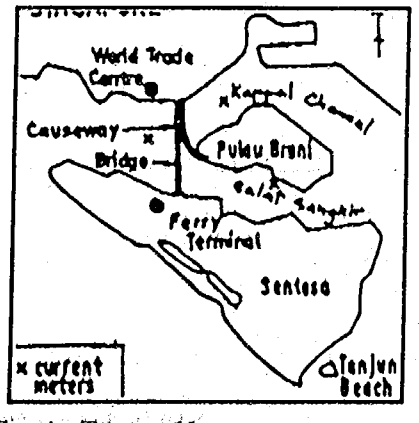
Design and Construction of Road Link (Causeway and Bridge) from Keppel to Sentosa

Tan Siong Leng
Director, Building Control Division,
Public Works Department,
Ministry of National Development

1 INTRODUCTION

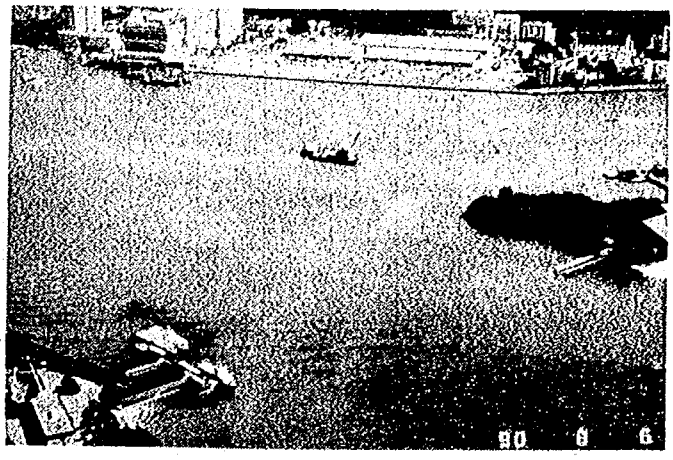
Sentosa and Pulau Brani are two main offshore islands located at the southern tip of Singapore separated from the Singapore Island by the Keppel Channel and Selat Sengkir Channel. Due to rapid development of Sentosa into one of the finest tropical paradise islands, visitors arrival has been increasing rapidly. An efficient means of transportation besides the present ferry and cable car services is deemed necessary to cope with the rising traffic demand. At the same time, to cope with the rapidly increasing demand for container services in port, the Port of Singapore Authority has to expand its container terminal facilities into Pulau Brani island, which is separated from the present container terminal at Tanjong Pagar by the Keppel Channel. To support intensified developments at Sentosa and Pulau Brani, an efficient mean of transport is becoming very critical. It was therefore decided that a road link is the only way to provide the needed transportation link between the mainland and the two southern islands.

Keppel and Selat Sengkir Channels are busy navigational channels. A variety of solutions were considered in the planning of the road link, including a submerged tube tunnel, a high bridge, a draw bridge, a rock filled causeway etc. Taking into consideration the various factors such as construction cost, operating cost, navigational requirements, environmental impact and aesthetics, it was decided that a combination of a causeway and low level bridge be adopted for the road link. Figure 1 shows the location of the road link which is made up of a 330m long causeway across the Keppel Channel and a 380m long arched bridge spanning the Selat Sengkir Channel.



2 GEOLOGY AND SUBSURFACE CONDITIONS

According to the geology of Singapore, the project site is located within the sedimentary formation which is characterized by mainly mudstone and muddy fine sandstone/siltstone. These interbedded sedimentary rocks are highly fractured and display a high degree of folding. Figure 2 shows the geological profile along the alignment of the road link.



3 HYDRAULIC CONDITIONS

The tidal currents in Singapore are of the mixed type and are diurnal in nature due to the effects of tropic tides. However, at the channels, the west-going current which prevails for as long as 14-16 hrs in a 25 hrs cycle time dominates over the east-going current. The peak current recorded at the channels could be up to 2 m/s during the east-going flow. The maximum recorded tide level at Keppel Harbour was +3.49m ACD and the minimum was -0.35m ACD. Because of the high current velocity and the predominant west-going flow, it is feared that the closure of the Keppel Channel by the causeway will

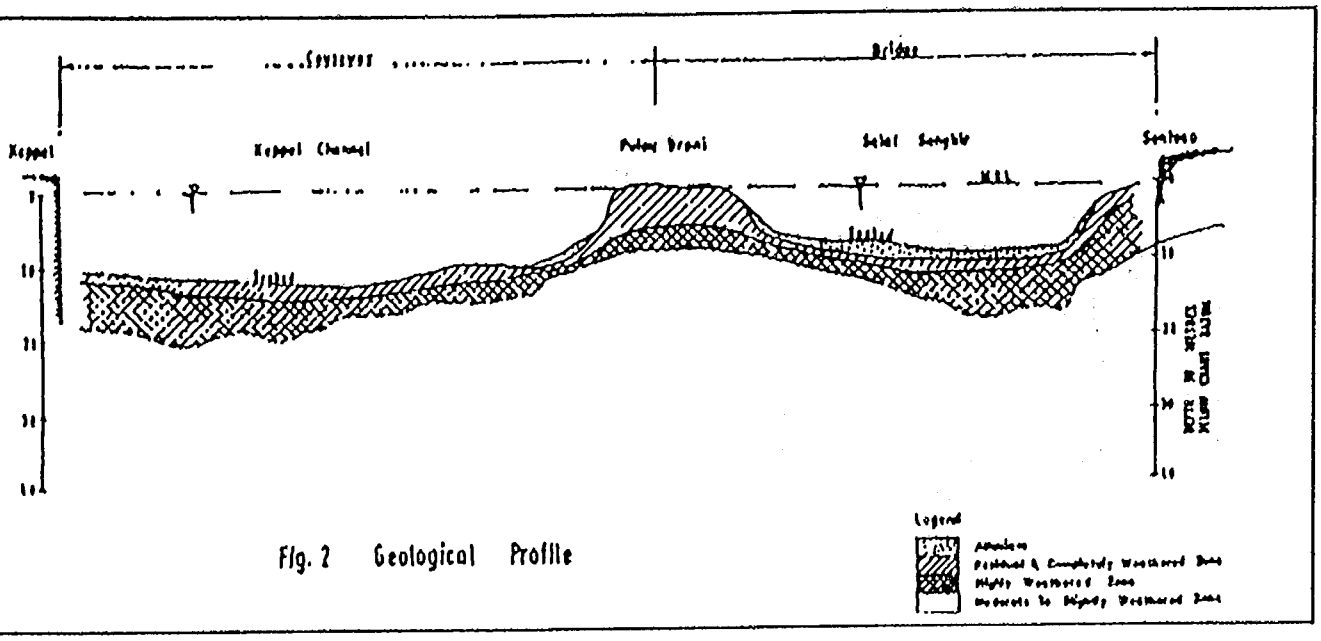


Fig. 2 Geological Profile

raise serious hydrodynamic problems. Also, the large tidal fluctuation will create some difficulties in the aesthetic treatment of the causeway wall.

4 HYDRAULIC MODEL STUDIES

To predict the effects of the closure of the Keppel Channel by the causeway, a series of model studies were conducted. This included physical modeling, mathematical modeling, sedimentation simulation and water quality studies.

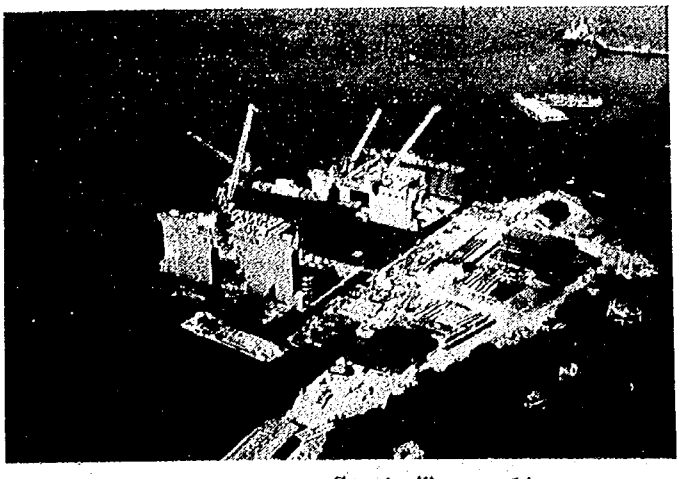
The physical model studies were carried out to evaluate the current conditions in the channels both during and after the construction, and the hydraulic forces that will be exerted on the causeway structure as the Keppel Channel is being closed. It was predicted that the current at Selat Sengkir will increase by 50% after the closure of the Keppel Channel. This predicted increase was considered undesirable to the operation of the nearby naval base. A submerged rock bund has to be considered for the Sengkir Selat Channel to reduce the current velocity and simulation was carried out to determine the appropriate level and rate of raising of the submerged bund to control the current velocity during and after the construction. To ensure safe navigation through Selat Sengkir Channel, an upper limit of 20% on the increase in the current velocity was specified. The physical modeling also predicted a maximum horizontal hydraulic force of 500 tonnes, which has to be taken care of during the construction of the causeway.

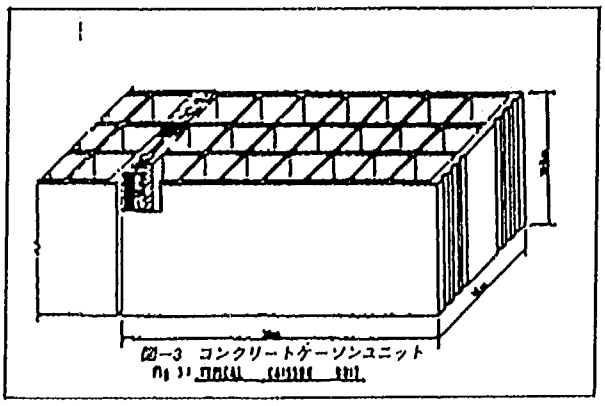
The mathematical model covering a much wider area was carried out to complement the physical model studies and also for evaluating the current increases in the surrounding water and their impact on the surrounding land.

With the closure of the Keppel Channel, sedimentation rate is expected to increase and water quality will deteriorate. Sedimentation and water quality studies were therefore conducted to evaluate the sedimentation rate and effect of the causeway construction on the water quality in the Keppel Channel.

5 DESIGN

The road link is to provide a land link to serve Sentosa and the Brani Container Terminal. However, there are differences in the two needs. The Port of Singapore Authority (PSA) requires a convenient road link for the port traffic to and from the Brani Terminal with a vertical sea wall to save space and possible anchorage by smaller crafts in the future whereas the Sentosa Development Corporation (SDC) needs an aesthetic vehicular road link to match the ambient of Sentosa as a tourist resort and hence a rubble mound sloping sea front. Two types of causeway structures across the Keppel Channel were considered - a rubble mound with sloping side wall and a concrete caisson type with vertical wall.





図−3 コンクリートケーソンユニット
Fig 3 : TYPICAL CAISSON UNIT

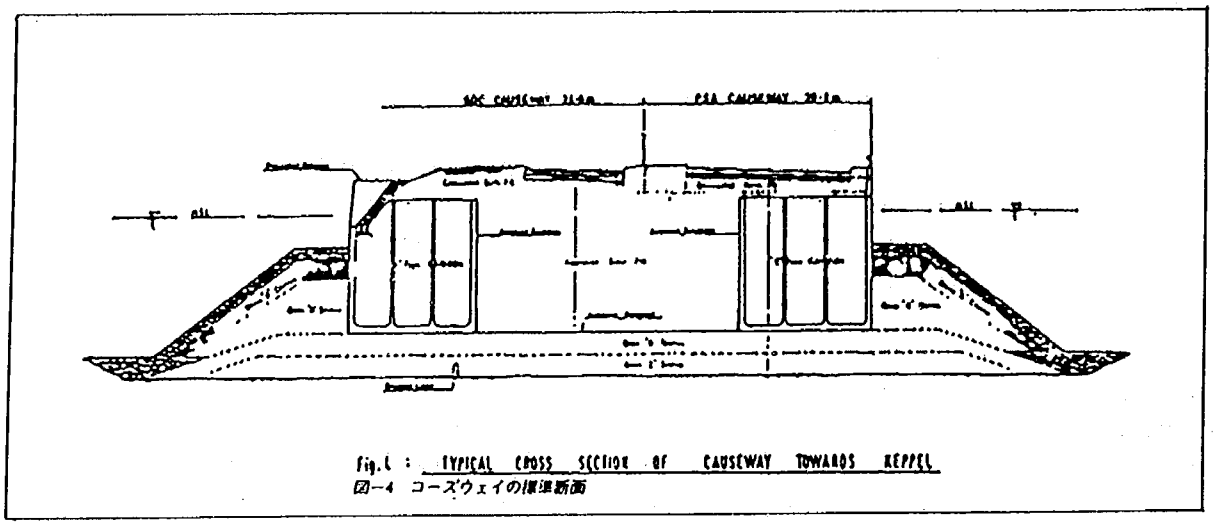
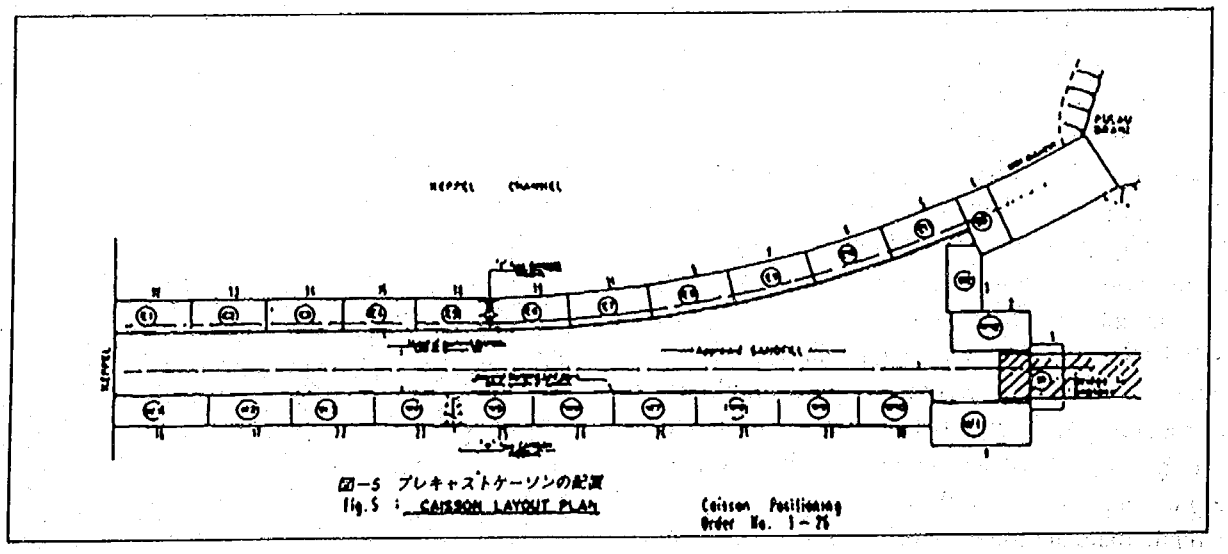


Fig.4 : TYPICAL CROSS SECTION OF CAUSEWAY TOWARDS KEPPEL
図−4 コーズウェイの標準断面



図−5 プレキャストケーソンの配置
Fig.5 : CAISSON LAYOUT PLAN
Caisson Positioning Order No. 1 – 75

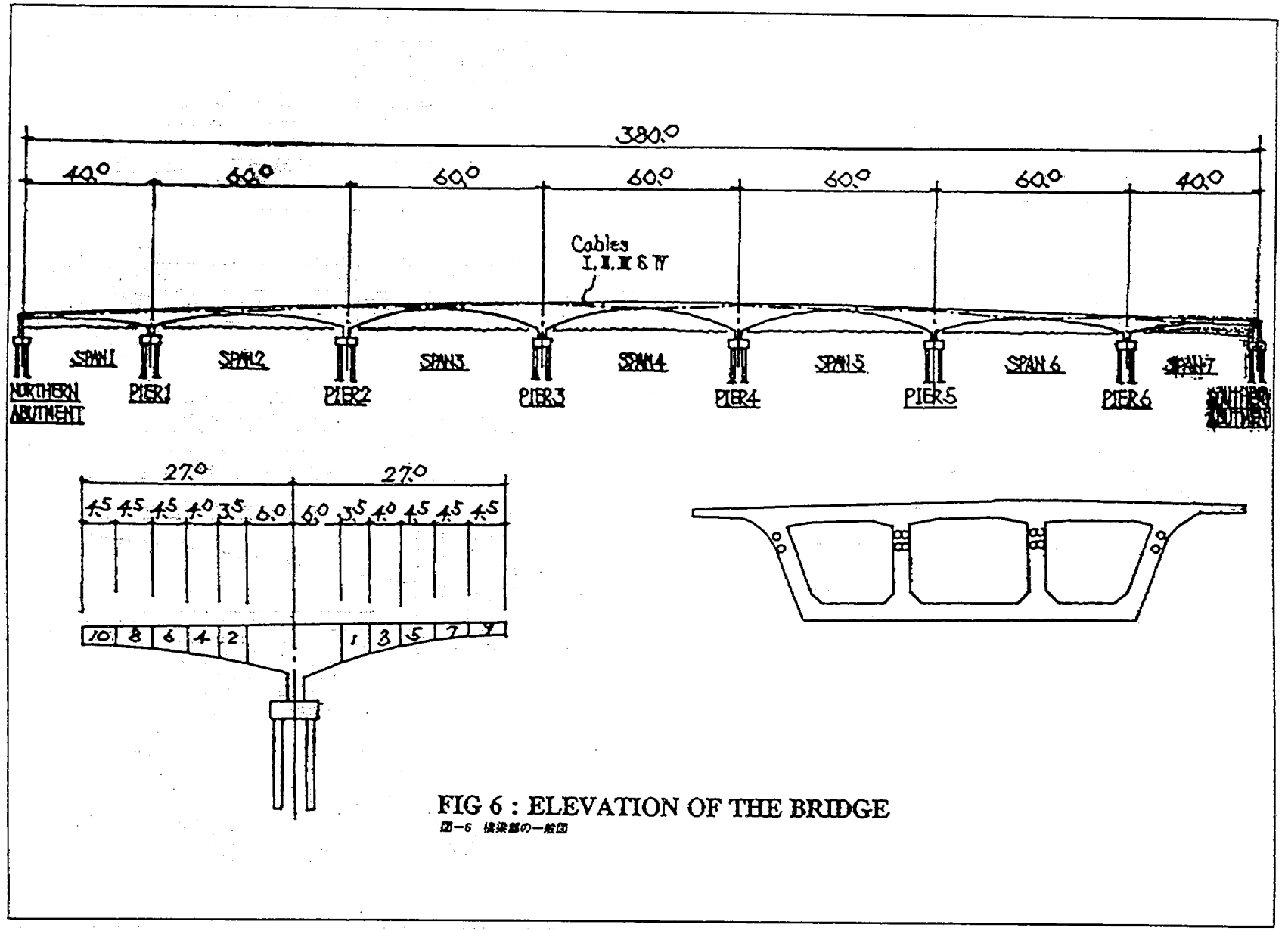
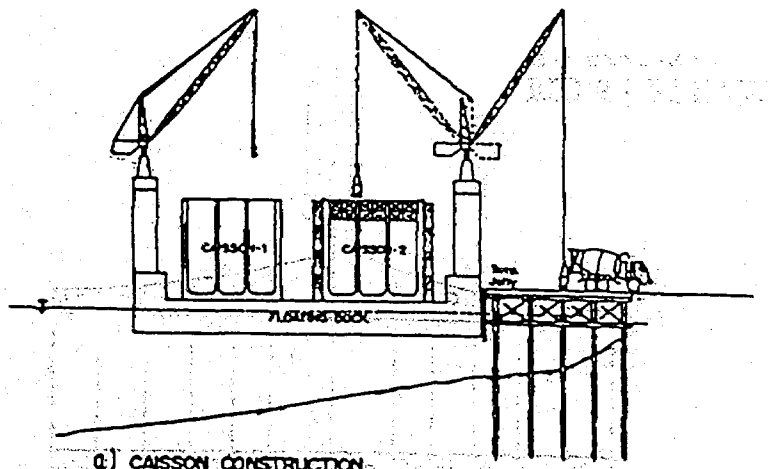


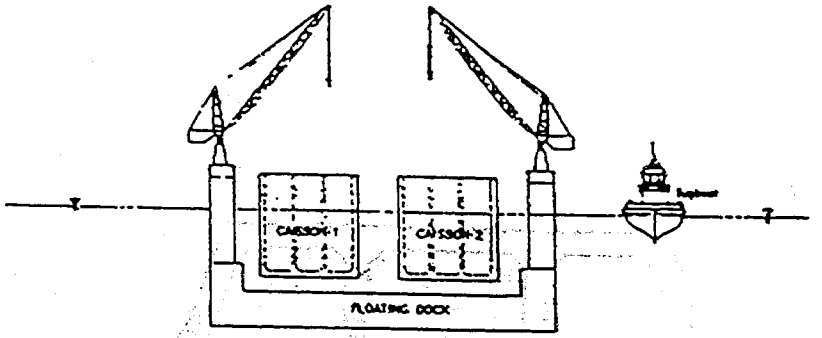
FIG 6 : ELEVATION OF THE BRIDGE

図－6 橋梁部の一般図



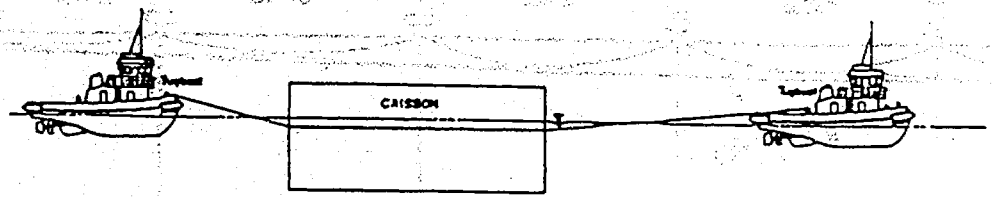
a) CAISSON CONSTRUCTION

- After assembling of steel re-bars and Formwork, Cast base slab of Caisson on Floating Dock. (F.D.)
- Slip-forms will be installed on top of the concrete wall.
- The installed slip-forms will be jacked-up simultaneously to reach the final elevation. At the same time, tying of steel re-bars and pouring of concrete will be carried out.



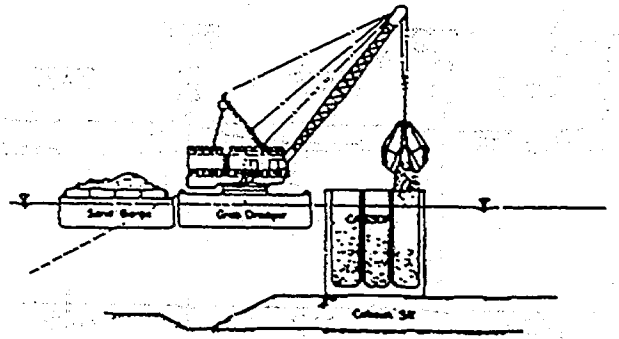
b) OFF-LOADING OF CAISSON

- After the completion of Caisson construction on the F.D., F.D. will be towed by tugboat to the proposed launching area.
- Upon arrival at the launching area, F.D. will be sunk in order to float the concrete caisson.



c) TOWING OF CAISSON

- Wire rope will be wound round the Caisson.
- The floating Caisson then be towed by tugboats to the proposed location.



d) POSITIONING AND FILLING OF SAND

- The Caisson will position at the exact location by operating the winches.
- After positioning, underwater pump will be installed and water will be pumped into the Caisson to sink down Caisson to final proposed alignment.
- The Caisson cells are then backfilled with sand.

図-7 コーズウェイ建設手順

FIG 7 : CONSTRUCTION SEQUENCE

The concrete caisson structural type was finally chosen, as it occupies less of the precious space of the Keppel Harbour and allows for longer continual usage of the Keppel Channel during its construction. Across the Selat Sengkir Channel, a low level concrete arched bridge was chosen. The bridge was given aesthetic treatments with ornamental lighting, railing and other architectural features to blend with the colonial architecture on Sentosa Island.

The concrete caisson unit measuring typically 12.5m in height, 12m in breadth and 30m in length (Fig 3) was to be cast off-site and towed to the road link location for sinking. A total of 26 precast caissons were designed to form the retaining wall for the causeway (see Fig 5). Typical section of the causeway is shown in Figure 4.

The caisson was designed based on hydraulic, maneuvering, structural and constructional requirements. An open top concrete gravity box structure with 3 x 7 nos of internal cells was designed. The dimension of the some caisson units were modified to suite the site requirement and configuration of the causeway. The caissons were designed for the various loading conditions during fabrication, towing, sinking, backfilling and the final positioning under varying tidal conditions with adequate factors of safety. Caisson sill made of stone filling provides the base support for the concrete caisson units. The seabed at the keppel Channel site varies from -8m to -14m ACD. A sill level of -10m ACD was chosen after considering various factors such as cost, stability of the caisson, current and scouring during final closure of the causeway.

The bridge across Selat Sengkir Channel was designed as a 7-span low level triple cells prestressed concrete arched bridge. The two end spans were 40m and the middle spans were 60m, giving a total length of 380m. The design was carried out to facilitate construction using balanced double cantilever method. Due to the hard soil condition, the piers of the bridge were designed to be supported on large diameter bored-piles. Figure 6 shows the elevation of the bridge.

6 CONSTRUCTION

This was the first time the caisson method of construction and balanced double cantilever method were used in Singapore. The general sequence of construction of the causeway is depicted in Figure 7. The concrete caissons, each weighing about 2250 tonnes dry, were fabricated on floating docks anchored at a casting yard about 2.2km west of the causeway site. While the fabrication of the caisson units was in progress, dredging was carried out at the site to remove the silt and soft materials on the seabed. After dredging, stones were placed on the dredged seabed to the required level to form the caisson sill. When the caisson sill was completed and leveled, the caisson units were floated and towed to the causeway site for placement. Due to the constraint in access, the eastern row of caissons (ie. E series caissons) was chosen as the closure caissons. Caissons were placed from both ends of the proposed causeway with the final closure gap in the middle of the Keppel Channel. The other caissons (ie. the W and S series caissons) were placed accordingly to match the sequence of the E series placement. When all the caisson units were placed in position, geotextile was laid and sand backfilled in between the two rows of caissons to form the causeway.

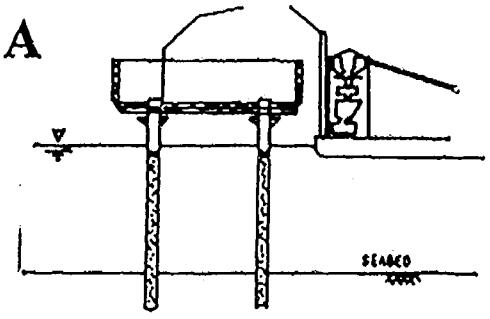
The construction of the bridge was carried out simultaneously with the construction of the causeway. Construction of the bridge began with the installation of the bored-pile and construction of pile cap for the end piers and proceeding to the middle piers. This was to enable the continued usage of the Selat Sengkir Channel for navigation during the construction of the bridge. Placement of the stones to form the submerged bund followed immediately after the pile cap construction. The construction of the bridge beam-deck for each pier using balanced double cantilever method began after stone placement for submerged bund. Two sets of form traveller were employed to enable bridge beam construction to be carried out at two piers at one time. The sequence of construction is shown in Figure 8.

The original program for the construction is shown in Figure 9. Under the program, the construction was to be completed in two phases. Phase I, which entailed the construction of the causeway, was to be completed in 15 months to meet the schedule for the early commissioning of the new container terminal being developed at Pulau Brani. Phase II was for the completion of the whole works in 24 months (including the Phase I period). However, due to minor delays and additional works, the actual completion periods for Phases I & II were 17 and 28 months respectively. The total construction cost was about S$116 million.

7 CURRENT MONITORING

During the construction of the road link, continuous monitoring of the current in the vicinity of the site was carried out using a Real-time Current Monitoring System (RCMS). The RCMS consisted of 3 acoustic doppler units which were mounted from the seabed at three locations shown in Figure 1. Each acoustic doppler is capable of measuring the current in 3 perpendicular directions at different depths. The 3 acoustic doppler units were connected to a master PC for continuous real-time data acquisition and monitoring of

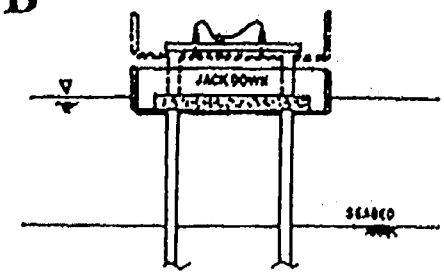
A



FABRICATION OF SOFFIT FORM FOR PILE CAP

- Concrete (t=50cm) for the soffit form of the pile cap is cast.
- The side form is made of steel. The height of the side form is designed to extend above the H.H.W.L.

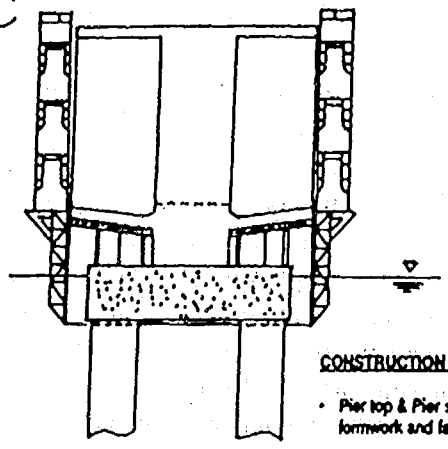
B



CONSTRUCTION OF PILE CAP

- Pile cap form is jacked down to the required position.
- The gaps between pipe and form are filled and sealed with grout.
- The pile cap re-bars are placed in position, and pile cap concrete is cast.

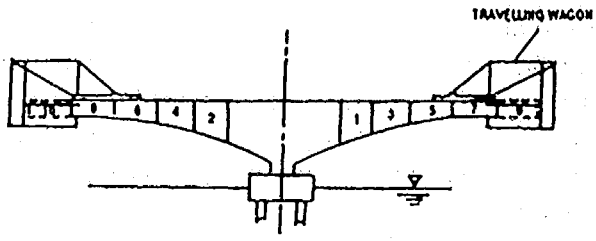
C



CONSTRUCTION OF PIER TOP & PIER SEGMENT

- Pier top & Pier segment will be constructed using formwork and falsework supported from the pile cap

D



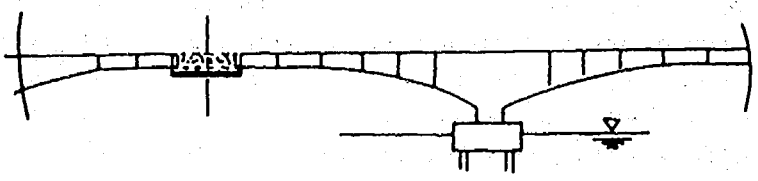
CONSTRUCTION OF CANTILEVER SEGMENTS

- The travelling wagons for segment 1 & 2 are erected on the pier top.
- The wagons are shifted for the construction of these two segments.
- The segment 1 & 2 are then stressed together.
- The operations are then repeated until segments 9 & 10.
- Dismantle wagons.

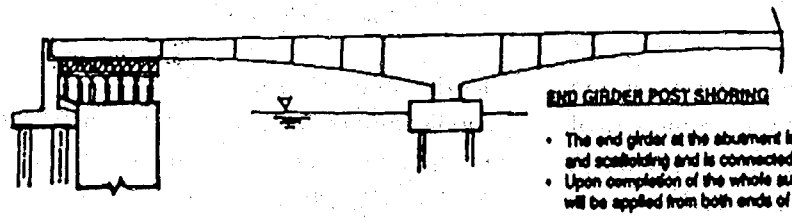
E

CONSTRUCTION OF MIDDLE SEGMENT

- Fabricate scaffolding and forms at the middle segment.
- Cast concrete at the middle segment.
- Stress cable at middle segment.
- Dismantle form and scaffolding at middle segment.



F



END GIRDER POST SHORING

- The end girder at the abutment is constructed using post shoring,staging and scaffolding and is connected to the cantilever girder by prestressing.
- Upon completion of the whole superstructure, continuous prestressing will be applied from both ends of the bridge.

FIG 8 : CONSTRUCTION SEQUENCE OF THE BRIDGE

図－8 橋梁部の施工手順

ROAD LINK FROM KEPPEL TO SENTOSA - CONSTRUCTION PROGRAMME

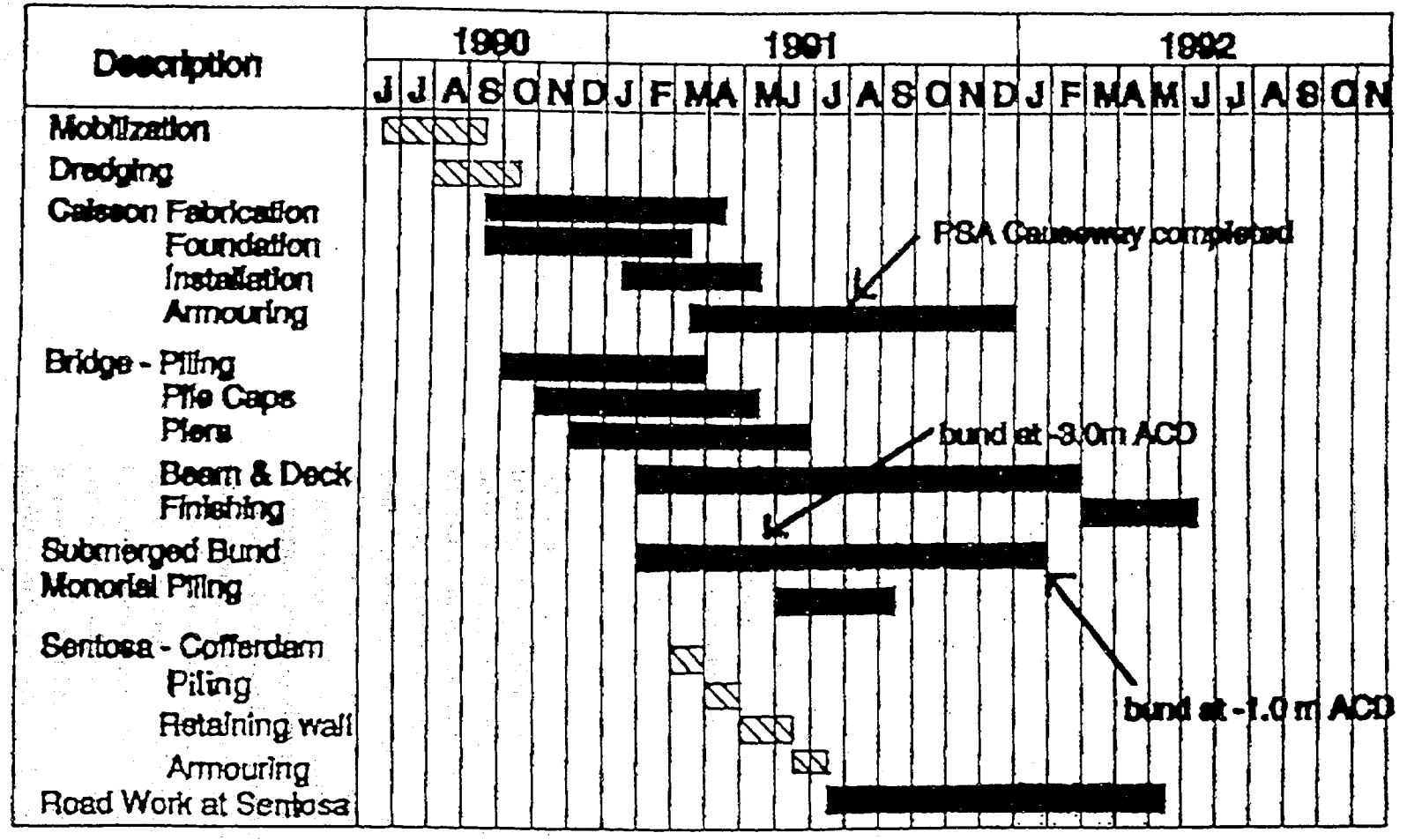
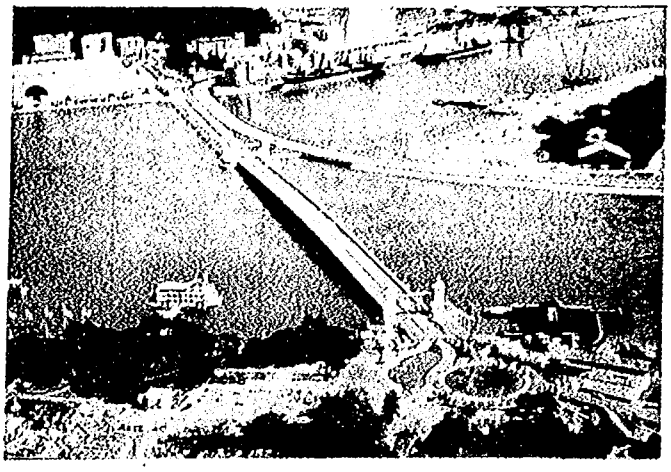


FIG 9 : CONSTRUCTION PROGRAMME
図－9 建設工程表



current. The master PC was also linked to 5 remote PCs housed at different locations for simultaneous display of the recorded current. The RCMS provided useful information for the prediction of the current in the busy navigation channels in advance. This prediction was necessary for the planning and scheduling of the caisson placement operation by the contractor and ship movement through the busy navigational channels by the Port Authority. The current monitoring at Selat Sengkir Channel had shown that the current increase in the channel did not exceed the limit of 20% required for safe navigation.

8 CONCLUSIONS

The construction of the first road link from the Singapore mainland to its offshore islands is described in this paper. This is the first time gravity caisson method for causeway construction and the balanced double cantilever method for bridge construction were employed in Singapore. This project showed clearly that the gravity caisson concept and the balanced double cantilever method are efficient in the construction of marine structures and long span bridges over waterways. Gravity caisson method enabled most work to be done off-site, thereby reducing the disturbance caused by the construction work in a busy harbour and navigational channels to a minimum. Off-site casting would also result in better concrete quality. The experience gained from this project will be of great value to engineers involved in planning, design and implementation of similar future projects. Presently, the Public Works Department, Singapore, is planning to use the gravity caisson method to construct another causeway to link the offshore Jurong islands to the main island.

Public Infrastructure Projects in Thailand and Technical Problems

Teeracharti Ruenkrairergsa
Director General, Road Research Development Center,
Department of Highways, Ministry of Transport and Communication

1. INTRODUCTION

In general for roadworks, considerations for corporatisation and privatisation concepts will be dependent on the following criteria: high project cost, high financial and economic rates of return and an anticipated long service life. Corporatisation has been employed for the expressway and mass transit system under the jurisdiction of the Expressway and Rapid Transit Authority of Thailand (ETA), while privatisation or build/operate/transfer (BOT) is being adopted by the Department of Highways. In this paper some examples of corporatisation and privatisation will be discussed.

Lastly, the motorway and 4-lane divided highway projects as well as some conventional road projects in which a considerable a large amount of money is being invested, because of both technical problems and the cost of land acquisition in the Central part of Thailand, will be discussed in more or less detail.

2. CORPORATISATION ON EXPRESSWAY SYSTEM

Under the ETA, two projects are in progress; firstly the Second Expressway System in Bangkok where the investors have already been appointed and have formed the Bangkok Expressway Company Limited (BECL). Secondly, for the mass rapid transit system, where the selection of an investor has not yet been concluded.

The Second Expressway System (SES): the project is a joint success between the government and the private sector for the development of the country. The investment value of the SES makes it the world's second largest public utilities concession project. This project is aimed at the spread and coordination of profit, rather than at a party's benefit of loss. The terms and conditions of the concession are as follows:

i) The investor must have a registered capital of approximately 20 percent of the project value, which must not be less than Baht 1,800.- million.
ii) BECL will bear the total costs of the construction and accessories and the investment risks without the government's guarantee to any loans.
iii) The expressway must be constructed according to the required standards of the ETA and the construction must commence by 1990 and be completed by 1995 in respect of the first stage covering 36.6 kilometres and a further section may be constructed prior to the traffic on Rama IX road becoming congested.
iv) BECL will refund the costs of land acquisition arrangement with interest totaling Baht 16,815 million.
v) The toll rates for the urban and the suburban areas must be Baht 30 and Baht 15 respectively with the discount of Baht 5 for use of a combined area.
vi) The toll revenue collected in the urban area will be shared between the ETA and BECL at the rates of 40/60, 50/50 and 60/40 in respect of the first, second and third nine-year periods respectively.
vii) The expressway and its accessories will belong to the ETA after the expiration of the 30-year period.

Mass Rapid Transit System (MTS): Three route alignments have been proposed, namely, Phra Khanong - Bang Sue Line, Wongwien Yai-Lad Phrao Line and Dao Khanong-Makkasan Line, with a total length of about 60 kms. The implementation of the MTS project

has been prolonged due to its high investment cost and the country's tight budgetary program. The project has subsequently been launched on a partial corporatisation basis by limiting the government's contribution to not more than 25 percent of the equity. The system is divided into parts on the basis of priority - the first part to be implemented is called MTS Part I Stage I: Phra Khanong - Bang Sue and Sathorn - Lad Phrao Lines, total length of 34kms.

Terms and conditions of investment under MTS Part I Stage I Project are as follows:

i) The government's share shall not exceed 25 percent of the value of shareholder's equity.
ii) The government shall not guarantee any loans.
iii) The bidders have to propose the following alternative conditions:
   a) The government shall acquire only the land necessary for the construction of the project at its own expense and the investor shall lease the land for the period of concession.
   b) The government shall undertake the land expropriation while the investor has to pay the amount of land acquired.
iv) The government shall render the investor maximum benefit under the Investment Promotion Act.
v) The investor shall be considered to have the first priority to be granted the preferential right to undertake the concession for the MTS Project Stage I Part II in greater Bangkok.

3. PRIVATISATION (BOT) ON HIGHWAY SYSTEM

Under the BOT method, the government will not participate in the investment but will assist with the implementation of the project; i.e., issue any legal act for land acquisition and cooperate with all the agencies concerned.

Generally, the government, through DOH, will adopt the following procedural steps for the selection of investor's for BOT projects.

	ACTIVITY	DURATION (mo.)
i)	Advertising for prelim. selection	2.0
ii)	Evaluation and shortlisting	1.0
iii)	Submission of the proposal by the shortlisted firms/groups	4.0
iv)	Evaluation of proposals	2.0
v)	Report to MOTC for concurrence	0.5
vi)	Negotiation with the top ranked firm	Varies
vii)	Cabinet approval	1.0

Guidelines for Consideration on the BOT Proposal

Generally, the investors will be advised to prepare their proposal for BOT Projects with the following contents:

i) Engineering
   - traffic analysis on the project road
   - effect on integrated traffic pattern of the network
   - environment impact assessment and recommendations
   - drainage system
   - proposed alignment and configuration for the concession road, including toll booth, toll operation, traffic controls and facilities.

ii) Construction and maintenance
   - construction methods and specifications
   - traffic management during construction
   - maintenance procedures

iii) Financial proposal
iv) Project management and organization
v) Toll collection/operation/rates
vi) Concession period and obligations
vii) Other recommendations

4. PAST AND PRESENT BOT HIGHWAY PROJECTS

DOH has conducted a number of projects under the BOT scheme, with varying results. The following is a summary of the various projects proposed.

PROJECT NAME	RESULT
i) 3-toll road projects	
- Bang Pa In-Nakhon Sawan	
- Thonburi - Pak Tho	Failed
- Saraburi - Nakhon Ratchasima	
ii) Vibhavadi Rangsit elevated highway	
Contract signed	
iii) Announcement for 4-road	
- Outer Bangkok ring road	
- Bangkok - Chonburi (new route)	No proposal
- Bangna - Chonburi	Submitted
- Thonburi - Pak Tho	
iv) Rt.1 : Rangsit - Saraburi	Failed

5. UNSUCCESSFUL BOT PROJECTS

Learning from the experience of unsuccessful BOT projects, several points upon which investors and the

government often disagree have been identified. These major requests of the investors are often proposed and found unacceptable by DOH.

- requests for the receipt of a promotion certificate under the Promotion Investment Act with too many rights and benefits.
- requests for tax exemptions on stamp duty, business tax, municipal tax and tax payable on toll revenues.
- requests for exemptions from provisions of building control act, exemption on the fee or tax for the land specially acquired.
- requires all approvals to enter the securities exchange of Thailand.
- requires all necessary financing securities.
- requires that fixed toll rate formula be approved by the government.

6. POTENTIAL BOT HIGHWAY PROJECTS IN THE FUTURE

- A fully-controlled access special highway network is under study. The project covers road networks all over Thailand. The expectation for adopting BOT measures is high.
- Expressway System in Bangkok Metro Area and its outskirts may require corporatisation and privatisation (BOT) measures.

7. PLANNED MOTORWAYS IN THAILAND

7. 1 Planning Concept

(1) To help in realizing the targets of the National Economic and Social Development Plan.
- To support the recent remarkable economic growth
- To promote well-balanced regional socio-economic development

(2) To alleviate traffic congestion and ensure safe and on-time driving.

(3) To consider the harmony and balance with ordinary highways and other transportation modes.

(4) To adopt the toll system in order to reduce the financial burden for construction and operation.

7. 2 Basic Ideas for Network Formation

(1) Connection of key locations
- Bangkok Metropolitan Area with other regions
- Growth Pole Cities and industrial development areas designated in the National Plan
- Changwat (Province) centers and main cities
- Airport and major sea/inland ports
- Famous places of interest
- Large industrial estates

(2) Dealing with Heavy Traffic Problems

(3) Formation of International Road Network

7. 3 Proposed Network

The proposed motorway network for Thailand is shown in Fig. 1. The total length is about 4345 kilometers.

7. 4 Implementation Plan

The plan of motorway construction in the initial stage is shown as the dark dotted lines in Fig. 1, with a total length of about 198 kilometers. The proposed implementation plan is shown in Table I.

7. 5 Design Features

Motorways should guarantee comfortable, safe and high speed driving for all types of vehicles. Therefore, motorways prohibit the access of bicycles and mopeds as well as pedestrians. All crossing are grade separation interchanges, so that interchanges are the only access points for all vehicles. Motorways will have special geometric features as regards width, curvature, grade, etc., to handle vehicles with safety and high speed.

The main element which characterizes motorways is the design speed. The design speed of 120 km/hr for passenger cars is adopted based on practice in various countries.

7. 6 Service Facilities

(1) Gate to Motorway Access to motorway is restricted to special interchanges. Interchanges are planned at crossing points with arterial highways near cities at intervals of 20 km to 30 km.

(2) Oasis an Motorway For long trips, motorways provided oases including service areas and parking areas, etc. Facilities include restaurants, lavatories, fuel stations, car maintenance shops, etc. Service areas are located at intervals of 50 km to 100 km and parking areas at intervals of 15 km to 20 km.

7. 7 Financing

(1) Toll System (Including Concession System) A toll on Non-Toll Systems for motorways is adopted for each country according to the financial and social conditions. Japan, Indonesia, Korea, Malaysia, Taiwan and the Philippines, which developed motorways rather late, adopt the toll system.

Motorway users should share a burden for receiving higher benefits - speed, safety and comfort - than on ordinary roads.

Toll rates are determined in a refund manner that the income from toll fees covers the expenditures including construction, maintenance and operation costs and interests of loan. At the same time, toll rates should be fair and reasonable in the social sense compared with the charges for the alternative transportation modes.

(2) Special Fund Many countries, such as Japan, U.S.A., Germany, France, Korea, etc., have established a special fund to be appropriated for the limited purpose of road development. This special fund is a special tax revenue raised from road user taxes such as gasoline tax, oil tax, vehicle tax, etc.

In addition, some countries have systems to collect part of the earnings through regional development by motorways so as to finance motorways.

8. PROPOSED FOUR-LANE DIVIDED HIGHWAYS IN THAILAND

The Department of Highways plans to construct four-lane divided highways in all parts of Thailand, as shown in Fig. 2. The widened highways will be constructed in the right of way of the existing road. Total length of the divided highways will be 1891 kilometers. Details of the projects are summarized in Table II. The Department of Highways has to try to finance the budget to widen the existing roadways without the problems of land acquisition, because the roadways will be constructed in the right of way of the existing roads.

9. DESIGN AND CONSTRUCTION OF THE BANGKOK-CHONBURI NEW ROUTE AND THE OUTER BOUND RING ROAD (OBRR) ON THE EAST SIDE

The Department of Highways has to invest about 20,000 million Baht to construct the Bangkok-Chonburi New Road and the Outer Bound Ring Road (OBRR) on the east side. The probable alignment of both highways is shown in Fig. 3. Both highways pass through the soft clay foundation in the outskirts of Bangkok, so a large amount of money has to be spent for the foundation treatment and for the land acquisition. The cost of the land along both highways is very high because it is very near Bangkok. For the foundation treatment it is designed to use the prefabricated vertical drain (PVD) to accelerate the consolidation settlement of the foundation soil. It is anticipated that about 70 - 90 percent of the total settlement of the soft clay could be induced within about one year. As a consequence, the service life of the highways is expected to be 15 - 20 years after opening to traffic.

10. CONCLUSIONS

10. 1

The major highways projects of the Department of Highways as well as the Expressway and Rapid Transit Authority of Thailand (ETA) under construction will be as follows.

(1) Second Expressway System (SES)
(2) Mass Rapid Transit System (MTS)
(3) Vibhavadi Rangsit Elevated Highway

All the above projects tend to serve the people in the city of Bangkok as well as its outskirts.

10. 2

At present, the Department of Highways plans to construct important road network projects in all parts of the country as follows.

(1) Motorway System, total length of 4345 kilometers.
(2) Four-Lane Divided Highway System, total length of 1891 kilometers.
(3) The Bangkok-Chonburi New Route and the Outer Bound Ring Road (OBRR) on the East Side.

All the above projects will invest a large amount of money in order to create safe and rapid transportation in Thailand.

11. REFERENCES

(1) ETA, "ETA Annual Report 1983"
(2) ETA, "SES Foundation Stone Laying Ceremony Report" Dec. 1989.
(3) DOH, "Tollway Concession Agreement on Viphavadi Rangsit Road" Aug. 1989.
(4) DOH, "Draft Concession Agreement on Highway 32 and 2" Sept. 1987.

MOTORWAY NETWORK

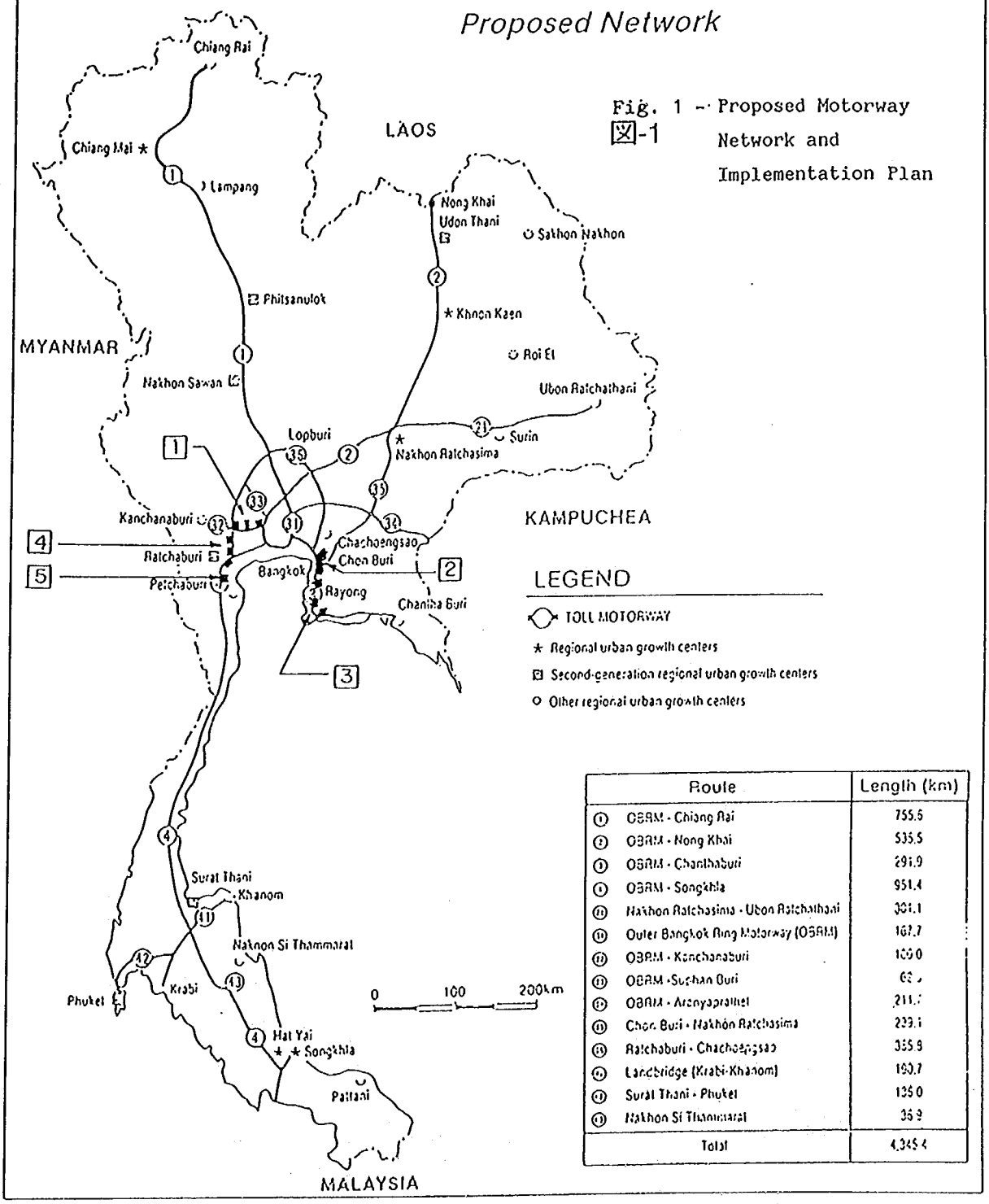


Fig. 1 - Proposed Motorway Network and Implementation Plan
図-1

	Route	Length (km)
①	OBRM - Chiang Rai	755.6
②	OBRM - Nong Khai	535.5
③	OBRM - Chanthaburi	291.9
④	OBRM - Songkhla	951.4
⑤	Nakhon Ratchasima - Ubon Ratchathani	301.1
⑪	Outer Bangkok Ring Motorway (OBRM)	167.7
⑫	OBRM - Kanchanaburi	109.0
⑬	OBRM - Suphan Buri	69.2
⑭	OBRM - Aranyaprathet	211.7
⑮	Chon Buri - Nakhon Ratchasima	229.1
⑯	Ratchaburi - Chachoengsao	355.9
⑰	Landbridge (Krabi-Khanom)	160.7
⑱	Surat Thani - Phuket	135.0
⑲	Nakhon Si Thammarat	36.9
	Total	4,345.4

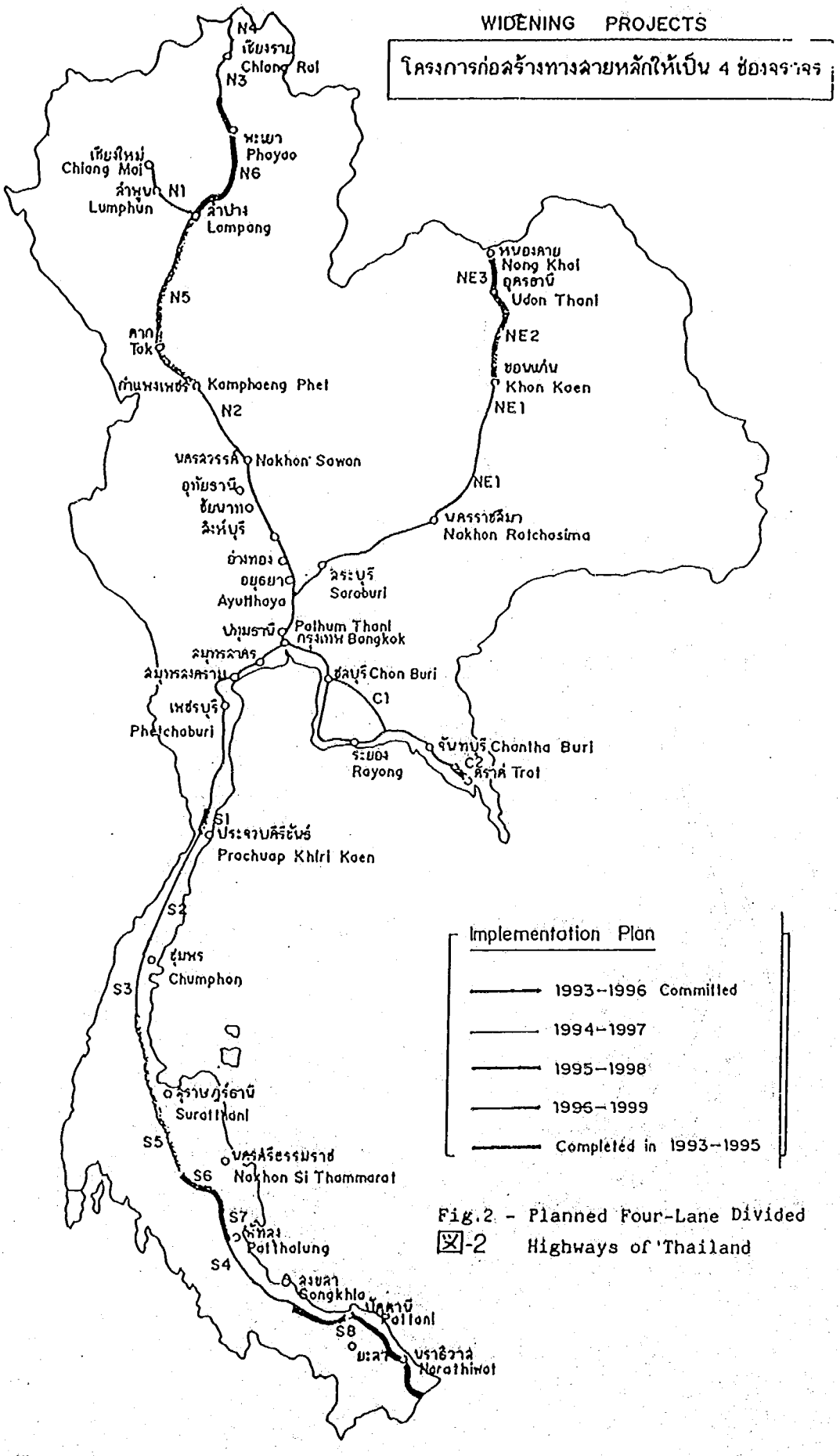
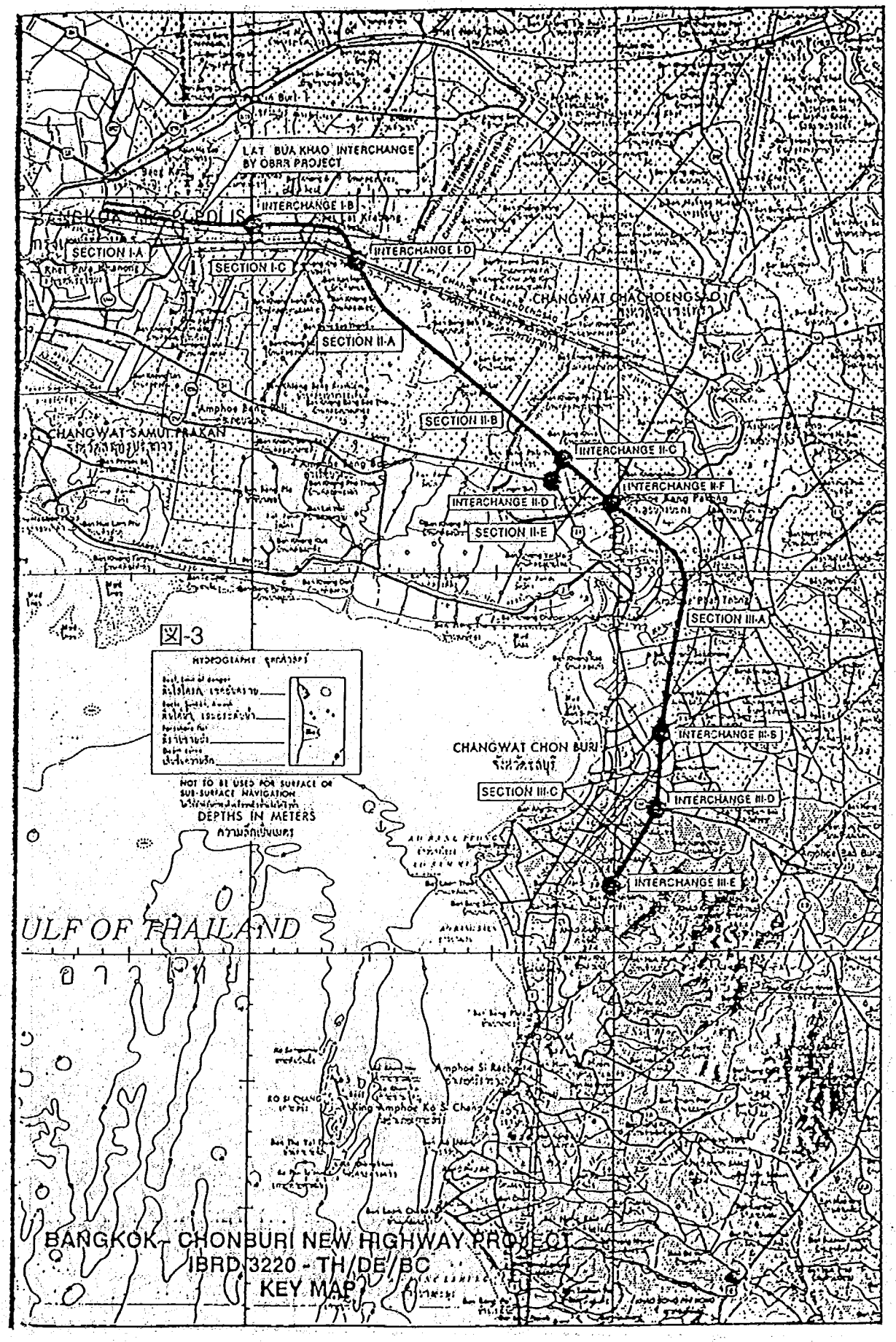


Fig.2 - Planned Four-Lane Divided Highways of Thailand

図-2


LAT BUA KHAO INTERCHANGE
BY OBRR PROJECT
INTERCHANGE I-B
SECTION I-A
SECTION I-C
INTERCHANGE I-D
CHANGWAT CHACHOENGSAO
SECTION II-A
SECTION II-B
CHANGWAT SAMUT PRAKAN
INTERCHANGE II-C
INTERCHANGE II-F
INTERCHANGE II-D
SECTION II-E
SECTION III-A
INTERCHANGE III-B
CHANGWAT CHON BURI
SECTION III-C
INTERCHANGE III-D
INTERCHANGE III-E
NOT TO BE USED FOR SURFACE OR SUB-SURFACE NAVIGATION
DEPTHS IN METERS
ULF OF THAILAND
BANGKOK - CHONBURI NEW HIGHWAY PROJECT
IBRD 3220 - TH/DE/BC
KEY MAP

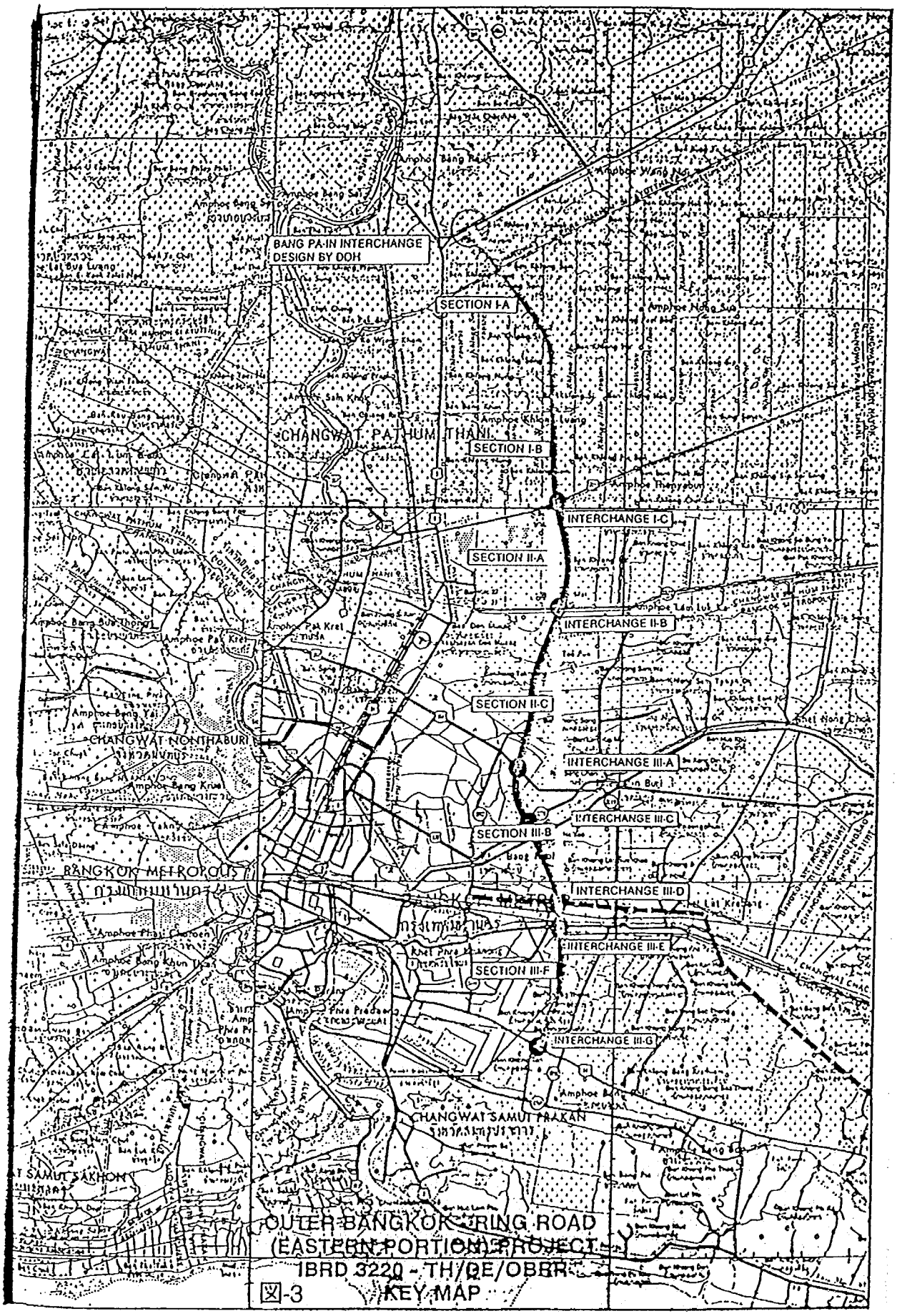

BANG PA-IN INTERCHANGE
DESIGN BY DOH
SECTION I-A
CHANGWAT PATHUM THANI
SECTION I-B
INTERCHANGE I-C
SECTION II-A
INTERCHANGE II-B
SECTION II-C
CHANGWAT NONTHABURI
INTERCHANGE III-A
INTERCHANGE III-C
SECTION III-B
BANGKOK METROPOLIS
INTERCHANGE III-D
INTERCHANGE III-E
SECTION III-F
INTERCHANGE III-G
CHANGWAT SAMUT PRAKAN
SAMUT SAKHON
OUTER BANGKOK RING ROAD
(EASTERN PORTION) PROJECT
IBRD 3220 - TH/QE/OBRR
KEY MAP
図-3

TABLE I
表-1
IMPLEMENTATION PLAN FOR MOTORWAY IN AN INITIAL STAGE

Priority	Origin - Destination	Distance (Km.)	Standard	Coustruction Cost (Million Baht)	Year of Implementation
1	Bang Yai-Ban Pong	57	P_D	5200	1993
2	Exit to Laem Chabang-Routi No.36	17	P_D	800	1994
3	Exit to Route No.36-Marb Ta Put	37	P_D	2600	1995
4	Ban Pang-Pak Tho	51	P_D	3900	1995
5	Pak Tho - Petchburi	36	P_D	2300	1996
	Total	198 Km.		14,800 Million Baht.	

TABLE II (CONTINUED)
表-2 (つづき)

PROJECT : Widening

REGION Northeastern

Proj. No.	Route No.	Region	Length Km.	Constr. Cost Baht mil. (1992 price)	F.S. (IRR) %	EIA	Design Status	Implementation Plan '93 '94 '95 '96 '97 '98 '99	Remarks
NE1	2	Nakhon Ratchasima Khon Kaen							
		Sect J.R. to Phimai B.Sida	36	900	25.5	None			
		Sect A.Ban Phai B.Tha Phra	32	800	31.5				
NE2	2	Khon Kaen Udorn Thani	112	1,600	39.5	None			
NE3	2	Udorn Thani Nong Khai	51	1,300	23.4	None			
		Sub–total	231	4,600					

TABLE II
表-2

SUMMARY

PROJECT : Widening

Proj. No.	Route No.	Region	Length Km.	Constr. Cost Baht mil. (1992 price)	F.S. (IRR) %	EIA	Design Status	Implementation Plan '93 '94 '95 '96 '97 '98 '99	Remarks
		Northern	647	16,600					
		Northeastern	231	4,600					
		Central	120	3,000					
		Southern	893	21,700					
		Total	1,891	45,900					

TABLE II (CONTINUED)
表-2 (つづき)

PROJECT : Widening

REGION Northern

Proj. No.	Route No.	Region	Length Km.	Constr. Cost Baht mil. (1992 price)	F.S. (IRR) %	EIA	Design Status	Implementation Plan '93	'94	'95	'96	'97	'98	'99	Remarks
N1	11	Lampang Lamphun	63	1,700	32.7	Minor				·····							
N2	1	Nakhonsawan Kamphaengphet Sect J.R. to Ladyao Kamphaengphet	97	2,400	27.7	None				·····							
N3	1	Payao Chiang Rai Sect J.R. to A,Maesuay Chiang Rai	19	500	36.3	None				·····							
N4	110	Chiang Rai Mae Sai Sect.Mae Chan Mae Sai	32	800	23	None				·····							
N5	1	Kamphaengphet–Tak–Lampang	241	6,200	22.6	None				·····							
N6	1	Lampang–Payao–J.R. to Mae Suay	195	5,000	16.8	Minor				·····							
		Sub–total	647	16,600													

TABLE II (CONTINUED)
表-2（つづき）

PROJECT : Widening

REGION Southern

Proj. No.	Route No.	Region	Length Km.	Constr. Cost Baht mil. (1992 price)	F.S. (IRR) %	EIA	Design Status	Implementation Plan '93	'94	'95	'96	'97	'98	'99	Remarks
S1	4	A.Kui Buri Prachuab Khiri Khan	30	800	–	None									Committed
S2	4	Prachuab Khiri Khan Chum Porn Sect. Prachuab Khirikhan A.ThaSae	155	3,800	30.7	None									
S3	41	Chum Porn Surat Thani Sect. Chum Porn Lang Suan	67	1,700	27.3	None									
S4	41	Phattalung Had Yai Sect. Phattalung Intersection Khuha	65	1,600	22.9	None									
S5	41	Chum Porn Surat Thani Sect. A.Lang Suan Surat Thani	107	2,600	21.5	None									
S6	41	Surat Thani Phattalung Sect. Surat Thani A.Thung Song	125	2,600	17.2	None									
S7	41	Surat Thani Phattalung Sect. A.Thung Song Phattalung	89	2,200	17.2	None									
S8	43,42, 4055, 4056	A.Chana – Pattani – Narathiwas – A.Sungaikolok	255	6,400	13.4	None									
		Sub total	893	21,700											

TABLE II (CONTINUED)
表-2（つづき）

PROJECT : Widening

REGION Central

Proj. No.	Route No.	Region		Length Km.	Constr. Cost Baht mil. (1992 price)	F.S. (IRR) %	EIA	Design Status	Implementation Plan '93	'94	'95	'96	'97	'98	'99	Remarks
C1	344	A.Ban Bung	A.Khlaeng	79	1,900	26.8	None				.....	.....	..			
C2	3	A.Khlung	Trad	41	1,100	22.7	None					.....	.....	..		
			Sub total	120	3,000											

THE FIRST CONFERENCE ON PUBLIC WORKS RESEARCH AND DEVELOPMENT IN ASIA

ISSN 0386−5878
Technical Memorandum
of PWRI No. 3186
March, 1993
Public Works Research Institute

This report is the proceedings of "The First Conference on Public Works Research and Development in Asia" held in February 1993.

郵 便 は が き

Postage stamp

3 0 5 - □ □

建設省土木研究所企画部企画課
〒305　茨城県つくば市旭１番地

Planning Division
Public Works Research Institute
Tsukuba Science City
Japan 305

No.

No.

配布先氏名

配布先住所

土木研究所資料第 3186 号　　部

上記のとおり受領しました。

Receipt of

Technical Memorandum of PWRI No. 3186

氏 名
Name _____

所属（住所）
Address _____

_____

_____