

Technical Memorandum of PWRI No. 1438

**FUNCTIONAL DAMAGE AND
REHABILITATION OF LIFELINES
IN THE MIYAGIKEN-OKI
EARTHQUAKE OF 1978**

December 1978

Earthquake Engineering Division
Earthquake Disaster Prevention Department
Public Works Research Institute
Ministry of Construction

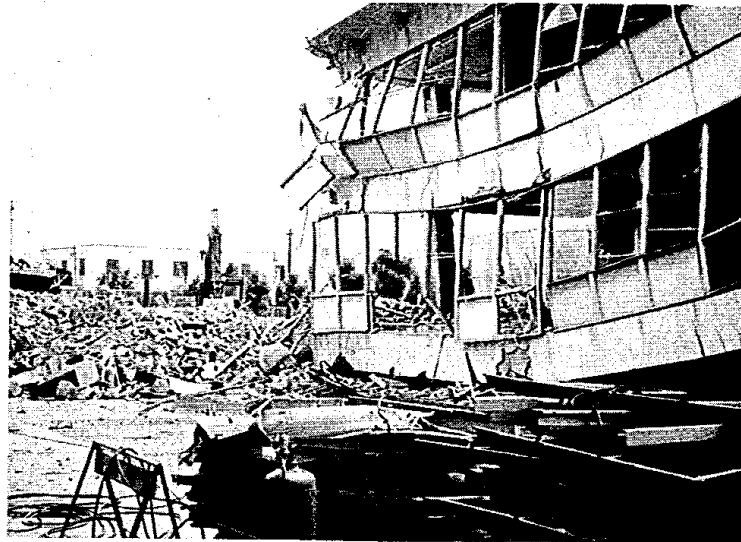


Photo. 1. Damaged Reinforced Concrete Building at Oroshi-machi, Sendai

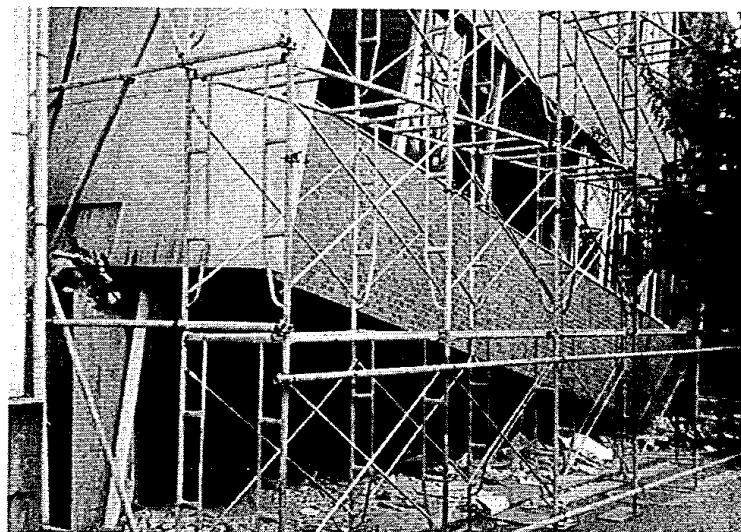


Photo. 2. Damaged Reinforced Concrete Building at Oroshi-machi, Sendai



Photo. 3. Damaged Wooden House at Naga-machi, Sendai

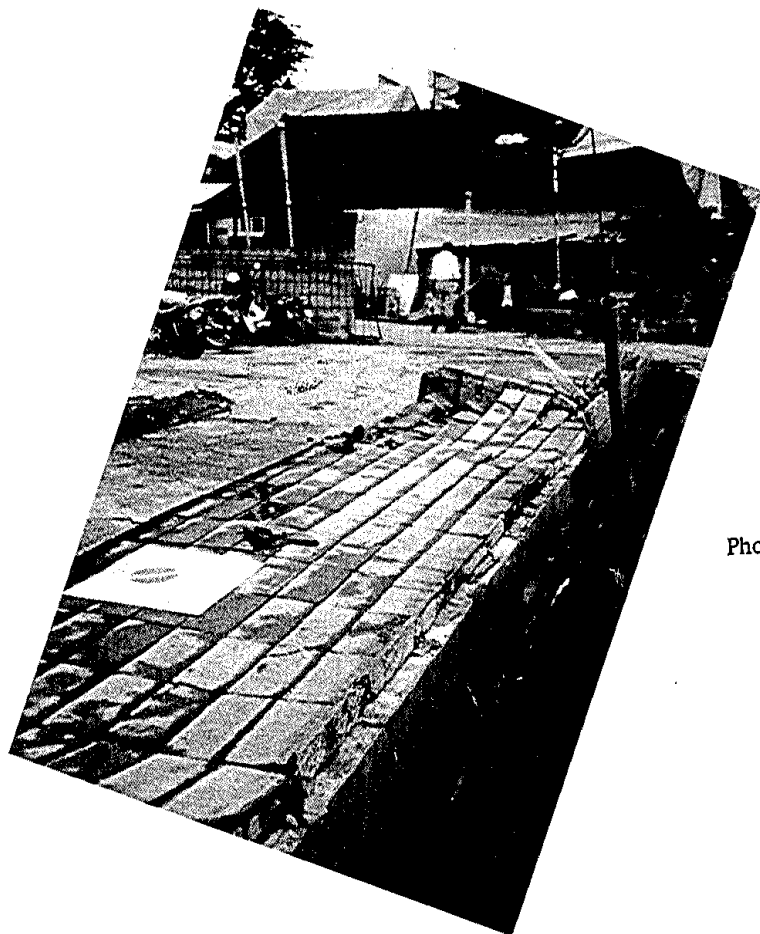


Photo. 4. Overturned Fence at Naga-machi, Sendai

Photo. 5. Landslide of the Lately Developed Land at Midorigaoka, Sendai



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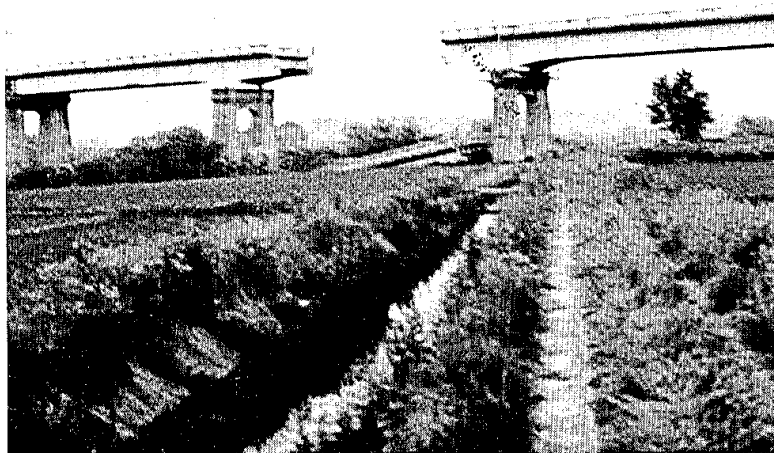


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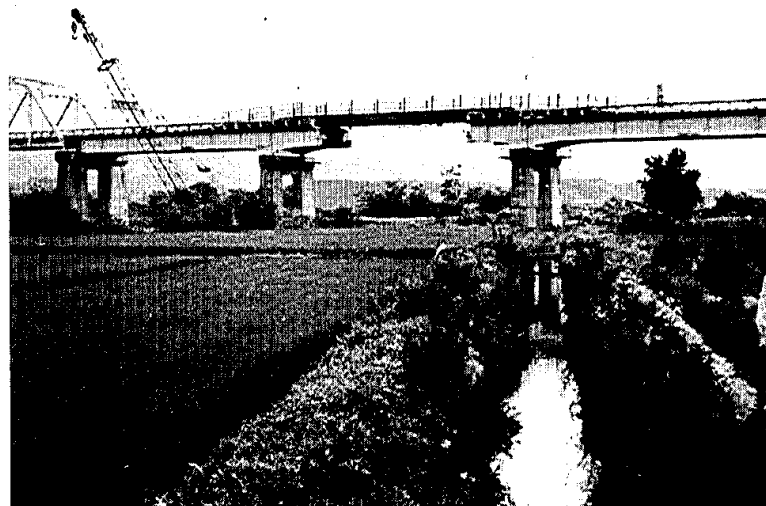


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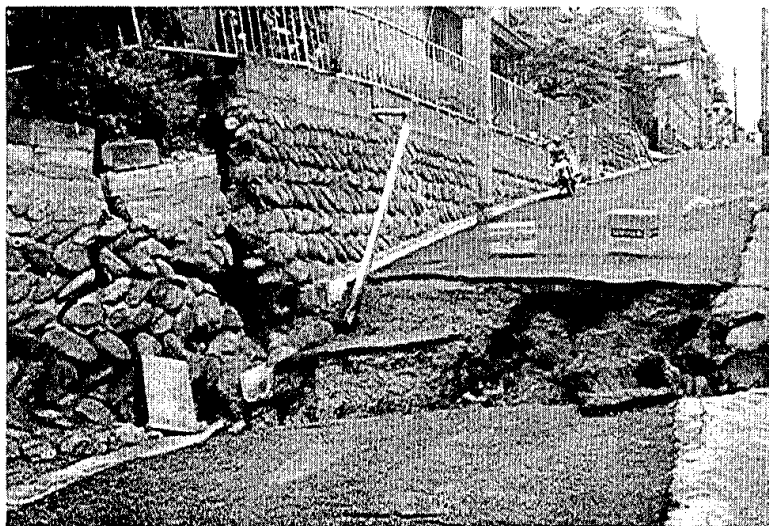


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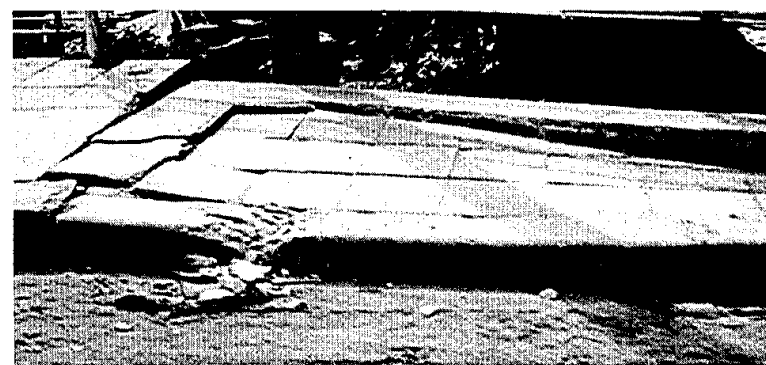


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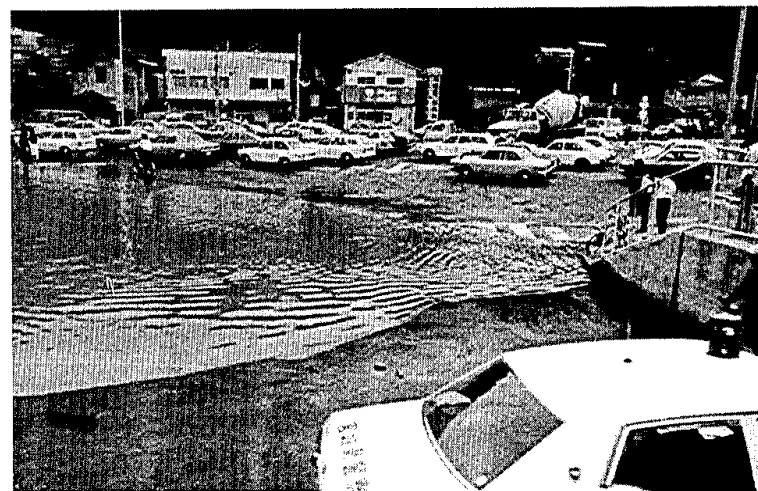


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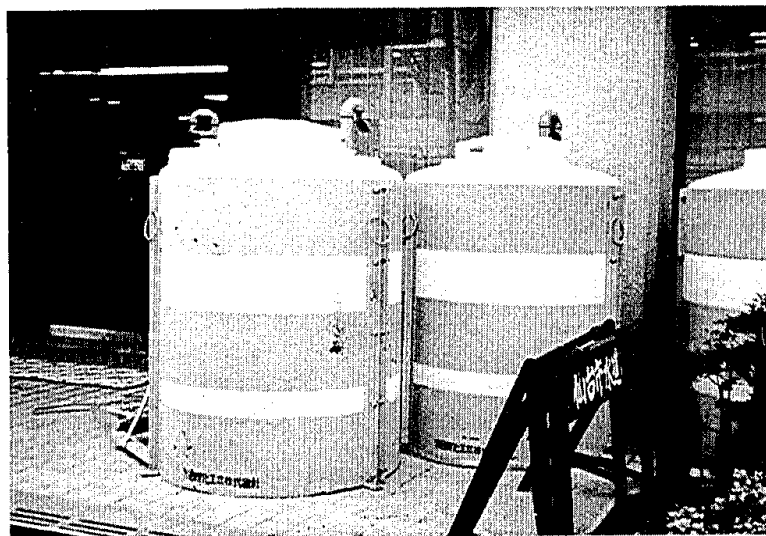


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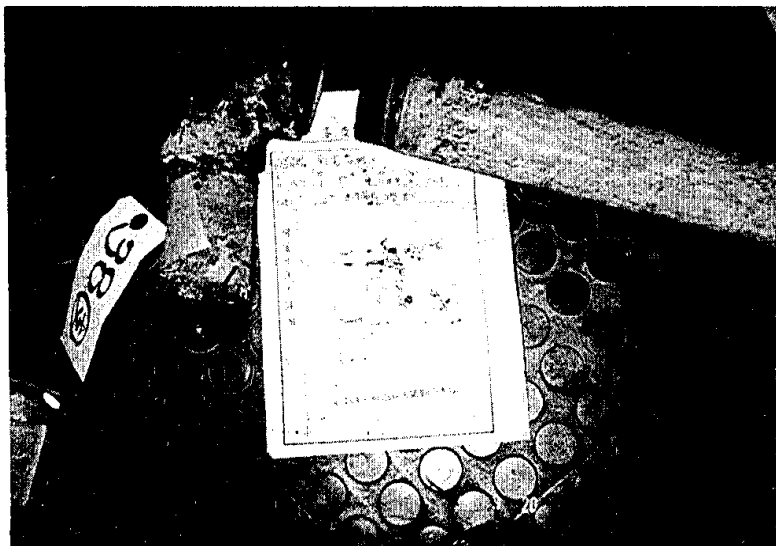


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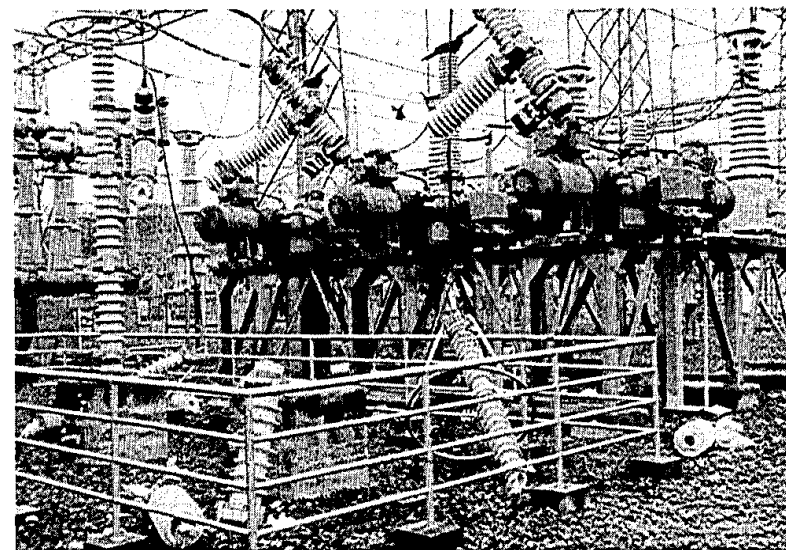


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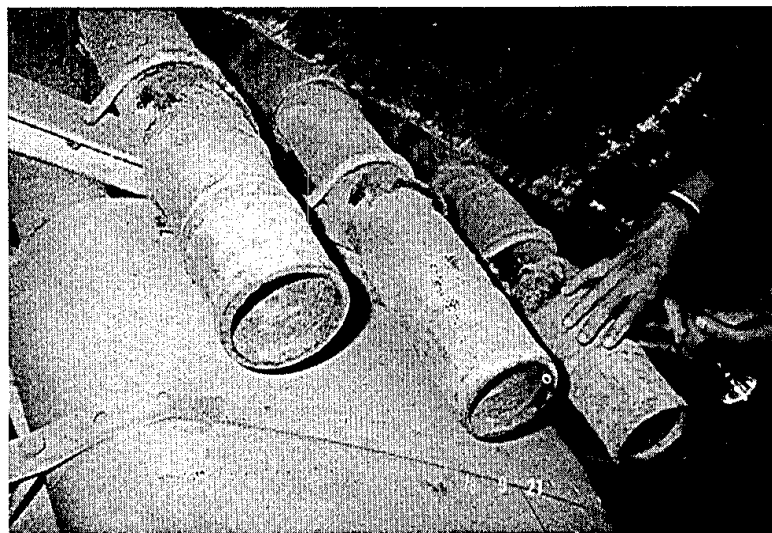


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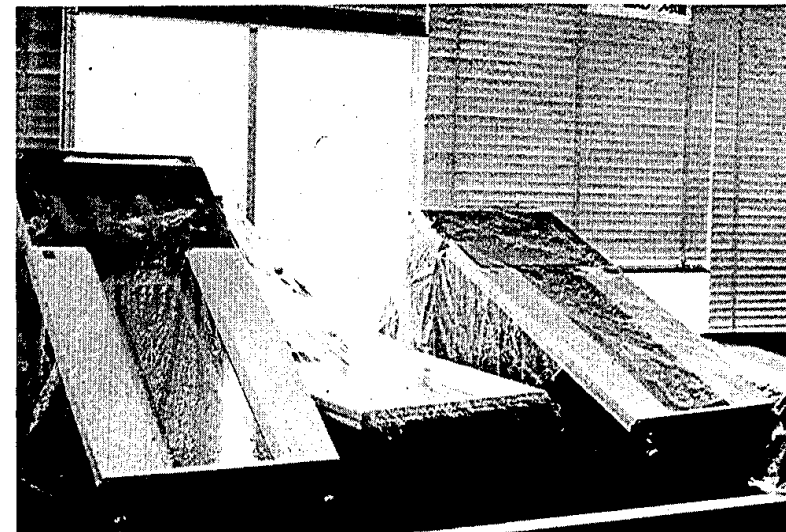


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PREFACE

The Miyagiken-oki Earthquake of June 12th, 1978 with 7.4 of Magnitude brought many disasters to Sendai City of about six hundred thousand at population and its adjacent area. The disaster is supposed as one of the biggest earthquake disasters since the Kanto Earthquake of 1923. After then such earthquake disasters in modernized prefectural metropolises have been experienced in the Fukui Earthquake of 1948 and the Niigata Earthquake of 1964. However Sendai City was more greatly urbanized than Fukui City and Niigata City at those days.

In this survey, various facts concerned with earthquake disaster prevention measures were investigated in cooperation with the various organizations listed latter. The survey mainly aims at a successful analysis on functional losses and rehabilitation of lifeline systems.

December 12, 1978

Earthquake Engineering Division
Earthquake Disaster Prevention Department
Public Works Research Institute
Ministry of Construction

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1. Functional Damage to Lifeline Facilities

1.1 General Description

This earthquake is characterized by the great damage to lifeline facilities and their functions in Sendai, a large city of 629,000 at population, and its adjacent area.

After the earthquake, Sendai City and the area experienced suspension of electric power, water and gas supply, suspension of railway operation, traffic confusion by the interruption of traffic signals, down of telephone lines, etc. The various damage brought a great inconvenience in urban activities.

Lifeline facilities can fulfil their function when they are organized as a network. The experiences through the earthquake show us the possibility of the functional paralysis of whole lifeline systems by partial damage to lifeline facilities and the seriousness of the influence of their functional damage on urban activities.

1.2 Transportation Facilities

(1) Roads

After the occurrence of the earthquake at 5:14 p.m. of June 12, the automatic control system at the traffic control center of Sendai Central Police Station did not work by electricity failures, and 260 traffic signals in Sendai City could not be operated. That was just at rush hours in the evening, and in such situations, the traffic in Sendai City became confused. After the recovery of electricity at the traffic control center at 8 p.m. and the disposition of policemen for traffic control and emergency vehicles for electric-power supply to traffic signals, traffic congestion was gradually dissolved.

On the other hand, the traffic through major roads was obliged to be suspended or restricted by structural damage to national and prefectural highways and Tohoku Expressway. (See Table 1-1 ~ 1-4)

(2) Railways

After the earthquake, all the railways under the control of Sendai Railway Control Bureau were suspended. Therefore many commuters and travelers were deprived of means of transit. As a result of inspection and temporary restoration, Tohoku Main Line south of Sendai and Joban Line

reopened on June 14, and Tohoku Main Line north of Sendai on June 15. As for local lines in and around Sendai, their reopening was completed on July 8.

(3) Harbors

Ishinomaki Industrial Harbor, Sendai Harbor, etc. were suffered such damage as cracks in aprons, breakdown of loading machines, etc. But by emergency measures, the function of harbors was secured.

(4) Airports

Sendai Airport suffered slight damage of small cracks in runways, and taking-off and landing of planes were suspended for a while. But normal operation was soon resumed. For the security of a long-distance transport, All Nippon Airways operated an additional flight between Sendai and Tokyo [June 13 (Tues.) ~ June 14 (Thurs.), June 17 (Sat.) ~ June 18 (Sun.)] .

1.3 Water Supply Facilities

Water supply facilities were damaged at 54 cities, towns and villages in Miyagi Prefecture.

In Sendai City, water supply was suspended at about 7,000 houses after the earthquake. The number of houses suspended water supply decreased to 2,000 on June 14, and that decreased to 700 on June 15, and water supply was secured day by day. As for other small cities, by the severance of water pipes, water supply was suspended at all houses (16,000 houses) in Shiogama City and at 10,500 houses in Izumi City. The functional recovery of water supply facilities are shown in Table 1-5.

On the other hand, by the damage to industrial water supply facilities, more than 20 factories were obliged to be suspended water supply for 24 ~ 79 hours.

1.4 Sewerage Facilities

In Miyagi Prefecture, the construction of public sewerage facilities has been advancing in 16 cities and towns.

After the earthquake, sewerage plants and pump yards in Sendai City and some other cities around Sendai could not work because of electricity failures and

structural damage. Under such situations, sewage was obliged to be discharged into a river without full treatment.

As a result of temporary restoration, the function of these damaged facilities was recovered within a few days except for Kooriyama Pump Yard (recovered at 4:25 p.m. of June 23) in Sendai City.

1.5 Medical Facilities

Medical activities after the earthquake were more or less impeded because of electricity failures and the damage to equipments and fittings at hospitals and clinics in Sendai City and its neighboring districts.

However, accidents of inpatients were prevented by emergency measures, and serious confusion of medical activities did not come about by means of the co-operation among non or slightly damaged facilities.

1.6 Energy Supply Facilities

(1) Electric Power Facilities

Total demanded electric power in Tohoku District (consisting of Aomori Prefecture, Iwate Prefecture, Akita Prefecture, Miyagi Prefecture, Yamagata Prefecture and Fukushima Prefecture) was 4,900 MW immediately before the earthquake. But after the earthquake, the loading electric power reduced 1,500 MW, and the electric power for supply reduced 1,000 MW in Miyagi Prefecture and other districts of Tohoku. The reduction of electric power are shown in Table 1-6 and Fig. 1-2.

By the influence of these functional damage, the number of electricity-failed houses reached 681,600 (419,100 houses in Miyagi Prefecture, 103,000 houses in Fukushima Prefecture, 95,800 houses in Yamagata Prefecture, 59,000 houses in Iwate Prefecture, etc.). With the advance of temporary restoration, the number of electricity-failed houses decreased to 280,000 at the end of June 12, and that decreased to 12,000 on June 13. The function of electric power facilities was completely recovered on the early morning of June 14.

(2) Gas Supply Facilities

The damage to gas supply facilities was brought by the earthquake in

four cities of Sendai (including Izumi City and Tagajo City), Shiogama, Furukawa and Ishinomaki. There was slight damage in these cities except for Sendai City, and after inspection and restoration, the function of gas supply facilities was completely recovered on June 13 in Ishinomaki City, on June 16 in Shiogama City and on June 18 in Furukawa City.

However, in Sendai City, gas production facilities at Minato Plant and Haramachi Plant were damaged, and what is worse, gas pipes severed at many places. The gas supply in Sendai City was wholly suspended by such serious damage. With the advance of temporary restoration, gas supply was resumed at some places in Sendai City on June 16. After the accomplishment of inspection and restoration of all gas pipes, from main pipe lines to twig pipes inside of every house, gas was supplied block by block. It was on July 9 that gas supply was resumed to every house in Sendai City. The restoration of gas supply facilities is shown in Table 1-7 and Fig. 1-3.

Propane-gas supply through gas pipes was also suspended at 7,861 houses among 16,266 houses in Miyagi Prefecture after the earthquake. Propane-gas supply to 4,444 houses was resumed on June 14, and the supply to the rest 3,417 houses was completed day by day.

1.7 Telecommunication Facilities

3,845 telephones of 1,738,000 subscription telephones in four prefectures of Miyagi, Fukushima, Iwate, Aomori were damaged by snapping of wires, the damage to telephone sets, etc. They were entirely restored on June 20 as shown in Table 1-8. As for long-distance transmission lines, 4,000 circuits of 70,000 circuits into, out of and through Sendai City were down as shown in Fig. 1-4 by the damage to coaxial cables, inclination of micro antennas, etc. All the circuits were restored on June 14 as shown in Table 1-9. Short-distance transmission lines were also damaged as shown in Table 1-10, but all the circuits were soon restored on June 13. Furthermore, as telephone calls for inquiries poured into Sendai City just after the earthquake, extraordinary congestion of calls arose until June 14 as shown in Fig. 1-5.

Besides, public telephones were unusable for several hours by electricity

failures, and telegraph service were not able to be given at Sendai Central Telegraph Office by the damage to transmission lines. Their functions were soon recovered. In three days after the earthquake till June 15, 64,000 telegrams reached Sendai City, that is 20 times more than usual.

On the other hand, wireless facilities for emergencies connecting the prefecture and cities, towns and villages were slightly damaged in Miyagi Prefecture. There was only one town that couldn't communicate by wireless.

As for broadcasting, TV and radio stations couldn't broadcast for a while after the earthquake by electricity failures and the damage to micro circuits. Their functions were soon recovered as shown in Table 1-11 and Table 1-12.

Table 1-1 Traffic Control on Designated National Highways

Number of the Route	Damaged Sites (Kilometer Post)	States of the Damage	Restriction	Period of the Restriction	
				Beginning of the Restriction	End of the Restriction
4	Tamachi, Shiroishi City (304.5km)	Sinking of the road surface by the bursting of a water pipe	One-side restriction	23:00, June 12	1:30, June 13
"	Tomiya Town, Kurokawa County (371.7km)	Upheaval of the road surface h=20.40cm	"	17:20, June 12	8:00, June 13
6	Kashima Town, Soma County (283.4km)	Sinking of the road surface near an abutment h=10cm	"	18:00, June 12	19:00, June 12
45	Naruse Town, Monou County (Ono Bridge) (38.0km)	Movement of the girder	Traffic suspension	19:00, June 12	18:00, June 17 Traffic restriction of vehicles loaded more than 1 ton continued.
"	Naruse Town, Monou County (38.2km)	Landslide V=400m ³	One-side restriction	19:00, June 12	13:00, June 16
"	Kanan Town, Monou County (Tenno Bridge) (58.3km)	Cracks in the pier	Traffic restriction of vehicles loaded more than 1 ton	18:00, June 20	
"	Oofunato, Oofunato City (165.5km)	Cracks in the road surface 70m	"	13:00, June 13	19:30, June 16
"	Sanriku Town, Kesen County (180.6km)	Cracks in the road surface 10m	"	19:05, June 12	17:00, June 15

(Table 1-1 continued)

Number of the Route	Damaged Sites (Kilometer Post)	States of the Damage	Restriction	Period of the Restriction	
				Beginning of the Restriction	End of the Restriction
45	Sanriku Town, Kesen County (183.6km)	Cracks in the road surface 50m	Traffic restriction of vehicles loaded more than 1 ton	19: 05, June 12	17: 00, June 15
"	Sanriku Town, Kesen County (184.3km)	Cracks in the road surface 32m	Traffic restriction of vehicles loaded more than 1 ton	17: 51, June 12	17: 00, June 15
"	Noda Village, Kunohe County (336.7km)	Landslide L=10m V=100m ³	"	18: 20, June 12	17: 00, June 14
48	Miyagi Town, Miyagi County (30.5km)	Falling down of a tree	"	17: 30, June 12	19: 50, June 12
108	Kanan Town, Monou County (5.8km)	Depression of the road L=6m h=70cm	Traffic suspension	18: 00, June 12	16: 25, June 13
"	Furukawa City (35.5km)	Leakage of gas	"	17: 30, June 12	19: 50, June 12

Table 1-2 Traffic Control on the Roads Administred by Miyagi Prefectural Government
from June 12 till July 10.

	Date and Time Restriction	18:00, June 12	17:00, June 13	17:00, June 14	17:00, June 15	17:00, June 16	17:00, June 17	17:00, June 18	8:00, June 19	~	10:00, July 10	Note
Road	Traffic suspen- sion	16	10	8	8	8	8	8	10		5	
	Traffic restric- tion of large- sized vehicles	1	2	2	1	0	2	2	2		1	Time restric- tion from July 7 except for on Sunday
	One-side restriction	12	9	7	7	8	7	7	7		0	
	Speed restric- tion	2	0	0	0	0	0	0	0		0	
	Total	31	21	17	16	16	17	17	19		6	
Bridge	Traffic suspen- sion	5	3	4	4	4	5	5	5		0	
	Traffic restric- tion of large- sized vehicles	2	1	1	1	2	2	2	2		3	Traffic suspen- sion of vehicles at Kinno Bridge, Eai Bridge and Komazuka Bridge
	One-side restriction	3	3	3	3	3	3	3	3		3	Traffic suspen- sion of vehicles loaded more than 1 ton
	Speed restric- tion	2	4	4	3	4	3	3	3		0	
	Total	12	11	12	11	13	13	13	13		6	

(Table 1-2 continued)

	Date and Time Restriction	18:00, June 12	17:00, June 13	17:00, June 14	17:00, June 15	17:00, June 16	17:00, June 17	17:00, June 18	8:00, June 19	~	10:00, July 10	Note
Total	Traffic Suspension	21	13	12	12	12	13	13	15		5	
	Traffic restriction of large-sized vehicles	3	3	3	2	2	4	4	4		4	
	One-side restriction	15	12	10	10	11	10	10	10		3	
	Speed restriction	4	4	4	3	4	3	3	3		0	
	Total	43	32	29	27	29	30	30	32		12	

Table 1-3 Suspension of Traffic on the Roads Administrated by Miyagi Prefectural Government
till July 5 after the Earthquake

Name of the Route	Damaged Sites	States of Damage	Restriction	Reopening Time
National Highway Route 113	Zaimokuiwa, Shiroishi Town	Falling of stones	Suspension of traffic	22:00, June 12
" Route 284	Kesennuma City	"	"	19:00, June 12
" Route 286	Hagurodai, Sendai City	Landslide	"	
" Route 286	Akaishi, Sendai City	Danger of stone falling	"	11:00, June 20 One-side restriction continued
" Route 346	Kinno Bridge, Towa Town	Falling of the bridge	"	12:00, June 24 Reopened by a temporary bridge
Principal Prefectural Road Okumatsushima · Matsu- shima Park Line	Tetaru, Matsu- shima Town	Depression of the road	"	11:00, June 13 One-side restriction continued
" Taiwa · Matsushima Line	Dobori Bridge, Taiwa Town	Depression of the abutment	"	22:00, June 19 Traffic restriction of large- sized vehicles continued
" Yuzawa · Tsukidate · Shizugawa Line	Onyu, Hanayama Village	Falling of stones	"	16:00, June 13
" Ishinomaki · Kashimadai · Oohira Line	Komazuka Bridge, Kashimadai Town	Cracks in the floor plate	"	
" Onagawa · Shizugawa Line	Kamaya, Okatsu Town	Collapse in the shoulder of the road and landslide	"	12:00, June 13

(Table 1-3 continued)

Name of the Route	Damaged Sites	States of Damage	Restriction	Reopening Time
Principal Prefectural Road Shiogama · Watari Line	Yuriage Bridge, Natori City	Sinking of the abutment	Suspension of traffic	12:00, June 21 Traffic restriction of large-sized vehicles continued
" Ishinomaki · Ayukawa Line	Bankoku Bridge, Wataha, Ishinomaki City	Cracks in the pier	"	15:00, June 29 One-side restriction continued
Prefectural Road Sendai · Yamadera Line	Takinohara, Akiu Town	Falling of stones	"	10:00, June 13
" Sadayoshi, Sendai Line	Sadayoshi, Miyagi Town	"	"	June 28, Time restriction continued
" Kensennuma · Motoyoshi Line	Kesennuma City	Cracks in the road surface and falling down of a tree	"	16:00, June 14
" Masusawa · Yoshioka Line	Taiwa Town	Falling of roof tiles	"	11:00, June 13
" Kurikoma Park Line	Ueda, Kurikoma Town~Komanoyu	Falling of stones	"	16:00, June 13
" Arikabe Station Line	Kannari Town	"	"	20:00, June 12 Traffic restriction of large-sized vehicles continued
" Gunsawa · Hasama Line	Hanayama Village	"	"	16:00, June 13
" Arikabe · Wakayanagi Line	Gobo Bridge, Waka- yanagi Town	Sinking of the abutment	"	20:00, June 12
" Wakuya · Sanbongi Line	Keshozaka Over- bridge, Kogota Town	Sinking of the road surface	"	13:30, June 13

(Table 1-3 continued)

Name of the Route	Damaged Sites	States of Damage	Restriction	Reopening Time
Prefectural Road Kitakami · Kahoku Line	Shunosu, Kitakami Town	Cracks in the road surface	Suspension of traffic	
" Kamaya · Oosu · Okatsu Line	Tachihama, Okatsu Town	Landslide	"	16:30, June 13
" Towa · Usuginu Line	Yoshine, Towa Town	Falling of stone	"	19:00, June 13
" Semine · Toyosato Line	Toinuki Bridge, Toyosato Town	Cracks in the abut- ment	"	10:30, June 22 Traffic restriction of large- sized vehicles continued
" Oosato · Rifu Line	Morisato, Rifu Town	Landslide	"	
" Kasukawa · Hataya Line	Kozunai, Oosato Town	"	"	
" Nenoshiroishi · Shiogama Line	Yaotome Bridge, Yaotome, Izumi City	Sinking of the road surface near the abutment	"	12:00, June 13
" Kitakami · Kahoku Line	Ookawa, Kahoku Town	Cracks in the road surface	"	12:00, June 17 Traffic restriction of large- sized vehicles continued
" Shizugawa · Toyoma Line	Uzawa Mountain Pass	Cracks in the road surface and landslide	"	16:30, June 13
" Naruse · Nango Line	Sunayama, Naruse Town	Cracks in the road surface	"	9:00, June 22
" Taiwa · Matsuyama Line	Sokawa Bridge, Ai- kawa, Taiwa Town	Cracks in the abutment	"	

(Table 1-3 continued)

Name of the Route	Damaged Sites	States of Damage	Restriction	Reopening Time
Prefectural Road Kashimadai · Naruse Line	Takeya, Matsushima Town		Suspension of traffic	8:00, June 4
" Sanbongi · Taiwa Line	Oohira Village~ Taiwa Town	Depression of the road	"	12:30, June 26
Toll Highway Cobalt Line	Whole line	Landslide, collapse of the shoulder of the road and crack in the road surface	"	7:00, July 1

Table 1-4 Traffic Restriction at Tohoku Expressway

Date	Closing	Reopening
June 12	17:17 (Shirakawa ~ Tsukidate) 17:32 (Ichinoseki ~ Hiraizumi · Maesawa)	18:30 (Shirakawa ~ Kooriyama) 19:15 (Ichinoseki ~ Hiraizumi · Maesawa : up line) 19:50 (Kooriyama ~ Fukushima · Iizaka) 20:25 (Ichinoseki ~ Hiraizumi · Maesawa : down line)
June 13	Closing continued at the rest sections because of temporary restoration works.	23:55 (Shiroishi ~ Izumi)
June 14		12:00 (Taiwa ~ Tsukidate) 16:00 (Fukushima · Iizaka ~ Shiroishi)
June 15	Reopening was completed at all sections, but speed restriction continued at some sections	7:00 (Izumi ~ Taiwa)
July 11	Traffic conditions returned to normal at all sections at 12:00	

Note: Maximum Speed

100km/h 80km/h 100km/h under construction
 Shirakawa ~ Zao P.A. ~ Izumi ~ Tsukidate ~
 80km/h 100km/h
 Ichinoseki ~ Maesawa ~ Morioka

Table 1-5 Suspension and Decrease of Water Supply in Miyagi Prefecture

Date	Number of Local Public Bodies Resumed Water Supply after Suspension	Number of Facilities Resumed Water Supply after Suspension	Number of Local Public Bodies Resumed Water Supply after Reduction
June 12	3	4	
June 13 (AM)	3	7	1
June 13	20	24	
June 14	10	13	1
June 15	6	8	
June 16	1	1	
June 17	2	4	
June 18	2	4	
June 19	1	1	
June 20	2	2	
June 21	2	2	
June 22	1	1	
June 23	1	1	
Total	54	72	2

Table 1-6 Functional Damage to Electric Power Facilities
(Tohoku Electric Power Co., Ltd.)

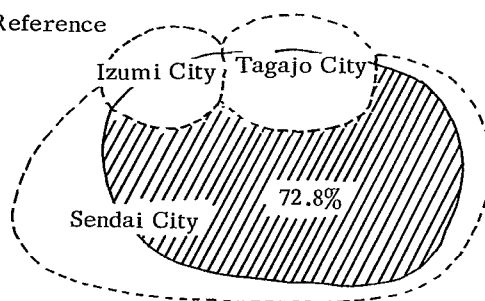
Decrease in Electric-power Generation	815,210 KW (Hydroelectric power 115,210 KW Thermal power 700,000 KW)
Decrease in Electric-power Supply	1,130,700 KW (General demand 762,650 KW Big demand 368,050 KW)
Decrease in Electric-power Reception	377,800 KW (General demand 105,300 KW Big demand 272,500 KW)

Table 1-7 Restoration of Gas Supply Facilities in Sendai City
Including Izumi City and Tagajo City (Gas Bureau
of Sendai Municipal Government)

Date	Percentage of Restoration Achievement	Number of Gas-Supplied Houses
June 16	Beginning of gas supply	
19	19 %	26,000
22	32 %	44,000
25	60 %	82,000
29	92 %	125,000
July 6	98.2 %	133,000
9	Restoration was completed except for at specified districts and deserted houses.	

Note : Total number of gas-supplied houses : 135,863 houses (The per-
centage of pervasion : 72.8%), total length of main pipe lines :
196km, total length of trunk and bough pipes : 1,225km, Total :
1,421 km. Specified districts consists of three dangerous
districts (Midorigaoka, Kitane-Kuromatsu, Kuromatsu in Izumi
City) which have 530 houses.

*Reference



-  Administrative Region
-  Gas-Supplied Region

The percentage of gas-supply
pervasion in gas-supplied
region of Sendai City : 72.8%

Table 1-8 Damage to Telephone Systems (The Nippon Telegraph and Telephone Public Corporation)

Name of the Branch	Number of Telephone Subscribers	Number of the Telephones Suspended	Date of the System Recovered
Miyagi (Sendai Station)	About 533,000 (273,000)	About 2,660 (1,160)	All telephone systems were recovered on June 20 except for 15 subscriptions impossible to be restored because of the collapse of houses.
Fukushima	488,000	530	
Iwate	331,000	650	
Aomori	386,000	5	
Total	1,738,000	3,845	

Note: Suspension of telephones was brought about by snapping of wires, damage to telephone sets, etc.

Table 1-9 Damage to Long-Distance Transmission Lines
(The Nippon Telegraph and Telephone Public Corporation)

a. Micro System

Damaged Section, System	Number of Accommodated Circuits	Number of Damaged Circuits	Time of the System Damaged	Time of the System Recovered	Cause of the Damage
Tokyo ~ Sendai (Jujo) (Tsutsujigaoka) 6GHz	circuits 6,100	circuits 6,100	17: 15, June 12	23: 18, June 12	Inclination of the wireless- relay phone antenna at Tsutsujigaoka Station.
Sendai ~ Hakodate 4GHz	250	250	"	19: 30, June 12	Cords connecting the facili- ties pulled out at Sendai Wireless Station.
Sendai ~ Ishinomaki 11GHz	1,500	400	"	19: 00, June 12	Fuses of the source of electric power for 3 systems gone at Oohira Wireless Station
Ishinomaki ~ Kesennuma 2GHz	320	130	"	19: 03, June 12	Recovered naturally Under investigation of the cause.
Tokyo ~ Sendai (Jujo) 4GHz	TV up 6 down 6	TV up 6 down 6	"	17: 24, June 12	Board of the source of electric power loosened at Sendai Wireless Station
Total	8,170 TV up 6 down 6	6,880 TV up 6 down 6			

b. Coaxial Cable System

Damaged Section	Number of Accommodated Circuits	Number of Damaged Circuits	Time of the System Damaged	Time of the System Recovered	Damaged Sites
Tohoku II (Fukushima ~ Sendai)	circuits 4,900	circuits 4,900	17:15, June 12	0:03, June 14	Breaking down of the cable at 1 point about 31 km from Sendai, 3 points about 37 ~ 38 km from Sendai at 1 point about 42 km from Sendai. The cable was damaged at 5 points.
Tohoku II (Sendai ~ Morioka)	4,600	4,600	"	21:55, June 13	Breaking down of the cable at the culvert about 18 km from Sendai. The cable damaged at 2 points.
Joban (Haranomachi ~ Sendai)	6,900	6,900	"	18:57, June 13	Breaking down of the cable at the culvert about 11 km from Sendai. The cable damaged at 2 points.
Total	16,400	16,400			

Note : The Damage to cables was brought about by sinking of the ground at weak-ground areas and near bridges of directly buried sections.

c. Long Distance Circuits

Date and Time	Total Circuits into; out of and through Sendai			Circuits into and out of Sendai (The number of circuits is included in the number of the left column)			Note
	Total Number of Circuits	Number of Damaged Circuits	Ratio of Damaged to Total	Total Number of Circuits	Number of Damaged Circuits	Ratio of Damaged to Total	
17:15, June 12	about circuits 70,000	about circuits 24,000	% 34	about circuits 31,000	about circuits 13,000	% 42	
19:30, June 12	"	16,000	23	"	7,700	25	
23:30, June 12	"	8,000	11	"	4,300	14	
12:00, June 13	"	5,500	8	"	3,500	11	
17:00, June 13	"	3,400	5	"	1,600	5	
0:03, June 14	"	0	0	"	0	0	All circuits recovered

Table 1-10 Damage to Short-Distance Transmission Lines
(The Nippon Telegraph and Telephone Public Corporation)

Damaged Section, System	Number of Accommodated Circuits	Number of Damaged Circuits	Time of the System Damaged	Time of the System Recovered	Cause of the Damage
Ishinomaki - Oshika PCM-24	circuits 180	circuits 161	17:15, June 12	0:01, June 13	Relay boards loosened at Oshika Station and Ooharahama Station.
Tsutsujigaoka - Nanakita PCM-24	637	48	"	18:50, June 12	Changing-over cords pulled out at Nanakita Station.
Ishinomaki - Kahoku PCM-24	177	112	"	0:45, June 13	An electric-power supply board loosened at Kahoku Station.
Tsutsujigaoka - Shiogama PCM-24	487	24	"	20:15, June 12	Changing-over cords pulled out at Shiogama Station.
Sendai - Natori PCM-24	690	212	"	18:52, June 12	Fuses of the electric-power dis- tribution board gone at Sendai Station.
Oogawara - Kawasaki PCM-24	194	113	"	17:30, June 12	A relay board loosened at Kawasaki Station.
Miyako - Iwaizumi T-12SR	121	12	"	20:30, June 12	A relay board loosened at Taro Relay Station.
Total	2,486	682			

Table 1-11 Functional Damage to TV and Radio Broadcasting
due to the Damage to Micro Circuits

TV	NHK : 94 stations (General : 47 stations, Educational : 47 stations) 24 stations in Miyagi Prefecture 36 stations in Iwate Prefecture 30 stations in Yamagata Prefecture 2 stations in Akita Prefecture 2 stations in Fukushima Prefecture 6 broadcasting companies : 46 stations
Radio	NHK : 3 stations (First : 1 station, Second : 2 stations) 2 broadcasting companies : 3 stations
Short-wave international broadcasting	NHK : 1 station

Table 1-12 Suspension of TV Broadcasting

Name of the Broadcasting Station	Time of the Beginning of Suspension	Time of the Recovery	Suspended Period	Cause of Suspension
Fukushima NHK General	17:15, June 12	17:47, June 12	32 minutes	Damage to relay lines between Tokyo and Sendai (4GHz). ○ Sakata NHK and Aomori NHK were recovered by round about routes. ○ Broadcasting of Fukushima NHK didn't suspend by receiving electric waves directly from a satellite station in Sendai Area.
Morioka NHK Educational	"	17:26, June 12	10 minutes 30 seconds	
Yamagata NHK Educational	"	17:24, June 12	9 minutes	
Sakata NHK Educational	"	17:18, June 12	3 minutes 40 seconds	
Akita NHK Educational	"	17:24, June 12	7 minutes 55 seconds	
Aomori NHK Educational	"	17:18, June 12	3 minutes 40 seconds	
Sendai NHK Educational	"	17:24, June 12	9 minutes	
Sapporo NHK Educational	"	17:25, June 12	10 minutes 35 seconds	

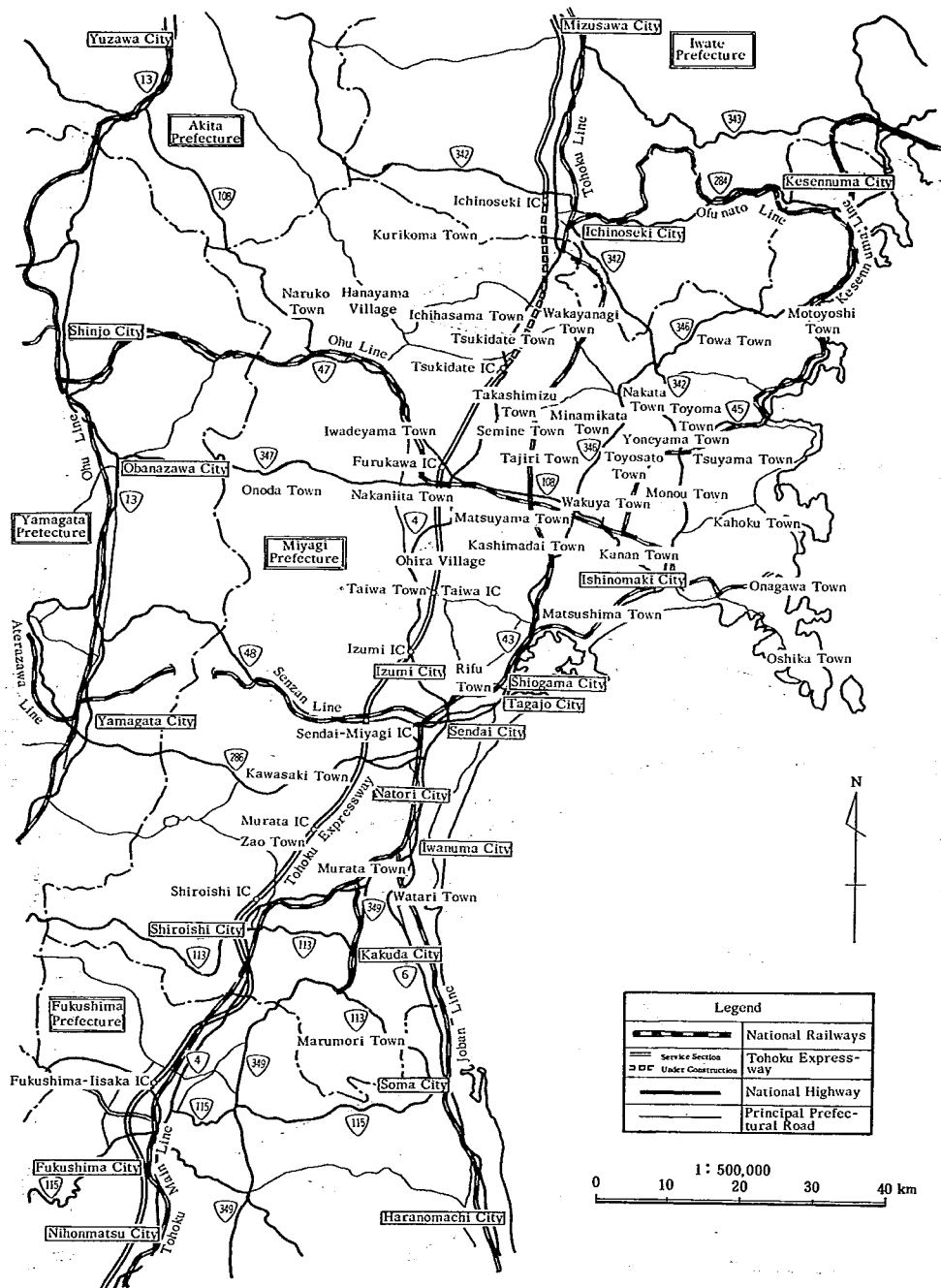


Fig. 1-1 Transportation Network in Miyagi Prefecture

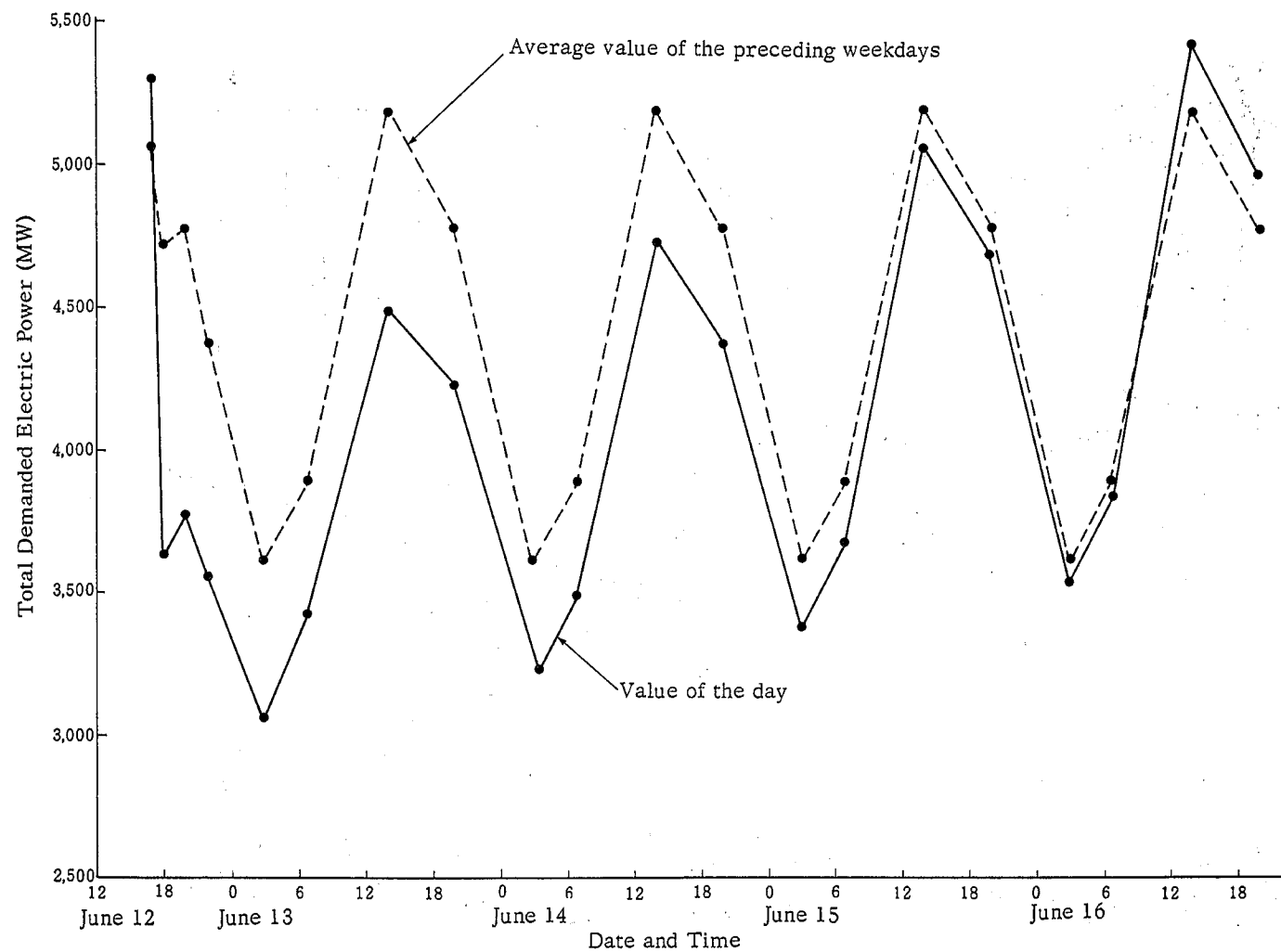


Fig. 1-2 Decrease and Recovery of Total Demanded Electric Power (Tohoku Electric Power Co., Ltd.)

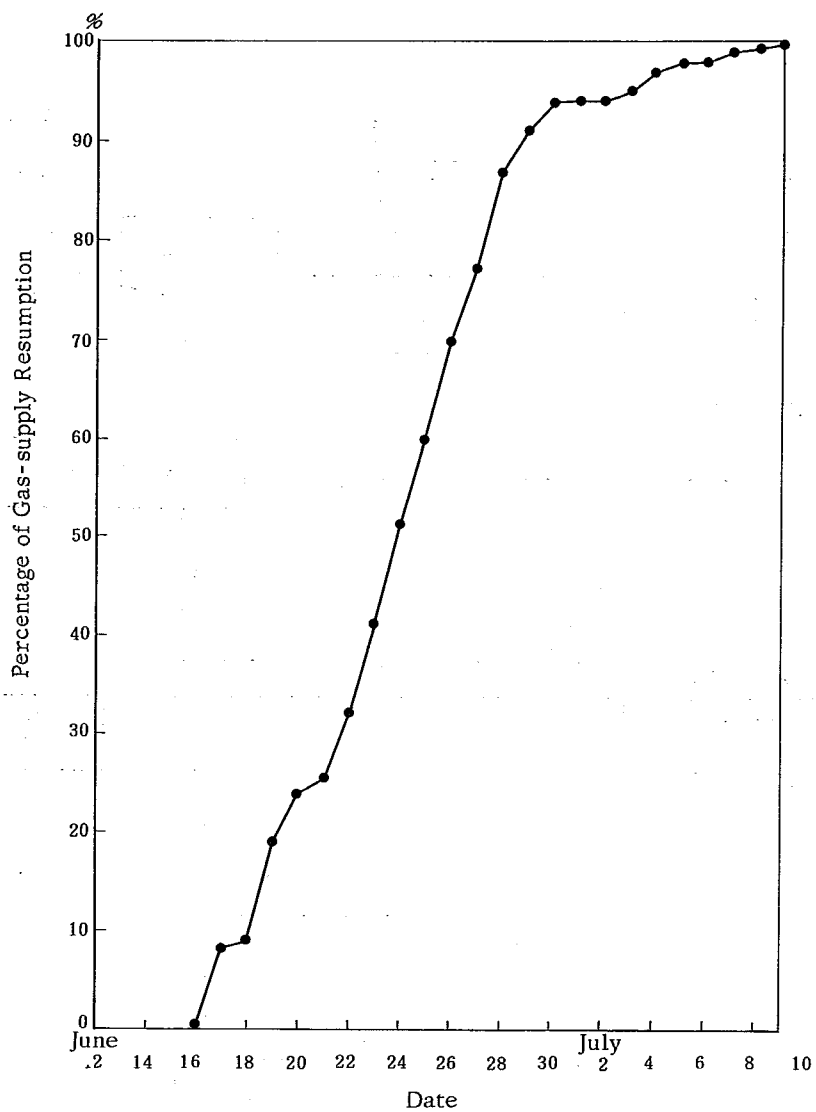


Fig. 1-3 Transition of Gas-supply Resumption
(Gas Bureau of Sendai Municipal Government)

Fig. 1-4 Damage to Long-Distance Transmission Lines (The Nippon Telegraph and Telephone Public Corporation)

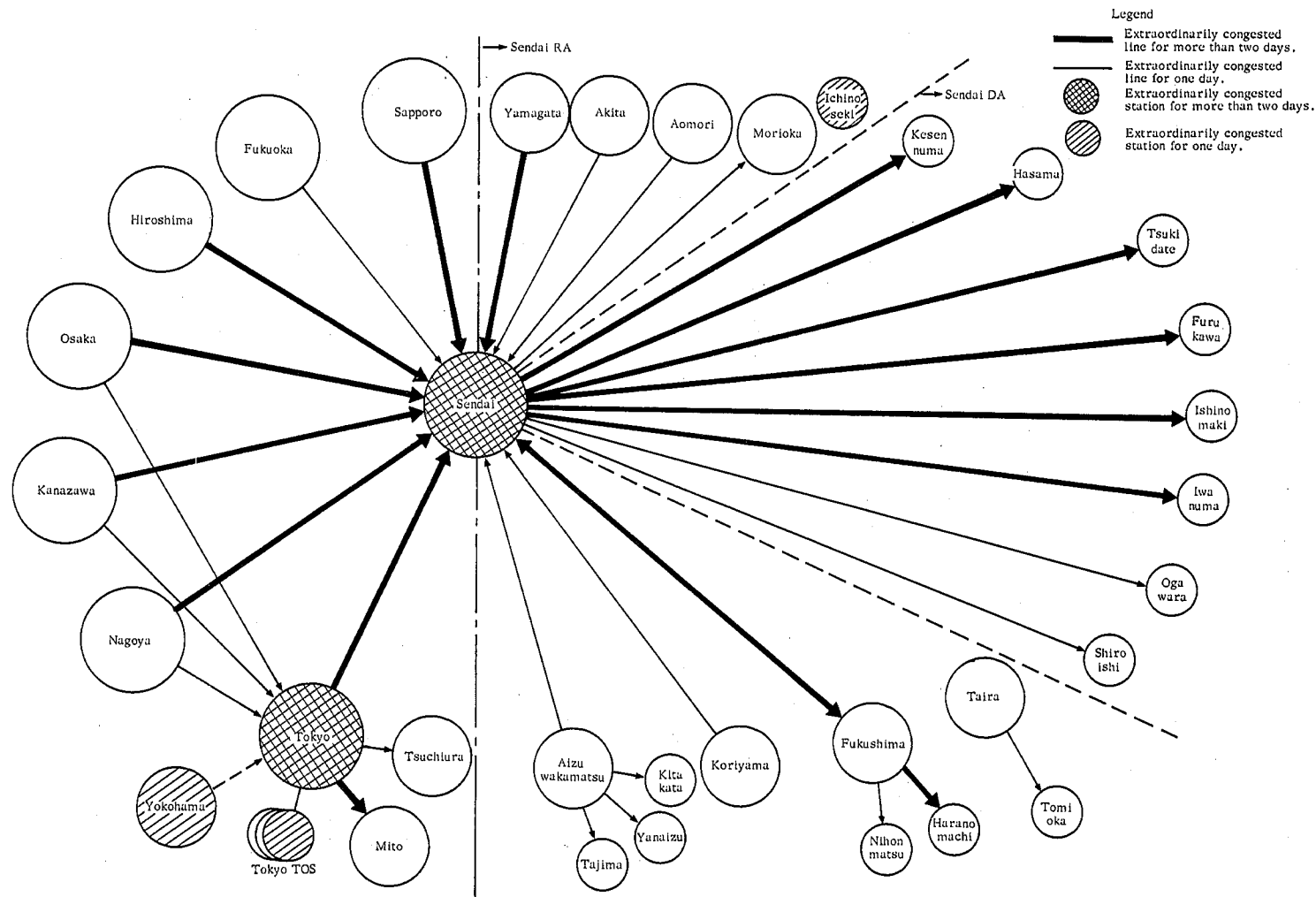


Fig. 1-5 Extraordinary Congestion of Trunk Calls (The Nippon Telegraph and Telephone Public Corporation)

2. Characteristics of the Damage to Lifeline Facilities and their Functions, and Rehabilitation

2.1 Relationship among Damage, Topography and Geology

The sites where structures suffered damage approximately correspond to the areas of topographically or geologically severe conditions. For example, Fig. 2-1 shows the distribution of razed houses and failed slopes. The razed houses are concentrated to alluvium, eastern suburb of Sendai City, and to the hilltop, northern and south-western suburb of the city. The latter area also suffered slope failures. The distribution of the damage roughly coincides with that of the water supply facility and of the gas supply facility shown in Fig. 2-4.

Through the experiences of past earthquakes, we have learned that structures on the alluvium are likely to suffer greater damage than those on the diluvial layer. The earthquake proved that the experience was fairly true. Some geologists assert that the back marsh behind the ocean ridge on the Pacific Ocean is vulnerable to earthquake effects. However little evidence of this was observed as far as in Fig. 2-1.

The hills in the western part of Sendai City (i.e. Aoba-yama, Yogi-yama and Dainenji) and the western part of Natori City (i.e. Minowa and Noda-yama) are covered with 5m thick loam layer at the top and with 10~20m thick gravel layer underneath, both of which are called the Aoba-yama Layers. The Tertiary layer of sandstone spreads beneath them. N-value of the loam layer at 2.5m beneath the surface and of the gravel layer are on the average 5m and 20~35m respectively. Midorigaoka District, Sendai City, where residential lots had been developed in late 1950s through early 1960s and much slope failures took place, has the same geological conditions as above. The residential lots had been developed by cutting the hilltops and filling the valleys. As shown in Fig. 2-2 and 3, there were the fills more than 10m thick and whose N-value was less than 10. Slope failure and settlements occurred mostly at these fills due to the earthquake, which caused the damage to residential houses, water supply and gas supply pipes.

As for the residential lots of northern part of Sendai City, and Izumi City, there are no loam and gravel layers. Hard rock and soft rock lies alternately. The residential lots had been developed by using bulldozers attached by the ripper. Fig. 2-4 shows the damage distribution of water supply and gas supply pipes at

Nanko-dai Housing Complex, Izumi City. The damaged sites concentrate to the areas where they have used to be valleys and they had been artificially filled.

2.2 Damage and Function of Lifeline Facilities after the Earthquake

Table 2-1 shows the individual loss ratios of lifeline facilities in Miyagi Prefecture. The individual loss ratio is defined as the ratio of the loss caused by the earthquake and the existing assets in the affected area. The existing assets can be estimated from the population density.

$$\text{Individual Loss Ratio} = \frac{L P}{W P_D}$$

where

L : loss valued in money,

W : national wealth,

P : national population and

P_D : population of the quake-affected area.

The national wealth of 1978 is not available, so that the data of 1970 were used here.

The individual loss ratio of harbor facility shown in the Table is the highest and that of highway and gas supply facilities is also high. Water supply and electric power facilities have relatively low ratios and telecommunication facility has the lowest. The sequence of the individual loss ratios suggests that the ratio represents the damage. It can be used as the index quantifying damage of various kinds of facilities.

The sequence also roughly coincides to that of the functional damage. In Ishinomaki Port, the most heavily damaged harbor, the harbor function was maintained after the earthquake by the emergency repair and by utilizing the little damaged warves. As for the harbor facility the functional damage was not minor but the reserved facilities had been well prepared.

Many highways were blocked due to the earthquake damage after the earthquake. As of October 5, 1978, about 4 months after the earthquake, two highway sections and four highway bridges were still out of service. Many bridges suffered considerable damage as shown in Appendix II, which caused discontinuity of highway networks in Miyagi Prefecture. The gas supply facility suffered great functional

damage, as the individual loss ratio was relatively high. It took about one month to resume gas supply. The area where gas supply stopped after the earthquake encompassed Sendai and adjacent cities. The water supply facility sustained less functional damage than the gas supply, as the individual loss ratio of the water supply was also less. The suspension of water supply in Sendai was over on June 20, eight days after the earthquake. Islands of Shiogama City experienced the longest suspension of eleven days. During the suspended period, water wagons supplied water to the residents. Functional damage of the electric power was not severe. The domestic power supply was resumed on June 14. On the other hand the suspension influenced other lifeline facilities. For example, traffic signals did not function because they did not have the reserved electric power. It brought traffic congestion in the central Sendai City. Traffic Control Center of Sendai Central Policestation, which had controlled areal traffic signals in Sendai, disordered due to the electric power suspension. It could not collect the data on the traffic just after the earthquake, which would be useful to analyze. Tohoku Electric Power Co., Ltd. asked industrial firms to reduce the consumption of electric power, until the power plants and transformer stations recovered. It would influence the industrial productivity to some extent. The telecommunication facility suffered little functional damage. However the demand for the telephone call increased after the earthquake, which caused difficulties of telephone calls.

As stated above, functional damage and individual loss ratio well correlate in each other.

Lifeline facilities can be classified into the terminal facilities (e.g. power plants, filtration plants, centrals) and distribution facilities (e.g. electric wires, conduits, telephone lines). Highway is a distribution facility and harbor is solely a terminal facility respectively, so that we have taken electric power, water supply, gas supply and telecommunication facilities as the examples of the classification.

Electric power facilities suffered damage mainly to the power plants and transformer stations, its terminal facilities. It caused the decrease of electric power supply for several days, although the individual loss ratio was low. This teaches us that the terminal facility is important to preserve functions after the earthquake.

On the other hand, water supply, gas supply and telecommunication facilities sustained more damage to the distribution facilities than to the terminal. The telecommunication facility was well prepared with the reserved networks, which prevented functional damage to the minimum. As for the conduits, valves had been equipped in order to separate the damaged section from the safe networks. Moreover they admitted water leakage due to the damage and kept supplying water. These helped to lessen the functional damage.

Valves had not been equipped in the gas pipe network. Explosivity of gas also delayed the resumption of supply.

Fig. 2-5 illustrates the difficulty of restoration of the function. The valves in the pipe networks are also considered as the reserved facility. The upper and right direction indicates the difficulty of resumption. In this earthquake electric power facility was considered to be classified into IV, water supply and telecommunication was into III and gas supply was I in the Figure respectively.

2.3 Characteristics of the Disaster in Urban Areas

The disaster of this earthquake is recognized as an urban-type disaster. Dwellings and lifeline facilities in urban area were concentratively damaged and functional damage due to the disorder of lifeline facilities followed. This type of the latest earthquake disaster was Niigata Earthquake of 1964 in Japan.

Even if an earthquake shakes the ground, it does not cause damage in a non-inhabited area. Urban-type disaster is an opposite case. Concentration of population and facilities accerelates the disaster. Table 2-2 shows the comparison of this earthquake and Kinkasan-oki Earthquake of 1936, whose epicenter was about 5 km far from that of this earthquake. Kinkasan-oki Earthquake caused less damage than this earthquake did. As shown in the Table the population had increased by 1.6 times between the two earthquakes. The population of Sendai City had increased from 260 thousand in 1944 to 620 thousand in 1975, although the population of Miyagi Prefecture in 1944 which amounted 1260 thousand had little changed from the one in 1936. The urbanization would aggravate the earthquake effects.

Typical examples of the urban-type disaster were observed at the newly developed residential lots in Sendai and adjacent cities. The residential lots have

been developed by cutting hilltops and filling valleys and by embanking on farm lands, which were usually soft and saturated. On the other hand the old city of Sendai except the downtown of Naga-machi spread over the terrace of the Hirose River, mostly consisted of diluvial gravel. The old city on the terrace suffered minor damage. The increase of population has made the residences expand to the area of steep slopes and soft ground, relatively vulnerable to earthquakes. The damage of lifeline facilities in the vulnerable area accelerated the inconvenience of citizens' lives.

Impact to and response of the residents caused by the earthquake was likely to be less than those which are expected in a metropolitan area of Tokyo or Osaka.

Table 2-3 shows the tenure of houses as of 1975 National Census. In the central part of Tokyo a sum of owned houses does not have high ratio. However in Sendai it is comparatively high. Moreover it is said that the citizens of Sendai have the tendency of domiciliation. It was proved in the disaster that they were eager to defend themselves. Panic, as rushing at food stores, did not take place. Only a little complaints for the electric power, water and gas supply suspension were brought to the relevant organizations.

2.4 Public Facilities and Private Goods

Public facilities are considered to be designed to possess an uniform resistivity to loadings for a public profit. In a severely natural circumstance a structure should be designed more resistible to it.

Private goods also have some relations to the public, so that they should have the resistivity to some extent. The prescription of building average in the Standard Building Law is an example of avoiding the nuisance to the neighbors. On the contrary private goods are apt to be designed as economically as possible, because they tend to emphasize economy compared to public facilities. Therefore the earthquake damage of private goods is likely to be more influenced by natural circumstances. For instance the damage of dwellings was concentrated on certain areas such as developed lots on hilltops and soft grounds.

The residents, whose houses were damaged, suffered the economic burden to reconstruct them. Prefectural and municipal governments aided them indirectly by reconstructing roads and sabo dams, and strengthening steep slopes in the damaged area. They also recommended loans for reconstruction. However the responsibility of reconstruction came to the residents in the end. Some of them had to continue to clear the loan which they had borrowed, although the houses were damaged.

2.5 Rescue and Rehabilitation

National, prefectural and municipal governments and public corporations set up the temporary organizations for rescue and rehabilitation. They functioned well, since they had experienced many disasters such as floods.

Department of Public Works and Police played an important role in communication of data, because they had the main responsibility for it in case of reconstruction of floods.

Table 2-1 Comparison of Individual Loss Ratios of Lifeline Facilities

	Loss (L) in million yen	National Wealth ^{*1} in billion yen	$\frac{L_K P}{W_K P_D}$
Highway	^{*2} 10,721	8,121.5	0.076
Harbor	3,746	2,076.5	0.103
Water Supply	1,733	4,502.2	0.022
Gas Supply	947	867.4	0.063
Electric Power	2,960	8,133.7	0.021
Telecommunication	850	4,857.2	0.010

*1 Referred from the National Wealth Survey of 1970.

*2 Excluding National Expressways.

P : 111,933 thousand

P_D : 1,955 thousand

Table 2-2 Comparison of the Earthquake of 1978 to Kinkasan-oki
Earthquake of 1936

Earthquake	Date	Magni- tude	Epicenter	Damage	Population in the Time of the Earthquake
Kinkasan- oki	Nov. 3, 1936	7.7	$\lambda = 142.2^\circ\text{E}$ $\varphi = 38.2^\circ\text{N}$	Injured 4, Razed Non- dwelled Building 3, Half-razed Dwelling 2, Half-razed Non- dwelled Building 2, Damage or Highways 35	^{*1} 1,234,801
Miyagiken- oki	June 12, 1978	7.4	$\lambda = 142^\circ 13'\text{E}$ $\varphi = 38^\circ 9'\text{N}$	Refer to Appendix II	^{*2} 1,955,274

*1 as of 1935

*2 as of 1975 referred from the National Census of 1975.

Table 2-3 Ordinary Households by Tenure of House and One Person
Quasi-households Living in Rented Rooms as of 1975

Area	Ordinary Households Living in Houses						One Person Quasi-households Living in Rented Room
	Total	Owned House	Rented House Publicly Owned	Rented House Privately Owned	Issued House	Rented Room	
Japan	31,321,700	18,151,500	2,343,300	8,547,900	2,056,300	222,600	547,200
Miyagi Pref.	506,100	309,800	28,400	134,300	31,100	2,500	16,800
Tokyo Pref.	3,820,700	1,446,200	382,200	1,695,100	248,100	49,000	102,600
Aichi Pref.	1,580,400	855,300	148,500	448,100	120,900	7,500	19,200
Ohsaka Pref.	2,467,500	999,700	320,900	989,300	143,400	14,200	21,700
Sendai City	186,100	76,400	10,300	80,500	18,200	700	12,000
Central Tokyo	2,920,900	1,064,100	229,900	1,391,100	194,000	41,700	87,500
Nagoya City	611,700	244,100	68,800	246,800	48,700	3,200	12,600
Ohsaka City	882,300	298,100	106,800	427,100	42,600	7,800	9,400

Referred from ; Bureau of Statistics, Office of the Prime Minister : Population of Japan, 1975
Population Census of Japan Abridged Report Series No. 1, 1977.

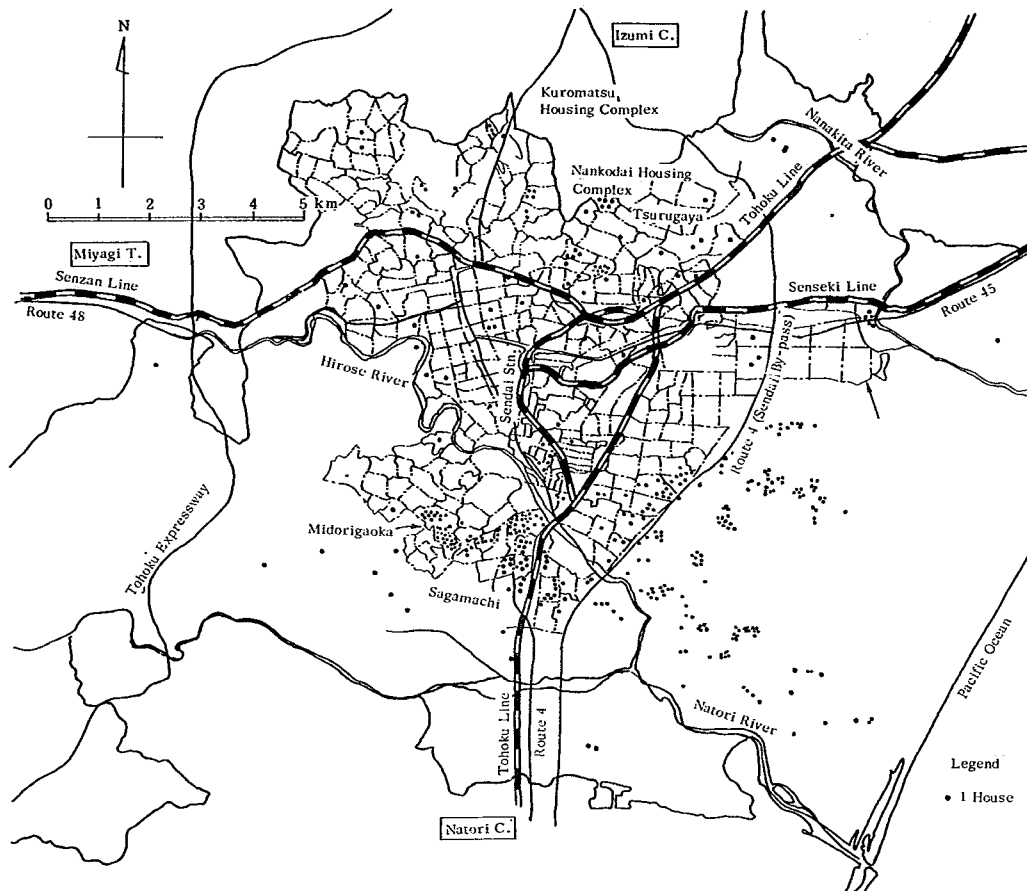


Fig. 2-1 (a) Distribution of Razed Houses in Sendai

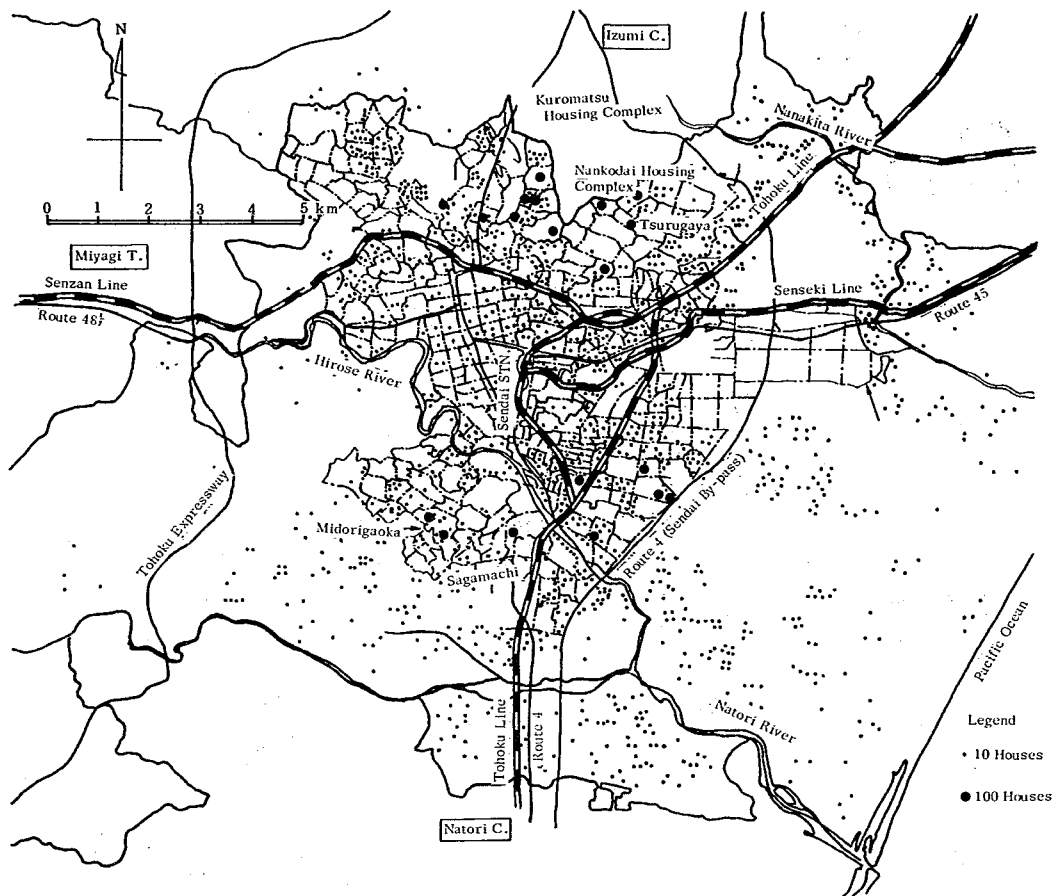


Fig. 2-1 (b) Distribution of Damaged Fences in Sendai

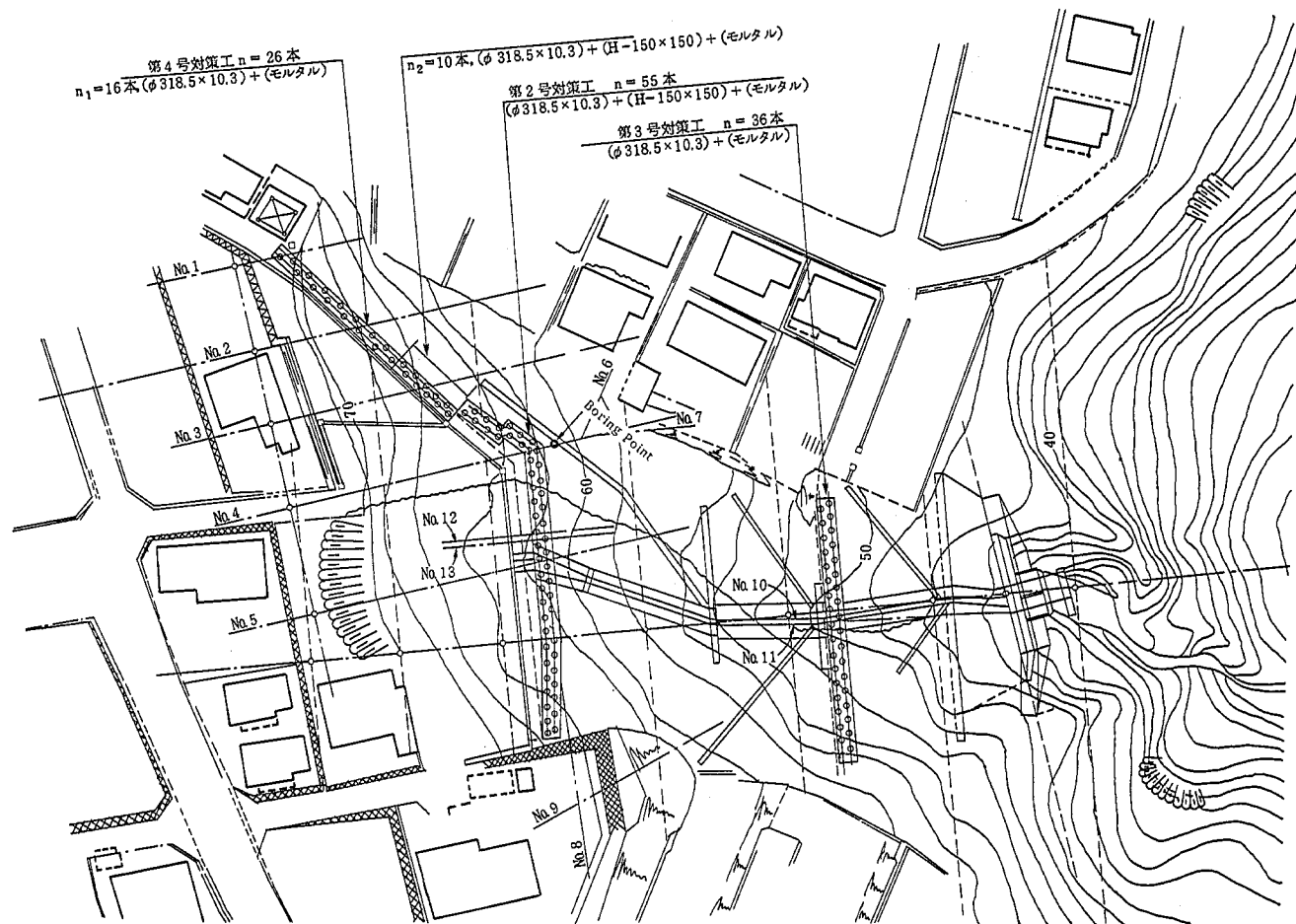


Fig. 2-2 Plan of the Residential Lots in Midorigaoka, Sendai

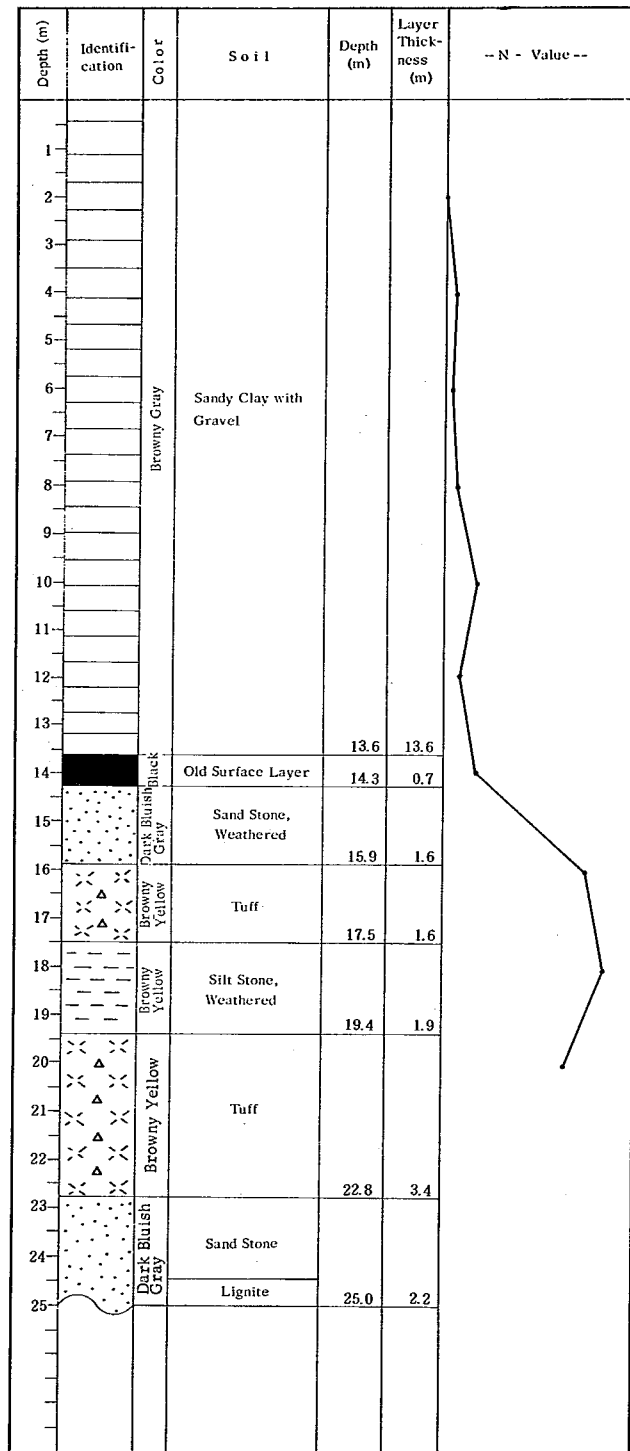


Fig. 2-3 Soil Profile at Midorigaoka, Sendai

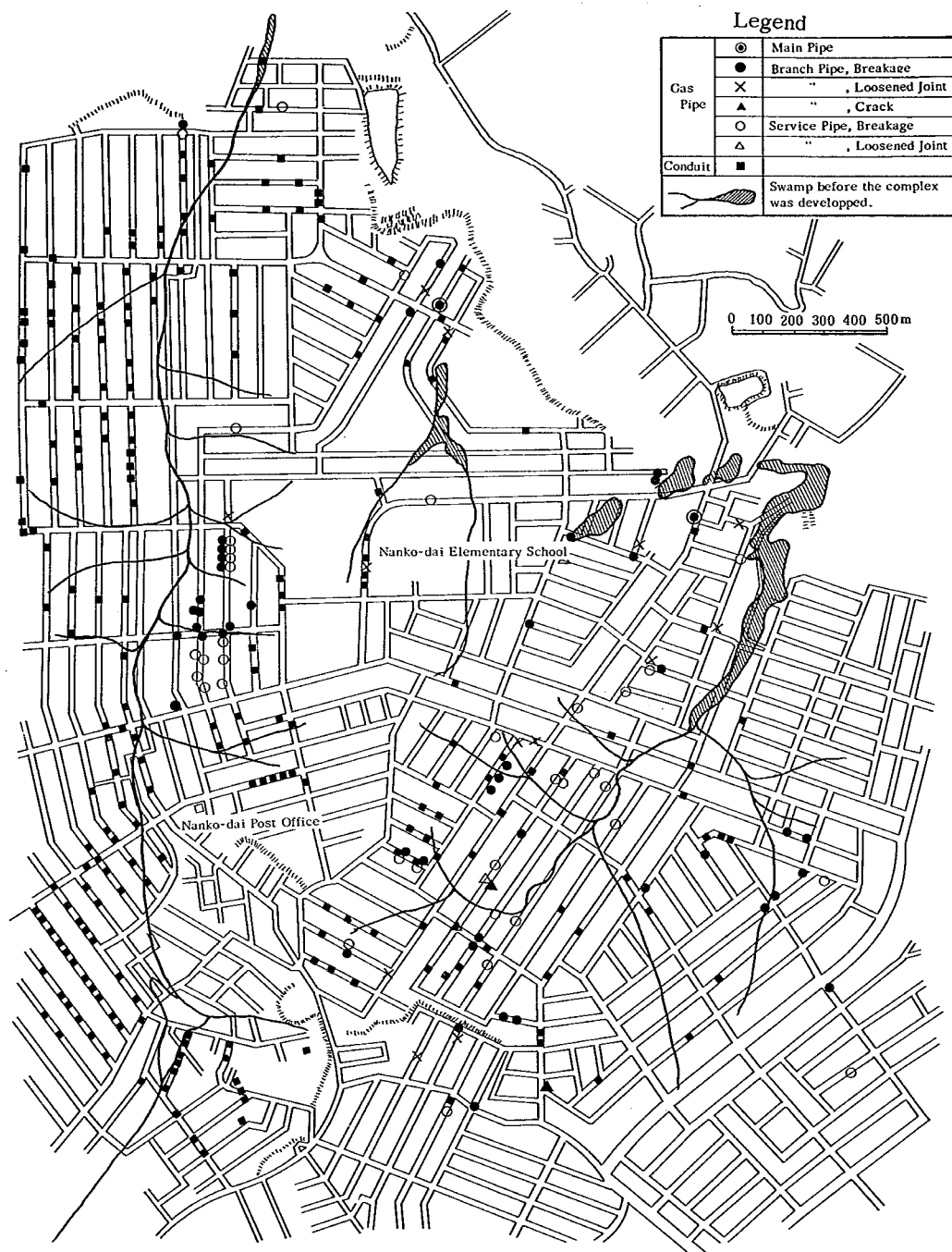


Fig. 2-4 Damaged Sites Distribution of Conduits and Gas Pipes at Nanko-dai, Izumi City

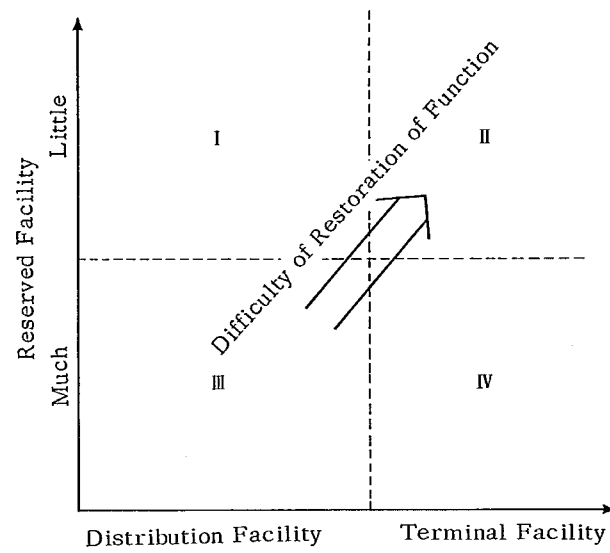


Fig. 2-5 Difficulty of Restoration of Function of Lifeline Facilities

3. Lessons for Earthquake Disaster Prevention Measures

3.1 Data Collection on the Disaster

One of the most important things to do just after the earthquake is to collect the data on the disaster as fast and accurately as possible. The data are also useful to determine the way of reconstruction and to analyze the disaster later.

The data were transmitted from the branch organizations to the head organizations. The media of transmission were mostly preserved their functions, although some of them were busy.

The earthquake caused much functional damage to several lifeline facilities. But the functional damage has not been quantified. Totalizing the functional damage of whole facilities and comparing in each other are not possible so far. The quantification of functional damage is important to relate it with the damage of facility.

3.2 Resumption of Functions

The function of roads were a little disturbed for a few days after the earthquake due to the damage on them. However it influenced little on goods transportation. There were no shortage of subsistence commodities.

The disaster was not big enough to apply the ministerial notification of The Designation of Charged-free Vehicles in Toll Roads.

Gas supply was stopped for about one month after the earthquake. One reason for this was that the gas pipe network was continuous within the supplying area. The supply could not be resumed until whole damages of pipes were repaired.

In Sendai the pipe network was divided into eight blocks temporarily in order to be efficiently repaired and to resume the supply as fast as possible. They were connected again after the repair was over.

Tokyo Gas Co., Ltd. has started to plan to divide the pipe network into several blocks, referring to the experience in Sendai.

Functional damage of the electric power facilities was not big. However it caused the disorder of traffic signals and water pumps of water supply. Functional

damage of the electric power facilities had much influence on other lifeline facilities.

3.3 Utilization of the Experience of Earthquake Disaster

Fortunately there occurred few fires due to the earthquake. The earthquake of February 20, 1978, described in the preceding chapter might have trained the people to extinguish the fire in earthquakes.

The Nippon Telegraph and Telephone Public Corporation suffered considerable damage by Tokachi-oki Earthquake of 1968 ($M = 7.9$). It had changed the design criteria through the experience. It avoided to route the line on high embankments and soft grounds as less as possible. It would contribute to reduce the damage in this earthquake.

The damaged residential lots in and adjacent to Sendai had been developed on valleys and soft grounds, vulnerable to earthquake effects. The researches to estimate the failure mechanism have been launched by universities and local governments. However the problem was that the vulnerability had not been disseminated to the residents preceding to the disaster. As for the dissemination on vulnerability, landslide prone areas and dangerous steep slopes have been legally designated. Designating the flood prone area has been introduced into by-law.

Miyagi Prefectural Government has started the investigation on seismic microzonation taking the earthquake as a trigger.

ACKNOWLEDGEMENTS

The authors express their sincere appreciation to the organizations listed belows, which provided them invaluable documents and informative opinions in this survey.

List of the organizations

1. Tohoku Regional Construction Bureau, Ministry of Construction
2. Sendai Regional Office, Japan Meteorological Agency
3. Structure Design Office, Japanese National Railway
4. Miyagi Prefectural Government
5. Water Supply Bureau, Sendai Municipal Government
6. Gas Bureau, Sendai Municipal Government
7. Iwate Prefectural Government
8. Fukushima Prefectural Government
9. Yamagata Prefectural Government
10. Sendai Maintenance Bureau, Japan Highway Public Corporation
11. Sendai Telephone Administration Office, Tohoku Telegraph and Telephone Bureau, The Nippon Telegraph and Telephone Public Corporation
12. Tohoku Electric Power Company Ltd.

APPENDIX

I. An Outline of the Miyagiken-oki Earthquake of 1978

I-1 The Earthquake Feature

The general feature of the earthquake is described as follows:

- (1) Date and time of the occurrence of the main shock : About 17h 14m, June 12th (Monday), 1978.
- (2) Epicenter and Focal depth : $142^{\circ}10' E$, $38^{\circ}09' N$ and $h=40$ km,
- (3) Location of the epicenter : The bottom of sea of about 60 km off Mt. Kinka-san of Miyagi Prefecture,
- (4) Magnitude in Richter's scale : $M=7.4$,
- (5) Seismic Intensity : Isoseismal Map shown in Fig. I-1,
- (6) Focal mechanism : The focal mechanism shown in Fig. I-2 proposed by T. Seno, K. Sudo and T. Eguchi,
- (7) Severest after-shock :
Date and time : About 20h 34m, June 14th (Monday), 1978,
Epicenter and Focal depth : $142^{\circ}29' E$, $38^{\circ}12' N$ and 40 km
Magnitude : $M=6.4$
- (8) After-shock area : After-shock area with 80km long and 30km wide shown in Fig. I-1.

I-2 Fore-sign of the Main shock

The outline of fore-shocks is described as follows:

- (1) On Feb. 20th, 1968, an earthquake with magnitude 6.7 which brought slight damage in Miyagi and Iwate Prefectures occurred at the sea bottom of about 60km far north from the epicenter of the Main shock,
- (2) On and after Feb. 20th, there occurred sensible earthquakes in and around the area at the rate of about four times a month, and
- (3) Eight minutes before the main shock, a shock ($M=5.8$) with 3rd degree of JMA's Intensity was observed at the meteorological station in Ohfunato and Miyako, Iwate Prefecture.

I-3 Weather in the Damaged Area before and after the Earthquake

The average temperature of June, in 1978 in Sendai City was little high in

comparison with the average and the precipitation was almost as the same as the average. (refer Table I-1)

The average temperature and precipitation of the severest damaged Sendai City range 17.6~20.3°C and 0~2.5mm/day, respectively.

I-4 An Outline of the Disaster

The earthquake mainly brought the damage and losses to Northern Japan, especially Miyagi, Iwate, Fukushima and Yamagata Prefectures. Miyagi Prefecture suffered from the severest damage. Urban functions were temporarily paralysed due to the damage of lifeline systems such as transportation, water and gas supply, electrical power and communication. Most casualties were caused by overturning of pre-fabricated concrete segment fences.

I-5 Historical Damaging Earthquakes off Mt. Kinka-san

Since seventeenth century, twelve earthquakes with the magnitude greater than 6.2 have occurred off the coast of Mt. Kinka-san. (refer Fig. I-3)

The earthquakes and the periods of occurrence are shown in Fig. I-3. According to the record, the reoccurrence period ranges 23~42 years with one exception.

As shown in Fig. I-3, Kinkasan-oki Earthquake of 1936 brought slight damage in Miyagi and Fukushima prefectures. The epicenter and magnitude of the earthquake were similar to those of Miyagiken-oki, Earthquake of June 1978.

Table I-1 Weather Conditions before and after the Main Shock

(a) Sendai Regional Office

Items Date	Weather	Temperature (°C)			Precipitation (mm/day)	Relative Humidity (%)	
		Average	Max.	Min.		Average	Min.
June 1	Fine	18.2	23.3	13.1	—	42	29
2	Cloudy, later fine	17.5	23.3	10.5	—	59	36
3	Cloudy	18.9	23.7	14.1	—	60	41
4	Cloudy, later rain	15.4	17.0	14.5	21.5	91	79
5	Fine, occasionally cloudy	19.1	23.4	15.1	0.0	61	44
6	Fine, temporarily rain	17.2	23.9	12.9	1.0	67	40
7	Fine	17.1	22.4	11.3	—	71	48
8	Fine	19.0	22.7	13.8	—	75	65
9	Cloudy	21.8	29.3	16.8	—	69	40
10	Cloudy	20.6	25.9	17.5	—	77	58
11	Cloudy, later rain	19.5	21.7	16.7	0.0	86	73
12	Cloudy	20.3	25.9	17.5	0.0	82	61
13	Cloudy, occasionally rain	18.1	21.0	16.0	3.5	96	82
14	Cloudy, later fine	19.5	24.3	16.0	1.5	90	67
15	Fine, later cloudy	19.8	24.9	16.5	—	86	64
16	Cloudy, temporarily rain	22.0	27.2	18.8	0.0	83	65
17	Cloudy	24.2	29.3	20.6	0.0	79	66
18	Fine	25.0	29.6	20.9	—	74	63
19	Fine, later rain	24.2	29.0	20.8	5.5	81	62
20	Fine, temporarily rain	24.2	28.7	20.9	0.0	81	63
21	Cloudy, later fine	24.1	29.8	20.6	2.0	75	52
22	Rain	19.4	21.8	17.7	25.5	86	77
23	Cloudy, temporarily rain	18.6	19.9	17.8	0.5	90	83
24	Cloudy	19.5	22.3	17.6	—	85	78
25	Cloudy	21.1	26.4	17.6	2.0	85	67
26	Rain, later cloudy	21.3	23.5	19.6	43.0	92	83
27	Rain	18.4	20.9	17.5	47.5	97	95
28	Cloudy, occasionally rain	19.8	23.5	17.4	6.0	86	75
29	Cloudy, temporarily fine	20.6	26.2	17.0	—	83	64
30	Fine	20.4	25.0	17.9	0.0	82	64
Total	—	604.8	735.8	505.0	159.5	2371	—
Average	—	20.2	24.5	16.8	—	79	—

Note: An average temperature and precipitation of June are 18.2°C and 160mm in 1941-1970 years in Sendai City.

Table I-1 Weather Conditions before and after the Main Shock

(b) Sendai Airport Meteorological Station

Items Date	Weather	Temperature (°C)			Precipitation (mm/day)	Relative Humidity (%)	
		Average	Max.	Min.		Average	Min.
June 1	Fine	18.0	23.9	10.6	—	46	—
2	Cloudy, later fine	15.5	20.1	8.9	—	75	—
3	Cloudy	17.5	21.9	13.3	0.0	74	—
4	Rain	15.3	16.3	13.6	18.0	96	—
5	Fine	19.9	24.1	13.5	0.0	60	—
6	Fine, later cloudy	17.3	23.9	12.2	1.0	75	—
7	Fine	16.1	20.3	9.7	—	81	—
8	Fine	17.9	21.9	12.1	—	85	—
9	Cloudy, temporarily fine	20.6	27.6	15.7	—	79	—
10	Cloudy	19.2	23.8	16.4	—	88	—
11	Cloudy, later rain	18.2	21.1	16.5	0.5	94	—
12	Cloudy	19.1	23.6	16.4	0.0	89	—
13	Rain, later cloudy	17.6	20.9	15.7	2.5	99	—
14	Cloudy	18.2	21.0	15.7	0.0	93	—
15	Fine, later cloudy	18.8	23.2	16.7	—	93	—
16	Cloudy	21.1	25.9	17.9	—	92	—
17	Cloudy	22.3	27.1	19.5	—	89	—
18	Cloudy	23.2	27.2	19.6	—	86	—
19	Fine, later cloudy	22.9	26.2	19.0	2.0	92	—
20	Fine, later cloudy	23.2	27.9	20.5	—	92	—
21	Cloudy, temporarily rain	23.4	30.8	19.9	2.0	84	—
22	Rain	18.9	21.0	17.9	25.5	93	—
23	Cloudy, temporarily rain	18.3	20.3	17.2	0.5	96	—
24	Cloudy	18.8	21.2	17.3	—	94	—
25	Cloudy	20.0	23.5	17.5	—	95	—
26	Rain, later cloudy	21.1	24.0	19.2	39.5	97	—
27	Rain	18.4	20.9	17.3	43.5	99	—
28	Cloudy	19.4	22.2	17.3	5.5	91	—
29	Cloudy	19.9	24.7	16.3	—	92	—
30	Fine, later cloudy	19.6	23.0	17.4	—	88	—
Total	—	579.7	699.5	480.8	140.5	2607	—
Average	—	19.3	23.3	16.0	—	87	—

Note: An average temperature and precipitation of June are 18.2°C and 160 mm in 1941-1970 years in Sendai City.

Table I-1 Weather Conditions before and after the Main Shock

(c) Ishinomaki Meteorological Station

Date	Weather	Temperature (°C)			Precipitation (mm/day)	Relative Humidity (%)	
		Average	Max.	Min.		Average	Min.
June 1	Fine, temporarily cloudy	16.3	21.1	12.2	—	48	36
2	Fine, temporarily cloudy	15.9	20.6	10.8	—	55	39
3	Cloudy, temporarily fine	17.5	22.6	12.7	—	64	41
4	Cloudy, later rain	15.9	17.7	14.2	31.0	86	74
5	Fine	17.6	22.0	14.1	0.0	63	47
6	Fine, later cloudy	16.2	22.8	11.8	0.5	69	40
7	Fine	16.0	20.7	11.2	—	72	53
8	Fine	17.3	21.6	12.5	—	77	60
9	Fine, occasionally cloudy	19.6	23.1	15.8	—	75	58
10	Fine, temporarily cloudy	19.2	23.9	16.1	—	76	60
11	Cloudy, later rain	17.6	19.6	16.0	0.0	89	75
12	Cloudy, later fine	19.8	24.1	16.9	0.0	80	64
13	Rain, later cloudy	17.3	20.5	15.6	3.0	91	85
14	Fine, occasionally cloudy	17.4	21.7	15.4	0.0	86	73
15	Fine, occasionally cloudy	18.8	23.5	15.9	0.0	85	60
16	Cloudy	20.6	25.2	17.7	0.0	83	63
17	Cloudy, temporarily fine	22.2	27.6	19.7	—	80	67
18	Fine	23.0	29.0	19.8	—	79	60
19	Fine, later cloudy	21.4	24.8	19.1	2.5	83	72
20	Cloudy, later fine	21.5	25.1	18.9	1.0	86	71
21	Cloudy, later fine	21.1	27.7	18.4	2.0	81	59
22	Cloudy, later rain	19.3	22.0	17.6	30.5	83	69
23	Cloudy, temporarily rain	17.6	19.3	16.9	0.0	91	82
24	Cloudy	18.2	20.6	16.4	—	88	82
25	Fine	20.4	24.9	16.9	—	84	73
26	Rain, temporarily cloudy	20.3	21.3	18.6	27.0	94	88
27	Cloudy, later rain	18.8	21.1	17.6	21.5	89	78
28	Cloudy	19.2	22.1	17.1	9.5	87	72
29	Cloudy, temporarily fine	19.0	23.7	17.2	—	85	69
30	Fine, temporarily cloudy	19.9	24.4	17.6	—	79	59
Total	—	564.9	684.3	480.7	128.5	2388	—
Average	—	18.8	22.8	16.0	—	80	—

Note : An average temperature and precipitation of June are 18.2°C and 160 mm in 1941-1970 years in Sendai City.

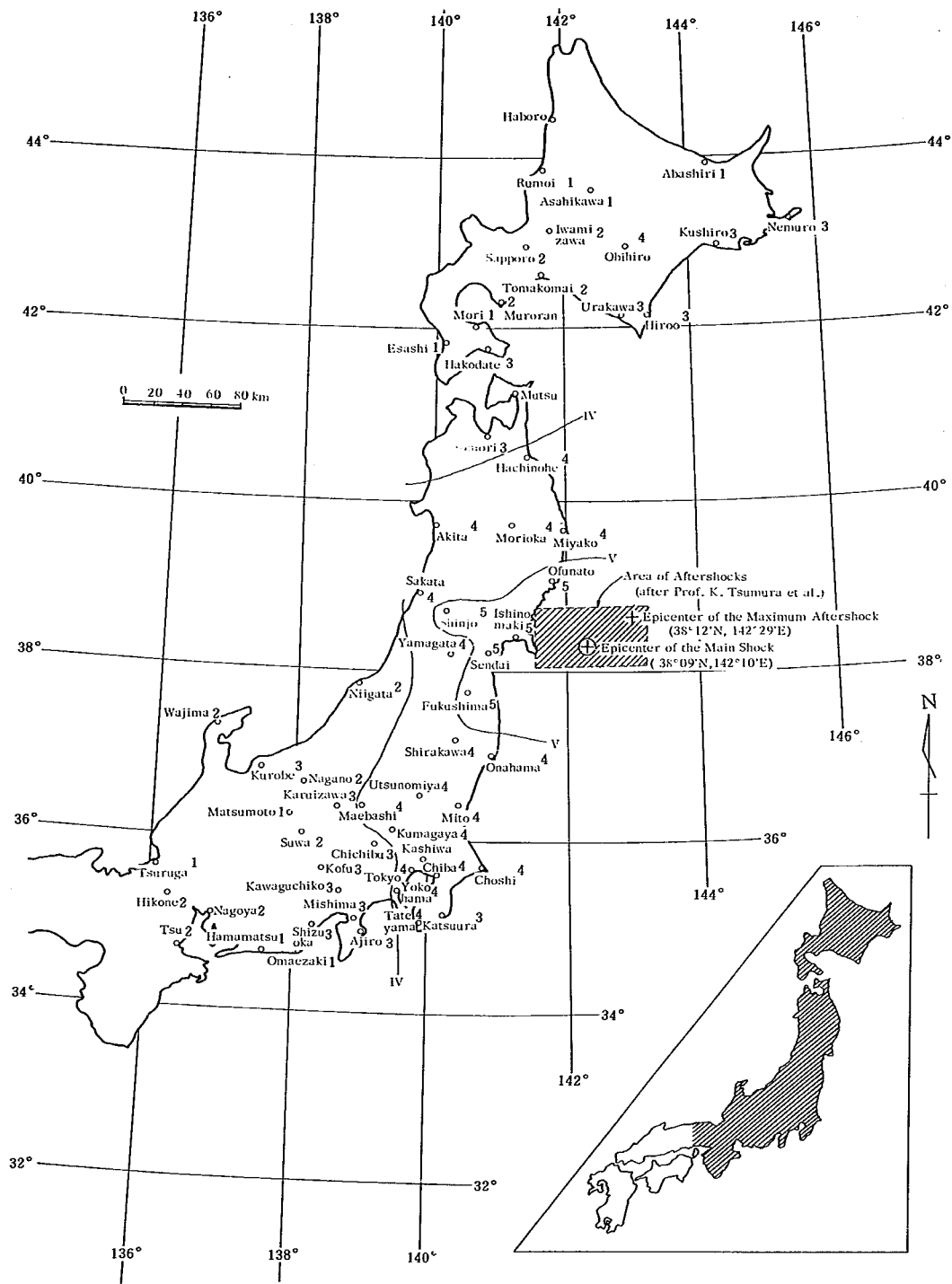
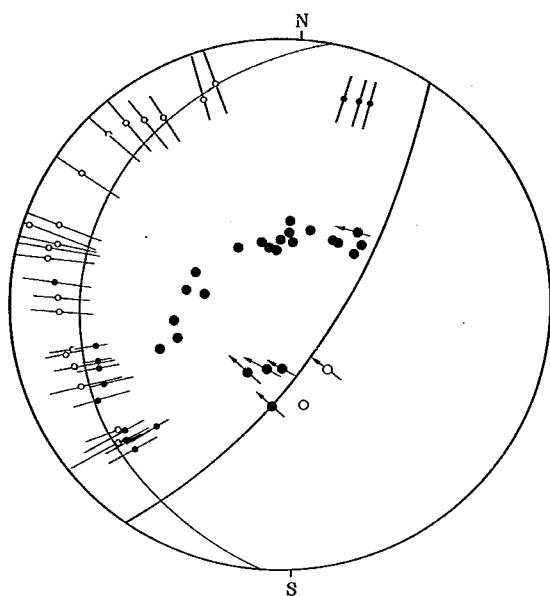


Fig. I-1 Isoseismals

Fault parameters

Length	30km
Down dip width	80km
Fault plane dip direction	N280°E
dip angle	20°
Seismic moment	$2.9 \cdot 10^{27}$ dyn-cm
Dislocation	1.7m
Stress drop	64bars



Legend
 ●: compression
 ○: dilatation
 —○: error bar
 →○: direction of S-wave

Fig. I-2 An Example of Focal Mechanism Solution (by T. Seno, K. Sudo and T. Eguchi)

①	VII 28, 1616	$\phi = 38.1^\circ$ $\lambda = 142.0^\circ$	M = 7.0
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} 30 years

②	IV 26, 1646	$\phi = 37.7^\circ$ $\lambda = 141.7^\circ$	M = 7.6
---	-------------	--	---------

} 90 years

③	III 20, 1736	$\phi = 38.3^\circ$ $\lambda = 140.8^\circ$	M = 6.2
---	--------------	--	---------

} 34 years

④	V 3, 1770	$\phi = 38.6^\circ$ $\lambda = 142.0^\circ$	M = 7.4
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} 23 years

⑤	II 17, 1793	$\phi = 38.3^\circ$ $\lambda = 142.4^\circ$	M = 7.1
---	-------------	--	---------

} 42 years

⑥	VI 25, 1835	$\phi = 37.9^\circ$ $\lambda = 141.9^\circ$	M = 7.6
---	-------------	--	---------

} 26 years

⑦	IX 18, 1861	$\phi = 37.7^\circ$ $\lambda = 141.6^\circ$	M = 6.4
---	-------------	--	---------

} 36 years

⑧	II 20, 1897	$\phi = 38.1^\circ$ $\lambda = 141.5^\circ$	M = 7.8 (7.3)
---	-------------	--	------------------

⑨	VIII 5, 1897	$\phi = 38.0^\circ$ $\lambda = 143.7^\circ$	M = 7.7 (7.2)
---	--------------	--	------------------

} 39 years

⑩*	XI 3, 1936	$\phi = 38.2^\circ$ $\lambda = 142.2^\circ$	M = 7.7
----	------------	--	---------

} 42 years

⑪	II 20, 1978	$\phi = 38.75^\circ$ $\lambda = 142.2^\circ$	M = 6.7
---	-------------	---	---------

⑫	VI 12, 1978	$\phi = 38.15^\circ$ $\lambda = 142.22^\circ$	M = 7.4
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* Kinkasan-oki Earthquake, Totally damaged 3 at Fukushima, Miyagi Pre.

Fig. I-3 Historical Damaged Earthquakes in the ofing Kinkasan-oki

II. Damage and Losses

II-1 General Description

The loss of lives and properties caused by the earthquake distributed in Miyagi, Iwate, Fukushima and Yamagata Prefectures. The casualty and property loss were estimated as about eleven thousand persons and three hundreds billion yen respectively. Fig. II-1 and II-2 show the loss of lives and the property loss valued in money. Based on Fig. II-1 and II-2, the property loss of ¥15,000,000,000, ¥300,000,000, ¥100,000,000 and ¥30,000,000 at one hundred thousand residents were brought in Miyagi, Iwate, Fukushima and Yamagata Prefectures, respectively. They are not proportional to the loss of lives.

Table II-1 and II-2 describes the classified property losses and casualties. The loss of lives and the amount of damage are detailed in the following sections.

II-2 Losses of Lives

Number of dead and injured are shown in Table II-2. The number of the loss of lives is the largest in Miyagi Prefecture.

The dead and injured were mainly due to the collapse of buildings, houses, fences and the drop of the fragments of pane. Especially, the collapse of fences occupies about 60% of the death in Miyagi Prefecture.

II-3 Buildings and Houses

The damage of buildings and houses mainly occurred in Sendai plain and Fukushima basin. The damage also occurred at the alluvium along the Kitakami River and the Hirose River. The greater part of damage occupied wooden dwelling houses.

The damage and loss are shown in Table II-3.

II-4 Medical and Sanitary Facilities

The loss of the medical and sanitary facilities, such as hospitals, medical stations and solid waste stations, is shown in Table II-4.

II-5 Commerce and Industry

The loss of commerce and industries, such as the loss of goods and factories, is shown in Table II-5.

II-6 Agriculture, Forestry and Fishery

The farmland and agricultural production were damaged. Roads and sawmills for forestry and the quay walls of fishing ports were damaged.

The loss are shown in Table II-6.

II-7 Educational Facilities

The loss of educational facilities were damaged mainly school buildings. The loss is shown in Table II-7. In this table the loss of cultural assets is included a little.

II-8 Facilities for Flood Control and Preservation of Mountainous Areas

The losses of the facilities for flood control and preservation of mountainous areas are mainly that of the dykes, the seashore facilities and sabo facilities. The losses are shown in Table II-8.

The countermeasures to prevent secondary disaster such as floods and debris flows were rapidly followed after the earthquake which occurred in the rainy season.

II-9 Transportation

The loss of transportations is shown in Table II-9.

II-10 Water Supply Facilities

As the water supply systems in Miyagi Prefecture suffered damage, the drinking water and water for industry were temporarily suspended.

The loss of the water supply facilities is shown in Table II-10, and II-11. The damage distribution of pipelines is shown in Fig. II-3 and II-4.

In these figures the damage was concentrated to the newly developed housing lots by cutting hills and banking on soft grounds of Sendai City. Detailed investigations have been conducted by the organizations concerned.

II-11 Gas Supply Facilities

The damage of gas supply facilities occurred in gas pipes and gas terminals.

Fig. II-5 shows damage distributions of the buried pipes. The damage distribution is similar to that of the pipeline of water supply.

The loss in Miyagi Prefecture is shown in Table II-12.

II-12 Electric Power Supply Facilities

The loss of thermal power plants and transformer stations is shown in Table II-13.

II-13 Telecommunication

Telephone calls were suspended for long distance, because buried coaxial cables in Sendai and Kakuta City were cut completely.

The loss is shown in Table II-1.

II-14 Sewerage

The damage of the sewerage was occurred in mainly pipes, treatment plants and pumping facilities.

The losses are shown in Table II-14. The damage distribution is shown in Fig. II-6.

II-15 Park

Kokeshi island of Matsushima Park in Rikuchu-kaigan National Park collapsed and depending facilities were damaged. Observatories and lodgings at Miyako and Rikuzen-takada Cities were slightly damaged.

The losses are shown in Table II-1.

II-16 Other Facilities

Damage of the other facilities occurred in a water tank for the fire fighting, furniture in the Offices, etc.

The losses are shown in Table II-1.

II-17 Indirect Losses

Indirect losses caused by suspensions of industrial activities have not yet been evaluated. The loss would be supposed in the commerce, agriculture, forestry, fishery, buildings and manufacturing.

Table II-1 Totaled Losses of Miyagi, Iwate, Fukushima and Yamagata Prefectures.

Classification	Loss in Thousand Yen	Note
[Direct Losses]	275,725,326	
Buildings and Houses	79,239,128	
Medical and Sanitary Facilities	3,618,040	
Commerce and Industry	96,853,864	
Agriculture, Forestry and Fishery	19,307,776	
Educational Facilities	9,456,640	
Facilities for Flood Control and Preservation of Mountainous Area	14,237,936	
Transportation	22,572,113	
Water Supply Facilities	1,744,948	
Gas Supply Facilities	947,000	
Electric Power Supply Facilities	3,116,862	
Telecommunication	871,582	
Sewerage	838,453	
Park	97,667	
Other Facilities	22,823,317	Water tank, etc.
[Indirect Losses]	Obscure	
Commerce	"	Due to impossibility of business
Agriculture, Forestry and Fishery	"	Due to impossibility of cultivation
Construction and Manufacture	"	Due to discontinue of operational
Others	"	
General Total	275,725,326	

Note: By Miyagi, Iwate, Yamagata and Fukushima Prefectural Government Office.

Table II-2 Contents of Losses of Lives in Four Prefectures.

Distinction		Miyagi Pre.	Iwate Pre.	Fukushima Pre.	Yamagata Pre.
Dead		27	0	1	0
Injured	Serious	262	0	3	0
	Slight	10,700	11	27	1
Missing		0	0	0	0
Total		10,962	11	31	1

Table II-3 Damage to Buildings and Houses

Classification		Number of Damage	Losses in Thousand Yen	Note
Dwelling	Totally Razed	1,377	60,180,765	
	Half Razed	6,178		
	Breakage	126,051		
	Flooding on the Floor	3		
	Flooding under the Floor	2		
Non-dwelling		43,532	19,058,363	
Total		177,143	79,239,128	

Table II-4 Damage to Facilities for Medical and Sanitary.

Classification	Number of Damage	Losses in Thousand Yen	Note
Medical	—	663,495	
Sanitary	—	1,300,977	
Others	—	1,653,568	
Total		3,618,040	

Table II-5 Damage to Commerce and Industry.

Distinction	Number of Damage	Losses in Thousand Yen	Note
Miyagi Pre.	53,524	95,753,230	
Iwate Pre.	2,252	562,782	
Fukushima Pre.	—	518,106	
Yamagata Pre.	—	19,746	
Total		96,853,864	

Table II-6 Damage to Agriculture, Forestry and Fishery.

Classification	Number of Damage	Losses in Thousand Yen	Note
Agriculture	—	14,108,580	
Forestry	—	1,102,045	
Fishery	—	4,097,151	
Total		19,307,776	

Table II-7 Damage to Education.

Classification	Number of Damage	Losses in Thousand Yen	Note
School	1,529	8,528,197	
Cultural Assets	—	245,940	
Facilities of Education and Welfare	—	682,503	
Total		9,456,640	

Table II-8 Damage to Facilities for Flood Control and Preservation of Mountainous Areas.

Distinction	Number of Damage	Losses in Thousand Yen	Note
Miyagi Pre.	River Facilities : 482 Seaside Facilities : 14 Sabo Facilities : 15	13,693,698	
Iwate Pre.	River Facilities : 31 Seaside Facilities : 2	443,870	
Fukushima Pre.	River Facilities : 3 Sabo Facilities : 21	94,980	
Yamagata Pre.	River Facilities : 1	5,388	
Total		14,237,936	

Table II-9 Damage to Transportation.

Classification	Number of Damage	Losses in Thousand Yen	Note
Roads	2,317	5,614,184	
Bridges	252	5,817,009	
Railways	—	6,377,883	
Harbors	89	4,000,872	
Others	—	762,165	
Total		22,572,113	

Table II-10 Damage to Water Supply Facilities.

Distinction	Number of Damage	Losses in Thousand Yen	Note
Miyagi Pre.	—	1,733,399	
Iwate Pre.	14	10,105	
Fukushima Pre.	—	0	
Yamagata Pre.	2	1,444	
Total		1,744,948	

Table II-11 Losses of Water Supply Facilities in Sendai City

Classification	Losses in Thousand Yen
Reservoir and Outlet	1,800
Washwater Facilities	12,400
Water Tanks and Dumping Station	33,400
Conduct Pipes	111,400
Facilities for Water Supply	13,600
Buildings	5,300
Others	77,100
Total	255,000

Table II-12 Damage to Gas Supply Facilities.

Distinction	Number of Damage	Losses in Thousand Yen	Note
Miyagi Pre.	190	947,000	
Total		947,000	

Table II-13 Damage to Hydroelectric Power Plants, Thermal Power Plants and Transformer Stations in Miyagi Prefecture.

Classification		Number of Damage
Hydroelectric Power Plants and Thermal Power Plants	Hydroelectric Power Plants	11
	Thermal Power Plants	2
Transformer Stations	Sendai, Miyagi and	18
	Others	
Total		31

Table II-14 Damage to Sewerage.

Classification	Number of Damage	Losses in Thousand Yen	Note
Pipelines	60	578,332	
Pumping Stations	19	142,231	
Treatment Plants	23	52,245	
Others	4	65,645	
Total	106	838,453	

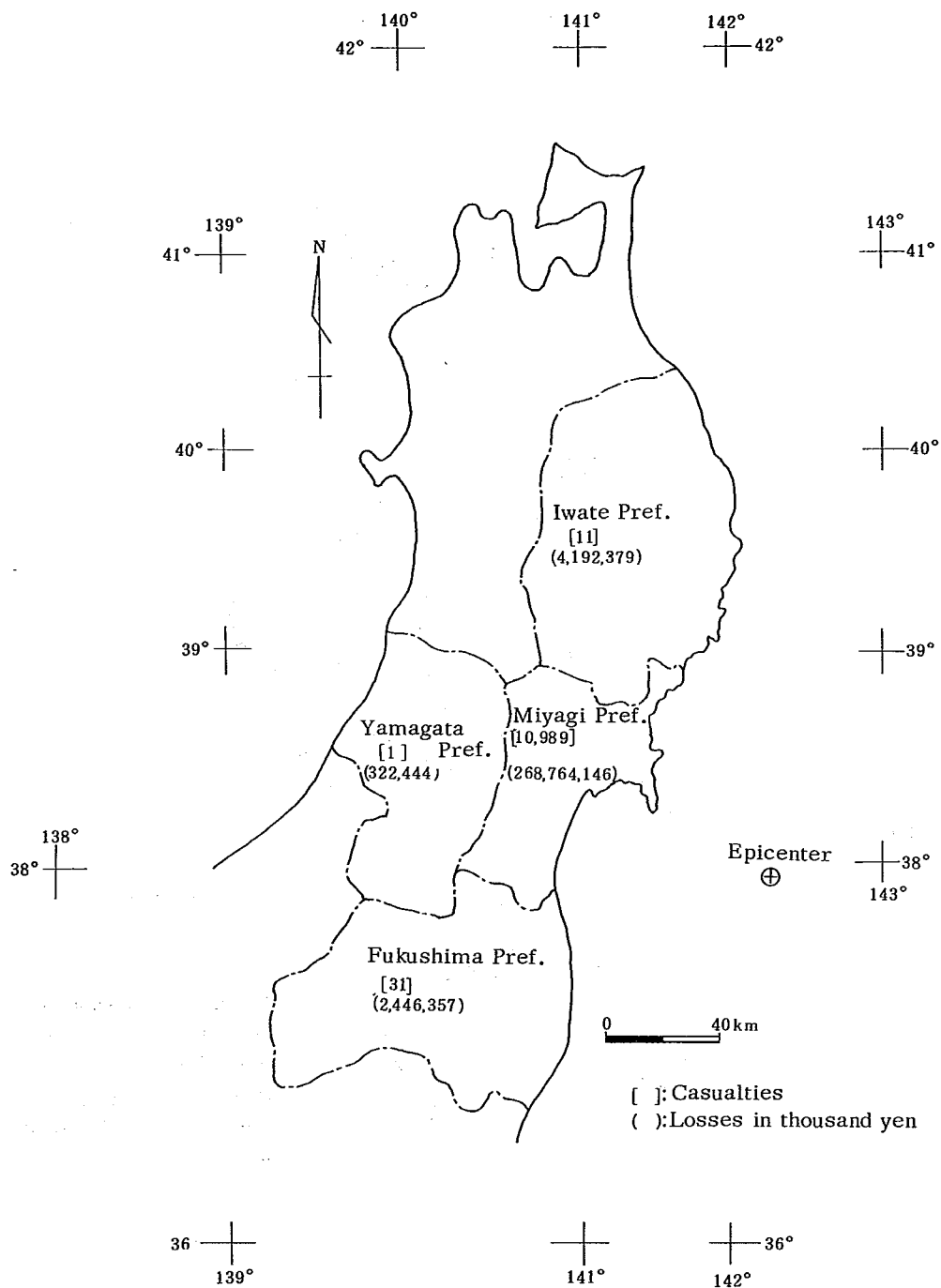


Fig. II-1 Casualties and Losses in Miyagi, Iwate, Fukushima and Yamagata Prefectures.

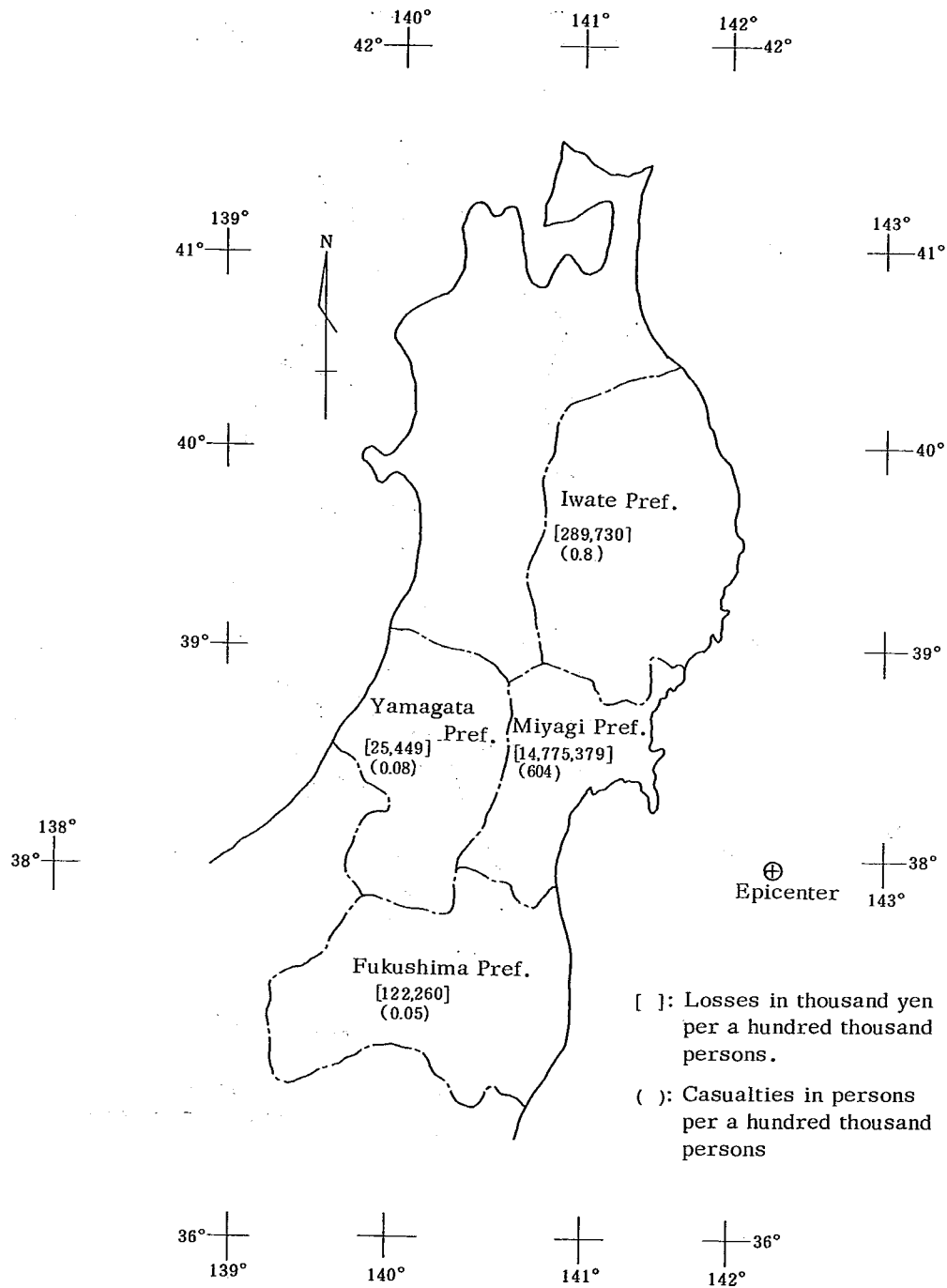


Fig. II-2 Casualties and Losses per a Hundred Thousand Persons.

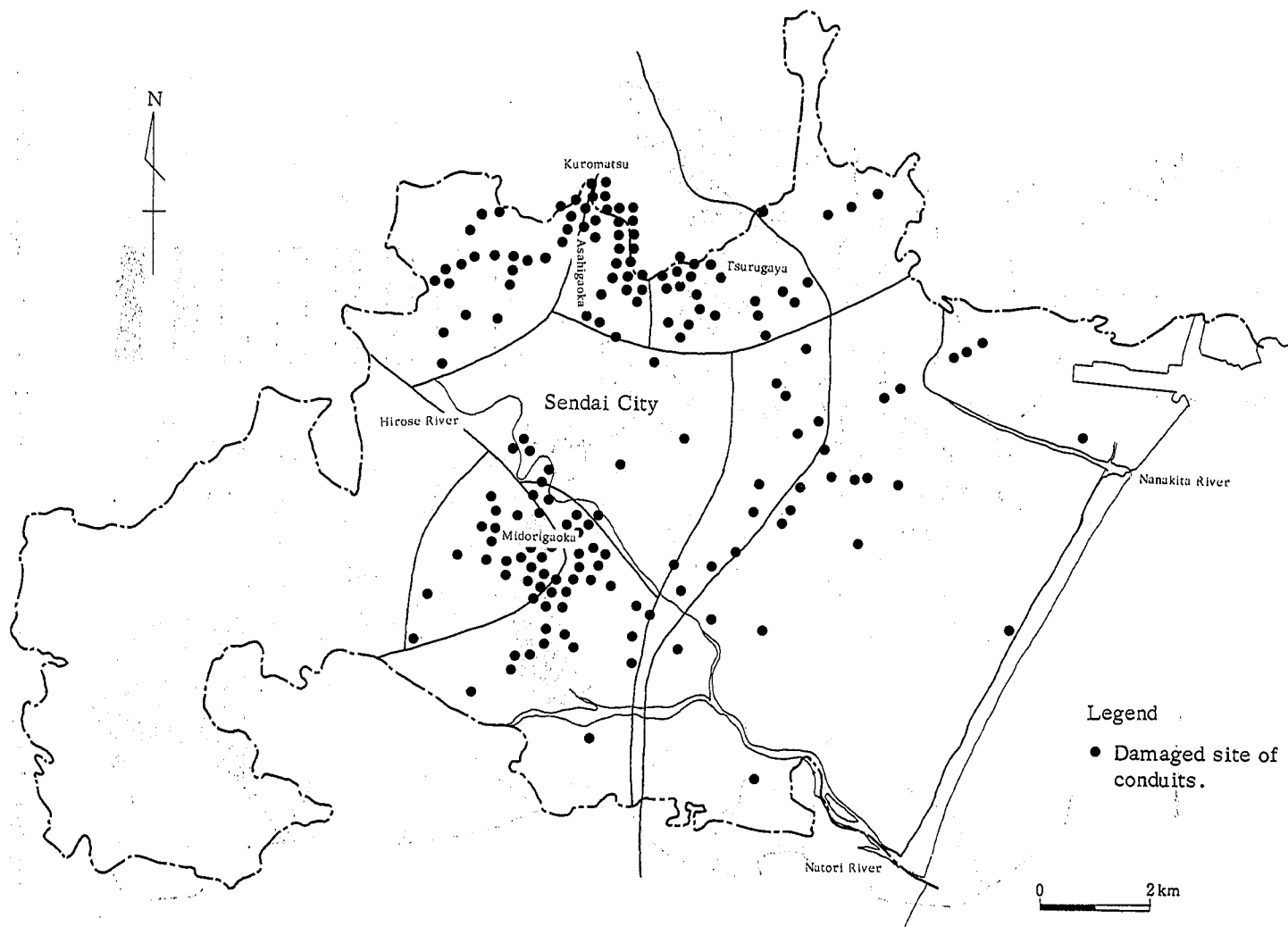


Fig. II-3 Damaged Sites Distribution of Conduits in Sendai City.

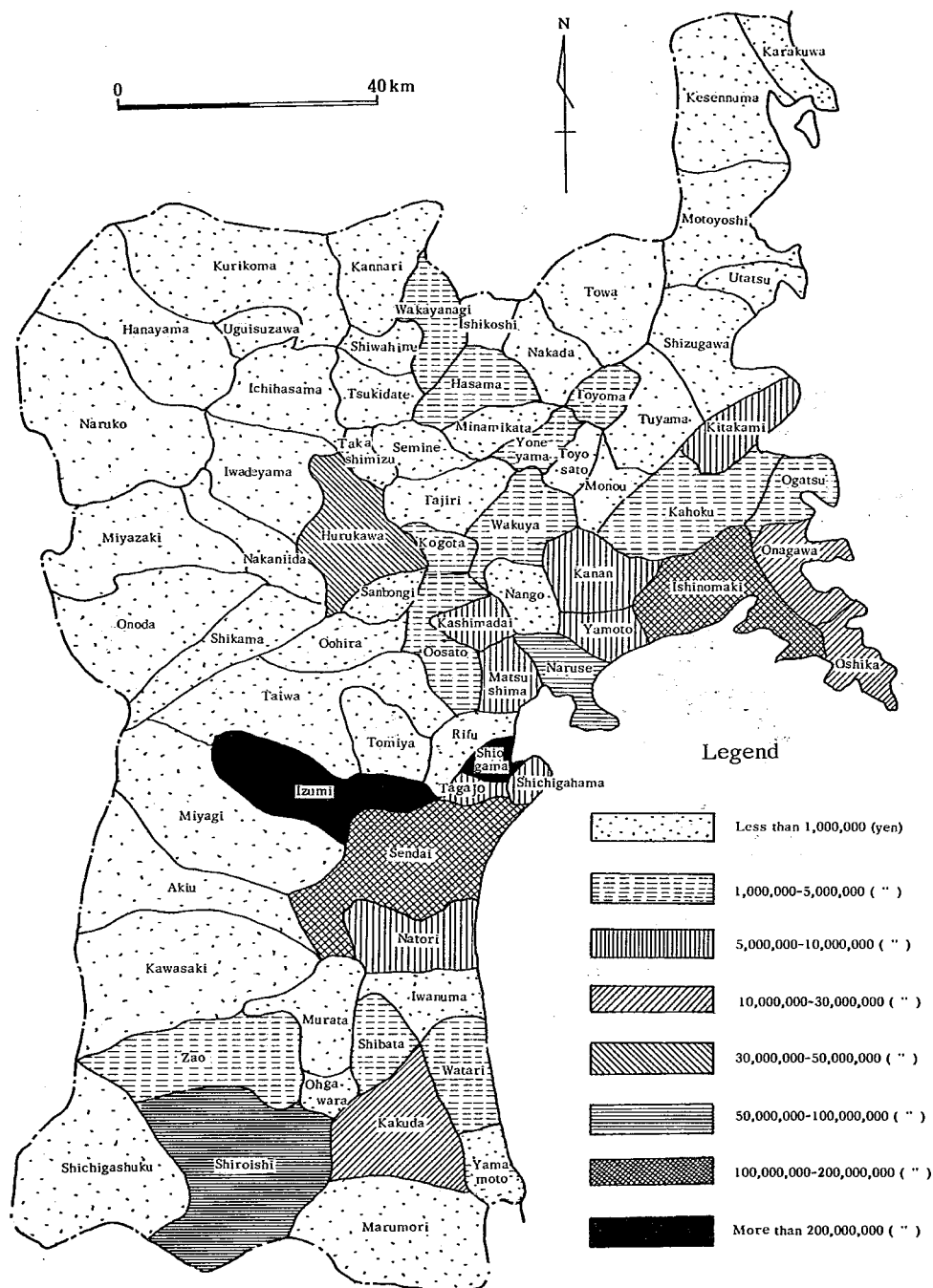


Fig. II-4 Losses Distribution of Water Supply Facilities in Miyagi Prefecture.

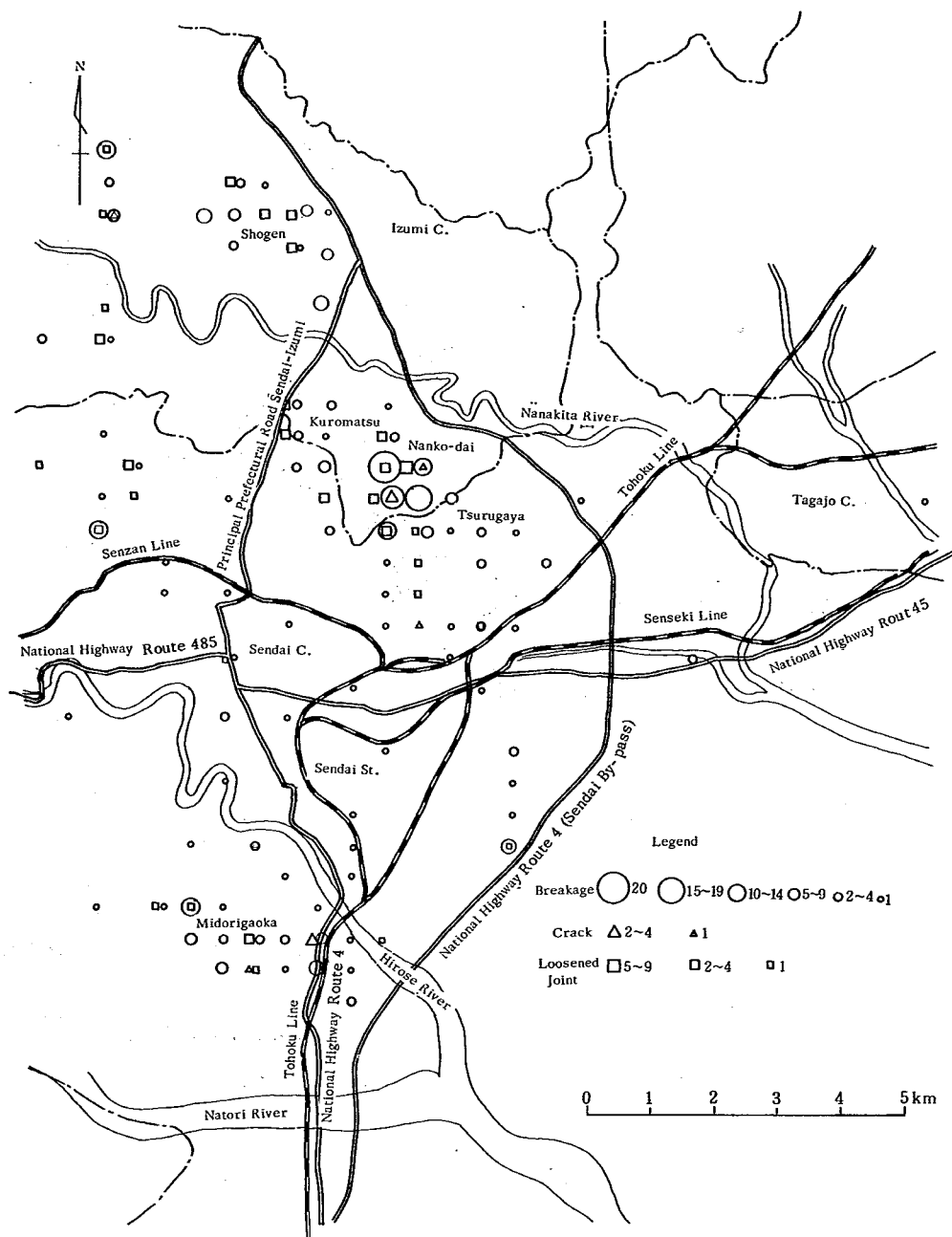


Fig. II-5 Damage Distribution of Gas Pipes

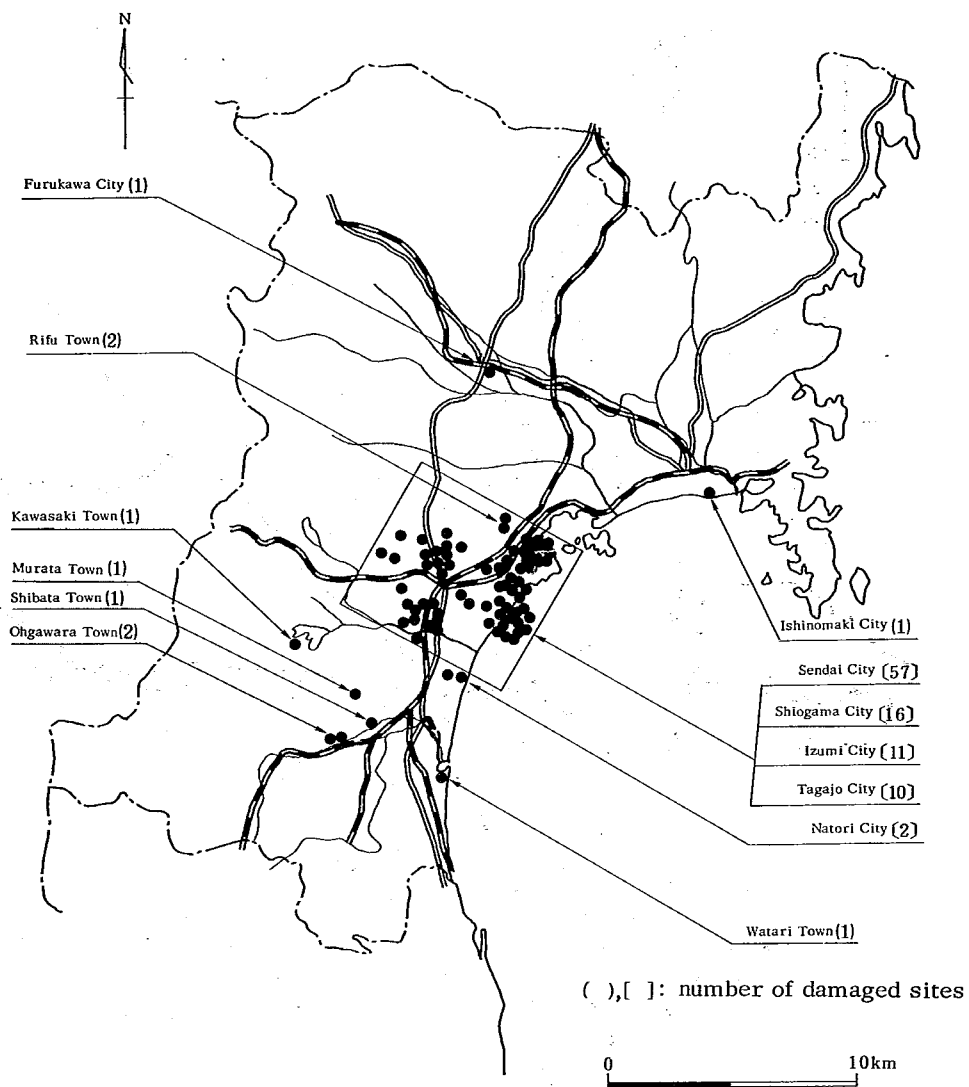


Fig. II-6 Damage Distribution of Sewerage.

III. Rescue and Rehabilitation after the Earthquake

III-1 General Description

The earthquake brought a great damage of the death of 28 persons, collapse of many houses, etc. The damage to railways and roads caused the paralysis of transportation in the felt area. In Sendai City and its adjacent area, confusion of traffics, suspension of water, electric power and gas supply, interruption of telephones and sewerage, caused the inconvenience in urban living and industrial activities.

Each administration proceeded with:

- Rescue of the casualties,
- Evacuation of inhabitants at dangerous areas,
- Guaranty of the necessities for living such as foods, drinking water, etc.,
- Restoration of basic facilities for living, such as facilities of water supply, electric power, gas supply and communication, and
- Restoration of the transportation.

Fortunately, there were only 3 fires that could not be extinguished by residents themselves among 12 fires occurred after the earthquake, which were soon extinguished by fire fighters. At a petroleum industrial area, an outflow of oil from the cracks of 3 oil tanks occurred, but there were no fires.

In spite of these extensive damage, great confusion was prevented by the rapid responses for countermeasures of the organizations concerned and the co-operative behaviour of inhabitants.

III-2 Organizational Systems and their Operations

In Miyagi Prefecture, rescue and rehabilitation centers for emergencies were constituted by each organization mentioned below:

- 1) Rescue and Rehabilitation Center of Miyagi Prefectural Government (constituted at 5:30 p.m. of June 12 as shown in Fig. III-1).
- 2) Rescue and rehabilitation centers of local public bodies (56 cities, towns and villages).
- 3) Rescue and rehabilitation centers of:
 - Designated government offices in Tohoku District (Tohoku District of Jurisdiction Police Bureau, Sendai International Trade and Industry Bureau, Sendai Overland Transportation Bureau, Sendai District of Jurisdiction Meteorological Bureau, Tohoku Regional Construction

- Bureau, etc.),

The Self-Defense Forces (Tohoku District General Administration Division, The 22nd General Course Regiment),

- Designated public organizations (Sendai Railways Superintendent Bureau of Japanese National Railways, Miyagi Telecommunication Division of the Nippon Telegraph and Telephone Public Corporation, Miyagi Prefectural Branch of Japan Red Cross Society, Tohoku Headquarters of Japan Broadcasting Corporation, Sendai Branch of Japan Transportation Co., Ltd., Miyagi Branch of Tohoku Electric Power Co., Ltd., etc.), and
- Headquarters of Miyagi Prefectural Police Department.

Miyagi Prefectural Government demanded the aid of the Ground Self-Defense Force with 2,025 personnel and 400 vehicles to 5 cities and 7 towns. Since June 13, Disaster Relief Law was applied to Sendai City, Izumi City, Hasama Town, Yoneyama Town, Kogota Town and Naruse Town. Each Organization carried out rescue and rehabilitation activities under mutual cooperation.

Miyagi Prefectural Government substituted Miyagiken-oki Earthquake Disaster Reconstruction Section for Rescue and Rehabilitation Center on July 10, which was charged with rehabilitation operations.

III-3 Emergency Communications

Emergency communications are necessary for activities of refuge, rescue and restoration.

The damage to telecommunication facilities by the earthquake was relatively slight, and their functions were recovered in an early stage. Meanwhile, the establishment of emergency telephone networks greatly contributed to rapid responses for the activities.

Informations were distributed to inhabitants through TV, radio, patrol-cars and other information media to mainly dissolve their anxieties.

III-4 Official Informations on the Earthquake

The Meteorological Agency announced the informations on the earthquake eleven times after the earthquake. The informations on tsunamis were announced after the earthquake as shown below:

Tsunami Warnings; Announced to the Pacific Coast of Tohoku District at 5:21 p.m. and the Pacific Coast of Chiba and Ibaragi

Prefectures at 5:24 p.m.

Tsunami Cautions; Announced to the Pacific Coast of Hokkaido Prefecture at 5:28 p.m.

Order of refuge was noticed to the coastal cities, towns and villages where dangers of damage by tsunamis were suspected. Heights of tsunamis were observed only between 14 ~ 22 cm at the Pacific Coast of Tohoku District. The tsunamis brought no damage. Cancellations of the warnings and the cautions were announced at the Pacific Coast of Hokkaido at 8:15 p.m. and the Pacific Coast of Tohoku District, Chiba Prefecture and Ibaragi Prefecture at 8:30 p.m.

III-5 Refuge and Rescue

13,650 of inhabitants were indispensably evacuated by collapse of houses and tsunami warnings. The refugees returned home after the cancellations. But the inhabitants in the area where houses were severely damaged continued refuge for fear of secondary disasters, as shown in Table III-1.

Even on July 20, more than one month later, 2,558 habitants of 751 families in 7 cities and 13 towns continued their living at refuge places (67 families in Sendai City, Izumi City, Kogota Town and Naruse Town), relative's houses, etc.

The rescue of the casualties was carried out almost without any trouble in cooperation with medical facilities which were kept their functions after the earthquake.

III-6 Fire Fighting Activities

12 of fires at 9 places occurred during the earthquake, but 9 of them were extinguished by residents. The rest 3 that could not be extinguished in an early stage occurred at the Science Faculty of Tohoku University, Tohoku Pharmaceutical College and a low-pressure gas holder of Sendai Gas Bureau. They did not spread to neighboring buildings.

The reasons for the slight damage by fires are supposed as follows:

- The earthquake occurred before the cooking hour of evening meals.
- Heaters were not used as it was early in summer.
- A fore shock of 3rd degree of JMA's Intensity in Sendai City occurred about 8 minutes before the main shock, and precautions were taken to prevent fires.
- The experiences of the earthquake of M = 6.7 in Richter Scale occurred offshore of Miyagi Prefecture on Feb. 20, 1978 were made good use of.

III-7 Traffics and Transportations after the Earthquake

(1) Roads

744 traffic signals were damaged in Sendai, Ishinomaki, Shiogama and Furukawa Cities. All traffic signals were unable to work by electricity failures. Traffic became confused in urban areas. Owing to the disposition of policemen for traffic control and emergency vehicles for electric-power supply to principal intersections, the confusion was gradually settled down in about five hours.

Tohoku Regional Construction Bureau, Miyagi Prefectural Government, etc. patrolled main roads and grasped information of the damage. The traffic controls are shown in Table I-1, I-2 and I-3.

The damage to the designated national highways and the methods of their restoration are shown in Table III-2.

As for Tohoku Expressway of JHPC, the traffic was suspended between Shirakawa and Tsukidate Interchanges at 5:17 p.m. of June 12 and between Ichinoseki and Hirasawa · Maesawa Interchanges at 5:32 p.m. of June 12. It was wholly reopened at 7:00 a.m. of June 15. However, speed restriction was followed at a few sections on account of restoration works. The traffic through the expressway resumed to normal speed on July 11.

(2) Railways

Facilities of Japanese National Railways (JNR) were damaged to railway bridges, tracks, platforms, etc. Railway operation was suspended in and around Miyagi Prefecture. JNR energetically restored Tohoku Line, the most important line in Tohoku District. Its southern side of Sendai was reopened early on the morning of June 14, and the rest of the line on June 15. All lines were restored about one month after the earthquake.

(3) Harbors

In spite of the damage to harbor facilities at Sendai Harbor, Ishinomaki Industrial Harbor, etc., their functions were kept by temporary measures. At some fishing ports, unloading was restricted by the damage to wharves and other facilities.

(4) Airports

The damage to Sendai Airport was not severe, and its operation was

returned normal soon after the earthquake.

III-8 Rehabilitation of Lifeline Facilities

(1) Water Supply Facilities

Water supply was suspended due to the damage to water supply facilities. The restoration works were started immediately after the earthquake.

Water Supply Bureau of Sendai Municipal Government ordered "3rd Disposition" based on "Disposition Plan for Disaster Prevention" and called up all staffs to establish Earthquake Disaster Countermeasures Headquarters at 5:30 p.m. of June 12. 4 water wagons and 40 water tanks were prepared at 7:00 p.m. 14 water wagons of 13 private companies were also prepared by 9:00 p.m. 40 water wagons at maximum were disposed. In Midorigaoka and Kuromatsuichinenbo of Sendai, water supply was suspended for the possibility of ground failures. Temporary common hydrants were provided. The temporary water supply are shown in Table III-3. The temporary water supply works required the mobilization of 149 water wagons and 702 m³ of water was supplied.

At Shiogama and Izumi Cities, water supply facilities were damaged severely, and the Self-Defence Forces were requested to help temporary water supply. Though restoration works were hastened in cooperation with the troops dispatched from other prefectures (see Table III-4), it took more than 10 days to complete the restoration of water supply facilities in these cities.

(2) Electric Power Facilities

The states of functional damage and its restoration of electric power facilities of Tohoku Electric Power Co., Ltd. are described as follows:

1) Hydroelectric Power Generation Facilities

Waterways and water tanks were damaged at hydroelectric power plants, but the influence on generating electricity was not serious, and they were restored by 10:48 p.m. of June 14.

2) Thermal Power Generation Facilities

Generators mentioned below were stopped by hand-operation after the earthquake.

- Sendai Thermal Power Plant ; No. 2, No. 3 generators (generating

power is 175,000 KW respectively)

- Shin-Sendai Thermal Power Plant ; No. 1 generator (generating power is 350,000 KW), No. 2 generator (generating power is 600,000 KW)
- Hachinohe Thermal Power Plant ; No. 3 generator (generating power is 250,000 KW)

As the result of inspection and restoration, their function was recovered at:

- Sendai Thermal Power Plant ; No. 1 generator (12:54, June 16), No. 2 generator (13:54, June 26), No. 3 generator (15:39, July 20)
- Shin-Sendai Thermal Power Plant ; No. 1 generator (18:16, June 18), No. 2 generator (13:02, June 19)
- Hachinohe Thermal Power Plant ; No. 3 generator (18:54, June 12)

3) Power Transmission Facilities

The inspection of power transmission lines was performed by using 3 helicopters. Their damage was not so great as to interrupt the transmission of electricity.

4) Transformer Facilities

Sendai Transformer Substation suffered serious damage. But as the result of restoration works, main transformers of No. 1, No. 3 and No. 4 were restored on June 15, June 14 and June 15 respectively. Zao Main Line, Miyagi Main Line and Shin-Sendai Thermal Power A Line were restored on June 15, June 16 and June 18 respectively. As for Miyagi Transformer Substation, main transformers of No. 1 and No. 3 were restored on June 12 and June 16 respectively.

5) Power Distribution Facilities

Collapse of poles for distributor, snapping of wires and inclination of transformers on the pole occurred mainly in southeastern part of Sendai City. The restoration of power distribution facilities was completed at 6:50 a.m. of June 14.

After the earthquake, a great number of personnel engaged in restoration works. They have endeavoured to restore the supply to the important organizations. Some electric power was transmitted temporarily

from outside of the damaged district. With such efforts, the function of electric power facilities was recovered on the early morning of June 14. The number of personnel pursued the restoration works are shown in Table III-5.

(3) Gas Supply Facilities

Gas Bureau of Sendai Municipal Government supplies gas to 135,863 houses in Sendai, Tagajo and Izumi Cities. After the earthquake, gas production was decreased by the burning-down of a low-pressure gas holder at Haramachi Plant and the electricity failure at Minato Plant. As about 200 informations on a gas leakage were reported from inhabitants, the suspension of gas supply was decided at 6:00 p.m. of June 12, and the supply was stopped completely at 6:15. After the decision, they disseminated the inhabitants to turn off a gas tap through TV and radio.

Under the cooperation of Disaster Countermeasure Headquarters of Gas Bureau, Sendai Municipal Government and Japan Gas Association, restoration works were carried out considering the priority of the supply to residential quarters. As the damage to gas pipes scattered widely (see Table III-6), the supply area (Sendai, Tagajo and Izumi Cities) was divided into 8 blocks as shown in Fig. III-3. Some of them, where many gas pipes were damaged, were subdivided into 2 ~ 8 sections for efficient restoration works. The procedure of the restoration works is shown in Fig. III-4. 25,635 man-days pursued the restoration of gas supply facilities by the middle of July with the help of 10,583 man-days (June 13 ~ July 9) of other 22 gas companies. The detailed inspection of underground structures has been continued.

(4) Telecommunication Facilities

The Nippon Telegraph and Telephone Public Corporation has established Disaster Countermeasure Headquarters immediately after the earthquake to secure the function of telecommunication facilities and restore damaged facilities. As the electricity failed at 165 telecommunication stations, 9 emergency vehicles for electric-power supply went round the stations to supply electric power temporarily for 40 hours until the electricity was recovered at all stations. Besides, coaxial cables were damaged at 9 sites, and temporary cables were provided. By these temporary measures, the function of telecommunication facilities was recovered rapidly as shown in Table 1-8 ~ Table 1-12. However, telephone calls poured into from the evening of June

12 till June 14, and extraordinary congestion of calls arose. The 25~75% restrictions of calls were placed by restricted call identification equipments. Telephonic communication routes for emergencies were established to maintain important communications.

Public telephones did not work because of the electricity failures. 29 emergency public telephones in Sendai were temporarily supplied with electric power. At the refuge places, 22 free telephones were installed.

As for telegrams, the function of telegraph facilities was recovered soon after the earthquake, and 150,000 telegrams arrived in Tohoku District. Urgent telegrams got the priority of delivery.

Temporary restoration works of telecommunication facilities required 5,000 man-days including 400 man-days from construction firms.

III-9 Schools and their Operations

99 elementary schools, 9 junior high schools and 9 senior high schools were closed. After the inspection of school buildings, almost all of them reopened within a few days.

143 of schools suspended meal service for about a week because of the damage to meal service facilities, the suspension of electric power and gas supply.

III-10 Other Measures for the Emergency

(1) Petroleum Industrial Facilities

Tohoku Petroleum Co., Ltd. has 87 oil tanks at Sendai Oil Factory. Three of them settled and were cracked by the earthquake causing the leakage of oil. It overflowed defensive banks to the precinct, and a part of which flowed into Sendai Bay. Oil fences were stretched to prevent the spread of the oil. The inspection of each tank and the collection of the oil flowed out of the tanks were completed by June 18. The details of the outflow and the collection of oil are shown in Fig. III-5.

(2) River Facilities

Dykes were suffered damage of cracking, settlement, and sliding on the Shin-Kitakami River, the Naruse River, and the Natori River. Tohoku Regional Construction Bureau made field inspections after the earthquake. Facing the rainy season, temporary restoration works were started on June 15 and were almost completed on June 30. Some severely damaged dykes were repaired with revetment. The details of the damage and the restoration of dykes are shown in Table III-7.

Table III-1 Residential Damage and Refuge in Sendai City till June 15 after the Earthquake

Date	Damaged Area	States of Damage	Number of Refugees	Shelter	Note
June 13 0:30	Midorigaoka	Danger of landslides Cracks in roads	About 70 inhabitants	Kano Elementary School	About 80 refugees on the evening of June 13. About 100 refugees on the evening of June 14.
2:00	Futatsusawa	Landslides	20 inhabitants of 4 households	"	About 20 refugees on the evening of June 13. About 20 refugees on the evening of June 14.
"	Minamoto-Shinden	Danger of landslides	11 inhabitants of 3 households	Kitane Assembly Hall	About 8 refugees on the evening of June 13. About 8 refugees on the evening of June 14.
"	Tsurugaya Housing Corporation Terrace	Electricity failures at multistory apartment houses	75 inhabitants	Tsurugaya First Assembly Hall (15 refugees) Tsurugaya Third Assembly Hall (30 refugees) Tsurugaya-higashi Elementary School (30 refugees)	Refuge was ended on the morning of June 13.
"	Takasago Sunny Heights	Bursting of a water tower	About 120 inhabitants	Takasago Elementary School	Refuge was ended on the morning of June 13.
"	Shinden Saito Mansion		About 40 inhabitants	Shinden Public Hall	Refuge was ended on the morning of June 13.

(Table III-1 continued)

Date	Damaged Area	States of Damage	Number of Refugees	Shelter	Note
June 13 16:00	Sunaoshi-cho	Landslides	5 inhabitants of a household	A house of an acquaintance	
"	Sunaoshi-cho	Landslides	6 inhabitants of a household	A house of an acquaintance	
"	Komatsushima	Landslides	1 household	A house of an acquaintance	
June 14 12:30	Anyoji	Landslides	1 household	A house of an acquaintance	
"	Kitane-ichinenbo	Collapse of an apartment house by landslides	11 inhabitants of 7 households	Houses of acquaintances	
"	"	Danger of the collapse of an apartment house by landslides	9 inhabitants of 9 households	Houses of acquaintances	
June 15 13:20	Kanisawa	Danger of the collapse of a house	1 household	A house of an acquaintance	

Table III-2 Damage and Restoration Methods in Designated National Highways
(More than 1 Million Yen of the Cost of the Restoration)

Number of the Route	Damaged Sites	Kilometer Post km	Damage		Restoration Method
			Main Damage	Other Damage	
4	Kanairo, Nihonmatsu City	249.2	Swelling of the protection blocks of the slope		Setting up of blocks and construction of protection wall
	Shindate, Shiroishi City	303.9	Cracks in the pavement		Pavement of the road surface
	Zao Town, Katsuta County	313.6	Sinking of the block piles		Piling of blocks
	Kooriyama, Sendai City (Chiyo Bridge)	347.3	Sinking of the road surface near the abutment		Pavement of the road surface
	Okino, Sendai City (Chiyo Bridge)	347.5	Damage to the pier		Reinforcement of the pier by wrapping with concrete
	Okino, Sendai City (Chiyo Bridge)	347.7	Sinking of the road surface near the abutment		Asphalt pavement of the road surface
	Furujiro, Sendai City	348.4	Sinking of the road surface near the artificial structure		"
	Oroshimachi, Sendai City	351.7	" "		"
	" "	352.0	" "		"
	" "	352.3	" "		"
	" "	352.4	" "		"

(Table III-2 continued)

Number of the Route	Damaged Sites	Kilometer Post km	Damage		Restoration Method
			Main Damage	Other Damage	
4	Hinode-cho, Sendai City	353.1	Sinking of the road surface near the artificial structure		Asphalt pavement of the road surface
	" "	353.8	" "		"
	" "	354.0	" "		"
	Kozuru, Sendai City	354.2	" "		"
	" "	354.4	" "		"
	Tsubamesawa, Sendai City	355.3	" "		"
	"	355.5	Landslide at the artificial bank	Sinking of the sidewalk and damage to the guard pipe	Restoration of the artificial bank, pavement of the sidewalk and restoration of the guard pipe
	Nanakita, Izumi City	363.5	Cracks in the pavement		Pavement of the road surface
	Sawada, Furukawa City	397.0	Sinking of the road surface near the abutment		Asphalt pavement of the road surface
6	Takashimizu Town, Kurihara County	404.4	Inclination of protection shelf of the artificial bank	Sinking of the sidewalk and inclination of the side blocks	Construction of the protection concrete wall, pavement of the sidewalk and resetting of the blocks
	Kashima Town, Soma County	283.4	Cracks in the abutment		Reinforcement of the abutment

(Table III-2 continued)

Number of the Route	Damaged Sites	Kilometer Post km	Damage		Restoration Method
			Main Damage	Other Damage	
6	Yamamoto Town, Watari County	321.3	Sinking of the road surface		Asphalt pavement of the road surface
	Watari Town, Watari County	321.9	Sinking of the shoulder of the road		Concrete pavement of the road surface
	" "	333.6	Damage to the pier	Damage to the shoe	Reinforcement of the pier by wrapping with concrete and restoration of the shoe
45	Fukudamachi, Sendai City	7.3	Landslide at the artificial bank	Sinking of the sidewalk and damage to the protection shelf	Protection of the artificial bank with sheet piles, pavement of the sidewalk and resetting of the protection shelf
	Matsushima Town, Miyagi County	28.3	Inclination of protection shelf of the artificial bank	Sinking of the sidewalk with cracks	Protection of the artificial bank with block piles and pavement of the sidewalk
	" "	28.4	Sinking of the road surface near the abutment		Asphalt pavement of the road surface
	" "	28.5	" "		"
	" "	28.6	Landslide at the artificial bank	Sinking of the sidewalk with cracks	Restoration of the artificial bank and pavement of the sidewalk
	" "	29.1	Inclination of the block piles	Inclination of the protection wall of the sidewalk	Restoration of the protection wall
	" "				

(Table III-2 continued)

Number of the Route	Damaged Sites	Kilometer Post km	Damage		Restoration Method
			Main Damage	Other Damage	
45	Naruse Town, Monou County	37.2	Sinking of the road surface with cracks		Pavement of the road surface
	Naruse Town, Monou County (Ono Bridge)	38.0	Movement of the girder	Damage to the shoe, the joint, the floor plate and the pier	Restoration of the girder, the joint, the floor plate and the pier
	Kanan Town, Monou County (Tenno Bridge)	58.3	Cracks in the pier	Damage to the abutment and the shoe	Reinforcement of the pier and the abutment and renewal of the shoe
	Kanan Town, Monou County	66.0	Cracks in the pavement		Pavement of the road surface
	Shizugawa Town, Motoyoshi County	98.4	Cracks in the artificial bank	Cracks in the protection wall and the pavement	Restoration of the artificial bank with protection piles
	Utatsu Town, Motoyoshi County (Utatsu Bridge)	102.5	Damage to the shoe		Reinforcement of the shoe
	Shimofunato, Oofunato City	165.5	Cracks in the pavement	Sinking of the road surface	Pavement of the road surface
	Noda Village, Kunohe County	336.2	Inclination of the protection concrete wall		Renewal of the protection concrete wall
108	Kanan Town, Monou County	5.0	Inclination of the protection block wall	Sinking of the sidewalk with cracks	Piling of blocks and pavement of the sidewalk

(Table III-2 continued)

Number of the Route	Damaged Sites	Kilometer Post km	Damage		Restoration Method
			Main Damage	Other Damage	
108	Kanan Town, Monou County	5.8	Sinking of the road surface	Damage to the block piles	Asphalt pavement of the road surface and piling of blocks
	" "	14.7	Cracks in the stone piles	Cracks in the pavement	Construction of the protection concrete wall and the pavement of the road surface

Table III-3 Temporary Water Supply after the Earthquake till June 21 in Sendai City
(Water Supply Bureau of Sendai Manicipal Government)

Date	Water Wagon			Personnel			Number of Cases	Amount of Temporary Water Supply (m ³)	Main Water-Supplied Districts
	Total (Wagons)	Water Supply Bureau (Wagons)	Assistance (Wagons)	Total (Personnel)	Water Supply Bureau (Personnel)	Assistance (Personnel)			
June 12	5	5	0	20	20	0	7	7	Tsurugaya Housing Corporation Terrace Asahigaoka, Midorigaoka Jiyugaoka, Futabagaoka, Izumigaoka Kofukugaoka Kitaneichinenbo Tomisawa, Fukurobara Idehana, Arai Izai, etc. Kuromatsu, Saiwai-cho Housing Corporation Apartment House Sakuragaoka, Tsurugaya Apartment House Sunny Heights Dainohara Lions Mansion Nissui Apartment House Toroku Elementary School, etc.
13	29	7	22	72	50	22	165	180	
14	37	7	30	90	60	30	213	230	
15	27	7	20	70	50	22	120	130	
16	17	7	10	50	40	10	60	65	
17	10	6	4	30	26	4	26	30	
18	10	6	4	30	26	4	18	20	
19	8	5	3	18	15	3	18	20	
20	4	4	0	9	9	0	7	14	
21	2	2	0	5	5	0	3	6	
Total	149	56	93	394	301	93	637	702	

Table III-4 Assisting Activities in Temporary Water Supply and Restoration of Conduit Pipes
(Based on Mutual Assisting Plan of Tohoku Local Branch of Japan Water Supply Association)

Prefectural Branch	Assisting City	Assisting Period	Accepting City	Assisting Activities	Dispatch Items
Aomori	Hachinohe City	June 13 - June 16	Shiogama City	Temporary water supply	15 water tanks, 10 vehicles. 20 drivers of related companies, 4 personnel of water supply bureau.
Akita	Akita City	June 14 - June 18	Izumi City	Restoration of conduit pipes	7 personnel of 2 related companies, 2 vehicles.
Yamagata	Yamagata City	June 14 - June 16	Shiogama City	Temporary water supply	A water wagons, 3 personnel of water supply bureau.
	"	June 15 - June 16	Izumi City	Restoration of conduit pipes	4 personnel of a related company
	Yonezawa City	June 14 - June 16	Shiogama City	Temporary water supply	A water wagon, 3 personnel of water supply bureau.
	Kaminoyama City	"	"	" "	A water wagon, 2 personnel of water supply bureau.
	Sagae City	"	"	" "	A water wagon, a personnel of water supply bureau.
Fukushima	Fukushima City	June 14 - June 17	Izumi City	Restoration of conduit pipes	4 personnel of related companies.
	Koriyama City	"	"	" "	4 personnel of related companies.
	Haranomachi City	"	"	" "	4 personnel of related companies.

(Table III-4 continued)

Prefectural Branch	Assisting City	Assisting Period	Accepting City	Assisting Activities	Dispatch Items
Iwate	Morioka City	June 14 - June 18	Izumi City	Restoration of conduit pipes, water-flow test and investigation of water-leakage	June 14-June 17, 16 personnel of water supply bureau, 7 vehicles. June 17-June 18, 4 personnel of water supply bureau, 16 personnel of related companies. 4 vehicles of related companies.
	Mizusawa City	June 14 - June 17	"	Restoration of conduit pipes	A personnel of water supply bureau, 4 personnel of related companies, 2 vehicles.
	Kitakami City	June 14 - June 17	"	" "	A personnel of water supply bureau, 4 personnel of related companies, 2 vehicles.
	Hanamaki City	June 17 - June 18	"	" "	A personnel of water supply bureau, 4 personnel of related companies, 2 vehicles.
Miyagi	Kesennuma City	June 15 - June 18	Izumi City	Temporary water supply	2 water wagons.
	"	June 17 - June 19	Shiogama City	Restoration of conduit pipes	3 parties of related companies.
	Sendai City	June 15 - June 17	Izumi City	" "	2 parties of related companies.
	"	June 17 - June 19	Shiogama City	" " "	3 personnel of water supply bureau, 5 parties of related companies.

Table III-5 The Number of Personnel Required for the Restoration of Electric Power Facilities till June 30 after the Earthquake (Tohoku Electric Power Co., Ltd.)

Items Facilities	Personnels of Tohoku Elec- tric Power Co., Ltd. (man-days)	Other Personnels (man-days)	Total (man-days)	Note
Thermal Power Generation	3,433	12,902	16,335	
Hydroelectric Power Generation	219	130	349	
Transformer	1,099	1,878	2,977	Assistance by Tokyo Electric Power Co., Ltd.
Power Trans- mission	1,107	283	1,390	"
Power Distribution	4,003	3,317	7,320	
Communication	339	194	533	
Total	10,200	18,704	28,904	

Note : Other personnels are from Tokyo Electric Power Co., Ltd., related companies and electrical machinery companies.

Table III-6 Damage to Gas Pipes (Gas Supply Bureau of Sendai Municipal Government)

Damage Block	Trunk Pipe						Bough Pipe						Branch Pipe						Twig Pipe						Total	
	Severance	Crack	Pulled Out	Slackness of Joint	The Others	Total	Severance	Crack	Pulled Out	Slackness of Joint	The Others	Total	Severance	Crack	Pulled Out	Slackness of Joint	The Others	Total	Severance	Crack	Pulled Out	Slackness of Joint	The Others	Total		
	Number	Percentage																								
I	2	1	1	1		5	10		3	1		14	30	3			2	35	31	2		1	3	37	91	16.5%
II			1			1	3	1	1			5	4					4	7	9				16	26	4.7
III			5	1	1	7	81	9	27	3	5	125	71	5		1	2	79	69	6	1		3	79	290	52.6
IV			3			3	8		5			13	4					4	3	1			1	5	25	4.5
V	1					1	2	1			1	4	3			1		4	9	2		1	1	13	22	4.0
VI				1		1							6				1	7	8					8	16	2.9
VII				1		1							3					3	10				1	11	15	2.7
VIII			1			1	22	3	10	1	1	37	6		2		1	9	12				4	16	63	11.4
Tagajo, Fukuda, Fukuzumi							1					1	2					2	1					1	4	0.7
Total Number	3	1	11	4	1	20	127	14	46	5	7	199	129	8	2	2	6	147	150	20	1	2	13	186	552	

Note : According to the data of restoration works from June 12 till July 8.

Table III-7 Damage to Dykes on Rivers and Their Restoration

Name of the River	Length of Adminis- trated Section (km)	Year of Improve- ment Under- taken	Total Length of Dykes (km)			Length of Damaged Dykes (km)				Note
			Finished	Provi- sional	Total	Emer- gency Disaster	Emer- gency Mainte- nance	Total	Restora- tion	
Lower Reaches of Kitakami River	137.5	1911	78.5	104.6	183.1	5.3	4.2	(0.052) 9.5	8.9	Including Eai River
Naruse River	82.4	1921	22.2	111.0	133.2	4.3	6.4	(0.080) 10.7	8.1	
Natori River	29.4	1941	28.6	3.4	32.0	2.3	9.0	(0.353) 11.3	3.0	
Lower Reaches of Abukuma River	63.7	1936	20.5	53.5	74.0	0.1	2.5	(0.035) 2.6	0.6	
Total	313.0		149.8	272.5	422.3	12.0	22.1	(0.081) 34.1	20.6	

Note : () in the column of "Length of Damaged Dykes" gives the ratio of length of damaged dykes to total length of dykes.

Length of "Restoration" is at the point of dykes reported to have been suffered disaster, and its restoration costs more than 1 million yen, and the length is included in "Total".

Numerical values in the column of "Emergency Disaster" gives the length of dykes coped with by emergency temporary restoration, and numerical values in the column of "Emergency Maintenance" gives the length of dykes coped with by the budget for maintenance expenses.

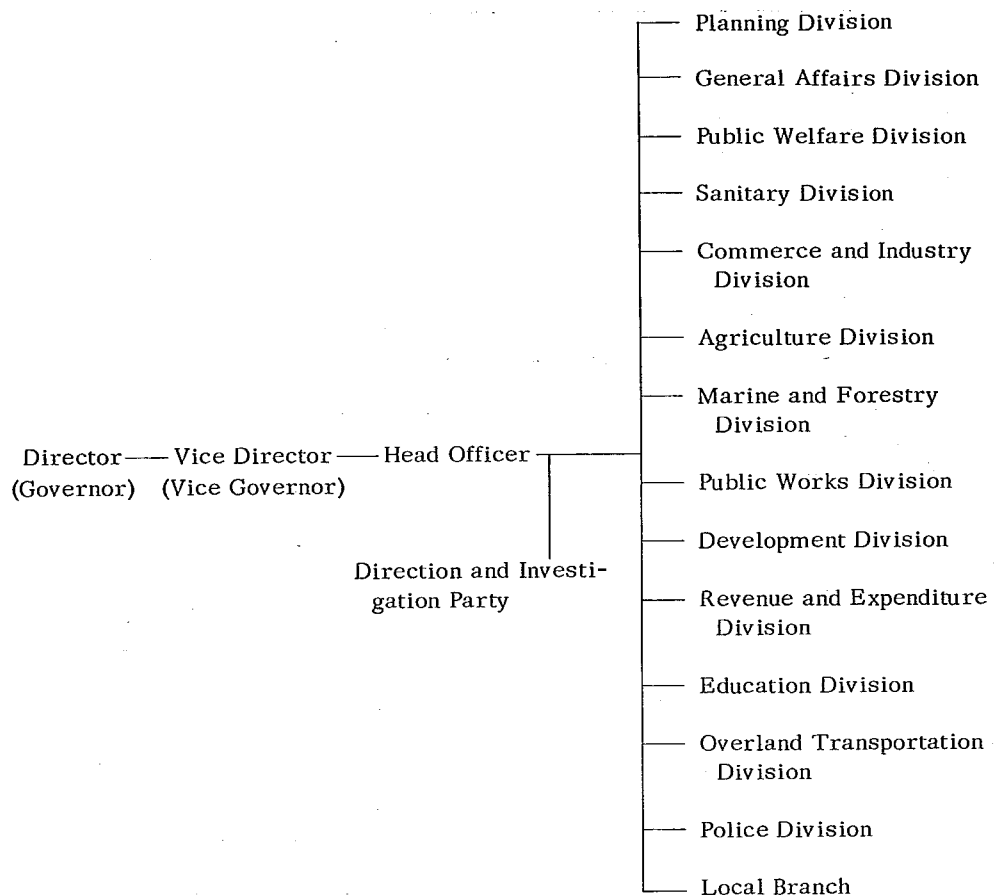


Fig. III-1 Structure of Rescue and Rehabilitation Center of Miyagi Prefectural Government.

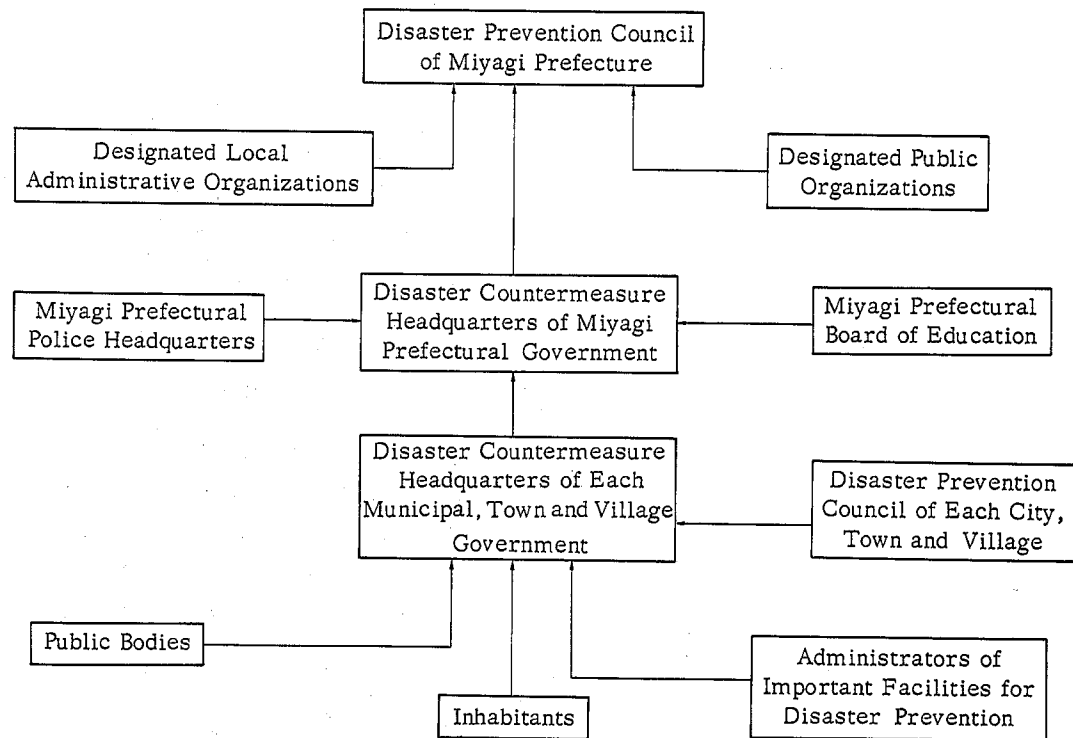


Fig. III-2 Disaster Countermeasure Structure in Miyagi Prefecture.

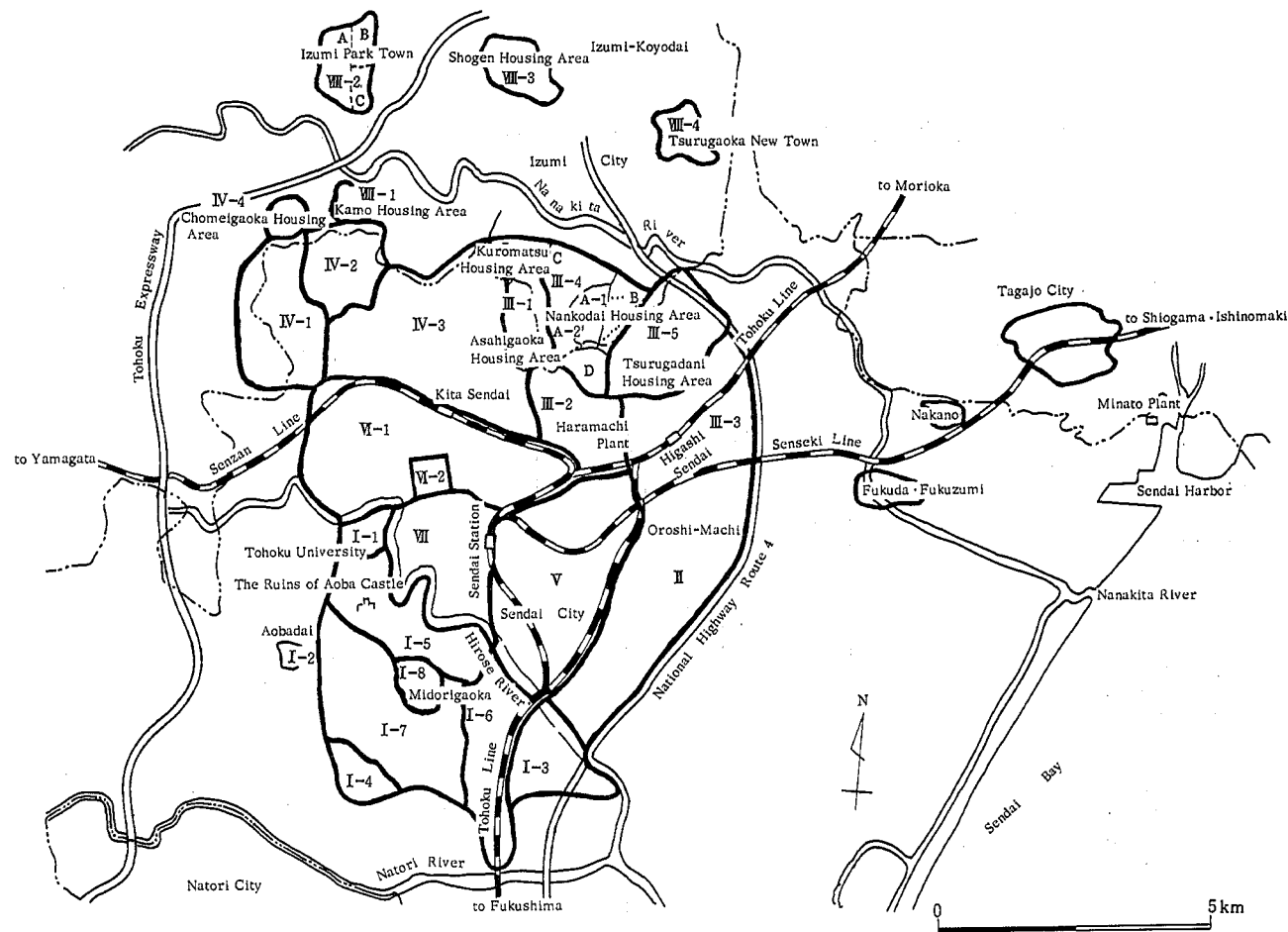


Fig. III-3 Regional Division for Restoration Works by Gas Supply Bureau of Sendai Municipal Government.

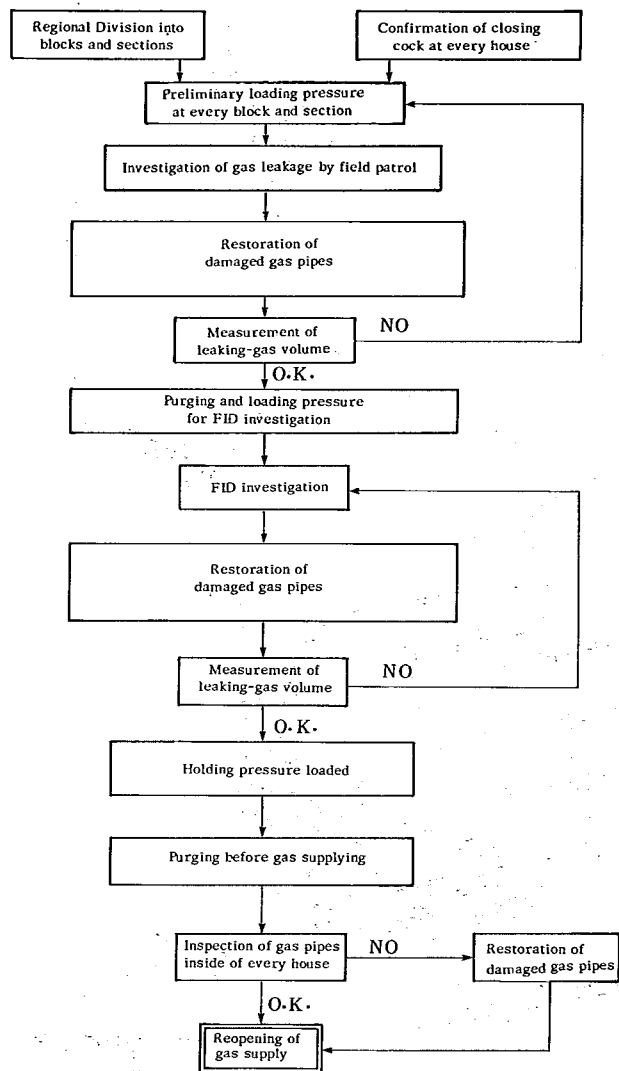


Fig. III-4 Flow Chart of the Restoration of Gas Supply Facilities from Regional Division to Reopening of Gas Supply
(Gas Supply Bureau of Sendai Municipal Government)

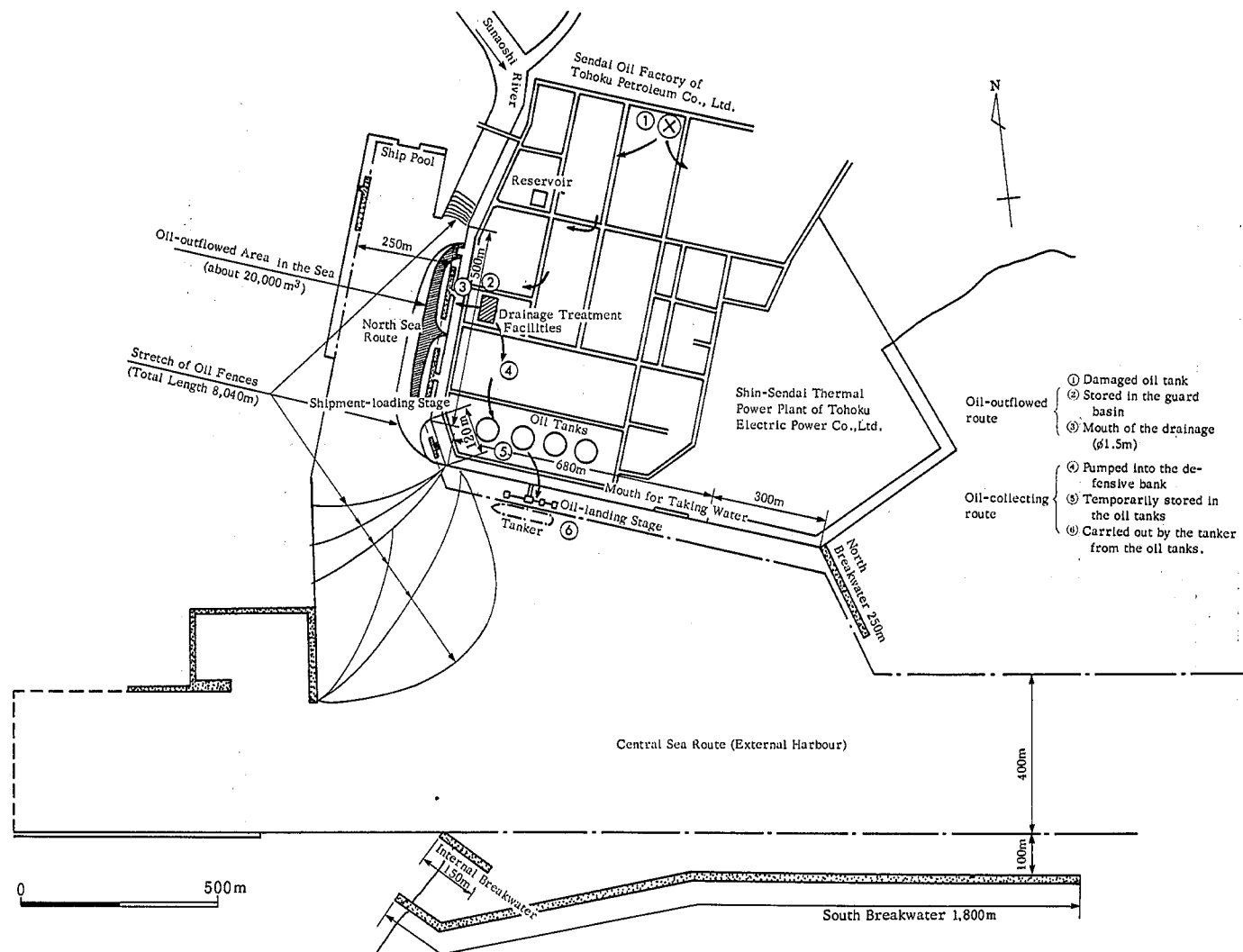


Fig. III-5 Arrangement of the Facilities and Outflow of Oil at Sendai Oil Factory of Tohoku Petroleum Co., Ltd.

IV. Reconstruction

IV-1 General Scopes

Reconstruction is the measures to restore the socio-economic disorder. It involves the measures to reconstruct the damaged structures, to construct the substitute, to review the design criteria for earthquake resistivity and to improve the organizational structures.

IV-2 Organizational System for Reconstruction

Relevant administrations set up the disaster-oriented organizations temporarily for reconstruction.

Miyagi Prefectural Government organized Earthquake Disaster Reconstruction Section on July 10, 1978. It controlled the reconstruction jobs in the Government.

IV-3 Reconstruction Works of Public Utilities

Reconstruction Works of roads, river works, harbors, agricultural facilities, schools and water supply facilities have been scheduled under the supervision of the Government. Table IV-1 and IV-2 show the budgets of reconstruction works of public facilities and water supply facilities.

IV-4 Long-term Reconstruction of Public Utilities

(1) Railroad

Japanese National Railroad has started Railroad Structures Aseismicity Committee headed by Prof. S. Okamoto of Saitama University, to review the aseismic design of railroad structures.

(2) Water Supply

Water supply administrators in the quake-affected area have compiled the data on the damage of water supply facilities.

(3) Gas Supply

Japan Gas Association is compiling the data on the damage and reconstruction of gas supply facilities.

Tokyo Gas Co., Ltd. has started to research on how to efficiently restore the gas supply function.

(4) Electric Power Facilities

The earthquake resistivity of insulators on transformers had been

studied by analyses and experiments. Insulators had been considered to have enough resistivity. Nevertheless some insulators suffered damage due to the earthquake. Electricity Enterprise Federation started Transformer Aseismicity Committee to research on the cause of the damage and the future countermeasures.

(5) Telecommunication Facilities

The Nippon Telegraph and Telephone Public Corporation started to research the cause of their damage and the future countermeasures. It concentrates on the study on the damage of coaxial cables buried directly under the ground.

IV-5 Application of Law Systems and Loans

Miyagi Prefectural Government applied the law systems and loans as shown below.

(1) Loans

Public Welfare Loan

Minor Enterprise Loan

Agriculture and Fishery Loan

Privately Owned House Loan

Municipal Finance Aid

(2) Exemption of Tax and Tuition

(3) Petition of Government Aid to Violent Disasters

Table IV-1 Budgets of Reconstruction Works of Public Utilities in Miyagi Prefecture

Classification	Prefectural Budget				Municipal Budget				Total			
	Applied		Assessed		Applied		Assessed		Applied		Assessed	
	Sites	Budget	Sites	Budget	Sites	Budget	Sites	Budget	Sites	Budget	Sites	Budget
River Works	138	1,912,146	139	1,573,696	24	113,303	24	91,112	162	2,025,449	163	1,664,808
Coastal Works	14	433,656	14	350,360					14	433,656	14	350,360
Sabo Works	1	129,256	1	98,783					1	129,256	1	98,783
Highways	339	1,683,673	335	1,401,613	219	1,526,148	214	1,260,573	558	3,209,821	549	2,662,186
Bridges	40	319,668	39	272,111	26	414,027	26	346,570	66	733,695	65	618,681
Total	532	4,478,399	528	3,696,563	269	2,053,478	264	1,698,255	801	6,531,877	792	5,394,818

Table IV-2 Budget of Reconstruction Works of Water Supply Facilities

Classification	Budget in Thousand Yen
Receiving and Storing Reservoirs	565
Filtration Plants	9,057
Distribution Stations	14,126
Conduits	79,303
Others	74,321
Total	177,372

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