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**PRESENT STATUS OF ROAD
ENVIRONMENTAL PROBLEMS
IN JAPAN**

July 1979

Traffic Environment Division
Road Department
Public Works Research Institute

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Foreward

This pamphlet is the brief summary of the present status of road environmental problems in Japan. It mainly consists of four parts —— the present condition of road environment, counter-measures for road environmental affairs, environmental impact assessment of road and the role of the Traffic Environment Division in Japan.

The road environmental problems have become socially the target of public nuisance at present, and we are making an effort to resolve this social problems as soon as possible.

I have an apology to be unable to translate in English completely, but you can understand the present situation in Japan without difficulty. I hope that this compilation would help all those who are interested in Japanese environmental problems.

Moreover, I gathered the list of the papers in English at the Traffic Environment Division and of the Japanese Environmental Laws as appendix at the end of the pamphlet. I would be able to give you the copy of them, if you would desire to read it.

July, 1979

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1. Introduction

It is only a period of some twenty years that the traffic situations surrounding the urban areas in Japan have presented sharply as problems in various meanings.

The first of such problems was the traffic accident. Increasing automobile traffic volume from 1955 resulted in multiplying traffic accidents, and the persons died in traffic accidents in 1970 numbered as many as 16,765. But, thereafter the fatality decreased year by year due to improvement in traffic safety facilities and reinforcement of traffic control, and in 1977 it decreased to 8,945, about one-half in 1970.

On the other hand, the high growth in the years subsequent to 1955, while it brought an improvement to the living of Japanese, induced with the word "Public Nuisance", coming to appear often on the newspapers. It was said that the emissions from a group of plants such as petrochemical complex polluted air and that the industrial and domestic waste ran into rivers. After 1965, the automobile traffic became a target of environmental problems, and movements against road construction were seen here and there in the country.

The traffic environmental problem became a serious one primarily in that the proportion of automobiles in many transportations increased sharply as shown in Tables 1 and 2. Furthermore, it was a great factor that the development of residential areas was made directly adjacent to major roads in disregard of harmonious use of land for road. And also there was a lack of considerations to the environment along the road, such as countermeasures to noise.

For such trend, the road administrator is executing the construction works with suitable consideration toward the road environmental problems from the stage of road planning including determination of the route.

Moreover, efforts are exerted for implementing the systems for preservation of the areas along the road from wrong environment, for example expanding the width of road on both side positively and thus providing an environmental protection zone for environmental countermeasures, or making the road administrator share part of the cost for construction of a buffer building as a countermeasure outside the road when it has a buffer function of noise to the dwelling houses in the hinterland.

In the Eighth Five-Year Road Improvement Program started from 1978, the investment for environmental countermeasures is doing more intensively.

Table 1 Shares of Domestic Passenger Transport (unit: %)

Fiscal Year	National Railways	Private Railways	Buses	Cars	Private Airlines	Inland Waterways
1955	55.0	27.1	14.1	2.5	0.1	1.2
1960	51.0	24.8	18.1	4.7	0.3	1.1
1965	45.5	21.3	21.0	10.6	0.6	0.8
1966	43.6	20.5	20.8	13.6	0.7	0.8
1967	41.7	19.5	20.5	16.8	0.9	0.7
1968	38.4	18.5	19.8	21.5	1.1	0.7
1969	31.4	17.8	19.0	26.9	1.2	0.7
1970	32.3	16.8	17.6	30.9	1.6	0.8
1971	30.8	16.1	16.3	34.3	1.7	0.8
1972	30.5	15.8	16.7	34.0	2.0	1.0
1973	30.9	15.6	16.6	33.5	2.4	1.1
1974	31.1	15.6	16.7	32.9	2.5	1.1
1975	30.3	15.3	15.5	35.3	2.7	0.9
1976	29.7	15.3	13.9	37.3	2.8	0.9

Table 2 Shares of Domestic Cargo Transport (unit: %)

Fiscal Year	National Railways	Private Railways	Motor Vehicles	Inland Waterways
1955	50.0	0.9	11.1	38.0
1960	39.2	0.6	15.2	45.0
1965	30.2	0.5	25.9	43.4
1966	26.2	0.4	31.0	42.4
1967	23.9	0.4	33.2	42.5
1968	21.8	0.4	37.5	40.3
1969	19.1	0.3	38.1	42.5
1970	17.8	0.3	38.8	43.1
1971	16.9	0.3	39.4	43.4
1972	15.1	0.3	39.5	45.2
1973	14.1	0.2	34.7	51.0
1974	13.7	0.2	34.7	51.3
1975	12.9	0.2	35.9	50.9
1976	12.2	0.2	35.5	52.0

However, in spite of the efforts of the road administrator the traffic environmental problem is still one of the important problems that the road construction works are facing with presently, and further study is required.

2. Present Condition of Road Environment

Fig. 1 shows the status of the occurrence of highway environmental problems investigated by the Ministry of Construction. With the roads in service, the cases of noise and vibration causing a direct influence on the body or house constitute a greater part, while with the roads in project or under plan, anxiety for air pollution occupies a considerable part in addition to the noise and vibration. From such result, it may be said that the road traffic noise, vibration and air pollution from automobile traffic constitute a greater part of the road environmental problems.

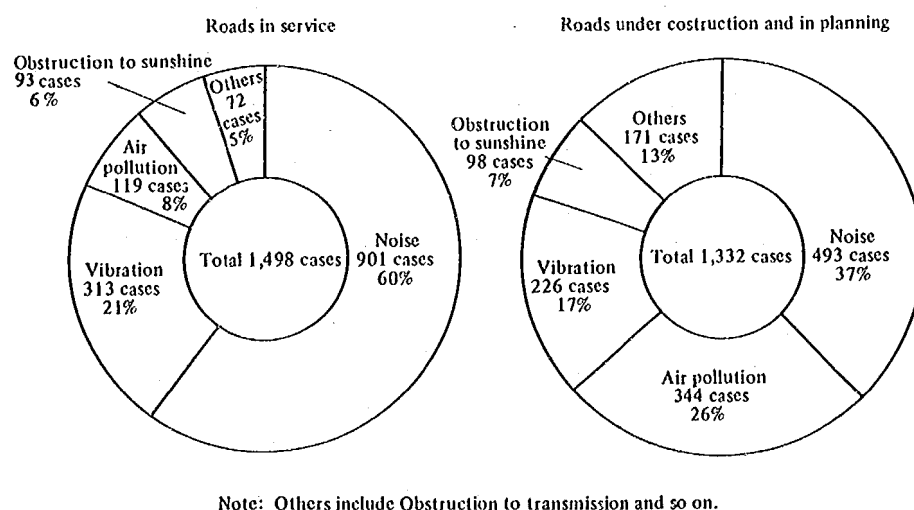


Fig. 1 Status of Occurrences of Highway Environmental Problems in Japan (1970-1976)

(1) Road traffic noise

In the roads in service, the traffic noise is the greatest problem as seen from Fig. 1, and the cases of complaint are increasing year after year shown in Table 3.

Now, seeing the results of measurement of noise at 2,263 points conducted by the prefectural governments in 1976 chosen in the areas where the road traffic noise is likely to produce problems, the environmental quality standard is satisfied only at 481 points, 21.3 percent of all points of measurement.

Table 3 Complaint Number of Road Traffic Noise

Fiscal Year	1971	1972	1973	1974	1975	1976
Number	479	527	691	819	844	716

Table 4 Survey Result of Measuring Points Satisfying the Environmental Quality Standard (in 1976)

Classification	Number of Lanes	Number of Measuring Points	Number of Measuring Points Satisfying the Environmental Quality Standard
Class I	1	24	5 (20.8)
	2	87	11 (12.6)
	3 ~ 4	43	20 (46.5)
	5 ~ 6	7	0 (0)
	7 ~ 8	1	0 (0)
	exceed 8	1	0 (0)
	Sub-total	163	36 (22.1)
Class II	1	73	9 (12.3)
	2	610	41 (6.7)
	3 ~ 4	272	25 (9.2)
	5 ~ 6	42	1 (2.4)
	7 ~ 8	8	0 (0)
	exceed 8	2	0 (0)
	Sub-total	1,007	76 (7.5)
Class III	1	100	85 (85.0)
	2	591	204 (34.5)
	3 ~ 4	239	42 (17.6)
	5 ~ 6	71	6 (8.5)
	7 ~ 8	16	2 (12.5)
	exceed 8	6	0 (0)
	Sub-total	1,023	339 (33.1)
Class IV	1	7	6 (85.7)
	2	41	22 (53.7)
	3 ~ 4	15	1 (6.7)
	5 ~ 6	5	1 (20.0)
	7 ~ 8	2	0 (0)
	exceed 8	0	0 (0)
	Sub-total	70	30 (42.9)
Total		2,263	481 (21.3)

Note:

Parenthesized shows the percentage.

Class I and Class II are districts which are mainly used for housing, generally correspond to the district A in Table 5.

Class III and Class IV are residential districts in which considerable area is used for commercial and industrial purposes, generally correspond to the district B in Table 5.

Table 5 Standard Values of Highway Noise

(a) General area

(in dB(A))

Category of area	Division of hours		
	Daytime	Morning and evening	Nighttime
	Not more than	Not more than	Not more than
AA	45	40	35
A	50	45	40
B	60	55	50

Note: Standard values vary depending on the area type. Therefore, classification of areas is left to the discretion of prefectural governors.

AA -- Areas which require particular quiet. For instance, areas where medical facilities are concentrated.

A -- Primarily residential areas.

B -- Areas where a substantial number of residences are located among shops and factories.

(b) Roadside areas

(in dB(A))

Categories of areas	Division of hours		
	Daytime	Morning and evening	Nighttime
	Not more than	Not more than	Not more than
Type A areas bordering on a two-lane road	55	50	45
Type A areas bordering on a more than two-lane road	60	55	50
Type B areas bordering on a not more than two-lane road	65	60	55
Type B areas bordering on a more than two-lane road	65	65	60

To such traffic noise along the road, countermeasures are being taken integrally, including measures at the source by improvement of the automobile structure, measures by improvement of road structure and environmental protection measures along the roadside areas.

(2) Air pollution

In the following is summarized the present situation of air pollution in our country from the data of the observatory stations of the general atmosphere and those installed along the highways operated by the Environment Agency and local governments.

a. Carbon monoxide (CO)

The carbon monoxide concentrations in 1976 according to the general air observatory stations and automobile exhaust gas observatory stations are shown in Table 6. The rate of achievement of the environmental quality standard of carbon monoxide (daily average of hourly values shall not exceed 10 ppm, and average of hourly values in eight consecutive hours shall not exceed 20 ppm) is 89 percent in the roadside areas where the air pollution is monitored by the observatory stations. Therefore the environmental quality standard of carbon monoxide is achieved generally except special areas.

Table 6 Carbon Monoxide (CO) Concentration Measurements in 1976

	General air measurement stations	Automobile exhaust gas measurement stations
Number of effective measurement stations	151	283
Mean of annual mean values (ppm)	1.4	3.1
Number of stations satisfying with environmental quality standard	151	89
Compliance percentage (%)	100	89

b. Nitrogen dioxide (NO₂)

For nitrogen dioxide, the environmental quality standard was revised by the Environment Agency Notification on 11th July 1978 and daily average of hourly values shall be within the range between 0.04 — 0.06 ppm or below. The data on measurement of nitrogen dioxide in 1977 are shown in Table 7.

Table 7 Nitrogen Dioxide (NO₂) Concentration Measurements in 1977

	General air measurement stations		Automobile exhaust gas measurement stations	
	Number	Percentage	Number	Percentage
When daily mean value exceeding 0.06 ppm	41	4.6	66	36.3
When less than 0.06 ppm but not less than 0.04 ppm	225	25.2	86	47.2
When less than 0.04 ppm	626	70.2	30	16.5

(3) Road traffic vibration

The vibration hazard refers to the vibration of the ground due to road traffic which propagates to the houses, so that the people in the house feels the vibration directly or indirectly through rattling of door and furnitures, resulting in complaints.

For the road traffic vibration, standards were provided in June 1976. To comply with the standards, various measures were carried out such as reducing the unevenness in the pavement and repairing the road surfaces causing vibration on one hand, while the speed limit of automobiles and traffic control were executed on the other. Thus, presently there are not many cases where a relatively large damage is caused continuously, and the vibration hazard is coped with by the countermeasures.

Table 8 Limited Value of Road Traffic Vibration

Category of Area	Division of Hours	
	Day time	Night time
Area 1	65 dB	60 dB
Area 2	70 dB	65 dB

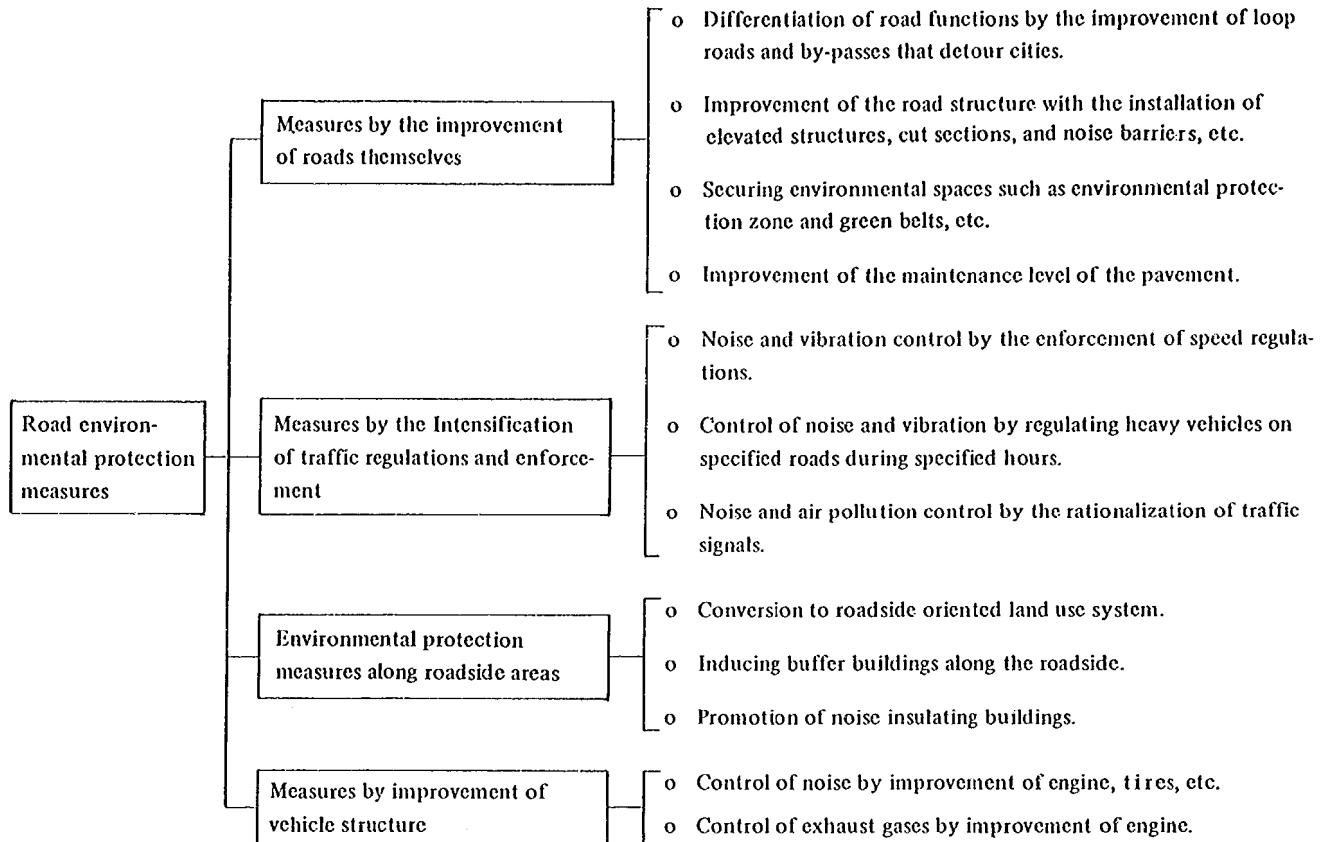
Note: Area 1 — Area which require particular tranquility, that is, primarily residential areas and the like.

Area 2 — Area in which substantial number of residential quarters are located in the shops and factories.

3. Countermeasures for Road Environmental Affairs

The road environmental measures are classified, according to the method, largely into the four cases shown in Fig. 2.

Fig. 2 Classification of Road Environmental Protection Measures



(1) Measures by the improvement of the roads themselves

a. Improvement of road structure

For the road structure of a highway running through the urban area, such a type as plane, embankment, elevated structure or cut section is conceivable. And as for the road environment, it is essential to look into the conditions of the area and to choose a most adequate road structure fundamentally in consideration with the land use along the highway and also with traffic safety. The advantages and shortcomings of these structures may be given as shown in Table 9, and on the choice of the road structure, it is important to consider such advantages and disadvantages and to predict the range of influence as well as economy. Such consideration by road structure is fundamental in all aspects, and where the road construction is carried out, this has been taken into consideration.

Table 9 Advantages and Disadvantages of Road Structures

Classification	Road structure			
	Plane	Embankment	Elevated structure	Cut section
Roadside land use	- o Preferable in an area having roadside use. - o Psychologically, no sense of breakage of the regional society involved, but traversing traffic restricted.	- o Not preferable for roadside use. - o Great sense of breakage of the regional society.	- o Roadside use precluded. - o No breakage of the regional society. - o Space beneath the elevated structure usable for various purposes.	- o Roadside use precluded. - o Psychologically, no sense of breakage of the regional society involved, but traversing traffic restricted. - o Problems involved in the treatment and maintenance of the drainage and underground deposits.
Roadside environmental conservation	- o Greater number of intersections, resulting in higher level of noise and exhaust gas - o Environmental protection required with, for example, green belt provided.	o Embankment slope serving as an environmental protection zone.	o Lower level of noise and air pollution.	- o Greater echo with vertical retaining wall. - o Exhaust gas tending to stagnate.
National environment	o Screened with ease by planting trees.	o Not preferable in the case of a large embankment.	o Preferable with no cutting or no embankment, but involving problems in view.	- o Not preferable with possibility of change in ground water. - o View improved relatively with ease by, for example, planting trees.
Traffic security		o Not preferable in that where a noise barrier is required, it has to be installed on the slope shoulder and thus causes a sense of oppression to the drivers.	o If a noise barrier is installed, not so much preferable because of a sense of oppression.	o If a wall structure is employed, not so much preferable because of a sense of oppression.

b. Installation of noise barrier

The method used conventionally as one of the countermeasures to noise is the installation of noise barrier. This is to block the noise from travelling vehicles by a barrier and thus to produce a noise reducing effect as the noise is diffracted when it comes to the noise reception point. Therefore, it is the most direct means and can be installed along the roadside with ease. For example, it provides a great noise preventing effect in comparison with no noise barrier installed, as shown in Fig. 3. In this figure, the calculation is made with 500 automobiles for hourly traffic volume per lane travelling at 50 km/hr and the traffic component as passenger cars 40%, small trucks 40% and large trucks 20%. However, in the plain streets in the cities, it is difficult to install a noise barrier directly at the roadside from the relationship with the land use along the road. The noise barrier is an effective means only in the case of an elevated structure, embankment or cut section with no direct use of the land along the road.

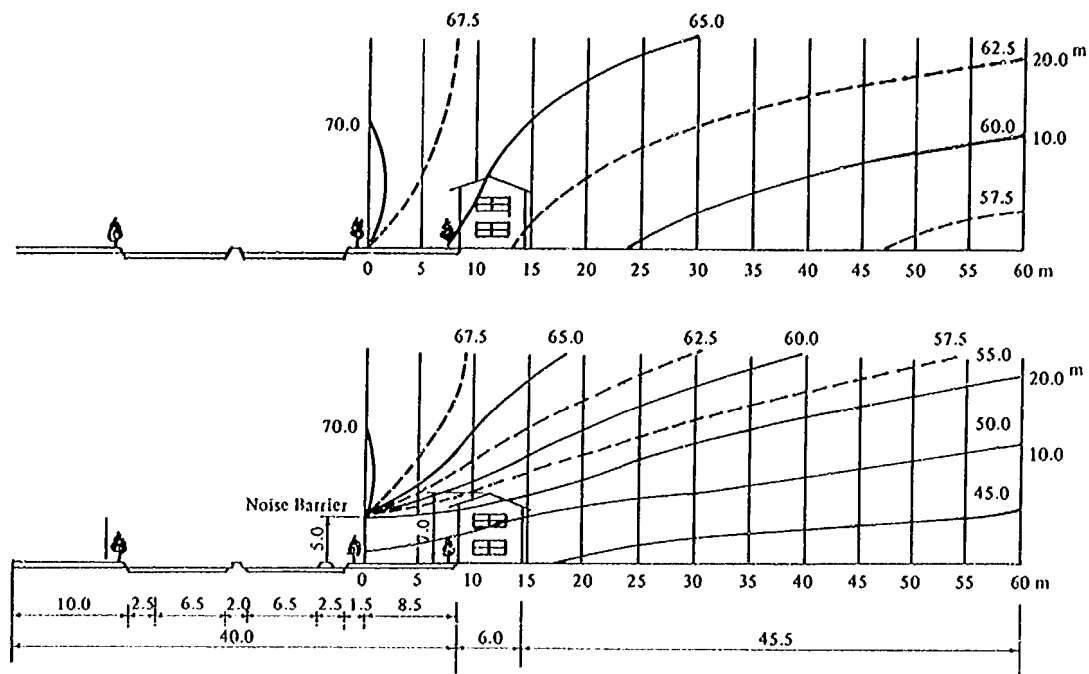


Fig. 3 Effect of Noise Prevention by Noise Barrier (in dB(A))

c. Installation of environmental protection zone

In any of the provided road structures, a greater part of the road site is placed in the service of traffic as vehicle lanes, and on both sides of the road there are dwelling houses located densely. Thus, for conservation of the living environment of the roadside, it is necessary to secure a broad space where a green belt, sidewalk, noise barrier and other necessary facilities are to be provided, between the vehicle lane and the roadside houses.

Where a major road such as expressway or national highway with four vehicle lanes or more is constructed newly, an environmental protection zone of a width of 10m is to be provided in the case of residential area. Where the major road is designed for motorway and is of a road structure of cut section, embankment or of an elevated structure over other road and when it has a heavy traffic such as 3000 vehicles/hour or more as converted to the passenger cars in the peak hourly traffic volume at night, an environmental protection zone of 20m has to be secured.

In the environmental protection zone, a green belt, noise barrier and so on are installed as illustrated in Fig. 4.

(1) Green belt-Bicycler and pedestrian way-Sidewalk

(2) Green belt-Bicycler and pedestrian way-Sidewalk
-Noise barrier

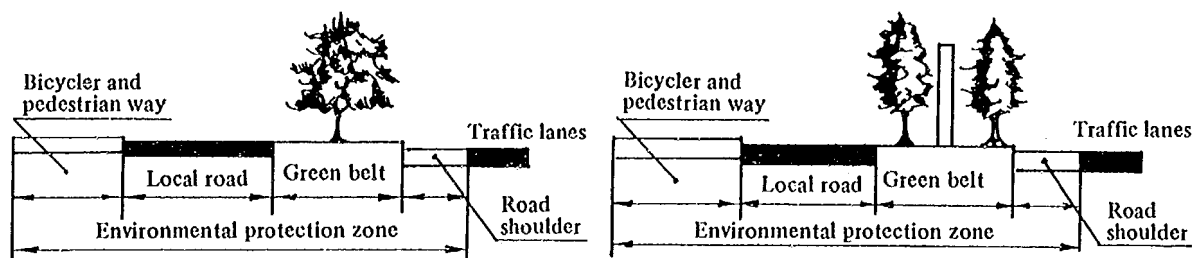


Fig. 4 Standard Diagram of an Environmental Protection Zone

(2) Measures by the intensification of the traffic regulations and enforcement

The level of automobile traffic noise varies greatly with the travelling speed, mixed percentage of large vehicles, traffic volume and travelling mode, and thus a great effect is provided due to control of them by the Public Safety Commission.

(3) Measures for Roadside Environmental Protection

The purpose of this measures is to protect the dwelling houses in the background from hazards resulting from automobile traffic noise and thus to promote harmony of the road with the roadside land use by constructing buildings of a structure not to be affected by noise or locating parks in the circumference of a major road. Where a buffer building has been constructed, the road administrator shares part of the expense required for building subject to agreement with the owner.

This share is limited to the portion of the building which comes under certain conditions, and is equal to the amount corresponding to 17% of the cost for the dwelling portion and to 8.8% for the non-dwelling portion.

Furthermore, where a buffer building is constructed after demolished the existing dwelling house, an amount equal to two-thirds of the expense required for demolition of the house will be paid.

When a buffer building is provided, it has a great barrier effect for the dwelling houses in the back, as shown in Fig. 6.

This Fig. 6 shows the effects calculated under the same assumption to those for Fig. 3.

(4) Measures by improvement of vehicle structure

a. Control of vehicle noise

The intensity of noise generated by the vehicles used for general transport is controlled by the Safety Standards of Road Transport Vehicles in the Environment Agency and the Ministry of Transport.

According to this control, the large vehicles must have the noise level reduced by 3 dB(A) in 1979 and additional 3 dB(A) subsequently in near future. When the traffic noise reduction effect is considered, the levels of traffic noise are estimated as shown in Table 10.

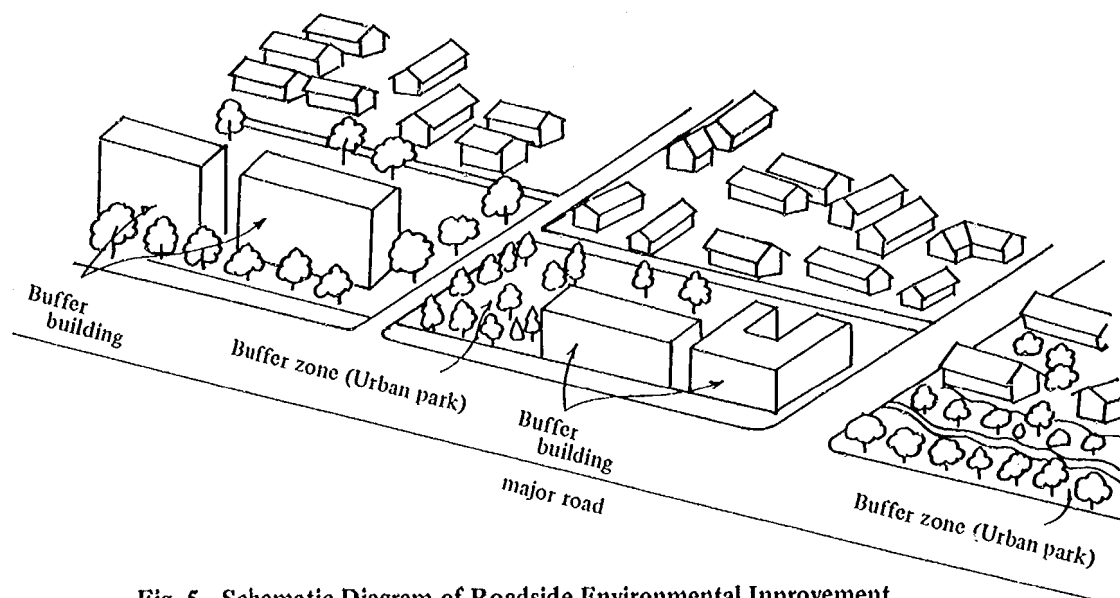
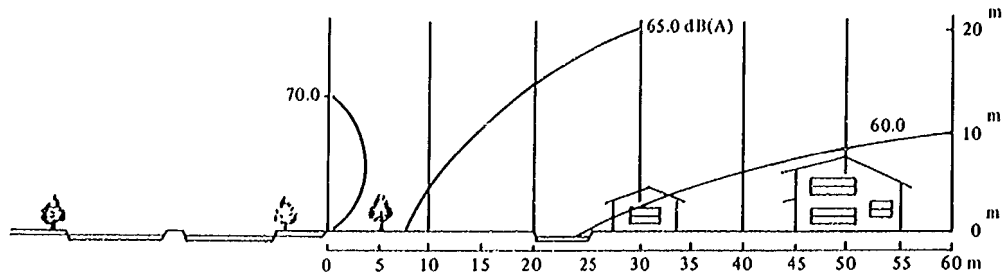
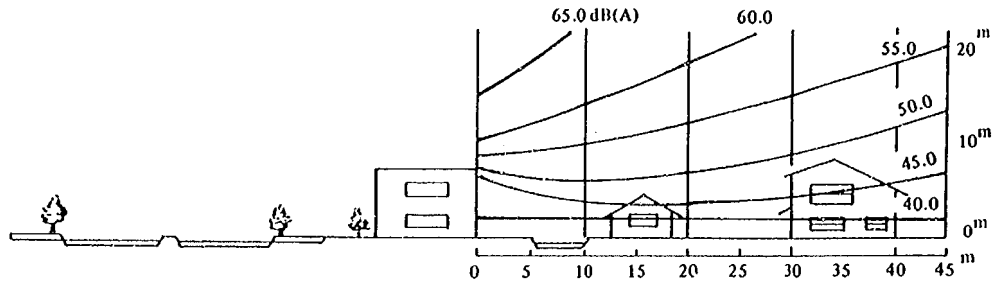


Fig. 5 Schematic Diagram of Roadside Environmental Improvement

(1) Where there is no buffer building



(2) Where there is a buffer building (two storied)



Unit: dB(A)

Fig. 6 Noise Barrier Effect of a Buffer Building

Table 10 Prediction of the Effect of Environmental Noise Level Reduction due to Intensification of the Regulation of Acceleration (unit: dB(A))

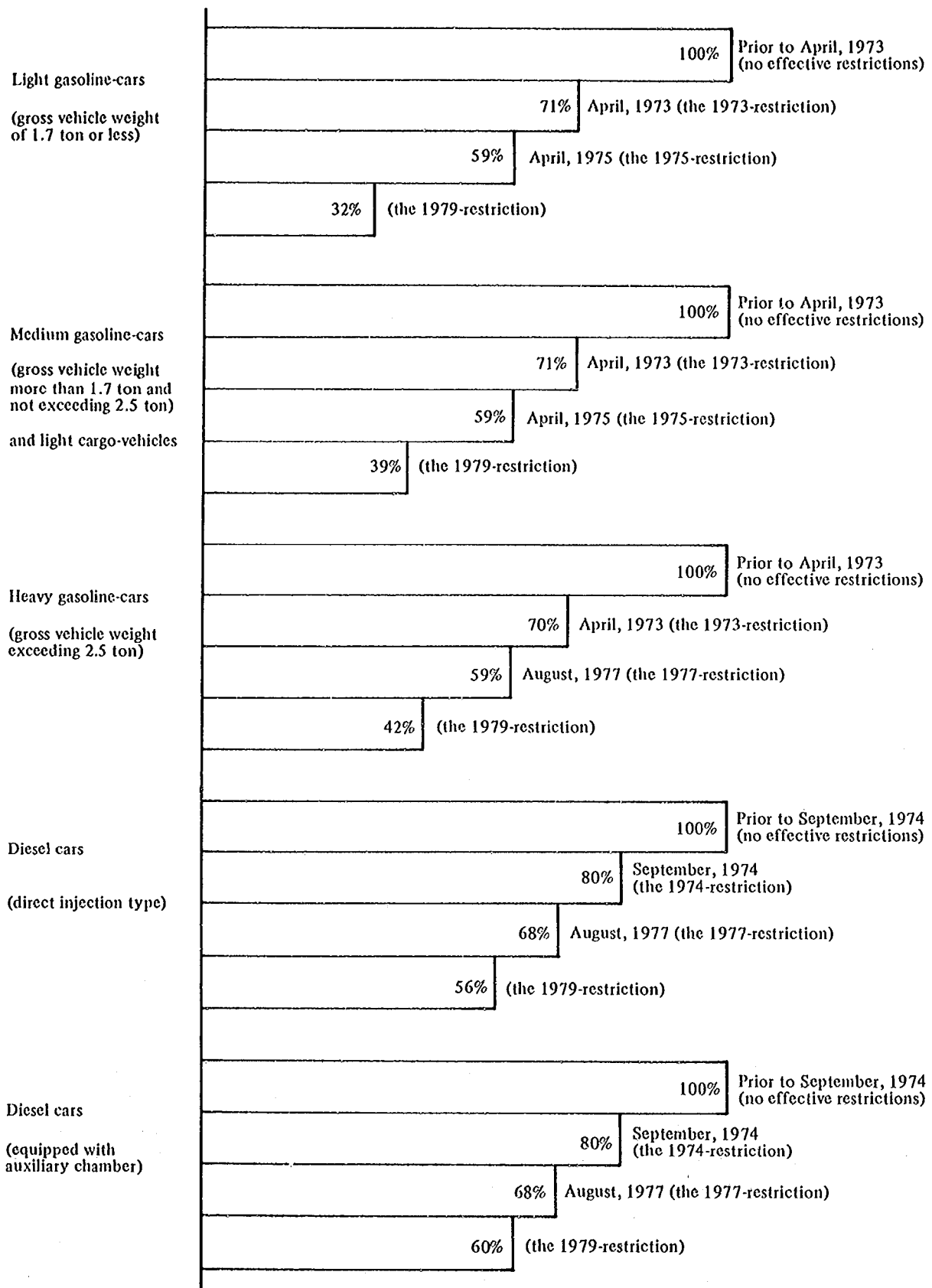
	1975 Regulation	1979 Regulation	Achieved as soon as possible
Near intersections	2 ~ 3	3.5 ~ 5	6.5 ~ 7.5
Near straight roads	1.5 ~ 2	2.5 ~ 3	3.5 ~ 5

Thus, a considerable effect of traffic noise reduction is expected in the future.

b. Control of Exhaust Gas from Motor Vehicles

For prevention of air pollution resulting from automobile traffic, countermeasures at the source of generation are carried out steadily. Taking nitrogen oxides, for example, emissions from automobiles are decreasing as shown in Fig. 7.

**Fig. 7 Effects of restrictions on automotive exhaust emission
(Average values of NOx emission)**



4. Environmental Impact Assessment of Road

In planning and executing the public works, it is very important to pay attention to the harmony with the regional society. And it is a matter of course to obtain the agreement of the inhabitants on condition that enough consideration will be given to conservation of the environment. For the road, we have exerted ourselves to prevent from the generation of public nuisance and the destruction of the natural environment, and at the same time we have performed the procedures of environmental impact assessment so that no serious hazard is generated in conservation of the environment.

For the projects carried out under the Ministry of Construction, assessment of the environmental effects is made in the following cases: construction of an express way, construction of a motorway of 4 lanes or more, construction of a national highway of 4 lanes or more, construction of a bypass.

Items of environmental impact assessment include those concerned with human health or living environment such as air pollution, water pollution, noise and vibration, those concerned with the natural environment such as topography and vegetation and those concerned with natural views.

Among them, the estimation of air pollution, noise and vibration involves a number of complex elements, such as those concerning the traffic flow including the traffic volume, mixed proportion of vehicles and vehicle speed, those concerning the automobile itself including power level and gas emission characteristics and those concerning the physical phenomena including propagation of noise, propagation of vibration and diffusion of exhaust gas. Therefore, it is very difficult to clearly the estimation method. These problems are examined ardently by the Public Works Research Institute and other investigating organizations at present, and in the following are described briefly the estimating procedures used currently.

(1) Air pollution

For estimation of propagation phenomena from exhaust gas of automobiles, it is required to measure the volume of gas from the automobiles and, upon such units, to estimate the concentrations in use of a diffusion formula.

The emission intensity S (in mg/sec·m) per meter in the direction of road extension is obtained from the gas emitted from an automobile travelling at any speed, and in use of the spot traffic volume by type of vehicle N_i (in vehicles/hr) and mean emission coefficient by type of vehicle W_i (in g/km·vehicles), the formula is following;

$$S = \frac{1}{3600} \sum_{i=1}^n W_i N_i$$

where i shows the types of vehicles passing the point in unit time, and the above formula means the sum of the individual emission coefficients.

The mean emission coefficient of the respective types of vehicles is variable with (1) engine type, (2) kind of fuel used, (3) history of the vehicle, (4) year of application of automobile emission gas control, (5) load, (6) travelling speed and (7) gradient. These may be taken into account, but the emission coefficient is subject to change with the vehicle condition, traffic condition, road condition and others individually even in the case of the same type of vehicles. Therefore, with these conditions added, the emission coefficients given as mean values are shown in Table 11. An automobile travelling along a road proceeds in repetition of acceleration, constant speed run, deceleration and stop normally. Therefore, in the case that the emission intensity of automobile exhaust gas is to be set, it is more practical to set it in a state at the actual running mode than in a state of running at a constant speed. Table 11 shows the emission coefficients obtained by chassis dynamo tests in use of the results of actual runs as large as 880km of road.

Table 11 Emission Coefficient of Vehicle

Type of Vehicle	Pollutants	Travel-speed (km/h)	Prior to 1973 (g/km-vehicles)	1973 (g/km-vehicles)	1974 (g/km-vehicles)	1975 (g/km-vehicles)	1976 (g/km-vehicles)	1977 (g/km-vehicles)	1978 (g/km-vehicles)	1979 (g/km-vehicles)	Achieved as soon as possible (g/km-vehicles)
Passenger Cars	CO	10	55.45	42.41	←	2.91	←	←	←	←	←
		20	28.82	20.65	←	1.56	←	←	←	←	←
		30	19.77	13.22	←	1.10	←	←	←	←	←
		40	14.91	9.22	←	0.86	←	←	←	←	←
		50	11.70	6.57	←	0.70	←	←	←	←	←
		60	9.39	4.61	←	0.58	←	←	←	←	←
		80	5.54	1.48	←	0.53	←	←	←	←	←
		100	2.41	1.63	←	0.35	←	←	←	←	←
	NOx	10	2.62	2.58	←	1.38	0.87	←	0.30	←	←
		20	2.54	2.16	←	1.13	0.73	←	0.25	←	←
		30	2.82	2.12	←	1.08	0.72	←	0.25	←	←
		40	3.15	2.13	←	1.06	0.73	←	0.25	←	←
		50	3.48	2.11	←	1.02	0.73	←	0.25	←	←
		60	3.75	2.04	←	0.95	0.70	←	0.24	←	←
		80	4.65	2.61	←	1.29	1.28	←	0.45	←	←
		100	4.63	3.63	←	2.54	2.65	←	0.93	←	←
Small Trucks	CO	10	62.29	58.16	58.13	32.45	←	←	←	←	←
		20	31.35	28.87	28.85	16.14	←	←	←	←	←
		30	20.80	18.88	18.87	10.58	←	←	←	←	←
		40	15.14	13.52	13.50	7.59	←	←	←	←	←
		50	11.39	9.95	9.94	5.61	←	←	←	←	←
		60	8.64	7.34	7.33	4.16	←	←	←	←	←
		80	3.89	2.53	2.51	1.86	←	←	←	←	←
		100	4.28	2.82	2.78	2.12	←	←	←	←	←
	NOx	10	6.70	4.22	4.21	3.21	←	3.09	←	1.87	1.21
		20	5.40	3.48	3.48	2.67	←	2.57	←	1.55	1.00
		30	5.12	3.38	3.38	2.60	←	2.50	←	1.52	0.98
		40	4.94	3.35	3.34	2.59	←	2.49	←	1.51	0.98
		50	4.69	3.27	3.27	2.54	←	2.44	←	1.49	0.96
		60	4.28	3.10	3.09	2.43	←	2.33	←	1.42	0.92
		80	5.12	4.61	4.60	3.68	←	3.55	←	2.15	1.37
		100	7.80	7.08	7.07	5.59	←	5.45	←	3.27	2.19
Large Trucks	CO	10	8.73	6.81	6.20	←	←	←	←	←	←
		20	4.90	3.92	3.49	←	←	←	←	←	←
		30	3.60	2.94	2.57	←	←	←	←	←	←
		40	2.91	2.42	2.09	←	←	←	←	←	←
		50	2.46	2.08	1.77	←	←	←	←	←	←
		60	2.14	1.85	1.54	←	←	←	←	←	←
		80	2.11	1.93	1.48	←	←	←	←	←	←
		100	2.92	2.64	2.31	←	←	←	←	←	←
	NOx	10	6.82	6.65	5.62	←	←	4.75	←	3.99	3.38
		20	5.61	5.47	4.70	←	←	3.96	←	3.34	2.83
		30	5.42	5.29	4.61	←	←	3.89	←	3.27	2.77
		40	5.35	5.21	4.61	←	←	3.89	←	3.28	2.78
		50	5.20	5.07	4.56	←	←	3.85	←	3.25	2.75
		60	4.90	4.77	4.38	←	←	3.70	←	3.12	2.65
		80	5.72	5.54	4.90	←	←	4.13	←	3.48	2.94
		100	8.02	7.82	5.80	←	←	4.97	←	4.21	3.54

The formula for calculation of diffusion to be used in estimation of the concentration is treating the road as a succession of point sources of gas and divides into two cases; one with the wind speed in excess of 1 m/sec and the other at 1 m/sec or less.

- a. When the wind speed is exceeding 1 m/sec:

The formula for calculation of diffusion for point source is

$$C(x,y,z) = \frac{Q}{2\sigma_y\sigma_zU} \exp\left(\frac{-y^2}{2\sigma_y^2}\right) \left[\exp\left\{-\frac{(H-z)^2}{2\sigma_z^2}\right\} + \exp\left\{-\frac{(H+z)^2}{2\sigma_z^2}\right\} \right]$$

where $C(x,y,z)$: Concentration at point (x,y,z) (ppm);

x : Leeward distance along the axis of wind direction (m);

y : Horizontal distance at right angle to x axis (m);

z : Vertical distance at right angle to x axis (m);

Q : Intensity at source of emission (cc/sec);

H : Effective height of emission source (m);

σ_y : Diffusion parameter in the direction of y axis (m);

σ_z : Diffusion parameter in the direction of z axis (m);

U : Wind speed (m/sec).

- b. When the wind speed is 1 m/sec or less:

The formula for calculation of diffusion for point source is given as

$$C(x,y,z,T) = \int_0^T \frac{Q}{(2\pi)^{3/2} \sigma_y^2(t) \sigma_z(t)} \exp\left\{\frac{-(x^2+y^2)}{2\sigma_y^2(t)}\right\} \left[\exp\left\{-\frac{(H-z)^2}{2\sigma_z^2(t)}\right\} + \exp\left\{-\frac{(H+z)^2}{2\sigma_z^2(t)}\right\} \right] dt$$

where $C(x,y,z,T)$: Concentration at point (x,y,z) at time T after exhaustion (ppm);

Q : Intensity at source of emission (cc/sec);

σ_y : Diffusion parameter in horizontal direction at time t after exhaustion (m);

σ_z : Diffusion parameter in vertical direction at time t after exhaustion (m);

H : Height of emission source (m).

- c. Conditions for calculation

- 1) The emission source is located at the center of the road at a height of 1m above the road surface.
- 2) The point of estimation of the concentration is, as a rule, at a height of 1.5m above the ground.
- 3) The concentration at the reception point is to be sought by superposition of the values of concentration upon calculation of diffusion at all point sources.
- 4) Diffusion parameters

When the wind speed exceeds 1 m/sec, the curves shown in Fig. 8 are proposed for the vertical diffusion parameters with modification to the extent of 100m from road side in addition to the Pasquill's parameter. Here, the initial diffusion parameter at the road-side is taken as 1.5m. The horizontal diffusion parameter is based on the values of Pasquill added the width of vehicle lane for the initial diffusion width. When the wind speed is less than 1 m/sec, a similar drawing is prepared.

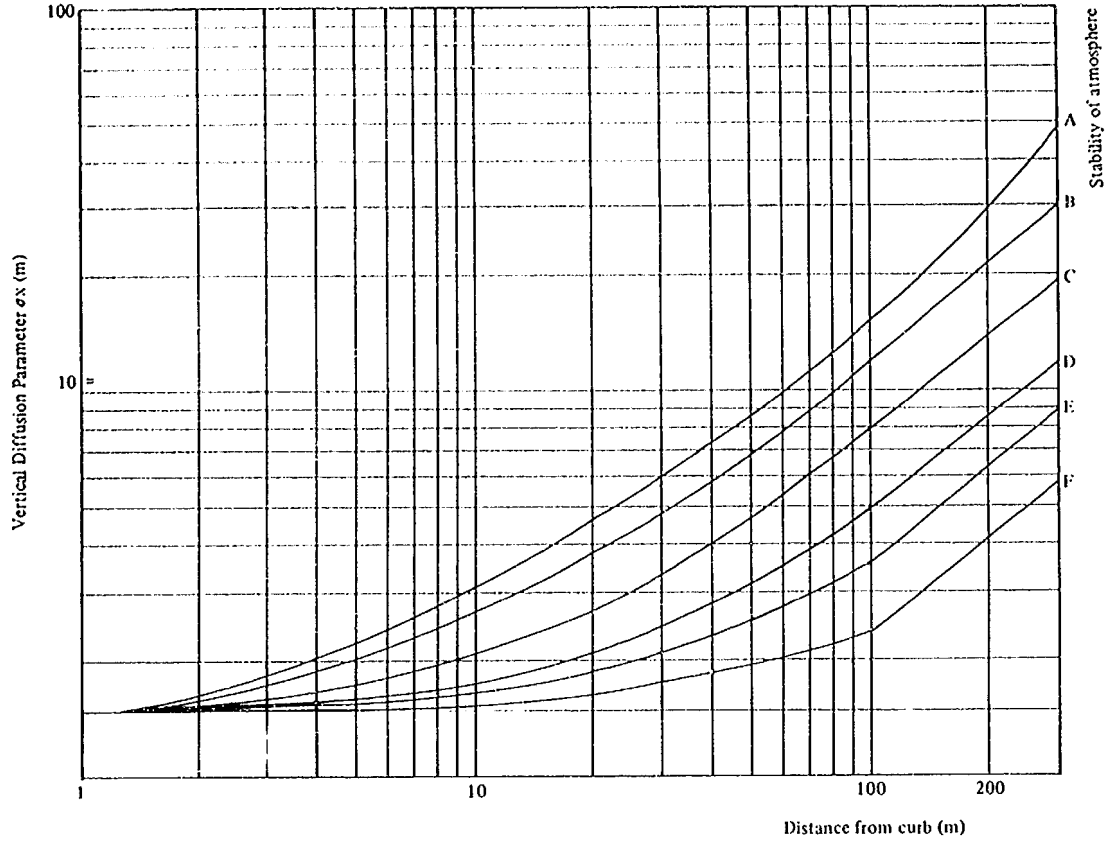


Fig. 8 Vertical Diffusion Parameter

(2) Traffic Noise

The evaluation of traffic noise is made of the median noise value L_{50} . For estimation of such median noise value of traffic noise the following formula of equally spaced vehicles modes is summarized as a result of the reseaches and investigations at a number of organizations.

$$L_{50} = L_W - 8 - 20 \log_{10} \ell + 10 \log(\pi \frac{\ell}{d} \tanh 2\pi \frac{\ell}{d}) + \alpha_d + \alpha_i$$

- where
- L_{50} : Median noise value of road traffic noise (dB(A));
 - L_W : Mean power level according to A characteristic of auditory organ for noise generated from a vehicle (dB(A));
 - ℓ : Distance from the center of the assumed lane to the reception point (m);
 - d : Mean spacing of each vehicle (m), that is $d = 1,000 V/N$;
 - V : Mean hourly velocity of traffic flow (km/h);
 - N : Traffic volume (vehicles/h);
 - α_d : Correct value depending on diffraction of sound (dB(A)), according to Fig. 9;
 - α_i : Correct value depending on unknown factors which affect on propagation of sound according to Fig. 10.

The mean power level of automobiles is obtainable by either of the following formulas depending on the mean velocity and component of vehicle types.

When the vehicle type component is of 2 type classification

$$L_W = 87 + 0.2 V + 10 \log_{10}(a_1 + 10a_2) \text{ (in dB (A))}.$$

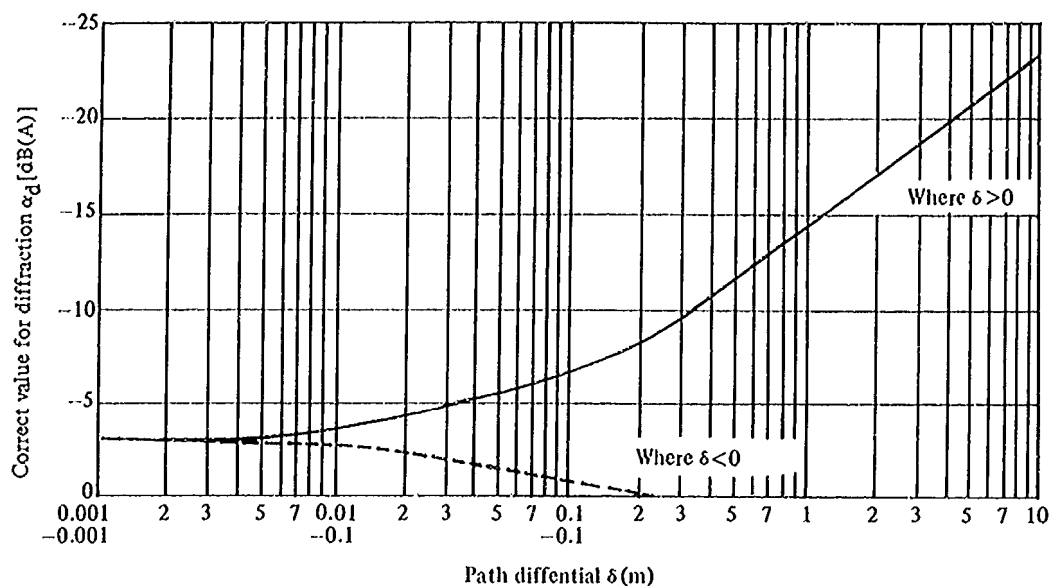


Fig. 9 Correct Value depending on Diffraction of Sound

when of 3 type classification

$$L_w = 85 + 0.2 V + 10 \log_{10} (b_1 + 2.3b_2 + 16b_3) \text{ (in dB(A))}.$$

where hourly velocity of the traffic flow (km/h);

a_1 : Ratio of the group of small vehicles in the case of 2 type classification;

a_2 : Ratio of the group of large vehicles in the case of 2 type classification;

b_1 : Ratio of the group of passenger cars in the case of 3 type classification;

b_2 : Ratio of the group of small trucks in the case of 3 type classification; and

b_3 : Ratio of the group of large trucks in the case of 3 type classification,

provided $a_1 + a_2 = 1.0$ or $b_1 + b_2 + b_3 = 1.0$.

With respect to the power level of automobile used here, a decreasing effect is expectable with improvement in the structure of the automobile itself, and such being taken into consideration, it will be reduced to the following value with, for example, the 1979 controlled vehicles.

$$L_w = 86 + 0.2 V + 10 \log_{10} (a_1 + 8a_2)$$

(3) Traffic Vibration

The following formula for estimation of traffic vibration is simplified on the basis of the measuring level of vibration occurring when vehicles are travelling, and upon the results of simulation of traffic flows.

$$L_{10} = a \log(\log Q) + b + \alpha_o + \alpha_f + \alpha_h + \alpha_l$$

where L_{10} : Level of vibration exceeding for 10% range of the time period (dB);

a, b : Values determined by the number of lanes and mean travelling speed, shown in Table 12;

Q : Equivalent traffic volume per lane during 500 seconds (vehicles/500 seconds/lane) according to the formula

$$Q = \frac{500}{3600} \cdot \frac{1}{M} (Q_1 + 12Q_2);$$

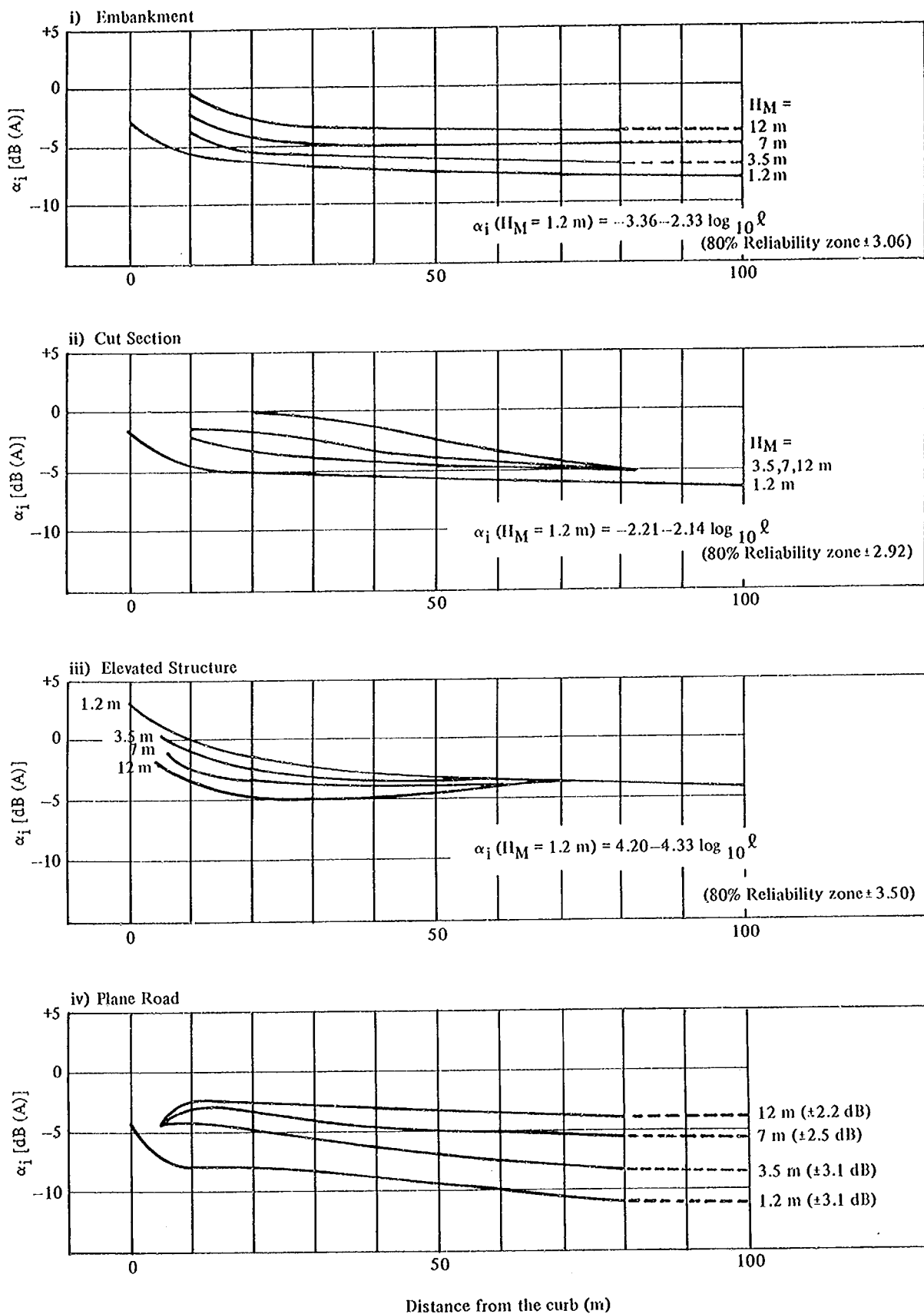


Fig. 10 Correct Value α_i (in the case of an ordinary road with a traffic volume of 1000 vehicles/hour or greater)

Table 12 Table for the Value a and b

(1) Value of a

		Total Number of Lanes			
		2	4	6	8
Mean Travelling Speed (km/hr)	35	65.8	58.3	56.9	57.0
	40	65.4	58.3	56.8	56.9
	45	65.7	58.4	56.8	56.8
	50	66.8	58.6	56.9	56.8
	55	67.9	59.2	57.4	57.1
	60	68.9	60.3	58.5	57.8
	65	70.0	62.4	60.1	59.7

(2) Value of b

		Total Number of Lanes			
		2	4	6	8
Mean Travelling Speed (km/hr)	35	24.3	28.2	29.1	29.2
	40	25.8	29.7	30.5	30.6
	45	27.1	31.0	31.9	32.0
	50	27.9	32.1	33.1	33.2
	55	28.4	32.7	33.7	34.0
	60	28.7	32.8	34.0	34.3
	65	28.8	33.0	34.2	34.5

Q_1 : Hourly traffic volume of the group of small vehicles (vehicles/hour);

Q_2 : Hourly traffic volume of the group of large vehicles (vehicles/hour);

M: Total of lanes;

α_σ : Correct Value depending on the flatness of pavement, and in use of standard deviation of surfact smoothness (mm),

$$\alpha_\sigma = 4(\sigma - 2.2);$$

α_f : Correct Value depending on the resonant frequency of ground vibration, and in use of the ground resonant frequency of vibration f (Hz),

$$\text{if } 1 \leq f \leq 4, \alpha_f = -10 \log(4/f) + 5.5,$$

$$\text{if } 4 < f \leq 8, \alpha_f = 5.5,$$

$$\text{if } 8 < f \leq 90, \alpha_f = -20 \log(f/8) + 5.5;$$

α_h : Correct value depending on embankment height, and in use of the road surface height h (m),

$$\text{if } h \leq 5, \alpha_h = -1.6h,$$

$$\text{if } h > 5, \alpha_h = -8.0;$$

α_ℓ : Correct value depending on damping by distance, and from L'_{10} obtained with $\alpha_\ell = 0$, the distance ℓ in meter between the reception point and the road,

$$\text{if } 1 \leq f \leq 10, \text{ and } L'_{10} < 50,$$

$$\alpha_\ell = -3.3 \log \ell + 1.8$$

$$\text{if over above value f and } L'_{10}$$

$$\alpha_\ell = -6.7 \log \ell + 3.6.$$

5. Role of the Traffic Environment Division at the Public Works Research Institute

The Public Works Research Institute of the Ministry of Construction had its main place of activities located in Tokyo, two branches and three laboratories. However, it moved into the new Science and Education City in March 1979 and its organizations had integrated except a laboratory.

The Science and Education City is constructed for the purpose of meeting the needs of the times to develop a better environment for advanced research and education of science and technology. This

city is located at about 60 km in the east of Tokyo and extends over six towns and villages of Tsukubamachi, Ohomachi, Toyosatomachi and Yatabemachi, Sakuramura and Kukisakimura, all of Ibaraki Prefecture and has an area of 18km south to north by 5km east to west.

The Public Works Research Institute is located in a zone where research authorities concerned with construction are gathering in the Science and Education City, and occupies a land in the form of a strip of 3km south to north and 150 ~ 700m east to west with its area of 126 hectares.

In this area, the research facilities are laid out in 7 sections with the main building and facilities for common use in A-subdivision, geotechnical, soil and foundation engineering facilities in B-subdivision, road traffic facilities in C and F-subdivision, structural facilities in D-subdivision, hydraulics and water quality facilities in E-subdivision and other facilities in G-subdivision.

The organization for research activities is consist of 35 divisions in 9 departments, and the Traffic Environment Division belongs to the Road Department, which includes Traffic Engineering Division, New Transportation Systems Division, Traffic Safety Division, Pavement Division, Tunnel Division and Planting Division.

The Traffic Environmental Division deals largely with researches and investigations concerning traffic noise, air pollution, infrasound, environmental impact assessment and roadside improvement planning. The main research works at present are as follows.

In the researches and investigations concerning traffic noise, the following items are performed.

- a. Estimation of traffic noise level connected to real unsteady traffic flow such as stop, start, acceleration and deceleration at signal intersections is being investigated.
- d. Propagation and distribution of traffic noise in an area where buildings are standing successively is being investigated.
- c. For simpler calculation of Traffic noise, a simulation model upon the unit pattern developed by P.M. Nelson is being investigated for improvement.
- b. The distribution and reduction effect in the level of traffic noise on the back ground of buffer building has been investigated, and a prediction model is being prepared.
- e. As traffic noise in a tunnel is hardly dissipated and is emitted from the opening, the distribution of the level of noise propagating from the tunnel opening is being investigated.
- f. As one of the countermeasures to noise on road, noise absorptive materials on the noise barrier, inner surface of the tunnel wall and lower surface of the elevated structure are being examined with respect to its acoustic characteristic and durability.
- g. Propagation characteristics of noise by wind are being studied.

In the researches and investigations concerning air pollution, the following items are performed.

- a. Through measurement of the travelling vehicle characteristics such as travelling speed, the degree of acceleration and deceleration and the number of engine rotation of test vehicles on a bypass of national highway, emission characteristics of automobile for the respective travelling modes are being tested with a chassis dynamo.
- b. The mechanism of generation, development and extinction of the ground inversion of atmospheric temperature, which is considered to exert influence on the diffusion of exhaust gas, is being investigated.
- c. Through experiment of diffusion with a tracer gas emitted at each of predetermined heights, the characteristics of diffusion parameters in a vertical direction is being examined.
- d. Examination of the diffusion parameters is being investigated by the tracer gas experiments for various road structures.
- e. In order to grasp the phenomena of diffusion related to the meteorological factors, the measurement of the concentration of NO_x with distance from the road are doing through

observation point successively for a year.

- f. Model experiments are being carried out in a wind tunnel completed in 1977 to grasp the basic behaviors of diffusion phenomena.
- g. And, in use of these above data, methods of estimating the diffusion phenomena in various road structures are being studied.

Furthermore, when a large scaled road is planned, it is required to grasp beforehand the air pollution by automobile emission gases over the whole road network in a wide area. Thus, the phenomenon of diffusion over a wide range is also studied.

In the researches and investigations concerning infrasound, for the purpose of clarifying the mechanism of infrasound induced from the highway bridges, test vehicle travels over truss bridge, and the relationship between the dynamic load of the test vehicle upon the bridge, vibration characteristic of the bridge and infrasound on the ground is being examined. Moreover, in order to grasp the actual conditions of infrasound occurring when vehicles travel over the highway bridges in national highways, the levels of infrasound are being measured at different kind of bridges. Theoretical studies are also made according to the beam and plate theories.

In the investigation concerning the environment impact assessment, a questionnaire of the inhabitants around a road placed in service recently is conducted to look into the change in the evaluation of the road and their damage consciousness before and after the use of the road, and the factors influencing the evaluation of road are chosen and how the road construction is regarded by the inhabitants is examined.

The investigations and researches concerning the natural environment were initially assumed by the Traffic Environment Division until 1978, but they were succeeded by the Planting Division created in April 1979. The researches are concerned mainly with the investigation of the scope of adverse effects which the construction work or use of road has upon plantation, examination of the method of survey of the plantation in use of aerial photos, follow-up investigation of the condition of recovery of the slope of road to its original state and investigation of the soil or soil strength adapted for growth of street trees to secure adequate growth.

The traffic vibration is assumed mainly by the Structural Division in Structures and Bridges Department, where methods of estimation of the vibration are examined upon the results of measurements to provide adequate countermeasures.

Furthermore, in the Traffic Environment Division is performed a study of the harmony in all aspects of the road with the living environment, land use and buildings surrounding the road integrally, on condition that the results of above survey are take into consideration fully.

Through such study, it is expected that the problems of traffic environment in the roadside will be resolved, although the resolution may take some time.

Such researches in the Traffic Environment Division and others will finally serve as environmental countermeasures of road and contribute to resolution of the road environmental problems and, at the same time, enhance the accuracy of prediction in the environment impact assessment.

6. Postscript

In the foregoing have been described the present status of the road environmental problems in Japan and the researches in the field of traffic environment Division, and the potential of researches to the environmental problems will now be understood.

In addition to the foregoing, the Environment Agency, the Ministry of International Trade and Industry and the Ministry of Transportation are also conducting various researches and investigations. Furthermore, at the construction sites, various surveys are conducted for explanation to the inhabitants.

By these, we are convinced that there will be formed and developed a national land good for living.

APPENDIX

I. List of papers in English at the Traffic Environment Division

I became a head of the Traffic Environment Division last year, so I wrote the papers in Japanese only. These papers in this list was written by Mr. K. Kaneyasu, Director of Road Department, a former head of the Traffic Environment Division.

II. List of the Japanese Environmental Laws etc.

The list is a portion of the environmental Law. Moreover, there are many Laws, Cabinet Orders, Notifications and Regulations etc., but not translated in English.

Appendix I: List of papers in English at the Traffic Environment Division

1. Noise Attenuation by Acoustic Shielding, Annual Report of Road, Japan Road Association, 1973.
2. Vehicle Noise and Tire Noise, Annual Report of Road, Japan Road Association, 1974.
3. Equation for Forecasting Highway Traffic Noise and Counter-Measures for Avoiding Noise, Symposium on Roads and the Urban Environment, OECD, 1974.
4. The Relationship between the Highway Traffic Noise and the Highway Structure, Proceedings of the First Conference of the Road Engineering Association of Asia and Australasia, 1976.
5. Research on an Evaluation Model for Proposed Roads, VIIIth IRF World Meeting, 1977.
6. Problems Associated with Highway and the Environment, Annual Report of Road, Japan Road Association, 1977.
7. Calculation Models of Noise, Air Pollution and Vibration caused by Road Traffic, Proceedings of the Second Conference of the Road Engineering Association of Asia and Australasia, 1978.

Appendix II: List of the Japanese Environmental Laws etc.

General

1. Basic Law for Environmental Pollution Control
2. Law for the Punishment of Crimes Relating to the Environmental Pollution which Adversely Affects the Health of Persons

Relief of Pollution Related Victims

3. Pollution-Related Health Damage Compensation Law
4. Enforcement Order of the Pollution-Related Health Damage Compensation Law

Cost Allocation

5. Pollution Control Public Works Cost Allocation Law
6. Cabinet Order for Implementation of the Pollution Control Public Works Cost Allocation Law

Air

7. Air Pollution Control Law
8. Enforcement Ordinances of Air Pollution Control Law
9. Enforcement Regulation of Air Pollution Control Law
10. Environmental Quality Standards Regarding Air Pollution

Water

11. Water Pollution Control Law
12. Cabinet Order for Implementation of the Water Pollution Control Law
13. Ordinance of the Prime Minister's Office on Effluent Standards
14. Environmental Quality Standards Regarding Water Pollution
15. Marine Pollution Prevention Law
16. Cabinet Order for Implementation of the Marine Pollution Prevention Law

Land, Agricultural Chemicals

17. Agricultural Land Soil Pollution Prevention, etc, Law
18. Cabinet Order for Implementation of the Agricultural Land Soil Pollution Prevention, etc, Law
19. Agricultural Chemicals Regulation Law
20. Cabinet Order for Implementation of the Agricultural Chemicals Regulation Law

Waste

21. Waste Management Law
22. Cabinet Order for Implementation of the Waste Management Law
23. Standards for Verification

Noise, Offensive Odor

24. Noise Regulation Law
25. Cabinet Order for Implementation of the Noise Regulation Law
26. Offensive Odor Control Law
27. Cabinet Order and Ordinance of the Prime Minister's Office for the Offensive Odor Control Law

Vibration

28. Vibration Regulation Law

Nature

29. Nature Conservation Law

30. Natural Parks Law

31. Wildlife Protection and Hunting Law and Related Legislation

32. Law Relating to the Regulation of Transfer of Special Birds and Related Legislation