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CURRENT SITUATION AND FUTURE TOPICS OF ROAD TRAFFIC NOISE PROBLEMS IN JAPAN

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Regarding the road traffic noise problem in Japan, the current situation and the administrative countermeasures are reviewed. Next, from the technological viewpoint, the progress of regulation of the vehicle noise emission and various kinds of noise reduction technologies are introduced. Regarding the assessment and prediction methods for road traffic noise, the historical course in Japan and future problems are briefly described. Lastly, as future subjects, not only technical developments but also administrative and socio-psychological measures are discussed.

1. Introduction

Japan has made a great stride industrially and economically during its rapid industrial development in the decade from about 1965. From this period, the volume of goods' transport has much increased. The amount of goods' transport in 1994 has become three times larger compared to that in 1965 and about 50% of the total amount of goods' transport is dependent on road vehicles. Meanwhile, motorization has greatly progressed and the number of motor vehicles owned has increased at almost the same rate (from 21 000 000 vehicles in 1971 to 68 000 000 in 1994).

Although road vehicles are indispensable for industrial activities and our everyday life, the progress of motorization has caused such environmental problems as air pollution and noise. In this paper, the current situation and future topics of road traffic noise problems in Japan are reviewed.

2. Current situation and administrative countermeasures

In Japan, we have "Basic Environmental Law" which aims to maintain standards desirable for the protection of human health and preservation of living environments. Based on this law, "Environmental Quality Standards" are specified. Regarding environmental noise, the desirable standards were decided in 1971 for general areas which are classified into two categories facing roads and other areas. According to these standards, various environmental conservation plans have so far been established. The annual "Report on the Environment" published in 1995 reported that the attainment rate of the environmental quality was more than 60% for areas other than areas facing roads, whereas the rate was only 14% for areas facing to roads. These statistics indicate that the road traffic noise problem is still very serious in Japan. Especially in urban roadside areas on trunk roads, the influence of road traffic noise is very serious.

3. The progress in noise abatement technologies

In alignment with Fig. 1, the present state of noise control technologies is reviewed below.

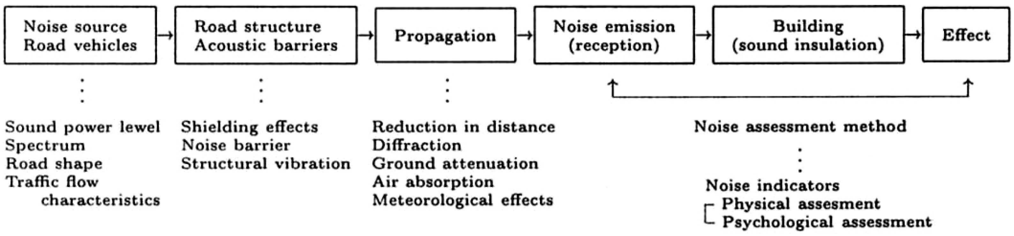


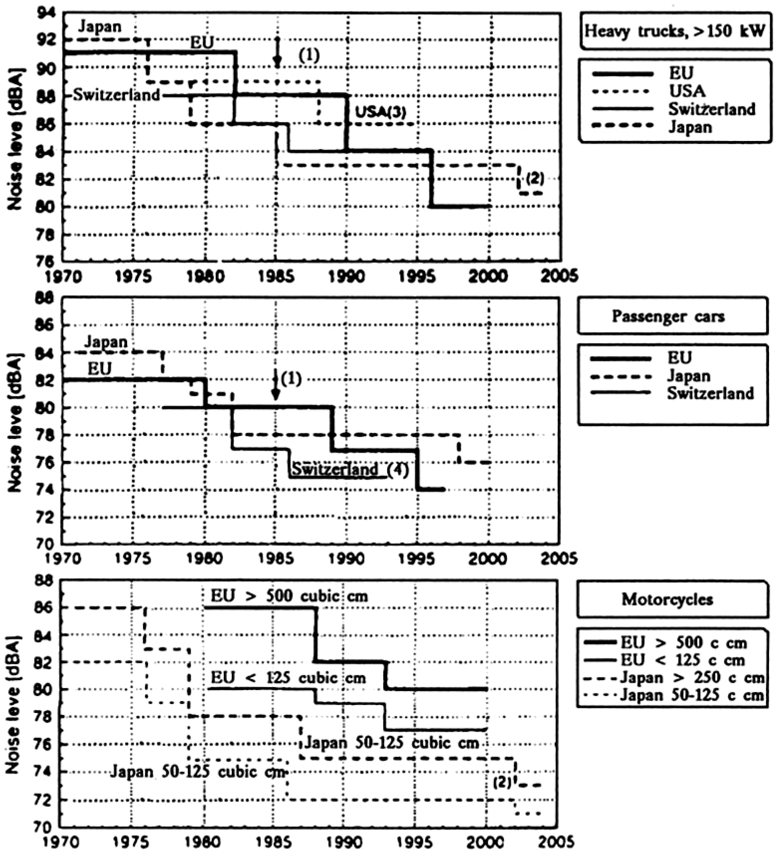
Fig. 1. Flow of the road traffic noise problem [Tachibana].

3.1. Regulation of vehicle noise emission

As a primary measure for the reduction of road traffic noise, noise abatement of road vehicles must be considered. Many industrialized countries have introduced regulations regarding maximum noise emission of road vehicles. Figure 2 shows the development of the vehicle noise emission limits regarding acceleration pass-by noise over the years in the EU, USA, Switzerland and Japan [1]. In Japan, the regulation for constant speed pass-by noise and exhaust noise was established in 1951. Regarding the acceleration pass-by noise, which is most important in urban areas, the regulations for heavy trucks, passenger cars and motorcycles began in 1971 and have been strengthened in three steps in 1976–1977, 1979 and 1982–1987.

Meanwhile, automobile manufacturers have been making a big effort to reduce the vehicle noise emission. The technical points are mechanical improvements of the engine (combustion process, intake system, etc.), acoustic treatments of the engine compartment, prevention of structure-borne sound, improvement of the transmission, differential gears, gear box and muffler, control of the fan, damping treatment of the propeller shaft, reduction of aerodynamic noise and so on.

To see the effect of such vehicle noise regulations on the actual traffic noise, a Working Party was set up in the I-INCE in 1992 and conducted international research until 1994. In the report of this research, it was concluded that, in spite of phased vehicle noise emission regulations in many countries, a tendency of decreasing of road traffic noise could not be clearly seen. The report described the reasons for this discouraging result



Notes:
1. The arrow indicates that in EU there was a change in the measuring procedure in 1985. For trucks, this corresponded to approximately 4 dB (A) of more stringent requirements on top of the other changes.
2. In Japan limit changes as indicated are targeted by 2002.
3. Truck values for USA increased by 6 dB to compensate for twice as large a measuring distance.
4. Cars with 4 gears (manual) may emit up to 77 dB (A).
5. In the USA, there are no noise requirements for cars.

Fig. 2. The development of vehicle noise emission limits over the years, including projected limits. (Top parts of the figure for trucks of 150 kW, middle part for cars and bottom part for motorcycles.) [1].

indicating that the contribution of the tire/road noise, which is dominant in actual road traffic noise, can not be assessed by the vehicle type approval test according to ISO 362 and the replacement of vehicles in service takes a long time and that the effect of vehicles noisier than average tends to dominate the results of the field measurements. However, some promising results were also introduced in the report. For example, Fig. 3 shows the data of acceleration noise measured at intersections with traffic signals in Japan. In these results, a slight decrease of the acceleration pass-by noise can be seen for both heavy trucks and passenger cars between the vehicles in conformity with the regulation in 1979 and in conformity with those in 1985. Figure 4 shows the sound power levels of vehicles under the constant speed running condition measured by a special technique

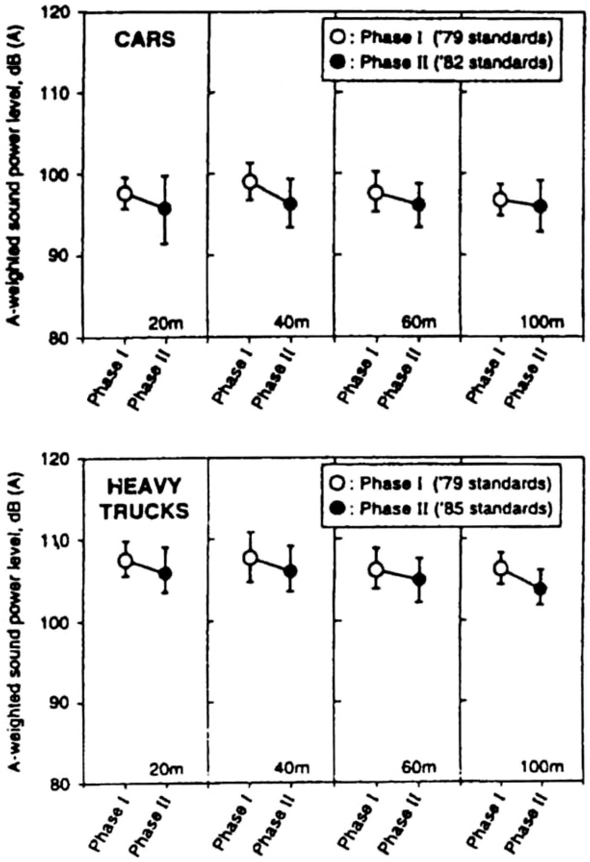


Fig. 3. Sound power level (maximum at pass-by 7.5 m from a microphone) from accelerating vehicles measured at different distances from a stoplight. Cars in the left part and heavy trucks in the right part of the figure [1].

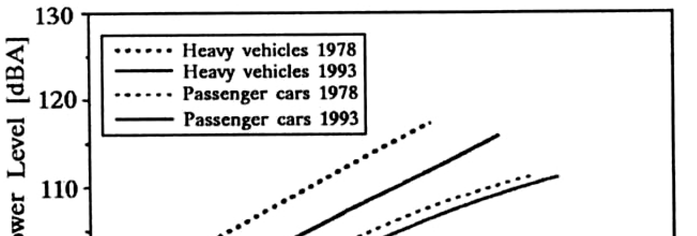


Fig. 4. Change in sound power levels of Japanese vehicles 1978–93, as measered in a tunnel [1, 2].

using a reverberand tunnel [2]. In this result, a decrease of the sound power level by 1 to 2 dB for passenger cars and by 4 to 5 dB for heavy trucks was seen between the data obtained in 1978 and those in 1993.

3.2. Reduction of tire/road noise

The dominant components of vehicle noise are the engine noise and the tire/road noise. The former has been reduced to some extent by the technical improvements mentioned above and, consequently, the latter has become relatively prominent. To reduce the tire noise, various improvements are being tried on the tread pattern, the structure and materials of tires.

Regarding the road surface, several kinds of low-noise pavements have been developed.

The most hopefull type for practical use is the drainage asphalt pavement which was originally developed for safety under rainy conditions. The porosity of the surface of this pavement is effective for sound absorption and, consequently, noise radiation can be reduced by 3 to 5 dB (A) [3]. The application of this type of pavement has already been started as an innovative noise reduction measure, whereas it is necessary to examine its endurance property and to develop a technique of recovering its sound absotption efficiency.

3.3. Measures by road structures

As a matter of course, the underground tunnel structure is the best one for roadside noise problems, but it is necessary to treat exhaust gases by artificial ventilation tech-

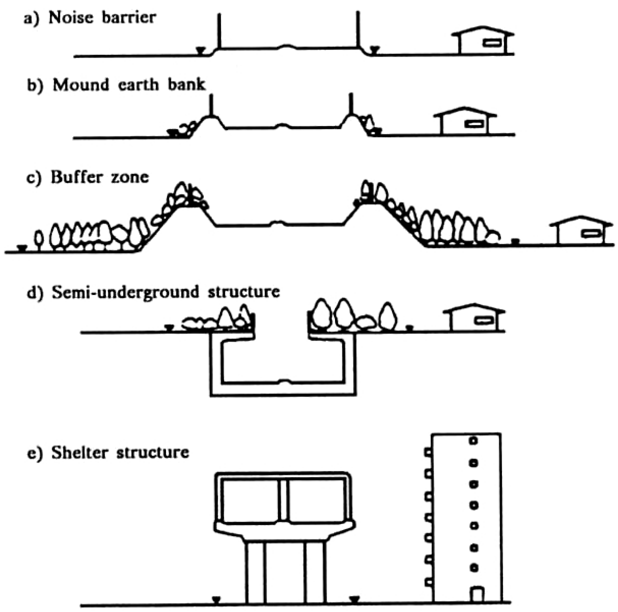


Fig. 5. Measures for highway structures.

niques. As the second best measure, semi-underground structures with openings in the ceiling have been developed and are being adopted in those areas, where a serious noise problem is estimated (Fig. 5).

In this type of structure, the sound absorption treatment on the side walls is very effective to suppress the multi-path reflection inside the structure and consequently to reduce the noise propagation outside. Recently, shelter type structure is introduced to densely built-up urban areas (Tokyo Outer Ring Road).

3.4. Use of noise barriers

Noise barriers are the most effective measure for the reduction of road traffic noise. In Japan, it has been widely used for highways for more than twenty years and the total length of noise barriers amount to about 3 460 km at the end of the 1994 fiscal year. The height of the barriers was about 3 meters previously, whereas it has recently become necessary to construct barriers of 5 to 8 meters high because of the rapid increase of the traffic volume. Since such a high barrier causes secondary problems of deterioration of the landscape and the obstruction of sunshine, various types of noise barriers with relatively low height and high noise reduction performance are being developed (Fig. 6).

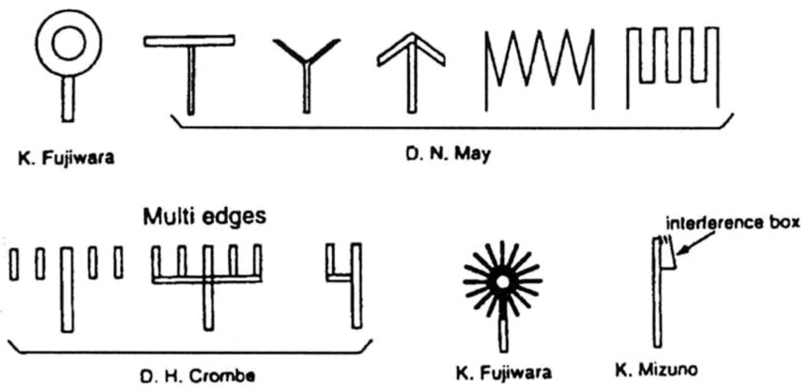


Fig. 6. Noise barriers of special shapes.

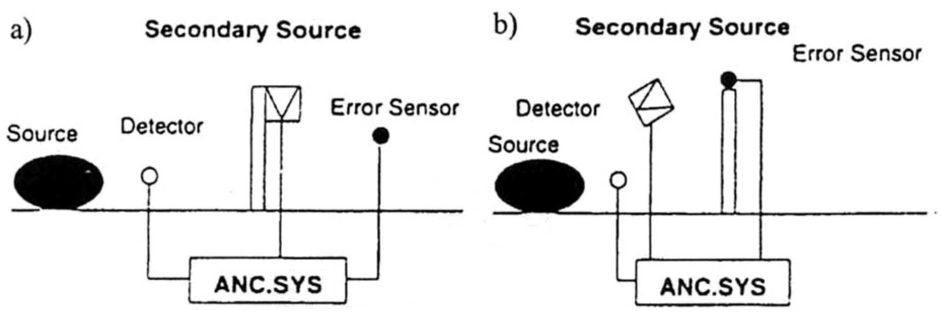


Fig. 7. Experiments of active noise barrier; a) S. ISE *et al.*, b) A. OMOTO *et al.*

As a new idea, the application of an active control technique to noise barriers is being investigated on the experimental stage (Fig. 7).

3.5. Environmental buffer zone

For noise problems, it is the most basic principle to keep a long distance between the noise source and the area influenced. For the traffic noise problem, it is the most desirable measure to provide an environmental buffer zone (Fig. 8). In Japan, the total length of buffer zones made for this purpose was only about 590 km in 1995 but it is gradually increasing. Here, it should be noted that the planting and greenfication of the ground cover are effective for landscape beautification and subjective impression, but they are not so effective for noise reduction as it is generally expected.

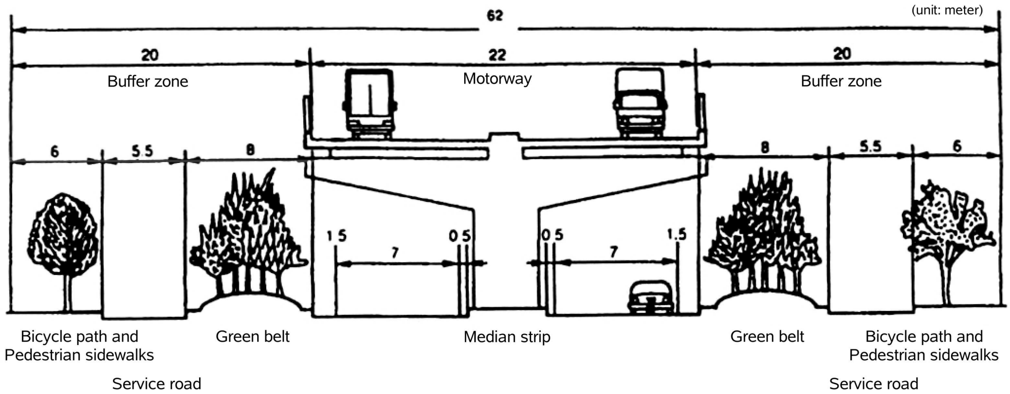


Fig. 8. Highway with buffer zone (Tokyo Outer Ring Road).

3.6. Sound insulation of roadside buildings

According to the draft recommendation by the WHO, the desirable noise level inside residential houses should be lower than 30 dB (A) for healthy sleeping and therefore lower than 45 dB (A) outside when considering the sound insulation performance of common houses. In the case of arterial roads in urban areas, however, it is almost impossible to sustain such a low noise level outside the buildings and therefore it is necessary to improve the sound insulation of buildings to realize desirable noise levels inside the buildings. As an administrative measure regarding sound insulation of roadside buildings, the "Law for improvement of the areas along trunk roads" was established in 1980 and partially revised in 1996. The aim of this law is to prevent serious road traffic noise hazards and to promote land use of roadside areas. In this law, the subsidy system for sound proofing works is specified, which can be applied if the noise level is over the specified value (for example, 65 dB (A)) both in the measurement and in the calculation for specified areas. If the conditions are fulfilled, such sound proofing works as reinforcement of building facades, provision of double glazed windows and air-conditioning systems are performed at the expense of the road administrators. This law also specifies the procedures of improving areas along trunk roads, such as urban planning in which the enhancement of the construction of buffer buildings and sound insulation of houses and schools are included. Up to this time, however, it can not be said that this law has fulfilled its function because of the difficulties of reaching a consensus among residents for the roadside measures and because the budget is not sufficient. In the future, this law should be improved and expanded so as to promote the construction of roadside buffer buidings which have sufficient sound insulation and are effective to protect the back areas from the road traffic noise.

4. Assessment method for road traffic noise assessment

As an indicator for environmental noises, L_{50} has been videly used in Japan so far and the Environmental Quality Standards are specified by this indicator. On the other hand, $L_{A\mathrm{eq}}$ is being used almost all over the world, and recent physiological and psychological researches have indicated that the doze-response relationship of noise is well assessed by $L_{A\mathrm{eq}}$. For these reasons, the Environmental Agency has started an investigation of the introduction of $L_{A\mathrm{eq}}$ into the Environmental Quality Standards. Thus, $L_{A\mathrm{eq}}$ will be adopted as the main indicator for the assessment of environmental noises in the near future in Japan.

5. Progress of the prediction method of road traffic noise

When dealing with noise problems, noise prediction methods are indispensable. Regarding road traffic noise, the Technical Committee of Road Traffic Noise Prediction was established at the Acoustical Society of Japan in 1974 and it proposed the first prediction method in 1975. This prediction model (ASJ-Model 1975), which provides L_{50} values through relatively simple calculations, has been widely used for the impact assessment of road traffic noise in Japan. On the other hand, it has become necessary to expand the applicability of the prediction method and to predict $L_{A\mathrm{eq}}$ at roadside areas. Hence, in 1988, the Committee started research work to develop an energy-based road traffic noise prediction model. As a result, a new model (ASJ-Model 1993) has been proposed in 1993 [4, 5]. In this model, a time pattern of sound pressure (unit pattern) at an observation point is calculated first and by integrating the pattern and considering such traffic conditions as the traffic volume, mean speed and vehicle constitution, $L_{A\mathrm{eq}}$ can be obtained as an energy-based time averaged value. In principle, the model can be applied to almost all types of roads including such special parts as interchanges and junction. The concrete calculation procedures are now being investigated by the Committee.

6. Conclusions

To conclude this paper, future topics for the improvement of the road traffic noise problem are enumerated below.

Firstly, from the engineering viewpoint, the following subjects should be further investigated.

• On-the vehicle noise source control: reduction of engine noise and tire/road noise, development and diffusion of low pollution cars;

• Improvement of road structures: underground, semi-underground and shelter type structures, development of effective noise barriers (phase control and active control), development of low noise pavements, absorption treatment of road structures, design of environmental buffer zone including planting and greenfication;

• Traffic control: speed control, heavy truck control, optimum control of traffic signals;

• Development of roadside buildings: new concepts of integrating road structures and buildings, new designs of building facades, development of building elements and facilities with high sound insulation;

• Improvement of the noise prediction methods.

Since the road traffic noise problem is a very complex social phenomenon, it can not be settlet only be engineering measures and the following counterplans must be considered at the same time.

• Urban planning: land use plans, transfer of urban structures, roadside countermeasures;

• Economic and transport system: total transportation schemes, modal shift, introduction of new transportation systems, road network planning, proper configuration of facilities for physical distribution, development of new physical distribution systems, traffic control measures;

• Legal and administrative improvement and enforcement of related laws (Law for improvement of areas along trunk roads, Building Codes, etc.);

• Socio-psychological approach: establishment of environmental ethics, consciousness of the environmental load, consensus of roadside measures.

In previous days, construction and preservation of the environment were apt to be considered contrary to each other but they have to be reconciled together to the future.

References

[1] U. Sandberg, *Noise emission of road vehicles — Effect of regulations. Final report of an I-INCE Working Party*, Noise News International, 83–113 (June 1995).

[2] M. Takahashi *et al.*, *Sound power levels of road vehicles measured using a reverberant tunnel — statistical analysis*, Proc. of Inter-noise '95, 207–210 (1995).

[3] Y. Oshino and H. Tachibana, *Relationships between road texture and tire/road noise*, Proc. of Noise-Con '96, 67–72 (1996).

[4] H. Tachibana and M. Sasaki, *ASJ prediction methods of road traffic noise*, Proc. of Inter-noise '94, 283–288 (1994).

[5] K. Takagi and K. Yamamoto, *Calculation method for road traffic noise propagation proposed by ASJ*, Proc. of Inter-noise '94, 289–294 (1994).