中華民國音響學會
第一屆學術研討會論文集

中華民國七十七年十一月十八日
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ABSTRACT

Environmental Criteria on Noise and Measures for Noise Control

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Pollution control act of Japan was enforced in 1967 and environmental criteria were requested to be published. Environmental noise standards including transportation noise; road traffic, aircraft and high-speed railway were established in series.
Details of each standard and process of discussion will be presented. Various measures have been performed to meet the standard, several successful examples and also unsolved problems will be mentioned.

Environmental Criteria on Noise and Measures for Noise Control

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1. Introduction.

The decade of the 1960's in Japan was a period of rapid industrial progress and many highways and high-speed railways were constructed over the country.
Consequently, many people were adversely affected by noise. The introduction of jet aircraft in domestic airlines resulted the most serious impact on the residents around Osaka airport. In addition to noise, air and water pollutions also were recognized as serious impacts in the environment. In 1967, Pollution Control Act was passed by the Diet, and guidelines of environmental criteria for controlling pollutants and countermeasures were requested to be reported. The committee on noise was established by the government in 1968.

2. Fundamental Concept of Noise Standard.

(1) The noise criterion is a guideline of the administration. The desirable limit of noise level in the environment, the method of measurement, counter-measures and the period of achievement have to be included in the report.

(2) Human reaction to various kinds of noises should be studied and the threshold levels for protection of human life have to be defined.

(3) The international trend of noise studies should be reflected. The ISO recommendation R 1996(1) is an important reference.

In 1971, the Environment Agency was established in the government and it was responsible for enforcement of the noise policy. Results of noise surveys and published papers on effects of noise impact were collected by the noise committee, and details of them were carefully discussed. Noise standards in general, on Road traffic, Aircraft and High-speed railway(Shinkansen) were promulgated in series based on reports of the committee.

3. Descriptors for various types of noises.

Noises in the environment usually fluctuate irregularly, and as a descriptor of noise impact, L_{50} was adopted for the environmental noise in general and road traffic noises. L_{50} was proposed in 1952 as an index of the environmental noise in the municipal ordinance of Tokyo. It was specified later in the national standard JIS of 1956(2).

For evaluation aircraft noise, the succession of intermittent noise had to be considered. In the JIS, the intermittent noise was specified to be measured by its peak level and frequency of occurrences. However, it was felt preferable to select a single number descriptor like NNI of Great Britain. In 1969, Special Meeting on Aircraft Noise was held in Montreal, Canada sponsored by ICAO. At the meeting, several items were discussed on Effects of Aircraft Noise, Special Indices of Aircraft Noise and their Measuring Methods, Procedure of Noise Certification of Aircraft, Noise Abatement Operational

Procedure, Land Use Planning around Airport(3).

As an unit of aircraft fly-over noise, EPNL(Effective Perceived Noise Level) was defined and proposed to use in the Noise Certification, and for succession of fly-over noises, an integrating and averaging level, ECPNL (Equivalent Continuous PNL) was defined based on EPNL. The noise certification has been very effective to reduce the fly-over noise of the recent aircraft. ECPNL was proposed to unify the various kinds of descriptors used in western countries for land use planning, NNI in Great Britain, NEF in USA, N in France and Q in West Germany. ICAO recommended also to use ECPNL, if any country would select a new descriptor on aircraft noise. It is written as follows,

$$\begin{aligned}\mathrm{ECPNL} = L_{PNeq} &= 10\log_{10}\{(10/T)\,\Sigma\,10^{\mathrm{EPNLi}/10}\}\\ &= 10\log_{10}\{(1/N)\,\Sigma\,10^{\mathrm{EPNLi}/10}\}+10+10\log_{10}N-10\log_{10}T\\ &= \overline{\mathrm{EPNL}}+10+10\log_{10}N-10\log_{10}T\\ &= \overline{\mathrm{EPNL}}+10\log_{10}N-39.4\end{aligned}$$

where $\overline{\mathrm{EPNL}}$:Average level of EPNL.

N : Frequency of aircraft operations per day.

The constant 10 means that the normalized duration of the fly-over noise(EPNL) is 10 seconds, and T is an averaging time in second of one day.

(24 hours = 86400 seconds) 10log 86400 =49.4

If corrections of times of day are included in ECPNL, it is written as WECPNL.

We decided to adopt the ICAO Unit for the aircraft noise descriptor, however, ECPNL was based on the scale of perceived noise level PNL, which included the frequency analysis of the fly-over noise. On the other hand, ICAO suggested to use the approximate value of PNL in the case of land use by adding a constant 13 to the A-weighted sound pressure level.

Accordingly, in the Japanese aircraft noise descriptor, WECPNL was modified as follows,

$$\begin{aligned}\mathrm{WECPNL}' &= \overline{L_{Amax}+13}+10+10\log N'-49.4\\ &\fallingdotseq \overline{L}_{Amax}+10\log N'-27\end{aligned}$$

$\overline{L}_{Amax}$: The average value of peak levels of fly-over noises in A-weighted sound pressure level.

$N' = N1 + 3N2 + 10\ N3$

N1 : Noise events in the day time. (07.00-19.00)

N2 : Noise events in the evening. (19.00-22.00)

N3 : Noise events in the mid-night.(22.00-07.00)

In the modified formula, the duration of fly-over noise was approximated as 10 seconds on the average, and a tone correction of noise was neglected. The times of day corrections of noise levels were replaced by the frequency of noise events, namely, instead of addition of 5 dB to the noise levels in the evening, the frequency of noise events were counted by 3 times of the actual ones, for addition of 10 dB in the night time levels, 10 times of the noise events.

For evaluation of high-speed railway noise, several descriptors were examined, $L_{Aeq,T}$, WECPNL and L_{Amax}. However, before 1950, we had only two lines of high-speed railway, from Tokyo to Kobe (Tokaido line) and Kobe to Okayama(Sanyo line). The frequency of operations were between 150 to 200. Then,as a simplified procedure for measurement, a single value L_{Amax} was adopted as an index of the intermittent noise following to JIS, neglecting the frequency of operations.

4. Evaluation of various kinds of noises.

(1) Effects of noise in general : For evaluation of noise, effects on hearing and sleep, impacts on daily life, disturbance to conversation and TV reception, psychological effect of annoyance were considered based on various materials published and results of noise measurements, social surveys performed at the related districts. Many results suggested that the outdoor noise level below 50 dB had little effect on daily life, and as a desirable level in the day time, 50 dB in A-weighted sound pressure level was defined. The report of the effect on sleep was also referred, it indicated that a threshold level of noise impact during sleep should be below 30 dB and taking into

account of the 10 dB reduction by the house construction the outdoor noise level should be 40 dB in the night(4).

Accordingly, in the noise standard, the corrections for times of day were considered. It is similar to ISO R 1996 ; those are,

Day time :	0
Early morning & Evening:	- 5
Night time:	-10

Another corrections for residential premises in different zones are

Exclusively residential area:	- 5
Residential area:	0
Commercial & Industrial areas:	+10

Table 1 shows the noise limits in general environment.

(2) As a noise standard of the area along the road, the additional correction of + 5 or + 10 dB to Table 1 was considered depending on numbers of traffic lanes. Table 2.

(3) The evaluation of aircraft noise was discussed based on the report of the special meeting in ICAO, published data in Europe and USA, and results of social surveys around Osaka airport and an airbase near Tokyo. The evaluation of aircraft noise by different descriptors of other countries were transferred to WECPNL' and referred too. The standard of aircraft noise was determined as WECPNL' 70 for residential area and 75 for other commercial and industrial areas, by taking into account of the human response to aircraft noise and by comparison with that of the road traffic noise (5). The noise limit of the road traffic noise, $L_{50} \sim 55$ dB was considered to be almost equivalent to WECPNL' 70, providing,

$L_{Aeq,T} \fallingdotseq L_{50} + 2$, and WECPNL' $\fallingdotseq \underline{L_{Amax} + 13}$

(4) There were few data for evaluation of railway noise, and results of measurement and social survey along Tokaido and Sanyo lines were important data to be referred(6). The noise standard of high-speed railway was set as L_{Amax}, 70 dB for residential area and 75 dB

for other commercial and industrial areas, from results of the human response and the equivalence to noise limits of road traffic and aircraft.

5. Counter-measures for various kinds of noises.

Efforts of control of transportation noises have been directed towards the reduction of noise radiated by the source and towards the land use. Several measures for improvement of the environment are as follows,

(1) Road traffic :

(a) The noise levels of motor vehicles have been regulated by a type test. The noise limits have become stringent as shown in Table 3.

(b) Assessment of noise environment has been performed at the planning stage of new roads or highways. The procedure of the prediction of the road traffic noise was established by the technical committee of the Acoustical Society of Japan in 1975(7).

(c) Several kinds of barriers were constructed to protect the near-by residents.

(d) Scale model experiment has been developed for the prediction of the road traffic noise radiated from complex road structures.

(2) Aircraft :

(a) Noise level contours were delineated for most airports and airbases in Japan and noise control measures were instituted, such as the introduction of the noise certificated aircraft, the application of noise abatement operational procedures, the purchase of noise impacted land around airports and the compensation of homeowners near airports for the sound insulation of houses.

(b)The monitoring of aircraft noise has been performed at airports and airbases in Japan. The aircraft noise is measured automatically at the specified locations around airfields. The discrimination of aircraft noise from other noises in the environment by a correlation technique has been applied to the monitoring system(8). In addition, the flight path is monitored, obtaining noise data at two separate locations. Identification of aircraft types in flight from noise spectra has been underway(9).

(c) Reflecting serious environmental noise problem around Osaka airport, a new airport has been under construction, at 5 km offshore in Osaka bay since 2 years ago. It will be opened by 1993 as an international airport with round-the-clock operations (without night curfew).

(3) High-speed railway :

Various noise control measures have been carried out to reduce the noise and the ground vibration generated by the high-speed railway. Many kinds of elevated structures were constructed, various types of barriers along the railway track were built. Another noise reduction measures are : polishing of the corrugated rail surface and the flat of wheels, improvement of the structural vibration characteristics of a pantograph to reduce the electric discharge noise, and also the reduction of numbers of pantographs.

6. Land Use.

The land use was considered as an important policy to be enforced by the government. However, it has been limited to the purchase of land and sound proofing of houses, and the legal regulation of private lands has been unsuccessful. Accordingly, budgets for land purchase and house insulation have become big economical impacts in Japan.

7. Litigation against Noise.

According to the serious impact of transportation noise, several legal actions were raised at Osaka and Fukuoka Airports,and also at a couple of Airbases. Final decision of the Supreme Court to that of Osaka Airport was arrived at a few years ago, it was as follows,

(a) The operation of aircraft should be restricted from 9 o'clock in the evening to 7 o'clock in the morning.

(b) The government should pay compensation to individuals who had been living in the area since 1973 when the standard on aircraft noise was first enforced.

(c) The government should take action to reduce the impact of people exposed to the aircraft noise.

A law suit against the high-speed railway in the Nagoya district had been in the court since 1975, but this suit was settled by the railroad's paying an indemnification to residents along its line.

8. Conclusion

(a) The noise limits of transportation noises were proposed as desirable guideline values, and standards were promulgated as Notice of Environment Agency, but they were received as tolerable limits and regarded as Law by most of people.

(b) The different type noise descriptors were adopted in the standards, they have to be unified in future based on $L_{Aeq T}$, which has been defined in the revised JIS. Recently, ICAO withdrew the index of (W)ECPNL and changed to $L_{Aeq T}$, because few countries had adopted ECPNL and Japanese WECPNL' was regarded as the equivalent A-weighted sound pressure level, $L_{Aeq T}$ too.

(c) Another new high-speed railways were constructed after 1950 when the noise standard was issued. The descriptor of railway noise, L_{Amax} has to be revised, because the frequency of operations of new lines are quite different from that of Tokaido line.

The evaluation and counter-measures of the rail way noise of local lines are next problems to be solved.

In conclusion, environmental standards in Japan have played an important role to improve the environment. However, the control of transportation noise by technical measures is limited for achievement of the goal, and the policy of the land use should be enforced in spite of the difficulty of the restriction of the private right.

9. References.

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(6) Measurement and Social Survey along Shinkansen.
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(8) T.Ono :Aircraft Noise Monitoring System with Identification by Correlation Technique.
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(9) I.Yamada: Acoustic Recognition of Aircraft Types in Flight. Proc. Inter-Noise 83. p.827

Table 1. Noise Standard in General Environment

Type of Areas	Day Time	Morn. & Even.	Night Time
AA	45	40	35 dB
A	50	45	40
B	60	55	50

Note: AA - Exclusively Residential Area

A - Residential Area

B - Others(Commercial & Industrial Areas)

Table 2. Noise Standard along the road

Type of Area	Day	Morn.& Eve.	Night
A, 2 lanes.	55	50	45
A, > 2 lanes	60	55	50
B, 2 lanes	65	60	55
B, > 2 lanes	65	65	60

Table 3. Regulation of Motor Vehicle Noise

Type of Vehicle	1971	1976	1979	1982	1083	1985
Heavy Vehicles						
> 3.5 tons,& > 200HP						
Trucks	92	89	86			*83
Busses	92	89	86			83
Medium Vehicles						
> 3.5 tons,& < 200HP	89	87	86	83		
Light Vehicles						
< 3.5 tons	85	83	81			
Passenger Cars	84	82	81			75
Motor Cycles						
> 250 cc	86	83	78			*75
25~250 cc	84	83	78			75
Mopeds						
50 ~125 cc	82	79	75			*72
< 50 cc	80	79	75			72

Note: Acceleration Test Method.(ISO) * Future Goal

Practical Calculation of Floor Impact Sound by Impedance Method

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SUMMARY

This paper describes a practical floor impact sound level calculation method for a impact source with heavy-weight and soft, such as children jumping and running. The floor impact sound for heavy and soft impact source is strongly influenced by structural factors as floor slab stifness and peripheral support conditions. The manner of analyzing these structural factors for performing the sound level calculation was described. We present a sample of measured values and calculated values from an actual structure to show the accuracy of this method.

1. Introduction

Practical calculation method of floor impact sound by using an impedance method was presented by the authors.[1),2)] According to this calculation method, designers can easily estimate performance of floor structure in order to reduce floor impact sound levels while at the design stage. In addition, this method can well correspond to actual values, and is expected to be an excellent practical method.

Under this method, floor impact sound is calculated according to the flow chart indicated in Fig.1. The flow chart is roughly composed of the following three sections: (1) impulsive force chracteristics of impulsive source which is input to floor slabs; (2) vibration characteristics of floor slabs; and (3) acoustic characteristics in the room below. The method to calculate floor slab vibration characteristics, which directly contributes to the generation of floor impact sound, is emphasized in this flow.

In this paper, the handling method of each factor which composes the flow of Fig.1 is explained and the examples are shown when this calculation method was applied to an actual floor structure.

JIS A 1418 (Japanese Industrial Standard) stipulates the use of light-weight and hard impact source (tapping machine) and heavy-weight and soft impact source (see Fig.2 Impulsive Force Characteristics) for measuring performance of floor impact sound level at site.

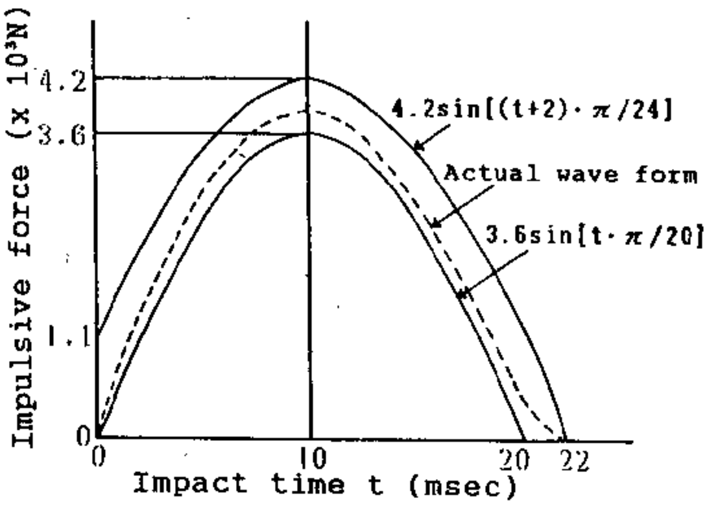

Fig.2 Time Characteristics of Heavy and Soft Impulsive Force (JIS A 1418)

Heavy-weight and soft impact sources are stipulated as simulation of children running and jumping on a floor." People living in multiple dwellings in Japan (a country where shoes are not worn in the house) overwhelmingly complain about floor impact sounds caused by children, i.e. heavy-weight and soft impact sound sources. Heavy-weight and soft impact sources, as shown in Fig.2, show the peak impulsive force 4,000N and duration 20msec. The floor impact sound insulation performance is related to the dynamic performance of the building structure. Thus, the JIS is also applicable when checking the rigidity of a floor structure.

In this report, we will explain the calculation method of floor impact sounds when the floor slabs are excited by heavy and soft impact sources as stipulated in the JIS.

We measured the impulsive force of people (the typical heavy-weight and soft impact sources generated in daily life)