REVIEW OF MEASURES FOR MITIGATION OF NOISE IMPACT AROUND CIVIL AIRPORTS AND MILITARY AIRFIELDS IN JAPAN

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ABSTRACT
This paper discusses noise measures that have been taken for mitigation of noise impact around civil airports as well as military airfields in Japan. First, it reviews the history of environment improvement activities during the last 30 years. Then, it speaks about the framework of noise exposure calculation methods, noise criteria and environment improvement programs of civil airports and military airfields. Finally, it also discusses the effectiveness of the environmental remedial measures.

1. INTRODUCTION

In Japan, aircraft noise first became an object of public concern in 1950's after World War II. People were exposed to severe noise due to military flight operations of jet fighters at several airbases such as Tokyo, Osaka, etc. Based on investigations, in which questionnaire surveys and noise measurements using maximum C-weighted sound pressure levels were carried out, soundproofing was applied to schools and hospitals since 1955 [1-3]. Next was the introduction of jet airliners to civil aviation. In 1960's there was a high-growth of Japanese economy with the 1964 Olympic Games held in Tokyo; expressways and high speed railways were constructed one after another. But, it was accompanied by various environmental pollution problems, against which many lawsuits were raised. For example, at the Osaka International Airport, it was in 1964 that an airline company started jet operation. Aircraft noise at once became a serious social problem, because it was already highly urbanized in the surrounding area. Residents filed many lawsuits against the national government through the middle of 1970s for compensation to noise damage and for enforcement of noise abatement measures.

To solve such severe noise impact around airports, the Ministry of Transportation at that time took various necessary control measures at the sound source such as the ban of nighttime flights at the Osaka and Tokyo International Airports, but it was insufficient because of rapid increase in air traffics. In 1967, the 'Basic Law for Anti-Pollution Measures' was enacted, which was revised to the present

'Basic Law for Environment' in 1993. It provides that environmental quality standards shall be established as desirable criteria to maintain people's health and living environment in good conditions. Based on this legislation, the 'Environmental Quality Standards for Environmental Noise' was specified as early as in 1971. There were, however, a lot of arguments how to evaluate intermittent or impulsive noise events, resulting in independent notification of noise standards for aircraft and rail; 'Environmental Quality Standards for Aircraft Noise' (abbr. EQSAN) in 1973 and 'Environmental Quality Standards for Shinkansen Railway Noise' in 1975. Based on these standards, laws and regulations have been enacted in order to fulfill measures for various noise issues.

Regarding aircraft noise, there are the 'Law for the Prevention etc. of Troubles due to Aircraft Noise around Public Airdrome' (abbr. ANPL) in 1967, 'Law for the Improvement, etc. of Living Environment around Defense Facilities' (abbr. LILEDF) in 1974, 'Law for Special Measures against Aircraft Noise around Designated Airports' in 1978 and so on. The Civil Aeronautics Law was also revised to include an institution for a noise certification system of civil airplanes in 1975.

As for civil aviation, the national government has promoted various noise measures under the ANPL in a well-balanced manner; 1) noise control at the sound source, 2) improvement of airport constructions and 3) environmental remedial measures. Resultantly, the noise situation around the airport was remarkably improved and complaints were gradually calmed down. The airport and surrounding local communities are now aiming at the establishment of partnership each other as the mainstay of revitalizing regional economy.

As for military case, in contrast to civil aviation, the noise situation around defense air fields seems to be still severe, although the Defense Facilities Administration Agency has fulfilled similar measures except noise control at the sound source, which was limited to the control of flight procedures and operations. Several court cases on noise issues are still going on in dispute at several airbases to ask for inhibition of flight operation and compensation to the impact of aircraft noise.

2. Environment Quality Standards and Noise Criteria for Aircraft Noise

The EQSAN, notified by the Environment Agency in 1973, specifies outdoor noise standards and target dates for attainment, as shown in Table 1 and Table 2, using $WECPNL_{\mathrm{J}}$;

$$WECPNL_{\mathrm{J}} = \overline{L_{\mathrm{ASmax}}} + 10 \cdot \log_{10}\left(N_{\mathrm{d}} + 3 \cdot N_{\mathrm{e}} + 10 \cdot N_{\mathrm{n}}\right) - 27 \quad , \qquad (1)$$

where $\overline{L_{\mathrm{ASmax}}}$ is the energy average of maximum A-weighted sound pressure levels, greater than the background noise by 10 dB or more, of aircraft noise events observed a day, and N_{d}, N_{e} & N_{n} numbers of events observed during daytime (07:00-19:00), evening (19:00-22:00) and nighttime (22:00-07:00). Note, in case of noise evaluation around defense facilities, a duration correction of adding 10 log10 (T/20) to maximum levels is applied to the calculation of WECPNL.

The institution of environmental quality standards for aircraft noise was discussed by a council organized by the Government since 1970. It started discussion with investigating details of an ICAO report published only half a year before. As the report had recommended WECPNL for use as an internationally standardized noise evaluation index for land use planning, the council decided to introduce it to the standards, taking the internationalism of air transportation into consideration as the most important, but the ICAO procedure was too complicated to apply to usual noise measurements. Then, the council proposed to approximate PNL as L_A+13, being based on experiments. Besides, it also proposed to use Eq. (1) instead of the equation calculating an equivalent continuous level of noise events with level adjustments. Here, the sound duration is assumed to be a fixed value of T~20s for all noise events. The sound duration may be shorter than 20 s at a site close to runway. But, the council decided to make the sound duration adjustment as zero so that no negative adjustment is included. The top priority was given to recover a quiet environment in the vicinity of airport.

For the calculation of WECPNL, the EQSAN requires outdoor noise measurements, which are basically carried out consecutive 7 days, at sites selected as representing aircraft noise in the area concerned. The council also discussed whether the standard could be applied not only to new airports, but also to existing airports and airbases and whether target dates for attainment should be described in the standard. Finally, the council decided that the standards apply to all airports at which there were more than 10 flight operations a day in yearly average.

Target dates for existing airports were set to 'be attained within 5 or 10 years'. It was felt difficult to improve the noise situation so fast, because the technology mitigating aircraft noise at the source was still underdeveloped at that time to satisfy the standards. Therefore, intermediate indoor improvement goals were established as 'less than 65 WECPNL indoors in areas exceeding 85 WECPNL outdoor' and 'less than 60 WECPNL indoors in areas exceeding 75 WECPNL outdoor' in order to encourage promotion of countermeasures. The target dates for Tokyo, Osaka and Fukuoka were not definitely specified, because these airports had been already surrounded in densely populated areas and residents did not want to leave away from lands where they had lived long. It was then recognized as in conformity with the standards if the noise exposure indoors remained below the alternative improvement goals.

In case of air fields of the Self Defense Forces, etc., the EQSAN only says in a note that efforts shall be made to attain the environmental quality standards till the same target dates as those for civil airports under similar conditions in Table 2, considering the average number of landings and take-offs, type of aircraft and concentration of houses.

Table 1: The Environment Quality Standards for Aircraft Noise.

Types of areas	Standard value in WECPNL	Application
I	70 WECPNL or less	Area exclusively for residential use
II	75 WECPNL or less	Area other than Type I, where ordinary living conditions is necessary

Table 2: Target dates to attain standards and indoor improvement goals of the EQSAN.

Type of Airports			Target Dates	Improvement Goals
New Airports & 3rd class existing airports			Immediately	----
Existing Airports	2nd class airports except Fukuoka Airport	A: Other than B	Within 5 years	----
		B: Turbo Jet	Within 10 years	(Within 5 years) to attain less than 85 WECPNL or less than 65 WECPNL indoors in areas exceeding 85 WECPNL
	New Tokyo International Airport		ditto	Ditto
	1st class airports excepting New Tokyo International Airport and Fukuoka Airport		As soon as possible within 10 years or more	(Within 5 years) The same as above (Within 10 years) to attain less than 75 WECPNL or less than 60 WECPNL indoors in areas exceeding 75 WECPNL

3. ENVIRONMENT REMEDIAL MEASURES IN JAPAN

Civil Airports

Environmental remedial measures around civil airports for reducing impact of aircraft noise and for improving living environment have been carried out mainly by the national government, being based on the 'Law Concerning Prevention etc. of Disturbance Caused by Aircraft Noise in the Vicinity of Aerodromes for Public Use' (abbr. Aircraft Noise Prevention Law, i.e. ANPL), enacted in 1967 and revised in 1974, as well as the Environment Quality Standards for Aircraft Noise (abbr. EQSAN) notified in 1973 [2-5]. During the discussion to make up the EQSAN, the national government council for

considering measures against public nuisances had stressed the importance of noise control measures at the source, land use planning and control, and relocation and improvement of green zones in especially noisy regions.

The law ANPL was amended in 1974 to cover inadequacies in the original 1967 law such as the lack of subsidies for insulating private houses. As shown in Figure 1 below, the amended law provides for: 1) subsidies to soundproof existing private houses in a 'Class-1' zone (WECPNL>75), 2) compensation for relocating families living in a 'Class-2' zone (WECPNL>90), and 3) improvement as green buffer zones in a 'Class-3' zone (WECPNL>95). During the discussion for the amendment, it was agreed that, on a long-term basis, future airport construction should have been planned on the sea surface or on a land after sufficient land use planning around the supposed area. As for existing airports, on a long-term basis, it was decided to consider removal to regions without severe noise impact. It was also decided, as environmental remedial measures for the time being, to relocate houses in the vicinity of airports (Class-1 and Class-2 zones) and re-develop the outer land area for noise compatible planned use (Class-1 zone). Besides, to complement these measures, it was decided to provide for subsidies to soundproof houses which still remain in Class-1 and 2 zones since the designation of the zones.

The environmental remedial measures are undertaken by the Organization for Environment Improvement around International Airports at Osaka and Fukuoka Airports, by the airport authority at

Fig.1 Environmental remedial measures carried out under the Law ANPL [4].

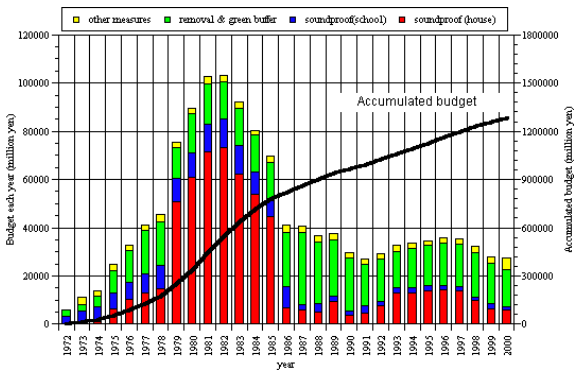

Fig.2 The monetary cost expenses for environmental countermeasures against aircraft noise around civil airports in Japan [4].

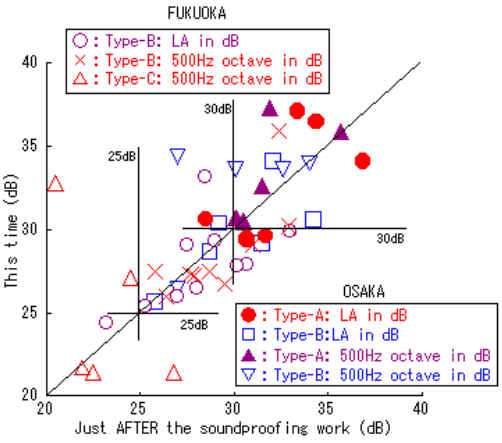

Fig.3 Comparison of sound insulation performance (CTL_A & $CTL_{500Hz,octave}$) of the soundproofed houses [5].

Narita Airport, and by the national government at all other specified public airports. In addition to it, private sector foundations such as the Airport Environment Improvement Foundation fulfill environment remedial projects that meet local needs around airports but that are not covered by the ANPL, to compliment the work of the national government. It is aimed at promotion of mutual understanding and partnership between the airport and the surrounding regional communities and at contribution to the growth of local communities.

Figure 2 shows the monetary cost spent by the national government each year for environmental remedial measures under the ANPL. It rapidly increased after the enactment of the law and it became a maximum during 1979-1985. It shows that the government tackled with its all strength the serious problem of aircraft noise around civil airports, in order to satisfy the standards until the target date, i.e. 10 years later the notification of the EQSAN. Roughly speaking, environmental remedial measures have been finished before the new century. Especially, almost 95% of eligible applicants (private houses) for soundproofing works have been treated until 1985. Now, few complaints against disturbances due to aircraft noise are brought from residents dwelling around civil airports. The total expense spent for environmental countermeasures fulfilled by the national government under the law ANPL during fiscal years from 1967 till 2000 is ¥1285 billion, which includes 'soundproofing to educational facilities'/ ¥159 billion and 'soundproofing to private houses'/ ¥590 billion.

The subsidy for 'soundproofing to private houses' covers the cost expense not only for the soundproof construction work, but also for the installation of air conditioners to keep clean air inside the soundproofed rooms, in rooms up to five according to the number of family members at almost 100% (Initially, it was limited to two rooms at most). Table 3 shows three classes of soundproofing methods for soundproofing and their target sound insulation performance, which are selected according to the noise exposure at the area concerned. The target performance is evaluated, being based on the composite sound transmission loss at a 500Hz octave band (abbrev. CTL_{500Hz}).

Figure 3 shows a comparison of changes in sound insulation performance of houses between a recent study and measurements just after the soundproofing work. The sound insulation performance was evaluated as level differences in maximum values of A-weighted sound level (CTL_A) and in 500 Hz octaveband sound pressure levels (CTL_{500Hz}) between inside of soundproofed rooms and outside of the houses. From Fig.3, the measured CTL_A and CTL_{500Hz} this time seem to be, roughly speaking, similar to those measured just after the soundproofing work, irrespective of construction methods. The average and standard deviation of the differences in CTL_A (or in CTL_{500Hz}) was -0.1 and 2.3 dB (or 1.4 and 3.4 dB) respectively. It means that the sound insulation performance still satisfies the planned target unexpectedly. The cause for this is not clear, but it is reported that it might be ascribed to 1) change in indoor sound absorption due to changes in interior conditions such as furniture and walls, 2) change in measurement conditions such as change of flight routes, urbanization of the surroundings, etc.

Table 3. Specified classes of soundproofing methods and target values in the ANPL.

Noise zones	WECPNL dB	Method	Target sound insulation
Class-1	75 – 80	C (only openings)	20 (dB)
Class-1	80 – 90	B (openings, walls & ceilings)	25 (dB)
Class-2	higher than 90	A (openings, walls & ceilings)	30 (dB)

Military Airfields

Being based on the Law Concerning Improvement, etc. of Living Environment around Defense Facilities (abbr. LILEDF), environment remedial measures similar to civil airports has been carried out by the Defense Facilities Administration Agency (abbr. DFAA). However, in the military case, we calculate WECPNL in a manner a little different from the civil case. First, in Eq.(1), we evaluate $\overline{L_{\mathrm{ASmax}}}$ with adjustments for duration correction as 10 $\log_{10}$(T/20) and tone correction for landing noise [6].

Secondly, 5% percentile of the frequency distribution of daily total operations throughout a year, i.e. N_5, is used as the representative value of daily operations $N = N_{\mathrm{d}} + N_e + N_n$ in Eq.(1), because the daily operation number changes day to day irregularly [6-7]. With these adjustments the estimated WECPNL becomes close to L_{den} except a constant bias.

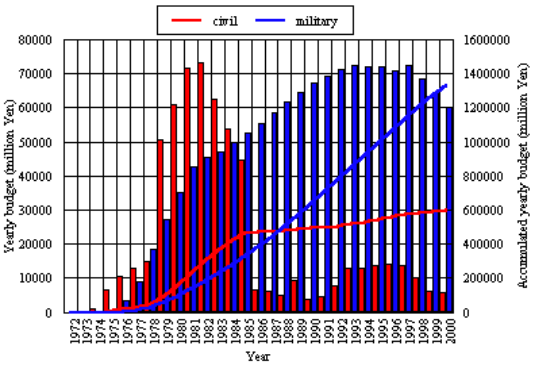

Fig.4 Comparison of change in yearly budget for subsidy to soundproofing of private houses between civil and military cases.

The subsidy system for soundproofing to private houses is similar to that of civil airports. The difference is that in military case the DFAA directly deals with the subsidy procedure, while in civil case people apply to the subsidy via related local governments. There are two methods for soundproofing work, i.e., I & II, which correspond to B and C respectively for the civil case in Table 3, but in case of method-I in the noise zone Class-2, it is considered to additionally apply attachment of soundproofing sheet material made of lead. According to experimental result the method-I brings a soundproofing performance of about 30 dB after the construction work. Figure 4 shows yearly change in the monetary cost spent each year for the soundproofing work of houses around defense facilities under the LILEDF. It shows that the DFAA had to cope with the tough job to deal with severe noise impact around defense facilities even after the environmental remedial measures around civil airports had mainly finished in mid 1980's. Around ten years later, the budget had reached a maximum and the accumulated total of the budget spent till 2000 for the soundproofing work around defense facilities amounts to ¥1,300 billion, twice higher than civil case, as is shown in Figure 4. However, local communities such as residents' associations and local governments point out negative health effects and disadvantages due to the presence of defense facilities and require further measures such as subsidy for the maintenance cost of air conditioners, higher soundproofing performance, etc. Even judicial decisions admit only a limited effectiveness of the soundproofing works.

4. CONCLUSION

This paper briefly reviewed the environmental remedial measures that have been taken for mitigation of noise impact around civil and military airfields in Japan. There are now only a few noise complaints around civil airports because of remarkable decrease of noise impact and remedial measures, but if we consider dealing with the increase in air traffics, it is expected to establish better partnership between the airport and local communities. On the other, the noise situation around defense facilities remains severe irrespective of endeavors by the national government, resulting in requests for enrichment of environmental measures, further compensation and subsidy from residents and local communities. Finally, there are also unsolved problems common to both cases such as effective use of a lot of unused sites left around the airport after the promotion of relocation of houses.

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