Annoyance caused by single and combined noise exposure from aircraft and road traffic

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The first synthesis study for the community annoyance to several traffic noises was conducted from an in-depth survey in Korea from 2003 to 2007, which was reported by the authors in ICBEN 2008. Previous research has investigated the effect of exposure from single source and compared the response of Korean with that of European and Japanese. The response varies with different cultures as well as different noise sources. A large part of the population is exposed to combined noise from multiple sources, but there is no standardized method for assessing the effects of combined noise. Although many researchers have investigated the response from combined noise exposure, it has little been reported that the annoyance caused by combined noise exposure from aircraft and road traffic. The purpose of this study is to assess the effects of dominant noise source with relatively high sound exposure level on total annoyance and compare the total annoyance from combined noise exposure with annoyance from single noise exposure. The result of this research would be useful when the effects of the multiple noise sources should be considered to establish the standard, regulation, and noise mitigation policies.

Key words: annoyance, combined noise exposure, %HA

1. INTRODUCTION

A number of social surveys have been conducted to assess the community response to environmental noise since the 1960s. Most previous studies focused on the establishment of annoyance curves for single noise sources which stand for the reaction of people live in a nation or a cultural area [1-5]. Recently Korean annoyance curves for four traffic modes (military and commercial aircraft, railway, and road traffic) have been also reported and the results showed the different responses to each noise source compared with those of European and Japanese [6-8].

Through the previous survey there has been increasing interest in the response from combined noise exposure. Most of the participants in the survey complained the annoyance from other noise sources as well as a main noise source in and around their house. The effect of the other noise on the annoyance rating for the main noise source cannot be negligible, even though the sound level of the main noise source is much higher than that of the others.

Although some studies have been conducted on the response from combined noise exposure [9-12], the methodology has not yet been made clear and conflicting results have been reported. Simulated laboratory experiments have been conducted during the past years by the authors to observe subjects' response from combined noise exposure and establish the acceptable models for prediction of the different annoyance according to various conditions of noise exposure. When the difference between two individual sources of a combined noise sample is less than 10 dB of $L_{Aeq,30s}$, overall response from combined noise showed more annoying than the response from its individual component sources. When the difference is more than 10 dB of $L_{Aeq,30s}$, on the other hand, overall response showed as annoying as the response from a dominant component source of higher level. There was no significant difference between overall response and the response from a dominant source.

We have extended our investigation to a field study 1) to assess the annoyance caused by combined noise exposure and 2) to compare the result of combined noise exposure with that of single noise exposure and 3) to establish the exposure -response relationships for various conditions of combined noise exposure. In this paper, the preliminary results of field study in community exposed to both aircraft and road traffic noise are introduced and annoyance curves of combined noise exposure are established. More details on this research are in preparation for publishing as a follow-up paper.

2. MATERIALS AND METHODS

In order to assess the annoyance from the combined noise exposure, noise measurements and social survey have been carried out in community exposed to both aircraft and road traffic noise. The procedure of the filed survey are designed according to the "Conference Reporting Guidelines" which were previously suggested by Fields et al. [13], and newly updated in 2009 by the Community Response Team of ICBEN.

2.1 Survey Sites and Assessment of Noise Exposure

Field survey was carried out at 16 sites in October and November of 2006 and 2008. The survey areas are located around Gimpo Int'l Airport, which 16 sites are also exposed to road traffic noise from Sinwol I/C and express way. Survey sites were selected according to various conditions of combined noise exposure. In this paper, the sites were divided into two categories like 'no dominant noise sites' and 'road noise dominant sites'. 'no dominant noise sites' is defined as equally noisy sites which the level difference of two component sources is 3 dB or less than 3 dB of $L_{Aeq,24h}$ and 'road noise dominant sites' is defined as sites which road noise level is higher than aircraft noise level as more than 5 dB of $L_{Aeq,24h}$.

Information on the survey sites of single and combined noise exposure are reported in Table 1. Survey data of single noise sites used for comparing the response with that of the combined noise exposure have been obtained from the previous research by the authors [8]. In case of the single noise sites, the difference between the main noise source and the others was more than 10 dB of L_{Aeq} of a passing-by event.

Table 1. Information on the survey areas

Category	Definition	Number of respondents
Total numbers of single noise exposure		*1,245*
Single road noise sites	Road – background > 10 dB	583
Single aircraft noise sites	Aircraft - background > 10 dB	662
Total numbers of combined noise exposure		*550*
No dominant noise sites	Level difference ≤ 3 dB	230
Road noise dominant sites	Road – Aircraft > 5 dB	320

Fig. 1 shows the location of the survey sites of this study. All of the sites are located in the residential area in Gimpo and Seoul, Korea. Noise measurements were made continuously with sound level meters (B&K type 2238, 2250 and Larson & Davis 812) for a week at the most exposed façade of the building, which all of the respondents live in the apartments. Measurement sites are situated at a distance of more than 10 meters from roads in a straight line and questionnaire surveys were performed to people living in the same building of noise measurement. The difference of outdoor noise exposures for respondents within the same building caused by the height of the floors and the sound insulation of the walls has been assessed as 1~2 dB from the simulation of noise propagation using CadnaA (DataKustik).

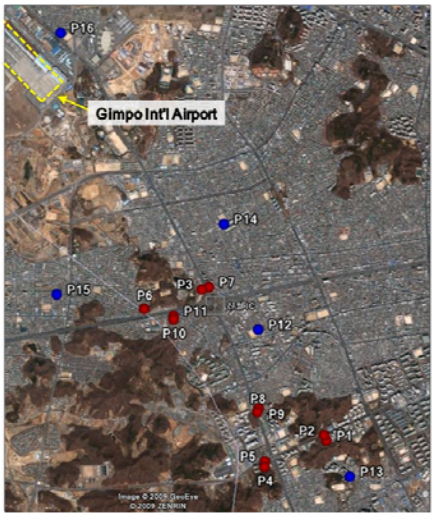

Fig. 1. Location of the survey sites (around Gimpo Int'l Airport and Sinwol I/C)

In this paper, $L_{Aeq,24h}$ is the only noise metric for analysis of the preliminary results. The penalty of noise exposure during the evening and night will be considered in a follow-up paper.

2.2 Social Survey

The questionnaire survey was carried out face to face. Reading and evaluations were done by the interviewees, under the provision of the interviewers. Annoyance caused by single and combined noise exposure has been investigated from the social survey and the percentage of respondents who felt highly annoyed (%HA) was assessed. Respondents were asked to answer the question, 'How much have you been bothered or annoyed from the commercial aircraft (or road traffic/total) noise when you are in and around the house for the last 12 months or so?'. A numerical scale from 0 (not annoyed at all) to 10 (extremely annoyed) was used in the survey and for the responses of exceeding 7, it is defined as the highly annoyed population.

Total number of respondents analyzed here in this study is 550 (Response rate = 65%). About 71% of the respondents are female and 29% are male. The percentage of people whose age from 20 to 60 years old is 88% and 64% of all respondents are married.

3. RESULTS

Logistic regression analysis has been done to establish the response curves of annoyance from single and combined noise exposure. %HA curves of various conditions of combined noise exposure are presented with respect to $L_{Aeq,24h}$ of total sound exposure level. 'Combined noise', 'Road noise dominant', and 'No dominant noise' present overall annoyance for combined noise exposure and that for combined noise exposure with and without dominant noise. 'Combined CA (Commercial Aircraft) noise' and 'Combined RT (Road Traffic) noise' in the figures represent annoyance response of people toward each component source (commercial aircraft or road traffic) of combined noise exposure.

3.1 Annoyance caused by Single and Combined Noise Exposure

First of all, annoyance curves for single traffic noise recently reported by the authors are presented as dashed lines in Fig. 2. At a given exposure level, commercial aircraft causes higher %HA than road traffic. The solid line presents the annoyance curve for combined noise of commercial aircraft and road traffic. Combined noise causes more annoying than 'Single RT (Road Traffic) noise', on the other hand, Combined noise causes less annoying than 'Single CA (Commercial Aircraft) noise' below 70 dB in $L_{Aeq,24h}$.

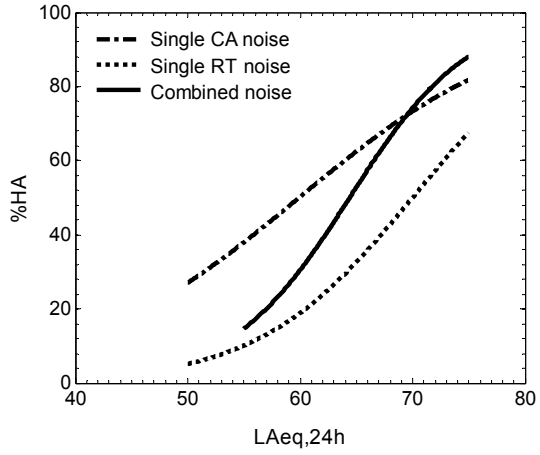

Fig. 2. %HA curves for independent single traffic noise and overall %HA curve for combined noise, as a function of LAeq,24h

3.2 Combined Noise Annoyance with and without Dominant Noise Exposure

Fig. 3 shows the exposure-response curve for combined noise annoyance. The dashed lines represent for 'No dominant noise' and 'Road noise dominant' independently. One is %HA curve of combined noise annoyance from no dominant noise sites and the other is that from road noise dominant sites. Combined annoyance from road dominant noise sites is slightly higher than that from no dominant noise sites.

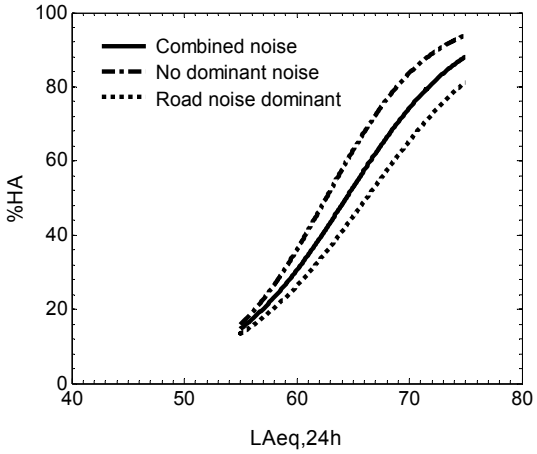

Fig. 3. %HA curves for combined noise with and without dominant noise exposure, as a function of LAeq,24h

Annoyance curves for two component sources of combined noise are independently established from 230 responses obtained through field survey in no dominant noise sites. %HA curve of 'Combined CA noise' and that of combined noise annoyance show the similar results in Fig. 4, which there is no significant difference between two curves. On the other hand, %HA curve of 'Combined RT noise' shows much lower response. The contribution of road traffic noise on the overall combined annoyance is negligible in this result.

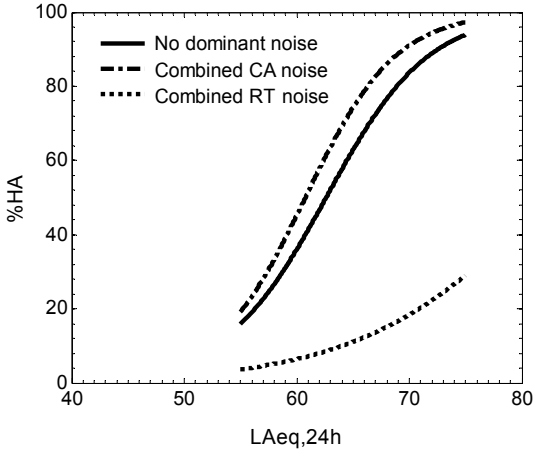

Fig. 4. %HA curve for combined noise without dominant noise exposure and %HA curves for component sources of combined noise, as a function of LAeq,24h

4. CONCLUSIONS

Field survey has been carried out in community exposed to both aircraft and road traffic noise in order to assess the annoyance from the combined noise exposure. The results of this preliminary study could be summarized and concluded in several points:

(1) The overall annoyance of combined noise exposure is different from that of single noise exposure. Even though when people are exposed to the same sound exposure level, overall annoyance caused by combined noise is higher than annoyance from single road traffic noise and lower than that from single commercial aircraft noise in the range of 55~70 dB in LAeq,24h. Therefore, it is necessary to assess the annoyance according to the conditions of noise exposure.

(2) Survey sites are divided into two categories and annoyance curves for the responses of people in no dominant noise sites and in road noise dominant sites are independently established. People complained more annoyance toward the combined noise with equally noisy sources than that with the situation which road noise is dominant.

(3) The responses of people toward a component source (commercial aircraft or road traffic) of combined noise are independently assessed as a function of total sound exposure level. Overall annoyance of combined noise exposure with no dominant noise shows a similar response with annoyance of a component commercial aircraft noise, but it is found that there is little contribution of a component road traffic noise on the overall annoyance.

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