MADRID
inter.noise 2019
June 16 - 19
NOISE CONTROL FOR A BETTER ENVIRONMENT

Differential limen of sounds transmitted from neighbors

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ABSTRACT

Various sounds are transmitted through walls from the neighboring houses in multi-dwelling houses and when these sounds are detected by the neighbors, they may cause noise problems. In order to examine whether the sounds transmitted from neighbors are detected, two experiments were conducted. In Exp.1 pink noise was used as a carrier. In Exp.2 pink noise whose frequency components were simulated to the speech and music performance transmitted through walls from a neighbor's house was used as carrier. Also weighting D-50 was added to the sounds in Exp.2. The sound insulation deficit was added to the comparison stimuli at 125 Hz, 2 kHz and 4 kHz octave bands in both experiments. The differential limen (DL) was obtained using the method of adjustment. Five females and 16 males aged between 21 and 30 years old (average was 22.7) participated in both experiments. All had normal hearing ability. The following results were found. (1) DL using pink noise in Exp.1 was less than 2 dB. (2) In Exp.2 the deficit of 125 Hz band was detected at the level of less than 2 dB. On the other hand, DL of 2 kHz and 4 kHz was around 3-4 dB.

Keywords: Differential Limen, Sound transmitted from neighbour, sound insulation rating
I-INCE Classification of Subject Number: 61

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1. INTRODUCTION

In Japan, it is recommended that Japanese Industrial Standard (JIS) should be equivalent to the corresponding International Standard (ISO). JIS A 1419-1 “Acoustics - Rating of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation” was revised in 2000 [1] so that it is equivalent to ISO A 717-1:1996 [2]. Rating with D-value that was standarized in the previous JIS A 1419 -1992 [3]. This rating method was moved to the Appendix 1 in JIS A 1419-2000.

In Japan, D-value (Fig.1) is still used to rate the sound insulation in buildings [1] Generally, D-50 is admitted as the first grade in multi-dwelling houses and TV or conversation will be scarcely audible when D-50 is fulfilled. However, in practical situations it is sometimes pointed that D-value may not be appropriate, especially in low and high frequency regions.

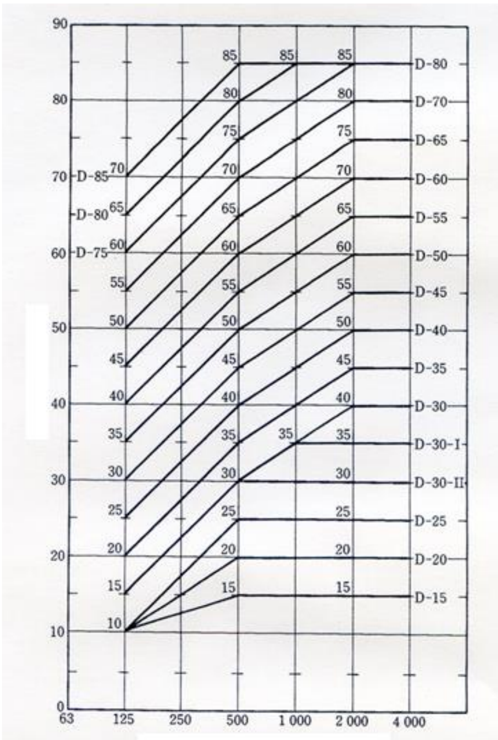

Fig.1 D-value [1]. The vertical line indicates the difference between walls in dB and the holizontal line indicates one octave center frequency in Hz.

In the present study, differential limen (DL) was measured in order to examine the appropriateness of D-values. The sound level of the sounds transmitted through walls is low in high frequency range and it is difficult to judge the difference. Therefore, Exp. 1 was conducted using pink noise. Since pink noise contains wide frequency range, it is easy to judge the difference and also Exp.1 can be a training for participants to judge DL using the method of adjustment. Exp.2 was conducted using pink noise, the frequency component of which was simulated to music and speech transmitted through walls.

2. EXPERIMENT 1

2.1 Stimulus

Pink noise was used as the standard stimulus (Ss) and recorded on the left channel. The duration of Ss was 1 s. The pink noise was used as a basis of the comparison stimulus (Sc) and recorded on the left channel. The duration of Sc was 1 s and there was 1 s silent interval between Ss and Sc. Three kinds of band noise were prepared using pink noise and their centre frequencies were 125, 2 k and 4 kHz. The band noise was recorded on the right channel at the timing so that band noise was overlapped on Sc. The duration of the band noise was 1 s. The A-weighted sound pressure level of pink noise was 40 dB.

2.2 Apparatus

The stimuli were reproduced with a personal computer (Panasonic, Let’s note) and presented to the participant through an audio interface (Roland UA-101), an amplifier (Yamaha, P3500S) and loudspeakers (Yamaha MSP7 STUDIO, DIATONE DSW461) in a sound proof room. A remote control attenuator was set between an audio interface and an amplifier in the right channel and both right and left channels were mixed so that the band noise was overlapped on Sc.

2.3 Procedure

The method of adjustment was used. There were one second silent interval between Ss and Sc and two seconds between pairs. The level of the band noise in the right channel was changed by the participant using the remote control attenuator so that the impressions of Ss and Sc were just different. In the instruction, the experimenter demonstrated how the impression of the sound changed by controlling the remote control attenuator by indicating the figure (Fig.2). A training session was given to the participant. If he/she did not understand the procedure, the training session was repeated until he/she understood the procedure. Four trials of ascending series and four trials of descending series were conducted.

2.4 Participants

Five females and 16 males aged between 21 and 30 years old (average 22.7) participated in the experiment. Hearing test was conducted between 125 and 4 kHz and confirmed that all participants had normal hearing ability.

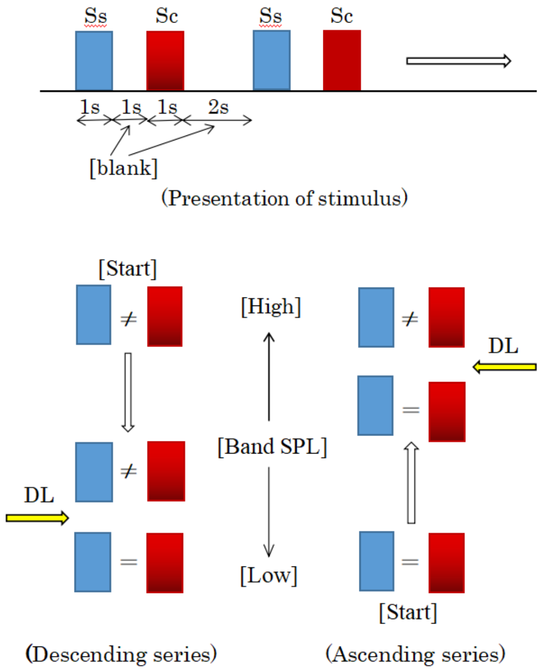

Fig.2 Procedure of the judgment of differential limen (DL)

2.5 Results of Exp.1

The sound level of the band noise where the participants judged the impressions of both Ss and Sc as being just different was admitted as differential limen (DL). The results of Exp.1 are shown in Table 1 and Fig.3. When pink noise was used as stimuli, DL was about 2 dB or lower in all the centre frequencies of the band noise. Since the participants well understood the experimental procedure, Exp.2 was conducted.

Table 1 Results of Exp.1

DL	125 Hz	2 kHz	4 kHz
PN	1.77	1.66	2.10

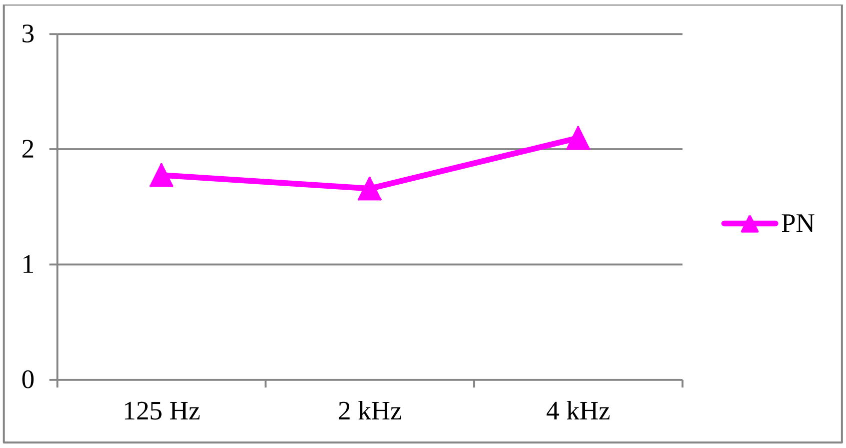

Fig.1 Results of Exp.1. Vertical line indicates DL in dB.

3. EXPERIMENT 2

3.1 Stimulus

Pink noise simulating average frequency components of five kinds of music performance (Exp.2-1) and five kinds of speech and/or conversation (Exp.2-2) used in our former study [4] was used in Exp.2. Their frequency components are shown in Fig.3. D-50 weighting was added to each of pink noises simulating music and speech. As in Exp.1, pink noise was used for band noises with three different centre frequencies; 125, 2 k and 4 kHz. Each of these band noises was overlapped on Sc. The A-weighted sound pressure level of Ss was 38 dB.

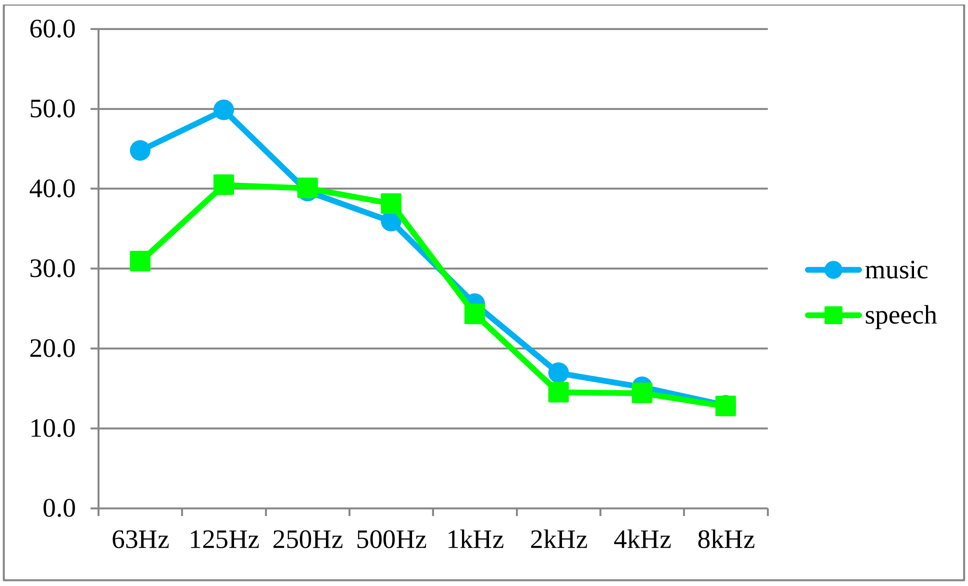

Fig.3 Frequency characteristics of the source sounds used in Exp2.1 and 2.2 [4].
The vertical line is the sound pressure level in dB when the sound is 60 dB (A-weighting).

3.2 Apparatus, procedure and participants

Apparatus, procedure and participants were the same as in Exp.1. Exp.2 was conducted after Exp.1 with about two hours rest between Exps.1 and 2. Eleven participants conducted Exp.2-1 first and the others Exp.2-2 first.

3.3 Results of Exp.2

The results of Exp.2 are shown in Table 2 and Fig.4 with the results of Exp.1. DL of 125 Hz was smaller than 2 dB. That is, the transmitted sound of centre frequency of 125 Hz can be detected when the insulation deficit is over 2dB from D-50 value. On the other hand, the transmitted sound pressure levels of high frequency range of music and speech were low and were not easily detected. DL of 2 kHz was about 3 dB for music and about 4 dB for speech. These DLs were the largest among the three centre frequencies. DL of 4 kHz was about 3 dB for both music and speech.

Table 2

DL	125 Hz	2 kHz	4 kHz
music	1.40	3.24	2.82
speech	1.93	4.19	2.92

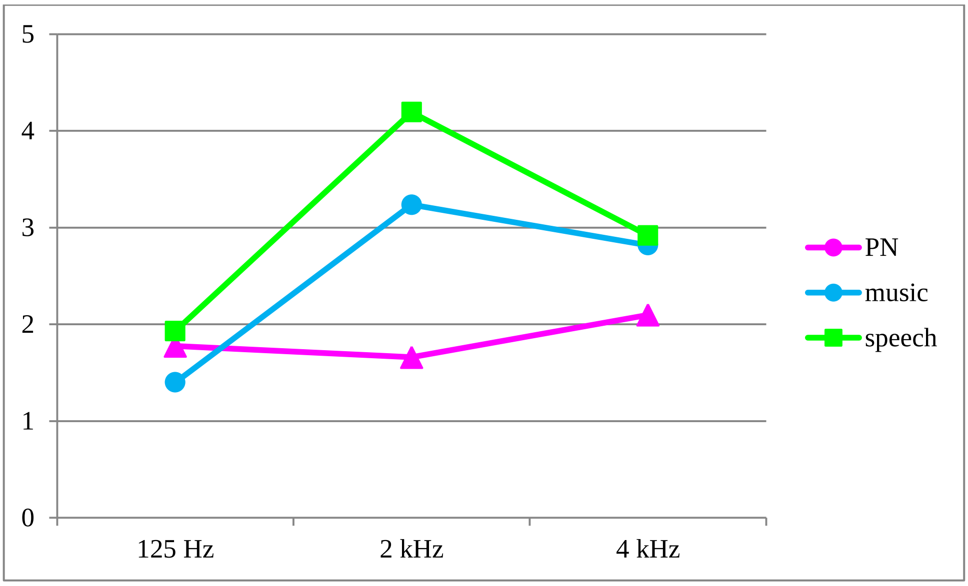

Fig.4 Results of Exps. 1 and 2. Vertical line indicates DL in dB.

3.4 Results of statistical test

Non-parametric sign test was conducted including the results of both Exps.1 and 2. The results are shown in Tables 3 and 4. Statistically significant difference between sound sources was found only in the case of 2 kHz as shown in Table 3. That is, DL of speech is the largest and DL of pink noise was the smallest. Though there is no significant difference in the case of 125 Hz and 4 kHz, DL of speech tended to be the largest among the three sound sources. Statistically significant difference was found between all the comparisons of the frequency components in the case of speech. As shown in Table 4, in the case of music, statistically significant was found between 125 Hz and 2 kHz, and between 125 Hz and 4 kHz.

Table 3 Results of statistical test beween sound sources

	125 Hz	2 kHz	4 kHz
PN - music	ns	**	ns
PN - speech	ns	**	ns
music - speech	ns	**	ns

** p<0.01 * p<0.05

Table 4 Results of statistical test beween centre fewquency of band noises

	PN	music	speech
125 Hz - 2 kHz	ns	**	**
125 Hz - 4 kHz	ns	**	*
2 kHz - 4 kHz	*	ns	**

** p<0.01 * p<0.05

4. DISCUSSION

The judgment of DL was a difficult task for the participants. They conducted eight trials for each of nine conditions. That is, in Exp.1 three condions in contre frequency of band noise and in Exp.2 six conditions; three kinds of center frequency of band noise and two kinds of sound source. In order to examine whether there was a difference between the former four trials and the latter four trials in each conditon, statistical test (t-test) was conducted. There was no condition where there was a significant difference between DLs of the former trials and the latter trials. Therefore, eight trials were averaged in each condtion.

Sometimes it was noticed in practical situations that the D-value may possibly be revised since human audibility is more sensitive to the deficit in low freqency region and less sensitive to the deficit in high frequency region of the transmitted sounds in buildings. In the preliminary experiments, two persons who were elder than 50 years old and whose hearing ability in high frequency regions were deteriorated tried the experiment. It was found that their the DLs of 2 and 4 kHz were larger than 10 dB. In such cases, D-value could be shifted to the lower by 10 dB. However, the participants who joined in Exps.1 and 2 were younger than 30 years old and had normal hearing ability. The reults showed that DLs for 2 and 4 kHz were less than 5 dB. Also DL for 125 Hz was about 2 dB. These results suggest that the D-value shown in JIS A 1419-1 Appendix 1 is approreate for rating the sound insulation in buildings.

5. FINAL REMARKS

Neighborhood noise problems are serious when they happen. In multi-dwelling houses, it is not seldom that TV sounds, conversation among family members and music performances are transmitted from the neighbors. If these sounds are audible, this may cause noise problems. In order to prevent from noise problems, it is desired that the walls between houses have high sound insulation performance. In order to examine how much deviation from D-50 value can be detected, the experiments were conducted using the method of adjustment. Three kinds of octave band, 125, 2 k and 4 kHz were examined. The results suggested that D-50 value is appropriate to rate the sound insulation performance.

6. ACKNOWLEDGEMENT

The authors are grateful to Dr. Jiro Kaku and Dr. Tadasu Hatoh for their kind support for preparing the stimuli and conducting the experiments.

7. REFERENCES

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