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LABORATORY MEASUREMENT OF AIR-BORNE SOUND INSULATION OF BUILDING ELEMENTS BY SOUND INTENSITY

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ABSTRACT
For the measurement of sound reduction index of building elements, ISO 15186 series are being drafted. On the other hand, the method of determining sound power levels of noise sources by sound intensity is specified in ISO 9614-1 and 2 and the precision method (ISO 9614-3) is now being drafted. Based on these standards, the measurement method of sound insulation of building elements by sound intensity was studied using an acoustic laboratory consists of a reverberation room and a hemi-anechoic room. In this paper, the methods for checking the sound field indicators to assess the measurement accuracy and the practical procedures of signal processing during the scanning of a probe are discussed and the measurement results for a variety of light-weight double layered panels are shown.

1 - INTRODUCTION
Regarding the determination of sound reduction index of building materials, ISO 15186-1 series are being drafted. In this draft standard, the measurement method of the transmitted sound power through the specimen is measured by sound intensity technique.
To inspect the measurement accuracy, we are making experimental studies on the accuracy of transmitted sound power determination by the discrete point method and the scanning method. In this paper, the methods for checking the sound field indicators to assess the measurement accuracy and the practical procedures of signal processing during the scanning are discussed and the measurement results for a variety of light-weight double layered panels are shown.

2 - SI MEASUREMENTS
The measurement method of sound insulation of building elements by sound intensity was studied using an acoustic laboratory consists of a reverberation room and a hemi-anechoic room shown in Fig. 1. As the source room, a reverberation room (220 m^3 air volume) with a rotating diffuser (1.8 m × 2.4 m, 30 s/turn) was used and as the transmission room a hemi-anechoic room covered the floor with absorptive material (30 cm thickness glass wool board) was used.
Figure 2 show the arrangement of test specimen and the SI measurement surface. To investigate the SI measurement method for the determination of sound reduction index, the test specimen (1.8 m × 2.7 m, gypsum board) was mounted in a half area of the regular test opening between the source room and the transmitted room. Two SI measurement surfaces, a flat surface (F) and a rectangular box (B) were set surrounding the test specimen in the transmission room.
The measurements were performed in each 1/3 octave band from 100 Hz to 5 kHz by the discrete point method and the scanning method as shown in Fig. 3. In case of the surface F, SI measurement was performed on 12 segments and at 108 discrete points. For the surface B, SI measurement was performed on 11 segments and at 84 discrete points.

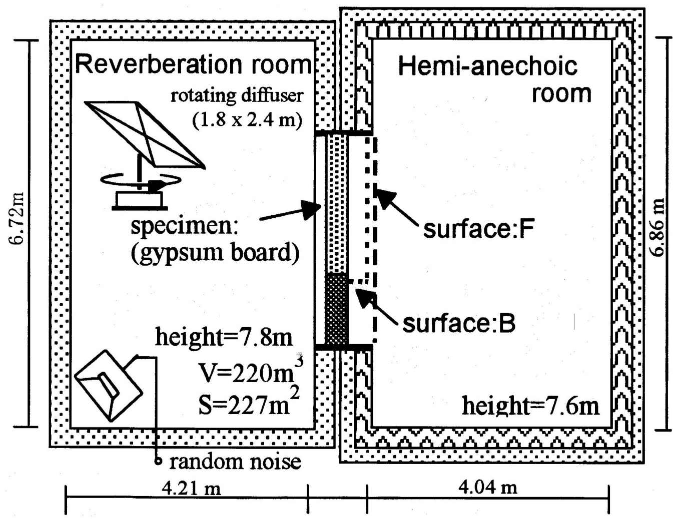


Figure 1: Arrangement of SI measurements.

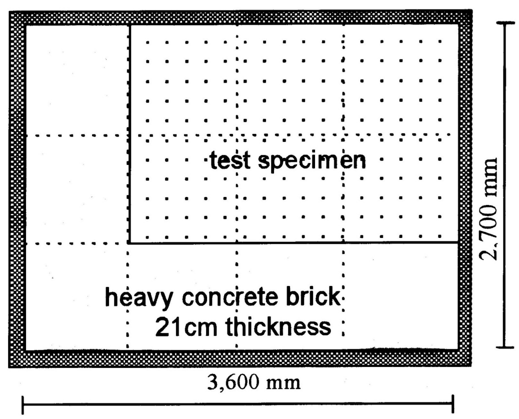


Figure 2: Configuration of test specimen.

The scanning measurement was performed in two scanning patterns on each segment. The scanning speed was kept at about 20 cm/s. For each segment, both of sound pressure and sound intensity data were gotten at the same time at the sampling rate of 0.5 second.

In the source room, the sound pressure levels were measured by six discrete points, and the mean sound pressure level in the room was obtained.

For the measurement, an intensity probe (B&K 4181: a pair of 1/2 in. condenser microphones, spacing: 12 mm) and a digital real-time analyzer (B&K 2133) were used. The field indicators specified in ISO 15186-1 and ISO 9614 series were obtained automatically in a desk-top computer.

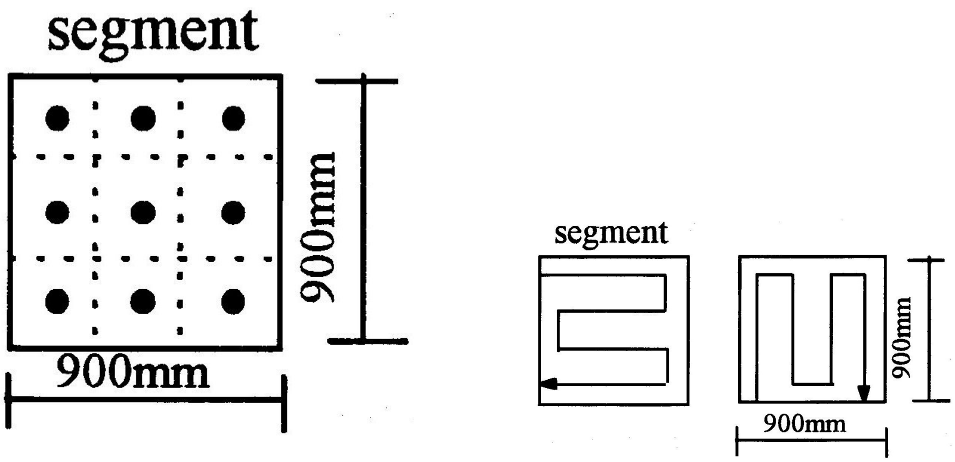
3 - EXPERIMENTAL RESULTS

Figure 4 shows the sound reduction index of a single wall made (gypsum board of 12.5 mm thickness). In this figure, it can be seen that the results obtained by the discrete point method and the scanning method are precisely in good agreement over all frequency bands. These experimental results were in good agreement with the calculated value based on the mass law as by assuming incidence angle of 0 to 78 degree.

In order to investigate the effect of the rotating diffuser, the sound reduction index of the single wall was measured under two conditions, rotating and standing still.

These experimental results are shown in Fig. 5. In the figure, it can be seen that the results obtained under the two conditions are in very good agreement.

To check the repeatability of the scanning measurements, SI measurement of ten times trial in each scanning pattern on surface B were performed. These results are shown in Fig. 6. In the figure, it can be seen that the results obtained on two scanning paths are in very good coincidence. The standard deviation is less than 0.2 dB all over the frequency bands.



(a): Discrete point method. **(b):** Scanning method.
Figure 3: Measurement position and two scanning patterns.

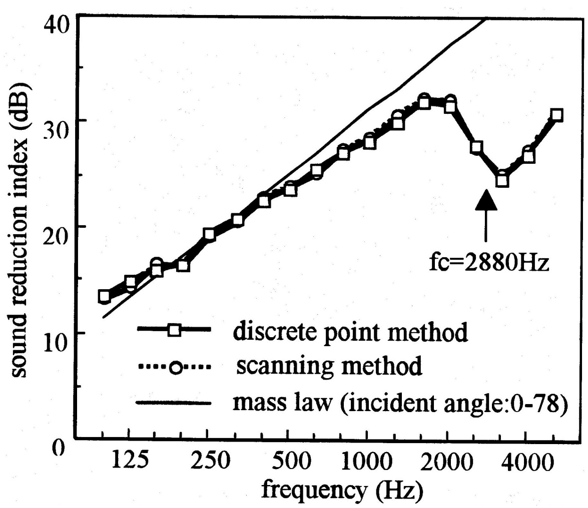


Figure 4: Measured results of single wall by two methods.

To check the measurement accuracy, the surface pressure-intensity indicator "F_{pI}" is defined in ISO 15186-1 as follows.

$$F_{pI} = L_{\overline{p}} - L_{\overline{I}_{\mathrm{n}}} \tag{1}$$

$$L_{\overline{I}_{\mathrm{n}}} = 10\log\left(\frac{1}{N}\sum_{n=1}^{N}\overline{I\mathrm{n}_{\mathrm{n}}}/I_0\right) \tag{2}$$

where $L_{\overline{p}}$ is the averaged sound pressure level and $L_{\overline{I}_n}$ is the averaged signed normal sound intensity level.

Figure 7 shows the results of F_{pI} obtained using two measurements method on the surface B. In this result, it can be seen that F_{pI} values obtained by the discrete point method and by the scanning method are less than 4 dB. These F_{pI} values are smaller than 6 dB prescribed in ISO 15186-1 and the SI measurement condition in this case meets the requirement.

As an example of the result of sound reduction index measured by the scanning SI method, the result for a double layered panel made of two gypsum boards with different thickness (21 mm and 6 mm) is shown in Fig. 8. In this figure, the measurement results for each gypsum board are shown together. In these results, it can be seen that by layering the two boards with different thickness, the dip of sound reduction index due to coincidence effect can be much mitigated.

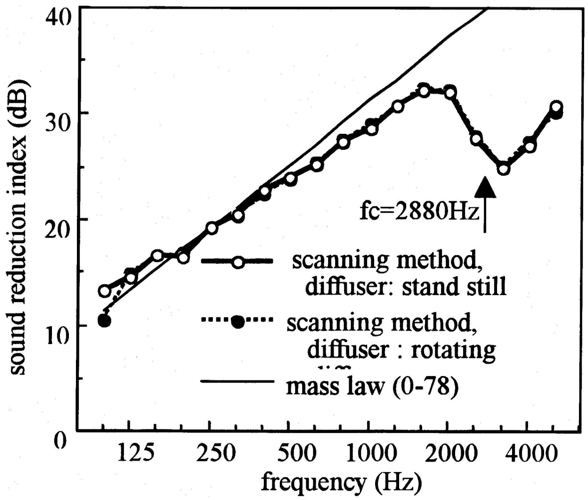


Figure 5: Measured results of single wall under two diffuser condition.

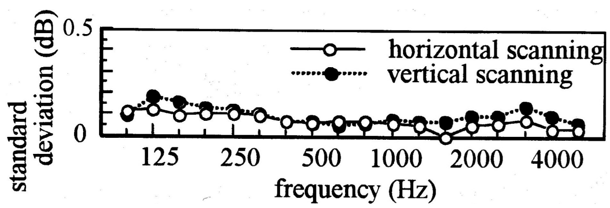


Figure 6: Repeatability of SI measurements.

4 - CONCLUSIONS

In this study, in order to check the accuracy of sound reduction index determination by sound intensity method, a basic experiment has been performed using a variety of light-weight double layered panels. As a result, it has been found that the scanning method provides almost the same results as those obtained by the discrete point method. The field indicators to check the measurement accuracy during the scanning can be obtained by the "running method" used in this study.

REFERENCES

1. *ISO 15186-1*

2. *ISO 9614-1, -2*

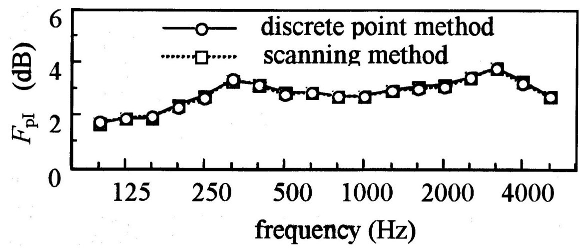


Figure 7: Measured result of F_{pI}.

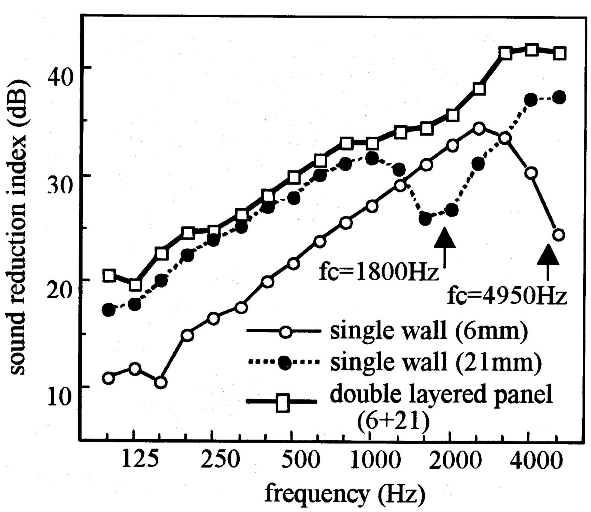


Figure 8: Measured results of double layered wall.