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International round robin test on sound insulation performance

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차음성능에 관한 국제간 round robin test

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요약문

차음성능 측정에 관한 국제간 신인도 향상을 위하여 home and away 테스트가 수행되었다. 동일 시편에 대한 비교 테스트 결과 대부분의 시편에서는 STC 1 dB 이내의 차이를 보였다. 다만, 특정 시편의 경우 STC 5 dB의 차이가 발생하였다. 주원인으로는 잔향시간 측정 오차가 주원이으로 추정되며, 또한 부수적인 원인으로는 시편의 제작 및 설치의 차이 때문인 것으로 사료된다.

1. Introduction

There have been paid much attentions to the accuracy and precision in laboratory accreditation procedure for sound insulation and absorption. To do this, many international or domestic organizations such as ISO and ASTM have been issued the code concerning the procedure and method for measurement and evaluation. Even if the test facility of a laboratory is well satisfied with the requirement specified in the code and the test is conducted by the method specified in the code, there may be a problem associated with the accuracy. Moreover, when the data obtained from different laboratories are compared each other, there should be some deviations. Hence, in order to enhance the validness of the laboratory accreditation, many works for intercomparisons among laboratories have been made. As an representative work, R. E. Jones issued a paper [1] relating to the intercomparison result with respect to sound insulation performance. He revealed that for single panels, an inter-laboratory difference of 2 dB was found, and for double-panel walls, TL data from two laboratories for *similar constructions* showed *unexpectedly* large variation in STC value, up to 6 dB.

This work also deals with the intercomparisons between two laboratories, i.e., KIMM (Korea Institute of Machienry and Materials) and GBRC (Genral Building Research Center in Japan). To do this, we prepare 5 specimens and performed the test for sound transmission loss at KIMM on Nov. 9-10, 2000, and at GBRC on Nov. 23-24, 2000.

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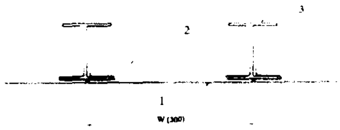
2. Specimens and test environments

The selected specimens were composed of two ceiling panels and three wall panels. The detail of panels is displayed in Fig.1 and names for each panel are designated as follows:

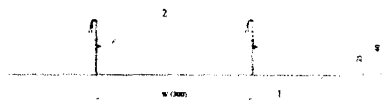
- Ceiling panel: Type A and Type B
- Wall panel: Type C, Type D and Type E.

Test participants are as follows:

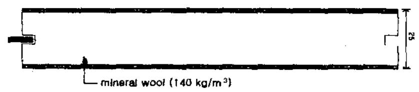
- At KIMM, Nov. 9 to 10, 2000.: Kang Hyun-Ju, Kim Sang-Ryul (KIMM), Kim Tae-Hee (SSE), and Kanichi Miyawaki (NSS)
- At GBRC, Nov. 23 to 24, 2000.: Akihiro Sakaguchi (GBRC), Kang Hyun-Ju, Kim Sang-Ryul (KIMM), Kim Tae-Hee (SSE), and Kanichi Miyawaki (NSS)



(a) Type A.

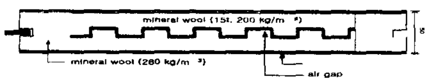


(b) Type B.



(c) Type C.

(d) Type D.



(e) Type E.

Fig. 1 Specimens to be tested.

As listed in Table 1, test methods and facilities of both KIMM and GBRC are well conformed with the ISO code. Essentially, it can be said that the methods adopted by both the institutes are same. However, there is a difference of the installation method of specimens on the test frame. As schematically illustrated in Fig. 2, while KIMM has installed the specimen to be **flushed** with the edge of the test frame, GBRC has installed the specimen to be located **on the center** of the test frame in accordance with the JIS code. Presumably, the JIS code may take into account the situation of the building elements such as windows, which have the protruded window frame. The reason for such a flushing method adopted by KIMM is as follows: the concept of the ISO code was in essence made by the principle that the installation of the specimen will be the same as the in-situ situation as possible. Hence, from the consideration of shipboard condition, KIMM has adopted the flushing method. Fig. 2 displays a typical difference in TL by varing with specimen location on the test frame, indicating that the difference will be lie within 2 dB.

Table 1. Test environment and method.

Specification	KIMM	GBRC
Vol. of source room(m^3)	51.7	178.5
Vol. of receiving room (m^3)	224.9	180.0
Area of the specimen (m^2)	2.5 × 2.5 (m) = 6.25	4.0 × 2.5(m) = 10.0
Sound source	Omni-directional speaker	general speaker 1 set
Test code	ISO and ASTM	JIS

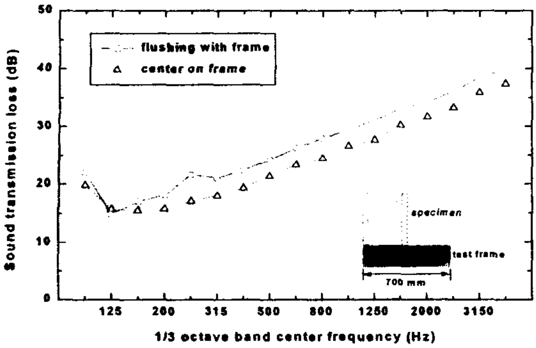


Fig. 2. Changes in TL measurement depending on the specimen positions on the test frame. The specimen is a steel plate(1 mm).

3. Intercomparison results and discussions

Figs. 3 and 4 are for the ceiling panels, i.e., Type A and B. The Two figures show a reasonably similar tendency that below 200 Hz, KIMM data are higher than GBRC data by 2 or 3 dB, at the mid frequency ranging from 250 to 1250 Hz, two data agrees quite well, and above 1250 Hz, GBRC data are considerably higher than KIMM data. Generally speaking, at the low frequency range, the data often show some fluctuation and are very sensitive to the status of sound field of test room, which depends largely on the volume and the shape of the test room. This is because the wavelength of the low frequency, i.e., $\lambda = c/f$, is very long compared to the room dimension, which make large difference of sound energy according to the measuring points. For example, the wavelength of 100 Hz equals to 3.4 m. Due to such fluctuations of sound variables at the low frequency, ASTM code increased the lower frequency limit such as 125 to 4000 Hz, in contrast to the ISO code, namely 100 to 3150 Hz.

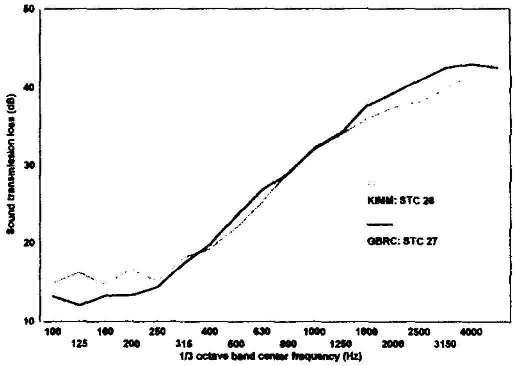


Fig. 3 Test result of the ceiling panel (Type A).

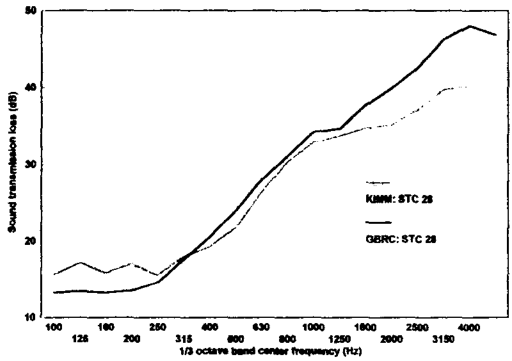


Fig. 4. Test result of the ceiling panel (Type B).

The difference in high frequencies will be due to the flanking transmission thru the common wall between the source room and receiving room, not due to the property of the specimen. From the data for the high frequencies and the data for the common wall given by GBRC, it can be seen that in the sound insulation, the common wall of GBRC shows much better performance than that of KIMM so that the GBRC data of high frequencies are hardly contaminated by the influence of the flanking transmission thru the common wall. Anyway, both data for high frequencies will not influenced on the evaluation of the STC or the Weighted Sound Reduction Index ratings because of nature of the rating curve, which is more stressed to the low and mid frequencies. Consequently, the intercomparison results show a very reasonable match for the STC values, not exceeding 1 dB.

Fig. 5 shows the sound insulation performance of the sandwiched wall panel, Type C. Its overall tendency is similar to Figs. 3 and 4. The dip of GBRC data at 3150 Hz is seemingly due to the sound leakage around the perimeter or joint part of the panel, because it is a typical phenomena of the chink transmission loss, which is a function of panel thickness. Hence, if the sealing is perfect, then the dip will be expected to disappear.

Comparison for the Type D is shown in Fig. 6. Considerable difference, about 5 dB, can be seen at the low and mid frequencies. Reasons for such a difference may be found by the various causes such as the difference between specimens and/or test environment. There is one thing strange in the measured data of the GBRC. That is the data for the reverberation time, so-called T_{60} (sec), which represents the absorptive ability of the receiving room. Fig. 7 displays the measured T_{60} of GBRC, which corresponds to the specimen, type C, D and E. Here, it should be noted that all the surfaces of three specimens will have the same property, in acoustic sense. As most of acoustic engineers know, the reverberation time is mainly determined by the absorption coefficients of the bounding surfaces such as walls, floor and ceiling in the room and is slightly changed by the temperature and humidity. Hence, it is normal that if the temperature is not greatly changed, within 5° C, and also the surface of each specimen toward the receiving room is acoustically similar, the fluctuation of T_{60} (sec) at the low frequency will be lie within 1 sec. However, the T_{60} data as plotted in Fig. 7 shows a considerable fluctuations up to 5 sec, in spite of a small temperature difference within 1° C.

In order to explain the influence of T_{60} on the evaluation of sound insulation, let us briefly introduce the relationship between TL and T_{60} as follows:

The Sound Transmission Loss (TL) of a partition panel between two adjacent rooms is determined as

$$TL = \overline{L_1} - \overline{L_2} + 10\log(S/A) \quad (1)$$

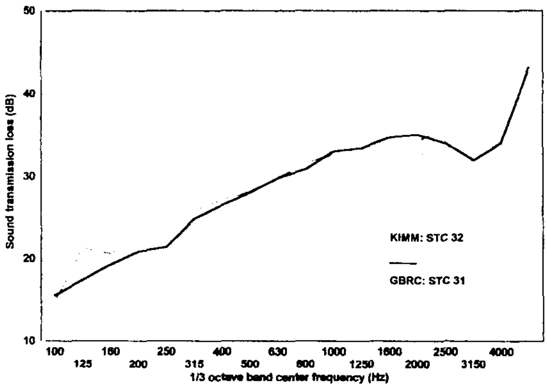


Fig. 5. Test result of the wall panel (Type C).

where $\overline{L_1}$ and $\overline{L_2}$ denote the average sound pressure levels in the source room and in the receiving room, respectively, and S = the area of the specimen(m²), A = $55.3\times\frac{V}{c\cdot T_{60}}$: the equivalent absorption area in the receiving room (m²), V = the volume of the receiving room (m³), $c=20.05\sqrt{273+T}$: sound speed (m/sec) and T is temperature (°C). Because S and V are a constant, and c is also a constant within the temperature difference of 1° C, the only variable of changing the value of $10\log(S/A)$ in Eq. 1 is T_{60}. As a result, such fluctuations of T_{60} as shown in Fig. 7 can yields about 3 dB difference in the evaluation of TL value. As a comparative data, Fig. 8 shows T_{60} data for KIMM, which represents the variation with season. Therefore, it can be said that if the T_{60} data is stable, there may be a possibility to reduce the 5 dB of STC difference between KIMM and GBRC as shown in Fig. 6.

The data for Type E is shown in Fig. 9. These data are not comparable because the specification for the specimen tested at GBRC is not the same as that tested at KIMM. As indicated in Fig. 1.(e), the specimen tested at GBRC is composed of a non-perforated steel plate within the air gap space, other than a perforated steel plate at KIMM. Such a difference plays major role on the sound insulation performance for this type of panels. For example, two curves corresponding to the SPP panels, which superficially appears to be the same type, typically show a difference in sound insulation performance.

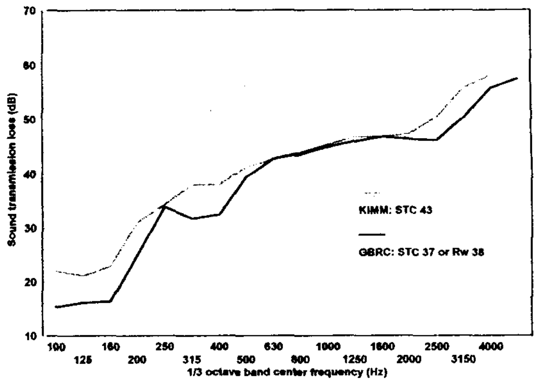


Fig. 6. Test result of the wall panel (Type D).

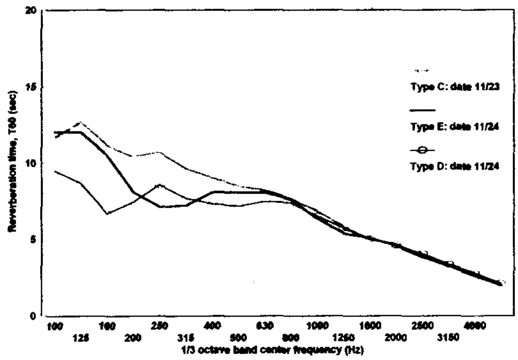


Fig. 7. Measured data of the reverberation time at GBRC.

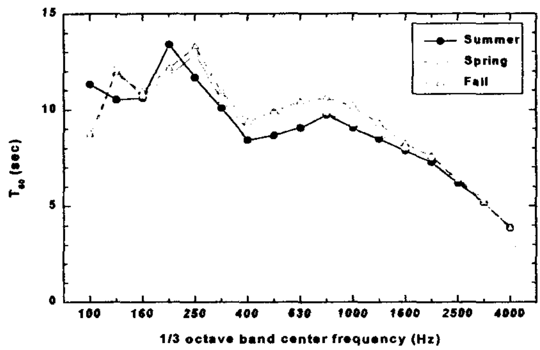


Fig. 8. Variation of reverberation time with seasons.

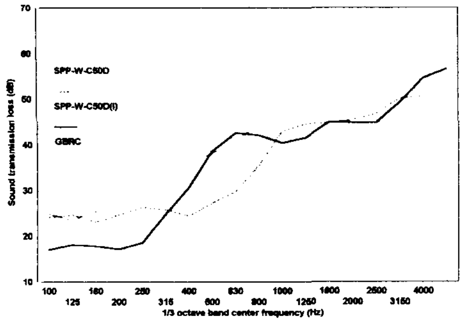


Fig. 9. Test result of the wall panel (Type E).

4. Concluding remark

Before drawing a concluding remark, it may be helpful so as to introduce a previous work closely relating to this work. As a famous reference, Jones[1] performed the round robin test for 6 test labs. located in America. Figs 10 and 11 as typical results are reproduced from his work. He concluded that 3 dB difference in the STC value will be common. Recalling his conclusion and the comparative results of the current work, it can insist that 1 or 2 dB difference in the STC value between KIMM and GBRC is very normal. However, 5 dB difference in the STC value as shown in Fig. 9 needs further study for the cause.

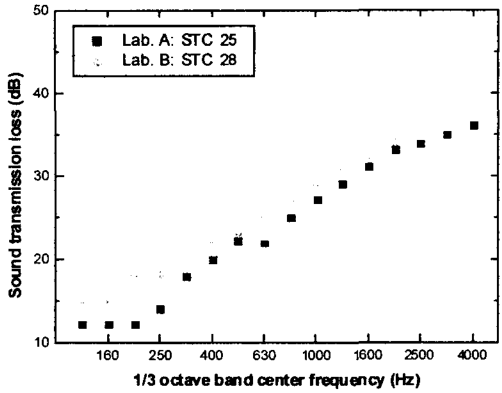


Fig. 10. TL difference between the test laboratories for a steel plate with t = 1 mm.

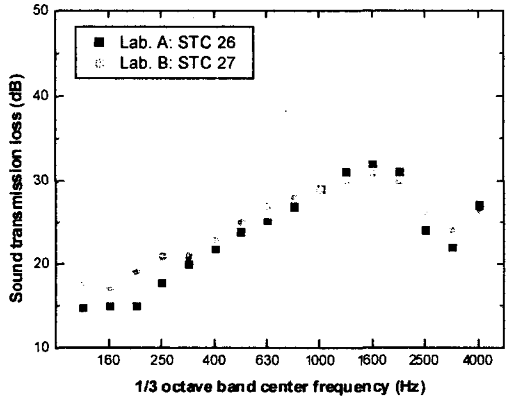


Fig. 11. TL difference between the test laboratories for a gypsum board with t = 13 mm.

후 기

본 논문은 과학기술부가 지원하는 특정연구개발사업 중 중점국가연구개발사업(기계설비요소기술개발)으로 지원되어 수행하였습니다.

Reference

[1] R. E. Jones, "Inter-comparisons of laboratory determinations of airborne sound transmission loss," Journal of Acoustical Society of America **66**, 148-164 (1979).