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JAPANESE STANDARD ON THE METHOD FOR MEASUREMENTS OF SOUND INSULATION IN BUILDINGS

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Sound insulation characteristics for various parts of buildings would play an important role for the noise reduction in buildings, such as houses, office buildings, factory buildings and so on.

Until now, laboratory measurements of airborne sound transmission loss and of impact sound transmission for various building elements have been carried our extensively in order to collect the design data. On the other hand, it would be necessary to be carried out the field measurements of sound insulation in buildings, with a view to evaluate the actual circumustances in buildings which are newly built or in use.

However, sound fields in various buildings would be different in case by case, and it would be rather difficult to expect a required accuracy of measurements, compared with laboratory measurements. In spite of these difficulties, it has become necessary to make field measurements.

Here, in order to improve the accuracy of measurements and to make insulation in buildings has been carried out in ISO/TC 43/SC 2, starting from the revision of ISO/R 140. Draft proposals have been prepared by secretariate of ISO/TC 43/SC 2, and circulated for ballot. They consist of 8 parts, of which Part II, IV, V and VII are connected with the method for field measurements of sound insulation.

In nearly the same time, Japanese Industrial Standards on the method for measurements of sound insulation have been established and announced officially. The titles of these standards are as follows:

JIS/A 1416	Method for Laboratory Measurement of Sound Transmission Loss
JIS/A 1417	Method for Field Measurement of Sound Pressure Level Difference
JIS/A XXXX	Method for Field Measurement of Sound Insulation of Windows (now in the state of draft proposal)
JIS/A 1419	Method for Field Measurement of Impact Sound Level of Floors

Fundamental concepts and contents of these Japanese Standards which specify the method for field measurements are somewhat different from those of draft proposals of ISO Standards. These discrepancies would be mainly due to the difference in the purpose of measurements, what is the difference in needs for measured data. In the course

of preparing the drafts of these Japanese Standards, these problems were discussed by working group and supplementary experiments were carried out.

In this paper, details of these Japanese Standards on the method for field measurements are described in comparison with the provisions in draft ISO Standards.

1. Basic problems underlying between Japanese Standards and the draft ISO Standards.

The most essential discrepancy between JIS and draft ISO Standards would be in the object of the field measurements of sound insulation. In draft ISO Standard, the quantity aimed to be measured would be the same with that of laboratory measurements in principle. Difference between field and laboratory measurements would be in the accuracy of might be realized actually. Of course, through field measurements, it is preferable to be able to obtain such quantities that have the same meaning with those obtained by laboratory measurements. However, it is rather difficult to realize a sound field which has the same order of sound diffusitivity with a sound field obtained in the laboratory reverberation room. This will cause the difference in the angular distribution of sound incident upon the partition or other boundary surface in a room, and finally lead to the discrepancy in the value of transmission loss and so on. Also, it is extremely difficult in actual situations to remove the flanking transmission which sometimes causes the serious effect on the measured results of sound pressure level difference between rooms and so on.

On the other hand, in most cases of field measurements required in Japan, the purpose of measurement is to obtain the actual situation of sound insulation properties for individual building. For example, in the case of airborne sound transmission, the quantity to be measured is the sound pressure level difference itself between both sides of window. These will be most cases for the test on newly-built buildings.

Also, from the practical point of view, it will be desirable in many cases to reduce the time of measurements in the field.

Measuring procedures specified in these Japanese Standards were determined by considering these requirements.

2. Comparison of Japanese Standard with corresponding draft proposal of ISO Standard.

2.1 Measurement of airborne sound insulation between rooms.

Several items which show difference between JIS and ISO are summarized in Table 1. Most significant difference would be in the measured quantity.

In draft ISO Standard, the measured quantity should be principally the apparent transmission loss of a corresponding building elements. For this case, it is necessary that the flanking transmission should be much lower than direct transmission through the test element. When it is difficult to confirm this condition, standardized level difference will be measured. Here, the sound absorption of the reveiving room is taken into consideration as a correction for the average sound pressure level difference between rooms.

There two quantities, apparent transmission loss and standardized level difference, are mainly used for the following two purposes:

(1) to check whether the desired acoustical conditions have been obtained (protection to the occupants).

(2) to determine whether building elements have met with specifications and to check whether faults have occured during construction.

On the other hand, JIS specifies the measurement of average sound pressure level difference between rooms. This value shows the actual situation of sound insulation between rooms, including the effect of flanking transmission, sound absorption in the receiving room and so on.

Different from the ISO Standard, where it is recommended to use some sorts of diffusers in order to maintain the sufficient diffusion in the room, JIS specifies that measurements should be carried out under the usual room condition in use. So, sometimes measured sound becomes meaningless to calculate the average sound pressure level. The local difference of sound pressure level through each room should not exceed 10 dB and the method for obtaining the average sound pressure level was settled according to the order of variations.

However, even in such cases that the local difference of sound pressure level exceeds 10 dB, it might become necessary to specify the sound insulation characteristics between rooms and so on. By considering these facts, sound pressure level difference between two specific positions was defined and measuring procedures were specified in this standard. Figure 1 shows the examples of these situations where it is required to measure the sound pressure level difference between two specific positions.

Table 1. Comparison of JIS and ISO proposal (sound insulation between rooms).

Items	JIS / A 1417	draft ISO / 140 Part IV
measured quantity	(1) average sound pressure level difference (2) sound pressure level difference between two specific positions	(1) apparent transmission loss (2) standardized level difference
sound source	1 octave band noise	band noise having the bandwidth of at least 1/3 octave
frequency of measurement	125, 250, 500, 1000, 2000, 4000 Hz	(1) 100 ~ 3150 Hz (1/3 octave) (2) 125 ~ 2000 Hz (1 octave)
sampling procedure of sound field	5 points in each room	(1) 6 points in each room (2) rotating microphone: minimum sweep radius is 0.7 m
calculation of average sound pressure level	local level difference < 5 dB: $\overline{L} = \frac{1}{n}\sum L_i$ 5 ~ 10 dB: $\overline{L} = 10 \log \frac{\sum p_i^2}{n\, p_0^2}$ 10 dB: should not be calculated	$\overline{L} = 10 \log \frac{\sum P_i^2}{n\, p_0^2}$

As can be seen from this figure, sound pressure level measured in one of two specific positions may be the average sound pressure level in the room. When it is not possible to measure the average sound pressure level in either source or receiving room, 3~5 microphone positions are set up around the specified area or position where the level difference should be within 5 dB. If the measuring position is not specified, microphone should be set up over the plane 1 m apart from the boundary wall and so on.

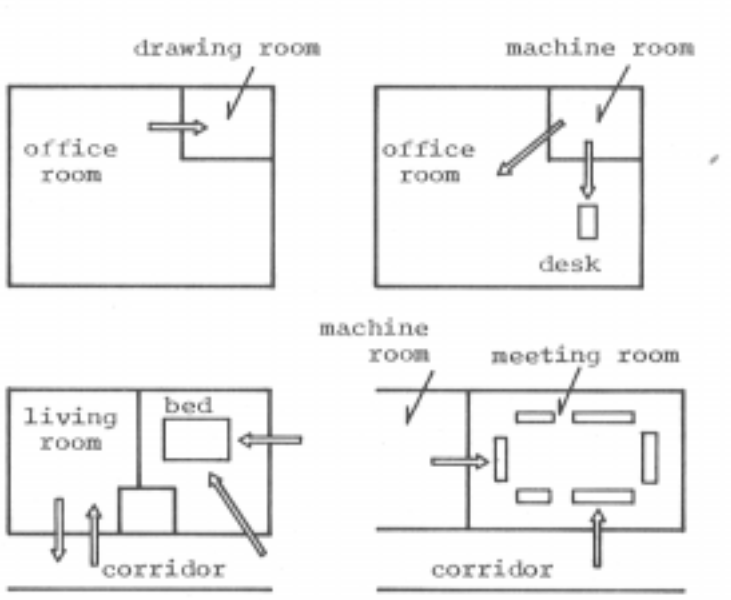

Fig. 1. Examples of situations for the measurement of sound pressure level difference between specific positions.

By adopting the sound pressure level difference between two specific positions, this standard might be applied more extensively for the field measurement of sound insulation in buildings.

2.2 Measurement of airborne sound insulation of facede elements and facedes.

At first, in the present state of JIS draft proposal, the measuring objects are limited to windows. As before, Table 2 shows the comparison of JIS and draft ISO Standard on the method for measurement of sound insulation of facade elements and facades.

ISO proposal specifies firstly the method for measurements of sound insulation by using the existing traffic noise as the source of sound. Certainly, traffic noise is the principal source of outside noise for many buildings, and so this method would correspond to the practical situations of sound insulation characteristics for facade elements and facades. However, from our experiences, it is not so easy to use the existing traffic noise as the source of sound by several reasons. Firstly, in the case of facades having relatively high sound insulation characteristics, sufficient sound pressure level for external traffic noise above the background noise level may not be obtained in the room. Secondly, for the measurements of equivalent sound pressure level, it is necessary to use a special integrating device in addition to an usual sound level meter.

Thus, the loudspeaker noise was adopted as the source of sound in this Japanese Standard. Arrangements of loudspeaker and of measuring microphone were decided through extensive field measurements. Eventually, loudspeaker is set in front of the test window at a distance

Table 2. Comparison of JIS of ISO proposal
(sound insulation of facade elements and facades)

Items	JIS / A XXXX	draft ISO / 140 Part V
measured quantity	$D = L_1 - L_2$ L_1: average sound pressure level in front L_2: average sound pressure level in the room	(1) transmission loss (2) standardized level draft
sound source type and position	1 octave band noise from loudspeaker which is placed in front of the window at a distance of more than two fold of maximum dimension of test window	(1) existing traffic noise (2) loudspeaker placed in order that the local difference of sound pressure level over the facade should be less than 5 dB. It is placed above ground, pregerably on the ground.
microphone (out side)	5 points on the plane at a distance of 1 m from the window	(1) 2 m from the facade (2) as close as possible to the facade ($\leqq$2 cm)
microphone (in the room)	5 points	(1) 6 points (2) rotating microphone: sweep radius is 0.7 m
calculation of average sound pressure level	same as JIS / A 1417 (Table 1)	(1) equivalent sound pressure level (for traffic noise) (2) same as Part IV (Table 1) (for loudspeaker noise)

of more than two fold of maximum dimension of the window. Also, the axis of loudspeaker is set in the direction perpendicular to the window.

Sound insulation characteristics are represented by the sound pressure level difference between both sides of test window. Outside of the window, average sound pressure level is obtained over the plane at a distance of 1 meter from the window. On the other hand, in the room, average sound pressure level is obtained by averaging through entire room. Of course, 10 dB limitation concerning the local difference of sound pressure level should still be held in the room. If it is rather difficult to measure the sound pressure level outside of the window, the average sound pressure level is obtained from the sound radiation of the loudspeaker in the free field. That is, the microphone should be placed at the same distance from the loudspeaker as the surface of the test window. The sound pressure level should be averaged over an area corresponding to the surface of the test window. This method is the same with the procedure specified in draft ISO proposal for the case of loudspeaker source.

2.3 Measurement of impact sound insulation of floors [1].

As a impact sound source, the standardized tapping machine is used for both JIS and ISO proposal. Recently, different type of impact sound source, the drop of automobile tire, is being proposed in Japan [2]. It is pointed out that in some cases these heavy impact sources would be necessary for the evaluation of impact sound insulation properties of floors. This problem was left in future and the ISO tapping machine was also adopted in this Japanese Standard.

Comparisons of several items in JIS and ISO proposal are shown in Table 3. Here, the most significant difference would be in the measured quantity. In ISO proposal, impact sound insulation should be represented by normalized impact sound level or standardized impact sound level. The former, impact sound level corrected by the adsorption

Table 3. Comparison of JIS and ISO proposal (impact sound insulation of floors)

Items	JIS / A 1419	draft ISO / 140 Part VII
measured quantity	impact sound pressure level	(1) normalized impact sound level (2) standardized impact sound level
positions of tapping machine	more than 3 points (preferably 5 points) equally distributed on the diagonal line. hammer connection line should be oriented at 90° to the direction of diagonal line.	at least 4 positions. hammer connection line should be oriented at 45° to the direction of ribs and beams.
microphone position	5 points, uniformly distribute in a room	(1) 1 position for each tapping machine (2) rotating microphone: minimum sweep radius of 0.7 m
frequency of measurements	63, 125, 250, 500, 1000, 2000, 4000 Hz	125 ~ 2000 Hz If 1/3 octave band levels are measured, impact sound level is obtained by summing energy in three adjoining 1/3 octave bands.
calculation of average sound pressure level	simple arithmetic averaging If local level diffe-rence for one tapping machine position exceeds 10 dB, average level should not be ontained. Even if sound pressure level for each tapping machine position differs more than 10 dB, average level can be obtained.	

of the receiving room, is used to determine the impact sound insulation properties of a building element. The latter, impact sound level corrected by the reverberation time of the receiving room, represents the room condition for the protection afforded to the occupants of the building against the impact sound transmission.

On the contrary, JIS determines the impact sound pressure level itself, which represents the practical situation of the building. The impact noise appearing in the room would correspond to measured impact sound pressure level itself. Of course, the absolute value of impact noise is dependent upon the existing impact source. But, the noise that is heard in the room is directly related with the sound pressure level generated by the standard tapping machine. Here, the correction concerning the sound absorption or reverberation time of the room would not have any concern. From the practical point of view, the applicability of the standard tapping machine might be another question which has been discussed for a long time.

In preparing the draft proposal of this Japanese Standard, an extensive field measurements had been carried out. There, the most serious problem was the position of tapping machine. Not only the position of tapping machine but the direction of hammer connection line showed serious effect on the measured results of impact sound pressure level. So, this was specified in detail in this Japanese Standard. Details are shown in Table 3.

Also, the measuring procedures of sound pressure level are somewhat different in JIS and ISO proposal. In ISO proposal, the impact sound pressure level at one microphone position is represented by the time average of sound pressure level. On the other hand, Japanese Standard specifies more practically the method of reading the output of sound level meter. That is, the average value of the peak indication of sound level meter should be read. Here, the dynamic characteristics of sound level meter should be set on "FAST".

2.4 Common problems for three Standards.

Throughout these three standards for the field measurements of sound insulation, it is pointed out that here is some difference in the method of representing the measured results. Usually, the measured results are given in the form of a curve and/or in tabular form. In the case of graphic representation, the ratio of the ordinate (decibels) to the abscissa (frequency) would have serious effect on the understanding of sound insulation characteristics. In ISO proposal, it is allowed to use three different ratio of the ordinate to the abscissa. The curve would become very cause some confusion. So, at least, the ratio of the ordinate to the abscissa should be limited to one value.

In many cases, the data of sound insulation properties are used in connection with noise data, for examples sound power level of noise sources, field data of existing noise, regulation or goal for environmental noise and so on. Form this point of view, Japanese Standards specified for the graphic representation of sound insulation such scale as the frequency of one octave in 15 millimeters and 10 decibels in 20 millimeters. This would correspond to one of the ISO specifications, where the lenght for a 10:1 frequency ratio should be equal to the length for 25 dB on the ordinate scale.

3. Conclusion

As shown in this paper, there are some discrepancies between Japanese Standards and ISO proposals on the method for field measurements of sound insulation in buildings. These would be caused mainly by the difference of the purposes of measurements and of the uses of the measured results.

Now, I understand that the standardization carried out in Japan would belong to the different category with ISO draft proposals, and so it would not be inconsistent with each other.

1) S.Kimura: JIS method for field measurement of impact sound level of floors, Proc.of the 8th ICA, Vol.2 (London 1974) p.650

2) M.YSUOKA: On the impact machines for the measurement of impact sound transmission, Proc.of the 8th ICA, Vol.2 (London) p.644