FLOOR IMPACT SOUND INSULATION PERFORMANCE AND IT'S REGULATION OF MULTI-FAMILY DWELLINGS IN JAPAN

SS-RBA-04-01 SOUND INSULATION OF MULTI-FAMILY DWELLINGS

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ABSTRACT

In Japan, there are many constructed high multi-family buildings in the city. As regards inside noise in these buildings, there are many problems for floor impact sound from up-stairs. For solutions to these problems in Japan, a great deal of research has gone into the improvement of floor impact sound insulation performance. And it is an important part of the new architectural law.

In this paper, we will introduce the present condition of floor impact sound insulation performance for multi-family dwellings, and it's standard and recommendations, in Japan.

1. INTRODUCTION

Since residential construction in Japan has basically been primarily of wooden construction, multifamily dwellings also frequently consists of structures that have 2 stories and are horizontally contiguous. Nevertheless, due to recent improvements in construction technology, concrete multifamily residential buildings that are 30.40 stories high are no longer a rarity.

Multifamily housing such as this in which other households reside in the spaces above and below and to the left and right gives rise to problems of sound insulation between dwelling units, among which, floor impact sound from the units above and below is the problem that is pointed out most frequently by residents. The problem of floor impact sound in Japan frequently originates in so-called “heavy floor impact sound,” i.e., people walking or stepping around, due to the characteristic lifestyle of barefoot ambulation. Major countermeasures adopted heretofore have been centered on increasing the mass of the floor structure and increasing flexural rigidity. Therefore, unique standards and criteria have been produced for measurement and evaluation methods.

Though there were previously no laws and regulations governing floor impact sound, the Law Concerning the Promotion of Residence Quality was enacted in April 2000 and this appears in the law as the labeling item “housing performance labeling system.” Application of the housing performance labeling system is voluntary and is left to the discretion of residential sales companies; however, there are hopes that it will become widely used due to the strong demands of the consumers (residents) for labeling.

Meanwhile, research into floor impact sound is being pursued vigorously in Japan centered in methods for predicting and improving performance. Research and development is bound to gain further in importance, especially in relation to the housing performance labeling system.

In this paper, we introduce regulations and standards as well as research and development activities relating to the floor impact sound problem in Japan.

2. STANDARDS AND CRITERIA RELATING TO FLOOR IMPACT SOUND INSULATION PERFORMANCE

The following standards and criteria are currently in place for floor impact sound measurement, evaluation, standards, design methods and so forth.

(1) Architectural Institute of Japan recommended standards

(2) Japan Industrial Standards (JIS)

1) JIS A 1418/1: Measurement of floor impact sound insulation of buildings ;
Part 1: Method using standard light impact source.

2) JIS A 1418/2: Measurement of floor impact sound insulation of buildings ;
Part 2: Method using standard heavy impact sources.

3) JIS A 1419/2:Rating of sound insulation in buildings and of building elements ;
Part 2: Floor impact sound insulation.

4) JIS A 1440: Laboratory measurement of the reduction of transmitted tapping machine impact sound by floor coverings on a solid standard floor

(3) Law Concerning the Promotion of Residence Quality: Housing performance labeling system

(4) Other: Government Housing Loan Corporation standards, Urban Development

Corporation standards, etc.

The Architectural Institute of Japan recommended standards indicated in item (1) above were first proposed in 1954 and were subsequently revised, the most recent version appearing in 1997. These standards serve as the basis for the initial proposals in Japan for methods for measuring floor impact sound as well as assessment criteria and methods and they are cited in many other standards. The introduction of the L-curve in the assessment of floor impact sound and the introduction of heavy impact sources as standard impact sources, in particular, can be given as characteristics. They are still in wide use as judgment criteria for assessing floor impact sound insulation performance and determining design target values. The assessment curve is indicated in Fig. 1 and application grades are shown in Table 1. A reverse A-weighting correction curve is used as the assessment curve and an ISO standard tapping machine and standard heavy impact source (peak impact force: 3900N, 1500N, impact duration: 20ms) are stipulated as the standard impact sources.

The JIS standards of item (2) basically conform to the relevant ISO standards. JIS A 1418/1, JIS A 1419/2 and JIS A 1440 conform, respectively, to ISO 140-7 (1998), ISO 717-2 (1996) and ISO/DIS 140-8 (1995). However, since the measurement method using a standard heavy impact source (JIS A 1418/2) and the assessment method for heavy floor impact sound (JIS A 1419/2) are standards unique to Japan, they are stipulated as additional. Incidentally, in the method for measuring heavy floor impact sound, average octave band F-peak values are stipulated for the measurement volume and a method using the L-curve is indicated for assessments.

As the treatment of floor impact sound insulation performance in the housing performance labeling system described in item (3) above, a labeling method in accordance with spatial performance corresponding to the measurement results based on JIS A 1418/1/2, a labeling method according to equivalent slab thickness and a labeling method according to the reduction of floor impact sound level of the flooring material are stipulated. Labeling according to equivalent slab thickness is a labeling method for heavy floor impact sound. It indicates thickness when a void slab or other synthetic floor structure is replaced by an ordinary uniform concrete slab so that driving point impedance is equal and enables the selection of either that or the labeling method according to spatial performance. In addition, labeling according to the reduction of floor impact sound level of the flooring material is for floor impact sound using tapping machine. It is a labeling method that divides the values measured by JIS A 1440 and other standards by grade and it is possible to select either that or the labeling method according to spatial performance. In Table 2, grades according to the spatial performance of heavy floor impact sound insulation performance indicate grades according to equivalent slab thickness in Table 3. In addition, in Table 4, grades according to the spatial performance of floor impact sound insulation performance using tapping machine indicate grades according to the reduction of floor impact sound level in Table 5. Decisions regarding these performance values are based on the Architectural Institute of Japan recommended standards of item (1) above (Table

2).

The Government Housing Loan Corporation and Urban Development Corporation indicated in item (4) are a public financing organization and a public multifamily dwelling supply organization for housing construction and purchasing, each of which has set up its own standards for floor impact sound insulation performance. The setting of the values is decided while referring to (1) the Architectural Institute of Japan recommended standards and (3) the grades of the housing performance labeling system.

3. CONDITIONS OF RESEARCH AND DEVELOPMENT RELATING TO FLOOR IMPACT SOUND

Research and development relating to floor impact sound is being undertaken enthusiastically as the result of the demands of residents for improvements in floor impact sound insulation performance and the implementation of the housing performance labeling system. Since the improvement of heavy floor impact sound is especially considered to be of high priority in Japan, there are numerous examples of research and development relating to floor frame structure. As the major content of this research, much of it is being conducted in the areas of (1) numerical and other prediction calculation methods using calculation methods, FEM, etc., based on the impedance method as advocated by the authors, (2) floor impact sound generating system and remedies and (3) the development of various flooring materials that have a high level of floor impact sound insulation performance using tapping machine. Thus, there are many studies among research and development relevant to heavy floor impact sound relating to the improvement of the floor frame structure and also many in the area of floor impact sound using tapping machine relating to flooring materials.

In research and development relating to methods for improving heavy floor impact sound insulation performance, since the important points are strongly dependent on the vibration performance of the floor frame structure, studies are being conducted focusing on methods for increasing driving point impedance of the floor structure cross-section, methods for improving restriction in the vicinity of the slab and the reduction of slab area, that is, reduction of the acoustic radiation area. The use of void slabs, a hollow-core slab structure, can be cited as a specific development for the purpose of suppressing increased flexural rigidity of the floor slab cross-section as well as increased mass. For example, it is possible to achieve L-50 or higher performance using a floor slab with a total thickness in the range of 250-300mm. An example of a floor slab cross-section for use as a heavy floor impact sound countermeasure is shown in Fig. 2.

In addition, development is also being carried out vigorously relating to soundproof type directly-applied wooden flooring such as that indicated in Fig. 3 in order to enhance floor impact sound insulation performance using tapping machine in which the floor is wood flooring material. There are many products that realize low elasticity in the finishing material cross-section and

achieve a performance in the range of L-40 – L-50 (performance when applied on ordinary concrete: thickness 15cm) by cutting notches in the wooden panels and then spreading cushioning material as indicated in Fig. 3.

Meanwhile, in the housing performance labeling system, "general floor cross-sectional specifications" for which performance is verified in the law are indicated for each grade and, as long as floors are constructed in accordance with the designated specifications, it is possible to label the corresponding grade and it is a mechanism that easily enables the achievement of performance. Table 6 shows examples of the specification stipulations for heavy floor impact sound.

As indicated above, floor impact sound is an extremely serious problem in Japan at present and there are many examples of relevant research and development. In addition, remedies for heavy floor impact sound caused by people walking or children stepping are deemed to be important.

4. FUTURE TRENDS

Floor impact sound is ranked as a major factor that determines performance in the sound environment in multifamily dwelling. The results of questionnaire surveys of multifamily dwelling residents conducted by the authors pointed to floor impact sound as the leading source of "irritating noises" and there is considered to be a need for further active research and development seeking improvements in performance.

The housing performance labeling system is currently being implemented, which enables residents to be aware of the floor impact sound insulation performance when they purchase a residence. The introduction rate of this system is still low but there are hopes for its further dissemination in the future.

In addition, it is also necessary to clearly define the correspondence between the floor impact sound insulation performance (L-value) and the sensations felt by residents in their everyday lives. Indicating this correspondence quantitatively is extremely difficult and has thus far been passed by without thorough examination. It is especially necessary to move ahead promptly with efforts to specify the performance that would naturally be expected of housing suppliers, that is, that we must be able to secure in society.

Bibliographical references:

1) K.Inoue,S.Kimura, " Research and Development of Floor Impact Sound Insulation of Multi-Family Dwellings in Japan ", INTER-NOISE2000, pp749-754

2) K.Inoue,M.Yasuoka,H.Tachibana, "Reduction of Floor Impact Sound On Floor Finishing For Wooden Floor Structure " , INTER-NOISE2001

Table 1 Application grades for floor impact sound (AIJ)

Building	Room use	Impact source	Application grades			
			special grade	grade 1	grade 2	grade 3
Multi-family dwellings	Sitting room	Heavy impact source	L-45	L-50	L-55	L-60,L-65*
		Tapping machine	L-40	L-45	L-55	L-60
Hotel	Guest room	Heavy impact source	L-45	L-50	L-55	L-60
		Tapping machine	L-40	L-45	L-50	L-55
School	Classroom	Heavy impact source	L-50	L-55	L-60	L-65
		Tapping machine				

,It is applied to wooden frame structure, light weight steel frame structure.

Table 2 Grades for heavy floor impact sound insulation performance (labeling system)

Rank	Impact sound level (heavy impact source) Octave-band center frequency(Hz)			
	63	125	250	500
5	• ..73dB	• ..63dB	• ..56dB	• ..50dB
4	• ..78dB	• ..68dB	• ..61dB	• ..55dB
3	• ..83dB	• ..73dB	• ..66dB	• ..60dB
2	• ..88dB	• ..78dB	• ..71dB	• ..65dB
1	•	•	•	•

Table 3 Grades according to equivalent slab thickness (labeling system)

	Equivalent slab Thickness(h)
a	• †27cm
b	• †20cm
c	• †15cm
d	• †11cm
e	the others

h=h1.10^(L/40).100(cm) h1=(2.m..(E.I).10^-13)^1/4

L reduction of heavy floor impact sound level by floor coverings

E.I.flexural rigidity per unit width of floor

„unit area density (kg/m²)

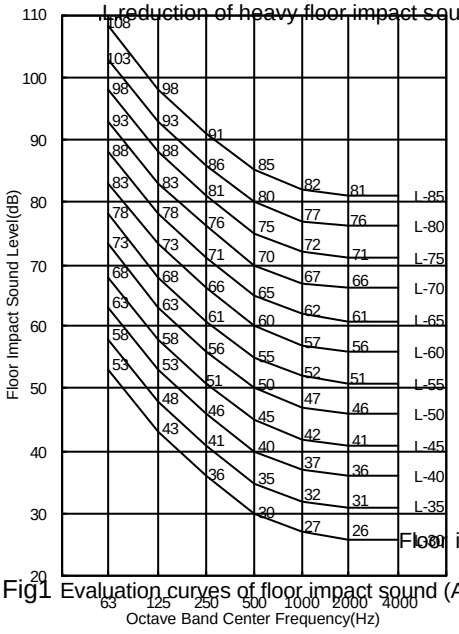


Fig1 Evaluation curves of floor impact sound (AIJ,JIS)

Table 4 Grades for floor impact sound using tapping (labeling system)

Rank	Impact sound level (tapping machine) Octave-band center frequency(Hz)				
	125	250	500	1k	2k
5	• ..58dB	• ..51dB	• ..45dB	• ..42dB	• ..41dB
4	• ..63dB	• ..56dB	• ..50dB	• ..47dB	• ..46dB
3	• ..68dB	• ..61dB	• ..55dB	• ..52dB	• ..51dB
2	• ..73dB	• ..66dB	• ..60dB	• ..57dB	• ..56dB
1	•	•	•	•	•

Table 5 Grades according to the reduction of Floor impact sound (tapping machine)

	Reduction of impact sound level (tapping machine) <octave band 500Hz>
@	• †30dB
A	• †25dB
B	• †20dB
C	• †15dB
D	The others

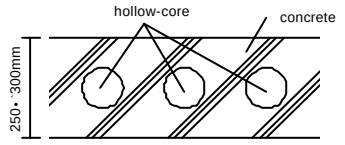
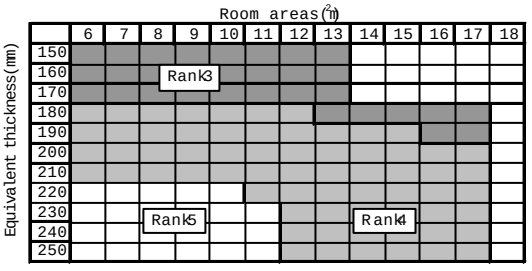


Fig2 Example of floor slab cross-section for heavy floor Impact sound countermeasure

Table 6 Example of the specification stipulation for heavy floor impact sound insulation performance



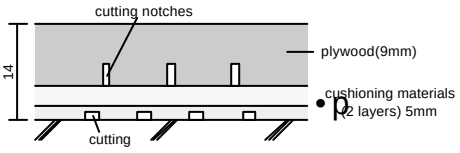


Fig3 Example of soundproof type directly-applied wooden flooring