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Floor Impact Noise Characteristics of Impact Ball Depending on the Drop Heights in the both Wooden and Concrete Structures

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ABSTRACT

This study aimed at measuring impact sound by drop heights using the impact ball adopted as the standard heavy-weighting impact source in Japan, comparing them with the jumping impact sounds that are the actual impact sources so as to examine the most similar drop heights to the actual impact sound and review the error that may occur from impact ball. In addition, the study was intended to find out the difference of the materials and method for installation by having the tests under the same condition performed in the laboratory building for timber structure of BRI in Japan and concrete structure of KIMM in Korea. According to the result of study, impact sound was found to show the similar sound pressure level to actual one at the drop height of 10 ~ 30cm in timber structure, while there was no similar height of sound pressure but it was desirable to drop at the height of 100~110cm to maintain a quiet environment in the concrete structure. In addition, the error that may occur from the difference of height of 10m up and down based on the standard drop height caused by the impact ball operated by human hands was approx. 1dB or less only in its value of characteristic, but it must be carefully taken into account in the L-Index assessment.

1. INTRODUCTION

Floor impact sound problems have been ceaselessly raised in the apartment in Korea. Recently, a number of cases regarding the noise-related dispute between the neighbours are brought before the Environmental Dispute Mediation Committee for their settlements, and it is sometimes developed into violence rather than a legal settlement to solve the problem in reality, emerging as a social issue. This is apparently proved from an objective indicator, that is, approx. 83% of the disputes in total brought before Environmental Dispute Mediation Committee fall under the disputes regarding noise and vibration, a majority of which are the civil complaints concerning floor impact sound.[1]

Thus, the Article 14 (3) of Enforcement Decree of Housing Construction Standard was revised in its concrete standard of performance on April 22, 2003, which requires the apartment that applies for business approval on and after April 22, 2003 to follow the rule after 1-year grace period. In view of the limited performance of the current wall type structure, the revised regulation requires the standard on light-weighting impact sound to be in force immediately, while the standard on heavy-weighting impact sound to be in force since July 1, 2005.[2] In addition, following the implementation of the Housing Performance Indicator System since Jan. 9, 2006, the regulation requires floor impact sound to be marked in Class 1 through 4, and encourages the importance of floor impact sound and induces the improvement of performance even in terms of institution through allocating the greatest points to the floor impact sound sector in the criteria of additional points with regard to the recent price upper limit system, etc.

Amid the number of disputes related with floor impact sound being increased [1], it is necessary to develop the structure that may reduce floor impact sound and build up the objective method for the resident to easily understand the sound insulation performance of such structure in order to solve this problem in a reasonable way. For this, assessing the floor impact sound that occurs in the actual apartment is the most objective way and easy for the actual resident to understand. Nevertheless, owing to the problems in reproducible floor impact sound and the subsequent lack of overall requisites, it is important to select the impact source that may simulate the floor impact sound to the best. The problem is, however, the characteristic of bang machine impact regulated as standard heavy-impact source at present is different from that of the impact from children which me it occur in the apartment in real. Impact of bang machine is assessed more excessively at 63Hz than the actual impact source of bang machine a sufficient revies of use for the standard impact source [3]. Furthermore, different from Korea, in Japan where timber structure is used, such impact of bang machine caused damage to the timber structure, and subsequently Tachibana came to suggest an impact ball as a new impact source [4]. Therefore, it is necessary to review the validity and physical property of this impact ball specified as heavy-weighting impact source in JIS, Japan.

Accordingly, this study was intended to compare the test conducted for wet-type floor structure and semi-dry type floor structure of the apartment in Korea with the test conducted for the Japan's actual build in timber structure using impact ball as its heavy-weighting impact source, and consequently carry out the test to examine the validity of impact ball through the comparison with actual impact source along with physical difference of floor impact sound between timber structure and concrete structure.

This test adopted the impact ball specified in JIS A 1418-2[6] was, in Korea, conducted against wet-type(Mortar 40mm+Autoclaved lightweight concrete 40mm+EPS 30mm+Concrete 150mm) and half-dry(Mortar 50mm+EPS 47mm+Isolation 13mm+Concrete 150mm) structure in the concrete structure (LxDxH: 2.8m x 4.3m x 2.6m) in the laboratory building of KIMM, while, in Japan, against a mock-up laboratory building (LxDxH: 2.7m x 3.6m x 2.7m) made of flooring plywood, reinforced gypsum board, and structural ply wood that is structured in timber normally used in Japan in the case of four-story slab laboratory building in BRI. In order to have an equal testing condition, excitation was done at the center and at the corner, and the sound was received at one point at the center and four points at the corners.

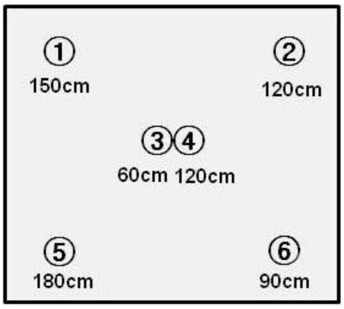

Figure 1. Measurement points and height of microphones

2. CHARACTERISTICS OF THE IMPACT BALL

According to the papers of J.Y. Jeon et al. [3], compared with the impact force of children jumping and running that is the main impact sounds occurred in the apartments in Korea, bang machine appeared higher at 63Hz band, and the impact force of impact ball was lower than that of bang machine, which was similar to the impact force caused by the child in fact.

In the case of Japan, they have developed an impact ball that reproduces the impact force of child weighing 25kg at the age of 8 years to avoid the damage of excessive impact of bang machine to the timber structure and adopts it as the standard heavy-weighting impact source [4]. In this test, floor impact sound was measured using an impact ball in the same shape and mass specified in JIS A 1418-2. JIS A 1418-2 regulates the impact ball with 2.5± 0.1kg, 185mm diameter in hollow sphere shape with 30mm for its exterior thickness, which requires 20ms for impact time when it freely drops from the height of 1m impacting the floor. The table 1 [3] shows the comparison of physical characteristics between impact balls and bang machine.

Table 1. Comparison of features between impact ball and bang machine

	Impact ball	Bang machine
Weight	2.5±0.1kg	Tire 7.3±0.2kg Bank Machine 20kg
Number of people required for measurement	2	3~4
Drop height	Free drop at 1 m	Mechanical blow at 85cm
Electricity	Not required	Required
Maintenance	Not required	Tire air pressure requires periodical maintenance
Damage to structure	N/A	Damage occurred in timber structure
Accuracy	Slight error exists	No error

Source: Review of the Impact Ball in Evaluating Floor Impact Sound (J.Y. Jeon et al., 2006)

3. RESULT OF MEASURING FLOOR IMPACT SOUND BY DROP HEIGHTS USING IMPACT BALL

3.1 Sound pressure levels by drop heights

As shown in the figure 2 for timber structure, L-Index varied between L-45 and L-65. Of them, floor impact sounds from free drop at the standard drop height of 1m appeared to respond from 'well audible' to 'audible but very bothered' in the degree of noise based on L-Index of Japan [7].

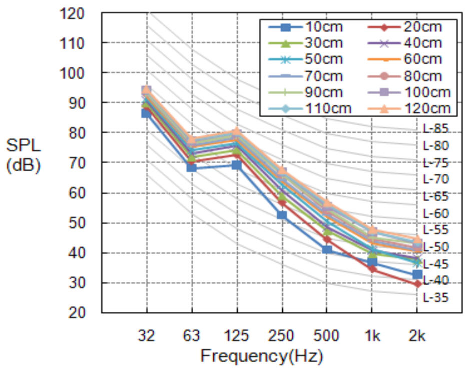

Figure 2. Floor impact sound pressure level in octave band by drop height of impact ball on wooden structure

Regarding the results shown in the figure 3 and figure 4 for two different concrete structures, L-Index varied between L-50 and L-35. Of them, floor impact sounds from free drop at the standard drop height of 1m appeared to respond from 'rarely audible' to 'slightly audible' in the degree of noise based on L-Index of Japan [7]. In addition, the concrete structure showed also different feature depending on the installation method. That is, as shown in the Figure, the results of floor impact sounds measured from wet-type structure and semi-dry structure showed different feature between each other; suddenly dropping down to 100Hz with 63Hz - low frequency as its inflection point in wet-type structure, while showing a smooth gradient throughout overall frequency band in semi-dry structure.

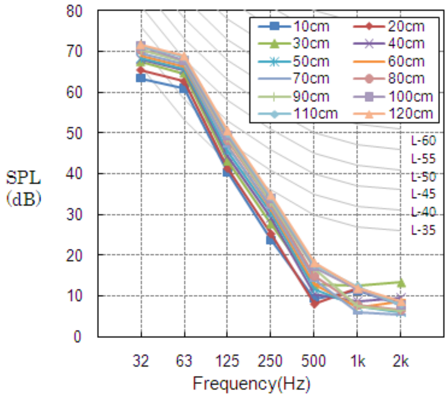

Figure 3. Floor impact sound pressure level by drop height of impact ball on concrete structure of wet-type

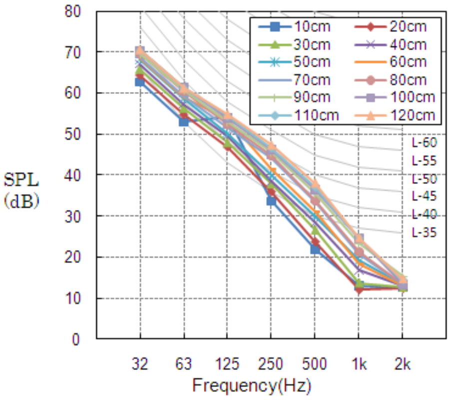

Figure 4. Floor impact sound pressure level by drop height of impact ball on concrete structure of half dry-type

In the test of timber structure as shown in figure 5, the pressure levels of floor impact sound at the drop height between 10cm~30cm appeared to be most similar as result of comparing the sound pressure levels of impact ball by drop heights with the actual impact sounds with regard to the sound pressure levels measured when a male adult weighing 65kg jumps approx. 10~15cm at full strength, medium strength, weak strength, and just walks at the same place respectively.

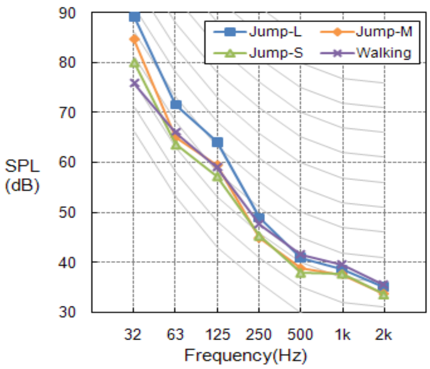

Figure 5. Sound press Level of Jumping and Walking

On the contrary, in the test of the concrete structure as shown in the figure 6, comparing with the prior test data stated in the paper of Jeon Jin-yong et al., the height between 100cm ~ 110cm is deemed optimal when the overall frequency band is compared although there was no similar sound pressures as shown in timber structure.

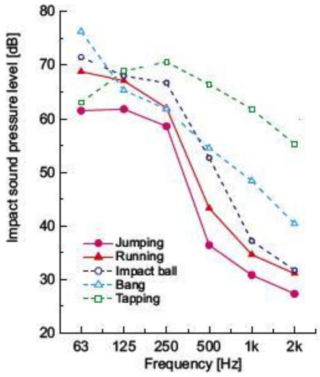

Figure 6. Frequency characteristics of real impact sounds generated by a 26-kg child and by standard impactors on concrete slab

Source: Review of the Impact Ball in Evaluating Floor Impact Sound (J.Y. Jeon et al., 2006)

3.2 Sound pressure levels in low-frequency band by drop heights

In the timber structure, as shown in figure 7, sound pressure tends to sharply rise as the drop height increases especially in the bands of 250Hz and 500Hz at the drop height of 10~50cm.

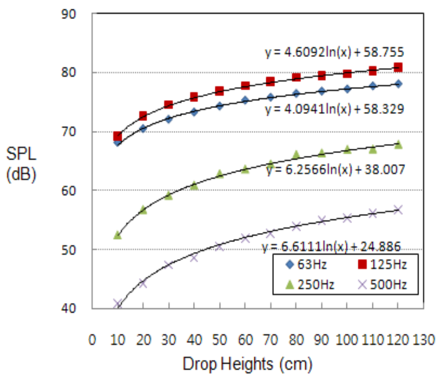

Figure 7. Floor impact sound pressure level for each octave band with drop height of impact ball

In the concrete structure, as shown in the figure 8 and Figure 9, sound pressure tends to rise in a smooth gradient as the drop height increases in the center frequency band of heavy-impact source in the wet-type structure, while it rises in a smooth gradient in the bands of 63Hz and 125Hz, although it also sharply increases in the bands of 250Hz and 500Hz in particular as the drop height increases.

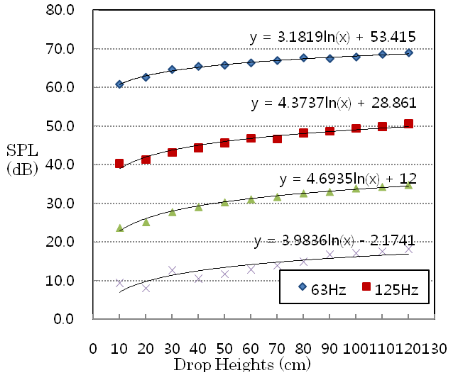

Figure 8. Floor impact sound pressure level by drop height of impact ball on wet-type concrete structure

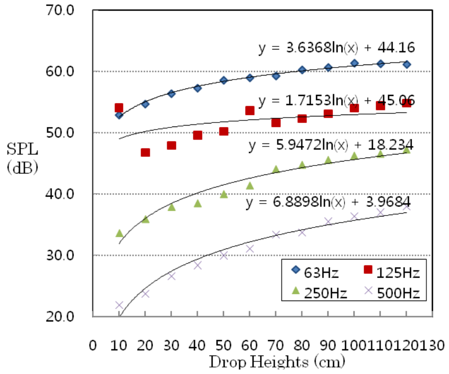

Figure 9. Floor impact sound pressure level by drop height of impact ball on half dry-type concrete structure

Figure 10 is the result of sound pressure level in the low frequency band when male adult jumps compared with sound pressure level of impact ball in the low frequency band by drop heights shown in the figure 7, in which the pressure levels of floor impact sound were found in the most similar way at the drop height between 10cm~30cm.

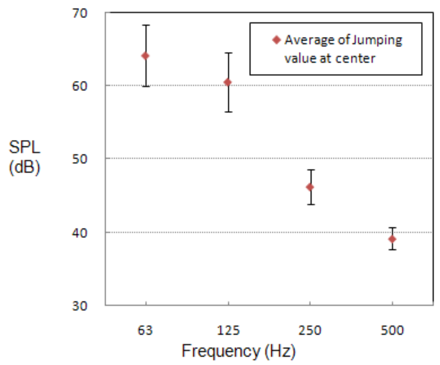

Figure 10. Sound press level of Jumping at low frequencies

In order to examine the error by the heights of receiving point, the sounds were measured simultaneously at the heights of microphone of 60cm and 120cm at the position of receiving point in the center. In result, there was the difference of approx. 5dB between both heights of receiving point in the band of 63Hz only. This is possibly because of room mode phenomenon, which must be taken into account without fail with regard to the site test of heavy-impact sound at the receiving point of 120cm from the floor.

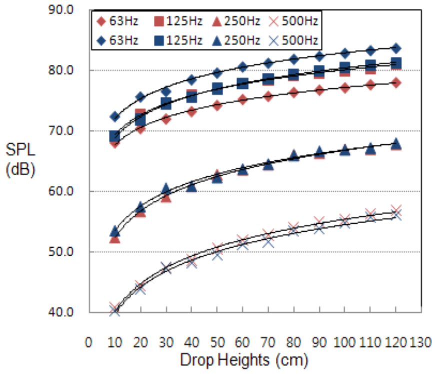

Figure 11. Floor impact sound pressure level at the low frequencies by the drop height of impact ball

3.3 Consideration on the accuracy of standard drop height

Impact ball operated by human hands adopted as the standard impact source in Japan was suspected of its less accuracy than bang machine operated by machine. Comparing the sounds at 10cm up and down from the standard height of 1m, results showed the difference less than 1dB as shown in the figure 12. It represents that such slight difference caused by human operation could be neglected.

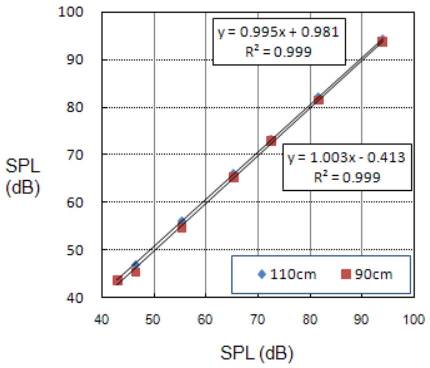

Figure 12. Consideration on the accuracy of standard drop height

3.4 Consideration on the accuracy of the exciting position of the drops

There could be an error in excitation points of the impact ball drops. In order to examine this error, comparison was attempted in such a manner of receiving the sounds at the center with sounds at the corner (No. 2 of the Figure 1) which were measured at the height of 120cm (microphone). As shown in the Figure 13, it appeared that aveage difference of 1.5dB was ocuurred depending on the drop position. And impact sound level at the center is 2dB larger than sound level at the corner at the drop height of 10dB while approximately 1 dB at the drop height of 20cm.

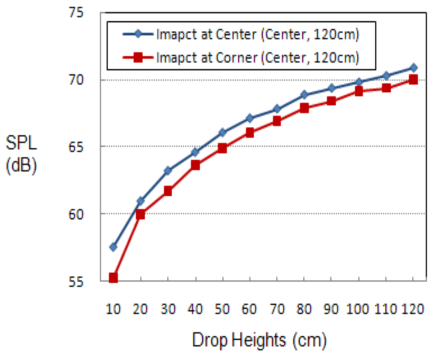

Figure 13. Consideration on the accuracy of the exciting position for the drops

4. CONCLUSIONS

Followings are the results of the acoustic experiments conducted to examine the impact sound pressure levels by drop heights and the frequency characteristics using the impact ball adopted as standard heavy-weighting impact source in a wooden structure in Japan and a concrete structure in Korea.

1) In the timber structure, sound pressure level and frequency characteristics appeared in a similar manner between jumping impact sound of children that is the actual impact source and dropped impact sound at the height of 10~30cm while, in the concrete structure, the height of 100cm~110cm is deemed to be proper drop height.

2) According to the assessment of sound pressure level at 1m, the standard drop height in Japan, the sound pressure in the L-Index was found to vary between L-45 ~ L-65 in the timber structure test, while L-50 ~ L-35 in the concrete structure test.

3) In the timber structure, sound pressure appeared to sharply increse with the drop height especially in the bands of 250Hz and 500Hz at the drop height of 10~50cm. While, in the concrete structure, sound pressure rose smoothly as the drop height increased although sound pressure suddenly rose with the increasing height in the bands of 125Hz and 250Hz in semi-dry structure.

4) In the space where absorption ratio is insufficient, room mode phenomenon took place at the height of microphone (120cm), which should be taken into account in the further study.

5) With regard to the accuracies of drop height of impact ball and exciting position, the error caused by human operation lies within 1dB or less, but this should be considered carefully in L-Index assessment.

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