Low-frequency impact sound pressure level characteristics with three standard impact sources in Korean reinforced concrete structured apartment buildings

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Abstract. Floor impact sound is one of the major low frequency sound which are generated in residential buildings. In ISO standard, rubber ball standardized as heavy/soft impact source and modified tapping machine was proposed to simulate frequency characteristics of real impact sound. Rubber ball is 2.5 kg silicone rubber hollow ball and free drop from 1 m height. However, low frequency impact sound pressure level of tapping machine in a residential buildings with high floor impact isolation performance is relatively lower than real impact sound. It is need to be checked that measurement of floor impact sound isolation performance in residential buildings with resilient materials using tapping machine is suitable method. In this study, floor impact sound isolation performances of reinforced concrete structured residential buildings with resilient buildings were measured using tapping machine, bang machine and rubber ball. The low frequency measurement results were compared. It was found from measurement results that tapping machine impact sound pressure level below 100 Hz bands were lower than rubber ball and bang machine impact sound in Korean residential building where 20 mm thick resilient material was installed. Single number quantity of tapping machine impact sound pressure level in Korean residential building was 50 dB in $L_{A,w}$. From these results, it can be concluded that measurement of low frequency impact sound isolation performance using tapping machine in reinforced concrete structured residential buildings with resilient material is not suitable.

1. Introduction

Floor impact sound is one of the major low frequency sound which are generated in residential buildings. In Korea, a lot of disputes and complains on low-frequency impact sound have been occurring. In order to measure and evaluation low-frequency impact sound isolation performance, bang machine and rubber ball have been used as standard impact sources are used in Korea and Japan [1, 2]. Rubber ball and bang machine was developed to simulate children’s running and jumping in residential buildings. It was reported that physical and subjective characteristics of rubber ball was similar with children’s running and jumping in Korean reinforced concrete structured multi story residential buildings [3, 4]. Rubber ball was standardized in ISO from 2010[5, 6, 7] as the only heavy/soft impact source. Rubber ball is 2.5 kg silicone rubber hollow ball. The detailed chemical composition and physical properties were standardized in ISO 10140-5 and ISO 16283-2. In order to generate low frequency impact sound, the operator have to make a free drop from 1 m height.
Rubber ball and bang machine directly impact floor system on the upper floor and measure transmitted impact sound in lower unit of the residential buildings. Impact force and impact sound pressure level of rubber ball and bang machine is usually concentrated in low-frequency band below 100 Hz.

Tapping machine have been widely used in ISO standard. Tapping machine simulate high heel drop and dropping hard material on the floor and usually generate mid and high frequency impact sound. In order to change frequency characteristics of tapping machine impact sound, resilient material or pad was used. By using a resilient material or pad, mid and high frequency tapping machine impact sound reduced and relatively high level of low frequency impact sound obtained; this method is called modified tapping machine. In ISO 10140-5 modified tapping machine was proposed.

Floor impact isolation performance of wooden structured residential buildings in low-frequency band is relatively low, therefore modified tapping machine can generate enough impact sound pressure level in low frequency band. However, the floor impact isolation performance of reinforced concrete structured residential building with resilient material is better than wooden structured buildings. It is need to be checked that measurement of floor impact sound isolation performance in residential buildings with resilient materials using tapping machine is suitable method.

In this study, floor impact sound isolation performances of reinforced concrete structured residential buildings with resilient buildings were measured using tapping machine, bang machine and rubber ball. The low frequency measurement results were compared.

2. Measurement of floor impact sound pressure level

Floor impact isolation performance of reinforced concrete residential building in Korea was measured according to KS F 2810-1 and 2, using fixed microphone method. Three kinds of standard impact sources were used. One is tapping machine which was standardized in ISO 10140-5[2] and KS F 2810-1[8], another is bang machine which regulated in KS F 2810-2[6] and the other is rubber ball which is standardized in ISO 10140-5[2] in 2010 as a heavy/soft impact source. Five positions on upper floor were impacted and impact sound five positions on lower floor including center position. Measurement setup was shown in Figure 2 (a).

![Figure 1. Three kinds of standard impact sources](image)

Floor impact sound isolation performance measurements were conducted in 40 typical Korean multi story residential units. Floating floor system to isolate transmission of floor impact energy into lower unit, shall be used all of the Korean residential buildings. Figure 2 (b) shows floor system of typical Korean reinforced concrete structured residential buildings. The thickness of reinforced concrete slabs was 210 mm.

On the reinforced concrete slab, 20 mm or 30 mm thick resilient material was installed to reduce floor impact sound. Then aerated light-weight concrete was installed thermal insulation. Floor heating system and cement mortar usually installed on the aerated light-weight concrete. Finally, finishing material such as wood floor or linoleum installed on the surface of cement mortar. Floor impact sound pressure level was measured in the living room of each units. The area of the living rooms was from 19.5 m² to 29.3 m². Frequency range of tapping machine impact sound was from 50 Hz to 3 150 Hz in 1/3 octave band.
Bang machine and rubber ball impact was measured from 25 Hz to 630 Hz.

![Measurement setup](image1)

**Figure 2.** Floor impact sound pressure level measurement setup and floor system of typical Korean reinforced concrete residential buildings

3. **Results of floor impact sound pressure level measurements**

Measurement results of impact sound pressure level from 40 reinforced concrete residential buildings using three kinds of standard impact sources were shown in Figure 3. Figure 3 (a) shows measurement results of tapping machine impact sound. Tapping machine impact sound shows relatively low impact sound pressure level above 200 Hz bands. Mid and high frequency tapping machine impact was reduced by resilient material. Below 100 Hz bands, tapping machine impact sound pressure level decreased.

![Measurement results of three kinds of standard impact sources](image2)

**Figure 3.** Measurement results of three kinds of standard impact sources in Korean reinforced concrete structured residential buildings

Figure 3 (b) shows measured results of bang machine impact sound. Rubber ball results was shown in Figure 3 (c). Bang machine and rubber ball impact have high relative high impact sound pressure level in low frequency bands. Both of them have similar frequency characteristics. However, bang machine
impact sound pressure level is higher than rubber ball impact sound in the frequency range below 100 Hz bands. Because, impact force of the bang machine is about three times higher than impact force of rubber ball impact.

![Graph](image)

**Figure 4.** Averaged impact sound pressure levels and standard deviations of three kinds of standard impact sources

Figure 4 (a) shows average frequency spectra of three kinds of impact sounds. Above 125 Hz bands, impact sound pressure level of tapping machine was higher than bang machine and rubber ball impact sound. However, below 100 Hz bands bang machine and rubber ball impact sound pressure levels were higher than tapping machine impact sound. In the case 50 Hz band, rubber ball impact sound pressure level was 14.3 dB higher than tapping machine impact sound. Even 63 Hz band, rubber ball impact sound was higher than 6.9 dB comparing with tapping machine impact sound. When comparing bang machine impact sound with tapping machine impact sound in 50 Hz and 63 Hz bands, bang machine impact sound pressure levels were higher 22.1 dB and 17 dB than tapping machine impact sound respectively.

Single number quantity of averaged tapping machine impact sound pressure level; \( L'_{n,W} \); was 50 dB. It was reported that average impact sound isolation performance of European dwellings was Class D; \( L'_{n,W} \leq 56 \text{ dB} \)[9]. When classification scheme from EU COST action applied on the tapping machine impact sound isolation performance of Korean residential buildings, it can be classified as Class C.

Figure 4 (b) shows standard deviation of 40 measurement results. Standard deviation of tapping machine impact sound above 100 Hz bands were smaller than bang machine and rubber ball impact sound. However, below 80 Hz bands, tapping impact sound show the highest standard deviation values among three kinds of floor impact sound.

4. Conclusions

Low frequency impact sound is one of the major noise sources in residential buildings. In order to reduce and control the low frequency impact sound, proper measurement and evaluation method is needed. In ISO standard, rubber ball standardized as heavy/soft impact source and modified tapping machine was proposed to simulate frequency characteristics of real impact sound. However, low frequency impact sound pressure level of tapping machine in a residential buildings with high floor impact isolation performance is relatively lower than real impact sound.
In this study floor impact sound isolation performance of 40 Korean reinforced concrete structured residential buildings with resilient material was measured using three kinds of standard impact sources for the comparison of low frequency impact sound pressure level characteristics. It was found from measurement results that tapping machine impact sound pressure level below 100 Hz bands were lower than rubber ball and bang machine impact sound in Korean residential building where 20 mm thick resilient material was installed. Single number quantity of tapping machine impact sound pressure level in Korean residential building was 50 dB in $L_{n,W}$.

From these results, it can be concluded that measurement of low frequency impact sound isolation performance using tapping machine in reinforced concrete structured residential buildings with resilient material is not suitable.

References

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