Floor Impact Sound Performance Variation in Old Apartment Housing

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ABSTRACT

The floor impact sound of the apartment house is the most uncomfortable noise among indoor noises. In order to reduce floor impact sound, slab thickness of 210mm or more is applied to apartment buildings. However, since the slab thickness is 120mm ~ 180mm in the old apartment buildings, the performance of heavy impact sound insulation is poor. The old apartment buildings are increased in area in the vertical and horizontal directions through the remodeling. This remodeling should also improve the floor impact sound performance, so it is also important to provide a direction to improve the performance. For this purpose, we investigated the performance variation of the floor impact sound insulation of old apartment buildings. The standard deviation of the flood impact sound level increased with the increase in the frequency. For the heavy impact sound, the analysis result exhibited that the largest standard deviation was found at 50 Hz among the low frequency domain.

Keywords: Floor impact sound, Old apartment buildings, Deviation, Slab thickness
I-INCE Classification of Subject Number: 51

1. INTRODUCTION

To reduce the floor impact sound generated in apartments, buildings loads should increase, or vibration transmission should be suppressed by installing a resilient material. Most apartments in South Korea are built with a box-frame structure method, in which vibration generated in the upper part is easily transferred to adjacent households through the slabs and walls. Generally, a method of increasing a slab thickness has been used to increase the load of box-frame structure buildings. Since 2005, a considerable number of apartments have applied 210 mm of slab thickness and the minimum slab thickness has been set to 210 mm from 2014. However, a slab thickness in old apartments was distributed variably from 120 mm to 180 mm. The slab thickness of old apartments is thin. Thus, the performance of floor impact sound reduction is generally degraded. Old apartments may be re-constructed after demolition or remodeled.

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Various methods can be applied to improve the performance of floor impact sound reduction if old apartments are reconstructed. However, if old apartments are remodeled with the main structure intact, it is limited to apply various methods for noise reduction. Newly built apartments should comply with the current standards, but remodeled houses do not need to apply the floor impact sound standards.

As the number of old apartments increases, the number of apartments that consider remodeling also increases. However, the insulation performance of floor impact sound in remodeled apartments has been degraded since the minimum standards have not been applied to improve the performance of floor impact sound reduction. To overcome this degradation, it is now necessary to have a standard that can be applied to remodeling of old apartments. This study first investigated the current status of insulation performance of floor impact sound in old apartments to provide a measure to improve the performance or standards. Through this, it aims to study a measure that can be applied to remodeling apartments.

2. METHODS

The slab thickness of old apartments is thinner than that of newly built apartments and old apartments did not use resilient materials. Thus, old apartments have lower insulation performance of floor impact sound compared to that of newly built houses. It is necessary to identify the performance level of buildings in the past to provide a measure required to improve the performance of floor impact sound.

Two methods were used to identify the performance level of old buildings. First, literature reviews were conducted based on previously published papers. Second, apartments that were built a long time ago were actually measured to accumulate the data. To do this, the insulation performances of floor impact sound in old 60 houses were measured. The measurements were conducted in the living room where heavyweight and lightweight impact sounds were measured. The heavyweight impact sources were bang machine and rubber balls. Since the design drawings of the measured houses were not available, the floor structures could not be identified accurately. Thus, coring the floors of some measured houses was conducted to see the cross-sectional structure. The slab thickness of the 30-year-old apartments was around 120 mm.

Based on the results using the above two methods, a performance range of floor impact sound of old apartments and their deviation by frequency were analyzed.

3. RESULTS AND DISCUSSION

3.1 Results of Other Studies

Fig. 1 shows the summarized analysis results of 66 data, which were measured at the site in previous studies [1] to [4]. The slab thickness was ranged from 120 mm to 165 mm, and some of the had a structure contained with resilient materials. The analysis results exhibited that the maximum and minimum values of the heavyweight impact sound were 61 dB and 47 dB, and the maximum and minimum values of the lightweight impact sound were 74 dB and 53 dB. The median values of the heavyweight and lightweight impact sounds were 54.5 dB and 61 dB. Compared to the current minimum standards, only two places satisfied the both standards regarding heavyweight and lightweight impact sounds. A ratio that satisfied the heavyweight impact sound regulation was 12.1%. The arithmetic mean of the heavyweight impact sound was 54.2 dB, but the standard deviation was large as 3.0 dB. The previous studies results reported that the performance mean of old apartments was 54.2 dB, which requires technical application to improve the performance by 4 dB approximately to satisfy the current standards. However, some data revealed up to 61 dB performance, which required more than 10 dB performance improvements to meet the current standards for all existing apartments.

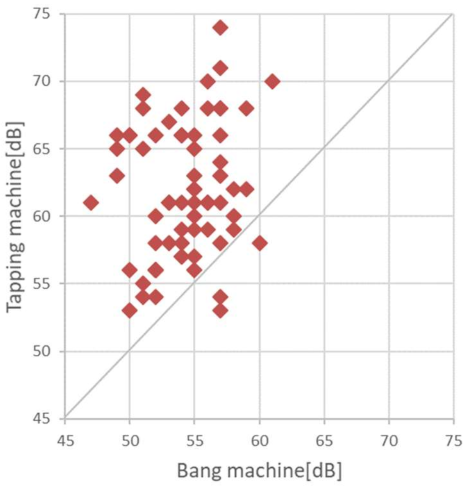
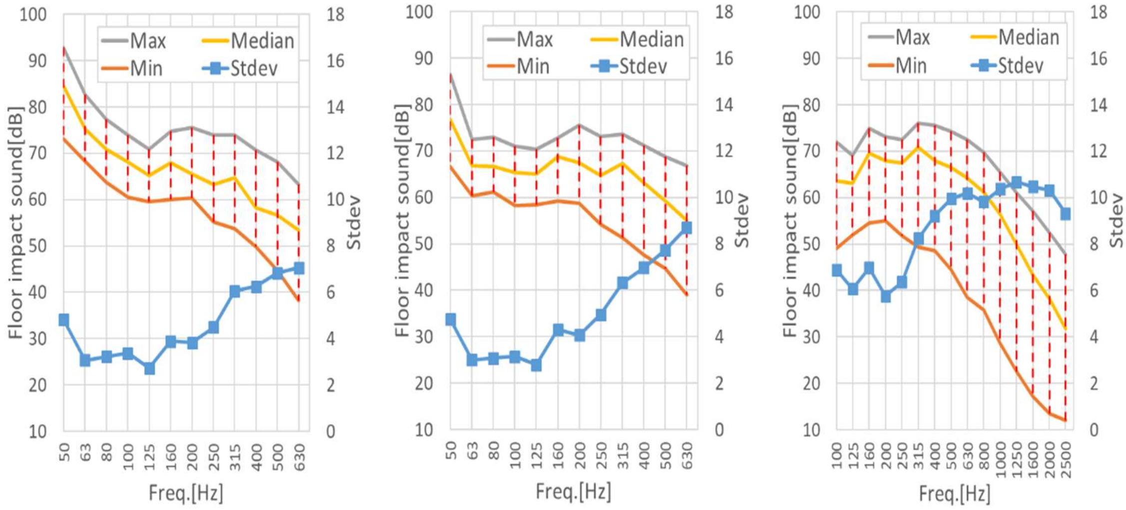


Fig. 1 Test results of other studies (reverse-A single number quantity) [1]~[4].

3.2 Field Test Results

Figs. 2 to 4 show the analysis results of the data measured at 60 places. Fig. 2 shows the statistical analysis results of each impact source. For the heavyweight impact sound, both of bang machine and rubber ball had a similar pattern. For the lightweight impact sound, the impact sound level was rapidly decreased as the frequency increased. A deviation of the impact sound level by frequency was more than 20 dB in all three impact sources. The results were shown because the floor impact sound insulation performance was different depending on floor slab thickness, cross-sectional structure, and surface finish material type. The standard deviation by frequency showed that as a frequency increased, the standard deviation tended to increase in all three impact sources. The heavyweight impact sound had the highest standard deviation at 50 Hz in the low frequency domain.

Figs. 3 and 4 show the analysis results of correlation between bang machine and other impact sources. The measurement results in the figures display the single number quantity using reverse A curve. The measurement results of the bang machine were ranged from 54 dB to 68 dB, and the median value and arithmetic mean were 62 dB and 61.0 dB. The measurement results of the rubber ball were distributed between 52 dB and 68 dB, and the median value and arithmetic mean were 63 dB and 60.3 dB, which were nearly the same with those of the bang machine results. The results of the lightweight impact sound were ranged from 47 dB to 69 dB, and the median value and arithmetic mean were 61 dB and 59.2 dB. The standard deviations were 4.1 dB (bang machine), 5.4 dB (rubber ball) and 6.7 dB (taping machine), which showed that the lightweight impact sound was the highest. The reason why the standard deviation of lightweight impact sound is large is that lightweight impact sound is more influenced by the type of surface finish and the used or not of resilient material than heavyweight impact sound.



(a) Bang machine (b) Rubber ball (c) Tapping machine

Fig. 2 Statistics of measurement results

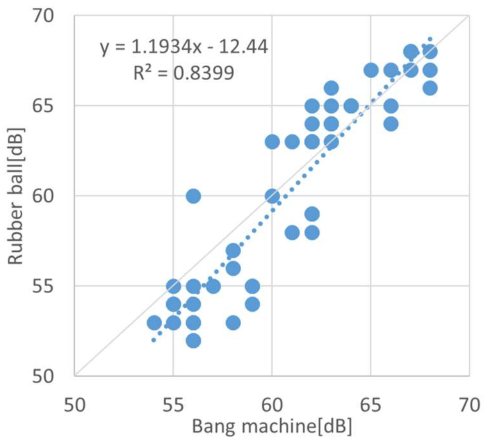


Fig. 3 Correlation between bang machine and rubber ball (reverse-A single number quantity).

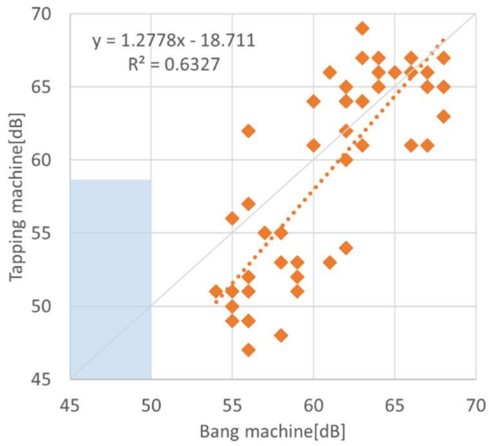


Fig. 4 Correlation between bang machine and tapping machine (reverse-A single number quantity).

Fig. 3 shows the analysis results of correlation between bang machine and rubber ball. The correlation analysis results showed that a linear regression was revealed between two impact sources, and the coefficient of determination was high as 0.8399. The single number quantity between two impact sources was nearly 1:1 matched. The correlation between bang machine and lightweight impact sound in Fig. 4 showed that the coefficient of determination was 0.6327, which was lower than that of the rubber ball. All the measurement results showed that all places did not satisfy the current floor impact sound standard. Considering the measurements only at 60 places, the performance level of heavyweight impact sound in the old apartments was approximately 60 dB. This meant that the performance should improve by 10 dB to meet the current standard, 50 dB.

The study results in Fig. 5 show the measurement results at 42 places, in which a correlation between bang machine and rubber ball was analyzed as heavy impact sources. The measurement results of bang machine were ranged between 44 dB and 56 dB, and the mean and standard deviations were 50.7 dB and 2.5 dB. The measurement data in Fig. 5 show the result of apartment whose slab thickness is all 210 mm, and resilient materials are all applied. The measurement results of rubber ball were lower than those of bang machine. In addition, a ratio that satisfied the regulation standard (50 dB) was 52.4%.

Figs. 3 and 5 are compared that Fig. 3 shows the measurement results when a slab thickness is around 120 mm, while Fig. 5 shows the result when a slab thickness is 210 mm. As compared in the figures, the insulation performance of heavyweight impact sound was better when the slab thickness was thicker, and these results were all the same in the bang machine and rubber ball results. The analysis results of correlation between bang machine and rubber ball showed that the higher coefficient of determination was found in Fig. 3 where the slab thickness was thinner. The reduction performance of bang machine and rubber ball impact sound is better in Fig. 5 than that in Fig. 3 since the slab thickness is 210 mm and a structure with resilient materials is used in Fig. 5. Fig. 3 shows better correlation between bang machine and rubber ball since its slab thickness is thinner and resilient material is not applied. This is because if resilient material is applied, evaluation results of rubber ball become better than that of bang machine.

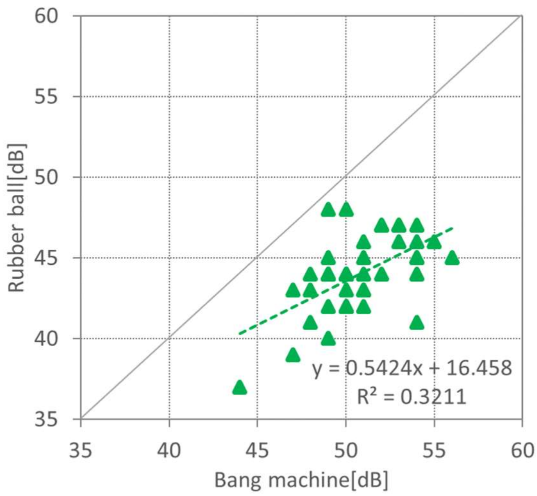


Fig. 5 Correlation between impact sources and reverse-A single number quantity [5].

4. CONCLUSIONS

The slab thickness in old apartments was thinner than the current standard, which is 210 mm, and previous study results and measurement results of current status in this study revealed the slab thickness of old apartment did not meet the current standard. The deviation of floor impact sound by frequency was up to 20 dB, and a deviation at 50 Hz was the largest in the low frequency domain. The insulation performance of floor impact sound in existing houses was ranged from 54 dB to 68 dB when the impact source was bang machine, which showed a large deviation. This meant that the required performance improvement differed significantly between houses. The correlation analysis results between bang machine and rubber ball showed that the coefficient of determination of older houses is higher than that of houses with slab thickness of 210 mm.

In order to improve the performance of existing old apartments with significant variation in performance to a certain level or higher, it is deemed necessary to develop the technology and policy approach should be taken at the same time. For the policy approach, various methods are needed to be reviewed including applying a uniform performance standard, applying a different performance standard by slab thickness, providing an improvement standard compared to existing performance, and voluntary method taken by builders.

Regardless of which method is taken, it is necessary to improve sound environment felt by residents ultimately because the aim is to improve the sound insulation performance of remodeling houses.

5. ACKNOWLEDGEMENTS

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