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# Analysis of the performance of the reduction of finishing materials according to floor structure of the floor

**Jinyun Chung**[1*] **Yonggin Yoon**[1]

[1] Korea Conformity Laboratoraries, 73, Yangcheong 3-gil, Ochang-eup, 28115 Cheongju-Si, Chungbuk, Republic of Korea

## ABSTRACT

In apartment houses in Korea, there is a unique heating system called ondol. Korea has a culture of taking off shoes in the living room. Ondol, which originated from Korea's apartment life culture, is a structure in which heating pipes are installed on the concrete floor. For this purpose, insulation materials and finishing mortar are constructed on the slab. Due to this culture of bare-foot living, low-frequency is the main cause of problems caused by floor impact sounds in apartment houses rather than mid-frequency. Since apartment houses in Korea construct insulation materials to reduce floor impact sound in the use of the ondol layer, the difference in floor impact sound reduction before and after the installation of the ondol layer is very large. This study aims to analyze the light-weight and heavy-weight impact sound reductions of PVC (Polyvinyl chloride) and wood-flooring, which are commonly used finishes in Korea.

**Keywords:** *floor impact sound, resilient layer, floor covering*

## 1. INTRODUCTION

In Korea, apartments that share floors and walls with neighbors are common. Therefore, disputes with neighbors often arise due to floor impact sound, leading to even murder cases. This is a very serious social problem. In particular, as the time spent living at home has increased due to COVID-19, complaints and disputes caused by noise are also increasing.

The types of noise generated at home are also very diverse. From the sound of electric drills and hammers due to remodeling work, the sound of motor-driven electronics such as washing machines, vacuum cleaners, massage machines, dehumidifiers, to footsteps, snoring, and even TV sounds. Compared to heavy, massive, low-frequency bands of heavy-weight sources, Light-weight sources often occur when residents are not paying attention. Floor impact sound, which exists only in Korea, rarely exceeds legal standards, but it is spreading to emotional problems with neighbors.

Korea has a sedentary life in which people walk barefoot in their homes. Therefore, there is a unique floor heating system called ondol, which is a method of constructing a heating pipe on the floor and heating the entire floor using hot water. The ondol layer is constructed with a resilient material to reduce floor impact sound, and the low reduction of the finishing material is relatively small due to the resilient material with good floor impact sound reduction performance in the medium-high frequency band.

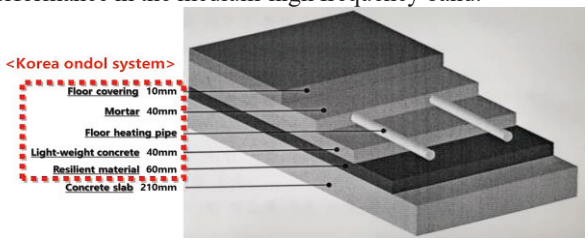
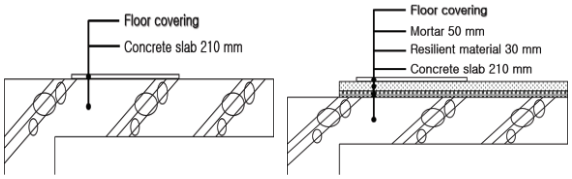



**Figure 1**. Korea ondol system.

In this study, a structure using one resilient material and five types of floor finishing materials were studied. The purpose is to analyze the difference in the reduction performance of floor finishing materials according to the installation of resilient materials and to provide basic data to suggest noise reduction measurement and evaluation methods suitable for korean characteristics.

[*] ***Corresponding author***: *jinyun97@kcl.re.kr*




(a) Without resilient layer (b) With resilient layer

**Figure 2**. Section of test structures.

## 2. MEASUREMENT AND EVALUATION METHOD OF FINISHING MATERIAL

In ISO 717-2, the reduction of light impact sound pressure level is expressed in a single figure as shown in Eqn. (1) and (2). This standard is a measurement method for installing floor covering on concrete slabs.

$$L_{n,r} = L_{n,r,0} - \Delta L \quad (1)$$

$$\Delta L_w = L_{n,r,0,w} - L_{n,r,w} = 78dB - L_{n,r,w} \quad (2)$$

Where

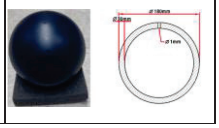
$L_{n,r}$ is the calculated normalized impact sound pressure level of the reference for with the floor covering under test;
$L_{n,r,0}$ is the defined normalized impact sound pressure level of the reference floor;
$\Delta L$ is the reduction in impact sound pressure level measured in accordance with ISO 10140-1;
$L_{n,r,w}$ is the calculated weighted normalized impact sound pressure level of the reference floor with the floor covering under test;
$L_{n,r,0,w}$ is obtained from $L_{n,r,0}$

The reduction of heavy impact sound pressure level does not have a single number index. Therefore, using the A-weighted evaluation method of ISO 717-2, it was expressed as a value obtained by subtracting the level of floor covering from the level of concrete slab.

## 3. MEASUREMENT OVERVIEW

There are five finishing materials used in this study: plywood floor 8.0mm(1), Polyvinyl chloride 4.5mm(1), and children's play mat 20.0~22.0mm(3), which are the most common finishing materials in Korea. The cross-section of the laboratory used in this study is shown in **Figure 2**. The laboratory is 3,000mm wide x 4,300mm long, and the slab thickness is 210mm. The most commonly used "Expanded polystyrene 30mm + mortar 50mm" in Korean apartments is applied to the resilient layer, and the measurement equipment used is shown in **Table 1**.

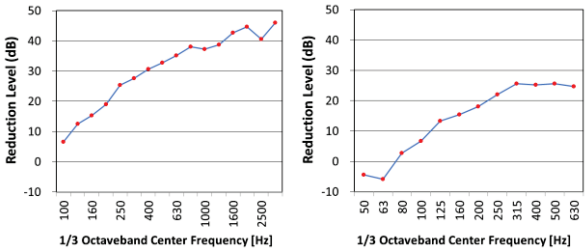
**Table 1.** Measurement system.

| Measurement system | Products | |
|---|---|---|
| Real Time Analyzer | PAK MK Ⅱ (12 channel), Müller-BBM, Germany | |
| Microphone | 46AE(1/2“), GRAS, Denmark | |
| Light-weight Impact Sound Source | Tapping Machine, 01dB, France |  |
| Heavy-weight Impact Sound Source | Rubber Ball, RION, Japan |  |

## 4. RESULTS

### 4.1 Performance changes by resilient installation

**Figure 3** shows the light and heavy-weight impact sound level reduction according to the installation of the resilient layer, which is the ondol layer. Calculation is the value obtained by subtracting the result of the with-resilient layer from the without-resilient layer. With the installation of the ondol layer, performance improves at mid and high frequency of 80Hz or higher, but resonance occurs rather by the resilient layer in the 50 to 63Hz low frequency band. This is the results of the general ondol installation of Korean apartments. **Figure 4** expresses a single number reduction according to the installation of the ondol layer. Comparing with a single number index of ISO 717-2, light-weight improved by 33 dB from 72 dB to 39 dB, and heavy-weight improved by 8 dB from 60 dB to 52 dB. It was confirmed that the performance of the resilient material was improving mainly light-weight source.




(a) Light-weight (b) Heavy-weight

**Figure 3**. Sound reduction level of resilient layer.

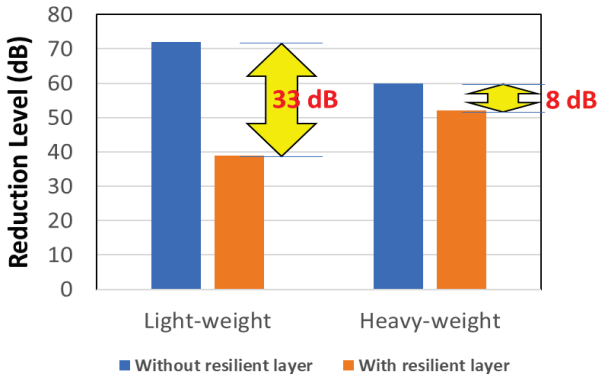



**Figure 4**. Frequency characteristics of floor impact sound before and after installation of resilient layer.

### 4.2 Reduction according to finishing materials

In Korea, almost all apartment houses install ondol floors. However, when an ondol layer is installed, as shown in **4.1**, the characteristics of the floor impact sound performance are significantly different. **Figure 5** shows the difference in floor impact sound reduction according to the resilient layer. Calculation is the value obtained by subtracting the result of the with-resilient layer from the without-resilient layer. The light-weight varies up to 29 dB (PE mat, 'PU+PE' mat) and the heavy-weight varies up to 10 dB (PE mat). Therefore, the performance of floor covering may be overestimated by measuring the low reduction of the finishing material in the slab before installing the resilient layer, which is a standard measurement method. On floors where ondol is installed, such as in Korea, a method of evaluating the performance of finishing materials with a resilient layer installed is necessary.

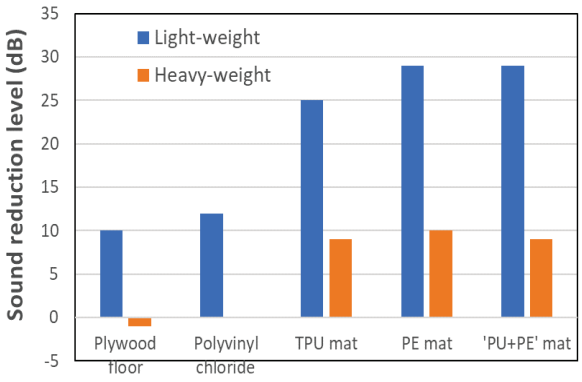



**Figure 5.** Reductions of floor impact sound according to the finishing materials.

## 5. ACKNOWLEDGMENTS

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