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PHYSICAL PROPERTIES OF RESILIENT MATERIALS FOR FLOOR IMPACT SOUND REDUCTION

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Floor impact sound is a major source of noise in apartment buildings. Floating floor structures using resilient materials are used for floor impact sound reduction. Physical properties of resilient materials include dynamic stiffness, compressibility, long-term deformation, and thermal conductivity. In order to predict the floor impact sound reduction, it is necessary to measure the exact dynamic stiffness. Also, the deformation of the On-dol layer should not occur due to the deflection of the resilient material. The dynamic stiffness was influenced by the size of the sample and temperature in test. Thickness reduction occurs when the load is continuously applied. In this paper, the effect of the factors affecting the physical properties of the resilient material was examined.
Keywords: Resilient materials, Dynamic stiffness, Compressibility, Long-term deformation

1. Introduction

A resilient material is important in terms of the reduction in floor impact sound. For a resilient material, various properties of materials are used. A number of physical factors should be taken into consideration for resilient materials. The dynamic stiffness is closely correlated to the reduction in lightweight impact sound. That is, the lower the dynamic stiffness is, the larger the reduction in lightweight impact sound is [1]. The dynamic stiffness of resilient materials used in the floors of apartment houses in Korea is limited to less than 40 MN/m^3, which is a minimum standard to ensure the reduction in floor impact sound. The most widely used resilient materials are expanded polystyrene (EPS) and ethylene vinyl acetate (EVA) among a variety of materials. Polyethylene (PE) and polyester can also be used.

Resilient material is installed inside the floor structure and a mortar that includes lightweight aerated concretes and heating pipes in the upper side of the resilient material is installed. Such upper structure of the resilient material is called On-dol in Korea, which is a traditional floor heating method. Due to this structural system, a resilient material takes a load and heat constantly. As a result, a resilient material is vulnerable to changes in properties due to loads and heat. Thus, this paper discusses, the dynamic stiffness that can affect the physical characteristics of resilient materials, long-term deflection due to load, and compressibility changes in thickness after applying a load.

2. Effect factors

The dynamic stiffness of resilient material is the most important physical factor that determines the characteristics of reduction in floor impact sound. The dynamic stiffness is affected by measuring method or loading time in the load plate [2] [3]. Since a resilient material is used under the condition of load and heat, the effect of heat is investigated. A part of existing study [4], which examined the effect of temperature conditions of the sample during the measurement on the dynamic stiffness of resilient material, was excerpted and investigated. The measurement results of the dynamic stiffness under three temperature conditions are explained.

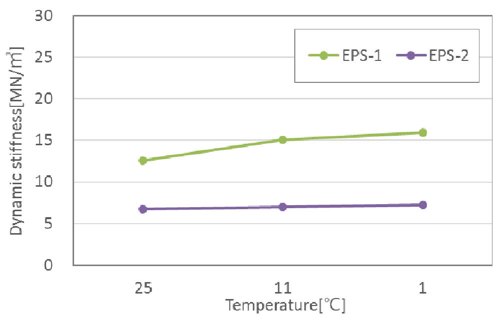
The other factor that should be investigated in addition to the dynamic stiffness of resilient material is compressibility. Compressibility is a factor that determines how well a thickness of resilient material is recovered back to the original thickness after taking a load. The standard of compressibility is 3 mm or less for samples whose thickness is 30 mm or thicker and 2 mm or less for samples whose thickness is 30 mm or thinner. Samples whose compressibility is large are likely to have a problem of reduction in floor impact sound due to increase in the dynamic stiffness and settlement of mortar layer, which is required for heating. A size and compressibility of sample as well as the dynamic stiffness and changes in compressibility are investigated. The characteristics are discussed by referring a figure that shows the results in previous study result [5].

Finally, a thickness of samples becomes thinner to some extent when a load is applied to the upper part of the resilient material constantly. In ISO 20392 [6], deflection of thickness is measured under various sizes of samples and loading conditions to predict deflection after 10 years. In the present study, a weight of loading plate in the upper side of resilient material is divided into 100 kg/m^2, 200 kg/m^2, and 400 kg/m^2 and a change in thickness for 1,800 hours is examined. Five types of 200 × 200 mm sample were used.

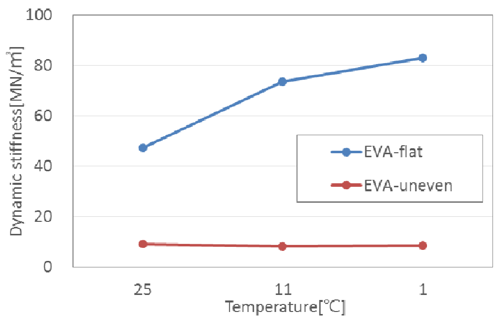
3. Analysis of effect factors

3.1 Dynamic stiffness with test temperature [4]

Four samples were selected to determine changes in the temperature of resilient material and dynamic stiffness, and measurements were conducted according to the set temperature. The measured samples were divided into two: ethylene vinyl acetate (EVA) and expanded polystyrene (EPS). Some of the EVA materials had a ragged and irregular surface under the material. The temperature conditions of the resilient material were set at 25℃, 11℃, and 1℃, and measurement was conducted after storing the material in a cooling chamber for 24 hours or longer. The measurement on dynamic stiffness adopted a pulse excitation method using an impact hammer. A sample was pulled out of the cooling chamber to immediately measure the surface temperature and dynamic stiffness.



(a) EPS



(b) EVA

Figure 1: Measurement result of dynamic stiffness according to changes in temperature

The measurement results of dynamic stiffness are shown in Fig. 1 based on three set temperature conditions. Except for the EVA-uneven sample, all samples increased their dynamic stiffness as the temperature decreased. In particular, the EVA-flat sample increased its dynamic stiffness by 75.4% when the temperature was 1℃ compared to 25℃. As the temperature of resilient material decreased, the materials became somewhat harder, thereby tending to increase dynamic stiffness. Even when the same material was used, some samples had little change in dynamic stiffness, which indicates dynamic stiffness is affected by the manufacturing method. The lower the dynamic stiffness, the better the insulation performance of the floor impact sound. Thus, this result indicates that if dynamic stiffness changes according to changes in temperature, the floor impact sound insulation performance will also change.

3.2 Compressibility

The measurement of compressibility is to determine a change in thickness of resilient material. The purpose is to prevent deflection of thickness in resilient material due to the On-dol layer in the upper part of the resilient material. In ISO 29770 [7], a size of samples is set to 200mm × 200mm for measurement of thickness. However, since a type of used resilient materials is various, changes in compressibility occur due to the size of measurement samples. Some products such as flat plate have the same structure between upper and lower parts whereas some products have a different structure between upper and lower parts due to the use of uneven surface in the lower part. These products have a point support shape in the lower part because of the uneven surface as the lower part of the resilient material cannot fit tightly to the slab surface. The samples (EVA-1, EVA-2, EVA-3, and EPS-1) shown in Fig. 2 are products to which uneven surfaces are installed in the lower part of the sample. When a size of the measurement sample was 300mm × 300mm, compressibility became smaller. PE and EPS-2 have no uneven surfaces as a flat plate type and no significant difference incompressibility was revealed according to changes in sample size. Since a force that endures a load applied to the upper side of the resilient material becomes larger according to the number of strips installed in the lower part of the resilient material, a size of the measurement sample becomes an important factor. Because a limit of compressibility in resilient material is set in the related regulations, technological developments have been underway by manufacturers not to have deformation in resilient materials.

Fig. 3 shows a relationship between dynamic stiffness and compressibility of resilient materials. The figure reveals that the lower the dynamic stiffness, the larger the compressibility. Due to this characteristic, it is difficult to lower the dynamic stiffness unconditionally to increase a reduction in floor impact sound. If a product whose dynamic stiffness is too low is developed, it may not satisfy the standard of compressibility. Thus, it is necessary to set up the appropriate dynamic stiffness.

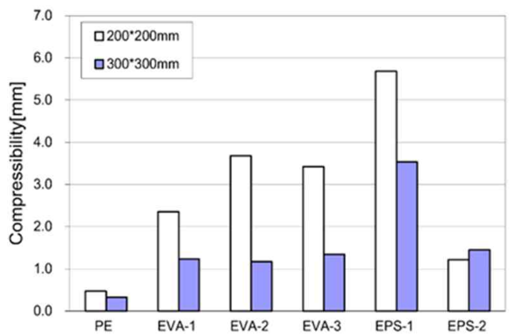


Figure 2: Changes in the specimen size and compressibility [5]

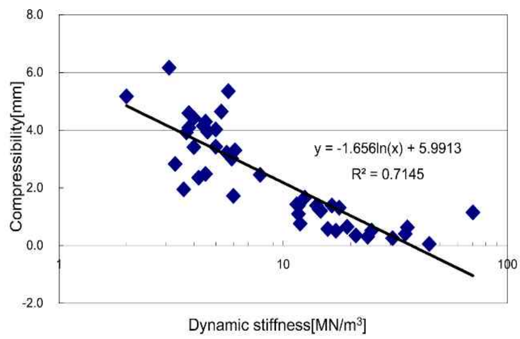
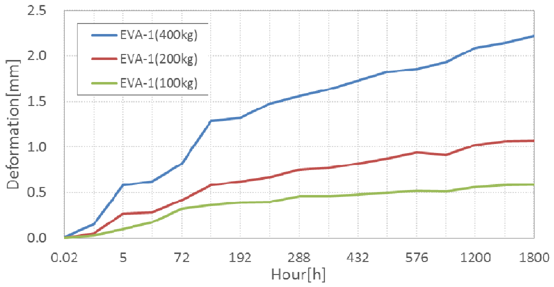


Figure 3: Correlation between dynamic stiffness and compressibility [5]

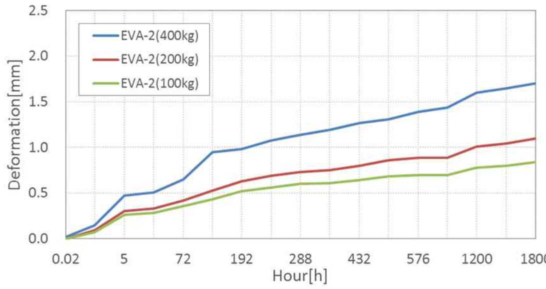
3.3 Long-term deformation

Long-term deformation of resilient material is measured to determine a level of deformation for a long time. In particular, since a floor structure in Korea applies a floor heating method through heating pipes, resilient materials are affected by heat and load considerably. Long-term deformation can be measured through the method specified in ISO 20392 [6]. That is, deformation after 10 years can be calculated based on a measured result for a certain period of time. Deformation after 10 years can also be predicted based on compressibility result simply [8]. The predicted deformation results after 10 years using ISO specifications [6] and method in previous study [5] in Korea were different. The previous study result showed that a reduction in thickness of resilient material was more than that of the ISO estimation equation over time. A long-term measurement is needed to determine how deformation in thickness of resilient material is progressed for 10 years. Thus, it is necessary to have a method that can predict 10-year deformation through short-term measurements.

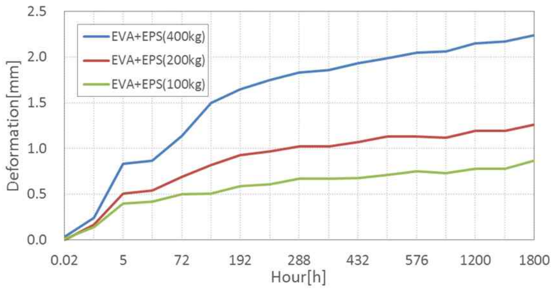
Fig. 4 shows the measured result of changes in thickness by changing a weight of the load plate with six different types of samples. Naturally, as a weight of the load plate became heavier, a change in thickness was increased. A deformation in thickness of EPS was smaller than that of EVA among the measured samples. The reason for the determination of changes in thickness according to various loads is to investigate a test method that determines a degree of long-term deformation after 10 years through short-term tests.



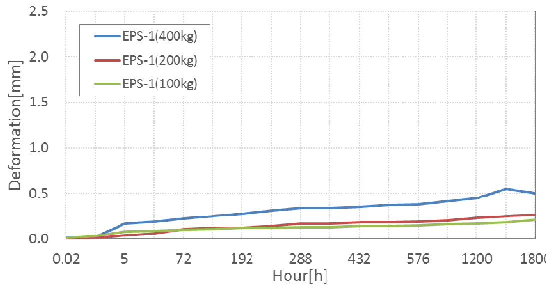
(a) EVA-1



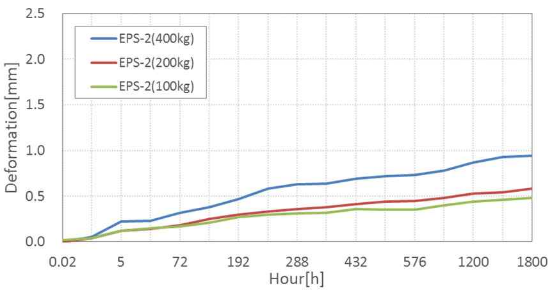
(b) EVA-2



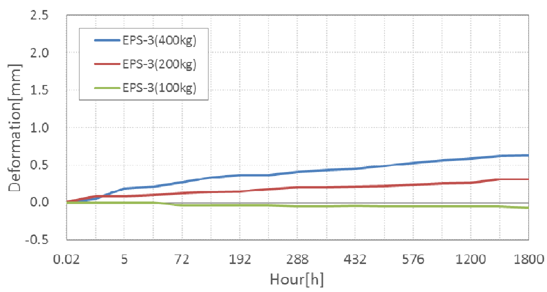
(c) EVA+EPS



(d) EPS-1



(e) EPS-2



(f) EPS-3

Figure 4: Deformation of thickness according to time and loads

4. Conclusions

In order to apply resilient materials, their physical properties of various materials should be evaluated and developed to reduce floor impact sound. Thus, dynamic stiffness, compressibility, and long-term deformation were selected and investigated as the effect factors. The dynamic stiffness was changed according to the temperature condition of the measured sample, and compressibility was changed according to a size of the sample.

The long-term deformation is to predict the deformation of the sample's thickness after a long time but take a long time to measure. It is necessary to prepare a method which can measure in shorter time. To do this, it is necessary to provide a method that can predict this in a short time. Since various materials and shapes are developed for resilient materials, it is important to identify changes in physical properties of resilient materials. Because the purpose of the identification of various physical properties is to reduce floor impact sound ultimately, it is necessary to continue the identification of relationship between physical properties and performance in floor impact sound insulation.

Acknowledgments

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