



CHANGES OF FLOOR IMPACT SOUND REGULATIONS AND FUTURE IMPROVEMENT DIRECTIONS IN KOREA

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ABSTRACT

Most types of housing in Korea are apartment houses. In Korea, the problem of floor impact sound in apartment houses is a social issue. The government has made regulations related to floor impact sound since 2004, and recently revised the regulations (Aug. 2022). The floor impact sound regulation is compulsory as a law that must be observed by apartment construction companies. The floor impact sound performance shall be evaluated after the completion of the apartment house through the revision of the floor impact sound performance should be evaluated. In addition, the floor impact sound performance standard was also strengthened from 50 dB to 49 dB. In this study, we will discuss the current status and future direction of Korean legal regulation.

Keywords: *floor impact sound, regulations, apartment buildings.*

1. INTRODUCTION

In Korea, 70% of residential properties are apartment buildings. With the limited land availability, it is inevitable that there will be an increase in high-rise apartments in urban areas. However, the increase in apartment buildings poses a problem for the residents who are easily exposed to various types of noise. In particular, the 'Inter-floor noise' transmitted from adjacent units is a highly sensitive issue. Although traffic noise generated in large cities has a significant impact on indoor acoustic environments, noise

generated between floors in apartment buildings can be even more serious.

Among Inter-floor noise, the sound of children running or the footstep sounds of adults are found to be the most uncomfortable noise. To reduce this type of impact noise, Korea has been regulating and managing it since 2004 by establishing regulations related to impact noise. Recently, the regulations related to impact noise have been revised extensively (Aug. 2022) in terms of performance standards, measurement methods, standard impact source, and evaluation methods.

This paper examined the contents of Korea's impact noise-related regulations before and after the revision and discussed the direction for improving the impact noise regulation in the future.

2. REGULATIONS RELATED TO INTER-FLOOR NOISE IN KOREA

Korea's regulations related to inter-floor noise can be divided into two categories. The first is the performance standard of the building itself (floor impact sound) which is applied from the construction stage of the apartment building, and the second is the resident behavior standard that targets residents living in the apartment. Both regulations are operated under legal mandatory regulations.

2.1 Performance Standards for Buildings

The performance standards for floor impact sound in apartment buildings were introduced in Korea in 2004. Prior to 2004, the regulation stated that 'the floors of apartment buildings should be constructed in a way that sufficiently insulate floor impact sound,' but this was a declarative statement that was too vague. To improve the sound insulation performance of housing, performance standards were introduced in 2004.

Newly constructed apartment housing must satisfy the floor impact sound insulation performance standards of 50 dB or

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less for heavyweight impact sound and 58 dB or less for lightweight impact sound (Housing Act). The standard impact sound sources used are tapping machine and bang machine [1][2]. Bang machine is only used in Japan and Korea to evaluate heavyweight impact sound. The evaluation method for performance standards introduced at that time was different from that of Japan, taking into account domestic environmental conditions, and used an evaluation method based on the inverse-A curve [3][4]. Most of the floor structures in Korean residential buildings are configured as shown in Figure 1, with box frame structure being common. Prior to 2004, various thicknesses of concrete slabs were applied, but minimum thickness was included in the regulation to improve the performance of heavyweight impact sound. Currently, a concrete slab thickness of 210 mm or more must be ensured. However, for rahmen structure (rigid frame), a slab thickness of 150 mm or more is sufficient.

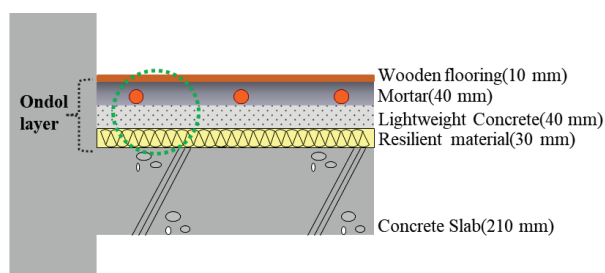


Figure 1. Floor structure in Korea.

To determine whether newly constructed apartments meet the floor impact sound performance standards, an indirect method has been used. The floor structure to be applied in the apartment is installed and evaluated in a laboratory or on-site mock-up to meet the performance standards set by law, and if it meets the standards, a certificate of recognition is issued. The laboratory consists of two units with floor areas of 84 m² and 59 m², respectively.

The floor of test lab is made only of the slab as shown in Figure 1, and the performance is evaluated under conditions where the Ondol layer is varied. The recognition process is carried out only on the Ondol layer without changing the building's structural elements. Most of the recognized configurations differed only in the resilient materials used. The technology developed mostly involved differences in the material properties of the resilient materials.

Since the application of the Ondol layer in apartment housing is tested and evaluated in a laboratory or on-site

mockup, the approved performance may differ from the actual performance of the completed building. These performance differences often result in a decrease in performance, highlighting the limitations of the 'pre-approval system'. In many cases, the legal performance standards are not met after the completion of the building. The introduction of the pre-approval system was intended to improve the overall performance of apartment housing, and was not intended to directly confirm performance after the building was completed. However, since the performance of buildings often falls short of the legal standards, the demand for improvement of related systems has increased, and the voices of consumers that the performance of buildings needs to be improved have further increased.

Starting from August 2022, a 'post-confirmation system' that confirms the performance of buildings even after completion, along with the 'pre-approval system,' has been implemented to improve the performance of residential buildings. This system involves sampling 2% of the total number of households and measuring their performance, and then determining whether they meet the legal standards based on the measurement results. With the implementation of the 'post-confirmation system,' the existing performance standards and evaluation methods have also been changed. For more details, refer to Table 1.

The standard heavyweight impact source has been replaced with a rubber ball, and the measurement and evaluation standards have been changed from KS (Korean Standard) to ISO standards. In addition, the performance standard for both heavyweight and lightweight impact sound has been changed to 49 dB. For heavyweight impact sound, both the standard impact source and evaluation index have been changed, and the standard has been lowered by 1 dB from 50 dB to 49 dB. For lightweight impact sound, only the evaluation index has been changed, and it has been strengthened by 9 dB from 58 dB to 49 dB. Both lightweight and heavyweight impact sound are classified into four grades with a 4 dB interval, with grade 1 indicating the best performance.

The measurement and evaluation methods have been changed to comply with international standards, and the performance standards have been strengthened to a certain extent. In particular, with the 9 dB enhancement of the lightweight impact sound, more attention should be paid to measures to ensure the insulation performance of the lightweight impact sound.

Table 1. Changes in floor impact sound performance rating standards.

index		before	current	
Light-weight impact sound	impact source	tapping machine	tapping machine	
	evaluation index	$L'_{n,AW}$	$L'_{nT,W}$	
	grade	1	$L \leq 43$	$L \leq 37$
		2	$43 < L \leq 48$	$37 < L \leq 41$
		3	$48 < L \leq 53$	$41 < L \leq 45$
		4	$53 < L \leq 58$	$45 < L \leq 49$
	test standard	KS F 2810-1 [1]	KS F ISO 10140-5 [5]	
evaluation standard	KS F 2863-1 [3]	KS F ISO 717-2 [6]		
Heavy-weight impact sound	impact source	bang machine	rubber ball	
	evaluation index	$L'_{i,Fmax,AW}$	$L'_{iA,Fmax}$	
	grade	1	$L \leq 40$	$L \leq 37$
		2	$40 < L \leq 43$	$37 < L \leq 41$
		3	$43 < L \leq 47$	$41 < L \leq 45$
		4	$47 < L \leq 50$	$45 < L \leq 49$
	test standard	KS F 2810-2 [2]	KS F ISO 10140-5 [5]	
evaluation standard	KS F 2863-2 [4]	KS F ISO 717-2 [6]		

2.2 Regulation Standards for Residential Noise

There are also standards for regulating the noise generated by human behavior, in addition to building performance standards. No matter how excellent the performance of a building is, excessive human behavior can cause significant noise. This law was introduced in June 2014 for the purpose of preventing excessive noise-generating behaviors of residents, as there were existing low-performance housing units built before 2004.

The standard for impact noise is set at 43 dB during the day time and 38 dB at night time. The measurement method

evaluates it with an equivalent sound level for one minute, and if the standard is exceeded three or more times within 24 hours, it is considered to have exceeded the standard. The standards are shown in Table 2. The target noises are direct impact noise and airborne noise. Direct impact noise refers to 'noise generated by actions such as jumping or walking,' while airborne noise refers to 'noise generated by the use of televisions, audio equipment, etc.' Starting from January 2023, the regulation standards for residential noise generated by residents have been strengthened by 4 dB, with the new standard set at 39 dB. The previous standard of 43 dB was deemed too high, resulting in very few cases of violations of the regulation. Although there are situations where impact noise causes discomfort, there were many opinions that the set standards were too lenient and needed to be strengthened.

Table 2. Revised Standards for Residential noise (Before → After)

classification		regulation [unit: dB(A)]	
		day time (06:00 ~ 22:00)	night time (22:00 ~ 06:00)
1. direct impact noise	1min L_{eq}	43 → 39	38 → 34
	L_{max}	57	52
2. airborne noise	5min L_{eq}	45	40

3. DIRECTIONS FOR IMPROVING FLOOR IMPACT SOUND INSULATION PERFORMANCE

As Korea has a high proportion of apartment housing, there are many complaints about noise generated within these buildings. The most common complaint is about floor impact sound, which has been linked to social problems such as arsons and murders. There are many claims that the performance standards should be continuously strengthened to improve the noise insulating performance of the building itself, and the behavioral standards for residents should also be strengthened. It is expected that both standards will continue to be strengthened in the future.

In addition to strengthening performance standards, there is also a high demand for changes in the building's structural design. Most of Korea's apartment housing applies the box frame structure, which is perceived as a vulnerable structure

type because the slab and wall are integrated, allowing vibrations to be easily transmitted.

There is an opinion that the rahmen structure format should be introduced to the apartment house. The rahmen structure supports the building's load through columns and beams without load-bearing walls, and is known to have better insulation performance against floor impact sound compared to box frame structure.[7]

To improve the performance of apartment housings, it is necessary to develop effective structural designs for vibration isolation in addition to developing resilient materials. Furthermore, research on technologies to improve the performance of existing buildings is also needed. Before any technological development, it is important to create a social atmosphere that considers the neighbors, as floor impact noise often occurs due to human behaviors.

4. CONCLUSION

The most problematic noise in Korea is the floor impact sound in apartment buildings. Performance standards and minimum slab thickness were introduced to reduce floor impact sound. However, residents are still complaining of inconvenience caused by noise between floors. To improve this inconvenience, a regulation was implemented to measure the floor impact sound insulation performance after the completion of apartment buildings. The implementation of this regulation is to improve the impact sound insulation performance of apartment buildings.

In addition, it is intended to control noise generation indoors by strengthening the regulation of residents' behavior. Inter-floor noise is mainly caused by human behavior, and sufficient research on noise generation behavior and human noise recognition characteristics should be conducted to prepare comprehensive inter-floor noise measures.

5. ACKNOWLEDGMENTS

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