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ON-SITE APPLICATION OF NOISE REDUCTION TECHNOLOGIES FOR BATHROOM DRAINAGE IN APARTMENT BUILDINGS

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ABSTRACT

In Korea, most apartment bathrooms use an under-slab-piping method, causing drainage to occur through the ceiling of the lower floor when the upper floor bathroom is used, inevitably leading to drainage noise issues. Especially in older apartment buildings, noise reduction measures have not been considered, resulting in significant harm to residents.

This study aims to apply noise reduction technology to older apartment buildings vulnerable to bathroom drainage noise and verify its effectiveness. The target site is an apartment built in 1997, with an exclusive area of 84 m². The existing PVC drainage pipes, asbestos slate ceiling material, and wooden doors were replaced with low-noise PVC pipes, sound-absorbing ABS ceiling material, and ABS doors.

The noise reduction performance was evaluated at maximum noise levels during toilet, sink, and bathtub drainage. Measurement results in the main bathroom showed a reduction of 22.9 dB(A) for toilet drainage noise and 16.6 dB(A) for sink drainage noise. In the family bathroom, reductions were 10.1 dB(A) for toilet drainage noise, 5.9 dB(A) for sink drainage noise, and 12.0 dB(A) for bathtub drainage noise. Applying this technology is expected to reduce living noise issues between neighbors in apartment buildings.

Keywords: *drainage noise, bathroom noise, apartment building, noise reduction*

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1. INTRODUCTION

According to the 2023 KOSIS survey, approximately 80% of Koreans reside in multi-unit housing such as apartments, villas, and studio flats [1]. Multi-unit housing is vulnerable to noise transmitted from neighbors due to shared walls, floors, and ceilings between adjacent units. In particular, floor impact noise caused by children running or adults walking has intensified conflicts between households, becoming a significant social issue. However, survey results on living noises in apartment buildings revealed that in the main bedroom, more respondents reported being affected by drainage noise from bathrooms rather than floor impact noise [2]. Unlike the living room, where the family gathers and spends time together, the main bedroom is used as a space for rest and sleep. As a result, background noise in the main bedroom is lower compared to other spaces, making individuals more sensitive to even small noises. Since floor impact noises, such as children running, mainly occur in living rooms or hallways, they are evaluated as being relatively less sensitive. On the other hand, bathroom drainage noises, which occur more frequently in main bedroom, are analyzed to have a higher sensitivity level. In particular, the method of installing drainage pipes beneath the slab in multi-unit housing is commonly used, which is believed to cause significant noise-related issues.

This study applied technologies designed to reduce bathroom drainage noise in multi-unit housing and evaluated their effectiveness on-site.

2. DRAINAGE NOISE REDUCTION TECHNOLOGIES

Technologies for reducing bathroom drainage noise in apartment buildings include low-noise piping, sound-absorbing ceiling boards, and high-soundproof doors.

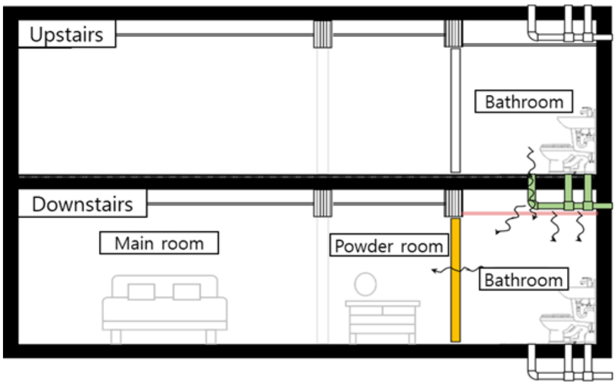

Figure 1. Section and drainage noise transmission path.

2.1 Low noise piping

Low-noise piping is designed with two or three layered structures to reduce internal noise through vibration isolation and sound insulation, while also preventing the transmission of noise externally. This technology has the greatest impact on reducing drainage noise and demonstrates highly effective noise reduction capabilities. The sound insulation performance of the piping can be evaluated in laboratories using ISO [3] and KS [4] standard test methods.

2.2 Sound absorbing ceiling board

Sound-absorbing ceiling materials are a technology designed to reduce the transmission of noise, generated by drainage pipes installed beneath the slab, to the interior of the downstairs bathroom. Typically, PVC, SMC, or ABS ceiling materials are used, with PU foam sound-absorbing material attached to the upper side of the ceiling material, aiming to reduce noise through absorption within the ceiling. This technology is expected to be particularly effective in narrow spaces within the frequency range of 500 Hz or higher, where the effects of sound absorption are more noticeable. Laboratory measurements can be conducted according to ISO 10140-2 standard [5].

2.3 High-soundproof door

High-soundproof doors can reduce the transmission of bathroom noise to the master bedroom. They are effective not only in minimizing noise caused by upstairs neighbors using their bathrooms, but also in decreasing the noise from family members within the same unit, making it less audible in the master bedroom. Generally, doors used indoors do not have high air-tightness or soundproofing performance. By enhancing the soundproofing performance of the door itself and improving the air-tightness of the door set, the soundproofing effect can be increased. The soundproofing performance of the door set can be evaluated using ISO 10140-2 test method [5].

3. ON-SITE APPLICATION

To verify the effectiveness of noise reduction technologies for bathroom drainage noise in actual multi-unit housing settings, these technologies were applied on-site. The target site was an apartment built in 1997, approximately 28 years old, with an exclusive area of 84 m² and a layout featuring one bathroom adjacent to the master bedroom and another to the living room. While the main focus of this study was noise reduction in the master bedroom bathroom, the same technologies were applied to the living room bathroom for comparison purposes.

The applied technologies included low-noise piping, sound-absorbing ceiling materials, and high-soundproof doors. Additionally, the walls, floor tiles, and sanitary fixtures were all reconstructed.

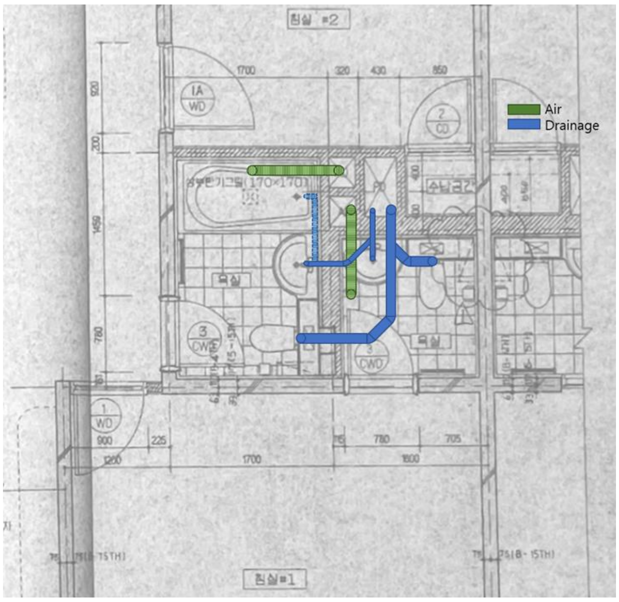

Figure 2. Plan of apartment noise reduction technology applied.

Figure 3. Images of bathroom before noise reduction technology application.

Figure 4. Images of bathroom after noise reduction technology application and measurement.

4. MEASUREMENT AND ASSESSMENT

4.1 Measurement method

The measurement of drainage noise followed the test methods outlined in KS F 2871 [4]. Noise levels were measured at the central point inside the downstairs bathroom and at a location 1 m in front of the bathroom door outside. During the whole drainage time, noise was measured after filling 6L of water into the flush toilet, 6L into the washbasin, and 60L into the bathtub. Both the equivalent noise level (L_{eq}) and the maximum noise level (L_{max}) were measured using the Fast time characteristic. Three measurement data were averaged.

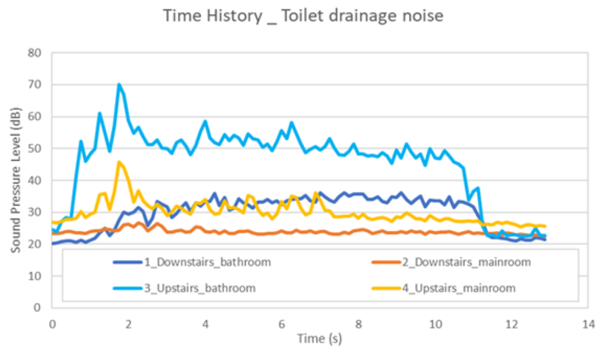

Figure 5. Time history graph of bathroom toilet drainage noise measurement after technologies application.

4.2 Measurement before and after application

To evaluate the noise reduction performance of drainage noise mitigation technologies, measurements were taken before and after the application of the technologies. To ensure comparability, the measurement locations and conditions were kept identical, and measurements were repeated three times under the same conditions. The arithmetic mean of the results was then compared. The noise reduction effects were evaluated for each sanitary fixture, including the toilet, sink, and bathtub.

Based on Figure 5, the noise was measured by identifying the time when noise occurred relative to the background noise, including the time during which the drainage process was ongoing.

4.3 Noise reduction

Changes in noise levels due to drainage time delays were anticipated, so the noise reduction performance was evaluated using the maximum noise level.

The toilet drainage noise from the bathroom adjacent to the master bedroom was reduced by 22.9 dB, from 59.8 dB to 36.9 dB, while the sink drainage noise decreased by 16.6 dB, from 49.1 dB to 32.5 dB. In the shared bathroom adjacent to the living room, the toilet drainage noise was reduced by 10.1 dB, from 45.5 dB to 35.4 dB, while the sink noise decreased by 5.9 dB, from 43.0 dB to 37.1 dB, and the bathtub noise was reduced by 12.0 dB, from 50.5 dB to 38.5 dB.

As shown in Figure 1, the drainage pipes of the living room bathroom were constructed to merge with the ceiling space of the master bedroom bathroom and meet the vertical pipes in the pipe duct (PD) space. Since the internal pipe length in the living room bathroom ceiling is shorter, the noise level was measured to be relatively lower than in the master bedroom bathroom, and the noise reduction effect due to the applied technology was also less significant.

Table 1. Maximum sound pressure level of bathroom drainage noise.

Room	Fixture	L_{Amax} (dB)	L_{Amax} (dB)	ΔL_{Amax} (dB)
Main bathroom	Toilet	59.8	36.9	22.9
	Sink	49.1	32.5	16.6
Public bathroom	Toilet	45.5	35.4	10.1
	Sink	43.0	37.1	5.9
	Bathtub	50.5	38.5	12.0

5. CONCLUSION AND DISCUSSION

5.1 Conclusion

This study aimed to verify the effectiveness of technologies applied on-site to reduce toilet drainage noise in apartment buildings. It assessed the current drainage noise condition in an apartment building approximately 28 years after completion, and applied technologies such as low-noise pipes, sound-absorbing ceiling materials, and high-soundproof doors. To verify the effectiveness of these technologies, noise was measured before and after construction for each drainage fixture, confirming the noise reduction performance of the technologies.

As a result of the application, maximum noise levels showed reductions of 22.9 dB for toilet noise and 16.6 dB for sink noise in the master bedroom bathroom, and reductions of 10.1 dB for toilet noise, 5.9 dB for sink noise, and 12.0 dB for bathtub noise in the shared bathroom adjacent to the living room. Following the application of these technologies, all drainage conditions presented low noise levels of under 40 dB. Particularly, the drainage noise reduction effect was significant in the master bedroom bathroom, where the piping from the shared bathroom and the master bedroom bathroom merged and connected to the pipe duct (PD).

5.2 Discussion

This study aimed to verify the field performance of noise reduction technologies, specifically targeting aging apartment buildings. While the significance of confirming the performance of technologies validated in existing experimental facilities and applying them on-site was acknowledged, the study was limited to results from a single site, making generalization difficult. Therefore, it is necessary to obtain additional field data to enhance the reliability of the findings. Furthermore, the testing methods for measuring drainage noise on-site require review and discussion.

6. ACKNOWLEDGMENTS

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