Proceedings of 20th International Congress on Acoustics, ICA 2010

23-27 August 2010, Sydney, Australia

The effect of Aerated Concrete Containing Glass Foam Aggregate on the Heavy-weight Impact Sound Isolation

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PACS: 43.55.Ti

ABSTRACT

As structural-borne sound, the floor impact sound is one of the serious noises in residential building Most of heating system applied to the typical Korean residential building is floor heating system which is called Ondol. The Ondol usually consists of finishing material, mortar with heating coil, light-weight aerated concrete and reinforced concrete. This study focus on the isolation of heavy-weight impact sound and modification of mortar and light-weight aerated concrete. Specifically the Glass foam aggregate was added on light-weight aerated concrete. Also, water-cement ratio and amount of cement on mortar were revised. The Sound pressure level of heavy-weight impact was measured in reverberation chamber using both bang-machine and impact ball. Size of specimen was 1 m by 1 m. Substitution ratio of glass foam aggregate on light-weight aerated concrete shows relationship with heavy-weight impact sound pressure level. In addition, heavy-weight impact sound pressure level was decreased with increment of water-cement ratio and amount of cement on mortar.

INTRODUCTIONS

More than 300 thousands multi-story residential units had being constructed every year in Korea. Koreans customarily do not wear shoes in their houses and heel to toe, for this reason heavy-weight impact noise caused by foot traffic is one of serious noise source in residential building. Dispute on the floor impact noise is increasing [1]. Heating system of Korean multi-story residential is floor heating system called Ondol; a system of floor radiant panel heating. Ondol is consisted of finishing material, mortar with heating coil, light-weight aerated concrete and reinforced concrete.

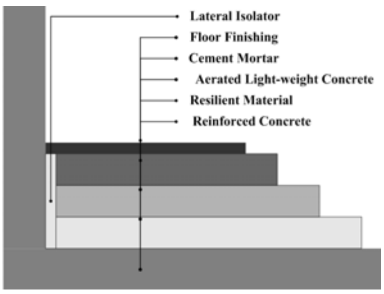

Figure 1. Section detail of Ondol

In order to reduce these disputes, Korean government enacted law on the floor impact noise isolation performance in 2005. In this law, minimum floor impact noise level was legislated. Also, standard floor impact noise isolation system and performance certification process of the floor impact sound isolation was proposed in law. Contractor shall use standard floor impact noise isolation system or certified floor impact isolation system. Many kinds of floor impact sound isolation methods were developed and applied in multi-story residential buildings. Also, structural reinforcement such as T-shape girder and FRP beam was studied and known for effective for isolation of heavy-weight impact sound [3]. Structural reinforcement reduces resonance frequency and vibration acceleration level on concrete slab. An experimental study on the effect of compression strength of cement mortar and aerated light-weight concrete on floor impact sound was conducted [4].

In this study, for the isolation of heavy-weight impact sound, mortar and light-weight aerated concrete was modified. Glass foam aggregate was added on light-weight aerated concrete. Also, water-cement ratio and amount of cement of mortar were revised.

EXPERIMENTAL SET-UP

Floor impact sound pressure level was measured in vertically connected reverberation chamber. Thickness of concrete slab in reverberation chamber was 150 mm. The Structural boundary condition of reinforced concrete slab was free end. Concrete slab was laid on the opening between reverberation chambers with damping rubber mount. Size of specimen was 1 m by 1 m. Floor impact sound pressure level Specimens which are used in experiments were precasted and consisted of cement mortar and aerated light-weight concrete. Resilient material such as EPS and PE foam were layed on concrete slab then precasted specimens were installed. Six resilient materials were applied on these experiments. These materials were also used in in-situ condition. Figure 2 shows six kinds of resilient materials.

Measurements of floor impact sound pressure level were conducted just on the heavy-weight impact sound. Heavy-weight impact sound pressure level was measured in reverberation chamber using bang-machine and impact ball [5, 6]. Centre position of specimens was impacted and heavy-weight impact sound was received at 5 receiving positions in the lower reverberation chamber. Frequency range of heavy-weight impact sound measurement is from 31.5 Hz to 500 Hz in 1/1 Octave band.

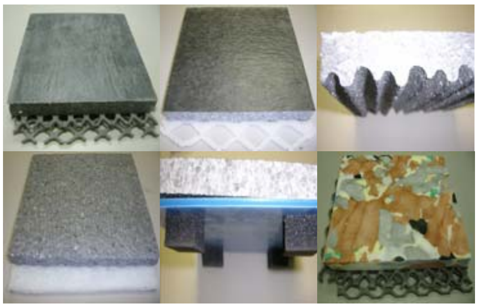

Figure 2. Six resilient materials used in experiments

Design factors of this study were percentage of glass foam aggregate on the aerated light-weight concrete, water-cement ratio and amount of cement on cement mortar. Whole experiments could be divided into two stages. In the first stage, percentage of glass foam aggregate on the aerated light-weight concrete was fixed as 50 percent. Water-cement ration and amount of cement on cement mortar was varied. Also from 3 to 6 kinds of resilient materials were tested at each experimental condition. Table 1 shows experimental conditions of the first experiment stage.

Table 1. Experimental conditions of the first experiment stage

No.	Glass foam aggregate percentage	Water-cement ratio	Amount of cement	Number of resilient materials
1-1		50	320	3
1-2		60	320	3
1-3		70	320	3
1-4		50	360	3
1-5	50%	60	360	6
1-6		70	360	3
1-7		50	400	3
1-8		60	400	6
1-9		70	400	3
1-0	0%	50	560	6

Table 2. Experimental conditions of the second experiment stage

No.	Glass foam aggregate percentage	Water-cement ratio	Amount of cement	Number of resilient materials
2-1	0	320	60	2
2-2	30	320	60	2
2-3	50	320	60	2
2-4	0	360	60	2
2-5	60	360	60	2
2-6	70	360	60	2
2-7	30	360	60	2
2-8	40	360	60	2
2-9	50	360	60	2
2-10	30	360	50	2
2-11	30	360	70	2
2-12	50	360	60	2
2-13	50	360	60	2
2-14	0	400	60	2
2-15	30	400	60	2
2-16	50	400	60	2

Based on the results of the first stage experiment, percentage of glass foam aggregate on the aerated light-weight concrete was varied from 30 to 70 percent with 10 or 20 percent interval. Also, thickness of aerated light-weight concrete varied from 40 to 60 mm with 10 mm interval. Table 2 shows experimental conditions of the second experiment stage. Figure 3 shows floor impact sound measurement in reverberation chamber.

Figure 3. Floor impact sound measurement in reverberation chamber with bang machine and impact ball

RESULTS

Figure 4 to 9 show measurement results of heavy-weight impact sound using bang machine and impact ball respectively. Heavy-weight impact sound measurement results were evaluated as single number index using inverse-A weighted method [7]. Inverse-A weight method was known for subjectively well correlated [8]. Measurement results shown from figure 4 to figure 9 were averaged value at each experimental condition.

Figure 4 and 5 indicate effect of glass foam aggregate on heavy-weight impact sound. Bang machine and impact ball impact sound pressure level was concentrated in low frequency bands especially from 63 Hz to 125 Hz bands. Impact sound pressure level generated using bang machine was higher than impact ball sound in low frequency bands.

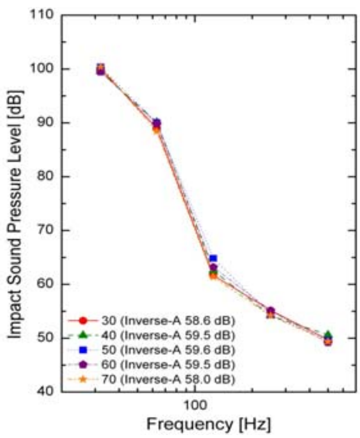

Figure 4. Effect of glass foam aggregate on heavy-weight impact sound using bang machine

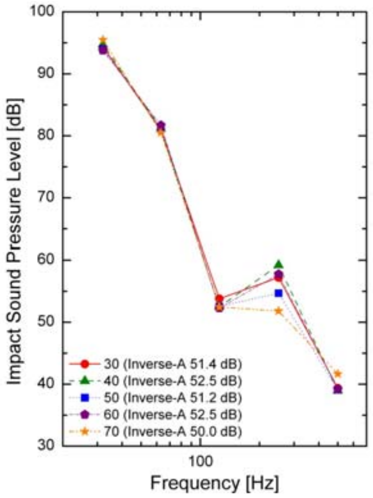

Figure 5. Effect of glass foam aggregate on heavy-weight impact sound using impact ball

Impact sound pressure level using bang machine decreased when percentage of glass foam aggregate on aerated light weight concrete. However, bang machine impact sound pressure level decrease was found in frequency range higher than 125 Hz. In case of impact ball, the lowest floor impact sound pressure level was shown at 70 percent condition. From these results it can be concluded that heavy-weight impact sound pressure level decreased when glass foam aggregate percent in aerated concrete increased.

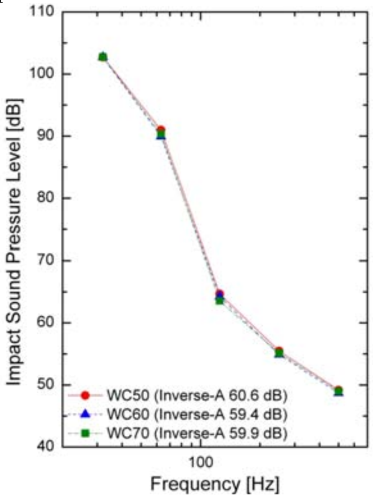

Figure 6. Effect water-cement ratio on heavy-weight impact sound using bang machine; first stage experiment

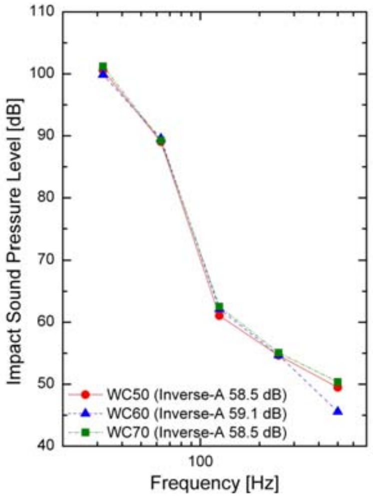

Figure 7. Effect water-cement ratio on heavy-weight impact sound using bang machine; second stage experiment

Effect of water-cement ratio on heavy-weight impact sound was shown in figure 6 to 8. In the result of first stage experiment bang machine impact sound pressure level was decreased when water cement ratio increased except for 250 Hz band. However, from the result from second experiment, relationship between impact sound pressure level and water cement ratio using bang machine was not shown clearly (see Figure 7.).

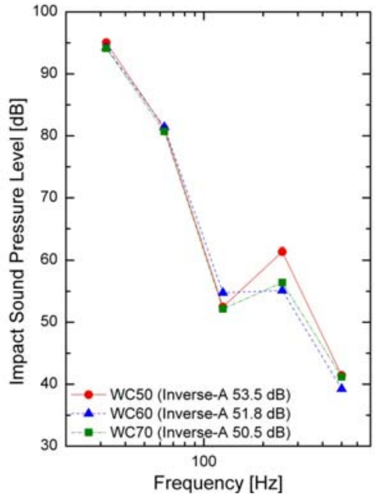

Figure 8. Effect water-cement ratio on heavy-weight impact sound using impact ball

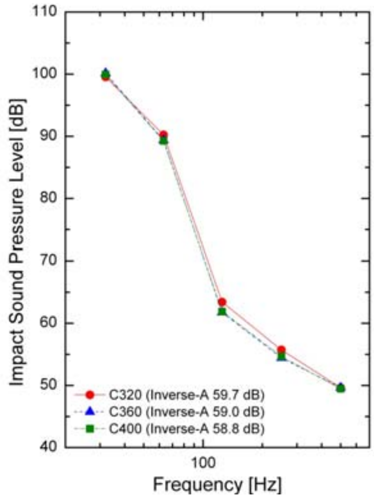

Figure 9. Effect amount of cement on heavy-weight impact sound using bang machine

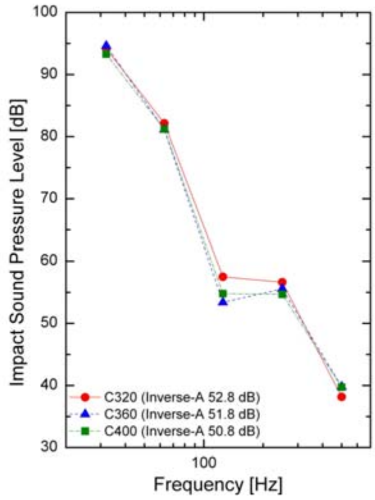

Figure 10. Effect amount of cement on heavy-weight impact sound using impact ball

Figure 8 shows relationship between impact sound pressure level and water cement ratio using impact ball. Inverse-A weight value was decreased when water cement ration increase. From these experiment results, it can be assumed that heavy-weight impact sound pressure level can be reduced by the increment of water cement ratio.

Results of experiment on amount of cement were shown in figure 9 and 10. As shown in figure 9, the lowest impact sound pressure level using bang machine found when amount of cement was 400 kg/m^3 condition. Single number rating value also decreased about 1 dB when amount of cement increased from 320 kg/m^3 to 400 kg/m^3.

In case of impact ball, single number rating value was decreased about 2 dB when amount of cement used in cement mortar from 320 kg/m^3 to 400 kg/m^3. Especially in 125 Hz and 250 Hz band, 5 to 6 dB decreased.

Increment of amount in cement means increment of surface density in concrete slab. Increment of surface density can change stiffness and resonance frequency in concrete slab. Therefore, heavy-weight impact sound pressure level can be decreased.

CONCULSIONS

In order to reduce a heavy-weight impact sound pressure level in residential buildings, material properties of aerated concrete and cement mortar was revised and bang machine and impact ball sound pressure level was measured in reverberation chamber using small size specimens. Design factors which are controlled in this study were percentage of glass foam aggregate on the aerated light-weight concrete, water-cement ratio and amount of cement on cement mortar.

Based on the result of experiments, it can be concluded that increment of glass foam aggregate on aerated concrete effective on the reduction of heavy-weight sound pressure level. Glass foam aggregate made from recycled glass bottle and so on. Use of glass foam aggregate on floor structure of residential buildings reduces heavy-weigh impact sound and environmental load simultaneously.

In addition, increment of water cement ration and amount of cement on aerated concrete and cement mortar reduce heavy-weight impact sound pressure level. By increment of these properties heavy-weight impact sound reduced about 2 dB. These factors can be used as quality control factor on the floor impact isolation performance at in-situ condition.

However, experiments and results on this study were conducted in laboratory condition; reverberation chamber. Reverberation chamber are different from actual residential building project, especially in structural condition, sound field and so on. In order to apply the results from this study, large scale or mock-up experiment should have to be conducted and verified.

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