Application of ETPU materials for reducing floor impact noises

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Summary

In South Korea, all new multi-stories apartment buildings should be designed to prevent floor impact noises. Therefore, use of floor resilient materials such as EPS or EVA with a dynamic stiffness of 40 MN/m^3 or less is almost mandatory. The current EPS or EVA materials can be economical solution with a thickness of 30 mm or more. However, as for renovation purpose with remaining the existing concrete structure, it needs to be designed as thinner materials. ETPU (expanded thermoplastic poly- urethane) is a new material as elastic as a rubber but lighter weight. Dynamic stiffness and thickness of ETPU were controlled, respectively, as 5 MN/m^3 to 20 MN/m^3, and 10 mm to 40 mm. Based on laboratory test of basic properties in accordance with KS F 2868, mock-up test with loading plate to simulate floating floor structure was carried out in comparison with the existing EPS or EVA materials. As results, ETPU showed better performance on reducing heavy-weight floor impact noises, especially for rubber ball as an impact source. In addition, combination strategy of ETPU and other materials was discussed to fulfill thermal insulation performance, economical and working efficiency.

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1. Introduction

In South Korea, all new multi-stories apartment buildings should be designed to prevent floor impact noises. Therefore, use of floor resilient materials such as EPS or EVA with a dynamic stiffness of 40 MN/m^3 or less is almost mandatory. The current EPS or EVA materials can be economical solution with a thickness of 30 mm or more. However, as for renovation purpose with remaining the existing concrete structure, it needs to be designed as thinner materials. ETPU (expanded thermoplastic poly- urethane) is a new material as elastic as a rubber but lighter weight.

In this study, many types of resilient materials including ETPU materials were tested with concrete slab of 150 mm for renovation purpose. After comparing their physical properties such as dynamic stiffness and compressibility in laboratory condition, a mock-up test with loading plate to simulate floating floor structure was carried out in comparison with the existing EPS or EVA materials. In addition, a field test for simulating practical construction process was conducted in a test building.

2. Measurement set-up

2.1. Physical properties in laboratory

The dynamic stiffness can be measured in accordance with ISO 9052-1 and KS F 2868 standards. The set-up for pulse exciting measurement consists of base plate, specimen, load plate, pick-up, pulse exciter and FFT analyzer as shown in Fig. 1 and 2. The steel load plate has dimension with 200 mm x 200 mm and mass of about 8 kg. The test specimen should be prepared larger than the load plate.

After hitting the center of the load plate with pulse exciter (impact hammer), the acceleration level is measured with pick-up (accelerometer). The resonance frequency can be obtained by analyzing the frequency response of vibration system with the equation 1.

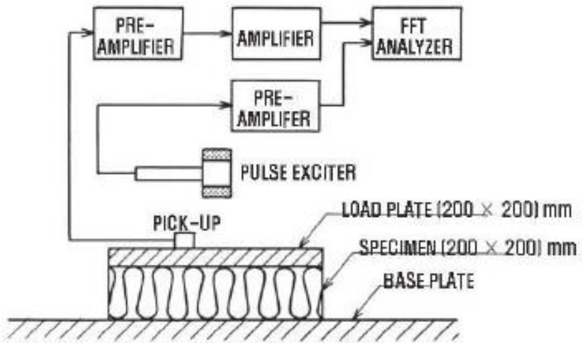

Figure 1. Pulse exciting dynamic stiffness measurement scheme

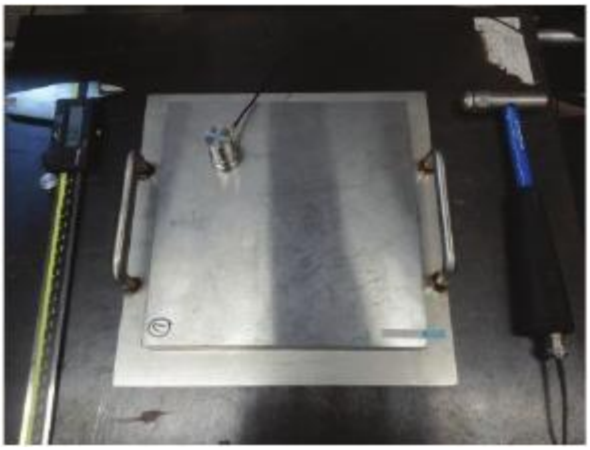

Figure 2. Pulse exciting dynamic stiffness measurement equipments

$$s' = (2\pi f_r)^2 m'_t, \qquad (1)$$

where s'_t is dynamic stiffness in MN/m^3, f_r is resonance frequency in Hz, m'_t is mass per unit area in kg/m^2.

2.2. Mock-up tests

A mock-up test was designed in two reverberation rooms connected up and down. A load plate which simulates mortar layer was constructed to cover resilient materials over concrete slab of thickness 150 mm as shown in Fig. 3 and 4. Heay/soft impact source (rubber ball) was used. Test result was reported as single number quantity (SNQ) value using rubber ball in accordance with KS F 2863-2.

3. Test results

Seven types of materials were considered; EPS, EVA, PE, polyester, glass wool, damping sheet, and ETPU. Table I shows the test results including the mock-up tests. EPS is the cheapest material and also the most effective materials for reducing floor impact noise using rubber ball. In comparison, ETPU showed better physical properties than EPS, but it costs almost 20 times. Its compressibility is less than 1 mm, moreover dynamic stiffness is almost 7.36 MN/m^3 for 20 mm thickness. In addition, combination of ETPU and EPS showed the best performance in terms of SNQ using rubber ball as 44 dB.

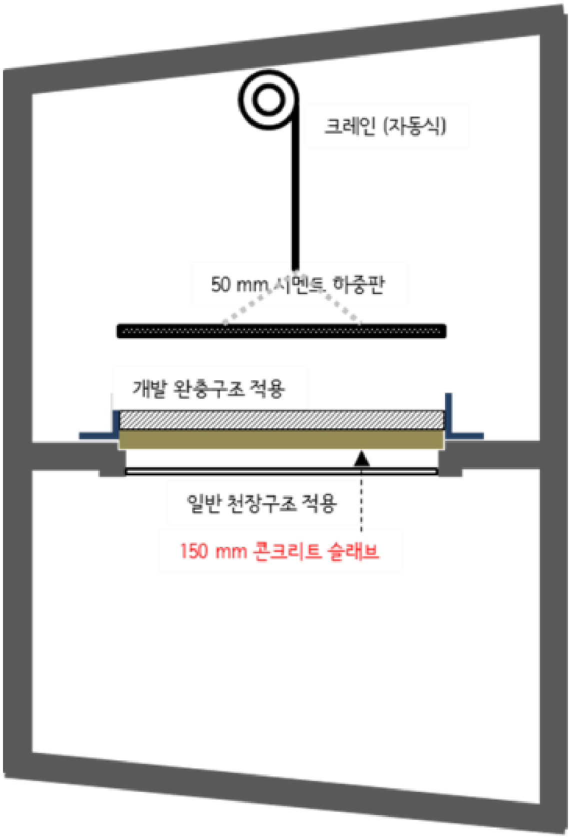

Figure 3. Mock-up test set-up

Figure 4. Pictures of mock-up facility

Table I. Test results

Name of specimen	Thickness (㎜)	Dynamic stiffness (MN/㎥)	Loss factor	Density (㎏/㎥)	Compressibility	SNQ (dB)
EPS(A)30F	32.0	25.99	0.19	13.23	2.6	49
EPS(B)30U	32.2	5.61	0.03	19.31	3.4	50
EPS(C)30U	31.2	10.97	0.06	18.79	3.1	50
EPS(C)15F	16.4	22.60	0.21	21.55	1.6	51
EPS(C)15U	14.7	13.44	0.07	17.55	1.8	51
P.E.(Lami)50F	52.5	1.12	0.26	35.38	22.4	40
XPE5F	6.2	138.90	0.33	24.55	0.4	54
EPS(C)15F+XPE5F	22.4	21.83	0.22	22.55	1.9	50
EPS(C)15U+XPE5F	20.6	13.40	0.08	19.82	2.1	50
EPS10	10.7	10.68	0.18	23.50	1.5	50
EPS20	20.1	11.90	0.12	19.50	2.9	48
EPS30	29.4	10.57	0.10	23.30	3.2	49
EPS10	10.1	16.53	0.19	21.30	1.4	51
EPS20	21.5	13.83	0.10	23.00	2.2	49
EPS30	30.6	20.56	0.18	18.80	2.5	49
EPS10	10.2	25.28	0.12	18.50	1.2	52
EPS20	21.0	22.90	0.15	17.80	2.0	51
EPS30	30.0	17.30	0.09	18.30	2.4	49
EPS10	10.8	27.33	0.18	19.70	1.1	52
EPS20	21.4	22.32	0.18	16.50	1.9	50
EPS30	29.6	24.50	0.10	17.20	2.2	50
ETPU10	10.5	18.79	0.13	130.26	0.3	48
ETPU10+ETPU10	21.7	7.32	0.12	140.97	0.9	47
ETPU20+ETPU10	34.0	5.52	0.13	132.80	1.1	45
EPS10+ETPU10	21.5	8.48	0.07	83.26	2.5	47
EPS20+ETPU10	31.2	7.32	0.07	63.45	2.9	46
EPS(K)10+ETPU10	20.4	12.57	0.10	80.45	2.1	47
ETPU20	21.6	7.36	0.13	144.46	0.7	46
ETPU10+ETPU20	32.6	4.62	0.12	135.29		45
ETPU20+ETPU20	44.0	4.05	0.12	142.75		44
EPS10+ETPU20	33.2	5.60	0.08	99.80		46
EPS(K)10+ETPU20	31.3	7.55	0.11	93.08		47
EVA15U	17.0	7.22	0.17	54.94		48
ETPU10	10.5	18.79	0.13	130.26	0.3	47

4. Field tests

Among Table I, three resilient materials were selected for field test. The test building was shaped a box of four connecting rooms with two stories. EPS 20 mm with dynamic stiffness of 10 MN/m^3 was installed with light-weight foamed concrete of 40 mm and finishing mortar of 40 mm in the first room. In the second room, ETPU 20 mm was installed as the same manner with EPS case. In the third room, EPS 10 mm on ETPU 10 mm was installed as the same manner. Fig. 5 shows the installation pictures. In all three rooms, ceiling finish using gypsum board and air backing 150 mm was applied commonly.

Fig. 6 to 8 shows the test results in each room. EPS 20 mm shows SNQ value of 46 dB using rubber ball. However, ETPU 20 mm showed better performance in terms of SNQ value of 43 dB. In addition, combination of ETPU 10 mm and EPS 10 mm showed the best results of SNQ value of 40 dB.

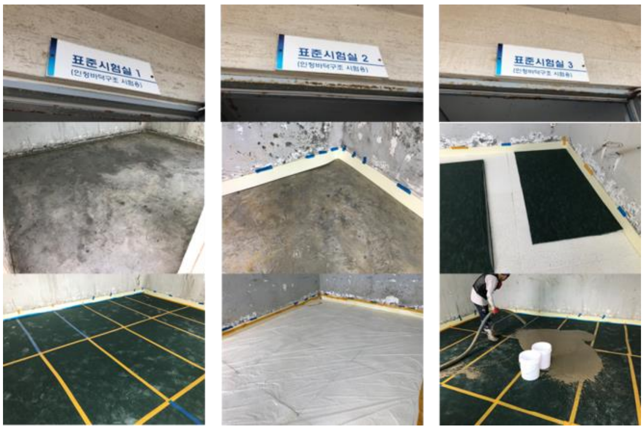

Figure 5. Pictures of the field tests

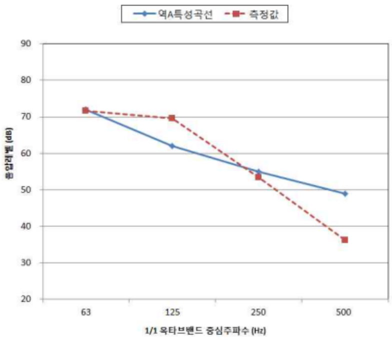

Figure 6. Test result of EPS 20 mm structure in the first test room with SNQ of 46 dB using rubber ball

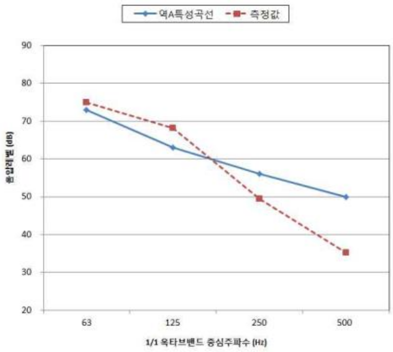

Figure 7.Test result of EPS 20 mm structure in the first test room with SNQ of 43 dB using rubber ball

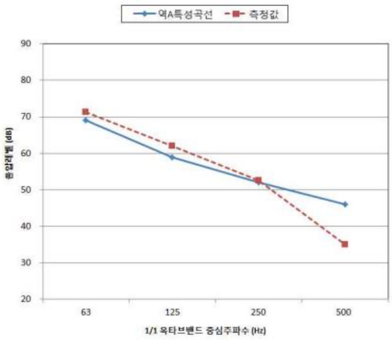

Figure 8. Test result of EPS 20 mm structure in the first test room with SNQ of 40 dB using rubber ball

5. Conclusions

ETPU showed better performance on reducing heavy-weight floor impact noises, especially for rubber ball as an impact source. In addition, combination strategy of ETPU and EPS showed better results. In further, thermal insulation performance, economical and working efficiency of ETPU is needed to be investigated.

Acknowledgement

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