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SOUND INSULATION CHARACTERISTICS OF MULTISTOREY DWELLINGS WITH RC SUSPENDED SLABS

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1. INTRODUCTION

As Japanese cities are well known to have high population density, buildings are required to keep a considerable balance with economics, safety, dweller's living environmental conditions, and so on. Recently, a group of architects in Japan presented a new construction method, which, they say, would overcome such problems around multistory dwellings. The new construction method uses the reinforced concrete (RC) suspended slabs[1)] (Fig. 1). Similar construction methods have been proposed and testified in experimental circumstances[2)3)], but the architects are applying it to their practical works. In the works, they plan to use the cavity under the floor both as piping and storage space, which makes the maintenance and repair of piping easier. Because the space for storage under the floor reduces the required site area for the building, the building expenses of a multistory dwelling with this method might be competitive with that of an ordinary one. However, there remains a question about the sound insulation between dwellings with such kinds of construction methods. This paper reviews our first study on the characteristics of the impact sound insulation of floors in a building with this construction method.

2. MEASUREMENTS

The following measurements were carried out to investigate the characteristics of the floor impact sound pressure level in a 7-story experimental building with a reinforced concrete structure and RC suspended slabs. Fig. 2 shows the plan of its dwelling area. The measurements followed the Japanese Industrial Standard (JIS) 1418, "method for field measurement of impact sound level of floors." In this standard there are two kinds of sound sources, heavy weight (tire) and light weight (ISO tapping machine). Peak sound pressure levels were measured with two microphones 1.2m above the floor surface in the room below. In these experiments, the following structural conditions in the floor components were compared;

Cond#1 : original structure (applied to Room-D, Fig.3).

Cond#2 : wooden floor soundproofed against the light weight impact sound was used, the other elements were equal to the Cond#1 (applied to Room-C).

Cond#3 : niches were executed between the wall and floor, and rubbers were inserted (applied to Room-C, Fig. 4).

Cond#4 : in addition to the Cond#3, glasswool was installed in the cavity under the floor. (applied to Room-C.)

Fig. 5 shows the results of the floor impact sound level measurements against the tapping machine in Cond#1, #2, and #3. Fig. 6 is those against the tire bang. In the frequency region of 125 Hz and 250 Hz, the characteristics of the Room-D on the Cond#1 against the tapping machine is inferior to those of the Room-C on the Cond#2; on the other hand, there is no significant difference between the levels of those against tire impact sound; so, it can be said that the better insulation against the tapping machine of Room-C on the Cond#2 is brought by use of the soundproofed wooden floor, and that it does not have distinct effect on the insulation against the tire bang; such properties of soundproofed wooden floors might be well known if it is executed in an ordinary building structure; but it is also confirmed in the structure with the RC suspended slabs.

As for the effect of rubbers and niches used in Cond#3, slight improvement can be seen both in Fig.5 and 6. In these measurements, the quantities are not enough to show distinct effect. It does not mean, however, that there remains no need to use any of them, because the rise in the measured level around 250 Hz indicates there exist some resonances of the structural elements to be damped or isolated from the main body of the building structure. Theoretically, typical resonances can be estimated to be; $f_{1,1}$ = 410 Hz for the simply supported plate bending mode of the sigma beam, $f_{1,1}$ = 360 Hz for the wooden beam with 0.91 m length and simply supported, $f_{0,0,1}$ = 280 Hz for the cavity under the floor.

Fig.7 shows that the effect of the glasswool installed under the floor is not so distinct. It is the case in both tapping machine and tire bang. Almost the same result was obtained in the measurement using a resonator made of perforated board whose peak of sound absorbing characteristics was designed to be around 250 Hz. To discuss the effect of the absorbent characteristics of the cavity under the floor more closely, we carried out the following finite elemental investigation.

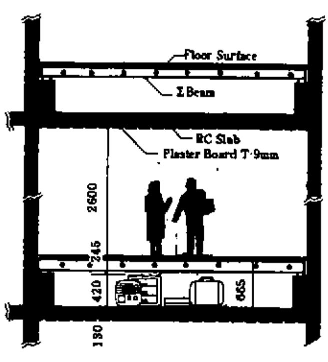

Fig.1 Section of a building with RC suspended slabs

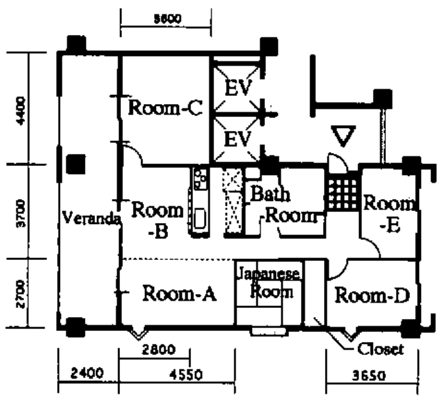

Fig.2 Plan of dwelling house in the experimental building

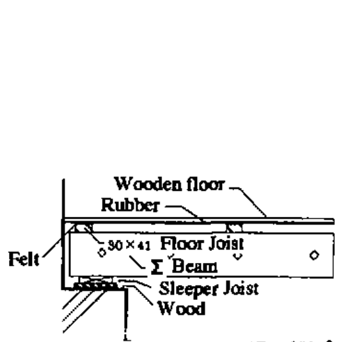

Fig.3 Detail of floor structure (Cond#1 & 2)

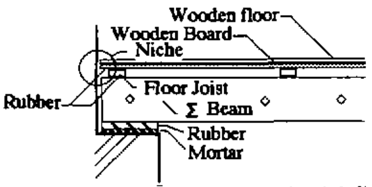

Fig.4 Detail of floor structure (Cond#3 & 4)

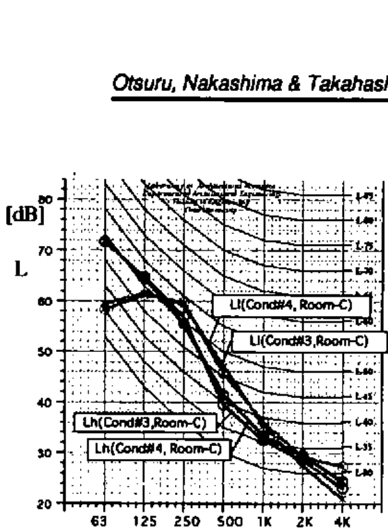

Fig.7 Comparison of floor impact sound level between Cond#3(no GW) and 4(with GW) (LI: tapping, Lh: tire)

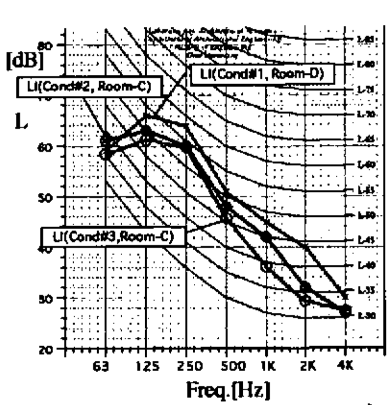

Fig.5 Comparison of floor impact sound level among Cond#1, 2 and 3 (tapping)

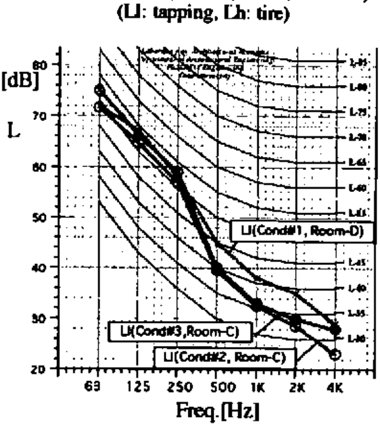

Fig.6 Comparison of floor impact sound level among Cond#1, 2 and 3 (tire)

3. A FINITE ELEMENT ANALYSIS OF THE CAVITY

The finite elemental analysis used here is based on the method presented in our former paper[4]. The convolution method using FFT is applied on it to obtain the transient response of sound pressure in the cavity with absorbent wall conditions. Fig.8 shows the geometry of the finite elemental division of the cavity. The sound source is assumed to be at the center of the cavity's ceiling (backside of the sound source room's floor), and to be 250 Hz tone burst with 6 waves. The absorbent conditions of the cavity's boundaries are:

#1 Side walls, floor, and ceiling -- hard ($\alpha = 0.08$, $z = 400$)
#2 Floor -- fiberous sheet t =2mm($\alpha_{250Hz} = 0.1$), others -- same as #1
#3 Side walls -- glasswool t =100mm($\alpha_{250Hz} = 0.2$), others -- same as #1
#4 Side walls & floor -- glasswool t =100mm, others -- same as #1.

The complex impedance values of the materials used here are measured by the two -microphone method[5]. By our FEM analysis, all the time-responses at every nodal point can be obtained at the same time, or in parallel. Two of them are shown in Fig.9, which shows that even a slight absorbent in the cavity in #2 decreases the reverberation considerably. The increases of the absorbent in #3 and #4 do not show significant difference from that of #2 in the tendency of the echo-time pattern.

In the cavity of a practical room, there are rubbers, wooden boards, wooden beams, pipings, etc. In general, the absorbent condition can be expected to be more than in #1. If it is similar to #2, then the installed glasswool under the cavity as #4 can not be expected to have significant difference in noise reduction, which corresponds to the result of the measurement described above.

4. CONCLUSIONS

The outline of the sound insulation characteristics of multi story dwellings with RC suspended slabs are presented above. The JIS A-1419 grades of the floors discussed above, lie between L-50 and L-55. According to the sound insulation standard of Japan Architecture Institute, L-55 is "allowable" for a room in an apartment house. As the "recommended" grade is less than L-55, further improvements are desirable to this structure. The cavity under the floor in this structure is large enough to allow such an improvement like the increase of the damping in the structural elements, or the increase of the thickness of the RC slabs .

5. ACKNOWLEDGMENT

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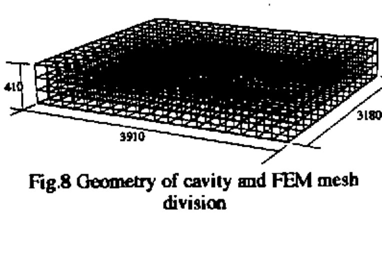

Fig.8 Geometry of cavity and FEM mesh division

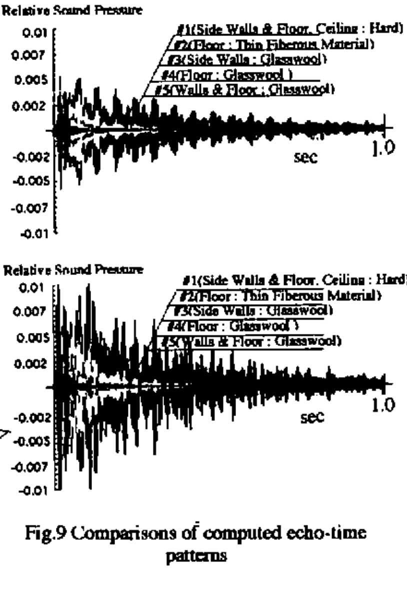

Fig.9 Comparisons of computed echo-time patterns