



Influence of floor finish structure on floor impact sound insulation in CLT model building

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ABSTRACT

A floor impact sound insulation is often objection or trouble in building. The Act on the Promotion of the Utilization of Wood in Public Buildings was enforced in 2010 in Japan. As a result, measures are being taken to use Japanese wood. For effective use of the Japanese wood, mainly Japanese cedar, CLT (Cross Laminated Timber) was standardized by Japanese Agricultural Standard as a building material. We, however, have little knowledge about performance of CLT building for satisfaction of Japanese standards. Therefore, we built a 2-story CLT model building for experiments. The floor impact sound insulation of the timber constructions is low compared with that of the concrete constructions. Although this CLT model building is assumed a detached house, these performances were very low performance. In this paper, the purpose of improving the floor impact sound insulation, we report the measurement results by changing the floor finish structure to dry-type double floor structure with rubber vibration insulator. We found that the effect of the dry-type double floor structure with rubber vibration insulator on the heavy-weight and the light-weight floor impact sound insulation. Furthermore, comparison was made with the reduction of transmitted floor impact sound level obtained in other experiment building.

Keywords: Cross Laminated Timber, Floor Impact Sound, Floor Finish Structure

I-INCE Classification of Subject Number: 51

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1. INTRODUCTION

The Act on the Promotion of the Utilization of Wood in Public Buildings was enforced in 2010 in Japan. The promotion of use of wood can contribute to reduce CO₂ emissions and to the prevention of global warming etc. As this Act, a public building in a low layer is supposed to attempt making to timber construction. It is expected that the building such as house comes to be made from wooden. Moreover, measures are being taken to use Japanese wood. For effective use of the Japanese wood, mainly Japanese cedar, CLT (Cross Laminated Timber) was standardized by JAS (Japanese Agricultural Standard) as a building material.

A floor impact sound insulation is often objection or trouble in building. A performance of sound insulation of timber building usually has inferior than of concrete construction building. Zeitler et al. conducted an investigation of the impact sound insulation of cross laminated timber floors¹. Hiramitsu et al. reported the sound insulation performance of cross laminated timber separation wall^{2, 3}, and the floor impact sound insulation in cross laminated timber building^{4, 5}. We have little knowledge about performance of cross laminated timber detached house. Hence we built a 2-story cross laminated timber model building and measured the floor impact sound insulation of the CLT model building. However, it is necessary to conduct investigations aimed at improving performance⁶. In this paper, the purpose of improving the floor impact sound insulation, we report the measurement results by changing the floor finish structure to dry-type double floor structure with rubber vibration insulator.

2. CLT MODEL BUILDING

The CLT model building consists of two high-ceiling spaces of “U-shaped” by the CLT panel with a maximum length of 6 m, and they are shifted and meshed with each other to form a 2-story detached house. Fig. 1 shows the photograph showing the outside view of CLT model building. Fig. 2 and 3 show the plan views of the CLT model building.

The floor impact sound insulation was measured in the dining room for the sound source room, and the private room 1 for the sound receiving room. The floor cross section specification at this place was the floor CLT panel (5-layer and 7-ply, 210 mm thickness), the dry-type double floor structure without rubber vibration isolator and constructed by 24 mm thick plywood and 6 mm thick tile carpet. Also, the ceiling structure was a suspended ceiling by a gypsum board of 9.5 mm thickness. Fig. 4 shows the photographs showing the under construction of floor finishing structure as existing specification specimen.



Fig. 1 – Photograph showing the outside view of CLT model building.

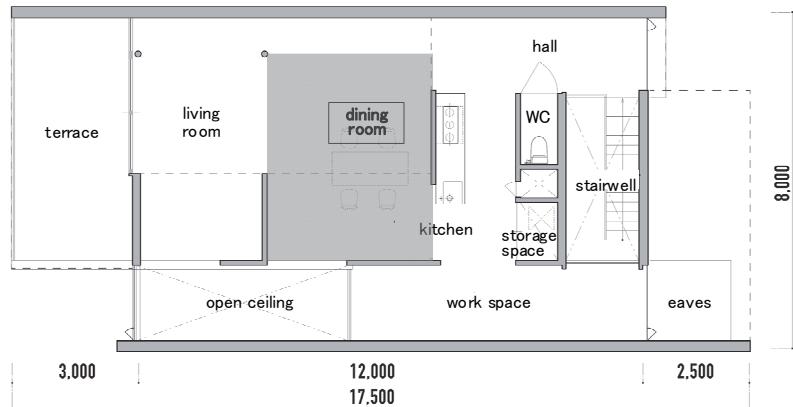


Fig. 2– Plan view of the CLT model building (2nd floor).

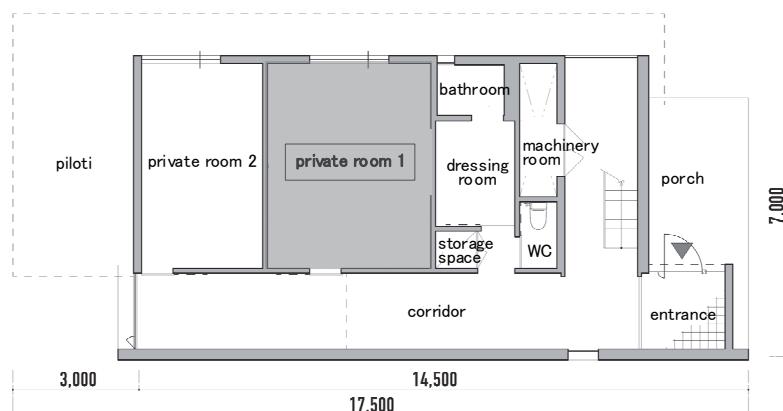


Fig. 3– Plan view of the CLT model building (1st floor).



Fig. 4– Photograph showing the under construction of floor finishing structure.

First, we measured the floor impact sound insulation of the existing specification specimen floor. Then, the existing specification specimen floor was removed and the performance of CLT bare floor was confirmed. Then, the purpose of improving the floor impact sound insulation, the floor finish structure was changed to dry-type double floor structure with rubber vibration insulator. Fig. 5 shows the cross-sectional view of specimens. For dry-type double floor structure A, B and D, the topping was changed with and without asphalt sheet and plywood.

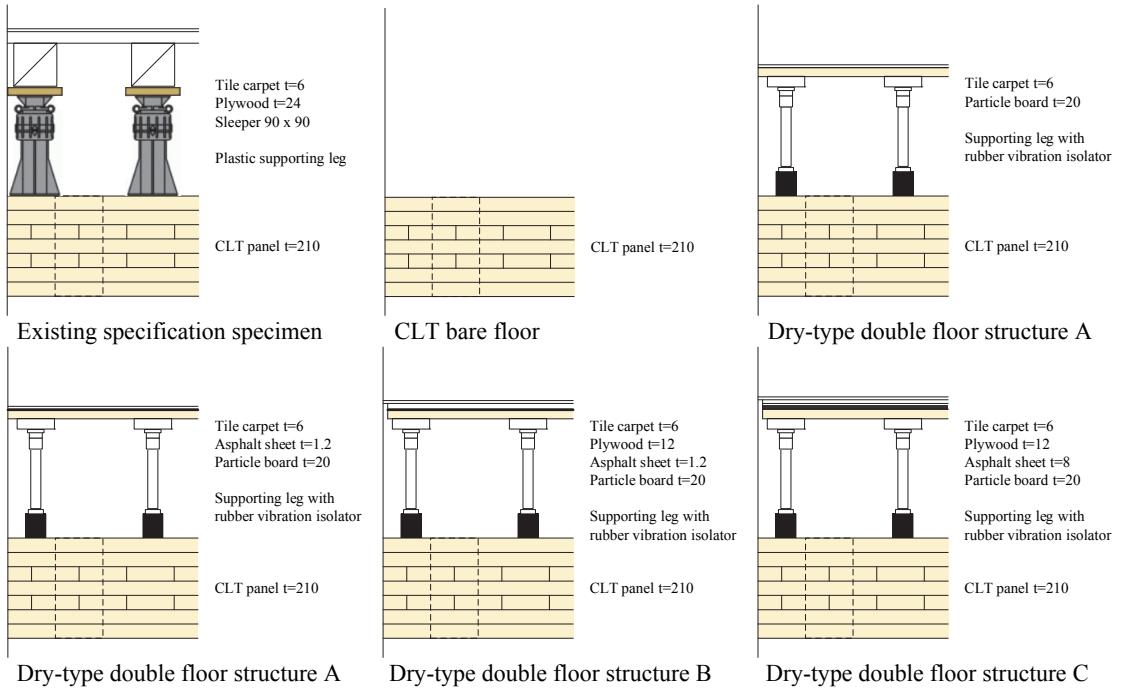


Fig. 5 – Cross-sectional view of specimens.

3. FLOOR IMPACT SOUND INSULATION

3.1 Method

The floor impact sound insulations were measured in conformity with requirements of JIS A 1418-2⁷ for the heavy-weight floor impact sound insulation and JIS A 1418-1⁸ for the light-weight floor impact sound insulation. The impact sources for measurement of the heavy-weight floor impact sound were a car-tire source (a bang machine) and a rubber ball source, and of the light-weight floor impact sound was a tapping machine. The impact positions were five positions, and the sound receiving positions were five positions. The floor impact sound insulations were evaluated with JIS A 1419-2⁹. A-weighted floor impact sound pressure levels by synthesis were also calculated; heavy-weight floor impact sound: 31.5 - 500 Hz octave band, light-weight floor impact sound: 125 - 2000 Hz octave band).

3.2 Results

Fig. 6 shows the measurement results of floor impact sound pressure level. In the case of existing specification specimen, the heavy-weight floor impact sound insulations were L_r -80 (74.9 dBA) using the car-tire source, L_r -70 (66.4 dBA) using the rubber ball source. Although the CLT model building is assumed a detached house, these performances were very low performance. On the other hand, in the case of CLT bare floor, the heavy-weight floor impact sound insulations were L_r -75 (71.5 dBA) using the car-tire source, L_r -70 (68.1 dBA) using the rubber ball source. From these results, it was found that the floor finish structure reduced the heavy-weight floor impact sound insulation in the case of car-tire source. The light-weight floor impact sound insulation was L_r -65 (63.2 dBA) in the case of existing specification specimen. In contrast, the light-weight floor impact sound insulation was L_r -80 (81.7 dBA) in the case of CLT bare floor, the effect of the floor finish structure was seen.

In the case of dry-type double floor structures for the purpose of improving floor impact sound insulation, the heavy-weight floor impact sound insulation was L_r -70 (car-

tire source), and L_r -60 or L_r -65 (rubber ball source), and the light-weight floor impact sound insulation was L_r -55 or L_r -60. We found that the effect of the dry-type double floor structure with rubber vibration isolator on the heavy-weight and the light-weight floor impact sound insulation.

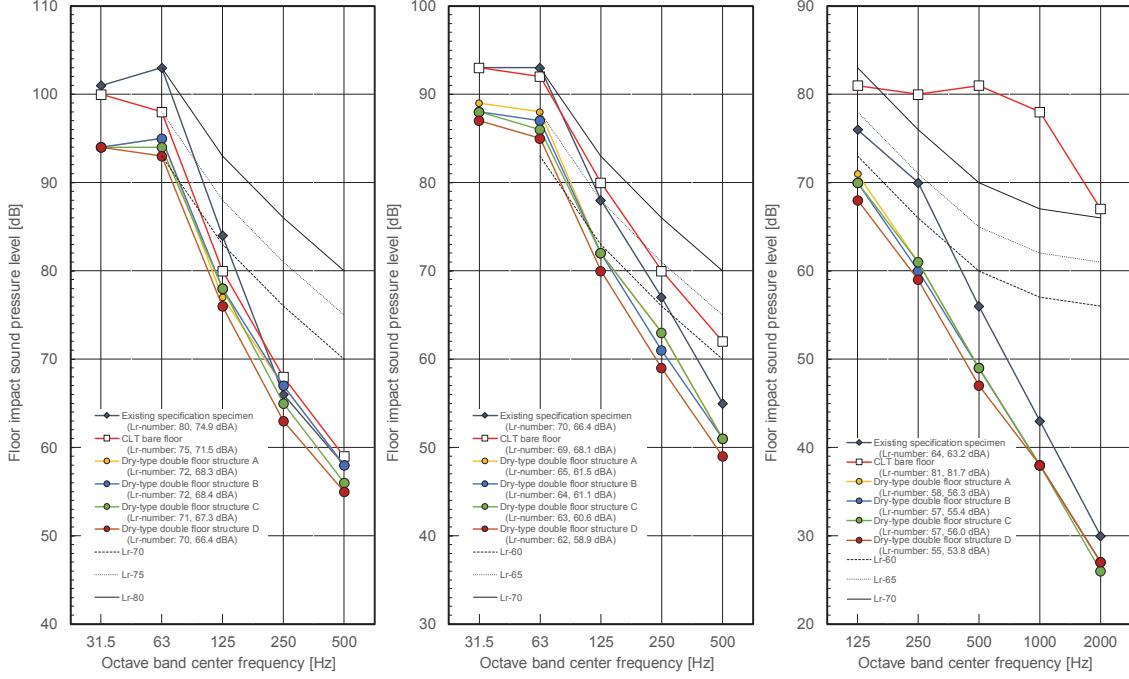


Fig. 6 – Measurement results of floor impact sound pressure level.
(left: car-tire source, center: rubber ball source, right: tapping machine)

4. DISCUSSIONS

To confirm the effects of the floor finish structures, the differences in floor impact sound pressure levels from CLT bare floor were calculated. Fig. 7 shows the improvements of floor impact sound pressure levels relative to that of CLT bare floor. A positive value in these figures indicates that the room has a higher floor impact sound insulation than CLT bare floor. In the heavy-weight floor impact sound insulation, we found that the effect of the dry-double floor structure on the heavy-weight approximately 5 dB in 63 Hz octave band, and on the light-weight floor impact sound insulation. Furthermore, the effect of rubber vibration isolator was also seen large.

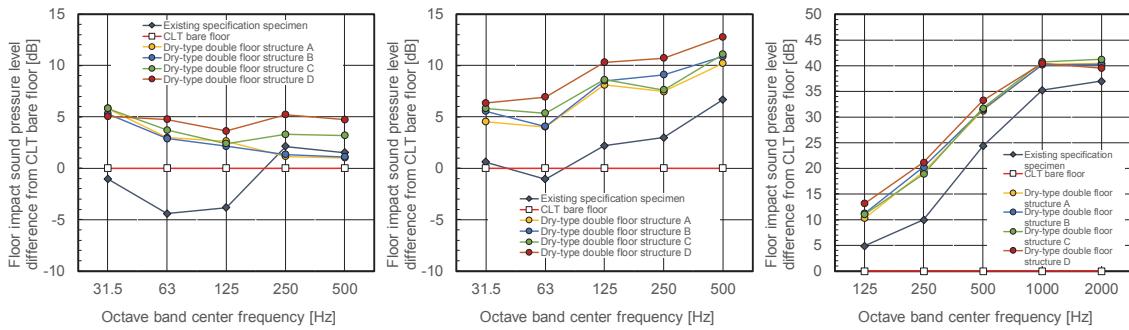
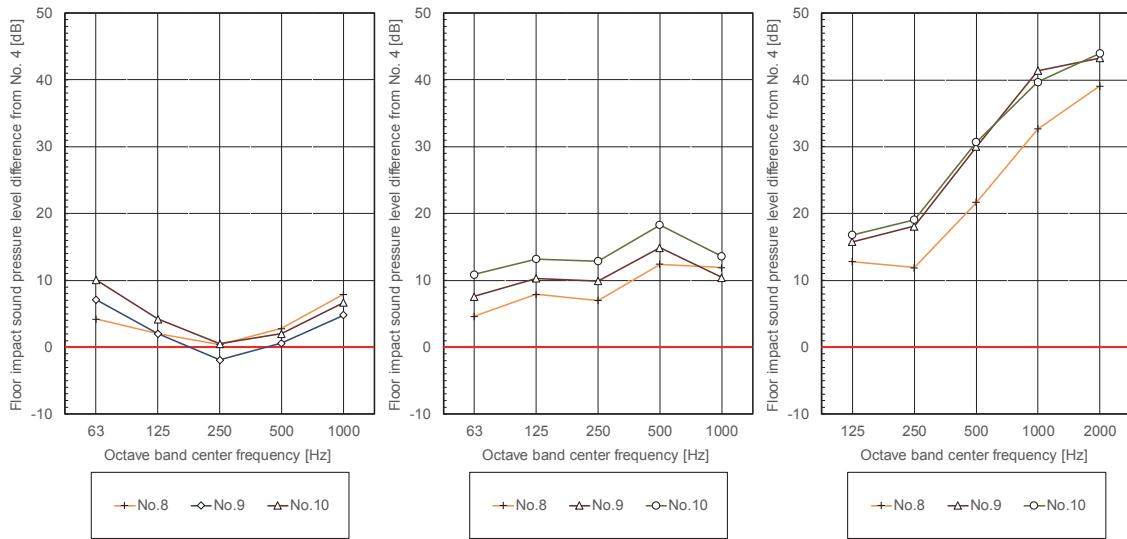


Fig. 7 – Influence of floor finish structure on floor impact sound insulation -
Improvements of floor impact sound pressure levels from CLT bare floor.
(left: car-tire source, center: rubber ball source, right: tapping machine)

The effects of dry-type double floor structure need to be confirmed in other buildings. Therefore, we tried to compare with the reduction of transmitted floor impact sound level in previous study. Fig. 8 shows the influence of dry-type double floor structure on impact sound insulation in reference 4. When Fig. 7 and Fig. 8 are compared, it can be seen that the value and frequency characteristics of effect of dry-type double structure are similar in both heavy-weight and light-weight floor impact sound insulation. From these results, it is considered that these values can be sufficient to predict the floor impact sound pressure level.



*Fig. 8 – Influence of dry-type double floor structure on impact sound insulation in previous study⁴.
(left: car-tire source, center: rubber ball source, right: tapping machine)*

4. CONCLUSIONS

This paper presents the influence of floor finish structure on floor impact sound insulation in CLT model building. The results suggest the influences of the dry-type double floor structure with rubber vibration isolator. We conclude that the effects on heavy-weight and light-weight floor impact sound insulation by using dry-type double floor structure with rubber vibration insulator for CLT building. Furthermore, we confirmed that the trend of the effect values are almost the same even if the building changed.

5. ACKNOWLEDGEMENTS

This CLT model building was constructed under the fund by Ministry of Land, Infrastructure and Transport. This research was conducted as a part of the joint research of the Building Research Institute (BRI) and the Japan CLT Association. A part of this research was supported by JSPS KAKENHI Grant Number 17K06690.

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