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Sound Decisions: Moving forward with Acoustics

Acoustics behaviour of CLT structure: transmission loss, impact noise insulation and flanking transmission evaluations

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ABSTRACT

Design and construction of CLT structures is now known throughout the world thanks to its known properties, its high thermal resistance to low energy consumption and its low environmental impact. For these reasons, the studies and research on the acoustic performance analysis of these wood panels have also been very successful in recent years. This document aims to present the continuation of the investigative work carried out by Isolgomma on CLT structures, completing the study on the acoustic behaviour of floors with wall and flanking transmission analysis. Therefore, the results of the laboratory acoustic characterization of the CLT walls are presented with the application of different techniques for improving the possible performances, according to the standards of the ISO 10140 series. Furthermore, the considerations related to the study carried out on the joints of the structures are reported. CLT on a large-scale test configuration, according to the standards of the ISO 10848 series. Through this analysis it was possible to obtain the vibration reduction indices both of the bare CLT structure and of the isolated structure through the insertion of a specific anti-vibration rubber mat.

1 INTRODUCTION

Cross Laminated Timber has begun to find widespread use in the construction sector. However, simultaneously with the diffusion of CLT elements, very different types of panels appeared on the market with a variation in thickness and composition of layers. In order to proceed methodically in the acoustic analysis of these elements, the most commonly used dimensions have been taken as reference. For this purpose, the 5-layer and 140 mm thick CLT panel was chosen for the floors, and the 100 mm 3-layer panel for the walls. Starting from these choices, a study was carried out on 8 configurations of floors, which highlighted the low acoustic performance of the base floor and the possibility of achieving good performance of Ln,w with under screed solutions using acoustical high performance materials. Through these solutions it was possible to reach weighted normalized impact sound pressure level values lower than 50 dB in which however typical trend of CLT floors remains to radiate markedly in the frequencies between 100 Hz and 160 Hz (Dall'Acqua d'Industria et. al., 2018). Therefore it was proceeded the analysis of performance of the CLT structures through the investigations of the walls and flanking transmissions. Nine wall configurations have been evaluated, with the use of both metal stud and coated wall, to understand the increase in sound reduction index of an acoustically weak base partition. The tests were carried out within Isolgomma internal acoustic laboratory in accordance with international standards ISO 10140.
With the collaboration with the universities of Padua and Bologna it was also possible to proceed with the analysis of the joints of a CLT structure. The different types of screws modify the effects of the flanking transmission, which are reduced with full thread screws. Fully threaded screws tend not to contact the panels despite the use of tensioners, while partially threaded screws bring the panels to a closer contact (Mecking et al., 2015 and Guigou-Carter et al., 2015). Even in the face of this investigation, the introduction of a continuous resilient layer can be functional during the assembly phases if integrated through a correct installation.
Starting from these considerations, in accordance with the international standards of the ISO 10848 series, the coefficients of transmission of the vibrations Kij for CLT elements, based on the panels of previously indicated thickness, were therefore measured for horizontal and vertical joints.

2 TRANSMISSION LOSS: LABORATORY MEASUREMENT AND RESULTS OF CLT WALLS

Starting from the bare wall in CLT of 100 mm a total of 9 configurations were analysed. Different solutions have been used with both metal stud and coated wall, to understand the increase in sound reduction index of an acoustically weak base element. The measurements were made at the internal Isolgomma acoustic laboratory, which was designed and built in cooperation with Padua University according to the international standard ISO 140-1 in 2008. In the bottom part of laboratory there are two rooms with an opening concrete frame where it is possible to build and test 10 m^2 partition wall.

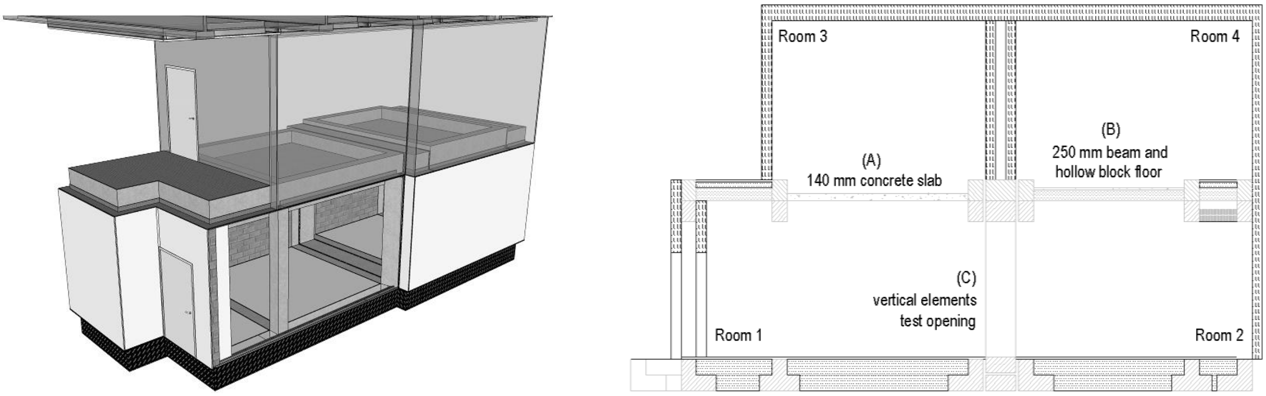

Figure 1: Isolgomma Building Acoustic Laboratory: (A) concrete slab, surface 12,96 m^2; (B) beam and hollow block floor, surface 12,60 m^2; (C) opening for the mounting of vertical elements, 10 m^2.

All the tests have been performed according to the series standards ISO 10140 in order to evaluate sound reduction indices in conformity with the ISO 717-1. Configurations are shown in Table 1.

Table 1: Configuration of the analyzed CLT walls

Configuration	Assembly scheme	Overall Thickness [mm]	Surface Density [kg/m^2]	Acoustical Performance [Rw]	[Rw+Ctr]
A	Bare 3-layer CLT wall	100	57	35	33
B	Configuration A with the addition of a 50 mm metal stud uninsulated and double plasterboard	185	73,5	47	41
C	Configuration B with the addition of 50 mm metal stud uninsulated on the other side and double plasterboard	270	90	51	43
D	Configuration B with the addition of a 50 mm metal stud insulated using acoustic panels th. 48 mm on the other side and double plasterboard	270	98,8	64	52
E	Configuration D with the replacement of a 50 mm metal stud uninsulated with a new one insulated using acoustic panels th. 48 mm and double plasterboard	270	107,6	74	60
F	Configuration A with the addition of an acoustic coupled multilayer panel plus a single plasterboard	140	75	48	41
G	Configuration F with the insertion of a second acoustic coupled multilayer panel on the other side plus a single plasterboard	180	93	58	44
H	Configuration A with the addition a single plasterboard on each side	125	73,5	33	31
I	Configuration H with the addition of a 50 mm metal stud insulated using acoustic panels th. 48 mm and double plasterboard	210	98,8	59	53

The graph, in Figure 2, presents the frequency values of the tests carried out with reference to the configurations described in Table 1. The analysis of the graph shows the poor acoustic performance of the base wall and the relative increases due to the different applications. The need to significantly increase the final thickness and the use of high performance insulating materials is confirmed to guarantee high insulation performance even at low frequencies.

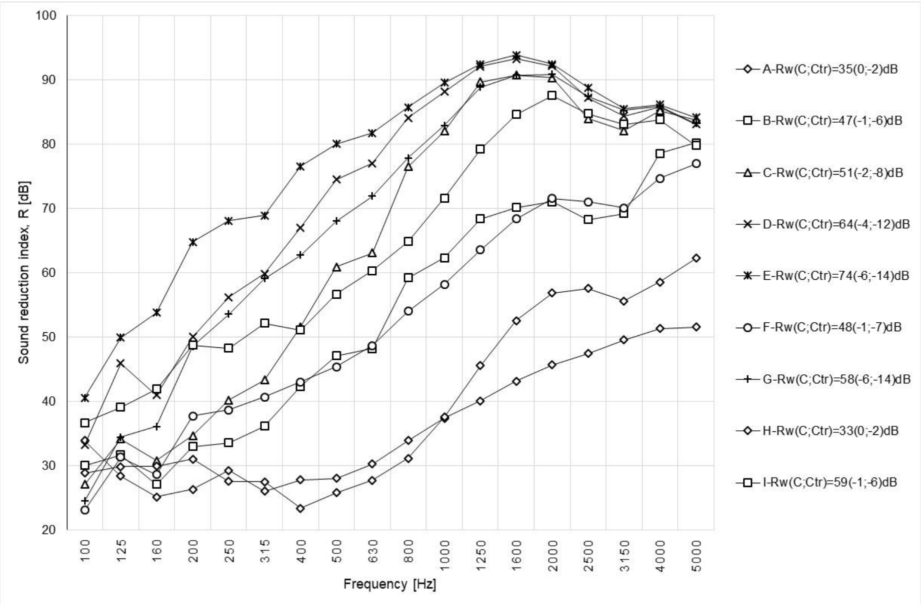

Figure 2: Normalized Transmission Loss level for all wall configurations

Through the campaign of measures carried out, it was also possible to confirm the compatibility of the reference curve for the base walls in CLT according to, and relating to the mass of 57 kg/m^2.

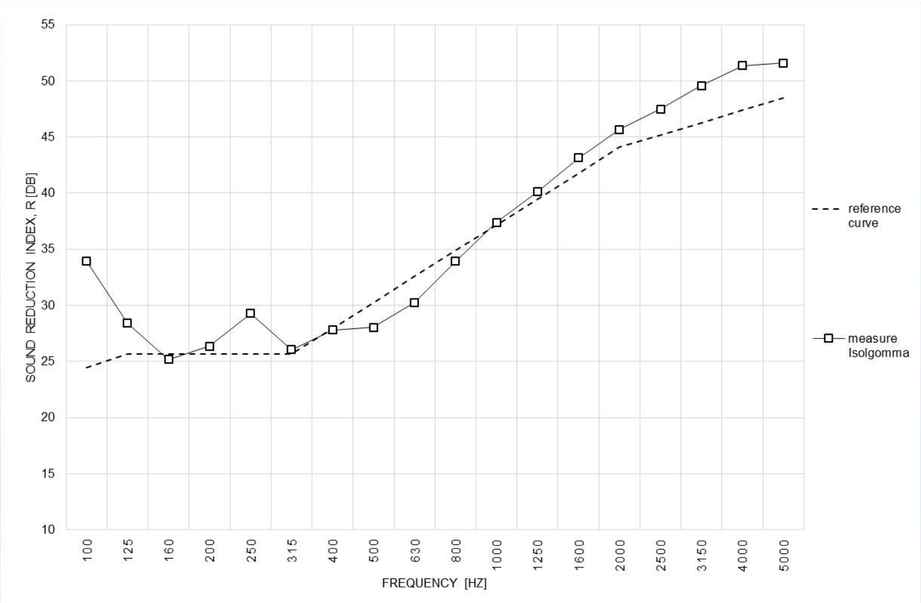

Figure 3: Sound reduction index comparison between measure bare wall and reference curve according to Di Bella at al., 2018

Figure 4 shows and compares the improvement of the sound reduction index compared to the bare wall. As can be seen from the graph, for all solutions with a metal structure, the coincidence effect flattens the improvement of the insulation of high-frequency walls, which is therefore the same even with a single non-isolated structure. It is instead in the field of medium-low frequencies where it is possible to concretely evaluate the increase in transmission loss.

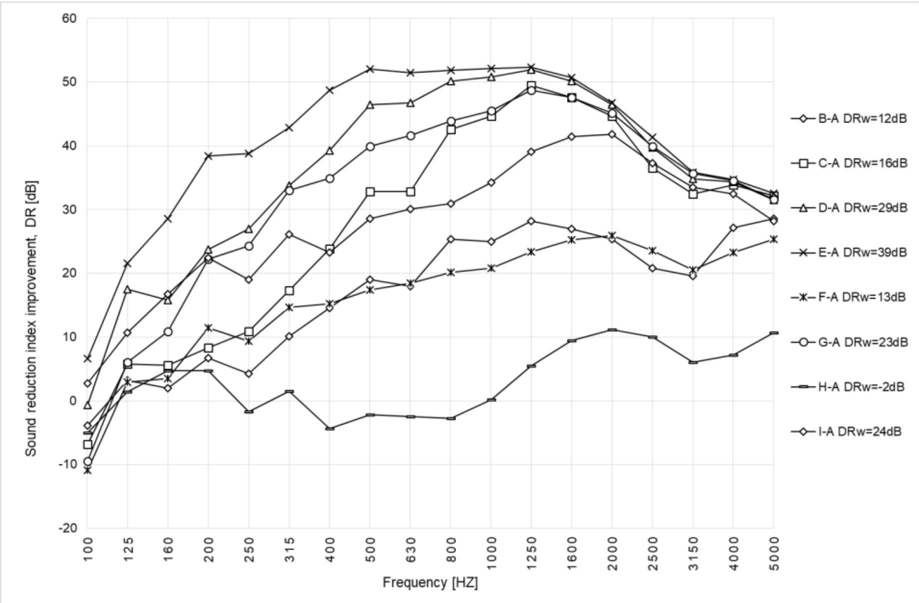

Figure 4: Sound reduction index improvement of the measured walls

The following graph, Figure 5, presents a comparison between two different construction solutions with one or two side linings. It can be seen that for the wall with air cavities, tests B and C, the increase in sound reduction index from one to two side linings is 4 dB while with the introduction of an acoustic coupled multilayer panel, tests F and G the increase is 10 dB.

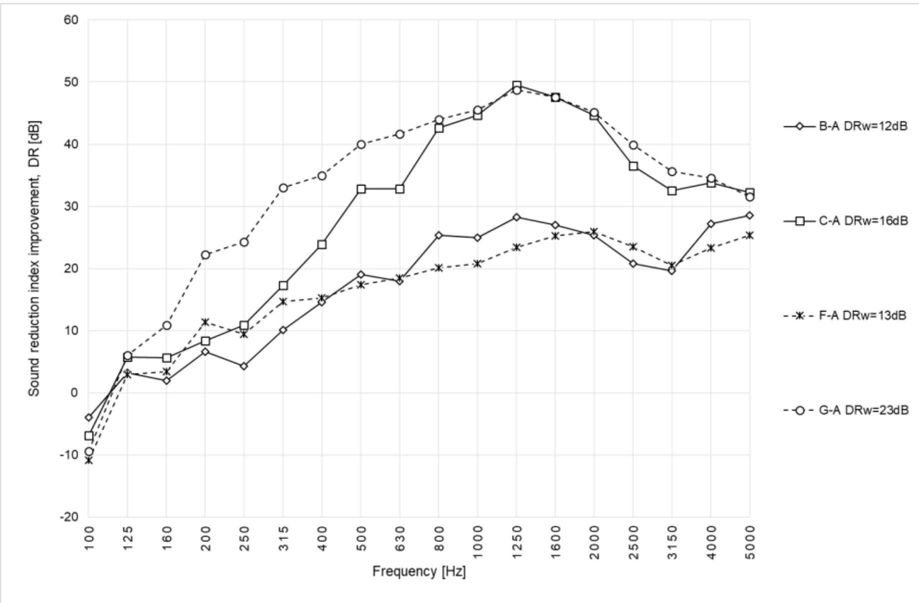

Figure 5: One side or two side linings comparison

3 FLANKING TRANSMISSION: ISO 10848 MEASUREMENTS IN CLT MOCK UP

The study for the evaluation of flanking transmissions was carried out in accordance with ISO 10848 on a large scale mock-up. The work done focused mainly on three aspects:

- The evaluation of the Kij vibration reduction indices
- The analysis of reverberation time
- The evaluation of the energy transmission

The set of measurements was repeated both on the joints of the bare structure and on the isolated structure through the insertion of an anti-vibration rubber layer. The tested vertical joints concern the L, T and X configurations, while only one horizontal joint has been tested.

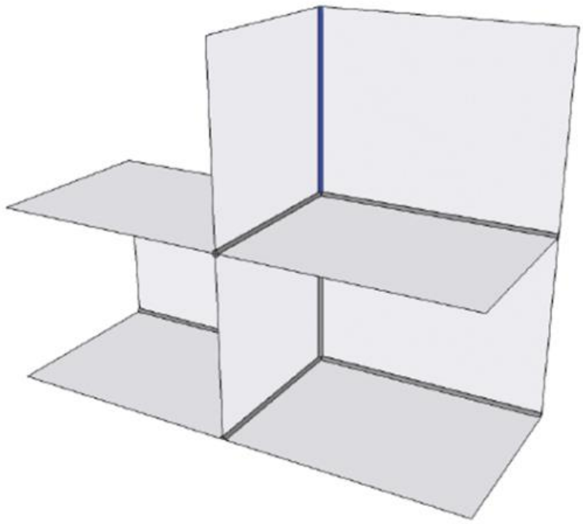

Figure 6: Large test mock-up scheme

The results of the study have already been reported in the article presented at INTER-NOISE 2019 (Di Bella at al., 2018). In Figure 7 and 8, the graphs of the L and vertical junctions are shown, where the effectiveness of the anti-vibration system it is becoming apparent. .

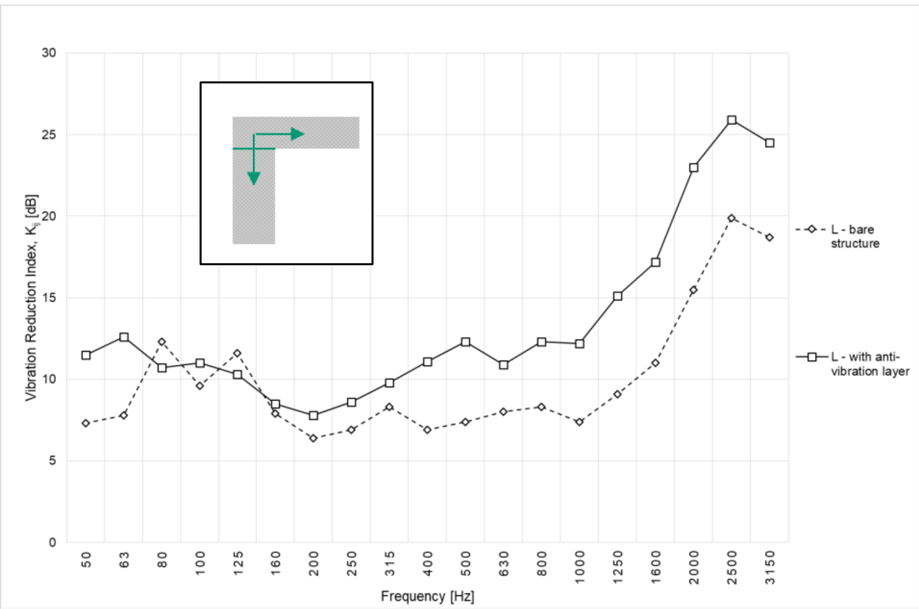

Figure 7: Vibration reduction index Kij - L Junction

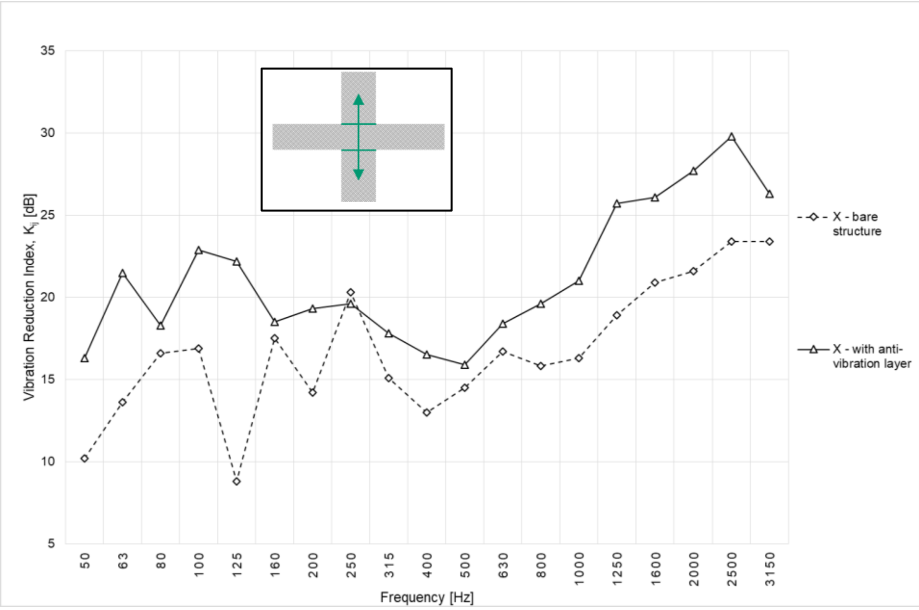

Figure 8: Vibration reduction index Kij - X Junction

The main aspects that emerged concern first of all the importance of the choice of material and its correct dimensioning according to the specific load. In fact, the choice of anti-vibrating material is evidently influenced by the structure of the building and its number of floors. Moreover, the effectiveness of this solution goes hand in hand with the need of attention to the assembly phases.

4 CONCLUSIONS

In this paper is presented the studies progress on the CLT structure carried out by Isolgomma, completing the research started initially on the floors. Similarly, the analysis showed that it is possible to achieve significant improvements in the weighted sound reduction index of the walls, through the use of high-performance materials. However, also due to the reduced surface mass, the behaviour at low frequencies can be very incident on the overall acoustic performance, as it is shaped by the Rw + Ctr values. The study on CLT joints has instead highlighted the importance of inserting an anti-vibration layer in the reduction of flanking transmissions. However, the effectiveness of this solution goes hand in hand with the need to pay attention to the assembly phases that are superior to those of traditional structures.

Through these investigations, studies on structural or partial elements were completed, outlining how the next step can only be a flanking transmission assessment, on a complete test in a building sample, and the acoustic insulation measurements of a finished structure under controlled conditions.

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