TESTING OF NOISE & VIBRATION ISOLATED FLOOR-CEILING SETUPS FOR CROSS-LAMINATED TIMBER (CLT) CONSTRUCTIONS

Marina Rodrigues CDM Stravitec
Sarah Huskie CDM Stravitec

1 INTRODUCTION

The requirement to decarbonize the construction industry has led to increased demand for timber construction, which can sequester more carbon than is emitted during its construction. However, timber's lightweight nature and relative lack of stiffness compared to traditional isotropic materials like concrete and steel present complex acoustic challenges in construction.
CDM Stravitec has developed and tested panelized floating floor solutions to reduce direct sound transmission. These solutions were showcased at a previous conference, focusing on asymmetric floor-ceiling assemblies. This approach aligns with the desire in mass timber construction to leave the building's structure exposed as a finish.
However, in some countries and projects, regulations or preferences may prevent the exposure of wood ceilings. In these cases, suspended ceilings, while less visually appealing than exposed timber structures, can offer several acoustic design benefits. They can effectively control airborne and impact sound insulation and address sound flanking issues through partitions, building services, structural penetrations, or elements. Additionally, suspended ceilings can help manage sound reverberation and noise from building services suspended from the soffits.
In light of these considerations, CDM Stravitec has continued its research into airborne sound reduction and impact noise isolation, focusing on symmetric floor-ceiling configurations. This paper presents the detailed measurements and key findings from this research.

2 TEST METHODOLOGY

2.1 Impact Sound Insulation of Floors

Tests were carried out according to NBN EN ISO 10140 Acoustics – Measurement of sound insulation in buildings and of building elements [Part 1 (2021): Application rules for specific products (ISO 10140-1:2021); Part 3 (2021): Measurement of impact sound insulation (ISO 10140-3:2021) and Part 5 (2021): Requirements for test facilities and equipment (ISO 10140-5:2021)] and NBN EN ISO 717-2:2021 Acoustics - Rating of sound insulation in buildings and of building elements [Part 2: Impact sound insulation (ISO 717-2:2020)].
Measurements were taken from 50 Hz to 5000 Hz and 100 to 3150 Hz was the frequency range for a rating in accordance with EN ISO 717-2. Tests were carried out on the bare 5-layer cross-laminated timber (CLT) slab, 140 mm (5-1/2”) thick, over a surface of 260 cm x 442 cm (8-1/2 ft x 5 ft 4”), with 210 mm (8-1/4’’) high elevated borders that simulate the surrounding walls of an actual floor slab. The test element was mounted according to the NBN EN ISO 10140-3 standard, similar to the actual construction, and tests were carried out on each system described in this paper.

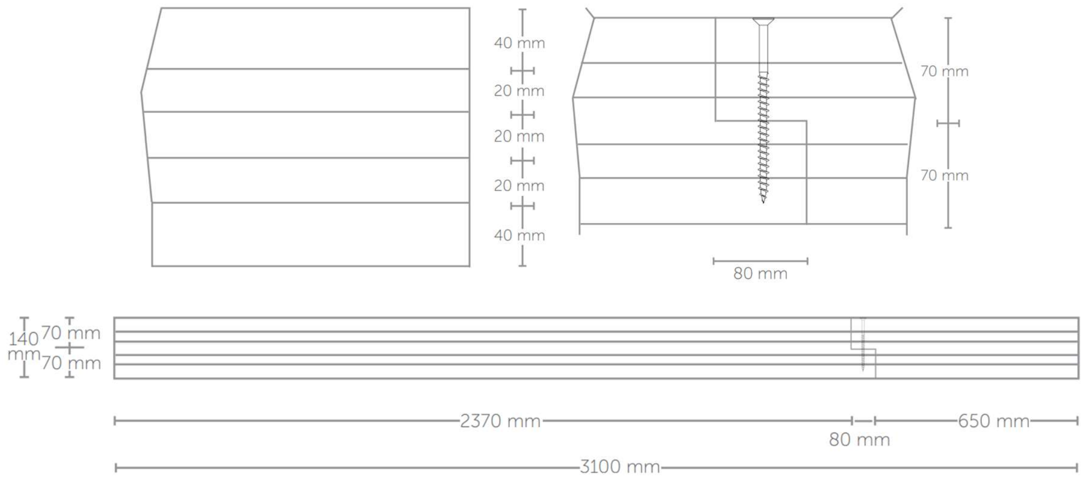

Figure 1 - Layer structure of CLT 140 L5s and joint/screw detail and section of the slab.

2.2 Airborne Sound Insulation of Floors

Tests were carried out according to NBN EN ISO 10140:2021 Acoustics - Measurement of sound insulation in buildings and of building elements [Part 1: Application rules for specific products - Annex G: Acoustical linings - Improvement of airborne sound insulation (ISO 10140-1:2021); Part 2: Measurement of airborne sound insulation (ISO 10140-2:2021)] and NBN EN ISO 717-1:2021 Acoustics - Rating of sound insulation in buildings and of building elements [Part 1: Airborne sound insulation (ISO 717-1:2020)].
Measurements were taken from 50 to 5000 Hz, and the frequency range for a rating in accordance with EN ISO 717-1 was 100 to 3150 Hz.
The tests were carried out on a 5 layers cross-laminated timber (CLT) slab, 140 mm (5-1/2'') thick, over a surface of 260 cm x 442 cm (8-1/2 ft x 5 ft 4"), with 210 mm (8-1/4'') high elevated borders that simulate the surrounding walls of an actual floor slab.
The test element was mounted according to the NBN EN ISO 10140-3 standard, in a similar manner to the actual construction, and tests were carried out on each system described in the results section.

3 RESULTS

Table 1 describes the different tested setups and an overview of the global ratings for all setups. The presence of a dropped ceiling is shown together with the elastic supports and board materials of the tested assembly.

Table 1: Section of tested setups and results overview (global ratings).

Setup	Dropped Ceiling	Elastic Support	Floating floor	Build-up Height[(2)]	Dry Screed Load [kg/m²]	$L_{n,w}$ (C_i) [dB]	ΔL_w (C_i ,Δ) [dB]	R_w (C;C_{tr}) [dB]
BS	n.a.	n.a.	n.a.	n.a.	n.a.	88 (-5)	n.a.	38 (-1;-3)
Q	Yes[(1)]	n.a.	n.a.	-	n.a.	56 (-2)	31 (-5)	67 (-52;-7)
R	Yes[(1)]	Stravifloor Mat-W8a	OSB/3 15 mm + Fermacell® Powerboard H20 12.5mm + OSB/3 15 mm	42.5 mm	32	43 (2)	44 (3)	74 (-4;-11)
S	Yes[(1)]	Stravifloor Mat-W8a	OSB/3 15 mm + OSB/3 15 mm	30 mm	22	46 (1)	42 (3)	71 (-3;-10)

[(1)] 2 layers 18 mm (11/16”) gypsum hung on metal grid with Stravilink CC60-150 clips [on grid of 600 mm x 800 mm (24” x 31-1/2’’)] 100 mm (4’’) below CLT.
Cavity filled with 50 mm (2’’) mineral wool.
[(2)] Not including bare slab or dropped ceiling.

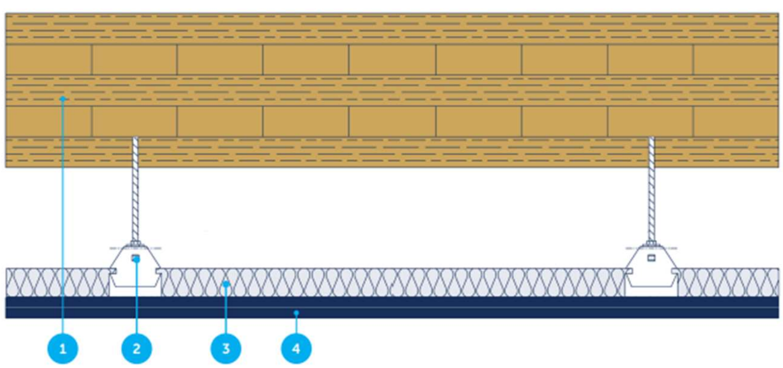

Figure 2 – Setup Q [1 – CLT 140L5S (CLT 5-ply) – 5-1/2"; 2 – Stravilink CC-150 clips; 3 – 50mm (2’’) mineral wool; 4 – 18 mm (11/16") gypsum hung on metal grid with (2 boards)].

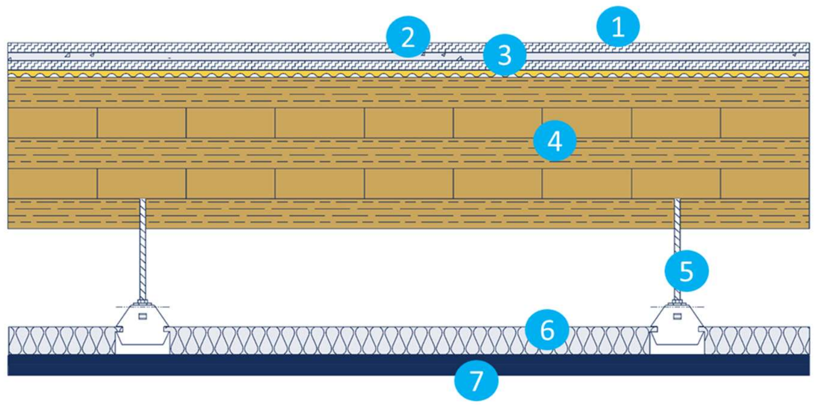

Figure 3 – Setup R [1 – OSB/3, 15 mm (9/16"); 2 – Fermacell® Powerboard H20 12 mm (1/2"); 1 – OSB/3, 15 mm (9/16"); 3 – Stravifloor Mat-W8$_a$ 8 mm (5/16“); 4 - CLT 140L5S (CLT 5-ply) – 5-1/2“; 5 – Stravilink CC-150 clips; 6 – 50mm (2") mineral wool ; 7 – 18 mm (11/16") gypsum hung on a metal grid (2 boards)].

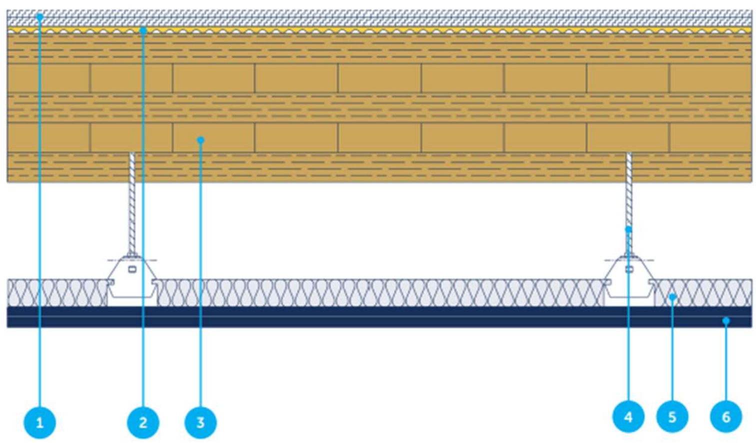

Figure 3 – Setup S [1 – OSB/3, 15 mm (9/16"); 2 – Stravifloor Mat-W8$_a$ 8 mm (5/16“); 3 – CLT 140L5S (CLT 5-ply) – 5-1/2“; 4 – Stravilink CC-150 clips; 5 – 50mm (2") mineral wool; 6 – 18 mm (11/16") gypsum hung on a metal grid (2 boards)].

4 CONCLUSIONS

Note on the influence of CLT bare slab thickness on performance:

When comparing bare slab setups from both campaigns [140 mm (5-1/2’’) vs 180 mm (7-1/16”) CLT slabs], the results are similar for impact sound insulation except under 200 Hz where 180 mm (7-1/16’’) bare slab brings up to 5 dB better performance. It should be noted that the performance decrease under 200 Hz has an impact on results comparing setups of both studies. Regarding airborne sound insulation, the 180 mm (7-1/16”) CLT slabs show more variance in positive and negative differences (up to 6 dB).

Influence of acoustical suspended ceiling on sound insulation performance (Bare CLT slab vs Setup Q):
As a result of the installation of an acoustical suspended ceiling, there is a significant improvement of up to 42 dB in airborne and impact sound insulation per octave band. The improvements are particularly better in medium and higher frequencies.
As mentioned in our previous technical bulletin, ceilings might not always be visually appealing, especially when you can expose a timber structure instead, but they have several acoustic design functions that can lead to important cost savings, such as controlling airborne and impact sound insulation, sound flanking (above partitions, via building services and structural penetrations or structural elements), sound reverberation, and noise of building services hung from the soffits.
Even if we can achieve good performances by only adding a treatment below the slab, it is always better to consider the acoustic design with a treatment on both sides of the slab.

Influence of floating floor on sound insulation performance (Setup Q vs Setup R):

Installing a floating floor is, as expected, a good improvement for both airborne and impact sound insulation, compared to the setup with an acoustical suspended ceiling only: up to 7 dB for the airborne sound insulation and up to 13 dB for the impact sound insulation, on all frequencies but more specifically below 80 Hz and above 125 Hz.

Influence of surface mass of board layers (Setup R vs Setup S):

As for the first campaign, the implementation of Fermacell® Powerboard H20, 12.5 mm (1/2”) thick and with a surface density of 13.5 kg/m² (2.77 lbs/sq ft), leads to an enhancement in both airborne and impact sound insulation by approximately 3 dB for both.

Influence of suspended ceiling type (Setup S vs Setup C from first campaign):

The acoustical suspended ceiling differs from the nonacoustical ceiling on three main features:
- Use of resilient hangers rather than stiff ones;
- Implementation of insulation material in the void;
- Use of thicker gypsum layers [18 mm instead of 12.5 mm (11/16” instead of 1/2")].

The results show a performance increase of 8 dB between the setup with acoustical and non-acoustical suspended ceiling for both Ln,w and Rw. That shows the benefits of designing a solution that treats both sides of the CLT slab correctly. However, it is important to mention there is another difference between setups from both test campaigns. The OSB layers on the top treatment are 18 mm (11/16”) for the first campaign and 15 mm (9/16”) for the current one. Higher differences between both test campaigns are mainly from 100 Hz to 2000 Hz. Also, the performance decrease below 80 Hz compared with the bare slab in the first campaign is almost eliminated when using an acoustical suspended ceiling. There is still a small decrease at 50 Hz, but this is related to the slab thickness difference, as explained in the bare slab performance comparison.

5 REFERENCES

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