ACOUSTIC PERFORMANCE OF TIMBER AND TIMBER-CONCRETE COMPOSITE FLOORS

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ABSTRACT: A major problem in light-weight timber floors is their insufficient performance coping with impact noise in low frequencies. There are no prefabricated solutions available in Australia and New Zealand. To rectify this and enable the implementation of light-weight timber floors, a structural floor was designed and built in laminated veneer lumber (LVL). The floor was evaluated in a laboratory setting based on its behaviour and then modified with suspended ceilings and different floor toppings. Twenty-nine different floor compositions were tested. The bare floor could not reach the minimum requirement set by the Building Code of Australia (BCA) but with additional layers, a sufficient result of $R_w' + C_{tr} \geq 53$ dB and $L_{nT,w} + C_I \leq 50$ dB was reached. Doubling of the concrete mass added a marginal improvement. With concrete toppings and suspended ceiling it is possible to reach the goal in airborne and impact sound insulation. The best result was achieved by combining of additional mass and different construction layers.

KEYWORDS: Acoustics, acoustic insulation, light weight floor, timber floor, timber-concrete composite

1 INTRODUCTION

Multi-storey timber buildings are a sustainable alternative to the dominating concrete structures. Timber is a different material to concrete, therefore there are specific ways to manipulate and use it. There are, however, challenges which have to be overcome to use timber as a competing solution. Timber floors do not provide sufficient insulation for impact sound in low frequencies. This acoustic behaviour and lack of knowledge about structural timber constructions are reasons why there is no noteworthy market for multi-storey timber buildings, especially in Australia. There are no prefabricated solutions available, in Australia and New Zealand, which provide a sufficient insulation of sound. The industrial fabricated construction timber is available but no acoustic insulation solutions. The Structural Timber Innovation Company (STIC), a research consortium based in Australia and New Zealand, is working towards solutions using local materials. STIC designed a floor in laminated veneer lumber (LVL). This extended abstract outlines the results of the acoustic testing of the LVL floor carried out at the University of Technology Sydney (UTS). Acoustic tests were undertaken to receive airborne and impact sound test results, in accordance with BS EN ISO 10140 and BS EN ISO 717-1 and 717-2.

2 THE AIM OF THE PROJECT

The aim for this project was to build a structural floor in acoustic compliance with level two and three buildings in the Building Code of Australia (BCA). The requirement is a weighted sound reduction index $R_w' + C_a$ adaption term of $\geq 50$ dB and a weighted standardized impact sound pressure level $L'n_{T,w} + C_I$ adaption term of $\leq 62$ dB.

3 TESTING FACILITY

An acoustic enclosure was built in the laboratories at the University of Technology Sydney (UTS). The enclosure was designed and constructed, to ensure it is suitable for testing timber panels. It conforms to the standards related
to the laboratory measurement of airborne and impact sound insulation.

4 FLOOR DESIGN

The floor was constructed in three different ways. Initially the bare timber floor was tested. Secondly a suspended ceiling was added. Finally the timber floor with a concrete topping and a suspended ceiling was examined. All compositions were in addition tested with an impact insulation rubber mat and ceramic or laminate floor finishing. The LVL floor contained seven LVL modules (Figure 1) with a total dimension of 4.2 m by 3.15 m or 13.25 m².

Figure 1: Section of a LVL module

4.1 SUSPENDED CEILING

Clips with rubber insulation were used to fix the suspend ceiling to the LVL floor (Figure 2). A cavity of 100 mm between the floor and the plasterboard was filled with 50 mm insulation wool. All the floor compositions were tested with either one or two layers of 13 mm fire-rated plasterboard (Figure 3).

Figure 2: Genie clip

Figure 3: Suspended ceiling

4.2 CONCRETE TOPPING

A concrete topping with non-structural purpose was poured on top of the LVL floor to add mass. Due to building and logistic restrictions concrete flags with the dimension of 520 x 520 x 50 mm were used. The concrete had a density of 2400 kg/m³, which resulted in additional mass of 120 kg/m². To simulate poured concrete; a layer of mortar was poured between LVL floor and the concrete slab. After the tests with 50 mm slabs, another layer of 50 mm concrete was installed.

5 RESULTS

The performance of the bare LVL floor was as expected, poor, but provided the basis for the upcoming modifications. The suspended ceiling resulted in a significant enhancement on both airborne, and impact sound insulation. An improvement of 11 to 19 dB for impact and 8 to 13 dB for airborne sound reduction. The concrete topping also significantly improved the airborne and impact sound insulation but did not reach the goal without a suspended ceiling. It is possible that the best constructions exceeded the limit of the testing facility.

Table 1: Selected results of the acoustic tests

<table>
<thead>
<tr>
<th></th>
<th>$R'<em>{w}+C</em>{tr}$ [dB]</th>
<th>$L'<em>{nT,w}+C</em>{I}$ [dB]</th>
<th>Compl.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare timber floor</td>
<td>31</td>
<td>88</td>
<td>No</td>
</tr>
<tr>
<td>Ceramic tile, rubber mat, suspended ceiling with two layers of plaster board.</td>
<td>46</td>
<td>61</td>
<td>No</td>
</tr>
<tr>
<td>Laminate, rubber mat, 60 mm concrete, susp. ceiling with two layers of plaster board and insulation wool in the cavity.</td>
<td>53</td>
<td>50</td>
<td>Yes</td>
</tr>
<tr>
<td>Laminate, rubber mat, 120 mm of concrete, LVL floor, suspended ceiling with two layers of plaster board and insulation wool in the cavity.</td>
<td>52</td>
<td>50</td>
<td>Yes</td>
</tr>
</tbody>
</table>

5.1 FAVOURITE COMPOSITION

The favourite composition (Figure 4) contains a layer of concrete with a floor finish. This was combined with ceramic tiles or laminate flooring on a rubber mat (Regupol). It included a suspended ceiling with insulation wool in the cavity and two layers of 13 mm fire-rated plasterboard, screwed on wooden battens. The result: $R'_{w}+C_{tr}$ 53 dB and $L'_{nT,w}+C_{I}$ 50 dB

Figure 4: Favourite composition

6 CONCLUSIONS

The bare floor, due to its low mass, is insufficient for multi-storey buildings. The addition of mass to the construction helps to improve the sound insulation. There was only a marginal improvement after doubling the concrete mass. This showed that in addition to the mass it is important to add layers of different materials with different characteristics. This process effectively insulates more frequencies.