Populärvetenskaplig sammanfattning av examensarbete i byggnadsmekanik, LTH, Lunds universitet.

Utilization of Different Wood Materials in Cross-laminated Timber Elements – A Study of Different Configurations

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The need of sustainable development and urban densification has incentivised construction of buildings in timber. An essential structural element therein is the engineered wood product cross-laminated timber (CLT), made of spruce, suitable for floor panels as well as wall panels. However, CLT panels are susceptible to human-induced vibrations, spoiling the comfort level. If the vibration performance of CLT panels can be improved, then the competitiveness of building with timber could rival that of conventional materials. One way to achieve this is by utilizing birch, densified spruce and spruce with varying strength grades, in specific lamellae arrangements in the CLT panels.

The aim of the study was to mitigate the vibration levels in CLT panels of spruce, by utilizing lamellae of either birch, densified spruce or higher strength grade spruce. The study was conducted by computer-based simulations of CLT panels. It was found that replacing the lamellae along the edges of the central layers of the CLT plate, see Figure 1, markedly improved its vibration performance.

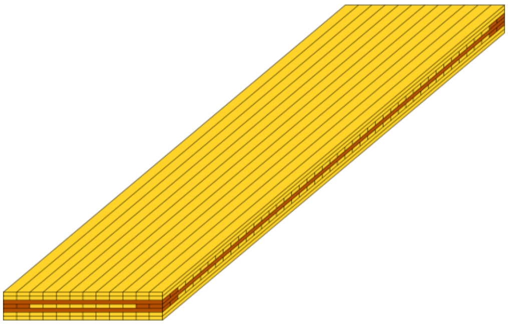

Figure 1. Model of CLT panel with the lamellae along the edges of the central layers replaced with birch (ID15-1).

Replacing 25% of a 9-meter-span CLT panel with birch or densified spruce lamellae in the perimeter could result in a reduction of up to 50% in vibration levels. With a 5-meter-span CLT panel, reductions of up to 40% could be achieved. Replacing the lamellae with higher strength grade spruce can lead to reductions in vibration levels of around 20% for panels spanning 5 and 9 meters.

Thus, strategically replacing the spruce within the CLT panel can significantly improve its vibrational performance. This improvement would render CLT plates more appealing for building projects that necessitate lightweight and sustainable materials with low vibrational levels.

To address the aim of the study, a set of research questions were formulated:

- How are the vibration levels of CLT panels affected with different arrangements of lamellae, made from birch, densified spruce, and varying strength grades of spruce?
- What CLT panel configurations have the greatest reduction of the vibration levels?

The study was conducted by simulating CLT panels suspended freely in the space, subjected to a point load in one corner. The acceleration response was evaluated in a single point in the opposite corner. The frequency range studied was 1-562 Hz. In this way, the important system property Frequency Response Function *accelerance,* involving all vertical modes, could be obtained. An example of such a mode is shown in Figure 2.

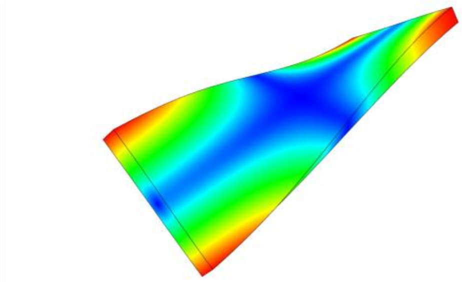

Figure 2. The first torsional mode shape.

Material parameters for spruce, birch and densified spruce were determined by replicating the results of a laboratory experiment, that investigated the behaviour of CLT panels, constructed from these materials. Subsequently, CLT panels with a width of 2.4 meters were modelled, spanning 5 and 9 meters, with thicknesses of 150 and 315 mm, respectively. Various configurations of CLT panels were modelled by replacing the lamellae in the panels following different patterns, in order to obtain favourable configurations that mitigate the vibration level.

The accelerance obtained from the analysed configurations, was compared against a reference case: a CLT panel made of spruce, see Figure 3. This amounted to calculating a single-valued measure of the frequency-dependent accelerance, the root mean square (RMS) and the relative change thereof. The accelerance curves were simplified by partitioning the frequency range into well-defined intervals (third-octave bands), whereby the RMS value was calculated for each band, see Figure 4.

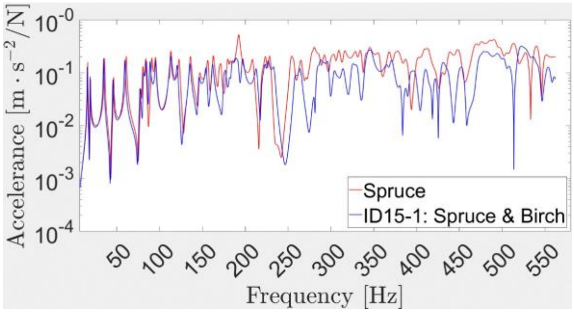

Figure 3. Accelerance of ID15-1 (blue curve) and the reference case (red curve).

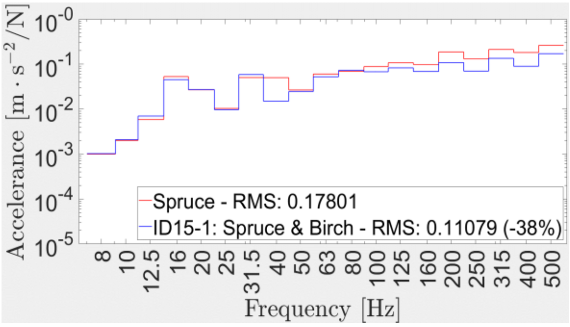

Figure 4. third-octave band plot of the accelerance of ID15-1 (blue curve) and the reference case (red curve). The relative change in the RMS value has been calculated over the entire frequency range.

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