Impact of different lamellae materials on vibrations in cross-laminated timber panels

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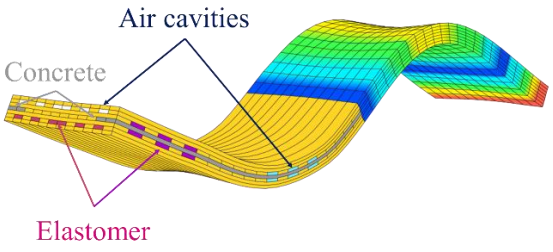
Timber structures are increasingly growing in importance and utilization. A contributing factor to this trend is the introduction of cross-laminated timber (CLT). CLT can be more advantageous in terms of sustainability and climate change compared to concrete. However, CLT is more sensitive to dynamic loading, necessitating the need to improve the dynamic performance of CLT panels. Significant improvement in dynamic performance of CLT panels was shown to be obtained by exchanging lamellae from traditional spruce to concrete or elastomers. Additionally, a potential to remove 20 percent of the spruce lamellae without significantly amplifying the vibration levels was found.

The aim of the project was to improve the dynamic performance of CLT panels. The objective was to investigate the impact of exchanging lamellae with alternative materials other than the conventional spruce on vibration levels. These alternative materials include concrete and two types of elastomer materials. Additionally, the possibility to remove lamellae without significantly amplifying the vibration levels of the panel was evaluated. This objective was achieved by addressing the following questions:

- How does the dynamic behavior of CLT panels change when lamellae of conventional timber are exchanged to other materials?
- Is there a favorable placement of these alternative materials?
- Is there potential to exclude lamellae from CLT panels without significantly amplifying the vibration levels?

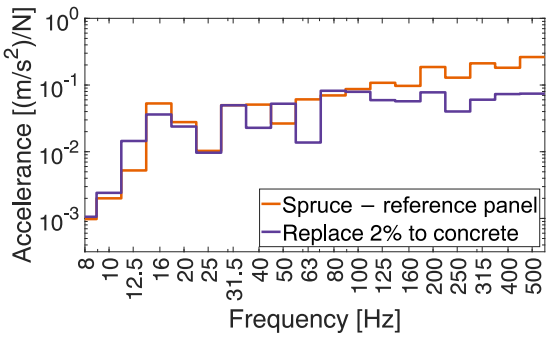


The concept of replacing spruce lamellae with other lamellae materials.

Analyzes Firstly, the mechanical properties of spruce and elastomers were obtained by using computer-based calculations and measurement data from published laboratory tests.

The impacts of different lamella materials on vibration levels were studied by computer-based models of CLT panels using the so-called finite element method. Two different panel sizes and lay-ups were studied regarding the impacts of different lamella materials. Totally, over 300 different panel configurations were analyzed. Most of the analyzes were performed on the larger sized panel, The fewer analyzes conducted on the smaller sized panel was for verifying the results found for the larger panel.

Results Significant reductions in the level of vibration can be achieved by replacing spruce lamellae with concrete, particularly when the concrete lamellae are located close to the outermost parts of the panels. Replacing 2% of the spruce lamellae with concrete indicated approximately 60% reduction in the vibration levels.



The accelerance response in third octave bands, when replacing 2% of spruce to concrete in comparison to the reference panel.

Furthermore, air cavities in CLT panels can be modeled as an empty space because modeling air as an acoustic medium in comparison to as an

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empty space indicated no significant difference in vibration level.

Moreover, a potential was found to remove spruce lamellae in CLT panels giving up to 20% material reduction without significantly amplifying the vibration levels.

Additionally, exchanging spruce lamellae to elastomer demonstrated reductions in vibration level at certain frequency intervals and amplifications in others. However, it indicated the potential to place elastomer lamellae in a way that is favorable for specific frequency intervals. For example, replacing 14% of the spruce lamellae with elastomer showed approximately 50% reduction in the vibration levels.

In conclusion, our work has shown that there are possibilities to significantly improve the dynamic performance of CLT panels.

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