Gap CLT – A study of modelling approaches and material savings

Examensarbetare: Anton Kristensen Lindberg

Cross laminated timber (CLT) is a prefabricated engineered wood product, consisting of various layers of timber lamellas which are stacked and glued upon each other crosswise. A common use for cross laminated timber is to act as a slab in a floor system, offering a more sustainable alternative to a concrete slab in a multistory building. In ongoing research, a modified version of a cross laminated timber slab is being studied. This version removes transverse and/or longitudinal members of the lamellas in order to reduce material usage. However, the influence on the mechanical performance is still relatively unknown. Therefore, the possibilities and the limitations of this "gap clt" needs to be studied further.

Aim and purpose

The purpose of this project is to contribute to a greater understanding of the structural behavior of optimized cross laminated timber (CLT), also known as "Gap CLT", while simultaneously helping the future development of the product, making it more environmentally and economically sustainable by reducing the material usage.

The project also aims to give further knowledge about what methods are the most suitable for the modelling of this "gap CLT". This is done by comparing analytical 1D modeling methods to 2D and 3D fininte element method models.

Problem statements:

- Do the gaps enable material savings?
- Are the current versions of the analytical methods valid for "Gap CLT"?
- What is the best way to represent the gaps for the chosen design case?

Method

The method of completing this project was to compare a design case for the most used 1D modeling methods such as the gamma method, Timoshenko method and the shear analogy method by calculations in the ultimate limit state and the serviceability limit state. To take the gaps into account in design, the relevant stiffness parameters was adjusted to a lower value, representing the lowered stiffness due to material removed in the direction in question.

The results from the analytical models were then compared with results of finite element models created in Abaqus and FEM-design respectively. As for one of the two methods used in FEM-design, a homogenization was performed through the creation and usage of RVE-models in Abaqus, to get a representative stiffness matrix to represent the "Gap CLT".

Result

For an examined design case, it was shown that frequency of the CLT plate was the governing design check. According to the analytical methods, a material savings of 22 % could be achieved when comparing an optimized regular CLT plate and a "Gap CLT" plate. However, the analytical methods could not correctly take gaps into account, as shown by the 3D finite element models in Abaqus and the homogenized FEM-design model, which are assumed to give the most realistic results. The effect of the gaps was underestimated in both serviceability limit state and ultimate limit state as stresses, deflection and frequency differed to varying extent between the methods. Therefore, an optimized configuration in Abaqus was made to explore the true extent of the possible material savings. Abaqus gave that a material savings result of 10 % could be achieved for the examined design case when removing transverse members of the lamella.

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Supervisors: Erik Serrano and Elif Appavuravther. In collaboration with Artelia DK.