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Numerical Analysis of Cross-Laminated Timber Connections with Mechanical Fasteners using a Beam-on-Foundation Model

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Increased popularity of timber as a major construction material, due to its environmentally friendly nature, has led to an increase in the construction of multi-storey Cross-Laminated Timber (CLT) structures [1]. As timber is an anisotropic material, it exhibits different mechanical properties when loaded at different angles to the grain. Therefore, CLT as an engineered wood-based product with layers of wooden boards in two alternating orthogonal orientations, exhibits different mechanical properties in each layer. CLT subjected to tension and bending shows brittle behaviour, while well-designed connections with metal fasteners provide ductility in CLT structures. Increased complexity of CLT structures requires more advanced models for engineering design, and the prediction of the connection's strength and stiffness has a major influence on the load distribution in CLT structures and their global stability. In this study, a numerical model that aims to predict the strength and stiffness of steel-to-CLT connections using a Beam-on-Foundation (BOF) model, is presented. This model is comprised of beam elements, representing the fasteners, with springs that describe the embedment behaviour between the fastener and the surrounding timber. An elasto-plastic material model is used for the fasteners in combination with non-linear springs for the embedment behaviour. The BOF model allows for prediction of the non-linear load-displacement behaviour of these connections and considers the layered structure of CLT. The spring properties and the mechanical properties of the fastener are key inputs to the model. The BOF model provides more information as the European Yield Model (EYM), as it not only predicts the strength but also the stiffness of the connections [2]. Using the BOF model, a parametric study on the; i) influence of fastener diameter, ii) layer thicknesses and orientation, and iii) steel plate thickness on the strength and stiffness of CLT connections with mechanical fasteners is investigated. Results from the parametric study show good agreement with experimental data, illustrating the efficiency of the computationally rather inexpensive BOF model.

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