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Design principles of green structures for northern conditions

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ABSTRACT

Cold climate leads to various challenges in structural engineering related to energy efficiency and hygrothermal performance. Design of low-energy buildings using structural elements with low embodied carbon is a key element of sustainable construction. One of the low embodied energy materials widely used in construction is wood. Engineered wood products such as cross-laminated timber CLT are known to have a relatively low carbon footprint in many scenarios. Mass timber envelopes are popular in boreal as well as other regions where traditional log houses have been constructed for centuries. However, single layer mass timber envelopes face significant challenges to pass building codes concerning energy efficiency especially in cold climate. The energy efficiency of mass timber envelopes can be improved for instance by widening the envelope by additional thermal insulation but special designs are required if the genuine mass timber outlook should remain visible.

Hygrothermal performance of complex building envelopes must be assessed to avoid any moisture problems. The importance of hygrothermal conditions increases if bio-based construction materials sensitive to microbial growth are used. The hygrothermal performance of building components can be assessed by following simplified steady-state or more sophisticated dynamic models described in various design standards.

In this study, we study the numerical simulation of heat and moisture transport in structural assemblies made of mass timber elements as well as of special cold-formed steel elements. We assess the sensitivity of the results with respect to the material properties, boundary and initial conditions and verify the calculations with simplified methods. Conclusions are drawn regarding the structural functionality and environmental sustainability of different panel configurations.

Keywords: sustainable construction, structural engineering, heat and moisture transport, numerical simulation.