Validation of a structural model of a large timber truss with slotted-in steel plates and dowels

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ABSTRACT

Tall timber buildings are becoming more common due to their environmental benefits and low weights. Large engineered wood products such as Glued-Laminated-Timber members or Cross-Laminated-Timber plates are often used. For instance, the largest column of the 18-storey tower Mjøstårnet in Norway, is made of glued spruce lumbers and has a cross sectional area equal to 625 x 1485 mm^2. To assemble the structural elements, slotted-in steel plates and dowels are used. This connection technique has traditionally been used in long-span bridges and roof structures. Moreover, the density and stiffness values of the wood material are fairly well known; they are lower than the corresponding values for steel and concrete. When the height of timber buildings rises in cities around the world, new types of challenges appear for structural designers. One of them is the wind-induced vibrations which appears to be annoying at lower heights for buildings made of timber than for traditional high-rise buildings. Unfortunately, the dynamical properties of large timber structures are not well known in general and the structural damping ratios are the least known properties. The physical process of energy dissipation between timber members and steel parts, such as plates and dowels, has mainly been studied through cyclic tests, representing seismic load histories, but not through vibrational tests. Additionally, new numerical models have so far been validated by data from vibrational tests.

A detailed finite element model of a large glulam truss with slotted-in steel plates and dowels connections has been developed and simulations have been made. In parallel, results from forced vibration tests on single components and on a full-scale truss for an eight-storey residential building have been analyzed. The materials' stiffness values and the properties of the contact between the steel and the timber parts in the models were calibrated. The structural damping caused by the embedment of fasteners and friction of mating surfaces of components in the selected connection types is quantified. The results from this study bring knowledge on the structural dynamic properties of large timber structures with mechanical connections and will facilitate the performance prediction of new tall timber buildings for better comfort at higher levels in environmentally friendly expansions of our cities.

References

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