Numerical analysis to study how out-of-plane imperfections affect the ultimate load bearing capacity of slender long span timber trusses

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Timber trusses are often used as main bearing elements in roof structures which span anywhere between 8 and 15 meters. During the last decades, there has been an increasing interest in pushing the limits for these structures and there are examples of roofs built with single spans well above 20 meters. In Sweden, the width of the cross-section used in timber trusses is typically 45 mm, implying such roofs to be very slender and an obvious risk for out-of-plane instability phenomena to occur. The desire of increased spans for the roof structure in combination with the fact that there have been several roof failures reported over the last decennium [1] calls for special attention into the topic. Several authors have made significant contributions on stability issues previously [2-4], and numerical simulations using 3D structural elements and eccentric element coupling has successively made it possible to include larger models thus avoiding difficulties associated with simplifications and limitations of the structural systems analyzed [5].

In Figure 1(a) a roof structure constructed with timber trusses is shown. Battens, top and bottom chords and tension strips are marked and stabilizing trusses installed in the plane of the top chords are numbered 1-4. The design of such stabilizing trusses may vary in several different ways and one type is shown in Figure 1(b) together with other trusses used for overall stability of the building. In the design of such a roof structure it is necessary to have a balance between the complexity of the calculation and the preciseness of the results. The desire of increasing spans implies that new models with sustained or increased preciseness as compared to those provided in EC5 today should be put forward.

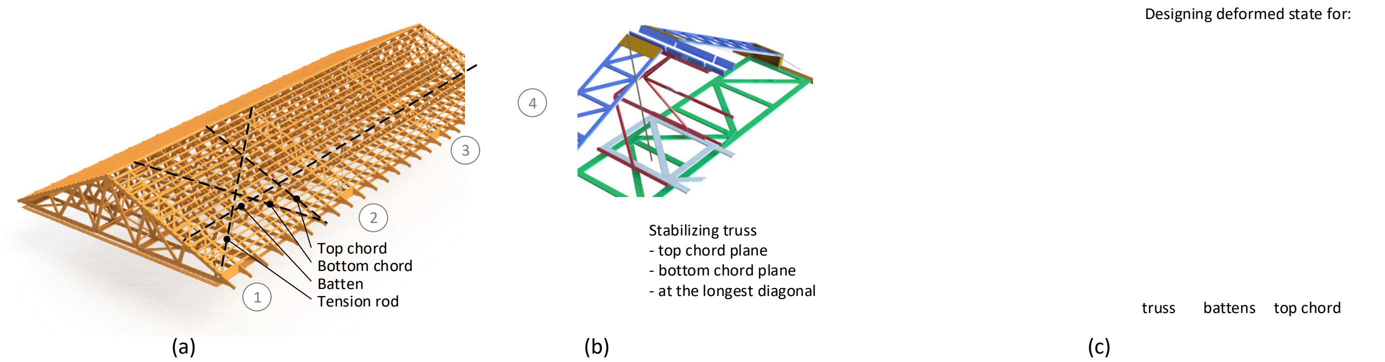

Figure 1: (a) Roof structure with 4 stabilizing trusses and steel strips in the plane of the top chords (b) four stability trusses in the roof system and (c) ultimate failure mode for the truss, the battens and the top chord respectively.

A geometrically non-linear parameterized finite element model is suggested for analysis of the critical loads for the top chords shown in Figure 1(c). The top chord is assumed to be laterally supported by discretely located elastic springs representing the stiffnesses provided by the stabilizing truss via the battens and the involved connections. Relevant imperfection modes are used to define the initial geometry of the structure. A parametric study is performed where the stiffness as well as distances between the lateral support springs are varied and effects of the load bearing capacity studied. Further on a parametric study on the influence of the magnitude of the initial deformation is performed.

References

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