Shape optimization of braced frames for tall timber buildings: influence of semi-rigid connections on design and optimization process

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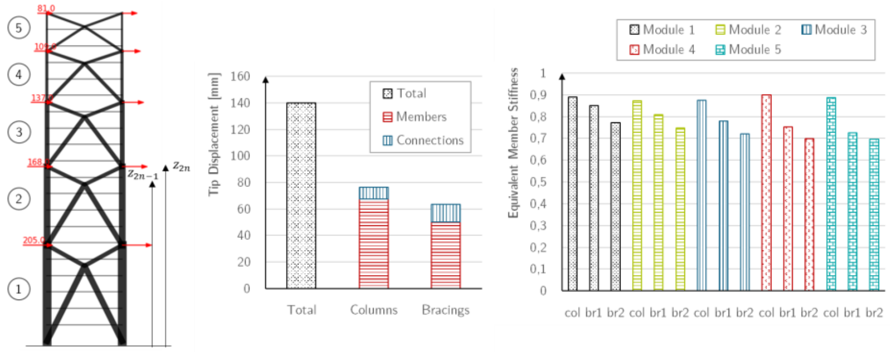
Abstract

With the projected growth of urban population by 2050 and rising concerns over the environmental footprint of the building industry, wood has recently (re)emerged as a sustainable construction material for high-rise structures, leading to a global race towards the world's tallest timber building. This fast development fosters today an extensive review of structural systems and constructive principles suited to the material's specific properties and design process. While steel and concrete has shaped city's landscape for more than a century, timber cannot stand for a pure substitute, but has to find its own structural and architectural expression [1].

While first generation of timber buildings were mainly CLT cellular walled systems, recent design proposal use glulam braced frames acting as one of the lateral load-resisting system of the building: Treet (49 m, Bergen, Norway, 2015), Mjøstårnet (89 m, Brumunddal, Norway 2019), 25 King (47 m, Brisbane, Australia 2018) or Silva (56 m, Bordeaux, France, completion planned in 2022).

In this paper we propose to illustrate one of the specificity of tall timber building design by investigating, through a simple illustrative example, the influence of semi-rigid connections on the overall behavior of a glulam braced frame under wind load and the optimization of its geometry. Joints are generally a critical factor in the design of timber structures, as their strength could dictate the strength of the structure, their stiffness influence global deformations of the structure and member sizes be determined by characteristics of the connector.

Dowel-type connections are first studied in order to obtain a simple relation between joint stiffness and axial load-carrying capacity. Then, the established local behavior law is introduced in the shape optimization process of the discrete 2D braced frame subject to lateral drift constraint, originally studied in [2]. The problem is finally solved by a rigorously derived Optimality Criteria (OC) method [3], and solutions are evaluated and compared with steel type design.



References

[1] Fleming, P., Smith, S., & Ramage, M. (2014). Measuring-up in timber: a critical perspective on mid- and high-rise timber building design. Architectural Research Quarterly, 18(01), 20–30.

[2] Stromberg, L. L., Beghini, A., Baker, W. F., & Paulino, G. H. (2012). Topology optimization for braced frames: Combining continuum and beam/column elements. Engineering Structures, 37, 106–124.

[3] Chan, C.-M., & Grierson, D. E. (1993). An efficient resizing technique for the design of tall steel buildings subject to multiple drift constraints. The Structural Design of Tall Buildings, 2(1), 17–32.