

Experimental characterisation of the behaviour and the rotational stiffness of Hornbeam (*Carpinus betulus* L.) bifurcations for structural applications

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Context

Over the past decade, irregular wood resources, such as curved timber, become the topic of renewed interest in architectural science for structural applications, with the aim of exploiting the entire forest biomass with a sustainable, circular and locally sourced approach. Bifurcations are particularly interesting for structural purposes due to their presumptive natural mechanical capacity and their geometric similarity to bracing systems. The current research mainly focuses on geometric design and digital fabrication methods but lacks addressing engineering or material science issues. There is a lack of methods for justifying the mechanical behaviour of these structures.

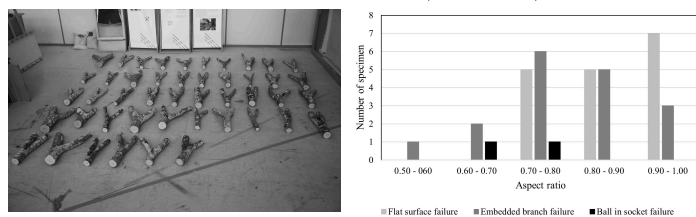
Objective

This research project contributes overcoming the existing research gap in structural engineering design with tree bifurcations by characterising, through destructive and then non-destructive methods, the mechanical properties of tree bifurcations. In this study, we focus on providing architects and engineers data on the bifurcation rotational stiffness and then discussing the often poetically attractive classification of the bifurcations as rigid connections, and preventing inappropriate structural applications.

Materials and methods

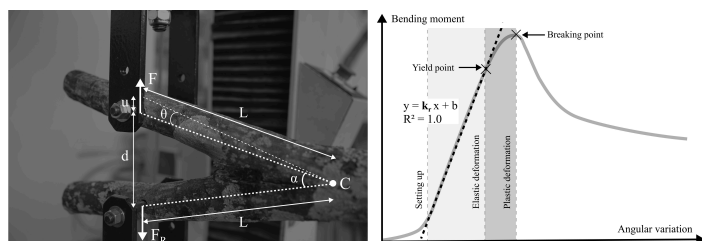
Sample

36 hornbeam (*Carpinus betulus* L.) bifurcations with a majority of codominant stems and small diameter (<150 mm) were tested.

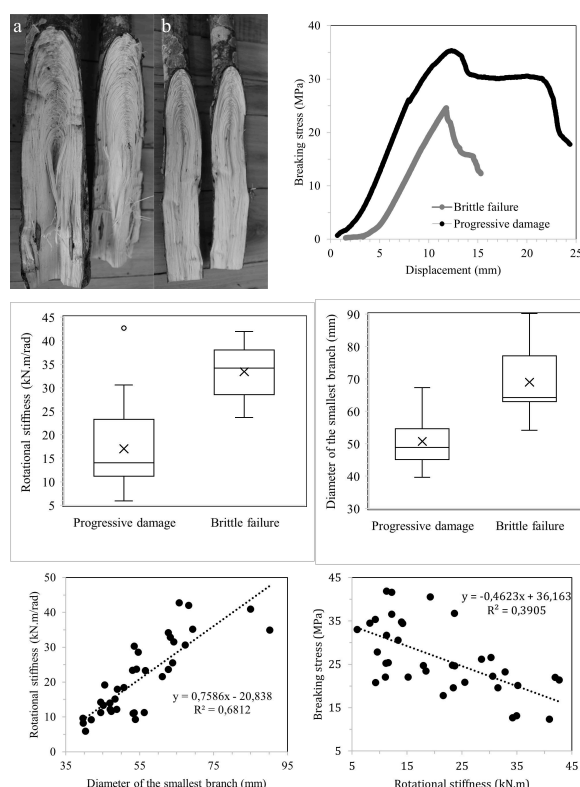


Tensile test

The tensile test protocol is based on the method proposed by Slater and Ennos (2013). The maximum breaking stress was calculated according to this protocol. The rotational stiffness was determined as the slope of the elastic portion of the constitutive relation between the bending moment and the angular variation, using the least square linear regression method.



Results



- The bending moment resistance of tree bifurcations is confirmed.
- Specimens exhibiting the highest measured rotational stiffness values tended to fail in a brittle manner.
- Very low rotational stiffness was measured, which means that bifurcations cannot be classified as rigid connections.

Conclusion

- The use of bifurcations when subjected to bending stress should therefore be avoided unless adequate reinforcement is provided.
- The opportunities for long-term structural applications appear to be restricted to elements subjected to axial stress.
- Experimental work, research on non-destructive analysis methods and modelling are required to integrate bifurcations into the architectural and the engineering design practices.