Timber connections

Fracture and Failure mechanisms

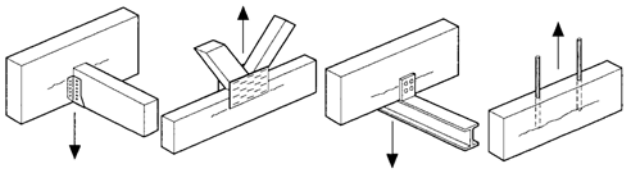
RESEARCH SCHOOL
INTEGRAL DESIGN OF STRUCTURES

Speerpunt BOUW

stw

Subject

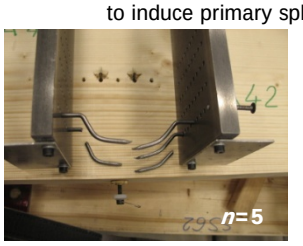
Timber loaded perpendicular to the grain by mechanical connections may fail due to mechanically induced loads. Either the connection itself or the splitting capacity of the timber is governing the ultimate strength.



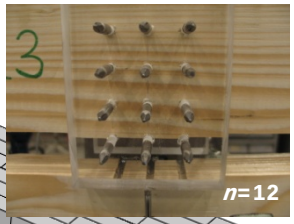
Frequently used timber details which all possess the ability to induce primary splitting cracks

Goal

The primary objective is to gain a better understanding of both failure mechanisms. It is intended to describe and explain these failure mechanisms in a more reliable way by means of mechanical models. These models are validated using FE-simulations and experiments.

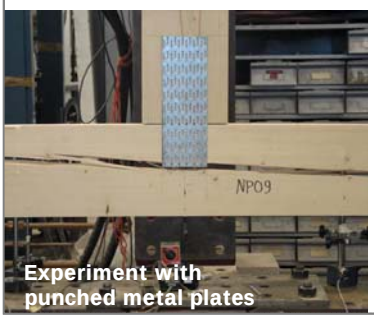


Mechanism dependent upon number of fasteners (n)

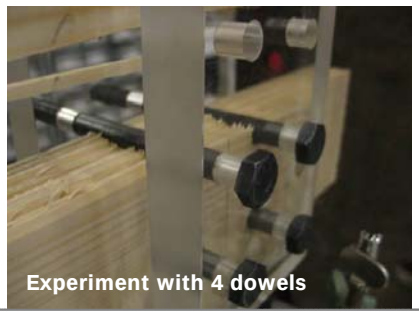


(Expected) Results

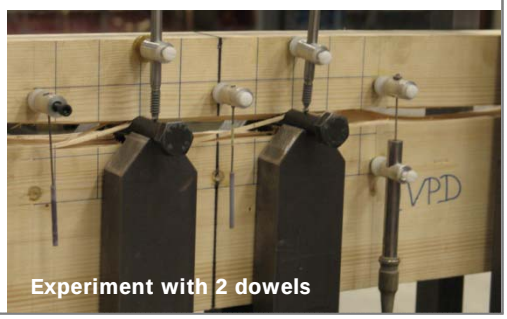
The results of this project will improve the knowledge of the safety margins of the vast majority of structural timber details (mechanical connections) and likely lead to modification of current structural design rules. A better knowledge of the crack capacity and the bearing behaviour could result in a reduction of the timber dimensions, leading to more competitive cost-effective structural timber design.



Experiment with punched metal plates



Experiment with 4 dowels



Experiment with 2 dowels

3TU.

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Timber connections

Fracture and Failure mechanisms

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Subject

Timber connections perpendicular to the grain may fail due to mechanically induced loads. Either the connection itself or the splitting capacity of the timber is governing the ultimate load-bearing capacity, and consequently the failure mechanism. Splitting is a brittle mechanism while connection failure is ductile. Although brittle failure mechanisms cause a safety concern, in the design of timber structures both mechanisms require improved design rules.

Goals

The objective of this research is to gain a better understanding in both failure mechanisms. It is intended to develop more general fracture mechanical models, able to describe and explain the crack phenomenon as well as the bearing failure mechanism in the connection area. From these, improved design rules for code implementation could be developed.

Research Question

Which parameters affect the load-bearing capacity of timber connections perpendicular to the grain, and how can these influences be taken into account in future design codes.

Strategy

The project first addresses the state-of-the-art regarding the research topic. Available models to predict to the load-bearing capacity are analyzed as well as experiments conducted in the past. Based on a qualitative approach on influencing parameters, experiments are designed that aim at their determination. Numerical models have been used to obtain insights in stress distributions and concentrations of stresses which initiate cracks. During this process attempts are made to model the load-bearing behaviour with the use of fracture mechanics and the method of characteristics. These models were validated using results gained from experiments and FE-simulations. After model validation design rules are to be derived which are able to predict and explain the failure behaviour of connections perpendicular to the grain with dowel-type fasteners.

Expected Results

The results of this project will improve the knowledge about the safety margins of the vast majority of structural timber details (mechanical connections) and likely lead to modification of current structural design rules. Today the connection strength can only be given as a lower bound approach, while the splitting strength is mostly underestimated as well, but in certain cases can't be reached in practice. This causes a safety concern. A better knowledge of the crack capacity and the bearing behaviour could result in a reduction of the timber dimensions, leading to more competitive cost-effective structural design. This project mainly focuses on European softwoods although a few hardwood species will be considered to determine the influence of the timber density. In order to generalize the theory to different fastener types an extensive experimental program has been performed.

Preferred Partners Applications / Sponsors

This research is supported by the Dutch Technology Foundation STW, applied science division of NWO and the Technology Program of the Ministry of Economic Affairs.

Prime Publication / Prototyping

- Schoenmakers, D., Jorissen, A. and Leijten, A.: *Failure of load-carrying timber beams caused by connections*. Proceedings of WCTE 2006, Portland, Oregon, United States of America, 2006.
- Leijten, A.J.M. and Schoenmakers, J.C.M.: *Bearing strength perpendicular to the grain of locally loaded timber blocks.* Proceedings of CIB/W18-40-6-1, Bled, Slovenia, 2007.
- Schoenmakers, J.C.M. (Dennis), Jorissen, A.J.M. and Leijten, A.J.M.: *Splitting behaviour of timber loaded perpendicular to the grain by punched metal plates*. Proceedings of WCTE 2008, Miyazaki, Japan, 2008.
- Schoenmakers, J.C.M. (Dennis), Jorissen, A.J.M. and Leijten, A.J.M.: *Duration of load effects on the splitting behaviour of timber loaded perpendicular to the grain by dowel-type connections*. Proceedings of WCTE 2008, Miyazaki, Japan, 2008.

Research Period

May 2006 – April 2010