Mechanical Properties of Diagonal Laminated Timber (DLT) with Respect to Point-Supported Floor Systems

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Introduction

With the increased application of massive timber for the construction of multi-storey buildings, architectural and structural more demanding applications like point-supported floor systems are addressed. The main benefits of this construction are increased clear heights, more flexibility for floor layouts, resource-conscious building due to higher efficiency of the structure by biaxial load transfer and additional architectural value.
Diagonal laminated timber (DLT) represents an application-optimized further development of cross laminated timber (CLT) (Fig.1).

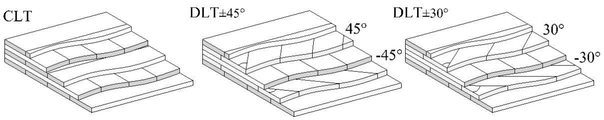

Fig. 1: Exemplary layer arrangement of DLT

By arranging individual layers between the orthogonal layers at angles of *45°/-45°* respectively *30°/-30° (60°/-60°)*, the stiffness properties are adjusted to provide a laminate ideal for plates under biaxial bending (κ_{xy}) (Fig. 2). The challenges when using point-supported floor systems made of massive timber are to handle the concentrated shear stresses at the load introduction points and to increase the torsional stiffness B_{xy} to minimize the deflection w.

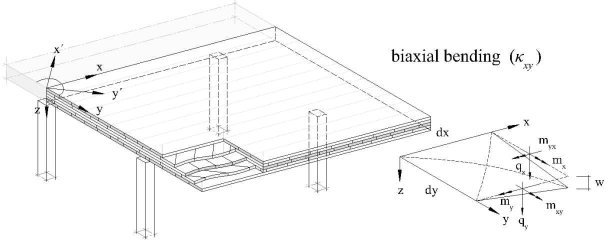

Fig. 2: Biaxial load transfer of DLT elements with point-supports

Theoretical investigations based on the laminate theory as well as mechanical testing substantiate a considerable increase in the out-plane load bearing capacity of diagonal laminated timber compared to conventional cross laminated timber.

Research aims

The aim is to develop and implement a standardized counterpart to CLT, which provides improved mechanical properties especially with respect to biaxial bending. Using the same material properties and layer thickness, the production of DLT can be integrated into the conventional production of CLT without great effort and additional costs.

Method

Using the kinematic assumptions according to 'Kirchhoff' & 'Reissner-Mindlin' plate theory the basic mechanical properties are investigated analytically using the laminate theory for DLT [1], [2].

By experimental investigations, the torsional stiffnesses of DLT elements compared to CLT elements are determined (Fig. 3). Following previous investigations [3], high shear stresses due to point-support cause a rolling shear failure in the transverse layers of CLT. To determine the shear capacity of DLT and to determine the interaction of rolling shear stresses and compression perpendicular to the grain, additional laboratory tests are carried out.

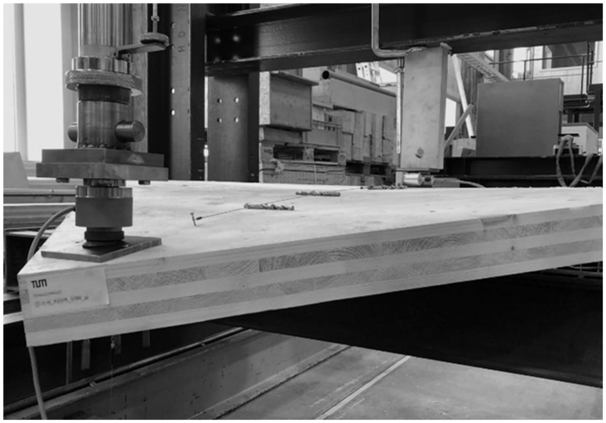

Fig. 3: Biaxial bending test

By means of numerical simulations, a comprehensive parameter study on layer thickness and arrangement is carried out using 3-D FEM volume models. The models extend the stiffness and strength values to a wider range of application.
Future tasks will be to determine the long-term deformation behavior such as the dynamic behavior of DLT floor systems with respect to the serviceability limit state (SLS).

State of research

The advantages of DLT elements loaded in-plane were published in 2011 [4]. The effect of different layer arrangements on the uniaxial bending stiffness of massive timber floor systems was investigated in 2016 [5].

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