Fachhochschule Rosenheim
faculty wood technology
wood building and construction

Diploma thesis
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Practical sizing of cross-laminated-timber panels with concentrated column support

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Abstract

Cross laminated timber can be the wooden answer to concrete. It takes advantage of its high prefabrication, the sustainability, the fast and dry construction method and the good building physical characteristics against other construction methods.
The statical advantage is its ability for two-axial load transfer and concentrated support without any line support. The problem is that there are no general and formal methods of sizing and calculation. The thesis will eliminate this lack.

The diploma thesis deals with the calculation of stresses and deformation of glued multilayered, wooden structures with concentrated column supports subjected to plate loads. The aim is to develop a contribution to calculate punching shear in an easy and simplified way without modeling the column.

For the computation of stresses and deformation different methods are analyzed and compared. First a laminated material is used. In different dissertations the theory of composite structures is transferred to multilayered, wooden structures. Characteristic material values of cross laminated timber take into account the anisotropic properties of wood, the anisotropic structure, and the missing glue connection between the board narrow edges. Material constants for the single layers are settled in agreement with these values. Second two methods of the german *DIN 1052* are used and compared. One is called “starrer Verbund”. This ignores the shear-deformation of cross-layers. Its results are nearly the same as with laminated materials. The other method is “Schubanalogieverfahren”. The laminate is modeled by two linked plates. One is assigned the sum of the second moment of area of all parts of the composite. The other is allocated the synergy of the whole laminate. This means that it takes account of shear-deformation in the cross-layers.

The different methods have different (dis-)advantages. But there is always the same problem of calculating the right value of the shear-forces. To avoid this and to provide a practical way for calculation a simplified method has been developed.

Based on the theory of “starrer Verbund” the relation of the load transfer in the two directions was identified. This was reached by analyzing 36 different plate-models. The plates were supported by 9 columns and were diversified in their spans. So it was possible to determine the shear-forces and their relations for middle, edge and corner columns in dependency to the span relation of different directions.

The result is a simply calculation of punching shear only with the knowledge of the column force. In this way, the thesis provides a contribution for the calculation of multilayered, wooden structures with concentrated column supports.

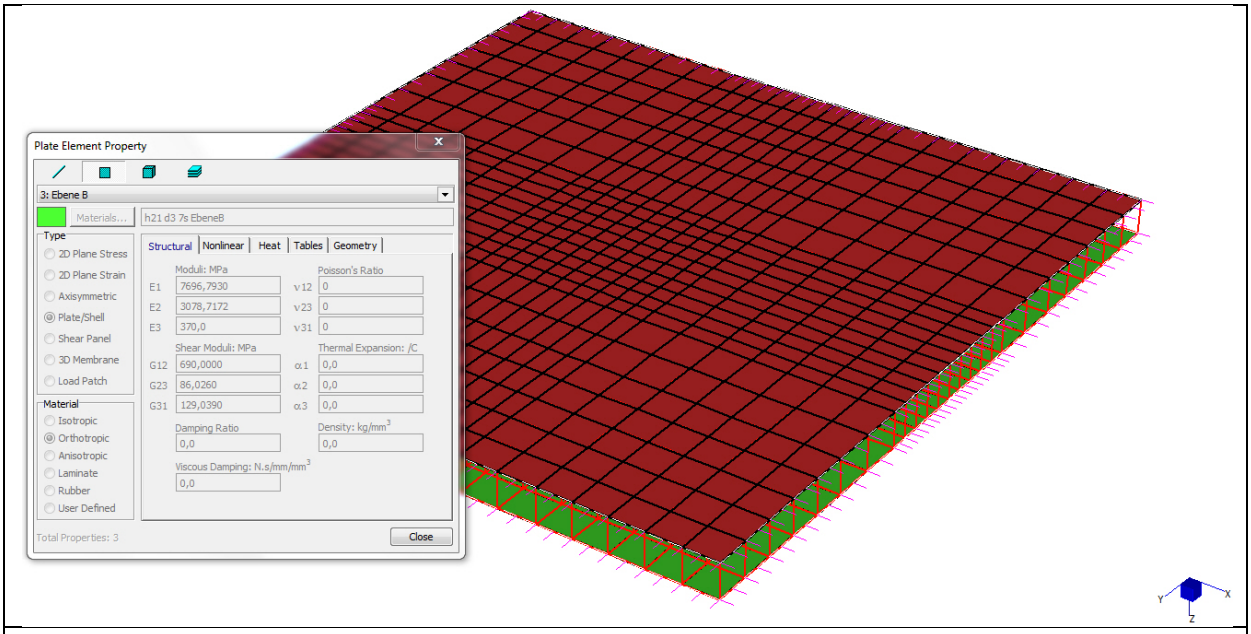

Fig. 1: “Schubanalogieverfahren” - system

Cross-laminated-timber represented by two linked layers. The layers were linked by flexible face attachments. Both plates (orthotropic) have different properties, which represent the stiffness of the sum of the plies (layer A) or the synergy of the whole laminate (layer B). The figure shows a part of an infinite column field. The edges are fixed for rotations but free for translations.

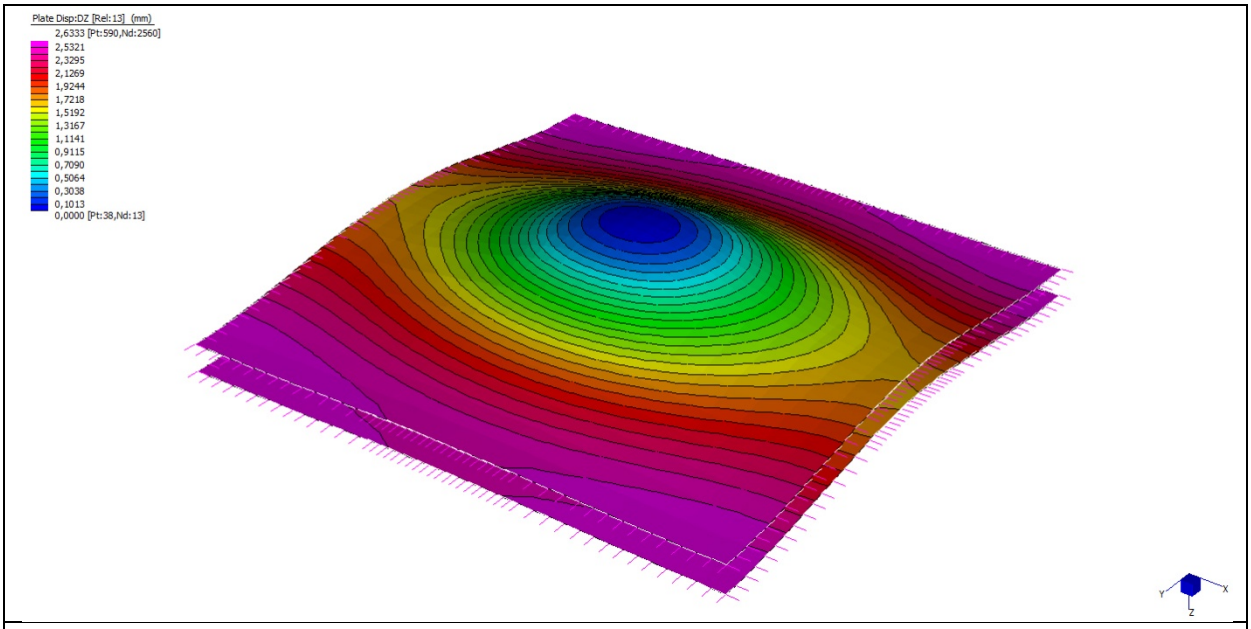

Fig. 2: “Schubanalogieverfahren” – deformation

This method takes account of the shear-deformation of the cross-plies. To identify the stress in each ply the moments and forces have to be determined for each layer and transformed back to the real laminate. It is based on the german *DIN 1052* and *EC5*.

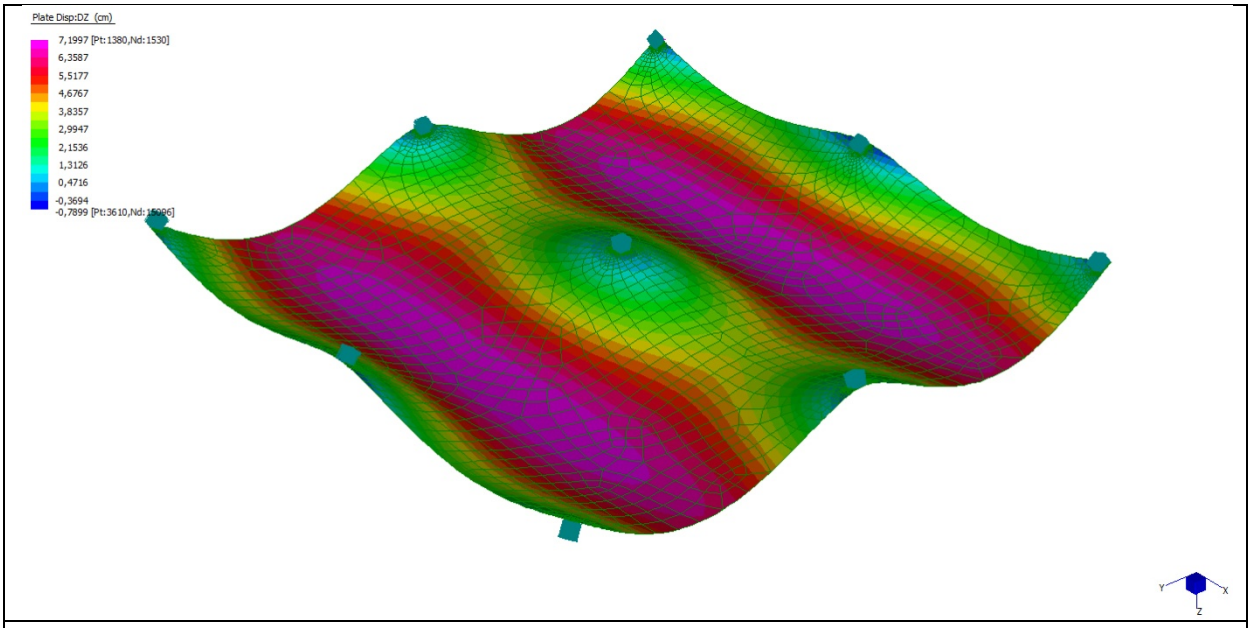

Fig. 3: "starrer Verbund" – *12m x 12m*

To analyze the load transfer, rectangular plates with 9 columns were modeled. Cuts were made at each column, in each direction. The shear-forces were integrated and their ratios analyzed. With the knowledge of the load-transfer-ratios it is possible to calculate the shear-forces only out of the column-force.

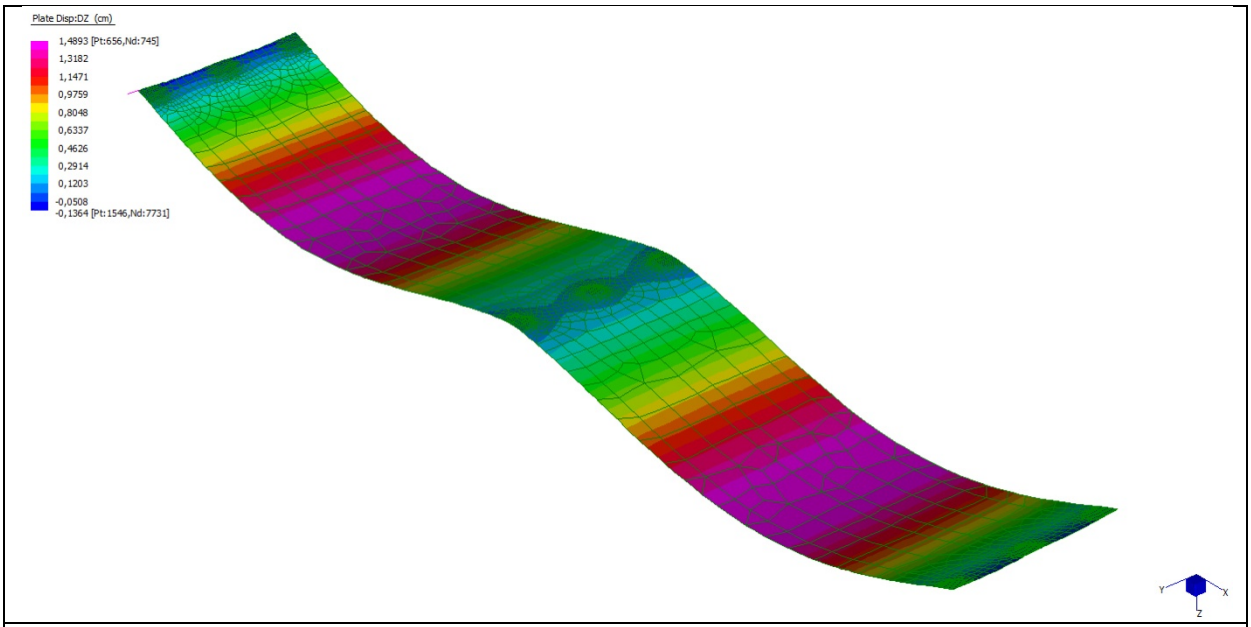

Fig. 4: "starrer Verbund" – *12m x 2m*

To compare the effect of different spans, 36 geometries were analyzed. The elements were automeshed out of iges-files. The nodes at the columns have the same attributes (mesh size, …).

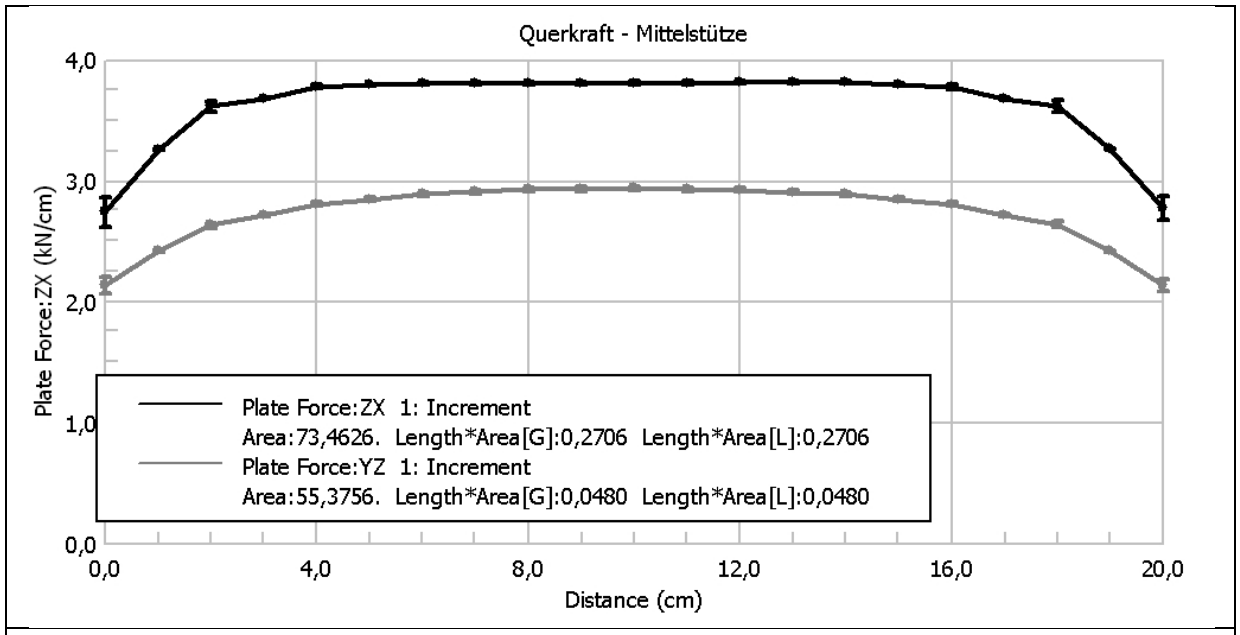

Fig. 5: Cut middle-column “QUAD9”

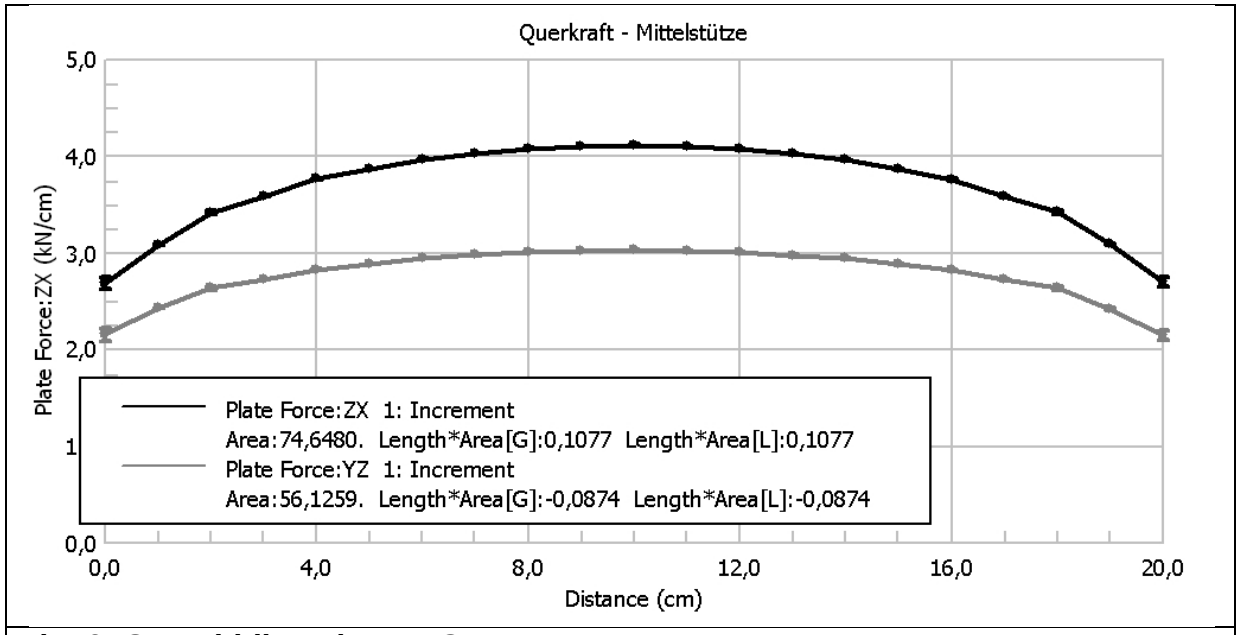

Fig. 6: Cut middle-column “QUAD4”