MECHANICAL BEHAVIOUR OF DOVETAIL CONNECTIONS FOR CROSS LAMINATED TIMBER WALL ELEMENTS

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ABSTRACT: The goal of this study is to determine the shear and tension resistance capacity of a tenon connector made out of beech plywood for the connection of cross laminated timber wall elements. To determine the tensile and shear capacity of the connector according to EN 26 891 [1], tensile and shear tests were performed on cross laminated timber elements with thicknesses of 100 mm, 150mm and 180 mm which were connected with the pin connector. The sample set consisted of 36 test specimens of which were 18 tensile specimens and 18 shear specimens. For each test series, three tensile and three shear tests with the top layer parallel and perpendicular to the load direction were performed. The test specimens were stored for four weeks in normal climate at 20 ° C and 65% relative humidity before they were tested. The shear and tension capacity shows a substantially linear behaviour by increasing the length of the connector. In the tensile tests a transverse tension failure happened in the transverse layer. In the shear tests a plastic failure of the beech plywood connector happened.

KEYWORDS: dovetail connection, cross laminated timber (clt), timber joint, tenon

1 INTRODUCTION

The tenon connector is presented in an actual double dovetail connector. The idea of this connector was created by an Austrian company that wanted to develop a simple, efficient wood connection for cross laminated timber elements (CLT). The goal was to develop a simple plug-in connection installed without special tools, which is intended for use in disaster areas where new houses must be built quickly. The choice fell on a wood to wood connection; a double dovetail connection which represents the tenon. To determine the bearing capacity and the maximum deformation, tensile and shear tests were performed on 3 different type of CLT panels with different lengths of the dovetail connector according to EN 26 891 [1].

2 MATERIALS AND METHODS

2.1 MATERIAL

Two different specimen geometries were used for the tests. 18 CLT-elements of coniferous wood of quality class C18 with the dimensions 200 x 1000 mm² (w x l) were used for the tensile tests and18 CLT-elements with the dimensions 206,1 x 300 mm² (w x l) were used for the shear tests (s. Figure 1, 2 and 3). Three different thicknesses of five layered CLT-elements (h = 100 mm, 150 mm, 180 mm) were used. Among the different element types six specimens in tensile and six specimens in shear have been tested. In three specimens the fiber direction on the top layer was perpendicular to the loading direction (shortcut DQ) and in three test specimens the orientation of the top layer was parallel to the loading direction (shortcut DL).

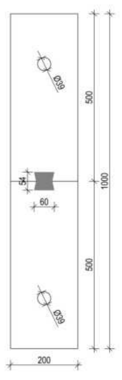

Figure 1: tensile specimen

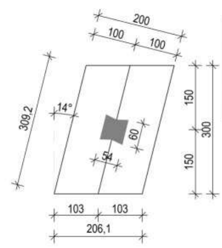

Figure 2: shear specimen

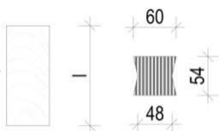

Figure 3: tenon

The tenon connector was produced out of CE-certified beech plywood plate. The connector had a length of 61 mm for the samples with 100 mm thickness, 110 mm for the samples with 150 mm thickness and 142 mm for the samples with180 mm thickness.

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2.2 TESTING SETUP

The test procedure used, were path-controlled at a constant speed in accordance with EN 26891 [1]. For the tensile tests a rate of 0,017 mm/s and for the shear tests a rate of 0,024 mm/s was used. According to the standard, the load is increased up to 40% of the predicted force F_{est}. At this level the holding time is 30 sec, and is afterwards reduced to 10% of F_{est}. After another 30 sec holding time under constant load the testing continuous until fracture or a displacement of 15 mm (Figure 4 and 5)occurs. The failure load was predicted separately for each test series. In total the test should last between 9.5 and 11.5 min. In the tensile tests the load was initiated via a fork and a bolt. In the shear tests, the load was initiated via 2 steel plates on top and bottom ends. The recording was performed by the deformation of the machine path and inductive displacement sensors which were placed next to the connector. After each experiment according to EN 13183 part 1 [2] wood samples were used to determine the wood moisture which was removed from the specimens.

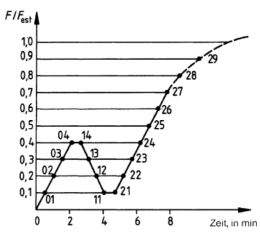

Figure 4: Charging method according to ÖNORM EN 26891

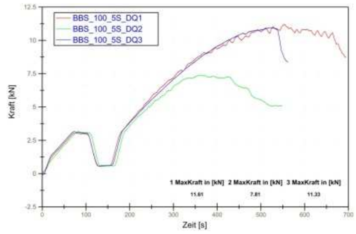

Figure 5: Real load curve of 3 tests

Figure 6: Built tensile test

Figure 7: Built shear test

3 RESULTS AND DISCUSSION

All tests show a linear behavior on the tensile and shear capacity by increasing the length of the dovetail connector. In the tensile tests in all specimens occurred a transverse tensile failure of the transverse layer. In the specimens in which the fiber direction of the top layer was oriented perpendicular to the load direction, the failure occurred in the top layer and in the same oriented middle layer. In the specimens in which the fiber direction of the top layer was oriented parallel to the load direction, the failure occurred in the middle layers. All shear tests show the failure within the plywood connector. In the middle of the connector a transverse compression failure happened witch caused a transverse tensile failure on the edges of the connector. This failure occurred in 50% of the specified breaking load. Since it was a plastic failure and force could be further increased, the experiments were drove up to a deformation of 15mm, which, according to EN 26 183 [1], is specified as the boundary shift. The ultimate strength was recorded at this time. The fractile R_{mk} of failure loads and displacements v at 80% of the failure load were determined. The values can be taken from Tables 1 and 2.

Table 1: Results of the tensile tests

Description	R_{mk} [kN]*	v [mm]
CLT 100 DL	8,27	6,99
CLT 100 DQ	5,01	3,51
CLT 150 DL	17,01	3,72
CLT 150 DQ	12,67**	2,32**
CLT 180 DL	17,94	4,56
CLT 180 DQ	16,55	3,56
*R_{mk} of 3 tests		
** Mean value of 3 tests		

Table 2: Results of the shear tests

Description	R_{mk} [kN]*	V [mm]
CLT 100 DL	29,65	7,5
CLT 100 DQ	16,47	7,9
CLT 150 DL	43,04	6,91
CLT 150 DQ	37,14	7,92
CLT 180 DL	49,93	6,27
CLT 180 DQ	55,18	8,46
*R_{mk} of 3 tests		

4 CONCLUSIONS

As result of the tests performed can be concluded that the shear and tension capacity of the connector show a substantially linear behaviour by increasing the length of the connector. In the tensile tests it was observed that only the layers in which the fiber direction was oriented perpendicularly to the load direction lead to failure. Therefore, it would certainly be advantageous to optimize the geometry of the connector, so that each layer of the cross laminated timer element has an approximately equal stiffness. This optimization could also be transferred to the shear tests.

In the final paper FEM stress simulations will be implemented, which are in accordance to the failure mechanisms.

REFERENCES

[1] EN 26 891: Holzbauwerke – Verbindungen mit mechanischen (ISO 6891:1983), Austrian Standards Institute, Wien

[2] EN 13 183-1: Feuchtegehalt eines Stückes Schnittholz; Teil 1: Bestimmung durch Darrverfahren, 2004; Austrian Standards Institute, Wien