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To the
SCHILCHER Trading & Engineering GmbH
Greenethic building & living systems Lamnitz 8
A-9833 Rangersdorf

Graz, 10th October 2016

EXPERT OPINION

NO. GU16-484-1-02

Definition of the characteristic load-carrying capacities and the slip moduli of the timber-to-timber-connections X-Fix-C and X-Fix-L

Number of order:	GU16-484-1
Client:	SCHILCHER Trading & Engineering GmbH
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1 Task

The company SCHILCHER Trading & Engineering GmbH, Greenethic building & living systems, Lamnitz 8, A-9833 Rangersdorf commissioned the Lignum Test Center (LTC), Institute of Timber Engineering and Wood Technology, Graz University of Technology, Inffeldgasse 24, A-8010 Graz on 31st May 2016, to create an expert's opinion for the timber-to-timber-connectors "X-Fix-C" and "X-Fix L". The expert's opinion includes the definition of the characteristic load-carrying capacities and the slip moduli of both connectors and refers to the research reports [1] and [2] which include the results of executed tension and shear tests of the timber-to-timber-connections X-Fix-C and X-Fix-L.

2 Documents

Following documents are the basis for writing the present expert's opinion:

[1] Silly, G.: Forschungsbericht zur FFG-Machbarkeitsstudie für Klein- und Mittelbetriebe "GREENETHIC X-FIX BSP-Verbindungssystem". holz.bau forschungs gmbh, Graz, June 2014, 91 pages (in german)

[2] Silly, G.: "Greenethic X-Fix-C und X-Fix-L Verbindungssysteme für BSP". Forschungsbericht, holz.bau forschungs gmbh, Graz, April 2016, 48 pages (in german)

[3] ÖNORM EN 1990:2013-03-15. Eurocode – Basis of structural design (consolidated version). Austrian Standards Institute (ASI)/Österreichisches Normungsinstitut, Vienna

[4] ÖNORM EN 1995-1-1:2015-06-15. Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings (consolidated version). Austrian Standards Institute (ASI)/ Österreichisches Normungsinstitut, Vienna

[5] ÖNORM B 1995-1-1:2015-06-15. Eurocode 5: Design of timber structures – Part 1-1: General – Common rules and rules for buildings – national specifications for the implementation of ÖNORM EN 1995-1-1, national comments and national supplements. Austrian Standards Institute (ASI)/ Österreichisches Normungsinstitut, Vienna

3 Findings

3.1 General indications of the connection system

The timber-to-timber-connections X-Fix-C and X-Fix-L are developed as birch or beech veneer plywood connectors for joining the cross laminated timber elements in wall-wall connections or ceiling joints. The X-Fix-C connector is designed as a locally placed, tapered (angle between the edges α = 12,5°) dovetail or x-shaped dowel with the dimensions L/b/h = 130/95/90 mm. The X-Fix-L connector consists of conically cut coupling bars with dimensions of b/h = 80/50 mm and enables a linear connection up to a length of 3,0 m.

3.2 General indications of the test programme [1], [2]

The load-carrying capacities and the slip moduli of the X-Fix-C and X-Fix-L connectors were determined from the tension and the shear tests carried out at the Lignum Test Center, Institute of Timber Engineering and Wood Technology at the Technical University of Graz. The test results can be found in the test reports [1] and [2]. The shear test configuration included tests with a load-to-grain angle of 10° and 0°

The test specimens were assembled with the 5-layered cross laminated timber (CLT) elements comprised of 20 mm thick single layers with a total thickness of 100 mm. Used material was “common” CLT with a characteristic density ρ_k = 380 kg/m³ and a mean density of ρ_{mean} = 450 kg/m. For the connection system X-Fix-L additional tension and shear tests were performed with a 5-layered CLT elements with a total thickness of 120 mm (lay-up: 30/20/20/30 mm) and coupling bars made of beech veneer plywood.

3.3 Definition of characteristic values of the load-carrying capacity and the slip modulus

The characteristic values of the load-carrying capacity and the slip modulus of the X-Fix-C and X-Fix-L connectors were defined based on the results of the tension- and shear tests according to [1] and [2] and the regulations given in the standards ÖNORM EN 1990 [3], ÖNORM EN 1995-1-1 [4] and ÖNORM B 1995-1-1 [5]. Details to the design of the connections can be found in the stated standards.

The suggested load-carrying capacities and slip moduli are valid for:

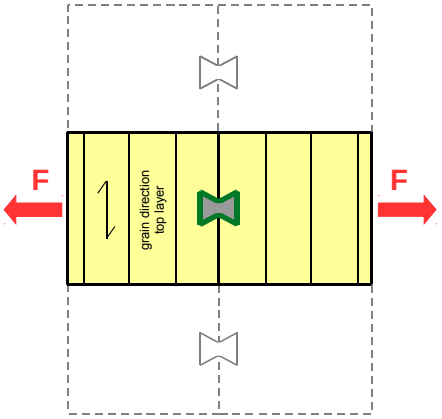
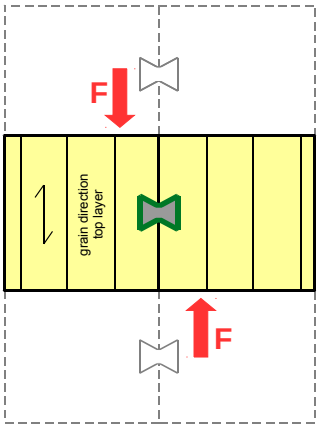
- X-Fix-C and X-Fix-L connectors made of beech or birch veneer plywood
- 5-layered, “common” CLT with a minimum element thickness of t_{CLT} = 100 mm (20/20/20/20/20 mm)
- the investigated orientation of the X-Fix connector perpendicular to the top layer of the CLT element

The given load-carrying capacities and slip moduli can also be applied to CLT elements with a thickness of 120 mm (lay-up: 30-20-20-20-30 mm) and a thickness of 140 mm (lay-up: 40-20-20-20-40).

3.3.1 Connector X-Fix-C

The load-carrying capacities and the slip moduli in Table 1 are related to one X-Fix-C connector.

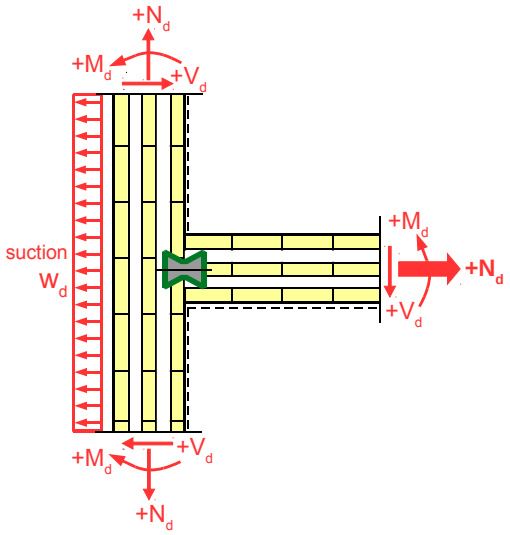
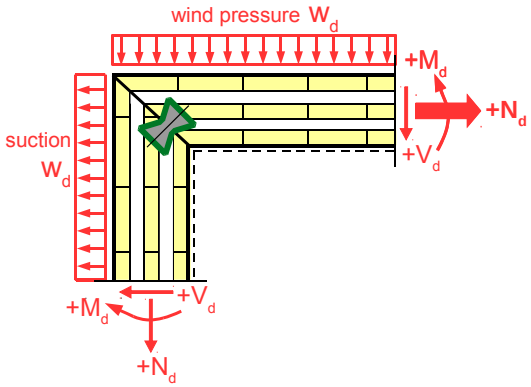
Table 1: load-carrying capacities and slip moduli of one X-Fix-C connector and for t_{CLT} = 100/120/140 mm

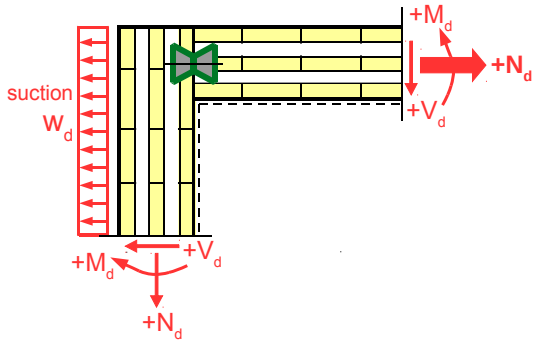
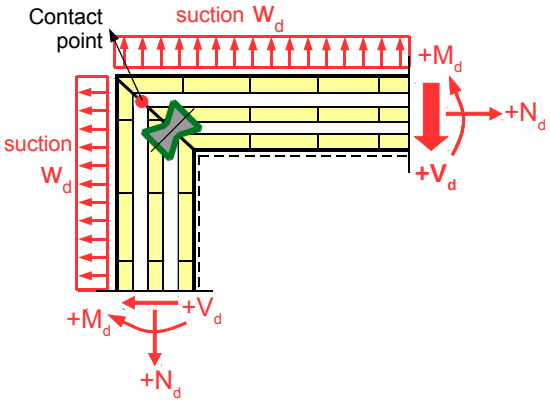
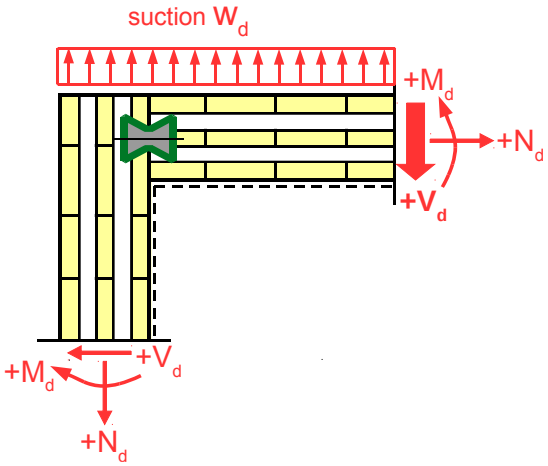
X-Fix-C – declaration per connector t_{CLT} = 100/120/140 mm; material of connector: beech or birch veneer plywood		
loads/application	**load-carrying capacity R_k [kN]**	**slip modulus K_{ser} [kN/mm]**
tension 	22.0	18.0
shear 	22.0	20.0

3.3.2 Connector X-Fix-L

The load-carrying capacities and the slip moduli in Table 2 are related to the unit metre for coupling bar of the X-Fix-L-connector.

Table 2: load-carrying capacities and slip moduli of the X-Fix-L connector per unit meter and for t_{CLT} = 100/120/140 mm

X-Fix-L – declaration per unit meter for coupling bar t_{CLT} = 100/120/140 mm; material of connector: beech or birch veneer plywood		
loads/application	**load-carrying capacity R_k [kN/m]**	**slip modulus K_{ser} [(kN/mm)/m]**
tension-T-joint 	15.0	14.5
tension edge-joint 45° 	14.0	8.3

tension edge-joint 0°		8.5	7.8
shear edge-joint 45°		8.0	6.5
shear edge-joint 0°		5.5	4.9

3.4 Service classes and partial factor for the material property

The connection systems X-Fix-C and X-Fix-L can be applied in the service classes (SC) 1 and 2 according to ÖNORM EN 1995-1-1 [4]. The recommended partial factor for material properties and resistances is γ_M = 1.3 for connections according to ÖNORM EN 1995-1-1 [4].

4 Expert opinion

4.1 Characteristic values of the load-carrying capacity and the slip moduli for connection systems X-Fix-C and X-Fix-L

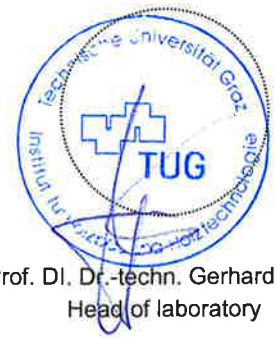
Table 3: characteristic values of the load-carrying capacity and the slip moduli for X-Fix-C and X-Fix-L connectors

basis: 5-s-CLT, t_{CLT} = 100/120/140 mm; SC 1 and 2 and γ_M = 1.3 according to ÖNORM EN 1995-1-1 [4]			
X-Fix-C – per connector			
load	**material of connector**	**load-carrying capacity R_k [kN]**	**slip modulus K_{ser} [kN/mm]**
tension	beech or birch veneer plywood	22.0	18.0
shear		22.0	20.0
X-Fix-L – per unit meter coupling bar			
load	**material of connector**	**load-carrying capacity R_k [kN/m]**	**slip modulus K_{ser} [(kN/mm)/m]**
tension T-joint	beech or birch veneer plywood	15.0	14.5
tension edge-joint 45°		14.0	8.3
tension edge-joint 0°		8.5	7.8
shear edge-joint 45°		8.0	6.5
shear edge-joint 0°		5.5	4.9

4.2 Recommendations for the application

The connection systems X-Fix-C and X-Fix-L shall be produced according to the manufacturer's recommended tolerances. For joint assembly it is important to ensure the exact fit of the X-Fix-connectors into the slots milled in the CLT elements. In addition to the load-carrying capacity, a particular attention should be given to the resulting deformations.

Graz, 10th October 2016



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