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Authorised and notified according  
to Article 29 of the Regulation (EU)  
No 305/2011 of the European  
Parliament and of the Council of 9  
March 2011

MEMBER OF EOTA



## European Technical Assessment ETA-11/0017 of 11/09/2015

### I General Part

**Technical Assessment Body issuing the ETA and designated according to Article 29 of the Regulation (EU) No 305/2011: ETA-Danmark A/S**

**Trade name of the construction product:**

Arras CF angle brackets type 50x50x35x2,5;  
60x60x40x2,5; 60x60x50x2,5; 60x60x60x2,5;  
70x70x55x2,5; 70x70x55x2,5 (with rib);  
80x80x60x2,5; 80x80x80x2,5; 90x90x40x3,0;  
90x90x65x2,5; 90x90x65x2,5 (with rib);  
100x100x80x2,5; 100x100x100x2,5

**Product family to which the above construction product belongs:**

Three-dimensional nailing plate (Angle brackets for timber-to-timber, timber-to-steel or timber-to-concrete connections)

**Manufacturer:**

Arras Construction Furniture OÜ  
Tähetorni 100A  
11625 Tallinn  
Estonia  
Tel. + 372 670 6000  
Fax + 372 670 6405  
Internet [www.arrascf.eu](http://www.arrascf.eu)

**Manufacturing plant:**

Arras Construction Furniture OÜ  
Tähetorni 100A  
11625 Tallinn

**This European Technical Assessment contains:**

20 pages including 2 annexes which form an integral part of the document

**This European Technical Assessment is issued in accordance with Regulation (EU) No 305/2011, on the basis of:**

Guideline for European Technical Approval (ETAG) No. 015 Three Dimensional Nailing Plates, April 2013, used as European Assessment Document (EAD).

**This version replaces:**

The previous ETA with the same number issued on 2011-03-18 and expiry on 2016-02-01

Translations of this European Technical Assessment in other languages shall fully correspond to the original issued document and should be identified as such.

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## II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

### 1 Technical description of product and intended use

#### Technical description of the product

Arras CF angle brackets with and without rib are one-piece non-welded, face-fixed angle brackets to be used in timber to timber connections. They are connected to the timber elements by a range of profiled nails.

The angle brackets are made from pre-galvanized steel DX 51 D / Z 275 according to EN 10327:2004 with  $R_e \geq 295 \text{ N/mm}^2$ ,  $R_m \leq 360 \text{ N/mm}^2$  and  $A_{80} \geq 34\%$  and are available with or without an embossed rib. Dimensions, hole positions and typical installations are shown in Annex A. Arras CF angle brackets are made from steel with tolerances according to EN 10143.

### 2 Specification of the intended use in accordance with the applicable EAD

The angle brackets are intended for use in making connections in load bearing timber structures, as a connection between a beam and a purlin, where requirements for mechanical resistance and stability and safety in use in the sense of the Basic Works Requirements 1 and 4 of Regulation (EU) 305/2011 shall be fulfilled.

The connection may be with a single angle bracket or with an angle bracket on each side of the fastened timber member (see Annex A).

The static and kinematical behaviour of the timber members or the supports shall be as described in Annex B.

The wood members may be of solid timber, glued laminated timber and similar glued members, or wood-based structural members with a characteristic density from  $290 \text{ kg/m}^3$  to  $420 \text{ kg/m}^3$ . This requirement to the material of the wood members can be fulfilled by using the following materials:

- Structural solid timber classified to C14-C40 according to EN 338 / EN 14081,
- Glulam classified to GL24-GL36 according to EN 1194 / EN 14080,
- LVL according to EN 14374,
- Parallam PSL,
- Intrallam LSL,
- Duo- and Triobalken,

- Layered wood plates,
- Plywood according to EN 636

Annex B states the load-carrying capacities of the angle bracket connections for a characteristic density of  $350 \text{ kg/m}^3$ . For timber or wood based material with a lower characteristic density than  $350 \text{ kg/m}^3$  the load-carrying capacities shall be reduced by the  $k_{\text{dens}}$  factor:

$$k_{\text{dens}} = \left( \frac{\rho_k}{350} \right)^2$$

Where  $\rho_k$  is the characteristic density of the timber in  $\text{kg/m}^3$ .

The design of the connections shall be in accordance with Eurocode 5 or a similar national Timber Code. The wood members shall have a thickness which is larger than the penetration depth of the nails into the members.

The angle brackets are primarily for use in timber structures subject to the dry, internal conditions defined by service classes 1 and 2 of Eurocode 5 and for connections subject to static or quasi-static loading.

The angle brackets can also be used in outdoor timber structures, service class 3, when a corrosion protection in accordance with Eurocode 5 is applied, or when stainless steel with similar or better characteristic yield and ultimate strength is employed.

The scope of the brackets regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions.

The angle brackets may also be used for connections between a timber member and a member of concrete or steel.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the connectors of 50 years.

The indications given on the working life cannot be interpreted as a guarantee given by the producer or Assessment Body, but are to be regarded only as a means for choosing the right products in relation to the expected economically reasonable working life of the works.

### 3 Performance of the product and references to the methods used for its assessment

Characteristic	Assessment of characteristic
<b>3.1 Mechanical resistance and stability*) (BWR1)</b>	
Characteristic load-carrying capacity	See Annex B
Stiffness	No performance determined
Ductility in cyclic testing	No performance determined
<b>3.2 Safety in case of fire (BWR2)</b>	
Reaction to fire	The angle brackets are made from steel classified as Euroclass A1 in accordance with EN 1350-1 and EC decision 96/603/EC, amended by EC Decision 2000/605/EC
<b>3.3 Hygiene, health and the environment (BWR3)</b>	
Influence on air quality	The product does not contain/release dangerous substances specified in TR 034, dated March 2012 0**)
<b>3.7 Sustainable use of natural resources (BWR7)</b>	
	No Performance Determined
<b>3.8 General aspects related to the performance of the product</b>	
	The angle brackets have been assessed as having satisfactory durability and serviceability when used in timber structures using the timber species described in Eurocode 5 and subject to the conditions defined by service class 1 and 2
Identification	See Annex A

\*) See additional information in section 3.8 – 3.9.

\*\*) In addition to the specific clauses relating to dangerous substances contained in this European technical Assessment, there may be other requirements applicable to the products falling within its scope (e.g. transposed European legislation and national laws, regulations and administrative provisions). In order to meet the provisions of the Construction Products Regulation, these requirements need also to be complied with, when and where they apply.

### 3.9 Methods of verification

The characteristic load-carrying capacities are based on the characteristic values of the connectors and the steel plates.

According to EN 1990 (Eurocode – Basis of design) paragraph 6.3.5 the design value of load-carrying capacity can be determined by reducing the characteristic values of the load-carrying capacity with different partial factors.

Therefore, to obtain design values according to the Eurocodes or appropriate national codes of practice, the capacities have to be multiplied with different partial factors for the material properties and – for the connectors mounted in wood – also the coefficient  $k_{mod}$  that takes into account the load duration class.

Thus, the characteristic values of the load-carrying capacity are determined also for timber failure  $F_{Rk,H}$  (obtaining the embedment strength of connectors subjected to shear or the withdrawal capacity of the most loaded connector, respectively) as well as for steel plate failure  $F_{Rk,S}$ . The design value of the load-carrying capacity is the smaller value of both load-carrying capacities.

$$F_{Rd} = \min \left\{ \frac{k_{mod} \cdot F_{Rk,H}}{\gamma_{M,H}}; \frac{F_{Rk,S}}{\gamma_{M,S}} \right\}$$

Therefore, for timber failure the load duration class and the service class are included. The different partial factors  $\gamma_M$  for steel or timber, respectively, are also correctly taken into account.

### 3.10 Mechanical resistance and stability

See annex B for the characteristic load-carrying capacity in the different directions  $F_1$  to  $F_5$ .

The characteristic capacities of the angle brackets are determined by calculation assisted by testing as described in the EOTA Guideline 015 clause 5.1.2. They should be used for designs in accordance with Eurocode 5 or a similar national Timber Code.

*Threaded nails (ringed shank nails) in accordance to EN 14592*

In the formulas in Annex B the capacities for threaded nails calculated from the formulas of Eurocode 5 are used assuming a thick steel plate when calculating the lateral nail load-carrying-capacity.

The load bearing capacities of the brackets has been determined based on the use of connector nails 4,0 x 40

mm in accordance with the German national approval for the nails.

The characteristic withdrawal capacity of the nails has to be determined by calculation in accordance with EN 1995-1-1: 2004, paragraph 8.3.2 (head pull-through is not relevant):

$$F_{ax,Rk} = f_{ax,k} \times d \times t_{pen}$$

Where:

$f_{ax,k}$	Characteristic value of the withdrawal parameter in N/mm <sup>2</sup>
$d$	Nail diameter in mm
$t_{pen}$	Penetration depth of the profiles shank in mm
	$t_{pen} \geq 30$ mm

Based on tests by Versuchsanstalt für Stahl, Holz und Steine, University of Karlsruhe, the characteristic value of the withdrawal resistance for the threaded nails used can be calculated as:

$$f_{ax,k} = 50 \times 10^{-6} \times \sigma_k^2$$

Where:

$\sigma_k$	Characteristic density of the timber in kg/m <sup>3</sup>
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The shape of the nail directly under the head shall be in the form of a truncated cone with a diameter under the nail head which exceeds the hole diameter.

4,0 mm threaded nails with a truncated cone below the head are used as fasteners, which are particularly suitable for nailed steel-to-timber connections. The specific shape below the head causes a clamping of nails in the steel plate.

It is assumed that angle brackets 70 with and without rib are fastened with nails 4,0x40 with a profiled length including the nail point of at least 30 mm and angle brackets 90 and 105 with and without rib are fastened with nails 4,0x60 with a profiled length including the nail point of at least 50 mm.

No performance has been determined in relation to ductility of a joint under cyclic testing. The contribution to the performance of structures in seismic zones, therefore, has not been assessed.

No performance has been determined in relation to the joint's stiffness properties - to be used for the analysis of the serviceability limit state.

### **3.11 Aspects related to the performance of the product**

#### **3.11.1 Corrosion protection in service class 1 and 2.**

In accordance with ETAG 015 the angle brackets are made from pre-galvanized steel S DX 51 D / Z 275 according to EN 10327:2004

### **3.12 General aspects related to the fitness for use of the product**

Arras CF angle brackets are manufactured in accordance with the provisions of this European Technical Assessment using the manufacturing processes as identified in the inspection of the plant by the notified inspection body and laid down in the technical documentation.

The nailing pattern used shall be either the maximum or the minimum pattern as defined in Annex B.

The following provisions concerning installation apply:

There shall be nails or screws in all holes or at least in holes as specified on technical drawings in accordance with this document.

All minimum spacing's and edge/end distances in accordance with Eurocode 5 or an appropriate national code shall be complied with.

The angle bracket connection shall be designed in accordance with Eurocode 5 or an appropriate national code.

The cross section of the connected wooden elements shall have a plane surface against the whole angle bracket.

Nails or screws to be used shall have a diameter which fits the holes of the angle brackets.

The structural members – the components 1 and 2 - to which the brackets are fixed shall be:

- Restrained against rotation. At a load  $F_4/F_5$ , the component 2 is allowed to be restrained against rotation by the Angle brackets.
- Strength class C14 or better, see section 1 of this ETA
- Free from wane under the bracket.
- The actual end bearing capacity of the timber member to be used in conjunction with the bracket is checked by the designer of the structure to ensure it is not less than the bracket capacity and, if necessary, the bracket capacity reduced

accordingly.

- The gap between the timber members does not exceed 3 mm.
- There are no specific requirements relating to preparation of the timber members.

## **4 Attestation and verification of constancy of performance (AVCP)**

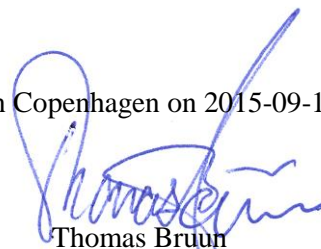
### **4.1 AVCP system**

According to the decision 97/638/EC of the European Commission<sup>1</sup>, as amended, the system(s) of assessment and verification of constancy of performance (see Annex V to Regulation (EU) No 305/2011) is 2+.

## **5 Technical details necessary for the implementation of the AVCP system, as foreseen in the applicable EAD**

Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark

Issued in Copenhagen on 2015-09-11 by



Thomas Bruun  
Managing Director, ETA-Danmark

**Annex A**  
**Product details definitions**

Table A.1 Materials specification

Bracket type	Thickness (mm)	Steel specification	Coating specification
50 x 50 x 35 x 2,5	2,5	DX 51 D	Z 275
60 x 60 x 40 x 2,5	2,5	DX 51 D	Z 275
60 x 60 x 50 x 2,5	2,5	DX 51 D	Z 275
60 x 60 x 60 x 2,5	2,5	DX 51 D	Z 275
70 x 70 x 55 x 2,5	2,5	DX 51 D	Z 275
70 x 70 x 55 x 2,5 (with rib)	2,5	DX 51 D	Z 275
80 x 80 x 60 x 2,5	2,5	DX 51 D	Z 275
80 x 80 x 80 x 2,5	2,5	DX 51 D	Z 275
90 x 90 x 40 x 3,0	3,0	DX 51 D	Z 275
90 x 90 x 65 x 2,5	2,5	DX 51 D	Z 275
90 x 90 x 65 x 2,5 (with rib)	2,5	DX 51 D	Z 275
100 x 100 x 80 x 2,5	2,5	DX 51 D	Z 275
100 x 100 x 100 x 2,5	2,5	DX 51 D	Z 275

Table A.2 Range of sizes

Bracket type	Height (mm)		Height (mm)		Width (mm)	
	vertical		horizontal			
50 x 50 x 35 x 2,5	47,5	50,5	47,5	50,5	34,0	36,0
60 x 60 x 40 x 2,5	59,0	61,0	59,0	61,0	39,0	41,0
60 x 60 x 50 x 2,5	58,0	61,0	58,0	61,0	49,0	51,0
60 x 60 x 60 x 2,5	59,0	61,0	59,0	61,0	59,0	62,0
70 x 70 x 55 x 2,5	69,5	72,5	69,5	72,5	54,0	56,0
70 x 70 x 55 x 2,5 (with rib)	70,0	73,0	70,0	73,0	54,0	56,0
80 x 80 x 60 x 2,5	79,0	81,0	79,0	81,0	59,0	61,0
80 x 80 x 80 x 2,5	79,0	81,0	79,0	81,0	79,0	81,0
90 x 90 x 40 x 3,0	88,0	91,0	88,0	91,0	37,0	41,0
90 x 90 x 65 x 2,5	88,0	91,0	88,0	91,0	64,0	66,0
90 x 90 x 65 x 2,5 (with rib)	88,0	91,0	88,0	91,0	62,0	66,0
100 x 100 x 80 x 2,5	97,5	100,5	97,5	100,5	79,0	81,0
100 x 100 x 100 x 2,5	97,5	100,5	97,5	100,5	99,0	101,0



Table A.3 Fastener specification

Nail type	Nail size (mm)		Finish
	Diameter	Length	
According to EN 14592			
Threaded nail	4,0	40	Electroplated zinc

In the load-carrying-capacities of the nailed connection in Annex B the capacities for threaded nails calculated from the formulas of Eurocode 5 are used assuming a thick steel plate when calculating the lateral nail load-carrying-capacity.

The load-carrying-capacities of the angle brackets have been determined based on the use of connector nails 4,0 x 40 mm in accordance with the German national approval for the nails.

The characteristic withdrawal capacity of the nails has to be determined by calculation in accordance with EN 1995-1-1:2004, paragraph 8.3.2 (head pull-through is not relevant):

$$F_{ax,Rk} = f_{ax,k} \times d \times t_{pen}$$

Where:

$f_{ax,k}$  Characteristic value of the withdrawal parameter in N/mm<sup>2</sup>

$d$  Nail diameter in mm

$t_{pen}$  Penetration depth of the profiled shank including the nail point in mm,  $t_{pen} \geq 31$  mm

Based on tests by Versuchsanstalt für Stahl, Holz und Steine, University of Karlsruhe (KIT), the characteristic value of the withdrawal resistance for the threaded nails used can be calculated as:

$$f_{ax,k} = 50 \times 10^{-6} \times \rho_k^2$$

Where:

$\rho_k$  Characteristic density of the timber in kg/m<sup>3</sup>

The shape of the nail directly under the head shall be in the form of a truncated cone with a diameter under the nail head which exceeds the hole diameter.

**Arras CF Angle Brackets**

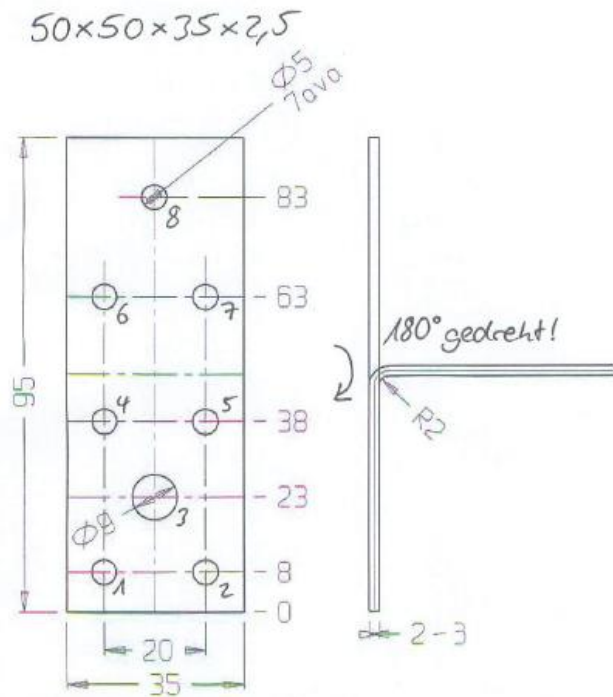


Figure A. 1 Dimensions of angle bracket 50x50x35x2,5

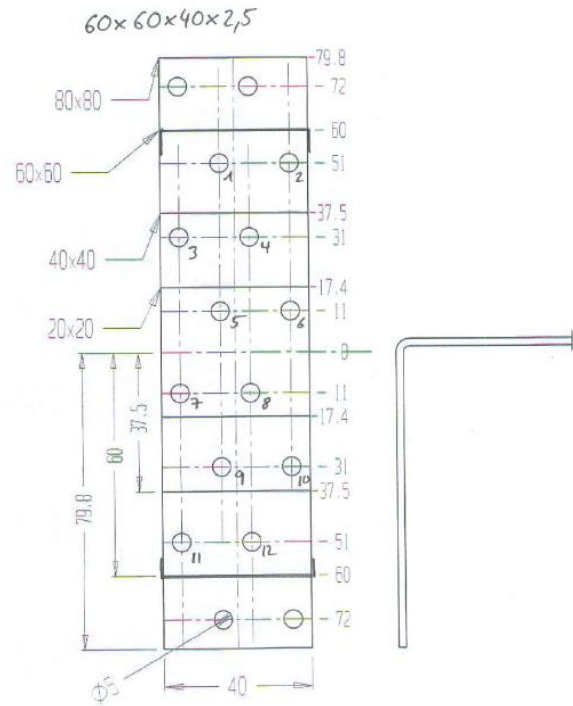


Figure A. 2 Dimensions of angle bracket 60x60x40x2,5

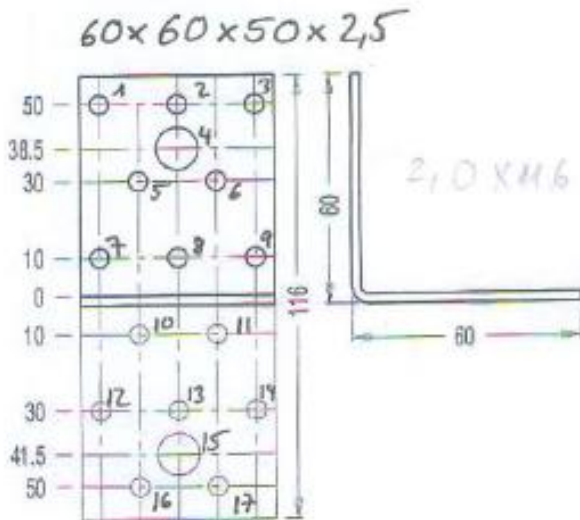


Figure A. 3 Dimensions of angle bracket 60x60x50x2,5

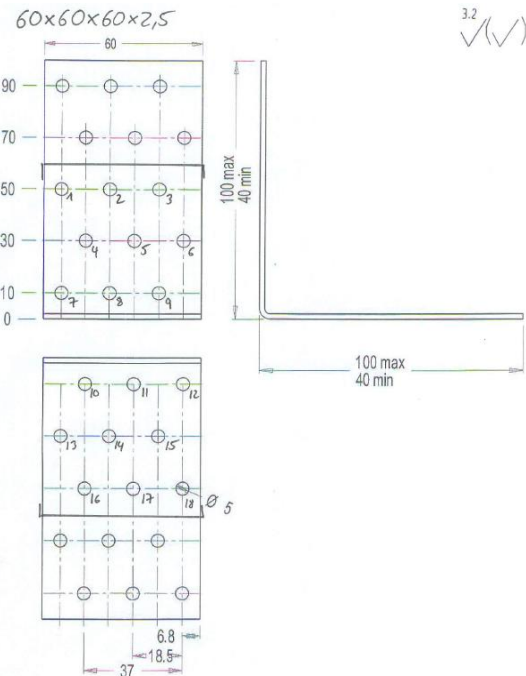


Figure A. 4 Dimensions of angle bracket 60x60x60x2,5

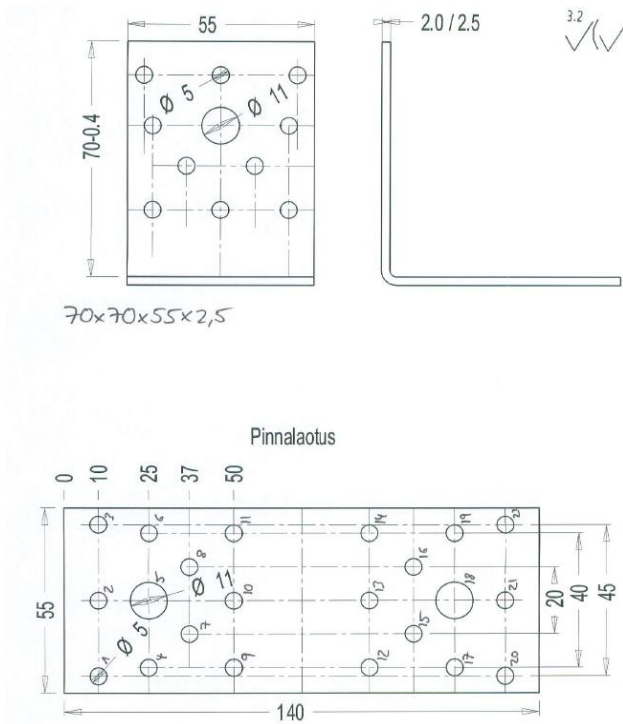


Figure A. 5 Dimensions of angle bracket 70x70x55x2,5

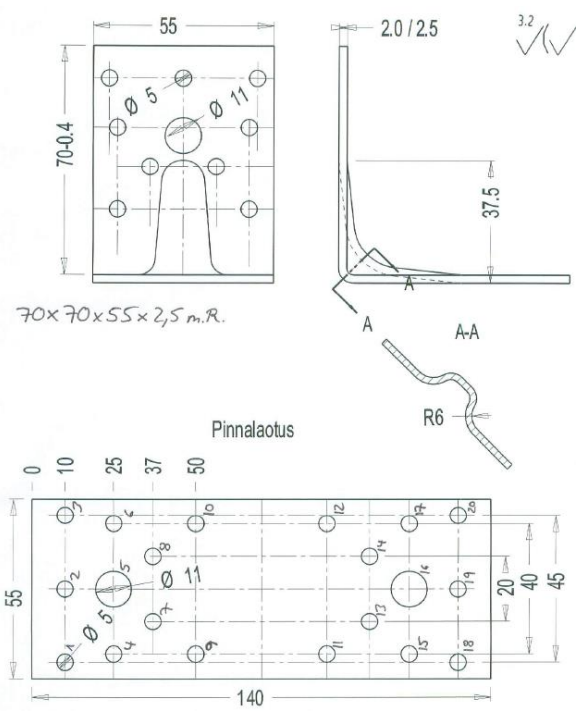


Figure A. 6 Dimensions of angle bracket 70x70x55x2,5 (with rib)

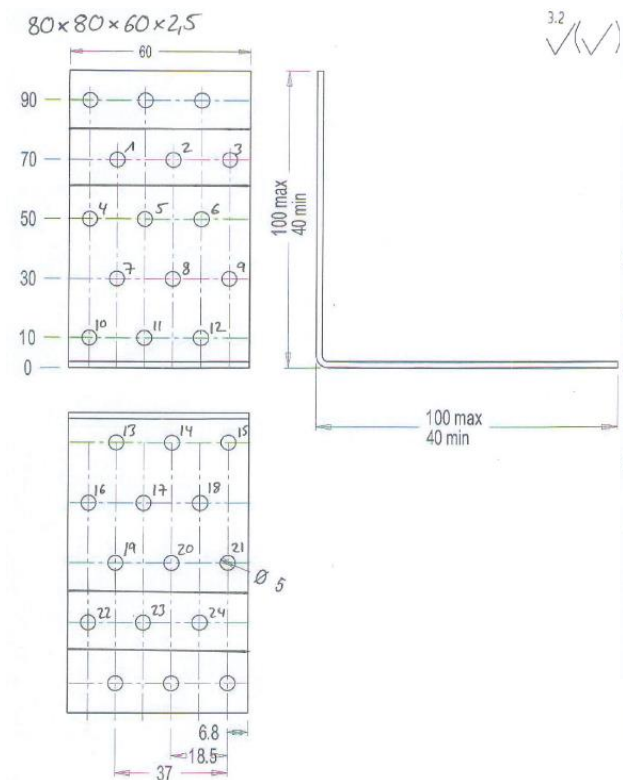


Figure A. 7 Dimensions of angle bracket 80x80x60x2,5

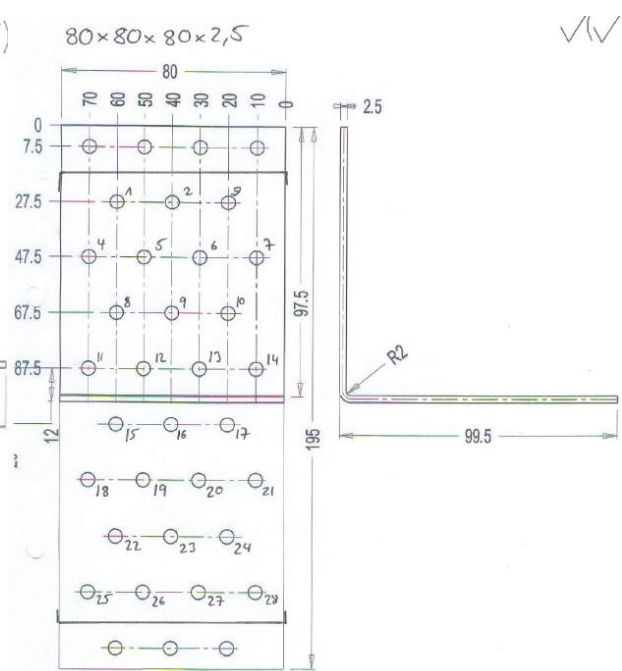


Figure A. 8 Dimensions of angle bracket 80x80x80x2,5

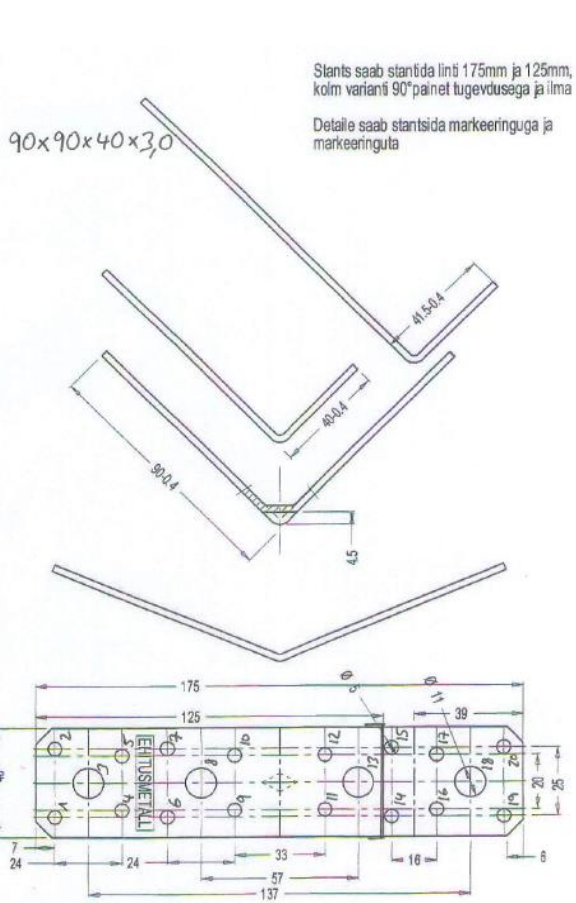


Figure A. 9 Dimensions of angle bracket 90x90x40x3,0

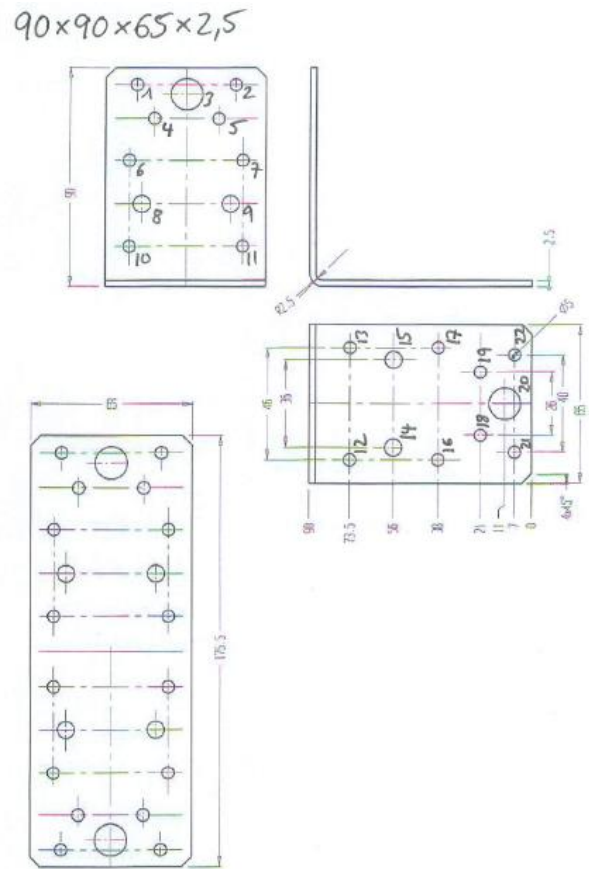


Figure A. 10 Dimensions of angle bracket 90x90x65x2,5

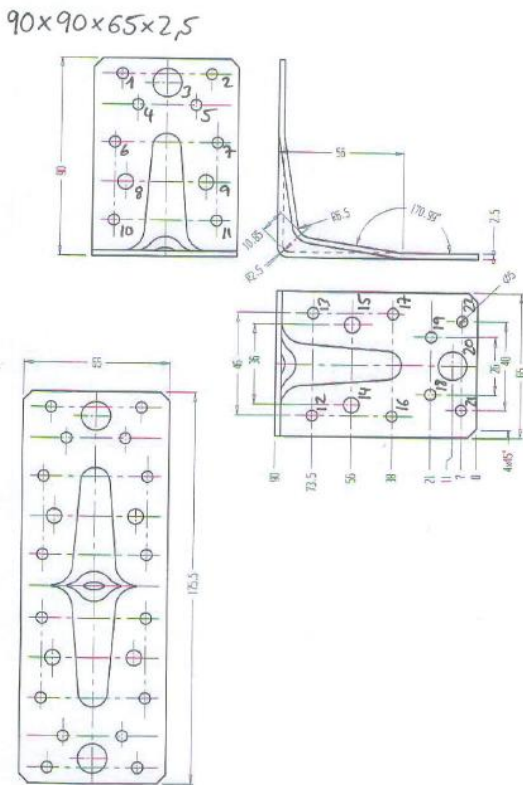


Figure A. 11 Dimensions of angle bracket 90x90x65x2,5(with rib)

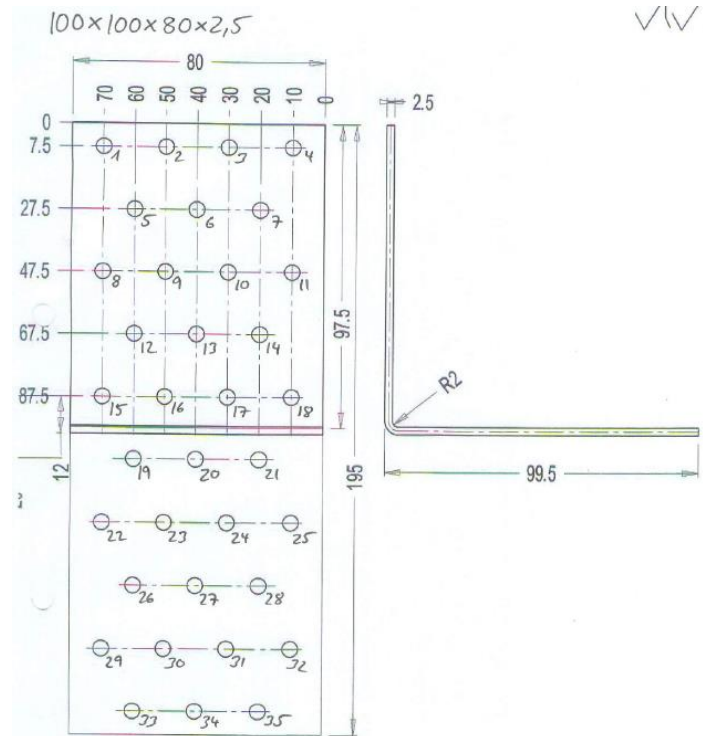


Figure A. 12 Dimensions of angle bracket 100x100x80x2,5

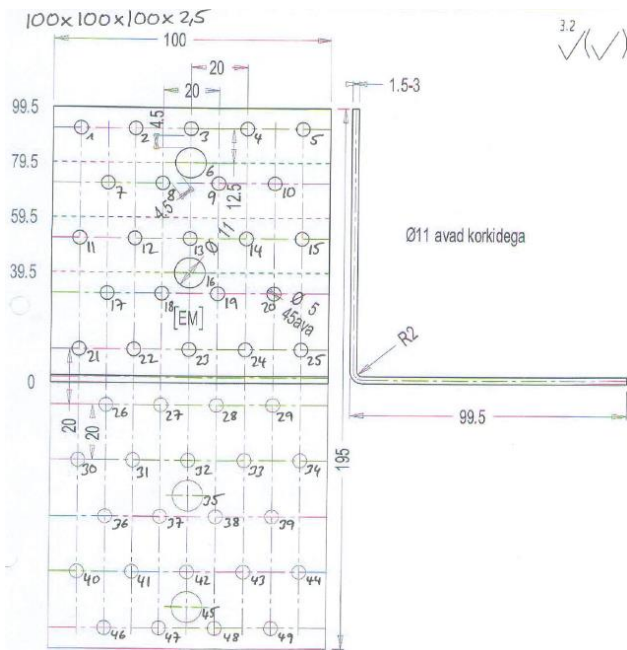


Figure A. 13 Dimensions of angle bracket  
100x100x100x2,5

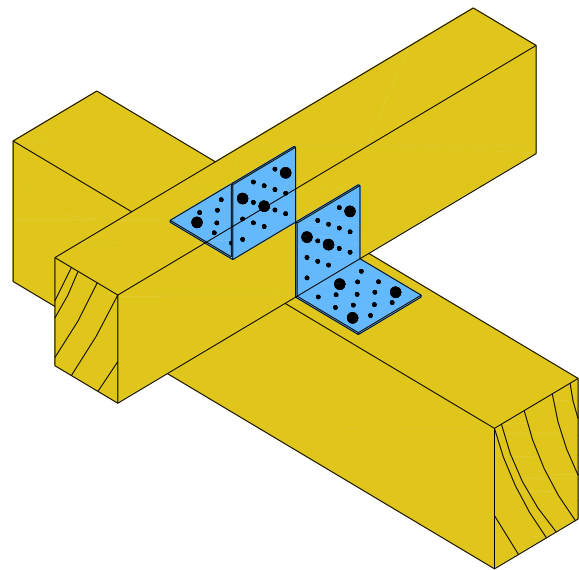


Figure A. 14 Typical installation

**Annex B**  
**Characteristic load-carrying capacities**

**Table 1:** Force  $F_1$  Column, 2 angle brackets / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{1,Rk}$ [kN] (column)	
			Timber	Steel
50 x 50 x 35 x 2,5	-	-	-	-
60 x 60 x 40 x 2,5	-	-	-	-
60 x 60 x 50 x 2,5	-	-	-	-
60 x 60 x 60 x 2,5	-	-	-	-
70 x 70 x 55 x 2,5	1,2,3	12,13,14,15,16,20,21,22	3,05	1,81
70 x 70 x 55 x 2,5 with rib	1,2,3	11,12,13,14,18,19,20	2,04	2,40
80 x 80 x 60 x 2,5	1,2,3	13,14,15,16,17,18,19,20,21,22, 23,24	3,82	4,08
80 x 80 x 80 x 2,5	1,2,3	15,16,17,18,19,20,21,22,23,24, 25,26,27,28	3,68	4,71
90 x 90 x 40 x 3,0	1,2	11,12,14,15,19,20	2,35	2,37
90 x 90 x 65 x 2,5	1,2	12,13,16,17,21,22	2,37	3,02
90 x 90 x 65 x 2,5 with rib	1,2	12,13,16,17,21,22	2,37	9,76
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7	19,20,21,22,23,24,25,26,27,28, 29,30,31,32,33,34,35	3,85	4,91
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	5,29	7,63

**Table 2:** Force  $F_1$  Column, 1 angle bracket / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{1,Rk}$ [kN] (column)	
			Timber	Steel
50 x 50 x 35 x 2,5	-	-	-	-
60 x 60 x 40 x 2,5	-	-	-	-
60 x 60 x 50 x 2,5	-	-	-	-
60 x 60 x 60 x 2,5	-	-	-	-
70 x 70 x 55 x 2,5	1,2,3	12,13,14,15,16,20,21,22	1,53	0,91
70 x 70 x 55 x 2,5 with rib	1,2,3	11,12,13,14,18,19,20	1,02	1,20
80 x 80 x 60 x 2,5	1,2,3	13,14,15,16,17,18,19,20,21,22, 23,24	1,91	2,04
80 x 80 x 80 x 2,5	1,2,3	15,16,17,18,19,20,21,22,23,24, 25,26,27,28	1,84	2,36
90 x 90 x 40 x 3,0	1,2	11,12,14,15,19,20	1,18	1,19
90 x 90 x 65 x 2,5	1,2	12,13,16,17,21,22	1,18	1,51
90 x 90 x 65 x 2,5 with rib	1,2	12,13,16,17,21,22	1,18	4,88
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7	19,20,21,22,23,24,25,26,27,28, 29,30,31,32,33,34,35	1,93	2,45
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	2,64	3,82

**Table 3:** Force  $F_1$  Purlin, 2 angle brackets / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{1,Rk}$ [kN] (purlin)	
			Timber	Steel
50 x 50 x 35 x 2,5	1,2	6,7,8	1,87	1,46
60 x 60 x 40 x 2,5	1,2,3,4	7,8,9,10,11,12	2,35	2,47
60 x 60 x 50 x 2,5	1,2,3,5,6	10,11,12,13,14,16,17	2,41	3,63
60 x 60 x 60 x 2,5	1,2,3,4,5,6	10,11,12,13,14,15,16,17,18	3,61	4,08
70 x 70 x 55 x 2,5	1,2,3,7,8	12,13,14,15,16,20,21,22	3,05	1,81
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	2,04	2,40
80 x 80 x 60 x 2,5	1,2,3,4,5,6,7,8,9	13,14,15,16,17,18,19,20,21,22, 23,24	3,82	4,08
80 x 80 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10	15,16,17,18,19,20,21,22,23,24, 25,26,27,28	3,68	4,71
90 x 90 x 40 x 3,0	1,2,4,5,6,7	11,12,14,15,19,20	2,35	2,37
90 x 90 x 65 x 2,5	1,2,4,5,6,7	12,13,16,17,21,22	2,37	3,02
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	2,37	9,76
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10, 11,12,13,14	19,20,21,22,23,24,25,26,27,28, 29,30,31,32,33,34,35	3,85	4,91
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10, 11,12,13,14,15,17, 18,19,20	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	5,29	7,63

**Table 4:** Force  $F_1$  Purlin, 1 angle bracket / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{1,Rk}$ [kN] (purlin)	
			Timber	Steel
50 x 50 x 35 x 2,5	1,2	6,7,8	0,93	0,73
60 x 60 x 40 x 2,5	1,2,3,4	7,8,9,10,11,12	1,18	1,24
60 x 60 x 50 x 2,5	1,2,3,5,6	10,11,12,13,14,16,17	1,20	1,81
60 x 60 x 60 x 2,5	1,2,3,4,5,6	10,11,12,13,14,15,16,17,18	1,80	2,04
70 x 70 x 55 x 2,5	1,2,3,7,8	12,13,14,15,16,20,21,22	1,53	0,91
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	1,02	1,20
80 x 80 x 60 x 2,5	1,2,3,4,5,6,7,8,9	13,14,15,16,17,18,19,20,21, 22,23,24	1,91	2,04
80 x 80 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10	15,16,17,18,19,20,21,22,23, 24,25,26,27,28	1,84	2,36
90 x 90 x 40 x 3,0	1,2,4,5,6,7	11,12,14,15,19,20	1,18	1,19
90 x 90 x 65 x 2,5	1,2,4,5,6,7	12,13,16,17,21,22	1,18	1,51
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	1,18	4,88
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10, 11,12,13,14	19,20,21,22,23,24,25,26,27, 28,29,30,31,32,33,34,35	1,93	2,45
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10, 11,12,13,14,15,17, 18,19,20	26,27,28,29,30,31,32,33,34, 36,37,38,39, 40,41,42,43,44,46,47,48,49	2,64	3,82



**Table 5:** Forces  $F_{2,3}$ , 2 angle brackets / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{2,3,Rk}$ [kN]
			Timber
50 x 50 x 35 x 2,5	1,2	6,7,8	2,07
60 x 60 x 40 x 2,5	1,2,3,4	7,8,9,10,11,12	4,24
60 x 60 x 50 x 2,5	1,2,3,5,6	10,11,12,13,14,16,17	5,33
60 x 60 x 60 x 2,5	1,2,3,4,5,6	10,11,12,13,14,15,16,17,18	7,58
70 x 70 x 55 x 2,5	1,2,3,7,8	12,13,14,15,16,20,21,22	5,71
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	5,56
80 x 80 x 60 x 2,5	1,2,3,4,5,6,7,8,9	13,14,15,16,17,18,19,20,21,22, 23,24	9,66
80 x 80 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10	15,16,17,18,19,20,21,22,23,24, 25,26,27,28	11,4
90 x 90 x 40 x 3,0	1,2,4,5,6,7	11,12,14,15,19,20	5,06
90 x 90 x 65 x 2,5	1,2,4,5,6,7	12,13,16,17,21,22	5,89
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	5,89
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14	19,20,21,22,23,24,25,26,27,28, 29,30,31,32,33,34,35	13,9
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10, 11,12,13,14,15,17, 18,19,20	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	20,3

**Table 6:** Forces  $F_{2,3}$ , 1 angle bracket / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{2,3,Rk}$ [kN]
			Timber
50 x 50 x 35 x 2,5	1,2	6,7,8	2,07
60 x 60 x 40 x 2,5	1,2,3,4	7,8,9,10,11,12	4,24
60 x 60 x 50 x 2,5	1,2,3,5,6	10,11,12,13,14,16,17	5,33
60 x 60 x 60 x 2,5	1,2,3,4,5,6	10,11,12,13,14,15,16,17,18	7,58
70 x 70 x 55 x 2,5	1,2,3,7,8	12,13,14,15,16,20,21,22	5,71
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	5,56
80 x 80 x 60 x 2,5	1,2,3,4,5,6,7,8,9	13,14,15,16,17,18,19,20,21, 22,23,24	9,66
80 x 80 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10	15,16,17,18,19,20,21,22,23, 24,25,26,27,28	11,4
90 x 90 x 40 x 3,0	1,2,4,5,6,7	11,12,14,15,19,20	5,06
90 x 90 x 65 x 2,5	1,2,4,5,6,7	12,13,16,17,21,22	5,89
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	5,89
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10,1 1,12,13,14	19,20,21,22,23,24,25,26,27, 28,29,30,31,32,33,34,35	13,9
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10, 11,12,13,14,15,17, 18,19,20	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	10,1



**Table 7:** Basic Forces  $F_{4,5}$ , 2 angle brackets / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{4,5,Rk}$ [kN]	
			Timber	Steel
50 x 50 x 35 x 2,5	1,2	6,7,8	5,38	2,24
60 x 60 x 40 x 2,5	1,2,3,4	7,8,9,10,11,12	5,08	2,81
60 x 60 x 50 x 2,5	1,2,3,5,6	10,11,12,13,14,16,17	5,56	3,62
60 x 60 x 60 x 2,5	1,2,3,4,5,6	10,11,12,13,14,15,16,17,18	7,40	4,11
70 x 70 x 55 x 2,5	1,2,3,7,8	12,13,14,15,16,20,21,22	5,92	4,27
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	5,85	5,43
80 x 80 x 60 x 2,5	1,2,3,4,5,6,7,8,9	13,14,15,16,17,18,19,20,21,22, 23,24	8,14	4,34
80 x 80 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10	15,16,17,18,19,20,21,22,23,24, 25,26,27,28	9,81	6,01
90 x 90 x 40 x 3,0	1,2,4,5,6,7	11,12,14,15,19,20	5,44	2,99
90 x 90 x 65 x 2,5	1,2,4,5,6,7	12,13,16,17,21,22	8,52	4,45
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	8,55	7,96
100 x 100 x 80 x 2,5	1,2,3,4,5,6,7,8,9,10,11, 12,13,14	19,20,21,22,23,24,25,26,27,28, 29,30,31,32,33,34,35	10,7	5,88
100 x 100 x 100 x 2,5	1,2,3,4,5,7,8,9,10, 11,12,13,14,15,17, 18,19,20	26,27,28,29,30,31,32,33,34,36, 37,38,39, 40,41,42,43,44,46,47,48,49	12,5	7,33

**Table 8:** Basic Forces  $F_4$ , 1 angle bracket / connection

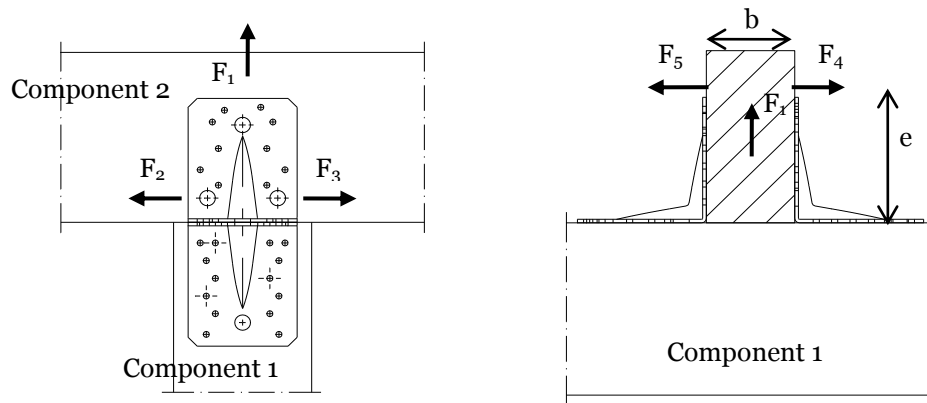
Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{4,Rk}$ [kN]	
			Timber	Steel
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	5,85	4,24
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	8,55	6,38

**Table 9:** Basic Forces  $F_5$ , 1 angle bracket / connection

Bracket type	Nail number $n_V$	Nail number $n_H$	$F_{5,Rk}$ [kN]	
			Timber	Steel
70 x 70 x 55 x 2,5 with rib	1,2,3,7,8	11,12,13,18,15,19,20	1,28	1,40
90 x 90 x 65 x 2,5 with rib	1,2,4,5,6,7	12,13,16,17,21,22	1,70	1,73

## Definitions of forces, their directions and eccentricity

### Forces - Beam to beam connection



### Fastener specification

Holes are marked with numbers referring to the nailing pattern in Annex A.

### Double angle brackets per connection

The angle brackets must be placed at each side opposite to each other, symmetrically to the component axis.

#### Acting forces

- $F_1$  Lifting force acting along the central axis of the joint.
- $F_2$  and  $F_3$  Lateral force acting in the joint between the component 2 and component 1 in the component 2 direction
- $F_4$  and  $F_5$  Lateral force acting in the component 1 direction along the central axis of the joint. If the load is applied with an eccentricity  $e$ , a design for combined loading is required.

### Single angle bracket per connection

#### Acting forces

- $F_1$  Lifting force acting in the central axis of the angle bracket. The component 2 shall be prevented from rotation. If the component 2 is prevented from rotation the load-carrying capacity will be half of a connection with double angle brackets.
- $F_2$  and  $F_3$  Lateral force acting in the joint between the component 2 and the component 1 in the component 2 direction. The component 2 shall be prevented from rotation. If the component 2 is prevented from rotation the load-carrying capacity will be half of a connection with double angle brackets.
- $F_4$  and  $F_5$  Lateral force acting in the component 1 direction in the height of the top edge of component 2.  $F_4$  is the lateral force towards the angle bracket;  $F_5$  is the lateral force away from the angle bracket. Only the characteristic load-carrying capacities for angle brackets with ribs are given.

### Wane

Wane is not allowed, the timber has to be sharp-edged in the area of the angle brackets.

### Timber splitting

For the lifting force  $F_1$  it must be checked in accordance with Eurocode 5 or a similar national Timber Code that splitting will not occur.

### Combined forces

If the forces  $F_1$  and  $F_2/F_3$  or  $F_4/F_5$  act at the same time, the following inequality shall be fulfilled:

$$\left( \frac{F_{1,d}}{F_{Rd,1}} \right)^2 + \left( \frac{F_{2,d}}{F_{Rd,2}} \right)^2 + \left( \frac{F_{3,d}}{F_{Rd,3}} \right)^2 + \left( \frac{F_{4,d}}{F_{Rd,4}} \right)^2 + \left( \frac{F_{5,d}}{F_{Rd,5}} \right)^2 \leq 1$$

The forces  $F_2$  and  $F_3$  or  $F_4$  and  $F_5$  are forces with opposite direction. Therefore only one force  $F_2$  or  $F_3$ , and  $F_4$  or  $F_5$ , respectively, is able to act simultaneously with  $F_1$ , while the other shall be set to zero.

If the load  $F_4/F_5$  is applied with an eccentricity  $e$ , a design for combined loading **for connections with double angle brackets** is required. Here, an additional force  $\Delta F_1$  has to be added to the existing force  $F_1$ .

$$\Delta F_{1,d} = F_{4,d} / F_{5,d} \cdot \frac{e}{B}$$

$B$  is the width of component 2.