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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-20/0773 of 2022/03/08

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:	DENEB Angle Brackets and plate connectors
Product family to which the above construction product belongs:	Three-dimensional nailing plate (angle brackets for connections between a CLT wall and floor or a beam and a purlin)
Manufacturer:	BB Stanz- und Umformtechnik GmbH Nordhäuser Str. 42 D-06536 Berga Tel. +49 34651 2988 0 Fax +49 34651 2988 20 Internet www.bb-berga.de
Manufacturing plant:	BB Stanz- und Umformtechnik GmbH Nordhäuser Str. 42 D-06536 Berga
This European Technical Assessment contains:	19 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:	EAD 130186-00-0603 for Three-dimensional nailing plates
This version replaces:	The ETA with the same number issued on 2020-10-20

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II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

Technical description of the product

DENEB angle brackets and plate connectors are one-piece non-welded, face-fixed nailing plates to be used in timber to timber or timber to concrete connections. They are connected to construction members made of timber or wood-based products with profiled (ringed shank) nails according to EN 14592 or ETA or screws according to ETA-11/0190 and to construction members made of concrete by metal anchors.

The angle brackets and plate connectors with a steel plate thickness of 2,0 mm are made from pre-galvanized steel S350GD / Z275 according to EN 10346.

Dimensions, hole positions and typical installations are shown in Annex B. DENEB angle brackets and plate connectors are made from steel with tolerances according to EN 10143.

2 Specification of the intended use in accordance with the applicable European Assessment Document (hereinafter EAD)

The angle brackets and plate connectors are intended for use in making connections in load bearing timber structures, as a connection between a CLT wall and floor or 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 nailing plate or with nailing plates on one or both sides of the fastened timber member (see Annex B).

The static and kinematical behaviour of the timber members or the supports shall be as described in Annex A and 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 kg/m^3 to 460 kg/m^3. This requirement to the material of the wood members can be fulfilled by using the following materials:

- Structural solid timber according to EN 14081,
- Glulam according to EN 14080,
- Glued solid timber according to EN 14080,
- LVL according to EN 14374,
- Cross laminated timber according to ETA.

Annex B states the load-carrying capacities of the connections for characteristic densities ρ_a = 350 kg/m^3 or ρ_a = 400 kg/m^3. For timber or wood based material with a lower or higher characteristic density than ρ_a the load-carrying capacities shall be reduced or may be increased by the factor k_{dens}:

$$k_{dens}^{lower} = \left(\frac{\rho_k}{\rho_a}\right)^{0,8} \qquad k_{dens}^{higher} = \left(\frac{\rho_k}{\rho_a}\right)^{0,5}$$

where ρ_k is the characteristic density of the timber or wood based material in 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 and plate connectors are primarily for use in timber structures subject to the dry, internal conditions defined by service class 1 and 2 of Eurocode 5 and for connections subject to static or quasi-static loading.

The angle brackets and plate connectors may also be used in outdoor timber structures, service class 3, when a corrosion protection in accordance with Eurocode 5, table 4.1 is applied, or when stainless steel with similar or better characteristic yield and ultimate strength is employed. To avoid contact corrosion, stainless steel angle brackets and plate connectors shall be used with nails or screws made from stainless steel.

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 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
3.1 Mechanical resistance and stability*) (BWR1)	
Joint Strength - Characteristic load-carrying capacity	See Annex B
Joint Stiffness	See Annex B
Joint ductility	No performance assessed
Resistance to seismic actions	No performance assessed
Resistance to corrosion and deterioration	See section 3.6
3.2 Safety in case of fire (BWR2)	
Reaction to fire	The angle brackets are made from steel classified as Euroclass A1 in accordance with EN 13501-1 and Commission Delegated Regulation 2016/364
3.3 General aspects related to the performance of the product	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 3.4 – 3.7.

3.4 Methods of verification

The characteristic load-carrying capacities are based on the characteristic values of the nailed or screwed connections and the steel plates. To obtain design values the capacities have to be divided by different partial factors for the nailed or screwed connection and in addition multiplied with the coefficient k_{mod}.

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

$$F_{Rd} = \frac{k_{mod} \cdot F_{Rk}}{\gamma_M}$$

Therefore, the load duration class and the service class are included. The different partial factors γ_M for timber or wood-based material, respectively, are also correctly taken into account.

3.5 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 and plate connectors are determined by calculation assisted by testing as described in the EAD 130186-00-0603 for Three-dimensional nailing plates. 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 and screws in accordance with ETA-11-0190
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.

Additionally, the angle brackets and plate connectors can be fastened to the concrete structure or steel member by bolts with a diameter of 12 mm in holes with a diameter up to 2 mm larger than the bolt.

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.

3.6 Aspects related to the performance of the product

3.6.1 Corrosion protection in service class 1 and 2.
In accordance with EAD 130186-00-0603 the angle brackets and plate connectors have a zinc coating Fe/Zn 12 according to EN ISO 2081 or a weight of min. Z275 according to EN 10346

3.7 General aspects related to the use of the product

BB DENEB angle brackets and plate connectors 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 fastener pattern used shall be either the maximum or the minimum pattern as defined in Annex A.

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 and plate connector 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.
- Strength class C24 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.
- The execution of the connection shall be in accordance with the assessment holder's technical literature.

4 Attestation and verification of constancy of performance (AVCP)

4.1 AVCP system

According to the decision 97/638/EC of the European Commission, 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 prior to CE marking

Issued in Copenhagen on 2022-03-08 by

Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Product details definitions

Table A.1 Materials specification

Nailing plate type	Thickness (mm)	Steel specification	Coating specification
DENEB angle bracket	2,0	S350GD	Z 275
DENEB plate connector	2,0	S350GD	Z 275

Table A.2 Range of sizes

Angle Bracket type	Height (mm) vertical		Height (mm) horizontal		Width (mm)	
DENEB angle bracket	116	118	116	118	221	223
DENEB plate connector	3,0	4,0	230	232	221	223

Table A.3 Fastener specification

Fastener	Length	Profiled Length	Fastener type
Nail 4.0 mm	50 mm	41 mm	Ringed shank nails according to EN 14592
	60 mm	51 mm	
ASSY plus VG 4 or TIMTEC plus VG Kombi screw 12.0 mm	120 mm	98 mm	Self-tapping screws according to ETA-11/0190
	140 mm	118 mm	
	160 mm	140 mm	
ASSY plus VG 4 or TIMTEC plus VG CS screw 6.0 mm	200 mm	183 mm	
ASSY 4 JH or TIMTEC Joist hanger screw 5.0 mm	50 mm	41 mm	
	70 mm	61 mm	

Metal anchor diameter	Correspondent hole diameter	Anchor type
12.0 mm	Max. 2 mm larger than the anchor diameter	See specification of the manufacturer

Annex B
Characteristic load-carrying capacities and slip moduli

Table 1: $F_{1,Rk}$ and $K_{1,ser}$ per angle bracket / connection timber to timber

Fastener configuration	$F_{1,Rk}$ [kN]		$K_{1,ser}$ [kN/mm]
	$\rho_k = 350$ kg/m³	$\rho_k = 400$ kg/m³	
1-120 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x120 per flap arranged in all 13 mm holes under 90° to the timber surface	7,0	8,0	$F_{1,Rk}/10$
1-140 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x140 per flap arranged in all 13 mm holes under 90° to the timber surface	9,0	10,0	$F_{1,Rk}/10$
1-160 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x160 per flap arranged in all 13 mm holes under 90° to the timber surface	10,0	12,0	$F_{1,Rk}/10$
2 - Four ASSY plus VG 4 or TIMTEC plus VG CS screws 6x200 per flap arranged with angle washers in all 13 mm holes under 45° to the timber surface	10,0	10,0	$F_{1,Rk}/10$
3a - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in all 5 mm holes under 90° to the timber surface	24,0	28,0	$F_{1,Rk}/2$
3b - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per horizontal flap and 30 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	24,0	28,0	$F_{1,Rk}/2$
3c - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per horizontal flap and 26 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	21,0	24,0	$F_{1,Rk}/2$
3d - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per horizontal flap and 23 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	18,0	21,0	$F_{1,Rk}/2$
3e - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per horizontal flap and 21 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	16,0	18,0	$F_{1,Rk}/2$
3f - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per horizontal flap and 16 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	14,0	17,0	$F_{1,Rk}/2$
4a - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in all 5 mm holes under 90° to the timber surface	37,0	42,0	$F_{1,Rk}/2$
4b - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per horizontal flap and 30 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	32,0	36,0	$F_{1,Rk}/2$
4c - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per horizontal flap and 26 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	27,0	31,0	$F_{1,Rk}/2$
4d - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per horizontal flap and 23 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	24,0	28,0	$F_{1,Rk}/2$
4e - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per horizontal flap and 21 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	22,0	25,0	$F_{1,Rk}/2$
4f - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per horizontal flap and 16 screws per vertical flap arranged in 5 mm holes under 90° to the timber surface	17,0	19,0	$F_{1,Rk}/2$

Table 2 continued: $F_{1,Rk}$ and $K_{1,ser}$ per angle bracket / connection timber to timber

5-120 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x120 per flap arranged in all 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 arranged in 5 mm holes close to the bend line under 90° to the timber surface	20,0	23,0	$F_{1,Rk}/3$
5-140 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x140 per flap arranged in all 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 arranged in 5 mm holes close to the bend line under 90° to the timber surface	24,0	28,0	$F_{1,Rk}/3$
5-160 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x160 per flap arranged in all 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 arranged in 5 mm holes close to the bend line under 90° to the timber surface	28,0	33,0	$F_{1,Rk}/3$
6a - 35 ringed shank nails 4x60 per horizontal flap and 35 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	13,0	15,0	$F_{1,Rk}/2$
6b - 35 ringed shank nails 4x60 per horizontal flap and 30 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	11,0	13,0	$F_{1,Rk}/2$
6c - 35 ringed shank nails 4x60 per horizontal flap and 26 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	10,0	11,0	$F_{1,Rk}/2$
6d - 35 ringed shank nails 4x60 per horizontal flap and 23 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	9,0	10,0	$F_{1,Rk}/2$
6e - 35 ringed shank nails 4x60 per horizontal flap and 21 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	8,0	9,0	$F_{1,Rk}/2$
6f - 35 ringed shank nails 4x60 per horizontal flap and 16 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	6,0	7,0	$F_{1,Rk}/2$
7a - 35 ringed shank step nails 4x50 per horizontal flap and 35 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	12,0	14,0	$F_{1,Rk}/2$
7b - 35 ringed shank nails 4x50 per horizontal flap and 30 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	10,0	12,0	$F_{1,Rk}/2$
7c - 35 ringed shank nails 4x50 per horizontal flap and 26 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	9,0	10,0	$F_{1,Rk}/2$
7d - 35 ringed shank nails 4x50 per horizontal flap and 23 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	8,0	9,0	$F_{1,Rk}/2$
7e - 35 ringed shank nails 4x50 per horizontal flap and 21 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	7,0	8,0	$F_{1,Rk}/2$
7f - 35 ringed shank nails 4x50 per horizontal flap and 16 nails per vertical flap arranged in 5 mm holes under 90° to the timber surface	5,0	6,0	$F_{1,Rk}/2$

Table 2: $F_{2/3,Rk}$ and $K_{2/3,ser}$ per angle bracket / connection timber to timber

Fastener configuration (see Table 1)	$F_{2/3,Rk}$ [kN]		$K_{2/3,ser}$ [kN/mm]
	$\rho_k = 350$ kg/m³	$\rho_k = 400$ kg/m³	
1-120 / 1-140 / 1-160	17,0 / 20,0 / 24,0	19,0 / 23,0 / 27,0	$F_{2/3,Rk}/4$
2	15,0	17,0	$F_{2/3,Rk}/4$
3a / 3b / 3c	40,0 / 37,9 / 36,3	44,0 / 41,1 / 39,3	$F_{2/3,Rk}/2$
3d / 3e / 3f	34,5 / 33,8 / 30,4	37,4 / 36,7 / 33,1	
4a / 4b / 4c	65,0 / 43,4 / 42,1	72,0 / 47,1 / 45,7	$F_{2/3,Rk}/2$
4d / 4e / 4f	40,6 / 40,0 / 36,9	44,2 / 43,5 / 40,2	
5-120 / 5-140 / 5-160	34,0 / 41,0 / 48,0	38,0 / 45,0 / 54,0	$F_{2/3,Rk}/2$
6a / 6b / 6c	44,0 / 31,3 / 29,0	49,0 / 33,8 / 31,3	$F_{2/3,Rk}/4$
6d / 6e / 6f	26,6 / 25,9 / 22,2	28,9 / 28,1 / 24,1	
7a / 7b / 7c	40,0 / 28,3 / 26,0	44,0 / 30,5 / 28,1	$F_{2/3,Rk}/5$
7d / 7e / 7f	23,7 / 23,0 / 19,4	25,6 / 24,9 / 21,3	

Table 3: $F_{4/5,Rk}$ and $K_{4/5,ser}$ per angle bracket for F_4 and F_5, per two angle brackets for $F_{4/5}$ / connection CLT to CLT ($\rho_k = 350$ kg/m³)

Fastener configuration (see Table 1)	$F_{4,Rk}$ [kN]	$K_{4,ser}$ [kN/mm]	$F_{5,Rk}$ [kN]	$K_{5,ser}$ [kN/mm]	$F_{4/5,Rk}$ [kN]	$K_{4/5,ser}$ [kN/mm]
1-120 / 1-140 / 1-160	31,0	$F_{4,Rk}/3$	7,0 / 9,0 / 10,0	$F_{5,Rk}/10$	38,0 / 40,0 / 41,0	$F_{4/5,Rk}/4$
2	10,0	$F_{4,Rk}/3$	10,0	$F_{5,Rk}/10$	20,0	$F_{4/5,Rk}/4$
3a	31,0		24,0		55,0	
3b	31,0		9,8		41,0	
3c	31,0	$F_{4,Rk}/3$	7,4	$F_{5,Rk}/2$	38,0	$F_{4/5,Rk}/2,5$
3d	31,0		4,9		36,0	
3e	31,0		5,1		36,0	
3f	31,0		4,3		35,0	
4a	38,0		37,0		75,0	
4b	38,0		11,1		49,0	
4c	38,0	$F_{4,Rk}/3$	8,0	$F_{5,Rk}/2$	46,0	$F_{4/5,Rk}/2,5$
4d	38,0		6,2		44,0	
4e	38,0		5,1		43,0	
4f	38,0		4,3		42,0	
5-120 / 5-140 / 5-160	33,0	$F_{4,Rk}/2$	20,0 / 24,0 / 28,0	$F_{5,Rk}/3$	53,0 / 57,0 / 61,0	$F_{4/5,Rk}/2,5$
6a	39,0		13,0		52,0	
6b	39,0		5,0		44,0	
6c	39,0	$F_{4,Rk}/3$	3,8	$F_{5,Rk}/2$	43,0	$F_{4/5,Rk}/2,5$
6d	39,0		2,5		42,0	
6e	39,0		5,1		44,0	
6f	39,0		4,3		43,0	
7a	38,0		12,0		50,0	
7b	38,0		4,0		42,0	
7c	38,0	$F_{4,Rk}/3$	3,0	$F_{5,Rk}/2$	41,0	$F_{4/5,Rk}/2,5$
7d	38,0		2,0		40,0	
7e	38,0		5,0		43,0	
7f	38,0		4,0		42,0	

Table 4: $F_{4/5,Rk}$ and $K_{4/5,ser}$ per angle bracket for F_4 and F_5, per two angle brackets for $F_{4/5}$ / connection CLT to CLT (ρ_k = 400 kg/m³)

Fastener configuration (see Table 1)	$F_{4,Rk}$ [kN]	$K_{4,ser}$ [kN/mm]	$F_{5,Rk}$ [kN]	$K_{5,ser}$ [kN/mm]	$F_{4/5,Rk}$ [kN]	$K_{4/5,ser}$ [kN/mm]
1-120 / 1-140 / 1-160	35,0	$F_{4,Rk}/3$	8,0 / 10,0 / 12,0	$F_{5,Rk}/10$	43,0 / 45,0 / 47,0	$F_{4/5,Rk}/4$
2	10,0	$F_{4,Rk}/3$	10,0	$F_{5,Rk}/10$	20,0	$F_{4/5,Rk}/4$
3a	35,0		28,0		63,0	
3b	35,0		11,0		46,0	
3c	35,0	$F_{4,Rk}/3$	8,0	$F_{5,Rk}/2$	43,0	$F_{4/5,Rk}/2,5$
3d	35,0		5,5		40,0	
3e	35,0		5,1		40,0	
3f	35,0		4,3		39,0	
4a	42,0		42,0		84,0	
4b	42,0		11,1		53,0	
4c	42,0	$F_{4,Rk}/3$	8,0	$F_{5,Rk}/2$	50,0	$F_{4/5,Rk}/2,5$
4d	42,0		6,2		48,0	
4e	42,0		5,1		47,0	
4f	42,0		4,3		46,0	
5-120 / 5-140 / 5-160	35,0	$F_{4,Rk}/2$	23,0 / 28,0 / 33,0	$F_{5,Rk}/3$	58,0 / 63,0 / 68,0	$F_{4/5,Rk}/2,5$
6a	42,0		15,0		57,0	
6b	42,0		5,6		48,0	
6c	42,0	$F_{4,Rk}/3$	4,2	$F_{5,Rk}/2$	46,0	$F_{4/5,Rk}/2,5$
6d	42,0		2,8		45,0	
6e	42,0		5,1		47,0	
6f	42,0		4,3		46,0	
7a	42,0		14,0		56,0	
7b	42,0		4,5		46,0	
7c	42,0	$F_{4,Rk}/3$	3,4	$F_{5,Rk}/2$	45,0	$F_{4/5,Rk}/2,5$
7d	42,0		2,2		44,0	
7e	42,0		5,1		47,0	
7f	42,0		4,3		46,0	

Table 5: $F_{1,Rk}$ per angle bracket / connection timber to concrete with two metal anchors 12 mm in 13 mm holes close to the bend line

Fastener configuration for timber connection in the horizontal flange (see Table 1)	ρ_k = 350 kg/m³ $F_{1,Rk}$ [kN]
1-120	Min {7 kN; 2·N_{Rk}}
1-140	Min {9 kN; 2·N_{Rk}}
1-160	Min {10 kN; 2·N_{Rk}}
2	Min {10 kN; 2·N_{Rk}}
3a, 3b, 3c, 3d, 3f, 3e, 4 a, 4b, 4c, 4d, 4f, 4e, 6a, 6b, 6c, 7a, 7b	Min {10 kN; 2·N_{Rk}}
5-120, 5-140, 5-160	Min {10 kN; 2·N_{Rk}}
6d	Min {9 kN; 2·N_{Rk}}
6e	Min {8 kN; 2·N_{Rk}}
6f	Min {6 kN; 2·N_{Rk}}
7c	Min {9 kN; 2·N_{Rk}}
7d	Min {8 kN; 2·N_{Rk}}
7e	Min {7 kN; 2·N_{Rk}}
7f	Min {5 kN; 2·N_{Rk}}
N_{Rk} is the characteristic axial load-carrying capacity per metal anchor	

Table 6: $F_{2/3,Rk}$ per angle bracket / connection timber to concrete with two metal anchors 12 mm

Fastener configuration for timber connection (see Table 1)	$\rho_k = 350$ kg/m³	
	$F_{2/3,Rk}$ [kN]*	$F_{2/3,Rk}$ [kN]**
1-120	Min {14 kN; 2·V$_{Rk}$}	Min {12 kN; 2·V$_{Rk}$}
1-160	Min {16 kN; 2·V$_{Rk}$}	Min {15 kN; 2·V$_{Rk}$}
1-160	Min {20 kN; 2·V$_{Rk}$}	Min {17 kN; 2·V$_{Rk}$}
2	Min {9,8 kN; 2·V$_{Rk}$}	Min {9,4 kN; 2·V$_{Rk}$}
3a	Min {36 kN; 2·V$_{Rk}$}	Min {27 kN; 2·V$_{Rk}$}
3b	Min {29 kN; 2·V$_{Rk}$}	Min {21 kN; 2·V$_{Rk}$}
3c	Min {24 kN; 2·V$_{Rk}$}	Min {18 kN; 2·V$_{Rk}$}
3d	Min {20 kN; 2·V$_{Rk}$}	Min {15 kN; 2·V$_{Rk}$}
3f	Min {19 kN; 2·V$_{Rk}$}	Min {14 kN; 2·V$_{Rk}$}
3e	Min {13 kN; 2·V$_{Rk}$}	Min {10 kN; 2·V$_{Rk}$}
4a	Min {42 kN; 2·V$_{Rk}$}	Min {34 kN; 2·V$_{Rk}$}
4b	Min {28 kN; 2·V$_{Rk}$}	Min {34 kN; 2·V$_{Rk}$}
4c	Min {24 kN; 2·V$_{Rk}$}	Min {28 kN; 2·V$_{Rk}$}
4d	Min {19 kN; 2·V$_{Rk}$}	Min {23 kN; 2·V$_{Rk}$}
4f	Min {18 kN; 2·V$_{Rk}$}	Min {22 kN; 2·V$_{Rk}$}
4e	Min {13 kN; 2·V$_{Rk}$}	Min {15 kN; 2·V$_{Rk}$}
5-120	Min {24 kN; 2·V$_{Rk}$}	Min {19 kN; 2·V$_{Rk}$}
5-140	Min {28 kN; 2·V$_{Rk}$}	Min {23 kN; 2·V$_{Rk}$}
5-160	Min {34 kN; 2·V$_{Rk}$}	Min {28 kN; 2·V$_{Rk}$}
6a	Min {27 kN; 2·V$_{Rk}$}	Min {16 kN; 2·V$_{Rk}$}
6b	Min {22 kN; 2·V$_{Rk}$}	Min {13 kN; 2·V$_{Rk}$}
6c	Min {18 kN; 2·V$_{Rk}$}	Min {11 kN; 2·V$_{Rk}$}
6d	Min {15 kN; 2·V$_{Rk}$}	Min {9 kN; 2·V$_{Rk}$}
6f	Min {14 kN; 2·V$_{Rk}$}	Min {9 kN; 2·V$_{Rk}$}
6e	Min {10 kN; 2·V$_{Rk}$}	Min {6 kN; 2·V$_{Rk}$}
7a	Min {24 kN; 2·V$_{Rk}$}	Min {13 kN; 2·V$_{Rk}$}
7b	Min {19 kN; 2·V$_{Rk}$}	Min {10 kN; 2·V$_{Rk}$}
7c	Min {16 kN; 2·V$_{Rk}$}	Min {9 kN; 2·V$_{Rk}$}
7d	Min {13 kN; 2·V$_{Rk}$}	Min {7 kN; 2·V$_{Rk}$}
7f	Min {12 kN; 2·V$_{Rk}$}	Min {7 kN; 2·V$_{Rk}$}
7e	Min {9 kN; 2·V$_{Rk}$}	Min {5 kN; 2·V$_{Rk}$}
* with two 12 mm metal anchors in 13 mm holes close to bend line ** with two 12 mm metal anchors in 13 mm holes away from bend line		

Table 7: $F_{4/5,Rk}$ per angle bracket for F_4 and F_5, per two angle brackets for $F_{4/5}$ / connection timber to concrete with two metal anchors 12 mm in 13 mm holes close to or away from the bend line (ρ_k = 350 kg/m³)

Fastener configuration for timber connection (see Table 1)	$F_{4,Rk}$ [kN] single angle bracket	$F_{5,Rk}$ [kN] single angle bracket	$F_{4/5,Rk}$ [kN] double angle brackets
1-120	Min {31 kN; 2·V_{Rk}}	Min {7 kN; 2·V_{Rk}}	Min {38 kN; 4·V_{Rk}}
1-140		Min {9 kN; 2·V_{Rk}}	Min {40 kN; 4·V_{Rk}}
1-160		Min {10 kN; 2·V_{Rk}}	Min {41 kN; 4·V_{Rk}}
2	Min {10 kN; 2·V_{Rk}}	Min {10 kN; 2·V_{Rk}}	Min {20 kN; 4·V_{Rk}}
3a	Min {31 kN; 2·V_{Rk}}	Min {24 kN; 2·V_{Rk}}	Min {55 kN; 4·V_{Rk}}
3b / 3c / 3d / 3e / 3f	Min {$F_{4,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{5,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{4/5,Rk,Table\ 3}$; 2·V_{Rk}}
4a	Min {31 kN; 2·V_{Rk}}	Min {37 kN; 2·V_{Rk}}	Min {68 kN; 4·V_{Rk}}
4b / 4c / 4d / 4e / 4f	Min {$F_{4,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{5,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{4/5,Rk,Table\ 3}$; 2·V_{Rk}}
5-120	Min {31 kN; 2·V_{Rk}}	Min {20 kN; 2·V_{Rk}}	Min {51 kN; 4·V_{Rk}}
5-140		Min {24 kN; 2·V_{Rk}}	Min {55 kN; 4·V_{Rk}}
5-160		Min {28 kN; 2·V_{Rk}}	Min {59 kN; 4·V_{Rk}}
6a	Min {31 kN; 2·V_{Rk}}	Min {13 kN; 2·V_{Rk}}	Min {44 kN; 4·V_{Rk}}
6b / 6c / 6d / 6e / 6f	Min {$F_{4,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{5,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{4/5,Rk,Table\ 3}$; 2·V_{Rk}}
7a	Min {31 kN; 2·V_{Rk}}	Min {12 kN; 2·V_{Rk}}	Min {43 kN; 4·V_{Rk}}
7b / 7c / 7d / 7e / 7f	Min {$F_{4,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{5,Rk,Table\ 3}$; 2·V_{Rk}}	Min {$F_{4/5,Rk,Table\ 3}$; 2·V_{Rk}}

Combined forces in DENEB angle bracket – timber-to-timber connection
If the forces F_1, $F_{2/3}$ or F_4/F_5 act at the same time, the following inequality shall be fulfilled:

$$\left(\frac{F_{1,Ed}}{F_{1,Rd}}\right)^2 + \left(\frac{F_{23,Ed}}{F_{23,Rd}}\right)^2 + \left(\frac{F_{4,Ed}}{F_{4,Rd}}\right)^2 + \left(\frac{F_{5,Ed}}{F_{5,Rd}}\right)^2 \leq 1$$

The forces F_4 and F_5 are forces with opposite direction. Therefore, only one force F_4 or F_5 is able to act simultaneously with F_1 or F_{23}, while the other shall be set to zero.

Combined forces in DENEB angle bracket – timber-to-concrete connection
If the forces F_1, $F_{2/3}$ or F_4/F_5 act at the same time, the requirements of the ETA for the metal anchors must be fulfilled.

Table 8: $F_{1,Rk}$ per DENEB plate connector / connection timber to timber

Fastener configuration	$F_{1,Rk}$ [kN]	
	$\rho_k =$ 350 kg/m³	$\rho_k =$ 400 kg/m³
1-120 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x120 per flap arranged in all 13 mm holes under 90° to the timber surface	15,4	17,2
1-140 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x140 per flap arranged in all 13 mm holes under 90° to the timber surface	17,1	18,6
1-160 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x160 per flap arranged in all 13 mm holes under 90° to the timber surface	18,4	20,0
3a - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	59,2	64,0
3b - 30 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	52,4	56,6
3c - 26 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	47,8	51,7
3d - 23 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	36,4	39,4
3e - 21 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	27,3	29,5
3f - 16 ASSY 4 JH or TIMTEC Joist hanger screws 5x50 per flap arranged in 5 mm holes under 90° to the timber surface	15,9	17,2
4a - 35 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	67,0	72,7
4b - 30 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	59,3	64,3
4c - 26 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	54,1	58,7
4d - 23 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	41,2	44,7
4e - 21 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	30,9	33,5
4f - 16 ASSY 4 JH or TIMTEC Joist hanger screws 5x70 per flap arranged in 5 mm holes under 90° to the timber surface	18,0	19,6
5-120 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x120 per flap in 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 in 5 mm holes under 90° to the timber surface	20,0	23,0
5-140 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x140 per flap in 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 in 5 mm holes under 90° to the timber surface	24,0	28,0
5-160 - Four ASSY plus VG 4 combi or TIMTEC plus VG Kombi screws 12x160 per flap in 13 mm holes and 9 additional ASSY 4 JH or TIMTEC Joist hanger screws 5x70 in 5 mm holes under 90° to the timber surface	28,0	33,0
6a - 35 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	50,5	54,3
6b - 30 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	44,6	48,0
6c - 26 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	40,8	43,8
6d - 23 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	31,1	33,4
6e - 21 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	23,3	25,1
6f - 16 ringed shank nails 4x60 per flap arranged in 5 mm holes under 90° to the timber surface	13,6	14,6

Table 8 continued: $F_{1,Rk}$ per DENEB plate connector / connection timber to timber

7a - 35 ringed shank nails 4x50 per flap arranged in 5 mm holes under 90° to the timber surface	46,1	49,5
7b - 30 ringed shank nails 4x50 per flap arranged in 5 mm holes under 90° to the timber surface	40,8	43,8
7c - 26 ringed shank nails 4x50 per flap arranged in 5 mm holes under 90° to the timber surface	37,2	40,0
7d - 23 ringed shank nails 4x50 per per flap arranged in 5 mm holes under 90° to the timber surface	28,4	30,5
7e - 21 ringed shank nails 4x50 per flap arranged in 5 mm holes under 90° to the timber surface	21,3	22,9
7f - 16 ringed shank nails 4x50 per flap arranged in 5 mm holes under 90° to the timber surface	12,4	13,3

Table 9: $F_{2/3,Rk}$ per DENEB plate connector / connection timber to timber

Fastener configuration (see Table 1)	$F_{2/3,Rk}$ [kN]	
	$\rho_k = 350$ kg/m³	$\rho_k = 400$ kg/m³
1-120 / 1-140 / 1-160	17,0 / 20,0 / 24,0	19,0 / 23,0 / 27,0
3a / 3b / 3c	40,0 / 37,9 / 36,3	44,0 / 41,1 / 39,3
3d / 3e / 3f	34,5 / 33,8 / 30,4	37,4 / 36,7 / 33,1
4a / 4b / 4c	65,0 / 43,4 / 42,1	72,0 / 47,1 / 45,7
4d / 4e / 4f	40,6 / 40,0 / 36,9	44,2 / 43,5 / 40,2
5-120 / 5-140 / 5-160	34,0 / 41,0 / 48,0	38,0 / 45,0 / 54,0
6a / 6b / 6c	44,0 / 31,3 / 29,0	49,0 / 33,8 / 31,3
6d / 6e / 6f	26,6 / 25,9 / 22,2	28,9 / 28,1 / 24,1
7a / 7b / 7c	40,0 / 28,3 / 26,0	44,0 / 30,5 / 28,1
7d / 7e / 7f	23,7 / 23,0 / 19,4	25,6 / 24,9 / 21,3

Table 10: $F_{1,Rk}$ per DENEB plate connector / connection timber to concrete with two metal anchors 12 mm in 13 mm holes in one flap

All fastener configurations for timber connections in one flap (see Table 8)	$F_{1,Rk} = \text{Min}\{F_{1,Rk,Table\ 8}; 2 \cdot V_{Rk}\}$
V_{Rk} is the characteristic lateral load-carrying capacity per metal anchor	

Table 11: $F_{2/3,Rk}$ per DENEB plate connector / connection timber to concrete with two metal anchors 12 mm in 13 mm holes in one flap

All fastener configurations for timber connections in one flap	$F_{2/3,Rk} = F_{2/3,Rk,Table\ 6}$

Definitions of forces, their directions and eccentricity
Forces - Timber to Timber connection
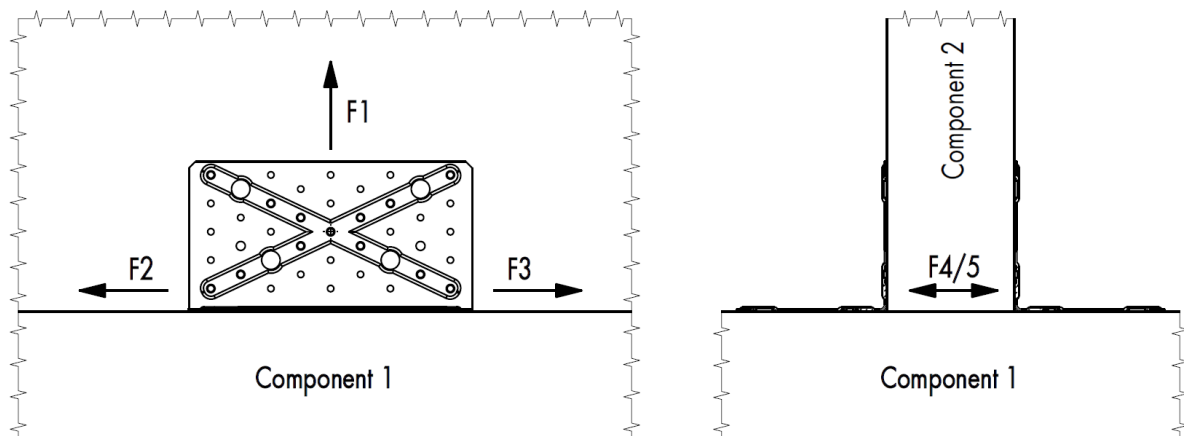
Fastener specification
Holes are marked referring to the fastener pattern.

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 Lateral force acting in the joint between the component 2 and component 1 in the component 2
F_3 direction
$F_{4/5}$ Lateral force acting in the joint between the component 2 and component 1 in the component 1
           direction

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.
F_2 and Lateral force acting in the joint between the component 2 and component 1 in the component 2
F_3 direction. The component 2 shall be prevented from rotation.
F_4 Lateral force acting perpendicular to the central axis of the joint towards the angle bracket.
F_5 Lateral force acting perpendicular to the central axis of the joint away from the angle bracket.

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.
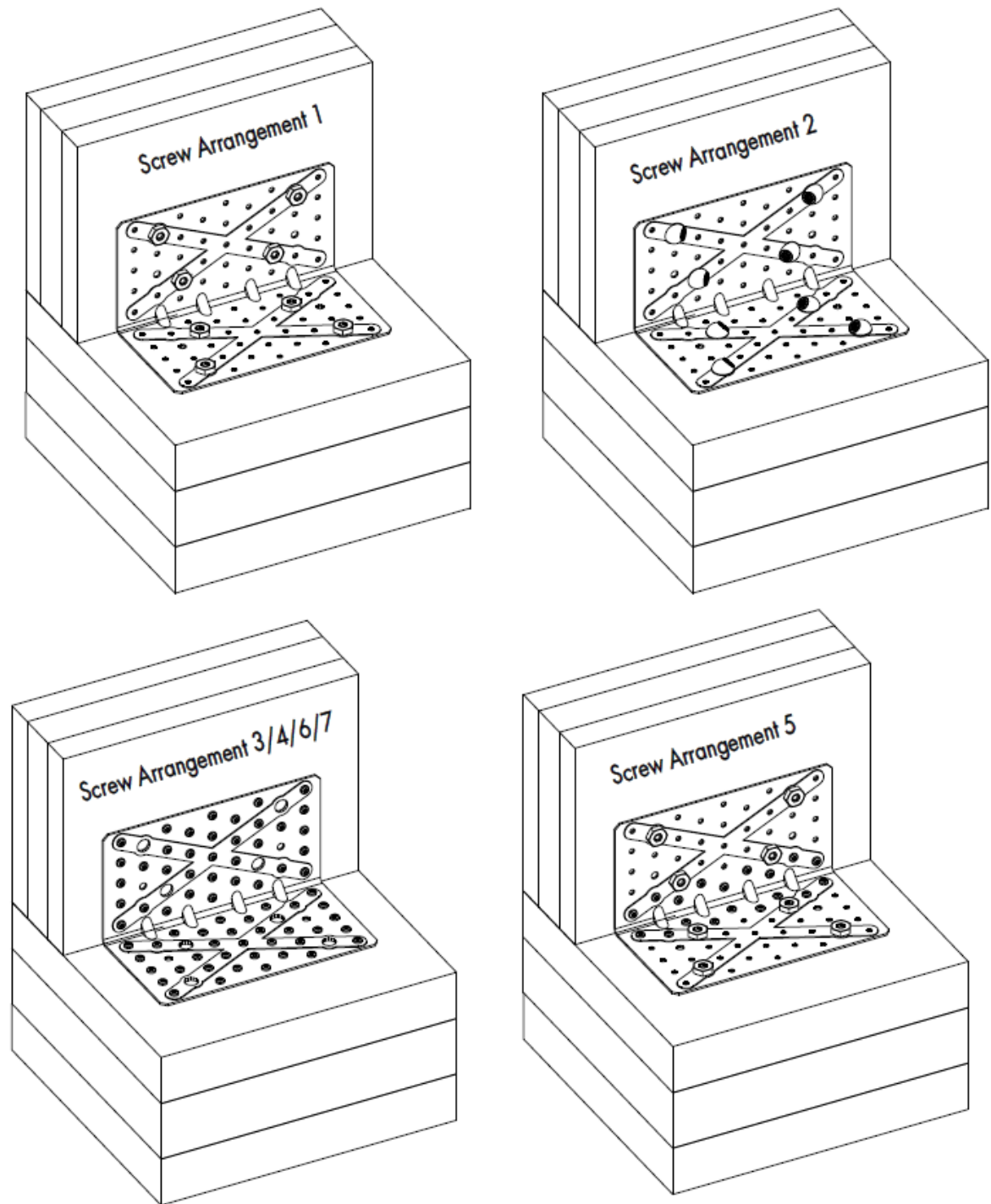
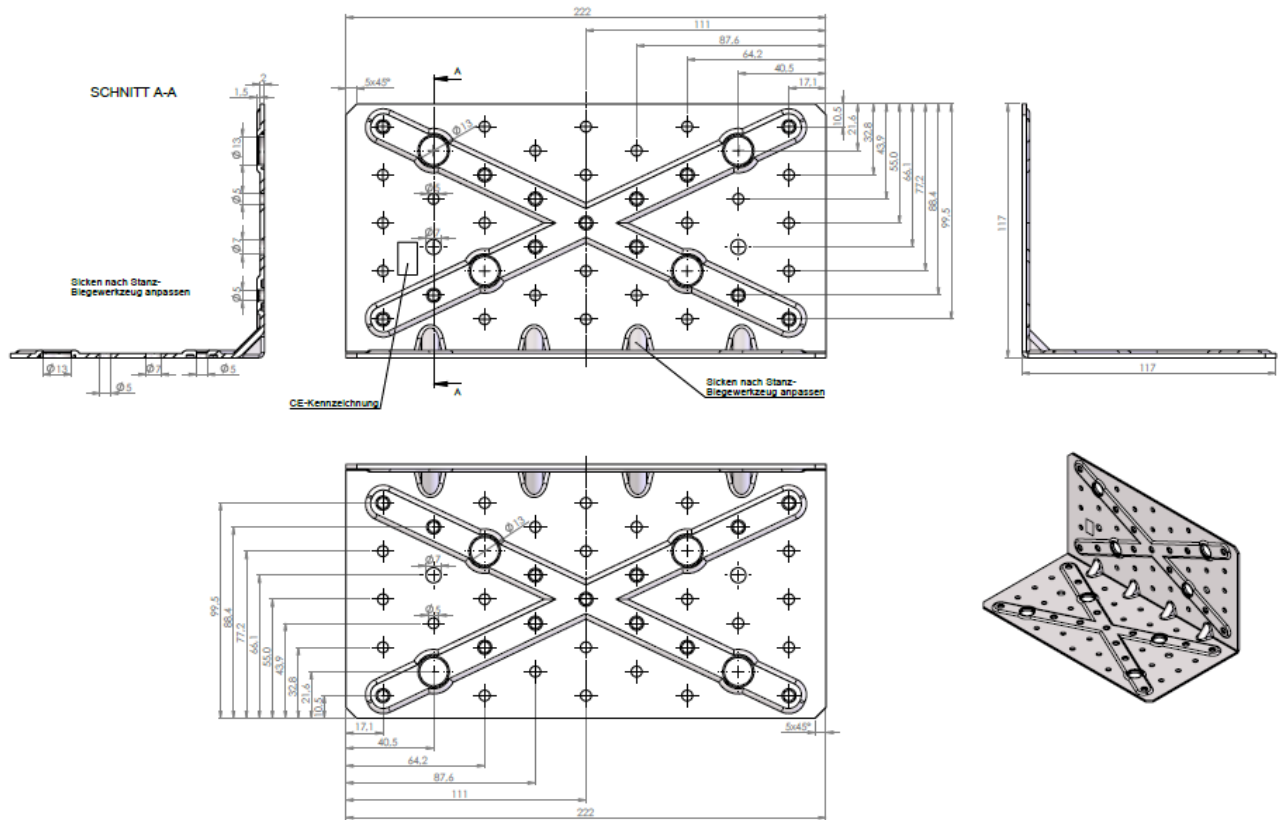**BB DENEB Nailing Plates**

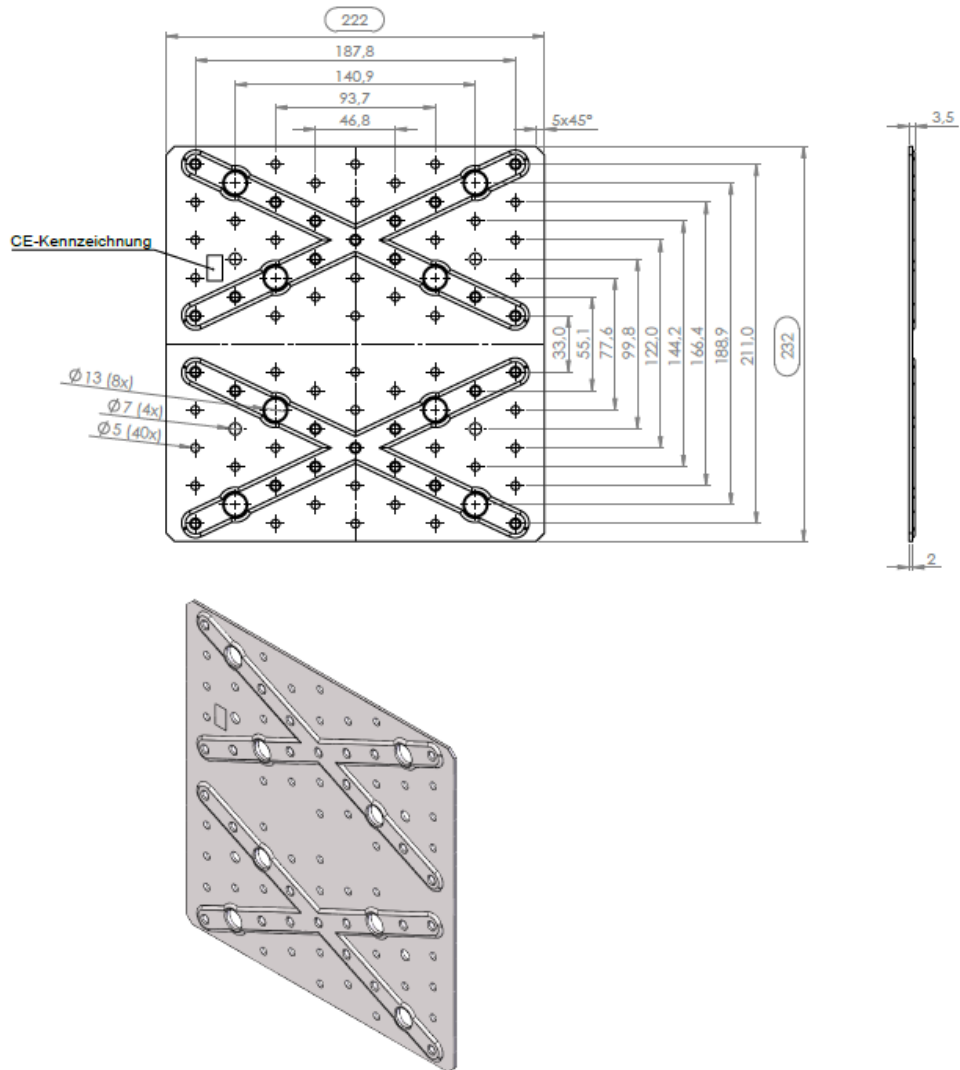Figure B. 1 Fastener Arrangements

Figure B.2 Dimensions DENEB Angle Bracket

Figure B.3 Dimensions DENEB Plate Connector