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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-09/0361 of 2024/05/23

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:	Rotho Blaas joist bearing AluMINI, AluMIDI and AluMAXI
Product family to which the above construction product belongs:	Three-dimensional nailing plate (Joist bearings)
Manufacturer:	ROTHO BLAAS SRL Via dell'Adige 2/1 IT-39040 Cortaccia (BZ) Tel. + 39 0471 818400 Fax + 39 0471 818484 Internet www.rothoblaas.com
Manufacturing plant:	ROTHO BLAAS SRL Held on file by ETA-Danmark AS
This European Technical Assessment contains:	42 pages including 3 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 previous ETA with the same number and issued on 2019-12-05

II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

Rotho Blaas joist bearings are one-piece, face-fixed joist bearings to be used in timber to timber or timber to concrete or steel connections.

The joist bearings are made from aluminium alloy EN AW-6005A T6 or EN AW-6060 T5 or EN AW-6082 T6 according to EN 573-3. Dimensions, hole positions, aluminium alloy and typical installations are shown in Annexes A and C.

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

The joist bearings are intended for use in making end-grain to side-grain connections in load bearing timber structures, as a connection between a wood based joist or column and a solid timber or wood based header as well as connections between a timber joist or column and a concrete structure or a steel member, 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.

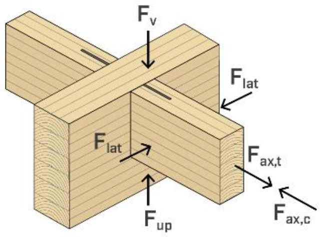
The joist bearings can be installed as connections between wood-based members such as:

- Structural solid timber according to EN 14081,
- Glued solid timber according to EN 14080
- Glulam according to EN 14080 or ETA,
- Cross-laminated timber according to ETA,
- Solid wood panels according to EN 13353 and EN 13986,
- LVL according to EN 14374 or ETA,
- FST according to ETA-14/0354,
- Plywood according to EN 636 or ETA,
- Parallam PSL,
- Intrallam LSL,
- Engineered wood products with certified mechanical resistances for connections with dowel-type fasteners

However, the calculation methods are only allowed for a characteristic wood density of up to 460 kg/m^3 for softwood and up to 730 kg/m^3 for LVL or hardwood. Even though the wood-based material may have a larger density, this must not be used in the formulas for the load-carrying capacities of the fasteners.

Annex B states the formulas for the characteristic load-carrying capacities of the connections with joist bearings. The design of the connections shall be in accordance with Eurocode 5 or a similar national Timber Code.

It is assumed that the forces acting on the joist bearing connection are F_{up} or F_{down} or F_{ax} perpendicular to the header axis and F_{lat} perpendicular to the joist bearing axis. The forces F_{up} and F_{down} shall act in the symmetry plane of the joist bearing. It is assumed that the forces F_{up}, F_{down} or F_{lat} are acting with an eccentricity e with regard to the side grain surface of the header.



$F_v = F_{down}$	downward
F_{up}	uplift
F_{lat}	lateral
$F_{ax,t}$	axial tension
$F_{ax,c}$	axial compression

It is assumed that the header beam is prevented from rotating. If the header beam only has installed a joist bearing on one side the eccentricity moment $M_v = F_d \cdot (B_H / 2 + e)$ shall be considered. The same applies when the header has joist bearing connections on both sides, but with vertical forces which differ more than 20%.

The joist bearings are intended for use for connections subject to static or quasi static loading.

The aluminium hangers are for use in timber structures subject to the conditions defined by the service classes 1, 2 and 3 of EN 1995-1-1, (Eurocode 5).

The scope of the joist bearings regarding resistance to corrosion shall be defined according to national provisions that apply at the installation site considering environmental conditions and in conjunction with the admissible service conditions according to EN 1995-1-1 and the admissible corrosivity category as described and defined in EN ISO 12944-2.

The provisions made in this European Technical Assessment are based on an assumed intended working life of the joist bearings 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 joist bearings are made from aluminium classified as Euroclass A1 in accordance with EN 13501-1 and Commission Delegated Regulation 2016/364
Resistance to fire	No performance assessed
3.3 General aspects related to the performance of the product	The joist bearings 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, 2 and 3
Identification	See Annex A

*) See additional information in section 3.4 – 3.7.

3.4 Methods of verification

Safety principles and partial factors

The characteristic load-carrying capacities are based on the characteristic values of the fasteners and the aluminium plates. To obtain design values the capacities have to be divided by different partial factors for the material properties, in case of timber failure 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.

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

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

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

3.5 Mechanical resistance and stability

See annex B for characteristic load-carrying capacities of the joist bearings.

The characteristic capacities of the joist bearings are determined by calculation as described in the EAD 130186-00-0603 clause 2.2.1. They should be used for designs in accordance with Eurocode 5 or a similar national Timber Code.

The design models allow the use of fasteners described in the table on page 15 in Annex A:

- *Threaded nails (ringed shank nails), screws, bolts, dowels, or self-drilling dowels in accordance with EN 14592*
- *Threaded nails (ringed shank nails) according to ETA-22/0002*
- *Self-tapping screws in accordance with ETA-11/0030*
- *Metal anchors in accordance with an ETA*

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

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, 2 and 3.
In accordance with EAD 130186-00-0603 the aluminium joist bearings are made from aluminium alloy EN AW-6005A T6 or EN AW-6060 T5 or EN AW-6082 T6 according to EN 573-3:2009 and may be either anodized or coated with an organic coating.

3.7 General aspects related to the use of the product

Rotho Blaas joist bearings 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.

Joist bearing connections

A joist bearing connection is deemed fit for its intended use provided:

Header – support conditions

- The header shall be restrained against rotation and be free from wane under the joist bearing.

  If the header carries joists only on one side the eccentricity moment from the joists $M_{ec} = R_{joist}$ (b_{header}/2+86mm) shall be considered for joist bearings AluMINI and AluMIDI and $M_{ec} = R_{joist}$ (b_{header}/2+139mm) for joist bearings AluMAXI at the strength verification of the header.
  R_{joist} Reaction force from the joists
  b_{header} Width of header

- For a header with joists from both sides but with different reaction forces a similar consideration applies.

Wood to wood connections

- Joist bearings are fastened to wood-based headers by nails, bolts, or screws and to wood-based joists by dowels.
- There shall be nails or screws and dowels in all holes.
- The characteristic capacity of the joist bearing connection is calculated according to the manufacturer's technical documentation, dated 2009-07-23, 2023-08-13 and 2023-08-16.
- The joist bearing connection is designed in accordance with Eurocode 5 or an appropriate national code.
- The gap between the end of the joist and the surface, where contact stresses can occur during loading shall be limited. This means that for joist bearings the gap between the surface of the flaps and the end of the joist shall be maximum 8 mm for AluMINI and AluMIDI and 14 mm for AluMAXI.
- The groove in the joist and the surface of the header shall have a plane surface against the whole joist bearing.
- The depth of the joist shall be so large that the top (bottom) of the joist is at least $a_{4,t}$ above (below) the upper (lower) dowel in the joist.
- Nails or screws to be used shall have a diameter and head shape, which fits the holes of the joist bearings.

Wood to concrete or steel

The above-mentioned rules for wood-to-wood connections are applicable also for the connection between the joist and the joist bearing.

- The joist bearing connection is designed in accordance with Eurocodes 2, 3, 5 or 9 or an appropriate national code.
- The joist bearing shall be in close contact with the concrete or steel over the whole face. There shall be no intermediate layers in between.
- The gap between the end of the joist and the surface, where contact stresses can occur during loading shall be limited. This means that the gap between the end grain surface of the joist and that of the concrete or steel shall be maximum 27 mm.
- The bolt or metal anchor shall have a diameter not less than the hole diameter minus 2 mm.
- The bolts or metal anchors shall be placed symmetrically about the vertical symmetry line. There shall always be bolts in the 2 upper holes.
- The upper bolts shall have washers according to EN ISO 7094.

4 Assessment and verification of constancy of performance (hereinafter AVCP) system applied, with reference to its legal base

4.1 AVCP system

According to the decision 97/638/EC of the European Commission1, 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 provided for 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.

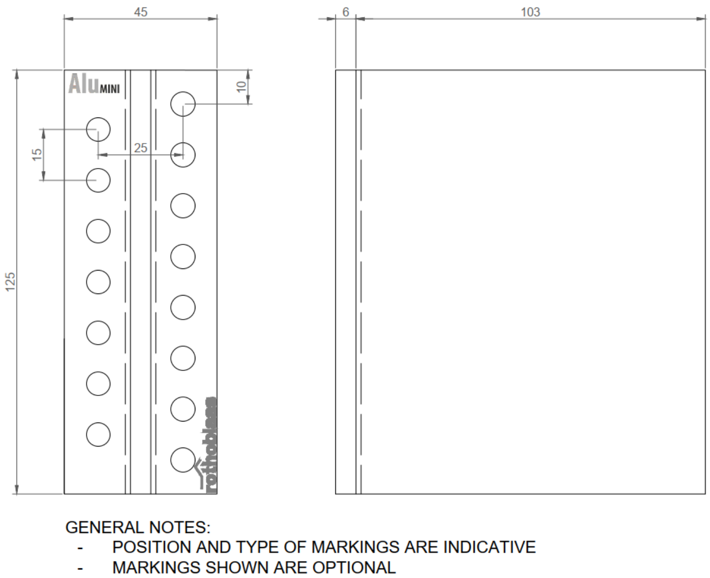
Issued in Copenhagen on 2024-05-23 by

Thomas Bruun
Managing Director, ETA-Danmark

Annex A
Product details and definitions

Joist bearing AluMINI

Face mount hanger with flanges without pre-punched holes for the joist connection. 6.0 mm thick aluminium alloy EN AW 6060 T5 according to EN 573-3:2009.



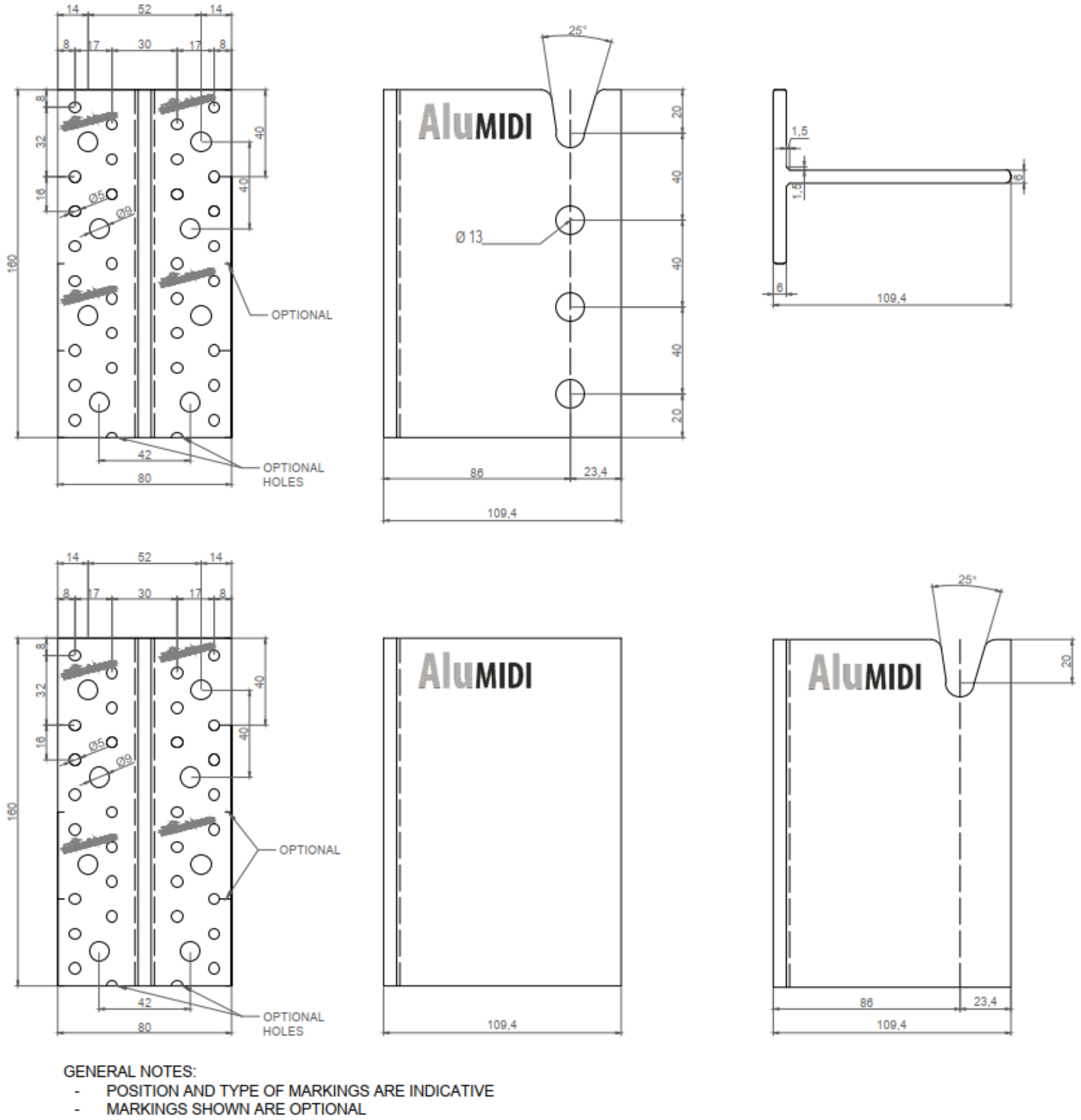
Drawing: joist bearing 125

Joist bearing	N° of nail holes	
	N°	d
65	7	7
95	11	7
125	15	7
155	19	7
185	23	7
215	27	7

For joist bearings AluMINI, the distance of the centroid of the joist connection from the header surface must not exceed 86 mm.

The joist bearing AluMINI are also supplied in lengths of 2165 mm, which are cut to fit the lengths in the above table and to intermediate sizes within the range of 65 mm - 215 mm. For the load-carrying capacity of an AluMINI with intermediate size, refer to the next smaller tabulated size.

Joist bearing AluMIDI
Face mount hanger with flanges with or without pre-punched holes for the joist connection. 6.0 mm thick aluminium alloy EN AW 6005A T6 according to EN 573-3:2009.



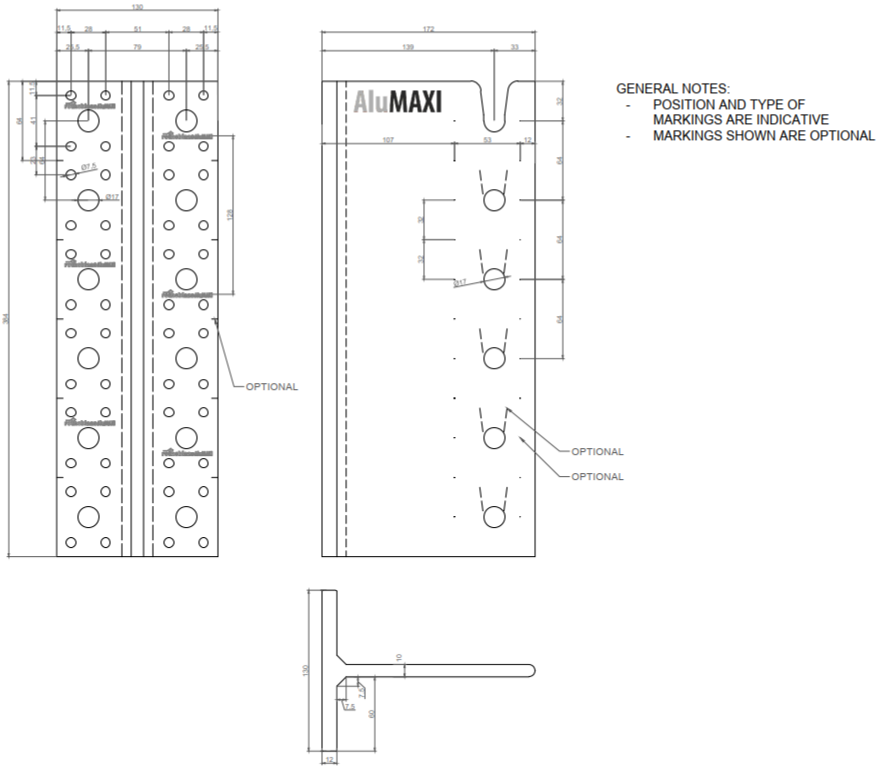
Drawing: Joist bearing AluMIDI 160 with pre-punched holes for the joist connection (top), joist bearing AluMIDI 160 without pre-punched holes for the joist connection (bottom centre) and joist bearing AluMIDI 160 without pre-punched holes and positioning notch (optional) (bottom right)

Joist bearing	N° of nail holes		N° of dowel holes		N° of anchor holes		Joist bearing	N° of nail holes		N° of dowel holes		N° of anchor holes	
	N°	d	N°	d	N°	d		N°	d	N°	d	N°	d
80	14	5	-	-	4	9	320	62	5	8	13	16	9
120	22	5	3	13	6	9	360	70	5	9	13	18	9
160	30	5	4	13	8	9	400	78	5	10	13	20	9
200	38	5	5	13	10	9	440	86	5	11	13	22	9
240	46	5	6	13	12	9	480	94	5	12	15	24	11
280	54	5	7	13	14	9	520	102	5	13	16	26	12

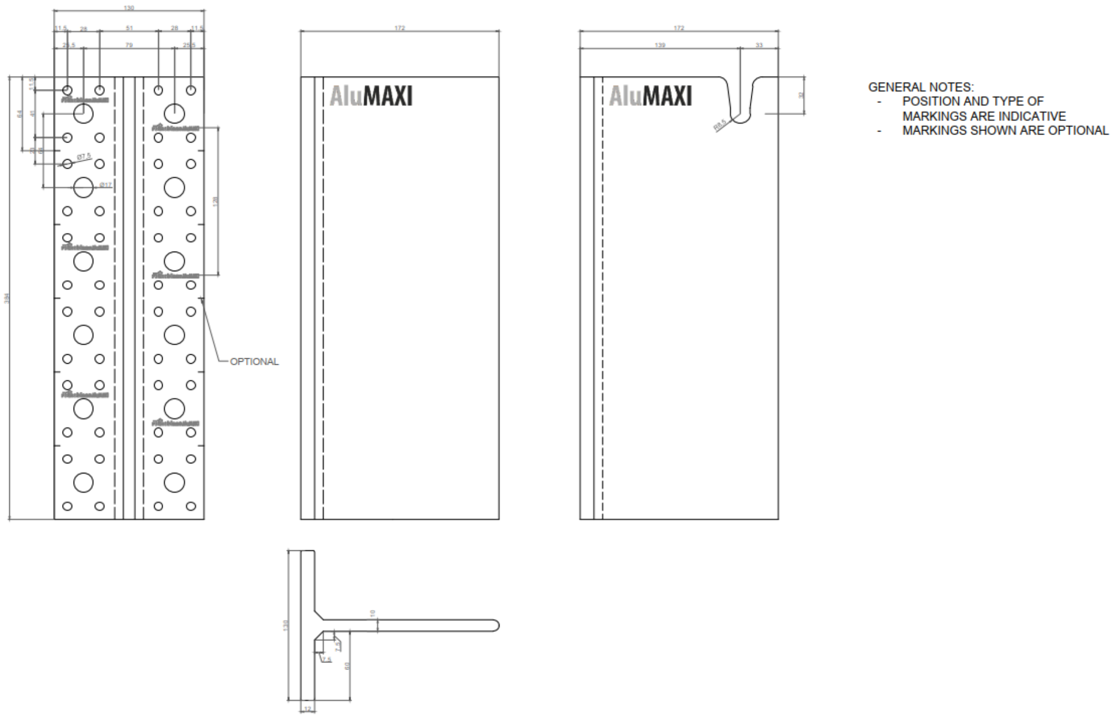
For joist bearings AluMIDI without pre-punched holes, the distance of the centroid of the joist connection from the header surface must not exceed 86 mm.

The joist bearings AluMIDI are also supplied in lengths of 2200 mm, which are cut to fit the lengths in the above table and to intermediate sizes within the range of 80 mm - 520 mm. For the load-carrying capacity of an AluMIDI with intermediate size, refer to the next smaller tabulated size.

Joist bearing AluMAXI
Face mount hanger with flanges with or without pre-punched holes for the joist connection. 10.0 and 12.0 mm thick aluminium alloy EN AW 6005A T6 according to EN 573-3:2009.

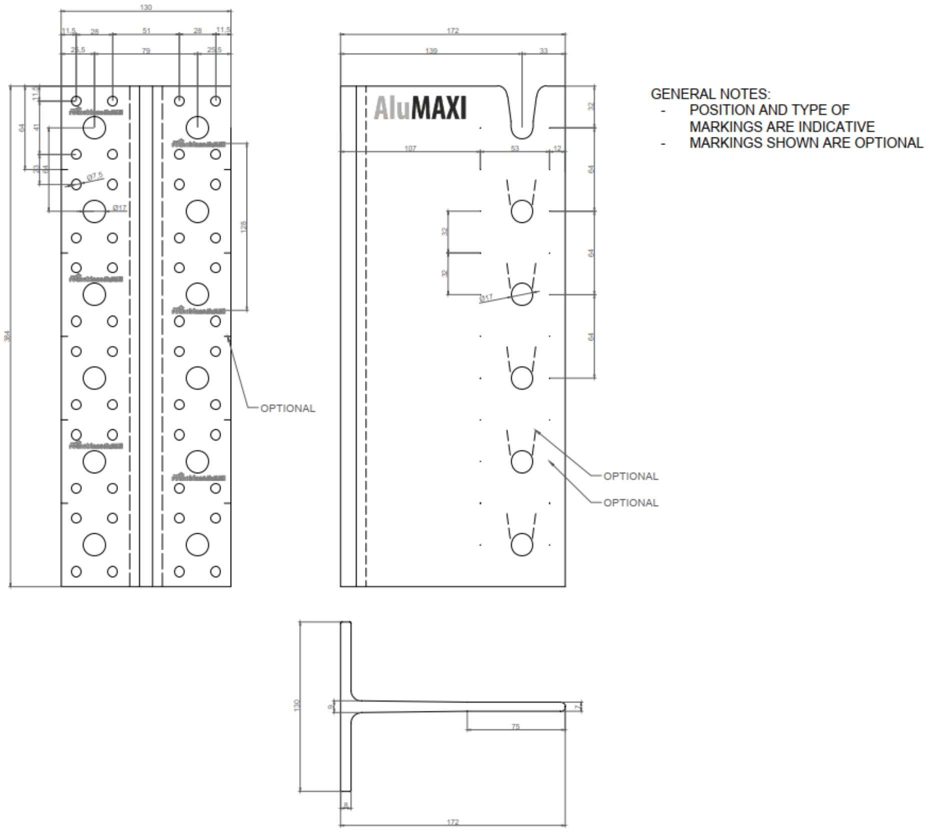


Drawing: Joist bearing AluMAXI 384 with pre-punched holes for the joist connection (top), joist bearing AluMAXI 384 without pre-punched holes for the joist connection (bottom left) and joist bearing AluMAXI 384 without pre-punched holes and with positioning notch (optional) (bottom right)

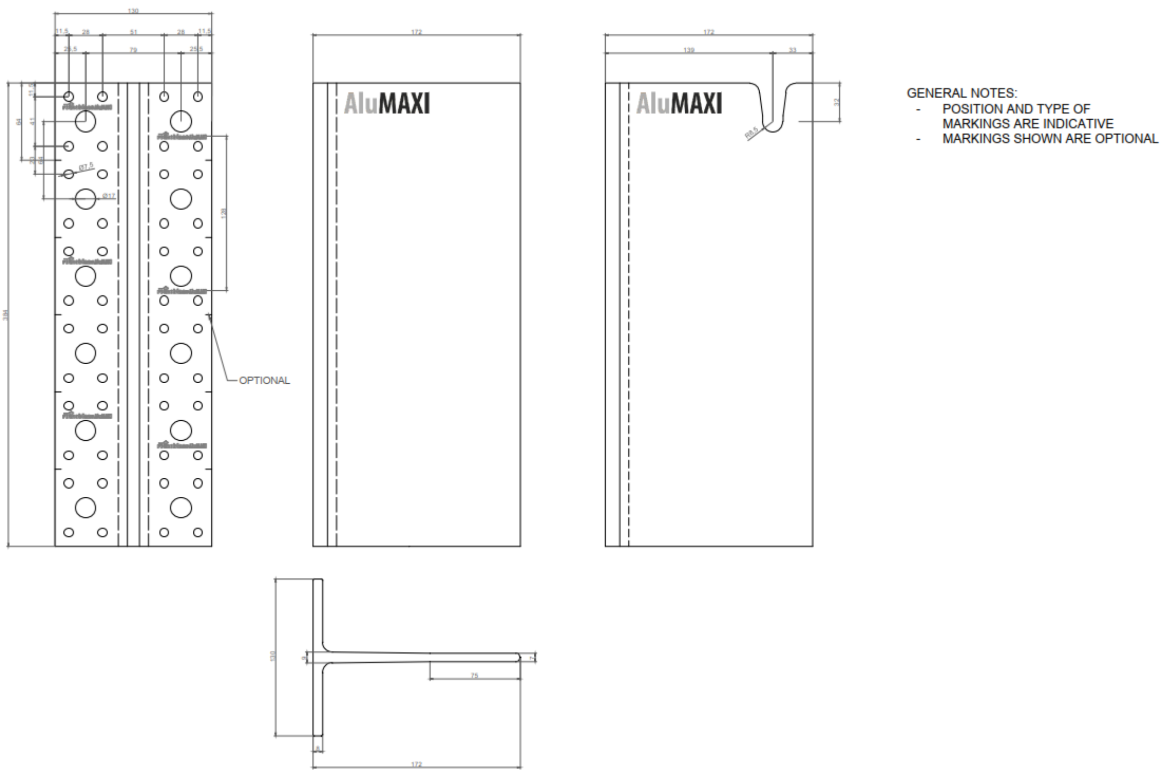


Joist bearing AluMAXI

Face mount hanger with flanges with or without pre-punched holes for the joist connection. 7.0 to 9.0 and 8.0 mm thick aluminium alloy EN AW 6082 T6 according to EN 573-3:2009.



Drawing: Joist bearing AluMAXI 384 with pre-punched holes for the joist connection (top), joist bearing AluMAXI 384 without pre-punched holes for the joist connection (bottom left) and joist bearing AluMAXI 384 without pre-punched holes and with positioning notch (optional) (bottom right)



Joist bearing	**N° of nail holes**		**N° of dowel holes**		**N° of anchor/bolt holes**	
	N°	**d**	**N°**	**d**	**N°**	**d**
320	40	7,5	5	17	10	17
384	48	7,5	6	17	12	17
448	56	7,5	7	17	14	17
512	64	7,5	8	17	16	17
576	72	7,5	9	17	18	17
640	80	7,5	10	17	20	17
704	88	7,5	11	17	22	17
768	96	7,5	12	17	24	17
832	104	7,5	13	17	26	17
896	112	7,5	14	17	28	17
960	120	7,5	15	17	30	17

For joist bearings AluMAXI without pre-punched holes, the distance of the centroid of the joist connection from the header surface must not exceed 139 mm.

The joist bearings AluMAXI are also supplied in lengths of 2176 mm, which are cut to fit the lengths in the above table and to intermediate sizes within the range of 320 mm - 960 mm. For the load-carrying capacity of an AluMAXI with intermediate size, refer to the next smaller tabulated size.

Fastener types and sizes

NAIL diameter	Length	Nail type
4.0	40 - 100	Ringed shank nails according to EN 14592 or ETA-22/0002
6.0	60 - 100	Ringed shank nails according to EN 14592 or ETA-22/0002

In the formulas in Annex B the capacities for threaded nails calculated from the formulas of Eurocode 5 for nails according to EN 14592 and from the formulas in ETA-22/0002 for LBA nails are used assuming a thick steel plate when calculating the lateral nail load-carrying-capacity. The load bearing capacities of the joist bearings have been determined based on the use of connector nails 6,0 x L mm (AluMINI and AluMAXI) and 4,0 x L mm (AluMIDI). The characteristic withdrawal capacity of the nails must be determined by calculation in accordance with EN 1995-1-1: 2004, paragraph 8.3.2 (head pull-through is not relevant):

$$F_{ax,Rk} = f_{ax,k} \cdot d \cdot \ell_{ef} \cdot \left(\frac{\rho_k}{350}\right)^{0,8}$$

Where:

$f_{ax,k}$ Characteristic value of the withdrawal parameter in N/mm^2 for Rotho Blaas LBA nails according to ETA-22/0002

d Nail diameter in mm

ℓ_{ef} Penetration depth of the profiled shank in mm

ρ_k Characteristic timber density in kg/m³

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.

Screw diameter	Length	Screw type
5.0	40 – 120	Self-tapping screw according to EN 14592 or ETA-11/0030
7.0	60 - 100	Self-tapping screw according to EN 14592 or ETA-11/0030

In the formulas in Annex B the capacities for self-tapping screws calculated from the formulas of Eurocode 5 are used assuming a thick steel plate when calculating the lateral load-carrying-capacity. The load bearing capacities of the joist bearings type AluMINI and AluMIDI have been determined based on the use of screws 5,0 x L mm in accordance with the ETA-11/0030 for the screws and joist bearings type AluMAXI have been determined based on the use of screws 7,0 x L mm in accordance with the ETA-11/0030 for the screws. The characteristic withdrawal capacity of the screws has to be determined by calculation:

$$F_{ax,\alpha,Rk} = \frac{n_{ef} \cdot k_{ax} \cdot f_{ax,k} \cdot d \cdot \ell_{ef}}{k_\beta} \left(\frac{\rho_k}{\rho_a}\right)^{0,8}$$

Where:

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

d Screw diameter in mm

ℓ_{ef} Penetration depth of the thread in mm

k_{ax} and k_β see ETA-11/0030.

The characteristic value of the withdrawal resistance $f_{ax,k}$ for Rotho Blaas LBS or LBSH screws d = 5,0 and 7,0 mm and for HBS and HBSP screws d = 5,0 mm are given in ETA-11/0030.

- in solid or glued laminated timber, cross laminated timber and SWP members with maximum characteristic density of 440 kg/m³ and ρ_a = 350 kg/m³: $f_{ax,k}$ = 11,7 N/mm²
- in non-pre-drilled LVL with 460 kg/m³ ≤ ρ_k ≤ 550 kg/m³ and ρ_a = 500 kg/m³: $f_{ax,k}$ = 15,0 N/mm²

The shape of the screw directly under the head shall be in the form of a truncated cone with a diameter under the screw head which fits or exceeds the hole diameter (see annex A of ETA-11/0030).

BOLTS, METAL ANCHORS or DOWELS diameter	Corresponding hole diameter in aluminium plate	Fastener type
5.5 to 7.5	-	Self-drilling dowels according to EN 14592
5.0 to 8.0	Max. 0.5 mm larger than the dowel diameter	Bolts or dowels according to EN 14592, metal anchors according to manufacturer's specification
10.0	Max. 1 mm larger than the bolt or dowel diameter	Bolts or dowels according to EN 14592, metal anchors according to manufacturer's specification
12.0		
16.0		

Annex B
Characteristic values of load-carrying-capacities and rotational stiffness

The downward and the upward directed forces are assumed to act in the middle of the joist.

Only a full fastener pattern is specified, where there are fasteners in all the holes of the header connection. Also, dowels are placed in all the dowel holes in the joist.

Up to three AluMINI, AluMIDI or AluMAXI connectors may be arranged side by side. For AluMINI, AluMIDI or AluMAXI connectors arranged side-by-side, the load-carrying capacity of the connection is the sum of the load-carrying capacities of the single connectors. The load-carrying capacity of continuous dowels through connectors arranged side by side may be determined according to EN 1995-1-1, 8.1.3. The timber parts outside or between the joist plates should be designed for the lateral dowel loads introduced in the respective timber parts.

For header connections with bolts or metal anchors, there must always be at least bolts or metal anchors in the two upper two holes for loading DOWN or in the two lower holes for loading up.

B.1 Joist bearings AluMAXI, AluMIDI and AluMINI fastened with nails or screws and dowels

Loading down or up assuming a hinged support:

$$F_{v,Rk} = F_{Z,Rk} = \min \begin{cases} n_{J,ef} \cdot \min\left\{F_{v,J,Rk}; F_{b,Rk}\right\} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_{H,ef} \cdot F_{v,H,Rk}}\right)^2 + \left(\dfrac{1}{k_H \cdot F_{ax,H,Rk}}\right)^2}} \end{cases} \quad \text{(B.1)}$$

$n_{J,ef}$ effective number of dowels in the joist, see Table B.1

$n_{H,ef}$ effective number of nails or screws in the header or column, $n_{H,ef} = n_H$ for header connections and CLT headers with horizontal outer layers, $n_{H,ef} = 4 \cdot (0,25 \cdot n_H)^{0,95}$ for AluMAXI column connections and CLT headers with vertical outer layers

$F_{v,J,Rk}$ Characteristic lateral load-carrying capacity of a dowel with two shear planes in the joist according to EN 1995-1-1, $F_{v,J,Rd} = k_{mod} \cdot F_{v,J,Rk} / \gamma_M$

For joists consisting of CLT where the aluminium joist plate is arranged parallel to the plane of the CLT member, the embedment strength for CLT may be assumed as:

$$f_{h,k} = \frac{32 \cdot (1 - 0,015 \cdot d)}{1,1 \cdot \sin^2 \alpha + \cos^2 \alpha} \cdot \left(\frac{\rho_k}{400}\right)^{1,2} \text{ in N/mm}^2$$

α Angle between the load direction and the grain direction of the CLT layer in contact with the joist plate

The minimum spacing, end and edge distance requirements for dowels in CLT joists are:

$a_1 = (3 + 2 \cos\alpha) \cdot d$	$a_2 = 3 \cdot d$
$a_{3,t} = 5 \cdot d$	$a_{3,c} = 4 \cdot d$
$a_{4,t} = 3 \cdot d$	$a_{4,c} = 3 \cdot d$

$F_{b,Rk}$ Characteristic embedment resistance of a dowel in the joist plate according to EN 1999-1-1 where α_b is calculated as the weighted average for one edge dowel and the remaining inner dowels, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$

$F_{v,H,Rk}$ Characteristic lateral load-carrying capacity of a nail or screw in single shear in the header according to EN 1995-1-1 assuming a thick plate, $F_{v,H,Rd} = k_{mod} \cdot F_{v,H,Rk} / \gamma_M$

$F_{ax,H,Rk}$ Characteristic axial load-carrying capacity of a nail or screw in the header according to EN 1995-1-1 and ETA-11/0030 or ETA-22/0002, $F_{ax,Rd} = k_{mod} \cdot F_{ax,Rk} / \gamma_M$

k_H form factor, see Table B.1

Table B.1: Rotho Blaas joist bearings: Form factors k_H and effective number of dowels $n_{J,ef}$

Joist bearing	n_J	n_H	k_H	$n_{J,ef}$	k_H	$n_{J,ef}$
			Loading DOWN		Loading UP	
AluMINI 65	depending on design	7	1,32	n_J	1,32	n_J
AluMINI 95		11	3,36	n_J	3,36	n_J
AluMINI 125		15	6,32	n_J	6,32	n_J
AluMINI 155		19	10,2	n_J	10,2	n_J
AluMINI 185		23	15,0	n_J	15,0	n_J
AluMINI 215		27	20,8	n_J	20,8	n_J
AluMIDI 80		14	3,67	n_J	3,31	n_J
AluMIDI 120*	3	22	9,12	2,89	8,57	1,92
AluMIDI 160*	4	30	17,1	3,85	16,3	2,89
AluMIDI 200*	5	38	27,5	4,81	26,6	3,85
AluMIDI 240*	6	46	40,4	5,77	39,3	4,81
AluMIDI 280*	7	54	55,8	6,74	54,5	5,77
AluMIDI 320*	8	62	73,6	7,70	72,1	6,74
AluMIDI 360*	9	70	94,0	8,66	92,3	7,70
AluMIDI 400*	10	78	117	9,62	114,7	8,66
AluMIDI 440*	11	86	142	10,6	140	9,64
AluMIDI 480*	12	94	170	11,6	168	10,6
AluMIDI 520*	13	102	200	12,5	198	11,6
AluMAXI 320*	5	40	30,0	5	30,0	4
AluMAXI 384*	6	48	43,3	6	43,3	5
AluMAXI 448*	7	56	59,1	7	59,1	6
AluMAXI 512*	8	64	77,4	8	77,4	7
AluMAXI 576*	9	72	98,1	9	98,1	8
AluMAXI 640*	10	80	121	10	121	9
AluMAXI 704*	11	88	147	11	147	10
AluMAXI 768*	12	96	175	12	175	11
AluMAXI 832*	13	104	205	13	205	12
AluMAXI 896*	14	112	238	14	238	13
AluMAXI 960*	15	120	274	15	274	14
* For AluMIDI and AluMAXI without pre-punched holes, $n_J = n_{J,ef}$ depends on the design.						

Loading down or up assuming moment transmitting support (only AluMIDI and AluMAXI):

$$F_{v,Rk} = F_{Z,Rk} = \min \begin{cases} F_{Z,J,Rk} \\ F_{Z,H,Rk} \end{cases} \tag{B.2}$$

$$F_{Z,J,Rk} = \frac{F_{v,J,Rk}}{\sqrt{\left(\frac{6 \cdot e_{FJ}}{a_2 \cdot n_J \cdot (n_J + 1)}\right)^2 + \left(\frac{1}{n_J}\right)^2}} \text{ for one dowel row} \tag{B.3}$$

$$F_{Z,J,Rk} = \frac{F_{v,J,Rk}}{\sqrt{\left(\frac{12 \cdot e_{FJ} \cdot (n_J - 2) \cdot a_2}{n_J \cdot \left[a_2^2 \cdot (n_J^2 - 4) + 12 \cdot a_1^2\right]}\right)^2 + \left(\frac{1}{n_J} + \frac{24 \cdot e_{FJ} \cdot a_1}{n_J \cdot \left[a_2^2 \cdot (n_J^2 - 4) + 12 \cdot a_1^2\right]}\right)^2}} \text{ for two dowel rows} \tag{B.4}$$

$$\alpha = \arctan\left(\frac{a_2 \cdot (n_J + 1)}{6 \cdot e_{FJ}}\right) \text{ for one dowel row} \tag{B.5}$$

$$\alpha = \arctan\left(\frac{a_2^2 \cdot (n_J^2 - 4) + 12 \cdot a_1 \cdot (a_1 + 2 \cdot e_{FJ})}{12 \cdot a_2 \cdot e_{FJ} \cdot (n_J - 2)}\right) \text{ for two dowel rows} \quad \text{(B.6)}$$

$$F_{Z,H,Rk} = \min\begin{cases} \dfrac{n_H}{\sqrt{\left(\dfrac{1}{F_{v,H,Rk}}\right)^2 + \left(\dfrac{6 \cdot e_{FH}}{H \cdot \min\left\{k_{row} \cdot F_{ax,H,Rk}; \dfrac{f_{u,k} \cdot t^2 \cdot 4 \cdot H}{3 \cdot e_{ALU} \cdot n_H}\right\}}\right)^2}} \\ \dfrac{f_{Xc,H,Rk} \cdot H^2}{4 \cdot e_{FH}} \end{cases} \quad \text{(B.7)}$$

Rotational stiffness (only AluMIDI and AluMAXI):

$$K_{r,ser} = \frac{2 \cdot \rho_m^{1,5} \cdot d}{23} \cdot \frac{a_2^2 \cdot (n_J^2 - 1) \cdot n_J}{12} \text{ [kNm/rad] for one dowel row} \quad \text{(B.8)}$$

$$K_{r,ser} = \frac{2 \cdot \rho_m^{1,5} \cdot d}{23} \cdot \left[\frac{a_2^2 \cdot (n_J^2 - 4) \cdot n_J}{48} + \frac{a_1^2 \cdot n_J}{4}\right] \text{ [kNm/rad] for two dowel rows} \quad \text{(B.9)}$$

Where:

$F_{v,J,Rk}$ Characteristic lateral load-carrying capacity of a dowel with two shear planes in the joist for load-grain angle α according to EN 1995-1-1, $F_{v,J,Rd} = k_{mod} \cdot F_{v,J,Rk} / \gamma_M$

$F_{v,H,Rk}$ Characteristic lateral load-carrying capacity of a nail or screw in single shear in the header according to EN 1995-1-1 assuming a thick plate, $F_{v,H,Rd} = k_{mod} \cdot F_{v,H,Rk} / \gamma_M$

$F_{ax,H,Rk}$ Characteristic axial load-carrying capacity of a nail or screw in the header according to EN 1995-1-1 and ETA-11/0030 or ETA-22/0002, $F_{ax,Rd} = k_{mod} \cdot F_{ax,Rk} / \gamma_M$

n_J number of dowels in the joist

n_H number of nails or screws in the header

d dowel diameter in mm

e_{FJ} $= |M_{Ed}/F_{Z,Ed}|$ in mm where M_{Ed} is the moment transferred by the joist connection

e_{FH} $= |M_{Ed}/F_{Z,Ed}|$ in mm where M_{Ed} is the moment transferred by the header connection
$e_{FH} = e_{FJ} + a_{CG}$
where a_{CG} is the distance between the centre of gravity of the joist dowels and the header surface

a_2 spacing of joist dowels perpendicular to grain in mm

H Depth of the joist bearing in mm

k_{row} Factor to consider the number of header fastener rows, k_{row} = 0,5 for AluMIDI, k_{row} = 0,6 for AluMAXI EN AW6005A T6, k_{row} = 0,43 for AluMAXI EN AW6082 T6

e_{alu} Load eccentricity, e = 15 mm for AluMIDI, e = 25 mm for AluMAXI

$f_{u,k}$ Aluminium tensile strength, f_u =260 N/mm² for EN AW 6005A T6, f_u =310 N/mm² for EN AW 6082 T6, $f_{u,d} = f_{u,k} / \gamma_{M2}$

t Header plate thickness in mm, t = 12 mm for AluMAXI EN AW6005A T6, t = 8 mm for AluMAXI EN AW6082 T6, t = 6 mm for AluMIDI

$f_{Xc,H,Rk}$ Characteristic compressive load-carrying capacity of a joist bearing with aluminium bending failure, $f_{Xc,H,Rk} = f_{Xc,H,Rk} / \gamma_{M2}$. $f_{Xc,H,Rk}$ = 416 N/mm for AluMAXI EN AW6005A T6, $f_{Xc,H,Rk}$ = 221 N/mm for AluMAXI EN AW6082 T6, and $f_{Xc,H,Rk}$ = 156 N/mm for AluMIDI

ρ_m Mean joist density in kg/m³

Loading perpendicular to the joist plate:

$$F_{lat,Rk} = F_{Y,Rk} = \min \begin{cases} A_k \cdot H \\ \dfrac{k_n \cdot h \cdot b \cdot f_{v,k}}{\sqrt{b} \cdot \left(1,5 + \dfrac{3,18 \cdot x}{b}\right)} \end{cases} \quad \text{(B.10)}$$

Where

- $F_{Y,Rk}$ Characteristic load-carrying capacity of a AluMINI, AluMIDI and AluMAXI joist bearing for loads perpendicular to the joist plate in N
- A_k Characteristic parameter to take into account bending of the aluminium joist plate, A = 24,3 N/mm for AluMINI, A = 45,3 N/mm for AluMIDI, A = 81,2 N/mm for AluMAXI; for calculating the design value A_d, the partial factor γ_{M2} for aluminium has to be applied.
- H Depth of the joist bearing in mm
- k_n Parameter according to Eurocode 5 equation (6.63)
- b Joist width in mm
- h Joist depth in mm
- x Eccentricity of the load $F_{Y,Ed}$ in mm, x = 69 mm for AluMINI and AluMIDI, x = 107 mm for AluMAXI.
- $f_{v,k}$ Characteristic joist shear strength [N/mm²]

Note: For calculating design values, the partial factor for aluminium γ_{M2} must be applied to the first expression in equation (B.10), and k_{mod} and the partial factor γ_M for timber to the second expression in equation (B.10).

Tensile loading parallel to the joist axis
(only if minimum end distances $a_{3,t}$ = max (7d; 80 mm) for all joist fasteners are met):

$$F_{Xt,Rk} = \min \begin{cases} k_{row} \cdot n_H \cdot F_{ax,Rk} \\ n_J \cdot \min\left\{2 \cdot F_{v,Rk}; F_{b,Rk}\right\} \\ \dfrac{f_{u,k} \cdot H \cdot t^2}{3 \cdot e_{alu}} \end{cases} \quad \text{(B.11)}$$

Where

- $F_{ax,Rk}$ Characteristic load-carrying capacity of an axially loaded header fastener according to EN 1995-1-1 and ETA-11/0030 or ETA-22/0002, $F_{ax,Rd} = k_{mod} \cdot F_{ax,Rk} / \gamma_M$
- n_H Number of header fasteners
- k_{row} Factor to take into account the number of header fastener rows, k_{row} = 1 for AluMINI, k_{row} = 0,5 for AluMIDI, k_{row} = 0,6 for AluMAXI EN AW6005A T6, k_{row} = 0,43 for AluMAXI EN AW6082 T6
- n_J Number of joist fasteners
- $F_{v,Rk}$ Characteristic load-carrying capacity of a laterally loaded joist fastener per shear plane according to EN 1995-1-1, $F_{v,Rd} = k_{mod} \cdot F_{v,Rk} / \gamma_M$
- $F_{b,Rk}$ Characteristic embedment resistance of a dowel in the joist plate according to EN 1999-1-1 where α_b is calculated as the weighted average for one edge dowel and the remaining inner dowels, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$
- $f_{u,k}$ Aluminium tensile strength, f_u =260 N/mm² for EN AW 6005A T6, f_u =310 N/mm² for EN AW 6082 T6, $f_{u,d} = f_{u,k} / \gamma_{M2}$
- H Depth of the joist bearing in mm
- t Header plate thickness in mm, t = 12 mm for AluMAXI EN AW6005A T6, t = 8 mm for AluMAXI EN AW6082 T6, t = 6 mm for AluMINI and AluMIDI
- e_{alu} Load eccentricity, e = 7 mm for AluMINI, e = 15 mm for AluMIDI, e = 25 mm for AluMAXI

Compressive loading parallel to the joist axis
(only if minimum end distances $a_{3,c}$ = 3d for all joist fasteners are met):

$$F_{Xc,Rk} = \min \begin{cases} \min\{N_{b,Rk}; F_{90,alu,Rk}\} \\ n_J \cdot \min\{2 \cdot F_{v,Rk}; F_{b,Rk}\} \end{cases} \quad \text{(B.12)}$$

Where:

$N_{b,Rk}$ Characteristic buckling capacity of the joist plate in N, $N_{b,Rk} = 533 \cdot H$ for AluMINI, $N_{b,Rk} = 947 \cdot H$ for AluMIDI, $N_{b,Rk} = 1617 \cdot H$ for AluMAXI EN AW6005A T6, $N_{b,Rk} = 1272 \cdot H$ for AluMAXI EN AW6082 T6, $N_{b,Rd} = N_{b,Rk} / \gamma_{M1}$

$F_{90,alu,Rk}$ Characteristic load-carrying capacity of a joist bearing with aluminium bending failure according to Table B.2, $F_{90,alu,Rd} = F_{90,alu,Rk} / \gamma_{M2}$

n_J Number of joist fasteners

$F_{v,Rk}$ Characteristic load-carrying capacity of a laterally loaded joist fastener per shear plane according to EN 1995-1-1, $F_{v,Rd} = k_{mod} \cdot F_{v,Rk} / \gamma_M$

$F_{b,Rk}$ Characteristic embedment resistance of a dowel in the joist plate according to EN 1999-1-1, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$

Table B.2: Rotho Blaas joist bearings: Load-carrying capacity $F_{90,alu,Rk}$ in kN

Joist bearing AluMINI	$F_{90,alu,Rk}$	Joist bearing AluMIDI	$F_{90,alu,Rk}$
65	9,1	80	12,5
95	13,3	120	18,7
125	17,5	160	25,0
155	21,7	200	31,2
185	25,9	240	37,4
215	30,1	280	43,7
		320	49,9
		360	56,2
		400	62,4
		440	66,6
		480	70,0
		520	73,7
Joist bearing AluMAXI EN AW 6005A T6	$F_{90,alu,Rk}$	Joist bearing AluMAXI EN AW 6082 T6	$F_{90,alu,Rk}$
320	133	320	71
384	160	384	85
448	186	448	99
512	213	512	113
576	240	576	127
640	266	640	141
704	293	704	155
768	319	768	169
832	346	832	183
896	373	896	198
960	399	960	212

B.2 Joist bearings fastened with bolts or metal anchors and dowels

$$F_{v,Rk} = F_{Z,Rk} = \min \begin{cases} n_{J,ef} \cdot \min\left\{F_{v,J,Rk}; F_{b,Rk}\right\} \\ \dfrac{1}{\sqrt{\left(\dfrac{1}{n_H \cdot F_{v,H,Rk}}\right)^2 + \left(\dfrac{e \cdot z_{max}}{I_{p,H,ax} \cdot F_{ax,H,Rk}}\right)^2}} \end{cases} \quad \text{(B.13)}$$

Tensile loading parallel to the joist axis

$$F_{Xt,Rk} = \min \begin{cases} F_{u,Rk} \\ n_J \cdot \min\left\{2 \cdot F_{v,Rk}; F_{b,Rk}\right\} \end{cases} \quad \text{(B.14)}$$

Compressive loading parallel to the joist axis

$$F_{Xc,Rk} = \min \begin{cases} N_{b,Rk} \\ n_J \cdot \min\left\{2 \cdot F_{v,Rk}; F_{b,Rk}\right\} \end{cases} \quad \text{(B.15)}$$

n_H Number of bolts or metal anchors in the header connection; there must always be at least bolts or metal anchors in the two upper to holes for loading DOWN or in the two lower holes for loading up;

e Distance between the centroid of the joist connection and the header surface;

z_{max} Distance between the uppermost bolt or metal anchor and the lower end of the joist bearing for loading DOWN or distance between the lowermost bolt or metal anchor and the upper end of the joist bearing for loading UP;

$I_{p,H,ax}$ Polar moment of inertia of the header fasteners where the centre of rotation may be assumed at the lower or upper end of the joist bearing;

$F_{v,H,Rk}$ Characteristic value of the lateral load-carrying-capacity per bolt or metal anchor in the header connection;

$F_{ax,H,Rk}$ Characteristic value of the axial load-carrying-capacity per bolt or metal anchor in the header;

$F_{u,Rk}$ Characteristic load-carrying capacity according to EN 1999-1-1, Annex B, $F_{u,Rd}$ see Annex B of EN 1999-1-1

$N_{b,Rk}$ Characteristic buckling capacity of the joist plate in N, $N_{b,Rk} = 533 \cdot H$ for AluMINI, $N_{b,Rk} = 947 \cdot H$ for AluMIDI, $N_{b,Rk} = 1617 \cdot H$ for AluMAXI EN AW6005A T6, $N_{b,Rk} = 1272 \cdot H$ for AluMAXI EN AW6082 T6, $N_{b,Rd} = N_{b,Rk} / \gamma_{M1}$

n_J Number of joist fasteners

$F_{v,Rk}$ Characteristic load-carrying capacity of a laterally loaded joist fastener per shear plane according to EN 1995-1-1, $F_{v,Rd} = k_{mod} \cdot F_{v,Rk} / \gamma_M$

$F_{b,Rk}$ Characteristic embedment resistance of a dowel in the joist plate according to EN 1999-1-1 where α_b is calculated as the weighted average for one edge dowel and the remaining inner dowels, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$

The characteristic load-carrying capacity $F_{b,Rk}$ per dowel in an aluminium joist plate for aluminium embedding failure may be assumed for load directions X and Z as:

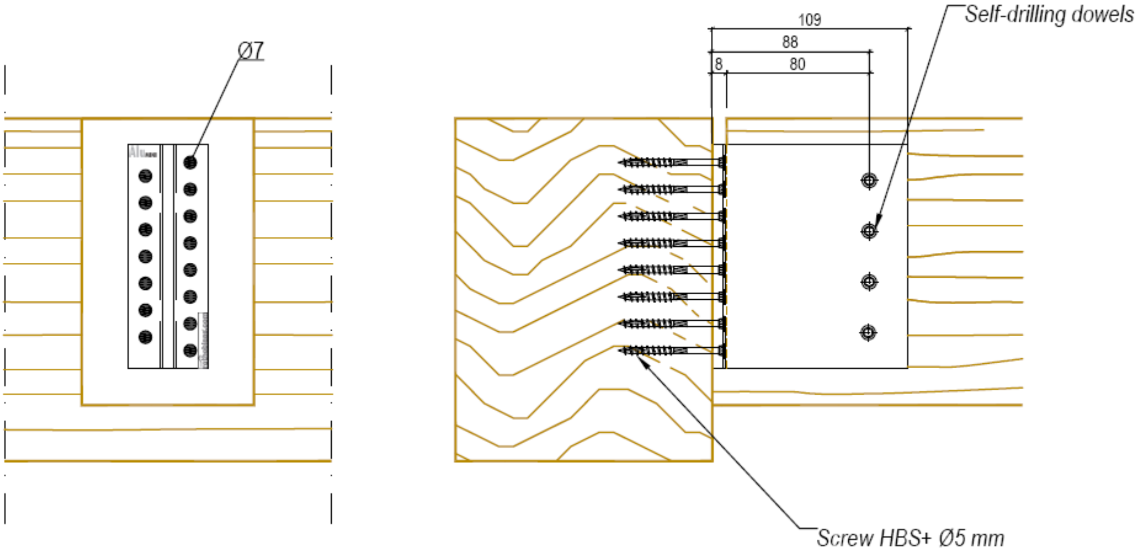
AluMINI:	d = 7,5 mm	$F_{b,Rk}$ = 15 kN
AluMIDI:	d = 7,5 mm	$F_{b,Rk}$ = 28 kN
AluMIDI:	d = 12 mm	$F_{b,Rk}$ = 39 kN
AluMAXI EN AW 6082:	d = 7,5 mm	$F_{b,Rk}$ = 35 kN
AluMAXI EN AW 6005A:	d = 7,5 mm	$F_{b,Rk}$ = 42 kN
AluMAXI EN AW 6082:	d = 16 mm	$F_{b,Rk}$ = 80 kN
AluMAXI EN AW 6005A:	d = 16 mm	$F_{b,Rk}$ = 96 kN

For load direction Y, equation (B.10) applies.

If $F_{X,Ed}$ or $F_{Y,Ed}$ or $F_{Z,Ed}$ act simultaneously, the following interaction equation shall be fulfilled:

$$\left(\frac{F_{X,Ed}}{F_{X,Rd}}\right)^2 + \left(\frac{F_{Y,Ed}}{F_{Y,Rd}}\right)^2 + \left(\frac{F_{Z,Ed}}{F_{Z,Rd}}\right)^2 \le 1{,}0 \quad \text{(B.16)}$$

Annex C
Installation of joist bearings



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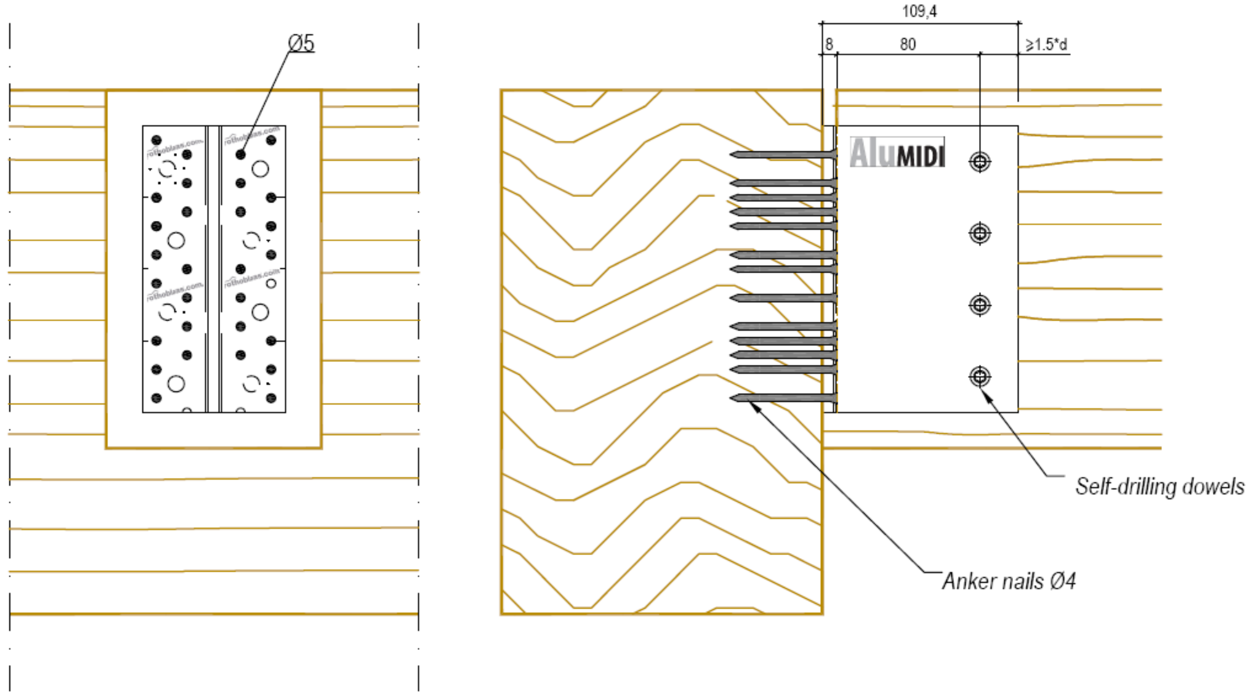
Use:

AluMINI Timber - Timber

Screws HBS+ Ø5 mm - Self-drilling dowels

Annex:

1a.



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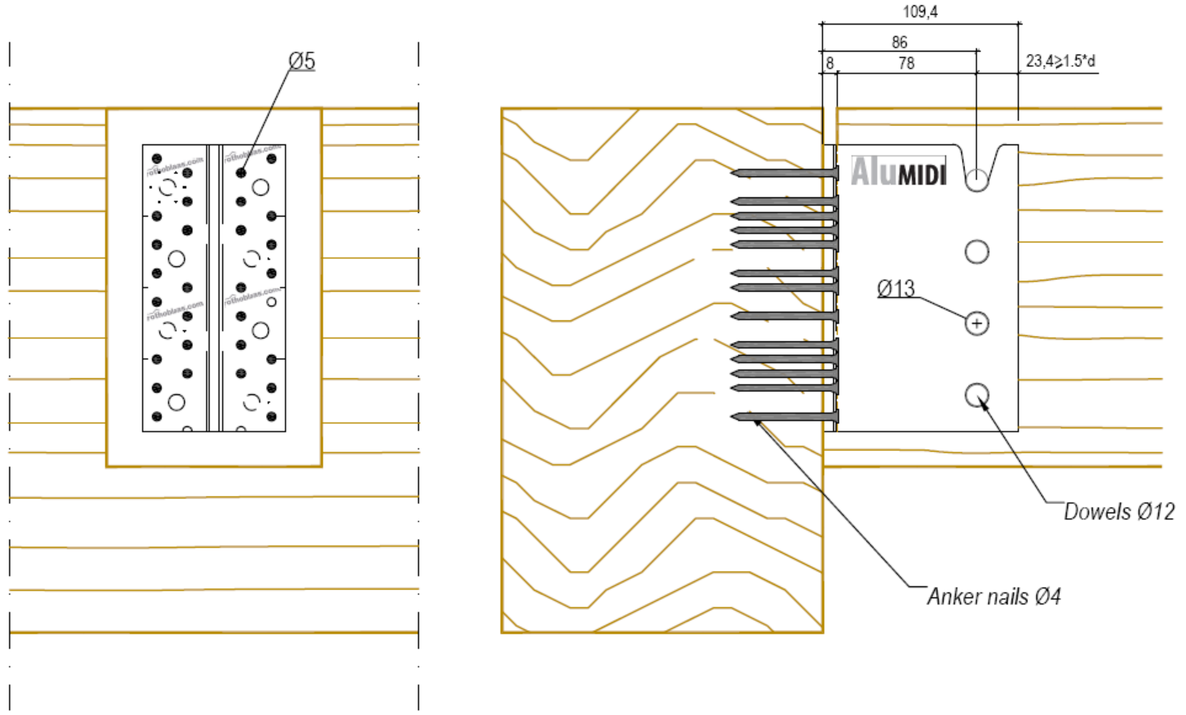
Use:

AluMIDI Timber - Timber

Anker nails Ø4 mm - Self-drilling dowels

Annex:

2a.



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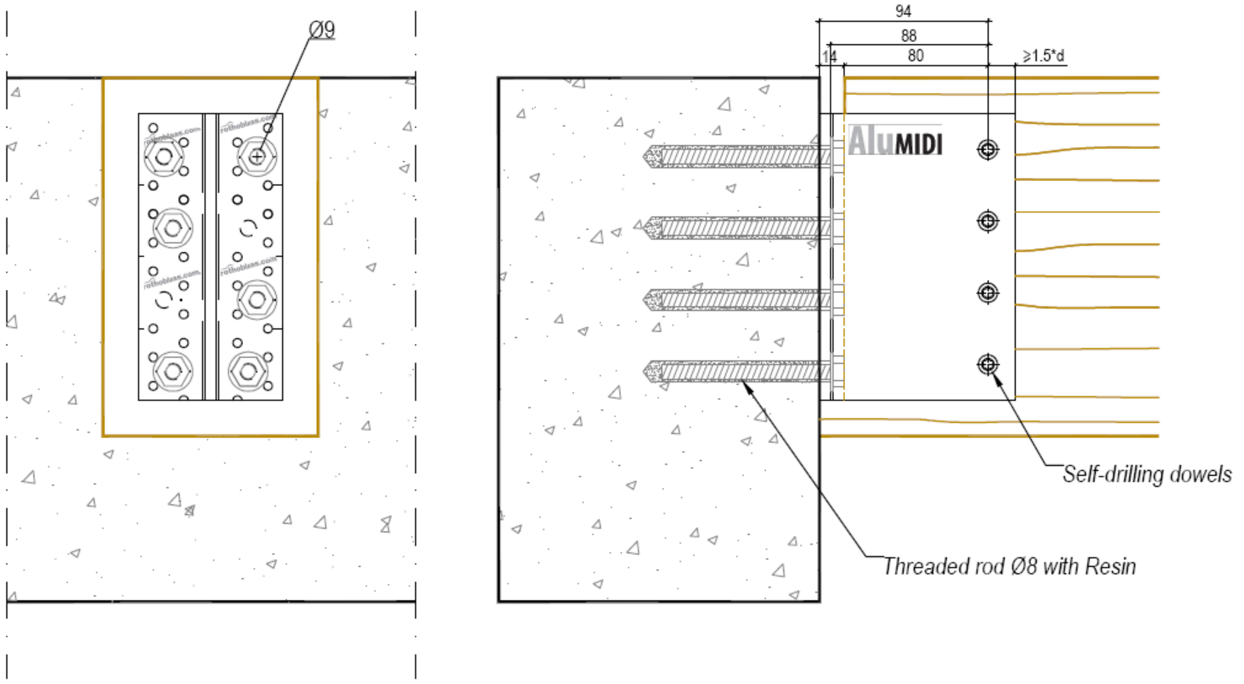
Use:

AluMIDI Timber - Timber

Anker nails Ø4 mm - Dowels Ø12 mm

Annex:

3a.



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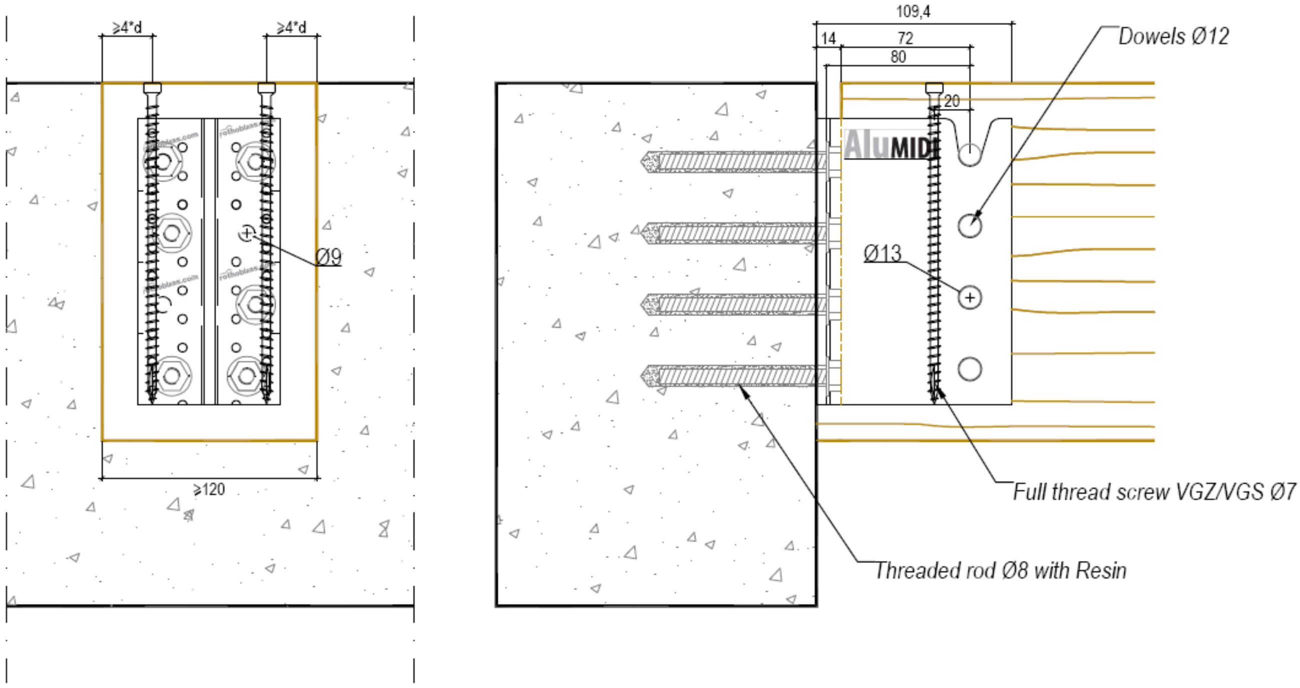
Use:

AluMIDI Timber- Concrete

Threaded rod Ø8 mm with resin- Self-drilling dowels

Annex:

4a.



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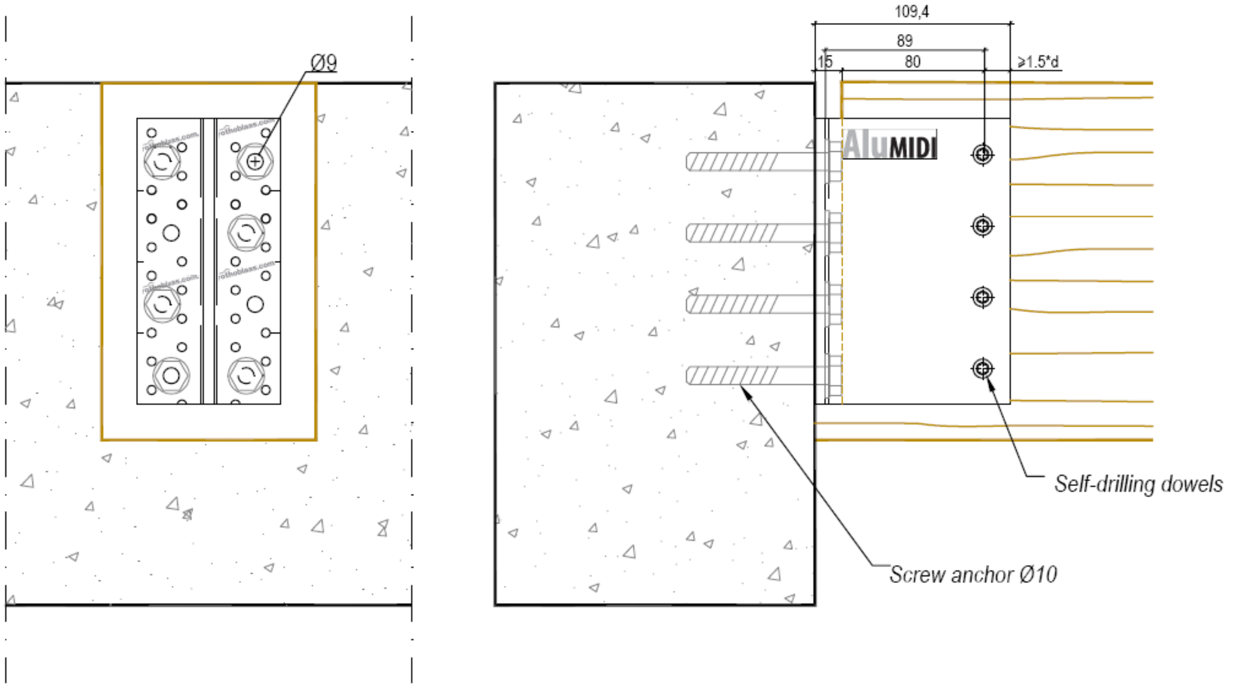
Use:

AluMIDI Timber- Concrete

Threaded rod Ø8 mm with resin - Dowels Ø12 mm

Annex:

5a.



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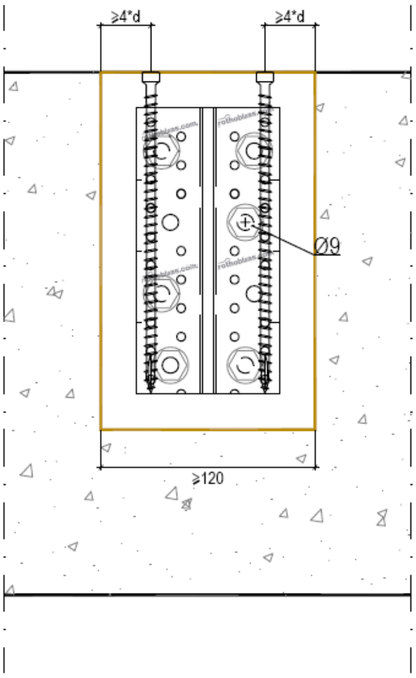
Use:

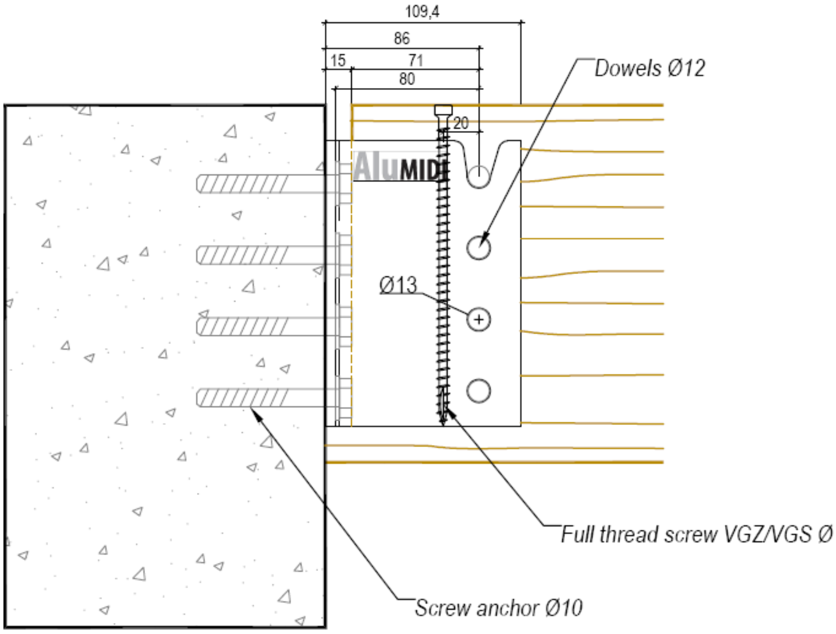
AluMIDI Timber- Concrete

Screw anchor Ø10 mm - Self-drilling dowels

Annex:

6a.





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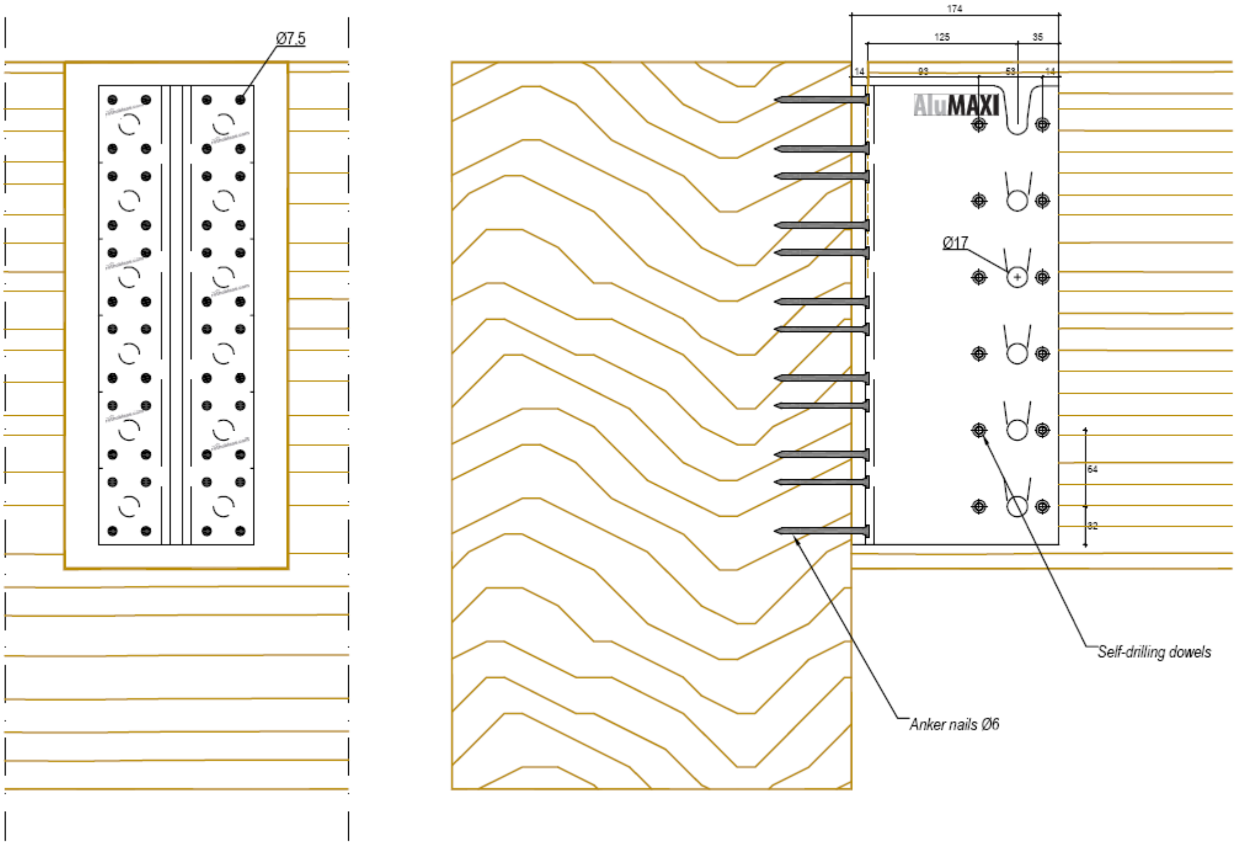
Use:

AluMIDI Timber- Concrete

Screw anchor Ø10 mm - Dowels Ø12 mm

Annex:

7a.



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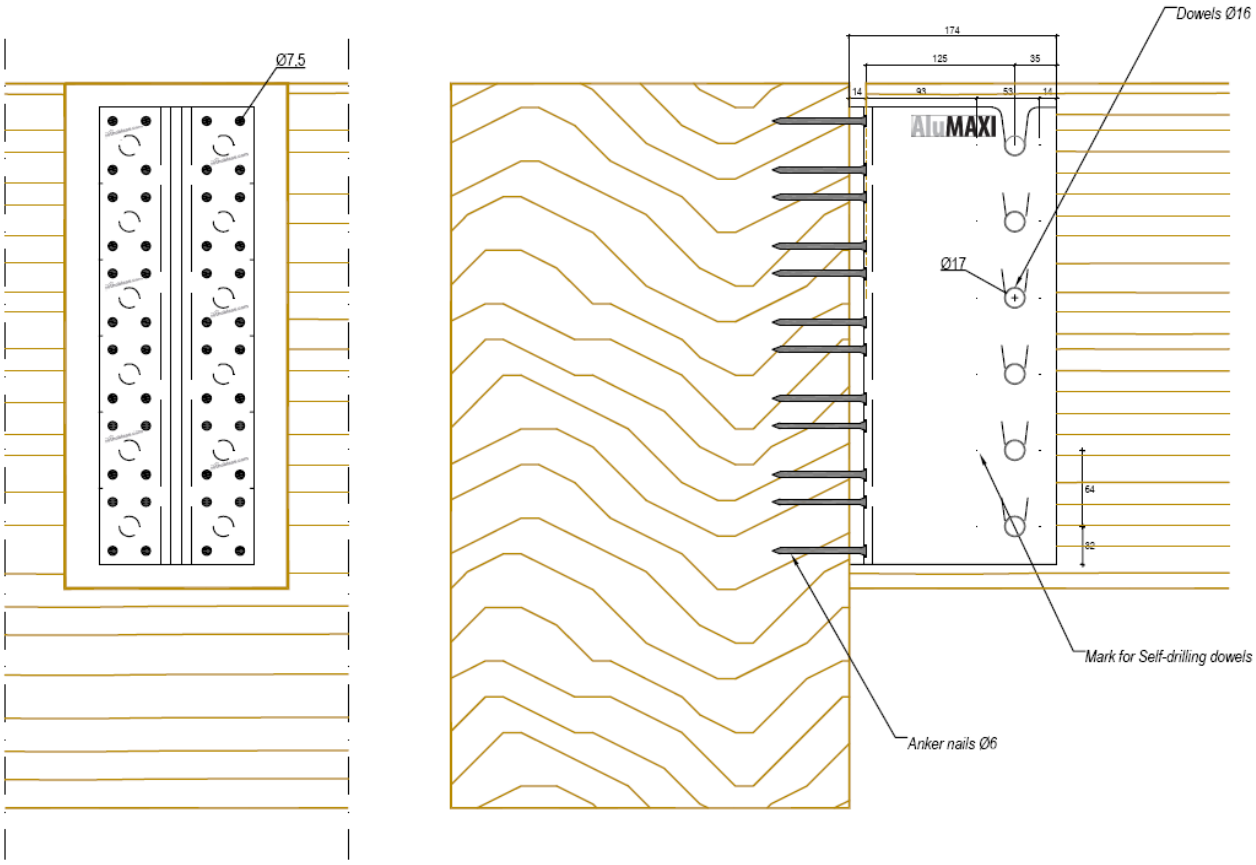
Use:

AluMAXI Timber - Timber

Anker nails Ø6 mm - Self-drilling dowels

Annex:

8a.



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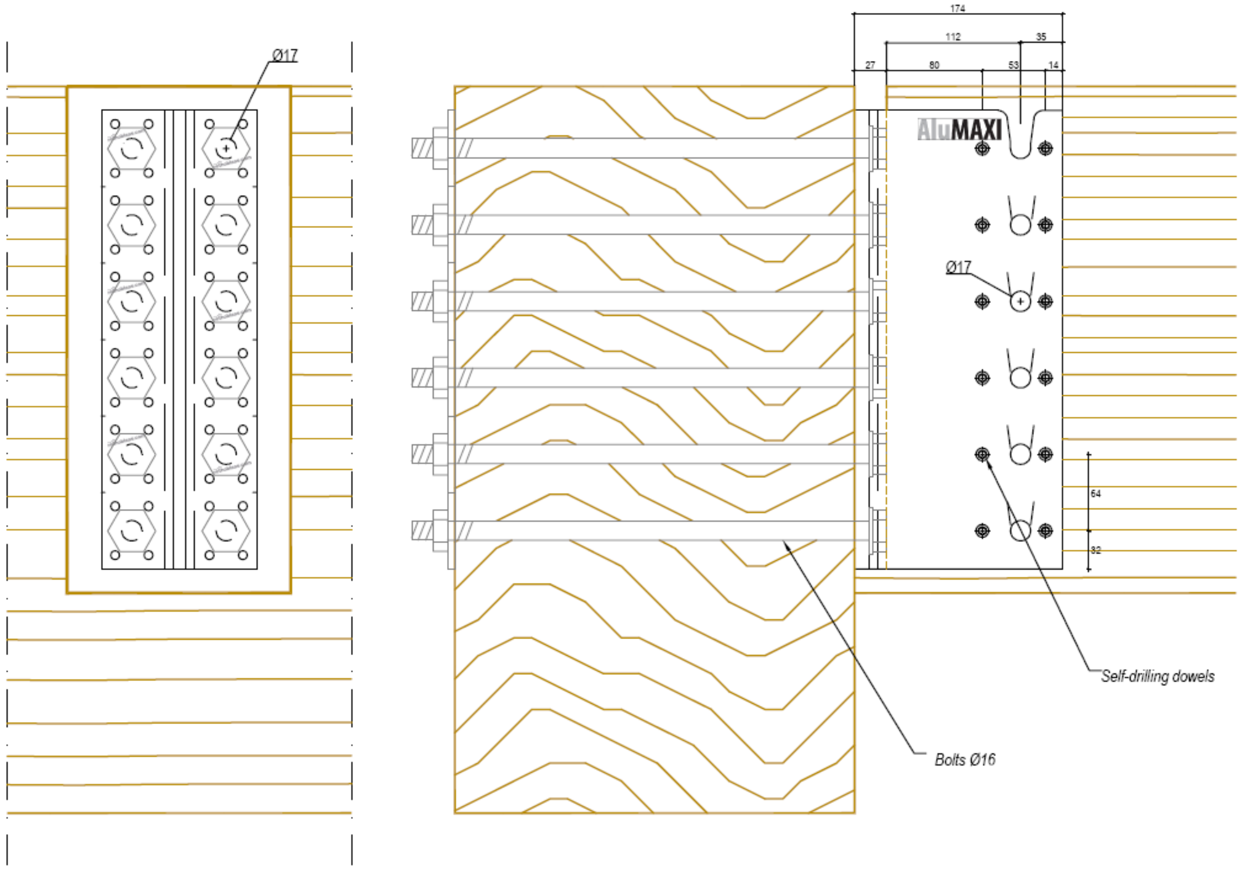
Use:

AluMAXI Timber - Timber

Anker nails Ø6 mm - Dowels Ø16 mm

Annex:

9a.



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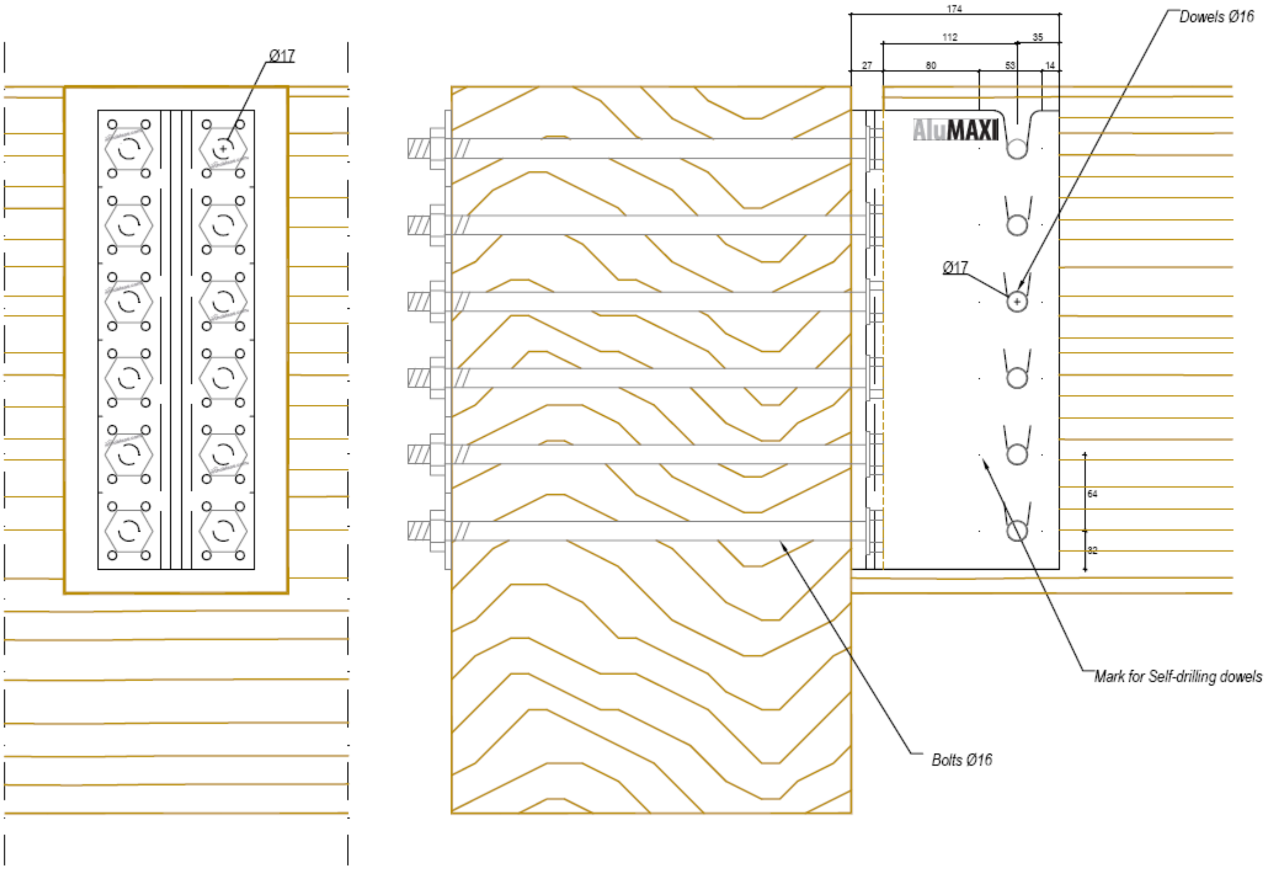
Use:

AluMAXI Timber - Timber

Bolts Ø16 mm - Self-drilling dowels

Annex:

10a.



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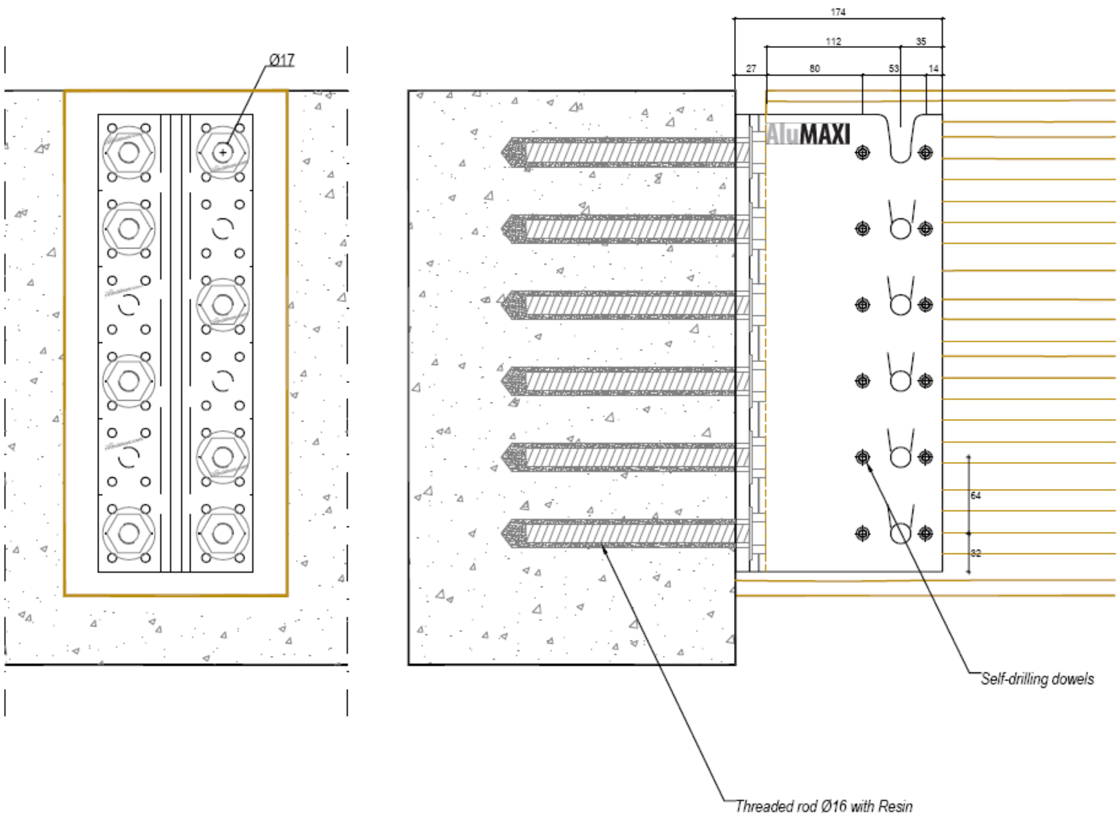
Use:

AluMAXI Timber - Timber

Bolts Ø16 mm - Dowels Ø16 mm

Annex:

11a.



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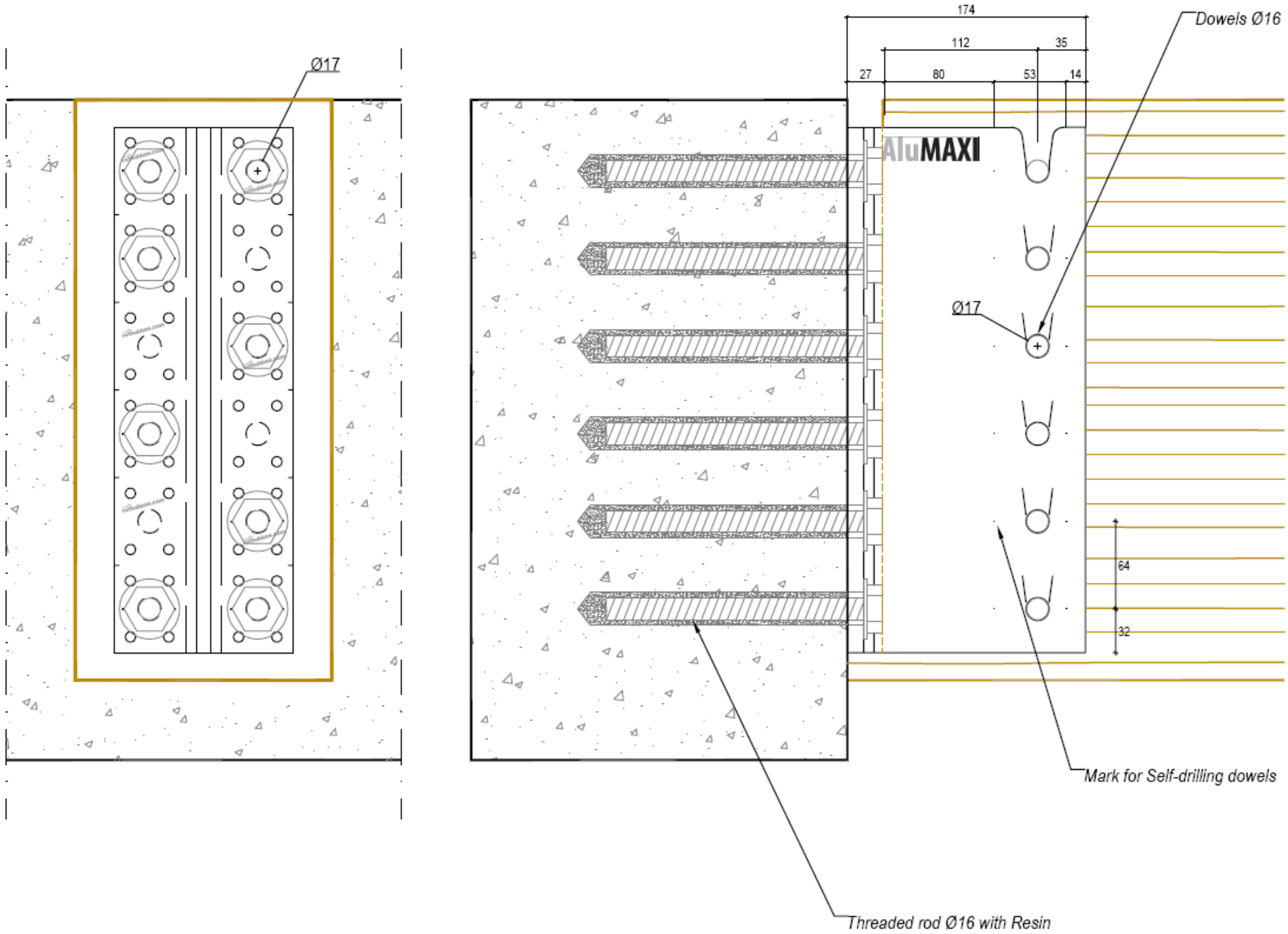
Use:

AluMAXI Timber - Concrete

Threaded rod Ø16 mm with resin -
Self-drilling dowels

Annex:

12a.



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Use:

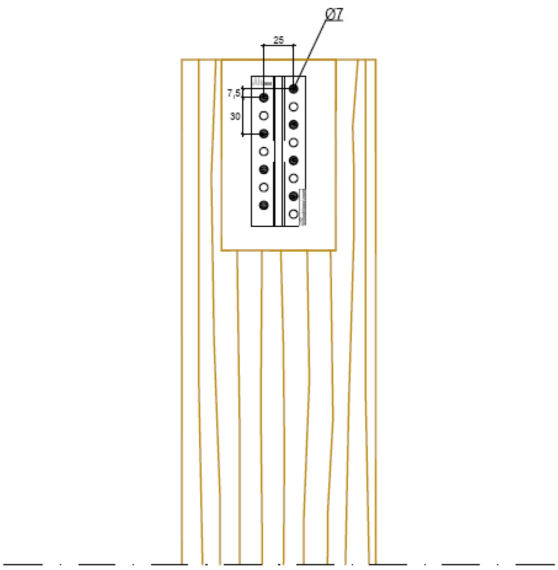
AluMAXI Timber - Concrete

Threaded rod Ø16 mm with resin - Dowels Ø16 mm

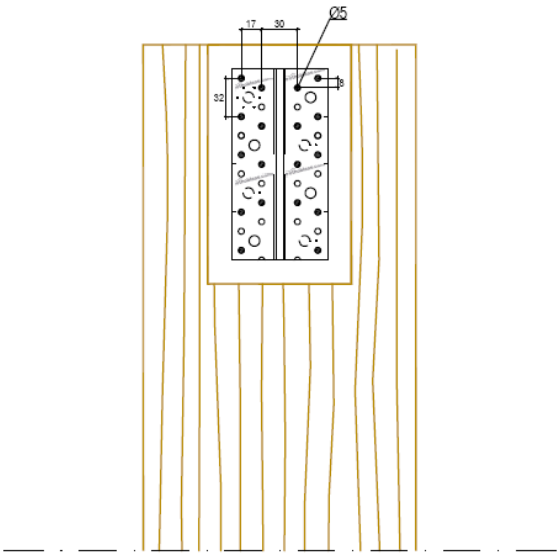
Annex:

13a.

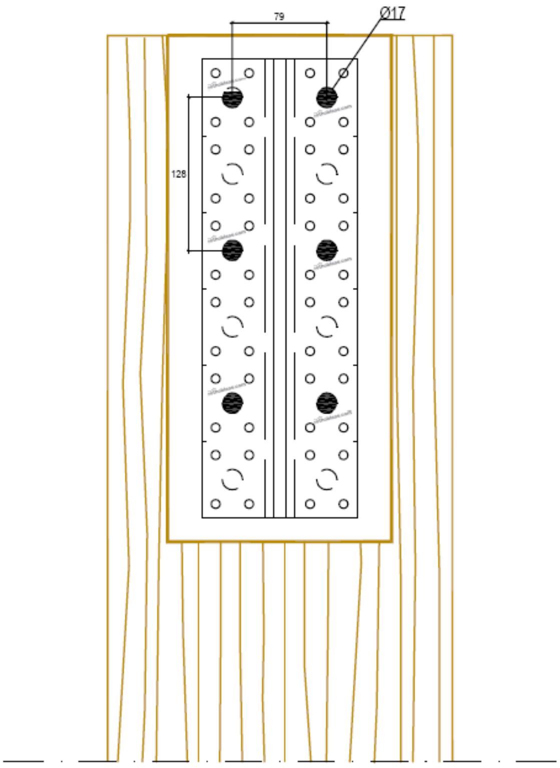
ALUMINI

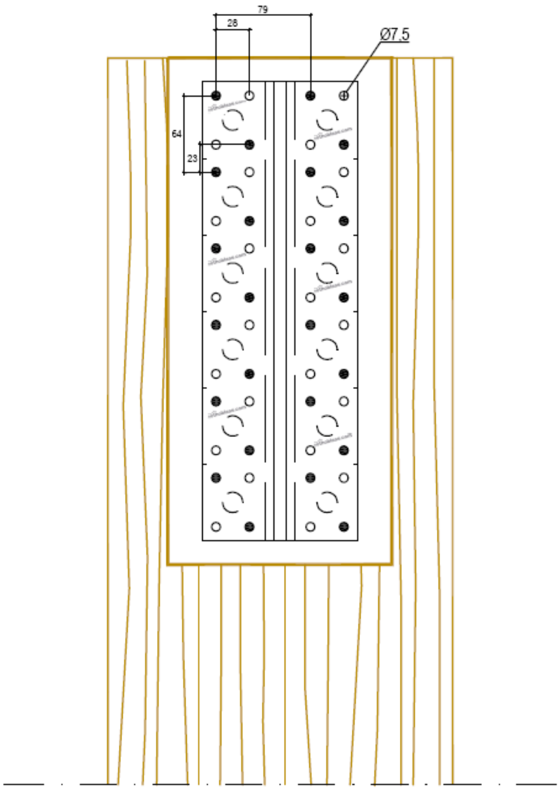


ALUMIDI



ALUMAXI





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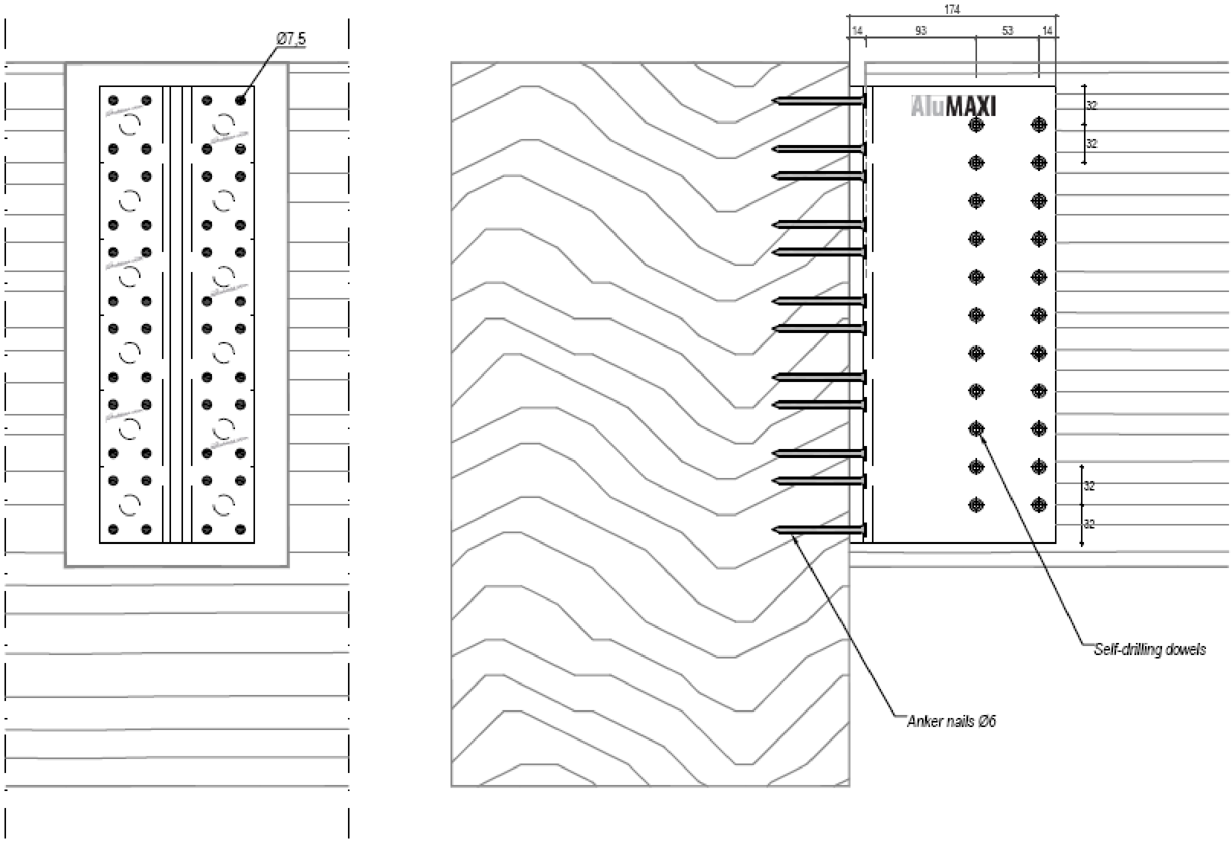
Use:

AluMINI - AluMIDI - AluMAXI
Timber - Timber
Load parallel to grain
(Column)

Annex:

14a.



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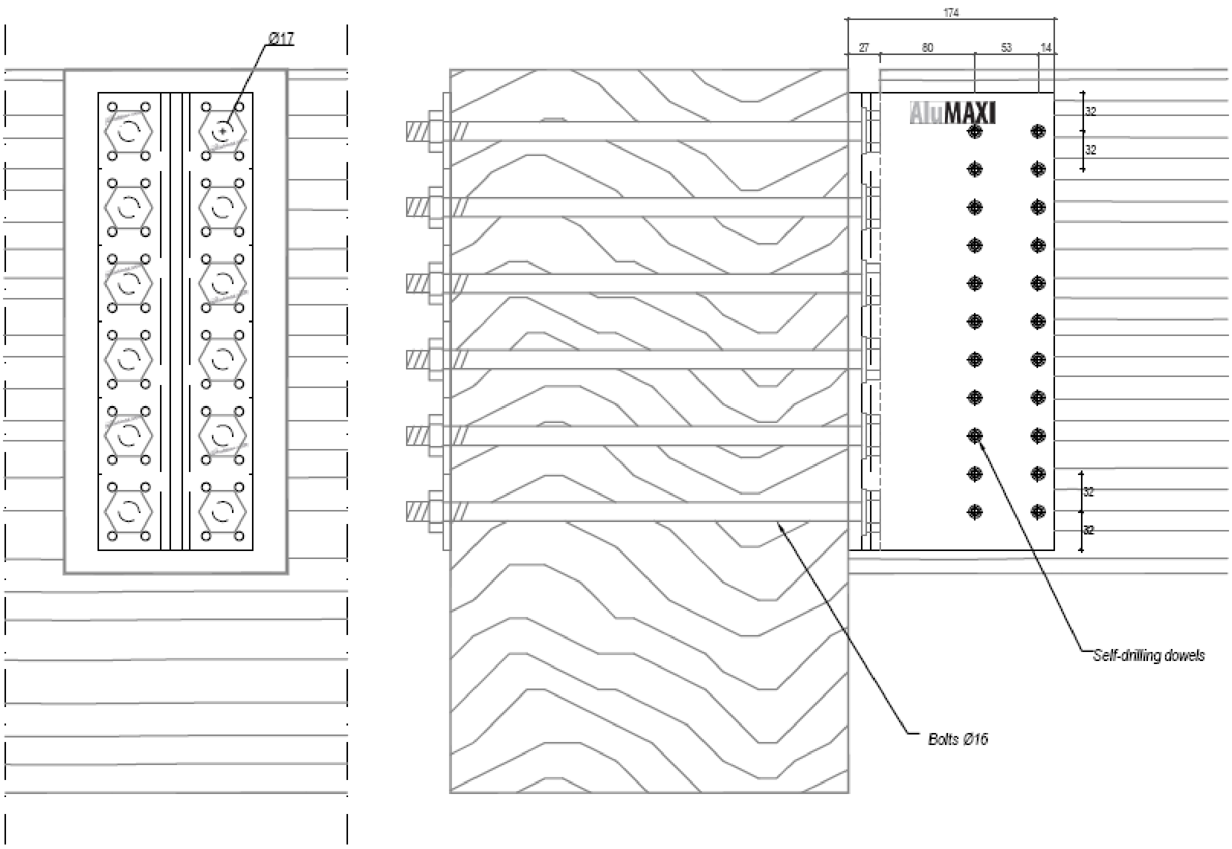
Use:

AluMAXI without holes
Timber - Timber

Anker nails Ø6 mm - Self-drilling dowels

Annex:

15a.



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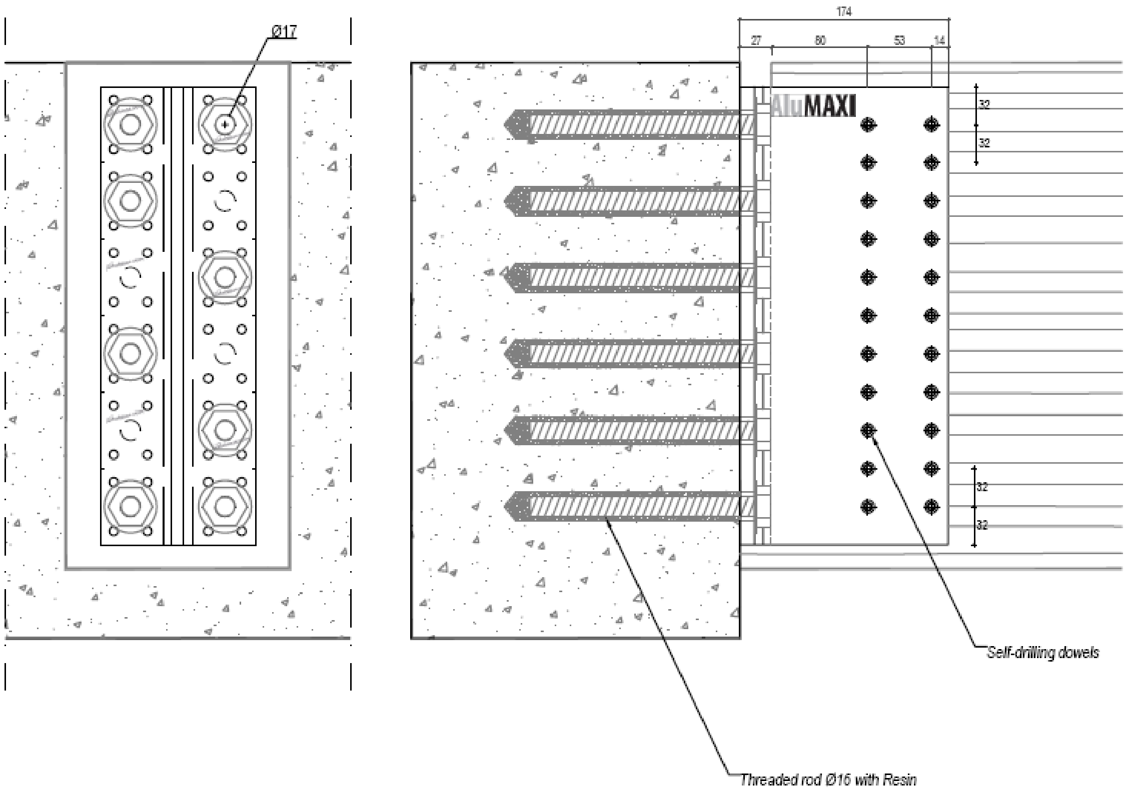
Use:

AluMAXI without holes
Timber - Timber

Bolts Ø16 mm - Self-drilling dowels

Annex:

16a.



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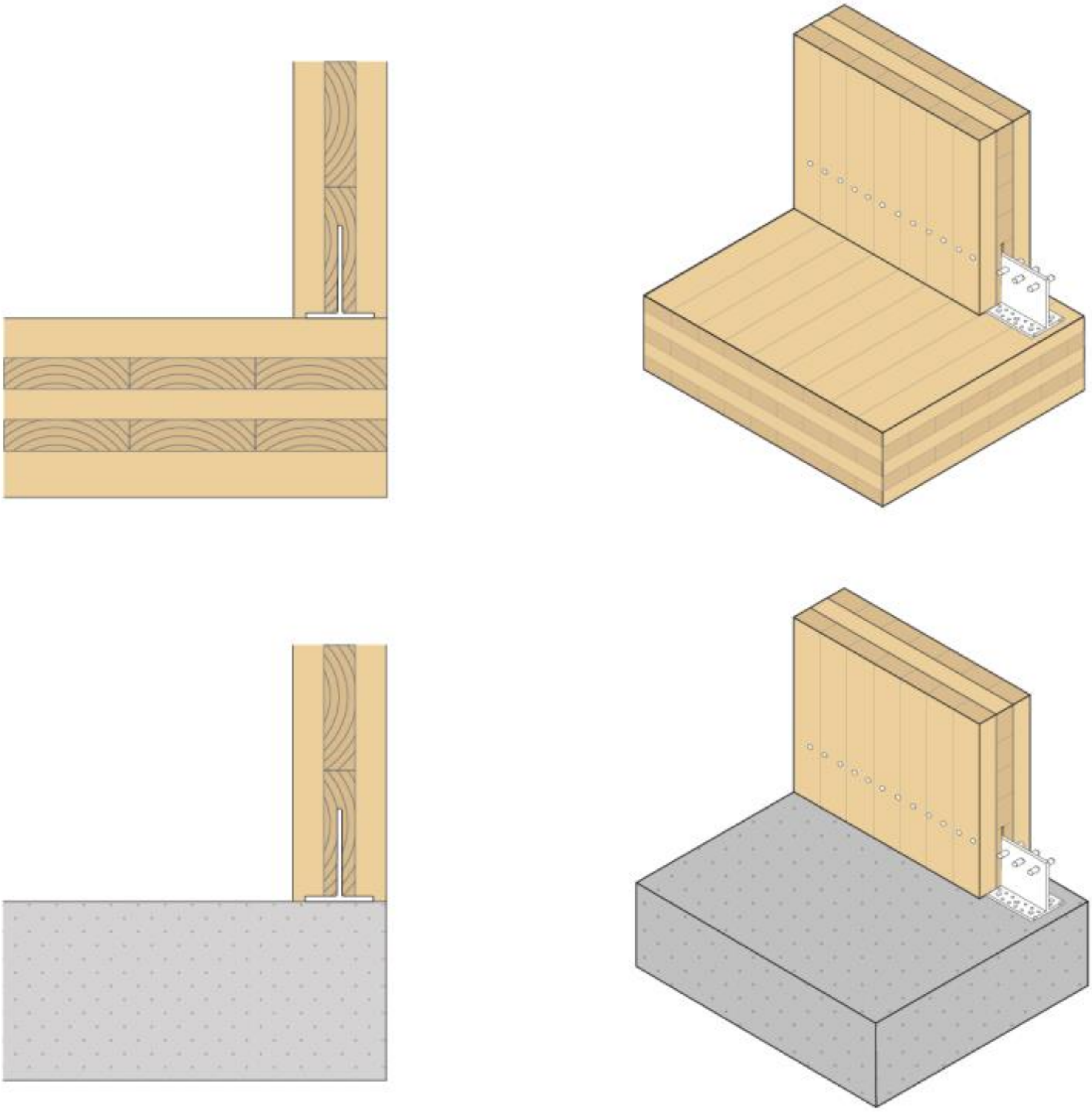
Use:

AluMAXI without holes
Timber - Concrete

Threaded rod Ø16 mm with resin -
Self-drilling dowels

Annex:

17a.



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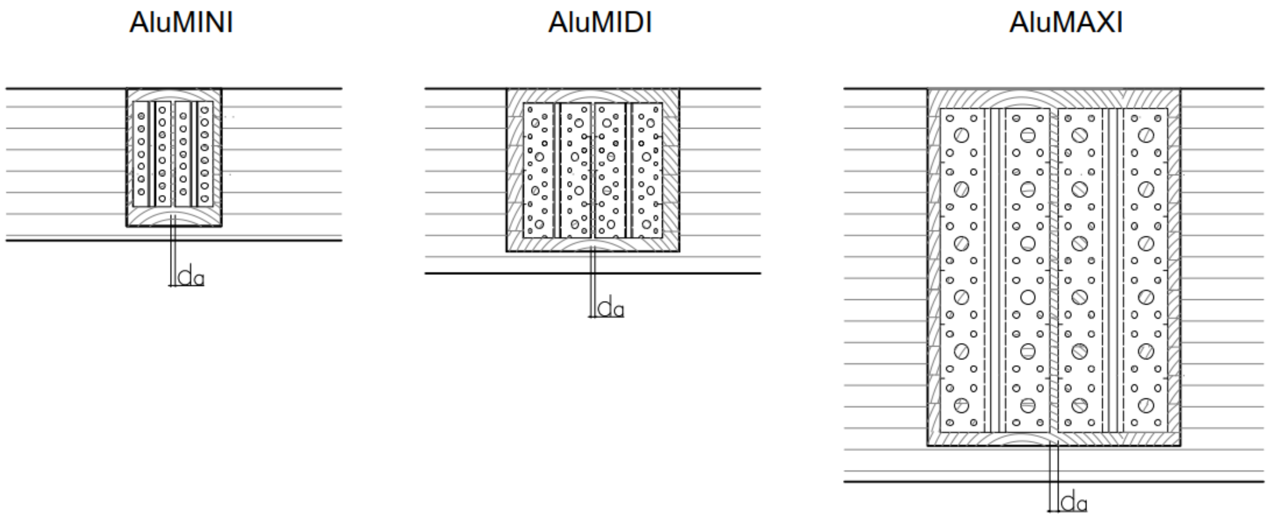
Use:

Alu joist bearings
CLT - CLT
CLT - concrete

Annex:

18a.

AluMINI, AluMIDI andAluMAXI connections with up to three parallel joist bearings



Minimum clear spacing d_a:

- Load direction F_{ax}:
    - AluMINI screws d = 5 mm: d_a = 5 mm
    - AluMINI nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 10 mm
    - AluMINI nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 22 mm
    - AluMINI screws d = 7 mm: d_a = 15 mm
    - AluMIDI nails d = 4 mm, $\rho_k \leq 420$ kg/m³: d_a = 4 mm
    - AluMIDI nails d = 4 mm, $\rho_k \leq 500$ kg/m³: d_a = 12 mm
    - AluMIDI screws d = 5 mm: d_a = 9 mm
    - AluMAXI nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 7 mm
    - AluMAXI nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 19 mm
    - AluMAXI screws d = 7 mm: d_a = 12 mm

- Load direction F_v or F_{up}:
    - AluMINI screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 5 mm
    - AluMINI screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 15 mm
    - AluMINI nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 10 mm
    - AluMINI nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 22 mm
    - AluMINI screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 15 mm
    - AluMINI screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 29 mm
    - AluMIDI nails d = 4 mm, $\rho_k \leq 420$ kg/m³: d_a = 4 mm
    - AluMIDI nails d = 4 mm, $\rho_k \leq 500$ kg/m³: d_a = 12 mm
    - AluMIDI screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 9 mm
    - AluMIDI screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 19 mm
    - AluMAXI nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 7 mm
    - AluMAXI nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 19 mm
    - AluMAXI screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 12 mm
    - AluMAXI screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 26 mm

- Load direction F_{lat}:
  - AluMINI column screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 5 mm
  - AluMINI column screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 15 mm
  - AluMINI header screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 22 mm
  - AluMINI header screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 33 mm
  - AluMINI column nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 10 mm
  - AluMINI column nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 22 mm
  - AluMINI header nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 30 mm
  - AluMINI header nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 43 mm
  - AluMINI column screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 15 mm
  - AluMINI column screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 29 mm
  - AluMINI header screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 39 mm
  - AluMINI header screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 53 mm
  - AluMIDI column nails d = 4 mm, $\rho_k \leq 420$ kg/m³: d_a = 4 mm
  - AluMIDI column nails d = 4 mm, $\rho_k \leq 500$ kg/m³: d_a = 12 mm
  - AluMIDI header nails d = 4 mm, $\rho_k \leq 420$ kg/m³: d_a = 12 mm
  - AluMIDI header nails d = 4 mm, $\rho_k \leq 500$ kg/m³: d_a = 26 mm
  - AluMIDI column screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 9 mm
  - AluMIDI column screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 19 mm
  - AluMIDI header screws d = 5 mm, $\rho_k \leq 420$ kg/m³: d_a = 26 mm
  - AluMIDI header screws d = 5 mm, $\rho_k \leq 500$ kg/m³: d_a = 36 mm
  - AluMAXI column nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 7 mm
  - AluMAXI column nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 19 mm
  - AluMAXI header nails d = 6 mm, $\rho_k \leq 420$ kg/m³: d_a = 27 mm
  - AluMAXI header nails d = 6 mm, $\rho_k \leq 500$ kg/m³: d_a = 40 mm
  - AluMAXI column screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 12 mm
  - AluMAXI column screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 26 mm
  - AluMAXI header screws d = 7 mm, $\rho_k \leq 420$ kg/m³: d_a = 36 mm
  - AluMAXI header screws d = 7 mm, $\rho_k \leq 500$ kg/m³: d_a = 50 mm

For combinations of load directions, the maximum value governs.