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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-24/0062 of 2024/06/26

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 RADIAL connectors
Product family to which the above construction product belongs:	Three-dimensional nailing plate
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 Manufacturing Plants: ROTHO BLAAS s.r.l. Held on file by ETA-Danmark AS
This European Technical Assessment contains:	28 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:	

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II SPECIFIC PART OF THE EUROPEAN TECHNICAL ASSESSMENT

1 Technical description of product

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

RADIAL connectors are made of steel S355 according to EN 10025-2 or an equivalent or better carbon steel or an equivalent or better stainless steel. Dimensions, hole positions 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)

RADIAL connectors are intended for use in making end-grain to end-grain or end-grain to side-grain connections in load bearing timber structures, as a connection between wood based members as well as connections between a timber member 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.

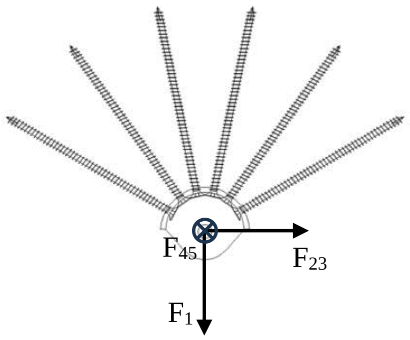
RADIAL connectors can be installed as connections between wood-based members such as:

- 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,
- LVL according to EN 14374 or ETA,
- 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 480 kg/m^3. 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 RADIAL connectors. 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 RADIAL connector are F_1 or F_{23} perpendicular to the half pipe's axis and F_{45} parallel to the half pipe's axis and perpendicular to the screw's axes. The forces shall act in the central bolt holes of the connector.



RADIAL connectors are intended for use for connections subject to static or quasi static loading. This includes seismic actions.

The RADIAL connectors are for use in timber structures subject to service classes 1, 2 and 3 of Eurocode 5 and for connections subject to static or quasi-static loading. In service class 1 and 2 the corrosion protection is given according to EN1995-1-1, or by equivalent measures.

In service class 3 the corrosion protection is given according to EN1995-1-1 or by stainless steel or zinc coating with minimum thickness of 55 μm according to EN ISO 1461, or by equivalent measures.

The metal fasteners must also be of stainless steel or have a coating for the intended use in service class 3 of EN 1995-1-1.

The scope of the connectors 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 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	RADIAL connectors are made from steel grade S355 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	RADIAL connectors 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

*) 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 steel connectors. To obtain design values the capacities must 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 1990:2002+A1:2005 (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 steel failure $F_{Rk,steel}$. The design value of the load–carrying capacity is the smaller value of both load–carrying capacities.

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

Therefore, for timber failure the load duration class and the service class are included. The different partial factors γ_M for steel or timber, respectively, are also correctly considered.

3.5 Mechanical resistance and stability

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

The characteristic capacities of the connectors are determined by calculation assisted by testing 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 in Annex A:

- Self-tapping screws in accordance with ETA-11/0030
- Bolts in accordance with ISO 4017 or ISO 4762
- Clevis pin according to ISO 2341
- Turnbuckles according to Annex A
- Threaded bars or bolts, right thread and left thread according to Annex A

In the formulas in Annex B the capacities for 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 assessed 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 RADIAL connectors are made from steel grade S355 according to EN 10025-2 or an equivalent or better carbon steel or an equivalent or better stainless steel and may be not coated for t ≥ 6 mm, zinc electro plated or hot dip galvanised.

3.6.2. Corrosion protection in service class 3

In service class 3 the corrosion protection is given according to EN1995-1-1, or by equivalent measure. The requirement is fulfilled by connectors with a corrosion protection stainless steel according to EN 10088-3 or hot-dip galvanized of approximately 55 µm according to EN ISO 1461, or by equivalent measures.

3.7 General aspects related to the use of the product

Rotho Blaas RADIAL 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.

RADIAL connections

A RADIAL connection is deemed fit for its intended use provided:

Wood to wood connections

- Connectors are fastened to wood-based members by screws.
- There shall be a bolt or pin in the central hole.
- The characteristic capacity of the RADIAL connection is calculated according to the manufacturer's technical documentation, dated 2023-12-12.
- The RADIAL connection is designed in accordance with Eurocode 5 or an appropriate national code.
- The gap between the hole in the timber member and the surface, where contact stresses can occur during

loading shall be limited. This means that for RADIAL connectors the gap between the surface of the half pipe and the timber member hole surface shall be maximum 1 mm.

- The width of the timber member shall allow the tip of any screw being at least 10 mm from the member surface. The edge distance, if not indicated by this document follows the requirements in ETA-11/0030.
- Screws to be used shall have a diameter and head shape, which fits the holes of the RADIAL connector.

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 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 provided for in the applicable EAD

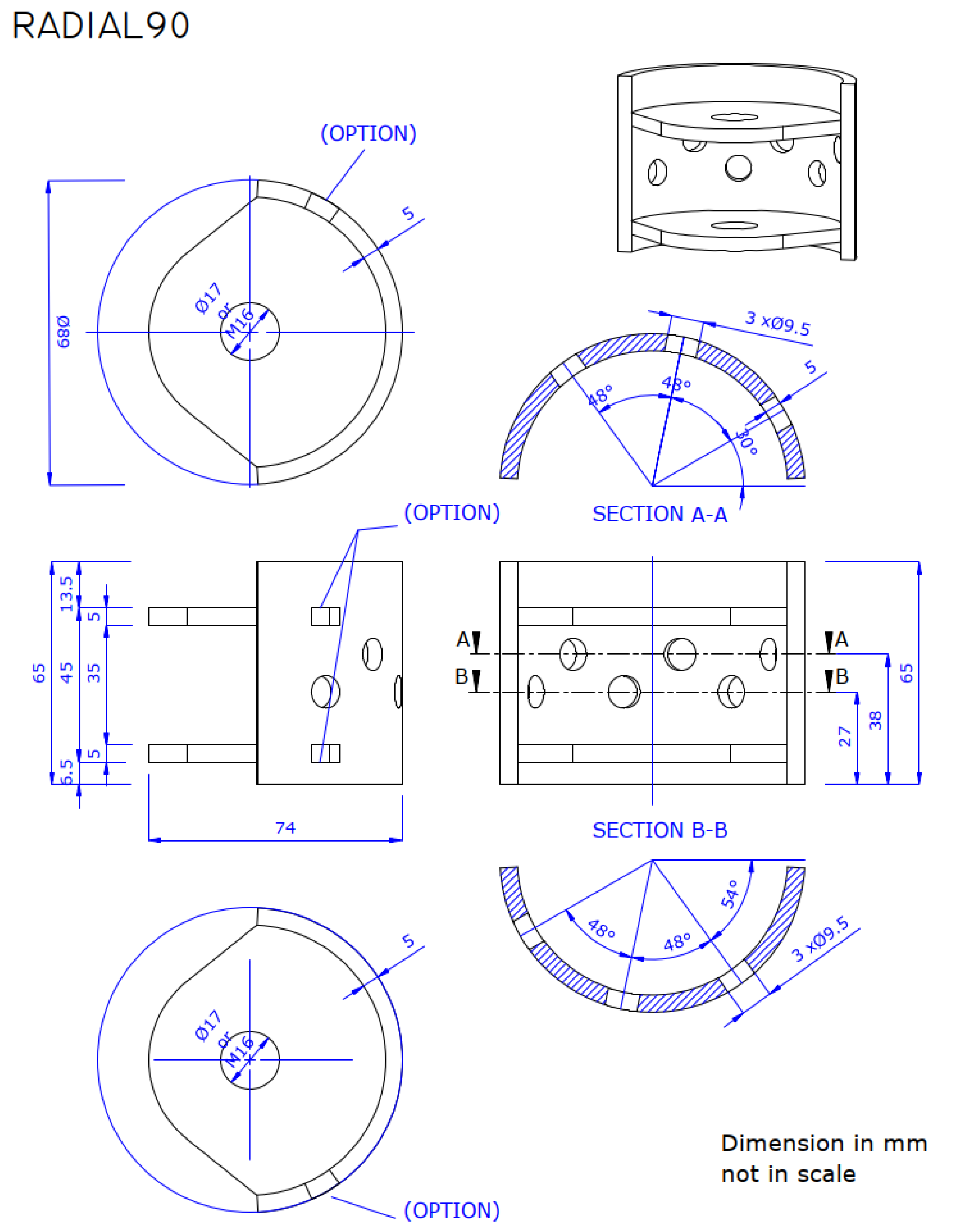
Technical details necessary for the implementation of the AVCP system are laid down in the control plan deposited at ETA-Danmark prior to CE marking.

Issued in Copenhagen on 2024-06-26 by

Thomas Bruun
Managing Director, ETA-Danmark

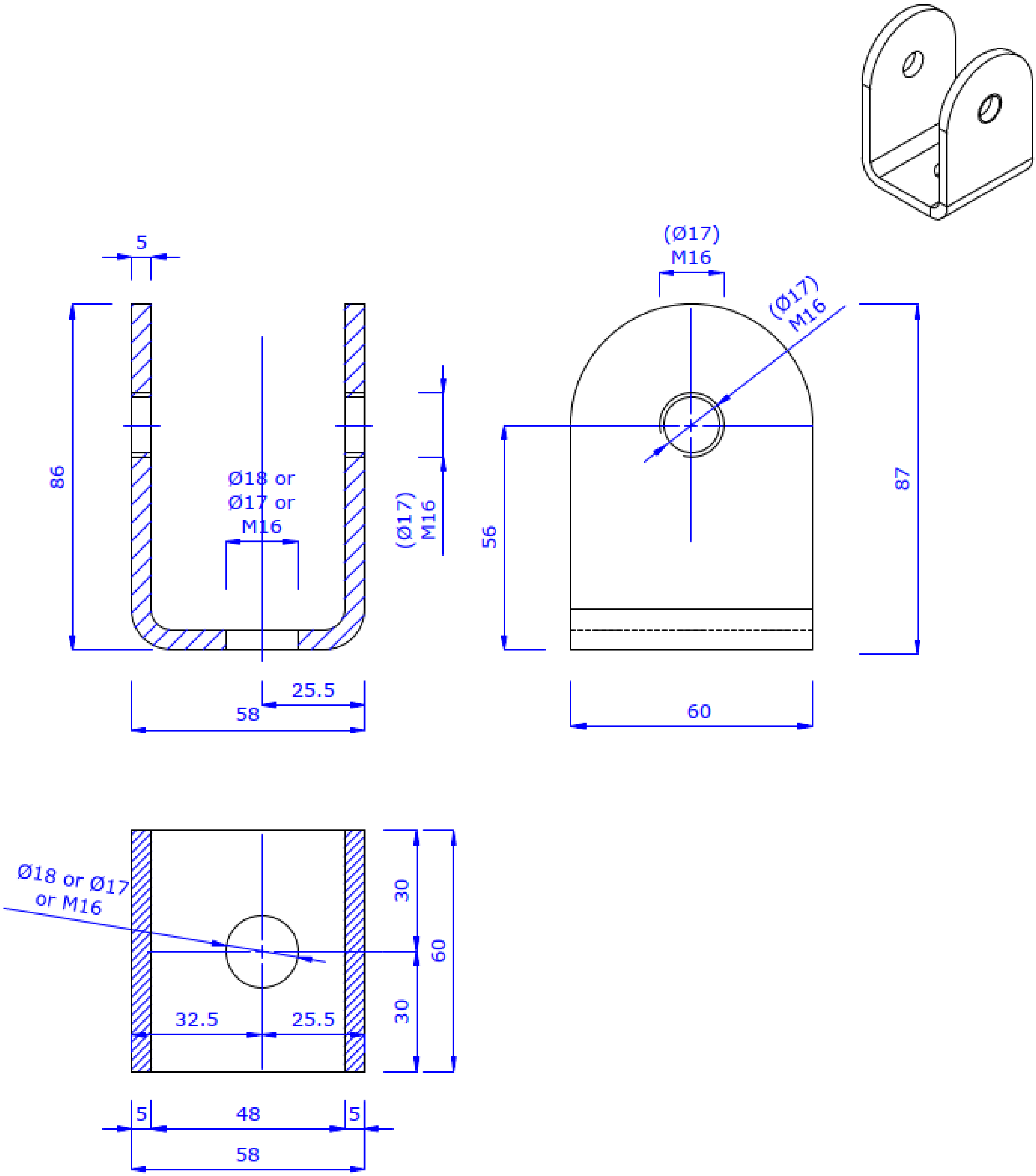
Annex A
Product details and definitions

RADIAL90
Face mount connector. 5.0 mm thick steel S355 according to EN 10025-2 or an equivalent or better carbon steel or an equivalent or better stainless steel.



RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: RADIAL90	

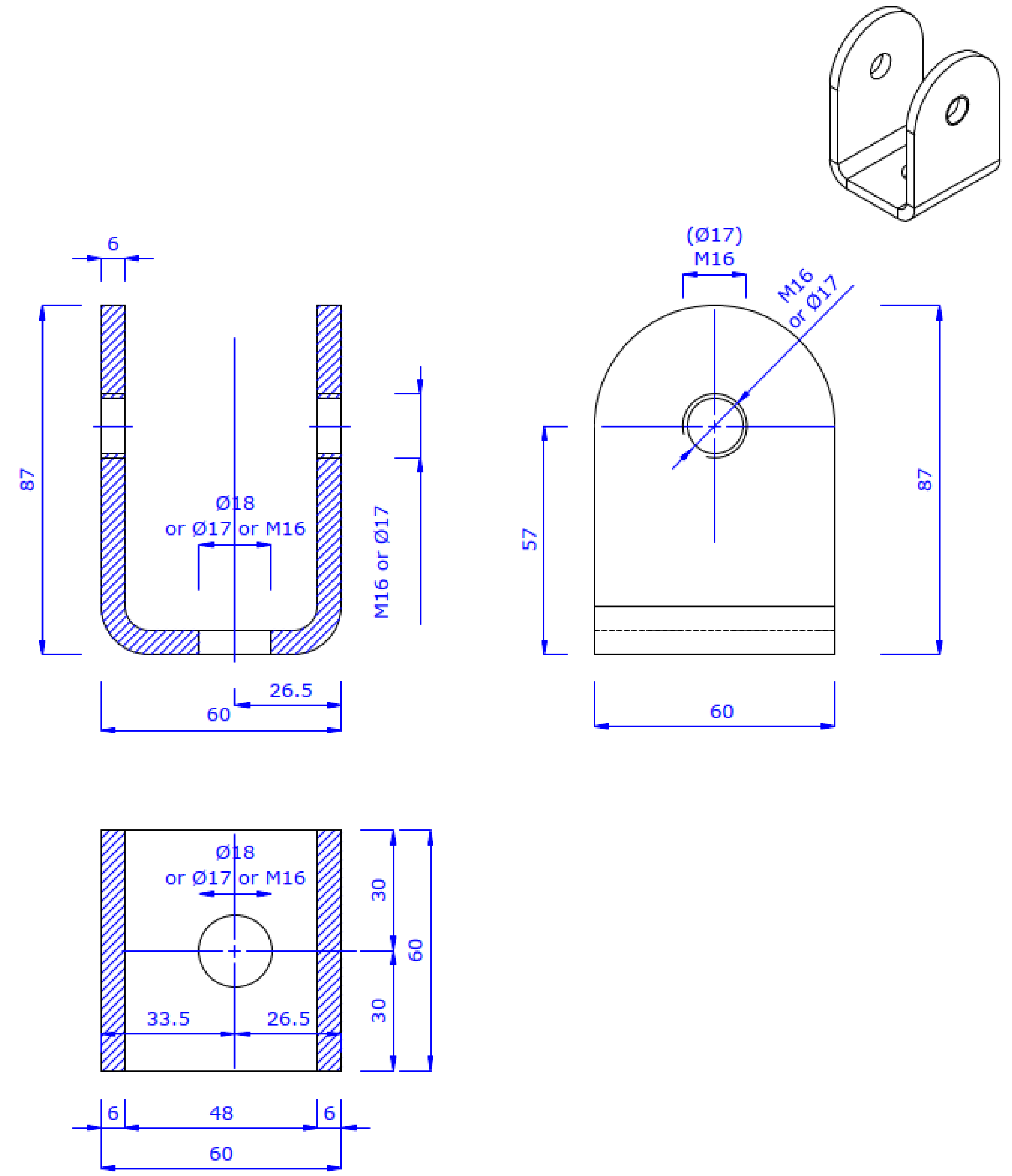
U-SHAPED FORK 90/5



Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: U-Shaped fork 90/5	

U-SHAPED FORK 90/6

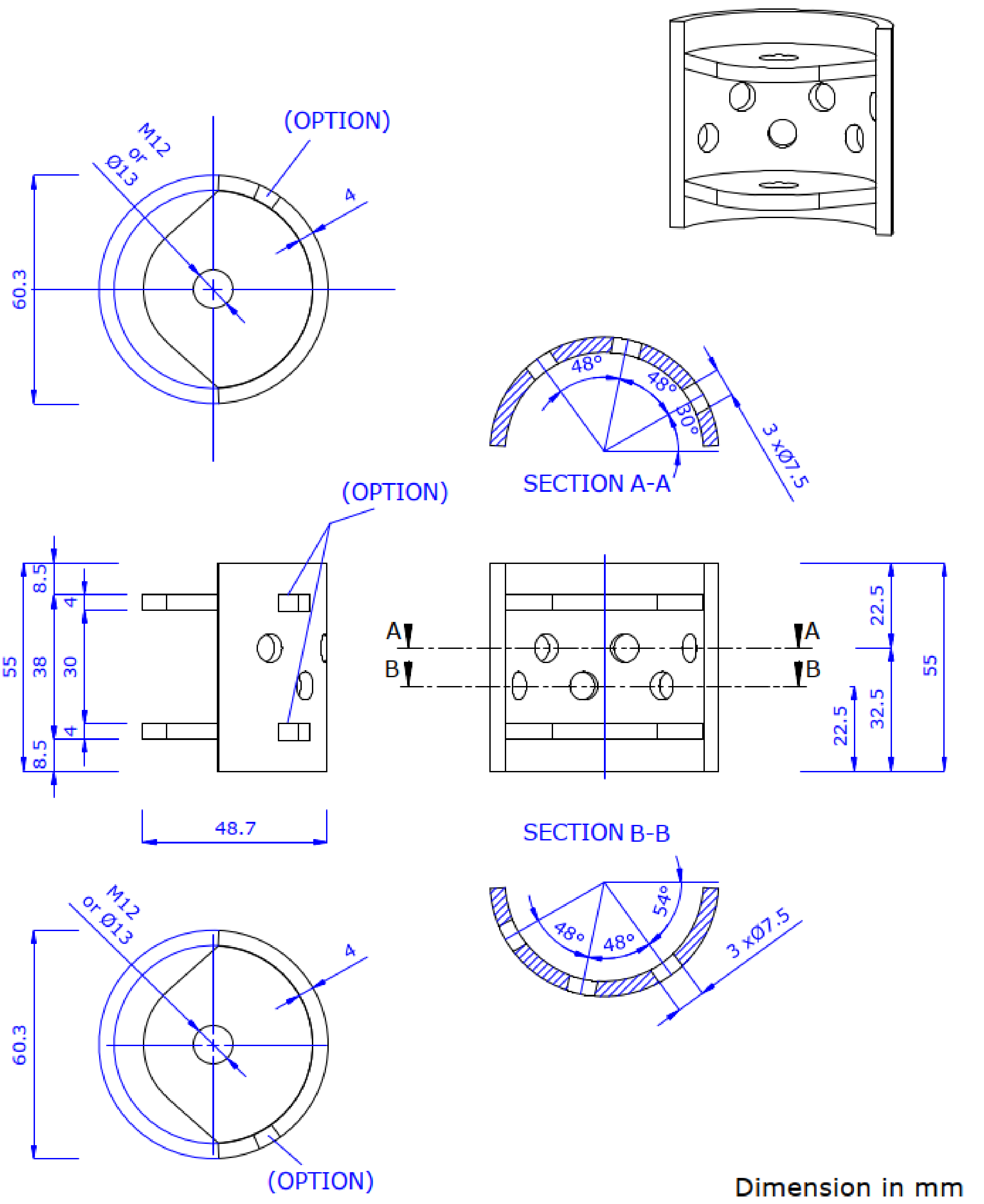


Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: U-Shaped fork 90/6	

RADIAL60D
Face mount connector. 4.0 mm thick steel S355 according to EN 10025-2 or an equivalent or better carbon steel or an equivalent or better stainless steel.

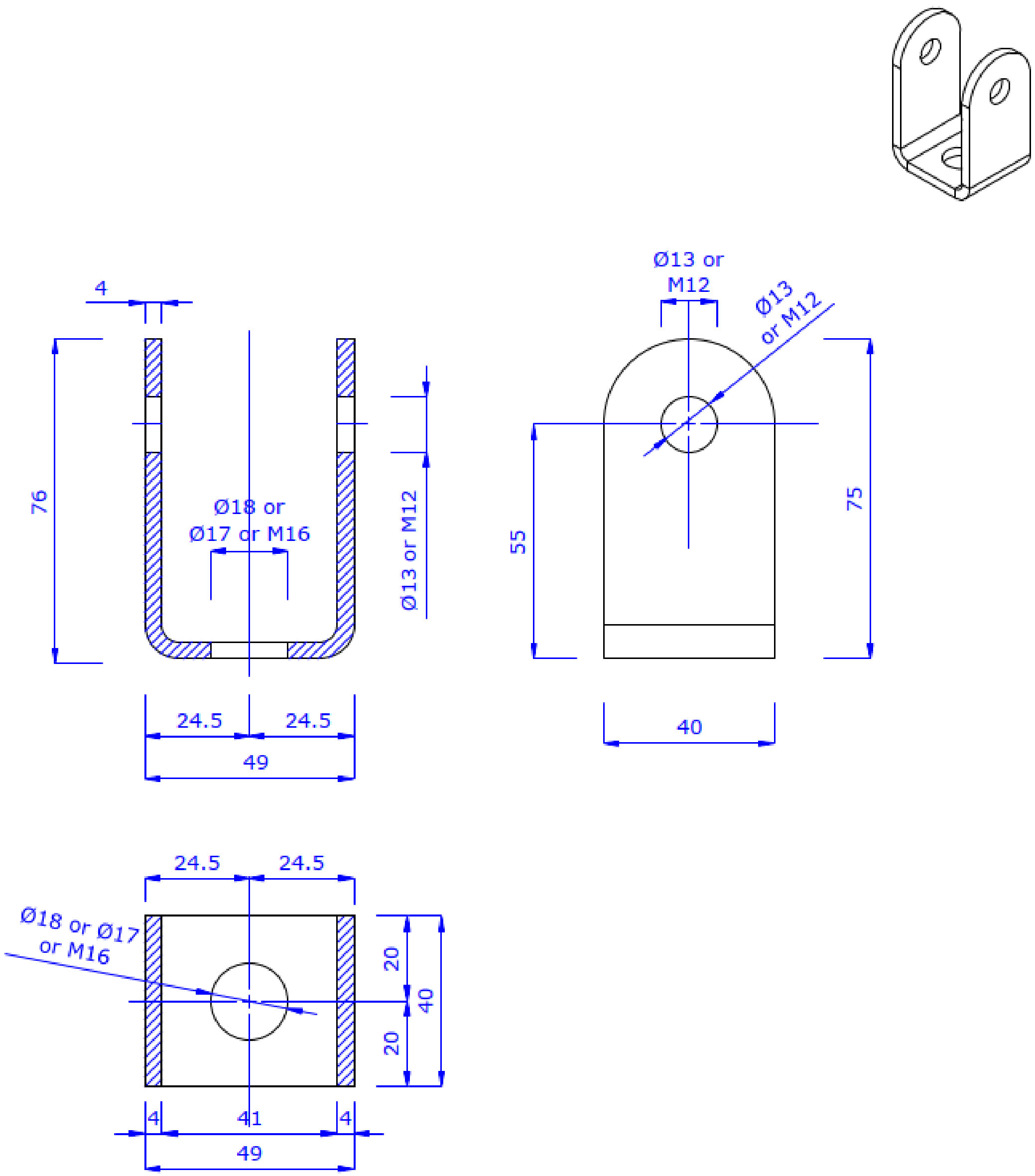
RADIAL60D



Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: RADIAL60D	

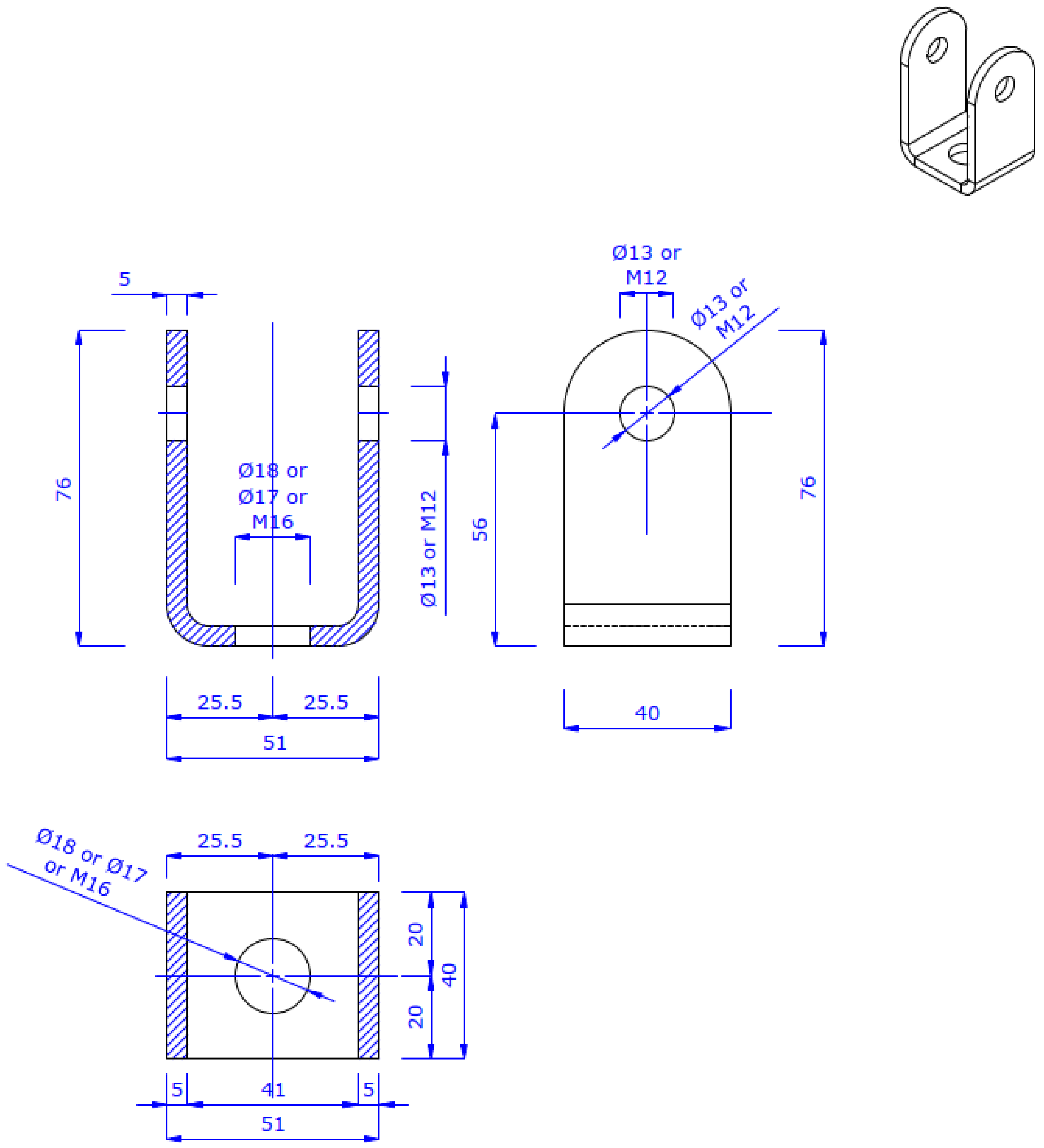
U-SHAPED FORK 60/4



Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: U-Shaped fork 60/4	

U-SHAPED FORK 60/5

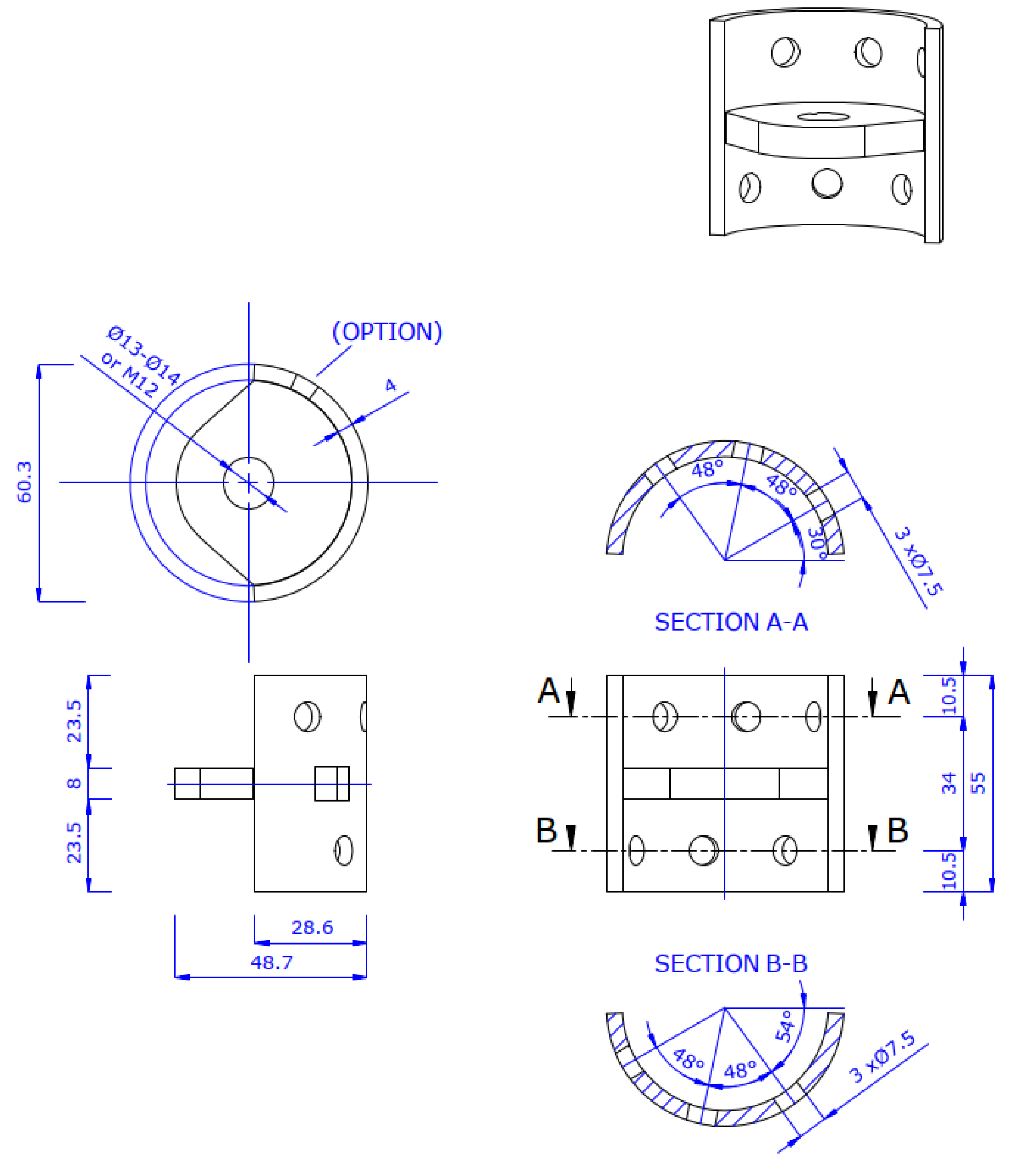


Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: U-Shaped fork 60/5	

RADIAL60S
Face mount connector. 4.0 mm thick steel S355 according to EN 10025-2 or an equivalent or better carbon steel or an equivalent or better stainless steel.

RADIAL60S

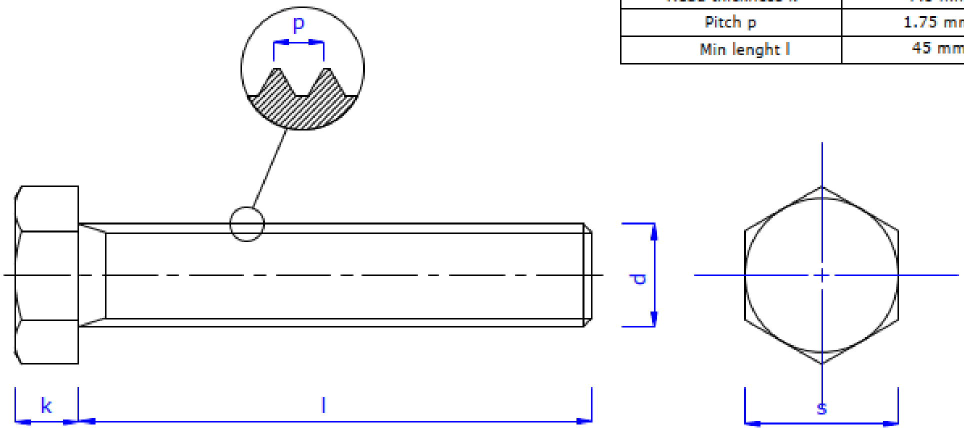


Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Product details: RADIAL60S	

RADBOLT M12

Hexagon head screw - fully threaded		
	M12	
Class	10.9	8.8
Char. yield srenght $f_{y,k}$	900 N/mm^2	640 N/mm^2
Mean tensile srenght $f_{u,m}$	1000 N/mm^2	800 N/mm^2
Nominal thread diameter d	12 mm	
Head diameter s	18 mm	
Head thickness k	7.5 mm	
Pitch p	1.75 mm	
Min lenght l	45 mm	



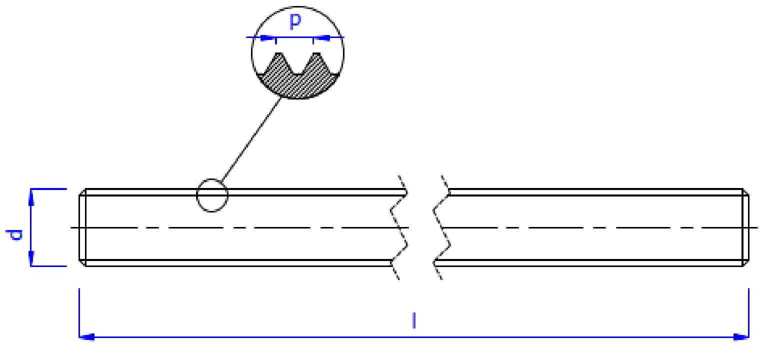
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

RADBOLT M12

(ALTERNATIVE VERSION THREADED RODS)

Threaded rod	
	M12
Class	8.8
Char. yield srenght $f_{y,k}$	640 N/mm^2
Mean tensile srenght $f_{u,m}$	800 N/mm
Nominal thread diameter d	12 mm
Pitch p	1.75 mm
Min lenght l	45 mm



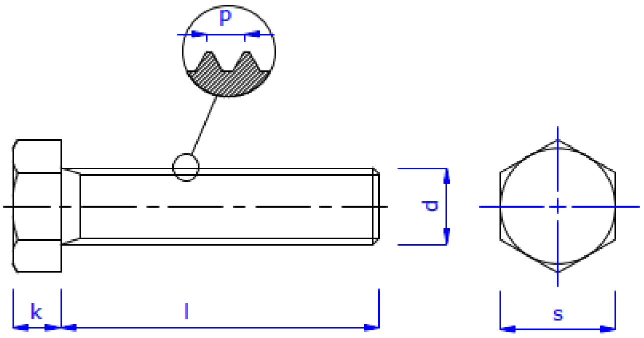
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Fastener specification: RADBOLT	

RADBOLT M16

Hexagon head screw - fully threaded	
	M16
Class	8.8
Char. yield srenght $f_{y,k}$	640 N/mm^2
Mean tensile srenght $f_{u,m}$	800 N/mm^2
Nominal thread diameter d	16 mm
Head diameter s	24 mm
Head thickness k	10 mm
Pitch p	2 mm
Min lenght l	45 mm



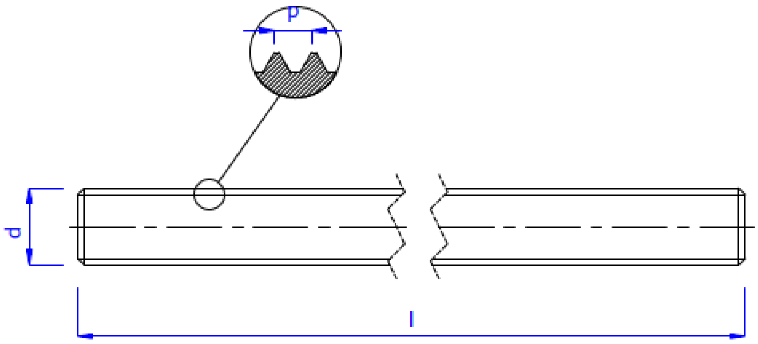
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

RADBOLT M16

(ALTERNATIVE VERSION THREADED RODS)

Threaded rod		
	M16	
Class	8.8	
Char. yield srenght $f_{y,k}$	640 N/mm^2	
Mean tensile srenght $f_{u,m}$	800 N/mm^2	
Nominal thread diameter d	16 mm	
Pitch p	2 mm	
Thread direction	Left	Right
Min lenght l	45 mm	



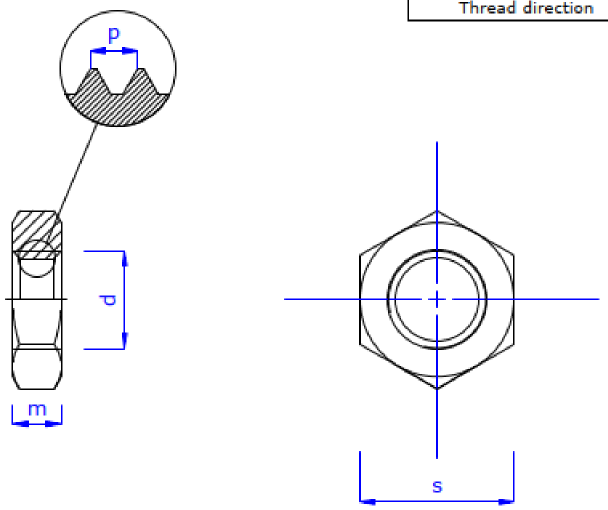
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Fastener specification: RADBOLT	

NUT M12/16

Hexagon tin nut (LH)				
	M12		M16	
Class	04 or +			
Nominal thread diameter d	12 mm		16 mm	
Head diameter s	19 mm		24 mm	
Head thickness m	6 mm		8 mm	
Pitch p	1.75 mm		2 mm	
Thread direction	Left	Right	Left	Right



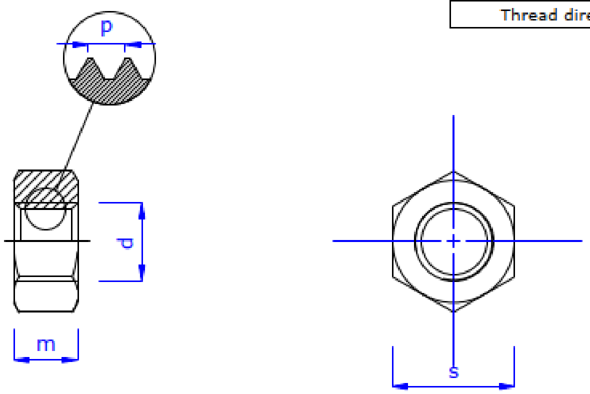
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

NUT M12/16

(ALTERNATIVE VERSION)

Hexagon nut				
	M12		M16	
Class	8			
Nominal thread diameter d	12 mm		16 mm	
Head diameter s	19 mm		24 mm	
Head thickness m	10 mm		13 mm	
Pitch p	1.75 mm		2 mm	
Thread direction	Left	Right	Left	Right



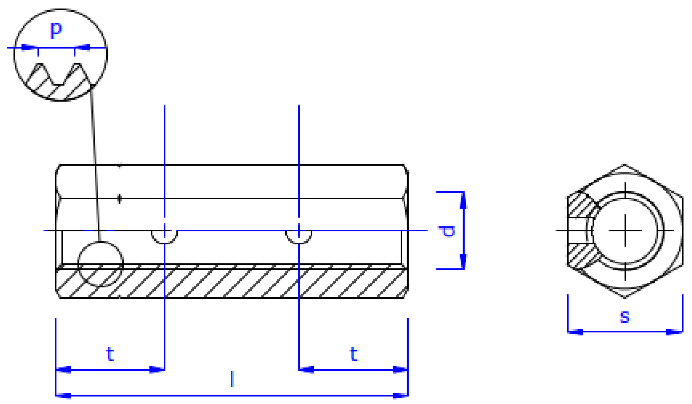
Dimension in mm
not in scale

Note: drawings is copiright Rotho Blaas

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Fastener specification: RADBOLT NUT	

HEXAGONAL TURNBUCKLE

Hexagon turnbuckle			
	M12	M16	M20
Nominal thread diameter d	12 mm	16 mm	20 mm
Head diameter s	18 mm	24 mm	30 mm
Lenght l	55 mm	75 mm	95 mm
Hole position t	17 mm	22 mm	26 mm
Pitch p	1.75 mm	2 mm	2.5 mm

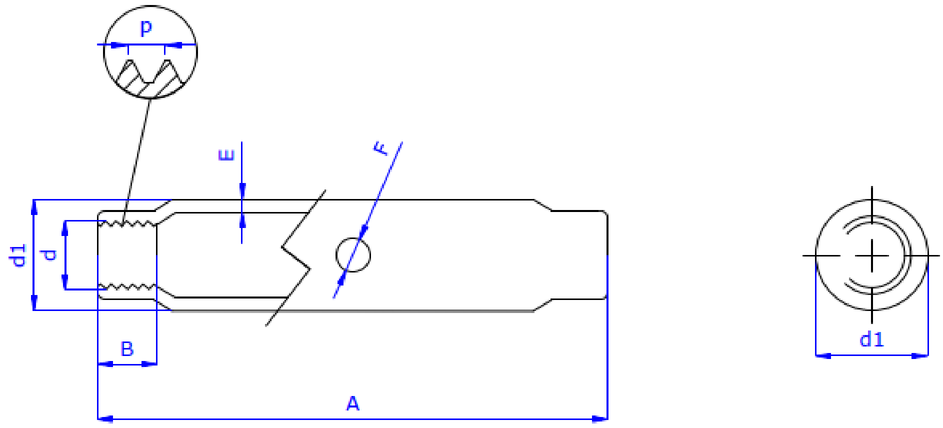


Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Fastener specification: TURNBUCKLE	

ROUND TURNBUCKLE

Round turnbuckle			
	M12	M16	M20
Nominal thread diameter d	12 mm	16 mm	20 mm
Outer diameter d1	25 mm	30 mm	33.7 mm
Thickness E	4 mm	4.5 mm	5.0 mm
Lenght A	125 mm	170 mm	200 mm
Threaded part B	15 mm	20 mm	24 mm
Pitch p	1.75 mm	2 mm	2.5 mm



Dimension in mm
not in scale

RADIAL Connectors	Annex A of European Technical Assessment ETA-24/0062
Fastener specification: TURNBUCKLE	

Fastener types and sizes

Screw diameter	Minimum Length (L)	Screw type
7.0	100	LBS or LBSH - LBS EVO or LBSH EVO screw according to ETA-11/0030
9.0	180	VGS – VGS EVO screw according to 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 characteristic axial capacity of the screws is determined by calculation:

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

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, $\ell_{ef} = L - 15$ mm

$f_{ax,k}$, $f_{tens,k}$, ρ_a, k_{ax} and k_β see ETA-11/0030.

BOLTS or PINS diameter	Corresponding hole diameter in steel plate	Fastener type according to Annex A or
Bolt M12	13 mm	Bolt according to ISO 4017 or ISO 4762
Bolt M12	M12	Bolt according to ISO 4017 or ISO 4762
Bolt M16	17 mm	Bolt according to ISO 4017 or ISO 4762
Bolt M16	M16	Bolt according to ISO 4017 or ISO 4762
Clevis pins with pin hole M12	13 mm	Clevis pin according to ISO 2341
Clevis pins with pin hole M16	17 mm	Clevis pin according to ISO 2341

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

One-piece RADIAL connectors consist of a steel half pipe and one or two welded steel plates. The half pipe is connected to the timber member with fully threaded LBS/LBS EVO, LBSH/LBSH EVO (RADIAL60D and RADIAL60S) or VGS /VGS EVO (RADIAL90) screws. The RADIAL connector steel plate is joined to a second RADIAL connector or to steel parts with 8.8 or greater metric steel bolts M12 or M16 or with clevis pins.

The forces are assumed to act in the central holes of the steel plates.

Two fastener patterns are foreseen. Fastener patterns have 4 or 6 symmetrically arranged fully threaded screws.

For RADIAL connectors arranged side-by-side, the load-carrying capacity of the connection is the sum of the load-carrying capacities of the RADIAL connectors.

B.1 Characteristic load-carrying capacity

Tensile loading in load direction 1

$$F_{1,t,Rk} = \min\left\{\sum_{i=1}^{n_s} F^1_{ax,i,Rk} \cdot \cos\alpha_i ; n_{sp} \cdot F_{b,Rk} ; F_{fork,Rk}\right\} \qquad \text{(B.1)}$$

Where:

n_s Number of symmetrically arranged screws in the RADIAL connector

$F^1_{ax,i,Rk}$ Characteristic axial load-carrying capacity of screw i according to ETA-11/0030

$$F^1_{ax,i,Rk} = \min\left\{\frac{k_{ax,i} \cdot f_{ax,i,k} \cdot d \cdot \ell_{ef}}{k_\beta}\left(\frac{\rho_k}{\rho_a}\right)^{0,8} ; f_{tens,k}\right\}$$

$f_{ax,k}$, $f_{tens,k}$, ρ_a, k_{ax} and k_β see ETA-11/0030.

α_i Angle between the axis of screw i and the direction of load $F_{1,Ed}$

n_{sp} Number of shear planes

$F_{b,Rk}$ Characteristic load-carrying capacity of an 8.8 steel bolt to EN 1993-1-8, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$

$F_{b,Rk}$ = 56,7 kN per shear plane for RADIAL90,

$F_{b,Rk}$ = 30,2 kN per shear plane for RADIAL60D,

$F_{b,Rk}$ = 40,5 kN per shear plane for RADIAL60S.

For connections with a U-shaped fork, see Annex A, $F_{fork,Rd} = F_{fork,Rk} / \gamma_{M2}$:

$F_{fork,Rk}$ = 71,2 kN per shear plane for RADIAL90 with 5 mm fork (U-Shaped fork 90/5),

$F_{fork,Rk}$ = 85,6 kN per shear plane for RADIAL90 with 6 mm fork (U-Shaped fork 90/6),

$F_{fork,Rk}$ = 43,8 kN per shear plane for RADIAL60D with 4 mm fork (U-Shaped fork 60/4),

$F_{fork,Rk}$ = 54,7 kN per shear plane for RADIAL60D with 5 mm fork (U-Shaped fork 60/5).

For connections between a RADIAL60D and a RADIAL60S, see Annex C, $F_{fork,Rd} = F_{fork,Rk} / \gamma_{M2}$:

$F_{fork,Rk}$ = 45,0 kN per connection for 10.9 bolt.

Compressive loading in load direction 1

$$F_{1,c,Rk} = \min\left\{f_{h,\varepsilon,k} \cdot d_{RADIAL} \cdot b_{RADIAL}; n_{sp} \cdot F_{b,Rk}\right\} \qquad (B.2)$$

Where:

$F_{1,c,Rk}$ Characteristic compressive load-carrying capacity of RADIAL connectors,

$f_{h,\varepsilon,k}$ Characteristic embedding strength for RADIAL connectors

$$f_{h,\alpha,k} = \frac{0,05 \cdot \rho_k}{2 \cdot \sin^2\beta + \cos^2\beta}$$ for timber and LVL members

$$f_{h,\alpha,k} = 0,04 \cdot \rho_k$$ for edge faces of CLT members

β Angle between the grain direction and the direction of load $F_{1,Ed}$

d_{RADIAL} Diameter of RADIAL connector
d_{RADIAL} = 89 mm for RADIAL90
d_{RADIAL} = 60 mm for RADIAL60D or RADIAL 60S

b_{RADIAL} Length of RADIAL connector
d_{RADIAL} = 65 mm for RADIAL90
d_{RADIAL} = 55 mm for RADIAL60D or RADIAL 60S

$F_{b,Rk}$ Characteristic load-carrying capacity of an 8.8 steel bolt to EN 1993-1-8, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$
$F_{b,Rk}$ = 75,4 kN per shear plane for RADIAL90
$F_{b,Rk}$ = 40,5 kN per shear plane for RADIAL60D or RADIAL60S

n_{sp} Number of shear planes

Shear loading in load direction 2/3

$$F_{23,Rk} = \min\left\{\sum_{i=1}^{6} F^{23}_{ax,i,Rk} \cdot \cos\alpha_i \; ; n_{sp} \cdot F_{b,Rk}\right\} \text{ for 6 screw pattern} \qquad (B.3)$$

$$F_{23,Rk} = \min\left\{\sum_{i=1}^{2} F^{23}_{ax,t,i,RK} \cdot \cos\alpha_i + \sum_{i=4}^{6} F^{23}_{ax,c,i,RK} \cdot \cos\alpha_i \; ; n_{sp} \cdot F_{b,Rk}\right\} \text{ for 4 screw pattern} \qquad (B.4)$$

Where:

$F^{23}_{ax,i,Rk}$ Lower value of axial load-carrying capacity $F^{23}_{ax,t,i,Rk}$ of screw i according to ETA-11/0030 and embedding capacity $F^{23}_{ax,c,i,Rk}$ of 24° segment of circle:

$$F^{23}_{ax,i,Rk} = \min\left\{F^{23}_{ax,t,i,Rk}; F^{23}_{ax,c,i,Rk}\right\}$$

$$F^{23}_{ax,t,i,Rk} = \min\left\{\frac{k_{ax,i} \cdot f_{ax,i,k} \cdot d \cdot \ell_{ef}}{k_\beta}\left(\frac{\rho_k}{\rho_a}\right)^{0,8}; f_{tens,k}\right\}$$

$$F^{23}_{ax,c,i,Rk} = 1,5 \cdot f_{h,\varepsilon i,k} \cdot b_{RADIAL} \cdot d_{RADIAL} \cdot \sin 12°$$

$f_{ax,k}$, $f_{tens,k}$, ρ_a, k_{ax} and k_β see ETA-11/0030.

$f_{h,\varepsilon i,k}$ Characteristic embedding strength for RADIAL connectors

$$f_{h,\varepsilon i,k} = \frac{0,05 \cdot \rho_k}{2 \cdot \sin^2\varepsilon_i + \cos^2\varepsilon_i}$$ for timber or LVL members

$$f_{h,\alpha,k} = 0,04 \cdot \rho_k$$ for edge faces of CLT members

α_i Angle between the axis of screw i and the direction of load $F_{23,Ed}$

ε_i Angle between the axis of screw i and the grain direction

$F_{b,Rk}$ Characteristic load-carrying capacity of an 8.8 steel bolt to EN 1993-1-8, $F_{b,Rd} = F_{b,Rk} / \gamma_{M2}$
$F_{b,Rk}$ = 56,7 kN per shear plane for RADIAL90,
$F_{b,Rk}$ = 30,2 kN per shear plane for RADIAL60D,
$F_{b,Rk}$ = 40,5 kN per shear plane for RADIAL60S.

n_{sp} Number of shear planes

Shear loading in load direction 4/5

$$F_{45,Rk} = \min\left\{\frac{1}{\sqrt{\left(\frac{1}{n_s \cdot F_{v,Rk}}\right)^2 + \left(\frac{r/a}{\min\left(0,5 \cdot F_{1,t,Rk}; f_{h,\varepsilon,k} \cdot d_{RADIAL} \cdot 15\,mm\right)}\right)^2}}; F_{45,weld,Rk}\right\} \quad \text{(B.4)}$$

Where:

n_s Number of symmetrically arranged screws in the RADIAL connector

$F_{v,Rk}$ Characteristic lateral load-carrying capacity of a screw according to ETA-11/0030 assuming thick steel plates

r/a Parameter
r/a = 1,5 for RADIAL90
r/a = 1,2 for RADIAL60D
r/a = 0,8 for RADIAL60S.

$F_{1,t,Rk}$ Characteristic load-carrying capacity according to equation (B.1)

$f_{h,\varepsilon,k}$ Characteristic embedding strength for RADIAL connectors

$$f_{h,\varepsilon,k} = \frac{0,05 \cdot \rho_k}{2 \cdot \sin^2\varepsilon + \cos^2\varepsilon} \text{ for timber or LVL members}$$

$$f_{h,\varepsilon,k} = 0,04 \cdot \rho_k \text{ for edge faces of CLT members}$$

α Angle between grain direction and load direction 1

$F_{45,weld,Rk}$ Characteristic load-carrying capacity of the welded connection, $F_{45,weld,Rd} = F_{45,weld,Rk} / \gamma_{M2}$
$F_{45,weld,Rk}$ = 17,9 kN for RADIAL90
$F_{45,weld,Rd}$ = 11,6 kN for RADIAL60D
$F_{45,weld,Rd}$ = 23,2 kN for RADIAL60S.

Combined loading

If $F_{1,Ed}$ or $F_{23,Ed}$ or $F_{45,Ed}$ act simultaneously, the following interaction equation shall be fulfilled:

$$\frac{F_{1,Ed}}{F_{1,Rd}} + \frac{F_{23,Ed}}{F_{23,Rd}} + \frac{F_{45,Ed}}{F_{45,Rd}} \leq 1,0 \quad \text{(B.5)}$$

B.2 Slip moduli of RADIAL connectors

The slip moduli do not consider the initial slip due to oversized connector holes for bolts or pins.

$$K_{1,t,ser} = \frac{F_{Rk}^1}{2,7\,mm} \text{ for RADIAL90} \quad \text{(B.6)}$$

$$K_{1,t,ser} = \frac{F_{Rk}^1}{2\,mm} \text{ for RADIAL60D and RADIAL60S} \quad \text{(B.7)}$$

$$K_{1,c,ser} = \frac{F_{Rk}^1}{0,6\,mm} \quad \text{(B.8)}$$

$$K_{23,ser} = \frac{F_{Rk}^{23}}{2,8\,mm} \text{ for RADIAL90} \quad \text{(B.9)}$$

$$K_{23,ser} = \frac{F_{Rk}^{23}}{1,8\,mm} \text{ for RADIAL60D and RADIAL60S} \quad \text{(B.10)}$$

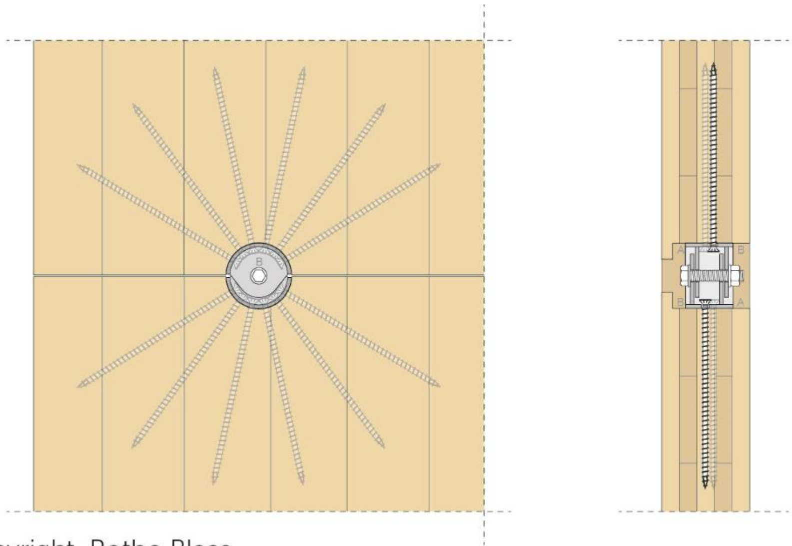
Annex C
Installation of RADIAL connectors

	RADIAL90	RADIAL60D	RADIAL60S	RADIALKIT90(*)	RADIALKIT60(*)
RADIAL90	1x M16	-	-	2x M16 1x M16	-
RADIAL60D	-	-	1x M12	-	2x M12 1x M16
RADIAL60S	-	1x M12	1x M12	-	-

Note: drawing is copyright Rotho Blaas

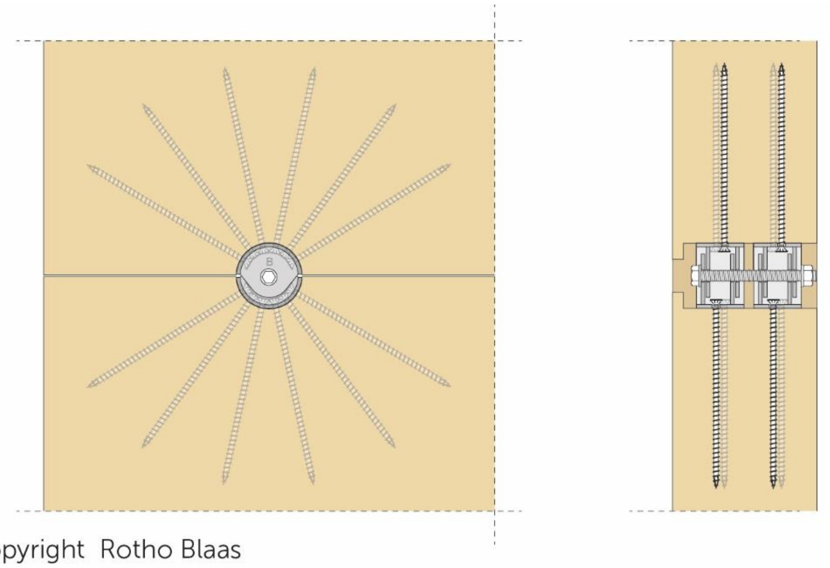
Installation of RADIAL connectors timber-to-timber

Direct connection single fasteners (example RADIAL90):

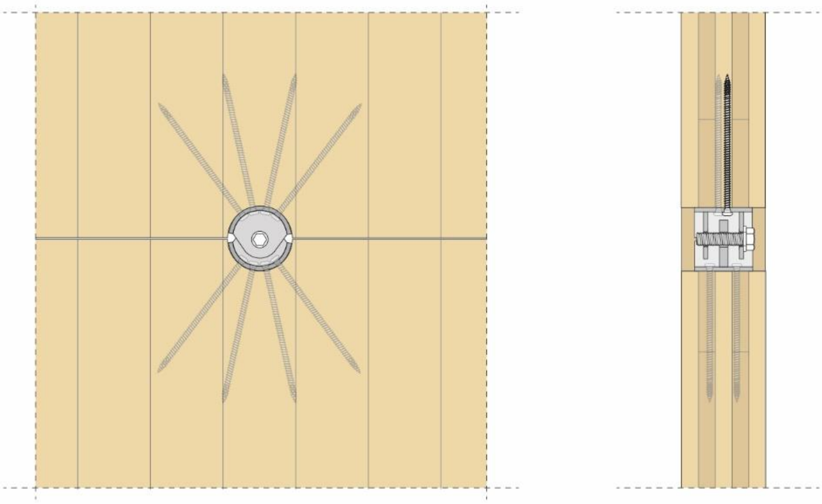


Note: drawing is copyright Rotho Blaas

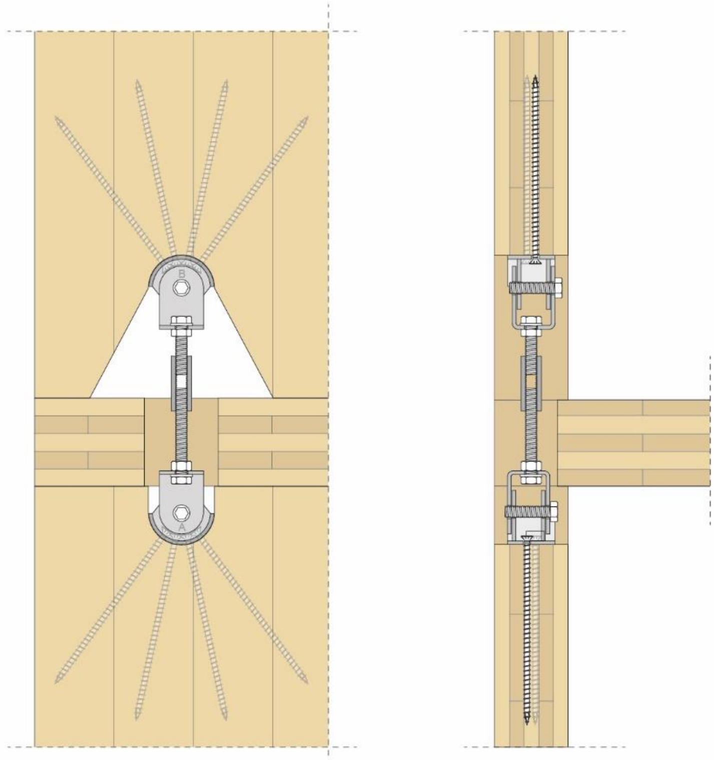
Direct connection multiple fasteners (example RADIAL90):



Direct connection RADIAL60D + RADIAL60S:



Spaced connection single fasteners (example 1 RADIAL90+RADIALKIT90):



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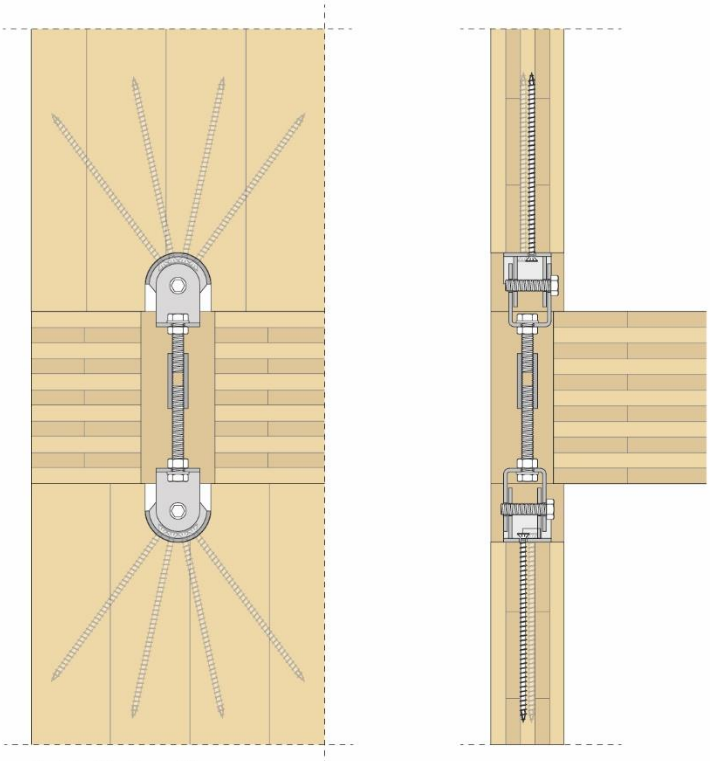
Spaced connection single fasteners (example 2 RADIAL90+RADIALKIT90):



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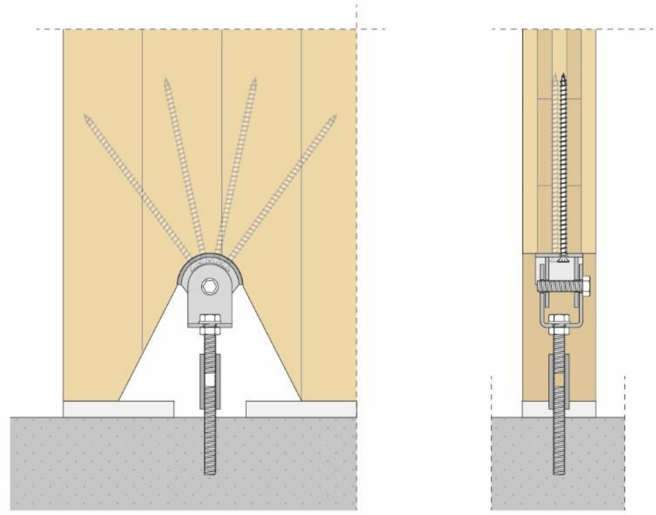
Installation of RADIAL connectors timber-to-concrete

Timber-to-concrete or steel direct connection (example RADIAL90+BRACKET+TURNBUCKLE):



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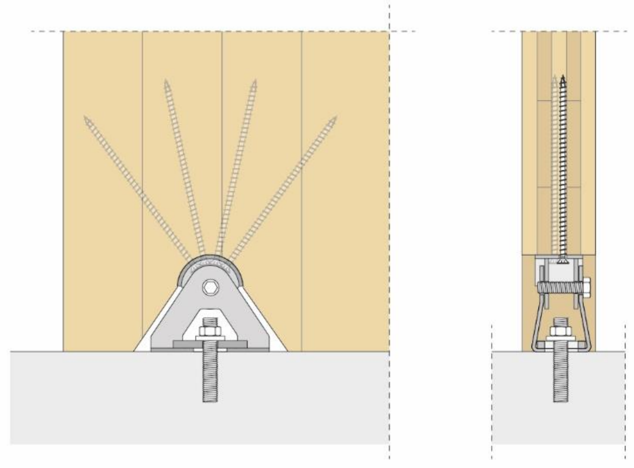
Timber-to-concrete or steel direct connection (example RADIAL90+BRACKET):



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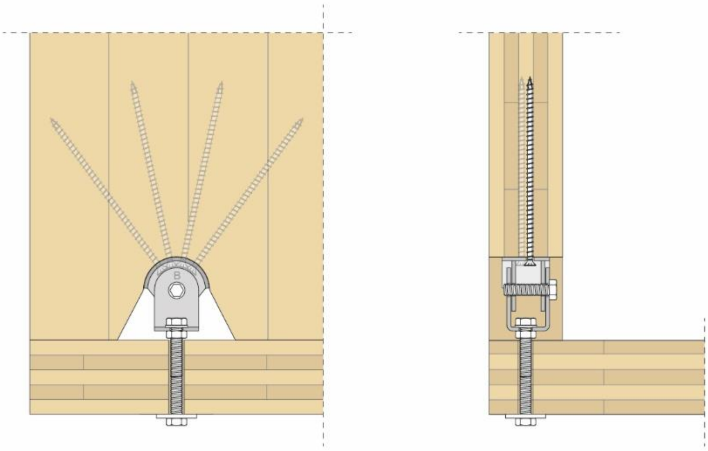
Installation of RADIAL connectors

RADIAL wall-to-wall (example RADIAL90+BRACKET):



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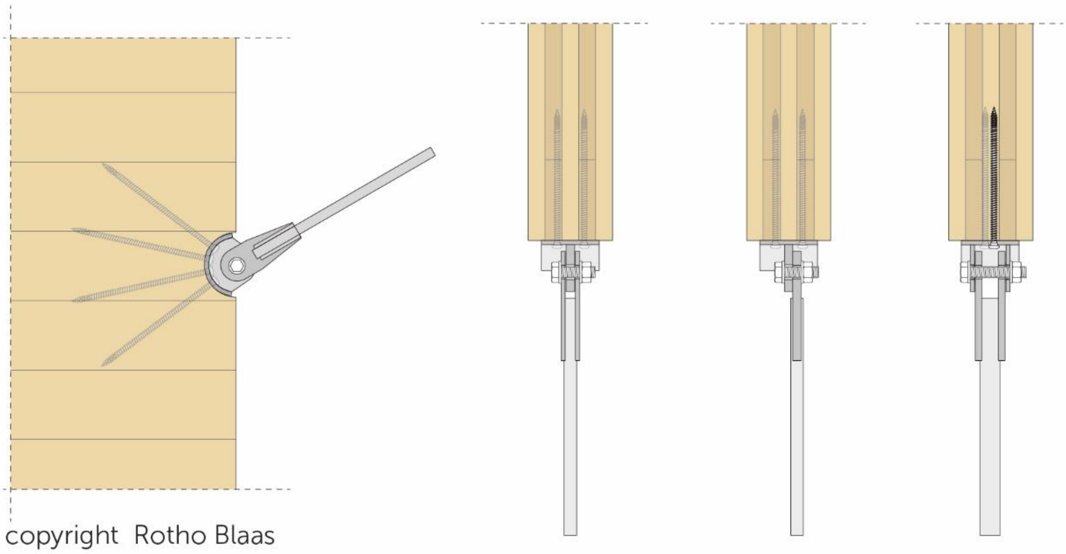
RADIAL bracing rods (example RADIAL60S-RADIAL60D + RODS):



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