TECHNICAL MANUAL

THRELDA® Anchor Plates

Anchor Plates for bolted connections between concrete and steel structures

Version PEIKKO GROUP 11/2022

peikko®

THRELDA® Anchor Plates

For bolted connections between concrete and steel structures

- THRELDA® Anchor Plates are used to transfer loads from steel structures to concrete.
- Easy installation into formwork with the help of standard accessories.
- The connection supports load as soon as concrete has the required strength and the bolts are tightened.
- The dimension may be customized according to customer requirements.
- The screw connection allows easy disassembly, dismantling and recycling of building material.
- No on-site welding.

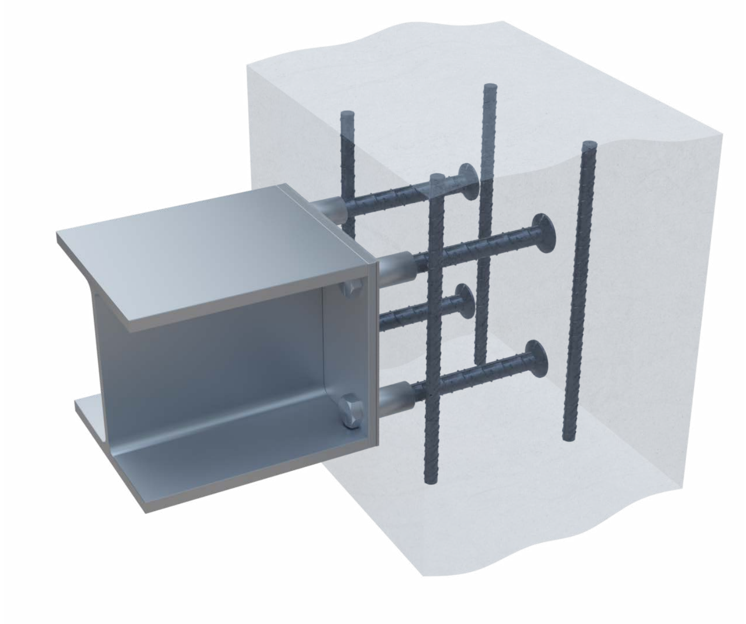


Figure 1. Connection of steel beam to THRELDA® Anchor Plate.

THRELDA® Anchor Plates are building products used to create one-sided or double-sided bolted connection between concrete and steel members such as beams, tension elements or other parts of the construction system. We offer a selection of multiple sizes of plates, with option of predefined or customized length of the anchors.

THRELDA® Anchor Plates consist of steel plates and headed studs with couplers embedded in concrete. Surface of the concrete member remains smooth without any protruding parts where the bolts are inserted during the installation. The bolted connection transfers axial and shear forces from connected steel member and anchors them into concrete.

THRELDA® Anchor Plates enhance all benefits of bolted connection such as cost effective, accurate, simple and quick installation, without welding and grouting on the building site. This connection can bear load right after installation of bolts.

CONTENTS

About THRELDA® Anchor Plates

1. Product properties

THRELDA® Anchor Plates (see *Figure 2*) are constructional elements that are embedded in concrete to enable create bolted structural joints between concrete and steel structures from one side. The loads from steel structure are transferred into the base concrete structure by headed anchors. The steel plate (*1*) (without load bearing function) secures correct position of threaded couplers (*2*) with headed anchor bars (*3*). To prevent damage of the thread, each threaded coupler has thread protection tapes (*4*). Couplers with headed anchors are welded at the steel plate. This assembly is delivered on site as one item. (See *Figure 2*).

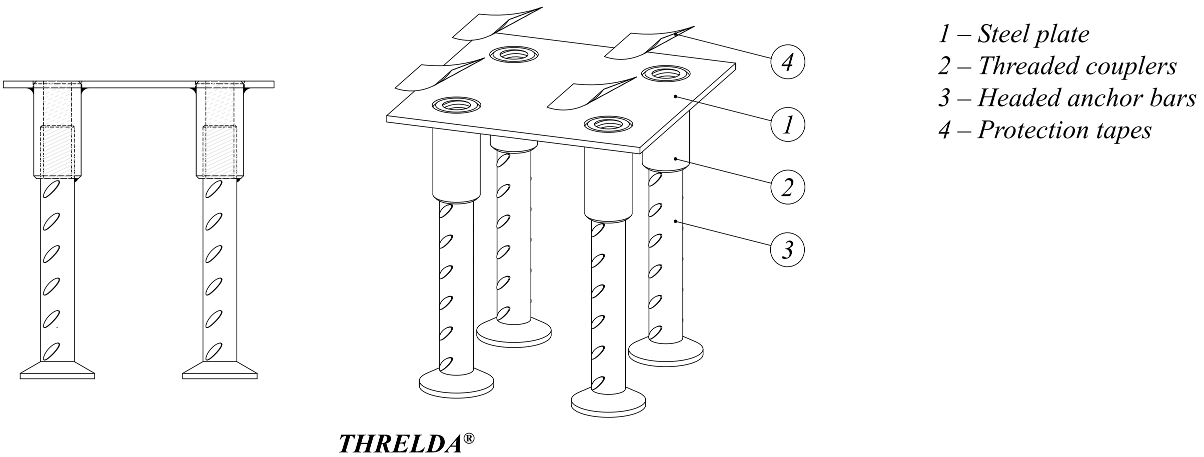


Figure 2. THRELDA® Anchor Plates.

THRELDA® Double Anchor Plates are constructional elements that are embedded in concrete to enable create bolted structural joints between concrete column and steel structures from two opposite sides.
There are two basic models:

THRELDA® Double T can be loaded from both sides at the same time or only from one side and later on from the opposite side (e.g., future extension of the building)

THRELDA® Double S shall be loaded from both sides at same time. Thin end plates (*1b*) have no load bearing function.

Both THRELDA® Double T and S models, presented in *Figure 3*, include two steel plates (*1a* or *1b*), threaded couplers (*2*), bars connecting plates (*3*) and thread protection tapes (*4*). Couplers at both sides of rebar are welded at the steel plates.

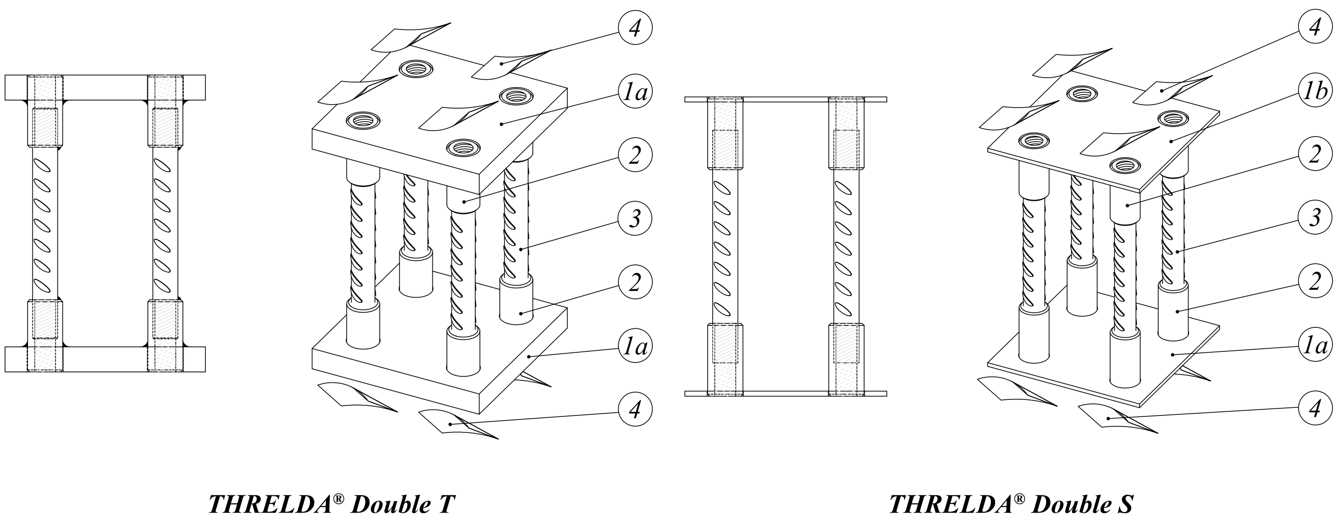


Figure 3. THRELDA® Double Anchor Plates.

1.1 Structural behavior

THRELDA®, THRELDA® Double T and THRELDA® Double S Anchor Plates are designed to transfer axial forces (acting alongside headed anchors) and shear forces (acting perpendicular to headed anchors) into concrete. The connection between THRELDA® (*1*) and steel plate of attached element (*2*) (see *Figure 4*) is assumed as fully rigid. Forces from the connected profile are transferred through the headed studs into concrete or in case of Double models through rebars to opposite side of concrete element. THRELDA® Double S should be loaded from both sides at same time.

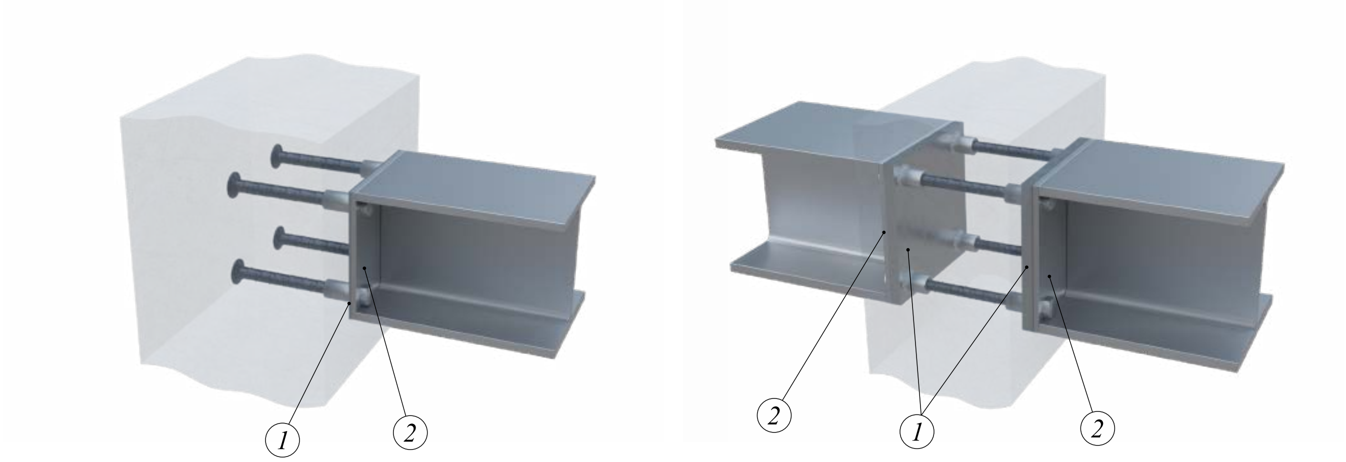


Figure 4. Bolted connection between concrete and steel structure.

1.2 Limitations for application

The resistances of the anchor plates have been calculated for static and quasi-static loads. For dynamic and fatigue loads, greater safety factors must be used individually for each case according to relevant standards. The tensile resistances are calculated assuming that the tensile capacity of THRELDA® Anchor Plates is limited by concrete cone failure. The shear resistances are calculated assuming that the shear capacity of THRELDA® Anchor Plates is limited by steel failure or by close edges of the concrete member.

In the case of THRELDA® Double Anchor Plates, only tension and shear resistances of steel are decisive. Dimensions and reinforcing of a concrete member are neglected in determined resistances. If THRELDA® Double Anchor Plates dimensions are complete, it is up to the designer to define resistances of the whole anchoring system made of THRELDA® Double Anchor Plates embedded in concrete and a concrete member. The design has to follow relevant standards: EN 1992-1-1 and EN 1992-4.

The tensile and shear resistances are calculated without influence of the edges ($c \geq 1.8 \cdot h_{ef}$), which may lower the resistances.

If concrete cone failure or concrete edge failure limits the design, both tensile and shear resistances can be increased by adding supplementary reinforcement. The resistance of the supplementary reinforcement has to be determined according to EN 1992-4 with anchorage lengths defined in EN 1992-1-1.

The shear and tensile capacity of the bolt is calculated and provided by the designer. The resistance of the designed bolts has to be compared with design resistance of the selected THRELDA® Anchor Plate and lower resistance must be chosen to specify the limits of the design. Pre-tension bolts for this connection cannot be used.

1.2.1 Environmental conditions

THRELDA® and THRELDA® Double Anchor Plates are designed to be used indoors and in dry conditions. The designed lifetime for THRELDA® and THRELDA® Double Anchor Plates in dry internal conditions (exposure class X0) is 50 years.

THRELDA® and THRELDA® Double Anchor Plates are designed for use in reinforced concrete structures such as walls, columns, beams, and foundations. The properties of the anchoring plates are valid for reinforced concrete with strength class in the range C25/30 to C50/60. Supplementary reinforcement shall be installed following relevant standards.

Total length of THRELDA Double® must be defined based on the geometry of the concrete member where it is embedded.

1.2.2 Positioning of THRELDA® Anchor Plates

The precise position of THRELDA® and THRELDA® Double Anchor Plates is indicated in the design drawings created by designer. THRELDA® Anchor plates have to be fixed to the formwork or the main reinforcement to prevent them from being displaced during the casting. THRELDA® can be fixed to the formwork/mold by nails or screws through holes in steel plate or other appropriate method.

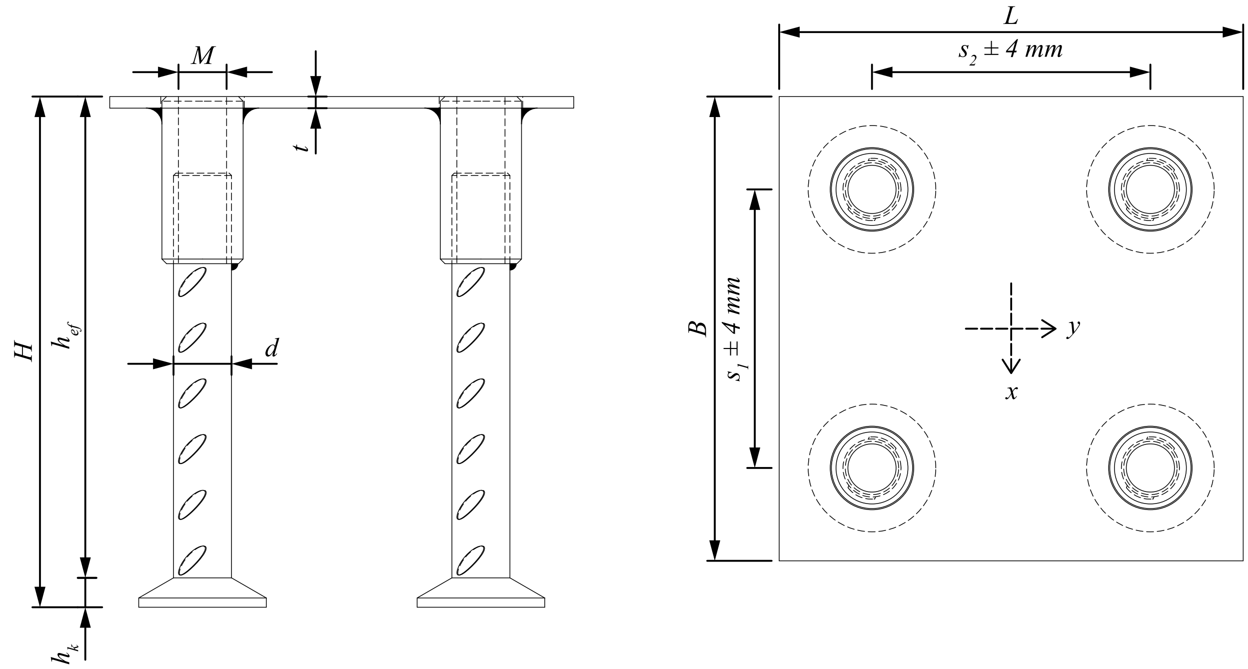
1.3 Materials and dimensions

Table 1. Materials.

Part	Material	Standard
Plates	S235, S355	EN 10025-2
Plates for THRELDA® Double T	S355	EN 10025-2
Headed bars and Threaded bars	B500B	EN 10080
Couplers	S355	EN 10025-2

Surface treatment can be applied upon request. For more information, please contact Peikko®.

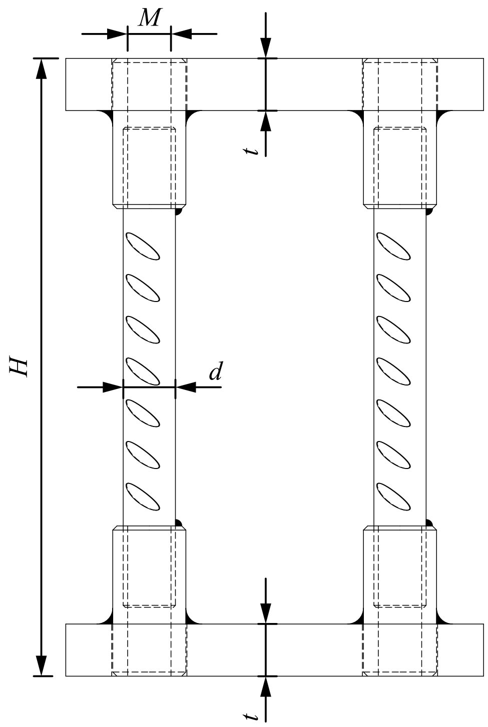
Table 2. Dimensions and weight of THRELDA® Anchor Plates.

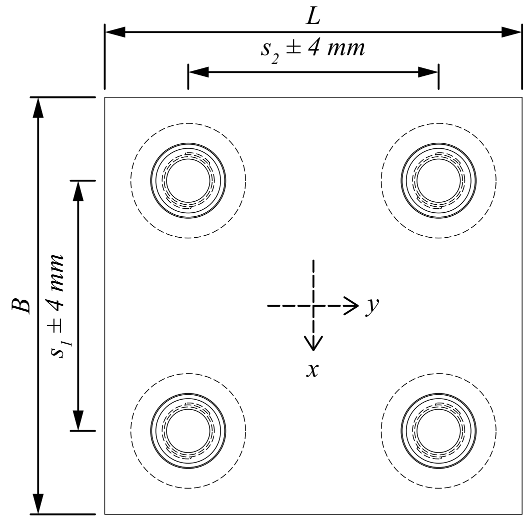


THRELDA® THRELDA® B × L - H / M	B mm	L mm	H mm	t mm	h_{ef} mm	s_1 mm	s_2 mm	d mm	n_x -	n_y -	weight kg
THRELDA 150×150-220/16	150	150	220	5	210	90	90	16	2	2	2.83
THRELDA 150×150-220/20	150	150	220	5	208	90	90	20	2	2	3.93
THRELDA 150×200-220/20	150	200	220	5	208	100	120	20	2	2	4.23
THRELDA 200×200-220/24	200	200	220	5	207	120	120	25	2	2	6.28
THRELDA 200×250-220/24	200	250	220	5	207	120	190	25	2	2	6.68
THRELDA 200×300-220/30	200	300	220	5	205	120	200	32	2	2	11.63
THRELDA 300×300-220/30	300	300	220	5	205	200	200	32	2	2	12.83
THRELDA 150×150-355/16	150	150	355	5	345	90	90	16	2	2	3.70
THRELDA 150×200-355/20	150	200	355	5	343	100	120	20	2	2	5.61
THRELDA 200×200-355/20	200	200	355	5	343	120	120	20	2	2	6.01
THRELDA 150×250-355/24	150	250	355	5	342	100	190	25	2	2	8.32
THRELDA 250×250-355/24	250	250	355	5	342	190	190	25	2	2	9.32
THRELDA 350×350-355/30	350	350	355	5	340	250	250	32	2	2	17.63
THRELDA 300×500-355/30	300	500	355	5	340	200	133.3	32	2	4	31.47
THRELDA 500×500-355/39	500	500	355	5	337	380	380	40	2	2	32.26

NOTE:
Values of dimension "h_k" are defined in *Table 7*.

Table 3. Dimensions and weight of THRELDA® Double T Anchor Plates.

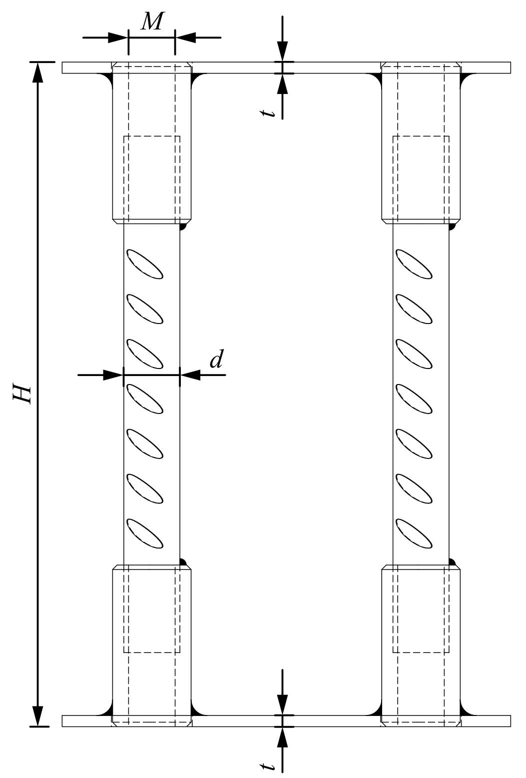


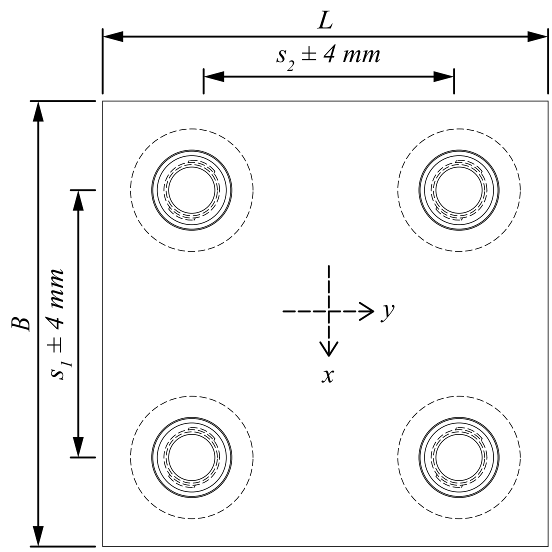


THRELDA® Double T THRELDA® Double T B × L - H / M	*B* mm	*L* mm	*H* mm	*t* mm	s_1 mm	s_2 mm	*d* mm	n_x -	n_y -	weight kg
THRELDA Double T 150×150-H/16	150	150	variable	15	90	90	16	2	2	-
THRELDA Double T 150×150-H/20	150	150	variable	20	90	90	20	2	2	-
THRELDA Double T 200×200-H/24	200	200	variable	20	120	120	25	2	2	-
THRELDA Double T 250×250-H/24	250	250	variable	25	190	190	25	2	2	-
THRELDA Double T 300×300-H/30	300	300	variable	30	200	200	32	2	2	-
THRELDA Double T 400×400-H/30	400	400	variable	35	300	300	32	2	2	-
THRELDA Double T 500×500-H/30	500	500	variable	35	400	400	32	2	2	-
THRELDA Double T 300×300-H/39	300	300	variable	35	180	180	40	2	2	-

NOTE:
THRELDA® Double T are customized products, weights are various for each type. Minimum heights for THRELDA® Double are defined in *Table 5*.

Table 4. Dimensions and weight of THRELDA® Double S Anchor Plates.



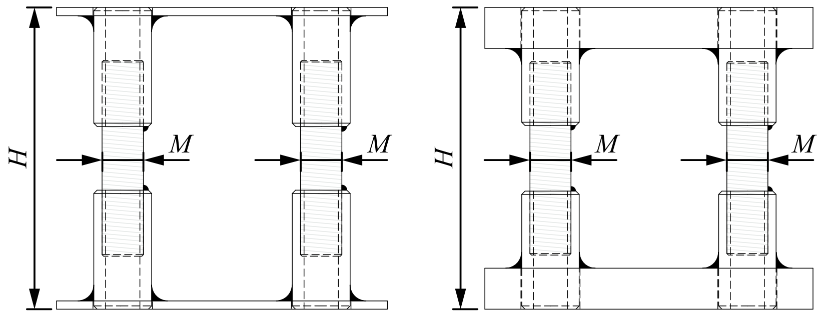


THRELDA® Double S THRELDA® Double S B × L - H / M	B mm	L mm	H mm	t mm	s_1 mm	s_2 mm	d mm	n_x -	n_y -	weight kg
THRELDA Double S 150×150-H/16	150	150	variable	5	90	90	16	2	2	-
THRELDA Double S 150×150-H/20	150	150	variable	5	90	90	20	2	2	-
THRELDA Double S 200×200-H/24	200	200	variable	5	120	120	25	2	2	-
THRELDA Double S 250×250-H/24	250	250	variable	5	190	190	25	2	2	-
THRELDA Double S 300×300-H/30	300	300	variable	5	200	200	32	2	2	-
THRELDA Double S 400×400-H/30	400	400	variable	5	300	300	32	2	2	-
THRELDA Double S 500×500-H/30	500	500	variable	5	400	400	32	2	2	-
THRELDA Double S 300×300-H/39	300	300	variable	5	180	180	40	2	2	-

NOTE:
THRELDA® Double S are customized products, weights are various for each type. Minimum heights for THRELDA® Double are defined in *Table 5*.

Table 5. Minimum heights for THRELDA® Double.

Thread size M [mm]	Minimum height H [mm]
M16	130
M20	150
M24	180
M30	210
M39	270



Bolt length

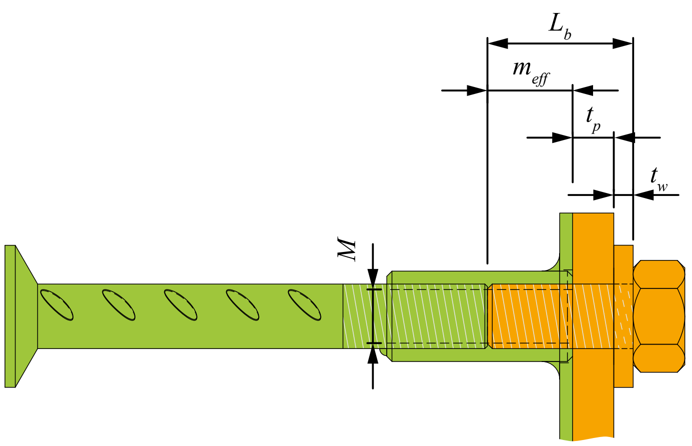
Bolt, connected plate and washer are not part of THRELDA® delivery. Bolt length is defined based on m_{eff} length plus thickness of attached base plate and washer minus 2 mm, rounded down to 5 mm. Value of m_{eff} is shown in *Table 6*.

Example how to define bolt length:
Thread diameter: $M = 20\ mm$
Engagement length: $m_{eff,M20} = 27\ mm$
Plate thickness: $t_p = 15\ mm$
Washer thickness: $t_w = 3\ mm$
Length of the bolt: $L_b = (m_{eff,M20} + t_p + t_w) - 2\ mm = (27\ mm + 15\ mm + 3\ mm) - 2\ mm = 43\ mm \Rightarrow L_b = 40\ mm$

Values of t_p, t_w and L_b have to be defined by customer.

Table 6. The maximum engagement depth for bolt.

Peikko components M – thread size [mm]	Components specified and designed by customer – not part of the delivery Engagement length m_{eff} [mm]
16	22
20	27
24	33
30	41
39	56



1.4 Manufacturing

Peikko Group's production units are controlled externally and audited periodically on the basis of the production certifications and product approvals provided by various independent organizations.

2. Resistances

The resistances of THRELDA® Anchoring Plates are determined by a design concept that refers to the following standards:

- EN 1992-1-1:2004/A1:2014
- EN 1992-4:2018
- EN 1993-1-1:2005/AC:2009
- EN 1993-1-8:2005/AC:2005
- VDI 2233-1:2003

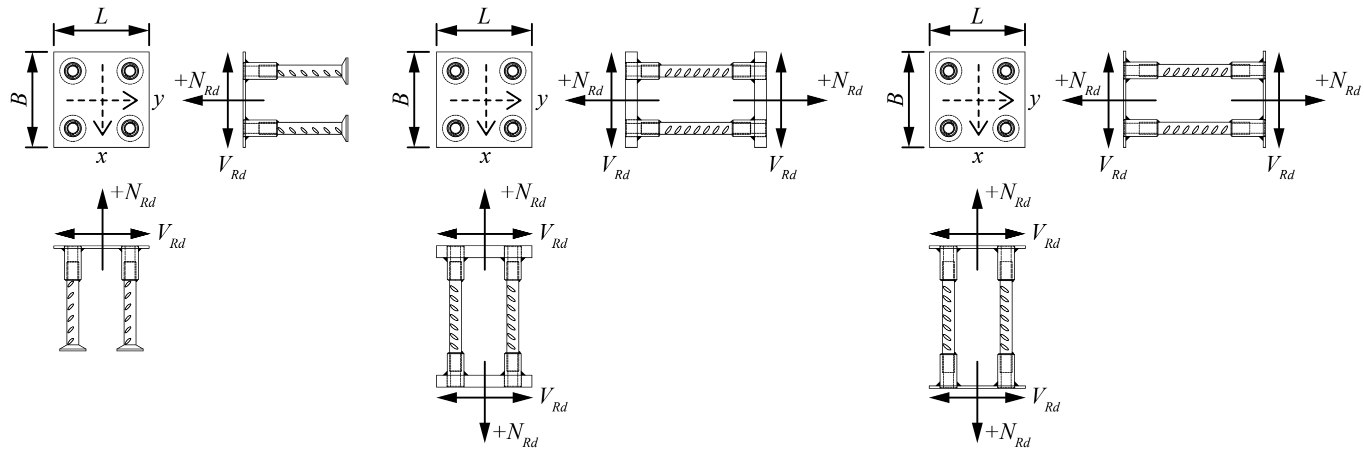


Figure 5. Symbols and direction of the loads.

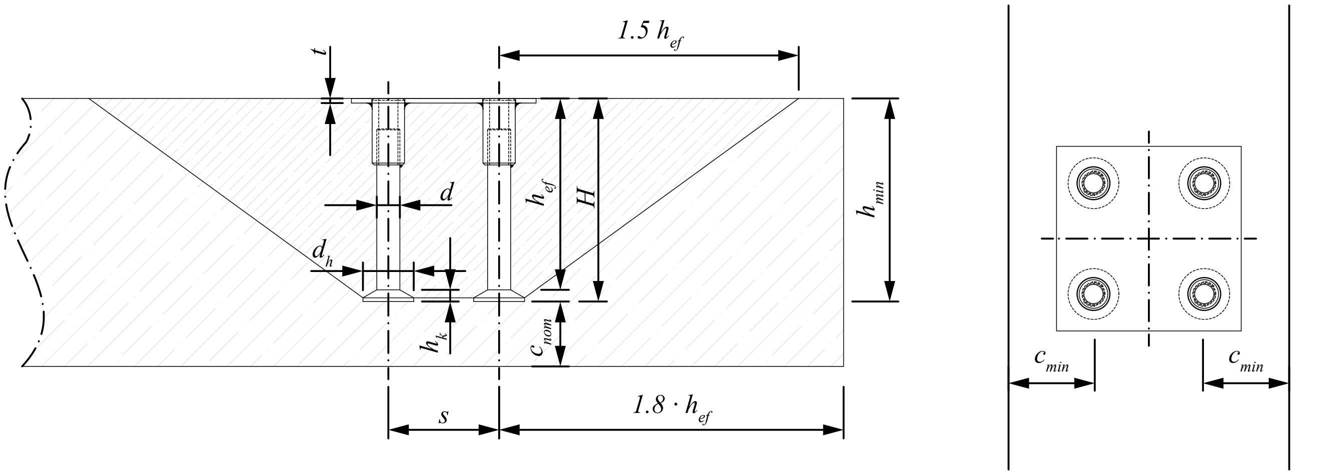
Assumptions for pre-calculated resistances (*Table 8*. and *Table 9*.):

- Concrete C25/30. Cracked, without supplementary reinforcement.
- Manufacturing and installation tolerances (15 mm in "x" and "y" direction) have been considered.
- The plate in N_{Rd} and V_{Rd} resistances is far away from the edges so that the edge does not fail, or the edge resistance does not have to be calculated.
- Resistances (concrete cone, blow-out and edge failure) marked as "c_1" and "c_1 and c_2" are examples of placing THRELDA® Anchoring Plates close to the edges with distances related to *Table 7*.
- Only the fasteners closest to the edge perpendicular to the direction of the force are considered in calculations of resistances in blow-out and concrete edge failure.
- Calculations have been made for static loads according to EN 1992-4 and EN 1993-1-8.

Resistances in this Technical manual are designed for THRELDA® Anchor Plates placed in cracked concrete with edge distance from axis of a fastener in all directions bigger than $1.8 \cdot h_{ef}$ and without supplementary reinforcement. In this case, the resistances are not affected by concrete edges. If edge distances are less than $1.8 \cdot h_{ef}$ (for splitting resistance), $1.5 \cdot h_{ef}$ (for concrete cone), $0.5 \cdot h_{ef}$ (for blow-out) or maximum of $10 \cdot h_{ef}$ and $60 \cdot d$ (for concrete edge), then individual design is required according to relevant standard EN 1992-4. Value c_{min} in *Table 7*. represents minimum concrete edge distances from axis of a fastener. These distances are considered in "c_1" or "c_1 and c_2" type resistances for several types of failures.

Resistance values for THRELDA® Double Anchor Plates are also calculated for cracked concrete with no edge influence and without supplementary reinforcement. In this case, the resistances are not affected by concrete edges because THRELDA® Double Anchor Plates are embedded in concrete columns and distribution of tensile forces is only through steel anchors and bolts, or steel anchors and baseplate if THRELDA® Double T is used. The direction of shear forces is considered only parallel with the axis of the column. If perpendicular shear forces are applied, then relevant verification is necessary, such as design of the reinforcement provided by the customer.

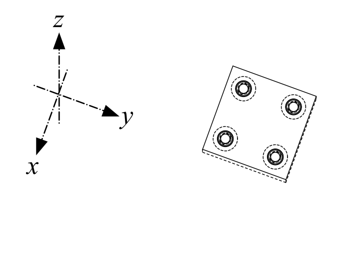
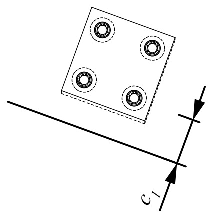
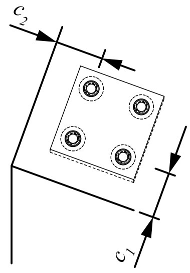
Table 7. Installation parameters for THRELDA®.



Nominal diameter of the rebar	d [mm]	16		20		25		32		40	
Height of the plate	h [mm]	220	355	220	355	220	355	220	355	-	355
Anchorage depth	h_{ef} [mm]	210	345	208	343	207	342	205	340	-	337
Thickness of the plate	t [mm]	5		5		5		5		5	
Thickness of the head	h_k [mm]	10		12		13		15		18	
Diameter of the head	d_h [mm]	38		46		55		70		90	
Minimum edge distance	c_{min} [mm]	50		70		70		100		130	
Minimum thickness of concrete member	h_{min} [mm]	$h_{ef} + h_k + c_{nom}$ [1] (1)									

[1] c_{nom} = required concrete cover according to national regulations

Table 8. THRELDA® – Resistances in tension and shear.

Edge Influence						
THRELDA®	N_{Rd}	V_{Rd}	N_{Rd} "c_1"	$V_{Rd,edge\ failure}$ "c_1"	N_{Rd} "c_1 and c_2"	$V_{Rd,edge\ failure}$ "c_1 and c_2"
THRELDA® B × L - H / M	kN	kN	kN	kN	kN	kN
THRELDA 150×150-220/16	111	67	57	9	36	7
THRELDA 150×150-220/20	109	105	61	14	40	11
THRELDA 150×200-220/20	116	111	66	16	44	13
THRELDA 200×200-220/24	118	158	67	17	45	13
THRELDA 200×250-220/24	129	169	77	20	52	16
THRELDA 200×300-220/30	129	259	84	29	61	24
THRELDA 300×300-220/30	144	265	94	29	70	24
THRELDA 150×150-355/16	170	67	66	9	46	7
THRELDA 150×200-355/20	222	111	111	16	67	13
THRELDA 200×200-355/20	226	110	113	16	69	13
THRELDA 150×250-355/24	235	170	121	23	74	19
THRELDA 250×250-355/24	254	166	131	23	83	19
THRELDA 350×350-355/30	277	270	156	39	106	32
THRELDA 300×500-355/30	298	535	176	49	117	41
THRELDA 500×500-355/39	334	479	208	60	152	50

N_{Rd}	Tensile resistance
V_{Rd}	Minimal shear resistance in "x" or "y" direction of V_{Ed} force
N_{Rd} "c_1"	Minimal tensile resistance of concrete cone or blow-out with edge distance c_{min} (*Table 7.*) from the axis of the anchor (in "y" direction)
$V_{Rd,edge\ failure}$ "c_1"	Shear resistance in edge failure with edge in distance c_{min} (*Table 7.*) from the axis of the anchor (in "y" direction)
N_{Rd} "c_1 and c_2"	Minimal tensile resistance of concrete cone or blow-out with edge distance c_{min} (*Table 7.*) from the axis of the anchor (in "y" direction) and with edge in distance c_{min} (*Table 7.*) from the axis of the anchor (in "x" direction)
$V_{Rd,edge\ failure}$ "c_1 and c_2"	Shear resistance in edge failure with edge in distance c_{min} (*Table 7.*) from the axis of the anchor (in "y" direction) and with edge in distance c_{min} (*Table 7.*) from the axis of the anchor (in "x" direction)

Note: Concrete edge influences for N_{Rd} "c_1", N_{Rd} "c_1 and c_2", $V_{Rd,edge\ failure}$ "c_1" and $V_{Rd,edge\ failure}$ "c_1 and c_2" resistances are described in chapter 2.1.1 and 2.2.1.

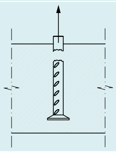
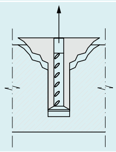
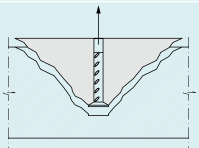
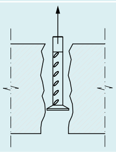
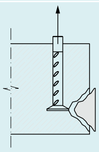
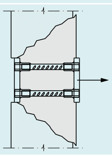
Table 9. THRELDA® Double – Resistances in tension and shear for T and S models.

THRELDA® Double T & S THRELDA® B × L - H / M	N_{Rd} kN	V_{Rd} kN
THRELDA Double 150×150-H/16	170	64
THRELDA Double 150×150-H/20	266	101
THRELDA Double 200×200-H/24	289	153
THRELDA Double 250×250-H/24	458	162
THRELDA Double 300×300-H/30	734	259
THRELDA Double 400×400-H/30	777	268
THRELDA Double 500×500-H/30	801	272
THRELDA Double 300×300-H/39	1255	446

PLEASE NOTE:
Please note that the resistances in *Table 9*. are applicable for THRELDA® Double S only when it is loaded from both sides at the same time. THRELDA® Double S must not be loaded from one side only.

2.1 Required verification for THRELDA® and THRELDA® Double Anchor Plates loaded by tension forces

Table 10. Required verifications for headed anchors loaded in tension.

Failure mode	Example	Most loaded anchor	Anchor group	Product
Steel strength of anchor		$N^h_{Ed} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$		THRELDA® THRELDA® Double T&S
Pull-out strength of anchor		$N^h_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$		THRELDA®
Concrete cone strength			$N^g_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$	THRELDA®
Splitting strength [1) 2)]			$N^g_{Ed} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Msp}}$	THRELDA®
Blow-out strength [3)]			$N^g_{Ed} \leq N_{Rd,cb} = \frac{N_{Rk,cb}}{\gamma_{Mc}}$	THRELDA®
Areas partially loaded by transferring tension forces [4)]			$N^g_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,cb}}{\gamma_{Mc}}$	THRELDA® Double T

1) Verification is not required if the edge distance in all directions equals $c \geq 1.5h_{ef}$ for groups with one anchor and $c \geq 1.8h_{ef}$ for groups with more than one anchor or if supplementary reinforcement is provided according to relevant standards.
2) Not required if the characteristic resistances for concrete cone failure and pull-out failure are calculated for cracked concrete and reinforcement resists the splitting forces and limits the cracks width to $w_k \leq 0.3\ mm$.
3) Not required if the edge distance in all directions equals $c \geq 0.5h_{ef}$
4) Only verification of compress stresses on non-reinforced concrete via baseplate are considered in this evaluation, such as verifications of tensile forces in anchors. Main reinforcement and supplementary reinforcement of the post must be managed by the customer.

2.1.1 Concrete edge influence on resistances

- **Concrete cone failure verification**
  When the fastening is close to the edge of the concrete member or in the corner of an element, these distances have to be considered. A reference projected area is still calculated with $s_{cr,N}$ value, but if the distance (c_1 or c_2) from the axis of the fastener is smaller than $0.6 \cdot s_{cr,N}$ (or $1.8 \cdot h_{ef}$), then the actual projected area $A_{c,N}$ will be changed according to the smaller dimensions. All limits, formulas and group and eccentricity effect determination of concrete cone resistance around the edges are provided in EN 1992-4, chapter 7.2.1.4.

- **Blow-out failure verification**
  This verification is necessary if the fastening is closer to the edge of the concrete element than the value of $0.5 \cdot h_{ef}$. In this case, only the anchors which are the closest to the edge can be considered in the calculation. This means that if THRELDA® Anchoring Plates are placed with its bottom "y" side of baseplate close to the edge in the same direction, only bottom two fasteners (in THRELDA® 300×500 355/30 – bottom 4 fasteners) can be taken into account as load-bearing anchors. The reference projected area is determined by value of c_1 and actual projected area $A_{c,N}$ takes into account both distances c_1 and c_2. Group and eccentricity effect has to be considered by ψ factors according to EN 1992-4, chapter 7.2.1.8.

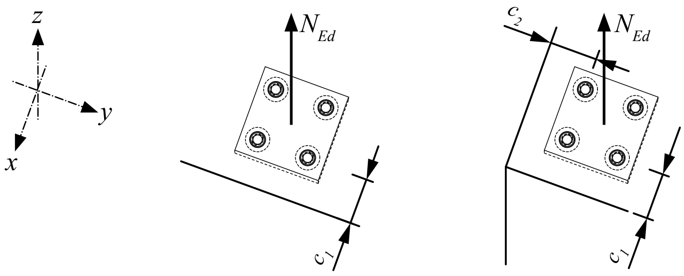
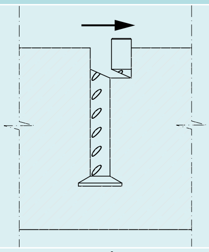
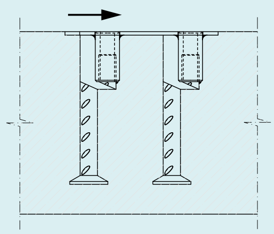
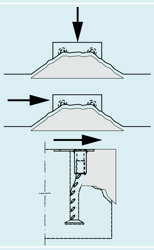
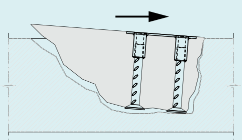


Figure 6. Edge distances for N_{Rd} "c_1" and N_{Rd} "c_1 and c_2".

2.2 Required verifications for THRELDA® and THRELDA® Double Anchor Plates loaded by shear forces

Table 11. Required verifications for headed anchors loaded in shear.

Failure mode	Example	Most loaded anchor	Anchor group	Product
Steel strength of anchor		$V_{Ed}^{h} \leq V_{Rd,s} = \frac{V_{Rk,s}}{\gamma_{Ms}}$		THRELDA® THRELDA® Double T&S
Concrete edge strength [1] • Shear perpendicular to the edge • Shear parallel to the edge • Inclined shear			$V_{Ed}^{g} \leq V_{Rd,c} = \frac{V_{Rk,c}}{\gamma_{Mc}}$	THRELDA®
Concrete pry-out strength			$V_{Ed}^{g} \leq V_{Rd,cp} = \frac{V_{Rk,cp}}{\gamma_{Mc}}$	THRELDA®

[1] Not required if the edge distances in all directions $c \geq min(10h_{ef};60.\ d)$ or if supplementary reinforcement is provided according to relevant standards.

2.2.1 Concrete edge influence on resistances

- **Concrete edge failure verification**
  When the fastening is closer to the edge of concrete member than the maximum value of $\{10 \cdot h_{ef}; 60 \cdot d\}$ or in the corner distanced more than the maximum of these values, this position has to be considered. A reference projected area is calculated with c_1 value, and in the case of distance c_1 and c_2 from the axis of the fastener, the actual projected area $A_{c,V}$ will be changed according to the smaller dimensions. Only fasteners located closest to the edge are used for the verification. All limits, formulas and group and eccentricity effect determination of concrete cone resistance around the edges are provided in EN 1992-4, chapter 7.2.2.5.

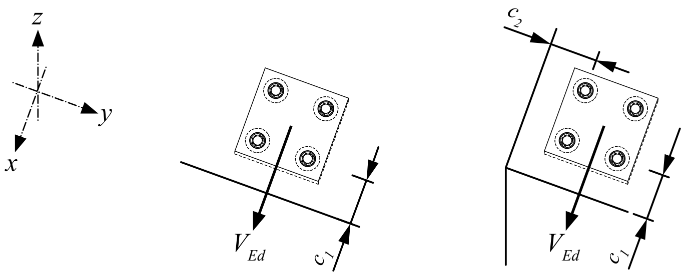


Figure 7. Edge distances for $V_{Rd,edge\,failure}$ "c_1", and $V_{Rd,edge\,failure}$ "c_1 and c_2".

2.3 Combined axial and shear load

When axial and shear forces strain the headed stud simultaneously, the interaction should be checked by satisfying the following equations for different failure modes.

With respect to steel verifications

Headed Anchors
The simultaneous tensile force and shear force in each headed stud should satisfy the condition (according to EN 1992-4 – 7.2.3):

$$|\beta_N|^2 + |\beta_V|^2 \leq 1 \tag{2}$$

where

$$\beta_N = \frac{|N^1_{Ed}|}{N_{Rd,s}} \leq 1 \text{ and } \beta_V = \frac{|V^1_{Ed}|}{V_{Rd,s}} \leq 1 \tag{3}$$

where

N^1_{Ed} = Axial tension force in the most loaded headed stud

V^1_{Ed} = Shear force in the most loaded headed stud

$N_{Rd,s}$ = Minimum value of axial resistance of headed stud from *Table 12*, and axial resistance of the bolt

$V_{Rd,s}$ = Minimum value of shear resistance of headed stud from *Table 12*, and shear resistance of the bolt

With respect to concrete verifications

Anchors without supplementary reinforcement
The simultaneous tensile force and shear force must satisfy one or both of the following conditions:

$$|\beta_N| + |\beta_V| \leq 1.2 \quad (4)$$

$$|\beta_N|^{1.5} + |\beta_V|^{1.5} \leq 1 \quad (5)$$

$$\beta_N = \frac{|N^1_{Ed}|}{N_{Rd,i}} \leq 1 \text{ and } \beta_V = \frac{|V^1_{Ed}|}{V_{Rd,i}} \leq 1 \quad (6)$$

where

N^1_{Ed} = Axial tension force on group of anchors

V^1_{Ed} = Shear force on group of anchors

$N_{Rd,i}$ = Minimum value of axial resistance of group of anchors for concrete failure

$V_{Rd,i}$ = Minimum value of shear resistance of group of anchors for concrete failure

Anchors with supplementary reinforcement
For anchors with a supplementary reinforcement transferring tension or shear loads, Eq. (4) and Eq. (5) should be used with the largest value of β_N and β_V for each failure mode. Values N_{Ed}, V_{Ed}, N_{Rd} and V_{Rd} in Eq. (4), (5) and (7) for concrete cone failure mode and concrete edge failure mode are replaced by the corresponding values for failure of supplementary reinforcement.

$$|\beta_N|^{K_{11}} + |\beta_V|^{K_{11}} \leq 1 \quad (7)$$

If the supplementary reinforcement is designed to carry whole value of tension and shear forces, Eq. (7) applies.
In the equations Eq. (2)–(7):

β_N = largest degree of utilization from concrete verifications under tensile force

β_V = largest degree of utilization from concrete verifications under shear force

k_{11} = factor given in the relevant European Technical Product Specification (⅔ may be assumed)

Table 12. Single fasteners resistances (taken from COPRA® Anchoring Couplers).

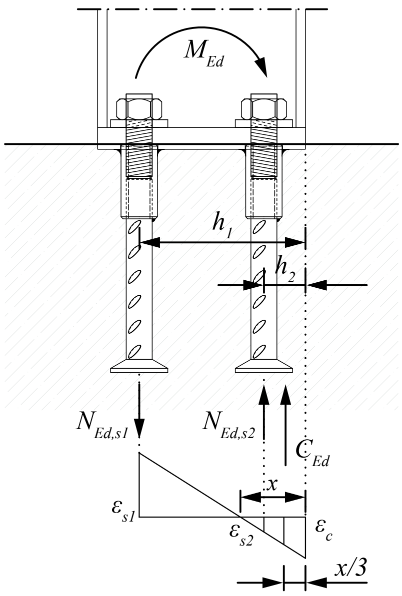
THRELDA® single anchors M [mm]	$N_{Rd,s}$ kN	$V_{Rd,s}$ kN
16	62	20
20	96	31
24	138	45
30	220	72
39	383	125

2.4 Bending moments

THRELDA® Anchor Plates can transfer bending and torsional moments, as well as normal and shear forces, into concrete. The assumption is that the steel plate of connected steel profile is fully rigid. THRELDA® Anchor Plates transfer forces from the attached profile with a connected steel plate to the headed studs through bolts and through compressed area to the concrete.

Dimensions of the baseplate of the selected THRELDA® Anchor Plate are given, but dimensions of the plate of the connected element are unknown. Compressed area of the concrete is derived from these dimensions, so resistances are different for every type of connection. It is up to the designer to provide calculation of bending moment resistances according to size of the connected plate.

The forces in fastenings Ⓝ and concrete Ⓒ are as follows:



$$N_{Ed,si} = A_s \cdot \varepsilon_{s,i} \cdot E_s \qquad C_{Ed} = 0.5 \cdot b \cdot x \cdot \varepsilon_c \cdot E_c \tag{8}$$

$N_{Ed,si} = N_{Rd,si}$ in tension (minimal of concrete or steel failure) of single fastener.
b = width of the baseplate

One must consider the size of the connected plate. Distances h_1 and h_2 could be smaller or bigger, which will affect the compressed concrete area and resistance $M_{el,Rd}$.

The design of the dimensions of the plate and anchor distances from the edges of the particular concrete member has to respect minimal edge distances from *Table 7*. Installation parameters for THRELDA®

Bending moment resistance:

$$M_{el,Rd} = N_{Ed,s1} \cdot h_1 - C_{Ed} \cdot \frac{x}{3} \tag{9}$$

Figure 8. Bending moment load distribution model.

2.5 Torsional moments

In the case of pure torsional moment, the force in the most loaded fastener has to be compared to its resistance according to the equation below.

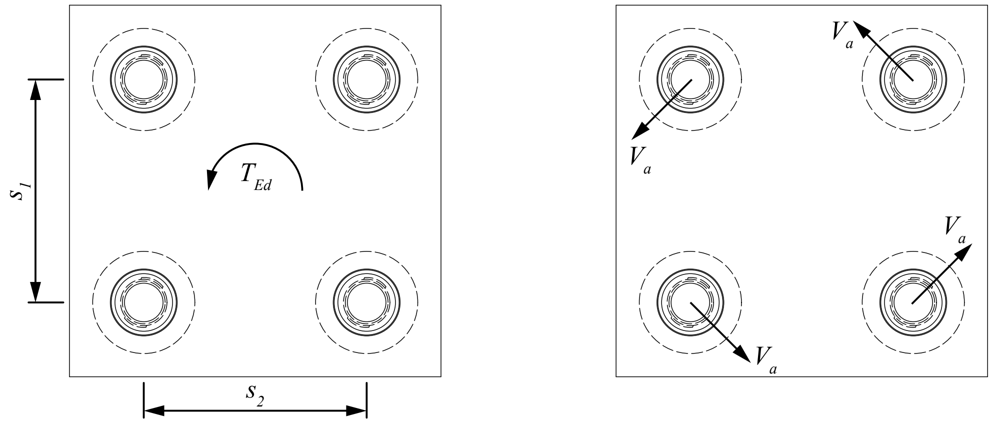


Figure 9. Pure torsional moment load distribution model.

The shear force in one fastening:

$$V_a = \frac{T_{Ed}}{I_p}\left[\left(\frac{s_1}{2}\right)^2 + \left(\frac{s_1}{2}\right)^2\right]^{0.5} \quad (10)$$

where:

$$I_p = s_1^2 + s_2^2 \quad (11)$$

The resistance of one fastening in shear is the minimum value of shear resistances of steel and concrete according to its parameters and distances from edges. If $V_a = V_{Rd}$ in shear (minimal of concrete or steel failure) of single fastener, then T_{Rd} can be derived from the previous:

$$T_{Rd} = \frac{V_{Rd} \cdot I_p}{\left[\left(\frac{s_1}{2}\right)^2 + \left(\frac{s_1}{2}\right)^2\right]^{0.5}} \quad (12)$$

Selecting THRELDA® Anchor Plate

The following aspects must be considered when selecting the right type of THRELDA® Anchor Plate:

- Design values of loads
- Direction of loading
- Dimensions of steel profile or member
- Position and layout of the anchoring couplers in the load-bearing structure
- Eccentricity of the steel profile: e_x, e_y
- Concrete class of base structure
- Cracked/uncracked concrete
- Existing and supplementary reinforcement
- Environmental conditions and exposure class: Dry internal / External atmospheric
- Required resistance of THRELDA® Anchor Plate
- Calculated resistance of bolted connection of connected member and THRELDA® Anchor Plate

If THRELDA® Anchor Plate is loaded with axial loads only, then the load bearing capacity is verified by:

$$N_{Ed} \leq N_{Rd}$$

where:

N_{Ed} is the design value of acting axial force [kN]
N_{Rd} is the design value of axial resistance read from *Table 8*. or *Table 9*. [kN]

If THRELDA® Anchor Plate is loaded with shear loads only, then the loadbearing capacity is verified by:

$$V_{Ed} \leq V_{Rd}$$

where:

V_{Ed} is the design value of acting shear force [kN]
V_{Rd} is the design value of shear resistance read from *Table 8*. or *Table 9*. [kN]

If THRELDA® Anchor Plate is loaded with axial and shear loads simultaneously, then the load bearing capacity has to be calculated by the designer according to Chapter 2.3 with values from *Table 12*.

Design of the connected plate and bolts is made by the customer. If the resistance of selected THRELDA® Anchor Plate is bigger than the resistance of designed bolts, then these bolts are decisive in the final load bearing capacity. Otherwise, the selected THRELDA® Anchor Plate can bear only loads in accordance with its defined resistance, as specified in *Table 8*. and *Table 9*.

Naming of THRELDA® Anchor Plates:

After selecting the correct THRELDA® Anchor Plate, a product code describing the product shall be defined according to the description in *Figure 10*. Please use this code in drawings and when ordering the product from Peikko's Sales Service.

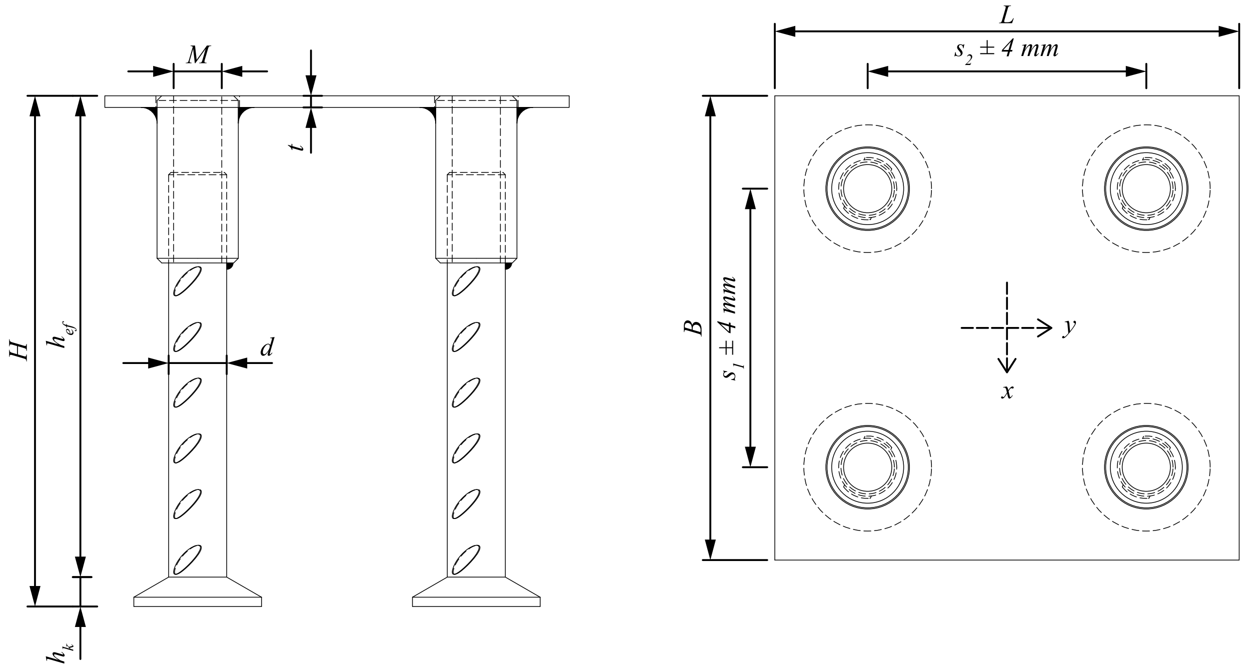
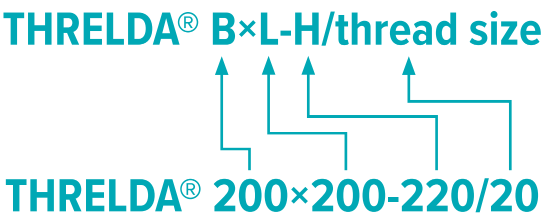


Figure 10. THRELDA® Anchor Plate.

Examples of naming:



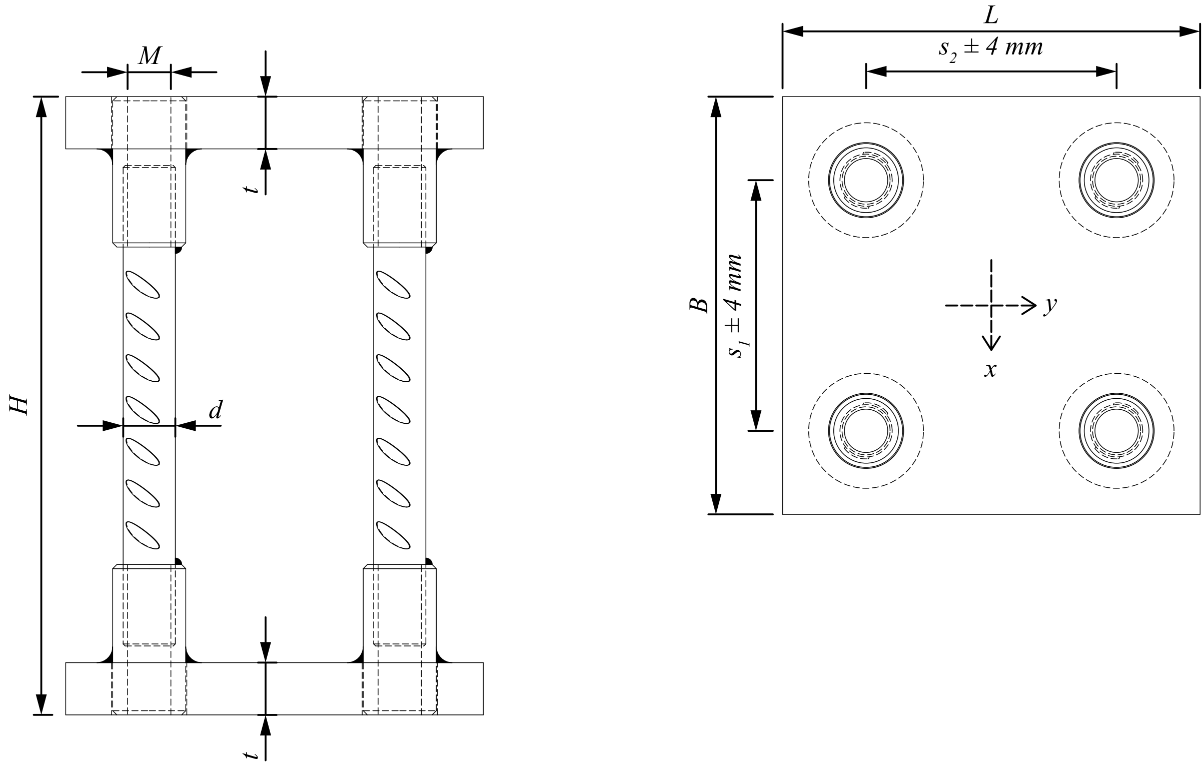


Figure 11. THRELDA® Double T Anchor Plate.

Examples of naming:

THRELDA® Double T B×L-H/thread size

THRELDA® Double T 200×200-220/20

(H – total length = column depth)

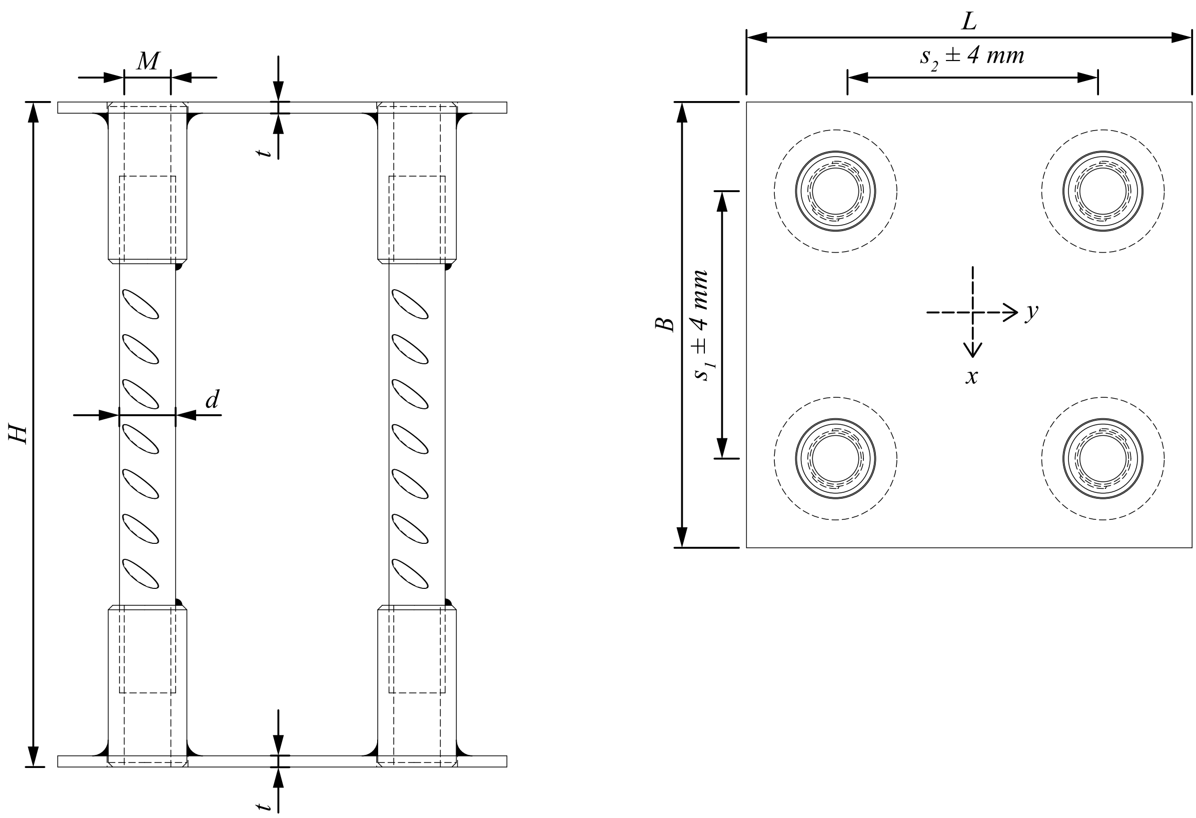


Figure 12. THRELDA® Double S Anchor Plate.

Examples of naming:

THRELDA® Double S B×L-H/thread size

THRELDA® Double S 200×200-220/20

(H – total length = column depth)

Example of THRELDA® Anchor Plate selection:

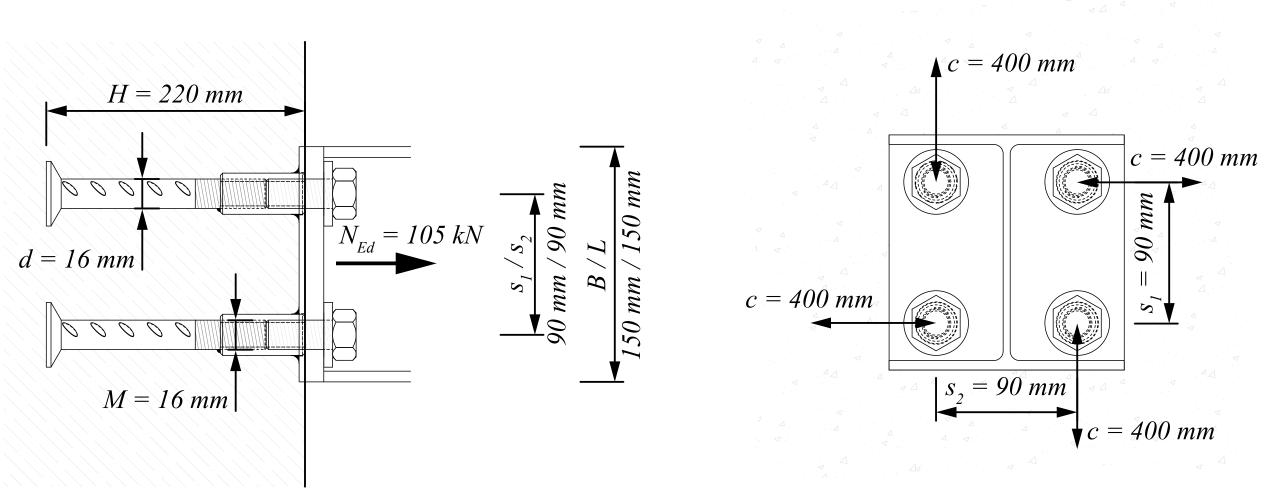


Figure 13. THRELDA® Anchor Plate with tension load.

Tensile force in the connected element: N_{Ed} = 105 kN

Assumptions: All edges of the concrete base are distanced more than 396 mm ($1.8 \cdot h_{ef}$) from axis of each fastener and the concrete base is equal or thicker than $H + c_{nom}$. No supplementary reinforcement against concrete cone, splitting, blow-out or edge failure is considered, while the main reinforcement of the concrete member designed to loads acting on THRELDA® Anchor Plate is present.

Cracked concrete: C25/30

Reinforcing steel: B500B

Exposure class: X0

Selection:

THRELDA® THRELDA® B × L - H / M	N_{Rd} kN	V_{Rd} kN	N_{Rd} "c_1" kN	$V_{Rd,edge\ failure}$ "c_1" kN	N_{Rd} "c_1 and c_2" kN	$V_{Rd,edge\ failure}$ "c_1 and c_2" kN
THRELDA 150×150-220/16	111	67	57	9	36	7
THRELDA 150×150-220/20	109	105	61	14	40	11
THRELDA 150×200-220/20	116	111	66	16	44	13

Selected:

THRELDA® 150×150-220/16
N_{Rd} **= 111 kN >** N_{Ed}

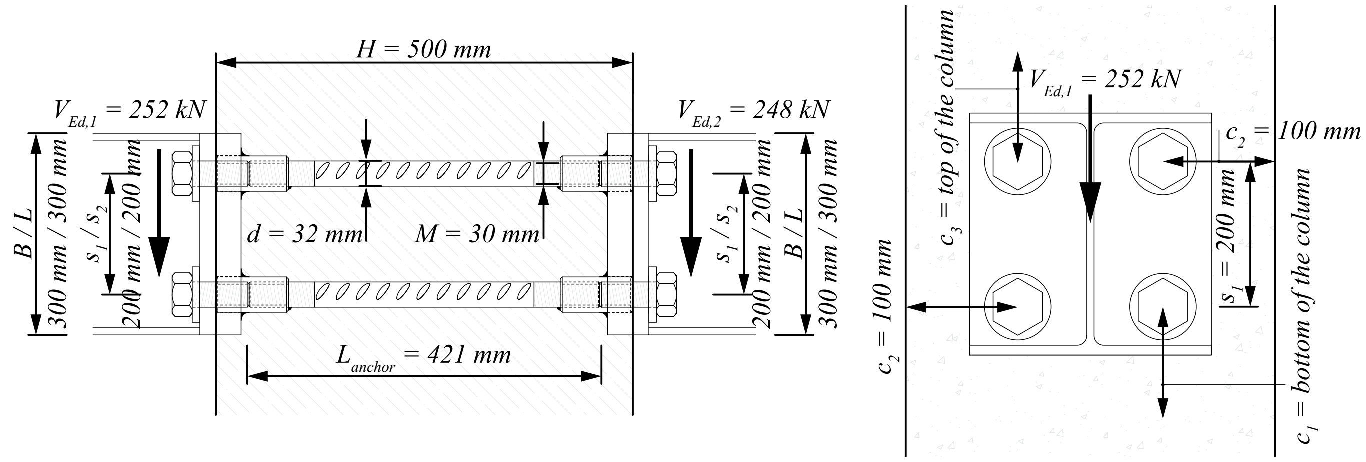


Figure 14. THRELDA® Double T Anchor Plate with shear load.

Shear force in the connected element:

$V_{Ed,1}$ = 252 kN
$V_{Ed,2}$ = 248 kN
V_{Ed} = max $\{V_{Ed,1}; V_{Ed,2}\}$

Assumptions:

Bottom and top edge are ends of the column with beams under and on the column. The column is 400 mm wide and 500 mm high in its cross-section. No supplementary reinforcement against concrete cone, splitting, blow-out or edge failure is considered, while the main reinforcement of the concrete member designed to loads acting on THRELDA® Anchor Plate is present.

Cracked concrete: C25/30

Reinforcing steel: B500 B

Exposure class: X0

Selection:

THRELDA® Double T & S THRELDA® Double B × L - H / M	N_{Rd} kN	V_{Rd} kN
THRELDA Double 150×150-H/16	170	64
THRELDA Double 150×150-H/20	266	101
THRELDA Double 200×200-H/24	289	153
THRELDA Double 250×250-H/24	458	162
THRELDA Double 300×300-H/30	734	259
THRELDA Double 400×400-H/30	777	268

Definition of length of the anchors: H = 500 mm

Selected:

THRELDA® Double 300×300-500/30
V_{Rd} = 259 kN > V_{Ed}

Installing THRELDA® Anchor Plates

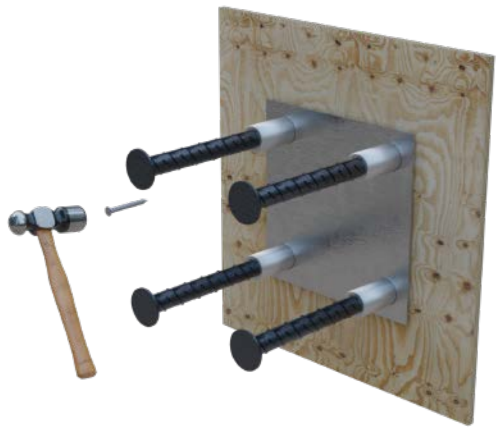
INSTALL THE PRODUCT – PRECAST FACTORY or CONSTRUCTION SITE

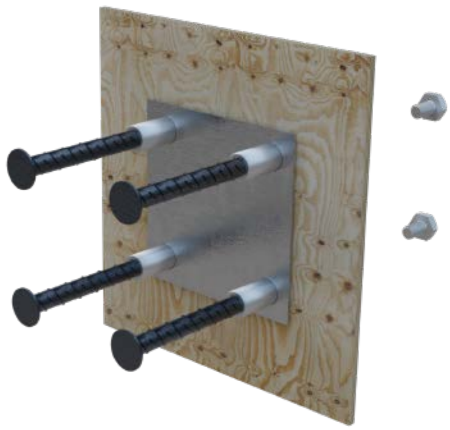
Identification of the product

THRELDA® Anchoring Plates are produced in various models using 5 types of bolts (16, 20, 24, 30, 39). The model of anchoring plate can be identified by the name on the label on the product.

Installation instructions:

1. Attach anchor plate by nails (protection tape must not be perforated or removed before attaching to formwork) or by other appropriate method (e.g., bolts) to formwork.

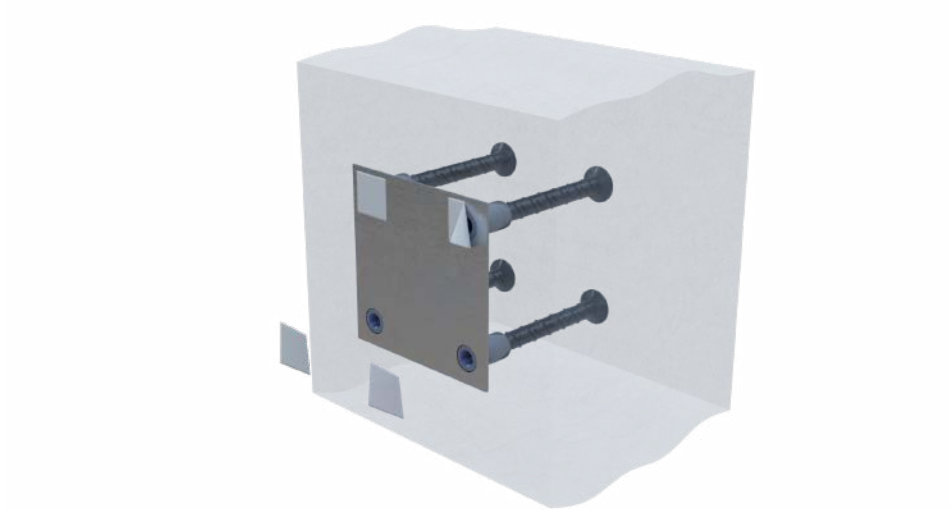




2. To secure position of headed anchor bars, they must be wire-tied to the main longitudinal reinforcement. It is not allowed to bend or cut the headed studs or anchors to make the plate fit the reinforcement.

3. During pouring the concrete into the formwork, ensure that the position of the anchor plates remains unchanged.

4. Remove the protection tapes.



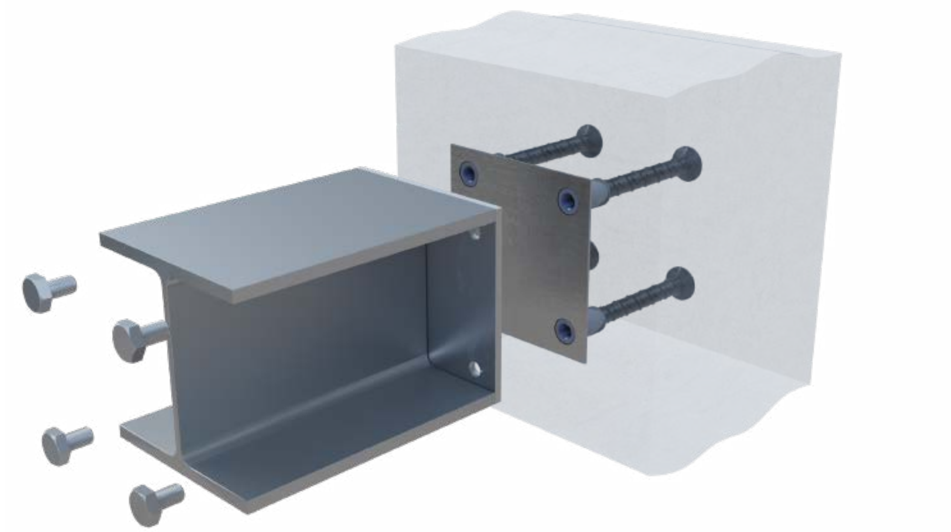
5. When concrete has enough capacity attach the steel element.

   The nuts are tightened to the recommended torque given in the table below. Adequate torque can be achieved typically by 10 – 15 impacts of a slogging ring wrench (DIN 7444) or open-ended slogging wrench (DIN 133) and a 1.5 kg sledgehammer.

Table 13. Recommended T_{rec} torque values of nuts.

Bolt	T_{rec} [Nm]	Size of the slogging wrench [mm]
M16	120	24
M20	150	30
M24	200	36
M30	250	46
M39	350	60

6. Effective screw depth m_{eff} must be observed from Table 7. Installation parameters for THRELDA®.



7. The size of holes in the end plate designed by customer is recommended to have a dimension of the particular thread size +4 mm. It means that the designer has to calculate the resistance of the bolts for oversized holes according to EN 1993-1-8 - Table 3.4.

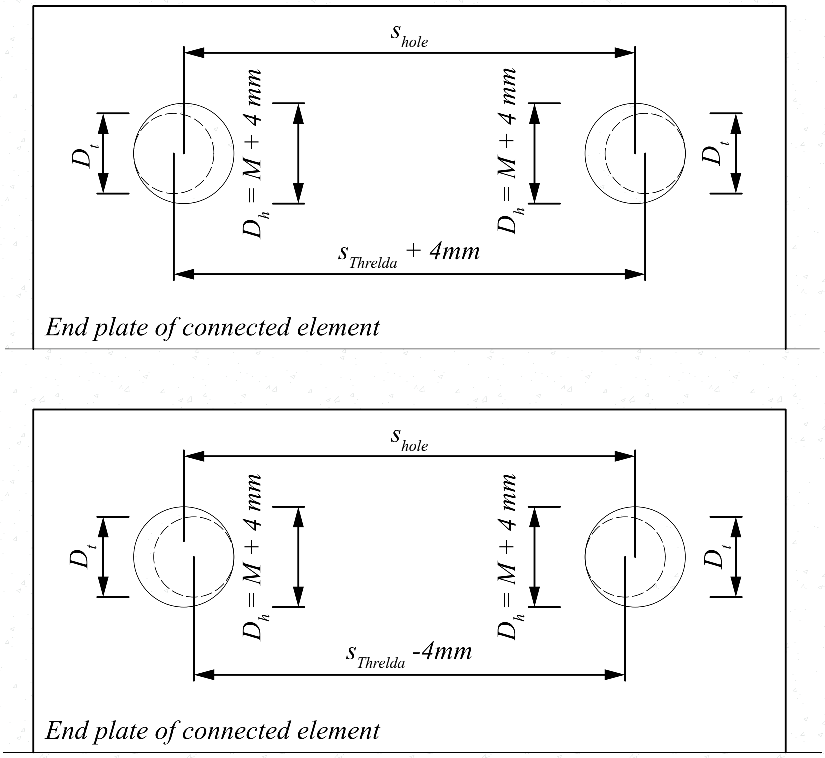


Figure 15. Tolerances for holes for bolts on connected end plate.

where:

D_t diameter of the selected thread size (bolt)
D_h diameter of the hole in customer-designed connected plate
s_{hole} axis distance of two holes in customer-designed connected plate, defined in *Table 2.*, *Table 3.* and *Table 4.*
$s_{Threlda}$ axis distance of THRELDA® couplers defined in *Table 2.*,*Table 3.* and *Table 4.* with consideration of possible manufacturing inaccuracies.

The calculation of resistances of bolts has to follow the design method given in EN 1993-1-8 while taking into account the classification of the hole-size according to EN 1090.

The maximum tolerable gap in the joint between THRELDA® Anchoring Plate and the connected plate is 2 mm, and 4 mm on the edge of the plates.

Note: The design of THRELDA® Anchoring Plates considers installation tolerances (position of the force) of 15 mm only in the "x" and in the "y" direction.

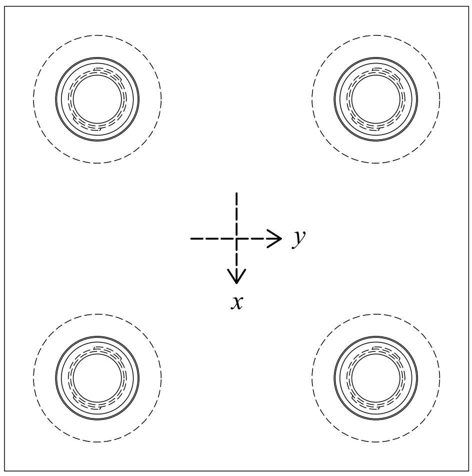


Figure 16. Direction of considered possible eccentricity of the forces.

NOTES

Revision History

Version: PEIKKO GROUP 11/2022. Revision: 002

- Updated values in Figure 14 and selection table.

Version: PEIKKO GROUP 10/2022. Revision: 001

- First publication.

Resources

DESIGN TOOLS
Use our powerful software every day to make your work faster, easier, and more reliable. Peikko design tools include design software, 3D components for modeling programs, installation instructions, technical manuals, and product approvals of Peikko's products.

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Environmental Product Declarations and management system certificates can be found at the quality section of our websites.

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CERTIFIED BY DNV
ISO 9001 ▪ ISO 14001
ISO 45001