RSTEEL®

Technical Manual

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Version 06.01.2020

RPP, RPP-E Base Bolts

Design According to Eurocodes

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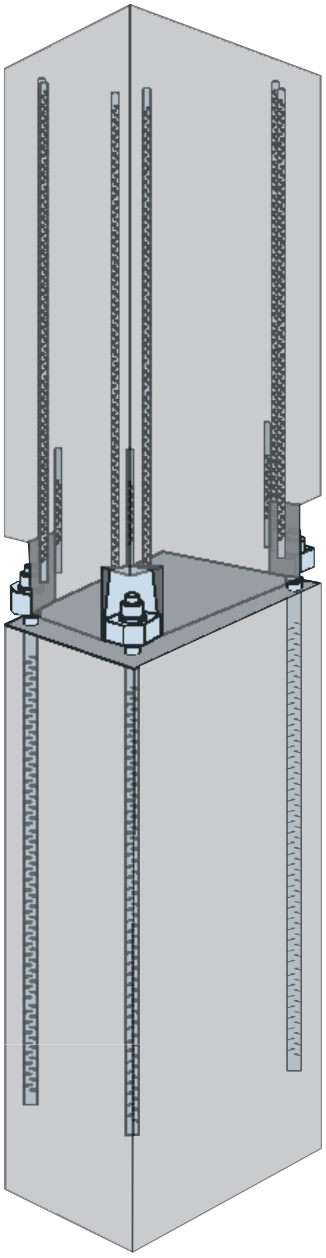
RPP and RPP-E Base Bolts

RPP Bolts are Anchor bolts used for moderate loads and RPP-E Bolts are used for high loads.

The product range consists of:

Headed Anchor Bolts (RPP-L and RPP-E-L) short stud-headed anchor bolts used as basic bolts suitable for use as foundation anchor connections.

Straight Anchor Bolts (RPP-P and RPP-E-P) long anchor bolts with ribbed bars used as overlapping bolts suitable for forming continuous columns which have been prepared as independent precast components.



RPP Base Bolts

RPP-E Base Bolts

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1. DESIGN APPROACH

Base bolts transfer tension, compression and shear forces to reinforced concrete foundation structures. Tension and compression forces are transferred by anchorage of the ribbed rebars, and by bearing onto anchorage plates.

Shear forces are transferred to the concrete by bearing onto the shank of the bolt.

2. MATERIALS AND DIMENSIONS

Materials and standards for the individual parts of the base bolts:

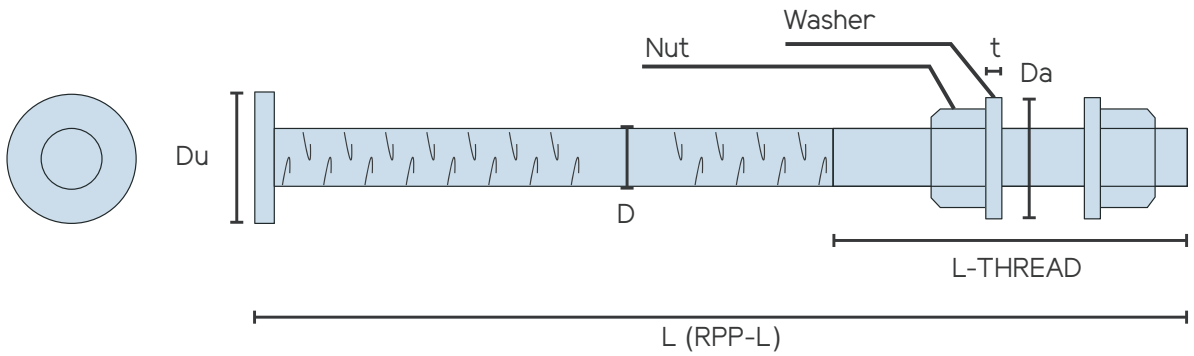
Rebars	B500B	SFS 1300
		EN 10080 (SFS 1268) (A500HW SFS 1215) (BSt500S DIN 488)
High Strength Steel Bars		f_{yk} ≥700MPa ; f_{uk} ≥ 800MPa ; f_{uk} / f_{yk} ≥ 1.08 ; ε_{uk} ≥ 5%
Anchorage Plates	S355J2	EN 10025
Washers	S355J2	EN 10025
Nuts (RPP)	grade 8	EN 20898-2
	dimensions	EN-ISO 4032
Nuts (RPP-E)	grade 10	EN 20898-2
	dimensions	EN-ISO 4032

Base bolts can be supplied either fully galvanised, or with only the threaded section galvanised.

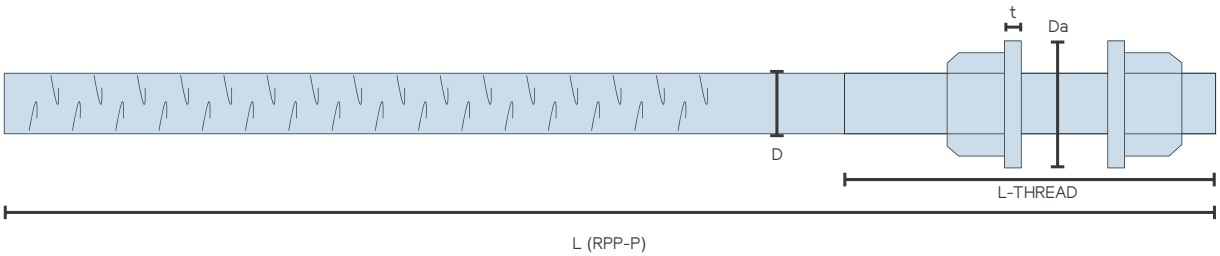
RPP Base Bolt dimensions

Base bolt	Thread			Bar		Washer	RPP-P		RPP-L	
	Size	l-thread	Net tensile area	D	Du	Da / t	L	weight	L	weight
		(mm)	(mm2)	-	(mm)	(mm)	(mm)	(kg)	(mm)	(kg)
RPP M16	16	140	157	16	38	38 / 6	810	1,7	280	0,9
RPP M20	20	140	245	20	46	46 / 6	960	2,9	350	1,4
RPP M24	24	170	352	25	55	55 / 6	1160	4,9	430	2,2
RPP M30	30	190	561	32	70	65 / 8	1460	9,8	500	4,1
RPP M39	39	200	976	40	90	90 / 10	2000	21,8	700	9,2

RPP-L



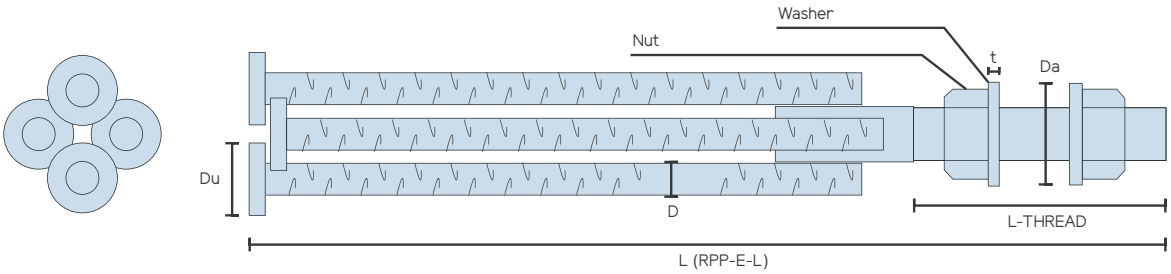
RPP-P



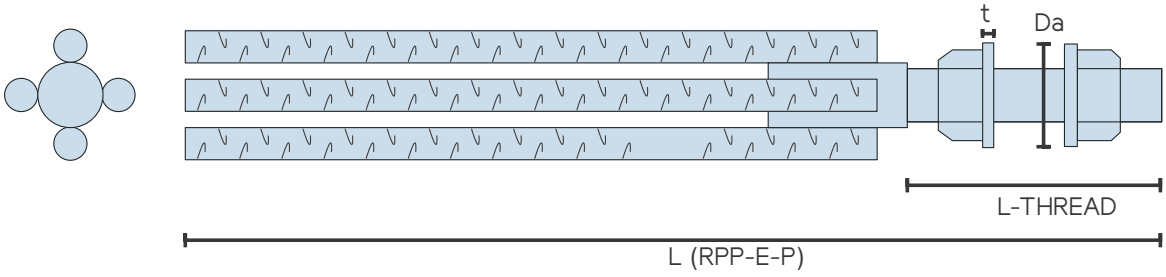
RPP-E Base Bolt dimensions

Base bolt	Thread			Bar		Washer	RPP-E-P		RPP-E-L	
	Size	l-thread	Net tensile area	n/ D	Du	Da / t	L	weight	L	weight
		(mm)	(mm2)		(mm)	(mm)	(mm)	(kg)	(mm)	(kg)
RPP-E M30	30	190	561	2 / 25	55	65 / 8	1705	14,6	670	7,0
RPP-E M36	36	190	817	4 / 20	46	80 / 8	1370	17,8	740	8,6
RPP-E M39	39	200	976	3 / 25	55	90 / 10	1710	21,1	880	11,0
RPP-E M45	45	220	1306	4 / 25	55	100 / 10	1720	30,0	980	15,9
RPP-E M52	52	250	1758	4 / 32	70	100 / 12	1860	49,6	1140	30,0
RPP-E M60	60	310	2362	4 / 32	70	115 / 12	2390	63,8	1330	36,4

RPP-E-L



RPP-E-P



3. FABRICATION

3.1 Fabrication Method

Execution standard	EN 1090-2
Rebars	Mechanically cut
High Strength Steel Bars	Mechanically cut
	Thread Coarse; ISO 68-1; ISO 261; ISO 965-1
	The threads are mechanically machined or rolled
Welding	Hand or robot MAG- welded
	Class C; EN ISO 5817

3.2 Manufacturing Tolerances

Overall Length	±10 mm
Threaded Length	+5, -0 mm

3.3 Quality Control

Fabrication and quality control in accordance with EN 1090-2. R-Group Oy internal quality control in accordance with ISO 9001 and ISO 14001. External quality control provided to R-Group Finland Oy by:

Inspecta Sertifiointi OY

3.4 Markings

Base bolts are marked with the R-Steel bolt identifier and the Inspecta certification mark.

4. RESISTANCES

The tension resistance of the base bolt is calculated in accordance with EC (EN 1992, 1993). The shear resistance of the base bolt is calculated in accordance with EC (EN 1992-4:2018). The thickness of the grout layer, as well as the thickness of the base plate to the column shoe or steel column, influences the shear resistance of the base bolt. The anchorage of the short base bolts is verified in accordance with EN 1992-4:2018; required additional reinforcement is presented below.

The tension/compression and shear resistances are governed by the net tensile area of the threaded section of the base bolt. Nominal design resistances are given below for individual base bolts. The nominal shear resistance of the base bolts has been calculated taking into account typical thickness of the grout layer. The total resistance of a bolt group is to be calculated in accordance with clause 6.2.2 of EN 1993-1-8 and EN 1992-4:2018.

Concrete grade C25/30. Anchorage coefficients, π_1 = 1,0, lap factor α_6 = 1,5 , α_2 =0,7, others α_1-α_5 =1,0.

Base bolt resistances:

RPP Base Bolt	N_{Rd} (kN)	V_{Rd} (kN)
M16	62,2	4,3
M20	97,0	8,2
M24	139,4	12,7
M30	222,2	22,4
M39	386,5	43,3

RPP-E Base Bolt	N_{Rd} (kN)	V_{Rd} (kN)
M30	299,2	34,5
M36	435,7	52,6
M39	520,5	61,4
M45	696,5	88,6
M52	937,6	124,1
M60	1260	174,6

N_{Rd} = nominal design tension resistance, and V_{Rd} = Nominal design shear resistance

Nominal Base Bolt Design Resistances:

NOTE. Shear resistance during installation and prior to grouting of the base

Base Bolt RPP Resistances:

Base Bolt	Tension	Shear	Net tensile area	Lever arm
	N_{Rd} (kN)	V_{Rd} (kN)	A (mm^2)	l (mm)
M16	62,2	4,3	157	68
M20	97,0	8,2	245	70
M24	139,4	12,7	352	77,5
M30	222,2	22,4	561	88,5
M39	386,5	43,3	976	105

EN 1993-1-8

$N_{R,d} = 0.9f_{uk}*A / \gamma_{Ms}$

$\gamma_{Ms} = 1,25$ and $f_{uk} = 550$ MPa

EN 1992-4:2018

$V_{R,d} = V_{Rk,s} / \gamma_{M,s}$

$V_{Rk,s} = \alpha_M M_{Rk,s} / l_i$

$M_{Rk,s} = M^o_{Rk,s} (1 - N_{sd} / N_{Rd,s})$

($N_{sd} = 0$; shear only)

$M^o_{Rk,s} = 1,2\ W_{el} f_{uk}$

$W_{el} = \pi d^3/32$

$\alpha_M = 2.0$

Base Bolt RPP-E Resistances:

Base Bolt	Tension	Shear	Net tensile area	Lever arm
	N_{Rd} (kN)	V_{Rd} (kN)	A (mm^2)	l (mm)
M30	299,2	34,5	561	83
M36	435,7	52,6	817	96
M39	520,5	61,4	976	108
M45	696,5	88,6	1306	115
M52	937,6	124,1	1758	129
M60	1259,7	174,6	2362	142

EN 1993-1-11

and EN 1992-4:2018

$N_{R,d} = f_{uk}*A / \gamma_{Ms}$

$\gamma_{Ms} = 1,5$ and $f_{uk} = 800$ MPa

$V_{R,d} = V_{Rk,s} / \gamma_{M,s}$

$V_{Rk,s} = \alpha_M M_{Rk,s} / l_i$

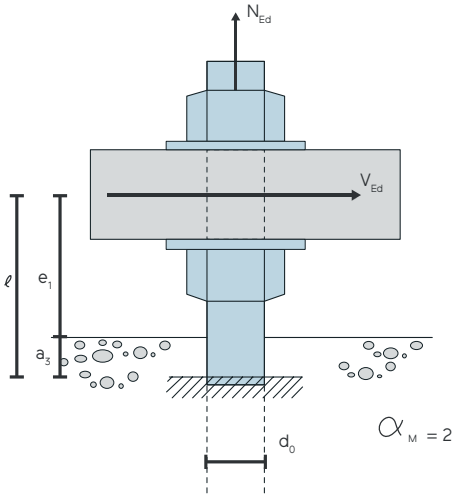
$M_{Rk,s} = M^o_{Rk,s} (1 - N_{sd} / N_{Rd,s})$

($N_{sd} = 0$; shear only)

$M^o_{Rk,s} = 1,2 W_{el} f_{uk}$

$W_{el} = \pi d^3/32$

$\alpha_M = 2.0$; $\gamma_{Ms} = 1,25$



e_1 = base grout thickness + 0,5 x base plate thickness

$a_3 = 0,5 \times d_0$

Base Bolt RPP-E Shear Resistances according to EN 1993-1-8; 6.2.2 (7):

NOTE. Shear resistance of the base bolt

Base Bolt	Shear	Net tensile area
	$F_{2,vb,Rd}$	A (mm^2)
M16	20,03	157
M20	31,26	245
M24	45,04	353
M30	71,58	561
M39	124,54	976

Base Bolt	Shear	Net tensile area
	$F_{2,vb,Rd}$	A (mm^2)
M30	71,2	561
M36	103,7	817
M39	123,9	976
M45	165,8	1306
M52	223,2	1758
M60	299,9	2362

Strength Resistance: V_{Rd} = min { $F_{1,vb,Rd}$; $F_{2,vb,Rd}$ }

$F_{1,vb,Rd} = (\alpha_v f_{bolt,u} A_{bolt}) / \gamma_{M2}$

$F_{2,vb,Rd} = (\alpha_b f_{ub} A_{bolt}) / \gamma_{M2}$ = Critical

$\alpha_b = 0,44 - 0,0003\ f_{bolt,y}$

$f_{bolt,u}$ is the ultimate tensile strength of the bolt

f_{ub} is the yield strength of the bolt ≤ 640 N/mm^2

A_{bolt} is the net tensile area of the bolt

$Y_{M2} = 1,25$

$\alpha_v = 0,5$

Design criteria:

Where N_{Ed} and V_{Ed} are applied coincident axial force and shear force.

In accordance with EN 1992-4:2018 section 7.2.3, the following requirements must also be taken into account for the coincident applied normal and shear forces:

Base bolts without provision of additional reinforcement:

EN 1992-4:2018 section 7.2.3.1, table 7.3

Base bolts that are installed with additional reinforcement for normal and shear forces, see section 5.2 Design Guidance:

EN 1992-4:2018 section 7.2.3.2

The tension and compression resistances of the cast-in-place base bolt are identical. The base bolt and bolt group capacities are to be calculated in accordance with EN 1992-4:2018, taking into account the dimensions of the foundations and the positions the bolts and bolt group.

The forces to be transferred through the base bolts influences the local reinforcement required to be provided to the concrete structures; the base bolt axial and shear forces are transferred to the concrete structures with the help of the local reinforcement. Reinforcement, base bolt edge and spacing distances, as well as their influence on the overall base bolt design resistance, are to be calculated in accordance with EN 1992 and EN 1992-4:2018.

Adjustment of the nominal design resistance for lower concrete grades

Base bolt nominal design resistances are to be adjusted according to the required concrete grade as follows:

The tension/compression design resistance is reduced according to the required concrete grade. The adjustment is only applied for lower concrete grades. The nominal tension/compression design resistance is reduced by factor: n1 = f_{cd} / f_{cd} (C25/30).

The nominal design shear resistance is not adjusted for other grades of concrete.

5. USER INSTRUCTIONS

Base bolts are used for transferring vertical and shear forces, as well as bending moments, between the base of a column and its foundation. RPP M16...M30 and M39 base bolts and RPP-E M36...M60 base bolts can also be used for transferring vertical and shear forces, as well as bending moments, across a joint in a column.

5.1 Limits of Use

The resistances of the base bolts have been calculated for static loads. Increased load factors are to be adopted for case specific dynamic and fatigue effects. For seismic actions, see also EN 1992-4:2018 section 9. For design in accordance with the Eurocodes, the lowest operating temperature is calculated from SFS-EN 1991-1-5.

5.2 Design Guidance

Base bolt minimum edge distance (from the centreline of the bolt) for tension/compression forces

The required minimum edge distance of the base bolt is determined from the cover and durability requirements that are based on the environmental conditions and design working life in which the base bolt is situated, EC2 clause 4.

Base bolt minimum spacing (centreline to centreline) for tension/compression forces

The minimum spacing of the long base bolts is determined taking into account the length, l, that is available for the lap joint.

Base Bolt	l (mm)
RPP M16 P	675
RPP M20 P	815
RPP M24 P	1000
RPP M30 P	1280
RPP M39 P	1790
RPP-E M30 P	1485
RPP-E M36 P	1130
RPP-E M39 P	1480
RPP-E M45 P	1470
RPP-E M52 P	1580
RPP-E M60 P	2050

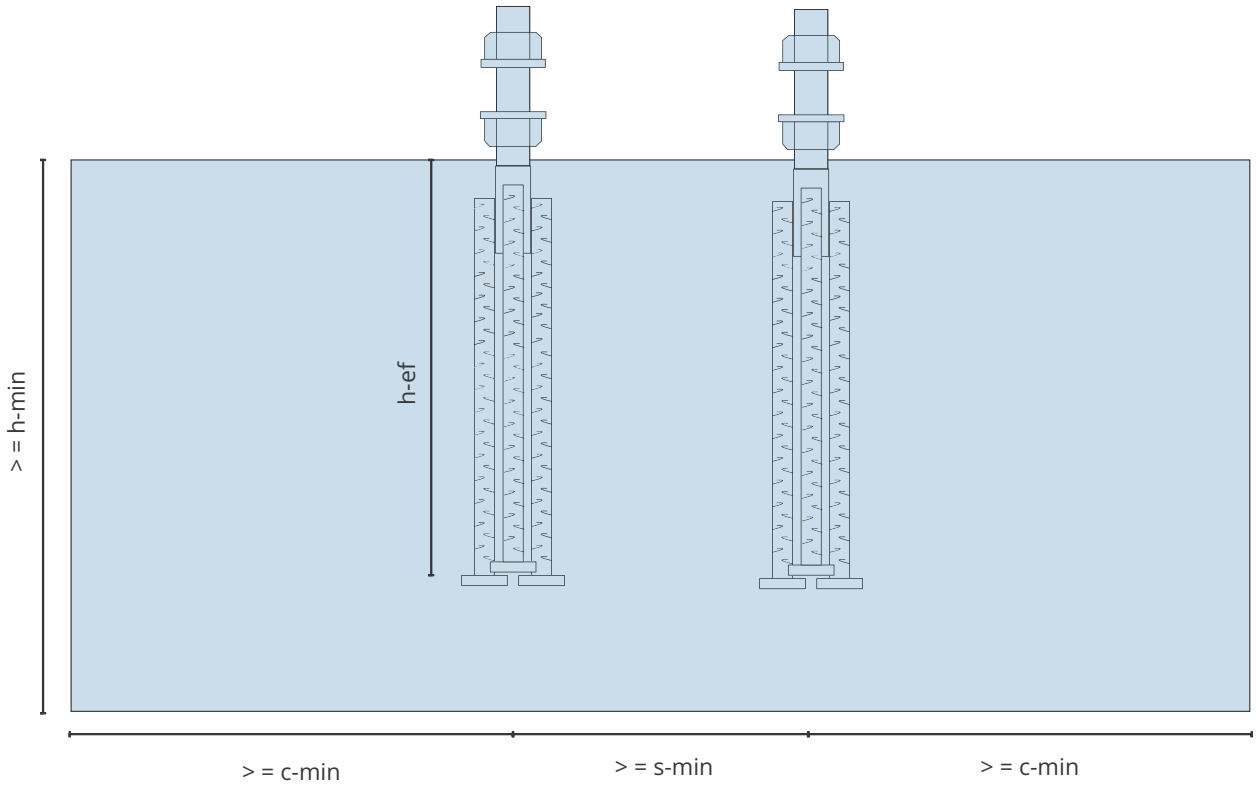
RPP M39 P: Additional requirements for the use of T40 bars

1. A 2T32 bundle of rebars or a 3T25 bundle of rebars must be used to form the lap to the T40 base bolt (RPP M39 P); that is the lap must not be formed to another T40 rebar directly. The base bolt forces must be transferred into the structure via smaller rebars, taking note of the reinforcement requirements for the lesser stressed level.
2. Shear link hooks are always used as expansion control reinforcement.
3. Splitting forces and crack control must be considered, and surface reinforcement must be designed taking into account additional rules given in Eurocode 2 section 8.8 for large diameter bars.

The short base bolts are anchored by bearing onto an anchorage plate. The minimum edge distance is determined according to local crushing of the concrete.

Positioning of the “L” type base bolts

Base Bolt	c_{min} (mm)	s_{min} (mm)	h_{min} (mm)	h_{ef} (mm)
RPP M16 L	60	80	270	169
RPP M20 L	80	110	330	229
RPP M24 L	90	120	395	294
RPP M30 L	130	180	445	342
RPP M39 L	160	280	610	510
RPP-E M30 L	120	130	600	507
RPP-E M36 L	140	160	665	562
RPP-E M39 L	150	180	780	680
RPP-E M45 L	160	200	865	765
RPP-E M52 L	180	280	995	893
RPP-E M60 L	180	280	1160	1058



Additional reinforcement

The following checks are to be carried out for base bolts / base bolt groups (EN 1992-4:2018 tables 7.1 and 7.2)

Required checks for N_{rd} (by failure mode):	**Single Base bolt**	**Group/ Most heavily loaded Base bolt**	**Group**	**-**
1. Base bolt steel fracture	x	x	-	-
2. Base bolt pull-out	x	x	-	-
3. Concrete blow-out failure	x	-	x	Not needed if: $c_1 \geq 0{,}5h_{ef}$
4. Concrete cone failure	x	-	x	-
5. Concrete splitting	x	-	x	Not needed if: $c_1 \geq 1{,}5h_{ef}$ (single base bolt) $c_1 \geq 1{,}8h_{ef}$ (group)

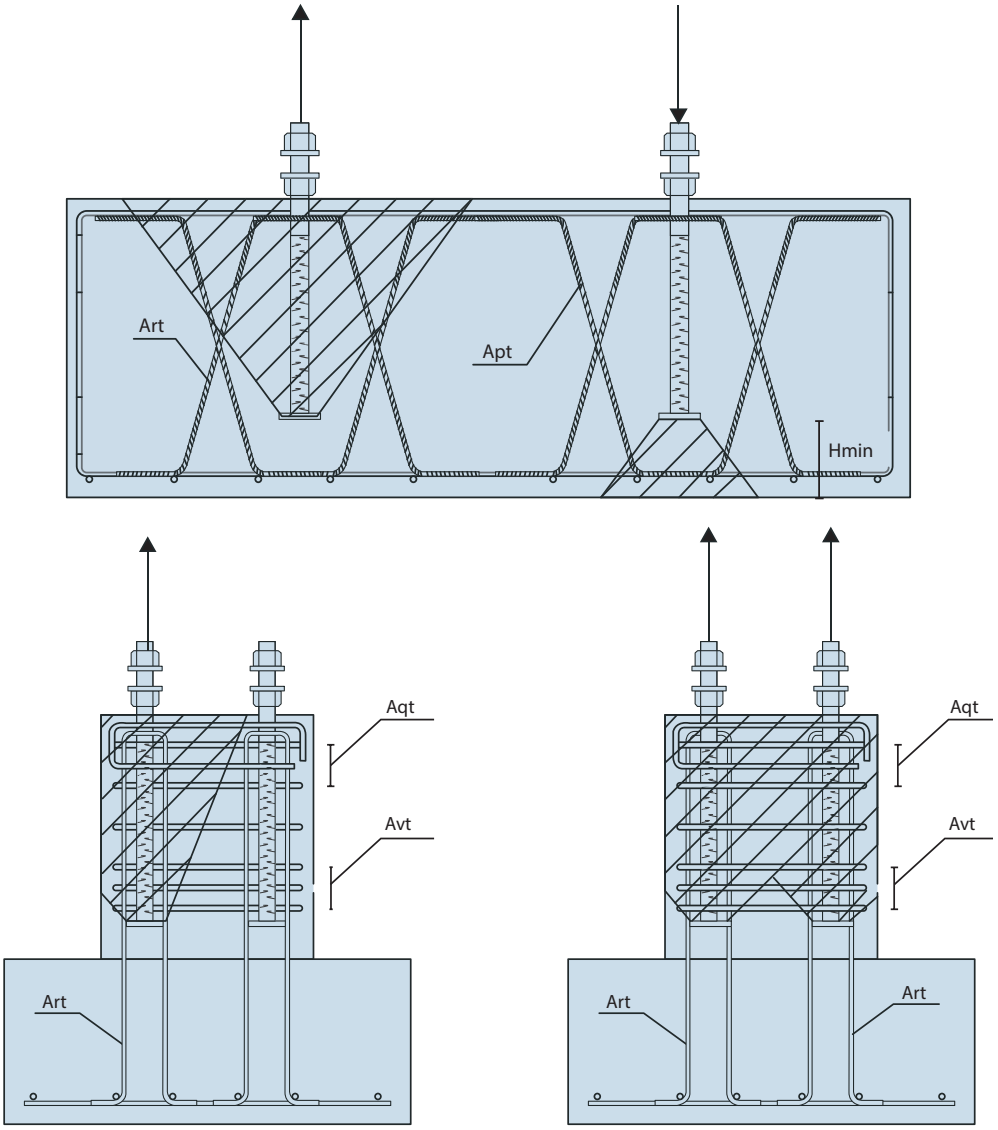
Required checks for V_{rd} (by failure mode):	**Single Base bolt**	**Group/ Most heavily loaded Base bolt**	**Group**	**-**
1. Base bolt steel fracture	x	x	-	Without Moment Lever Arm
2. Base bolt steel fracture	x	x	-	With Moment Lever Arm
3. Concrete edge failure	x	-	x	-
4. Concrete pry-out failure	x	-	x	-

Additional reinforcement is to be designed according to the applied base bolt axial forces, as well as edge and spacing distances, taking into account shear cone failure as illustrated in the image below. Base bolt axial forces are always designed to be transferred to the concrete structures using reinforcement.

Tension forces are to be anchored using shear links A_{rt}. Shear links are to be anchored to the bottom of the concrete slab.

Compression forces are to be anchored using shear links A_{pt}. Dimension H_{min}, measured from the bottom of anchor bolt to the bottom of the concrete foundation, is to be taken into account in the design of the shear links.

Additionally, if the edge distance is small, for example in the case of column stools, transversely arranged hooks are required for the lapped connection as well as for the transfer of applied shear forces. Links are to be positioned at the top and bottom of the base bolts, as shown in the image.



Base bolt minimum edge distance (from the centreline of the bolt) for shear

The minimum edge distance of the base bolt for shear forces is 10M (all sizes except M60, which is 12M) (M = size of the threaded section), where shear links are not designed for transfer of the shear force.

For other cases, the minimum edge distance requirements for tension/compression forces may be adopted. In this case, the whole of the base bolt shear force must be transferred as follows:

1. The shear forces from base bolts that are located near corners are to be transferred using shear link hooks.

2. Elsewhere, the shear force is transferred using U-bars beneath the surface of concrete.

The concrete grade of the column that is attached on the lower side of a column joint must be at least as strong as that of the column above. The strength of the grout to the joint must be at least as strong as the strongest grade of concrete used in the elements that are joined. The grout must be of non-shrinkage type.

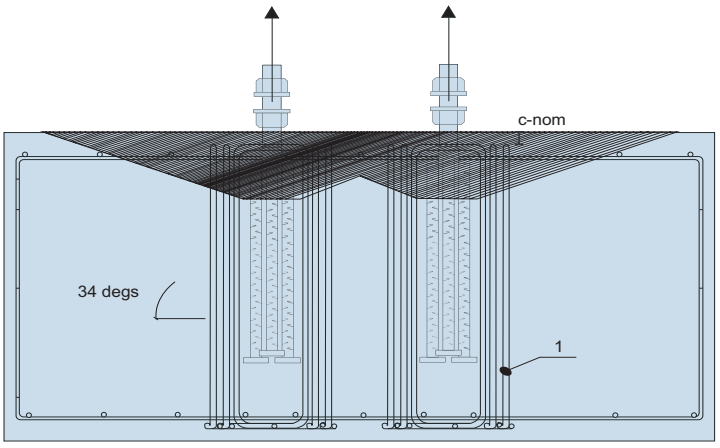
RPP and RPP-E Base bolts: Additional reinforcement:

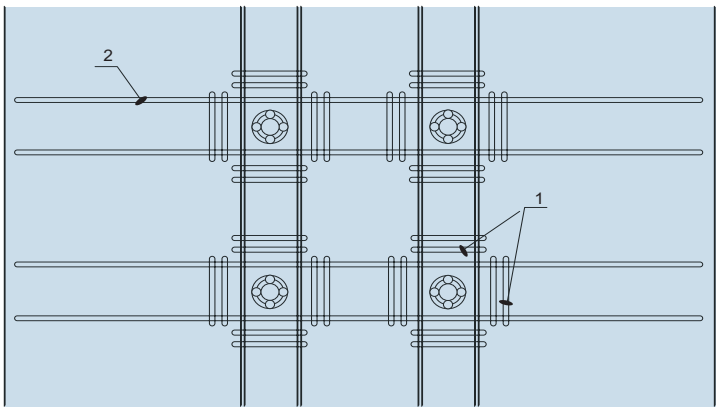
Concrete cone failure, RPP type “L” base bolts

Base bolt	Link 1	Horiz. rebars 2	Rebars quantity, Link 1 (mm²)
M16	2x D8	D8	200
M20	3x D8	D8	300
M24	4x D8	D8	400
M30	4x D10	D10	628
M39	4x D12	D12	904

Concrete cone failure, RPP-E type “L” base bolts

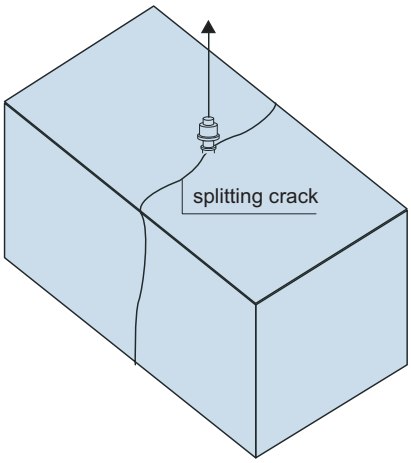
Base bolt	Link 1	Horiz. rebars 2	Rebars quantity, Link 1 (mm²)
M30	4x D12	D8	904
M36	8x D10	D10	1004
M39	6x D12	D12	1199
M45	8x D12	D12	1605
M52	6x D16	D16	2160
M60	8x D16	D16	2903





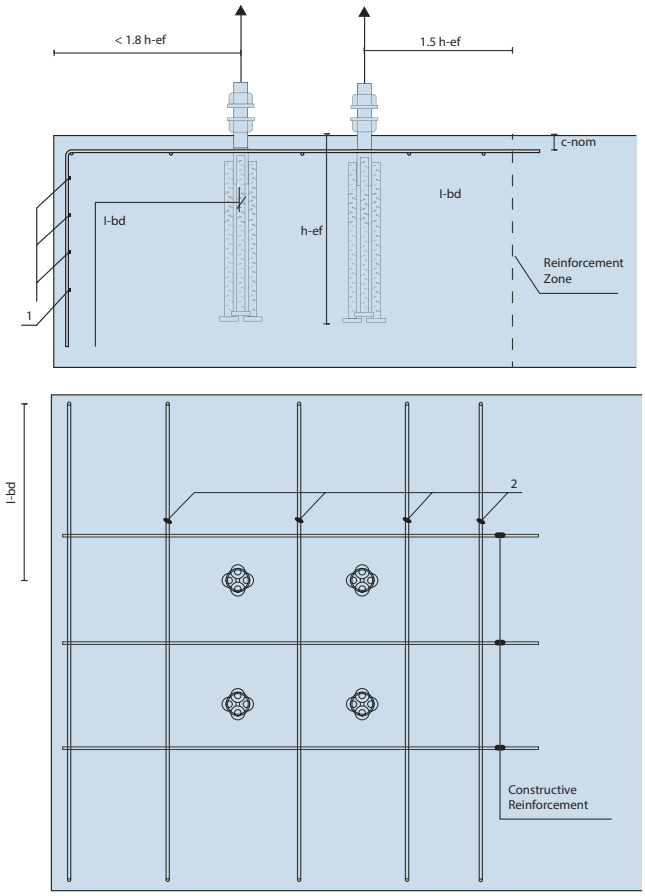
Concrete splitting, RPP type “L” base bolts

Base bolt	Horiz. rebars 1+2	Rebars quantity (mm^2)
M16	3x D6	72
M20	4x D6	112
M24	4x D8	161
M30	4x D10	256
M39	4x D12	445



Concrete splitting, RPP-E type “L” base bolts

Base bolt	Horiz. rebars 1+2	Rebars quantity (mm^2)
M30	4x D12	344
M36	5x D12	502
M39	6x D12	600
M45	4x D16	802
M52	6x D16	1080
M60	8x D16	1451

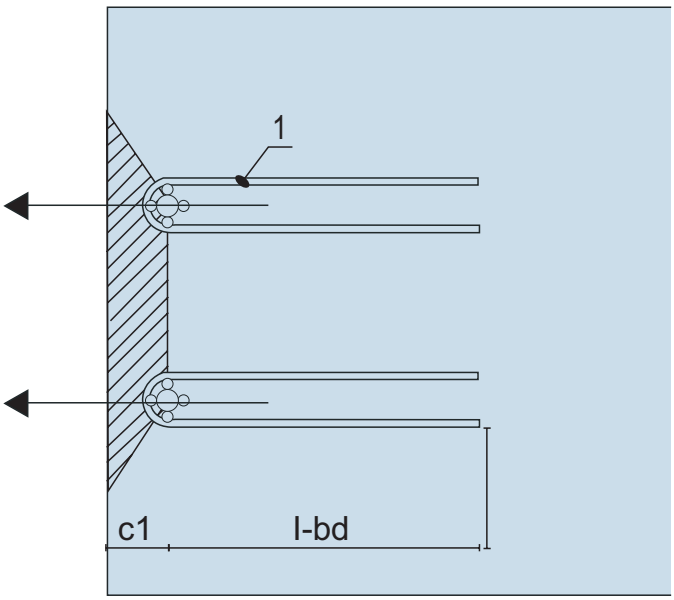


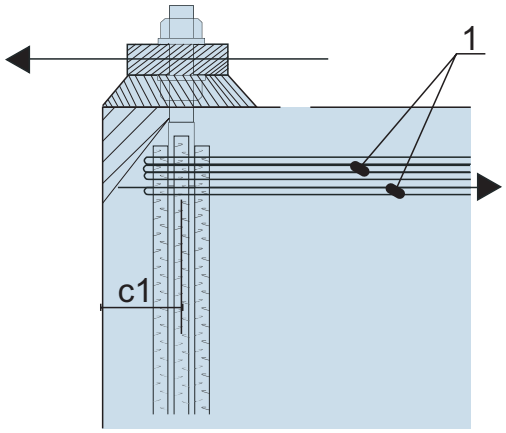
Concrete edge failure, RPP type “L” and type “P” base bolts

Base bolt	Link 1 / per bolt
M16	1x D12
M20	2x D12
M24	1x D16
M30	2x D16
M39	3x D16

Concrete edge failure, RPP-E type “L” and type “P” base bolts

Base bolt	Link 1 / per bolt
M30	3+1x D12
M36	3x D16
M39	3x D16
M45	3+1x D16
M52	3+2 D16
M60	3+2 D16





6. INSTALLATION

Installation frames are to be used when forming bolt groups from the base bolts. The installation frames help to obtain the correct spacing of base bolts and general alignment and positioning of the bolt groups relative to the building or structure. Furthermore the installation frames help to obtain the correct installation level of the bolts as well as help with protecting the threads of the base bolts during concrete casting.

6.1 Base bolt installation tolerances

The positional tolerance of the bolt group for installation of the precast concrete elements = ±10 mm. Tolerance for the level of the top of the base bolt = ±20 mm.

Base bolt height positions and positional tolerances:

Base bolt	Grout Thickness (mm)	height of top of bolt above the top of the concrete surface (mm)	base bolt spacing tolerance within the bolt group (mm)
RPP M16	50	105	±3
RPP M20	50	115	±3
RPP M24	50	130	±3
RPP M30	50	150	±3
RPP M39	60	180	±3
RPP-E M30	50	150	±3
RPP-E M36	55	170	±4
RPP-E M39	60	190	±4
RPP-E M45	65	205	±4
RPP-E M52	70	235	±5
RPP-E M60	80	260	±5

6.2 Bending and welding of the base bolts

Where space for installation is limited, the straight anchorage section of the ribbed bar to the base bolt may be bent on site. Bending of the bars must be performed taking into account requirements and instructions in design standards, in relation to bending radii and working temperatures. Furthermore the modified anchorage length of the bar must be taken into account in relation to the required anchorage.

The base bolts can be welded using all common fusion welding methods. All welding of the reinforcement to reinforced concrete structures must be performed taking into account the requirements and instructions presented in EN 17660-1.

It is not allowed to weld connection plates or fasteners to the base bolts without prior approval from the structural designer.

6.3 Installation of the column

The column is installed to the correct level by adjusting at the nuts of the base bolts and by using packer plates placed under the columns. The verticality of the columns is checked and the nuts are tightened, for example using an impact wrench. Recommended tightening torques for the column shoe to base bolt connection are given in the table below. The space below the base plate and (where required) the void presented by the column shoes, must be grouted prior to further installation of structural elements on top of the column. The column joint must not be loaded before the grout has reached the required strength for the design.

Indicative nut tightening torque values:

Base bolt	Tmin (Nm)	Tmax (Nm)
RPP M16	120	200
RPP M20	150	250
RPP M24	200	380
RPP M30	200	450
RPP M39	350	1000
RPP-E M30	250	700
RPP-E M36	300	1200
RPP-E M39	350	1400
RPP-E M45	400	2000
RPP-E M52	450	3300
RPP-E M60	500	3800

Tmin = minimum tightening torque, and Tmax = maximum tightening torque

6.4 Inspection instructions for installation of the base bolts

Before casting:

- Check that the correct base bolts and the correct installation frame are being used (centreline to centreline dimensions, thread size), and that the base bolts have not been damaged during delivery.
- Check that the positions of the base bolts and bolt groups within the mould are within the required tolerances.
- Check that the levels of the top of the base bolts are within the required tolerances.

- Check that the reinforcement required for the base bolts is installed
- Check that the installation frame is horizontal and within required tolerances.
- Protect the threads of the base bolts until the column is installed.

After casting:

- Check the position of the base bolt group. Dimensions that are greater than the tolerance requirements are to be reported to the structural designer.
- Protect the thread of the base bolt until the column is installed (using for example tape, plastic tube, etc.)

6.5 Inspection instructions for installation of the column

The column is to be installed in accordance with the project's erection plans. The installation inspector must check the following items:

- Installation sequence of the elements as presented in the erection plan.
- Temporary support requirements for the column during erection.
- Tightness of the nuts to the base bolts.
- Timing of joint grouting as well as the type of grout to be used.

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Notes

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Notes

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About
R-Group

R-Group is a leading provider of steel connections for precast and cast-in- situ construction around the globe.

With over three decades of our participation in huge projects, we don't compromise on quality or customer satisfaction and we create connections for a lifetime.

Our customer-oriented service, excellent and reliable network of suppliers plus our extensive product portfolio ensure that we are able to offer professional and flexible solutions for any kind of projects.

In our operations we comply with the ISO 9001 and 14001 standards

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