RSTEEL®

KL-fastening plate

Design according to Eurocodes

TECHNICAL MANUAL

Technical changes and errors reserved

Version: **20.07.2022***

RSTEEL®

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1. DESCRIPTION OF THE SYSTEM

KL-fastening plates are steel plates equipped with resistance welded stud head anchors. The fastening plates are cast into concrete. KL-fastening plates are intended to be used as base plates to which steel profiles are welded. The fastening plates transfer loads from structures welded on it to concrete structures. The loads are transferred through rebar anchors.

KL-fastening plates consist of a steel on which stud head anchors are welded. Multiple sizes of plates are manufactured with different material options.

2. DIMENSIONS AND MATERIALS

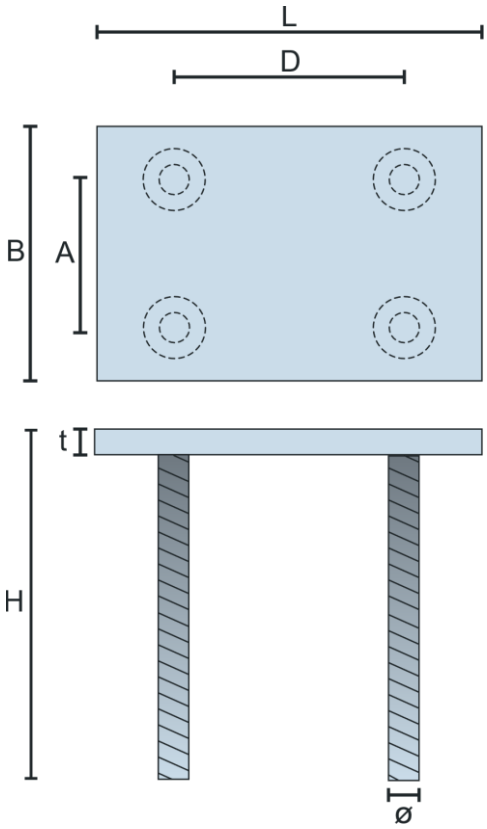

Figure 1. KL-fastening plates dimensions

Table 1. KL-fastening plates dimensions and tolerances

Fastening plate		H [mm]	A [mm]	D [mm]	t [mm]	Ø [mm]
KL	B x L					
KL	**50 x 100**	218	-	60	8	12
KL	**100 x 100**	218	60	60	8	12
KL	**100 x 150**	220	60	90	10	12
KL	**150 x 150**	222	90	90	12	16
KL	**100 x 200**	222	60	120	12	16
KL	**200 x 200**	312	120	120	12	20
KL	**250 x 250**	315	150	150	15	20
KL	**100 x 300**	315	60	180	15	20
KL	**200 x 300**	315	120	180	15	20
KL	**300 x 300**	315	180	180	15	20

2.1. Manufacturing tolerances

Plate side lengths:	± 3 mm L ≤ 120 mm
	± 4 mm 120 mm < L ≤ 315 mm
Plate straightness:	L/150
Plate cut edge surface roughness:	SFS-EN 1090-2
Squareness of cut edges:	SFS-EN 1090-2
Steel part height:	± 3 mm
Anchor location:	± 5 mm
Anchor spacing:	± 5 mm
Anchor inclination:	± 5°

2.2. Materials and standards

Table 2. Materials and standards

Fastening plate type	Part	Material	Standard
KL	Steel plate	S355J2+N	SFS-EN 10025
	Anchor part	B500B	SFS 1300:2017
KLR	Steel plate	1.4301	SFS-EN 10088
	Anchor part	B500B	SFS 1300:2017
KLH	Steel plate	1.4401	SFS-EN 10088
	Anchor part	B500B	SFS 1300:2017

3. MANUFACTURING

3.1. Manufacturing markings

KL-fastening plates are marked with RSTEEL logo and type of fastening plate.

Products are delivered on a truck palette. Product package is equipped with an RSTEEL pallet label, which contains the following information: product type, product name, quantity, ISO 9001 and ISO 14001 quality and environment system markings.

3.2. Quality control

Quality control of the fastening plates is done according to the requirements of the Finnish Code of Building Regulations and Eurocodes and the instructions according to quality and environment system of the R-Group Baltic OÜ (ISO 9001 and ISO 14001).

R-Group Baltic OÜ has a quality control contract with Inspecta Estonia OÜ.

4. RESISTANCES

4.1. Calculation principles

Capacities of the KL-fastening plates are calculated for static loads according to the limit state dimensioning method presented in Eurocodes.

The calculations are made according to the following regulations and instructions:

SFS-EN 1992: Eurocode 2: Design of concrete structures

SFS-EN 1993: Eurocode 3: Design of steel structures

4.2. Resistances without the effect of edge distances or additional reinforcement

Table 3 presents the resistances of KL-fastening plates when only one loading acts at a time. The resistance of KL-fastening plates with respect to combinations of load effects shall be checked according to 5.3.

The resistances given in table 3 have been calculated using the following assumptions:

- Concrete strength minimum C25/30.
- No additional reinforcement at the location of the fastening plate. Structure only reinforced with minimum reinforcement. The resistances of fastening plate with additional reinforcement are presented in section 5.6.
- The fastening plate is located so far from the edge that the breakage of the edge of concrete structure is not a governing failure mechanism (the required edge distances are given in section 5.1). If the edge distance is smaller than what given in 5.1, the resistances need to be reduced according to section 5.4 or additional reinforcement according to section 5.6 needs to be installed at the location of the fastening plate.
- The thickness of the member on which the fastening plate is mounted is according to section 5.2.
- The tolerance for the location of a load is max. ± 15 mm (In addition the manufacturing tolerance ± 5 mm has been considered in the calculations).
- The fastening surface of the steel component to be mounted on the fastening plate shall have minimum area according to section 4.3.

- Shear force V_{Ed} can act in both directions of the plate but in one direction at a time. Shear force acting in both directions need to be considered according to section 5.3.
- Torsional moment T_{Ed} can act in both plate directions but only in one direction at a time. Torsional moment acting in both directions simultaneously shall be considered according to section 5.3.
- Bending moment M_{Ed} can act in both plate directions but only in one direction at a time. Bending moment acting in both directions simultaneously shall be considered according to section 5.3.

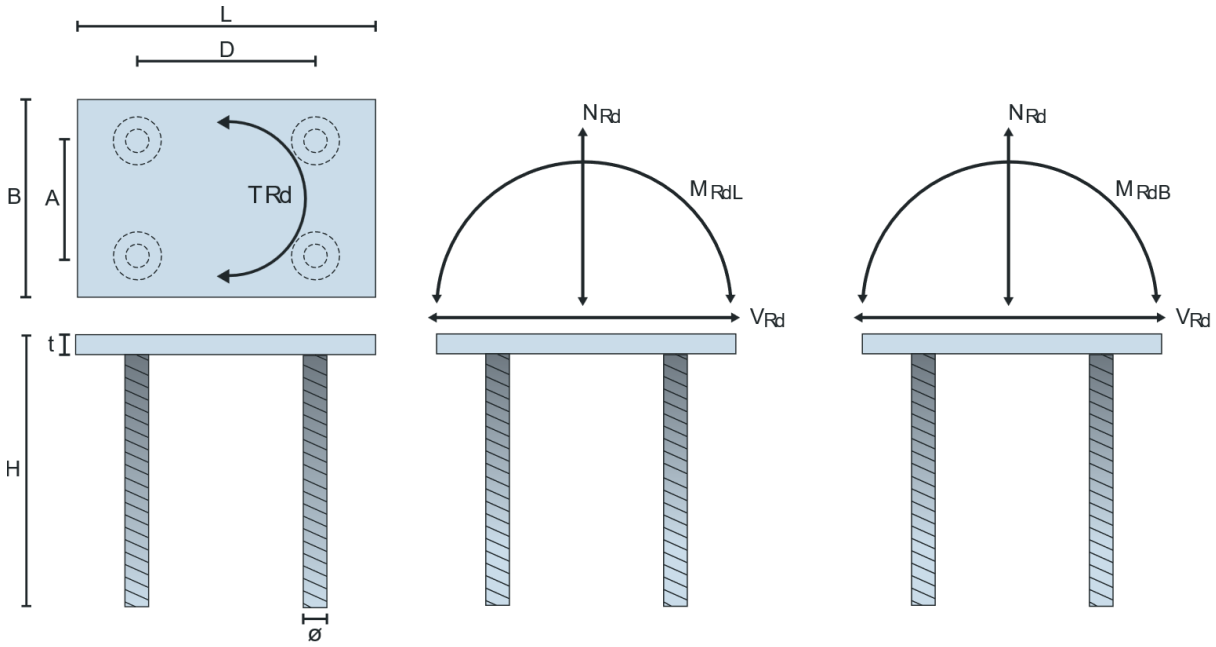

Figure 2. Notation for force directions in KL-fastening plates

Table 3. Resistances of KL-fastening plates for single load effects for cracked C25/30 concrete without additional reinforcement and without considering the effect of edge distances

Fastening plate		H	N_{Rd}	V_{Rd}	M_{RdB}	M_{RdL}	T_{Rd}
KL	B x L	[mm]	[kN]	[kN]	[kNm]	[kNm]	[kNm]
KL	**50 x 100**	218	15.3	17.6	0.7	1.4	0.7
KL	**100 x 100**	218	39.6	35.1	2.8	2.8	2.1
KL	**100 x 150**	220	45.2	35.1	3.0	4.6	2.7
KL	**150 x 150**	222	73.4	71.3	6.7	6.7	5.8
KL	**100 x 200**	222	58.9	62.4	3.7	7.7	6.1
KL	**200 x 200**	312	158.2	119.5	16.7	16.7	12.3
KL	**250 x 250**	315	195.8	124.9	24.9	24.9	15.4
KL	**100 x 300**	315	110.3	97.5	6.3	19.9	13.8
KL	**200 x 300**	315	170.3	119.5	17.6	26.8	15.8
KL	**300 x 300**	315	207.9	128.6	31.1	31.1	18.6

The values in table 3 are maximum resistances of KL-fastening plates for individual load effects without additional reinforcement. The fastening plates are placed according to table 4. The values are calculated for “good“ bond conditions. In “poor“ bond conditions values in table 3 need to be multiplied by factor 0.7.

4.3. Fastening area

When using resistances given in table 3, the fastening areas of the steel components to be attached on the KL-fastening plates shall have minimum values according to table 4. If the steel component is welded all around, the welds can be taken as part of the fastening area. If needed, stiffeners can be used in the connection between the fastening plate and the steel component to achieve the required fastening area.

Table 4. Minimum fastening areas of KL-fastening plates

Fastening plate		Minimum fastening area					
		KL			KLR, KLH		
KL	B x L	[mm]	X	[mm]	[mm]	X	[mm]
KL	50 x 100	15	X	60	15	X	70
KL	100 x 100	60	X	60	70	X	70
KL	100 x 150	40	X	80	55	X	90
KL	150 x 150	70	X	70	85	X	85
KL	100 x 200	40	X	105	55	X	120
KL	200 x 200	110	X	110	120	X	120
KL	250 x 250	120	X	120	140	X	140
KL	100 x 300	30	X	170	50	X	180
KL	200 x 300	75	X	155	100	X	170
KL	300 x 300	140	X	140	165	X	165

If the fastening area of the component to be mounted on the fastening plate is smaller than value given in table 5, the resistances of KL-fastening plate need to be reduced according to formula 1.

$$N_{Rd,red} = N_{Rd} \times \frac{(c - a_0)}{(c - a_1)}, a_0 > a_1 \quad (1)$$

where

$N_{Rd,red}$ = reduced resistance to normal force

N_{Rd} = given normal force resistance for the minimum fastening area

c = distance between anchor centers

a_0 = side length of the minimum fastening surface (value according to table 3)

a_1 = side length of the fastening surface

The same formula for the reduction of capacity can be used for moment capacity also. For shear force and torsional moment, it is not necessary to reduce the resistances due to fastening area.

4.4. Minimum edge and center distances for resistances according to 4.2

When using resistance values given in table 3, the center and edge distances of KL-fastening plates need to equal to at least the values given in table 6. The values given in table 6 are such that the edge of the concrete will not break. With smaller edge or center distances, the resistances of KL-fastening plates shall be reduced according to section 5.4.

The edge distances in table 5 are distances between the center of an anchor in KL-fastening plate to the edge of the concrete structure, according to Figure 3. Similarly, the center distances are distances between the centers of adjacent anchors in KL-fastening plates.

The center distance K_t has the minimum value of 2 x the edge distance if the full resistances according to table 3 are used. With smaller center distances, the resistance of the fastening plates shall be reduced according to section 5.4 as with single fastening plates. The center distance reducing factor is calculated using half of the center distance as the value of edge distances.

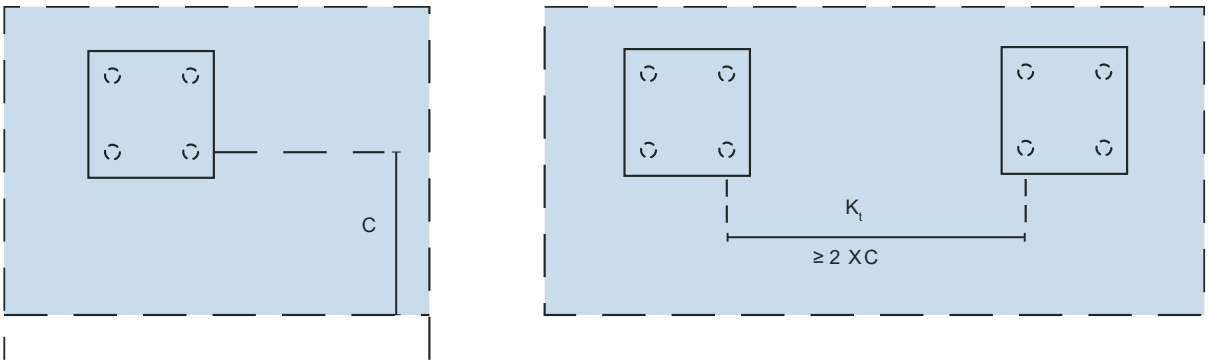

Figure 3. The edge distance and the center distance between adjacent fastening plates

Table 5. Minimum edge distances of KL-fastening plates for resistances according to section 4.2.

Fastening plate		Minimum edge distance for resistances N_{Rd}, M_{RdL} and M_{RdB} in Table 2	Minimum edge distance for resistances V_{Rd} and T_{Rd} in Table 2
KL	**B x L**	c_N [mm]	c_V [mm]
KL	**50 x 100**	42	102
KL	**100 x 100**	42	102
KL	**100 x 150**	42	102
KL	**150 x 150**	56	136
KL	**100 x 200**	56	136
KL	**200 x 200**	70	170
KL	**250 x 250**	70	170
KL	**100 x 300**	70	170
KL	**200 x 300**	70	170
KL	**300 x 300**	70	170

4.5. Minimum thickness of the concrete base

Thickness of the concrete base of KL-fastening plates is decided by the concrete cover demand of the concrete structure exposure class. Thickness of the concrete base must be height of the KL-fastening plate + concrete cover + concrete cover tolerance. The concrete base must be designed to withstand the loading coming from the KL-fastening plate.

4.6. Resistances of fastening plates for combinations of load effects

If multiple load effects act simultaneously on KL-fastening plate the resistance of the fastening plate shall be checked according to the following formula.

$$\left(\frac{N_{Ed}}{N_{Rd}}+\frac{M_{EdB}}{N_{RdB}}+\frac{M_{EdL}}{N_{RdL}}\right)^{\frac{4}{3}}+\left(\frac{V_{EdB}}{V_{Rd}}+\frac{V_{EdL}}{V_{Rd}}+\frac{T_{Ed}}{T_{Rd}}\right)^{\frac{4}{3}} \leq 1.0 \qquad (2)$$

Where subscript E_d means the ultimate limit state value for the dimensioning value of the load effect and Rd the corresponding resistance of the fastening plate.

4.7. Effects of edge and center distances to resistances

If the center or edge distances are smaller than the values given in table 6, the resistance values of the fastening plates according to section 4.2 need to be reduced. With smaller edge distances, the dimensioning values of shear and torsional moment resistances need to be reduced such that when the edge distance is 1.5 x anchor diameter, the resistance is 0 kN / kNm. Intermediate values can be interpolated linearly.

4.8. Effect of additional reinforcement on edge distances

In positioning a KL-fastening plate with additional reinforcement edge distances according to table 5 and reduction factors according to section 5.4 must be used.

4.9. Effect of additional reinforcement on resistances

Additional reinforcement does not increase resistances of KL-fastening plates. In location of a KL-fastening plate additional reinforcement must always be installed to guarantee ductile action of the structure in ultimate limit state. Amount of reinforcement needed to make the structure ductile can be calculated according to the formula:

$$A_s = \frac{F_k}{f_{uk}} \tag{3}$$

where

F_k = characteristic value of the corresponding dimensioning load effect

f_{uk} = characteristic strength of additional reinforcement

Additional reinforcement is installed in direction of the corresponding force and as close as possible to the anchors and steel plate of KL-fastening plate. The additional reinforcement is anchored according to SFS-EN 1992.

5. INSTALLATION

5.1. Attachment to formwork

KL-fastening plates are installed to the planned positions before or during casting of concrete. The precise position of the anchor plate is indicated on the design drawings. Anchor plates can be fixed on the formwork or on the reinforcement by nails, glue, double-sided tape, or clamps. If steel mould is used fixing using magnets is possible. Upon request, KL-fastening plates can also be supplied with nail holes for easy fixing. If the anchor plates are fixed to formwork special attention should be paid to achieve the required post-concreting tolerances.

In casting, the dropping height of the concrete should be kept as small as possible. This ensures that the mass stays even and the anchor plate is not exposed to great impelling forces.

The concrete under the base plate, should be properly compacted. If a vibrator is used for compacting, contact between the anchor plate and the vibrator is to be avoided. Especially bigger horizontal anchor plates are to be provided with air holes to enable adequate compacting under the plate area.

5.2. Supervision of installation

Following controls should be done by the user.

Check list before casting:

- KL-fastening plate is in good condition
- KL-fastening plate is according to designs and in the right place
- KL-fastening plate is attached firmly

During the casting:

- KL-fastening plate stays in the right place
- Concrete is thoroughly vibrated around the KL-fastening plate

After the casting:

- The situation of the KL-fastening plate is according to designs.

6. DESIGN EXAMPLE

Resistance of a KL-fastening plate is checked for positioning and loadings according to figure 4. No separate additional reinforcement is used. The structure only has minimum reinforcement.

The dimensions of the component fixed to the KL-fastening plate are 140 mm x 140 mm. Distance of the component fixed to the edge of the concrete structure is 100 mm. On other sides the distance from the fixed component to the edges of the concrete structure is 1m. Thickness of the concrete structure is 450 mm. The fixed component subjects following loads to the fastening plate in two different load cases.

Load case 1: N_{Ed} = 44 kN, V_{Ed} = 18 kN, M_{Ed} = 0 kNm

Load case 2: N_{Ed} = 30 kN, V_{Ed} = 10 kN, M_{Ed} = 5 kNm

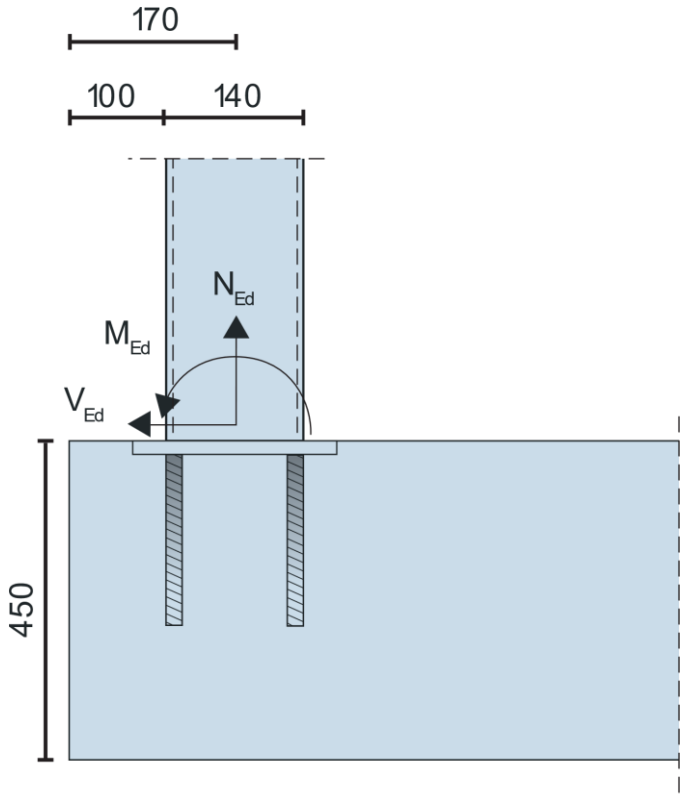

Figure 4. Design example of a KL-fastening plate without additional reinforcement, dimensions of the fastening plate

KL 200x200 fastening plate is chosen and its resistance is checked for load effects. Resistances of KL 200x200 fastening plate without reductions according to table 3 are Tensile force resistance N_{Rd} = 125,6 kN, bending moment resistance M_{Rd} = 13,7 kNm and shear force resistance V_{Rd} = 119,5 kN. Next the edge distances of the fastening plate, fastening area of the fixed component, thickness of the

concrete structure are checked along with possible reductions given for the fastening plate resistances. The resistance of the fastening plate against combinations of load effects is checked.

Effect of edge distances to resistances

The distance c of the fastening plate anchor to the edge of the concrete structure is given with dimensions in table 1.

$$C = \frac{200\text{mm} - 120\text{mm}}{2} + 170\text{mm} - \frac{200\text{mm}}{2} = 110\text{mm}$$

The minimum edge distances of KL 200x200 fastening plate for resistances according to table 3 are given in table 5. The minimum edge distances for normal force and bending moment resistances are fulfilled with dimensions according to figure 4. For shear force the edge distance given in figure 4 is smaller than the minimum value and the shear resistance needs to be reduced from the value given in table 3.

Reduction of shear force resistance is done according to section 5.4. The edge distance with resistance 0 kN is 1.5 x ø = 1.5 x 20 mm = 30 mm. The shear force resistance for situation in figure 4 is calculated with linear interpolation.

$$V_{Rd,red} = \frac{119.5\text{kN} - 0\text{kN}}{170\text{mm} - 30\text{mm}}(110\text{mm} - 30\text{mm}) = 68.2\text{kN}$$

Effect of the dimensions of the fixed component to the resistances

In table 4 of section 4.3, the minimum fastening surfaces of steel components fixed on KL-fastening plates are given. For KL 200x200 fastening plates the minimum fastening surface is 91 mm x 91 mm. This minimum value is exceeded by the exterior dimensions of the fixed component 140x140 mm given in figure 4. Resistances do not need to be reduced or the size of the fixed part increased due to minimum fastening surface.

Effect of concrete structure thickness on the resistances

The effect of thickness of the concrete structure is checked according to section 5.2. With thickness of the concrete structure according to figure 4 and KL 200x200 fastening plate the concrete cover is 450 mm - 312 mm = 138 mm. This value fulfills the requirements of SFS-EN 1992.

Resistance of KL-fastening plate for combinations of load effects

The resistance of KL-fastening plate for combinations of load effect combinations are calculated according to section 5.3 using formula (2).

Load case 1:

$$\left(\frac{44\text{kN}}{125.6\text{kN}}\right)^{\frac{3}{4}} + \left(\frac{44\text{kN}}{125.6\text{kN}}\right)^{\frac{3}{4}} = 0.82$$

Load case 2:

$$\left(\frac{30\text{kN}}{125.6\text{kN}} + \frac{5\text{kNm}}{13.7\text{kNm}}\right)^{\frac{3}{4}} + \left(\frac{10\text{kN}}{68.2\text{kN}}\right)^{\frac{3}{4}} = 0.92$$

KL 200x200 fastening plate with dimensions according to figure 4 has enough resistance for the loadings given in both load cases.

NOTES

TECHNICAL MANUAL REVISIONS

20.07.2022 (AV/FA/JK)

- New format