RSTEEL®

JKL Fastening Plates

Design According to Eurocodes

Technical Manual

Technical changes and errors reserved

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THE STRONGEST IN FINLAND
2017
R-Group Finland OY
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This manual is written in cooperation between the companies listed below and Betoniteollisuus Ry.

The companies listed are entitled to manufacture the JKL-fastening plates presented in this manual.

By harmonizing JKL-fastening plates, the work of designers, manufacturers, concrete element manufacturers, contractors and officials is made easier owing to the interchangeability of the fastening plates.

The guidelines given are intended to be used by qualified persons with the ability to understand the restrictions of the guidelines and to take responsibility for applying the guidelines in practical construction projects. Although the preparation of this manual has been done by the leading technical experts in the nation, neither Betoniteollisuus Ry or the persons involved in the preparation do not assume liability for guidelines given in this manual.

Manufacturers:

R-Group Finland Oy

Peikko Finland Oy

Anstar Oy

Semko Oy

Publisher: Rakennusteollisuus ry

Betoniteollisuus ry

Table of Content

1. Principle of Operation of the Fastening Plates

JKL fastening plates are steel plates equipped with resistance welded stud head anchors. The fastening plates are cast into concrete. JKL 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.

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

The resistances of JKL fastening plates are calculated for static loads.

Minimum reinforcement according to SFS-EN 1992-1-1 is always to be used in the location of the fastening plates to guarantee ductility of the structure in ultimate limit state. If in this manual the resistance is given without additional reinforcement, the minimum reinforcement is not contributing to the resistance given. When in this manual the resistance is presented with additional reinforcement, in addition to the minimum reinforcement, the structure has additional reinforcement according to section 4.9.

2. Dimensions and Materials

2.1 Materials of the fastening plates and corresponding standards

Type	Component	Material	Standard
JKL	Steel plate	S355J2+N + Z15	SFS-EN 10025 + SFS-EN 10164
	Anchor	B500B	SFS 1300
JKLR	Steel plate	1.4301 + Z15	SFS-EN 10088 + SFS-EN 10164
	Anchor	B500B	SFS 1300
JKLH	Steel plate	1.4401 + Z15	SFS-EN 10088 + SFS-EN 10164
	Anchor	B500B	SFS 1300

Entirely stainless fastening plates are special cases and not considered in this manual. Entirely stainless fastening plates are to be designed separately with respect to manufacturer.

2.2 Dimensions of the fastening plates

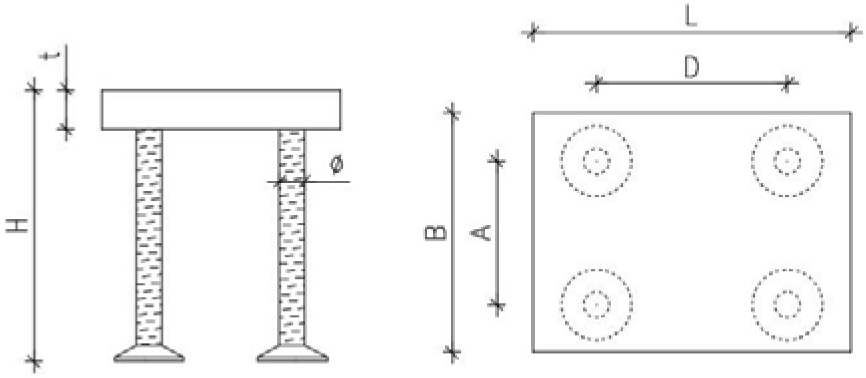

Figure 1. Dimension markings of JKL fastening plates

Table 1. Dimensions of JKL fastening plates

JKL fastening plate				H	A	D	t	Ø
JKL	L	x	B	[mm]	[mm]	[mm]	[mm]	[mm]
JKL	150	x	150	220	90	90	25	16
JKL	150	x	200	220	90	120	25	20
JKL	150	x	250	220	90	190	25	20
JKL	200	x	200	220	120	120	25	20
JKL	200	x	250	220	120	190	25	20
JKL	250	x	250	220	190	190	25	20
JKL	300	x	200	280	200	120	25	25
JKL	300	x	300	280	200	200	25	25
JKL	400	x	400	280 / 285	300	300	30	25
JKL	500	x	500	280 / 285	400	400	30	25
JKL	600	x	600	280 / 285	500	500	30	25
JKL	500	x	300	280 / 285	200	140	30	25

Stud head dimensions according to the manufacturer of the fastening plate. As an alternative to resistance welding the plate can also be arc stud welded. JKL 500 x 300 fastening plate has 6 stud anchors.

3. Manufacturing and Tolerance

3.1 Manufacturing method and execution class

Steel plates:	Thermal or mechanical cutting
Steel bars:	Mechanical cutting, heading (cold/hot)
Welding:	MAG welding, manual or robotic, resistance welding or arc stud welding
Welding class:	C (SFS-EN ISO 5817), EXC2 (SFS-EN 1090-2 section 7.6)
Execution class:	EXC2 (SFS-EN 1090-2) [more demanding classes according to a separate guideline]

3.2 Manufacturing tolerances

Plate side lengths:	± 4 mm 150 mm < L ≤ 600 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:	± 5 mm
Anchor location:	± 5 mm
Anchor spacing:	± 5 mm
Anchor inclination:	± 5°

3.3 Surface treatment

Protective painting shall be applied to the visible surfaces of the fastening plates. The fastening plates are delivered with an approximately 40 µm shop priming. Upon request the fastening plates are delivered with a 60 µm epoxy painting or hot dip galvanized according to galvanizing standard. Stainless and acid-proof fastening plates are delivered without protective painting.

3.4 Quality control

Demands of product standards are to be applied in quality control. The manufacturer of the fastening plates has a valid quality control agreement for the quality control of steel part manufacturing.

4. Resistances

4.1 Basis of structural design

The resistances of JKL fastening plates have been calculated according to the following norms, rules and regulations:

SFS-EN 1992 Eurocode 2 Design of concrete structures
SFS-EN 1993 Eurocode 3 Design of steel structures
CEN/TS 1992-4 Design of fastenings for use in concrete

The resistances have been calculated with respect to static loads. For dynamic and fatigue loads the resistances need to be separately checked on a case-by-case basis.

4.2 Resistances without effects of additional reinforcement and edge distance

Tables 2 and 3 present the resistances of JKL fastening plates when only one loading acts at a time. The resistance of JKL fastening plates with respect to combinations of load effects shall be checked according to 4.6.

The resistances given in tables 2 and 3 have been calculated using the following assumptions:

- Concrete strength C25/30 (table 2) or C40/50 (table 3)
- Cracking can occur in the location of the fastening plate.
- No additional reinforcement at the location of the fastening plate. Structure only reinforced with minimum reinforcement. The resistances of fastening plate with additional reinforcement is presented in section 4.9.
- 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 4.4). If the edge distance is smaller than what given in 4.4, the resistances need to be reduced according to section 4.7 or additional reinforcement according to section 4.9 needs to be used at the location of the fastening plate.
- The thickness of the member on which the fastening plate is mounted is according to section 4.5 table 5 column h_{min}. With smaller thicknesses, the resistances need to be reduced according to section 4.5.
- The tolerance for the location of a load is max. ± 20 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 4.6.
- 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 4.6.
- 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 4.6.

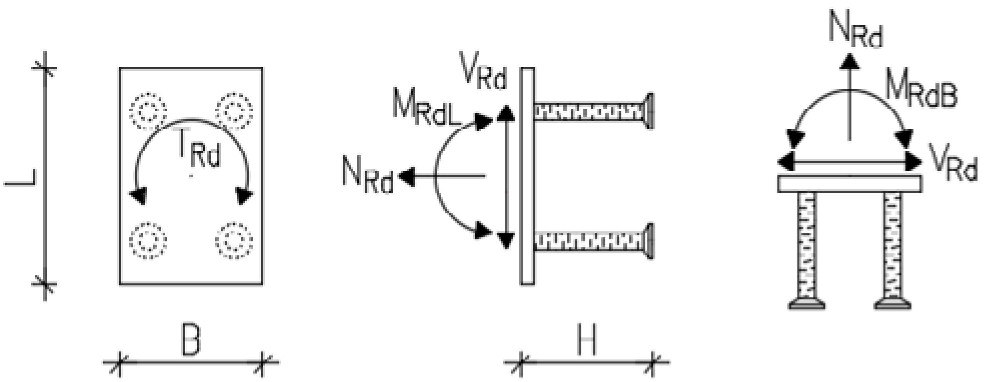

Figure 2. Notation for force directions in JKL fastening plates

Table 2. Resistances of JKL fastening plates for single load effects for cracked C25/30 concrete without additional reinforcement and without considering the effect of edge distances.

JKL fastening plate				N_{Rd}	V_{Rd}	M_{RdL}	M_{RdB}	T_{Rd}
JKL	L	x	B	[kN]	[kN]	[kNm]	[kNm]	[kNm]
JKL	150	x	150	113	142	11,1	11,1	10,6
JKL	150	x	200	117	223	11,7	15,1	16,8
JKL	150	x	250	128	233	12,8	21,1	26,1
JKL	200	x	200	122	234	15,7	15,7	19,8
JKL	200	x	250	133	238	17,3	22,0	29,0
JKL	250	x	250	145	249	24,0	24,0	36,2
JKL	300	x	200	182	364	35,2	23,8	41,2
JKL	300	x	300	198	391	38,6	38,6	54,5
JKL	400	x	400	238	404	59,9	59,9	90,1
JKL	500	x	500	283	411	84,3	84,3	120,7
JKL	600	x	600	331	415	111,9	111,9	151,2
JKL	500	x	300	213	426	60,7	43,5	61,2

Table 3. Resistances of JKL fastening plates for single load effects for cracked C40/50 concrete without additional reinforcement and without the effect of edge distances.

JKL fastening plate				N_{Rd}	V_{Rd}	M_{RdL}	M_{RdB}	T_{Rd}
JKL	L	x	B	[kN]	[kN]	[kNm]	[kNm]	[kNm]
JKL	150	x	150	146	142	14,5	14,5	10,6
JKL	150	x	200	151	223	15,2	19,7	19,8
JKL	150	x	250	165	233	16,7	27,4	28,1
JKL	200	x	200	158	234	20,5	20,5	22,5
JKL	200	x	250	172	238	22,4	28,5	30,1
JKL	250	x	250	188	249	31,1	31,1	36,2
JKL	300	x	200	235	374	45,7	31,1	48,9
JKL	300	x	300	255	391	50,0	50,0	59,6
JKL	400	x	400	308	404	77,6	77,6	90,1
JKL	500	x	500	365	411	109,1	109,1	120,7
JKL	600	x	600	427	415	144,6	144,6	151,2
JKL	500	x	300	275	550	78,6	56,2	79,0

The values in tables 2 and 3 are maximum resistances of JKL fastening plates for individual load effects. The maximum resistances given are values for concrete structures with minimum reinforcement and fastening plate locations according to tables 5 and 6 without additional reinforcement.

NOTE! In normal situations, the maximum resistances in tables 2 and 3 are reduced according to section 4.7. Section 7 contains a design example.

4.3 Fastening area

When using resistances given in tables 2 and 3 the fastening areas of the steel components to be attached on the JKL 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 JKL fastening plates

JKL fastening plate				Minimum fastening plate					
				JKL			JKLR, JKLH		
JKL	L	x	B	[mm]	x	[mm]	[mm]	x	[mm]
JKL	150	x	150	50	x	50	70	x	70
JKL	150	x	200	55	x	75	70	x	100
JKL	150	x	250	60	x	120	75	x	150
JKL	200	x	200	75	x	75	100	x	100
JKL	200	x	250	85	x	125	105	x	150
JKL	250	x	250	130	x	130	155	x	155
JKL	300	x	200	155	x	90	180	x	105
JKL	300	x	300	165	x	165	190	x	190
JKL	400	x	400	220	x	220	260	x	260
JKL	500	x	500	305	x	305	350	x	350
JKL	600	x	600	390	x	390	440	x	440
JKL	500	x	300	220	x	130	270	x	165

If the fastening area of the component to be mounted on the fastening plate is smaller than value given in table 4, the resistances of JKL fastening plate need to be reduced according to formula 1.

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

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.

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

When using resistance values given in tables 2 and 3, the center and edge distances of JKL fastening plates need to equal to at least the values given in table 5. The values given in table 5 are such that the edge of the concrete will not break. With smaller edge or center distances the resistances of JKL fastening plates shall be reduced according to section 4.7.

The edge distances in table 5 are distances between the center of an anchor in JKL 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 JKL fastening plates.

The center distance k_t has the minimum value of 2 x the edge distance, if the full resistances according to tables 2 and 3 are used. With smaller center distances, the resistance of the fastening plates shall be reduced according to section 4.7 as with single fastening plates. The center distance reducing factor is calculated using half of the center distance as the value of edge distances.

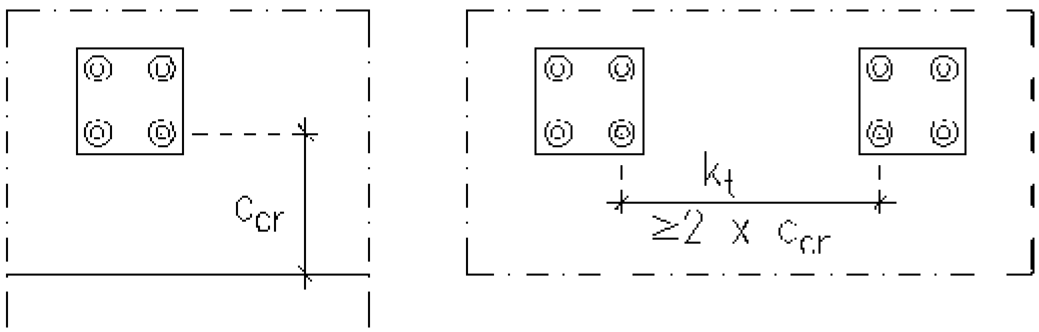

Figure 3. The edge distance c_{cr} of JKL fastening plate from the center of the anchor to the edge of the concrete structure and the center distance between adjacent fastening plates.

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

JKL 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
JKL	L	x	B	$c_{cr.N}$ [mm]	$c_{cr.V}$ [mm]
JKL	150	x	150	325	960
JKL	150	x	200	325	1200
JKL	150	x	250	325	1200
JKL	200	x	200	325	1200
JKL	200	x	250	325	1200
JKL	250	x	250	325	1200
JKL	300	x	200	415	1500
JKL	300	x	300	415	1500
JKL	400	x	400	415	1500
JKL	500	x	500	415	1500
JKL	600	x	600	415	1500
JKL	500	x	300	415	1500

4.5 Minimum thickness of the concrete base and the effect of base thickness to resistances

When using the resistances given in tables 2 and 3 the thickness of the concrete base must have the minimum value given in table 6. With smaller thicknesses of the base, the resistances of JKL fastening plates need to be reduced. The manufacturing tolerances of the JKL fastening plates have been considered in the minimum concrete structure thickness values given in table 6.

Table 6. Minimum thicknesses for the concrete base structure for JKL fastening plates

JKL fastening plate				Minimum thickness h_{min} of the base (concrete structure) for resistances according to table 2.	Minimum thickness $h_{min.cb}$ of the base (concrete structure) when concrete cover c_b = 20 mm
JKL	L	x	B	[mm]	[mm]
JKL	150	x	150	450	245
JKL	150	x	200	450	245
JKL	150	x	250	450	245
JKL	200	x	200	450	245
JKL	200	x	250	450	245
JKL	250	x	250	450	245
JKL	300	x	200	570	305
JKL	300	x	300	570	305
JKL	400	x	400	580	310
JKL	500	x	500	580	310
JKL	600	x	600	580	310
JKL	500	x	300	580	310

The effect of base thickness h_c to JKL fastening plate resistance can be taken into account by using reduction factor $k_{h.red}$. Given in the following formula. Base thicknesses smaller than minimum value $h_{min.cb}$ given in table 6 may not be used with the fastening plates.

$$k_{h.red} = \left(\frac{h_c}{h_{min}}\right)^{\frac{2}{3}} \leq 1.0 \qquad (2)$$

where

h_c = thickness of the concrete structure (minimum value of the concrete structure is $h_{min.cb}$ given in table 6).
h_{min} = Value of h_{min} according to table 6.

4.6 Resistances of fastening plates for combinations of load effects

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

$$\left(\frac{N_{Ed}}{N_{Rd}} + 1.8\left(\frac{M_{EdB}}{M_{RdB}} + \frac{M_{EdL}}{M_{RdL}}\right)\right)^{\frac{2}{3}} + \left(\frac{V_{EdB}}{V_{Rd}} + \frac{V_{EdL}}{V_{Rd}} + \frac{T_{Ed}}{T_{Rd}}\right)^{\frac{2}{3}} \leq 1.0 \qquad (3)$$

Where subscript Ed 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 5, the resistance values of the fastening plates according to section 4.2 need to be reduced. In table 7 reduction factors are given for cases where the fastening plate edge or center distances in one, two or three sides are the minimum values given in table 8. Linear interpolation can be used for the intermediate values between resistances given in tables 2 and 3 and the ones calculated with the reduction factors in table 7.

Table 7. Fastening plate resistance reduction factor when edge distance c = $c_{cr.X.min}$

Load effect	Reduction factor when edge distance is $c_{cr.X.min}$		
	on single side (fastening plate in the edge of the structure)	on two sides (fastening plate in corner or in a narrow structure)	on three sides (fastening plate in the edge of a narrow structure)
N_{Rd}	0,23	0,16	0,10
M_{RdB} ja M_{RdL}	0,23	0,16	0,10
V_{Rd} ja T_{Rd}	0,10	0,08	0,07

In addition to the reduction factor given in table 7, the effect of the base thickness on the resistance of the fastening plates needs to be taken into account according to section 4.5.

Minimum values of edge distances are given in table 8. The edge distances cannot be smaller than these values. With edge distances smaller than ones given in table 8 additional reinforcement needs to be used according to sections 4.8 and 4.9.

Table 8. Minimum edge distances of JKL fastening plates for reduction factors according to table 7.

JKL fastening plate				Minimum edge distances for reduction factors N_{Rd}, M_{RdL} and M_{RdB} according to table 7	Minimum edge distances for reduction factors V_{Rd} and T_{Rd} according to table 7
JKL	L	x	B	$c_{cr.N.min}$ [mm]	$c_{cr.V.min}$ [mm]
JKL	150	x	150	50	150
JKL	150	x	200	60	150
JKL	150	x	250	60	190
JKL	200	x	200	60	150
JKL	200	x	250	60	190
JKL	250	x	250	60	190
JKL	300	x	200	75	200
JKL	300	x	300	75	200
JKL	400	x	400	75	300
JKL	500	x	500	75	400
JKL	600	x	600	75	500
JKL	500	x	300	75	200

4.8 Effect of additional reinforcement on edge distances

Positioning a JKL fastening plate with additional reinforcement shall be made according to the minimum values of the edge distances given in column $c_{cr.N.min}$ of table 8.

The effect of additional reinforcement on the resistances of JKL fastening plates are given in section 4.9. Principles of additional reinforcement placement are presented in figures 4 and 5.

4.9 Effect of additional reinforcement on resistances

Additional reinforcement can be used to increase the resistances of JKL fastening plates when the edge distances are smaller than ones given in table 5. In tables 9…11 tensile and shear resistances of additional reinforcement placed as in figures 4 and 5 are given. Tables 9…11 give resistance of a single additional reinforcement link. The total resistance of a JKL fastening plate with additional reinforcement can be calculated by multiplying the resistance of a single additional reinforcement with the number of additional reinforcement links. The additional tensile force due to eccentricity needs to be taken into account according to section 4.9.2 when placing additional reinforcement for shear resistance.

The maximum resistances for JKL fastening plate with additional reinforcement are presented in section 4.10.

Reinforcing steel B500B or equivalent reinforcing steel has been used for additional reinforcement in the calculations.

4.9.1 Additional reinforcement for tensile force and bending moment resistance

Additional reinforcement for tensile resistance and bending moments must be placed in the concrete structure in location of the JKL fastening plate as presented in figure 4. The additional reinforcement is to be added as close as possible to the steel plate and anchors of the JKL fastening plate. In lateral direction, the additional reinforcement can be located a maximum distance of 0,5H from center of an anchor in JKL fastening plate as presented in figure 4. The additional reinforcement must be anchored to full tensile capacity outside of the failure cone of the JKL fastening plate as presented in figure 4.

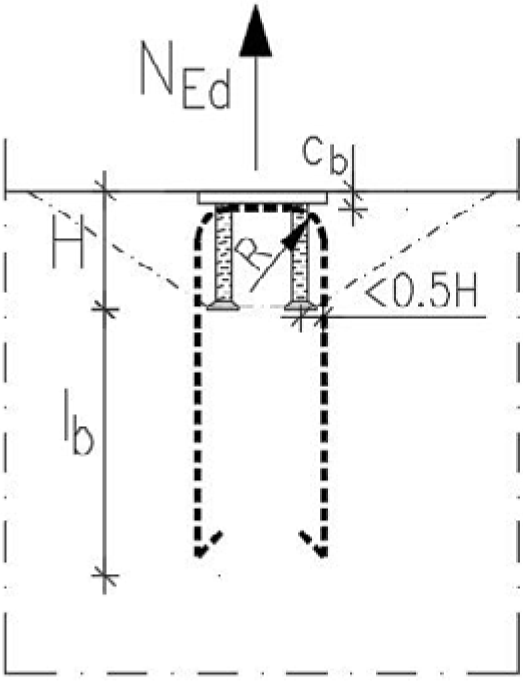

Figure 4. Additional reinforcement of JKL fastening plate for tensile force and bending moment resistance.

c_b = concrete cover (Asm. 20mm) l_b = anchorage length according to SFS-EN 1992-1-1
R = interior bend radius of additional reinforcement according to SFS-EN 1992-1-1

Tables 9 and 10 give the anchorage capacities of additional reinforcement of JKL fastening plates in the failure cone of a fastening plate with additional reinforcement positioned as in figure 4. Values in tables 9 and 10 are calculated in good bond conditions. Resistance of a JKL fastening plate with additional reinforcement is calculated by multiplying the value for single additional reinforcement link given in tables 9 or 10 with the number of additional reinforcement links at the location of the fastening plate.

Table 9. Tensile resistances of additional reinforcements of JKL fastening plates (tensile resistance value for singe link placed according to figure 4) in concrete C25/30

JKL fastening plate				Tensile resistance of additional reinforcement $N_{Rd.s}$ [kN]			
				Bar diameter Φs [mm]			
JKL	L	x	B	T6	T8	T10	T12
JKL	150	x	150	23,6	31,5	39,3	47,2
JKL	150	x	200	23,6	31,5	39,3	47,2
JKL	150	x	250	23,6	31,5	39,3	47,2
JKL	200	x	200	23,6	31,5	39,3	47,2
JKL	200	x	250	23,6	31,5	39,3	47,2
JKL	150	x	200	23,6	31,5	39,3	47,2
JKL	300	x	200	24,6	41,1	51,4	61,7
JKL	300	x	300	24,6	41,1	51,4	61,7
JKL	400	x	400	24,6	41,1	51,4	61,7
JKL	500	x	500	24,6	41,1	51,4	61,7
JKL	600	x	600	24,6	41,1	51,4	61,7
JKL	500	x	300	24,6	41,1	51,4	61,7

Table 10. Tensile resistances of additional reinforcements of JKL fastening plates (tensile resistance value for singe link placed according to figure 4) in concrete C40/50

JKL fastening plate				Tensile resistance of additional reinforcement $N_{Rd.s}$ [kN]			
				Bar diameter Φs [mm]			
JKL	L	x	B	T6	T8	T10	T12
JKL	150	x	150	24,6	43,1	53,8	64,6
JKL	150	x	200	24,6	43,1	53,8	64,6
JKL	150	x	250	24,6	43,1	53,8	64,6
JKL	200	x	200	24,6	43,1	53,8	64,6
JKL	200	x	250	24,6	43,1	53,8	64,6
JKL	250	x	250	24,6	43,1	53,8	64,6
JKL	300	x	200	24,6	43,7	68,3	84,4
JKL	300	x	300	24,6	43,7	68,3	84,4
JKL	400	x	400	24,6	43,7	68,3	84,4
JKL	500	x	500	24,6	43,7	68,3	84,4
JKL	600	x	600	24,6	43,7	68,3	84,4
JKL	500	x	300	24,6	43,7	68,3	84,4

If concrete cover for additional reinforcement is larger than 20mm used in calculations, the anchorage capacity of additional reinforcement in failure cone needs to be separately calculated on a case-by-case basis.

Under poor bond conditions the resistance values given in tables 9 and 10 need to be multiplied by factor 0,7.

4.9.2 Additional reinforcement for shear force and torsional moment

Additional reinforcement for shear force and torsional moment must be place into concrete in the location of the JKL fastening plate according to figure 5. Additional reinforcement for shear force is placed perpendicular against the shear force and as close as possible to the steel plate of the JKL fastening plate in the vertical direction. Additional reinforcement is bent in a such way that the additional reinforcement steels are contacting the anchors of the JKL fastening plate. Additional reinforcement must be anchored in the concrete structure for full tensile capacity of the steel outside of the failure cone of the JKL fastening plate according to section A-A in figure 5. The resistance values in table 11 are calculated for good bond conditions.

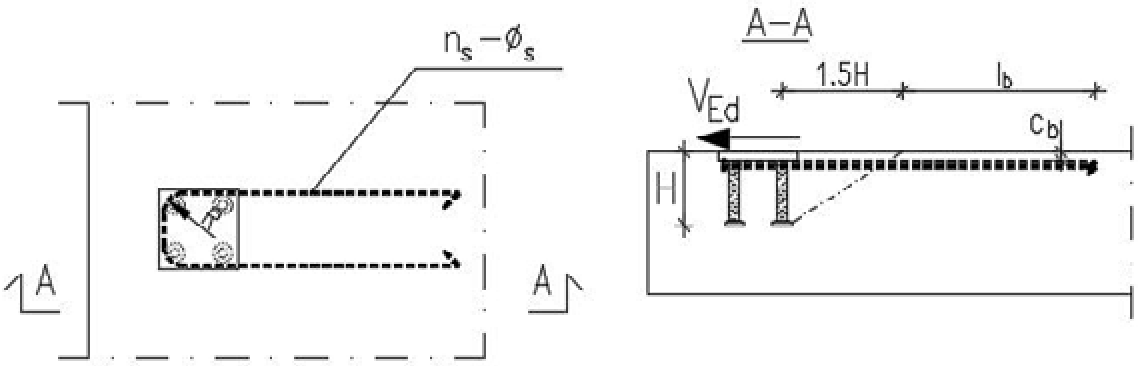

Figure 5. Additional reinforcement of JKL fastening plate for shear force and torsional moment

c_b = concrete cover (Asm. 20mm) l_b = anchorage length according to SFS-EN 1992-1-1
R = interior bend radius of additional reinforcement according to SFS-EN 1992-1-1

Table 11. Shear resistances of JKL fastening plates with additional reinforcement (Shear resistance of single additional reinforcement link positioned according to figure 5)

JKL fastening plate				Shear resistances of JKL fastening plates with additional reinforcement $V_{Rd.s}$ [kN]			
				bar diameter Φs [mm]			
JKL	L	x	B	T6	T8	T10	T12
JKL	150	x	150	9,1	12,2	15,2	18,3
JKL	150	x	200	9,1	12,2	15,2	18,3
JKL	150	x	250	9,1	12,2	15,2	18,3
JKL	200	x	200	12,2	16,2	20,3	24,4
JKL	200	x	250	12,2	16,2	20,3	24,4
JKL	250	x	250	12,3	21,9	32,2	38,6
JKL	300	x	200	12,2	16,2	20,3	24,4
JKL	300	x	300	12,3	21,9	33,8	40,6
JKL	400	x	400	12,3	21,9	34,1	49,2
JKL	500	x	500	12,3	21,9	34,1	49,2
JKL	600	x	600	12,3	21,9	34,1	49,2
JKL	500	x	300	12,3	21,9	34,1	49,2

Under poor bond conditions the resistance values of table 11 shall be multiplied by factor 0,7.

Eccentricity between shear force and reinforcement causes additional tensile force into additional reinforcement. This additional force is accounted for in the following way:

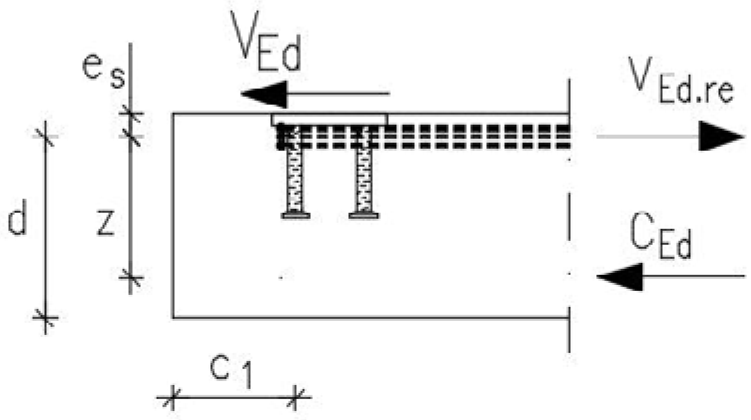

Figure 6. Additional tensile force in additional reinforcement

$$V_{Ed.re} = \left(\frac{e_s}{z} + 1\right) \cdot V_{Ed} \qquad (4)$$

where

e_s = distance between shear force (surface of steel plate) and center of the reinforcement

z = internal moment arm of the concrete structure ≈ 0,85d ($d \leq \min\begin{cases}2H \\ 2c_1\end{cases}$)

Example: JKL300x300 fastening plate with additional reinforcement for shear force. V_{Ed} = 75 kN, e_s = 35 mm, z = 160 mm, additional reinforcement T12 links in good bond conditions.

True tensile force in additional reinforcement when considering eccentricity $N_{Ed.re}$ = (35 mm / 160 mm + 1) x 75 kN = 91,4 kN.

91,4 kN / (2 x 40,6 kN) = 112 % -> 2 pieces T12 links is not enough.

91,4 kN / (3 x 40,6 kN) = 75 % -> 3 pieces T12 links is needed for additional reinforcement

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4.10 Maximum resistances with additional reinforcement

Table 12 gives maximum resistances for JKL fastening plates. True resistance of JKL fastening plates depends on the amount of additional reinforcement used according to sections 4.9.1 and 4.9.2 (compare examples A and B below). Additional reinforcement is placed according to figures 4 and 5. In positioning JKL fastening plate to a structure minimum edge distances given in table 7 column $c_{cr.N.min}$ must be complied with. Effect of the height of the concrete structure to the maximum resistances need to be taken into an account according to 4.5.

Table 12. Maximum resistances for JKL fastening plates

JKL fastening plate				$N_{Rd.max}$	$V_{Rd.max}$	$M_{RdL.max}$	$M_{RdB.max}$	$T_{Rd.max}$
JKL	L	x	B	[kN]	[kN]	[kNm]	[kNm]	[kNm]
JKL	150	x	150	149	142	14,5	14,5	10,6
JKL	150	x	200	249	223	15,2	19,7	19,8
JKL	150	x	250	268	233	16,7	27,4	28,1
JKL	200	x	200	267	234	20,5	20,5	22,5
JKL	200	x	250	269	238	22,4	28,5	30,1
JKL	250	x	250	316	249	31,1	31,1	36,2
JKL	300	x	200	455	374	45,7	31,1	48,9
JKL	300	x	300	501	391	50,0	50,0	59,6
JKL	400	x	400	556	404	77,6	77,6	90,1
JKL	500	x	500	588	411	109,1	109,1	120,7
JKL	600	x	600	609	415	144,6	144,6	151,2
JKL	500	x	300	605	550	78,6	56,2	79,0

Example A:

4 pieces of T10 additional reinforcement links are installed in location of JKL 200x200 fastening plate. The links are positioned according to figure 4 and the bond conditions are good. The total tensile resistance of the links is F_{re} = 4 pcs x 39,3 kN/pc = 157,2 kN. Maximum value of tensile resistance is $N_{Rd.max}$ = 267 kN so the maximum value cannot be used for the fastening plate but resistance value of the additional reinforcement, F_{re} = 157,2 kN, must be used as the resistance value.

Example B:

6 pieces of T12 additional reinforcement links are installed in location of JKL 200x200 fastening plate. The links are positioned according to figure 4 and the bond conditions are good. The total tensile resistance of the links is F_{re} = 6 pcs x 47,2 kN/pc = 283,2. Maximum value of tensile resistance is $N_{Rd.max}$ = 267 kN so for fastening plate with described additional reinforcement the maximum value $N_{Rd.max}$ must be used as the resistance of the fastening plate with additional reinforcement.

5. Use of fastening Plates

5.1 Service life and allowed exposure classes

Service life of JKL fastening plates depends on the chosen fastening plate material. JKL fastening plates may be used in all concrete structure exposure classes when the requirements of the exposure classes for the concrete cover of steel parts of the fastening plate are complied with. If necessary, stainless JKLR or acid-proof JKLH fastening plate types are to be used.

5.2 Limitations for use

Capacities for JKL fastening plates are calculated for static loads. For dynamic or fatigue loads larger partial safety factors for loads must be used and the components of the connection must be checked on a case-by-case basis.

Resistances for JKL fastening plates have been calculated for cracked concrete with strength C25/30 or C40/50.

A reinforcement to guarantee ductile action of the structure in ultimate limit state must always be installed in location of the JKL fastening plates.

6. Storage Transportation and Marking

JKL fastening plates are to be stored protected from the rain.

Marking is made into JKL fastening plates that shows at least the manufacturer, type and identifier and manufacturing date of the fastening plate.

7. Design Example

7.1 Design example 1: JKL fastening plate without additional reinforcement in the upper part of a column

Resistance of a JKL fastening plate is checked for the situation presented in figure 7. No additional reinforcement for the JKL fastening plate is installed and the column has regular column reinforcement.

Column 680 x 680 mm^2, fastening plate JKL300x300, outline of the steel component to be fixed to the plate 160 x 160 mm^2.

Resistance and utilization ratios are calculated for concrete grades C25/30 and C40/50.

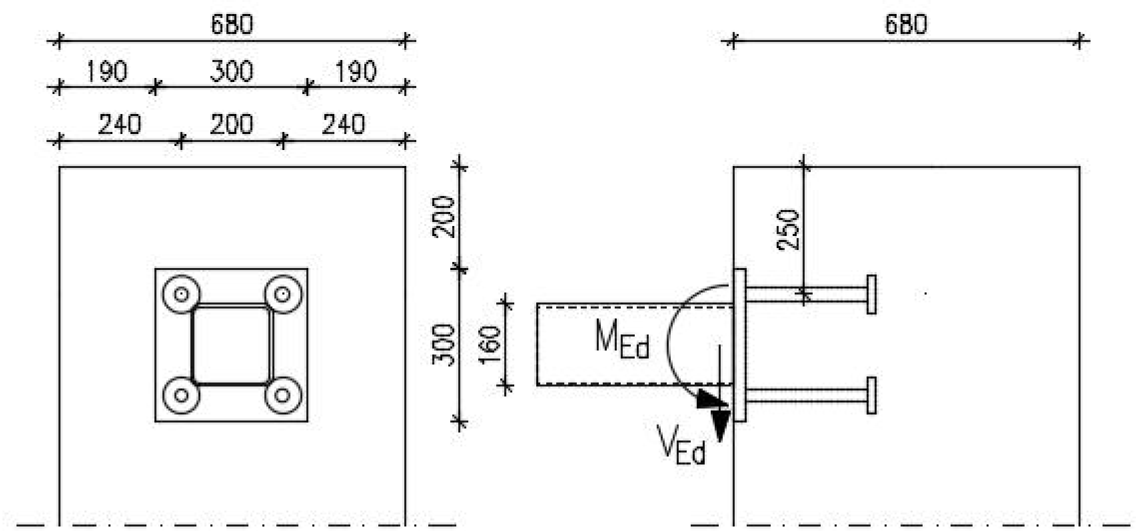

Figure 7. Design example for JKL fastening plate, fastening plate in the upper part of a column.

Load effects applied to the fastening plate: V_{Ed} = 15 kN, M_{Ed} = 4 kNm.

<u>Effect of edge distances to resistances</u>

Smallest edge distance for JKL300x300 fastening plate from center of anchor to edge of the concrete structure is 240mm. According to table 5 the smallest edge distances for which the resistances of the fastening plates do not need to be reduced are for normal force and bending moment $c_{cr.N}$ = 415 mm and for shear force and torsional moment $c_{cr.V}$ = 1500 mm. The actual values are below the minimum values of table 5 so the resistances need to be reduced due to the edge distances.

The reducing factors for JKL fastening plates due to edge distances are calculated according to section 4.7. The minimum edge distances according to table 8 are for normal force and bending moment $c_{cr.N.min}$ = 75 mm and for shear force and torsional moment $c_{cr.V.min}$ = 200 mm. The reduction factors for minimum edge distances are found in table 7. Reduction factors can be linearly interpolated so the reduction factors are calculated as follows:

$$k_{red.M.edge} = 0{,}14 + \frac{1\text{-}0{,}14}{415\text{mm-}75\text{mm}}(240\text{mm-}75\text{mm}) = 0{,}55$$

$$k_{red.V.edge} = 0{,}07 + \frac{1\text{-}0{,}07}{1500\text{mm-}200\text{mm}}(240\text{mm-}200\text{mm}) = 0{,}10$$

Effect of dimensions of the steel part to be fastened to resistances

In table 4 of section 4.3 the minimum fastening areas for which the full resistance of the JKL fastening plate can be utilized are given. Size of the fixed part in the example, 160 x 160 mm^2, is smaller than the minimum fastening surface for JKL300x300 so the moment resistance is reduced according to section 4.3.

$$k_{red.M.Area} = \frac{(200mm - 165mm)}{(200mm - 160mm)} = 0{,}87$$

Effect of concrete structure thickness on the resistances

Section 4.5 table 6 gives minimum thickness of the concrete structure for which the resistances do not need to be reduced. For JKL300x300 fastening plate this value is 570mm. Thickness of the column in the design example fulfills this requirement and the resistances of the fastening plate do not need to be reduced due to thickness of the concrete structure.

Reduced resistances, concrete C25/30

The non-reduced resistances for JKL300x300 fastening plates in concrete C25/30 are: V_{Rd} = 391 kN, M_{Rd} = 38,6 kNm.

The reduced resistances are:

$M_{Rd.red} = k_{red.N.edge} \times k_{red.N.area} \times M_{Rd}$ = 0,55 x 0,87 x 38,6 kNm.= 18,4 kNm.

$V_{Rd.red} = k_{red.V.edge} \times V_{Rd}$ = 0,10 x 391 kN = 39,1 kN.

Resistance for combinations of load effects, concrete C25/30

The resistance of JKL fastening plate for combinations of load effect combinations are calculated according to section 4.6.

$$\left(1.8\left(\frac{4\ kNm}{18{,}4\ kNm}\right)\right)^{\frac{2}{3}} + \left(\frac{20\ kN}{39{,}1\ kN}\right)^{\frac{2}{3}} = 1{,}06$$

JKL300x300 fastening plate does not have enough resistance for the loadings given with position according to figure 7 without additional reinforcement in concrete C25/30.

Reduced resistances, concrete C40/50

The non-reduced resistances for JKL300x300 fastening plates in concrete C40/50 are: V_{Rd} = 391 kN, M_{Rd} = 50,0 kNm.

The reduced resistances are:

$M_{Rd.red} = k_{red.N.edge} \times k_{red.N.area} \times M_{Rd}$ = 0,55 x 0,87 x 50,0 kNm.= 23,9 kNm.

$V_{Rd.red} = k_{red.V.edge} \times V_{Rd}$ = 0,10 x 391 kN = 39,1 kN.

Resistance for combinations of load effects, concrete C40/50

The resistance of JKL fastening plate for combinations of load effect combinations are calculated according to section 4.6.

$$\left(1.8\left(\frac{4\ kNm}{23{,}9\ kNm}\right)\right)^{\frac{2}{3}} + \left(\frac{20\ kN}{39{,}1\ kN}\right)^{\frac{2}{3}} = 0{,}98$$

JKL300x300 fastening plate has enough resistance for the loadings given with position according to figure 7 without additional reinforcement in concrete C40/50.

7.2 Design example 2: JKL-fastening plate in a slab

Resistance of a JKL fastening plate is checked for the situation presented in figure 8. No additional reinforcement for the JKL fastening plate is installed.

Fastening plate JKL300x300, outline of the steel component to be fixed to the plate 180 x 180 mm^2.

Resistance and utilization ratios for the fastening plate are calculated for concrete grade C25/30

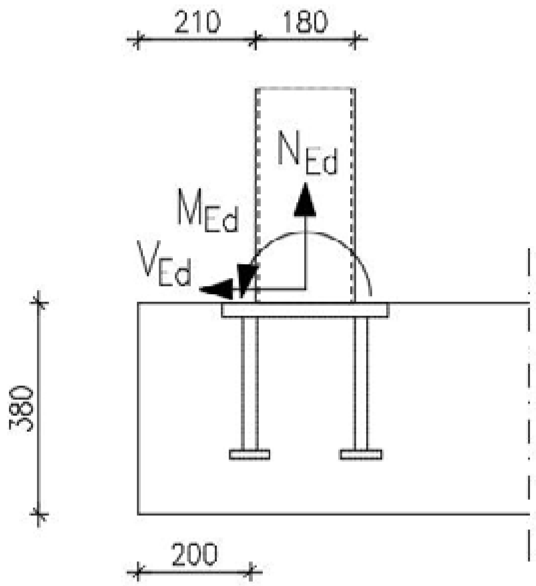

Figure 8. Dimensioning example for JKL fastening plate, fastening plate on a slab

Load effects applied to the fastening plate: N_{Ed} = 15 kN, V_{Ed} = 20 kN, M_{Ed} = 1,5 kNm.

Effect of edge distances to resistances

Smallest edge distance for JKL300x300 fastening plate from center of anchor to edge of the concrete structure is 200mm. According to table 5 the smallest edge distances for which the resistances of the fastening plates do not need to be reduced are for normal force and bending moment $c_{cr.N}$ = 415 mm and for shear force and torsional moment $c_{cr.V}$ = 1500 mm. The actual values are below the minimum values of table 5 so the resistances need to be reduced due to the edge distances.

The reducing factors for JKL fastening plates due to edge distances are calculated according to section 4.7. The minimum edge distances according to table 8 are for normal force and bending moment $c_{cr.N.min}$ = 75 mm and for shear force and torsional moment $c_{cr.V.min}$ = 200 mm. The reduction factors for minimum edge distances are found in table 7. Reduction factors can be linearly interpolated so the reduction factors are calculated as follows:

$$k_{red.M.edge} = 0{,}14 + \frac{1\text{-}0{,}14}{415\text{mm-}75\text{mm}}(200\text{mm-}75\text{mm}) = 0{,}46$$

$$k_{red.V.edge} = 0{,}07 + \frac{1\text{-}0{,}07}{1500\text{mm-}200\text{mm}}(200\text{mm-}200\text{mm}) = 0{,}07$$

Effect of dimensions of the steel part to be fastened to resistances

In table 4 of section 4.3 the minimum fastening areas for which the full resistance of the JKL fastening plate can be utilized are given. Size of the fixed part in the example, 180 x 180 mm^2 fulfills the requirements so the resistance does not need to be reduced because of the dimensions of the fastened part.

Effect of concrete structure thickness on the resistances

Section 4.5 table 6 gives minimum thickness of the concrete structure for which the resistances do not need to be reduced. For JKL300x300 fastening plate this value is 570mm. Thickness of the column in the design example does not fulfill this requirement and the resistances of the fastening plate need to be reduced with the factor:

$$k_{h.red} = \left(\frac{380mm}{570mm}\right)^{\frac{2}{3}} = 0{,}76$$

Reduced resistances, concrete C25/30

The non-reduced resistances for JKL300x300 fastening plates in concrete C25/30 are: N_{Rd} = 198 kN, V_{Rd} = 391 kN ja M_{Rd} = 38,6 kNm.

The reduced resistances are:

$N_{Rd.red} = k_{red.N.edge} \times k_{h.red} \times N_{Rd}$ = 0,46 x 0,76 x 198 kN = 69,2 kN

$M_{Rd.red} = k_{red.N.edge} \times k_{h.red} \times M_{Rd}$ = 0,46 x 0,76 x 38,6 kNm.= 13,5 kNm.

$V_{Rd.red} = k_{red.V.edge} \times k_{h.red} \times V_{Rd}$ = 0,07 x 0,76 x 391 kN = 20,8 kN.

Resistance for combinations of load effects, concrete C25/30

The resistance of JKL fastening plate for combinations of load effect combinations are calculated according to section 4.6.

$$\left(\frac{15kN}{69{,}2kN} + 1.8\left(\frac{1{,}5\ kNm}{13{,}5\ kNm}\right)\right)^{\frac{2}{3}} + \left(\frac{20\ kN}{20{,}8\ kN}\right)^{\frac{2}{3}} = 1{,}53$$

JKL300x300 fastening plate resistance without additional reinforcement is not high enough for the loadings given and position according to figure 8 and concrete strength C25/30.

Additional reinforcement for shear force

Additional reinforcement 3-T12 is installed in the location of the JKL300x300 fastening plate according to figure 9.

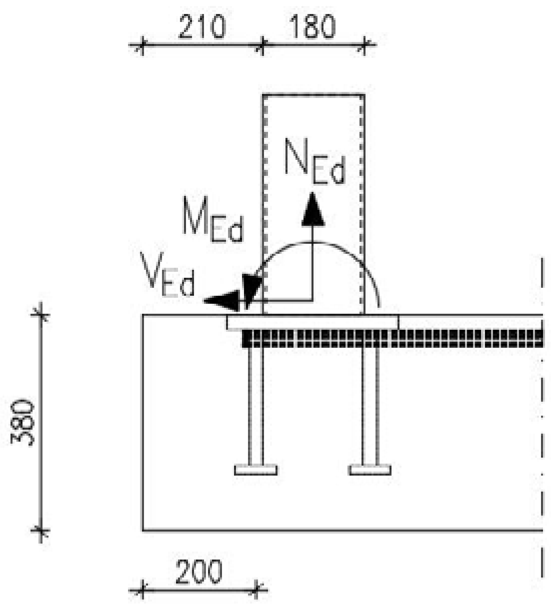

Figure 9. Positioning of additional reinforcement for shear force in the design example

The additional reinforcement for shear force is installed in the ”bad” bond conditions of the structure. Resistance of the shear reinforcement is $V_{Rd.s}$ = 3 x 0,7 x 40,6 kN = 85,3 kN.
Shear force induces additional tensile force into the shear force additional reinforcement. This force can be calculated in the following way:

e_s = 25 mm + 3 x 12 mm / 2 = 43 mm

z = 0,85 x min(2 x 280 mm ; 2 x 200 mm) = 340 mm

$k_{red.e}$ = 1 / (e_s / z +1) = 0,89

$V_{Rd.re}$ = $k_{red.e}$ x $V_{Rd.s}$ = 75,9 kN

Resistance for load effect combinations with additional reinforcement

The resistance of JKL fastening plate for combinations of load effect combinations are calculated according to section 4.6.

$$\left(\frac{15\text{kN}}{69{,}2\text{kN}} + 1.8\left(\frac{1{,}5\text{ kNm}}{13{,}5\text{ kNm}}\right)\right)^{\frac{2}{3}} + \left(\frac{20\text{ kN}}{75{,}9\text{ kN}}\right)^{\frac{2}{3}} = 0{,}97$$

JKL300x300 fastening plate has enough resistance for the loadings given with position according to figure 9 and additional reinforcement 3-T12 for shear force.

8. Literature Related to the Manual

CEN/TS 1992-4-1:2009. Design of fastenings for use in concrete. Part 1 General

CEN/TS 1992-4-2:2009. Design of fastenings for use in concrete. Part 2 Headed fasteners

fib bulletin 58:2011 Design of anchorages in concrete

SFS-EN 1992-1-1 Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings

SFS-EN 1993-1-1 Eurocode 3: Design of steel structures. Part 1-1: General rules and rules for buildings

SFS-EN 1993-1-8 Eurocode 3: Design of steel structures. Part 1-8: Design of joints

SFS-EN 1993-1-10 Eurocode 3: Design of steel structures. Part 1-10: Material toughness and through-thickness properties

SFS-EN 1090-2 Execution of steel structures and aluminium structures. Part 2: Technical requirements for steel structures

SFS-EN 10080 Steel for the reinforcement of concrete. Weldable reinforcing steel. General

SFS 1216 Betoniteräkset. Hitsattava kuumavalssattu harjatanko A700HW

SFS 1257 Betoniteräkset. Kylmämuokattu harjatanko B500K

SFS 1259 Betoniteräkset. Kylmämuokattu ruostumaton harjatanko B600KX

SFS 1268 Betoniteräkset. Hitsattava kuumavalssattu harjatanko B500B

SFS 1269 Betoniteräkset. Hitsattava kuumavalssattu harjatanko B500C1

SFS 1300 Betoniteräkset. Hitsattavien betoniterästen ja betoniteräsverkkojen vähimmäisvaatimukset

SFS-EN 10025 Hot rolled products of structural steels.

SFS-EN 10088 Stainless steels

SFS-EN ISO 17660-1 Welding. Welding of reinforcing steel. Part 1: Load-bearing welded joints

SFS-EN ISO 5817 Welding. Fusion-welded joints in steel, nickel, titanium and their alloys (beam welding excluded). Quality levers for imperfections.

SFS-EN ISO 3834-3 Quality requirements for fusion welding of metallic materials. Part 3: Standard quality requirements

SFS-EN ISO 14554-2 Quality requirements for welding. Resistance welding of metallic materials. Part 2: Elementary quality requirements.

SFS-EN 15609-1 Specification and qualification of welding procedures for metallic materials. Welding procedure specification. Part 1: Arc welding.

SFS-EN 15609-2 Specification and qualification of welding procedures for metallic materials. Welding procedure specification. Part 2: Gas welding

SFS-EN 15609-5 Specification and qualification of welding procedure for metallic materials. Welding procedure specification. Part 5: Resistance welding

SFS-EN 287-1 Qualification test of welders. Fusion welding Part 1: Steels

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SFS-EN ISO 9606-1 Qualification testing of welders. Fusion welding. Part 1: Steels

SFS-EN ISO 14731 Welding coordination. Tasks and responsibilities

SFS-EN ISO 14732 Welding personnel. Qualification testing of welding operators and weld setters for mechanized and automatic welding of metallic materials

SFS-EN ISO 9018 Destructive tests on welds in metallic materials. Tensile test on cruciform and lapped joints.

SFS-EN 10204 Metallic products. Types of inspection documents

NA SFS-EN 1992-1-1 Finnish national annex

NA SFS-EN 1993-1-1 Finnish national annex

NA SFS-EN 1993-1-8 Finnish national annex

NA SFS-EN 1993-10 Finnish national annex

ETAG 001 Guideline for European technical approval of metal anchors for use in concrete.
Annex A: Details of tests.
Annex B: Tests for admissible service conditions, detailed information.

Notes

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.

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R-Group Finland Oy

Head Office:
Katajanokankatu 6B 12,
00160 Helsinki Finland
Tel : +358 (0)20 722 9420
VAT No. : FI- 2025044-5

R-Group Baltic OÜ

Lõõtsa 2B
11415 TALLINN
Mob. : +372 578 396 76

OOO R-Group

18A Bolshoj pr. V.O.
199034, St.Petersburg Russia
Tel : +358 (0)20 722 9420
+372 578 396 76

R-Group Gulf FZE

PO Box 14755
Ras Al Khaymah U.A.E
Tel : +971 505119223
+91 840 894 45 78

RSTEEL®

www.repo.eu
info@repo.eu
linkedin/rsteel