RSTEEL®

Technical Manual

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KL Fastening Plates

Design According to Eurocodes

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THE STRONGEST IN FINLAND
2017
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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 KL-fastening plates presented in this manual.

By harmonizing KL-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

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Betoniteollisuus ry

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1. Principle of Operation of the Fastening Plates

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.

The resistances of KL 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.

2. Dimensions and Materials

2.1 Materials of the fastening plates and corresponding standards

Type	Component	Material	Standard
KL	Steel plate	S355J2+N	SFS-EN 10025
	Anchor	B500B BSt 500 S	SFS 1300
KLR	Steel plate	1.4301	SFS-EN 10088
	Anchor	B500B BSt 500 S	SFS 1300
KLH	Steel plate	1.4401	SFS-EN 10088
	Anchor	B500B BSt 500 S	SFS 1300

2.2 Dimensions of the fastening plates

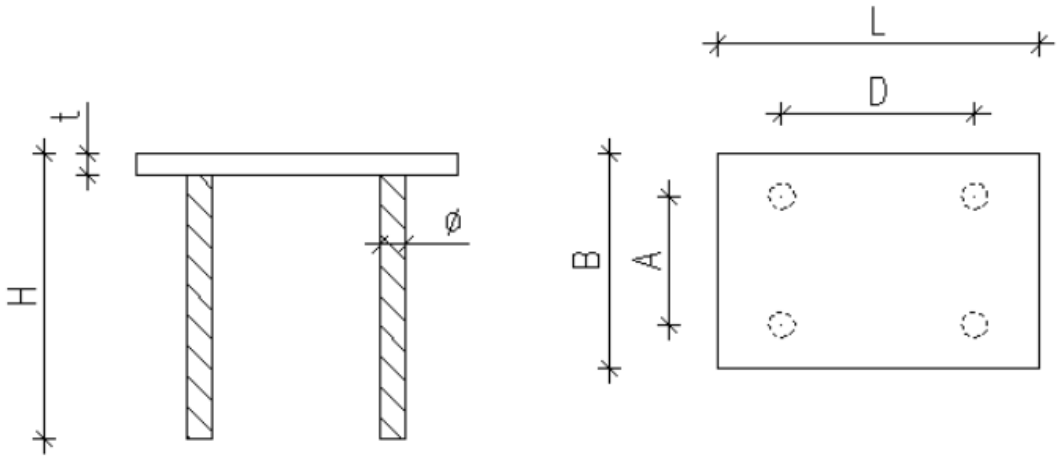

Figure 1. Dimension markings of KL fastening plates

Table 1. Dimensions of KL fastening plates

KL fastening plate				H	A	D	t	Ø
KL	B	x	L	[mm]	[mm]	[mm]	[mm]	[mm]
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

3. Manufacturing and Tolerance

3.1 Manufacturing method and execution class

Steel plates:	Thermal or mechanical cutting
Steel bars:	Mechanical cutting
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:	± 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°

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 KL 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

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 the effect of edge distances or additional reinforcement

Table 2 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 4.6.

The resistances given in table 2 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 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 installed 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
- 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 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.

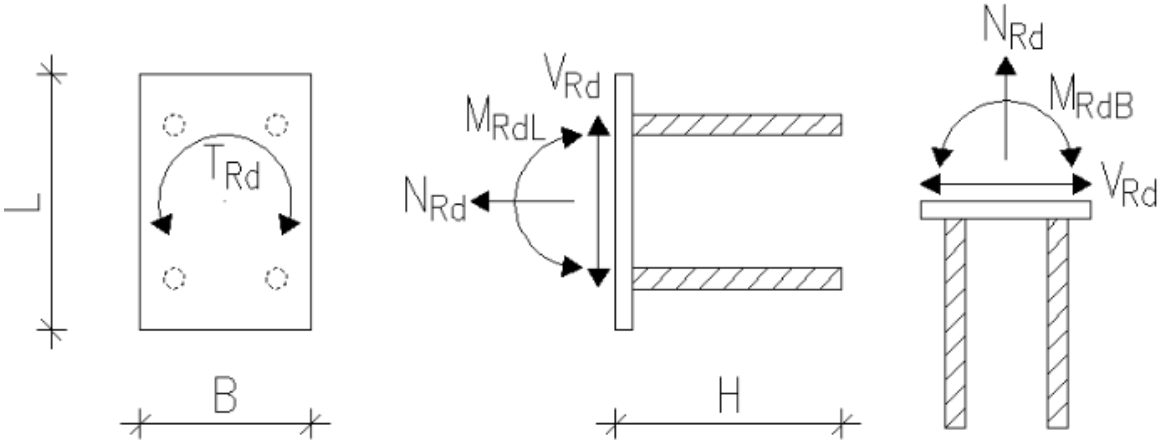

Figure 2. Notation for force directions in KL fastening plates

Table 2. 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 2 are maximum resistances of KL fastening plates for individual load effects without additional reinforcement. The fastening plates are placed according to table 3. The values are calculated for “good” bond conditions. In “poor” bond conditions values in table 2 need to be multiplied by factor 0,7.

4.3 Fastening area

When using resistances given in table 2, the fastening areas of the steel components to be attached on the KL fastening plates shall have minimum values according to table 3. 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 3. 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 4, the resistances of KL fastening plate need to be reduced according to formula 1.

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

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.

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

When using resistance values given in table 2, the center and edge distances of KL 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 KL 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 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 $_{kt}$ has the minimum value of 2 x the edge distance, if the full resistances according to table 2 are used. With smaller center distances, the resistance of the fastening plate
dista
dista

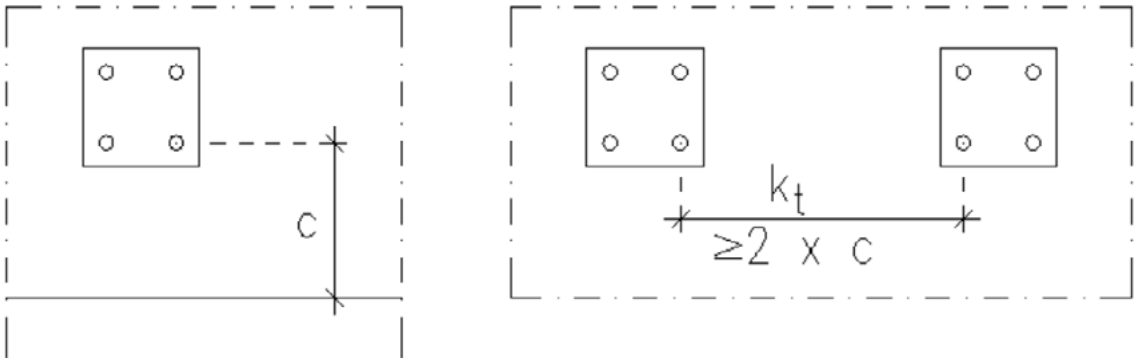

Figure 3. The edge distance c of KL fastening plate from the center of the anchor to the edge of the concrete structure and the center distance between adjacent fastening plates.

Table 4. 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 and the effect of base thickness to resistances

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.

$$\left(\frac{N_{Ed}}{N_{Rd}} + \frac{M_{EdB}}{M_{RdB}} + \frac{M_{EdL}}{M_{RdL}}\right)^{\frac{4}{3}} + \left(\frac{V_{EdB}}{V_{Rd}} + \frac{V_{EdL}}{V_{Rd}} + \frac{T_{Ed}}{T_{Rd}}\right)^{\frac{4}{3}} \leq 1{,}0 \qquad (2)$$

Where subscript 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. 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 4 and reduction factors according to section 4.7 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:

$$A_{s.\text{additional reinforcement}} = \frac{F_k}{f_{uk}} \qquad (3)$$

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. Use of fastening Plates

5.1 Service life and allowed exposure classes

Service life of KL fastening plates depends on the chosen fastening plate material. KL 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 KLR or acid-proof KLH fastening plate types are to be used.

5.2 Limitations for use

Capacities for KL 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 KL fastening plates have been calculated for concrete with strength C25/30

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

6. Storage Transportation and Marking

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

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

7. DESIGN EXAMPLE FOR KL FASTENING PLATE

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.

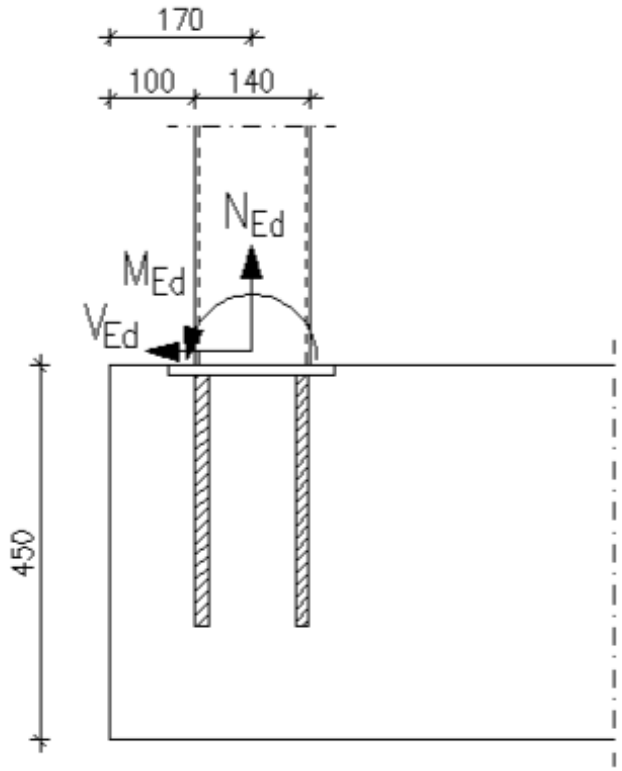

Figure 4. Design example of a KL fastening plate without additional reinforcement, dimensions of the fastening plate

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 2 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.

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

The minimum edge distances of KL 200x200 fastening plate for resistances according to table 2 are given in table 4. 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 2.

Reduction of shear force resistance is done according to section 4.7. 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.

$$V_{Rd.red} = \frac{119,5kN\text{-}0kN}{170mm\text{-}30mm}(110mm\text{-}30mm) = 68,2kN$$

Effect of the dimensions of the fixed component to the resistances

In table 3 of section 4.3, the minimum fastening surfaces of steel components fixed on KL fastening plates are given. For KL 200x 200 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 4.5. 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 4.6 using formula (2).

Load case 1: $\left(\frac{44kN}{125,6kN}\right)^{\frac{3}{4}} + \left(\frac{18kN}{68,2kN}\right)^{\frac{3}{4}} = 0,82$

Load case 2: $\left(\frac{30kN}{125,6kN} + \frac{5kNm}{13,7kNm}\right)^{\frac{3}{4}} + \left(\frac{10kN}{68,2kN}\right)^{\frac{3}{4}} = 0,92$

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

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

Notes

Notes

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R-Group

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