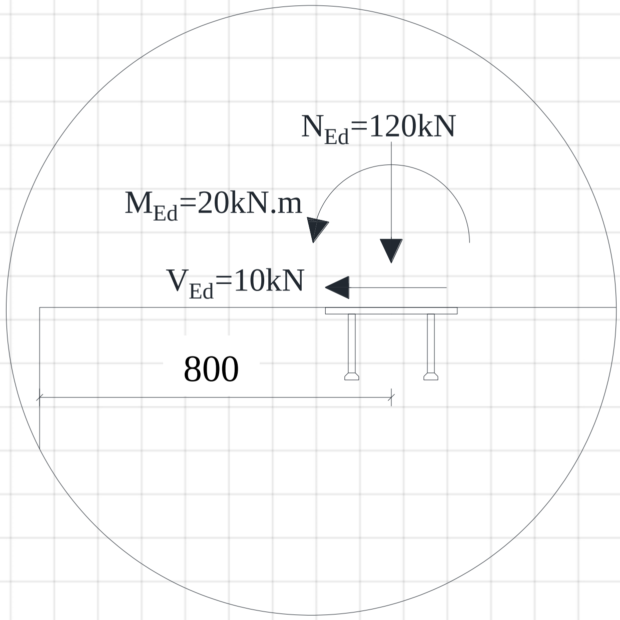
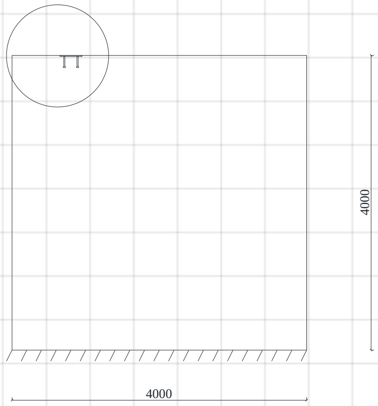
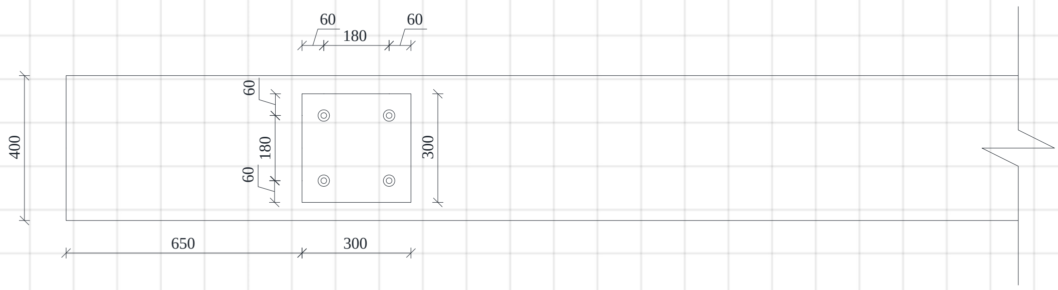
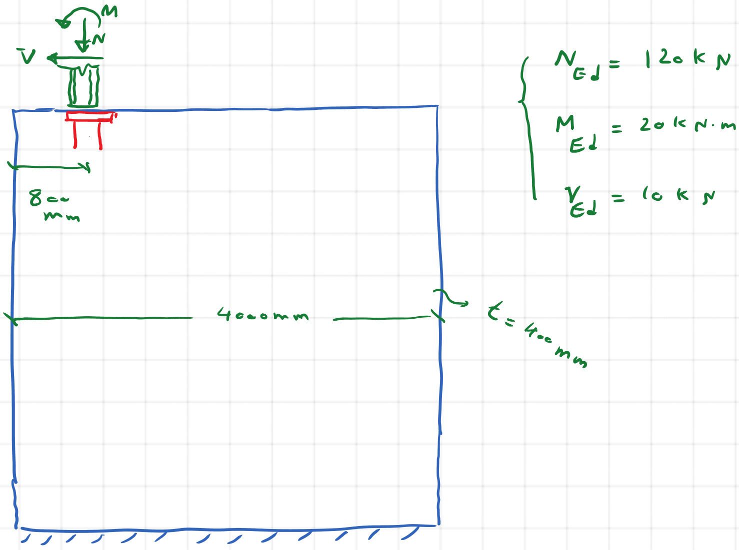
In this playlist, a simple example is provided to be solved according to Eurocode1992-4. The code is for fasteners inside the concrete elements, and the example will give an understanding of the code to get into it. Since there are many steps, the videos are provided in several parts.

The example is about one embedded plate from Peikko product installed on the top of a concrete wall with a thickness of 400mm. The wall is 4 meters in height and 4 meters in width, made of C30/37 concrete class. The plate is a headed anchor bolt connection known as the pre-installed embedded plate. The loads applied to the plate are given in design format (Ed), as shown in the figure. Dimensions are provided in mm.

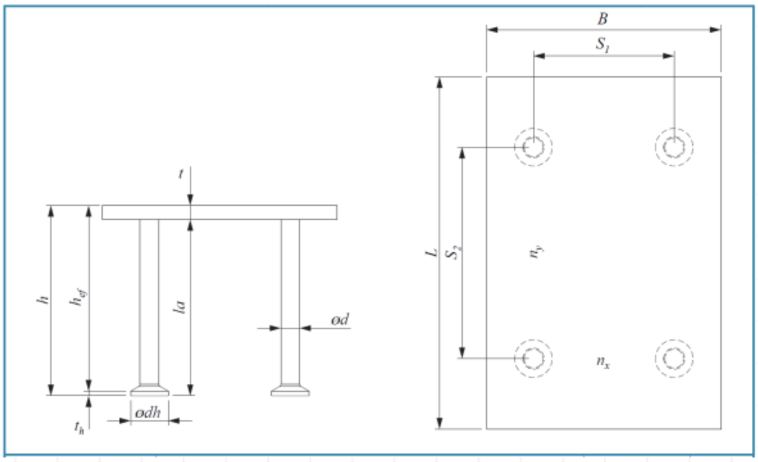








WELDA® $B \times L$ - H	B	L	H	t	h_{ef}	s_1	s_2	$Ød$	n_x	n_y	Weight
	[mm]										[kg]
WELDA 300x300-165	300	300	165	15	157	180	180	16	2	2	11.7



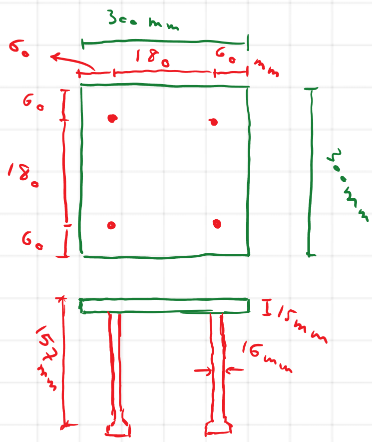
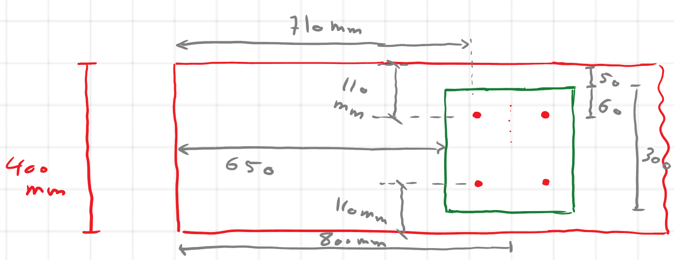


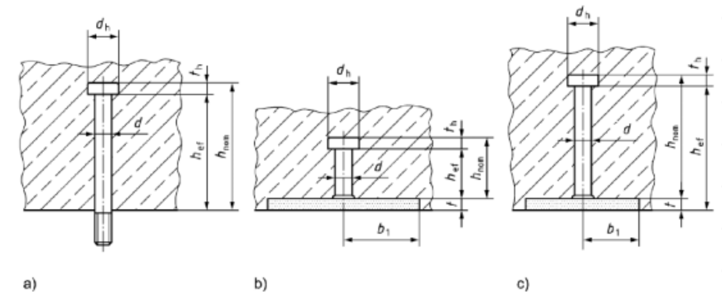
Table 2. Materials.

Types	Plate material	Standard	Anchor material	Standard
WELDA	S355J2+N	EN 10025-2	SD1 (black steel)	EN ISO 13918
WELDA R	1.4301	EN 10088-2	SD1 (black steel)	EN ISO 13918
WELDA Rr	1.4301	EN 10088-2	SD3 (stainless steel)	EN ISO 13918
WELDA A	1.4401	EN 10088-2	SD1 (black steel)	EN ISO 13918
WELDA Ar	1.4401	EN 10088-2	SD3 (stainless steel)	EN ISO 13918
WELDA Strong	S355J2+N	EN 10025-2	B500B (black steel)	EN 10080
WELDA Strong R	1.4301	EN 10088-2	B500B (black steel)	EN 10080
WELDA Strong A	1.4401	EN 10088-2	B500B (black steel)	EN 10080

SD1: $f_{yk} \geq 350$ N/mm², $f_{uk} \geq 450$ N/mm², A5 ≥ 15 %
SD3: $f_{p0,2} \geq 350$ N/mm², $f_{uk} \geq 500$ N/mm², A5 ≥ 25 %



3.1.28
fastening
assembly of fixture and fasteners or anchor channel used to transmit loads to concrete



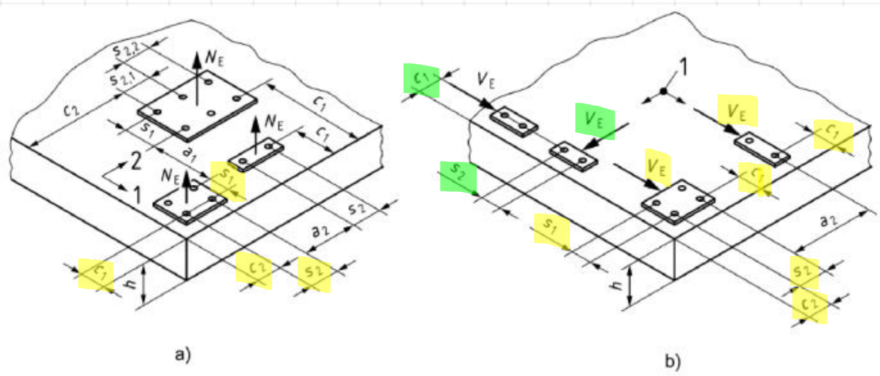
Key

a) without anchor plate

b) with a large anchor plate at least in one direction, $b_1 > 0{,}5\ h_{nom}$ or $t > 0{,}2\ h_{nom}$

c) with a small anchor plate in both directions, $b_1 \leq 0{,}5\ h_{nom}$ and $t \leq 0{,}2\ h_{nom}$

Figure 3.1 — Definition of effective embedment depth h_{ef} for headed fasteners



Key

1 indices 1 and 2: For fastenings close to an edge under tension loads, index 1: direction perpendicular to the edge, index 2: direction parallel to the edge. For shear loads the indices depend on the edge for which the verification of concrete edge failure is performed (index 1: direction perpendicular to the edge for which verification is made; index 2: perpendicular to direction 1)

a) fastenings subjected to tension load

b) fastenings subjected to shear load in the case of fastenings near an edge

Figure 3.4 — Definitions related to concrete member dimensions, fastener spacing and edge distance

4.3 Design format

(1) At the ultimate limit state it shall be shown that:

$$E_d \leq R_d \tag{4.1}$$

and at the serviceability limit state it shall be shown that

$$E_d \leq C_d \tag{4.2}$$

(2) The forces in the fasteners shall be derived using appropriate combinations of actions on the fixture in accordance with EN 1990. Forces Q_{ind} resulting from restraint to deformation, intrinsic (e.g. shrinkage) or extrinsic (e.g. temperature variations), of the attached member shall be taken into account in the design of fasteners. The design action shall be taken as $\gamma_{ind} \cdot Q_{ind}$.

(3) In general actions on the fixture may be calculated ignoring the displacement of the fasteners or of the anchor channels. However, the effect of displacement of the fasteners or of the anchor channels should be considered when a statically indeterminate stiff element is fastened.

(4) In the ultimate limit state the value of the design resistance is obtained from the characteristic resistance of the fastener, the group of fasteners or anchor channels as follows:

$$R_d = R_k / \gamma_M \tag{4.3}$$

Table 4.1 — Recommended values of partial factors

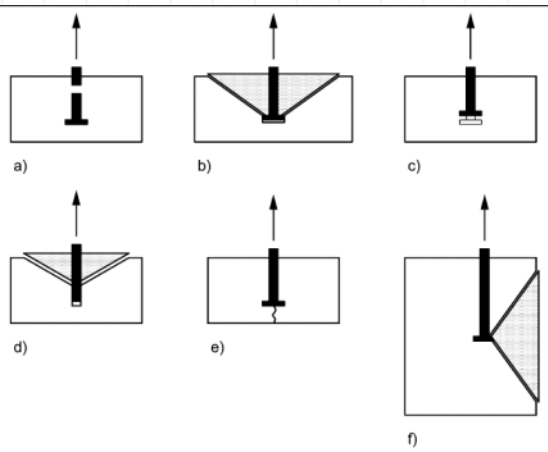
Failure modes	Partial factor		
		Permanent and transient design situations	Accidental design situation
Steel failure – fasteners			
Tension	γ_{Ms}	$= 1{,}2 \cdot f_{uk}/f_{yk} \geq 1{,}4$	$= 1{,}05 \cdot f_{uk}/f_{yk} \geq 1{,}25$
Shear with and without lever arm	γ_{Ms}	$= 1{,}0 \cdot f_{uk}/f_{yk} \geq 1{,}25$ when $f_{uk} \leq 800$ N/mm² and $f_{yk}/f_{uk} \leq 0{,}8$	$= 1{,}0 \cdot f_{uk}/f_{yk} \geq 1{,}25$ when $f_{uk} \leq 800$ N/mm² and $f_{yk}/f_{uk} \leq 0{,}8$
		$= 1{,}5$ when $f_{uk} > 800$ N/mm² or $f_{yk}/f_{uk} > 0{,}8$	$= 1{,}3$ when $f_{uk} > 800$ N/mm² or $f_{yk}/f_{uk} > 0{,}8$
Concrete related failure			
Concrete cone failure, concrete edge failure, concrete blow-out failure, concrete pry-out failure	γ_{Mc}	$= \gamma_c \cdot \gamma_{inst}$	$= \gamma_c \cdot \gamma_{inst}$
	γ_c	$= 1{,}5$[a] for seismic repair and strengthening of existing structures see the EN 1998 series	$= 1{,}2$[a] for seismic repair and strengthening of existing structures see the EN 1998 series
	γ_{inst}	= 1,0 for headed fasteners and anchor channels satisfying the requirements of 4.6 (in tension and shear)	
		≥ 1,0 for post-installed fasteners in tension, see relevant European Technical Product Specification	
		= 1,0 for post-installed fasteners in shear	
Concrete splitting failure	γ_{Msp}	$= \gamma_{Mc}$	
Pull-out and combined pull-out and concrete failure	γ_{Mp}	$= \gamma_{Mc}$	

7.2 Headed and post-installed fasteners

7.2.1 Tension load

7.2.1.1 Required verifications

The verifications of Table 7.1 apply. The failure modes addressed are given in Figure 7.1.



Key

a) steel failure
b) concrete cone failure
c) pull-out failure
d) combined pull-out and concrete failure of bonded fasteners
e) concrete splitting failure
f) concrete blow-out failure

Figure 7.1 — Failure modes of headed or post-installed fasteners under tension load

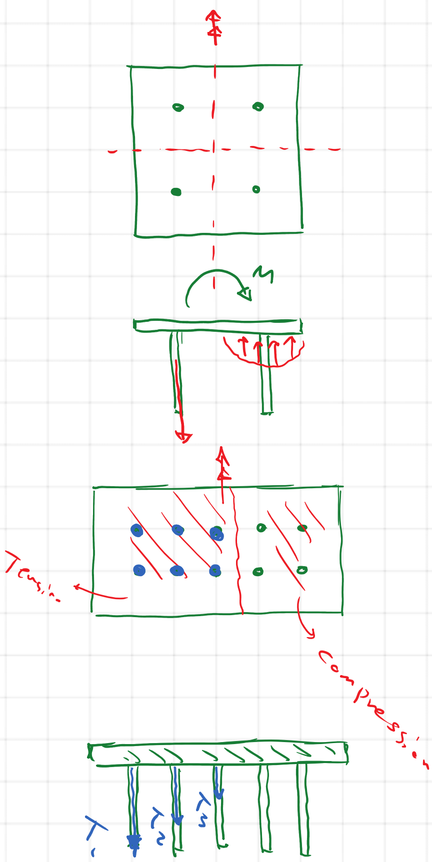


Table 7.1 — Required verifications for headed and post-installed fasteners in tension

	Failure mode	Single fastener	Group of fasteners: most loaded fastener	Group of fasteners: group
1	Steel failure of fastener	$N_{Ed} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$	$N_{Ed}^{h} \leq N_{Rd,s} = \frac{N_{Rk,s}}{\gamma_{Ms}}$	
2	Concrete cone failure	$N_{Ed} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$		$N_{Ed}^{g} \leq N_{Rd,c} = \frac{N_{Rk,c}}{\gamma_{Mc}}$
3	Pull-out failure of fastener [a]	$N_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$	$N_{Ed}^{h} < N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$	
4	Combined pull-out and concrete failure [b]	$N_{Ed} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$		$N_{Ed}^{g} \leq N_{Rd,p} = \frac{N_{Rk,p}}{\gamma_{Mp}}$
5	Concrete splitting failure	$N_{Ed} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Msp}}$		$N_{Ed}^{g} \leq N_{Rd,sp} = \frac{N_{Rk,sp}}{\gamma_{Msp}}$
6	Concrete blow-out failure [c]	$N_{Ed} \leq N_{Rd,cb} = \frac{N_{Rk,cb}}{\gamma_{Mc}}$		$N_{Ed}^{g} \leq N_{Rd,cb} = \frac{N_{Rk,cb}}{\gamma_{Mc}}$
7	Steel failure of reinforcement	$N_{Ed,re} \leq N_{Rd,re} = \frac{N_{Rk,re}}{\gamma_{Ms,re}}$	$N_{Ed,re}^{h} \leq N_{Rd,re} = \frac{N_{Rk,re}}{\gamma_{Ms,re}}$	
8	Anchorage failure of reinforcement	$N_{Ed,re} \leq N_{Rd,a}$	$N_{Ed,re}^{h} \leq N_{Rd,a}$	

[a] Not required for post-installed bonded fasteners.
[b] Not required for headed and post-installed mechanical fasteners.
[c] For cases which require verification see 7.2.1.8 (1).

6.2 Headed fasteners and post-installed fasteners

6.2.1 Tension loads

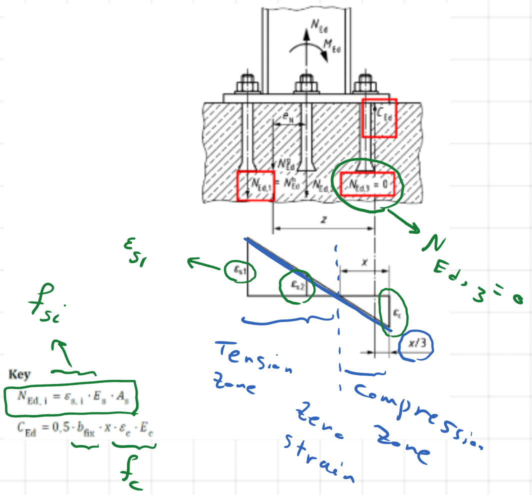
(1) The design value of tension loads acting on each fastener due to the design values of normal forces and bending moments acting on a rigid fixture may be calculated assuming a linear distribution of strains as shown in Figure 6.2 and a linear relationship between strains and stresses. If the fixture bears on the concrete with or without a grout layer, the compression forces are transmitted to the concrete by the fixture. The load distribution to the fasteners may be calculated analogous to the elastic analysis of reinforced concrete using the following assumptions (see Figure 6.2).

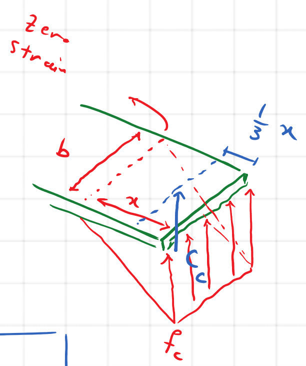
a) The fixture is sufficiently rigid such that linear strain distribution will be valid (analogous to Bernoulli hypothesis).

b) The axial stiffness of all fasteners is equal. The stiffness should be determined on the basis of the elastic steel strains in the fastener.

c) The modulus of elasticity of the concrete is taken from EN 1992-1-1. As a simplification, the modulus of elasticity of concrete may be assumed as $E_c = 30\,000$ N/mm^2. If no specific information is available in the relevant European Technical Product Specification, the modulus of elasticity of steel of the fastener may, as a simplification, be assumed as $E_s = 210\,000$ N/mm^2.

d) In the zone of compression under the fixture the fasteners do not take up normal forces.





$$C_c = 0.5 f_c \cdot b \cdot x$$