MEMO 65 A

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TSS 25 L	Last rev.:	13.10.2020	Sign.:	JB
ANCHORING DESIGN	Dok. nr.:	K3-10/60	Contr.:	SSS
DESIGN				

ANCHORING DESIGN FOR TSS 25 L

CONTENTS

PART 1 – BASIC ASSUMTIONS

GENERAL

The following calculations of anchorage of the units and the corresponding reinforcement must be considered as an example illustrating the design model.

It must always be checked that the forces from the anchorage reinforcement can be transferred to the main reinforcement of the concrete components. The recommended reinforcement includes only the reinforcement necessary to anchor the unit to the concrete.

In the vicinity of the unit the element must be designed for the force R_1.

STANDARDS

The calculations are carried out in accordance with:

- Eurocode 2: Design of concrete structures. Part 1-1: General rules and rules for buildings.
- Eurocode 3: Design of steel structures. Part 1-1: General rules and rules for buildings.
- Technical Specification CEN/TS 1992-4-1:2009 Design og fastenings for use in conrete Part 4-1: General.
- Technical Specification CEN/TS 1992-4-2:2009 Design og fastenings for use in conrete Del 4-2: Headed Fasteners.
- Technical Specification CEN/TR 15728:2016. Design and use of inserts for lifting and handling of precast concrete elements

The selected values for the NDP's in the following calculations are:

	Concrete							Steel		
State	γ_c	α_{cc}	α_{ct}	η_1	η_2	$\alpha_{Early\ strength}$ 1)	γ_s	γ_{MO}	γ_{M1}	γ_{M2}
Value - Ultimate limit state (ULS)	1,5	0,85	0,85	1,0	1,0		1,15	1,05	1,05	1,25
Value – lifing		0,85	0,85	1,0	1,0	0,8				

1) Reduction factor $\alpha_{Early\ strenght}$ is determined by the designer, indicates the minimum value of concrete strenght when lifting elements.

Table 1: NDP-s in EC-2 and EC-3.

	γ_c, γ_s	γ_1	γ_{l+h}	Global safety factor SF	Design formulas
Concrete					
Concrete failure	1,5	1,35	1,5	3,04	$SF=\gamma_c \times \gamma_1 \times \gamma_{l+h}$
Anchorage reinforcement	1,15	1,35	1,5	2,33	$SF=\gamma_s \times \gamma_1 \times \gamma_{l+h}$
Steel					
Structural steel	1,25	1,35	1,8	3,04	$SF=\gamma_s \times \gamma_1 \times \gamma_{l+h}$

Table 2: Global safety factors in CEN/TR 15728:2016.

QUALITIES

	Concrete strength classes / reinforcement					Steel	Design formulas / references
Material parameters	C30/37 (N/mm^2)	C35/45 (N/mm^2)	C45/55 (N/mm^2)	C55/67 (N/mm^2)	B 500 C (N/mm^2)	S355 (N/mm^2)	
f_{ck}	30	35	45	55			EC2, Table 3.1
$f_{ck,cube}$	37	45	55	67			EC2, Table 3.1
$f_{ctk,0,05}$	2,00	2,20	2,70	3,00			EC2, Table 3.1
f_{yk}					500		EC2, Annex C
f_{cd}	17,0	19,8	25,5	31,2			$f_{cd} = f_{ck} \times \alpha_{cc} / \gamma_c$
f_{ctd}	1,13	1,25	1,53	1,70			$f_{ctd} = f_{ctk,0,05} \times \alpha_{ct} / \gamma_c$
f_{bd}	2,55	2,81	3,44	3,83			$f_{bd} = 2,25 \times \eta_1 \times \eta_2 \times f_{ctd}$
f_{yd}					435		$f_{yd} = f_{yk}/\gamma_s$
$f_{cd.lifting}$	6,7	7,8	10,1	12,3			$f_{cd,lifting} = f_{ck} \times \alpha_{cc} \times \alpha_{Early\ strength} / SF$
$f_{ctd,lifting}$	0,45	0,49	0,60	0,67			$f_{ctd,lifting} = f_{ctk,0,05} \times \alpha_{ct} \times \alpha_{Early\ strength} / SF$
$f_{bd,lifting}$	1,01	1,11	1,36	1,51			$f_{bd,lifting} = 2,25 \times \eta_1 \times \eta_2 \times f_{ctd,lifting} / SF$
$f_{yd,lifting}$					215		$f_{yd,lifting} = f_{yk}/SF$
E						210000	Modulus of elasticity, EC3 clause 3.2.6
G						81000	Shear modulus, EC3 clause 3.2.6
ν						0,3	Poisson's ratio, EC3 clause 3.2.6
f_u						510	EN 10025-2
f_y						355	EN 10025-2
f_{yd}						338	$f_{yd} = f_{yk} / \gamma_{MO}$
$f_{sd,\ weld}$						262	$f_{sd,weld} = f_u / (\gamma_{M2} \times \sqrt{3} \times \beta_w)$; $\beta_w = 0,9$
f_{sd}						195	$f_{yd} = f_{yk} / (\gamma_{MO} \times \sqrt{3})$
$f_{yd,\ lifting}$						117	$f_{yd,\ lifting} = f_{yk} / SF$
$f_{sd,\ weld,lifting}$						108	$f_{sd,weld,\ lifting} = f_u / (SF \times \sqrt{3} \times \beta_w)$; $\beta_w = 0,9$
$f_{sd,\ lifting}$						67	$f_{sd,lifting} = f_{yk} / (SF \times \sqrt{3})$

DIMENSIONS AND CROSS SECTION VALUES

Steel constructions

Tube : CFRHS 50x50x5, L=245 mm. Cold formed S355

Cross section values (NS-EN 10219-2)	B mm	H mm	S mm	Weight kg/m	A mm^2	$I \cdot 10^{-6}$ mm^4	$W_{ely} \cdot 10^{-3}$ mm^3	A_v mm^2
 Standard cross section	50	50	5,0	6,56	836	0,270	10,82	400
 Reduced cross section	50	50	5,0	6,56	756	0,225	9,97	400
 Rotated (45°) cross sectioan during lifting.	70,7	70,7	5,0	6,56	836	0,270	8,66	400

Steelplate welded to tube CFRHS 50x50x5	B mm	H mm	A mm^2	W_{ely} mm^3	W_{ply} mm^3
Steelplate 80x80x10	80	80	800	-	-
Steelplate 30x170x15	30	15	450	1125,000	1687,50

Concrete constructions

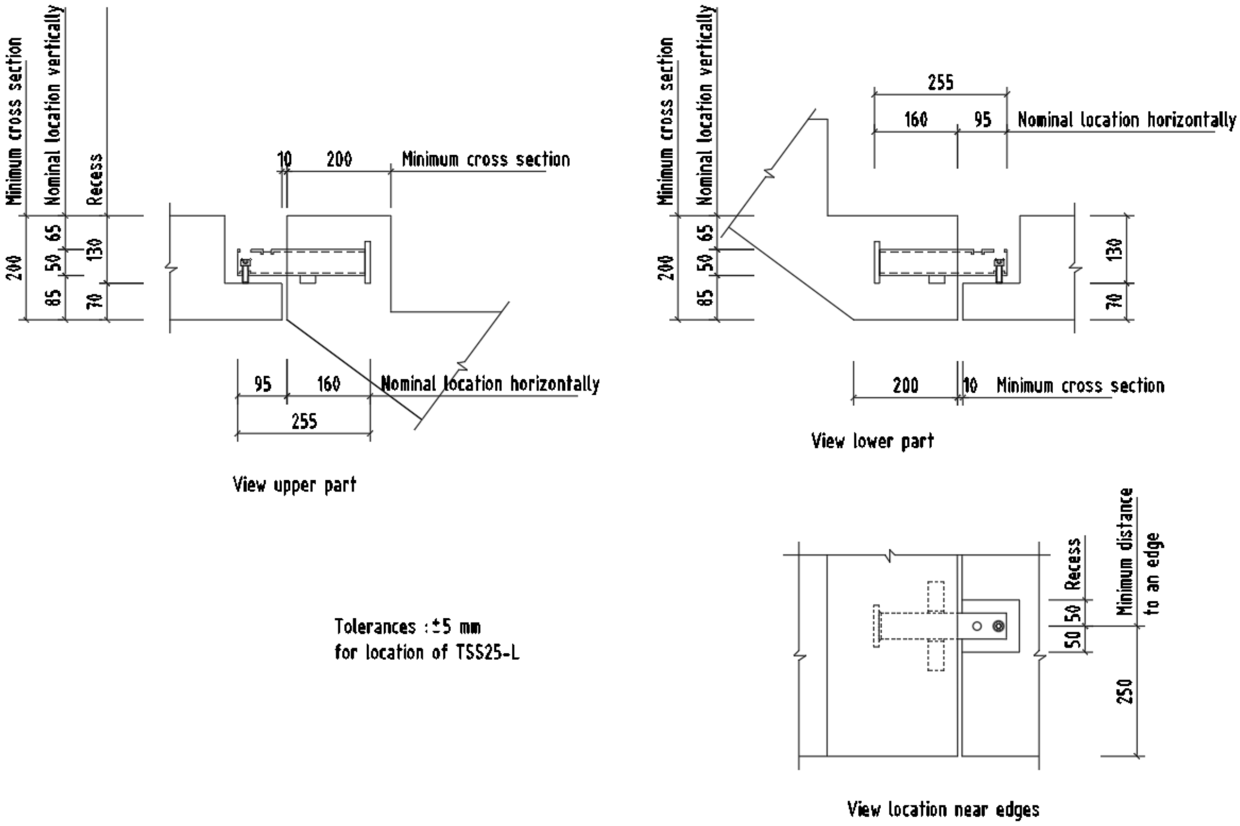


Figure 1: Minimum cross sections for stair- and repos elements

LOADS

Ultimate limit state (ULS)

Vertical ultimate limit state load: F_{Ed} = 25 kN.

Horizontal ultimate limit state load (friction force): $H_{Ed} = 0{,}15 \times F_{Ed} = 0{,}15 \times 25kN = 3{,}75 \sim 4$ kN.

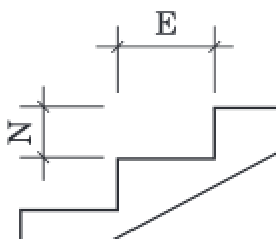
The horizontal load (H_{Ed}) is an assumed friction force at support, included in design of the unit, and in the calculation of the vertical equilibrium reaction forces. It is not a capacity that can be utilized for transfer of forces in design purpose

Lifting

Loads during lifitng of stair are calculated in 5 cases. Those cases depends of various combinations of stair slopses (Various combinations of width of steps and height of rises).

The maximum vertical lifting load is 8 kN (Lifting anchor M16, maximum weight of stair element : 4 x 8 = 32 kN = 3,26 tons)

Load situation	Width of step (E) (mm)	Height of rise (N) (mm)	The angle of the stairs (°)	$F_{V,lifting}$ (kN)	$F_{H,lifting}$ (kN)
case 1	400	110	15,38	7,71	2,12
case 2	250	185	36,50	6,43	4,76
case 3	380	120	17,53	7,63	2,41
case 4	200	210	46,40	5,52	5,79
case 5			0	8,00	0,00
case 6 [1)]			0	12,00	0,00



1) Case 6 applies to TSS25 L with reinforcement to achieve lifting capasity up to 12 kN

Maximum loads :

$F_{V,Lifting}$ = 8,00 kN (Vertical)
$F_{H,\ lifting}$ = 5,79 KN (Horizontal)
$F_{V,Lifting,\ reinforcement}$ = 12,00 kN (Vertical) , see page 13.
$F_{H,\ lifting,\ reinforcement}$ = 8,69 KN (Horizontal)

PART 2 – ANCHORING OF TSS25 L

STATIC MODELS AND EQUILIBRIUM CALCULATIONS

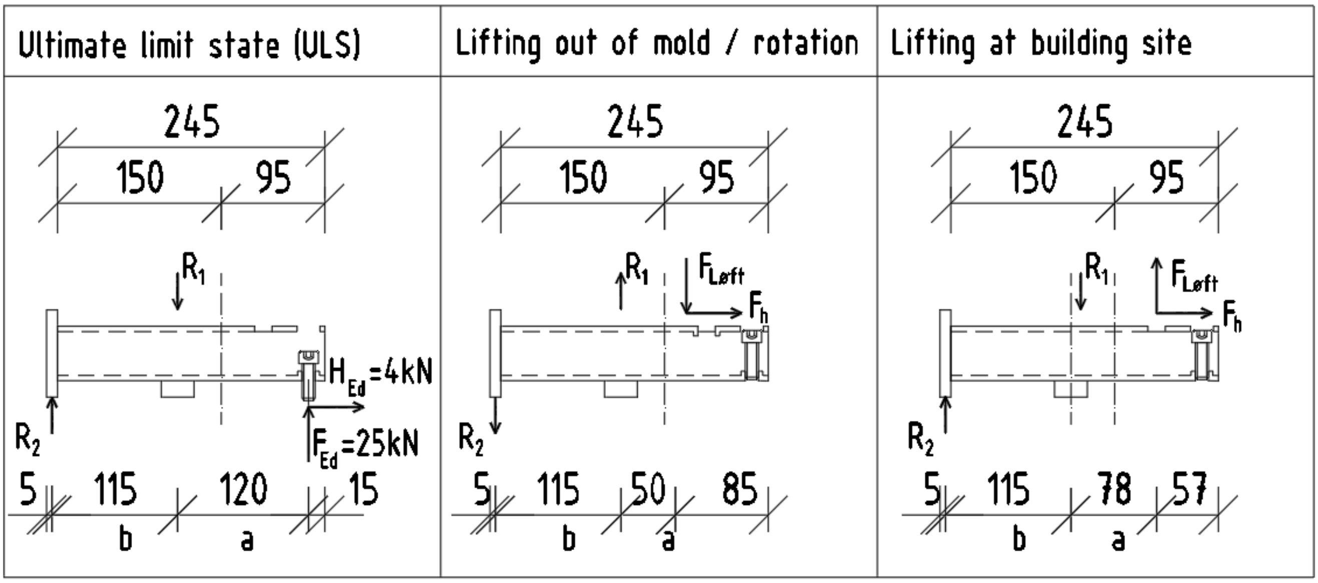


Figure 2: Static models

Load case regarded figure 2	Load (F_{Ed} or $F_{Lifting}$)	a (mm)	b (mm)	R_1 (kN)	R_2 (kN)
Ultimate limit state (ULS)	25	120	115	39,56	14,56
Lifting at building site	8	78	115	13,43	5,43
Lifting out of mold/ rotating the element	8	50	115	11,48	3,48
Reinforced anchor Lifting at building site.	12	78	115	20,14	8,14
Reinforced anchor Lifting out of mold/ rotating the element	12	50	115	17,22	5,22

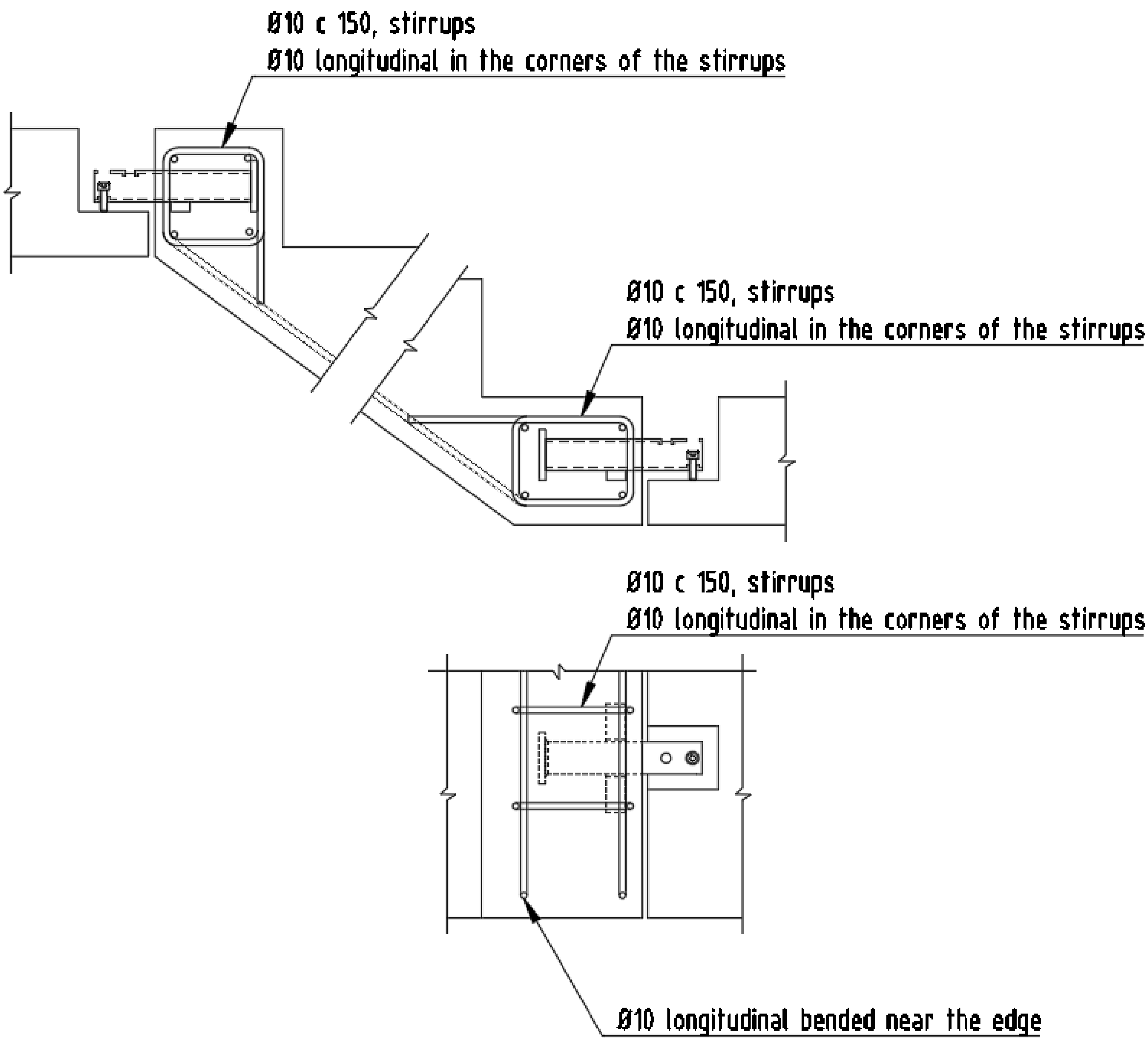


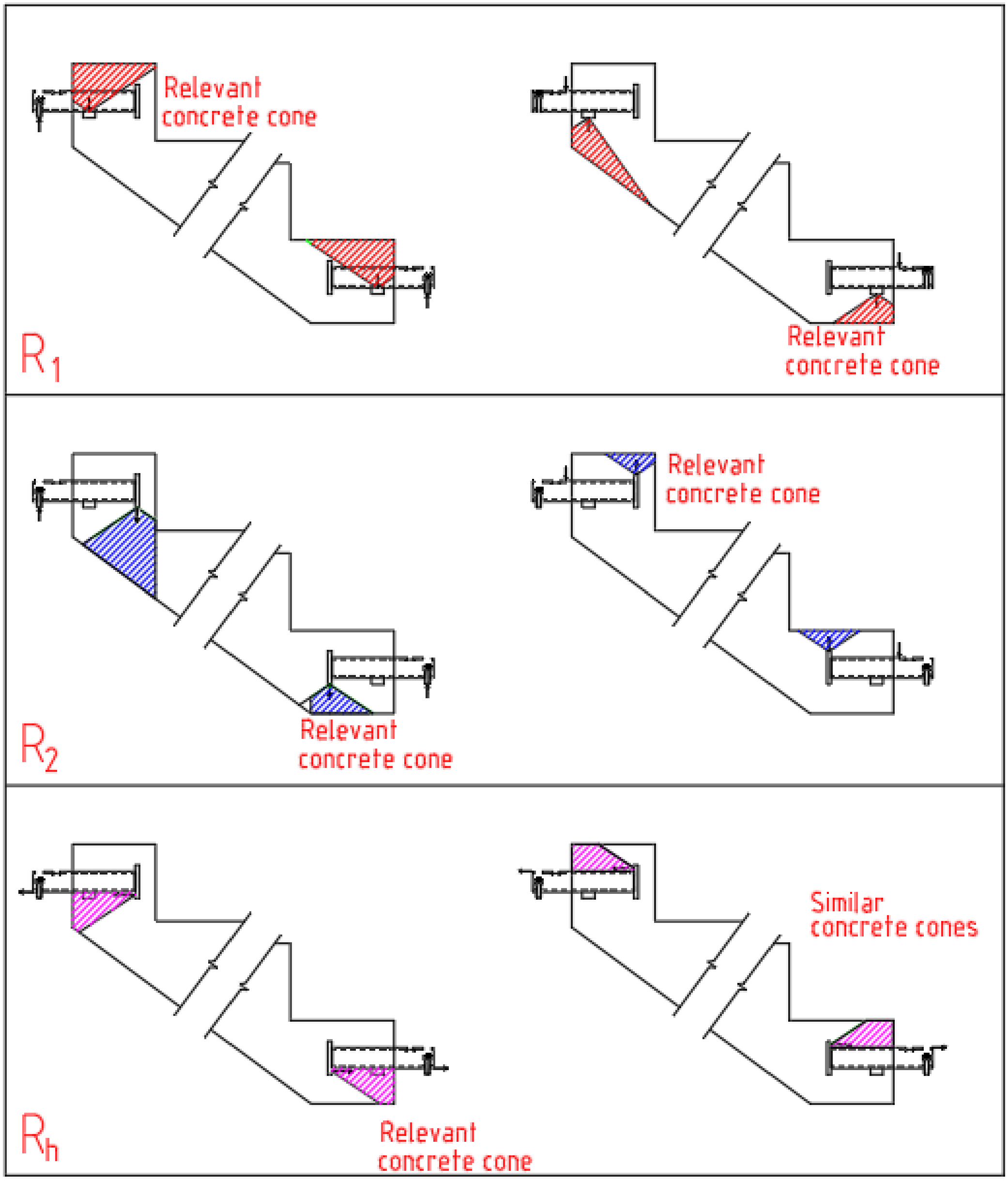
Figure 3: Minimum reinforcement

Anchoring of TSS25-L is calculated according to the rules given in Technical Specification CEN / TS 1992-4-2: 2009.
TSS25-L has steelplate welded to the main tube which activates the concrete in the conditions written above.
The assumptions for the calculations are as follows :

a) Non-cracked concrete structure for the force R_1 and for the horizontal forces H_{Ed} and $F_{H,lifting}$.
This assumption requires reinforcement to be applied to the boundary zones as shown in Figure 3.
The required reinforcement is determined from the largest calculated amount of reinforcement in the following three points:
   1) EC2, section 9.3.1.1 notice to (1), Minimum reinforcement at TSS25-L corresponding to reinforcement Ø10 c 150 mm. (20% increase of load R_1.)
   2) EC2, section 9.3.1.1, determined by formula $A_{s,min} = 0.26\ (f_{ctm} / f_{yk})\ bd$
   3) EC2, section 9.3.1.2 (1)

b) Cracked concrete structure for the force R_2

CONCRETE CONE FAILURE REGARDS TO R_1, R_2 og R_h



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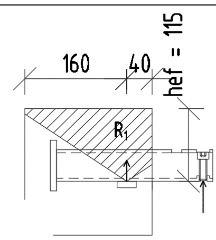
CONCRETE PARAMETERS, CEN/TS 1992-4-2:2009,pkt 6.2.5.1

Parameters	Strenght classes of concrete C30/37 (N/mm²)	C35/45 (N/mm²)	C45/55 (N/mm²)	C55/67 (N/mm²)	Design formulas / references
$f_{ck,cube}$	37	45	55	67	EC2, Tabell 3.1
Non-cracked $K_{1,\gamma c}$ (N/mm^{1,5})	48,3	53,2	58,8	64,9	CEN/TS 1992-4-2, 6.2.5.1 (5) - $K_{1,\gamma c}$ =11,9/1,5 x $\sqrt{f_{ck,cube}}$
Non-cracked $K_{1,SF}$ (N/mm^{1,5})	23,8	26,3	29,1	32,1	CEN/TS 1992-4-2, 6.2.5.1 (5) - $K_{1,SF}$ =11,9/SF x $\sqrt{f_{ck,cube}}$
Cracked $K_{1,\gamma c}$ (N/mm^{1,5})	34,5	38,0	42,0	46,4	CEN/TS 1992-4-2, 6.2.5.1 (6) - $K_{1,\gamma c}$ =8,5/1,5 x $\sqrt{f_{ck,cube}}$
Cracked $K_{1,SF}$ (N/mm^{1,5})	17,0	18,8	20,8	22,9	CEN/TS 1992-4-2, 6.2.5.1 (6) - $K_{1,SF}$ =8,5/SF x $\sqrt{f_{ck,cube}}$

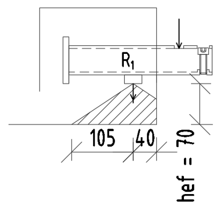
ANCHORING OF FORCE R_1

CEN/TS 1992-4-2, Figure 4, s_1 =	83 mm (two forces)	Area of anchoring A_h: b=	30
distance to nearest egde a_1 =	40 mm 0 if $a_1 > 1,5 \times h_{ef}$	l=	40
Distance to egde a_2 =	160 mm 0 if $a_2 > 1,5 \times h_{ef}$	A_h =	1200
Distance to egde b_1 =	0 mm 0 if $b_1 > 1,5 \times h_{ef}$		
h_{ef} =	115 mm		
Actual projected area A_{cN} =	85600 mm²		
Anchoring depth h_{ef} = 115	A^0_{cN} (for $N^0_{Rd,c}$ or $N^0_{Rd,c,SF}$) = 119025	Reference projected area $A^0_{cN} = (3 \times h_{ef}) \times (3 \times h_{ef})$	



Parameters	Strenght classes of concrete C30/37	C35/45	C45/55	C55/67	Design formulas / references	
$N^0_{Rrd,c}$	59,5	65,6	72,6	80,1	$N^0_{Rd,c} = K_{1,\gamma c} \times h_{ef}^{1,5}$	
$N^0_{Rrd,c,SF}$	23,5	25,9	28,7	31,6	$N^0_{Rd,c,SF} = K_{1,SF} \times h_{ef}^{1,5} \times \alpha_{early\ strenght}$	
Non-cracked $N_{Rd,c,non-cracked}$	42,8	47,2	52,2	57,6	$N_{Rd,c,non-cracked} = N^0_{Rd,c} \times A_{cN} / A^0_{cN}$	$R_{1,ULS}$ = 39,56 kN, capacity OK for B30
Max. compressive stress σ_c	207,200	252,000	308,000	375,200	CEN/TS 1992-4-2, 6.2.4 (2) $\sigma_c = 8,4 \times f_{ck,cube}/\gamma_c$	
Non-cracked $N_{Rrd,c,SF,non-cracked}$	16,9	18,6	20,6	22,8	$N_{Rd,c,SF,non-cracked} = N^0_{Rd,,c,SF} \times A_{cN} / A^0_{cN}$	$R_{1,Lifting}$ = 13,43 kN, capacity OK for B30
Max. compressive stress σ_c	81,9	99,6	121,7	148,2	CEN/TS 1992-4-2, 6.2.4 (2) $\sigma_c = 8,4 \times f_{ck,cube} \times \alpha_{early\ strenght}/SF$	Notice: Lifting capacity B30 : 800 kg

CEN/TS 1992-4-2, Figure 4, s_1 =	83 mm (two forces)	Area of anchoring A_h: b=	30
distance to nearest egde a_1 =	40 mm 0 dersom $a_1 > 1,5 \times h_{ef}$	l=	30
Distance to egde a_2 =	105 mm 0 dersom $a_2 > 1,5 \times h_{ef}$	A_h =	900
Distance to egde b_1 =	0 mm 0 dersom $b_1 > 1,5 \times h_{ef}$		
h_{ef} =	70 mm		
Actual projected area A_{cN} =	42485 mm²		
Anchoring depth h_{ef} = 70	A^0_{cN} (for $N^0_{Rd,c}$ or $N^0_{Rd,c,SF}$) = 44100	Reference projected area $A^0_{cN} = (3 \times h_{ef}) \times (3 \times h_{ef})$	



Parameters	Concrete C30/37	C35/45	C45/55	C55/67	Design formulas / references	
$N^0_{Rrd,c,SF}$	11,2	12,3	13,6	15,0	$N^0_{Rd,c,SF} = K_{1,SF} \times h_{ef}^{1,5} \times \alpha_{early\ strength}$	Case : Lifitng out of mold
Non-cracked $N_{Rrd,c,SF,non-cracked}$	10,8	11,9	13,1	14,5	$N_{Rd,c,SF,non-cracked} = N^0_{Rd,,c,SF} \times A_{cN} / A^0_{cN}$	$R_{1,Lifting}$ = 11,48 kN, capacity OK for B35
Max. compressive stress σ_c	81,9	99,6	121,7	148,2	CEN/TS 1992-4-2, 6.2.4 (2) $\sigma_c = 8,4 \times f_{ck,cube} \times \alpha_{early\ strenght}/SF$	Notice: Lifitng capacity B30 : 700 kg

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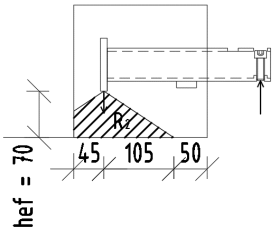
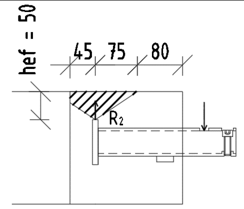
ANCHORING OF FORCE R_2

CEN/TS 1992-4-2, Figure 4, s_1 =	0 mm (one force)	Area of anchoring A_h: b=	10
distance to nearest egde a_1 =	45 mm	l=	15
h_{ef} =	70 mm	A_h =	150
Actual projected area A_{cN} =	31500 mm^2		
Anchoring depth h_{ef} = 70	A^0_{cN} (for $N^0_{Rd,c}$ ($N^0_{Rd,cSF}$) = 44100	Reference projected area A^0_{cN} = (3 x h_{ef}) x (3 x h_{ef})	



Parameters	C30/37	C35/45	C45/55	C55/67	Design formulas / references	
	Concrete strength classes					
$N^0_{Rrd,c}$	28,3	31,2	34,5	38,0	$N^0_{Rd,c}$= $K_{1,\gamma c}$ x $h_{ef}^{1,5}$	
$N^0_{Rrd,c, SF}$	11,2	12,3	13,6	15,0	$N^0_{Rd,c,SF}$ = $K_{1,SF}$ x $h_{ef}^{1,5}$ x $\alpha_{early\ strength}$	
Cracked $N_{Rd,c,\ cracked}$	14,1	15,6	17,2	19,0	$N_{Rd,c,cracked}$ = 0,7 x $N^0_{Rd,c}$ x A_{cN} / A^0_{cN}	$R_{2,\ ULS}$ = 14,56 kN
Max. compressive stress σ_c	148,000	180,000	220,000	268,000	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=6,0 x $f_{ck,cube}/\gamma_c$	Notice : C30/37 for F_{Ed} < 24,27 kN
Cracked $N_{Rrd,c,\ SF,\ cracked}$	5,6	6,2	6,8	7,5	$N_{Rd,c,SF,cracked}$ = 0,7 x $N^0_{Rd,c,SF}$ x A_{cN} / A^0_{cN}	$R_{2,\ Lifting}$ = 5,43 kN, capacity OK for C30/37
Max. compressive stress σ_c	58,5	71,1	86,9	105,9	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=6,0 x $f_{ck,cube}$ x $\alpha_{early\ strength}$/SF	Notice: Lifting capcity C30/37 : 800 kg

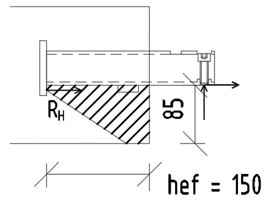
CEN/TS 1992-4-2, Figure 4, s_1 =	0 mm (one force)	Area of anchoring A_h: b=	10
distance to nearest egde a_1 =	45 mm	l=	15
h_{ef} =	50 mm	A_h =	150
Actual projected area A_{cN} =	18000 mm^2		
Anchoring depth h_{ef} = 50	A^0_{cN} (for $N^0_{Rd,c}$ or $N^0_{Rd,c,SF}$) = 22500	Reference projected area A^0_{cN} = (3 x h_{ef}) x (3 x h_{ef})	



Parameters	C30/37	C35/45	C45/55	C55/67	Design formulas / references	
	Concrete strength classes					
$N^0_{Rrd,c,\ SF}$	6,7	7,4	8,2	9,1	$N^0_{Rd,c,SF}$ = $K_{1,SF}$ x $h_{ef}^{1,5}$ x $\alpha_{early\ strenght}$	Case : Lifitng out of mold
Cracked $N_{Rrd,c,\ SF,\ cracked}$	3,77	4,16	4,60	5,08	$N_{Rd,c,SF,cracked}$ = 0,7 x $N^0_{Rd,c,SF}$ x A_{cN} / A^0_{cN}	$R_{2,\ Lifting}$ = 3,48 kN, capacity OK for C30/37
Max. compressive stress σ_c	58,5	71,1	86,9	105,9	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=6,0 x $f_{ck,cube}$ x $\alpha_{early\ strenght}$/SF	Notice: Lifting capacity C30/37 : 800 kg

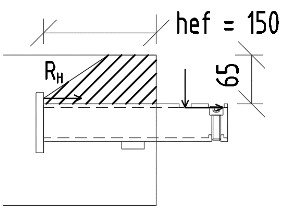
ANCHORING OF FORCE R_h

CEN/TS 1992-4-2, Figure 4, s_1 =	0 mm (one force)	Area of anchoring A_h: b=	30
distance to nearest egde a_1 =	85 mm, a_2 = 77,5 mm	l=	75
h_{ef} =	150 mm	A_h =	2250
Actual projected area A_{cN} =	38250 mm^2		
Anchoring depth h_{ef} = 150	A^0_{cN} (for $N^0_{Rd,c}$ or $N^0_{Rd,c,SF}$) = 202500	Reference projected area A^0_{cN} = (3 x h_{ef}) x (3 x h_{ef})	



Parameters	C30/37	C35/45	C45/55	C55/67	Design formulas / references	
	Concrete strength classes					
$N^0_{Rrd,c}$	88,7	97,8	108,1	119,3	$N^0_{Rd,c}$= $K_{1,\gamma c}$ x $h_{ef}^{1,5}$	
$N^0_{Rrd,c,\ SF}$	35,0	38,6	42,7	47,1	$N^0_{Rd,c,SF}$ = $K_{1,SF}$ x $h_{ef}^{1,5}$ x $\alpha_{early\ strenght}$	
Non-cracked $N_{Rd,c,\ non\text{-}cracked}$	16,7	18,5	20,4	22,5	$N_{Rd,c,non\text{-}cracked}$ = $N^0_{Rd,c}$ x A_{cN} / A^0_{cN}	$H_{Ed,\ ULS}$ = 4,0 kN, capacity Ok for C30/37
Max. compressive stress σ_c	207,200	252,000	308,000	375,200	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=8,4 x $f_{ck,cube}/\gamma_c$	
Non-cracked $N_{Rrd,c,\ SF,\ non\ cracked}$	6,6	7,3	8,1	8,9	$N_{Rd,c,SF,non\text{-}cracked}$ = $N^0_{Rd,c,\ SF}$ x A_{cN} / A^0_{cN}	$F_{H,lifting}$ = 5,79 kN, capacity Ok for C30/37
Max. compressive stress σ_c	81,9	99,6	121,7	148,2	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=8,4 x $f_{ck,cube}$ x $\alpha_{early\ strenght}$/SF	Notice: Lifting capacity C30/37 : 800 kg

CEN/TS 1992-4-2, Figure 4, s_1 =	0 mm (one force)	Area of anchoring A_h: b=	30
distance to nearest egde a_1 =	65 mm, a_2 = 57,5 mm	l=	75
h_{ef} =	150 mm	A_h =	2250
Actual projected area A_{cN} =	29250 mm^2		
Anchoring depth h_{ef} = 150	A^0_{cN} (for $N^0_{Rd,c}$ or $N^0_{Rd,c,SF}$) = 202500	Reference projected area A^0_{cN} = (3 x h_{ef}) x (3 x h_{ef})	



Parameters	C30/37	C35/45	C45/55	C55/67	Design formulas / references	
	Concrete strength classes					
$N^0_{Rrd,c}$	88,7	97,8	108,1	119,3	$N^0_{Rd,c}$= $K_{1,\gamma c}$ x $h_{ef}^{1,5}$	
$N^0_{Rrd,c,\ SF}$	35,0	38,6	42,7	47,1	$N^0_{Rd,c,SF}$ = $K_{1,SF}$ x $h_{ef}^{1,5}$ x $\alpha_{early\ strenght}$	Case : Lifitng out of mold
non-cracked $N_{Rrd,c,\ SF,\ non\text{-}cracked}$	5,1	5,6	6,2	6,8	$N_{Rd,c,SF,non\text{-}cracked}$ = $N^0_{Rd,c,\ SF}$ x A_{cN} / A^0_{cN}	$F_{H,lifting}$ = 5,79 kN, capacity ok for C45/55
Max. compressive stress σ_c	81,9	99,6	121,7	148,2	CEN/TS 1992-4-2, 6.2.4 (2) σ_c=8,4 x $f_{ck,cube}$ x $\alpha_{early\ strenght}$/SF	Notice: Lifing capacity C30/37=700 kg , C35/45=750 kg

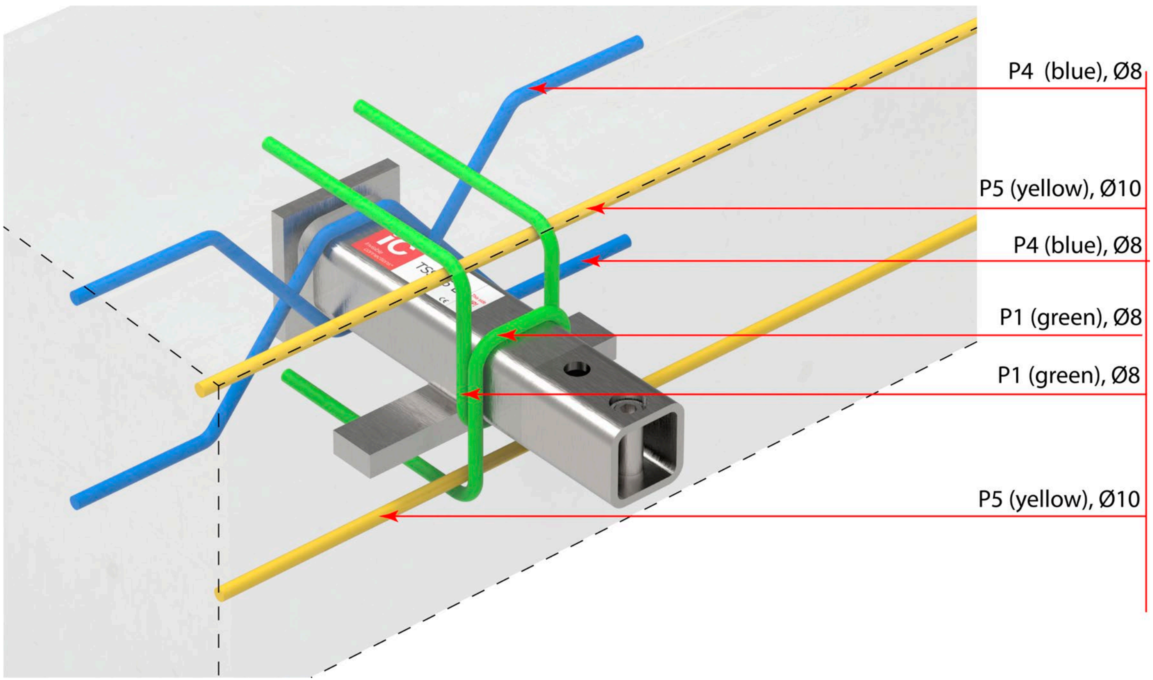
REINFORCEMENT FOR LIFT FROM 800 kg -1200 kg

Note : It is recommended a reinforcement for both forces R_1 (20,15 kN) and R_2 (8,15 kN).
The force R_h is taken care of by 2 Ø10 c150 stirrups (See fig 3)

Necessary cross section to maintain the force R_1 (20,15 kN) : $As_{lifting} = R_1/f_{yd,lifting}$ =20150 / 215 = 93,9 mm^2
Ie. Ø8 mm stirrup, As = 50,26 x 2 = 100,52 mm^2

Force R_2 : The same cross section as R_1
You can choose to use the same reinforcement in R1 and R2

Reinforcement guidance :

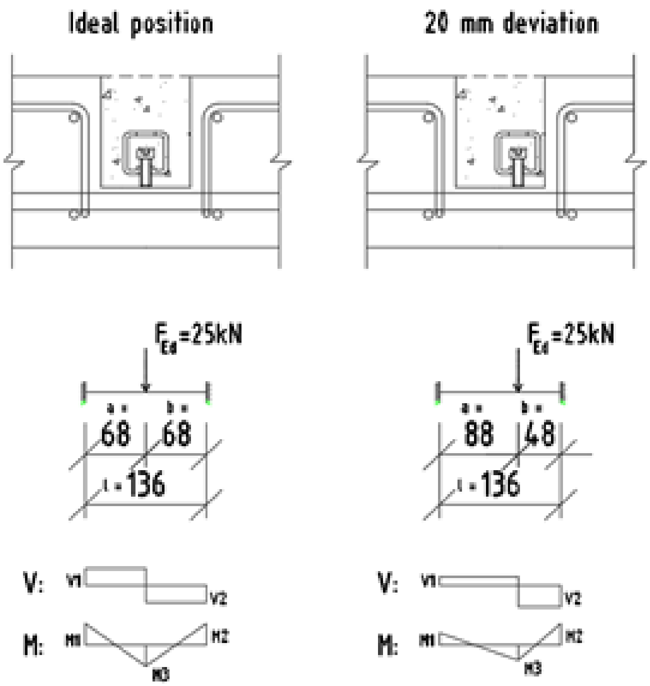


CAPACITY OVERVIEW

Load case	Concrete strength classes C30/37	C35/45	C45/55	C55/67
Ultimate limit state (ULS)	< 23 kN	25 kN		
Lifting out of mold / rotating the element	700 kg	750 kg	800 kg	800 kg
Lifting at building site	800 kg	800 kg	800 kg	800 kg
Reinforced lifting connection	1200 kg	1200 kg	1200 kg	1200 kg

PART 3 – EXAMPLE: LOCAL REINFORCEMENT AROUND RECESS IN LANDING

STATIC MODELS AND EQUILIBRIUM CALCULATIONS



Ideal position of the load F_{Ed} :

F_{Ed} = 25 kN
a= 68 mm
b= 68 mm
l= 136 mm

$V_{Ed,R2}$ = 12,50 kN
$V_{Ed,R1}$ = 12,50 kN

$M_{Ed,1}$ = 425,00 kNmm
$M_{Ed,3}$ = 425,00 kNmm
$M_{Ed,2}$ = 425,00 kNmm

20 mm deviation in position of load F_{Ed} :

F_{Ed} = 25 kN
a= 88 mm
b= 48 mm
l= 136 mm

$V_{Ed,R2}$ = 17,86 kN
$V_{Ed,R1}$ = 7,14 kN

$M_{Ed,1}$ = 274,05 kNmm
$M_{Ed,3}$ = 354,65 kNmm
$M_{Ed,2}$ = 502,42 kNmm

The largest shear force and the largest bending moment occur in the same section.

M_{Ed} = 502,42 kNmm
V_{Ed}= 17,86 kN

Assume that the entire load F_{Ed} is taken up in reinforcement without contribution from the concrete structure.
The main bar is calculated for a combinded loads M_{Ed} and V_{Ed}.

Reinforcement Ø20.

Capasity for the main bar due to bending moment :

$M_{Rd,s,1\ stang} = W f_{yd} =$ 341,5 kNmm < ME_d ⇒ 2 Ø20, $M_{Rd,s,tot}$ = 683,0 kNmm, OK

$W = \pi Ø^3/32 =$ 785,40 mm^3

$f_{yd} =$ 435 N/mm^2

Capasity for the main bar due to shear force :

$V_{Rd,s,1\ stang} = A_s f_{yd}/\sqrt{3} =$ 78,9 kN > V_{Ed} , OK Capasity of 2 bars $V_{Rd,s,tot}$ = 157,72 kN

$A_s =$ 314,16 mm^2

Combined loads : $(V_{Ed}/V_{Rd})^2 + (M_{Ed}/M_{Rd})^2 \leq 1{,}0$ 0,554 < 1,0 ok

Force V2 :

V2 = 17,86 kN

Necessary reinforcement: $A_{s2} = V2/\ f_{yd} =$ 41,1 mm^2, stirrup Ø8 : A_s = 100 mm^2

Stabilization of the bending moment M2

Distance from V2 to the end of the Ø20 bar; L_2 =120 mm

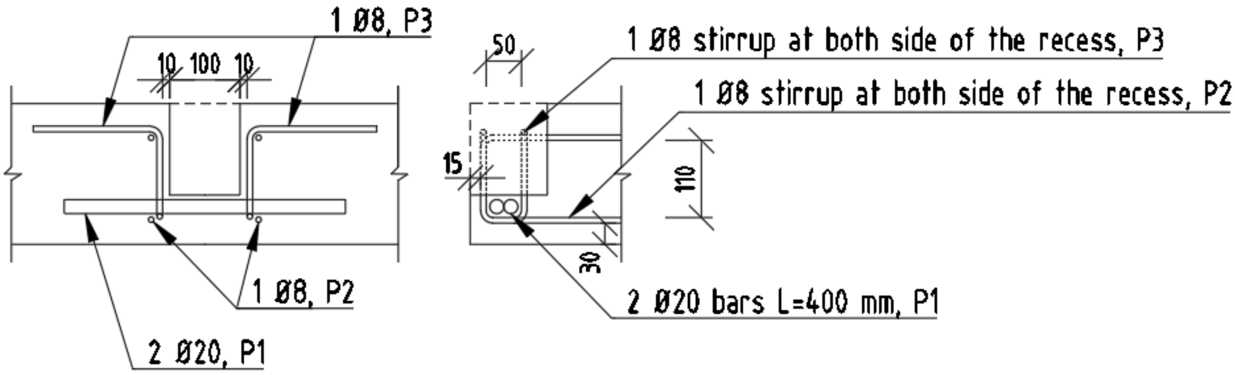
Force : $P = M_2 / L_2$ = 4,19 kN

Necessary area - concrete C30/37 : $\sigma = P/f_{cd,C30/37}$ = 246,29 mm^2 (area 10 mm x 25 mm)

$f_{cd,C30/37} =$ 17 N/mm^2

The force at the end of the bar is not large enough to be a main issue in the connection, hence not dimensioning.

LOCAL REINFORCEMENT



P1	Ø20 L= 400	
P2	310 / 115 / 310	Ø8
P3	180 / 135 / 180 / 135 / 70	Ø8

REVISION HISTORY	
Dato:	**Beskrivelse:**
13.10.2020	descriptive image anchouring 1200 kg
10.04.2015	First edition
08.01.2016	Included note on reinforcement ductility grade.
20.05.2016	New template
04.09.2019	Included horizontal friction force. Introduced reduced material factor $\gamma_{s,red2}$
24.01.2020	TSS25-L
27.03.2020	Include local reinforcement around recess in landing.
24.04.2020	Table – capacity overview. Small revision of text, page 6
28.09.2020	Lifing capacity – 1200 kg