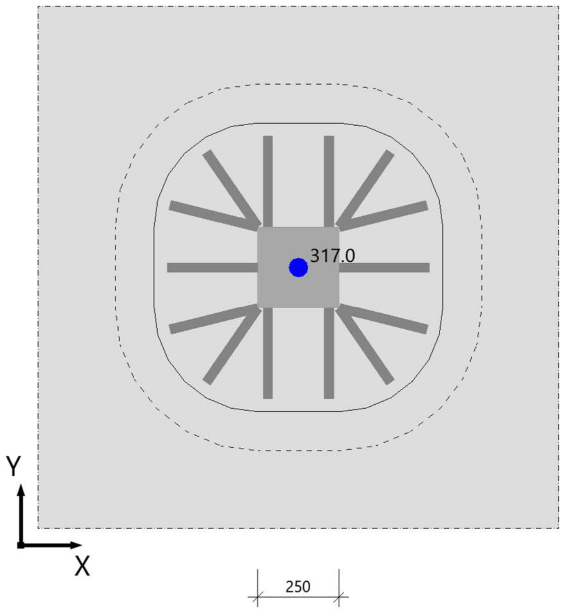
Item: B6+ Hand Calculation_RFA

RFA-Tech Sheartech Design Software (x64) B6+ RFA 02/22B (FRILO R-2022-2/P06)

Click on the blue numbered buttons to jump to the associated Output/Hand calculated position

System

Graphics



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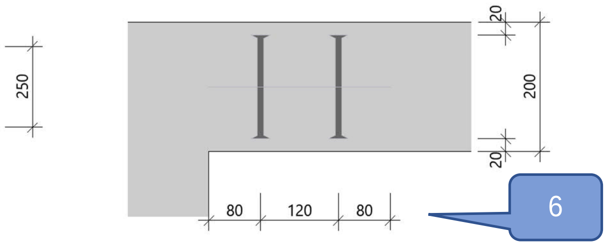

u1
u-out, Dx-out = 1130 mm
Dy-out = 1130 mm

Geometry and Material

Slab	h =	200	mm	d_m =	160	mm
Intern. column	c_x =	250	mm	c_y =	250	mm
Concrete covering	c_u =	20	mm	c_o =	20	mm

Materials	Concrete:	C 20/25		Steel:	B 500A	
	γ_c =	1.50		γ_s =	1.15	
	f_{ck} =	20.0	N/mm²	f_{yk} =	500.0	N/mm²

Longitudinal reinforcement ratio (**ρ** per direction) :

max. reinforc. ratio	permρ ≤	2.000 %	=	3200 mm²/m
exist reinforc. ratio	existρ =	0.963 %	=	1541 mm²/m

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Reinforced areas :

cal. reinforcement width	cal b_q =	1000	mm
required installation width in the y-direction for A_{sx}	req b_{gy} ≥	1606	mm
required installation width in the x-direction for A_{sy}	req b_{gx} ≥	1606	mm

Loads

Given shear force	V_E =	317.0	kN (= V_{Ed})
Increase	β =	1.150	
Pretension	σ_{cd} =	0.500	N/mm²(Compression)

Results

Punching through NA to BS EN 1992-1-1/A2:2015-07

CHECK for RFA-TECH strips acc.to TA7 5028

Loaded area perimeter	u_0	=	1000	mm (at a= 0 mm)
Design shear force	$v_{Ed,u0}$	=	2.278	N/mm^2
max. design resistance	$v_{Rd,max}$	=	3.680	N/mm^2 5
basic control perimeter	u_1	=	3011	mm (at a= 320 mm) 2
Design shear force	v_{Ed}	=	0.757	N/mm^2 3
Prefactor	$C_{Rd,c}$	=	0.120	
Scale factor	k	=	2.000	
Coefficient	k_1	=	0.100	
Design resistance	$v_{Rd,c}$	=	0.693	N/mm^2(with a proportion ofσ_{cd}) 4
	v_{min}	=	0.493	N/mm^2(with a proportion ofσ_{cd})
	$v_{Rd,c}^*$	=	0.643	N/mm^2(without a part ofσ_{cd})
Load capacity (concrete + steel)	$v_{Rd,cs}$	=	1.844	N/mm^2> v_{Ed}

Result: $v_{Rd,c}< v_{Ed}\leq 2 * v_{Rd,c}$, $v_{Ed,u0}\leq v_{Rd,max}$Punching shear reinforcement required

Punching shear reinforcement with RFA-TECH Punching Shear Stud System according to CARES Technical Approval Report TA7 5028

outer control	req u_{out}	=	3199	mm		req. L_s	=	160	mm
	exist u_{out}	=	3765	mm 7		exist L_s	=	200	mm

Increase	β	=	1.150	
Design shear force	v_{Ed}	=	0.605	N/mm^2
Coefficient	k_1	=	0.150	
Design resistance	$v_{Rd,c}$	=	0.718	N/mm^2(with a proportion
	v_{min}	=	0.518	N/mm^2(with a proportion
	$v_{Rd,c}^*$	=	0.643	N/mm^2(without a part ofσ_{cd})

max perm. distance*)	at 2 * d_m	=	240	mm ≥	exist.distance*)	at 2 * d_m	=	227	mm
	at L_s	=	320	mm ≥		at L_s	=	188	mm
max perm. distance**)	on stud	=	120	mm ≥	exist.distance**)	on stud	=	120	mm

Note: L_s is the distance from the column edge to the outermost one studs. *) Maximum permissible or existing distance of the Anchor in the tangential direction at a radial distance of 2 * dm or Ls from the column edge. **) Maximum permissible or existing distance of the Anchor on the strip (in the radial direction).

Studs : B 500C, $f_{yw,ef}$= 314.8 N/mm^2, Ø= 10 mm, Height = 160 mm 8
There are 14 Strips available, with each 2 studs per strip.
Covering above/ below Studs : c_{bot}= 20 mm, c_{top}= 20 mm

Selected type of rails per column :
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The longitudinal reinforcement is to be anchored outside the outermost perinmeter.

Calculation by hand

Building materials and reinforcement

Concrete: C20/25 $f_{cd} = \propto_{cc} \cdot \frac{f_{ck}}{\gamma_c} = 0{,}85 \cdot \frac{20}{1{,}5} = 11{,}33\ {}^{N}/_{mm^2}$

Reinforcement Steel: B 500 A $f_{yd} = \frac{f_{yk}}{\gamma_S} = \frac{500}{1{,}15} = 435\ {}^{N}/_{mm^2}$

Reinforcement: out of static analysis of the slab: ∅14/10

$a_{sx} = a_{sy}$ = 154 mm²/m

Geometry and loading

Slap depth = 200 mm

Static height d_m = 160 mm

Column thickness and width c_x/c_y = 250/250 mm

Loading: V_{Ed} = 317 kN

Compressive stress from prestressing in slab:

σ_{cp} = 0,5 N/mm²

Reinforcement ratio slab averaged (EN 1992 (6.4.4):

$$\rho_{l=\sqrt{\rho_{lz} \cdot \rho_{ly}}} = \frac{a_s}{A_c \cdot d} = \frac{154}{100 \cdot 160} = 0{,}0096$$

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$$< \begin{cases} 0{,}02 \\ 0{,}4 \cdot \frac{f_{cd}}{f_{yd}} = 0{,}4 \cdot \frac{11{,}33}{435} = 0{,}010 \end{cases}$$

Basic control perimeter (EN 1992 (6.4):

Distance from loaded area: $r = 2{,}0 \cdot d_m = 2{,}0 \cdot 160 = 320$ mm

Length of the basic control perimeter: $u1 = 4 \cdot a + 2 \cdot \pi \cdot r = 4 \cdot 250 + 2 \cdot \pi \cdot 320 = 3011$ mm

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Maximum punching shear stress at the control perimeter (6.4.3):

$$v_{Ed,u1} = \frac{\beta \cdot V_{Ed}}{u_1 \cdot d} = \frac{1{,}15 \cdot 317}{3{,}01 \cdot 0{,}16} = 757{,}0 \frac{kN}{m^2} = 0{,}757\ MN/m^2 \qquad (6.38)$$

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Punching shear resistance without shear reinforcement (6.4.4):

$$v_{Rd,c} = C_{Rd,c} \cdot k \cdot (100 \cdot \rho_l \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \geq (v_{min} + k_1 \cdot \sigma_{cp}) \qquad (6.47)$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{160}} \leq 2{,}0$$

$$v_{Rd,c} = \frac{0{,}18}{1{,}5} \cdot 2{,}0 \cdot (100 \cdot 0{,}0096 \cdot 20)^{\frac{1}{3}} + 0{,}1 \cdot 0{,}5 = 0{,}693\ MN/m^2$$

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$$v_{min} = 0{,}035 \cdot k^{\frac{3}{2}} \cdot f_{ck}^{\frac{1}{2}} = 0{,}035 \cdot 2{,}0^{\frac{3}{2}} \cdot 20^{\frac{1}{2}} + 0{,}1 \cdot 0{,}5 = 0{,}493\ MN/m^2$$

$$v_{Ed,u1} = 0{,}757 \frac{MN}{m^2} > v_{Rd,c} = 0{,}693 \frac{MN}{m^2}$$

Shear reinforcement required.

Punching shear resistance with shear reinforcement (6.4.5):

Evidence of maximum punching shear resistance $v_{Rd,max}$

$$v_{Ed} = \frac{\beta \cdot V_{Ed}}{u_0 \cdot d} = \frac{1{,}15 \cdot 317}{4 \cdot 0{,}25 \cdot 0{,}16} = 2278{,}4 \frac{KN}{m^2} = 2{,}278\ MN/m^2$$

$$v_{Rd,max} = 0{,}5 \cdot \nu \cdot f_{cd}$$

$$\nu = 0{,}6 \cdot \left[1 - \frac{f_{ck}}{250}\right] = 0{,}6 \cdot \left[1 - \frac{20}{250}\right] = 0{,}552$$

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$$f_{cd} = \frac{f_{ck}}{\gamma_C} = \frac{20}{1{,}5} = 13{,}3\ MN/m^2$$

$$v_{Rd,max} = 0{,}5 \cdot 0{,}552 \cdot 13{,}3 = 3{,}68\ MN/m^2$$

$$v_{Ed} \leq v_{Rd,max}$$

Required shear reinforcement

$$v_{Rd,cs} = 0{,}75 \cdot v_{Rd,cs} + 1{,}5 \cdot \left(\frac{d}{s_r}\right) \cdot A_{sw} \cdot f_{ywd,ef} \cdot \left(\frac{1}{u_1 \cdot d}\right) \cdot sin\alpha \qquad (6.52)$$

$$f_{ywd.ef} = \min \begin{cases} 250 + 0{,}25 \cdot d = 250 + 0{,}25 \cdot 160 = 290 \dfrac{N}{mm^2} \\ f_{ywd} = 435\ N/mm^2 \end{cases}$$

For $v_{Ed} = v_{Rd,cs}$ after rearranging the equation (6.52)

$$A_{sw} = \frac{(v_{Ed} - 0{,}75 \cdot v_{Rd,c}) \cdot d \cdot u_1}{1{,}5 \cdot \left(\frac{d}{s_r}\right) \cdot f_{ywd,ef} \cdot sin\alpha} = \frac{(0{,}757 - 0{,}75 \cdot 0{,}643) \cdot 160 \cdot 3010}{1{,}5 \cdot \left(\frac{160}{0{,}75 \cdot 160}\right) \cdot 290 \cdot 1{,}0} = 228{,}1\ mm^2 = 2{,}28\ cm^2$$

Control perimeter u_{out}, at which shear reinforcement is not required

$$req.u_{out} = \frac{\beta \cdot V_{Ed}}{v_{Rd,c} \cdot d} \quad (6.54)$$

$$v_{Rd,c} = C_{Rd,c} \cdot k \cdot (100 \cdot \rho_l \cdot f_{ck})^{1/3} = \frac{0{,}18}{1{,}5} \cdot 2{,}0(100 \cdot 0{,}0096 \cdot 20)^{1/3} = 0{,}643\ MN/m^2 \qquad (6.2)$$

$$req.u_{out} = \frac{1{,}15 \cdot 0{,}317}{0{,}643 \cdot 0{,}16} = 3{,}55\ m = 3550\ mm$$

Arrangement of the shear reinforcement (9.4.3)

Radial

1.Row:	0,5	·d	from loaded area:	0,5	·160 = 80 mm
2.Row:	0,75	·d	from loaded area:	0,75	·160 = 120 mm
Distance from second row to u_{out}: 1,5·d=				1,5	·160 = 240 mm

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Existing $u_{out} = 4 \cdot a + 2 \cdot \pi \cdot r = 4 \cdot 250 + 2 \cdot \pi \cdot (0{,}5 + 0{,}75 + 1{,}5) \cdot 160 =$ 3765 mm > 3550 mm

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Tangential

Maximum spacing of link legs: 1,5 · d = 1,5 · 160 = 240 mm

Length of the first control parameter at a = 2 · d from loaded area:

$u = 4 \cdot a + 2 \cdot \pi \cdot r = 4 \cdot 250 + 2 \cdot \pi \cdot 2 \cdot 160$ = 3011 mm

Required number of shear rails: 3011 : 240 = 12,5 rails

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Choosen number of shear rails: 14 rails

Existing A_s = 14 Ø 10 = 14 · 78,5 = 1100 mm² > req. A_s = 228 mm²