1 Demo

Standard

Calculation standard **EN 1992-1-1/Czech Rep.**.

Concrete capacity - basic load combination	:	γ_C	= 1,50
Reinforcement capacity - basic load combination	:	γ_S	= 1,15
Maximal stress in joint CCC	:	k_1	= 1,00
Maximal stress in joint CCT	:	k_2	= 0,85

2 indirect supported corbel

2.1 Input data

Materials

Exposure class :	X0		
Concrete :	**C 25/30**		
Cylinder compressive strength	f_{ck}	= 25,0	MPa
Tensile strength	f_{ct}	= 2,6	MPa
Elasticity modulus	E_{cm}	= 3,100E+04	MPa
Longitudinal reinf. :	**B500**		
Yield strength	f_{yk}	= 500,0	MPa
Elasticity modulus	E_s	= 2,000E+05	MPa
Shear reinf. :	**B500**		
Yield strength	f_{yk}	= 500,0	MPa
Elasticity modulus	E_s	= 2,000E+05	MPa

Dimensions

Corbel length : l_c = 250,0 mm
Corbel height : h_c = 400,0 mm
Beam width : b_b = 400,0 mm
Beam height : h_b = 800,0 mm
Width : b = 350,0 mm

Slide plate

Height : Δh = 20,0 mm
Length : l_p = 120,0 mm
Width : b_p = 300,0 mm

8 × Diameter 20 mm - Cover 30 mm

Beam reinforcement

Cover: 34 mm
Reinf. diameter: 20 mm
Links diameter: 12 mm

Vertical strirrups

4 × Diameter 10 mm - Count of legs 2

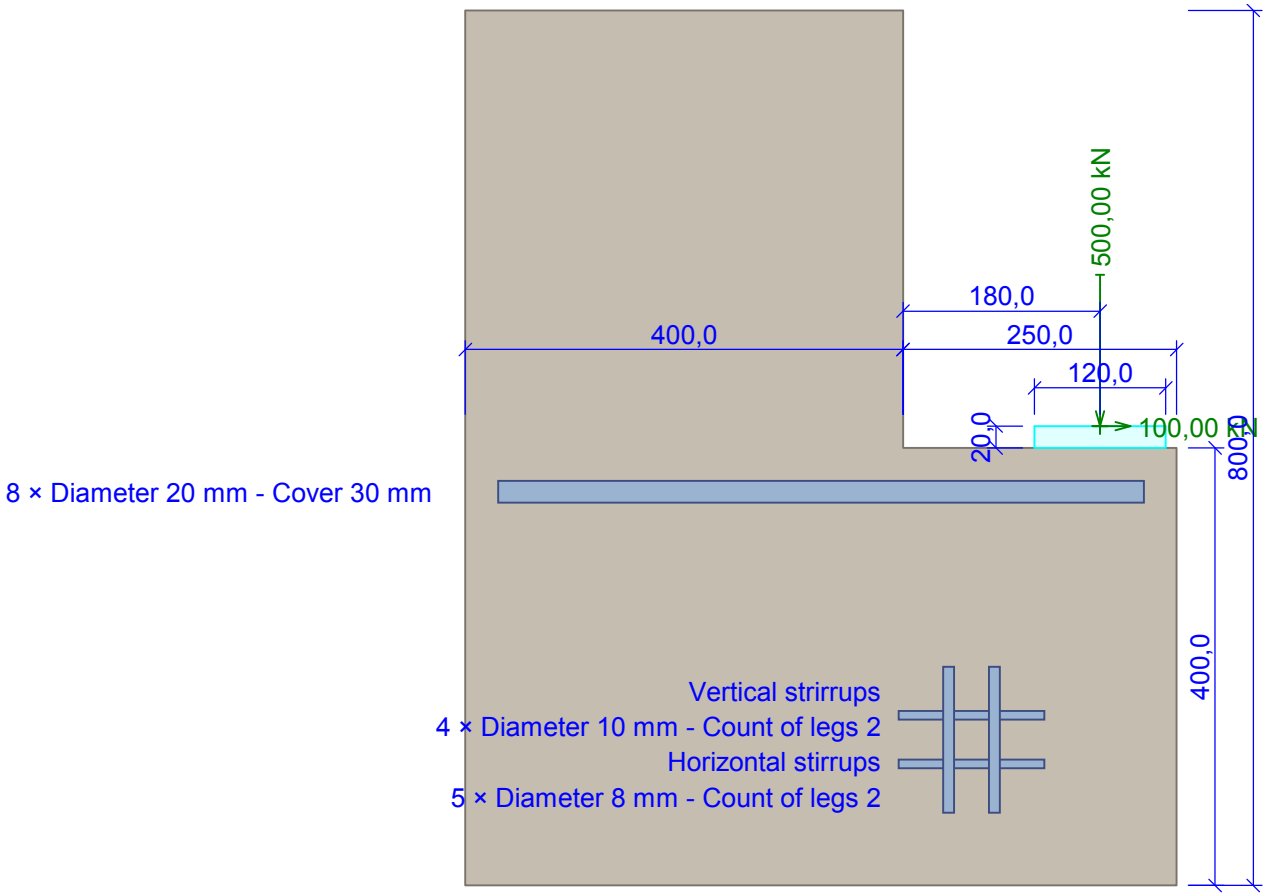
Horizontal stirrups

5 × Diameter 8 mm - Count of legs 2

Vertical force : F_{Ed} = 500,00 kN
Horizontal force : H_{Ed} = 100,00 kN

Eccentricity : a_c = 180,0 mm

Scheme



2.2 Results

	$\nu' = 1 - f_{ck} / 250 = 1 - 25 / 250 = 0,9$
	$f_{cd} = \alpha_{cc} \times f_{ck} / \gamma_C = 1 \times 25 / 1,5 = 16,67$ MPa
Maximal stress in joint type CCC	$\sigma_{Rd,max} = k_1 \times \nu' \times f_{cd} = 0,85 \times 0,9 \times 16,67 = 12,75$ MPa
Compressed area width	$x_1 = F_{Ed} / b / \sigma_{Rd,max} = 500 / 350 / 12,75 = 112$ mm
	$d' = c + 0,5 \times \varnothing = 30 + 0,5 \times 20 = 40$ mm
Outer force arm	$a = a_c + 0,5 \times x_1 + H_{Ed} / F_{Ed} \times (d' + \Delta h) = 180 + 0,5 \times 112 + 0,2 \times (40 + 20) = 248$ mm
	$d = 0,36 - c - 12 - 20 / 2 = 0,36 - 34 - 12 - 20 / 2 = 304$ mm
Compressed area height	$y_1 = d - \sqrt{(d^2 - 2 \times x_1 \times a)} = 304 - \sqrt{(304^2 - 2 \times 112 \times 248)} = 112,1$ mm
	$d = 0,36 - c - 12 - 20 / 2 = 0,36 - 34 - 12 - 20 / 2 = 304$ mm
Inner lever arm	$z = d - 0,5 \times y_1 = 304 - 0,5 \times 112,1 = 248$ mm
Main tension force	$F_t = F_{Ed} \times a / z + H_{Ed} = 500 \times 248 / 248 + 100 = 600,1$ kN
	$f_{yd} = f_{yk} / \gamma_S = 500 / 1,15 = 434,8$ MPa
Required area of main reinforcement	$A_{sl,req} = F_t / f_{yd} = 600,1 / 434,8 = 1\,380$ mm^2
Specified area of main reinforcement	$A_{sl} = 2\,513$ mm^2 $\geq A_{sl,req} = 1\,380$ mm^2 $\Rightarrow$ **PASS** 54,9 %
Compression chord inclination	$\theta = 44,99$ °
Force in compression chord	$F = F_{Ed} / \sin(\theta) = 500 / \sin(44,99) = 707,2$ kN
	$C_{Rd,c} = 0,18 / \gamma_C = 0,18 / 1,5 = 0,12$
	$d = 0,36 - c - 12 - 20 / 2 = 0,36 - 34 - 12 - 20 / 2 = 304$ mm
	$k = \min(1 + \sqrt{(200 / d)}; 2) = \min(1 + \sqrt{(200 / 304)}; 2) = 1,811$
	$\rho_l = \min(A_{sl} / (b \times d); 0,02) = \min(2\,513 / (350 \times 304); 0,02) = 0,02$

	$v_{min} = 0,035 \times k^{1,5} \times \sqrt{f_{ck}} = 0,035 \times 1,811^{1,5} \times \sqrt{25} = 0,427$ MPa
	$\sigma_{cp} = \min(-H_{Ed} / (h \times b); 0,2 \times f_{cd}) = \min(-100 / (344 \times 350); 0,2 \times 16,67) = -0,831$ MPa
Resistance without shear reinf.	$V_{Rdc} = (\max(C_{Rd,c} \times k \times \sqrt[3]{(100 \times \rho_l \times f_{ck})}; v_{min}) + k_1 \times \sigma_{cp}) \times b \times d = (\max(0,12 \times 1,811 \times \sqrt[3]{(100 \times 0,02 \times 25)}; 0,427) + 0,15 \times (-0,831)) \times 350 \times 304 = 71,93$ kN
	$l = \sqrt{(a^2 + z^2)} = \sqrt{(248^2 + 248^2)} = 350,7$ mm
Transverse tension force	$T = 1 / 4 \times [1 - 0,7 \times \sqrt{(x_1^2 + y_1^2)} / l] \times F = 0,25 \times [1 - 0,7 \times \sqrt{(112^2 + 112,1^2)} / 350,7] \times 707,2 = 120,9$ kN
Requirement according to chapter 6.2	$A_{sv,req} = \beta \times F_{Ed} / f_{yd} = 0,25 \times 500 / 434,8 = 287,5$ mm^2
Vertical component of tension force	$T_{vert} = 2,4 \times T \times \cos(\theta) = 2,4 \times 120,9 \times \cos(44,99) = 205,2$ kN
Requirement according to chapter 6.5	$A_{sv,req} = T_{vert} / f_{yd} = 205,2 / 434,8 = 471,9$ mm^2
Specified area of vertical reinforcement	$A_{sv} = 628,3$ mm^2 $\geq A_{sv,req} = 471,9$ mm^2 $\Rightarrow$ **PASS** 75,1 %
It required at least 287,5 mm^2 (2× stirrup) place in the middle three-quarters of the area between the column and the slide plate	
Horizontal component of tension force	$T_{horz} = 2,4 \times T \times \sin(\theta) = 2,4 \times 120,9 \times \sin(44,99) = 205,1$ kN
Requirement according to chapter 6.5	$A_{sh,req} = T_{horz} / f_{yd} = 205,1 / 434,8 = 471,8$ mm^2
Specified area of horizontal reinforcement	$A_{sh} = 502,7$ mm^2 $\geq A_{sh,req} = 471,8$ mm^2 $\Rightarrow$ **PASS** 93,9 %