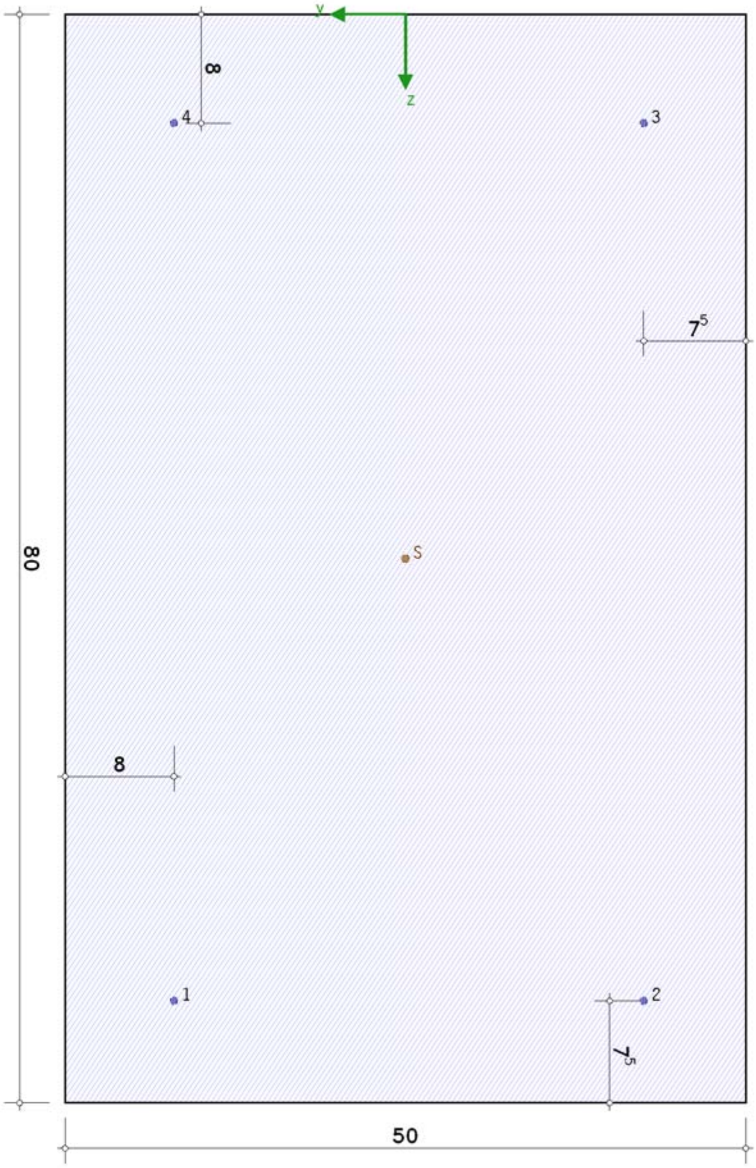
POS. 24: RECTANGLEQUERSCHNITT

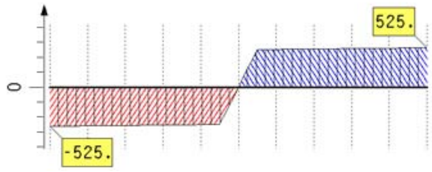
reinforced concrete design EC 2 (1.11), NA: Deutschland 4H-EC2QB Version: 10/2023-1b

1. input protocol



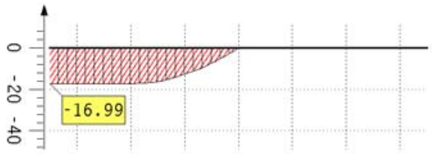
1.1. building material

reinforcing steel B500A, concrete C30/37
stress-strain line of reinforcing steel: EC 2-1-1, 3.2.7 (bilinear)



σ in N/mm²
ε in ‰
max ε = 25.00
max σ = 525.00

stress-strain line of concrete: EC 2-1-1, 3.1.7 (parabola-rectangle diagram)



σ in N/mm²
ε in ‰
min ε = -3.50
min σ = -16.99

1.2. material safety factors

design situation: basic combination
design resistance: concrete γ_c = 1.50, reinforcement γ_s = 1.15

1.3. cross section

rectangle: h = 80.0 cm, b = 50.0 cm
reinforcement variant 2: single reinforcement bar

no	y cm	z cm	Grp	A_{s0} cm²	A_{s1} cm²	Rng
1	17.0	72.5	1	0.00	10.00	-
2	-17.5	72.5	2	0.00	10.00	-
3	-17.5	8.0	3	0.00	10.00	-
4	17.0	8.0	4	0.00	10.00	-

y,z: coordinates relative to origin; Grp: reinforcement group; A_{s0}: base/minimum reinforcement; A_{s1}: maximum reinforcement
Rng: design sequence of reinforcement groups variable per load case

axis distances: d_o = 8.0 cm, d_u = 7.5 cm, d_l = 8.0 cm, d_r = 7.5 cm
max. reinforcement ratio ρ_s = 8.00%

1.4. durability and concrete cover

minimum strength class, concrete cover
due to reinforcement corrosion X0 ⇒ C12/15, c_{min} = 10 mm (≥ $Ø_s$!!), Δc = 10 mm, $c_{nom} = c_{min}+\Delta c$ = 20 mm
minimum concrete quality C12/15 with f_{ck} = 12.0 N/mm² < 30.0 N/mm² ok

1.5. design parameters

1.5.1. bending/shear design

1.5.1.1. bending design
minimum reinforcement for beams
ranking automatically (variable per load case)
minimum center of compression normal force

1.5.1.2. shear design
reinforcing steel like flexural reinforcemant
shear force
angle of the shear force reinforcement α = 90°
simplified approach of the compression strut angle
with minimum reinforcement (beam)
inner lever arm $z = 0.9 \cdot d \le d-2 \cdot c_{v,l} \le d-c_{v,l}-3$ cm
with concrete cover to longitudinal reinforcement in the compress. zone $c_{v,l}$ = 3.0 cm
limit the design value of the shear force resistance without shear force reinforcement $V_{Rd,c}$
torsion
effective thickness of a wall t_{eff} acc. to design code

1.5.1.3. design calculation values

lc	N_{Ed} kN	$M_{y,Ed}$ kNm	$V_{z,Ed}$ kN	$M_{z,Ed}$ kNm	$V_{y,Ed}$ kN	
1	-742.03	39.43	-9.86	-174.55	-38.24	Import lc 1
2	-96.56	-270.04	52.51	24.01	6.00	Import lc 2
3	-691.63	34.01	-8.50	-266.32	-57.58	Import lc 3
4	-655.63	39.43	-9.86	-29.08	-7.27	Import lc 4
5	-240.56	-270.04	52.51	-218.45	-45.61	Import lc 5
6	-218.99	15.83	-3.96	-8.68	-2.17	Import lc 6
7	-668.58	-132.09	24.02	-154.94	-33.33	Import lc 7
8	-534.56	-255.29	48.82	-232.62	-49.16	Import lc 8
9	-253.63	19.26	-4.81	-9.69	-2.42	Import lc 9

2. note

shear design: in the case of biaxial loading, each direction is examined separately

3. bending/shear design

material properties
bending design:
concrete acc. to EC 2, 3.1.7(1): C30/37, ε_{c2} = -2.00‰, ε_{cu2} = -3.50‰, f_{cd} = 17.00 N/mm²
σ-ε line acc. to EC 2, 3.2.7(2a): B500A, ε_{ud} = 25.0‰, f_{yd} = 434.78 N/mm², f_{td} = 456.52 N/mm², E_s = 200000.0 N/mm²
shear design:
σ-ε line acc. to EC 2, 3.2.7(2a): B500A, ε_{ud} = 25.00‰, f_{yd} = 434.78 N/mm², f_{td} = 456.52 N/mm², E_s = 200000.0 N/mm²

3.1. results table

lc	N_{Ed} kN	$M_{y,Ed}$ kNm	$V_{z,Ed}$ kN	$M_{z,Ed}$ kNm	$V_{y,Ed}$ kN	A_{s1} cm²	A_{s3} cm²	A_{s4} cm²	a_{sbV} cm²/m	
1	-742.03	39.43	-9.86	-174.55	-38.24	0.36	---	0.36	7.41	
2	-96.56	-270.04	52.51	24.01	6.00	---	3.75	3.75	7.41	
3	-691.63	34.01	-8.50	-266.32	-57.58	3.59	---	3.59	7.41	
4	-655.63	39.43	-9.86	-29.08	-7.27	---	---	---	7.41	
5	-240.56	-270.04	52.51	-218.45	-45.61	0.31	---	10.00	7.41	
6	-218.99	15.83	-3.96	-8.68	-2.17	0.00	0.00	0.00	7.41	
7	-668.58	-132.09	24.02	-154.94	-33.33	---	---	0.98	7.41	
8	-534.56	-255.29	48.82	-232.62	-49.16	---	---	7.86	7.41	
9	-253.63	19.26	-4.81	-9.69	-2.42	0.00	0.00	0.00	7.41	
		0.00		-96.55		2.35	---	2.35		min reinf.
		-154.48		0.00		---	2.19	2.19		min reinf.

N, M_y, V_z, M_z, V_y: design calculation values; A_s: flexural reinforcement; a_{sbV}: shear reinforcement

3.2. lc 5 (decisive)

3.2.1. bending design (EC 2, 6.1)

design calculation values: N_{Ed} = -240.56 kN, $M_{y,Ed}$ = -270.04 kNm, $M_{z,Ed}$ = -218.45 kNm
limit strains: ε_{c1} = -3.500‰, ε_{s1} = -1.555‰, ε_{s2} = 8.820‰, ε_{c2} = 10.895‰, α_k = 347.31°
design aid values: d = 56.8 cm, z = 58.7 cm, x = 16.13 cm
reinforcement (bending/normal force): A_{s1} = 0.31 cm², A_{s2} = 0.00 cm², A_{s3} = 0.00 cm², A_{s4} = 10.00 cm²

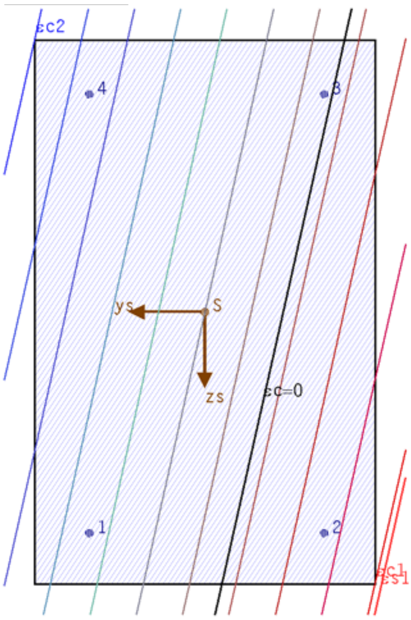
messages for calculation run

bending design: bar-shaped compression member

notes

the longitudinal reinforcement of bar-shaped compression members is to be enclosed by shear reinforcement acc. to EC 2, 9.5.3

limit strains



limit strains: ε_{c1} = -3.500‰, ε_{s1} = -1.555‰, ε_{s2} = 8.820‰, ε_{c2} = 10.895‰, α_k = 347.31°

3.2.2. shear design (EC 2, 6.2) - each in the coordinate directions

shear force in y-direction

design shear force $V_{y,Ed}$ = 45.61 kN
design aid values: ρ_{ly} = 0.31%, z_y' = 36.0 cm, $V_{y,Rd,c}$ = 165.77 kN, Θ_y = 39.81°, $V_{y,Rd,max}$ = 1805.90 kN, AB_y = 1 for $V_{y,Ed}/V_{y,Rd,max}$ = 0.025, $\Delta F_{ys,Ed}$ = 27.37 kN
reinforcement $a_{sbv,y}$ = 7.41 cm²/m

shear force in z-direction

design shear force $V_{z,Ed}$ = 52.51 kN
design aid values: ρ_{lz} = 0.29%, z_z' = 64.8 cm, $V_{z,Rd,c}$ = 138.57 kN, Θ_z = 39.81°, $V_{z,Rd,max}$ = 2031.64 kN, AB_z = 1 for $V_{z,Ed}/V_{z,Rd,max}$ = 0.026, $\Delta F_{zs,Ed}$ = 31.51 kN
reinforcement $a_{sbv,z}$ = 4.63 cm²/m

reinforcement total

a_{sbv} = 7.41 cm²/m

messages for calculation run

shear design: minimum reinforcement (s. EC 2, 9.2.2)
shear design: longitudinal reinforcement considered

3.3. result

resulting reinforcement: A_{s1} = 3.59 cm², A_{s2} = 0.00 cm², A_{s3} = 3.75 cm², A_{s4} = 10.00 cm²
a_{sbV} = 7.41 cm²/m, a_{sbT} = 0.00 cm²/m, A_{sT} = 0.00 cm²

4. final result

maximum reinforcement: A_{s1} = 3.59 cm², A_{s2} = 0.00 cm², A_{s3} = 3.75 cm², A_{s4} = 10.00 cm²
a_{sbV} = 7.41 cm²/m, a_{sbT} = 0.00 cm²/m, A_{sT} = 0.00 cm²

design resistance ensured

5. selected reinforcement

concrete cover c_V = 5.0 cm

group 1: minimum strength class, concrete cover for $Ø_s$ = 25 mm, $Ø_{sb}$ = 10 mm
due to reinforcement corrosion X0 ⇒ C12/15, c_{min} = $Ø_s$ = 25 mm, Δc = 10 mm, c_{nom} = c_{min}+Δc = 35 mm < c_V = 50 mm ok
minimum concrete quality C12/15 with f_{ck} = 12.0 N/mm² < 30.0 N/mm² ok
minimum axial spacing min d = c_V+$Ø_{sb}$+$Ø_s$/2 = 73 mm < clc d = 75 mm ok
group 2: minimum strength class, concrete cover for $Ø_s$ = 25 mm, $Ø_{sb}$ = 10 mm
due to reinforcement corrosion X0 ⇒ C12/15, c_{min} = $Ø_s$ = 25 mm, Δc = 10 mm, c_{nom} = c_{min}+Δc = 35 mm < c_V = 50 mm ok
minimum concrete quality C12/15 with f_{ck} = 12.0 N/mm² < 30.0 N/mm² ok
minimum axial spacing min d = c_V+$Ø_{sb}$+$Ø_s$/2 = 73 mm < clc d = 75 mm ok
group 3: minimum strength class, concrete cover for $Ø_s$ = 25 mm, $Ø_{sb}$ = 10 mm
due to reinforcement corrosion X0 ⇒ C12/15, c_{min} = $Ø_s$ = 25 mm, Δc = 10 mm, c_{nom} = c_{min}+Δc = 35 mm < c_V = 50 mm ok
minimum concrete quality C12/15 with f_{ck} = 12.0 N/mm² < 30.0 N/mm² ok
minimum axial spacing min d = c_V+$Ø_{sb}$+$Ø_s$/2 = 73 mm < clc d = 75 mm ok
group 4: minimum strength class, concrete cover for $Ø_s$ = 28 mm, $Ø_{sb}$ = 10 mm
due to reinforcement corrosion X0 ⇒ C12/15, c_{min} = $Ø_s$ = 28 mm, Δc = 10 mm, c_{nom} = c_{min}+Δc = 38 mm < c_V = 50 mm ok
minimum concrete quality C12/15 with f_{ck} = 12.0 N/mm² < 30.0 N/mm² ok
minimum axial spacing min d = c_V+$Ø_{sb}$+$Ø_s$/2 = 74 mm < clc d = 80 mm ok

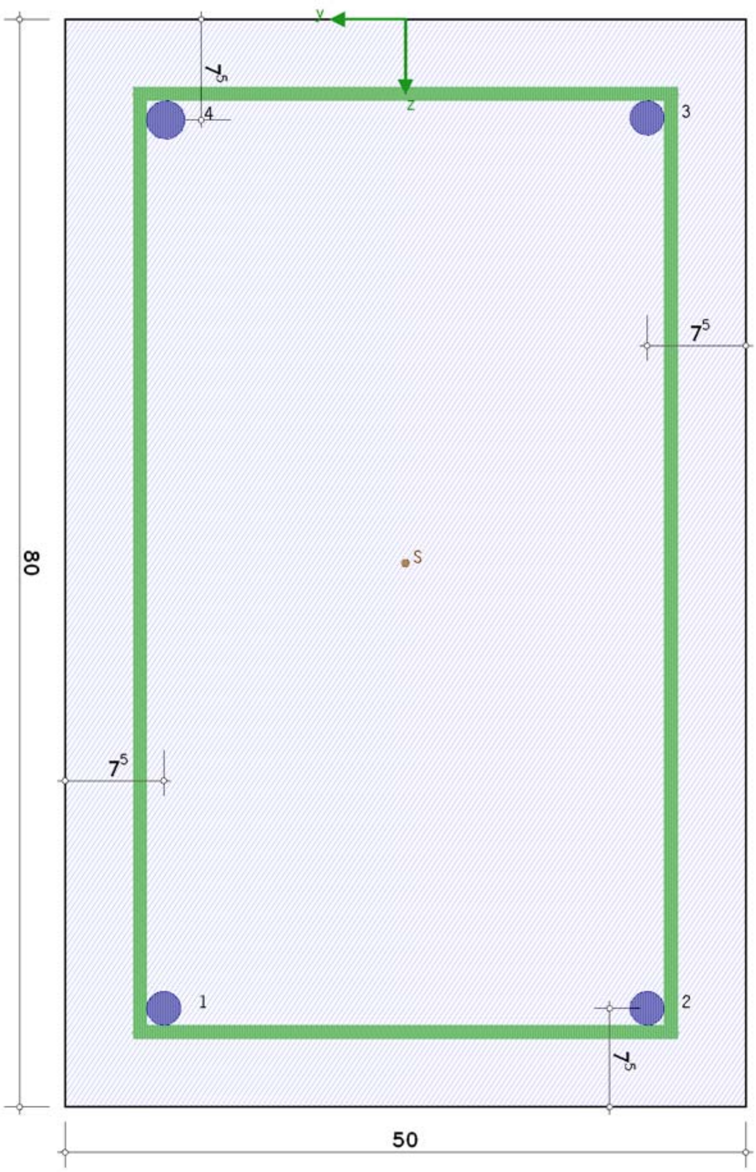
flexural reinforcement:

Grp	n_s	$Ø_s$ mm	exst A_s cm²		req A_s cm²	exst d cm		clc d cm	
1	1	25	4.91	≥	3.59	7.25	≤	7.50	ok
2	1	25	4.91		0.00	7.25	≤	7.50	not ok !!
3	1	25	4.91	≥	3.75	7.25	≤	7.50	ok
4	1	28	6.16	<	10.00	7.40	≤	8.00	not ok !!

Grp: reinforcement group; n_s, $Ø_s$: number and bar diameter per group; exst A_s: existing reinforcement of one group
req A_s: required reinforcement of one group; exst d: existing center distance of the group; clc d: calculation center distance of the group

shear reinforcement:
stirrup reinforcement from shear force Ø10 / 20.0 cm, 2-cut
reinforcement exst a_{sbV} = 7.85 cm²/m > req a_{sbV} = 7.41 cm²/m ok

graphic:



6. regulations

EN 1990, Eurocode 0: Grundlagen der Tragwerksplanung;
Deutsche Fassung EN 1990:2002 + A1:2005 + A1:2005/AC:2010, Ausgabe Dezember 2010
EN 1990/NA, Nationaler Anhang zur EN 1990, Ausgabe Dezember 2010

EN 1992-1-1, Eurocode 2: Bemessung und Konstruktion von Stahlbeton- und Spannbetonbauteilen -
Teil 1-1: Allgemeine Bemessungsregeln und Regeln for den Hochbau;
Deutsche Fassung EN 1992-1-1:2004 + AC:2010, Ausgabe Januar 2011
EN 1992-1-1/NA, Nationaler Anhang zur EN 1992-1-1, Ausgabe April 2013