Project

Job name : Demo01
Date : 25. 1. 2010

Standard

Standard **EN 1992-1-2/Czech Rep.**.

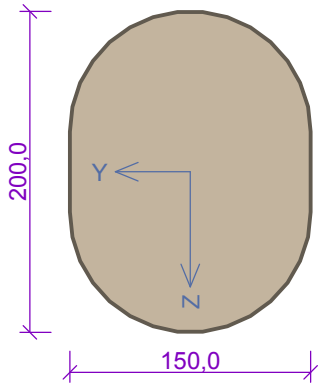
Reliability of concrete and reinforcement in fire : $\gamma_{M,fi}$ = 1,000

1 Column C1

1.1 Input data

Member type: column
Environment: X0
Length: 2,00m
Limit fire resistance period: 90,0min

Cross-section



Materials

Concrete : C 25/30

Cylinder compressive strength	f_{ck}	=	25,0	MPa
Tensile strength	f_{ctm}	=	2,6	MPa
Elasticity modulus	E_{cm}	=	30500	MPa

Longitudinal steel : B500 (cust.)

Yield strength	f_{yk}	=	500,0	MPa
Elasticity modulus	E_s	=	200000	MPa

Transverse steel : B500

Yield strength	f_{yk}	=	500,0	MPa
Elasticity modulus	E_s	=	200000	MPa

Aggregates kind: Silicate aggregates
Reinforcement kind: Rolled
Concrete moisture: 1,5%
Parameter of thermal conductivity: 0,000

Fire detail

Exposed to fire on all sides

Temperature curve

Standard temperature curve

Internal forces - basic design (ULS)

no.	Load name	N_{Ed} [kN]	V_{Edz} [kN]	V_{Edy} [kN]	M_{Edy} [kNm]	M_{Edz} [kNm]	T_{Ed} [kNm]	QP coef. [-]
1	Zat. případ 1	-180,82	0,00	0,00	3,28	0,00	0,00	1,000

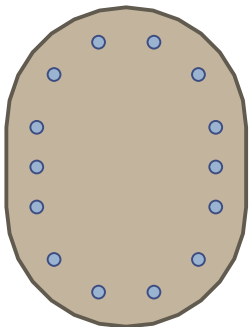
Buckling

Length [m]	Buckling coef. [–]	Buckling length [m]
2,00	1,00	2,00

Longitudinal reinf.

Oval:4pc × profile 8 in arc, 3pc × profile 8 on even edge, cover 15,0 mm

14x8-cov.15,0



Longitudinal reinf. - details

Number	Y [mm]	Z [mm]	Profile [mm]
1	120,3	157,9	8
2	120,3	42,1	8
3	92,3	178,3	8
4	92,3	21,7	8
5	57,7	178,3	8
6	57,7	21,7	8
7	29,7	157,9	8
8	29,7	42,1	8
9	131,0	125,0	8
10	19,0	125,0	8
11	131,0	100,0	8
12	19,0	100,0	8
13	131,0	75,0	8
14	19,0	75,0	8

Centre of coordinate system lies in lower left corner of section envelope

Reinforcement in compression not considered.

Shear reinf.

Section without shear reinforcement.

Minimum cover

Structural class: S4

c_{min} = max($c_{min,b}$; $c_{min,dur}$; 10) = max(8; 10; 10) = 10 mm

c_{nom} = c_{min} + Δc_{dev} = 10 + 10 = 20 mm

1.2 Results

Calculation in prescribed fire resistance time t = 90,0 min

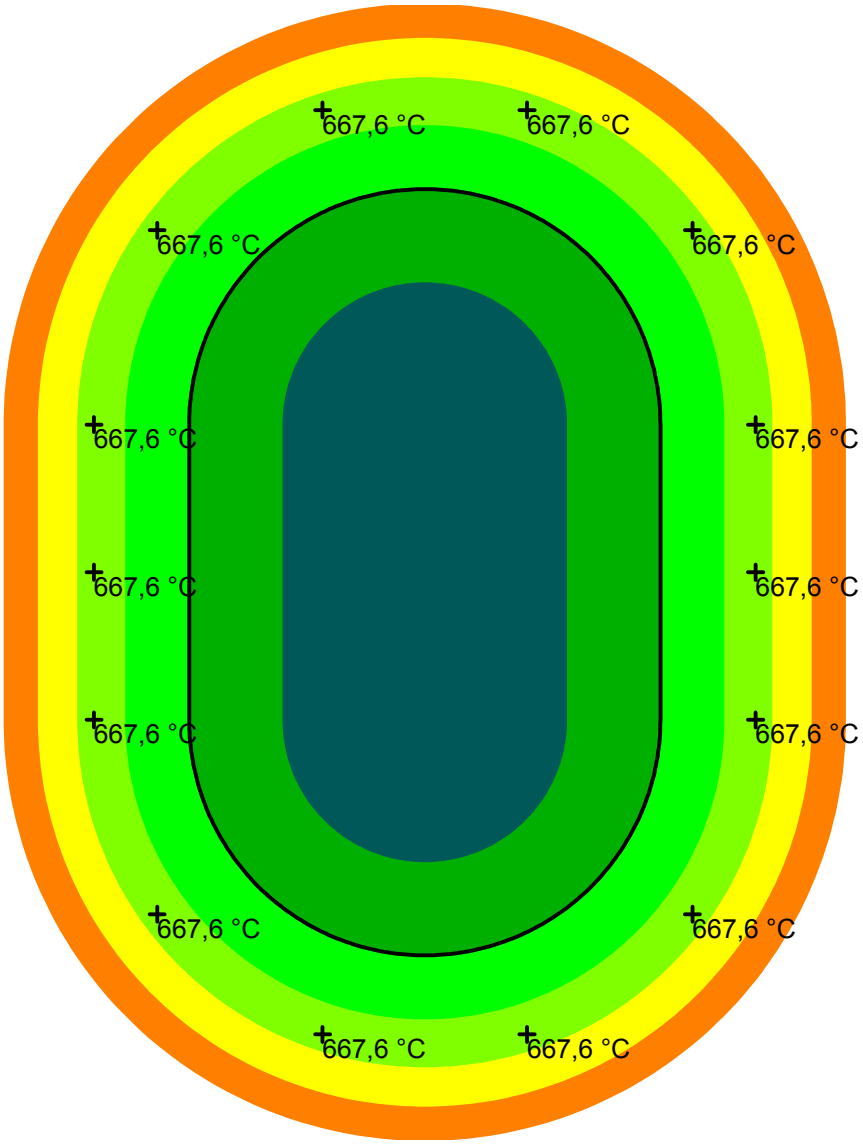
Isotherm 500 method

Temperature distribution

Number	Y [mm]	Z [mm]	Profile [mm]	Temperature [°C]	k_s
1	120,3	157,9	8	667,6	0,31
2	120,3	42,1	8	667,6	0,31
3	92,3	178,3	8	667,6	0,31
4	92,3	21,7	8	667,6	0,31
5	57,7	178,3	8	667,6	0,31
6	57,7	21,7	8	667,6	0,31

Number	Y [mm]	Z [mm]	Profile [mm]	Temperature [°C]	k_s
7	29,7	157,9	8	667,6	0,31
8	29,7	42,1	8	667,6	0,31
9	131,0	125,0	8	667,6	0,31
10	19,0	125,0	8	667,6	0,31
11	131,0	100,0	8	667,6	0,31
12	19,0	100,0	8	667,6	0,31
13	131,0	75,0	8	667,6	0,31
14	19,0	75,0	8	667,6	0,31

Centre of coordinate system lies in lower left corner of section envelope



Zat. případ 1

N=-126,57kN; V_z=0,00kN; V_y=0,00kN; M_y=2,29 → 3,33kNm; M_z=0,00kNm; T=0,00kNm

Detailed check COMPRESSION AND BENDING: Zat. případ 1

Calculate min eccentricity

e_i = l_0 / 400 = 2 / 400 = 0,005 m

e_0 = max(h / 30; 0,02) = max(0,157 / 30; 0,02) = 0,02 m

M_{0Edy} = max(M_y + e_i × |N_{Ed}|; e_0 × |N_{Ed}|) = max(2,293 + 0,005 × |-126,6|; 0,02 × |-126,6|) = 2,926 kNm

M_{0Edz} = 0 kNm

Creep coefficient:

h_0 = $2 \times A_c / u = 2 \times 8\,984 / 350,6 = 51,26$ mm

φ_{RH} = $1 + (1 - RH / 100) / (0,1 \times \sqrt[3]{h_0}) = 1 + (1 - 50 / 100) / (0,1 \times \sqrt[3]{51,26}) = 2,346$

$\beta(f_{cm})$ = $16,8.10^6 / \sqrt{f_{cm}} = 16,8.10^6 / \sqrt{33} = 2,925$

$\beta(t_0)$ = $1 / (0,1 + t_0^{0,2}) = 1 / (0,1 + 28,00^{0,2}) = 0,488$

φ_0 = $\varphi_{RH} \times \beta(f_{cm}) \times \beta(t_0) = 2,346 \times 2,925 \times 0,488 = 3,351$

β_H = $\min(1,5 \times [1 + (0,012 \times RH)^{18}] \times h_0 + 250; 1\,500) = \min(1,5 \times [1 + (0,012 \times 50)^{18}] \times 51,26 + 250; 1\,500) = 326,9$

$\beta(t/t_0)$ = $[(t - t_0) / (\beta_H + t - t_0)]^{0,3} = [(25\,550 - 28,00) / (326,9 + 25\,550 - 28,00)]^{0,3} = 0,996$

φ = $\varphi_0 \times \beta(t/t_0) = 3,351 \times 0,996 =$ **3,338**

Buckling

Buckling calculated by method based on nominal stiffness.

Slenderness perp. to y:

i_y = $\sqrt{(I_{cy} / A_c)} = \sqrt{(10,2.10^{-6} / 0,00898)} = 0,0336$ m

λ_y = $L_{0y} / i_y = 2 / 0,0336 = 59,45$

φ_{ef} = $\varphi \times 1 = 3,338 \times 1 = 3,338$

A = $1 / (1 + 0,2 \times \varphi_{ef}) = 1 / (1 + 0,2 \times 3,338) = 0,6$

ω = $A_s \times f_{yd} / (A_c \times f_{cd}) = 0,000704 \times 500 / (0,00898 \times 25) = 1,567$

B = $\sqrt{(1 + 2 \times \omega)} = \sqrt{(1 + 2 \times 1,567)} = 2,033$

C = $1,7 - 1 = 1,7 - 1 = 0,7$

n = $|N_{Ed}| / (A_c \times f_{cd}) = |-126,6| / (0,00898 \times 25) = 0,564$

λ_{lim} = $\min(20 \times A \times B \times C / \sqrt{n}; 75) = \min(20 \times 0,6 \times 2,033 \times 0,7 / \sqrt{0,564}; 75) =$ **22,73**

Direct. y: $\lambda_y > \lambda_{lim} \Rightarrow$ Detailed buckling calculation needed

β = $\pi^2 / c_{0y} = 3,142^2 / 10 = 0,987$

k_1 = $\sqrt{(f_{ck} / 20)} = \sqrt{(25 / 20)} = 1,118$

n = $-N_{Ed} / (A_c \times f_{cd}) = -(-126,6) / (0,00898 \times 25) = 0,564$

k_{2y} = $\min(n \times \lambda_y / 170; 0,2) = \min(0,564 \times 59,45 / 170; 0,2) = 0,197$

φ_{ef} = $\varphi \times 1 = 3,338 \times 1 = 3,338$

K_{cy} = $k_1 \times k_{2y} / (1 + \varphi_{ef}) = 1,118 \times 0,197 / (1 + 3,338) = 0,0508$

EI_y = $K_{cy} \times E_{cd} \times I_{cy} + K_s \times E_s \times I_{sy} = 0,0508 \times 25\,833 \times 10,2.10^{-6} + 1 \times 200.10^3 \times 2,03.10^{-6} = 419,6$ kNm^2

N_{By} = $\pi^2 \times EI_y / L_{0y}^2 = 3,142^2 \times 419,6 / 2^2 = 1\,035$ kN

M_{Edy} = $M_{0Edy} \times \{1 + \beta / [N_{By} / (-N_{Ed}) - 1]\} = 2,926 \times \{1 + 0,987 / [1\,035 / (-(-126,6)) - 1]\} =$ **3,328 kNm**

Check of min and max reinforcement level

Column (total reinforcement):

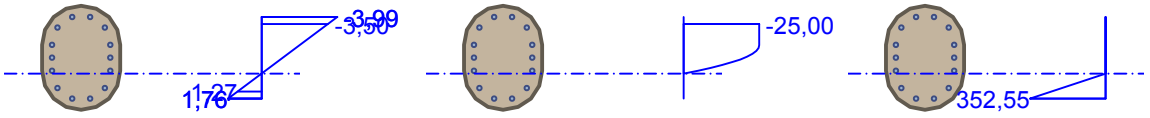
ρ_s = $A_s / A_c = 703,7 / 25\,086 = 0,0281$

$\rho_{s,min}$ = $\max(0,1 \times |N_{Ed}| / (f_{yd} \times A_c); 0,002) = \max(0,1 \times |-126,6| / (434,8 \times 25\,086); 0,002) = 0,002$

$\rho_s = 0,0281 \geq \rho_{s,min} = 0,002 \Rightarrow$ **Pass**

$\rho_s = 0,0281 \leq \rho_{s,max} = 0,04 \Rightarrow$ **Pass**

Deformation in concrete [‰] Stress in concrete [MPa] Stress in reinforcement [MPa]



Deformation in marginal cross-section fibres

Smallest deformation in concrete: -3,50 ‰

Largest deformation in concrete: 1,27 ‰
Smallest deformation in reinf.: -3,99 ‰
Largest deformation in reinf.: 1,76 ‰
Direction of neut. axis: 0,00 °

N_{Ed} = -126,57 kN ≤ N_{Rd} = -224,61 kN
M_{Edy} = 2,29 → 3,33 ≤ M_{Rdy} = 3,63 kNm
M_{Edz} = 0,00 ≤ M_{Rdz} = 0,00 kNm
CS check for compression and bending Pass
Utilization: 91,7 %

Detailed check SHEAR: Zat. případ 1

CS is not subject to shear.

Detailed check TORSION: Zat. případ 1

CS not subject to torsion.

Check of min and max reinforcement level

Column (total reinforcement):
ρ_s = 0,0281 ≥ $\rho_{s,min}$ = 0,002 ⇒ **Pass**
ρ_s = 0,0281 ≤ $\rho_{s,max}$ = 0,04 ⇒ **Pass**

Check of ultimate limit state

Zat. případ 1

N_{Ed} = -126,57 kN ≤ N_{Rd} = -224,61 kN
M_{Edy} = 2,29 → 3,33 ≤ M_{Rdy} = 3,63 kNm
M_{Edz} = 0,00 ≤ M_{Rdz} = 0,00 kNm
CS check for compression and bending Pass
Utilization: 91,7 %

CS is not subject to shear.

CS not subject to torsion.

Ultimate limit state PASS

Section utilization: 91,7 %

Interaction diagram