



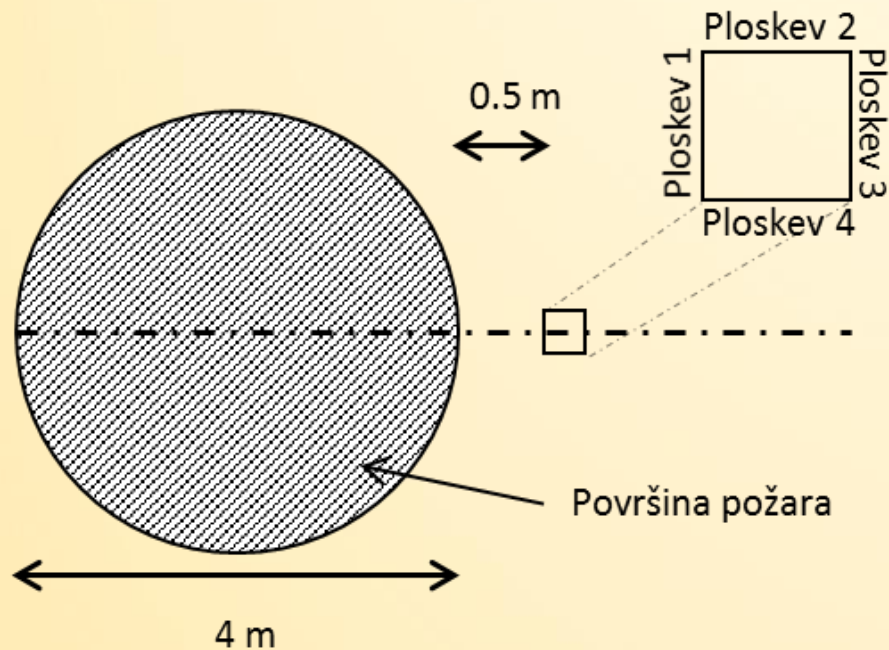
LOCAFI+

Določitev temperatur navpičnih elementov izpostavljenih lokaliziranim požarom (LOCAIised FIre)
Diseminacija
Grant Agreement n° 754072

7. Računski primeri

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru



Profil stebra: HEB 300

Premjer požara: 4m

Razdalja med požarom in stebrom: 0.5m

Hitrost sproščanja toplote na enoto površine: 1000 kW/m²

Stožčasta oblika plamena

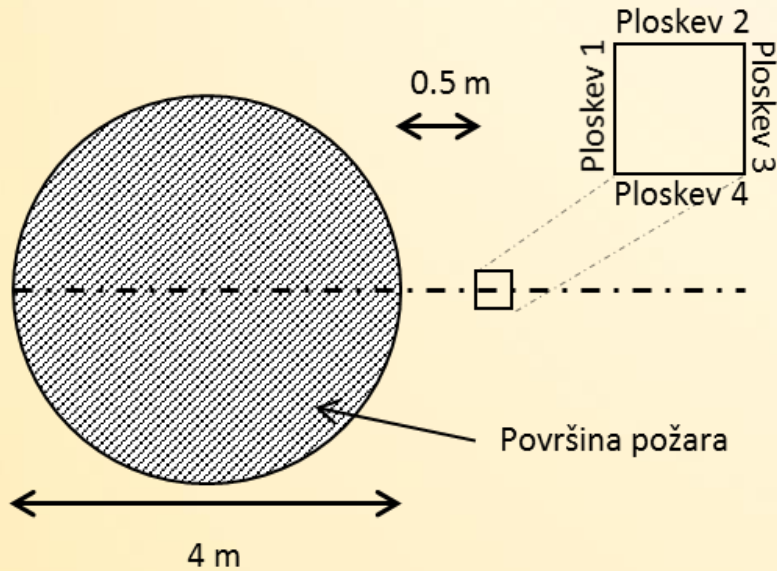
Steber izven plamenov in dimne plasti

Brez stropa

Izračun opravljen za $z = 1.0m$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru



$$D = 4 \text{ m}$$

$$Q = RHR * \frac{\pi}{4} * D^2 = 12566371 \text{ W}$$

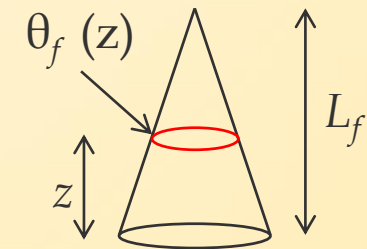
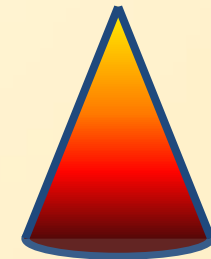
$$L_f = -1.02 D + 0.0148 Q^{0.4} = 6.15 \text{ m}$$

$$z_0 = -1.02 D + 0.00524 Q^{0.4} = -0.48 \text{ m}$$

Temperatura plamena

$$\theta_f(z) = \min \left(900; 20 + 0.25(0.8Q(t))^{2/3} (z - z_0)^{-5/3} \right)$$

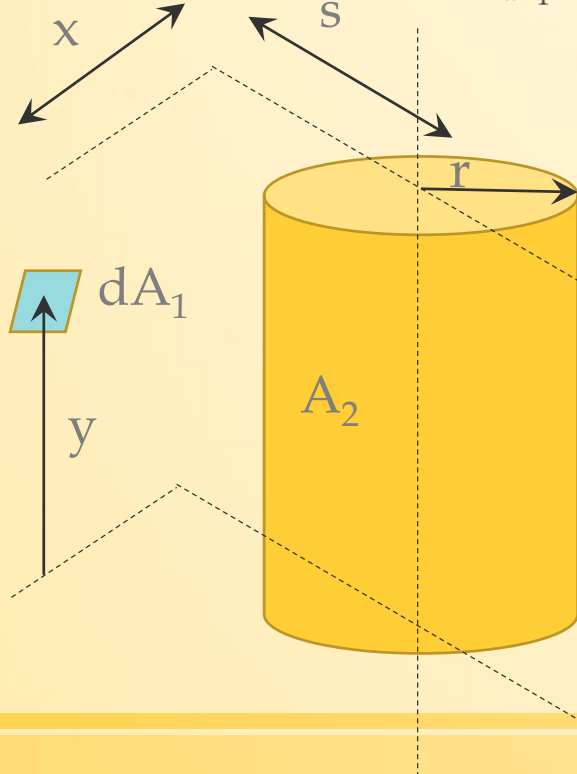
z (m)	T (°C)
0	900
0.5	900
1	900
1.5	900
2	900
2.5	900
3	900
3.5	900
4	900
4.5	827.9
5	708.4
5.5	614.8
6	540.0
6.5	479.3
7	429.1
7.5	387.2



7. Računski primeri

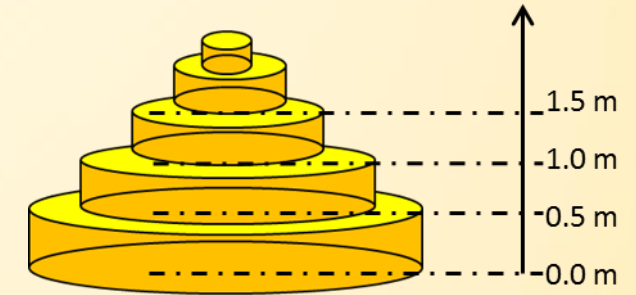
7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 1



$$F_{dA_1 \rightarrow A_2} = \frac{S}{B} - \frac{S}{2B\pi} \left\{ \begin{aligned} &\cos^{-1} \left(\frac{Y^2 - B + 1}{A - 1} \right) + \cos^{-1} \left(\frac{C - B + 1}{C + B - 1} \right) \\ &- Y \left[\frac{A + 1}{\sqrt{(A - 1)^2 + 4Y^2}} \cos^{-1} \left(\frac{Y^2 - B + 1}{\sqrt{B}(A - 1)} \right) \right] \\ &- \sqrt{C} \frac{C + B + 1}{\sqrt{(C + B - 1)^2 + 4C}} \cos^{-1} \left(\frac{C - B + 1}{\sqrt{B}(C + B - 1)} \right) \\ &+ H \cos^{-1} \left(\frac{1}{\sqrt{B}} \right) \end{aligned} \right\}$$

$$\begin{aligned} S &= s/r \\ X &= x/r \\ H &= h/r \\ A &= X^2 + Y^2 + S^2 \\ B &= S^2 + X^2 \\ C &= (H - Y)^2 \end{aligned}$$

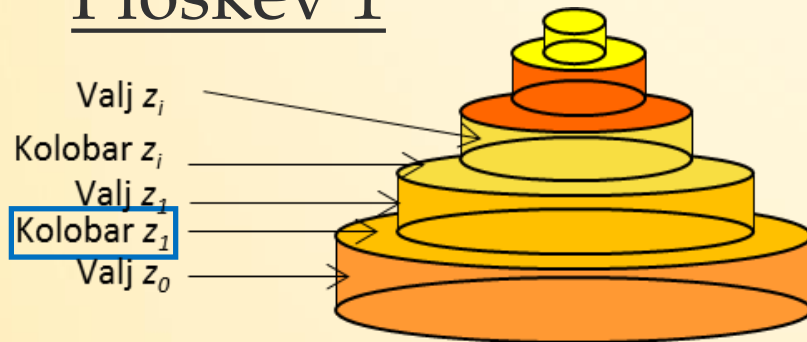


$$\begin{aligned} F_i &= F_{dA_1 \rightarrow A_2}(s = s_f, x = x_f, r = r_i, h = |z_i - z_f|) \\ F_{i+1} &= F_{dA_1 \rightarrow A_2}(s = s_f, x = x_f, r = r_i, h = |z_{i+1} - z_f|) \\ \left| \begin{aligned} &\text{if } z_i \geq z_f \text{ then } F = F_{i+1} - F_i \\ &\text{else } F = F_i - F_{i+1} \end{aligned} \right. \end{aligned}$$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 1



$$z_f = 1.0m$$

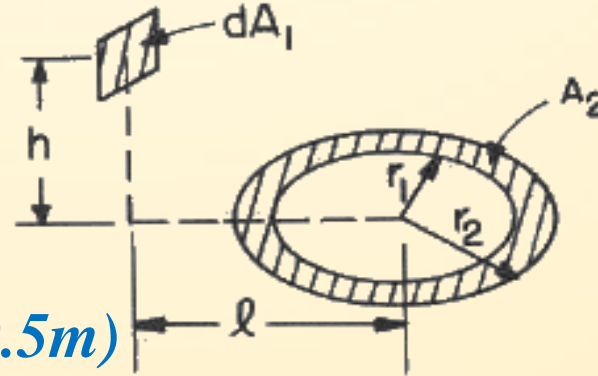
→ Upoštevamo samo en kolobar ($z_i = 0.5m$)

Zunanji radij $r_2 = 2.0m$

Notranji radij $r_1 = (6.15 - 0.5) / 6.15 * 2.0m = 1.84m$

Poenostavitev: $l = 2.5m$

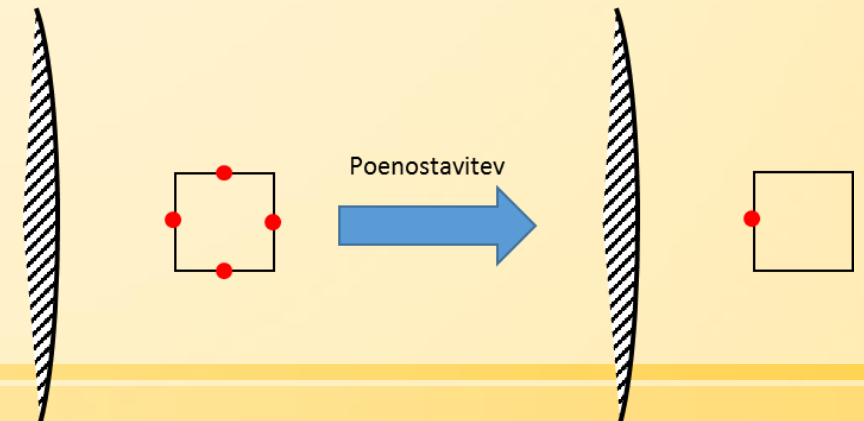
$$F_{dA_1 \rightarrow A_2} = \frac{H}{2} \left(\frac{H^2 + R_2^2 + 1}{\sqrt{(H^2 + R_2^2 + 1)^2 - 4R_2^2}} - \frac{H^2 + R_1^2 + 1}{\sqrt{(H^2 + R_1^2 + 1)^2 - 4R_1^2}} \right)$$



$$H = h/l = (1 - 0.5)/2.5 = 0.2$$

$$R_2 = r_2/l = 2/2.5 = 0.8$$

$$R_1 = r_1/l = 1.84/2.5 = 0.73$$



7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 1


Input data					Constant		Section coordinate			Intermediate variables							
HRR kW/m²	Dfire m	Q W	Q MW	hf m	σ	Tab _s	sf m	xf m	zf m	z _{virt}	l						
1000	4	12566370.6	12.57	6.15	5.67E-08	273.15	2.5	0	1	-0.46	2.5						
					Cylinder							Ring					
z _i m	T _f °C	r _i m	F _{cylinder_zi} -	F _{ring_zi} -	Flux _{face1} kW/m²	F _i -	F _{i+1} -	S -	X -	A -	H _i -	H _{i+1} -	z _i -z _f m	z _{i+1} -z _f m	H -	R _i -	R _{i+1} -
0	900	2.00	0.0726	0	7.79	0.3705	0.2979	1.25	0	1.56	0.50	0.25	1.00	0.50	0	0.00	0.00
0.5	900	1.84	0.2374	0.0555	31.45	0.2374	0.0000	1.36	0	1.85	0.27	0.00	0.50	0.00	0.20	0.80	0.73
1	900	1.67	0.1893	0	20.33	0.0000	0.1893	1.49	0	2.23	0.00	0.30	0.00	0.50	0	0.73	0.67
1.5	900	1.51	0.0823	0	8.84	0.1514	0.2337	1.65	0	2.73	0.33	0.66	0.50	1.00	0	0.67	0.60
2	900	1.35	0.0361	0	3.88	0.1953	0.2315	1.85	0	3.43	0.74	1.11	1.00	1.50	0	0.60	0.54
2.5	900	1.19	0.0177	0	1.91	0.1958	0.2136	2.11	0	4.43	1.26	1.68	1.50	2.00	0	0.54	0.47
3	900	1.02	0.0095	0	1.02	0.1797	0.1893	2.44	0	5.95	1.95	2.44	2.00	2.50	0	0.47	0.41
3.5	900	0.86	0.0054	0	0.58	0.1564	0.1618	2.90	0	8.41	2.90	3.48	2.50	3.00	0	0.41	0.34
4	900	0.70	0.0031	0	0.34	0.1296	0.1328	3.57	0	12.77	4.29	5.00	3.00	3.50	0	0.34	0.28
4.5	828	0.54	0.0018	0	0.15	0.1009	0.1027	4.66	0	21.68	6.52	7.45	3.50	4.00	0	0.28	0.21
5	708	0.37	0.0010	0	0.05	0.0711	0.0720	6.68	0	44.58	10.68	12.02	4.00	4.50	0	0.21	0.15
5.5	615	0.21	0.0004	0	0.02	0.0405	0.0409	11.80	0	139.24	21.24	23.60	4.50	5.00	0	0.15	0.08
6	540	0.05	0.0001	0	0.00	0.0095	0.0096	50.71	0	2571.11	101.41	111.55	5.00	5.50	0	0.08	0.02
6.5	479	0	0	0	0	0	0	0	0	0	0	0	5.50	6.00	0	0.02	0
7	429	0	0	0	0	0	0	0	0	0	0	0	6.00	6.50	0	0	0
7.5	387	0	0	0	0	0	0	0	0	0	0	0	6.50	1.00	0	0	0
Incident heat flux on face 1					76.36	kW/m²											
Absorbed heat flux on face 1					53.45	kW/m²											

7. Računski primeri

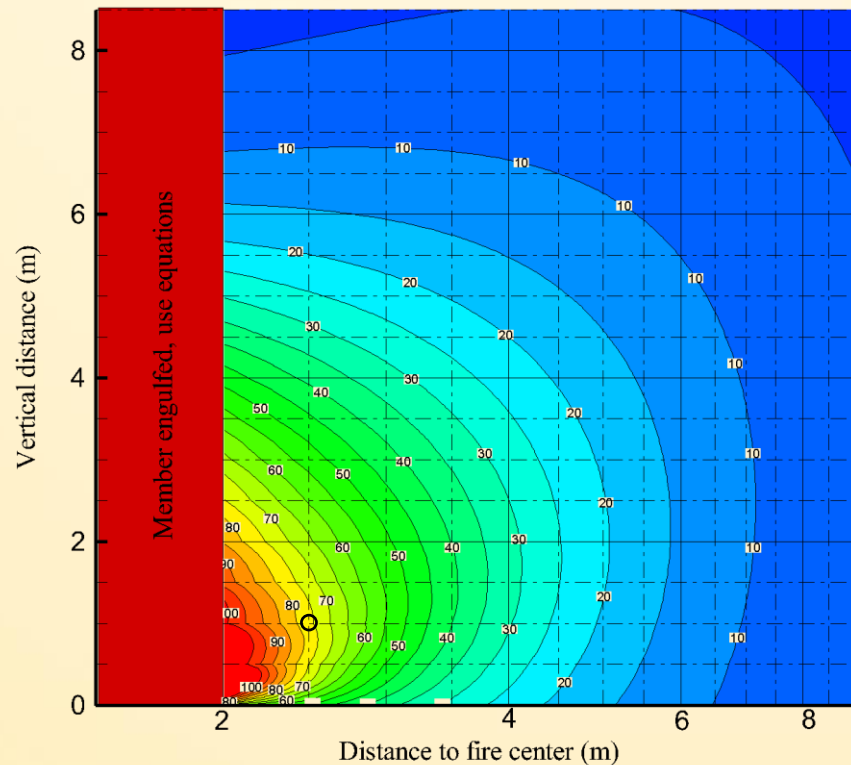
7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 1

Radiative heat flux (face at 0°)



0 10 20 30 40 50 60 70 80 90 100 (kW/m²)



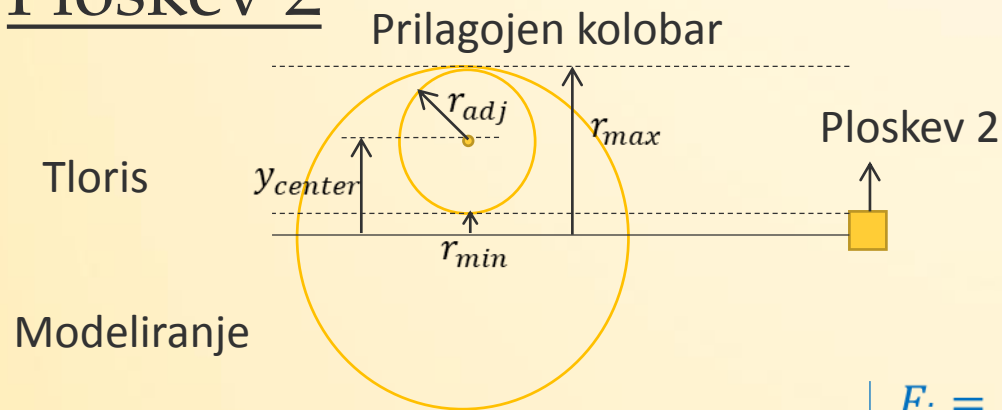
Absorbirani toplotni tok

$$\begin{aligned} &= \varepsilon * \varphi_{tot} \\ &= 0.7 * 77 \text{ kW/m}^2 \\ &= 53.9 \text{ kW/m}^2 \end{aligned}$$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 2



$$\underline{z = 0}$$

$$r_{min} = \max(-r_i, x_f) = 0$$

$$r_{max} = r_i = 2.0 \text{ m}$$

$$y_{center} = \frac{r_{min} + r_{max}}{2} = 1.0 \text{ m}$$

$$r_{adjusted} = \frac{r_{max} - r_{min}}{2} = 1.0 \text{ m}$$

$$F_i = F_{dA_1 \rightarrow A_2}(s = y_{center} - x_f, x = s_f, r = r_{adjusted}, h = |z_i - z_f|)$$

$$F_{i+1} = F_{dA_1 \rightarrow A_2}(s = y_{center} - x_f, x = s_f, r = r_{adjusted}, h = |z_{i+1} - z_f|)$$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

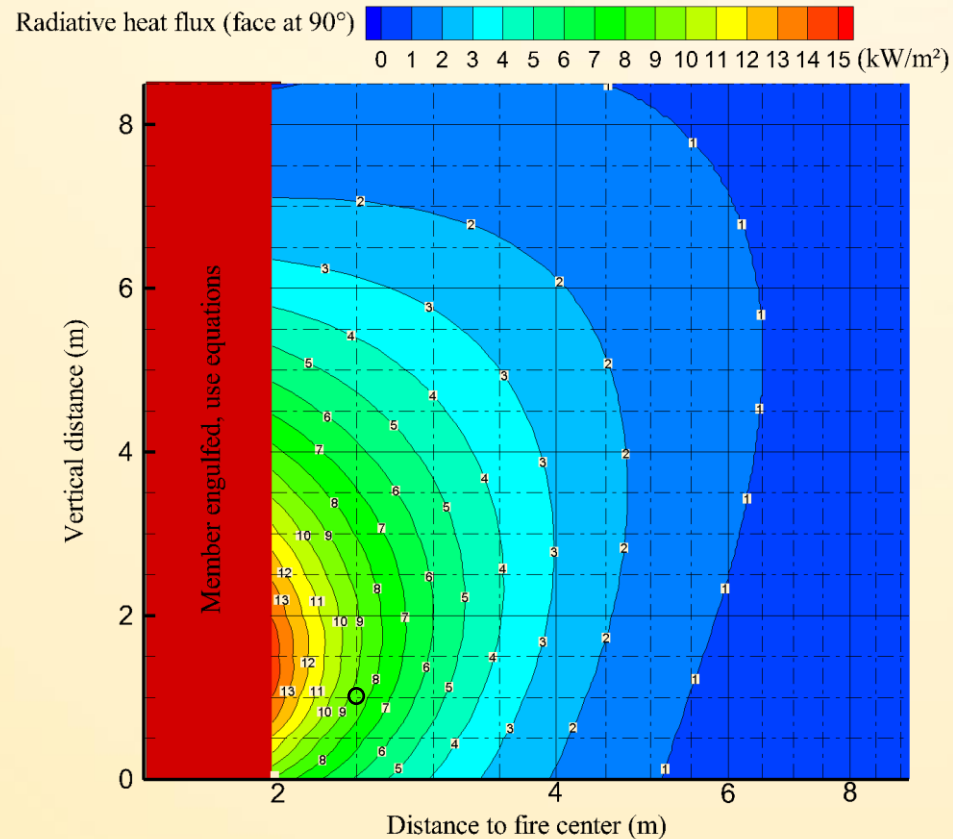
Ploskev 2

						Ring							
zi	Tf	ri	F _{cylinder_zi}	F _{ring_zi}	Flux _{face2}	H	Ri	Ri+1	Input data				
m	°C	m	-	-	kW/m ²	-	-	-	HRR kW/m ²	Dfire m	Q W	Q MW	hf m
0	900	2.00	0.0175	0	1.88	0	0.00	0.00	1000	4	12566370.6	12.57	6.15
0.5	900	1.84	0.0193	0.0060	2.71	0.20	0.40	0.37					
1	900	1.67	0.0160	0	1.72	0	0.37	0.33					
1.5	900	1.51	0.0103	0	1.10	0	0.33	0.30					
2	900	1.35	0.0056	0	0.60	0	0.30	0.27					
2.5	900	1.19	0.0028	0	0.30	0	0.27	0.24					
3	900	1.02	0.0014	0	0.15	0	0.24	0.20					
3.5	900	0.86	0.0006	0	0.07	0	0.20	0.17					
4	900	0.70	0.0003	0	0.03	0	0.17	0.14					
4.5	828	0.54	0.0001	0	0.01	0	0.14	0.11					
5	708	0.37	0.0000	0	0.00	0	0.11	0.07					
5.5	615	0.21	0.0000	0	0.00	0	0.07	0.04					
6	540	0.05	0.0000	0	0.00	0	0.04	0.01					
6.5	479	0	0	0	0	0	0.01	0.00					
7	429	0	0	0	0	0	0	0					
7.5	387	0	0	0	0	0	0	0					
Incident heat flux on face 2					8.57	kW/m ²							
Absorbed heat flux by face 2					6.00	kW/m ²							
Modified cylinder / ring				Cylinder									
rmin	rmax	ri _{adjusted}	Y _{center}	Fi	Fi+1	s	S	X	A	Hi	Hi+1	z _i -z _f	z _{i+1} -z _f
m	m	m	m	-	-	-	-	-	-	-	-	m	m
0	2.00	1.00	1.00	0.0403	0.0229	1.00	1.00	2.50	7.25	1.00	0.50	1.00	0.50
0	1.84	0.92	0.92	0.0193	0.0000	0.92	1.00	2.72	8.40	0.54	0.00	0.50	0.00
0	1.67	0.84	0.84	0.0000	0.0160	0.84	1.00	2.99	9.91	0.00	0.60	0.00	0.50
0	1.51	0.76	0.76	0.0130	0.0233	0.76	1.00	3.31	11.93	0.66	1.32	0.50	1.00
0	1.35	0.67	0.67	0.0185	0.0241	0.67	1.00	3.70	14.72	1.48	2.22	1.00	1.50
0	1.19	0.59	0.59	0.0187	0.0215	0.59	1.00	4.21	18.74	2.53	3.37	1.50	2.00
0	1.02	0.51	0.51	0.0161	0.0174	0.51	1.00	4.88	24.81	3.90	4.88	2.00	2.50
0	0.86	0.43	0.43	0.0124	0.0130	0.43	1.00	5.80	34.64	5.80	6.96	2.50	3.00
0	0.70	0.35	0.35	0.0086	0.0089	0.35	1.00	7.15	52.09	8.58	10.01	3.00	3.50
0	0.54	0.27	0.27	0.0053	0.0054	0.27	1.00	9.31	87.70	13.04	14.90	3.50	4.00
0	0.37	0.19	0.19	0.0026	0.0027	0.19	1.00	13.35	179.33	21.37	24.04	4.00	4.50
0	0.21	0.11	0.11	0.0009	0.0009	0.11	1.00	23.60	557.97	42.48	47.20	4.50	5.00
0	0.05	0.02	0.02	0.0000	0.0000	0.02	1.00	101.41	10285.43	202.82	223.11	5.00	5.50
0	0	0	0	0	0	0	0	0	0	0	0	5.50	6.00
0	0	0	0	0	0	0	0	0	0	0	0	6.00	6.50
0	0	0	0	0	0	0	0	0	0	0	0	6.50	1.00

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Ploskev 2

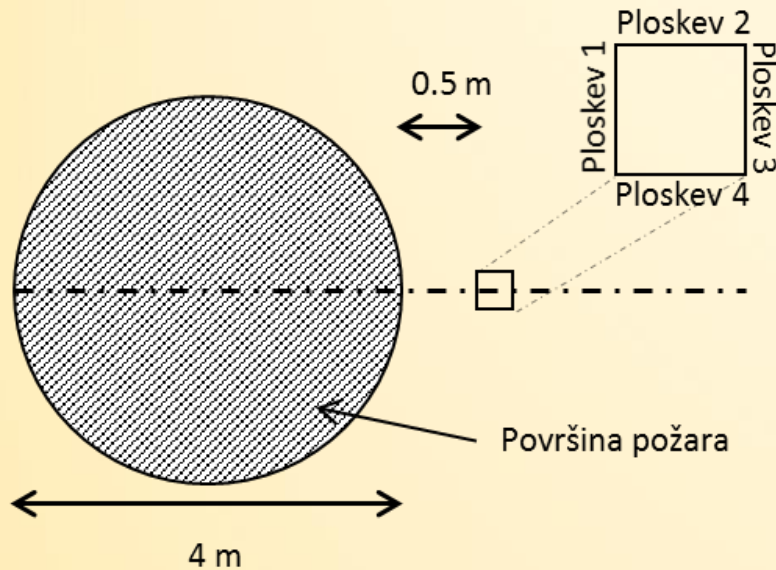


Absorbirani toplotni tok

$$\begin{aligned} &= \varepsilon * \varphi_{tot} \\ &= 0.7 * 8.7 \text{ kW/m}^2 \\ &= 6.1 \text{ kW/m}^2 \end{aligned}$$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru



Toplotni tok, ki ga absorbira vsaka ploskev (predpostavka $\varepsilon = 0.7$)

Ploskev 1 : 53.45 kW/m²

Ploskev 2 : 6.00 kW/m²

Ploskev 3 : 0.00 kW/m²

Ploskev 4 : 6.00 kW/m²

→ Povprečni toplotni tok = 16.36 kW/m²

$$0 = \underbrace{h(\theta - 20)}_{\text{Oddani konvekcijski toplotni tok}} + \underbrace{\sigma\varepsilon[(\theta + 273)^4 - (20 + 273)^4]}_{\text{Oddani sevalni toplotni tok}} - \underbrace{\varepsilon * \varphi_{tot}}_{\text{Absorbirani toplotni tok}}$$

Oddani konvekcijski
toplotni tok

Oddani sevalni
toplotni tok

Absorbirani
toplotni tok

$$h = 35 \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}; \sigma = 5.67 * 10^{-8} \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-4}$$

θ (°C)	Oddani toplotni tok W/m ²
20	0
30	392.03
40	788.42
50	1189.49
...	...
280	12519.26
290	13145.11
300	13786.06
310	14442.65
320	15115.43
330	15804.96
340	16511.80
350	17236.55
360	17979.78

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Fire - Worked Example 1

File Tools View Help

Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires: 1

Select fire: 1

Fire	Diameter [m]	Pos X [m]	Pos Y [m]
Fire 1	4	0	0
Fire 2			
Fire 3			
Fire 4			
Fire 5			

	Time [min]	RHR [MW]
Point 1	0	12.56
Point 2	20	12.56
Point 3		
Point 4		
Point 5		
Point 6		
Point 7		
Point 8		
Point 9		
Point 10		
Point 11		
Point 12		
Point 13		
Point 14		
Point 15		
Point 16		
Point 17		
Point 18		
Point 19		
Point 20		

Geometrical Data

Ceiling Height: 10 m

Distance on Axis (x): 2.5 m

Height on Axis (z): 1 m

OK Cancel

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Fire - Worked Example 1

File Tools View Help

Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires: 1

Select fire: 1

Fire	Diameter [m]	Pos X [m]	Pos Y [m]
Fire 1	4	0	0
Fire 2			
Fire 3			
Fire 4			
Fire 5			

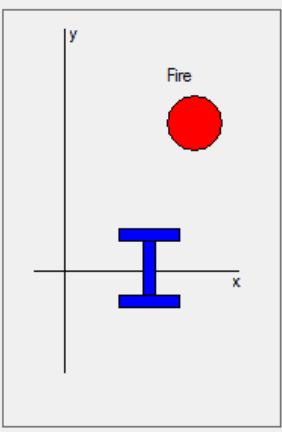
	Time [min]	RHR [MW]
Point 1	0	12.56
Point 2	20	12.56
Point 3		
Point 4		
Point 5		
Point 6		
Point 7		
Point 8		
Point 9		
Point 10		
Point 11		
Point 12		
Point 13		
Point 14		
Point 15		
Point 16		
Point 17		
Point 18		
Point 19		
Point 20		

Geometrical Data

Ceiling Height: 10 m

Distance on Axis (x): 2.5 m

Height on Axis (z): 1 m



OK Cancel

Heating - Worked Example 1

File Tools View Help

Profile Heated By

☐ Hot Zone Temperature ☐ ISO 853 Fire Curve

☒ Localised Fire Temperature ☐ ASTM E119 Fire Curve

☐ Maximum Between Both ☐ Hydrocarbon Fire Curve

Steel Profile - Worked Example 1

File Tools View Help

Cross Section

☒ Unprotected Cross Section ☐ Protected Cross Section

Steel Profile

Profile Type: HE

Profile: HE 300 B

Exposure

☒ Exposed on Four Sides ☐ Exposed on Three Sides

Encasement

☒ Contour Encasement ☐ Hollow Encasement

Protection Material

☒ From Catalog ☐ Constant Values ☐ Temperature Dependent

Thickness: mm

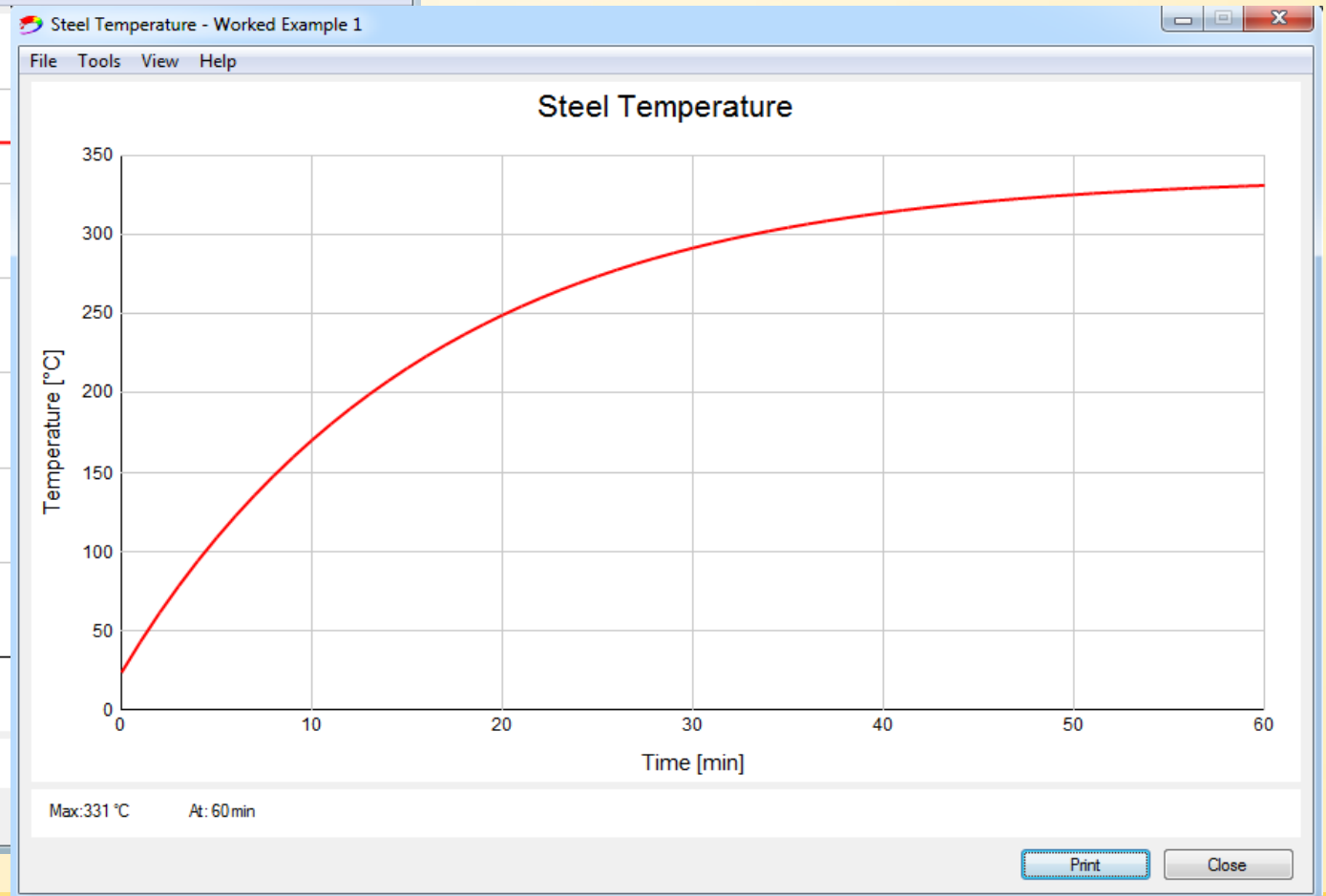
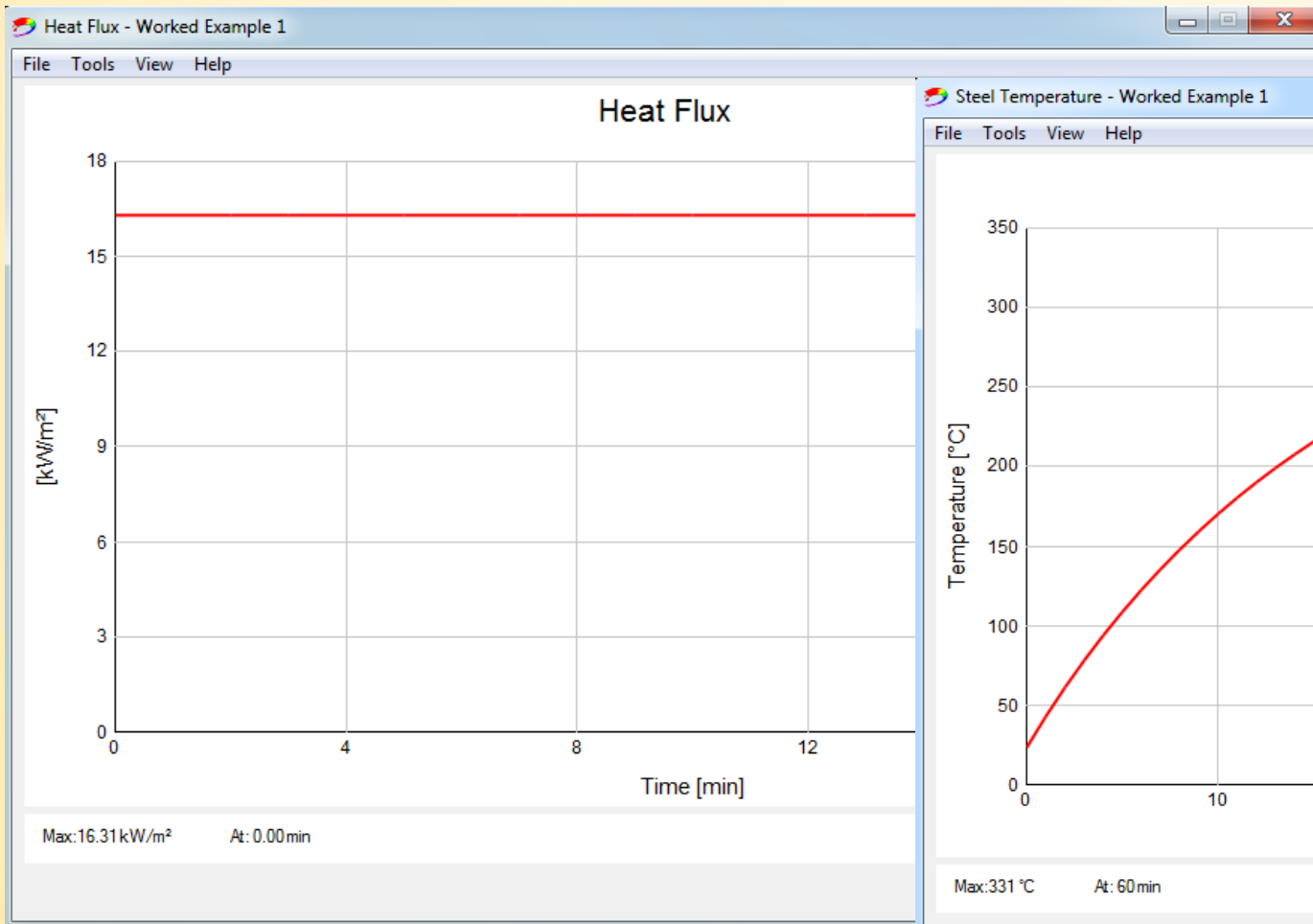
Material Name: Spray Mineral Fiber

Temperature °C	Unit mass kg/m²	Specific Heat J/kgK	Conductivity W/mK
300		1200	0.12

OK Cancel

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

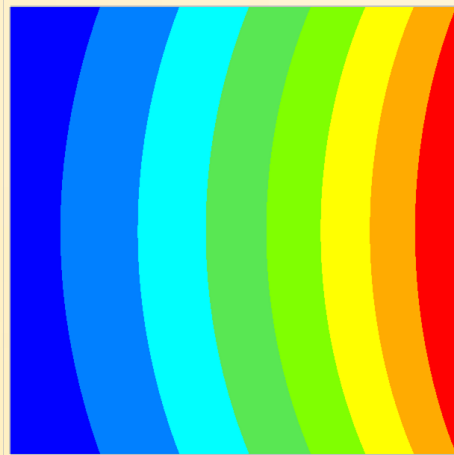


7. Računski primeri

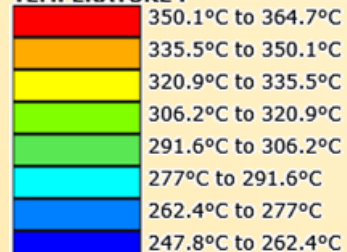
7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

Razporeditev temperatur (LOCAFI)

Kvadrat 300x300

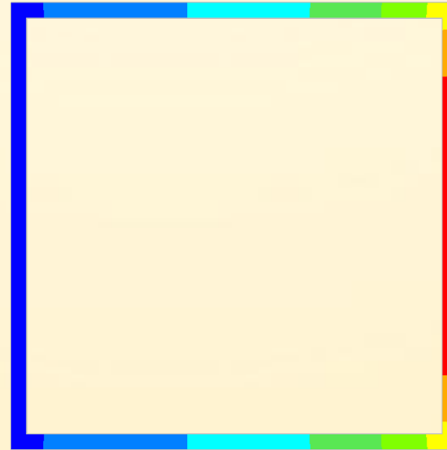


TEMPERATURE :

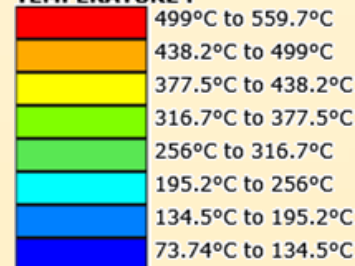


$$(T_{\max} + T_{\min})/2 = 306^{\circ}\text{C}$$

Škatla 300x300x10



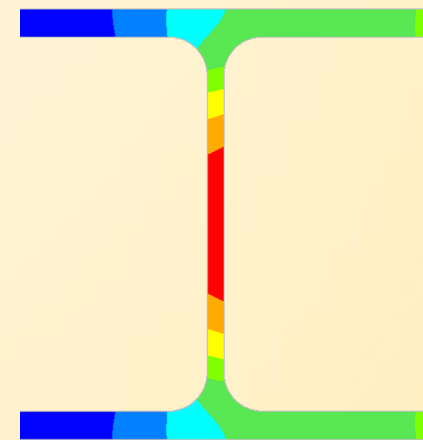
TEMPERATURE :



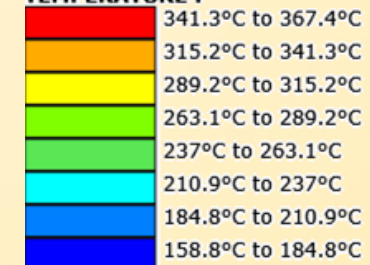
$$(T_{\max} + T_{\min})/2 = 317^{\circ}\text{C}$$

Velike razlike po prerezu

HEB 300



TEMPERATURE :

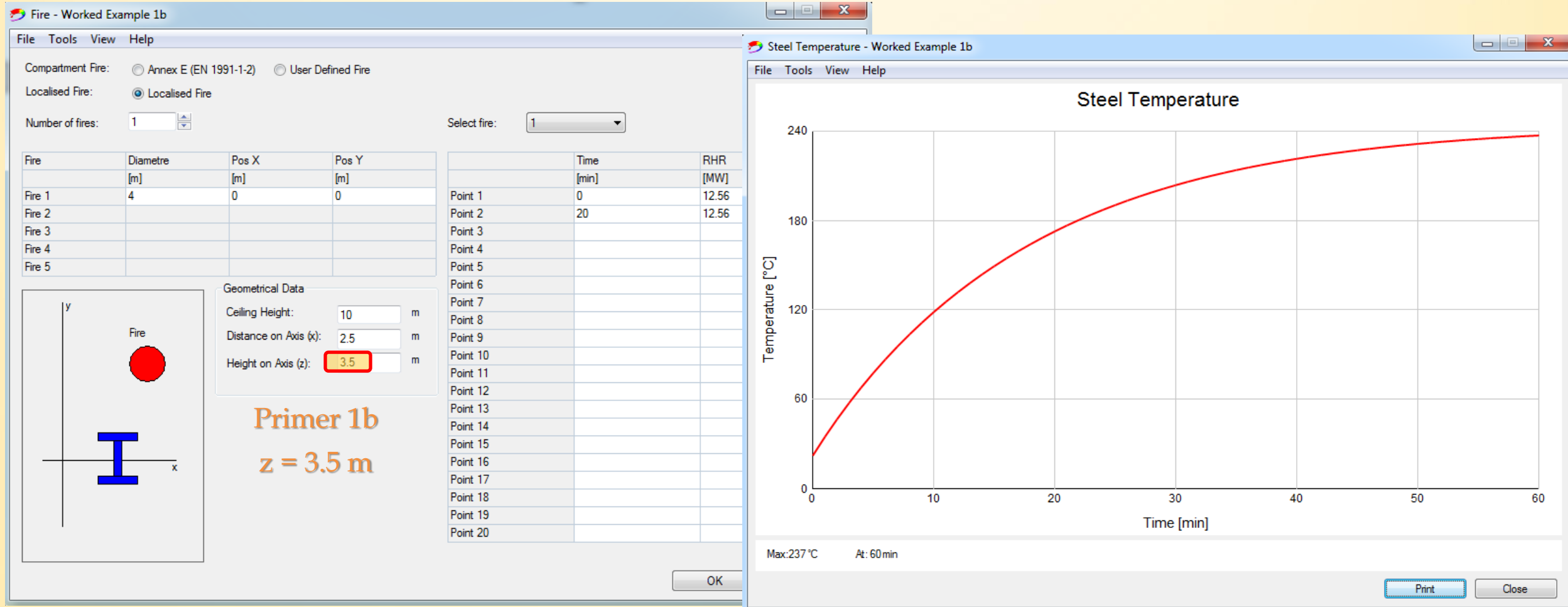


$$(T_{\max} + T_{\min})/2 = 262^{\circ}\text{C}$$

Model upošteva vpliv zasenčenja

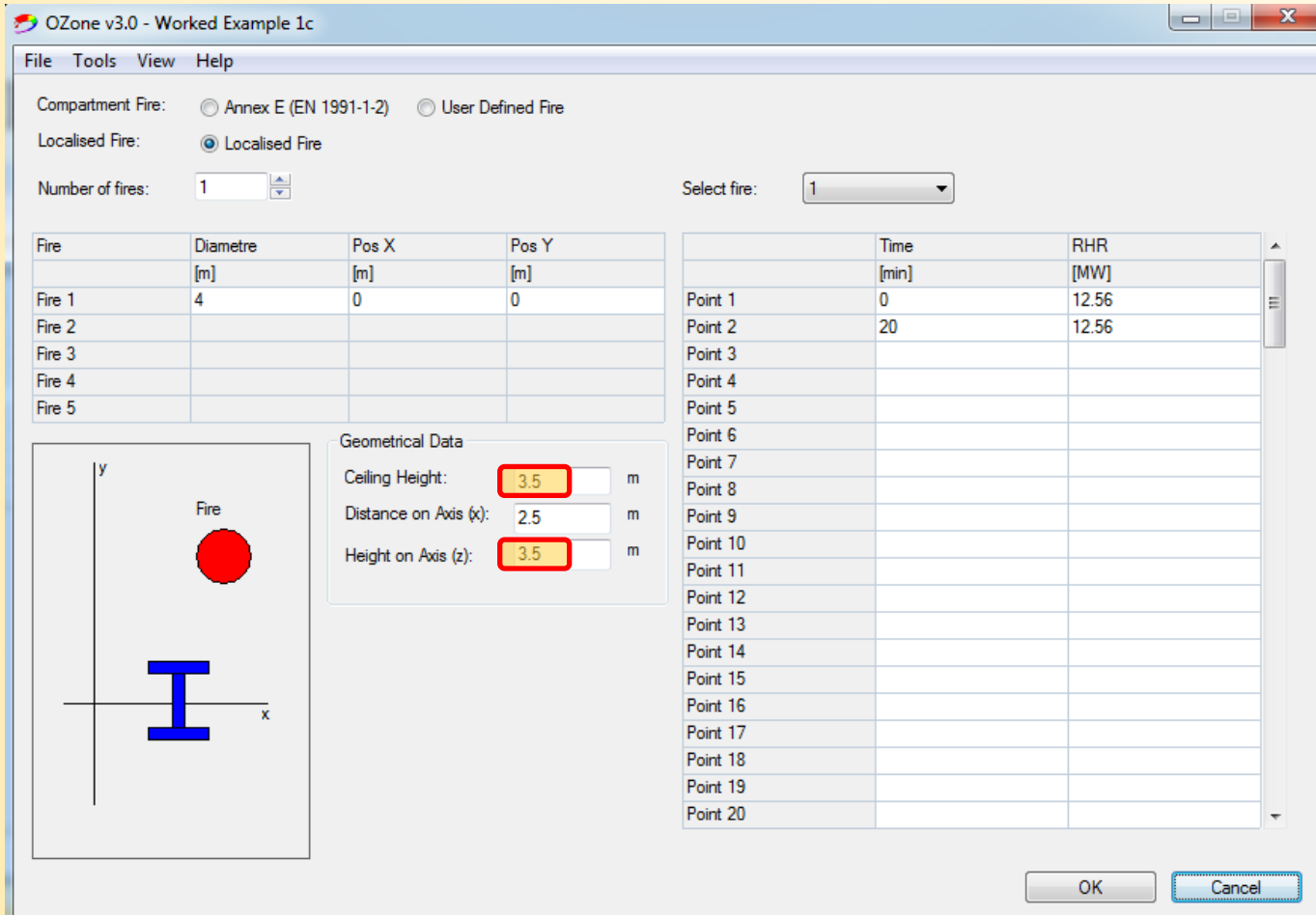
7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru



7. Računski primeri

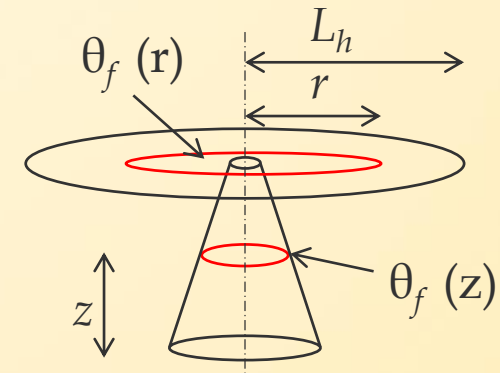
7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru



Primer 1c

$z = 3.5 \text{ m}$

$z_{\text{ceiling}} = 3.5 \text{ m}$



$$L_h = H(2.9Q_H^{0.33} - 1) = 4.54 \text{ m}$$

7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

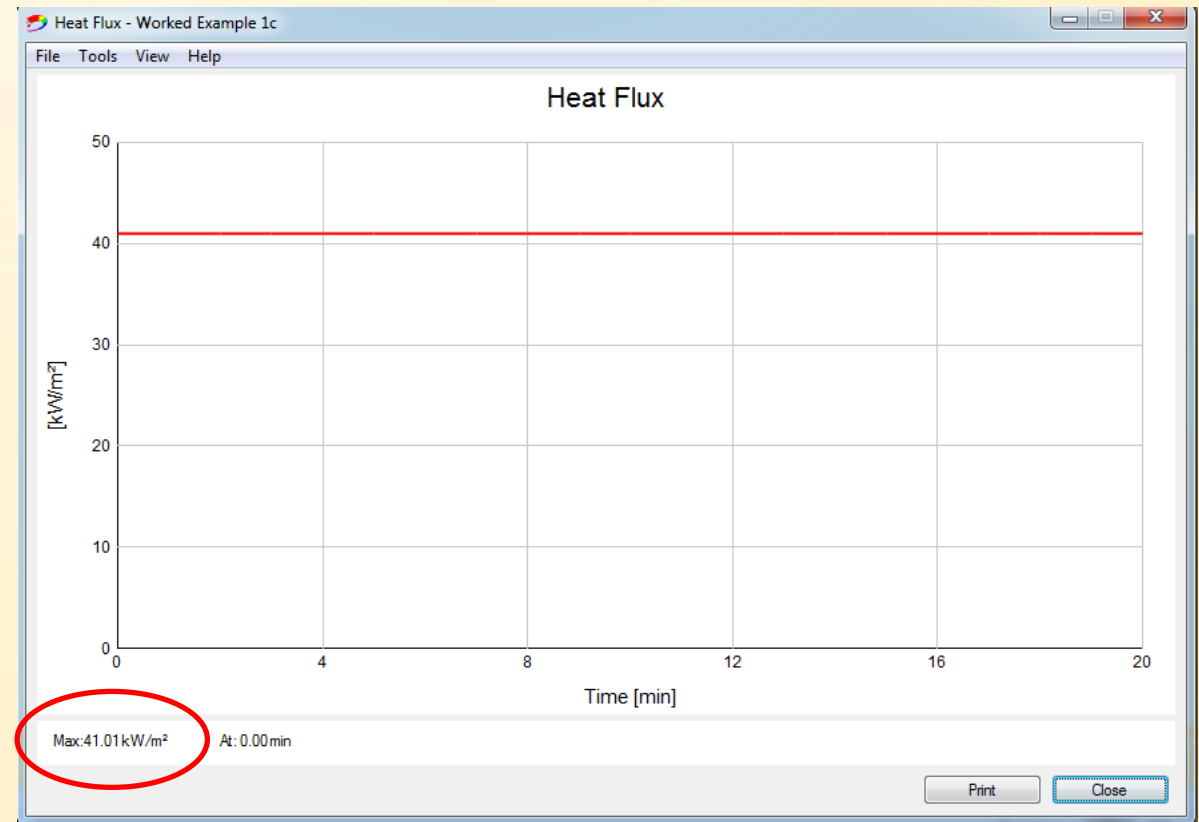
HASEMI (EN 1991-1-2 – Annex C)

$$Q_D^* = \frac{Q}{1.11 \cdot 10^6 \cdot D^{2.5}} = 0.3536$$

$$z' = 2.4 \cdot D \cdot (Q_D^{*2/5} - Q_D^{*2/3}) = 1.535$$

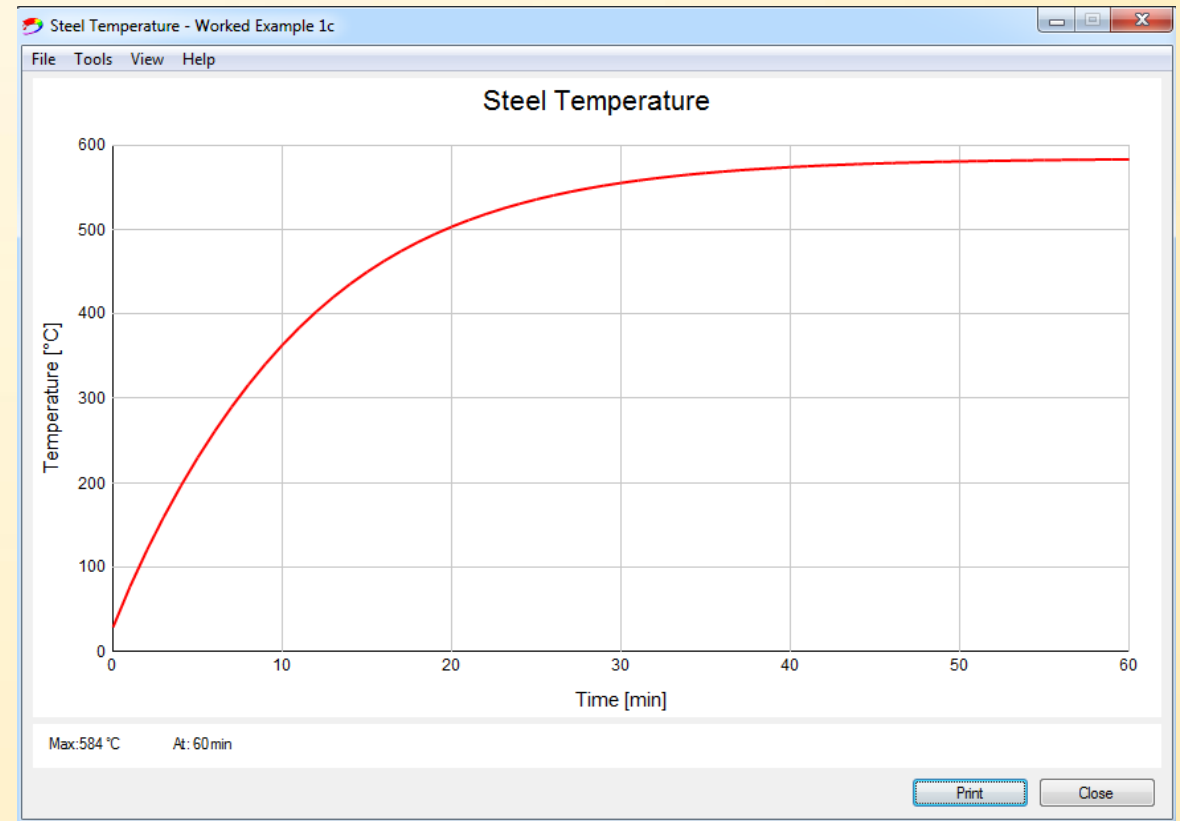
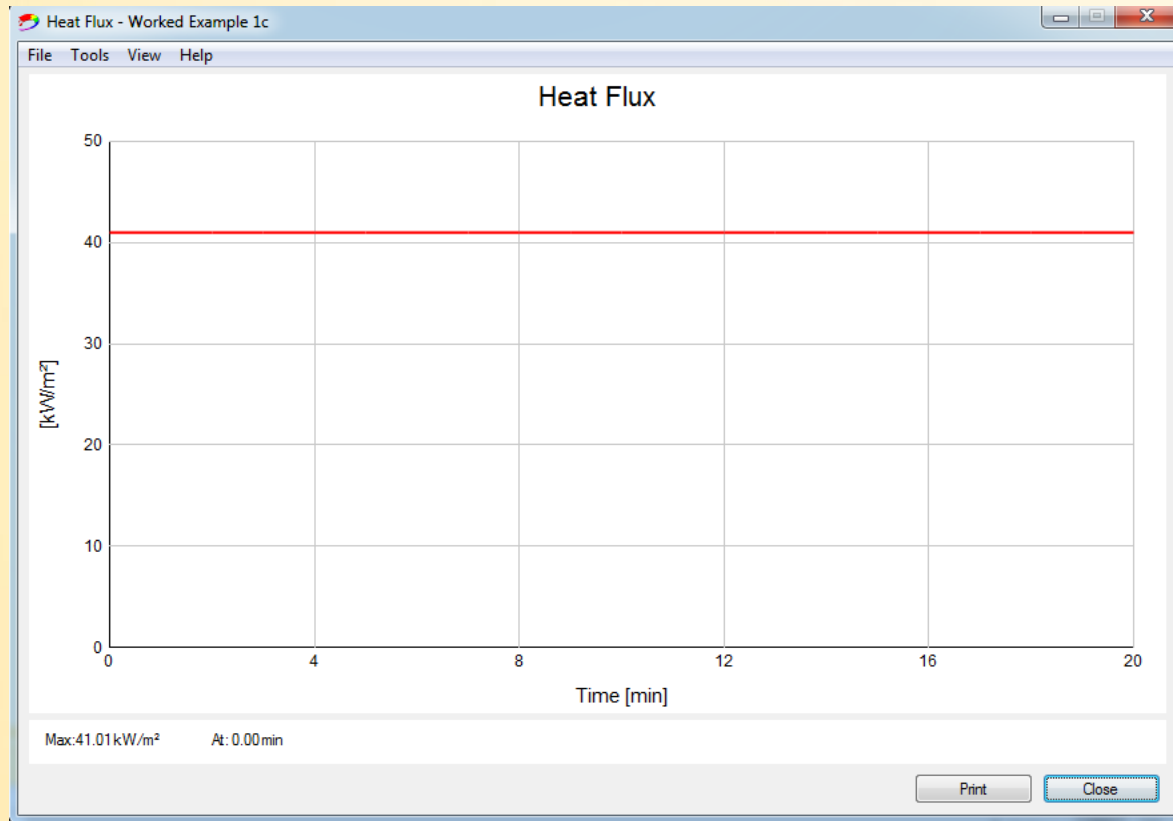
$$y = \frac{r + H + z'}{L_h + H + z'} = 0.787$$

$$0.3 < y < 1 \rightarrow \dot{h} = 136300 - 121000 y$$
$$\rightarrow \dot{h} = 41073 \text{ W/m}^2$$



7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

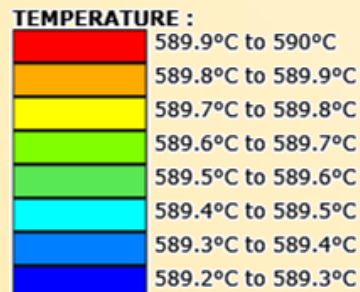
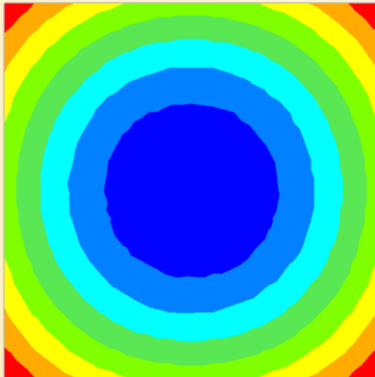


7. Računski primeri

7.1. Primer 1 : Sevalni toplotni tok pri lokaliziranem požaru

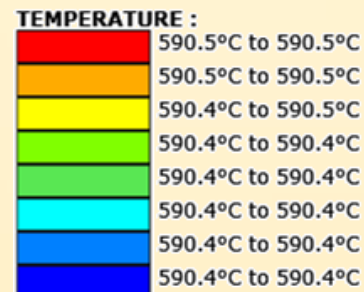
Razporeditev temperatur(HASEMI)

Kvadrat 300x300



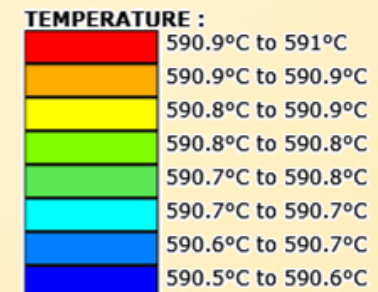
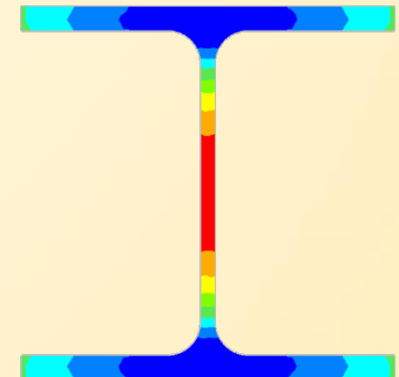
$T_{povp} =$
589°C

Škatla 300x300x10



$T_{povp} =$ **590°C**

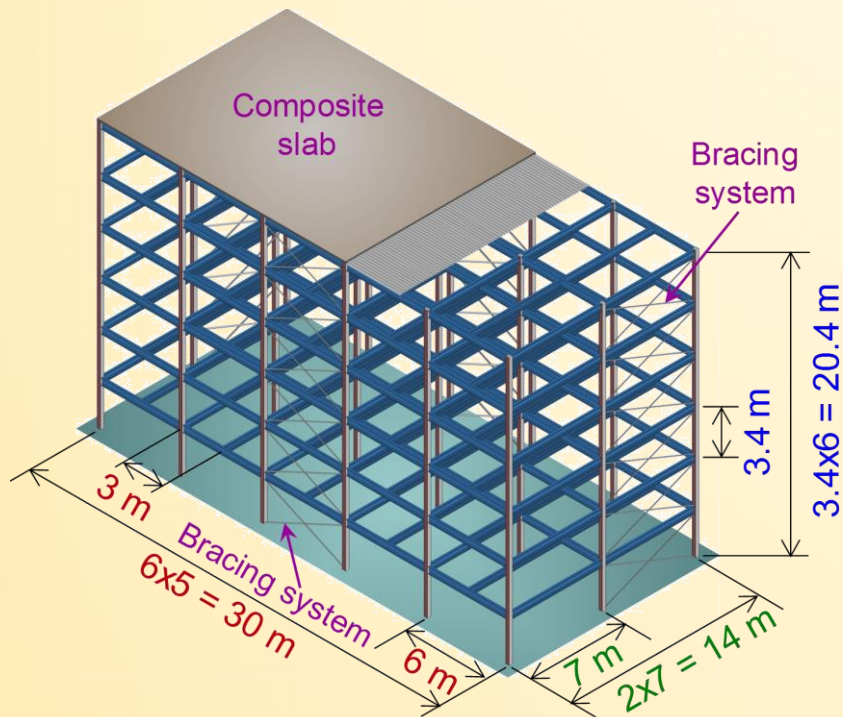
HEB 300



$T_{povp} =$ **591°C**

7. Računski primeri

7.2. Primer 2 : Steber v poslovni stavbi

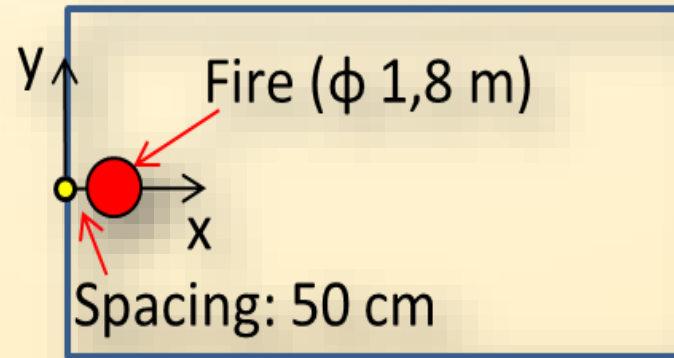


Vir požara se nahaja na razdalji 0.5 m od stebra

Višina stropa: 3.5 m

Požar: 500 kg papirja (17.5 MJ/kg) na 2.5m²

$RHR_{max} = 1000 \text{ kW/m}^2$

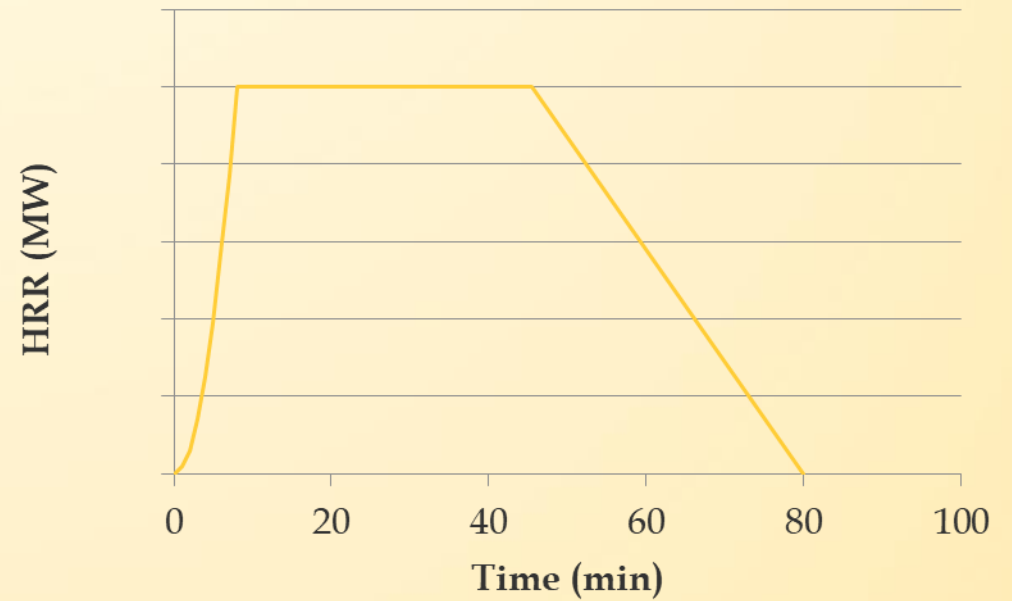


7. Računski primeri

7.2. Primer 2 : Steber v poslovni stavbi

Hitrost sproščanja toplote v skladu z EN 1991-1-2 Dodatek E

- Faza razvoja: $Q(t) = 10^6 * (t/t_\alpha)^2$
- Srednja hitrost razvoja požara
→ $RHR = 1 \text{ MW pri } t_\alpha = 300 \text{ sec}$
- $RHR_{max} = 2.5 \text{ m}^2 * 1000 \text{ kW/m}^2 = 2.5 \text{ MW}$
- Faza pojemanja po izgorelih 70% goriva



7. Računski primeri

7.2. Primer 2 : Steber v poslovni stavbi

File Tools View Help

Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires: 1 Select fire: 1

Fire	Diameter [m]	Pos X [m]	Pos Y [m]
Fire 1	1.8	1.4	0
Fire 2			
Fire 3			
Fire 4			
Fire 5			

Geometrical Data

Compartment Height: 3.5 m

Distance on Axis (x): 0 m

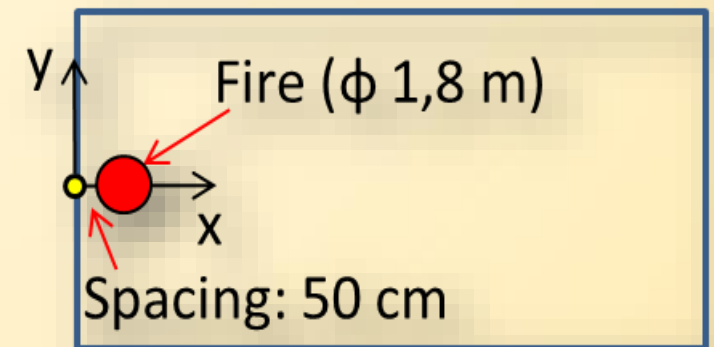
Height on Axis (z): 2.5 m

Time [min] RHR [MW]

Point 1	0	0
Point 2	1	0.05
Point 3	2	0.15
Point 4	3	0.35
Point 5	4	0.625
Point 6	5	0.975
Point 7	6	1.425
Point 8	7	1.925
Point 9	8	2.5
Point 10	45	2.5
Point 11	45.5	2.5
Point 12	80	0
Point 13		
Point 14		
Point 15		
Point 16		
Point 17		
Point 18		
Point 19		
Point 20		

OK Cancel

$$\text{Poz } x : 0.5\text{m} + 1.8\text{m}/2 = 1.4\text{m}$$



7. Računski primeri

7.2. Primer 2 : Steber v poslovni stavbi

File Tools View Help

Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires: 1

Select fire: 1

Fire	Diameter [m]	Pos X [m]	Pos Y [m]
Fire 1	1.8	1.4	0
Fire 2			
Fire 3			
Fire 4			
Fire 5			

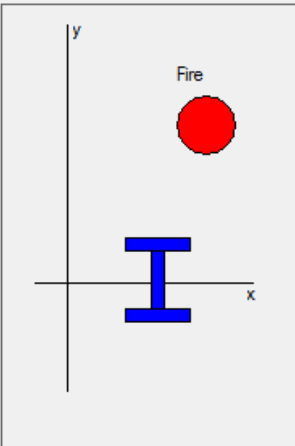
Geometrical Data

Compartment Height: 3.5 m

Distance on Axis (x): 0 m

Height on Axis (z): 2.5 m

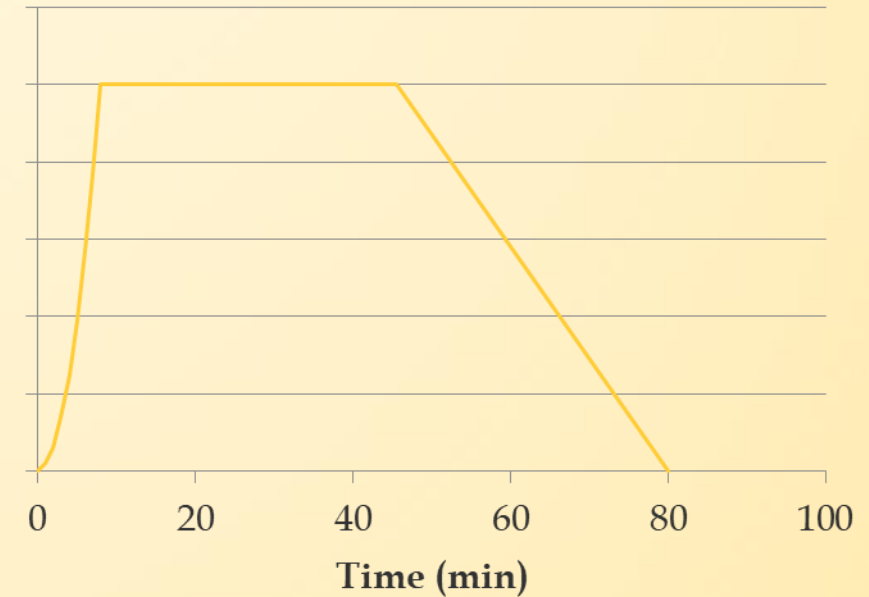
Fire



	Time [min]	RHR [MW]
Point 1	0	0
Point 2	1	0.05
Point 3	2	0.15
Point 4	3	0.35
Point 5	4	0.625
Point 6	5	0.975
Point 7	6	1.425
Point 8	7	1.925
Point 9	8	2.5
Point 10	45	2.5
Point 11	45.5	2.5
Point 12	80	0
Point 13		
Point 14		
Point 15		
Point 16		
Point 17		
Point 18		
Point 19		
Point 20		

OK Cancel

HRR (MW)



7. Računski primeri

7.2. Primer 2 : Steber v poslovni stavbi

File Tools View Help

Cross Section

☒ Unprotected Cross Section
☐ Protected Cross Section

Steel Profile

Profile Type: HE - HL
Profile: HE 260 A

Exposure

☒ Exposed on Four Sides
☐ Exposed on Three Sides

Encasement

☒ Contour Encasement
☐ Hollow Encasement

Protection Material

☒ From Catalog
☐ Constant Values
☐ Temperature Dependent

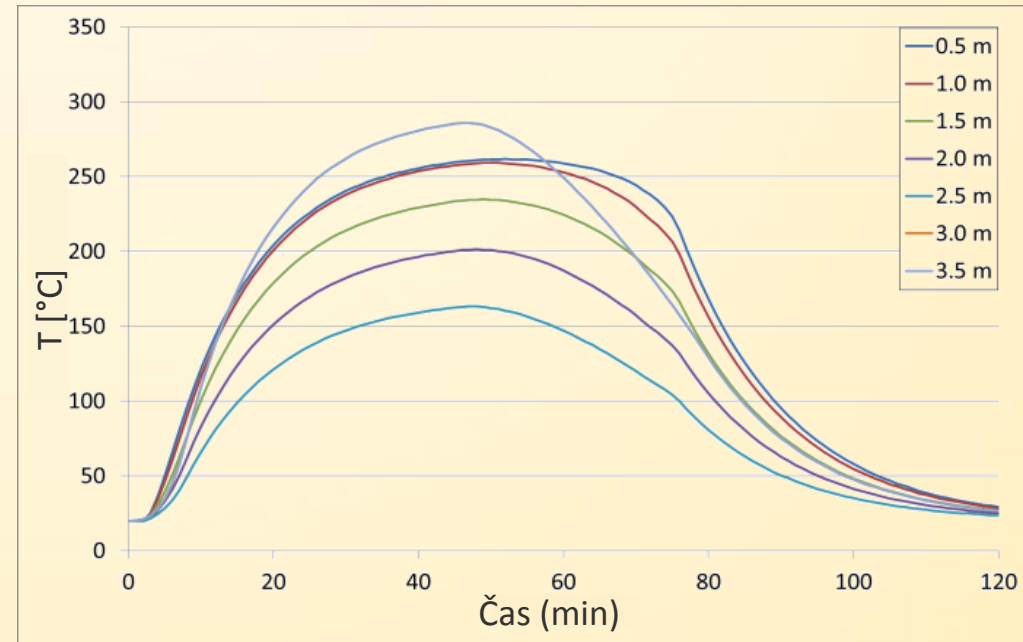
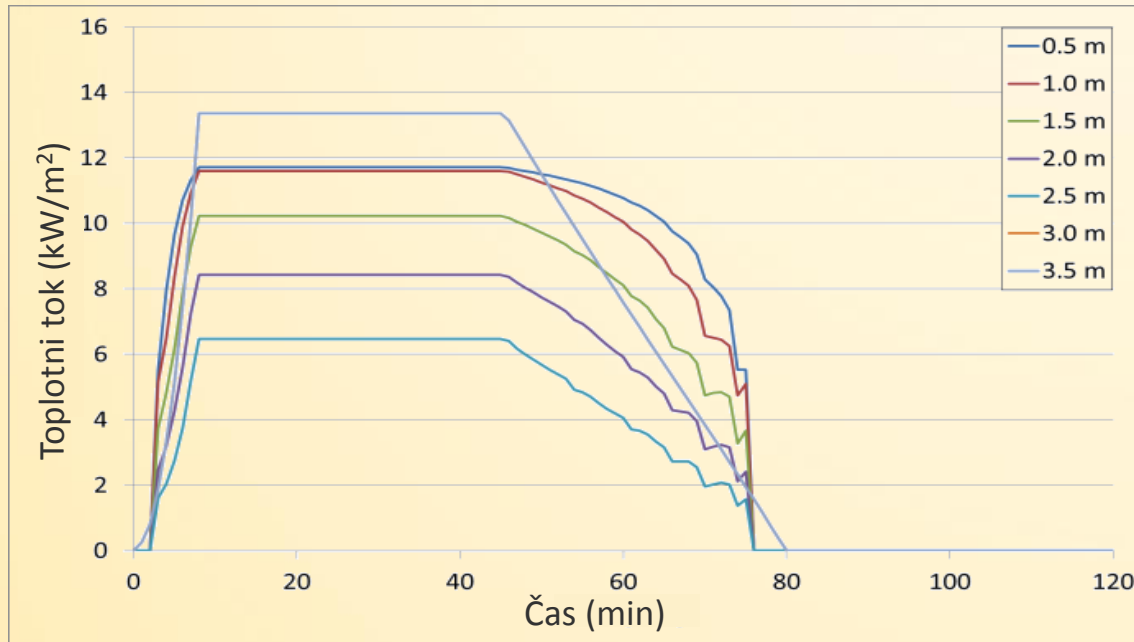
Thickness: 0 mm
Material Name: Spray Mineral Fiber

Temperature	Unit mass	Specific Heat	Conductivity
°C	kg/m³	J/kgK	W/mK
	300	1200	0.12

OK Cancel

7. Računski primeri

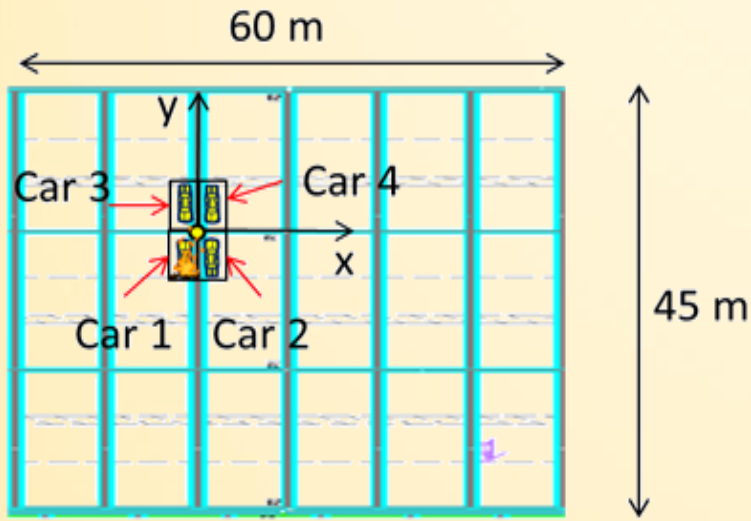
7.2. Primer 2 : Steber v poslovni stavbi



- Največji absorbirani sevalni toplotni tok v vroči dimni plasti
- Vroča dimna plast ($z = 3.5\text{m}$) : temperatura doseže 290°C
- Izven dimne plasti ($z = 0.5\text{m}$ in $z = 1\text{m}$) : $\sim 250^{\circ}\text{C}$

7. Računski primeri

7.3. Primer 3: Steber v parkirni hiši



Steber HEA 300

Višina stropa: 3.5 m

*Dimenzije parkirnega mesta: 2.5 m*5 m*

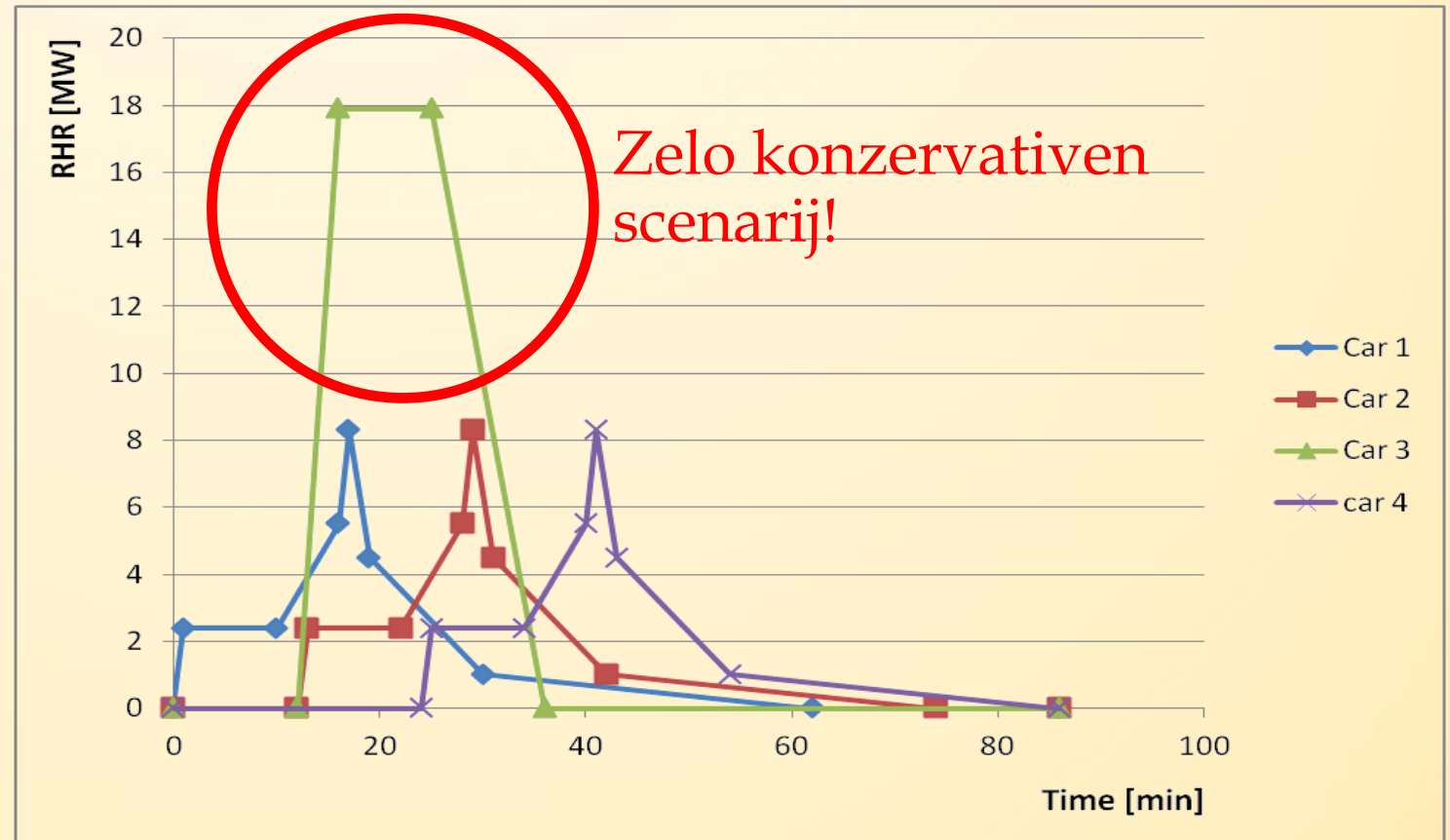
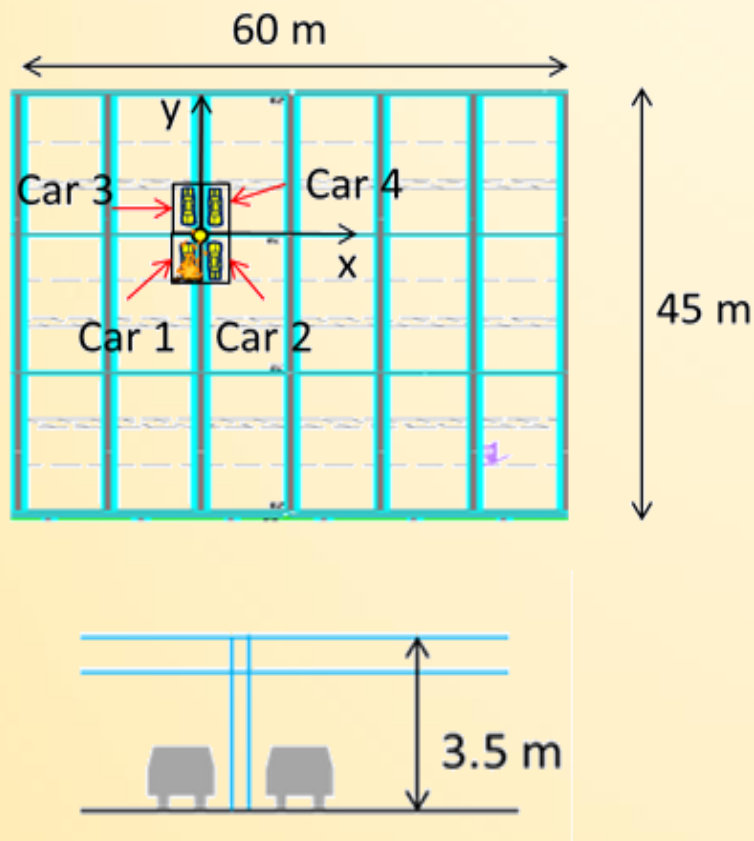
→ Ekvivalenten premer požara: 4 m

*Požarni scenarij: 3 avtomobili + 1 kombinirano vozilo
(analiza tveganja – zelo konzervativna predpostavka)*

*Čas vžiga med dvema vzporednima avtomobiloma: 12
minut*

7. Računski primeri

7.3. Primer 3: Steber v odprti parkirni hiši



7. Računski primeri

7.3. Primer 3: Steber v odprti parkirni hiši

File Tools View Help

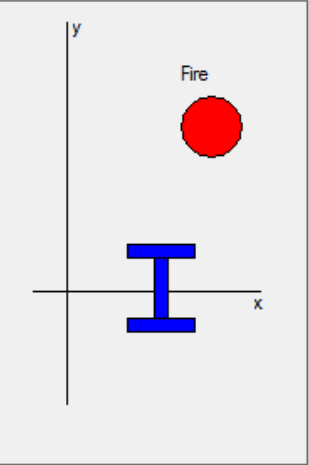
Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires:

Select fire:

Fire	Diametre	Pos X	Pos Y
	[m]	[m]	[m]
Fire 1	4	-1.25	-2.5
Fire 2	4	1.25	-2.5
Fire 3	4	-1.25	2.5
Fire 4	4	1.25	2.5
Fire 5			



Geometrical Data

Compartment Height: m

Distance on Axis (x): m

Height on Axis (z): m

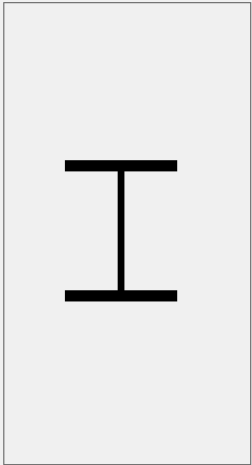
	Time	RHR
	[min]	[MW]
Point 1	0	0
Point 2	1	2.4
Point 3	10	2.4
Point 4	16	5.5
Point 5	17	8.3
Point 6	19	4.5
Point 7	30	1
Point 8	62	0
Point 9	86	0
Point 10		
Point 11		
Point 12		
Point 13		
Point 14		
Point 15		
Point 16		
Point 17		
Point 18		
Point 19		
Point 20		

OK Cancel

File Tools View Help

Cross Section

☒ Unprotected Cross Section☐ Protected Cross Section



Steel Profile

Profile Type:

Profile:

Exposure

☒ Exposed on Four Sides☐ Exposed on Three Sides

Encasement

☒ Contour Encasement☐ Hollow Encasement

Protection Material

☒ From Catalog☐ Constant Values☐ Temperature Dependent

Thickness: mm

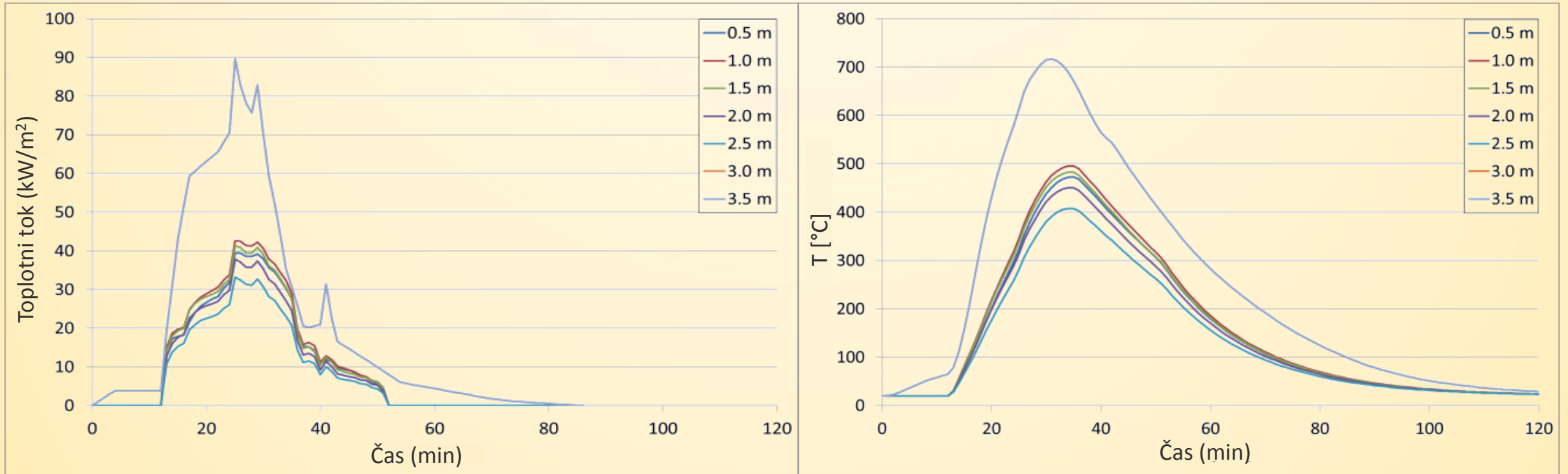
Material Name:

Temperature	Unit mass	Specific Heat	Conductivity
°C	kg/m³	J/kgK	W/mK
	300	1200	0.12

OK Cancel

7. Računski primeri

7.3. Primer 3: Steber v odprti parkirni hiši



- Izven dimne plasti ($z = 1 \text{ m}$) : $T_{\max} = 500 \text{ °C}$
- V dimni plasti ($z = 3.5 \text{ m}$) : $T_{\max} = 718 \text{ °C}$

7. Računski primeri

7.4. Primer 4 : Paličje v industrijski stavbi

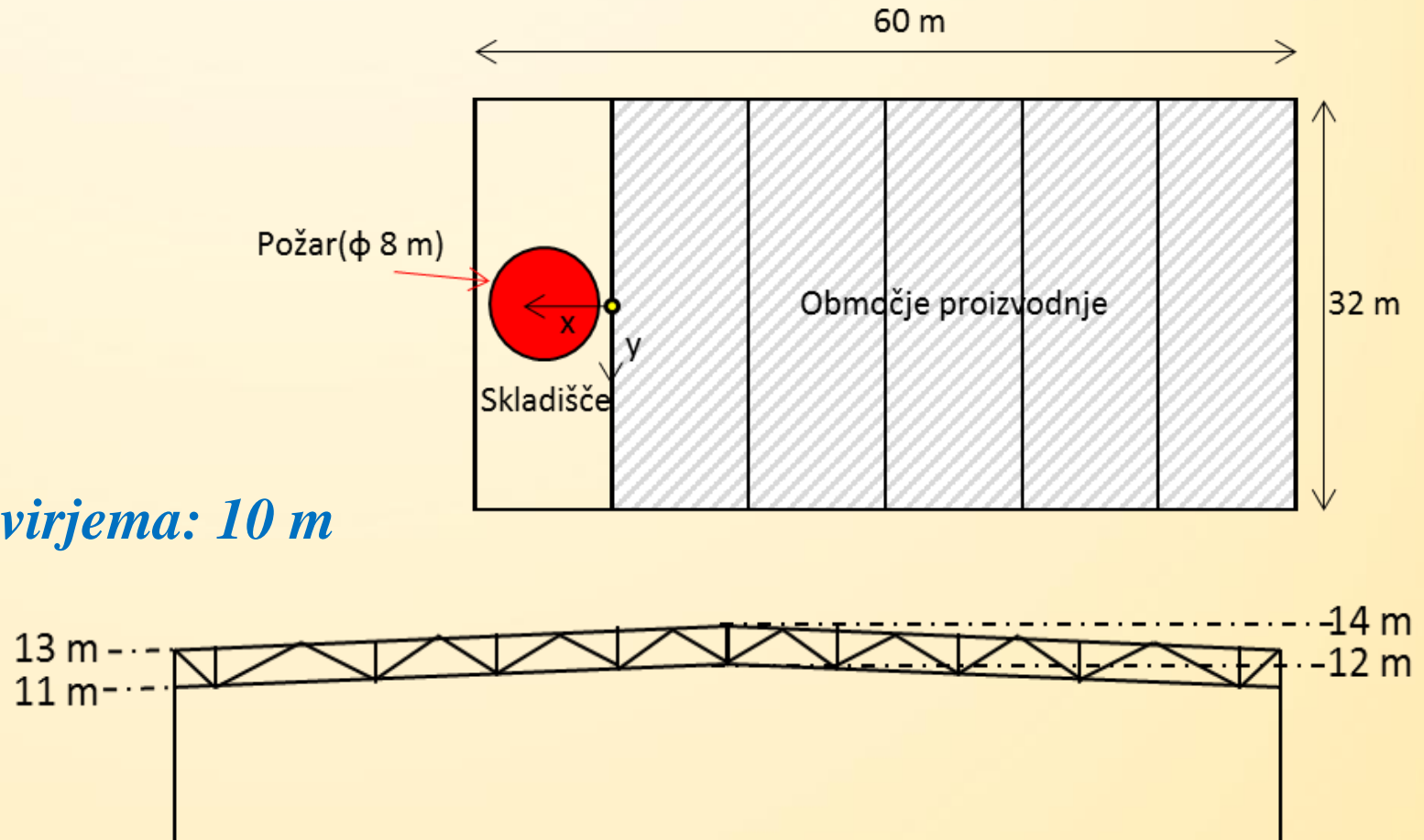
Opis konstrukcije:

Pasnice paličja: HEA 220

*Diagonale: 2 L60*60*6*

Razdalja med 2 jeklenima okvirjema: 10 m

Višina slemena: 14 m



7. Računski primeri

7.4. Primer 4 : Paličje v industrijski stavbi

Požarni scenarij:

Površina požara: 50 m² (v središču skladišča)

→ Enakovreden premer požara: 8 m

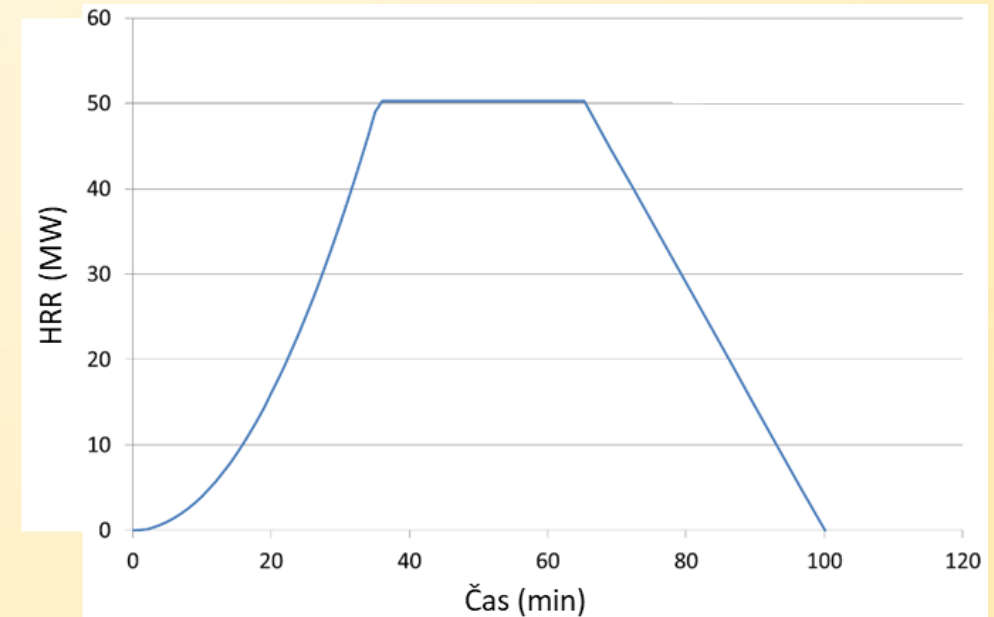
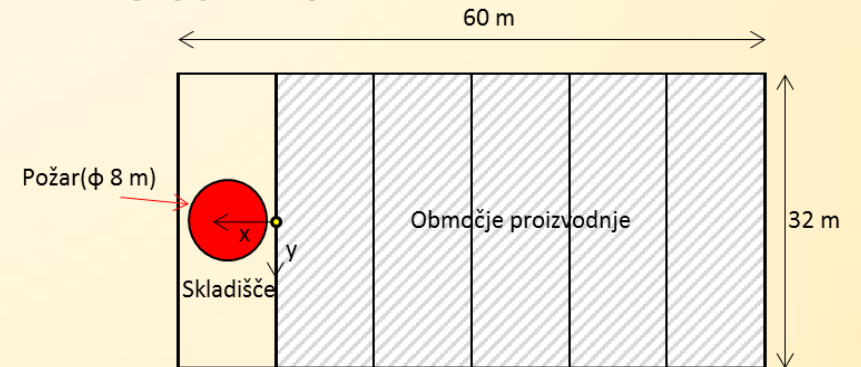
Hitrost razvoja požara: Srednja

→ RHR = 1 MW po $t_{\alpha} = 300$ sec

*$RHR_{max} = 1000 \text{ kW/m}^2 * 50 \text{ m}^2 = 50 \text{ MW}$*

Požarna obtežba: 10 ton (celulozen tip)

*→ $Q = 17.5 \text{ MJ/kg} * 10000 \text{ kg} = 175000 \text{ MJ}$*



7. Računski primeri

7.4. Primer 4 : Paličje v industrijski stavbi

File Tools View Help

Compartment Fire: ☐ Annex E (EN 1991-1-2) ☐ User Defined Fire

Localised Fire: ☒ Localised Fire

Number of fires:

Select fire:

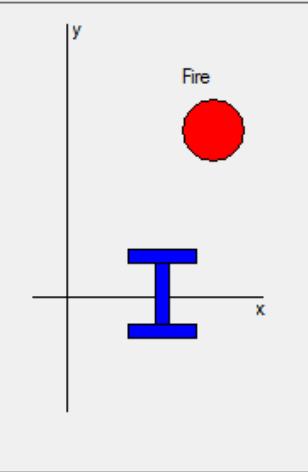
Fire	Diametre [m]	Pos X [m]	Pos Y [m]
Fire 1	8	0	0
Fire 2			
Fire 3			
Fire 4			
Fire 5			

Geometrical Data

Compartment Height: m

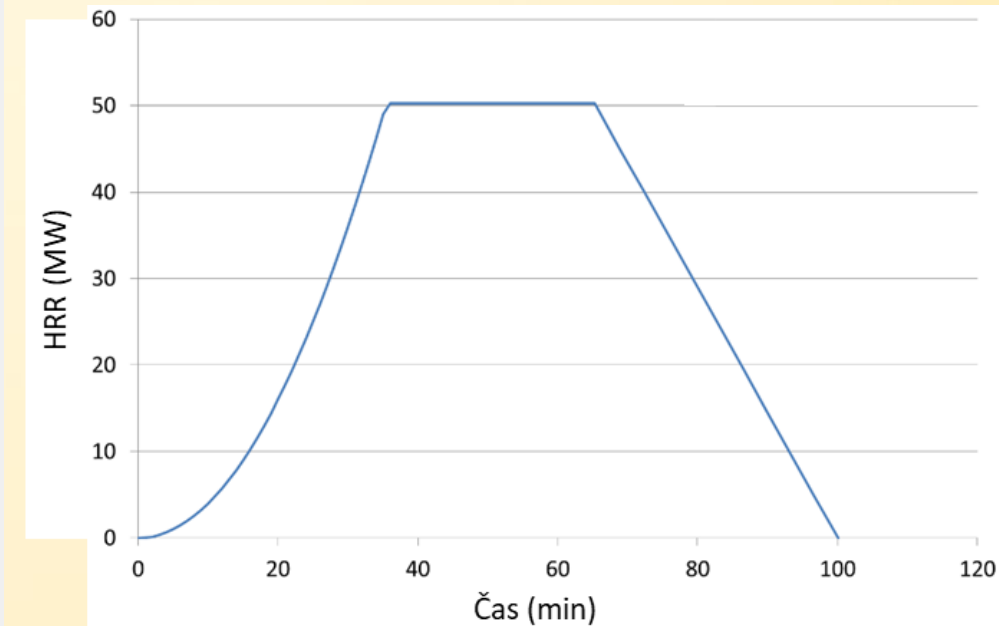
Distance on Axis (x): m

Height on Axis (z): m



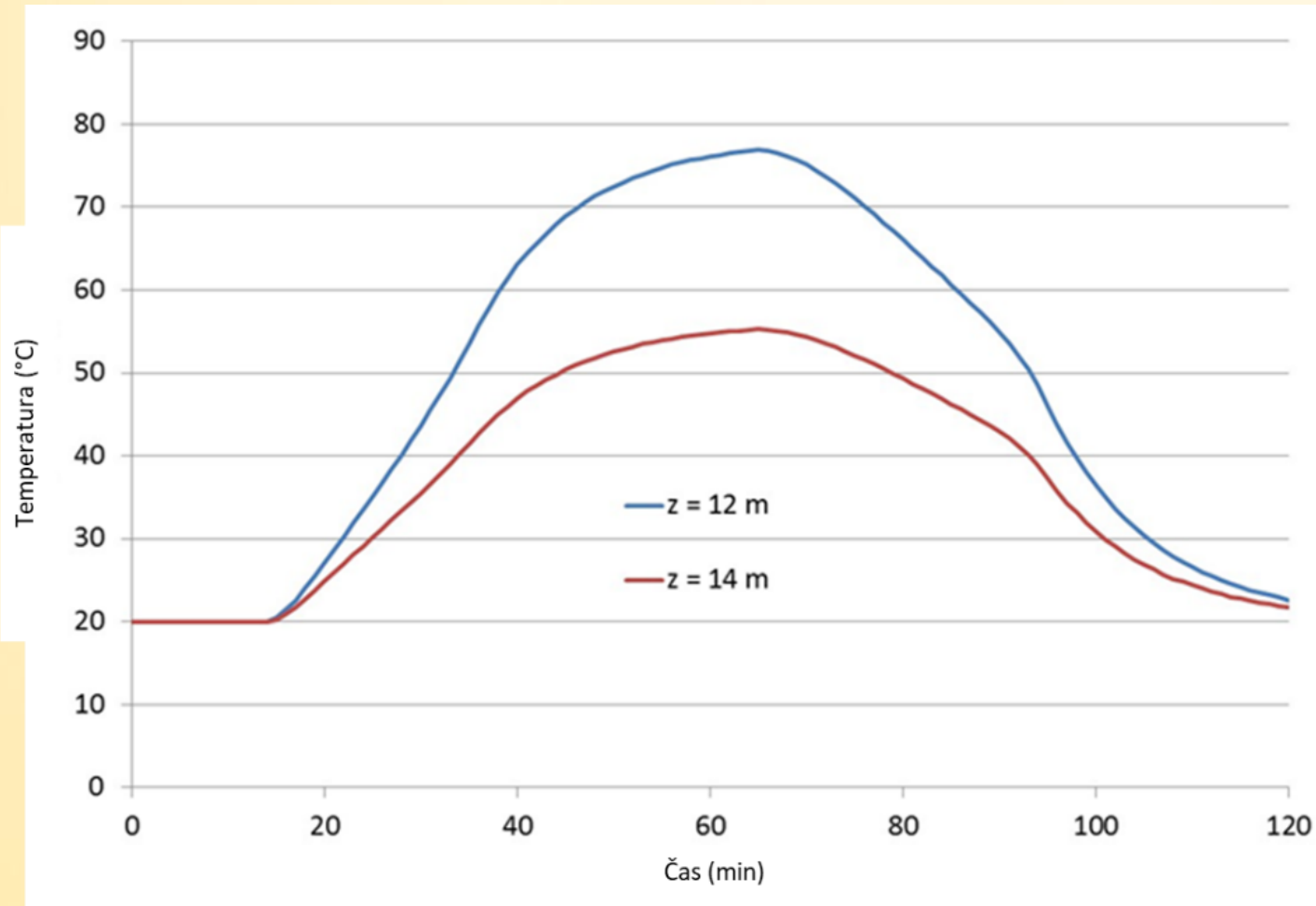
	Time [min]	RHR [MW]
Point 1	0	0
Point 2	2	0.15
Point 3	4	0.65
Point 4	6	1.45
Point 5	8	2.55
Point 6	10	4
Point 7	12	5.75
Point 8	14	7.8
Point 9	16	10.2
Point 10	18	12.9
Point 11	20	15.9
Point 12	22	19.25
Point 13	24	22.9
Point 14	26	26.9
Point 15	28	31.2
Point 16	30	35.8
Point 17	32	40.75
Point 18	34	46
Point 19	36	50
Point 20	64	50

OK Cancel



7. Računski primeri

7.4. Primer 4 : Paličje v industrijski stavbi



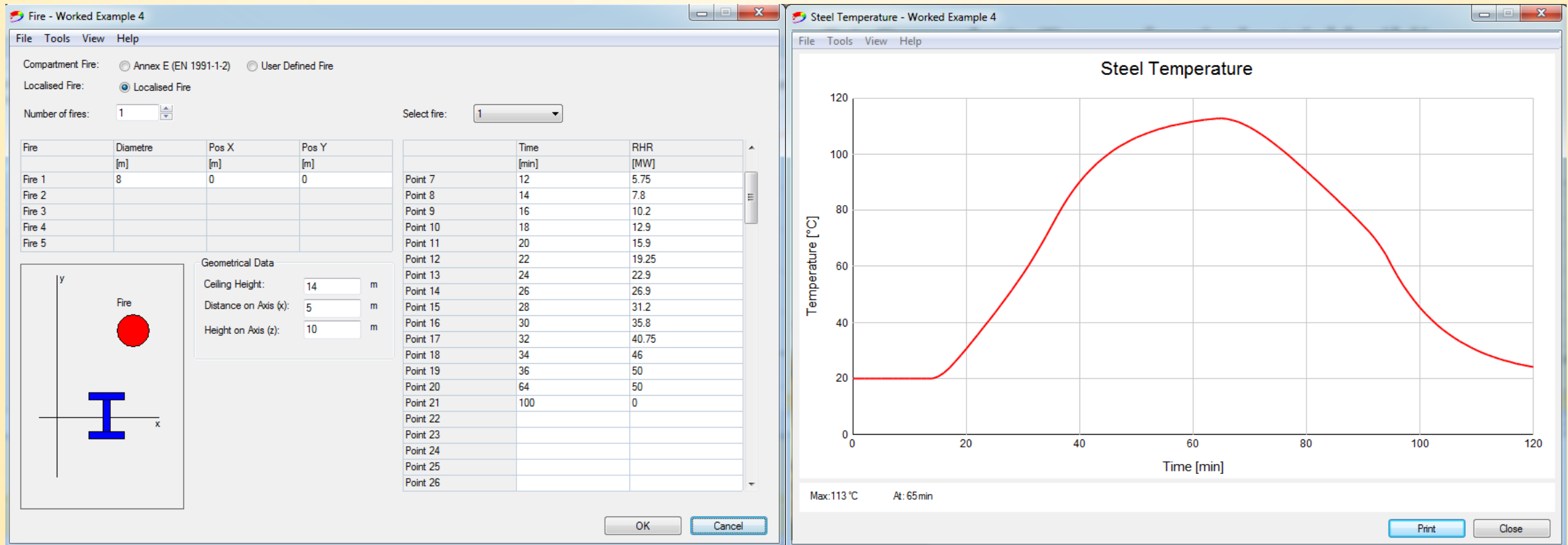
Višina plamena = 9.7 m

→ Elementi paličja se nahajajo nad trdnim plamenom

Največja temperatura paličja = 78 °C

7. Računski primeri

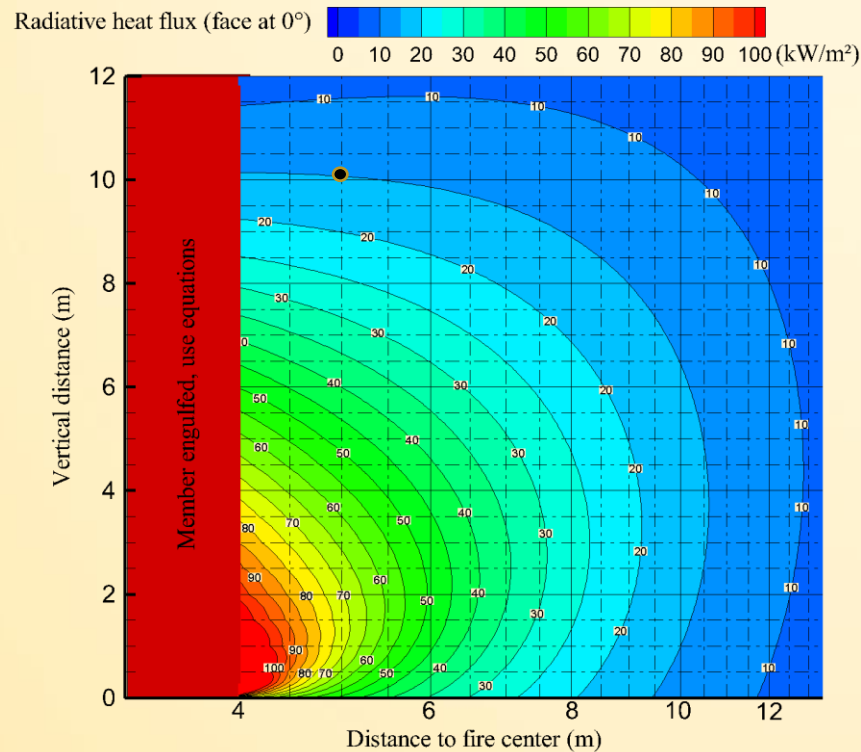
7.4. Primer 4 : Paličje v industrijski stavbi



7. Računski primeri

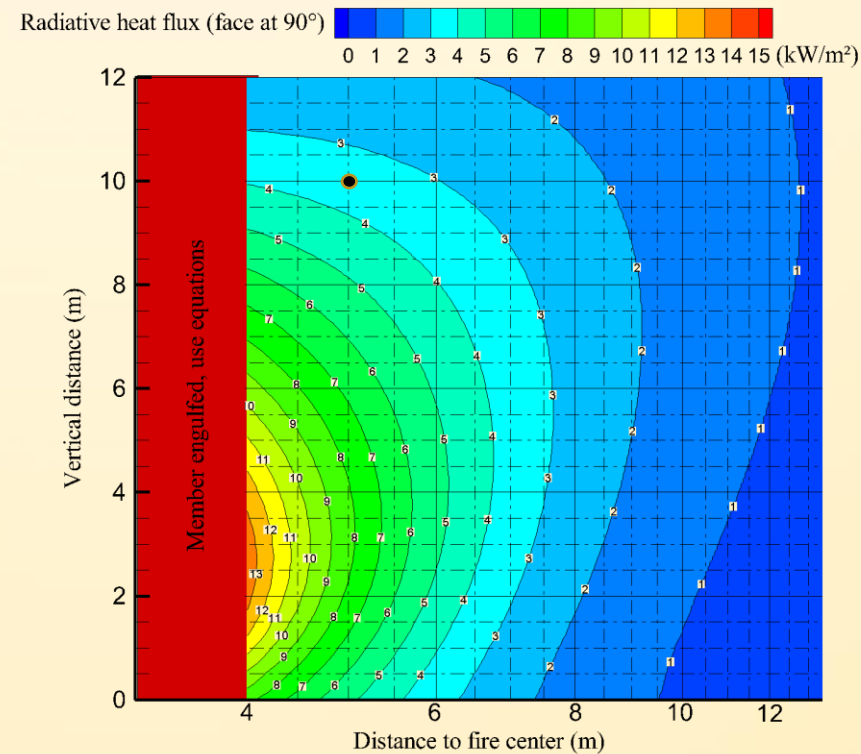
7.4. Primer 4 : Paličje v industrijski stavbi

Ploskev 1



$$\varepsilon * \varphi_{tot} = 0.7 * 15 \text{ kW/m}^2 = 10.5 \text{ kW/m}^2$$

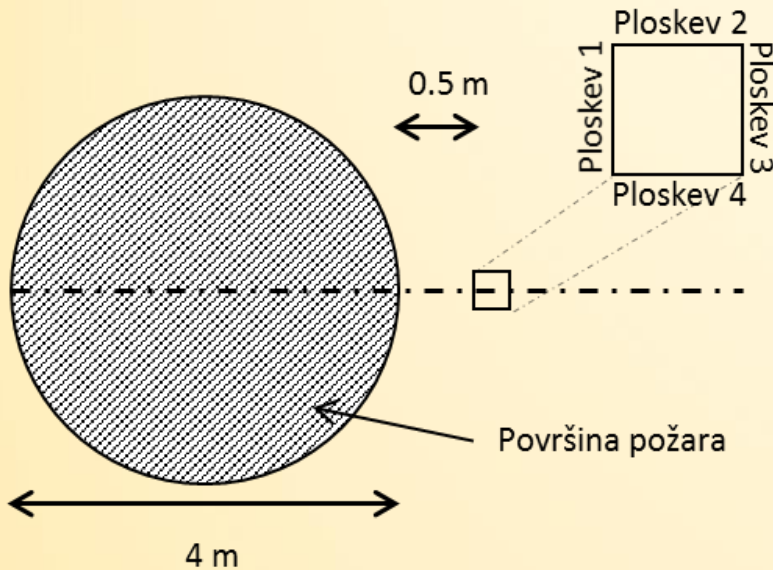
Ploskev 2



$$\varepsilon * \varphi_{tot} = 0.7 * 3.5 \text{ kW/m}^2 = 2.45 \text{ kW/m}^2$$

7. Računski primeri

7.4. Primer 4 : Paličje v industrijski stavbi



Toplotni tok, ki ga absorbira vsaka ploskev (predpostavka $\varepsilon = 0.7$)

Ploskev 1 : 10.5 kW/m²

Ploskev 2 : 2.45 kW/m²

Ploskev 3 : 0.00 kW/m²

Ploskev 4 : 2.45 kW/m²

→ Povprečni toplotni tok = 3.85 kW/m²

$$0 = \underbrace{h(\theta - 20)}_{\text{Oddani konvekcijski toplotni tok}} + \underbrace{\sigma\varepsilon[(\theta + 273)^4 - (20 + 273)^4]}_{\text{Oddani sevalni toplotni tok}} - \underbrace{\varepsilon * \varphi_{tot}}_{\text{Absorbirani toplotni tok}}$$

Oddani konvekcijski
toplotni tok

Oddani sevalni
toplotni tok

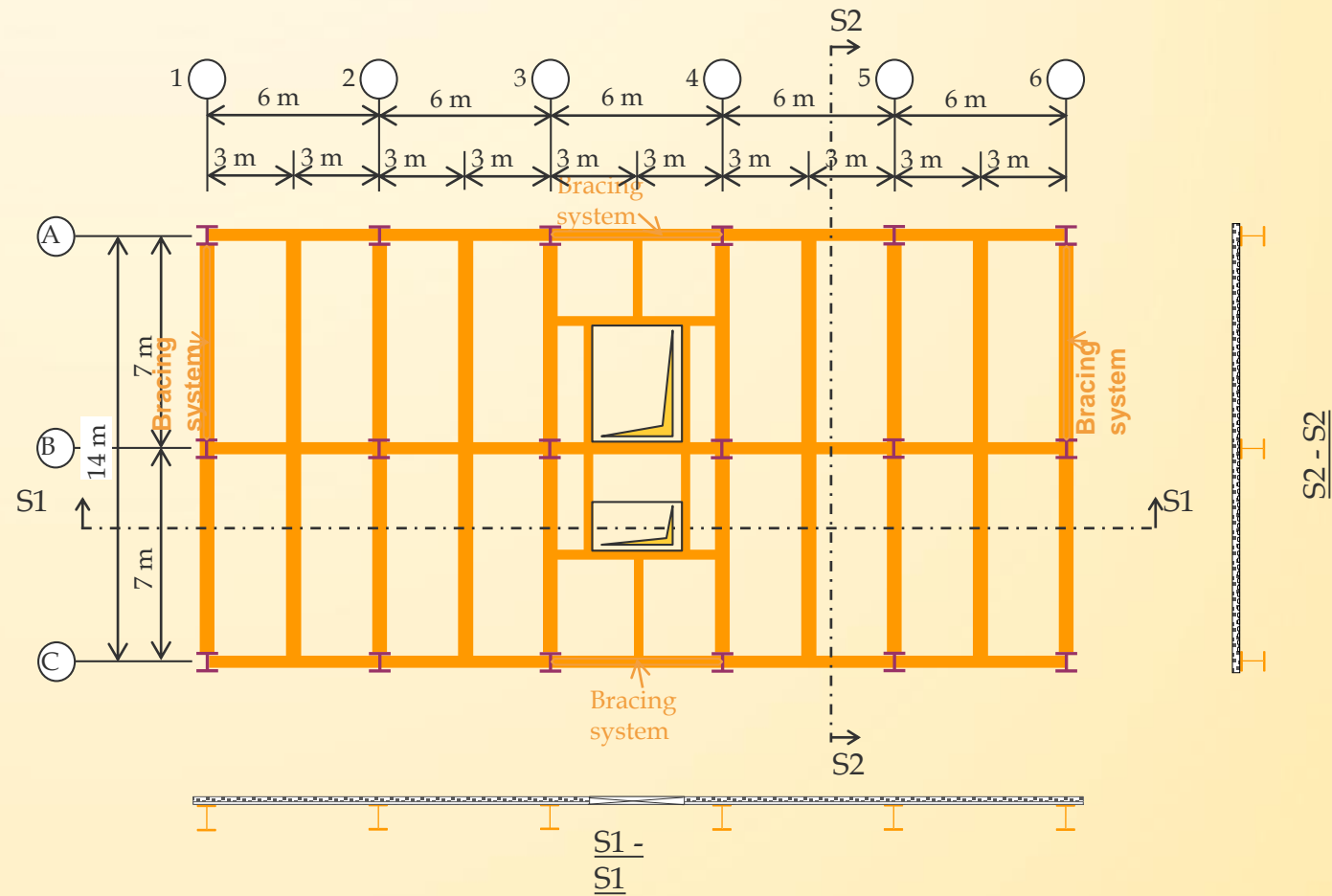
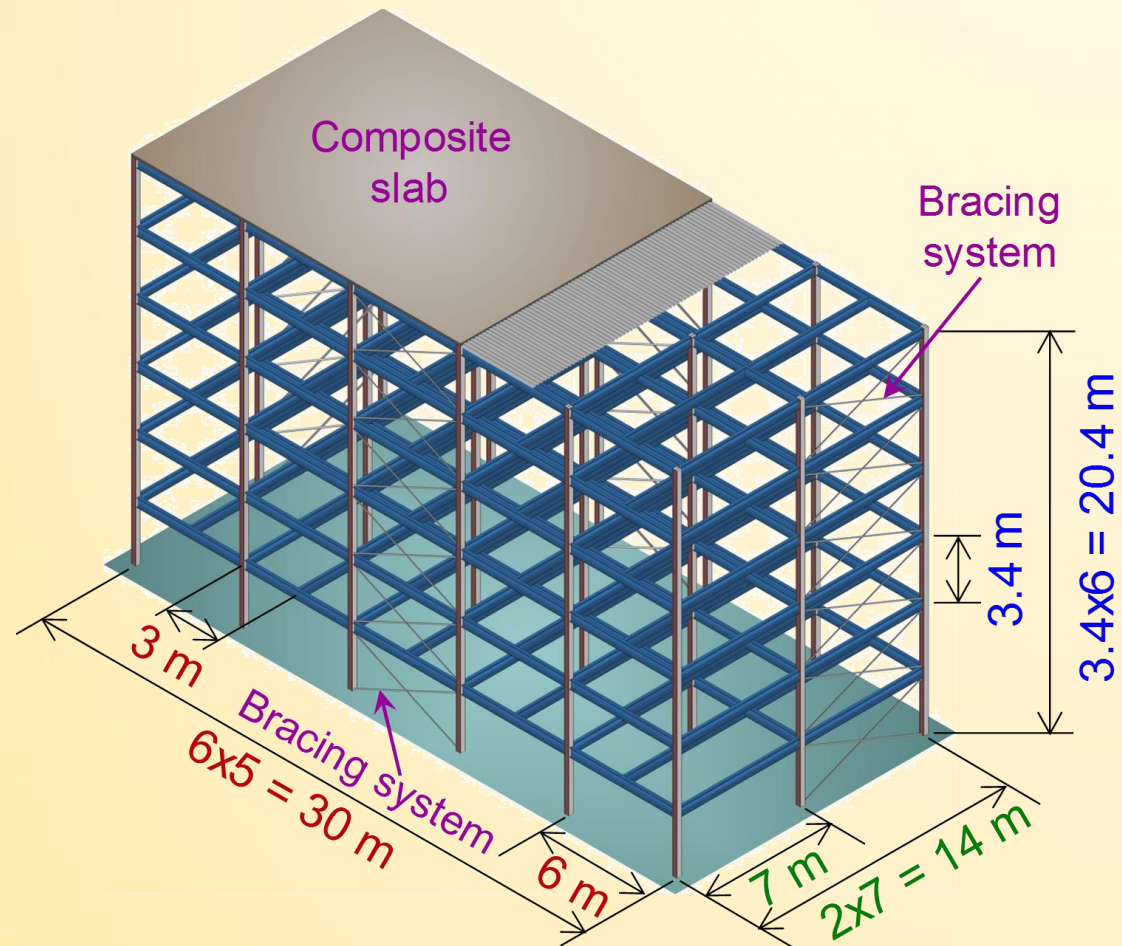
Absorbirani
toplotni tok

$$h = 35 \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-1}; \sigma = 5.67 * 10^{-8} \text{ W} \cdot \text{m}^{-2} \cdot \text{K}^{-4}$$

θ (°C)	Oddani toplotni tok W/m ²
20	0
30	392.03
40	788.42
50	1189.49
60	1595.53
70	2006.84
80	2423.77
90	2846.62
100	3275.76
110	3711.52
120	4154.27
130	4604.37
140	5062.21
150	5528.18

7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra



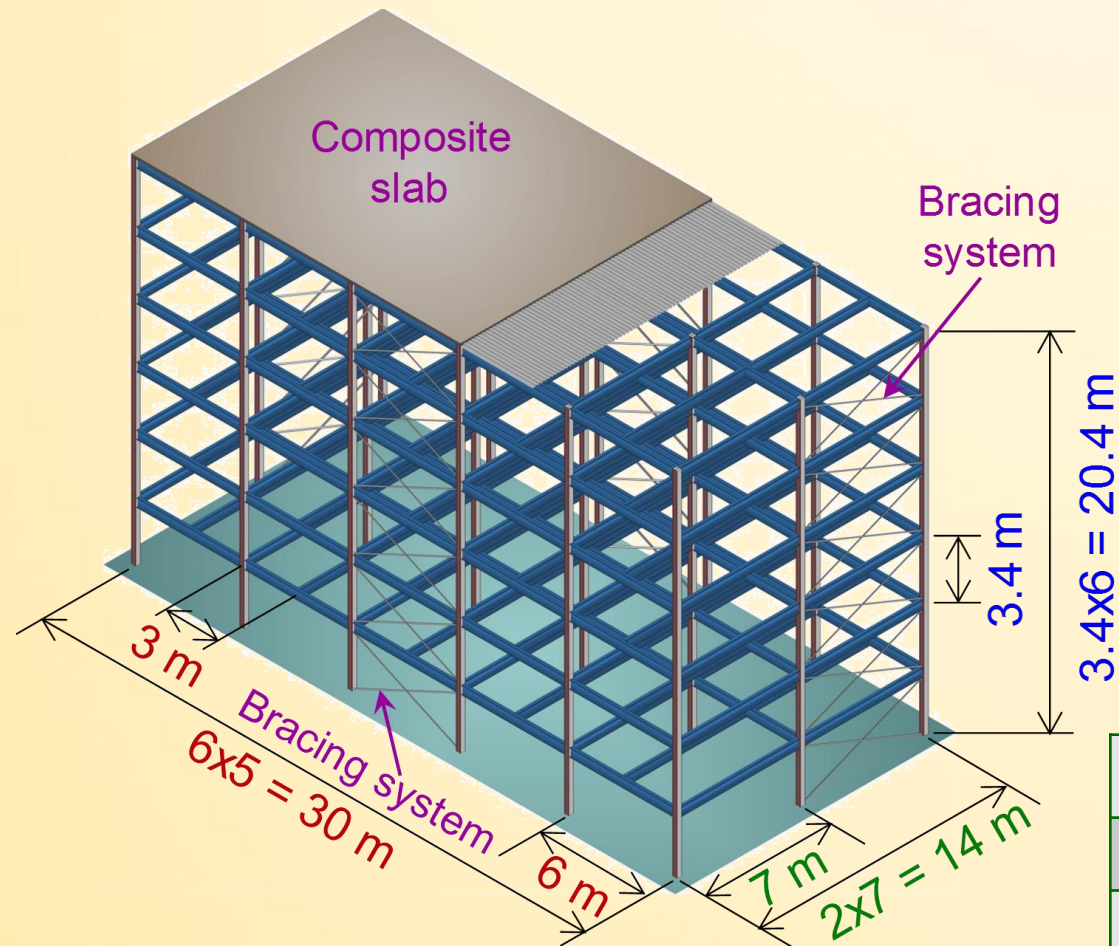
7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

Vplivi (za vsa nadstropja)

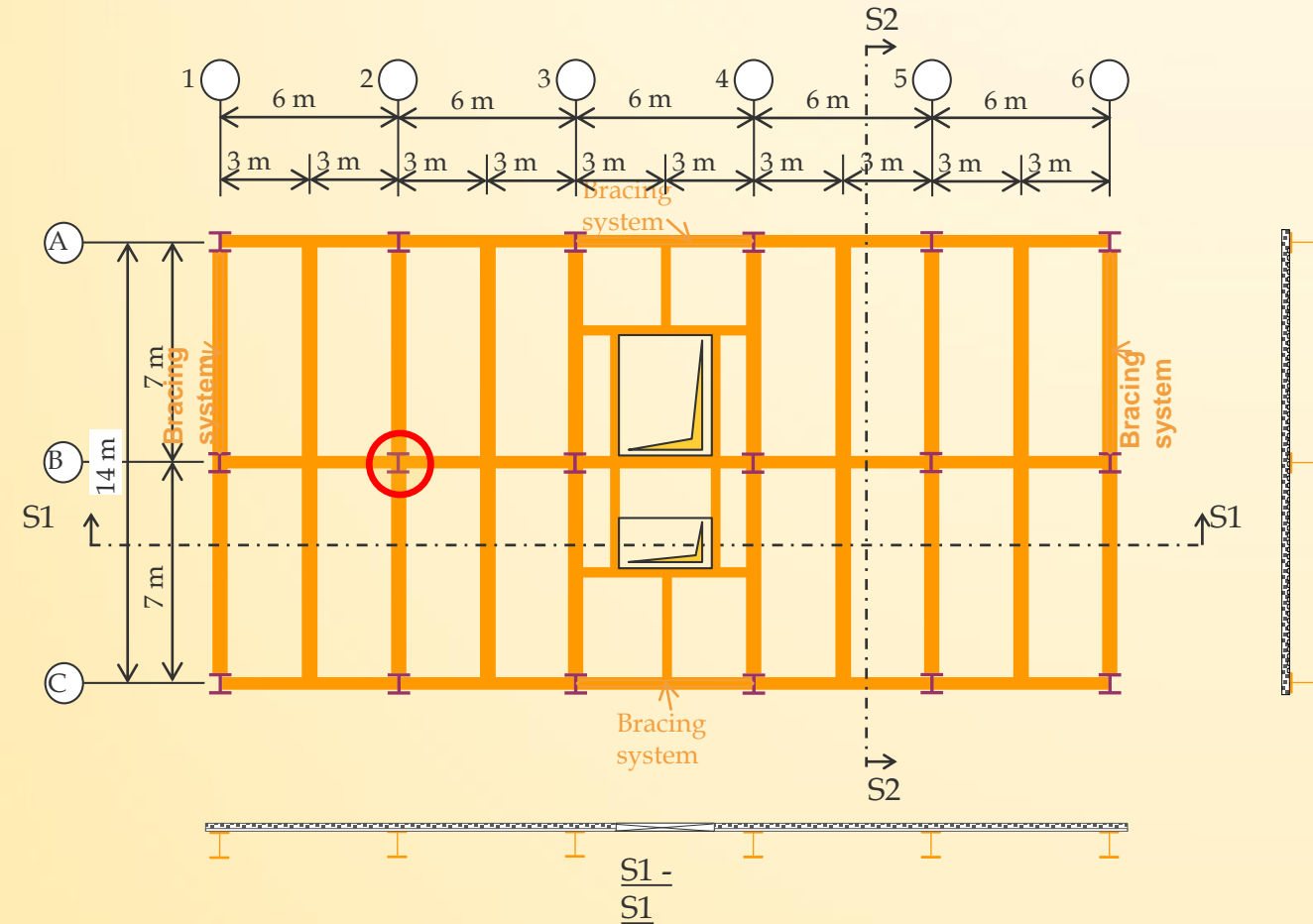
- Lastna teža G1:
 - ✓ teža sovprežne plošče 2.12 kN/m^2
 - ✓ jekleni konstrukcijski elementi (skladno s tabelami)
- Stalna obtežba G2:
 - ✓ Zaključni sloji, servis, predelni el.: 1.50 kN/m^2
- Stalna obtežba G3:
 - ✓ Obtežba fasadni panelov: 2.00 kN/m
- Karakteristične vrednosti spremenljive obtežbe in ψ faktorji

Vrsta	q_k	ψ_1	ψ_2
Koristna obtežba na nad.	4.0 kN/m^2	0.7	0.6
Sneg na strehi	1.7 kN/m^2	0.2	0.0



7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

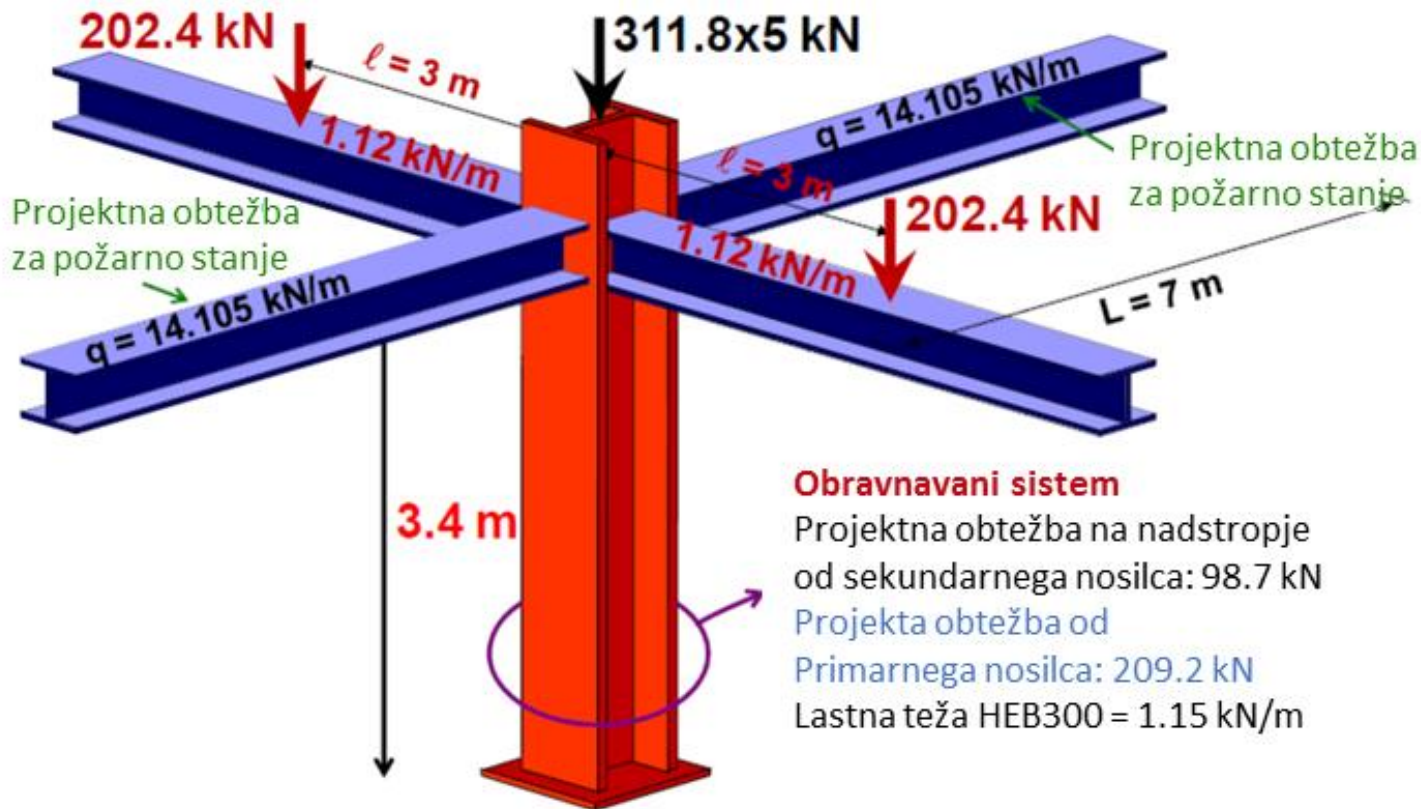


Konstruktivski elementi

- Sovprežna plošča:
 - ✓ Skupna debelina: 12 cm
 - ✓ Jeklena pločevina: COFRAPLUS60
 - ✓ Debelina pločevine: 0.75 mm
 - ✓ Kontinuirana plošča čez dve polji
- Sekundarni nosilce:
 - ✓ IPE 360 - S275
- Notranji primarni nosilci:
 - ✓ HEA 360 - S275
- Stebri v pritličju:
 - ✓ Robni stebri (pritličje): HEA 300 - S275
 - ✓ **Notranji stebri (pritličje): HEB 300 - S275**

7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra



Korak 1: Projektni vpliv v požaru

- Projektna obtežba v pož. proj. stanju

$$E_{fi,d,t} = \sum_{j \geq 1} G_{k,j} + \Psi_{2,1} Q_{k,1} + \sum_{i \geq 2} \Psi_{2,i} Q_{k,i}$$

- Lastna teža stebra

$$q_{fi,d,t} = 1.15 \text{ kN/m}$$

- Celotna koncentrirana osna sila od jeklenih nosilcev

$$P_{fi,d,t} = \sum (G_{k,1} + \psi_{2,1} Q_{k,1})$$
$$= 14.105 \times 7 + 202.4 + 1.13 \times 6$$
$$\approx 307.9 \text{ kN}$$

sekundarni
nosilci

Primarni
nosilec +
stember

Opomba : $\psi_{1,1}$ in $\psi_{2,1}$ je potrebno uporabiti glede na nacionalni dodatek

7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

Korak 1: Projekti vplivi v požaru

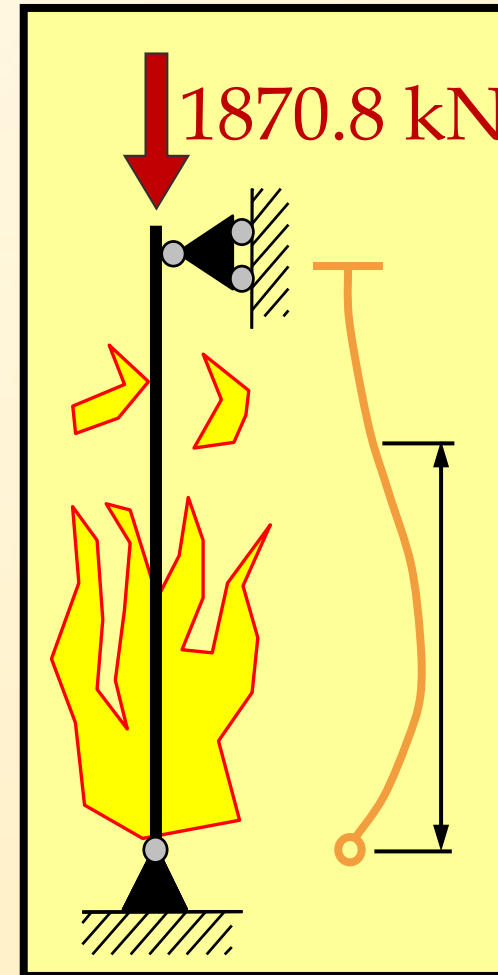
- Celotna projektna obtežba za požarno projektno stanje:

$$N_{fi,d,t} = (307.9 + 3.9) \times 6 = 1870.8 \text{ kN}$$

- Uklonska dolžina za požarno projektno stanje

- Vrtljivo vpet steber

$$L_{fi} = 0.7L = 0.7 \times 3.4 = 2.38 \text{ m}$$



7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

Korak 2: Klasifikacija elementa

- Tlačeni element

Zveza 4.2 v Evrokodu 3 del 1-2

$$\varepsilon = 0.85 \sqrt{235/f_y} = 0.786$$

\searrow S275

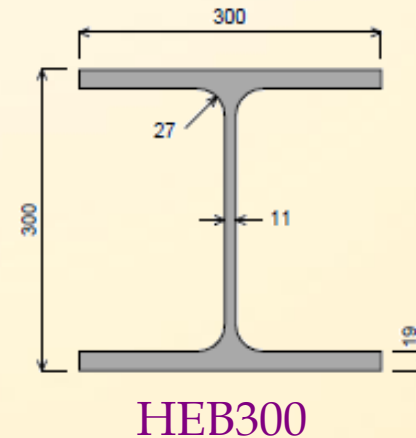
Preglednica 5.2 v Evrokodu 3 del 1-2

$$c/t_w \leq 33\varepsilon \rightarrow \text{Stojina razred 1}$$

$$\searrow = 18.9 \quad \searrow = 25.9$$

$$c/t_f \leq 9\varepsilon \rightarrow \text{Pasnica razred 1}$$

$$\searrow = 6.2 \quad \searrow = 7.07$$



Razred prereza 1

7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

Korak 3: Projekta odpornost pri sobni temperaturi v skladu z Evrokodom 3 del 1-2

➤ Projektna osna nosilnost

$$N_{pl,fi,0} = A \times f_y / \gamma_{M,fi} = 4099.7 \text{ kNm}$$

➤ Brezdimenzijska vitkost

$$\bar{\lambda}_{fi,0} = \sqrt{\frac{A f_y}{N_{cr}}} = \frac{L_{fi}}{i_z} \frac{1}{93.9 \varepsilon} = 0.362$$

HEB300	
A (cm ²)	149.08
I _z (cm)	7.58

7. Računski primeri

7.5. Primer 5: Uklonska nosilnost stebra

Step 4: Stopnja izkoriščenosti

$$\mu_0 = \frac{N_{fi,d,t}}{N_{pl,fi,0}} = 0.452$$

Korak 5: Kritična temperatura

Linearna interpolacija tabelarnih podatkov $\bar{\lambda}_{fi,0} = 0.362$

$\bar{\lambda}_{fi,0}$	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0
μ_0											
...
0.40	629	603	578	544	499						
0.42	621	595	569	535	477						
0.44	613	588	561	525	455						
0.46	604	581	553	516	433						
0.48	597	573	545	506	411						
0.50	590	566	536	494	367						
0.52	584	559	528	477							

