LOCAFI+

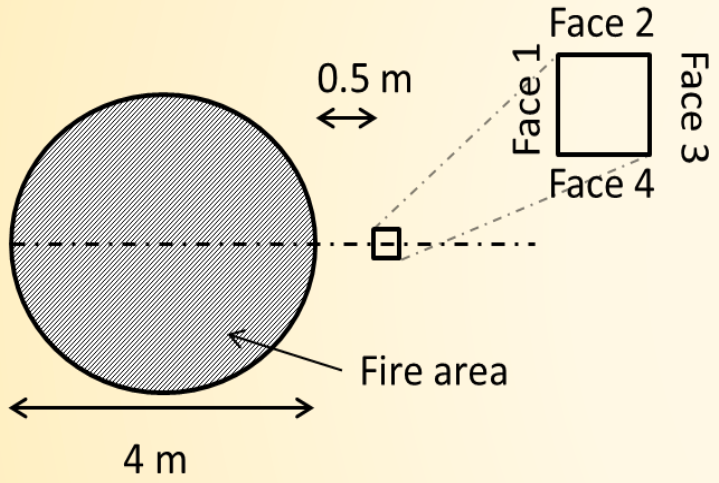
Temperatuur vertikaalses konstruktsioonielemendis kohaliku põlengu tingimustes

Leping n° 754072

7. Arvutusnäited

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



Posti ristlõige : HEB 300

Tuleallika diameeter : 4m

Tule ja posti vaheline kaugus : 0.5m

Soojuse eraldumiskiirus : 1000 kW.m^{-2}

Kooniline leek

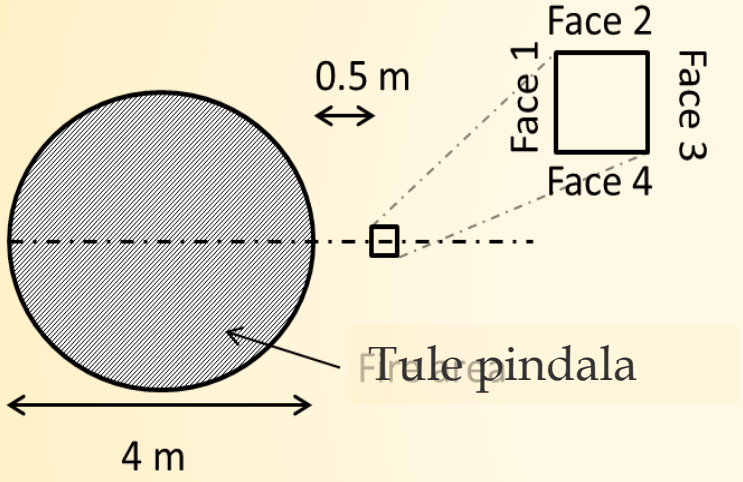
Post asub tulest ja suitsust väljaspool

Lage ei ole

Arvutus tehakse kõrgusel z = 1.0m

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



$$D = 4\ m$$

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

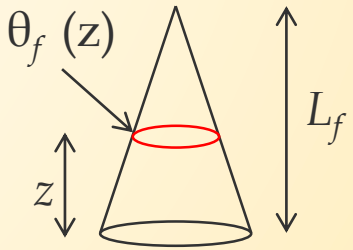
$$L_f = -1.02\ D + 0.0148\ Q^{0.4} = 6.15\ \text{m}$$

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

Leegi tempetratuur

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

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

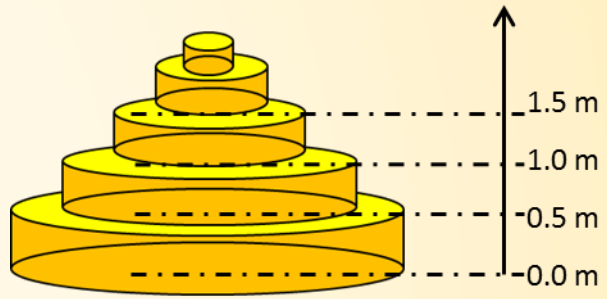


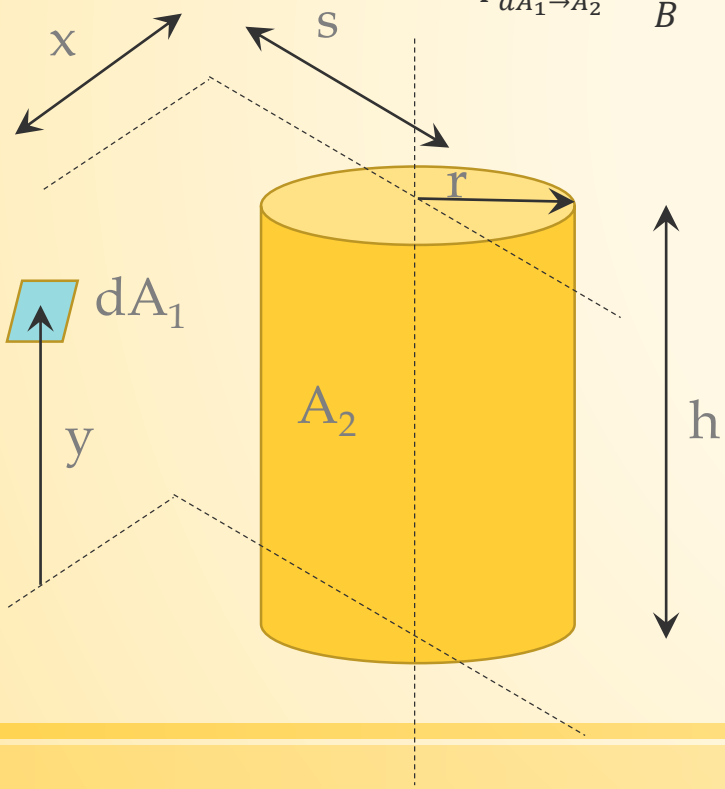
7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Külg 1

$$F_{dA_1\to A_2} = \frac{S}{B} - \frac{S}{2B\pi}\left\{\begin{array}{l} cos^{-1}\left(\frac{Y^2-B+1}{A-1}\right) + cos^{-1}\left(\frac{C-B+1}{C+B-1}\right) \\ -Y\left[\frac{A+1}{\sqrt{(A-1)^2+4Y^2}}cos^{-1}\left(\frac{Y^2-B+1}{\sqrt{B}(A-1)}\right)\right] \\ -\sqrt{C}\frac{C+B+1}{\sqrt{(C+B-1)^2+4C}}cos^{-1}\left(\frac{C-B+1}{\sqrt{B}(C+B-1)}\right) \\ +Hcos^{-1}\left(\frac{1}{\sqrt{B}}\right) \end{array}\right\}$$





$$S = s/r$$
$$X = x/r$$
$$H = h/r$$
$$A = X^2 + Y^2 + S^2$$
$$B = S^2 + X^2$$
$$C = (H - Y)^2$$

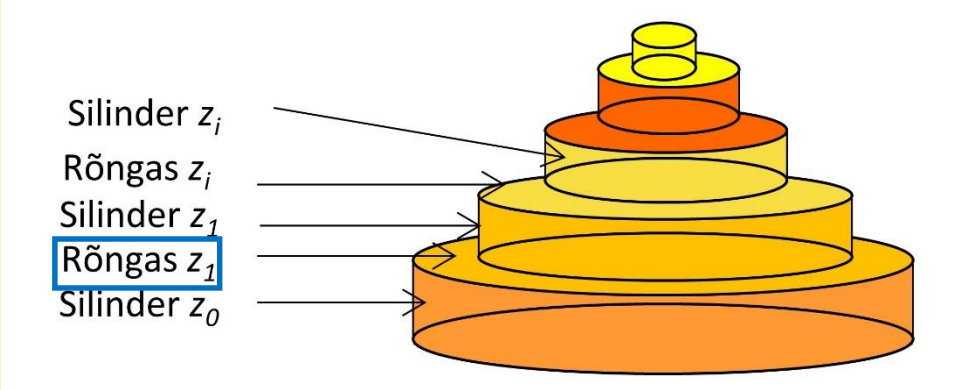
$$F_i = F_{dA_1\to A_2}\left(s = s_f, x = x_f, r = r_i, h = |z_i - z_f|\right)$$
$$F_{i+1} = F_{dA_1\to A_2}\left(s = s_f, x = x_f, r = r_i, h = |z_{i+1} - z_f|\right)$$

$$if\ z_i \geq z_f\ then\ F = F_{i+1} - F_i$$
$$else\ F = F_i - F_{i+1}$$

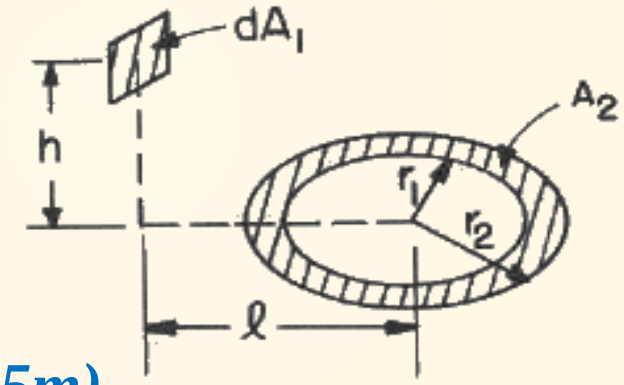
7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Külg 1



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



$$H = h/l = (1 - 0.5)/2.5 = 0.2$$
$$R_2 = r_2/l = 2/2.5 = 0.8$$
$$R_1 = r_1/l = 1.84/2.5 = 0.73$$

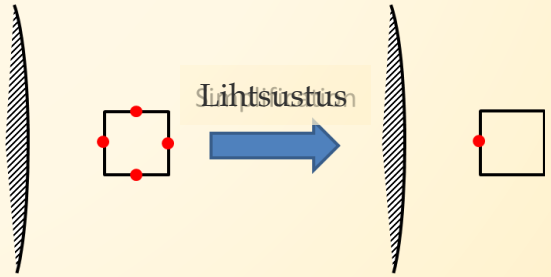
z_f = 1.0m

→ Ainult ühte rõngast arvestades (z_i = 0.5m)

Väline raadius r_2 = 2.0m

Sisemine raadius r_1 = (6.15-0.5)/6.15*2.0m = 1.84m

Lihtsustus: l = 2.5m



7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Külg 1

Input data				
HRR	Dfire	Q	Q	hf
kW/m²	m	W	MW	m
1000	4	12566370.6	12.57	6.15

Constant	
σ	Tabs
5.67E-08	273.15

Section coordinate		
sf	xf	zf
m	m	m
2.5	0	1

Intermediate variables	
z_{virt}	l
-0.46	2.5

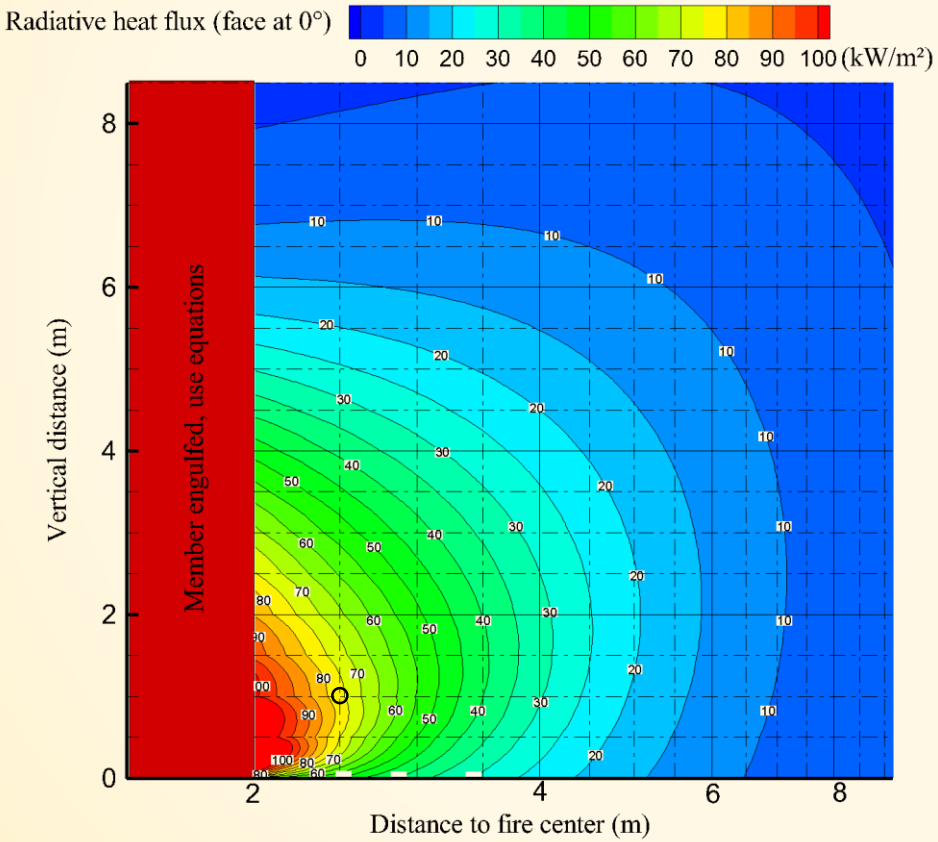
						Cylinder									Ring		
zi	Tf	ri	$F_{cylinder_zi}$	F_{ring_zi}	$Flux_{face1}$	Fi	Fi+1	S	X	A	Hi	Hi+1	|zi-zf|	|zi+1-zf|	H	Ri	Ri+1
m	°C	m	-	-	kW/m²	-	-	-	-	-	-	-	m	m	-	-	-
0	900	2.00	0.0726	0	7.79	0.3705	0.2979	1.25	0	1.56	0.50	0.25	1.00	0.50	0	0.00	0.00
0.5	900	1.84	0.2374	0.0555	31.45	0.2374	0.0000	1.36	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. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

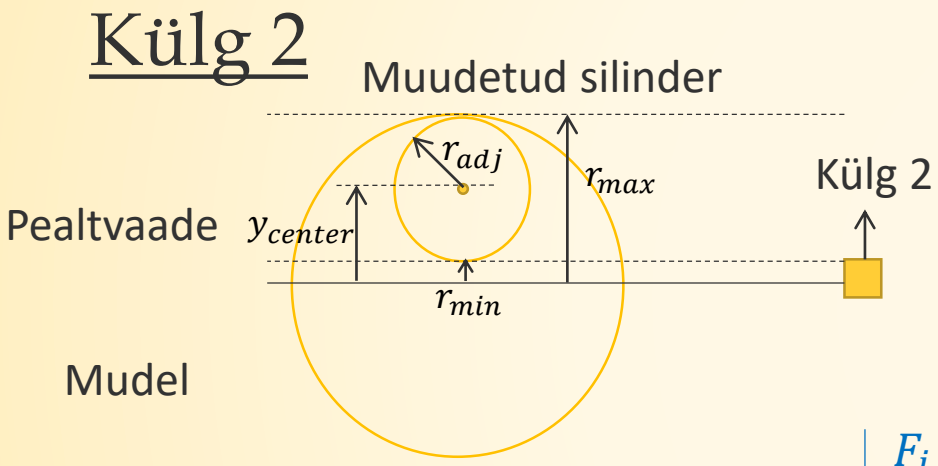
Külg 1



Neeldunud voog $= \varepsilon * \varphi_{tot}$
$= 0.7*77$ kW/m2
$= 53.9$ kW/m2

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



z = 0

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

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

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

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

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

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

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Külg 2

zi	Tf	ri	$F_{cylinder_zi}$	F_{ring_zi}	$Flux_{face2}$	Ring H	Ring Ri	Ring Ri+1
m	°C	m	-	-	kW/m²	-	-	-
0	900	2.00	0.0175	0	1.88	0	0.00	0.00
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/m²
Absorbed heat flux by face 2	6.00	kW/m²

Input data				
HRR	Dfire	Q	Q	hf
kW/m²	m	W	MW	m
1000	4	12566370.6	12.57	6.15

Section coordinate		
sf	xf	zf
m	m	m
2.5	0	1

Constant	
σ	Tabs
5.67E-08	273.15

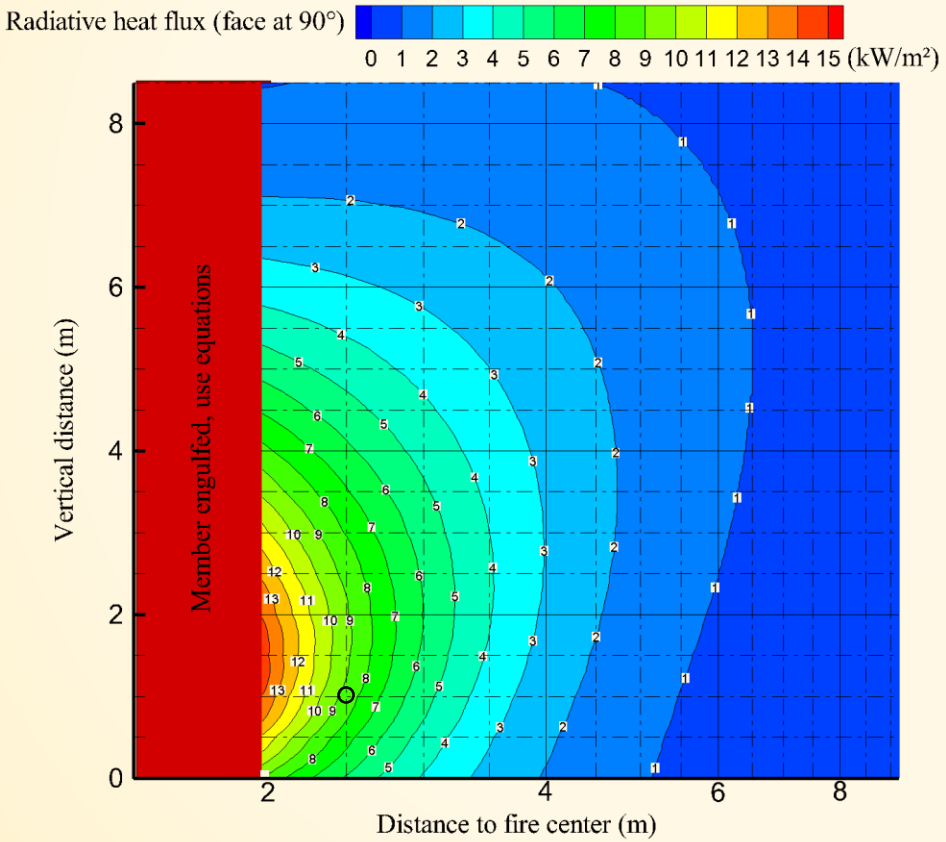
Intermediate variables	
z_{virt}	l
-0.46	2.5

Modified cylinder / ring				Cylinder									
rmin	rmax	$ri_{_adjusted}$	y_{center}	Fi	Fi+1	s	S	X	A	Hi	Hi+1	$\lvert z_i-z_f \rvert$	$\lvert z_{i+1}-z_f \rvert$
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. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

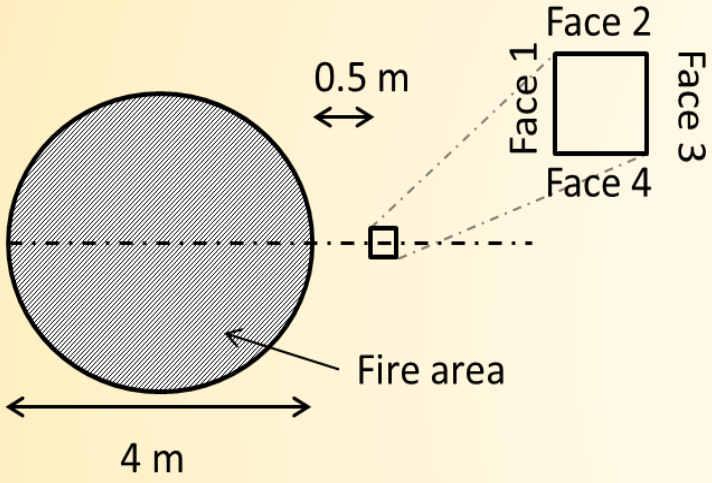
Külg 2



Neeldunud voog $= \varepsilon * \varphi_{tot}$
$= 0.7*8.7$ kW/m2
$= 6.1$ kW/m2

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



Soojusvoog, neeldunud igale küljele (eeldades $\varepsilon = 0.7$)

Külg 1 : 53.45 kW/m²

Külg 2 : 6.00 kW/m²

Külg 3 : 0.00 kW/m²

Külg 4 : 6.00 kW/m²

→ Keskmine soojusvoog = 16.36 kW/m²

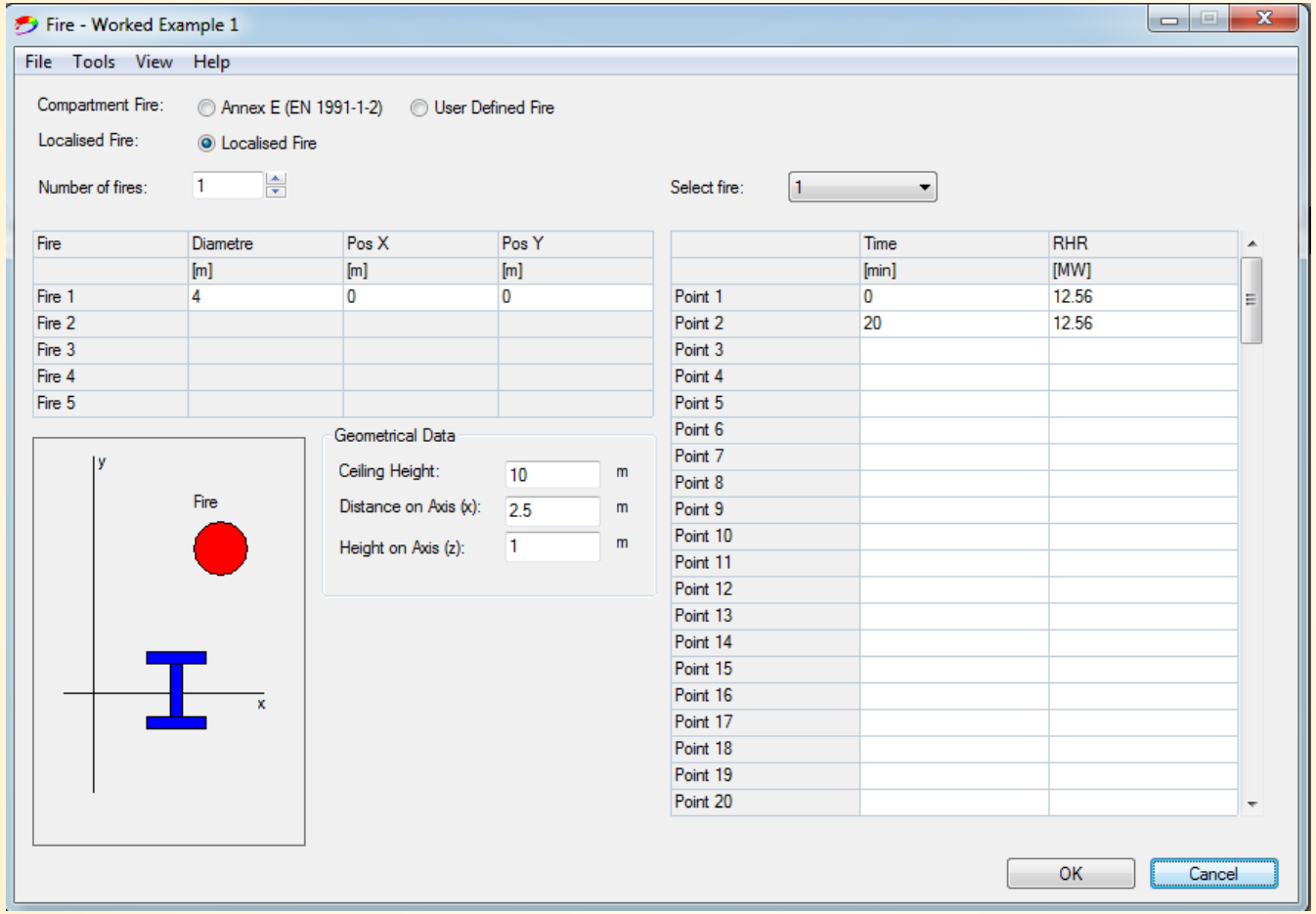
$$0 = \underbrace{h(T-20)}_{\text{Eralduv neto konvektiivne voog}} + \underbrace{\sigma\varepsilon[(T+273)^4 - (20+273)^4]}_{\text{Eralduv kiirgusfoog}} - \underbrace{\varepsilon * \varphi_{tot}}_{\text{Neeldunud voog}}$$

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

θ (°C)	Emitted flux W/m²
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

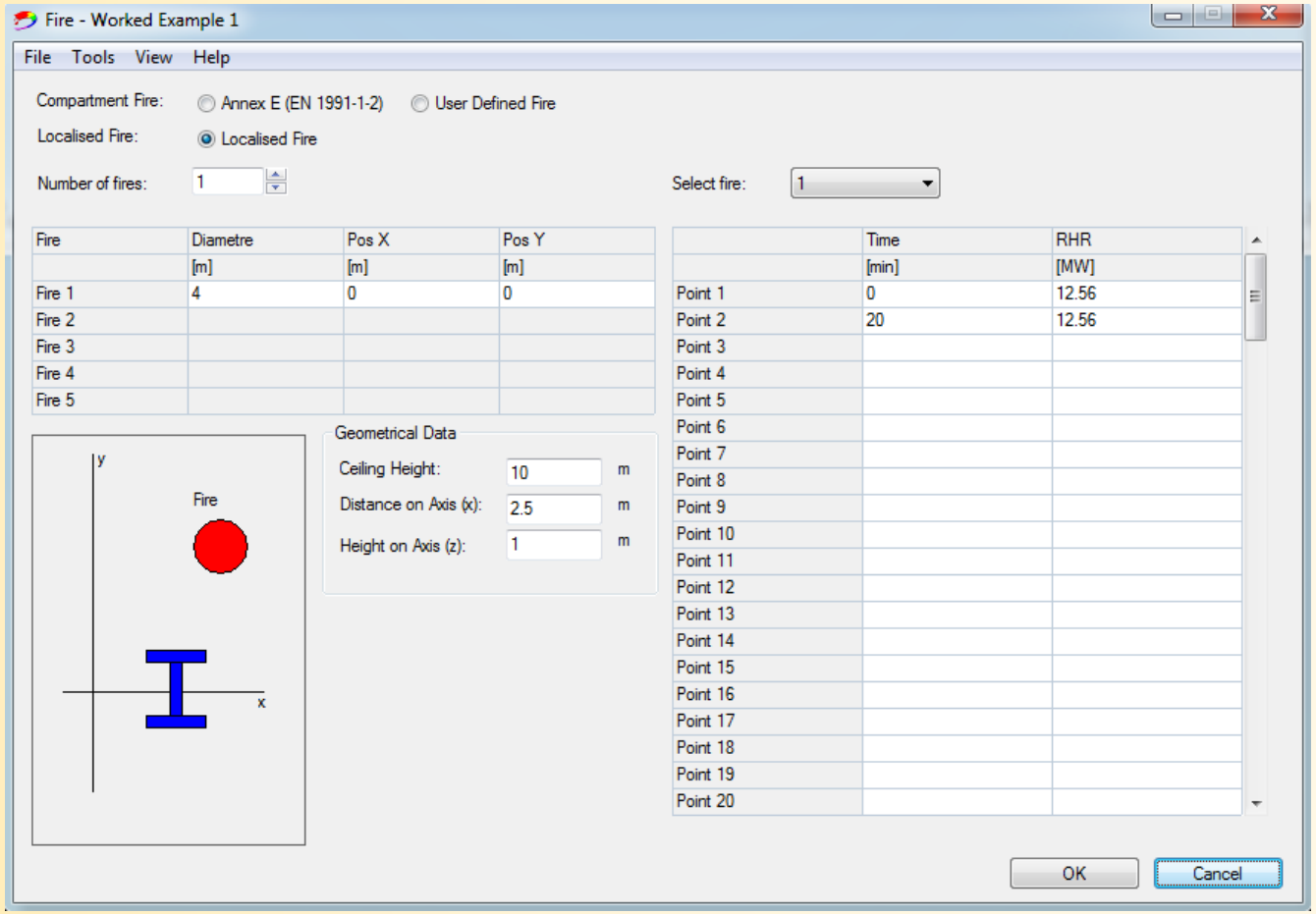
7. Arvutusnäited

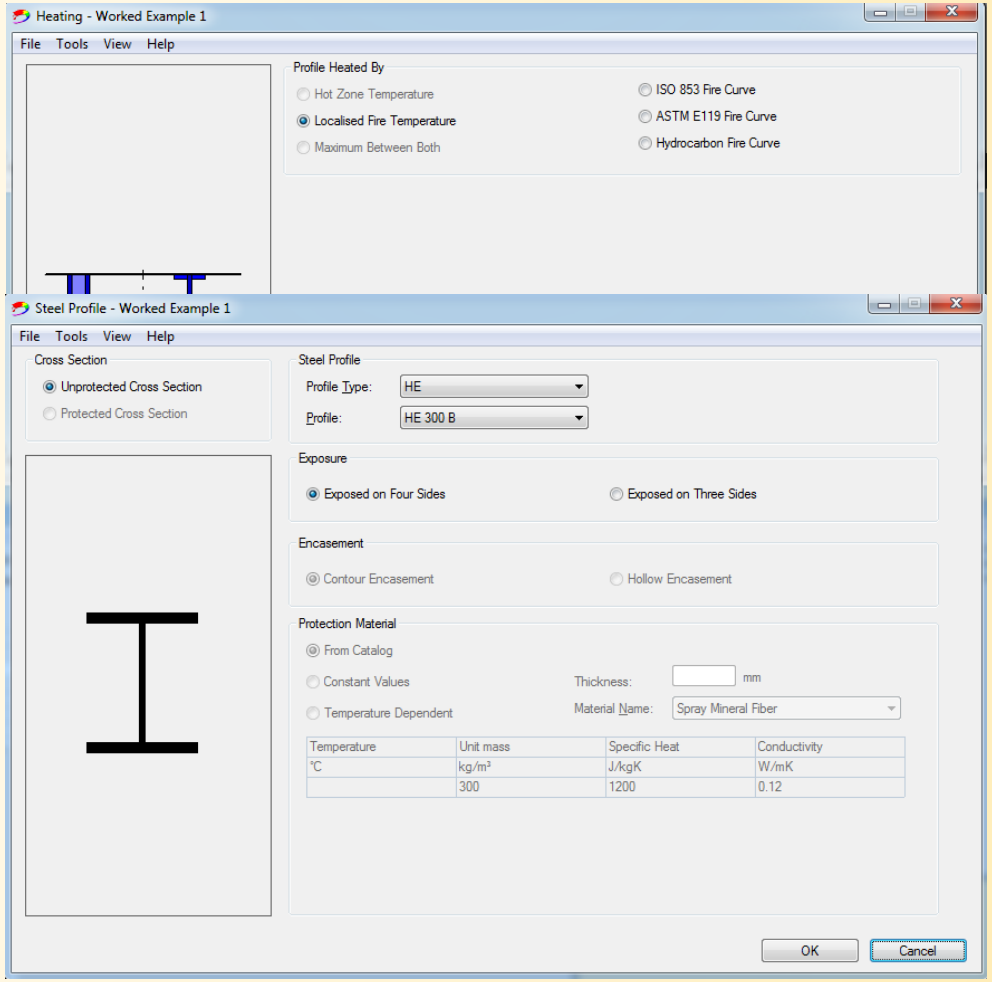
7.1. Näide 1 : Kiirgusvoog kohaliku põlengu puhul



7. Arvutusnäited

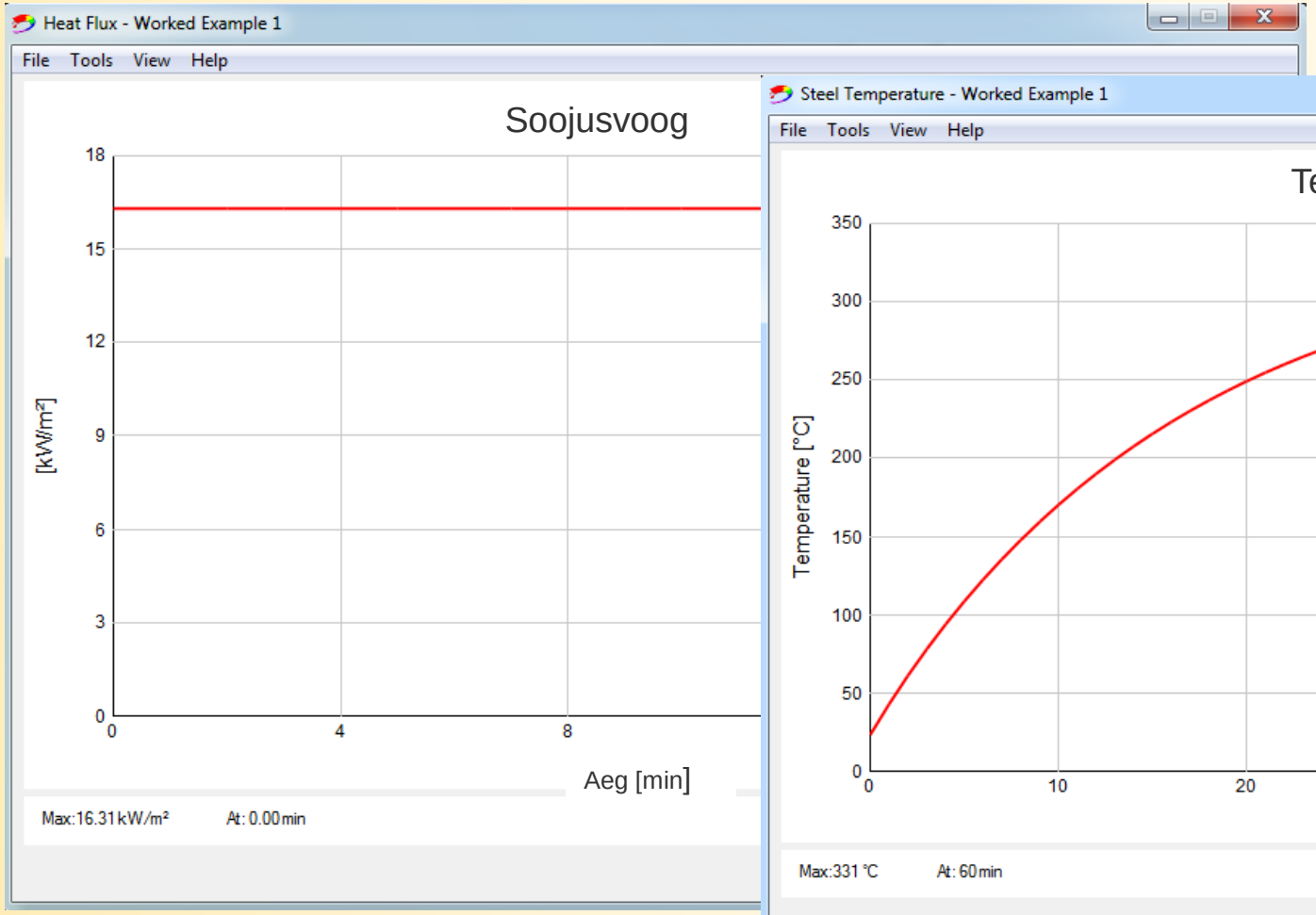
7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

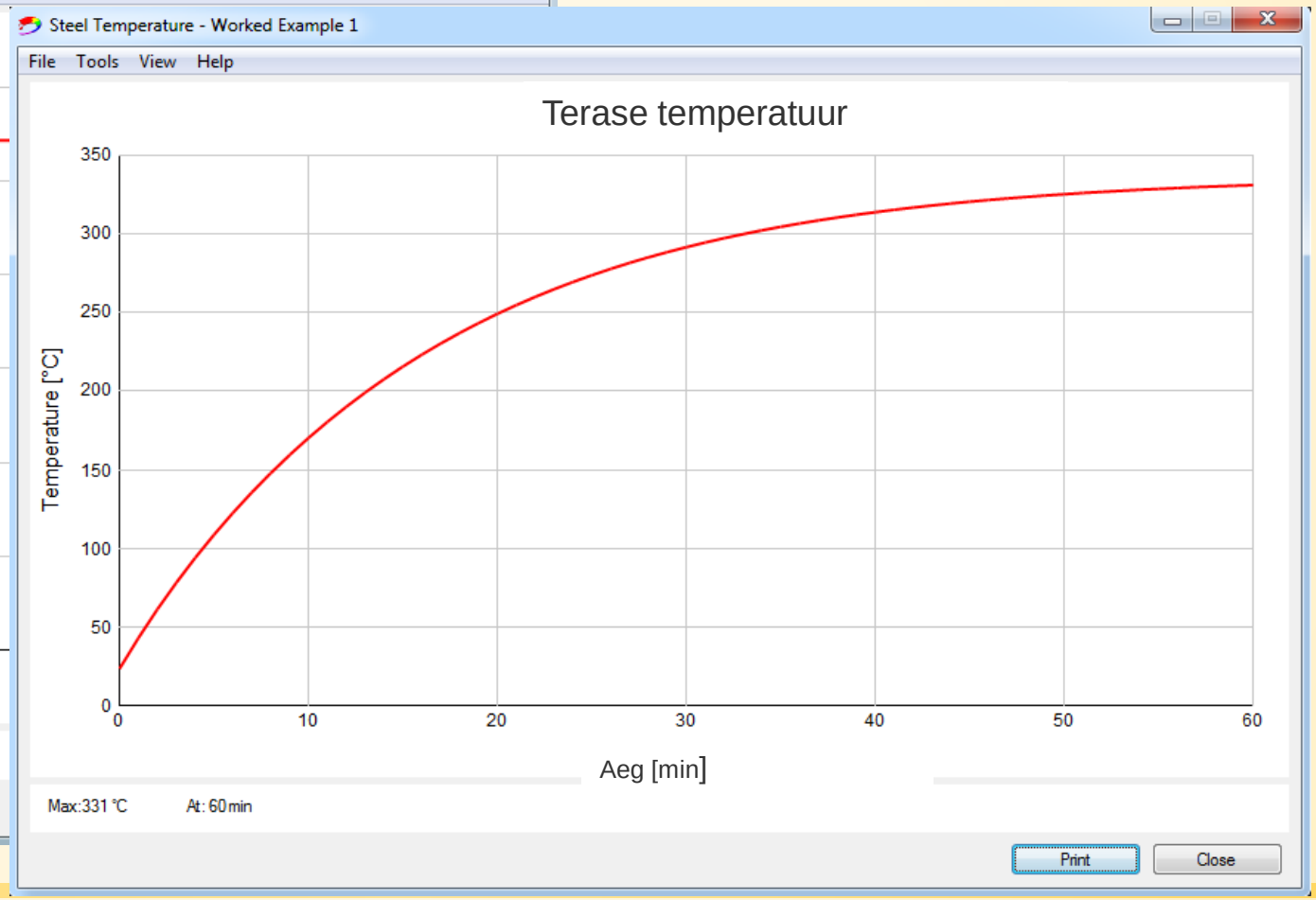




7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



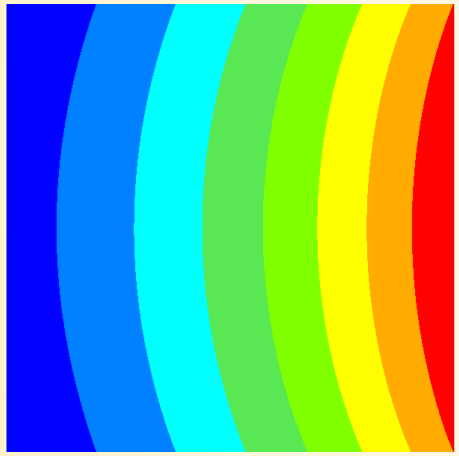


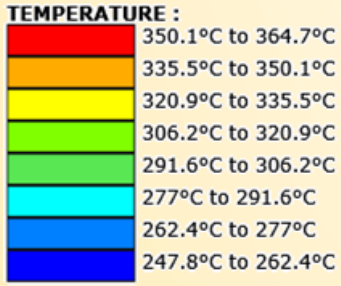
7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Temperatuuri jaotus tasakaalu puhul (LOCAFI)

Ruut 300x300

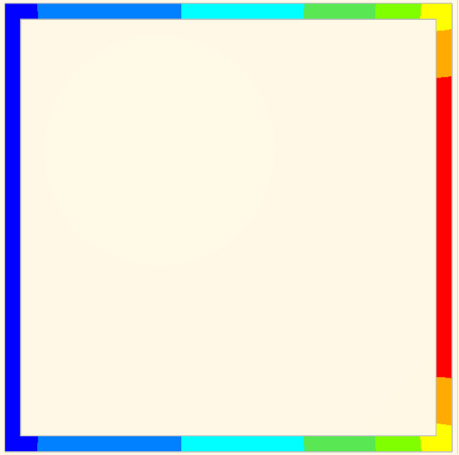


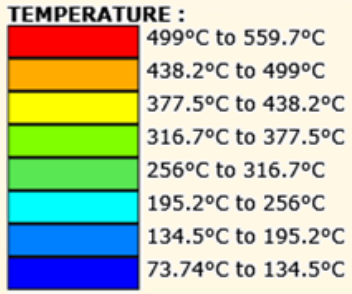


$(T_{max} + T_{min})/2$

$= 306°C$

Toru 300x300x10



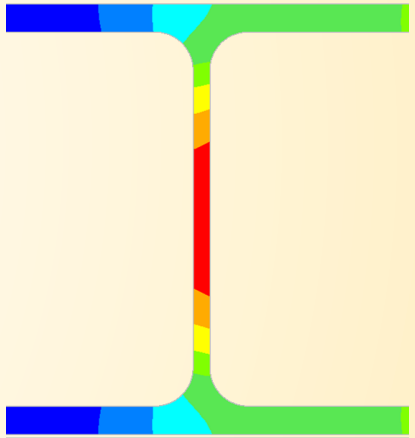


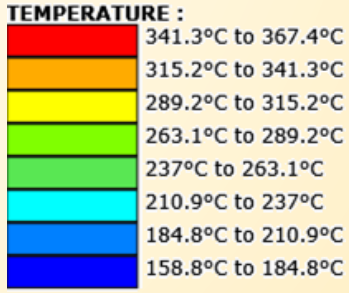
$(T_{max} + T_{min})/2 =$

$317°C$

Suur varieeruvus ristlõikes

HEB 300





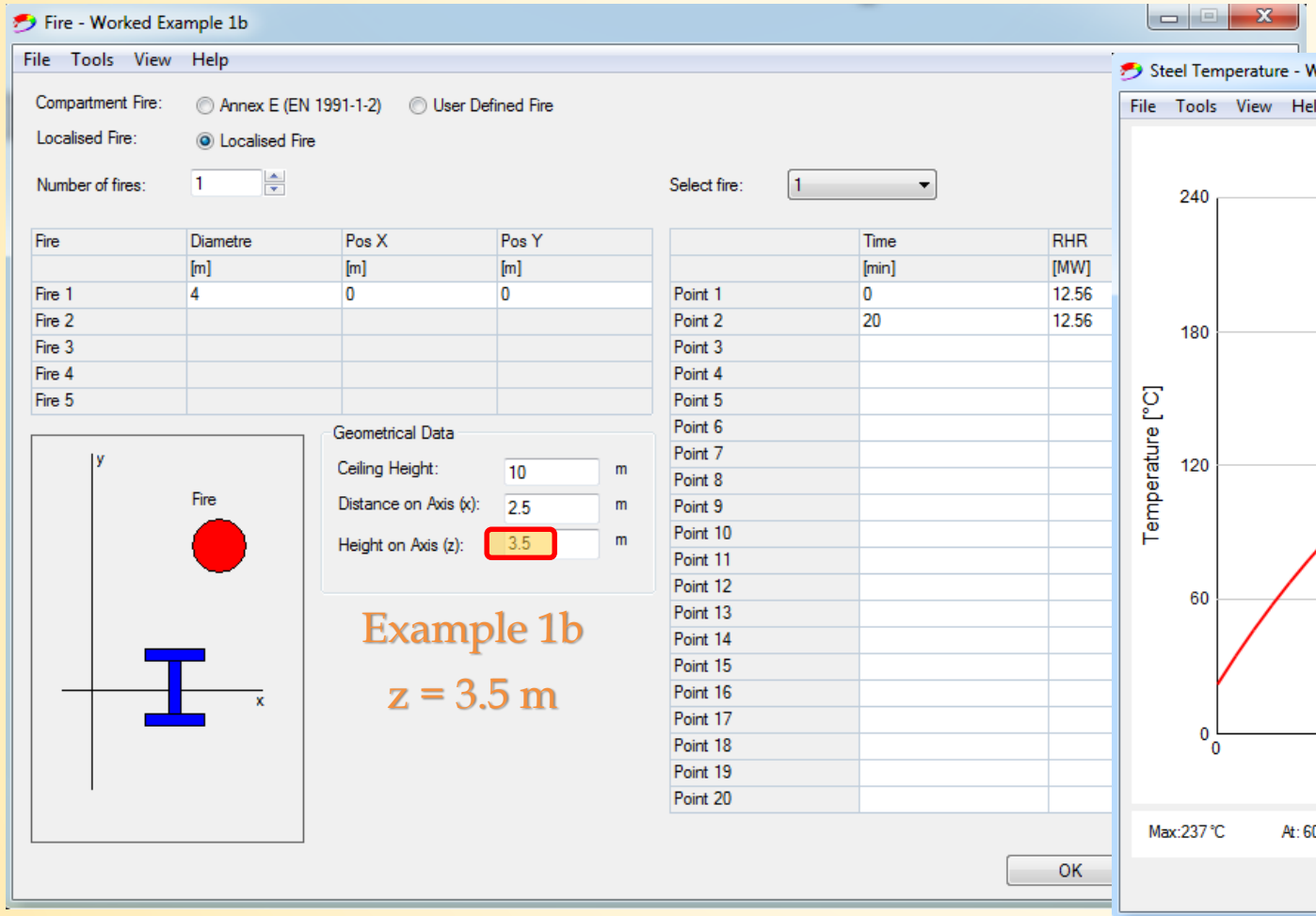
$(T_{max} + T_{min})/2 =$

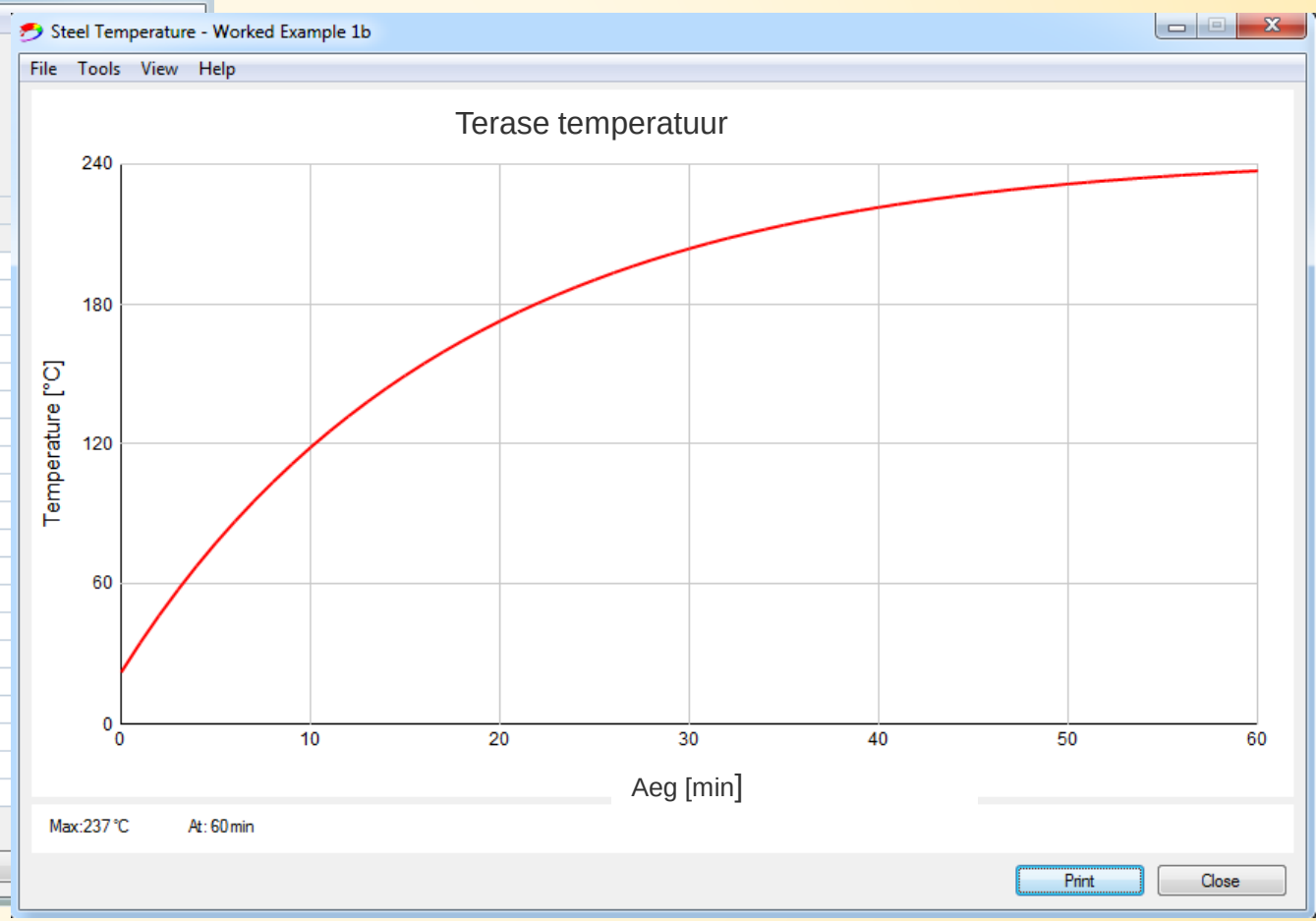
$262°C$

Mudel arvestab varje mõju

7. Arvutusnäited

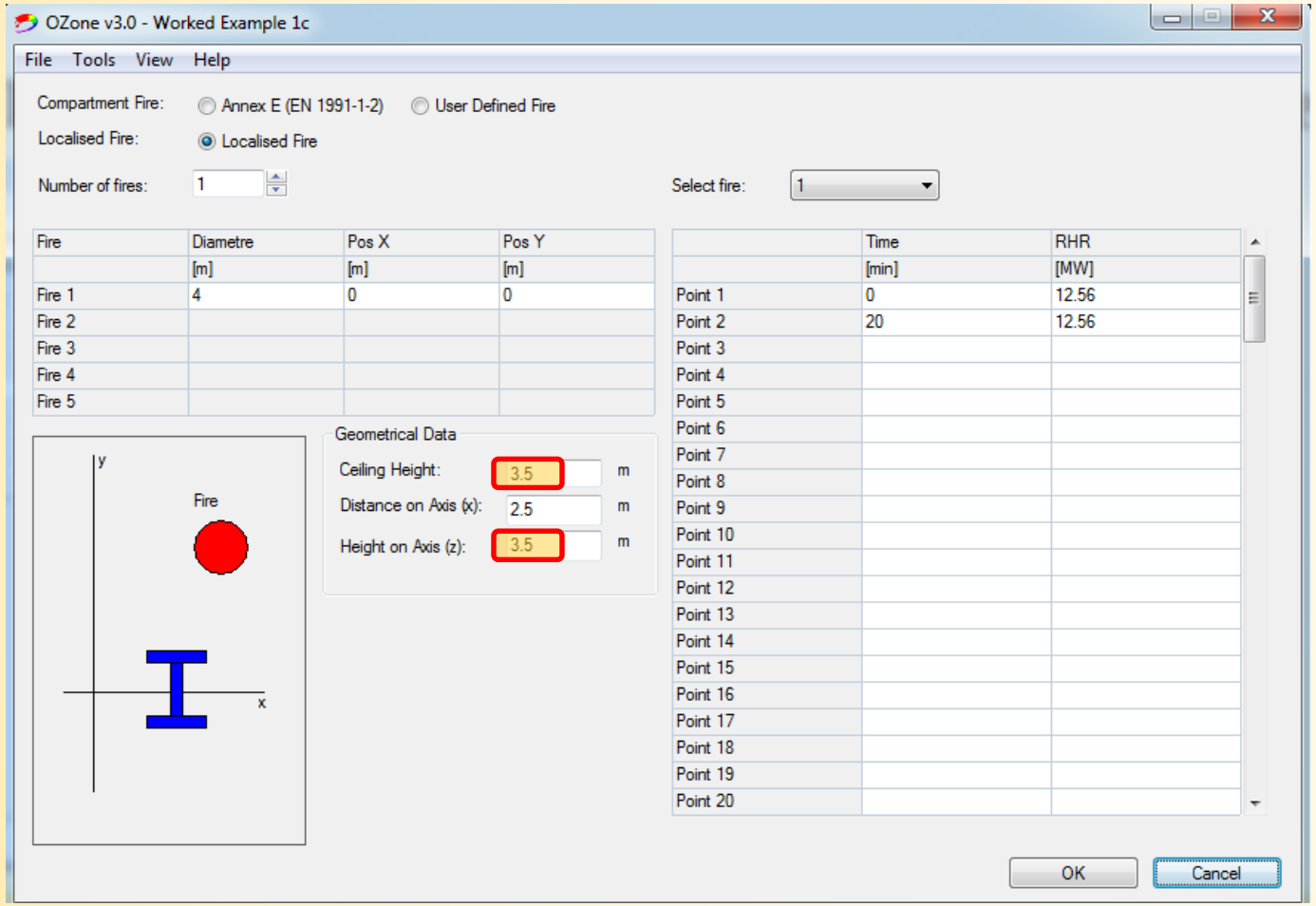
7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul





7. Arvutusnäited

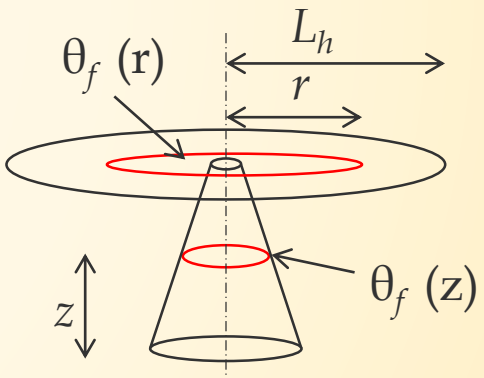
7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



Näide 1c

z = 3.5 m

z_{lagi} = 3.5 m



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

7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

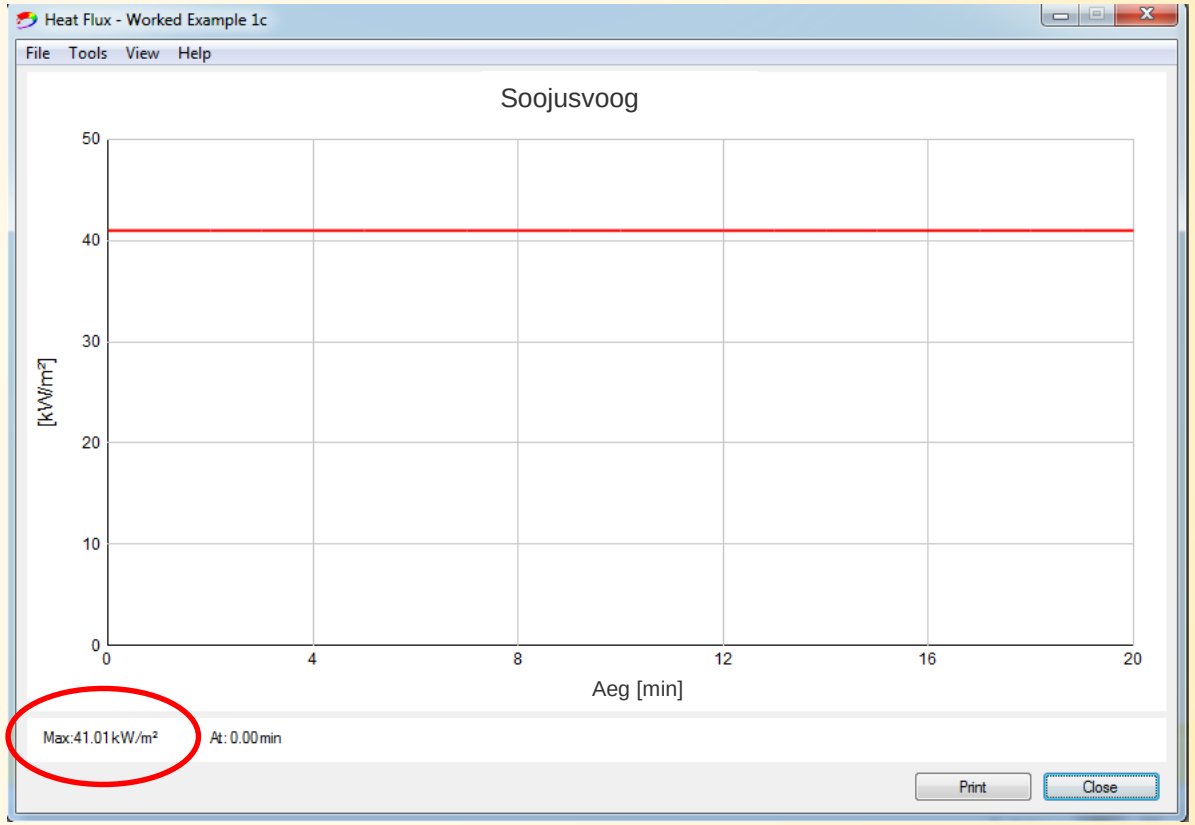
HASEMI (EN 1991-1-2 – Lisa C)

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

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

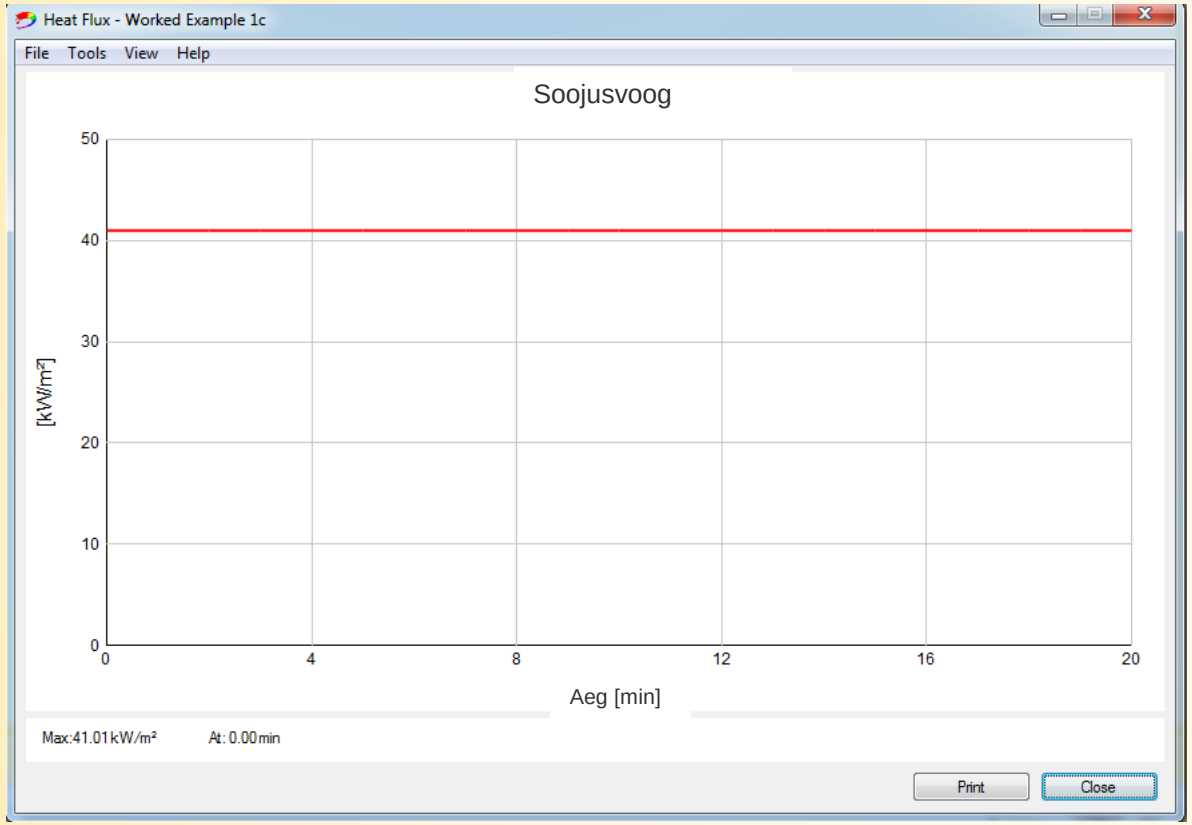
$$y = \frac{r + H + z'}{L_h + H + z'} = 0.787$$

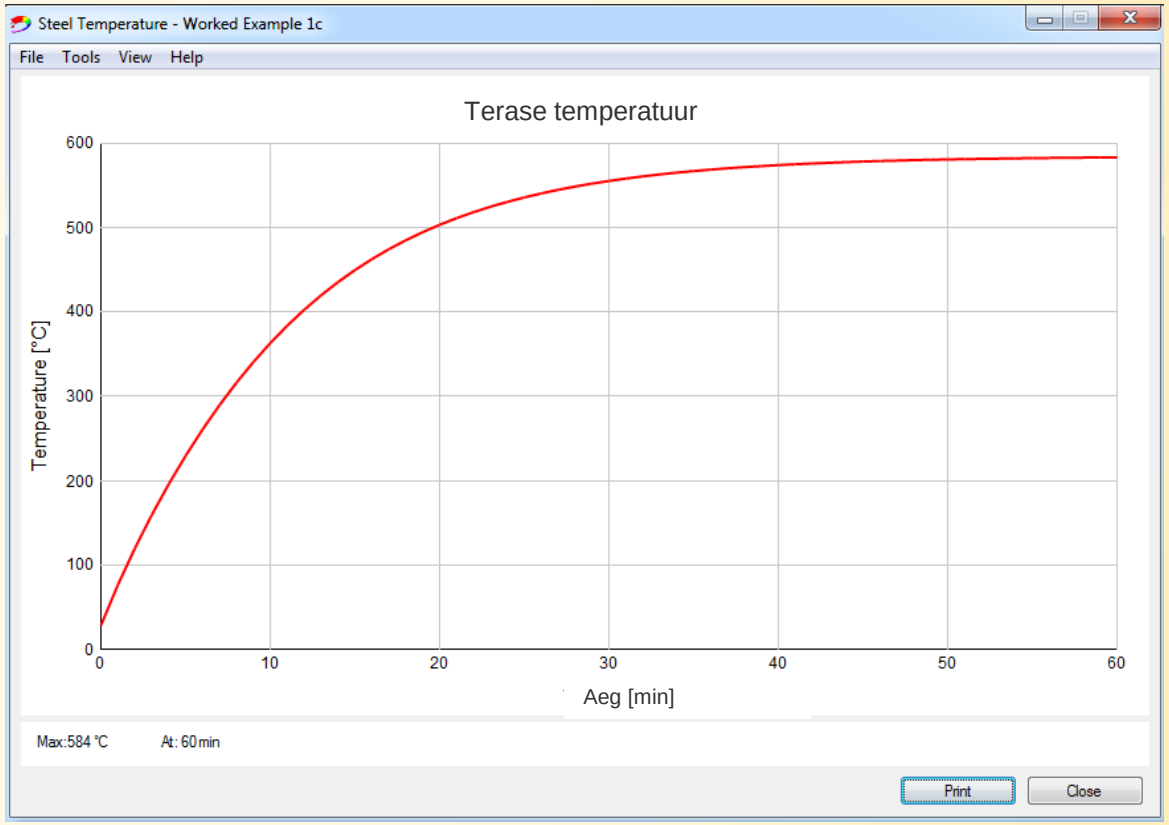
$$0.3 < y < 1 \rightarrow \dot{h} = 136300 - 121000\,y$$
$$\rightarrow \dot{h} = 41073\ W/m^2$$



7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul



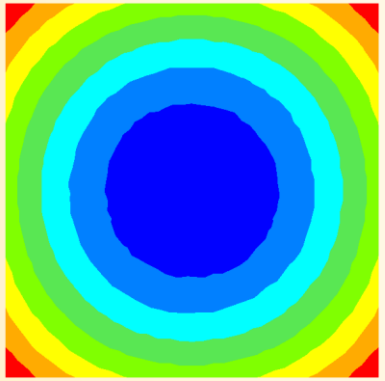


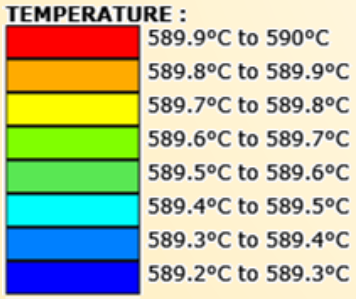
7. Arvutusnäited

7.1. Näide 1 : Kiirgusvood kohaliku põlengu puhul

Temperatuuri jaotud tasakaalu puhul (HASEMI)

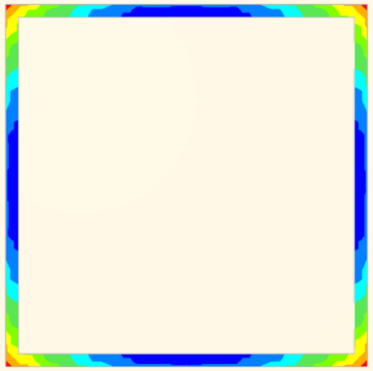
Ruut 300x300

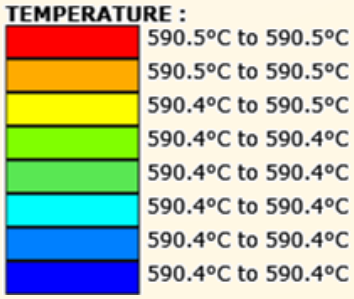




T_{aver} = 589°C

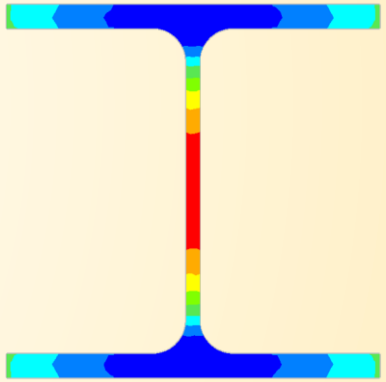
Toru 300x300x10

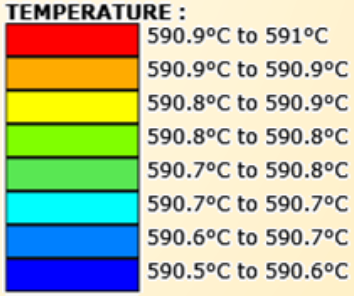




T_{aver} = 590°C

HEB 300

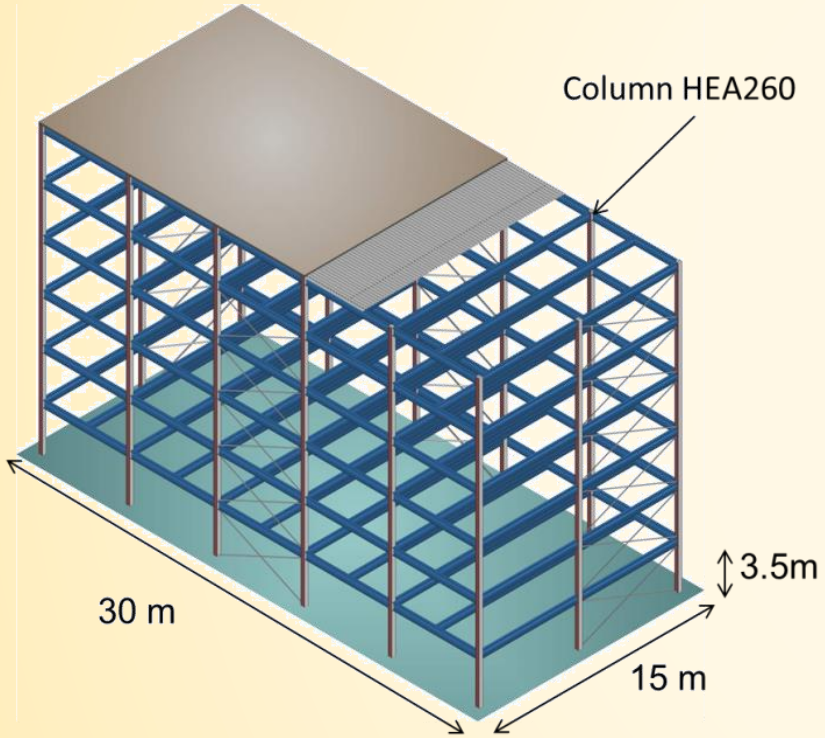




T_{aver} = 591°C

7. Arvutusnäited

7.2. Näide 2 : Büroohoone post

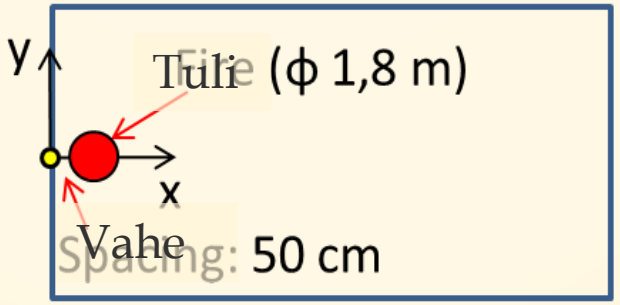


Tuleallika kaugus postist 0.5 m

Lae kõrgus : 3.5 m

Tuleallikas : 500 kg paberit (17.5 MJ/kg) pindalal 2.5m²

RHR_{max} = 1000 kW/m²



7. Arvutusnäited

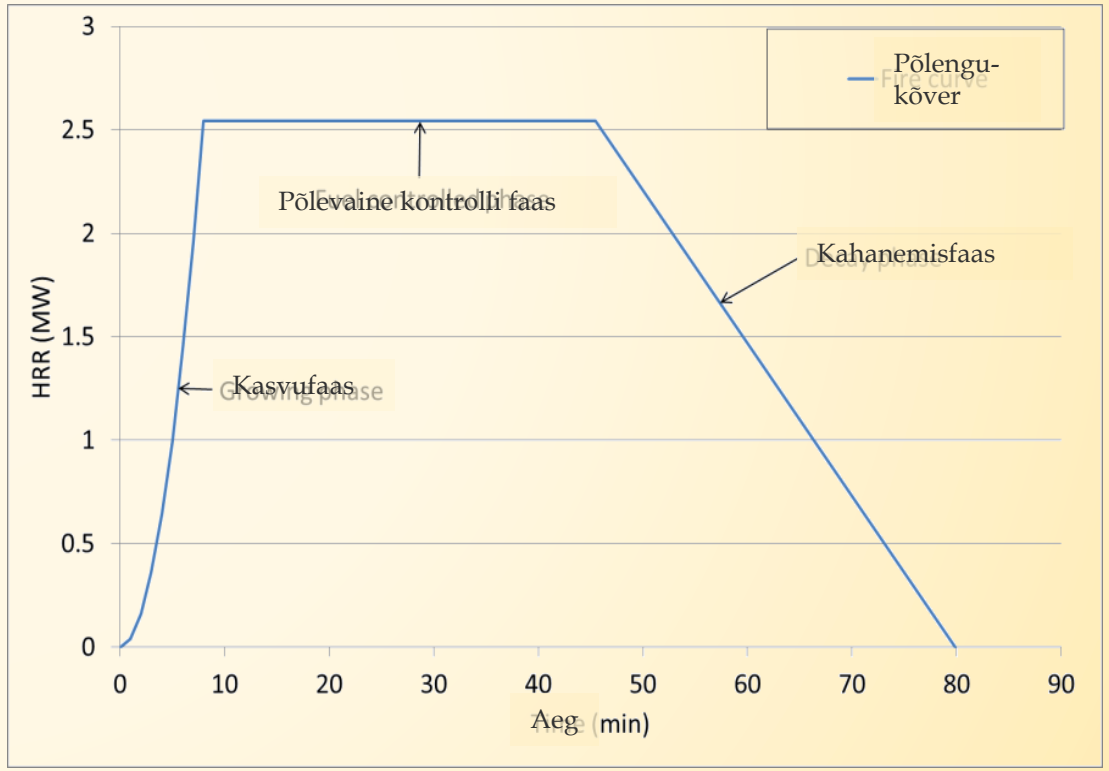
7.2. Näide 2 : Büroohoone post

Põlengu areng vastavalt EN 1991-1-2 Lisa E

- *Kasvufaas : $Q(t) = 10^6 * (t/t_\alpha)^2$*
- *Arengu kiirus : Medium*

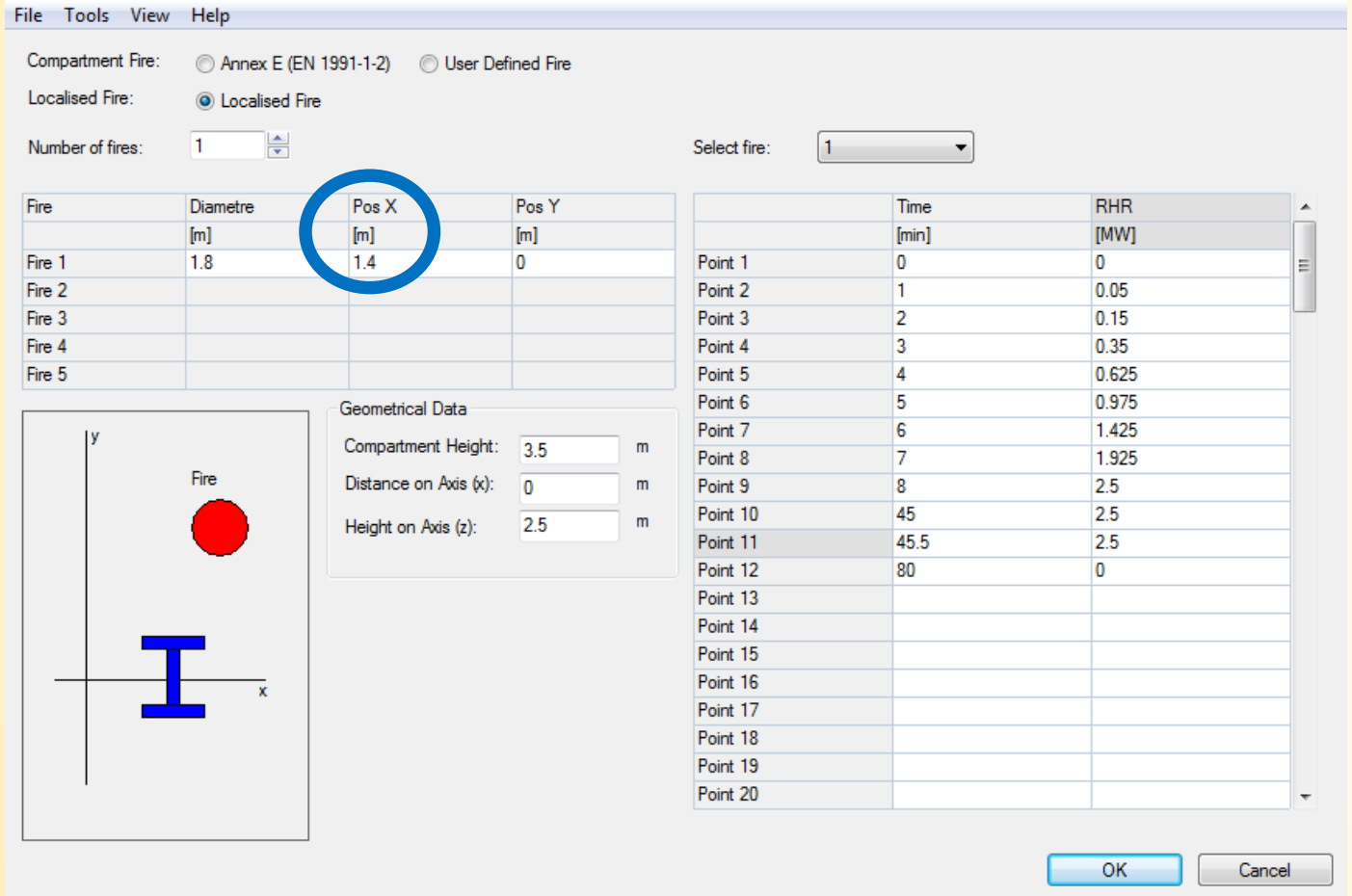
→ *RHR = 1 MW pärast t_α = 300 sec*

- *RHR_{max} = 2.5m2 * 1000kW/m² = 2.5 MW*
- *Kahanemisfaas algab pärast 70% põlevaine põlemist*

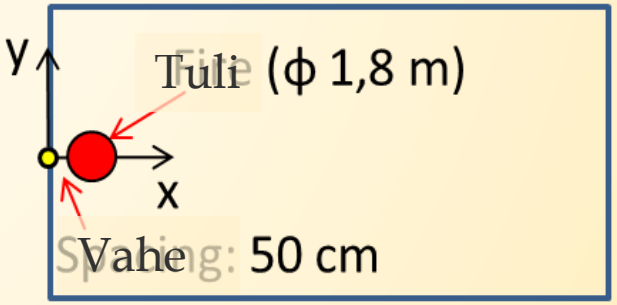


7. Arvutusnäited

7.2. Näide 2 : Büroohoone post

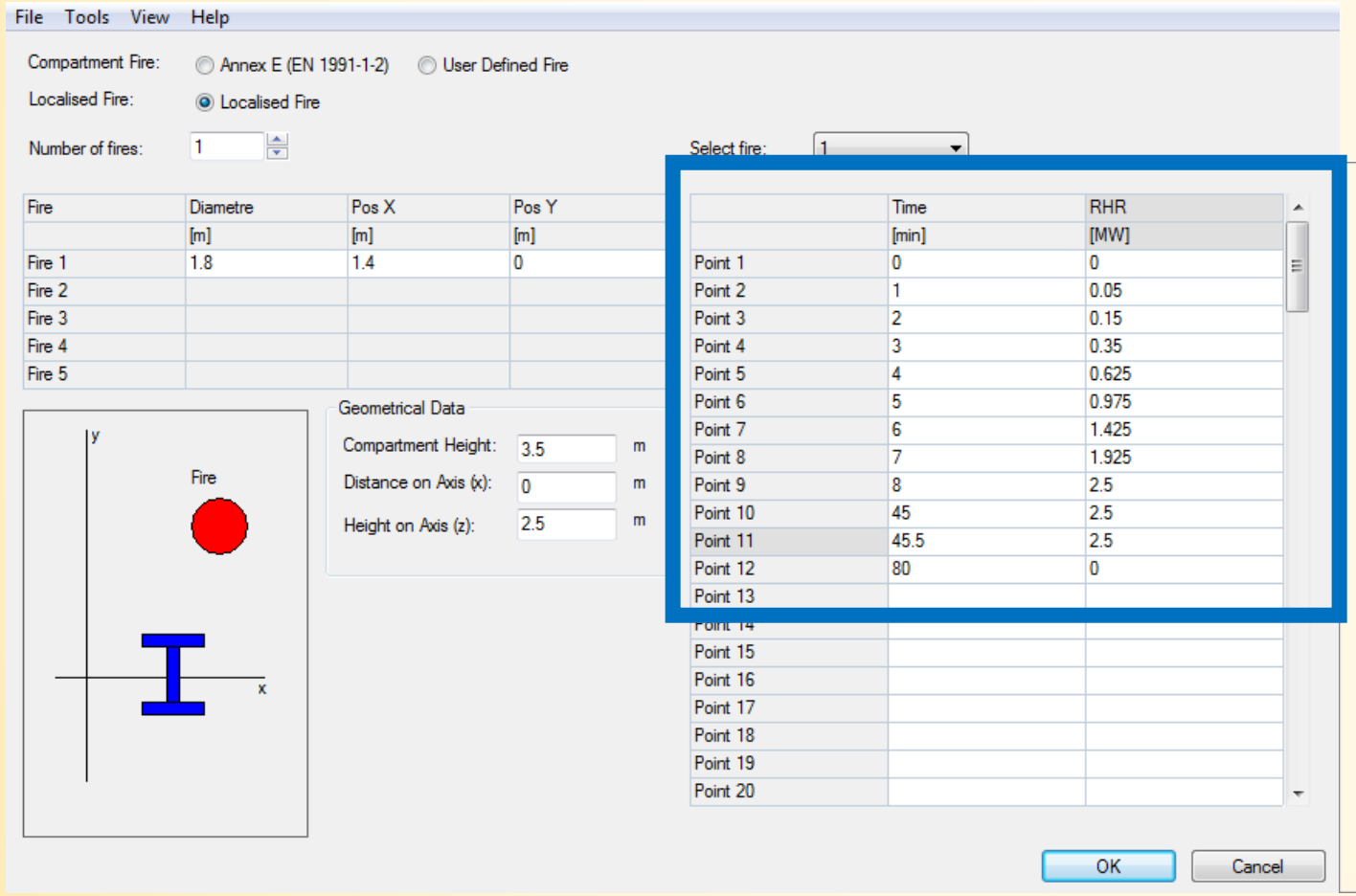


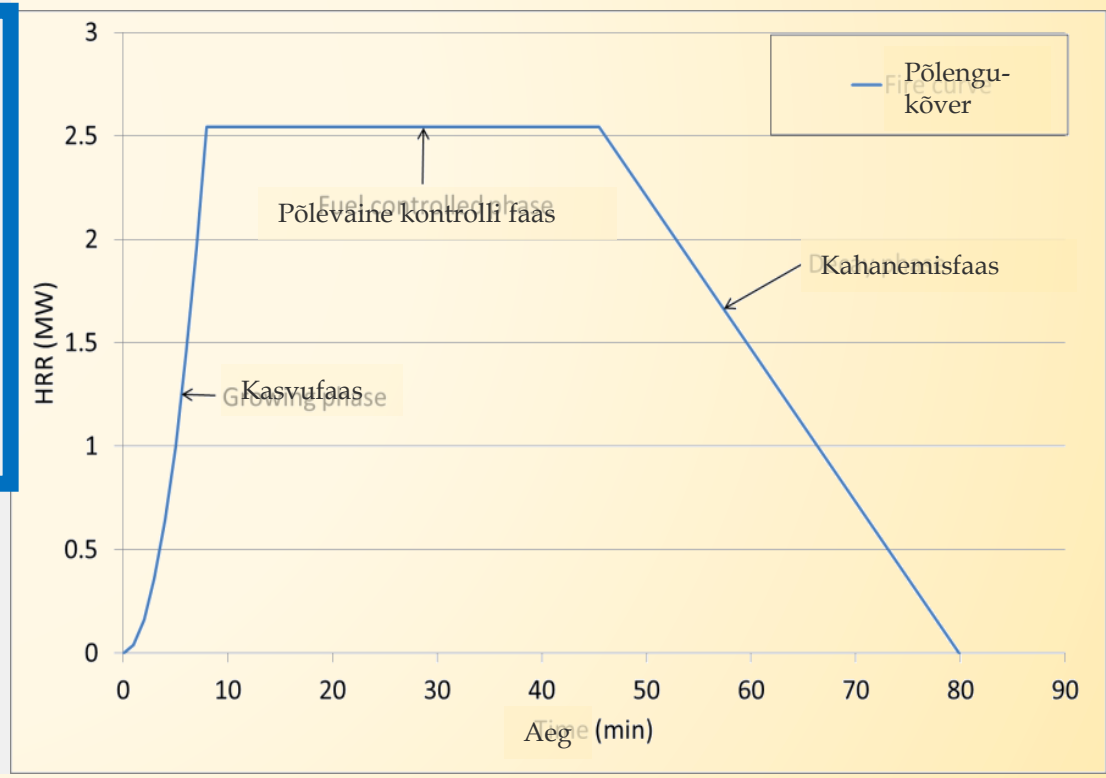
Pos x : 0.5m + 1.8m/2 = 1.4m



7. Arvutusnäited

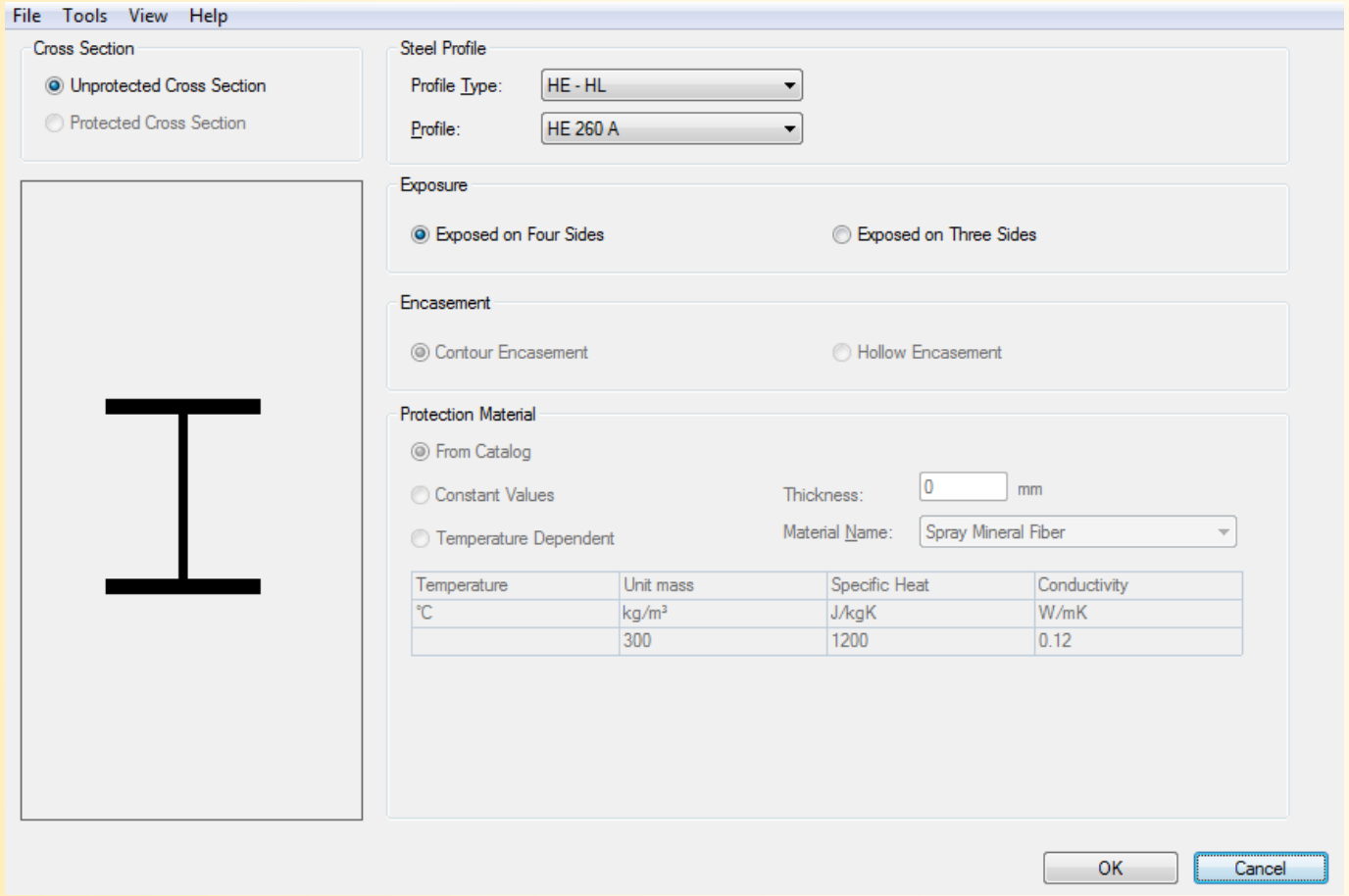
7.2. Näide 2 : Büroohoone post





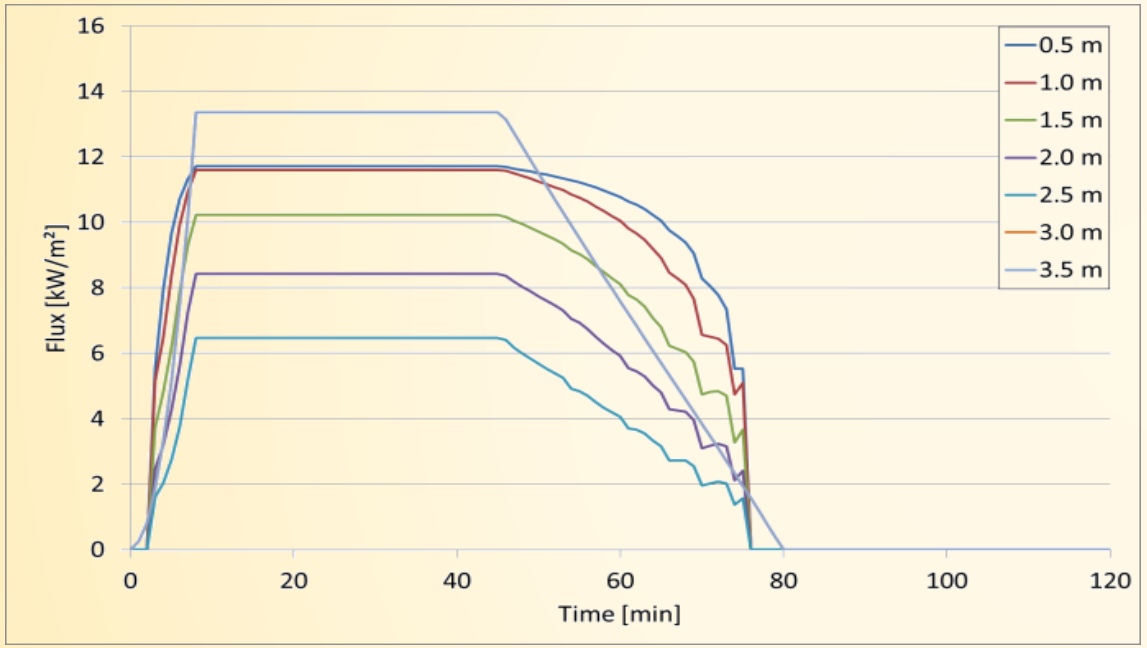
7. Arvutusnäited

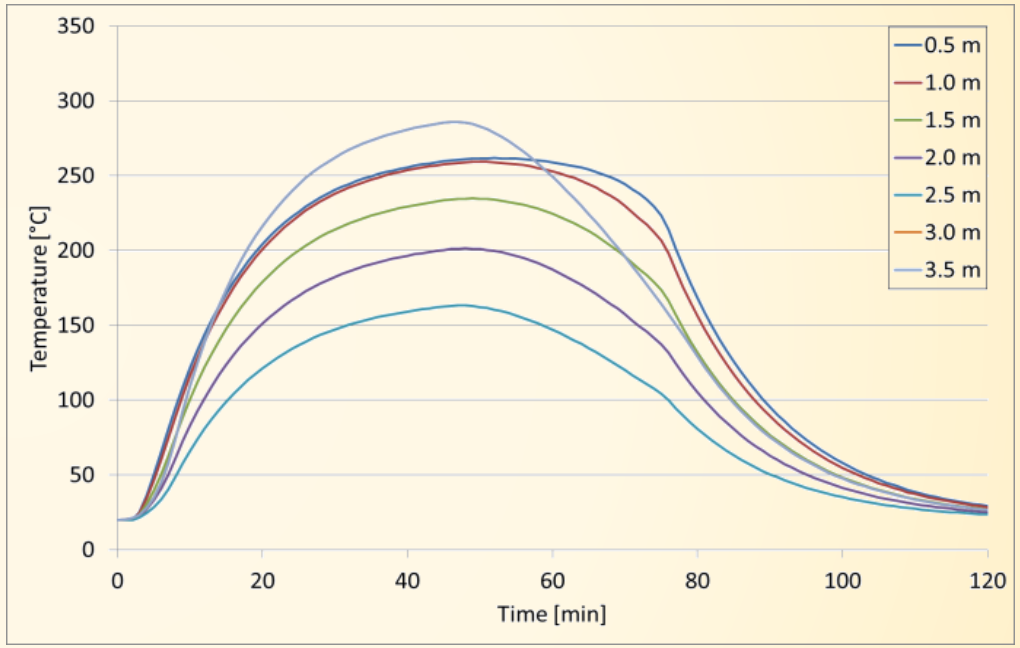
7.2. Näide 2 : Büroohoone post



7. Arvutusnäited

7.2. Näide 2 : Büroohoone post

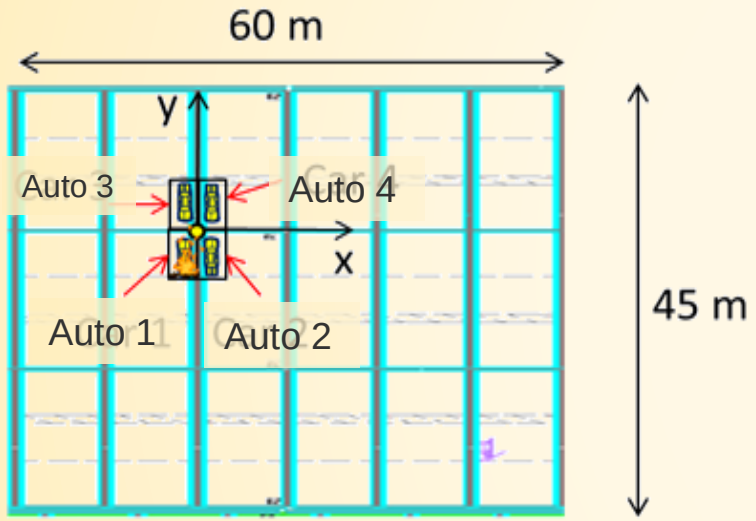


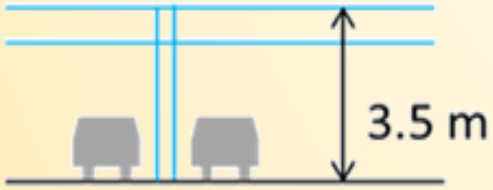


- Maksimaalne kuumas suitsukihis neeldunud kiirgusvoog
- Kuum suitsukiht (z = 3.5m) : temperatuur jõuab kuni 290°C
- Väline suitsukiht (z = 0.5m and z = 1m) : ~250°C

7. Arvutusnäited

7.3. Näide 3 : Parkimismaja post





HEA 300 posti ristlõige

Lae kõrgus : 3.5 m

Parkimisboksi mõõtmed : 2.5m*5m

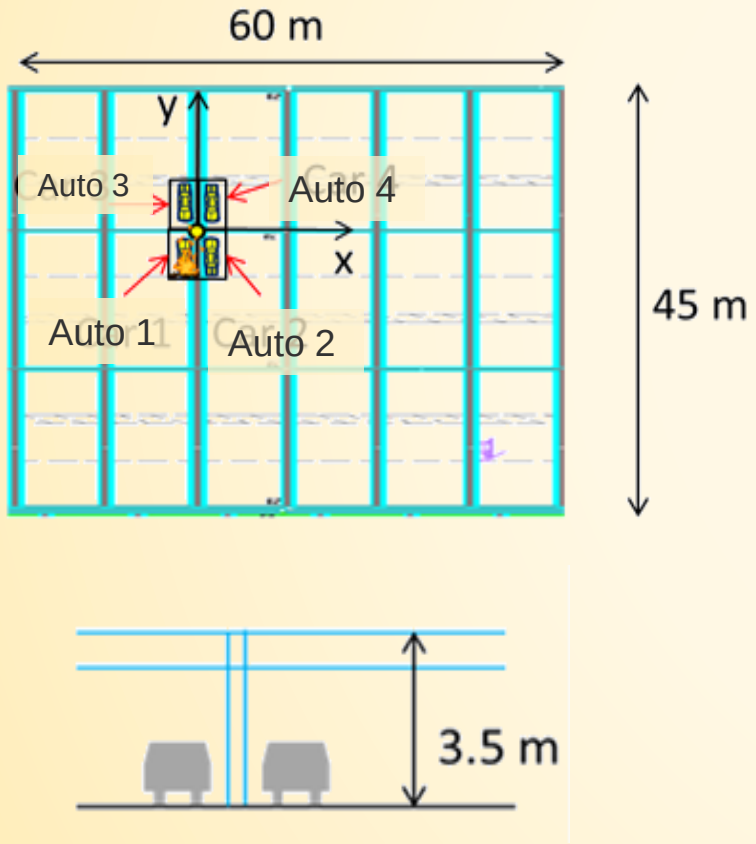
→ Tule ekvivalentdiameeter : 4 m

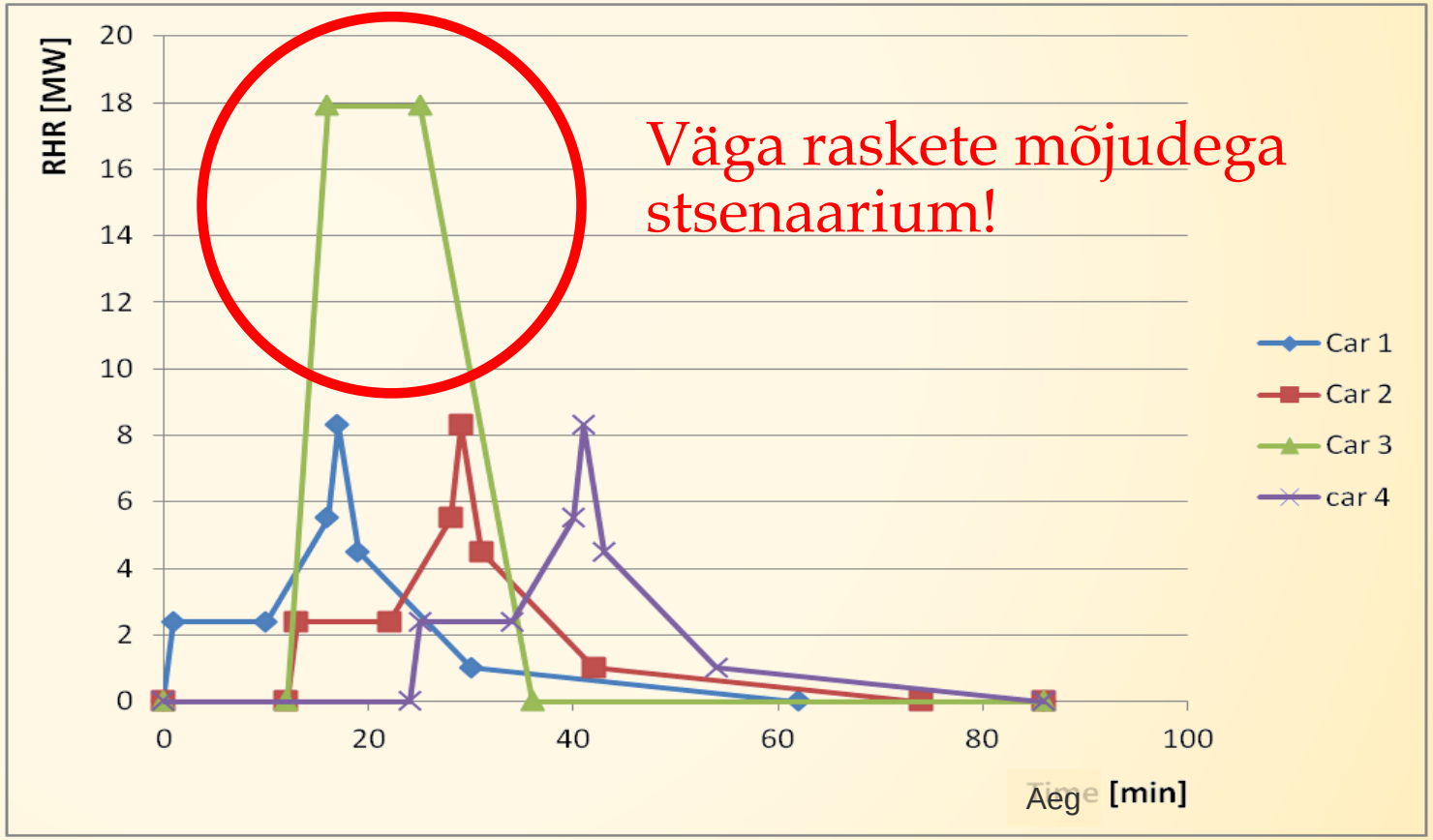
Põlengustsenaarium : 3 autot + 1 kaubik (riskianalüüs – eeldatavalt väga raskete mõjudega olukord)

Autode süttimise vaheaeg : 12 minutit

7. Arvutusnäited

7.3. Näide 3 : Parkimismaja postpark





7. Arvutusnäited

7.3. Näide 3 : Parkimismaja post

File Tools View Help

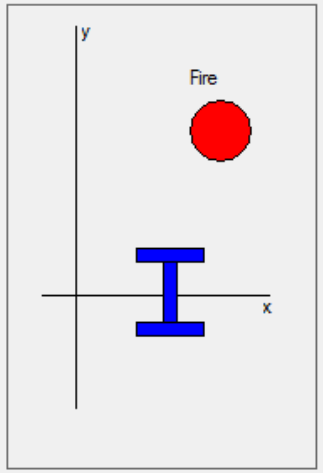
Compartment Fire: Annex E (EN 1991-1-2) User Defined Fire

Localised Fire: Localised Fire

Number of fires: 4

Select fire: 1

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: 3.5 m

Distance on Axis (x): 0 m

Height on Axis (z): 0.5 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

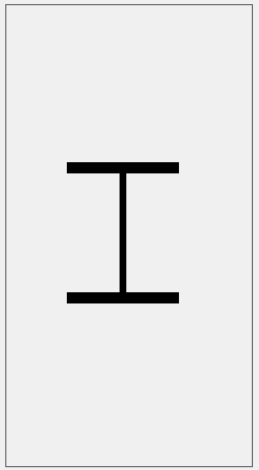
Unprotected Cross Section

Protected Cross Section

Steel Profile

Profile Type: HE - HL

Profile: HE 300 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

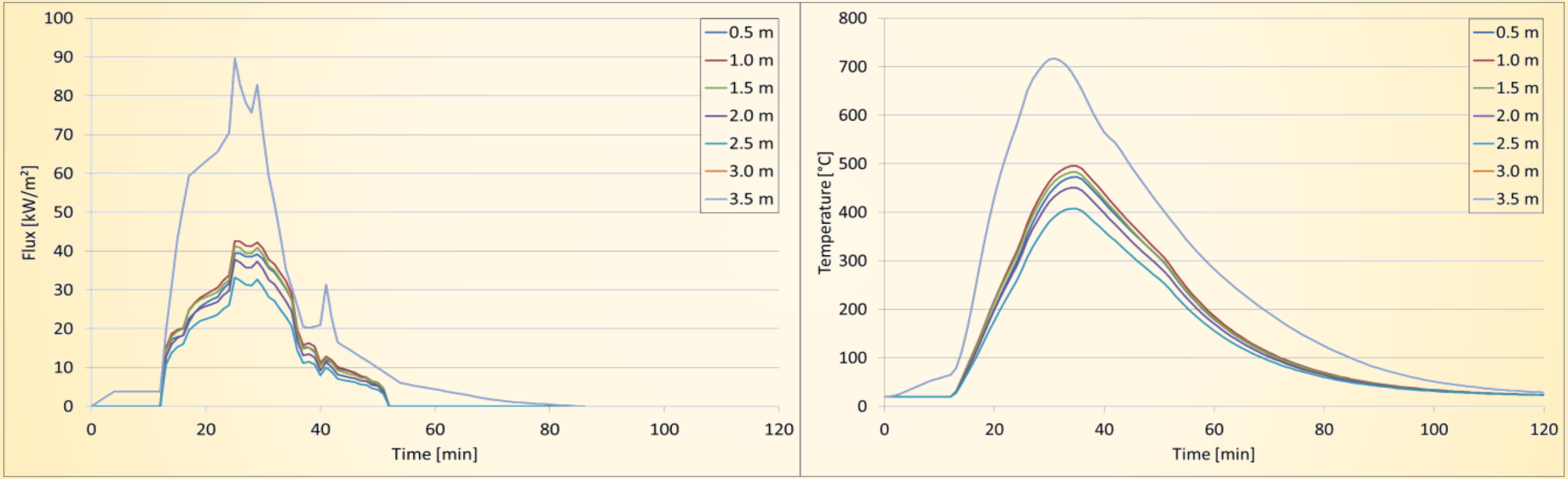
Material Name: Spray Mineral Fiber

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

OK Cancel

7. Arvutusnäited

7.3. Näide 3 : Parkimismaja post



- Väljaspool kuuma suitsu kihti (z = 1 m) : t_{max} = 500°C
- Kuuma suitsu kihi sees (z = 3.5 m) : t_{max} = 718°C

7. Arvutusnäited

7.4. Näide 4 : Tööstushoone sõrestik

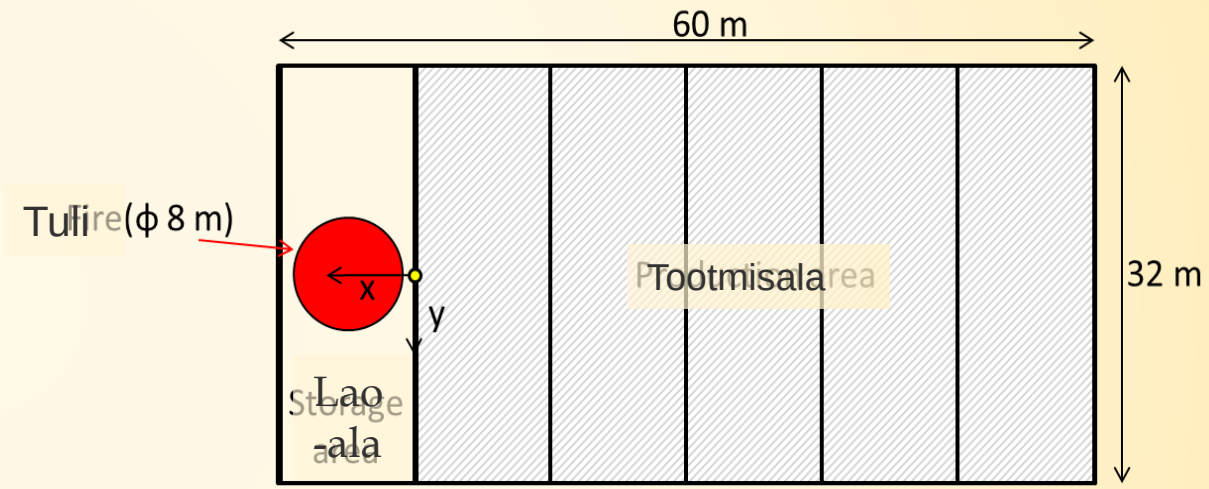
Konstruktsiooni kirjeldus

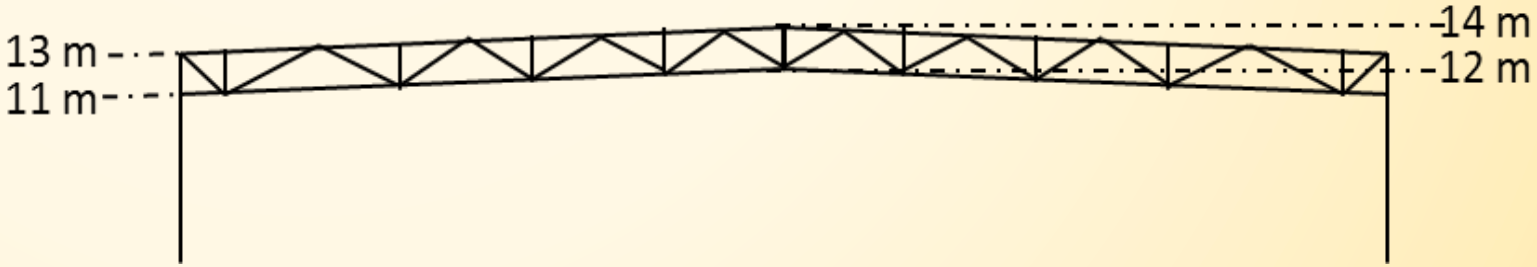
Sõrestiku vööd : HEA 220

Sõrestiku diagonaalid : 2 L60*60*6

Terasraamide vaheline kaugus : 10 m

Harja kõrgus : 14 m





7.4. Näide 4 : Tööstushoone sõrestik

Põlengustsenaarium :

Tule pindala : 50 m² (laoala keskel)

→ Ekvivalentdiameeter : 8 m

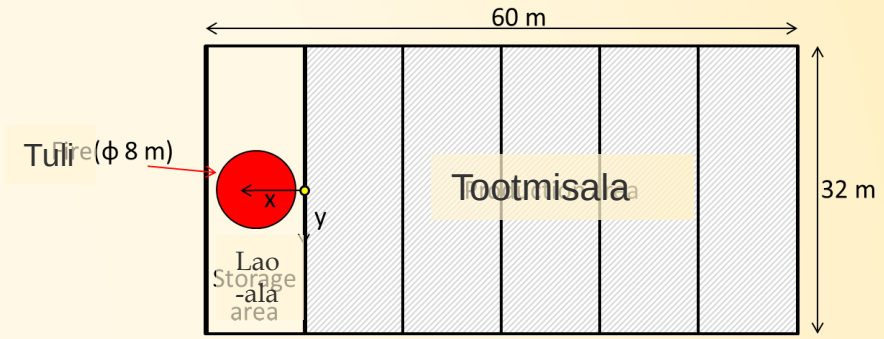
Kasvu kiirus : Keskmine

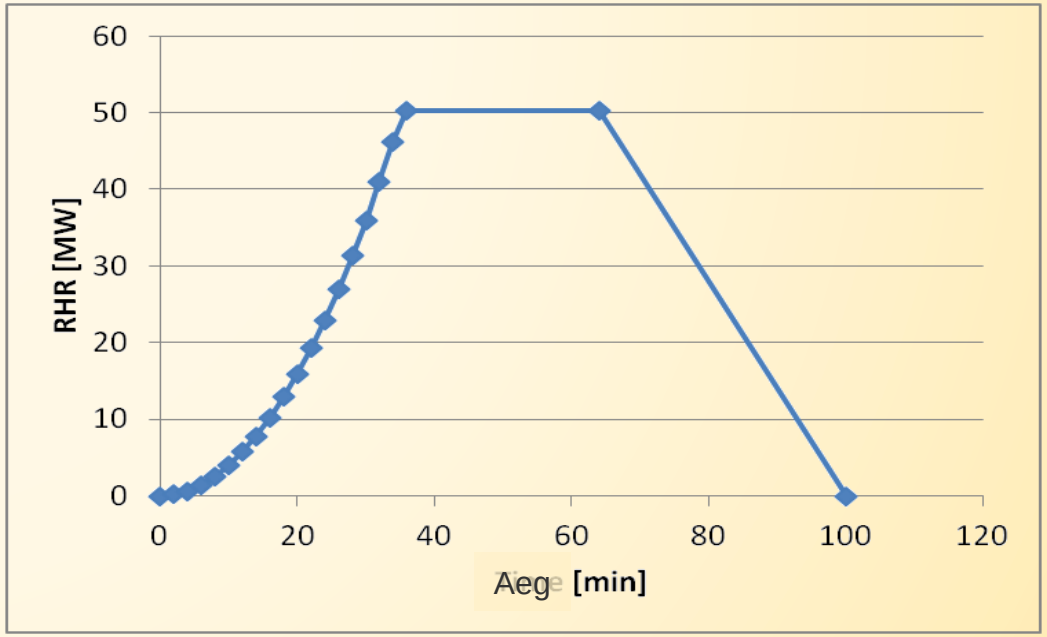
→ RHR = 1 MW pärast t_α = 300 sec

RHR_{max} = 1000 kW/m²*50m² = 50 MW

Põlemiskoormus : 10 T (tselluloos)

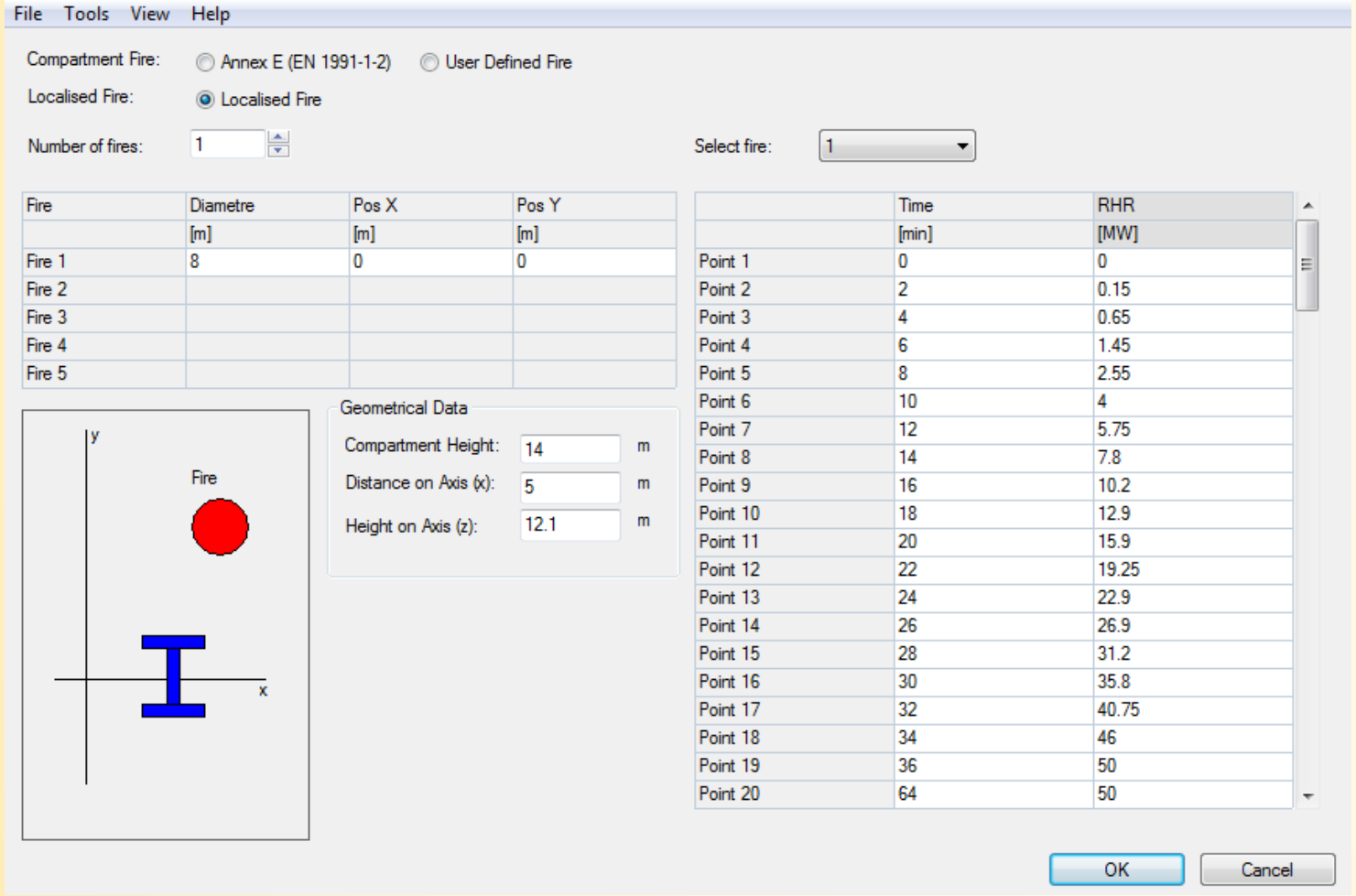
→ Q = 17.5 MJ/kg*10000 kg = 175000 MJ

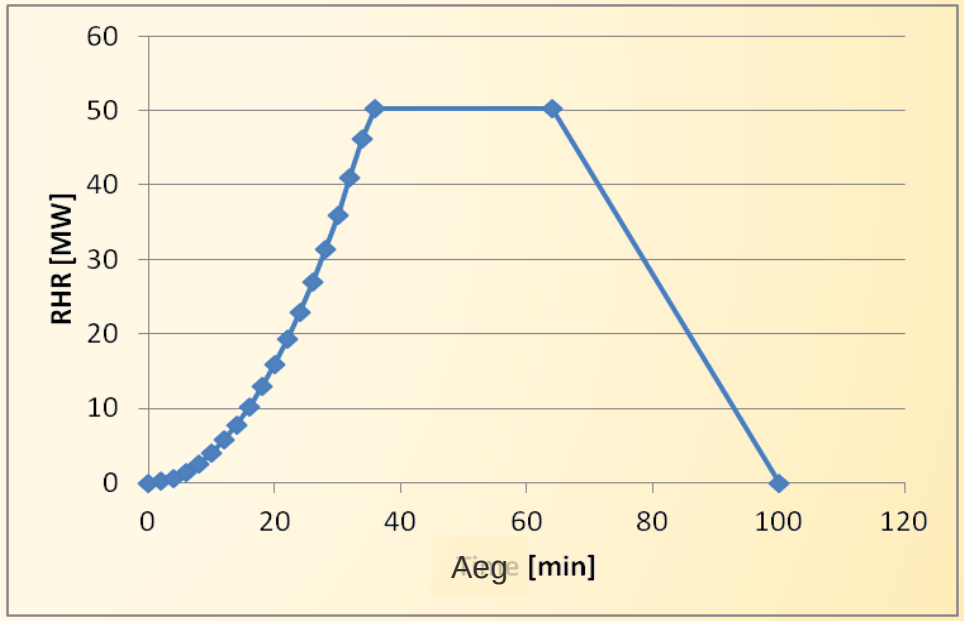




7. Arvutusnäited

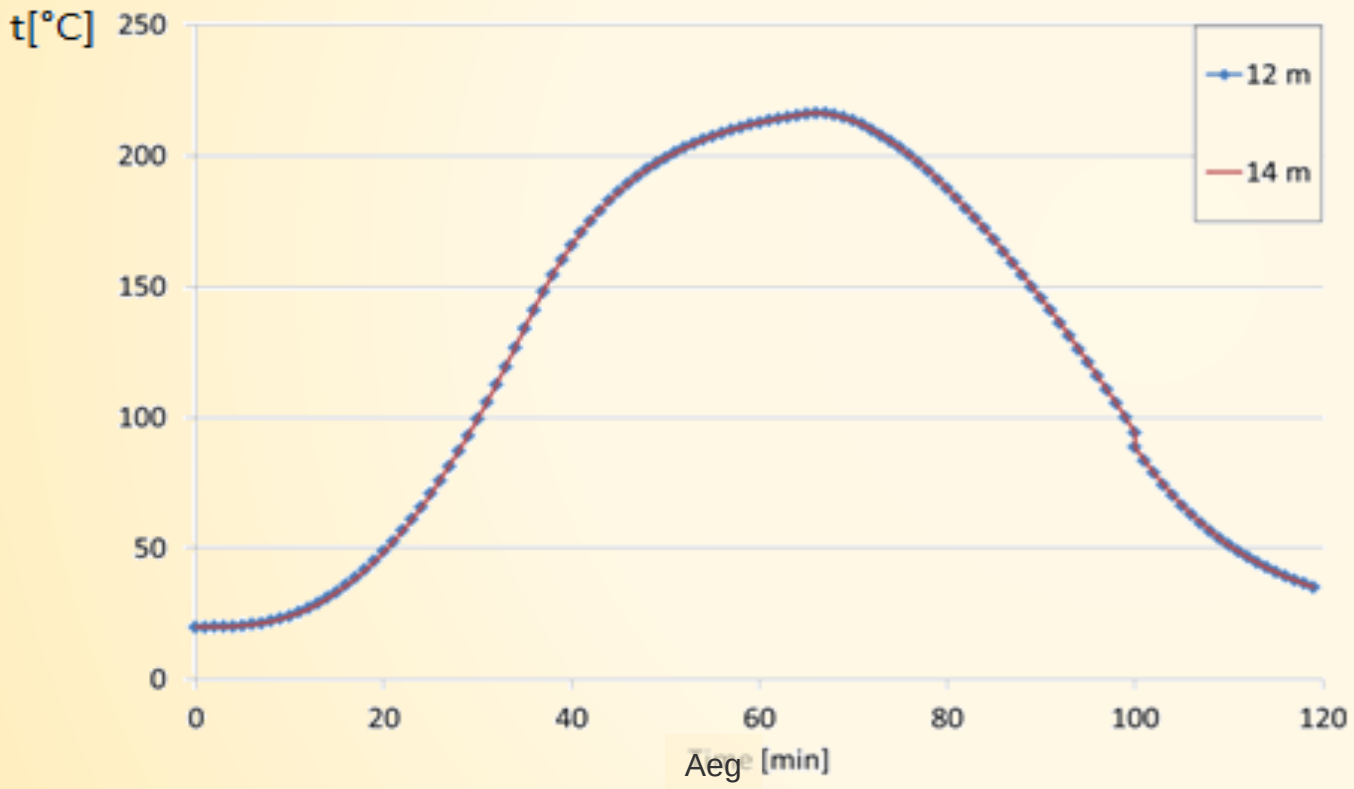
7.4. Näide 4 : Tööstushoone sõrestik





7. Arvutusnäited

7.4. Näide 4 : Tööstushoone sõrestik



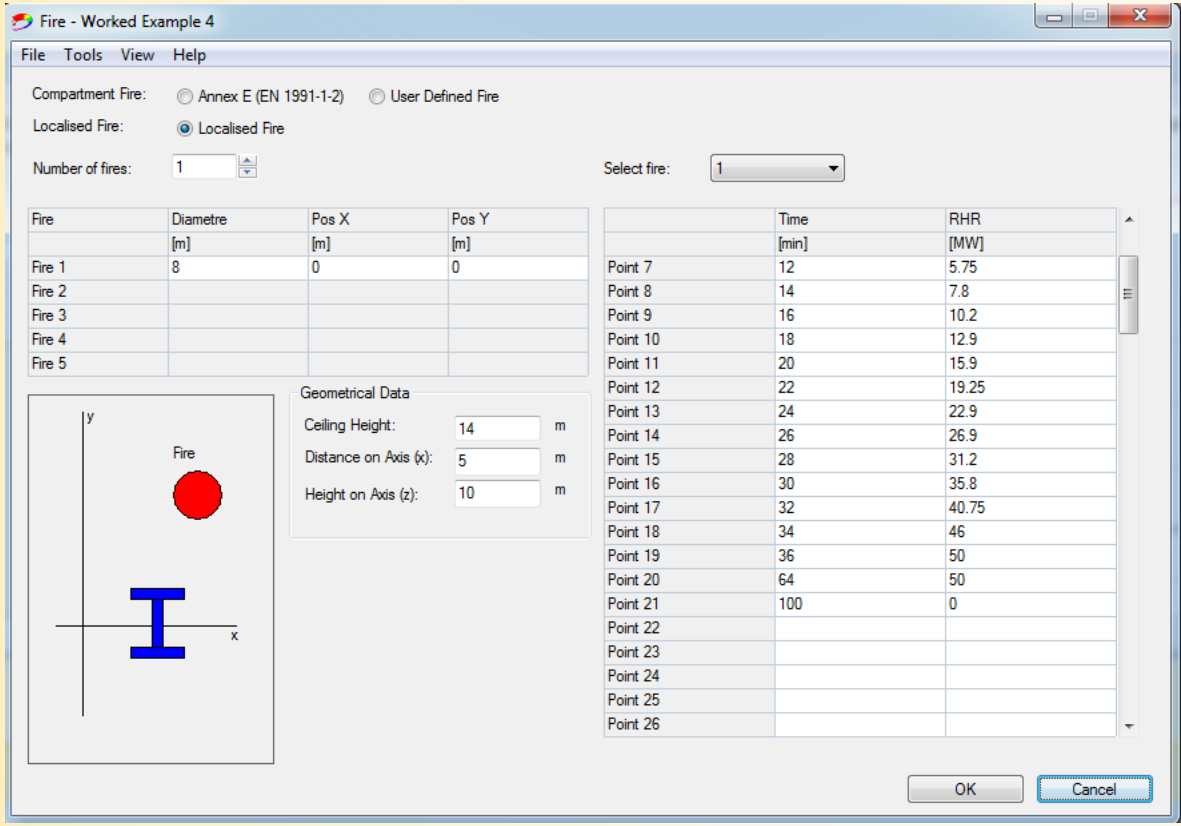
Leegi kõrgus = 9.7m

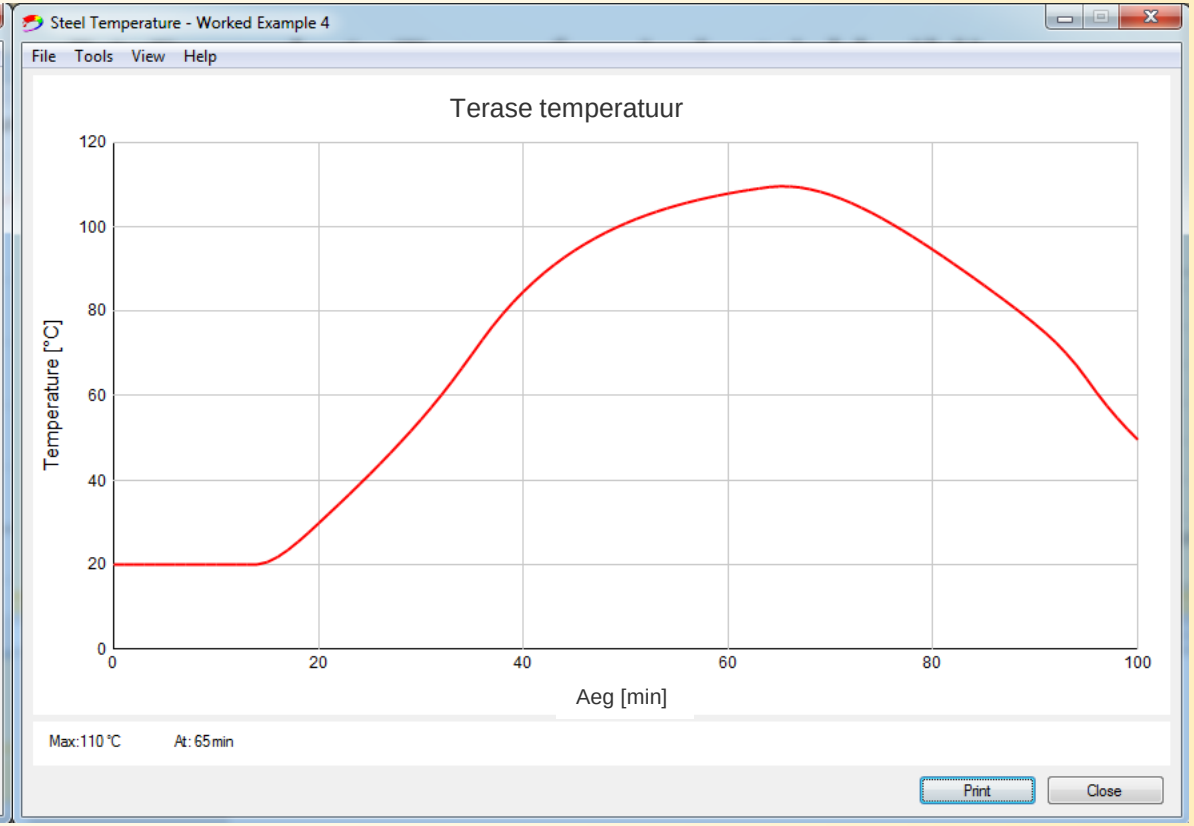
→ Sõrestiku elemendid asuvad leegist kõrgemal

Sõrestike Max temperatuur = 210°C

7. Arvutusnäited

7.4. Näide 4 : Tööstushoone sõrestik

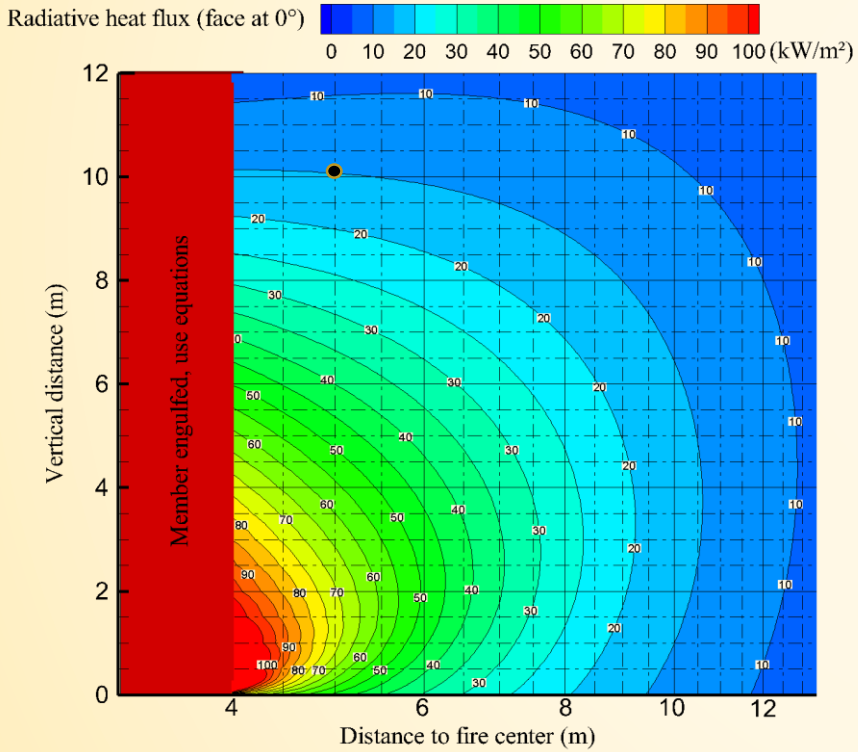




7. Arvutusnäited

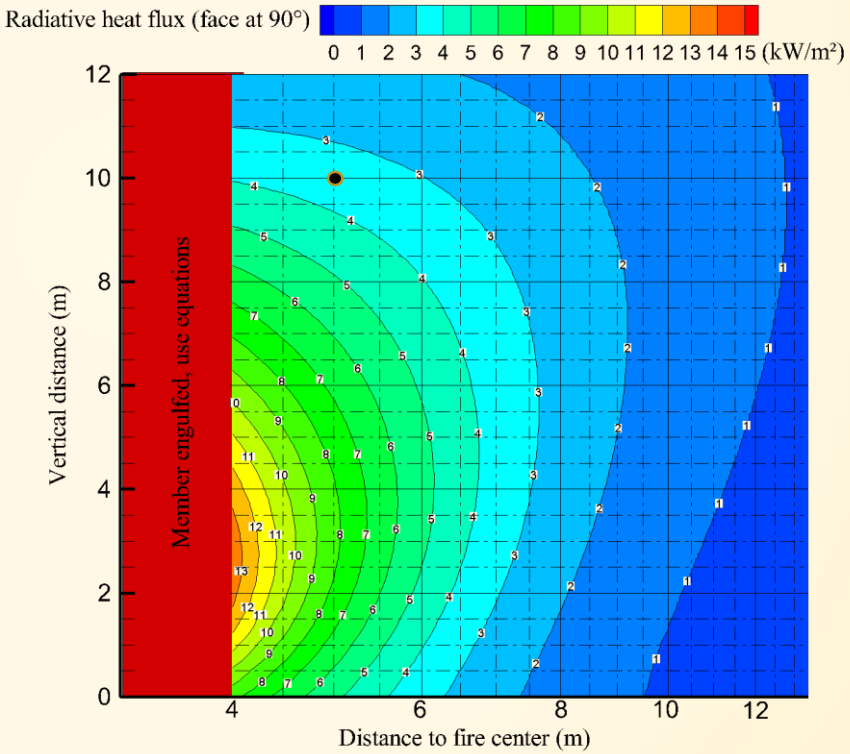
7.4. Näide 4 : Tööstushoone sõrestik

Külg 1



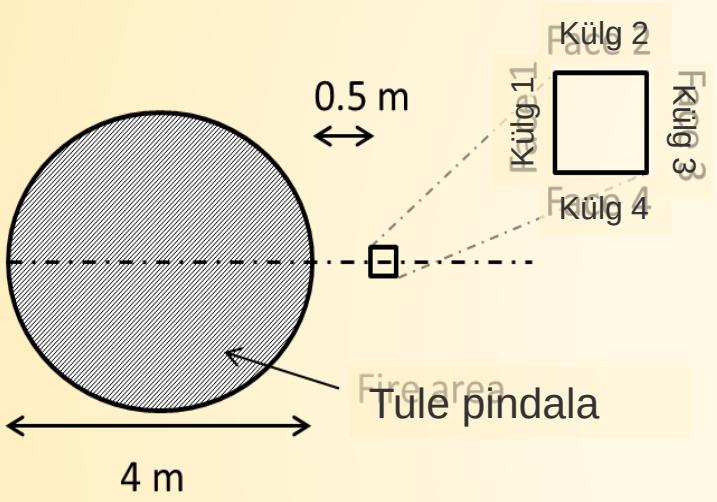
$\varepsilon * \varphi_{tot} = 0.7*15\ \mathrm{kW/m^2} = 10.5\ \mathrm{kW/m^2}$

Külg 2



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

7.4. Näide 4 : Tööstushoone sõrestik



Vastuvõetud soojusvoog igal küljel (eeldades $\varepsilon = 0.7$)

Külg 1 : 10.5 kW/m²

Külg 2 : 2.45 kW/m²

Külg 3 : 0.00 kW/m²

Külg 4 : 2.45 kW/m²

→ Keksmine soojusvoog = 3.85 kW/m²

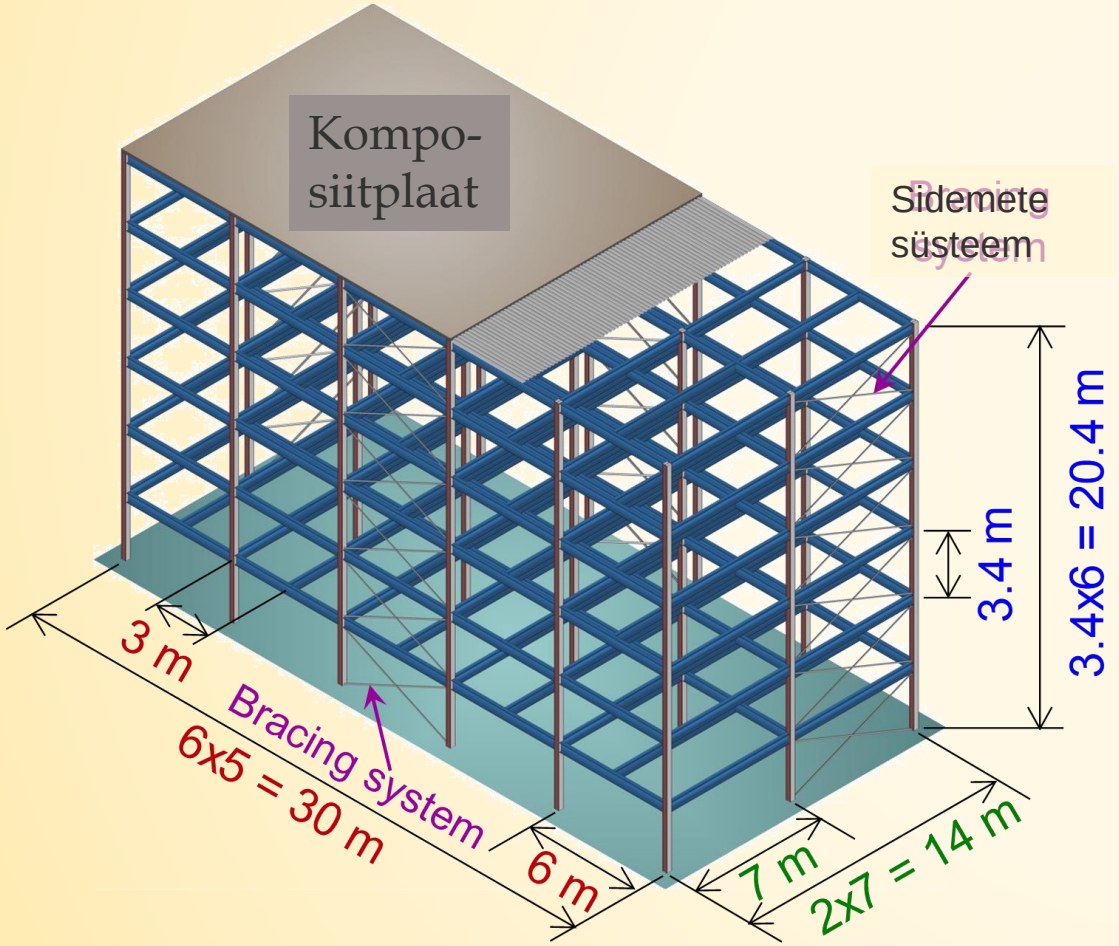
$$0 = \underbrace{h(\theta - 20)}_{\text{Eralduv konvektiivne voog}} + \underbrace{\sigma\varepsilon[(\theta + 273)^4 - (20 + 273)^4]}_{\text{Eralduv kiirgusvoog}} - \underbrace{\varepsilon * \varphi_{tot}}_{\text{Neeldunud voog}}$$

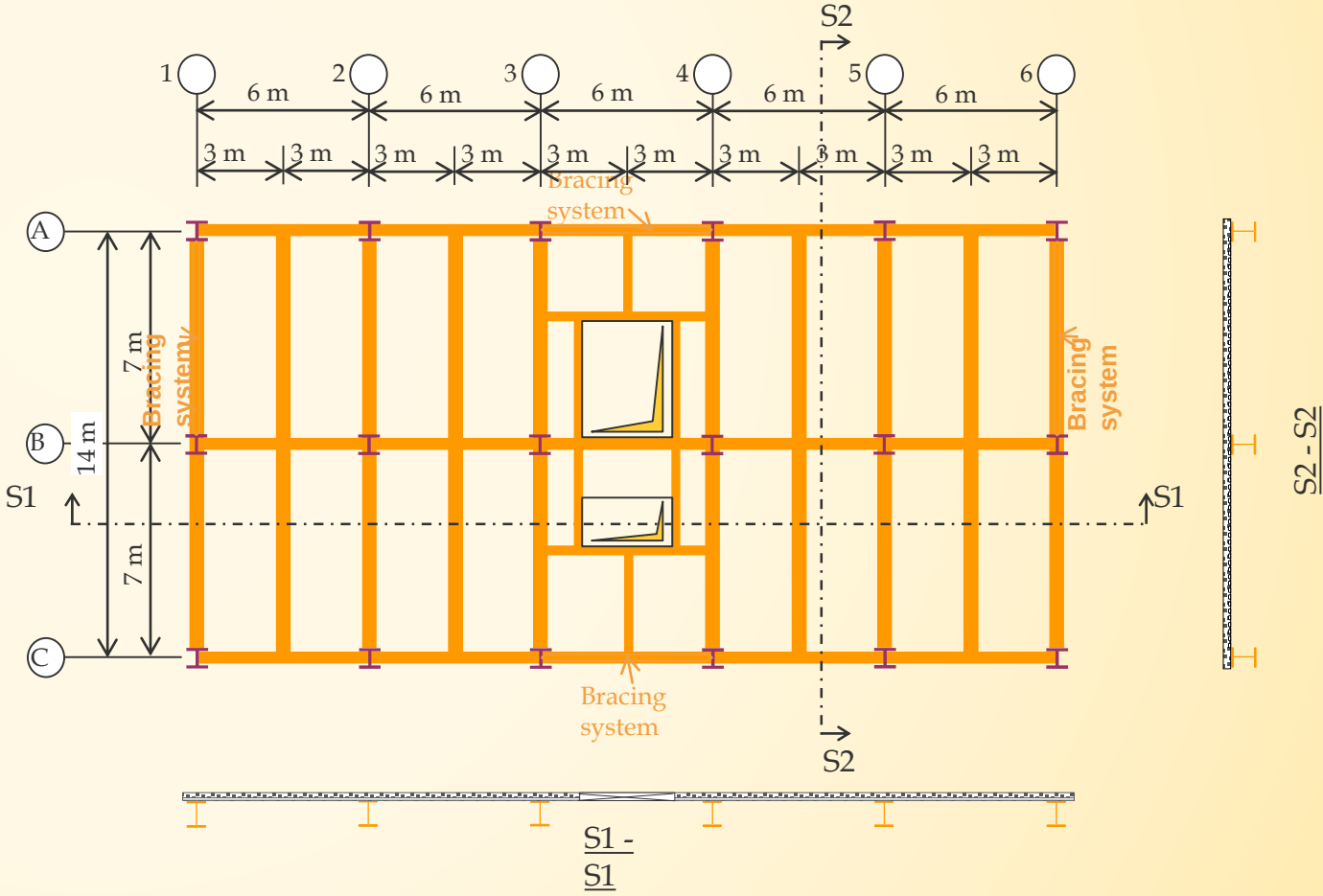
$$h = 35\ W.m^{-2}.K^{-1};\ \sigma = 5.67 * 10^{-8}\ W.m^{-2}.K^{-4}$$

θ (°C)	Kiiratud voog W/m²
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. Arvutusnäited

7.5. Näide 5 : Posti nõtkekandevõime





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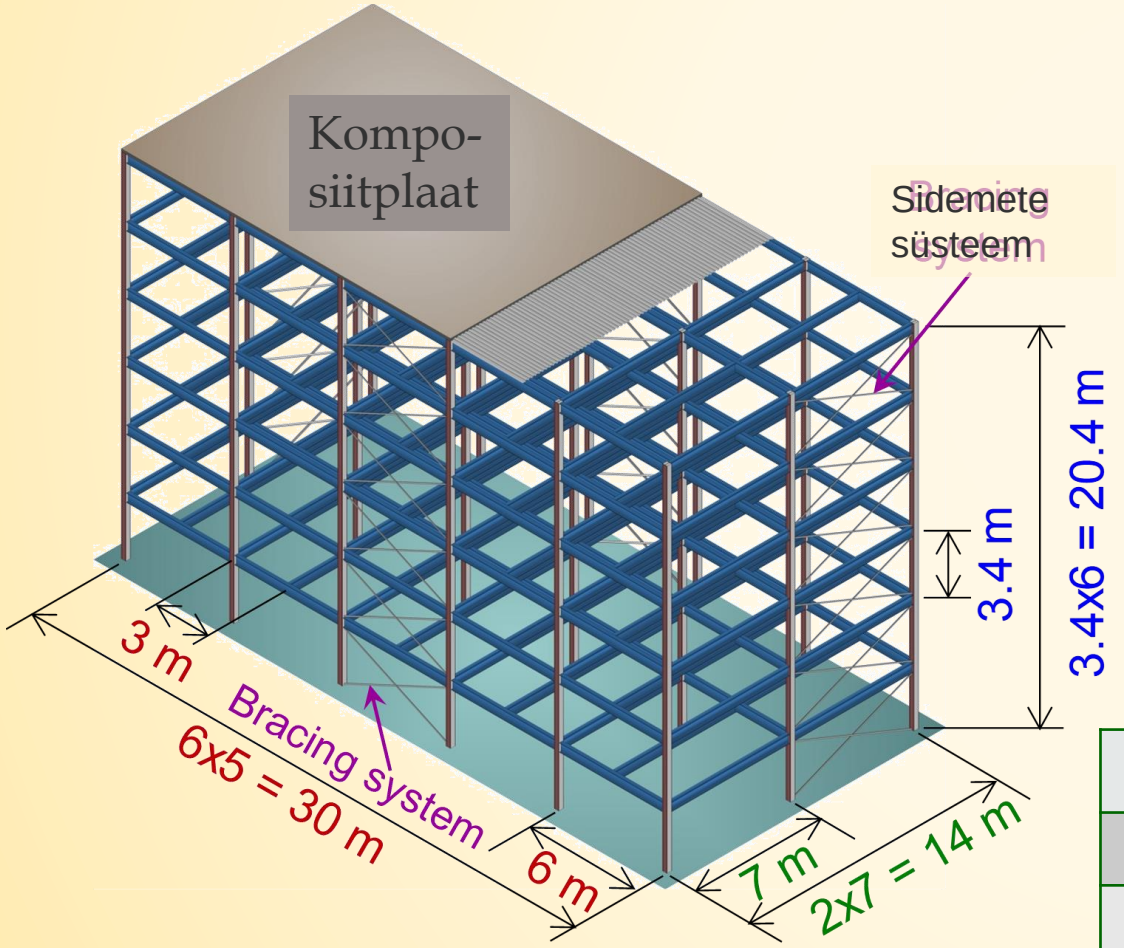
7. Arvutusnäited

7.5. Näide 5 : Posti nõtkekandevõime



Koormused (kõikide korruste vahelagedele)

- Omakaal G1:
  - ✓ Komposiitplaadi ühikukaal: 2.12 kN/m²
  - ✓ Terasest elemendid: vastavalt mõõtmetele
- Alaline koormus G2:
  - ✓ Viimistlus, vaheseinad, kommunikatsioonid: 1.50 kN/m²
- Alaline koormus G3:
  - ✓ Fassaadikate: 2.00 kN/m
- Muutuvkoormuste normatiivsed väärtused ja ψ tegurid

Tüüp	q_k	ψ_1	ψ_2
Kasuskoormus	4.0 kN/m²	0.7	0.6
Lumekoormus	1.7 kN/m²	0.2	0.0

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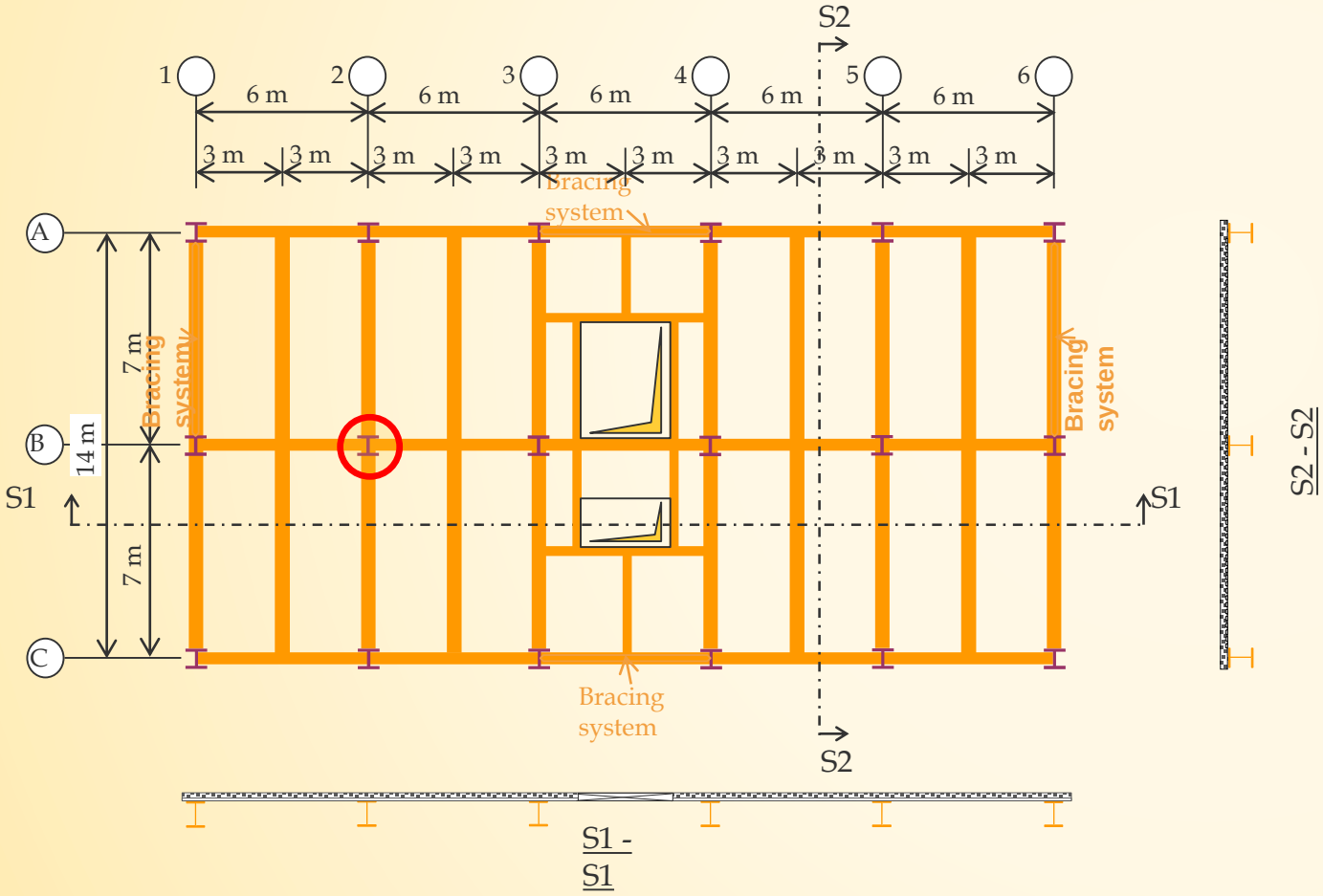
7. Arvutusnäited

7.5. Näide 5 : Posti nõtkekandevõime



Konstruktsioonielemendid

- Komposiitplaat:
  - ✓ Kogupaksus: 12 cm
  - ✓ Profiilplekk: COFRAPLUS60
  - ✓ Profiilpleki paksus: 0.75 mm
  - ✓ Kahesildeline jätkuvplaat
- Abitalad:
  - ✓ IPE360 - S275
- Sisemised peatalad:
  - ✓ HEA360 - S275
- Esimese korruse postid:
  - ✓ Äärepostid (esimene korrus): HEA300 - S275
  - ✓ **Keskmised postid (esimene korrus): HEB300 - S275**

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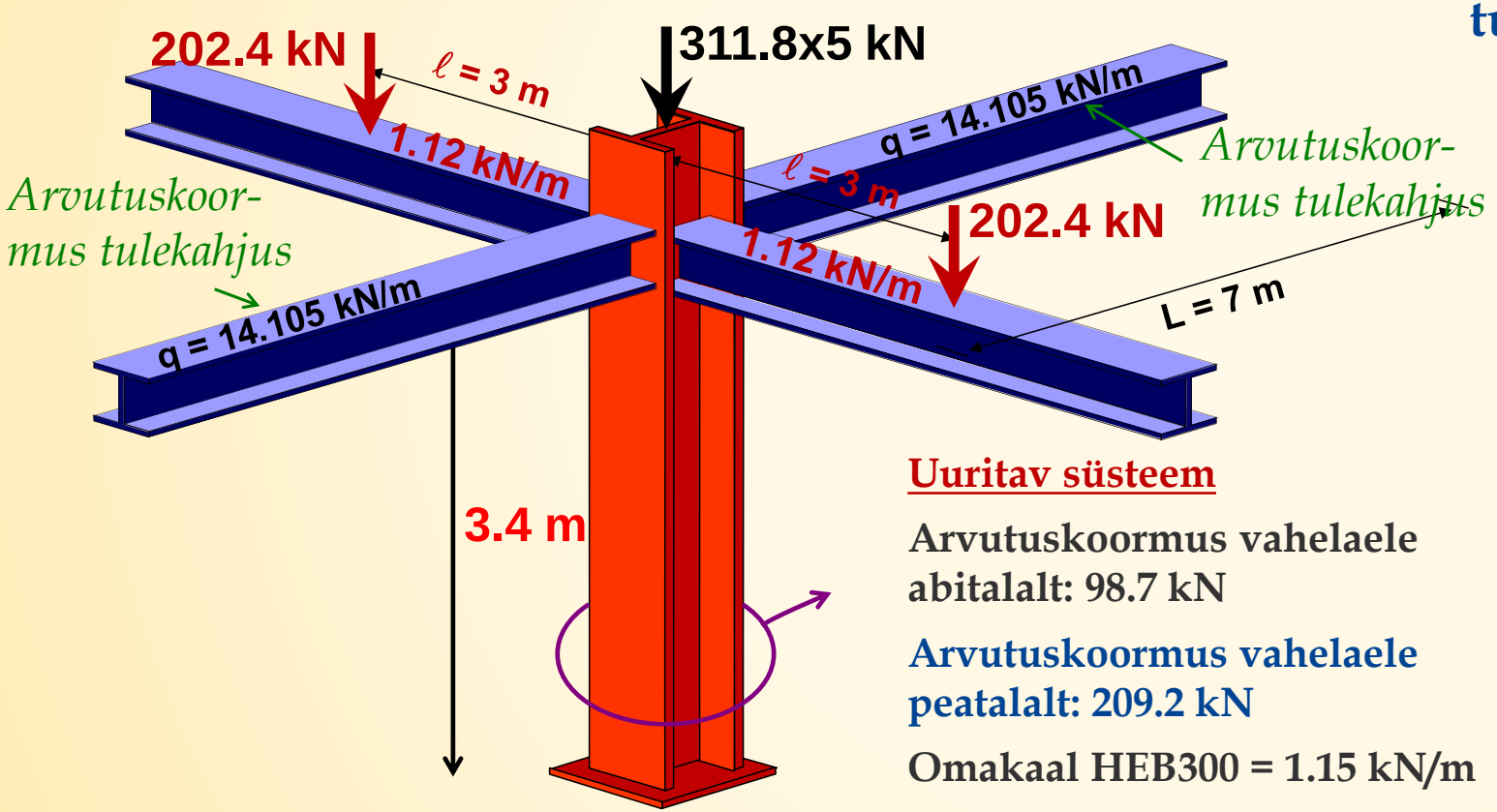
7.5. Näide 5 : Posti nõtkekandevõime



Uuritav süsteem

Arvutuskoormus vahelaele abitalalt: 98.7 kN

Arvutuskoormus vahelaele peatalalt: 209.2 kN

Omakaal HEB300 = 1.15 kN/m

Samm 1: Mehaaniline arvutus tulekahjus

- Arvutuskoormus tulekahjus

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

➢ Posti omakaal

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

➢ Koondatud koormus terastaladelt

$$P_{fi,d,t} = \sum \left(G_{k,1} + \psi_{2,1} Q_{k,1} \right)$$

$$= \underbrace{14.105 \times 7}_{\text{Abitalad}} + \underbrace{202.4 + 1.12 \times 6}_{\text{Pea-tala + postid}}$$

$$\approx 307.9\, kN$$

Märkus: Vastavalt Rahvuslikule lisale, kasutada $\Psi_{1,1}$ või $\Psi_{2,1}$.

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7.5. Näide 5 : Posti nõtkekandevõime

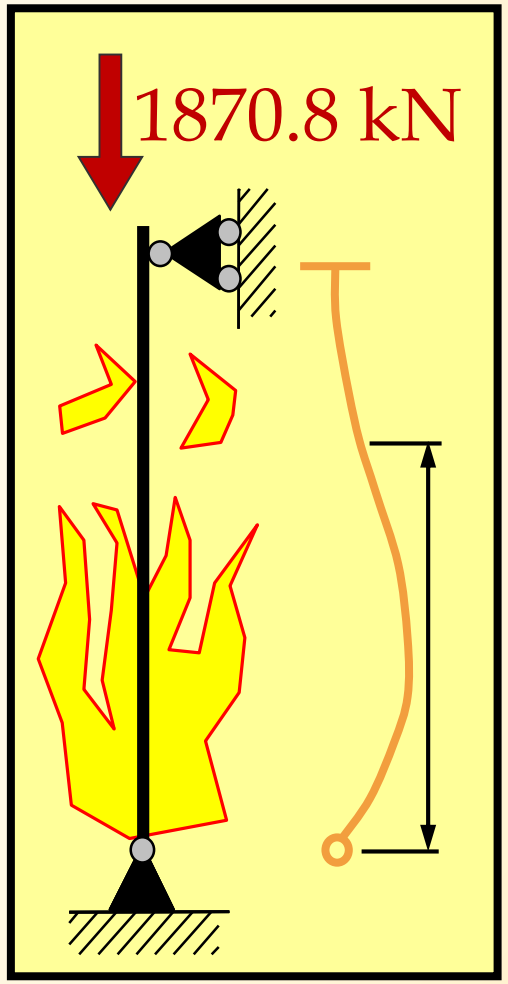
Samm 1: Mehaaniline arvutus tulekahjus

- Arvutuslik kogukoormus tulekahjuolukorras

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

- Nõtkepikkus tulekahjuolukorras
  - Liigendkinnitus postijalal

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



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7.5. Näide 5 : Posti nõtkepikkus

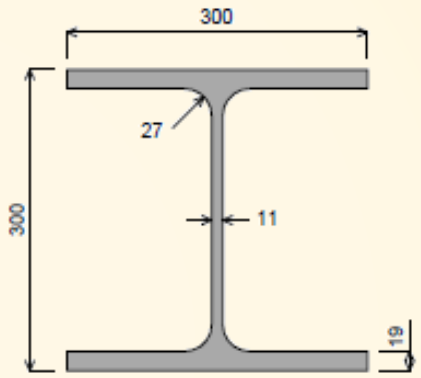
Samm 2: Elemendi klass

Paindeelement

Avaldis 4.2 Eurokoodeks 3 osa 1-2

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

S275



HEB300

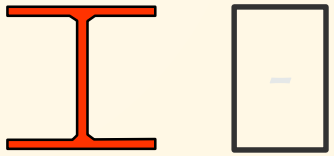
Tabel 5.2 Eurokoodeks 3 osa 1-1

$c/t_w \leq 33\varepsilon$ → *Seina klass 1*

= 18.9 *= 25.9*

$c/t_f \leq 9\varepsilon$ → *Vöö klass 1*

= 6.2 *= 7.07*



Surve

Ristlõike-klass

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7.5. Näide 5 : Nõtkekandevõime

Samm 3: Arvutuslik kandevõime ajahetkel 0 (normaaltemperatuur)

Arvutuslik kandevõime ajahetkel 0 (normaaltemperatuur) vastavalta Eurokoodeks 3 osa 1-2

- Plastne survekandevõime

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

- Dimensioonita saledus

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

HEB300	
A (cm²)	149.08
I_z (cm)	7.58

7.5. Näide 5 : Nõtkekandevõime

Samm 4: Kasutusaste tabeli kasutamiseks

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

Samm 5: Kriitiline temperatuur

lineaarne interpolatsioon tabeli väärtuste vahel $\bar{\lambda}_{fi,0} = 0.362$

$\bar{\lambda}_{fi,0}$	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							

$$\theta_{cr} \approx 560 \ °C$$