Temperature of Steel Columns Exposed to Localised Fire

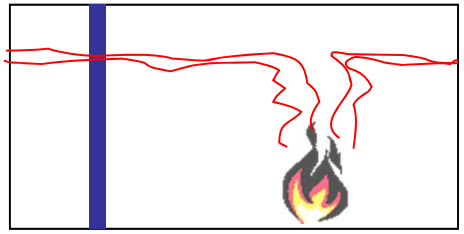
Zdeněk Sokol

Czech Technical University
in Prague

Fire scenarios and column temperature

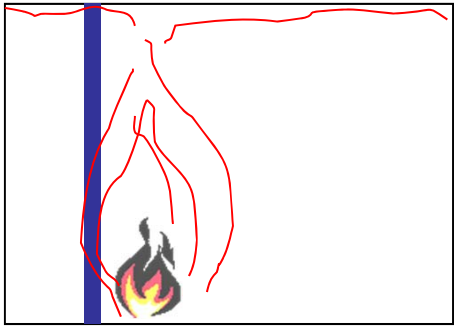
compartment fire

- nominal curves, zone model
- uniform gas temperature
- uniform temperature along the column height



localised fire

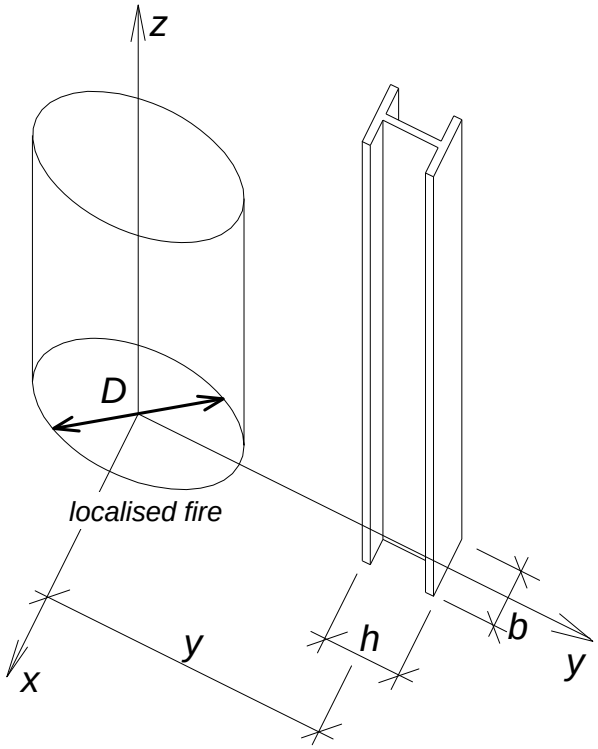
- low compartment, flames reach the ceiling
- the highest temperature in upper part of the column



localised fire

- high compartment, flames do not reach the ceiling
- the column is heated by radiation from the flames, highest temperature in lower part

Model for column temperature calculation



Assumptions

- temperature of the flames calculated according to EN 1991-1-2, Annex C
- the flames are replaced by cylindrical surface
- the column is heated by radiation from the flames
- non-uniform temperature in the cross-section is neglected
- heat conduction along the column length is not considered (conservative approach)

The temperature is calculated using step-by-step method at several points along the column height

$$\Delta\theta_{a,t} = \frac{A_m / V}{c_a \, \rho_a} h_{net} \, \Delta t$$

The heat flux

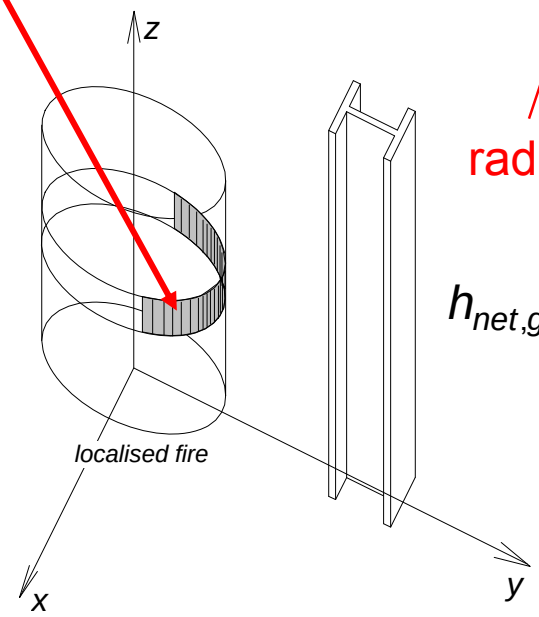
Total heat flux to a point on the column

uniform flame temperature

$$h_{net} = \sum h_{net,gain} - h_{net,loss}$$

radiation and conduction to surrounding environment

radiation from the flames



$$h_{net,gain} = \Phi\, \varepsilon_{res}\, \sigma \left(\left(\theta_g(z) + 273\right)^4 - \left(\theta_m + 273\right)^4 \right)$$

numerical calculation of the configuration factor

$$\Phi = \frac{1}{A_1} \int_{A_1} \int_{A_2} \frac{\cos \varphi_1 \cos \varphi_2}{\pi r^2}\, dA_2\, dA_1$$

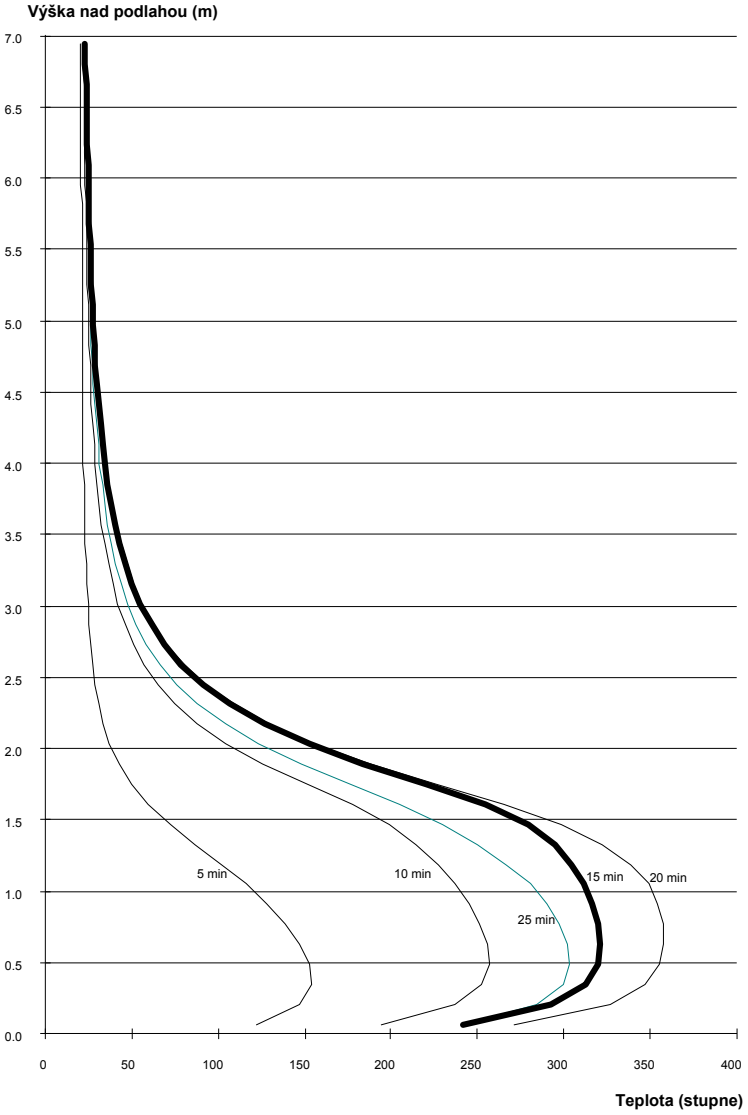
$$h_{net,loss} = \left(1 - \Phi\right) \varepsilon_m\, \varepsilon_f\, \sigma \left(\left(\theta_m + 273\right)^4 - \left(20 + 273\right)^4 \right) + \alpha_c \left(\theta_m - 20\right)$$

radiation to surrounding environment

conduction to surrounding air

$\alpha_c = 25\ \mathrm{W/m^2K}$

Localised fire of metal-forming machine

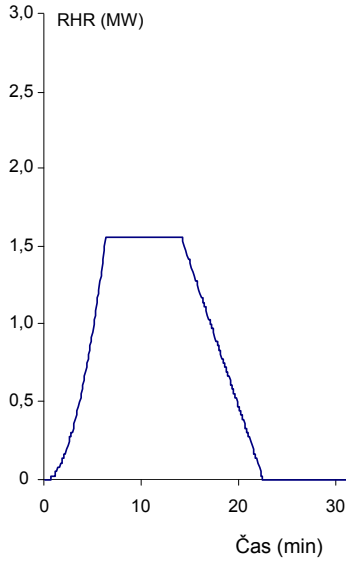


maximum temperature at 15 minutes

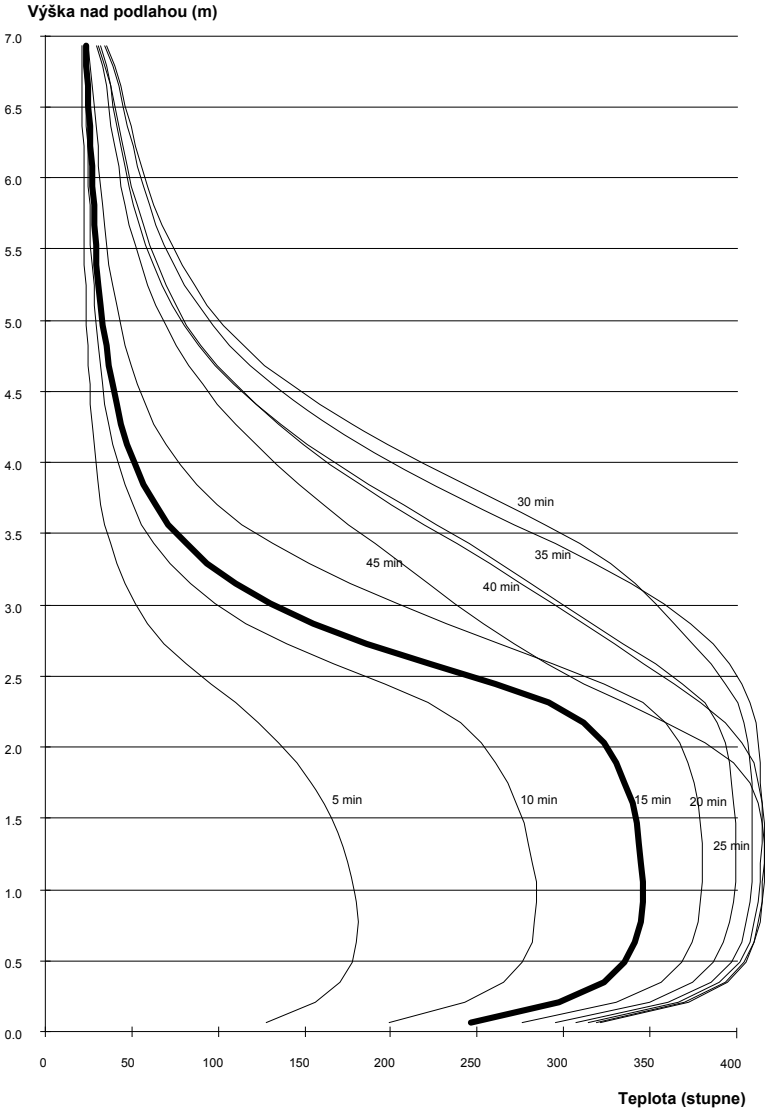
320°C

0,65 m above the floor

Rate of Heat release



Localised fire of forklift



maximum temperature at 15 minutes

345°C

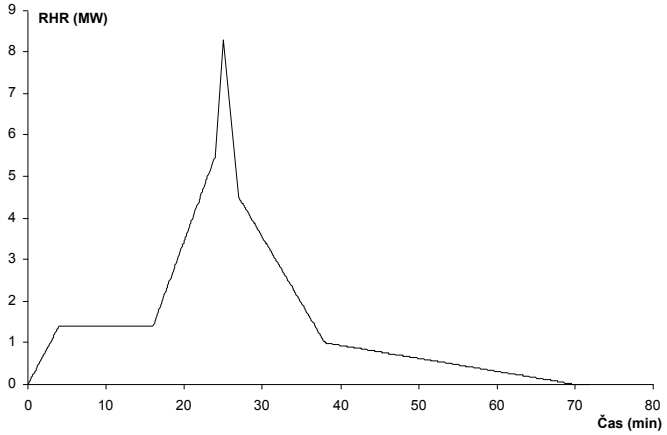
1,10 m above the floor

maximum temperature at 30 minutes

412°C

1,50 m above the floor

Rate of Heat release



Thank you for your attention

URL: www.ocel-drevo.fsv.cvut.cz