FIRE RESISTANCE OF GALVANISED MEMBERS

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Contents of the presentation

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- Fire tests
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Motivation

- Surfacing of the Steel Structures is not accounted in the calculation of Fire Resistance
- Advantages of Galvanazing compared to Intumescent Coating
  - Price availability
  - Reduction of labour consumption
  - Acceleration of construction
  - Aesthetic properties
  - New possibility of using zinc coated members

Heat Transfer in Fire Technology

Conduction – molecular process of heat transfer

Fourier´s Law $$\frac{\partial}{\partial x}\left(k\frac{\partial T}{\partial x}\right)+\frac{\partial}{\partial y}\left(k\frac{\partial T}{\partial y}\right)+\frac{\partial}{\partial z}\left(k\frac{\partial T}{\partial z}\right)=c\rho\frac{\partial T}{\partial t}$$

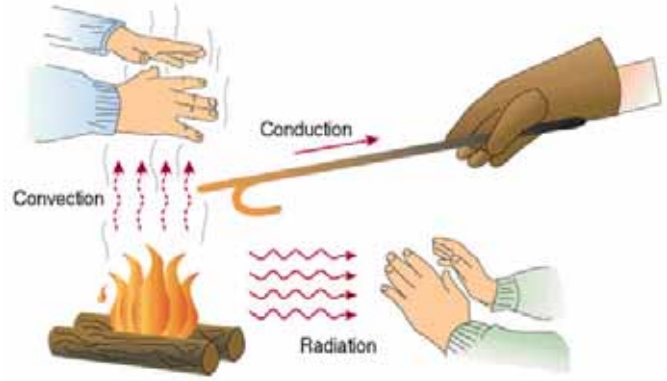
Heat flux to boundary depends on surrounding and surface temperature: $$\dot{q}''_{tot}=\dot{q}''_{rad}+\dot{q}''_{con}$$

Radiation - heat flux of electromagnetic waves

$$\dot{q}''_{rad}=\varepsilon\sigma(T_r^4-T_s^4)$$

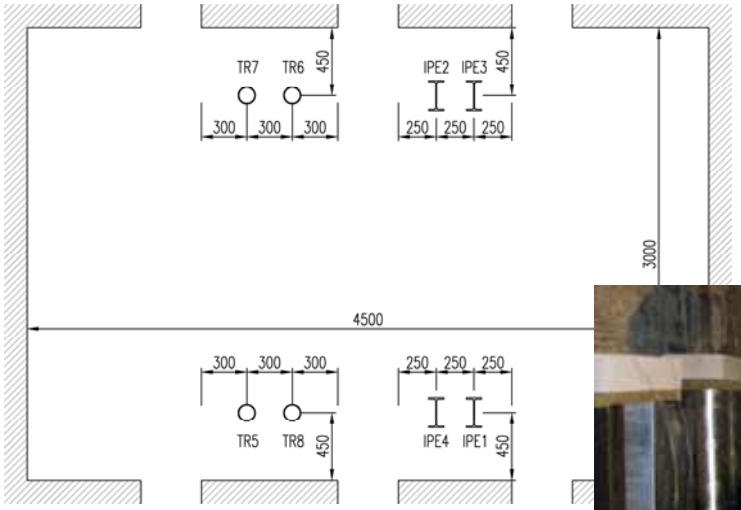
Convection – fluid passing by the surface

$$\dot{q}''_{con}=h_c(T_g-T_s)$$



Fire Test 2010

- Pavus a.s., Veselí nad Lužnicí, 20. 10. 2010
- Horizontal Furnace with System of Oil-burners
- Standard Fire Curve



Fire Test 2010

Specimens:

- Hollow Cross Sections – TR 114,3 x 4 – 1000 mm
- Opened Cross Sections – IPE 200 – 1000 mm

Galvanized Surface:

- Average Thickness 119 µm
- Temperature of Galvanizing 460°C
- 1 Specimen – Admixure Al in Galvanizing Bath

Fire Test 2010

Fire Test 2010

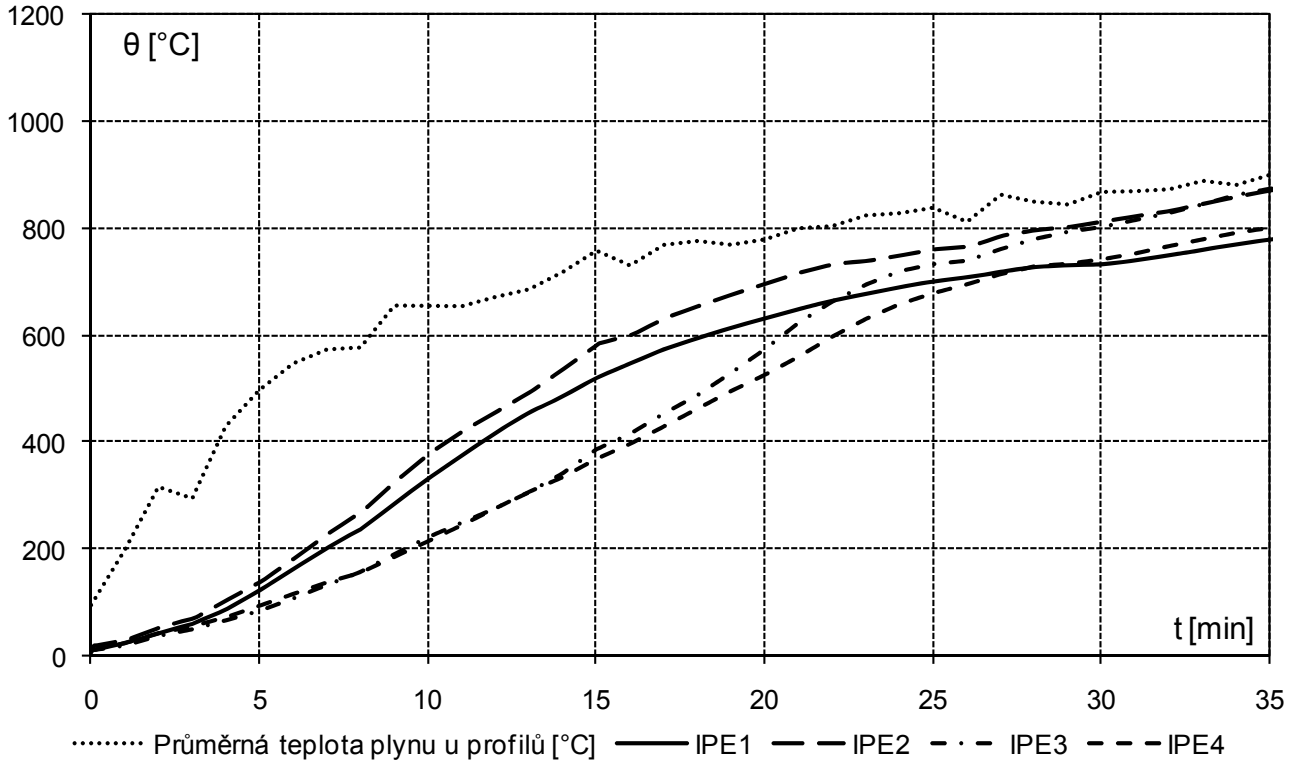
- Specimens after Fire Test

Fire Test 2010

Surfacing after fire test

Fire Test 2010

Measured Values



Results - Analytical Approach

Heat Transfer – „black“ specimen:

$$h_{net} = h_{net,c} + h_{net,r}$$

$$\Delta\Theta_a(t) = k_{sh} \cdot \frac{A_m/V}{c_a(t) \cdot \rho_a} h_{net}(t) \cdot \Delta t$$

$$h_{net,c}(t) = \alpha_c \cdot \left[\Theta_g(t) - \Theta_a(t)\right]$$

$$h_{net,r}(t) = \phi \cdot \varepsilon_m \cdot \varepsilon_f \cdot \sigma \cdot \left[(\Theta_g(t) + 273)^4 - (\Theta_a + 273)^4\right]$$

Results - Analytical Approach

Heat Transfer – galvanised specimen:

$$h_{net} = h_{net,c} + h_{net,r}$$

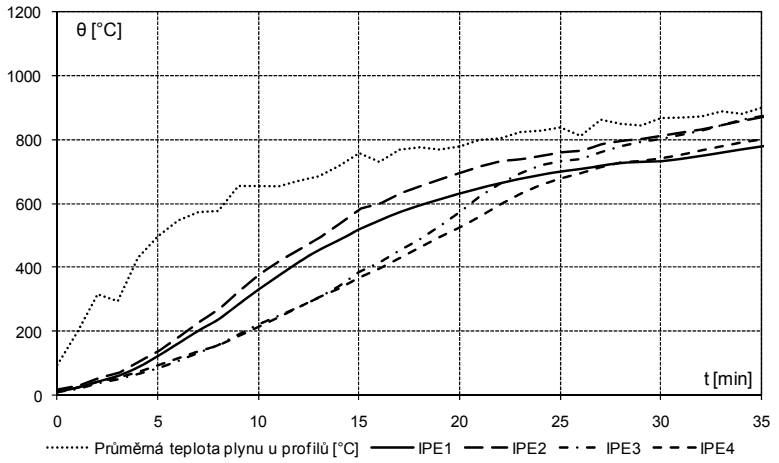
$$\Delta\Theta_a(t) = k_{sh} \cdot \frac{A_m / V}{c_a(t) \cdot \rho_a} \cdot h_{net}(t) \cdot \Delta t$$

$$h_{net,c}(t) = \alpha_c \cdot \left[\Theta_g(t) - \Theta_a(t)\right]$$

$$h_{net,r}(t) = \phi \cdot \varepsilon_m \cdot \varepsilon_f \cdot \sigma \cdot \left[(\Theta_g(t) + 273)^4 - (\Theta_a + 273)^4\right]$$

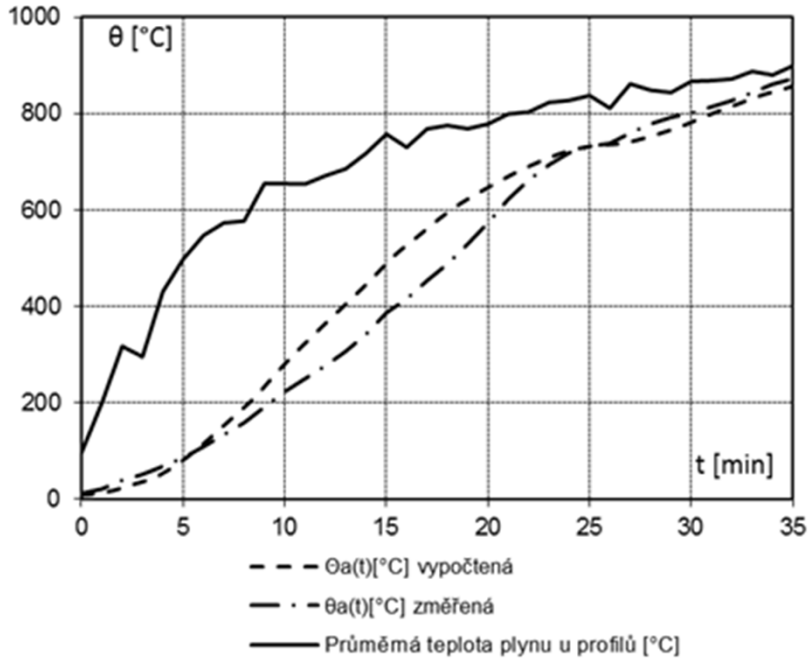
Results - Analytical Approach

- Surface Emissivity
  - Aluminum $\varepsilon_m = 0,3$
  - Galvanized Steel $\varepsilon_m = 0,32$
  - Stainless Steel $\varepsilon_m = 0,4$
  - Steel without surfacing $\varepsilon_m = 0,7$



Results - Analytical Approach

$\varepsilon_m = 0{,}32$



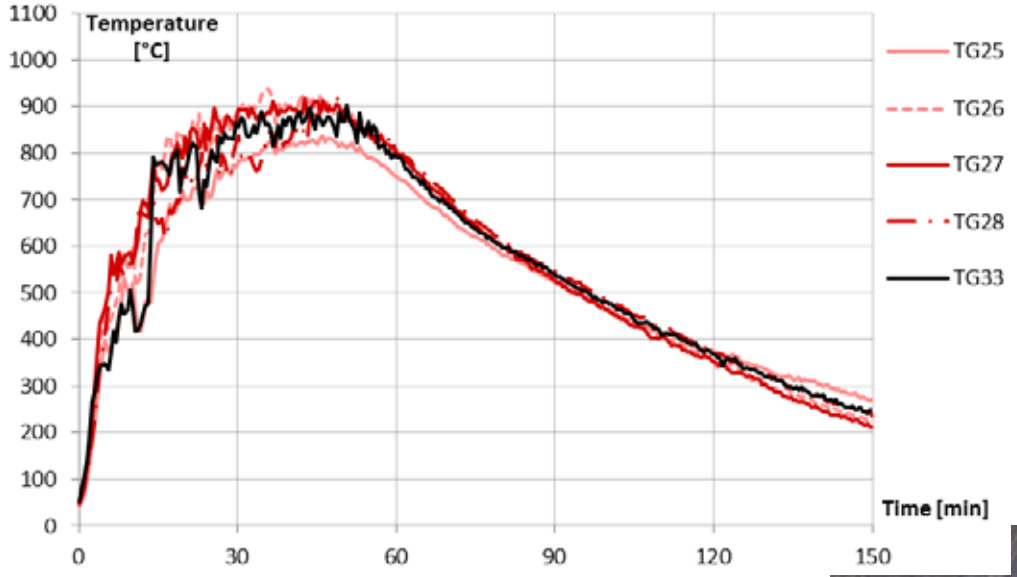
Fire Test 2011 – Real structure

Pavus a.s., Veselí nad Lužnicí, 15. 09. 2011

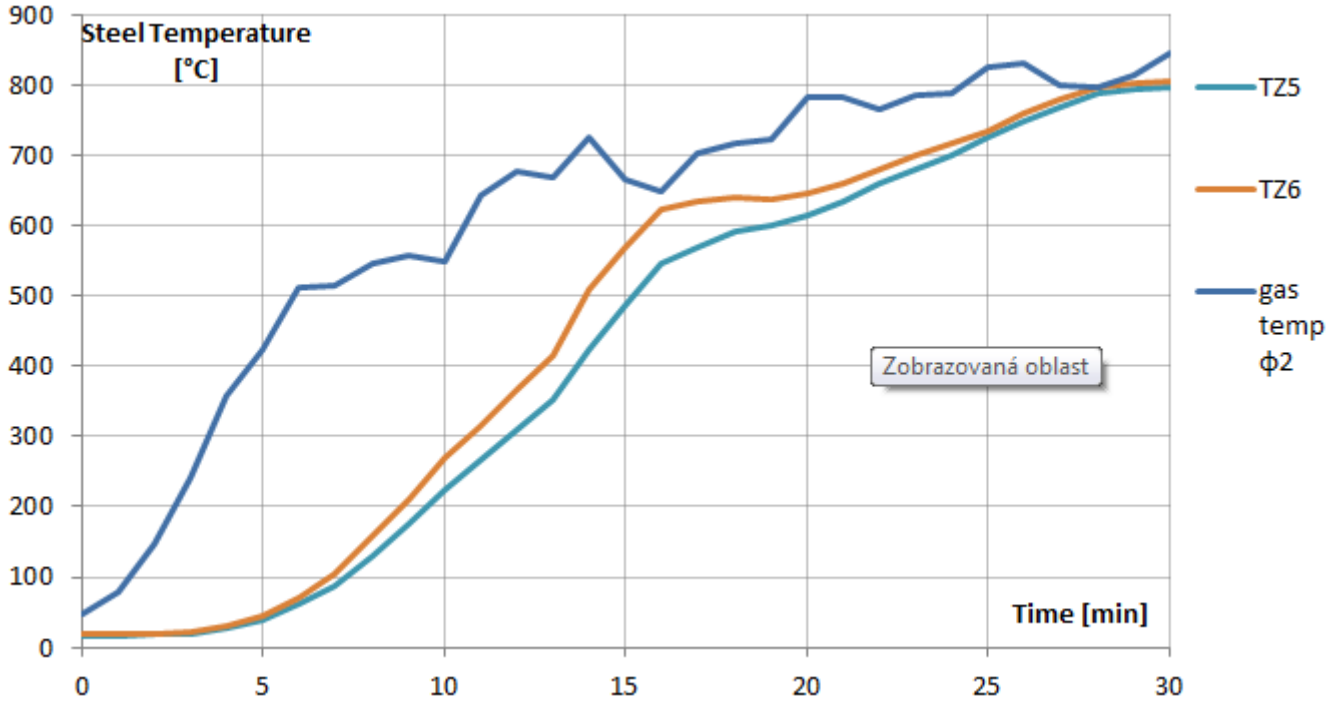
Full scale test on real structure, dimensions 10,4 x 13,4 m

$q_{fi,d}$ = 525 MJ/m^2, opening 5 x 2 m

Fire Test 2011 – Real structure



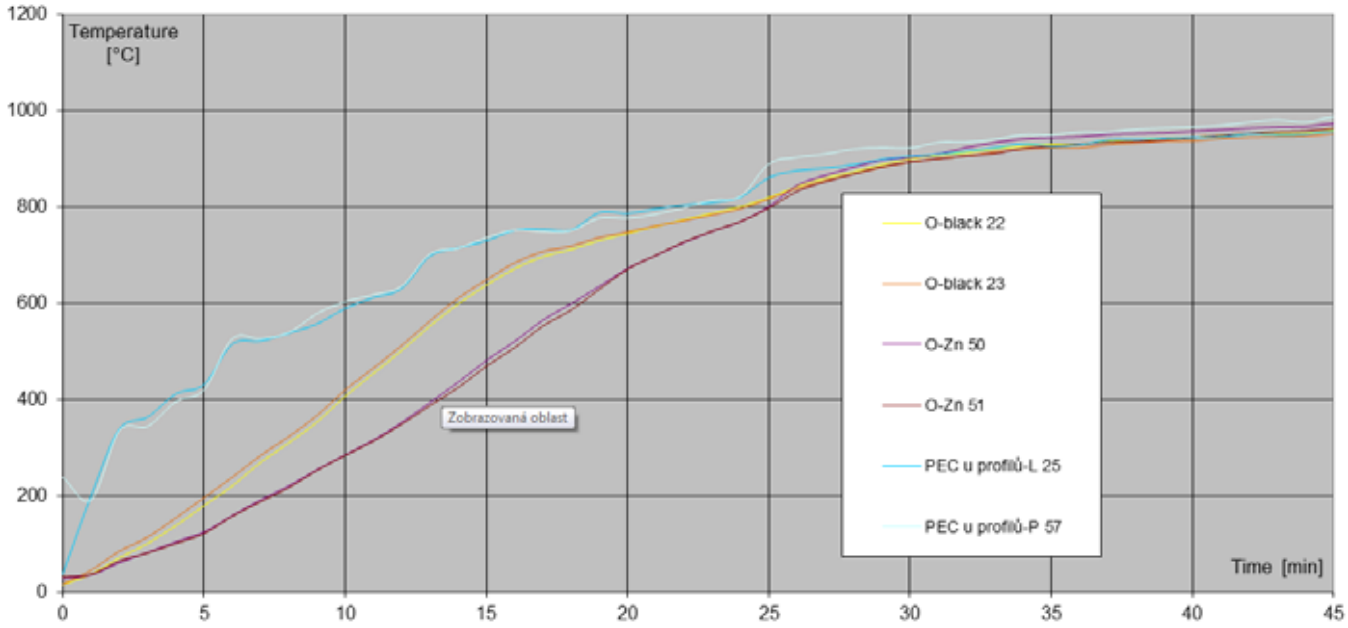
Fire Test 2011 – Real structure



Fire Test 2011 – Furnace

Pavus a.s., Veselí nad Lužnicí, 11. 10. 2011

Fire Test 2011 – Furnace



Further research

- Aging of zinc coated members
- Influence of thickness of zinc coating surfacing
- Composition of galvanizing bath
- Numerical model

Goal of the work

- Specify emissivity of galvanised surface
- Calibrated numerical model
- Shedule of temperatures for zinc coated steel members in standard temperature curve

Thank you for attention

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

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