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INFLUENCE OF CONCRETE COVER THICKNESS ON FIRE RESISTANCE OF RC BEAMS

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1. Introduction

- *Fire can be regarded as the most severe condition in the life of a concrete structure.*
- *Our exposure to fire hazard is largely filtered through the built environment in which we live our lives.*
- *On this paper we are going to do different scenarios of fire in a section of a 3 m reinforced beam with the help of the Ansys software.*

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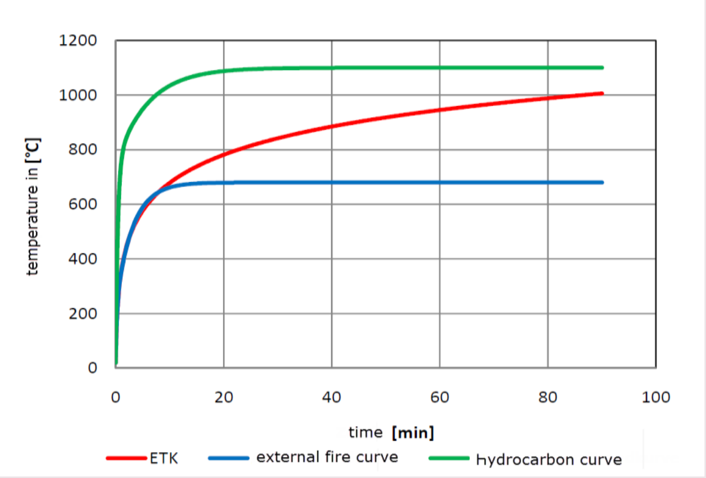
2. Fire Curves

- Standard temperature-time curve (ISO 834) $\theta_g = 20 + 345 \cdot \log_{10}(8 \cdot t + 1)$
- External fire curve (EXT) $\theta_g = 660 \cdot (1 - 0.687 \cdot e^{-0.32 \cdot t} - 0.313 \cdot e^{-3.8 \cdot t}) + 20$
- Hydrocarbon fire curve (HC) $\theta_g = 1080 \cdot (1 - 0.325 \cdot e^{-0.167 \cdot t} - 0.675 \cdot e^{-2.5 \cdot t}) + 20$



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3. Types of Heat Transfer

- Conduction
- Convection
- Radiation

$$\dot{q}_{x-net} = \left[\dot{q}''\left(x+\frac{dx}{2}\right) - \dot{q}''\left(x-\frac{dx}{2}\right)\right]dydz$$

- Equation of Heat Conduction

$$= \left\{\left[\left(k_1 + \frac{\partial k_1}{\partial x}\frac{dx}{2}\right)\left(\frac{\partial T}{\partial x} + \frac{\partial^2 T}{\partial x^2}\frac{dx}{2}\right)\right] - \left[\left(k_1 + \frac{\partial k_1}{\partial x}\frac{dx}{2}\right)\left(\frac{\partial T}{\partial x} - \frac{\partial^2 T}{\partial x^2}\frac{dx}{2}\right)\right]\right\}dydz$$

3.1 Heat flux calculation from a flame

- It is important to predict the radiative heat flux from a flame in determining the hazard of ignition and fire spread.
- Flames are idealized as simple geometric forms like plane layers or axisymmetric cylinders and cones in most calculations.

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4 Case Study

4.1 Design of RC beam according to Eurocode standards

- The beam cross-section dimensions are 16/30 cm with a span of 3 m.
- Permanent load $g = 8\ \text{kN/m'}$ and Imposed load $q = 10\ \text{kN/m'}$.
- 3 reinforcement bars Ø12

4.2 Transient thermal analysis

- ANSYS Workbench
- Material thermal properties are taken according to Eurocode 2 part 1-2 and Eurocode 3 part 1-2.

5 Results

Standard fire curve ISO 834

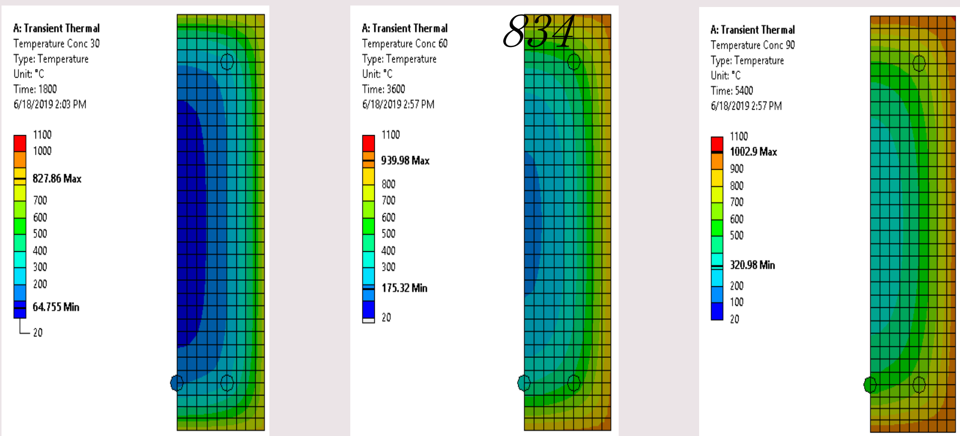

Figure 1 – Temperature in the beam with a concrete cover of 2.2 cm at 30 min (left), 60 min (middle) and at 90 min (right) for Standard fire exposure

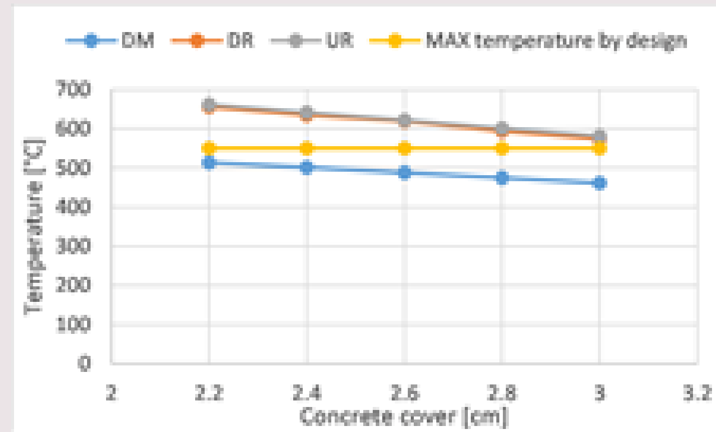

Figure 2 – Maximum temperature in the reinforcement bars after 90 min Standard fire exposure and fire resistance in relation to concrete cover thickness

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6 Discussion And Conclusion

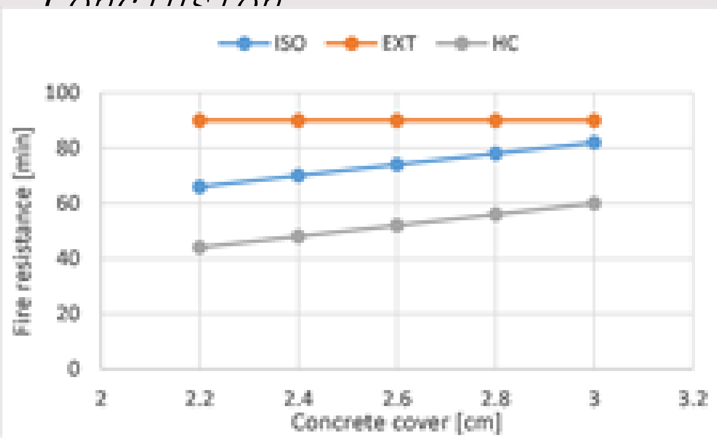

Figure 3 – Fire resistance in relation to concrete cover for various types of fire exposure

- *The failure criteria is when the temperature of the reinforcement reaches 550°C.*
- *In case of external fire curve, 2.2 cm concrete cover would be sufficient.*
- *The beam fire resistance would be below 90 and 60 minutes for ISO 834 and hydrocarbon fire, respectively*

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Thank you
for your attention

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