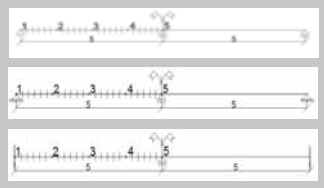
Fire resistance of Reinforced Concrete beams

M.Sc. Elena Trimcheska
Prof. Ph.D. Meri Cvetkovska

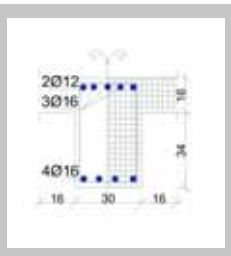
Parameters influencing the fire resistance of RC beams

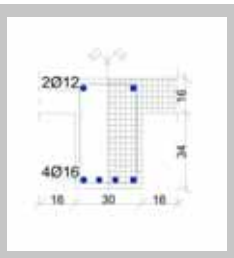
- Support conditions;
- Fire scenario;
- Thickness of the protective concrete layer;
- Dimensions of the cross section;
- Type of aggregate;
- Intensity of initial load.

- Case study 1
- Case study 2
- Case study 3



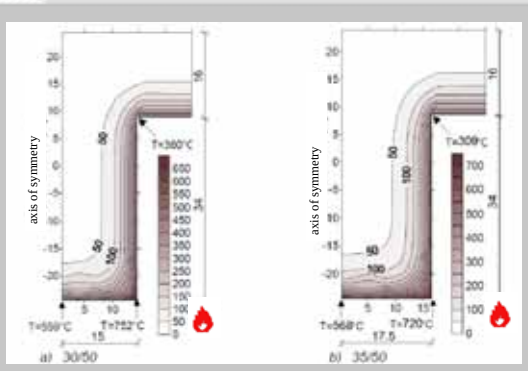
Beam and cross section geometry





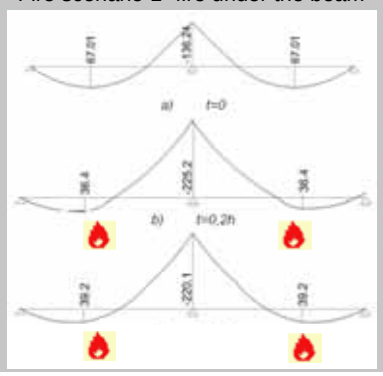
g=40kN/m'
a=2cm
f_c=30MPa
f_{cz}=3Mpa
f_y=400Mpa

Isotherms in the cross section of the beams after 0.5 h fire expose



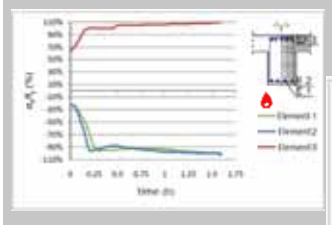
Case study 1
Time redistribution of bending moments

Fire scenario 1- fire under the beam

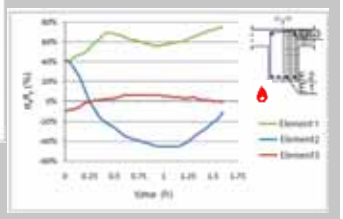


Case study 1

Fire scenario 1- fire under the beam



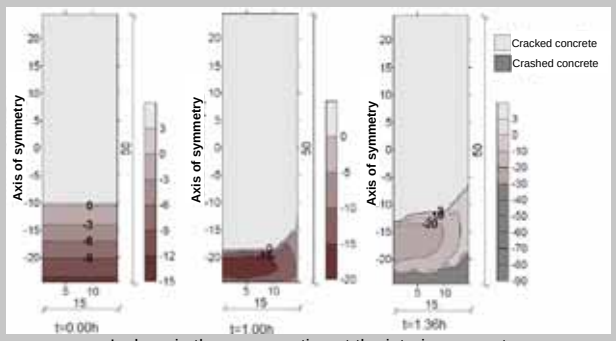
Time redistribution of the stresses in reinforcement at the interior support



Time redistribution of the stresses in reinforcement at the middle of the span

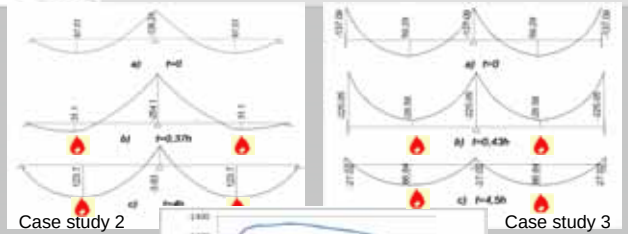
Case study 1
Stresses in concrete

Fire scenario 1- fire under the beam



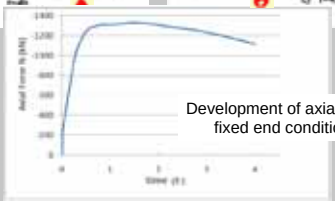
Isobars in the cross section at the interior support

Case studies 2 and 3
Time redistribution of bending moments



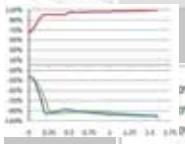
Case study 2

Case study 3

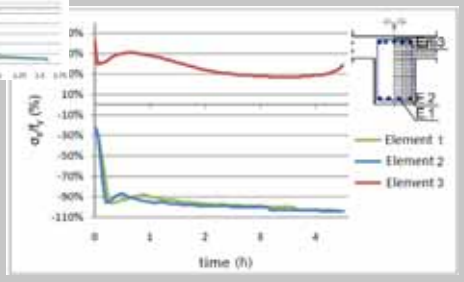


Development of axial force as e result of fixed end conditions of the beam

Case studies 2&3
Stresses in reinforcement

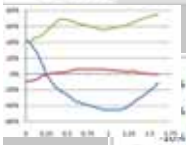


Fire scenario 1- fire under the beam

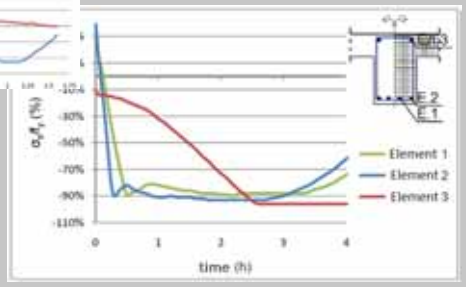


Time redistribution of stresses in reinforcement
for the cross section at the interior support

Case studies 2&3
Stresses in reinforcement



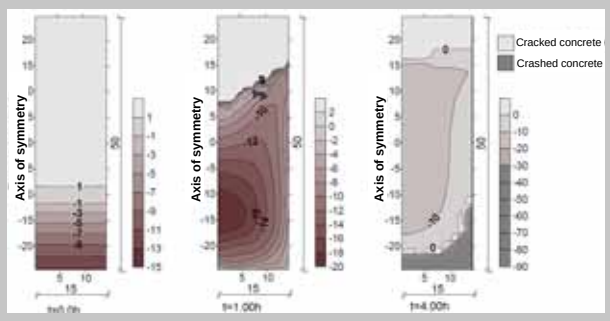
Fire scenario 1- fire under the beam



Time redistribution of stresses in reinforcement
for the cross section at the middle of the span

Case studies 2&3
Stresses in concrete

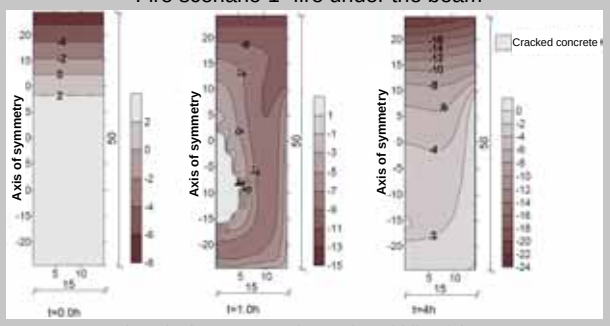
Fire scenario 1- fire under the beam



Isobars in the cross section at the interior support

Case studies 2&3
Stresses in concrete

Fire scenario 1- fire under the beam



Isobars in the cross section at the middle of the span

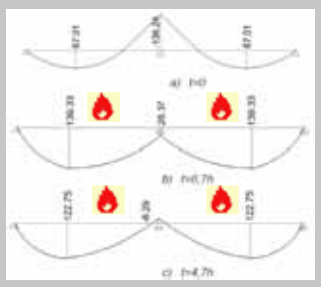
Comparison of case studies

Fire scenario 1- fire under the beam

	Deflection (cm)	Fire resistance
Case study 1	6,05	1h 36min
Case study 2	2,02	5h 05min
Case study 3	2,88	4h 30min

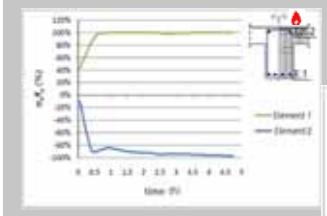
Case study 1
Time redistribution of bending moments

Fire scenario 2- fire over the beam

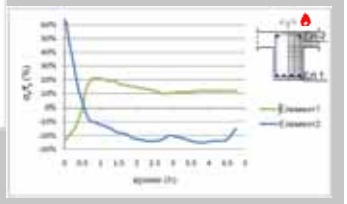


Case study 1
Stresses in reinforcement

Fire scenario 2- fire over the beam



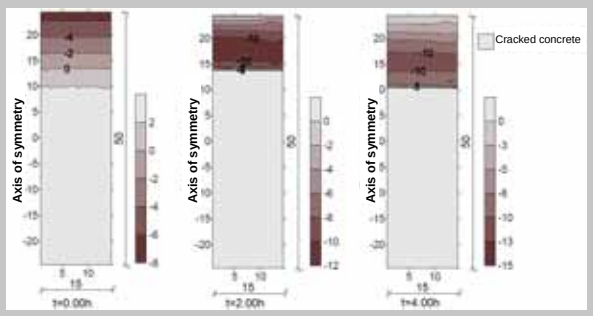
Time redistribution of stresses in reinforcement at the middle of the span



Time redistribution of stresses in reinforcement at the interior support

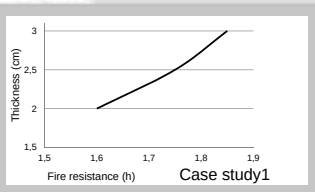
Case study 1
Stresses in concrete

Fire scenario 2- fire over the beam

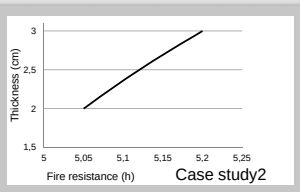


Isobars in the cross section at the middle of the span

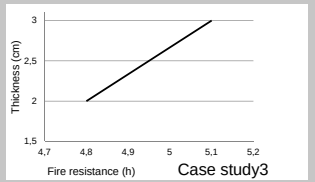
Thickness of the protective concrete layer and Dimensions of the cross section



Case study1



Case study2



Case study3

	Fire resistance [h]		First plastic hinge [h]	
	30/50	35/50	30/50	35/50
Case study 1	1:36	1:58	0:12	0:15
Case study 2	5:15	5:48	0:15	0:21
Case study 3	4:30	5:15	0:15	0:18

Fire resistance for different types of aggregate

	Agregat	Deflection [cm]	First plastic hinge	Fire resistence [h]
Case study 1	siliceous	6,05	0:06	1:36
	carbonate	6,033	0:15	1:39
	light weight	6,019	0:12	1:39
Case study 2	siliceous	2,02	0:15	5:05
	carbonate	2,567	0:21	5:24
	light weight	4,846	0:15	5:18
Case study 3	siliceous	2,884	0:15	4:30
	carbonate	3,87	0:18	4:51
	light weight	7,6	0:15	4:48

Conclusions

- Intensity of the initial load, support conditions, dimensions of the cross section, fire scenario and the type of aggregate significantly influence the fire resistance of reinforced concrete beams.
- For higher values of the initial load the initial stresses in the reinforcement have higher values too, respectively higher level of utilization of the cross section is achieved at ambient temperature and this results with lower value for the fire resistance of the beam.
- If the initial load is changed, but the support conditions are the same, the behavior of the element and the mechanism of failure are not changed.

Conclusions

- The moment redistribution, caused by the non-uniform temperature field in the cross section of the beam exposed to fire from the bottom side, results in increase of negative moment at the supports and decrease of positive moment at the mid-span and this effect is positive for the fire resistance of the beam.
- The support conditions are significant factors that influence the fire resistance of the RC beams. The fire induced axial force in case of restrained axial displacements acts as pre-stressing force and delays the moment when yielding of the top reinforcement will occur, so it has a positive effect on the fire resistance of the beam.