2.25 Fire design practice and research in Romania

Zaharia R., Romania

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IFER- Integrated Fire Engineering and Response

Workshop Barcelona
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WG 2: Structural Safety

Fire design practice and research in Romania

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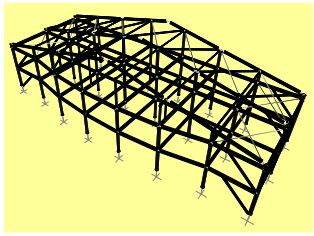
Application of Advanced Calculation Models for Fire Design

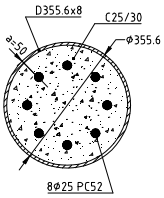
Reinforced concrete filled Circular Hollow Section columns

Office building for LINDAB-ROMANIA in Bucharest
Field of activity: systems of steel industrial buildings

OWNER DEMAND:
The resistance structure must be visible steel, made by circular columns

FIRE DEMAND FOR THE COLUMNS : R120





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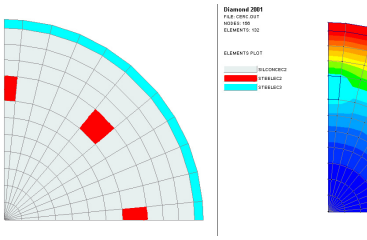
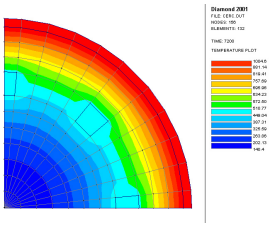
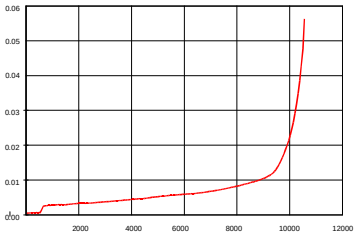




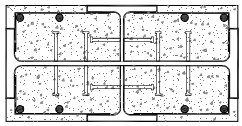


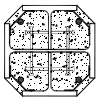
Time - Displacement characteristic
Collapse after 2h56'

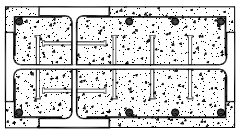
3

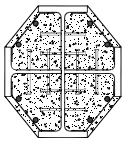
Partially concrete encased columns with crossed I section

Bucharest Tower Centre Building
FIRE DEMAND FOR THE COLUMNS : R150









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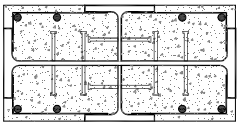
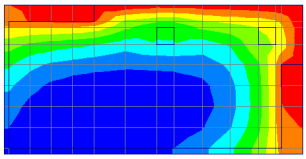
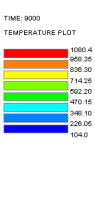
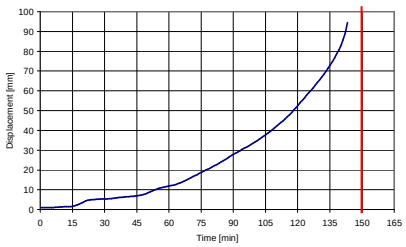
Fire Resistance HEB 1000 HEB 500









Fire Resistance

Ground Floor: 143 min
Over 1st Floor: > 150 min

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Fire Resistance Summary in Minutes

Column	Ground floor	Floors I - X	Over floor XI
2HEB500 Octogonal section with identical profiles	70	100-149	>150
HEM800HEM700 Octogonal section with different profiles	146	>150	>150
HEB1000HEB500 Double symmetrical rectangular section	143	>150	>150
HEB1000HEM500 Mono-symmetrical rectangular section	>150	>150	>150

Fire protection is needed for all the columns on the ground floor, excepting for the columns with rectangular cross-section with one axis of symmetry, while the 2HEB500 columns need protection up to the 11th floor.

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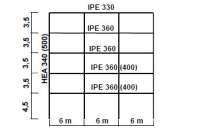
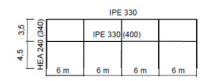
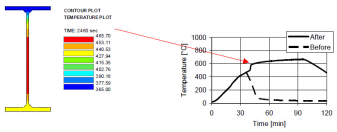
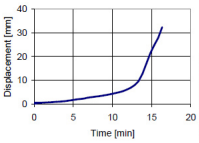
Fire after earthquake



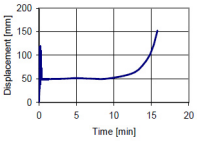
Fire scenario	Sprinklers	Indep. water supply	Auto fire detection	Alarm fire brigade	Fire brigade	Access routes	Fire fighting devices	Smoke exhaust	Total
	δ_1	δ_2	δ_{34}	δ_5	δ_{67}	δ_8	δ_9	δ_{10}	$\Pi\delta_i$
Before	0,61	0,87	0,73	0,87	0,78	1,0	1,0	1,0	0,26
After	1,0	1,0	1,0	1,0	1,0	1,5	1,5	1,0	2,25







Undamaged structure



Damaged structure

21 % 5 % 11 %

ISO fire	Frame A		Frame B	
	Banat (elastic)	Vrancea (2.7% drift)	Banat (1.8% drift)	Vrancea (2.2% drift)
Undamaged	16' 10" global	26' 10" global	16' 30" global	26' 30" global
Damaged		20' 40" global	15' 40" global	23' 20" global
Natural fire (after earthquake)	**Frame A**		**Frame B**	
	Banat	Vrancea	Banat	Vrancea
Undamaged	74' 00" global	no collapse	56' 20" beam	71' 40" beam
Damaged		no collapse	54' 40" global	71' 20" beam

Numerical Modelling of Membrane Action of Composite Slabs in Fire Situation*

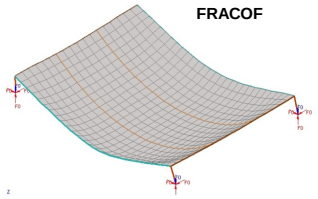
Numerical simulations, done with the SAFIR program, where performed in order to derive more simple models for representing the partially protected composite floors in fire situation.

The numerical models were calibrated using the results of full scale tests that have been performed in recent years in order to investigate various aspects of the tensile membrane action, performed by CTICM in France - FRACOF and COSSFIRE.

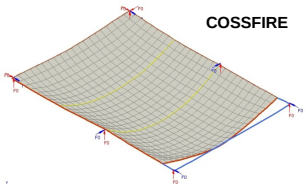
Different parametric analyses have been performed on these tests, in order to highlight the influence of some critical parameters on the behaviour and fire resistance of composite slabs, such as the amount of reinforcing steel in the slab, the thickness of the slab and the flexibility of the protected edge beams.

** Research done by PhD Student C. Vulcu (The "Politehnica" University of Timisoara) in the frame of an ERASMUS Bilateral Agreement between The "Politehnica" University of Timisoara and Liege University (Coordinators Prof. Jean Marc Franssen and Assoc. Prof. Raul Zaharia).*

FRACOF



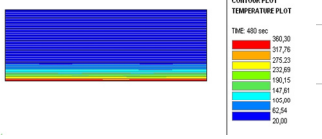
COSSFIRE



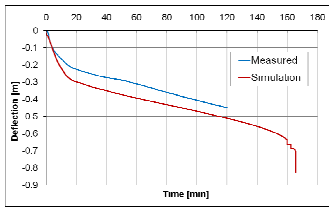
In the numerical model, the beams have been idealised using beam type elements, and the slab using shell type elements. Vertical supports have been used instead of columns.

For the thermal distribution, the section of the slab containing ribs was replaced by a section with an average thickness.

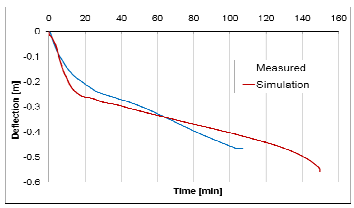
The rebars have been modelled as a layer on the slab cross-section with equivalent thickness. The temperatures calculated in the rebars of the slab, based on the equivalent thickness as recommended by Eurocode 4, were reasonably close to the temperatures observed during the test.



FRACOF



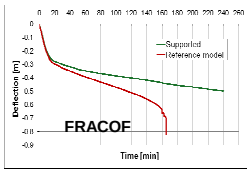
COSSFIRE

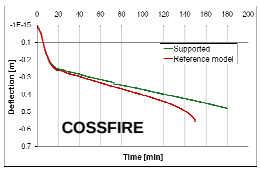


FRACOF and COSSFIRE structures (numerical models) failed due to the large deflections of the secondary edge beam.

The membrane action, characterised by the equilibrium between the compression of the concrete on the edges of the slab and the tension in the bars from the middle of the slab, was overreached, and the slabs could not support the load any longer.

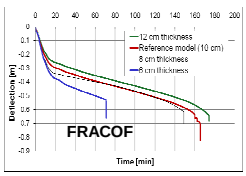
Influence of the Vertical Supports on the Edges

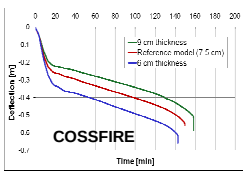




When the edges of the slabs are completely restrained vertically, the plastic hinge forming in the secondary edge beams is avoided and the fire resistance time is increased.

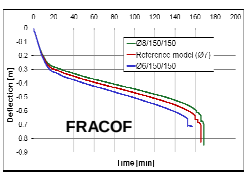
Influence of the Thickness of the slab

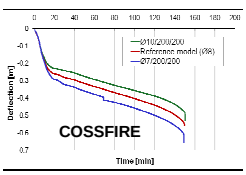




Increasing the thickness of the slab improves its behavior.

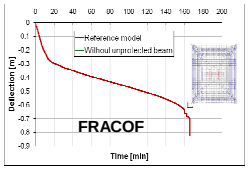
Influence of the Amount of Reinforcement

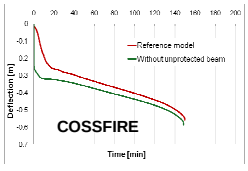




Different quantities of reinforcements were considered, with nearly unchanged results in terms of fire resistance.

Considering the Intermediate Secondary Unprotected Beams





In the absence of the intermediate secondary beams, the yield lines lead to early failure for FRACOF model. For the COSSFIRE model, the slab enters from the beginning into tensile membrane, but the failure time and the evolution of deflections are nearly the same.