Numerical Modelling of Membrane Action of Composite Slabs in Fire Situation

C. Vulcu, T. Gernay, R. Zaharia, J.M. Franssen

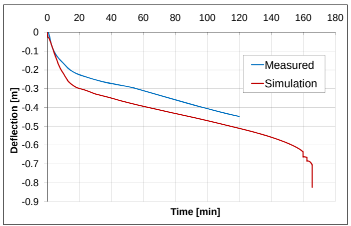
C. Vulcu, R. Zaharia, The "Politehnica" University of Timisoara, 2, Pta. Victoriei, Timisoara, Romania
T. Gernay, J. M. Franssen, Université de Liège, 1, Chemin des Chevreuils, 4000, Liège, Belgium

THE NUMERICAL MODELLING OF THE TESTS

For the thermal distribution, the section of the slab containing ribs was replaced by a section with an average thickness. In the numerical model, the beams have been idealised using beam elements (for castellated beams, the "minimum section" was used), and the slab using shell elements. The bars have been modelled as smeared layer having only uniaxial strength and stiffness.

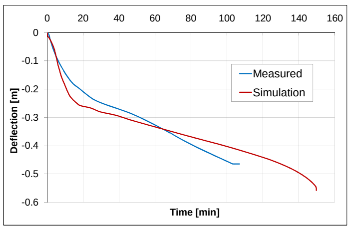
The charts show the comparison between the measured and the calculated deflections in the middle of the three considered composite slabs.

FRACOF



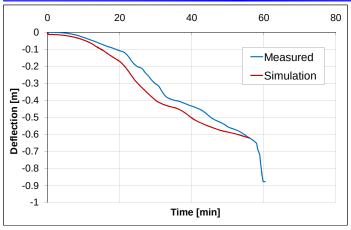
7.35 x 9.53 m²
10 cm slab
256 mm²/m
4.7 cm cover
3.87 kN/m²
ISO fire

COSSFIRE



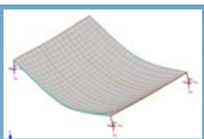
6.66 x 8.50 m²
7.5 cm slab
251 mm²/m
3.5 cm cover
3.75 kN/m²
ISO fire

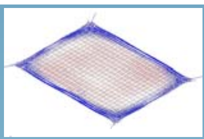
MOKRSKO

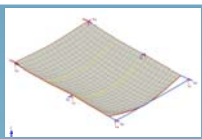


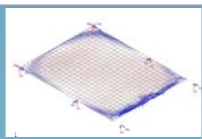
9.0 x 12.0 m²
6.0 cm slab
196 mm²/m
2.0 cm cover
3.0 kN/m²
Natural fire

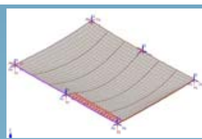
The calculated deformed shape and the membrane forces for the three composite slabs are shown below. These correspond to the failure time in the numerical simulation.

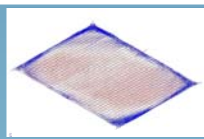












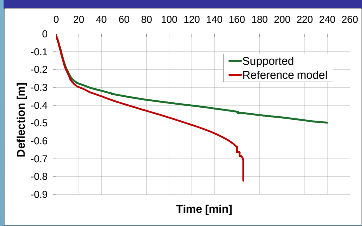
PARAMETRIC STUDY

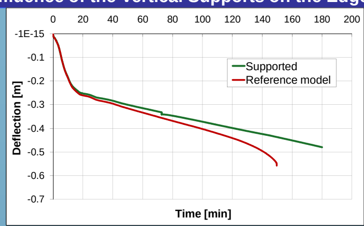
For the three tests, a sensitive analysis has been performed in order to see the influence of a number of parameters on the mechanical response of a composite slab. The investigated parameters are:

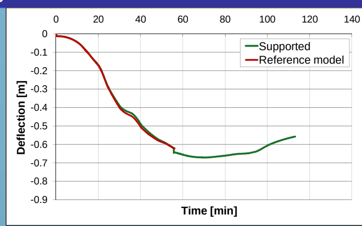
- the vertical supports on the edges;
- the thickness of the slab;
- the amount of reinforcement;
- the modeling of the unprotected beam;
- the influence of the lateral restraints of the slab.

FRACOF | **COSSFIRE** | **MOKRSKO**

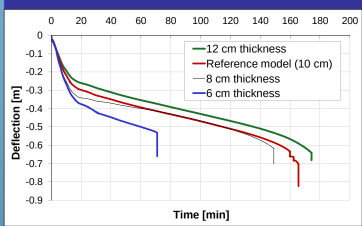
Influence of the Vertical Supports on the Edges

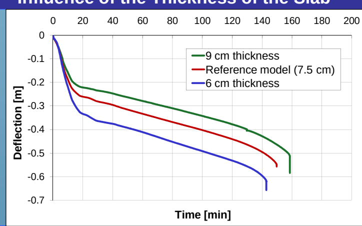


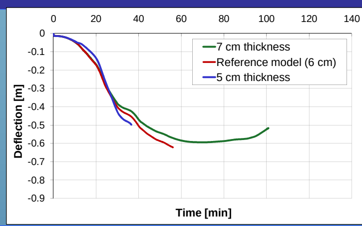




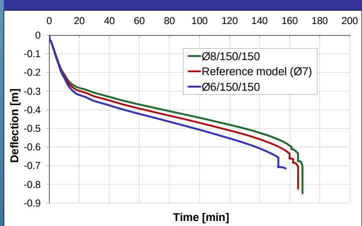
Influence of the Thickness of the Slab

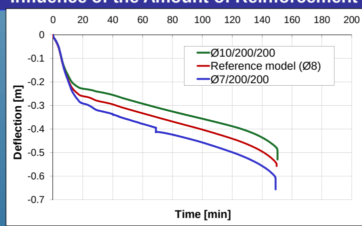


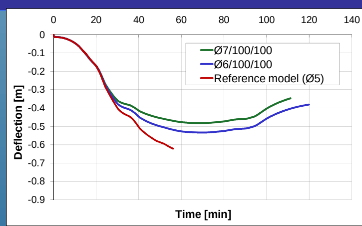




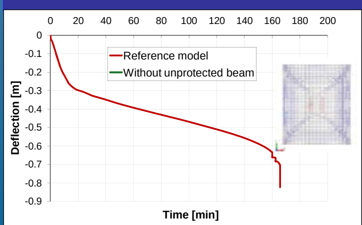
Influence of the Amount of Reinforcement

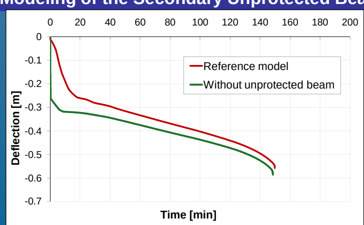


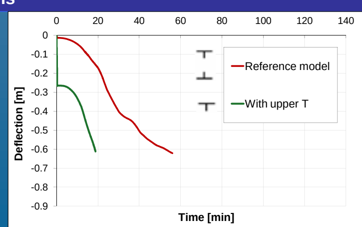




Modeling of the Secondary Unprotected Beams







CONCLUSIONS

Influence of different parameters on the behavior of the composite slabs:

• 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.

• Increasing the thickness of the slab improves it's behavior. The average thickness for the section of the slabs containing ribs, calculated according to Annex D of EC4-1-2, may be used for the thermal distribution in the numerical simulation.

• Models with different quantities of reinforcements were considered, with nearly unchanged results for the first 2 tests and a dramatic improvement in the test of Mokrsko.

• For the Mokrsko test, using the minimum section for the Angelina beams showed good correlation with the test. If the secondary beams are not modelled, the transition from the compressive membrane to the tensile membrane is "violent" for the Fracof test so that the yield lines lead to early failure. In the same situation, for the Cossfire test, the slab enters from the beginning into tensile membrane. However, the failure time and evolution of vertical deflections are nearly the same than for the reference model. For Mokrsko structure, using just the upper T for the castellated Angelina beams, large deflections are obtained at the beginning, like in the Cossfire test, but the vertical deflection curve does not converge to the same displacement and time resistance as in the reference numerical model.