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Validation models on the fire resistance of composite slab with steel deck

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Introduction

Concrete slabs with profiled steel deck are slabs that use steel deck as a permanent formwork, and reinforced concrete placed on the top. The fire rating of this type of element is determined by standard fire tests, accounting for load bearing (R), integrity (E) and insulation (I).

In this work, different composite slabs are numerically tested using the standard fire curve ISO 834 to evaluate the insulation criterion (I) and the load bearing criterion (R). Three-dimensional numerical simulations are performed using the Finite Element Method to investigate the thermal effects of standard fire exposure.

In some simulations, an air gap with constant thickness is included between the steel deck and the concrete in order to simulate debonding effects. The results are validated with experimental results published by different authors.

Methodology

The composite slab is meshed (perfect contact) to solve a nonlinear transient thermal analysis, using 3-D models. The finite element method requires the solution of equation (1) in the domain and equation (2) in the exposed side.

In these equations: T represents the temperature of each material; $\rho_{(T)}$ is the specific mass; $Cp_{(T)}$ is the specific heat; $\lambda_{(T)}$ is the thermal conductivity; α_c is the convection coefficient. T_g represents the gas temperature of the fire compartment, using a standard fire ISO 834 applied to the bottom part of the slab; ϕ is the view factor; ϵ_m is the emissivity of each material; ϵ_f specifies the emissivity of the fire and σ represents the Stefan-Boltzmann constant.

Results and Discussion

The figures illustrate the temperature development (numerical and experimental) at different points as well as the average and maximum temperatures on the unexposed surface of the slab for the validation of the thermal model.

Concerning the mechanical model, the time history for displacement and rate of displacement, and the fire resistance (R) as function of the load level are also presented.

Remarks and Conclusions

For the thermal analyses, the results obtained with the air gap model presented better agreement with experimental results and satisfactorily represent the debonding effect.

The mechanical model underestimate the fire resistance for load bearing condition.

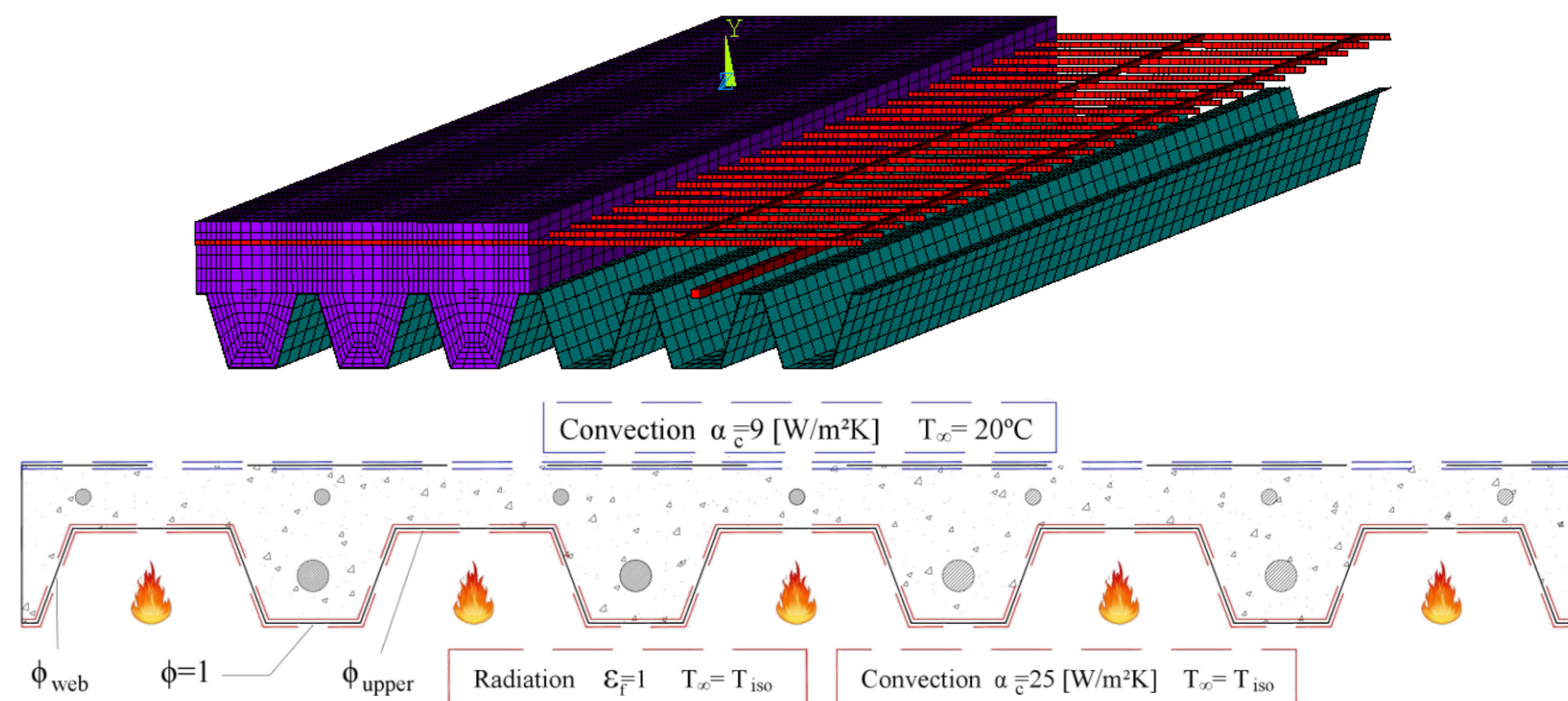
The fire resistance decreases with the load level.

Assumptions

$$\nabla(\lambda_{(T)} \cdot \nabla T) = \rho_{(T)} \cdot Cp_{(T)} \cdot \partial T / \partial t \quad (1)$$

$$\lambda_{(T)} \cdot \nabla T \cdot \vec{n} = \alpha_c \cdot (T_g - T) + \phi \cdot \epsilon_m \cdot \epsilon_f \cdot \sigma \cdot (T_g^4 - T^4) \quad (2)$$

Modelling



Results

