ROBUSTNESS OF STEEL COMPOSITE OPEN CAR PARKS UNDER LOCALISED FIRE – NUMERICAL EVALUATION OF THE EFFECT OF AXIAL RESTRAINTS

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The work presented is part of the European RFCS ROBUSTFIRE project, in which a design philosophy aiming at the economical design of car parks exhibiting a sufficient robustness under localised fire is intended to be developed and practical design guidelines for the application of this design philosophy are expected to be derived.

The presentation will mainly focus on the numerical model developed on a composite steel-concrete beam-to-column frame. The numerical model is calibrated against experimental tests that were performed at the University of Coimbra. A sub-frame extracted from an actual composite open car park building, with real cross-section dimensions (beams IPE 550, columns HEB 300, and bolts M30, cl 10.9) was tested. Seven tests were performed: five tests at 500ºC or 700ºC; one reference test at ambient temperature; and a demonstration test, for which the frame was subjected to an increase of the temperature up to the failure of the column. Realistic axial restraints to the beams coming from the unaffected part of the building were simulated.

The objective of the numerical model is to study the detailed behaviour of the composite steel-concrete joint when the frame is subjected to the loss of a column due to a localised fire. The commercial general finite element package Abaqus is used to model the sub-frame extracted from a real open car park building. In the model, the symmetry of the joint is taken into account, and the structural elements are modelled combining C3D8R solid elements and contact pairs. An initial deformation of the end-plate centre (space of 0.6 mm between the end-plate and the column flange) was measured before the experimental test and is reproduced in Abaqus. Geometrical and material nonlinearities are also taken into account. Materials for steel members and connection components are established by steel tensile coupon tests, whereas the concrete behaviour is defined according to Eurocode 2 part 1.2. A static general analysis is performed, with thermal and mechanical loadings: first, an initial hogging bending moment is applied at the joint at ambient temperature; after, the loss of the column is simulated due to a localised fire (the temperatures measured during the experimental test are applied in the numerical model); at the end, the joint sagging bending moment is increased by controlling the column vertical displacements. The axial restraints due to the unaffected part of the structure are taken into account on the development of the internal forces.

Currently, this numerical model is still being improved. The behaviour of the joint under localised fire should be discussed. The effect of different axial restraints coming from the unaffected part of the building on the combined bending moment and axial forces in the heated joint should be evaluated and discussed. Moreover, the consideration of the large dimensions of the members on the development of the catenary action should also be analysed in detail.