CERIS : Civil Engineering Research and Innovation for Sustainability

Numerical and parametric analysis of composite steel and concrete tubular columns subjected to fire

PhD student
Sérgio Roberto Oberhauser Quintanilha Braga

PhD program
Fire Safety Engineering (FCT, University of Coimbra)

Supervisor
Pedro Dias Simão (FCT, University of Coimbra)

Co-supervisors
João Paulo Rodrigues (FCT, University of Coimbra; CERIS, IST, University of Lisbon) and António Moura Correia (IPC, Polytechnic Institute of Coimbra)

Period
2019-2024

Funding
-

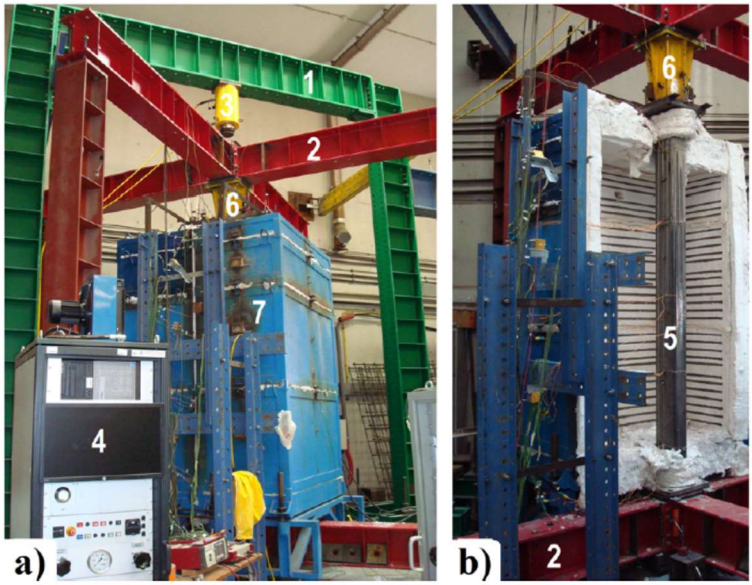
Summary

Composite columns made up by steel tubular sections filled with reinforced concrete are very competitive structural systems these days. They are economical and easy to erect, and they enable simple connections to the neighbouring frame. These composite columns take profit from the main attributes of both materials: the high compressive strength and low thermal conductivity of concrete, and the lightness and high tensile strength of steel. Given the recurrent occurrence of hazardous events that may cause a large number of casualties and/or the destruction of priceless heritage and valuable goods, the study of structural frames in fire conditions is of paramount interest these days. Within this context, the present thesis is devoted to the numerical study of restrained concrete-filled hollow steel columns in fire, by means of the Finite Element Method, for a wide range of cross sections geometries, slenderness ratios and support conditions, concrete area to steel area ratios, reinforcement areas, temperatures distributions, axial restraint and serviceability load levels, and termomechanical properties of the specimen.

To this end, a comprehensive review of the state of the art was performed at first. Presently, a thorough calibration of the numerical models against the results of previously made experimental tests is being carried out, in order to develop reliable numerical methodologies. This callibration study comprises two distinct parts: i) at first and related to the thermal problem, the heat propagation along of the structural element is analysed, and afterwards ii), based on the temperatures distributions that arise from the thermal problem, the structural behaviour of columns is deeply analysed. Based on these callibrated numerical models, in the near future we predict to perform and extensive sensitivity analysis, by varying the most relevant properties to the problem. These results shall then be compared against corresponding results available in the literature and to alternative strategies, such as the direct evaluation by means of simple structural models, and by the voxels-based Rayleigh-Ritz method. These findings will predictably be used to formulate improvement proposals for the fire resistance design procedures listed in the codes of practice.

Keywords

Columns, composite, tubular, fire resistance, experimental, numerical.



General (a) and detailed (b) view of experimental test set-up: 1 - reaction frame; 2 - restraining frame; 3 - hydraulic jack; 4 - servo hydraulic central unit; 5 - specimen; 6 – load cell device.