**Experimental tests and numerical modelling on eight slender steel columns**

**under increasing temperatures**

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When stocky steel members are submitted to compression or bending, they deform globally, which means that their longitudinal axis is bent but their sections does not change in shape. Members made of slender plates, on the contrary, distort on the whole length and may also exhibit short waves distortions. Such behavior is much more complex than the behavior of stocky sections and this is the reason why design methods for slender members are lagging behind design methods developed for other members. Eurocode 3, for example, recommends that the temperature in Class 4 sections should be designed according to a method that is a direct extrapolation of a method developed for room temperature, the extrapolation being based on reasonable but unverified hypotheses. Alternatively, the steel temperature should not exceed 350°C.

In order to fill the lack of knowledge about slender elements behavior at elevated temperatures,, a European research project called FIDESC4 has been funded by the RFCS. This project involves experimental testing, parametric numerical analyses and development of simple design rules. The present paper reports the characteristics and the results of the FIDESC4 experimental test campaign performed at the University of Liege on slender steel columns at elevated temperatures.

A total of eight columns have been tested, all of them with I shape section. Six columns were made of welded sections (some prismatic and some tapered members) and two columns were with hot rolled sections.

The nominal length of the columns was 3 meters with the whole length being heated.

The strength of the material (webs and flanges) was measured on sample before the tests. The order of magnitude of the initial geometrical imperfections was recorded.

The columns were not restrained against longitudinal thermal elongation. The supports at the ends were cylindrical thus inducing a restrain against rotation in one plane while allowing rotation in the other plane. The allowed direction of rotation was chosen in each test to induce buckling around the strong or the weak axis.

The load was applied at ambient temperature and maintained for a period of 15 minutes after which the temperature was increased under constant load. The load was applied concentrically on some tests and with an eccentricity in other tests. The load eccentricity was either applied at both ends, leading to constant bending moment distribution along the length, or at one end only, leading to a triangular bending moment distribution. Heating was applied by electrical resistances enclosed in ceramic pads. The columns and the ceramic pads were wrapped in ceramic wool insulating material. This technique was preferred to gas heating in a standard test furnace because it allows applying a slower and better controlled heating rate and thus obtaining a more uniform temperature distribution in the member. It is also easier to measured lateral displacements of the column.

Preliminary blank tests were performed on unloaded specimen in order to determine the heating range to be used later on the loaded columns. The paper will also report on a modification of the heating technique that was applied and improved significantly the uniformity in the temperature distribution.

Numerical simulations were performed before the tests using shell elements of the software SAFIR and assumed values of the material properties in order to predict the failure modes. It was essentially crucial to determine whether lateral supports at intermediate levels should be provided in order to ensure failure in the desired direction. Experience showed that the failure modes developed as predicted by the numerical simulations.

Besides a thorough description of the experiments, the paper will also present the obtained results in terms of failure mode, ultimate temperature and evolution of longitudinal and transverse displacement.

Some information will also be given about the level of detail that has to be used in the numerical model in order to get accurate results at a reasonable price.

The authors believe that this is the first time that such a series of well reported full scale tests on class 4 columns is presented. The results will be useful for improving the understanding of failure modes that combine global and local buckling, for the calibration of numerical models and for the development of simple design equations.

References:

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