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BENDING RESISTANCE OF STAINLESS STEEL BEAMS AT ELEVATED TEMPERATURES

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ABSTRACT

Structural stainless steel elements at elevated temperatures behave differently than structural carbon steels. To analyse this behaviour, a set of three-point bending tests on 150x100 RHS, Class 1 cross-section, stainless steel grade 1.4301 beams at elevated temperatures were conducted. Numerical modelling of these tests has been afterwards performed at the measured temperatures, achieving close approximation to observed experimental results.

Keywords: Bending resistance / Stainless steel / Elevated temperatures / Experimental tests

1. INTRODUCTION

Due to the increasing application of stainless-steel members in structures, considering the demanding in load carrying capacity, aesthetics and corrosion resistance, several investigations have been developed in beams and columns (Gardner and Baddoo, 2006). Regarding its fire behaviour, stainless steel offers superior strength and higher stiffness retention at elevated temperatures when compared to carbon steel. Research on stainless steel members under fire has been focusing on the development of new design formulas for beams and columns (Buchanan *et al.*, 2018) (Xing *et al.*, 2021), but still there is a lack of experimental evidence of the fire resistance of stainless steel members, in particular for beams.

2. EXPERIMENTAL BENDING TESTS

The material properties have been determined at normal temperature and at elevated temperatures (Lopes et al. 2021), using three specimens. The yield stress at room temperature is $f_{0.2\%}$ = 382 MPa, the ultimate stress is f_u = 743 MPa and the Elastic modulus is E = 203 GPa.

Temperature has been applied using the fire resistance furnace, following the standard heating curve and then keeping it constant during the incremental loading step. Thermocouples were used to measure the beam temperature at two points of the cross-sections and along the length of the beams. The load has been applied with a hydraulic jack applied at mid span, using the 3-point bending test configuration (see Fig. 1). A beam is deemed to have failed when it is no longer supporting the test load. The beams are deformed and all attained the local buckling deformed shape mode near the loading point following with high deformations near this region. The ultimate load has been determined as the first peak load. The tests continue until the maximum hydraulic load or displacement has been reached.

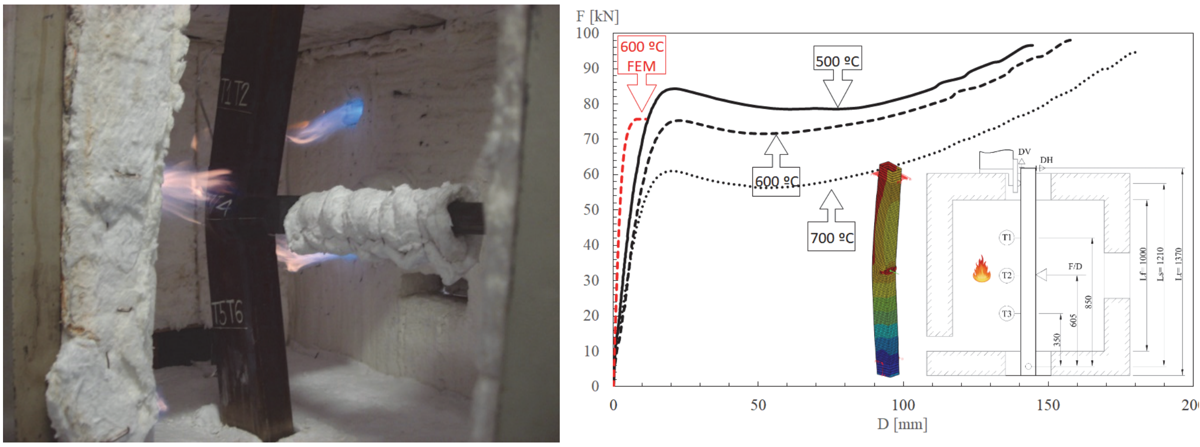

Fig. 1 – Stainless steel under bending tests.

3. NUMERICAL MODELLING

After applying the measured steel material properties at 600 ºC (Lopes et al., 2021) a numerical modelling (FEM) of the tests was performed (Fig. 1), considering geometrical imperfections, with the finite element software SAFIR (Franssen and Gernay, 2017). An acceptable approximation to the experimental results was achieved as it is shown in Fig. 1 for the beam at 600 ºC.

4. CONCLUSIONS

Similar load-displacement curves have been determined at elevated temperatures. The load bearing capacity and the stiffness decrease with temperature. From 500 ºC to 600 ºC there is a reduction of 10% in the loadbearing, while from 600 ºC to 700 ºC there is a reduction of 18%. The numerical modelling has provided close approximations to the obtained results. More experimental tests are being developed with numerical validation.

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