COST Action TU0904
Integrated Fire Engineering
and Response

STRUCTURAL BEHAVIOUR OF COLD-FORMED STEEL ELEMENTS SUBJECTED TO FIRE

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Part I – CFS Beams

❖ OBJECTIVES

- Study the effect of the instability phenomena on cold-formed steel beams under uniform fire conditions, basing on the results of a large programme of experimental tests.

- Investigate the influence of the cross-sections, the axial restraint to the thermal elongation of the beam and the rotational stiffness of the beam supports on the failure mode and on the critical temperature of this kind of beams.

- Perform a numerical study (ABAQUS) in order to carry out a parametric study outside the bounds of the original experimental tests.

- Provide experimental and numerical results for the development of simplified equations for fire design of cold-formed steel beams, so that they may be considered for a future revision of Eurocode 3, Part 1.2.

EXPERIMENTAL INVESTIGATION

Tested Beams

- 48 tests
  - 12 tests at ≈ 20 ºC
  - 36 fire tests
    - 12 tests on simply supported beams
    - 12 tests on beams with RTE
    - 12 tests on beams with ka + kr

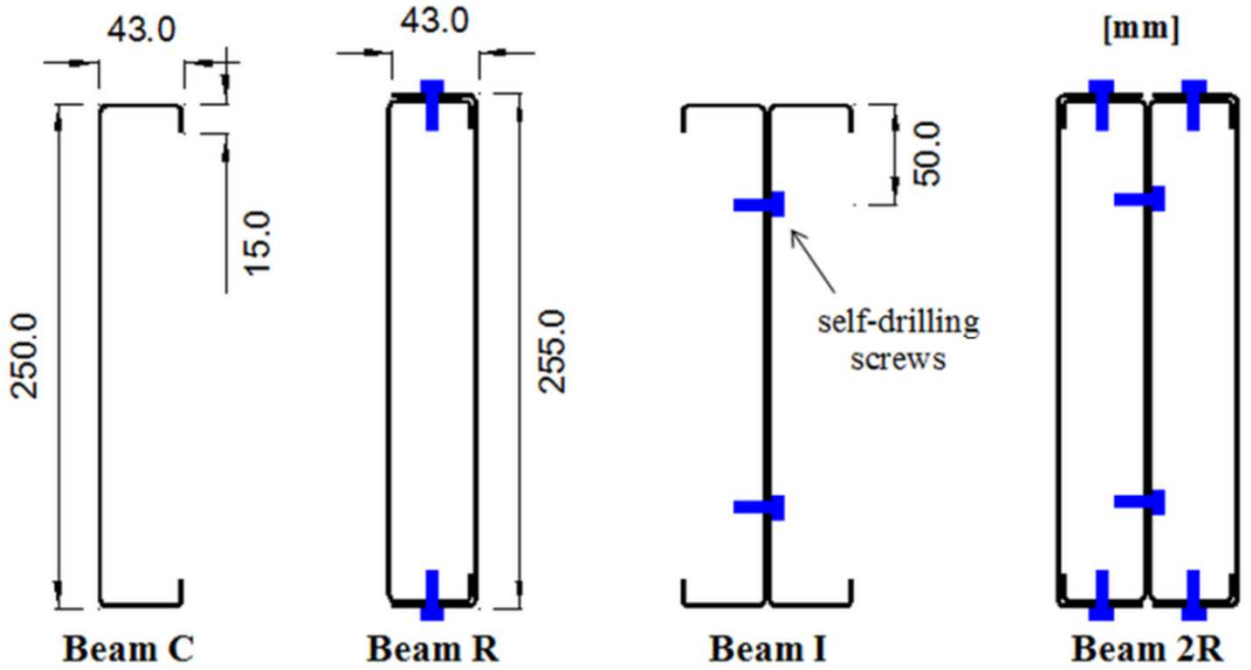
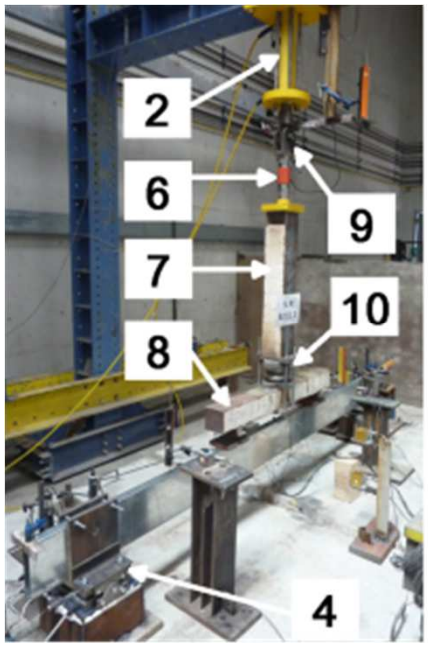
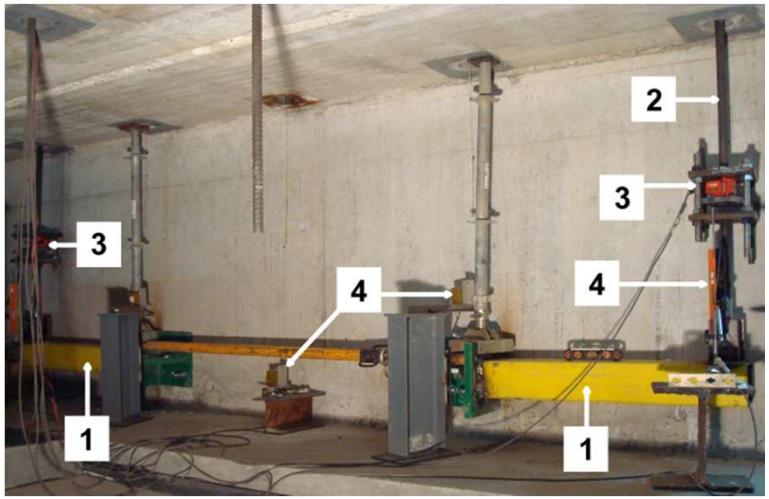


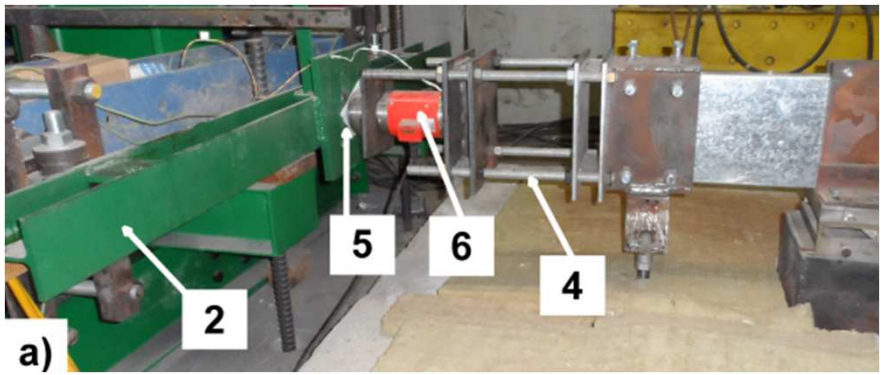
Figure 1 – Scheme of the cross-sections of the tested beams

❖ EXPERIMENTAL INVESTIGATION

↳ Test Method







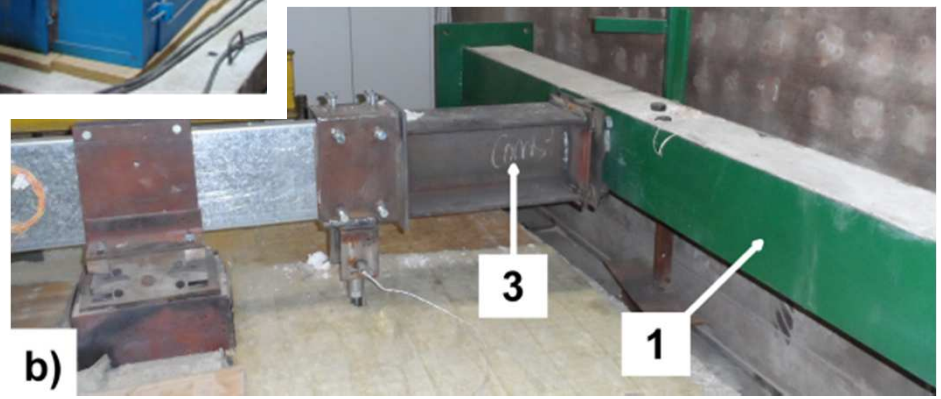
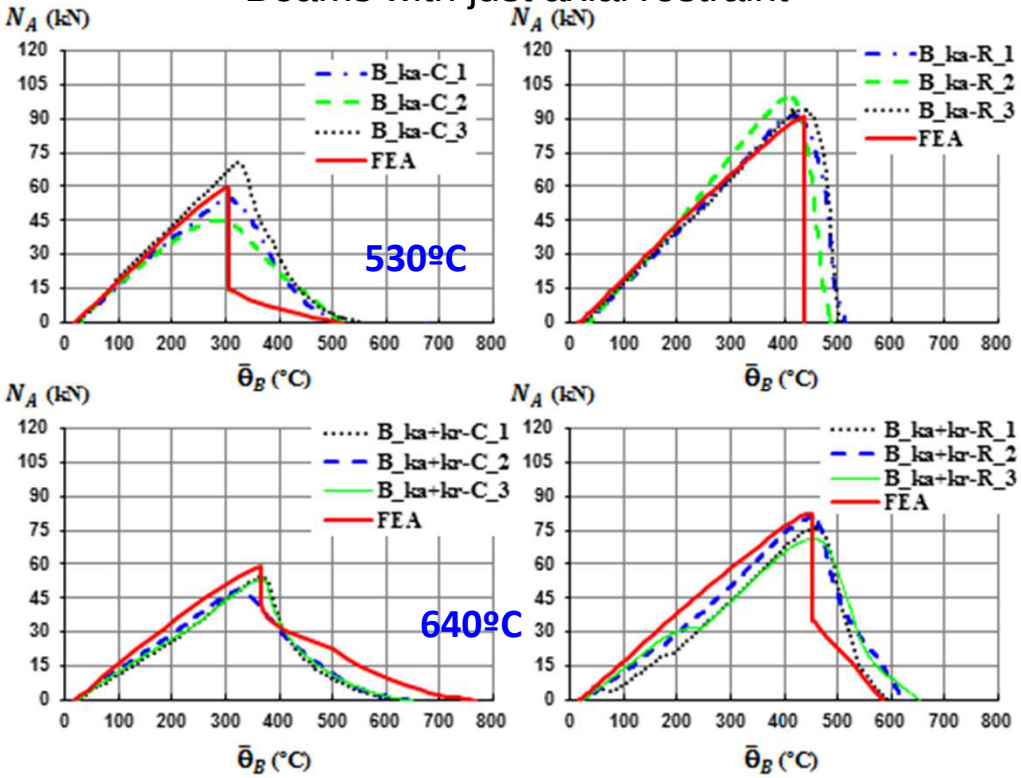


Figure 2 – Test set-up for structural fire tests of CFS beams

❖ EXPERIMENTAL INVESTIGATION

↳ Results

Beams with just axial restraint



Beams with axial and rotational restraint

Figure 3 – Comparison of the FEA and experimental results

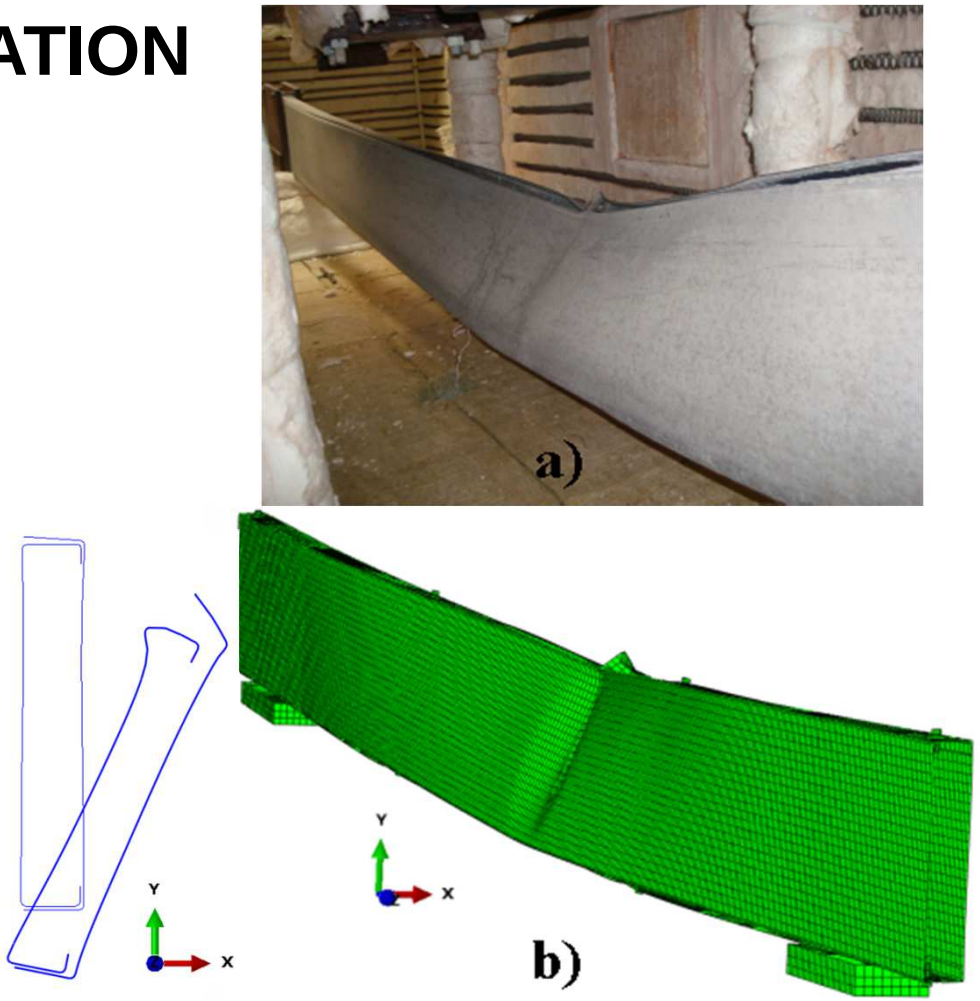


Figure 4 – Experimental (a) and numerical (b) configuration of the deformed R beam with no restraints after fire test

CONCLUSIONS

- The results of this research study showed above all that all these members had low fire resistances, as it was expected.
- However, it was observed that the closed built-up beams showed an enhanced fire resistance than the open beams in spite of the fact that, in some cases, the closed built-up beams may present critical temperatures rather lower than the open beams.
- In general the axial restraint has a bad effect on the fire resistance of beams in contrast to the rotational restraint, but it must be remembered that their effect depends strongly on the relation between the axial stiffness of the surrounding structure and the elastic axial stiffness of the beam.
- CFS beams usually have complex buckling behaviour as expected, involving local, distortional and lateral-torsional buckling, but it seems that the failure modes become more complicate in CFS beams with complex boundary conditions.

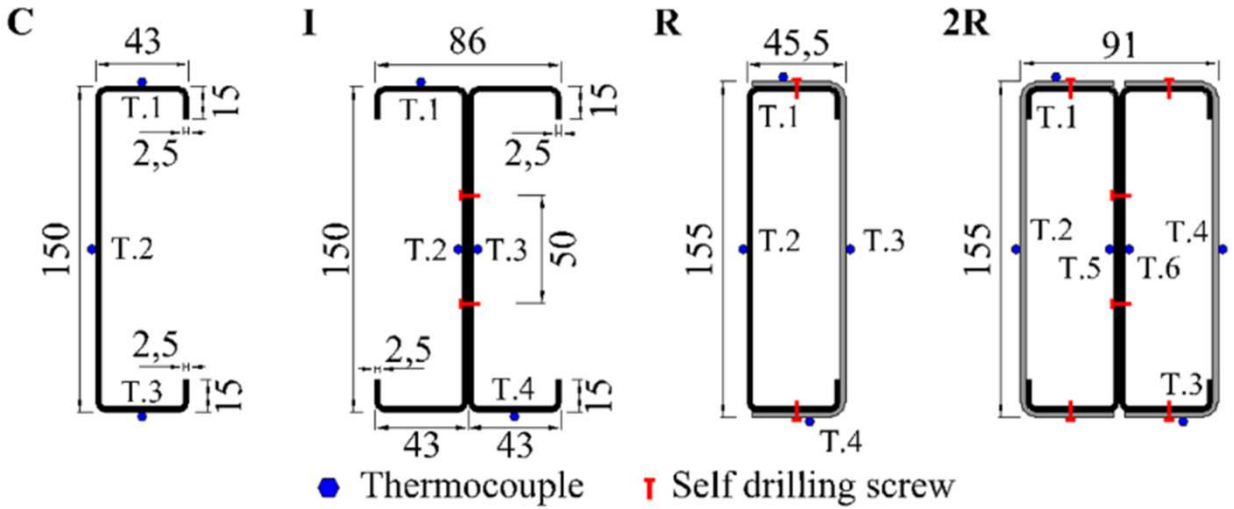
Part II – CFS Columns

❖ OBJECTIVES

- Assess the fire performance, physical behaviour and characterize failure modes of CFS slender columns with restrained thermal elongation under fire situation;
- Investigate the influence of the cross-section geometry, end-support conditions, load level, levels of axial restraint provided by the surrounding structure;
- Provide experimental data for calibration of numerical models for future parametric studies outside the bounds of the original tests.
- Provide data for the development of simplified equations for fire design of cold-formed steel columns, to be incorporated in future revisions of EN 1993-1-2:2005

❖ EXPERIMENTAL INVESTIGATION

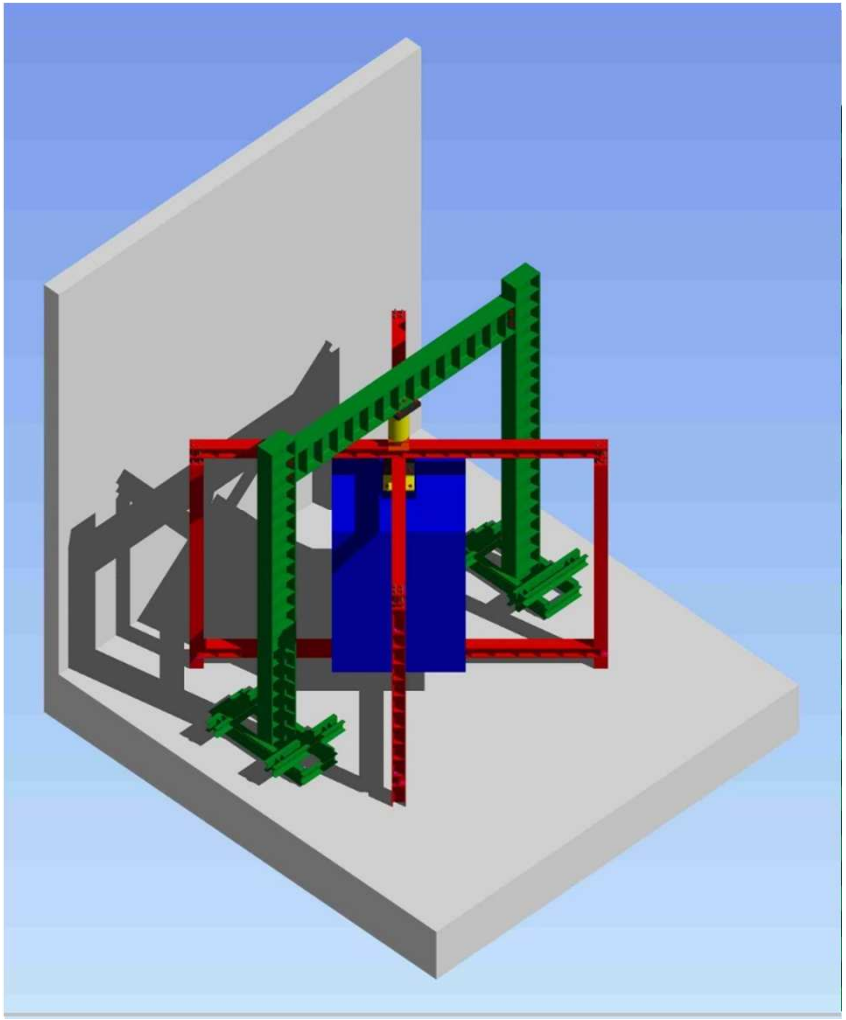
↳ Tested Columns



Cross-section	End-support condition	Load level	Rep.	Tests
C	Pin-ended and semi-rigid with 3 and 13 kN/mm of axial restraint to thermal elongation	30 and 50% of the design buckling resistance of a compression member, $N_{b,Rd}$	3	24
I [C+C]				24
R [C+U]				24
2R [2C (I) + U]				24
TOTAL				96

❖ EXPERIMENTAL INVESTIGATION

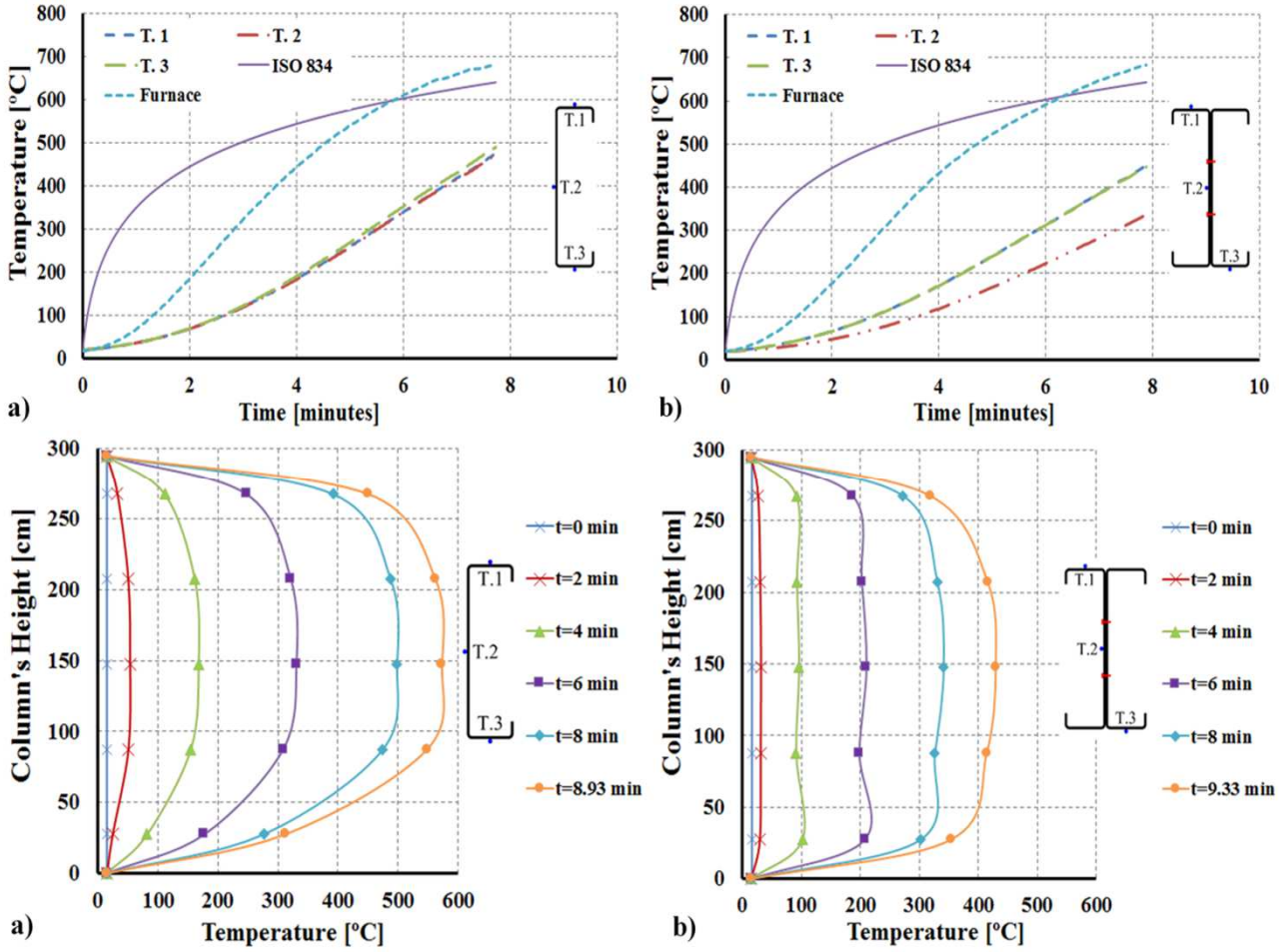
↳ Test Method



❖ EXPERIMENTAL INVESTIGATION

↳ Results

Evolution of restraining forces:



CONCLUSIONS

- Significant influence of the load level, end-support conditions and load level applied in the fire performance of CFS columns;
- For certain conditions high levels of axial restraint may significantly reduce the critical temperatures of the CFS columns;
- For the presented conditions limiting the temperature to 350 ºC as predicted in the EN 1993-1-2:2005 is too conservative for the 30% load level;
- Cross-section shape plays an important role in the fire performance of a CFS column;
- Observed complex buckling behavior, predominantly the interaction between global flexural buckling about the minor axis and distortional buckling at mid-height of the column. Local buckling in these tests was residual.
- Imperfections may affect final buckling mode without interfering with failure loads.

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Muito Obrigado

Many Thanks

Muchas Gracias

Viel Dank

Merci Beaucoup