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COUPLED STRUCTURAL-THERMAL CALCULATIONS

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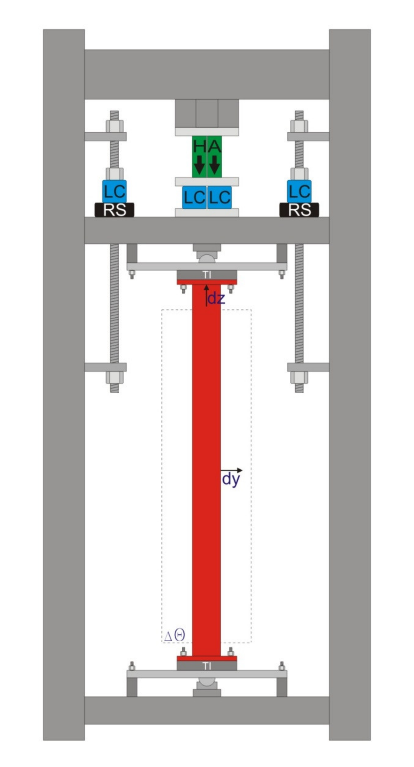

Figure 1. Experimental test setup
(Ali and O'Connor, 2001)

INTRODUCTION

The paper presents a study on numerical modeling of steel columns subjected to axial and rotational restraints and time dependent temperatures. The problem is investigated using coupled thermal – stress, nonlinear finite element simulations carried out using general purpose program LS-DYNA®. Numerical predictions of structural response during heating are compared with published experimental data. As an example of validation, the experimental test presented by (Ali and O'Connor, 2001) has been selected.

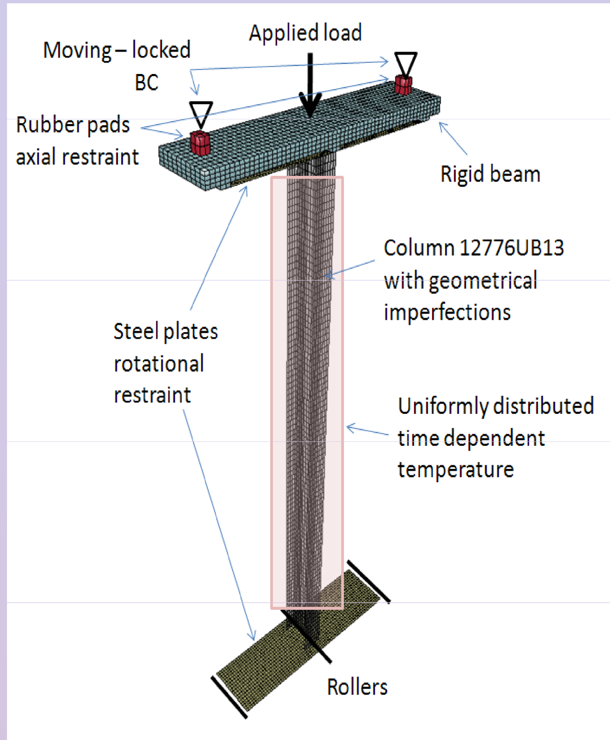

Figure 2. FE model configuration
Kwasniewski,et. al., 2010)

FE MODEL DEVELOPMENT

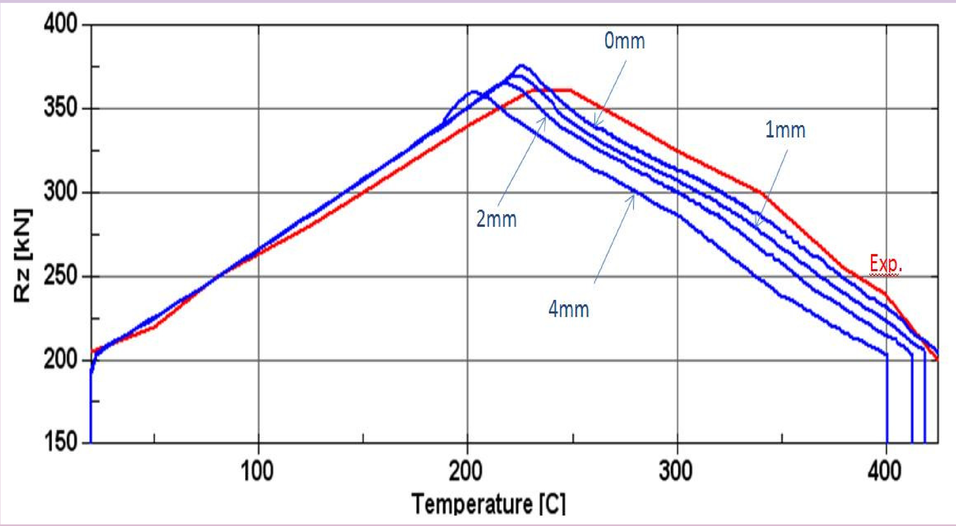

Figure 3. Axial force vs. column temperature for different magnitudes of imperfections compared to experiment.

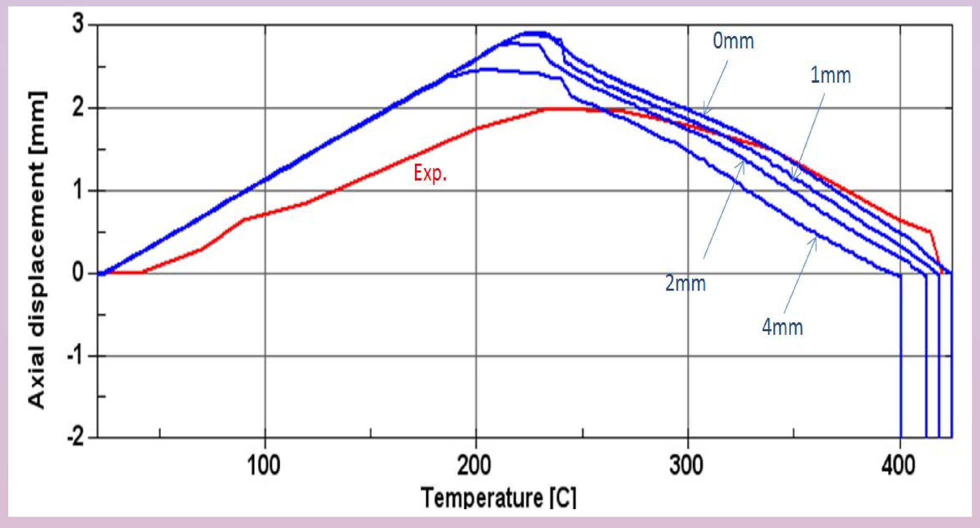

Figure 4. Axial displacement vs. column temperature for different magnitudes of imperfections.

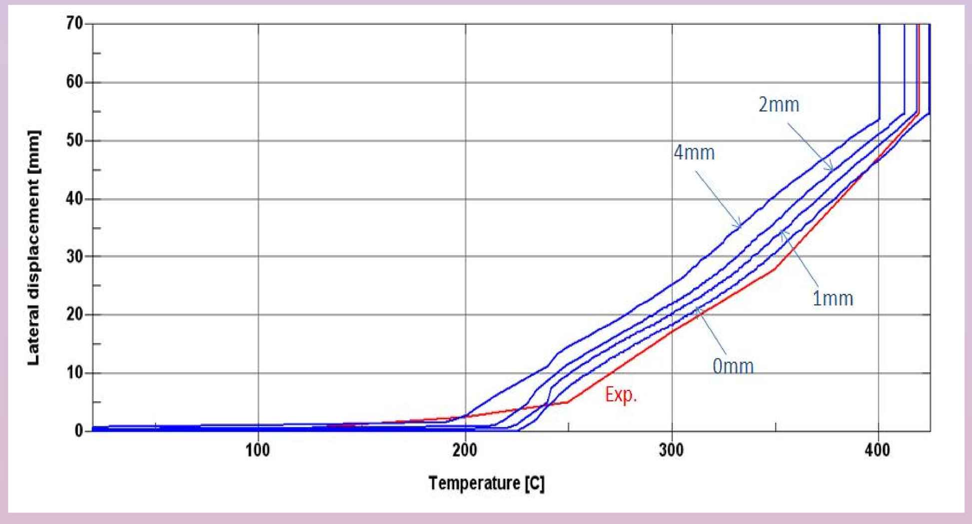

Figure 5. Lateral displacement vs. column temperature for different magnitudes of imperfections compared to experiment.

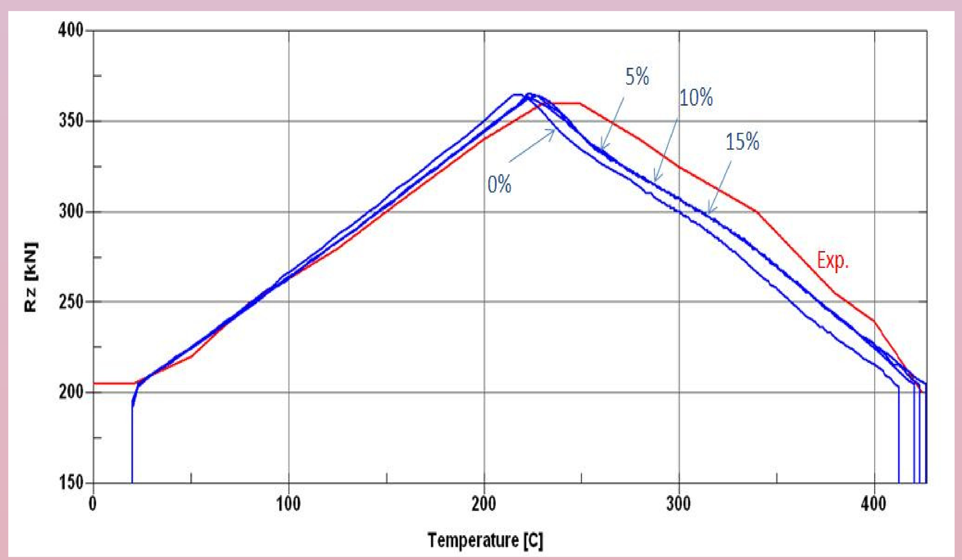

Figure 6. Axial force vs. column temperature for varied temperature distribution - results for perturbation 2 mm.

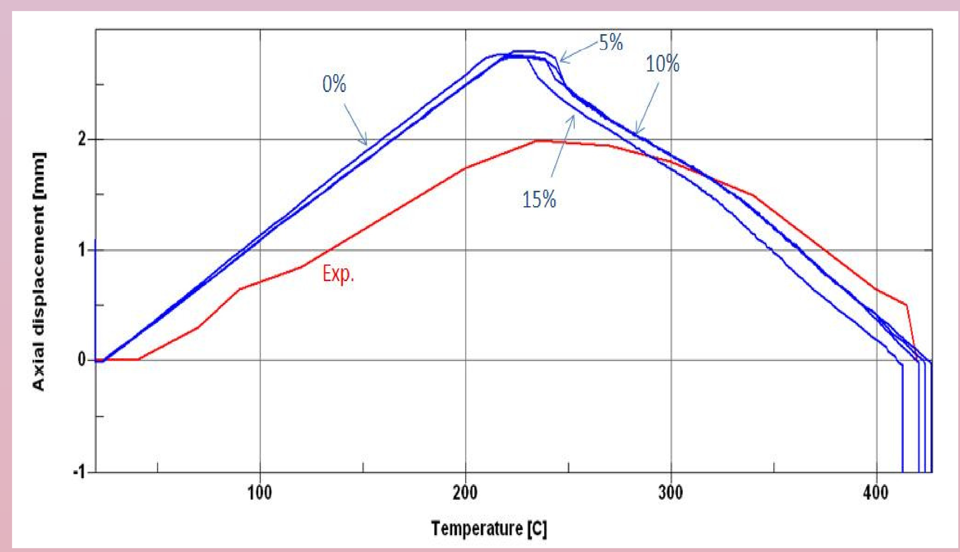

Figure 7. Axial displacement vs. column temperature for varied temperature distribution - results for perturbation 2 mm.

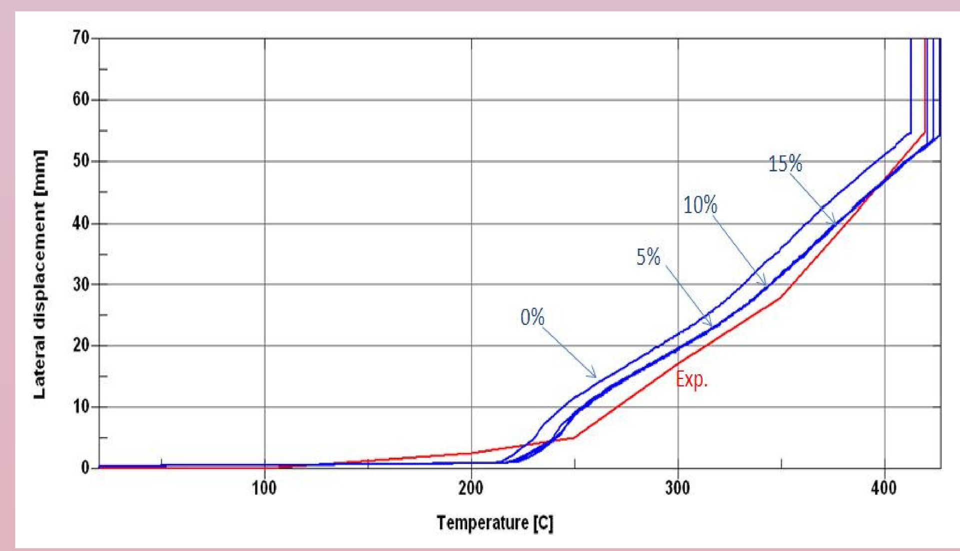

Figure 8. Lateral displacement vs. column temperature for varied temperature distribution - results for perturbation 2 mm.

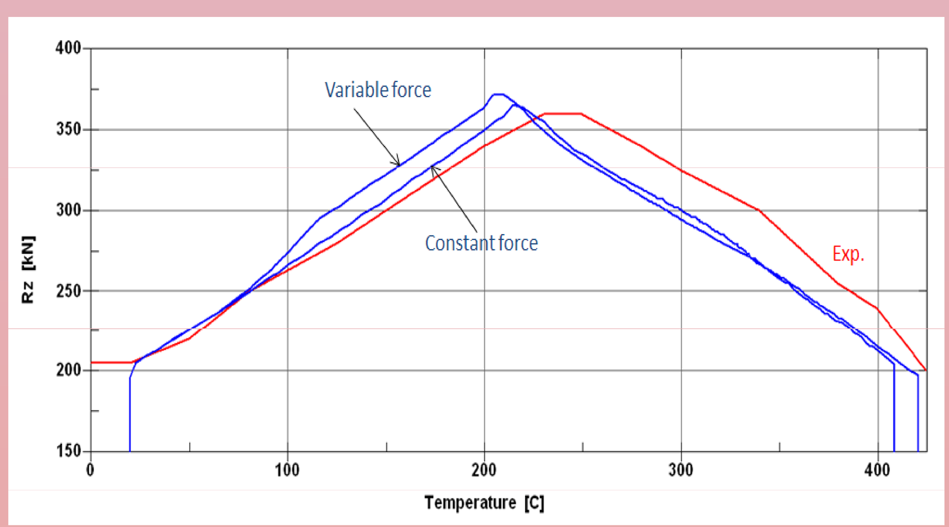

Figure 9. Axial force vs. column temperature for constant and variable applied force - results for perturbation 2 mm.

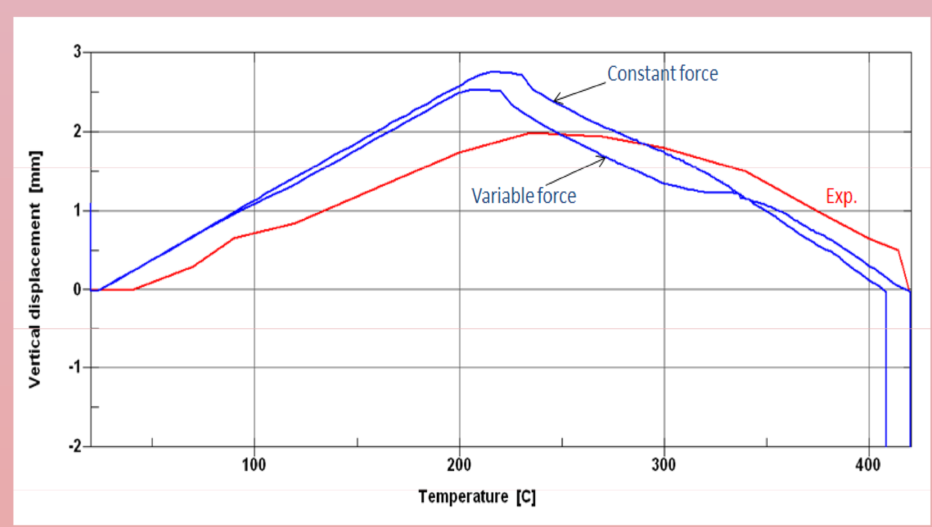

Figure 10. Axial displacement vs. column temperature for constant and variable applied force - results for perturbation 2 mm.

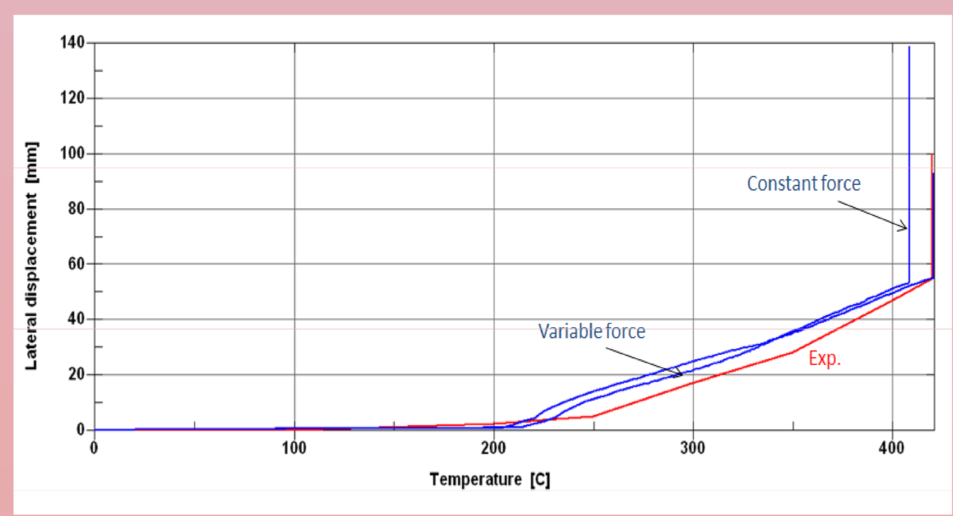

Figure 11. Lateral displacement vs. column temperature for constant and variable applied force - results for different perturbation 2 mm.

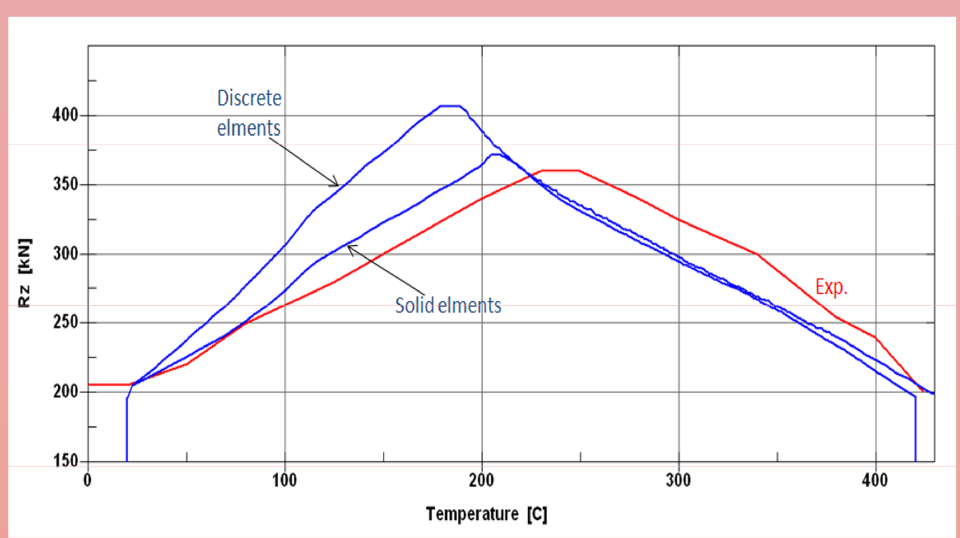

Figure 12. Axial force vs. column temperature for standard and modified constraints - results for different perturbation 2 mm..

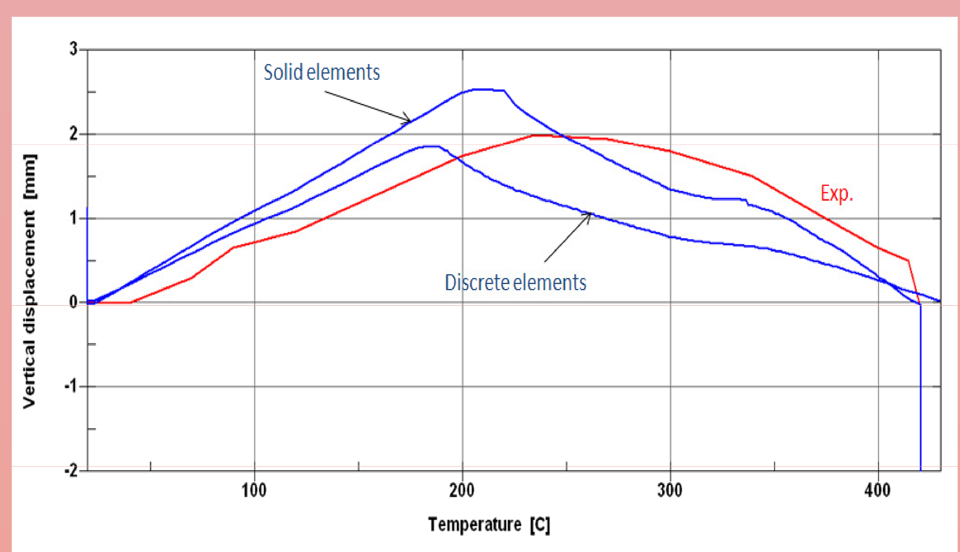

Figure 13. Axial displacement vs. column temperature for standard and modified constraints - results for perturbation 2 mm.

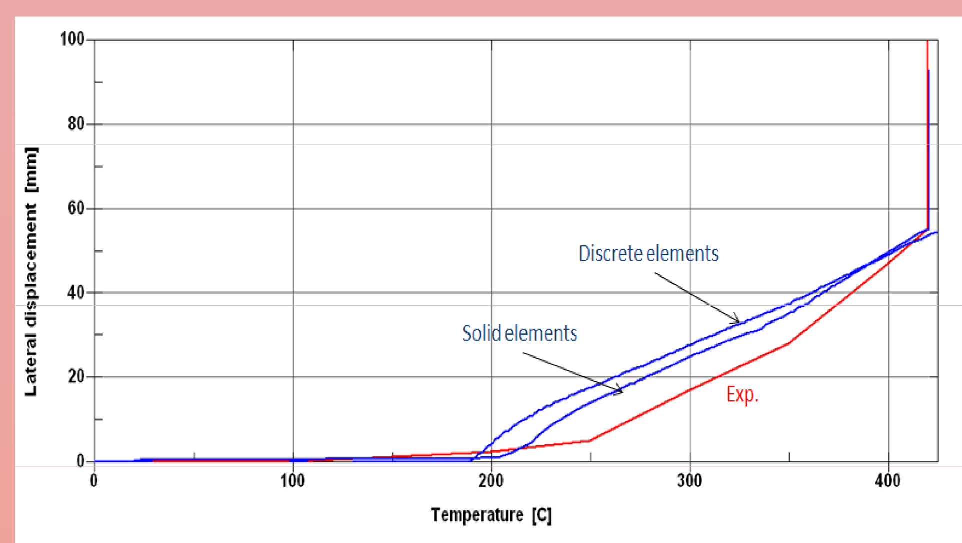

Figure 14. Lateral displacement vs. column temperature for standard and modified constraints - results for perturbation 2 mm.

SUMMARY

The study was focused on improving prediction capabilities for the purpose of virtual testing. Beyond material properties three critical modeling characteristics were determined: geometrical imperfections, longitudinal variation of the column temperature, variation of applied axial force and type of longitudinal constraints. It was found that the postponed buckling occurring at higher furnace temperatures is due to nonuniform temperature distribution along the column, caused by heat transfer at the partially insulated furnace openings. The study shows how the modeling factors affect the numerical results without attempts to calibrate the FE model. In the authors' opinion it is not possible to correlate better numerical results with the existing experimental data without reducing model uncertainties (e.g. imperfection magnitudes and loading variation) through additional experiments and measurements.

Tab. 1 Comparison of maximum generated forces

Column ref.	Loading level	Max. force generated in column [kN]	Calculated max. generated force in column
P3UB1	0	260	279
P3UB2	0.2	220	218
P3UB3	0.4	179	191
P3UB4	0.6	142	160
P3UB5	0.8	69	112

REFERENCES

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Ali, F. and O'Connor, D., Structural performance of rotationally restrained steel columns in fire, Fire Safety Journal, 2001, 36, Issue 7, pp. 679-691.
Kwasniewski, L., Krol, P.A., Lacki K., Numerical modeling of steel columns in fire, in: Proceedings of COST Action C26 International Conference: Urban Habitat Constructions Under Catastrophic Events, Naples, Italy, 16-18 September 2010.
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