COST Action TU0904, Czech Republic 18-19, April 2013

# WP4 – BENCHMARK STUDIES
# BENCHMARK STUDY OF LATERAL TORSIONAL-BUCKLING OF CLASS 4 STEEL PLATE GIRDERS UNDER FIRE CONDITIONS EXPERIMENTAL AND NUMERICAL COMPARISON

Czech Technical University in Prague
Department of Steel and Timber Structures

decivil universidade de aveiro departamento de engenharia civil

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## Summary

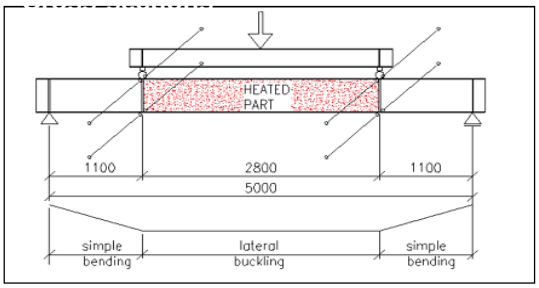
- Case study
- Mesh Convergence Study
- Results

## Case Study



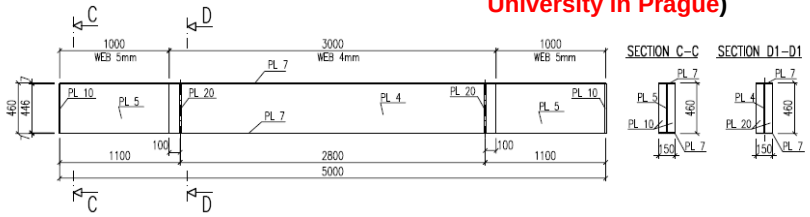
## Dimensions

**FIDESC4 - FIre DESign of Steel Members with Welded or Hot-rolled Class 4**

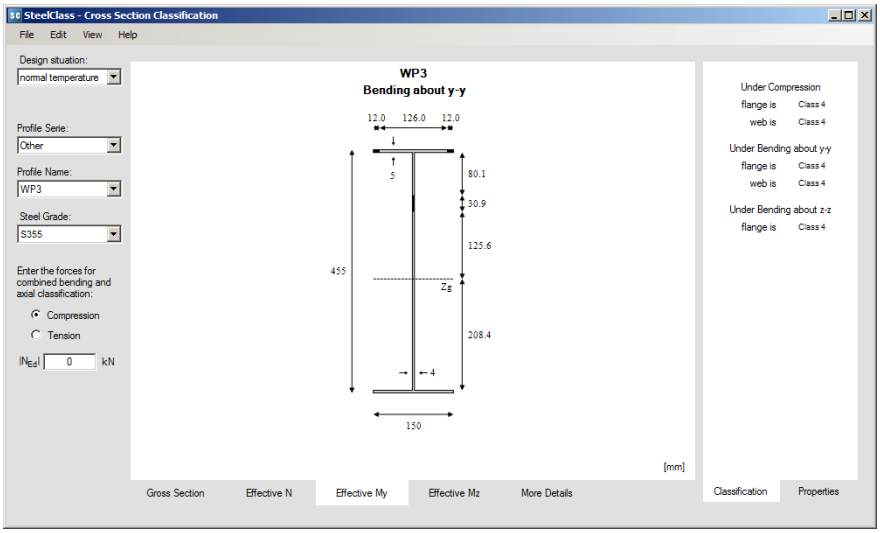



Case study taken from WP3 of project FIDESC4, a RFCS project funded by the European Comission leaded by CTICM

WP3 - Lateral buckling behaviour of fire exposed steel members with welded or hot-rolled class 4 cross sections under bending (Czech Technical University in Prague)



## Cross-sectional classification



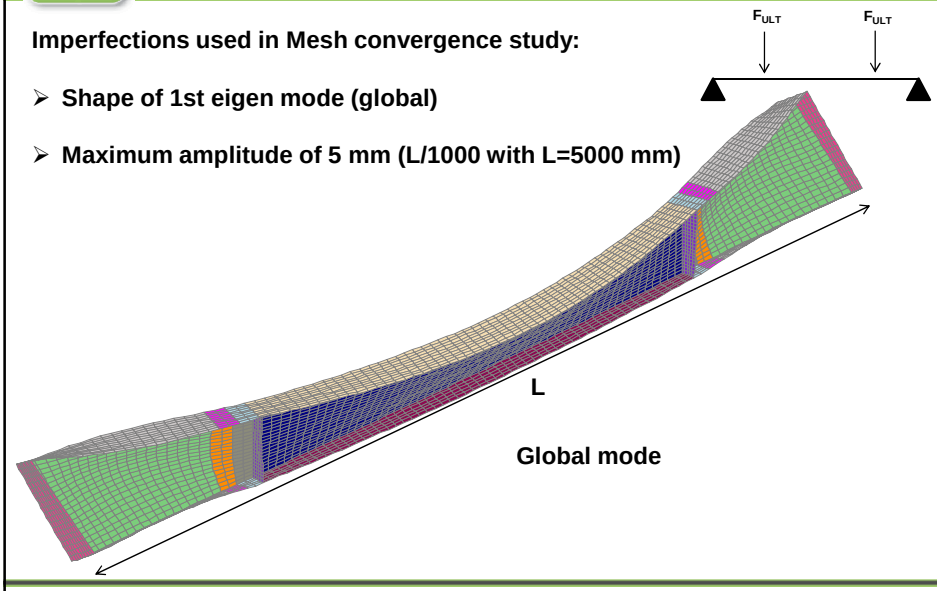



## Mesh Convergence Study

## Mesh convergence study - imperfections used

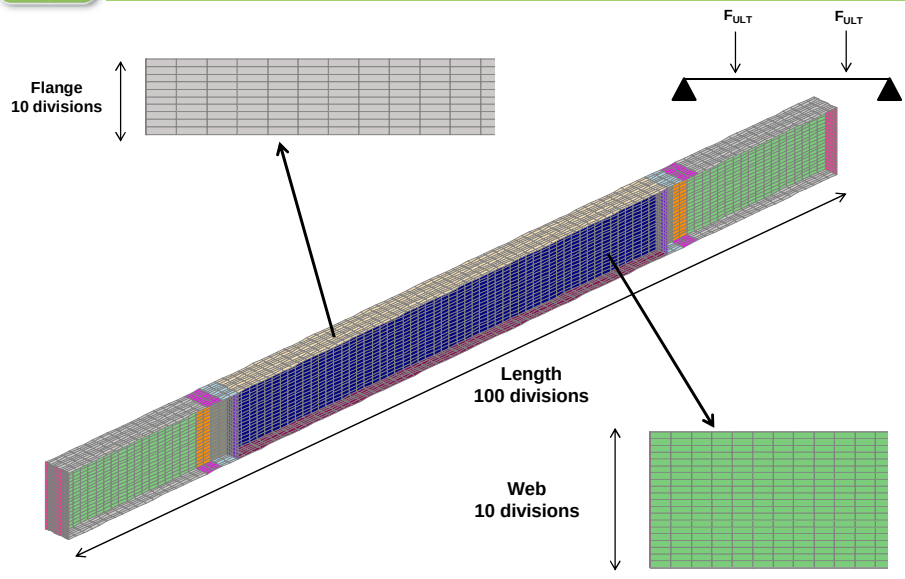
**Imperfections used in Mesh convergence study:**

- **Shape of 1st eigen mode (global)**
- **Maximum amplitude of 5 mm (L/1000 with L=5000 mm)**

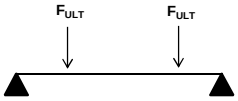




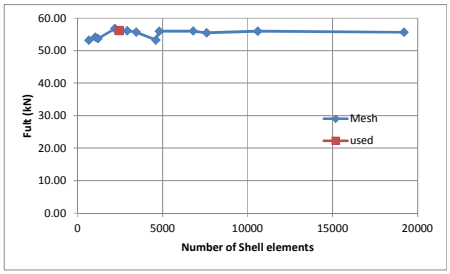

## Mesh convergence study – no. of divisions Example



## Mesh convergence study




| Number of Elements | Flange Divisions | Web Divisions | Length Divisions | $F_{ULT}$ (kN) |
|---|---|---|---|---|
| 664 | 4 | 4 | 50 | 53.19 |
| 1044 | 6 | 6 | 50 | 54.16 |
| 1192 | 6 | 8 | 50 | 53.71 |
| 2192 | 6 | 8 | 100 | 56.78 |
| 2920 | 8 | 10 | 100 | 56.11 |
| 3448 | 8 | 14 | 100 | 55.68 |
| 4600 | 20 | 20 | 50 | 53.25 |
| 4800 | 10 | 20 | 100 | 55.96 |
| 6800 | 10 | 20 | 150 | 55.99 |
| 7600 | 20 | 20 | 100 | 55.46 |
| 10600 | 20 | 20 | 150 | 55.97 |
| 19200 | 20 | 40 | 200 | 55.64 |
| | | | | |
| 2440 (used) | 6 | 10 | 100 | 56.19 |



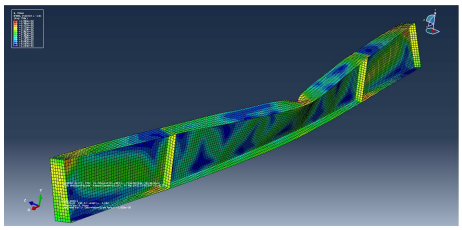



## Comparison between experimental and numerical results
## ABAQUS vs SAFIR

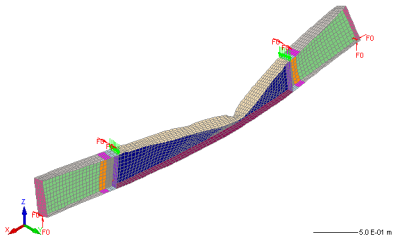
## Experimental vs numerical results

**Experimental tests at Czech Technical University in Prague**

**Czech Technical University in Prague ABAQUS**



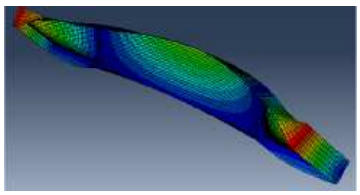
**University of Aveiro SAFIR**



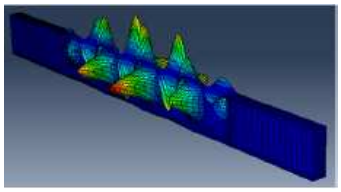


## Global and local eigenmodes Imperfection combination (EN 1993-1-5)

**Global eigenmode (G)**



**Local eigenmode (L)**



**G – global eigenmode shape with the maximum measured amplitude**
**L – local eigenmode shape with maximum measured amplitude**

EN 1993-1-5: 2006 (E)

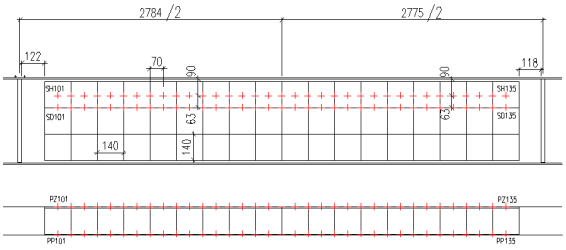
**Annex C [informative] – Finite Element Methods of analysis (FEM)**

(5) In combining imperfections a leading imperfection should be chosen and the accompanying imperfections may have their values reduced to 70%.

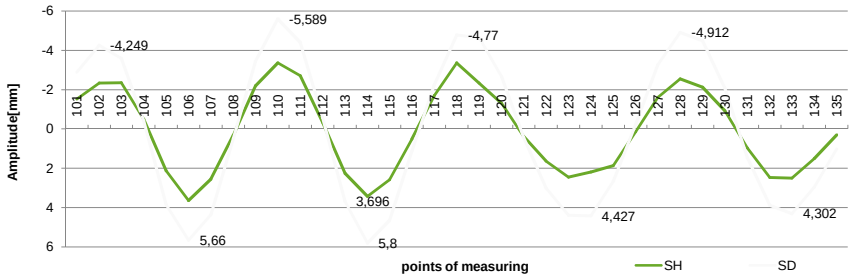
NOTE 1: Any type of imperfection should be taken as the leading imperfection and the others may be taken as the accompanying imperfections.

**According to EN 1993-1-5 ⇒ G + 0.7L or L + 0.7G**

## Measured Local imperfections Example




local imperfections of web



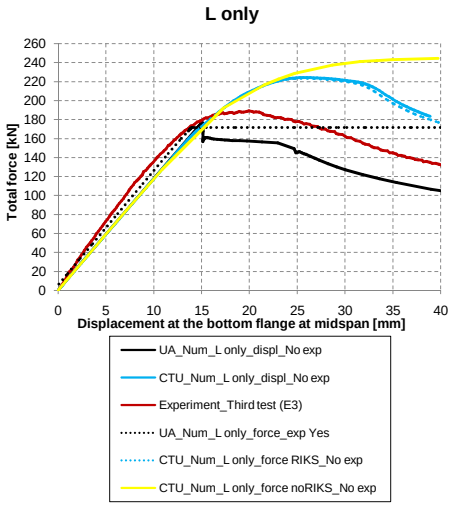


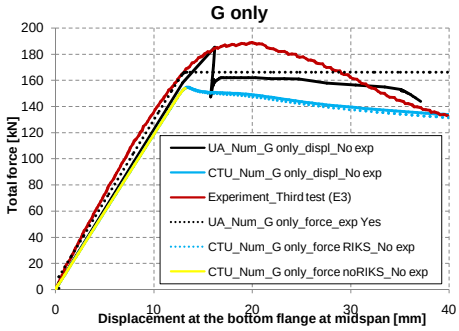

## Legend for numerical simulations

**Legend for next charts**

**G + L imp - global + local imp; the deformed shape is based on global and local eigenmode**
**G only - global imperfection only; the deformed shape is based on global buckling eigen mode**
**L only - local imperfection only; the deformed shape is based on local buckling eigen mode**
**displ - Controled by displacement**
**force - Controled by force**
**No exp - without termal expansion**
**exp Yes - include termal expansion**
**RIKS - using RIKS - ABAQUS can show decreasing part of load displacement curve**
**noRIKS - ABAQUS shows load-displacement curve to max**

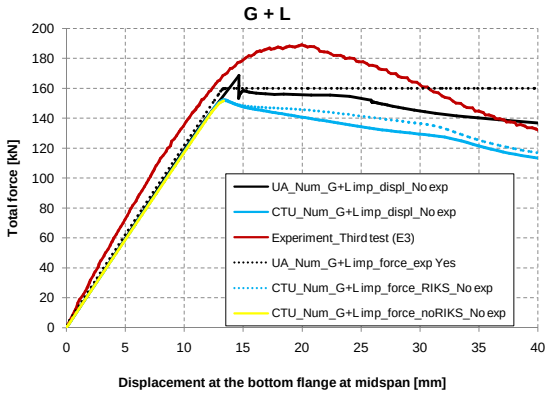
## Experimental vs Numerical simulations (ABAQUS and SAFIR)



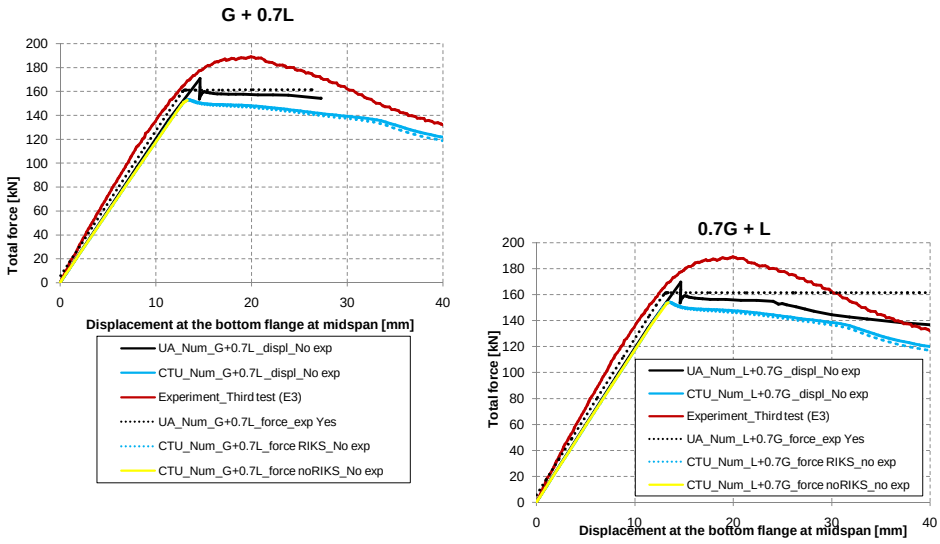






## Experimental vs Numerical simulations (ABAQUS and SAFIR)



## Experimental vs Numerical simulations (ABAQUS and SAFIR)






## Conclusions

- An overview of the benchmark study has been showed.
- Complete data information will be given in the paper version of the benchmark, including:
  - Type of finite element used;
  - Geometrical dimensions;
  - Mechanical and thermal material properties;
  - Mechanical and thermal boundary conditions;

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## Thank you for your attention!

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