cost **Integrated Fire Engineering and Response**

COST action network number TU0904 in domain Transport and Urban Development

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Software Covering Steel Frame Structural Behaviour

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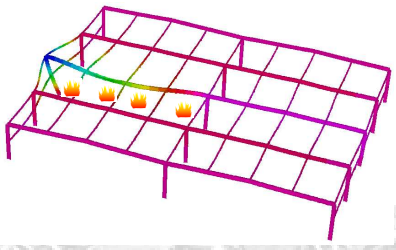
Benchmark Study: Real fire in one storey buildings

CEC Agreement 7210-PR-378 (2001)
benchmark between different softwares (ANSYS, ABAQUS, SAFIR)
to model a double frame structure partially submitted to fire.



Protection of occupants and goods

- fire spread
- smoke propagation
- active fire fighting measures
- evacuation facilities

Structural behavior of simple storey buildings
→ **relevant for the safety of the firemen.**

- brittle failure
- progressive collapse
- partial failure of façades elements outwards

may endanger the fire fighters and have to be avoided

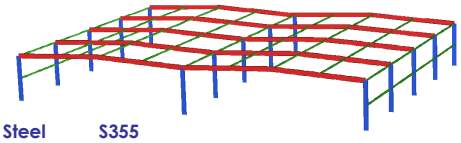
The simulation has to include membrane and restrained effects as well as the failure mode so that post-local failure stage can be analyzed.

Aim of our benchmark study

Same model with STRAND 7 / STRAUS 7 → commercial widely used software with a simplified constitutive law for steel

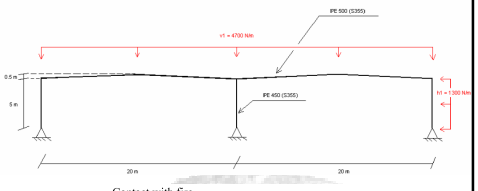
Case study overview

Complete structural model

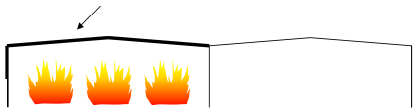


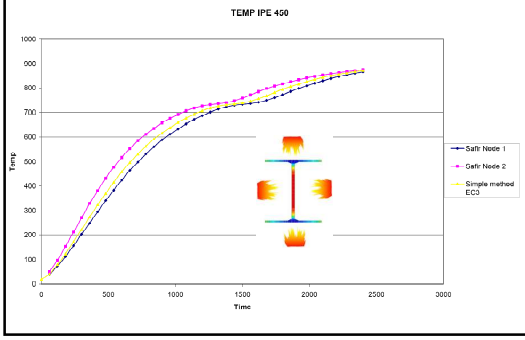
Steel S355
Frame IPE 450 (IPE 100 secondary)
Column IPE 500
Span 20 m
Column 5 m
Top Heigth 5,5 m

Double frame sub-structure



Contact with fire





Simple calculation method of EC3-1-2 (4.2.5) the temperature curves of steel

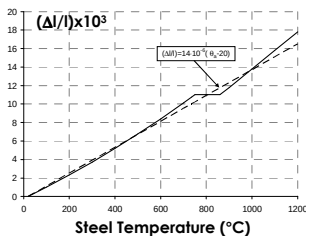
Uniform distributed temperature field on each cross section.

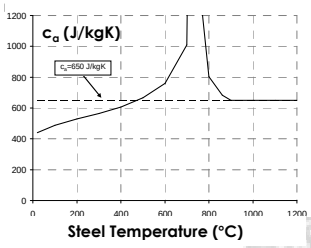
$$\Delta\theta_{a,t} = k_{sh}\frac{A_m/V}{c_a\rho_a}\dot{h}_{net}\Delta t$$

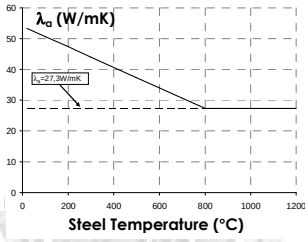
Good approximation (<10%)

Comparison between thermo-mechanical properties

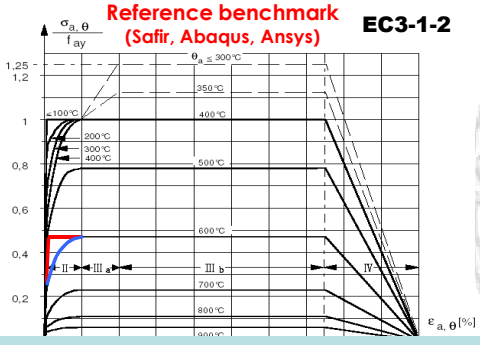
Steel thermal properties (EC3-1-2)



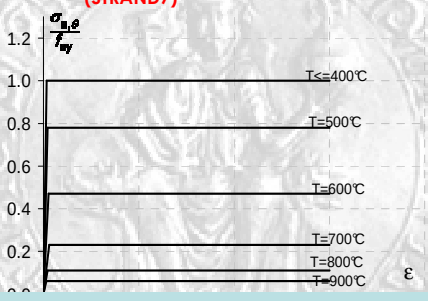




Reference benchmark (Safir, Abaqus, Ansys) — EC3-1-2



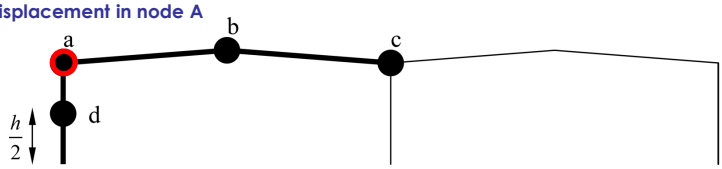
New benchmark (STRAND7) (elasto-plastic)

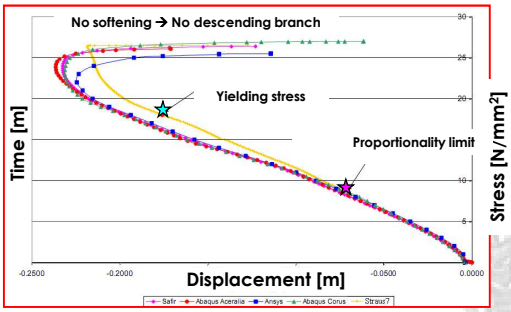


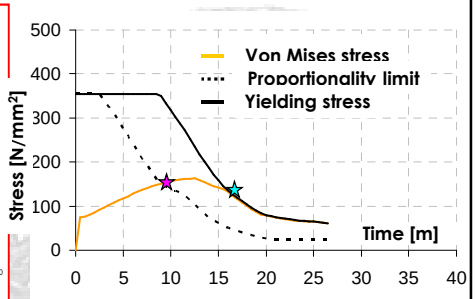
no parabolic branch & no softening

Benchmark analysis

Horizontal displacement in node A



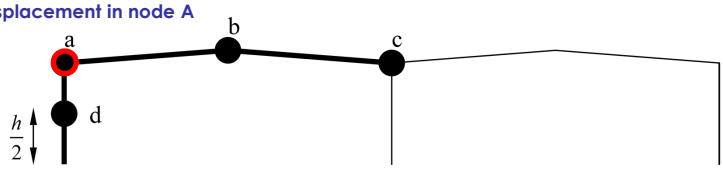


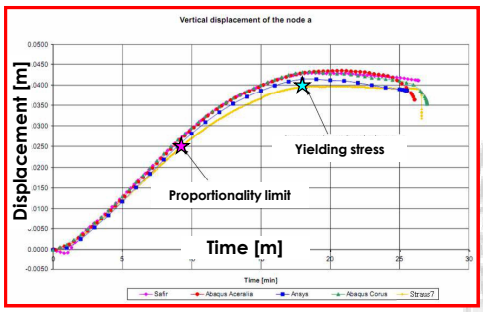


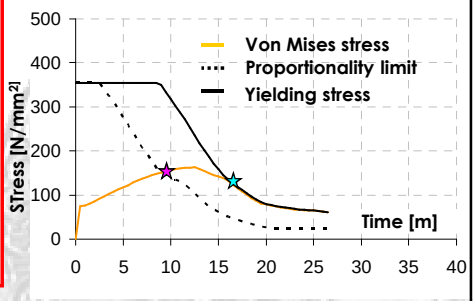
Until the proportionality limit is attained the behavior is the **same for all the software.**
After the curve obtained through **Strand7** deviates **(difference of about 10%)**
However, **collapse time is the same** (better prediction than Ansys model)

Benchmark analysis

Vertical displacement in node A



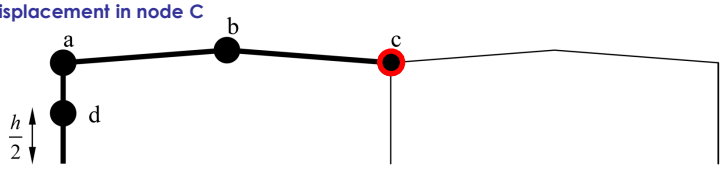


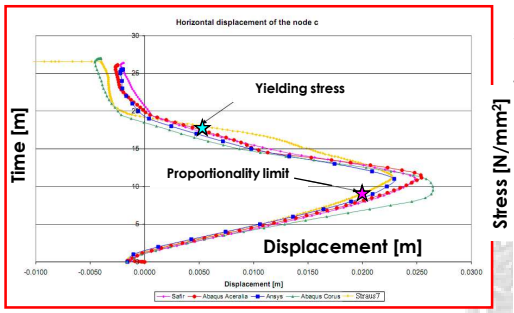


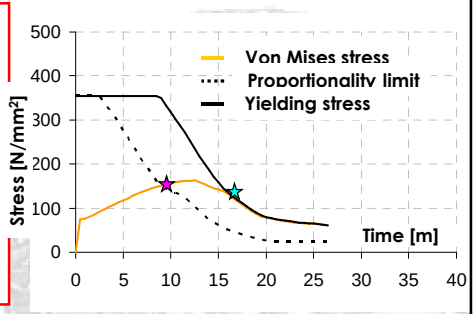
previous remark is confirmed

Benchmark analysis

Horizontal displacement in node C





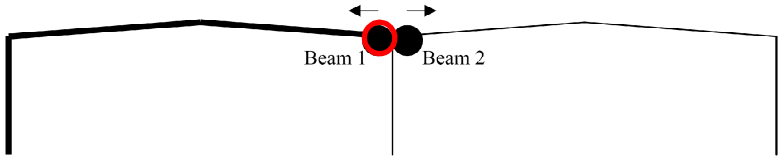


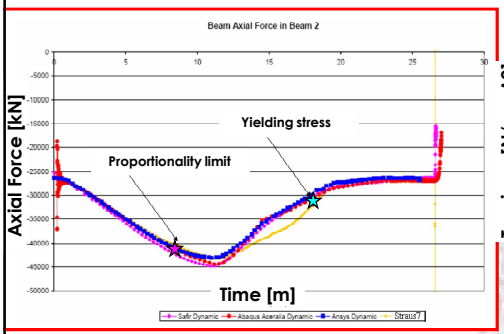
Strand7's displacement larger than other softwares due to higher the stiffness

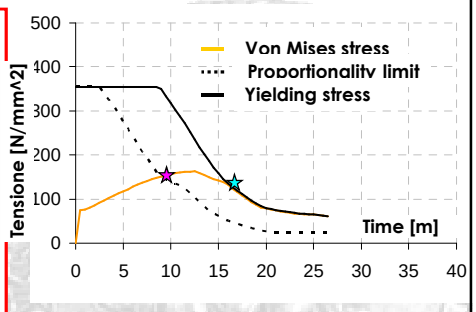
the capacity of the hot substructure to push the cold substructure is higher

Benchmark analysis

Beam 1 - Axial Forces



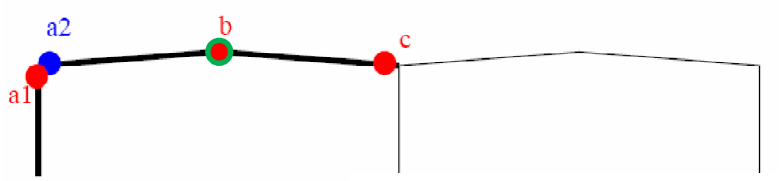


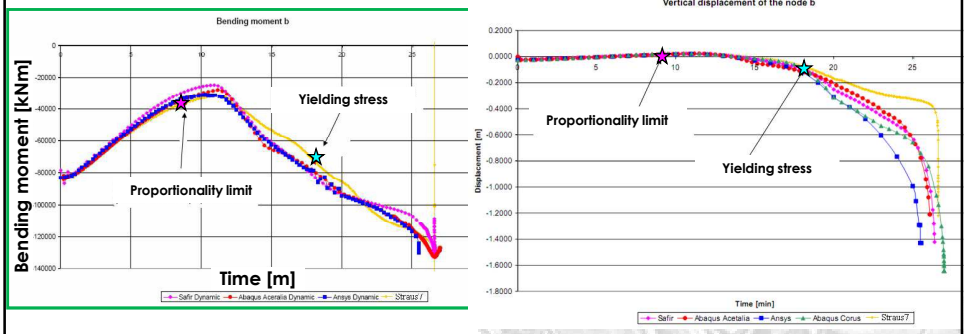


Greater stiffness of Strand7's model after the achievement of proportionality limit at least in one point of the structure determines some differences also in the beam1 axial force trend

Benchmark analysis

Bending Moment in node B





The bending moment trend evaluated in the point b confirms all the previous remarks

Conclusions

Influence of a simplified constitutive law for steel in case of fire
(adopted in a widespread commercial software)

The use of a simplified constitutive law for steel at high temperature is applicable for 2D model because the approximation determines **no differences for the time and the type of collapse** (for this typology of structures).

However, the absence of parabolic branch in the simplified constitutive law can determine **considerable differences in terms of deformation** (plastic strain).

This can induce a **not correct redistribution of forces**

This aspect, expecially in redundant structures, could not be neglected.