Thermal actions for structural analysis of existing buildings: case study and developments

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SUMMARY

Retrofitting and refurbishment of existing buildings is an everyday challenge for fire safety engineers, and maybe even more for structural engineers that must deal with buildings made following old codes and practices. In order to respond to these subjects (verification of structural strength, reduction or optimization of passive protection costs), engineering studies are increasingly using performance-based methods. This article describes some of the strategies that are being used on real projects as part of our daily duties.

ABSTRACT

To determine the resistance of structural members or plates in case of fire many options are available for the structural engineer: simplified methods, tabulated data, simple models (based on Eurocodes or ASTM for example) or advanced methods using finite elements calculations. Calculations are "quite obvious", well documented and widely accepted.

To achieve these calculations, we first need to heat the section of beams or shell elements. The simple and quick way to do it is achieved by considering the ISO fire curve. These analyses often show a lack of resistance thus involve the use of expensive (and maybe unnecessary) passive protective measures.

Standard curve analyses often over- or underestimate de real fire risk: in this case, performance-based design (PBD) should be used to analyze properly all the fire risk hazards and then decide the most effective technical and/or protection measures to use: localized and CFD fires.
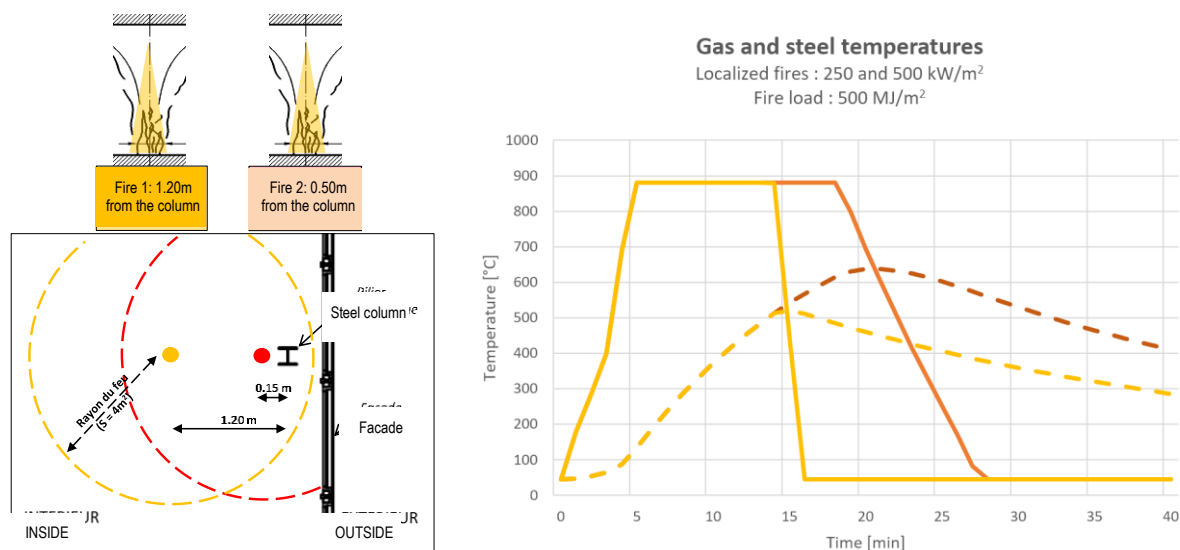
Simplified localized fires to check columns: resulting to stand without ruin

Most of our retrofitting project concern office buildings, made of composite (steel–concrete) or ribbed concrete floors, with relatively limited fire load and risk, that allow these analyses and optimizations to be done. Hopefully swiss authorities allows the PBD.

During our activities we often separate the full design process on several phases: normal situation (cold), simplified ISO (fire), and, if necessary, advanced methods analyses (CFD, FEM, etc.), with the following steps and findings:

1) <u>First round of analysis</u>

- ISO calculations are theoretical and often too conservative
- Natural fire scenarios are more realistic and less severe
- When simplified methods (like large compartment fires) are at « their limit »: run CFD validations
- Columns collapse is dangerous: consider localized fires, that may be more critical
- Assumptions on robustness

2) <u>Second round of analysis</u>

- Design of localized fires and columns check.
- 3D design of full large compartments (CFD): run many models (fully post-flash-over developed fires, traveling fires and localized fires), with a parametric approach
- Sprinkler to be considered (or not): influence on results to be compared with codes simplified models
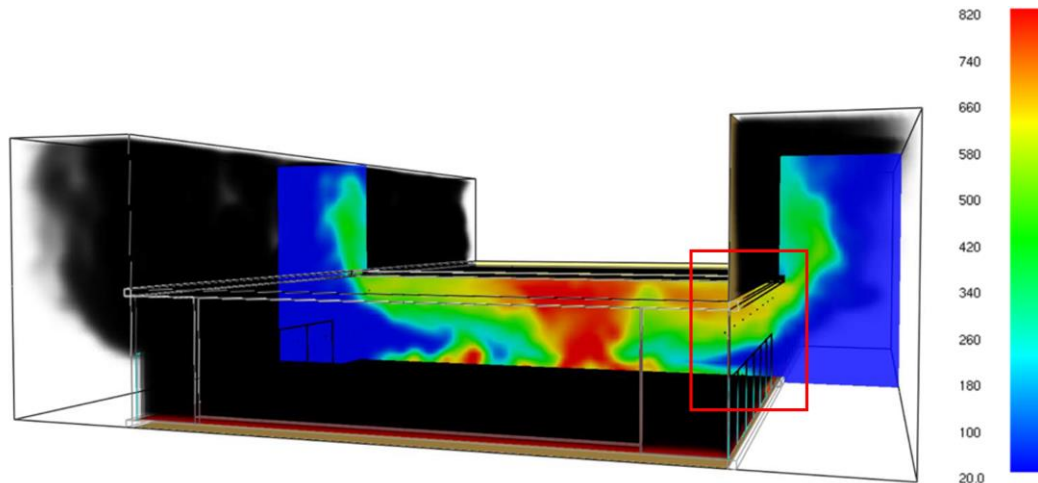
FDS model 1: Fully developed fire / gas temperatures near the façade
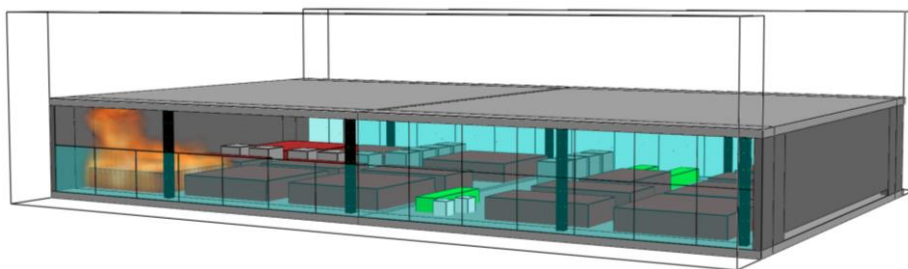
FDS model 2/3: Traveling fire / Localized fire
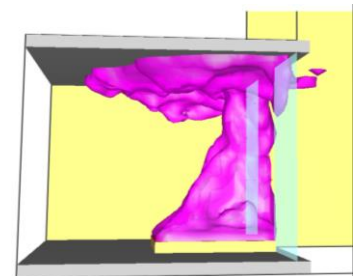
With the and the presentation, we will show the full design process and compare the different results that helped the engineers to take the good decisions and give the correct and optimized advices to the client, summarized as:

- The temperatures of the natural fire scenarios are good enough but a bit lower (to double check with CFD temperatures)
- CFD models show a range of temperature close to those found with simplified zone and localized models
- Sprinkler action considered (CFD) shows good correlation with assumptions
- The several types of thermal actions considered confirmed the choice of the holistic approach and safety results

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