Framework for stochastic FEM analysis of structures in fire

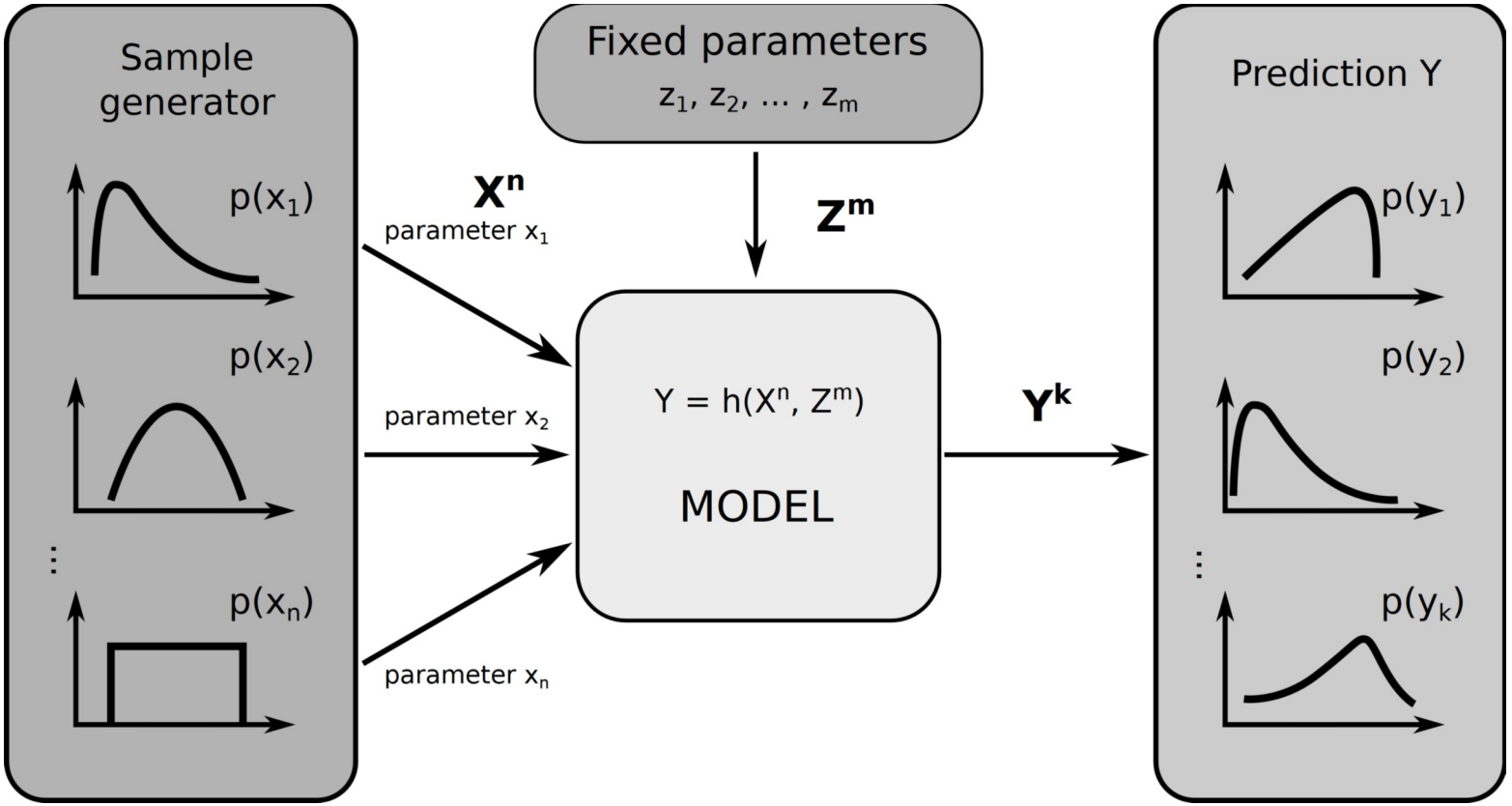
Wojciech Kowalski

Goals

- Propose a methodology for stochastic analysis of structures in fire

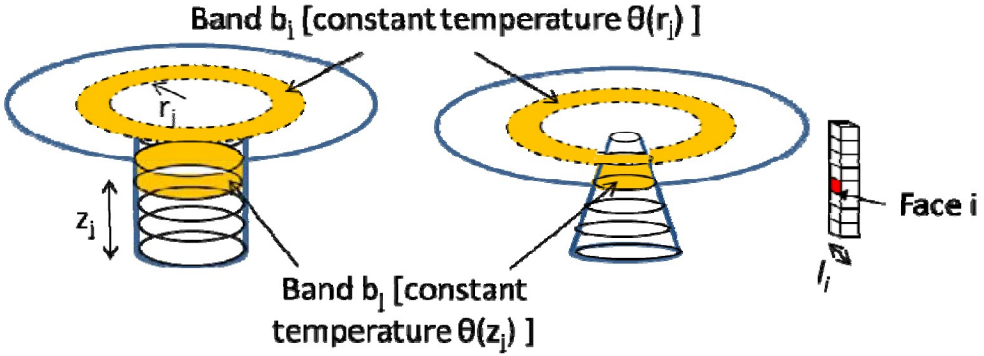
- Build a Python framework to handle multisimulation process (*Monte Carlo*)

Basic concept – Monte Carlo (*multisimulation*)



Deterministic models

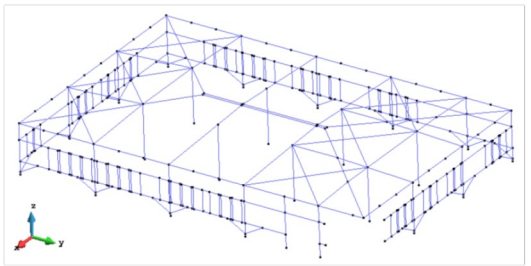
- SAFIR® – thermal and mechanical response calculations
- LOCAFI – localised fire model



Source: Temperature assessment of a vertical steel member subjected to localised fire (LOCAFI), 2018

Framework – input

Drawing geometry in CAD/CAE software



Fire events identification

Defining flammables and risks of ignition

DXF file

configuration
(text file)
+ STEP or OBJ with geometry

Multisimulation of thermal response

McSteel + SAFIR® Thermal 2D

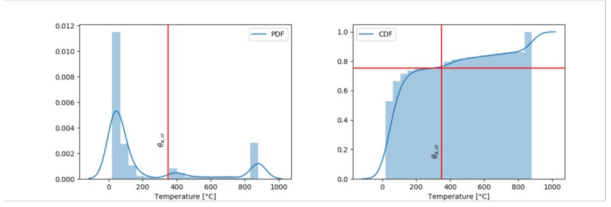
Framework – processing

Multisimulation of thermal response

McSteel + SAFIR® Thermal 2D

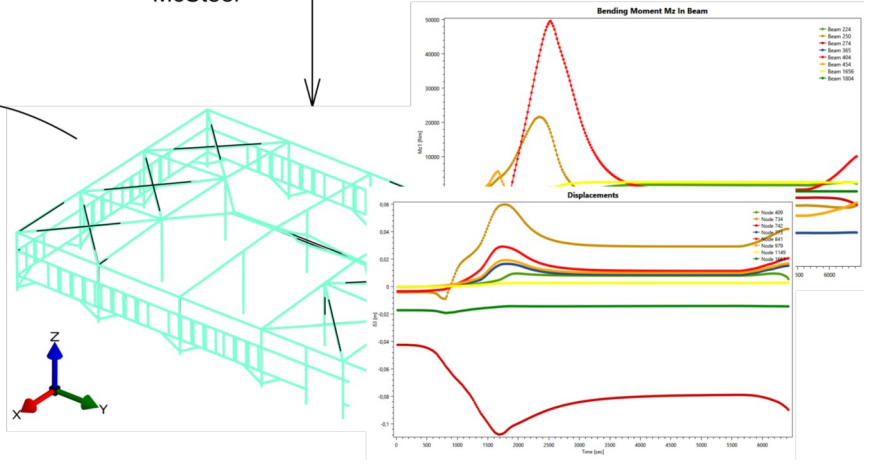
$\theta_a > \theta_{a,cr}$

$t_{\theta a,cr} < RSET$



Multisimulation of mechanical response

McSteel + SAFIR® Structural 3D



Risk assessment

Fire scenarios sampling

- Draw fire localization (concerning fire hazard and flammables distribution) – OBJ or STEP file with fuel areas and text file with properties.
- Draw fire properties from distributions (implemented or to be specified by user):
  - α – i.e. *Deguchi et al., 2011*;
  - HRRPUA – i.e. *EN 1991-1-2 (Appendix E)*.
- Different fire curves can be used (*steady-state, t-squared, αt^3, traveling*).

Element–fire mapping

- Associating the nearest (most exposed) section for thermal analysis
- Calculating thermal response
- Define if $\theta_{a,cr}$ has been reached
- If $\theta_{a,t} > \theta_{a,cr}$ find t

Basic post-process

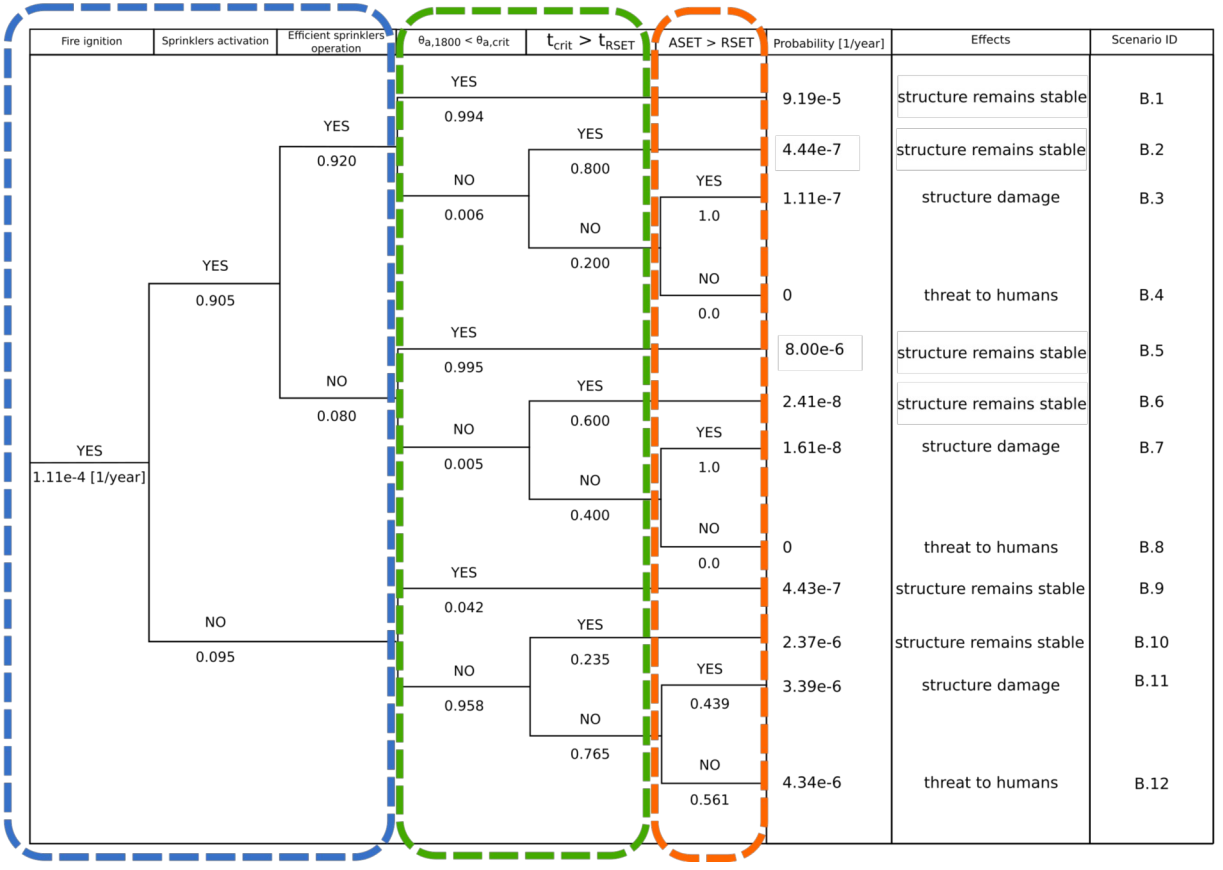
- CDF and PDF charts ($\theta_{a,max}$ *and* $t_{\theta a,t > \theta a,cr}$)
- Summary file
- Detailed results to be used in further postprocess

Risk assessment example

Multisimulation of thermal response

Multisimulation of thermal and mechanical response

Fire events identification (ignition, sprinklers...)



Current problems & future work

- Is it possible to represent traveling fire with localised models that SAFIR® provides?
  Implement one of existing traveling fire models in the framework (i.e. ETFM – *Dai et al., 2020*)
- There is no simple criterion for full mechanical analysis – results of all cases (ASET) need to be evaluated individually
- Consider stochastic parameters of structure (f_y, *geometry etc.*)
- Extend the framework to concrete and slabs (not only post and beam structures)
- GUI and documentation

Thank you!

*https://www.github.com/**kowalskiw/mcsteel***