COST Action IFER TU0904
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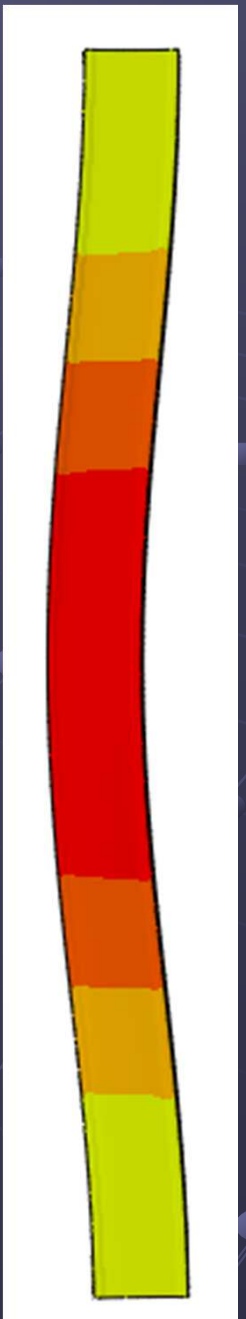
Numerical analysis of a composite column subjected to fire

Ioan Both
Raul Zaharia
Leslaw Kwasniewski
Dan Dubina



Analysis of elements subjected to fire

??? Output quantities ??? Method ???

detailing

fire resistance time

bearing capacity

stresses

deformation

integrity

etc.

Tabulated data

Simple calculation models

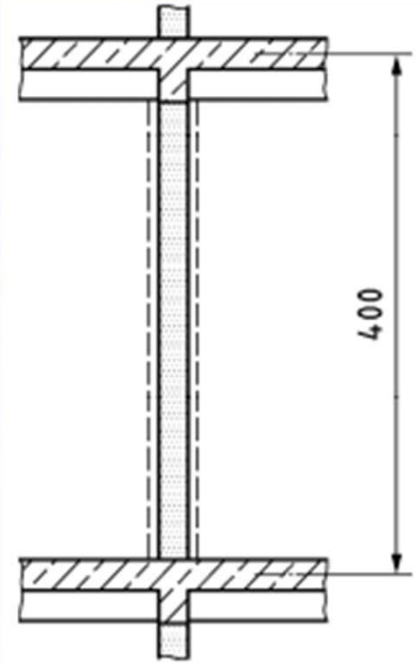
Advanced calculation models

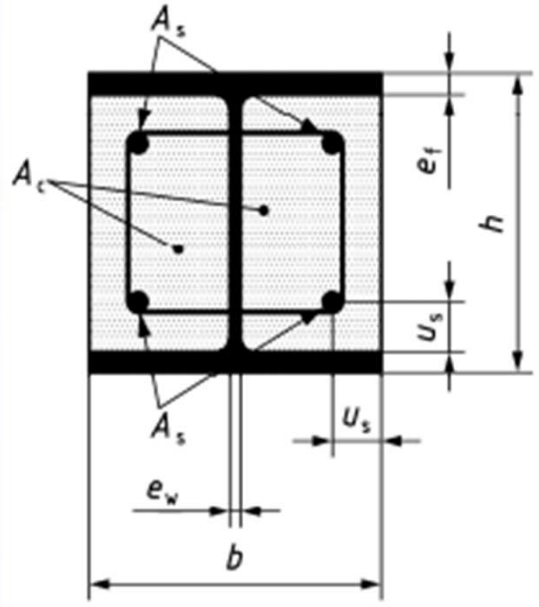
Case study / benchmark

Parabolic longitudinal path – midspan imperfection L/1000

Dimensions		l / h / b	cm	400 / 30 / 30
		u_s	mm	50
		e_f	mm	19
		e_w	mm	11
Buckling length		$l_{0,fi}$	cm	200
Load		$N_{E,fi,d,t}$	KN	-1700
Concrete C25/30 (3 % moisture (by mass))		$f_{ck(20°C)}$	N/mm²	25
Reinforcing steel S 500		$f_{yk(20°C)}$	N/mm²	500
Structural steel S 235		$f_{ak(20°C)}$	N/mm²	235
Stress – strain curve		Concrete a.		DIN EN 1994-1-2
		Reinforcing steel b.		
		Structural steel		
Temperature load		ETK (four sides)		DIN EN 1991-1-2
Heat transfer coefficient		α_c	W/(m² × K)	25
Emissivity		ε_m		0.7
Thermal and physical material properties	Concrete	λ, ρ, c_p, $\varepsilon_{th,c}$		DIN EN 1994-1-2
	Steel	λ, ρ_s, c_a, $\varepsilon_{th,s}$, $\varepsilon_{th,a}$		DIN EN 1994-1-2

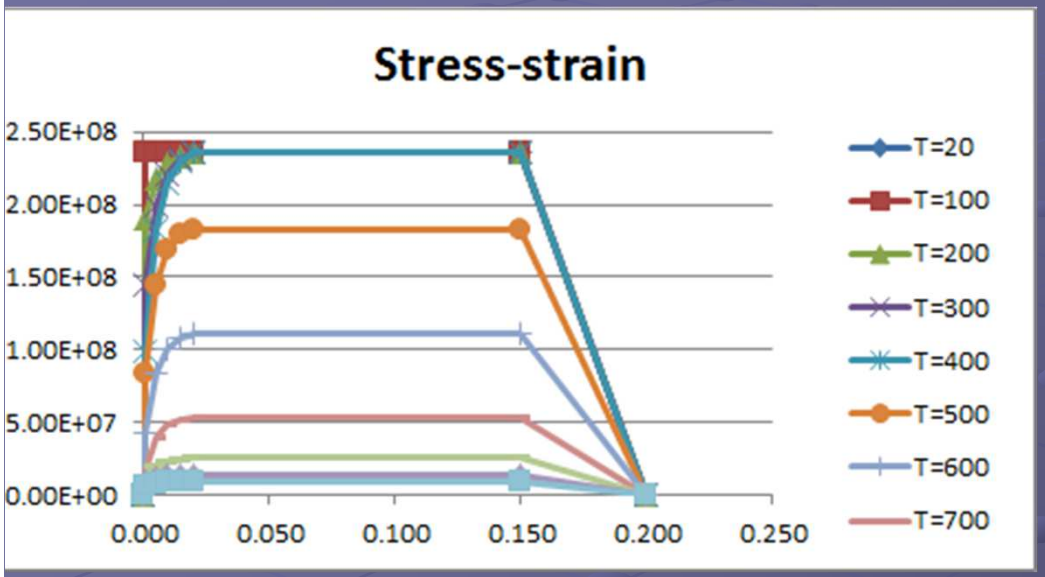
a. Containing mainly quartzite aggregate and density ρ=2400 kg/m³
b. Hot-rolled



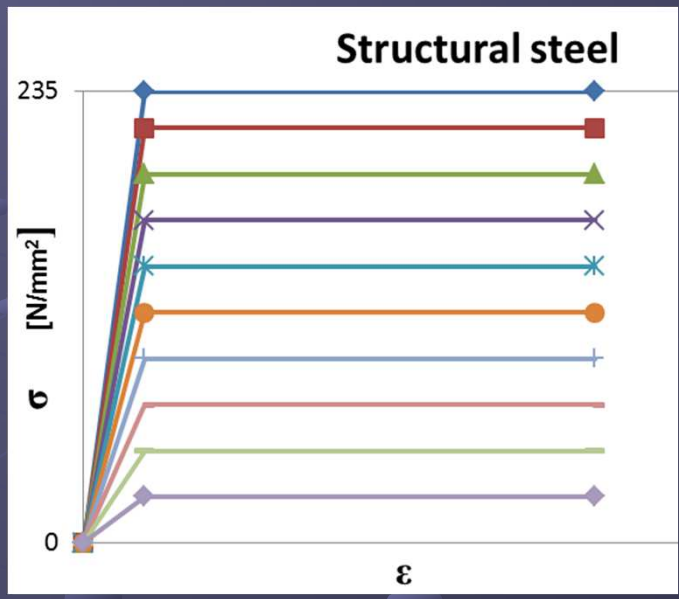


Material properties

Steel

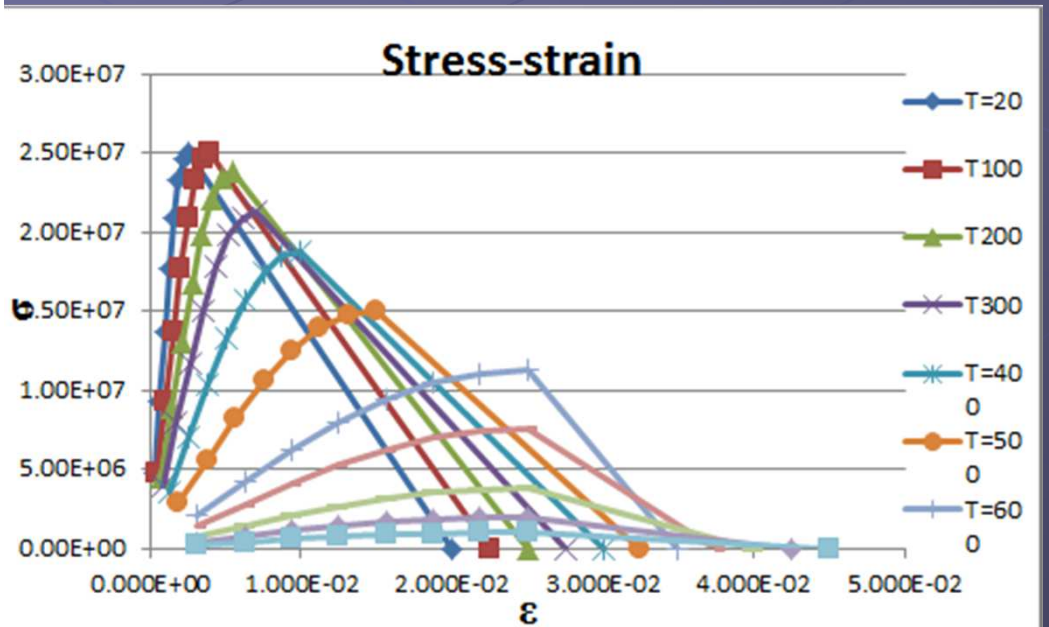


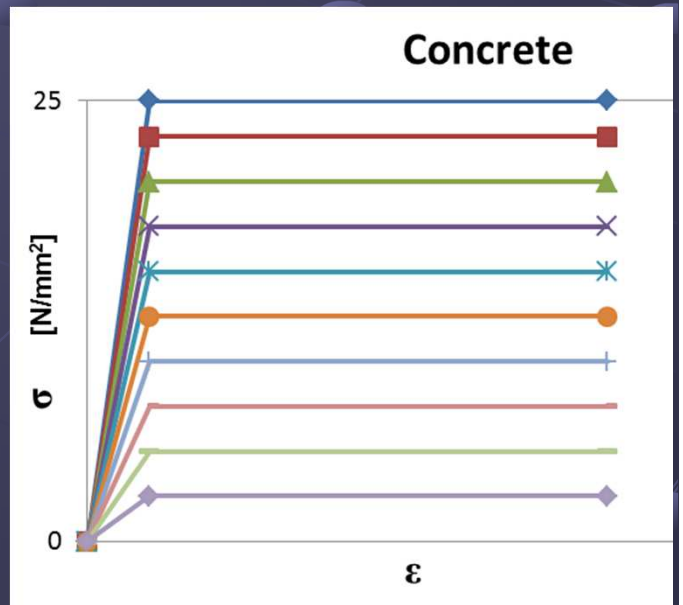
complex



Concrete

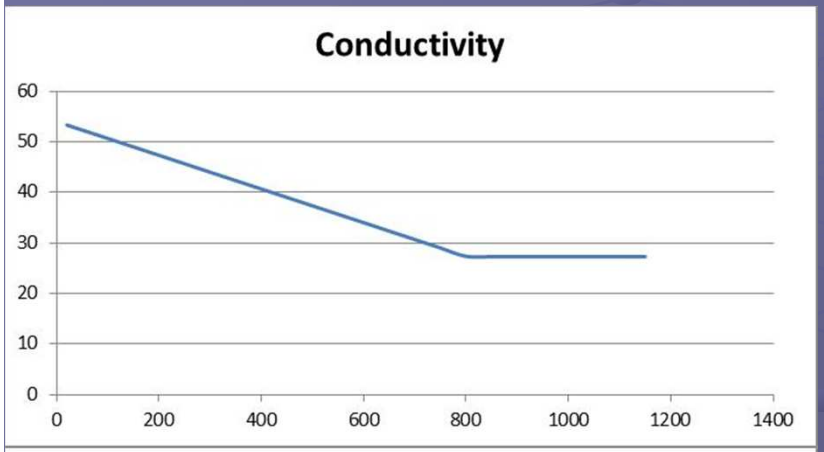
simple

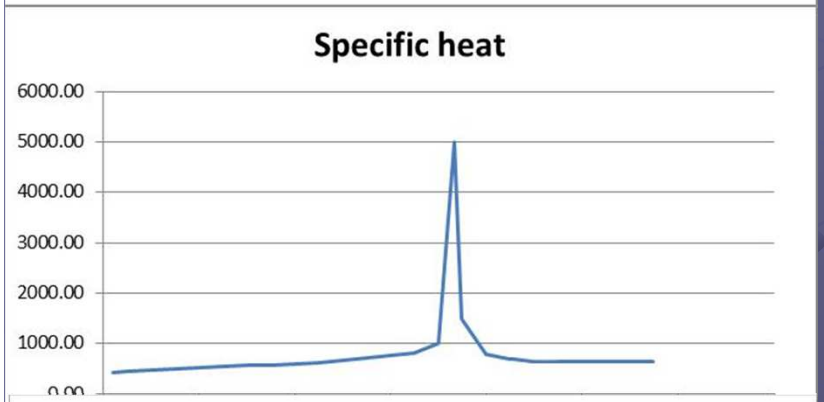


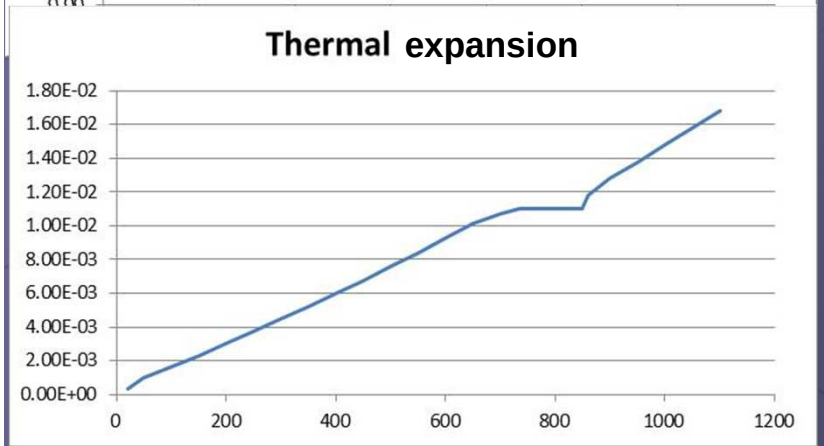


Material properties

Steel







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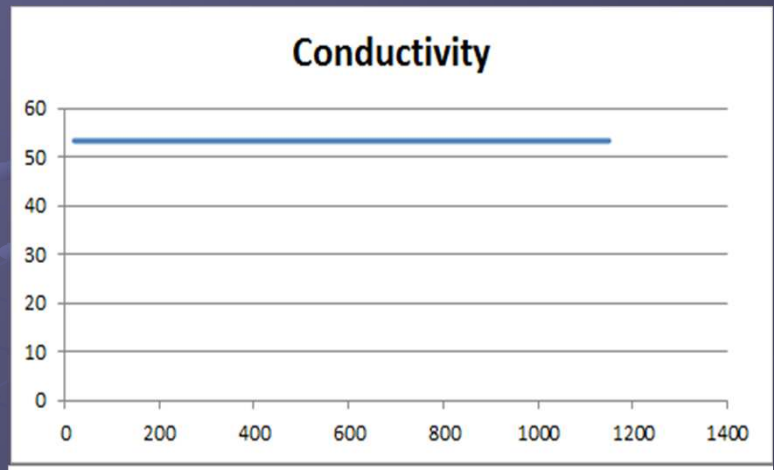
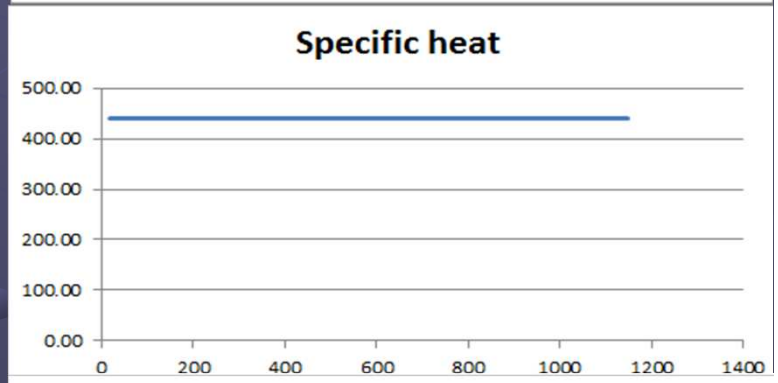
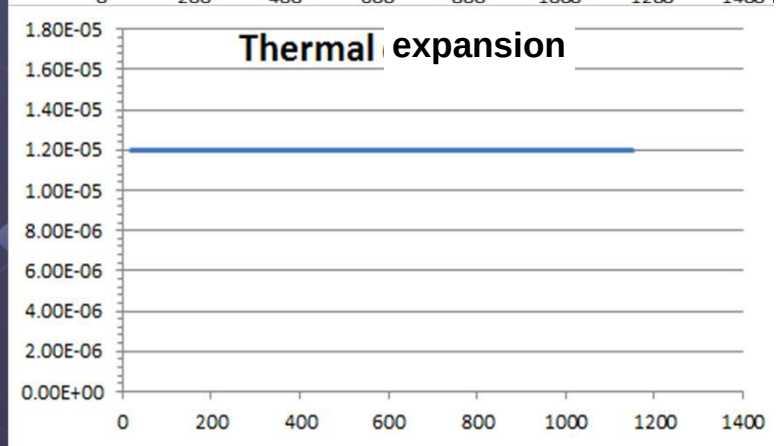
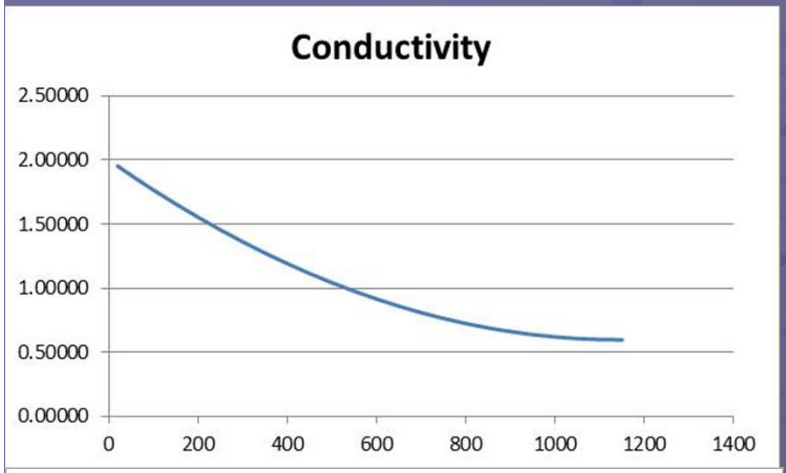


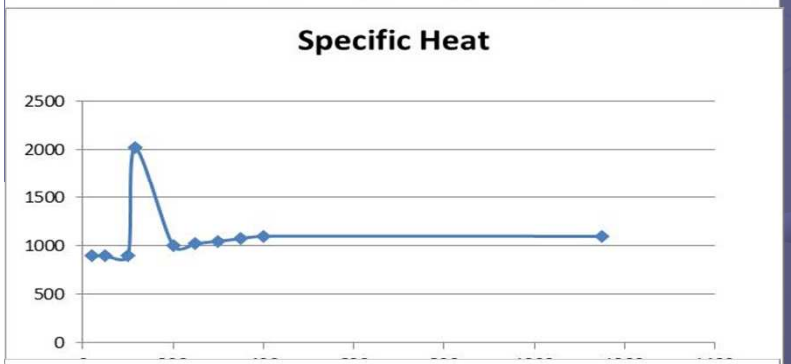


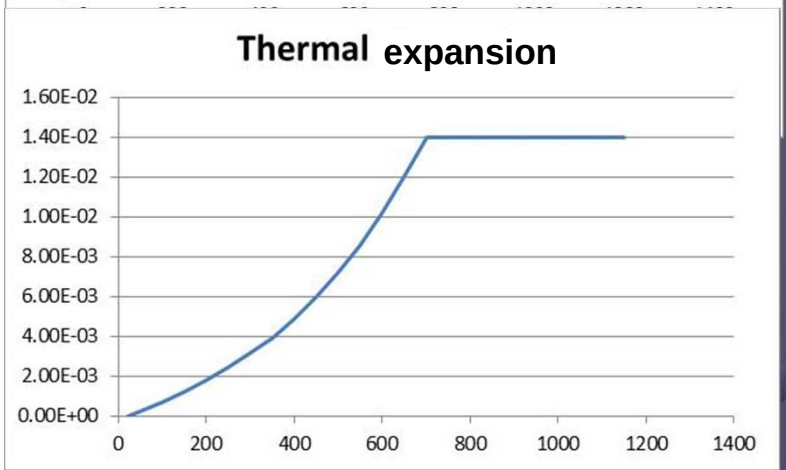


Material properties

Concrete







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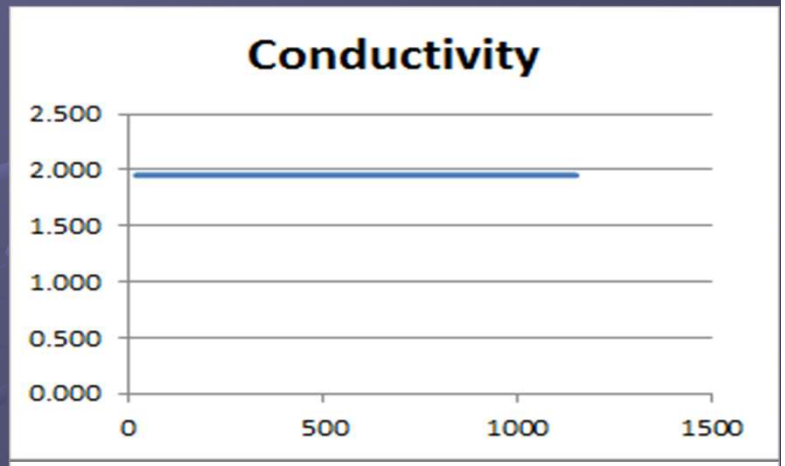
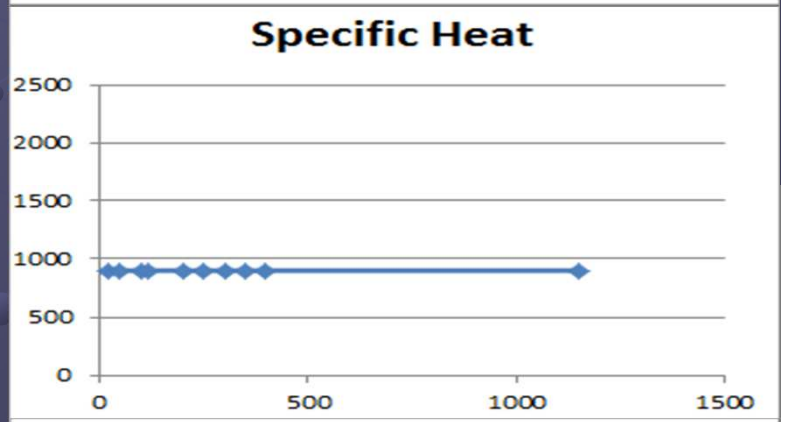
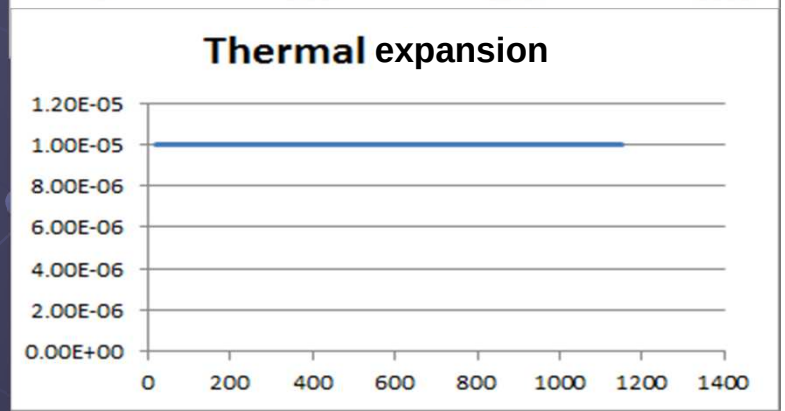
simple

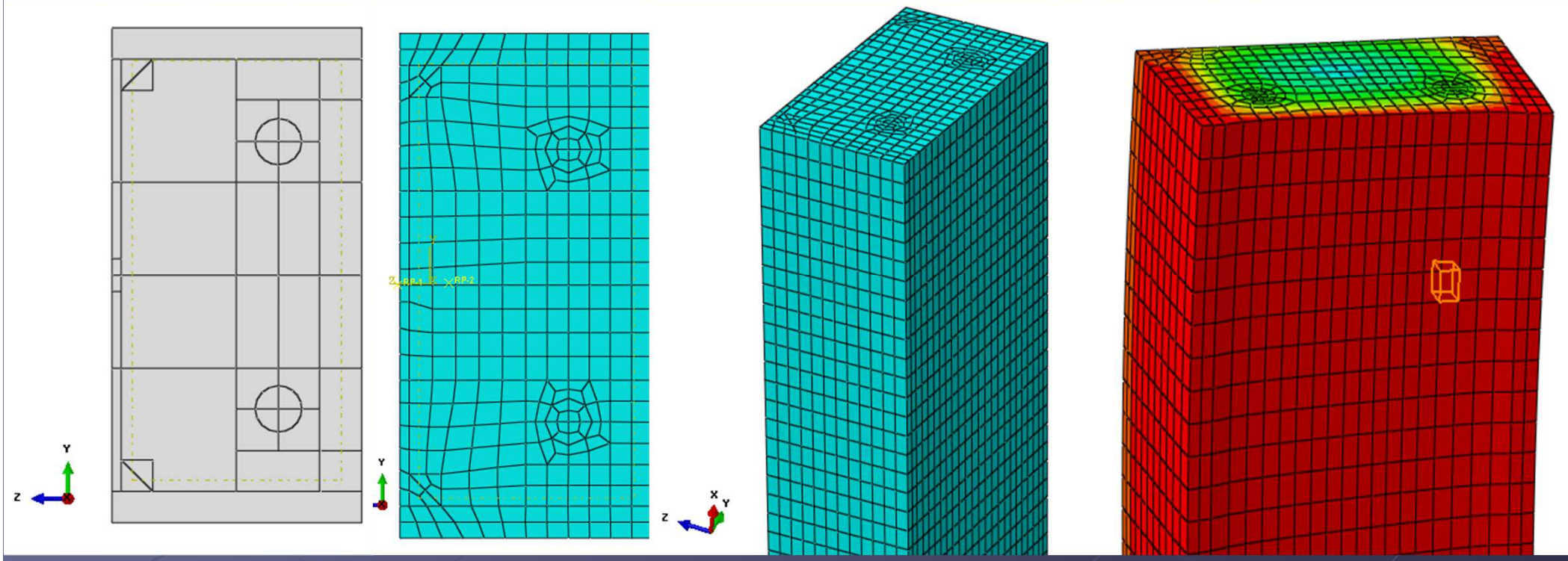






Analysis

Coupled thermal-displacement analysis

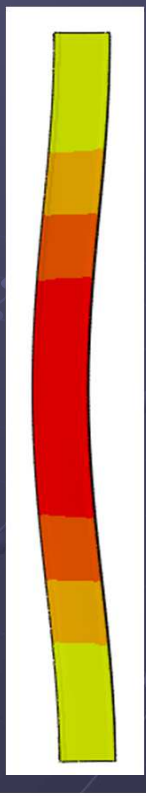


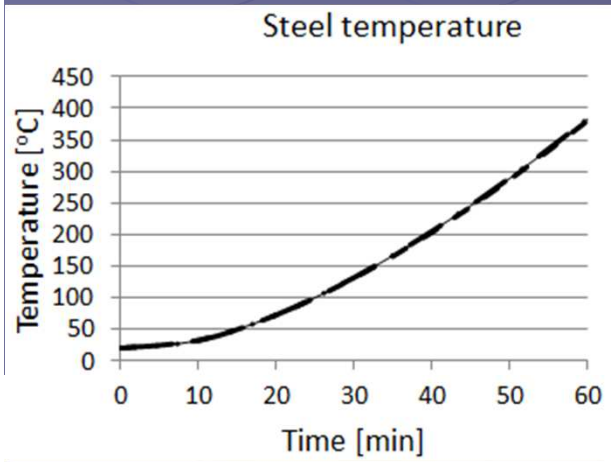
Results

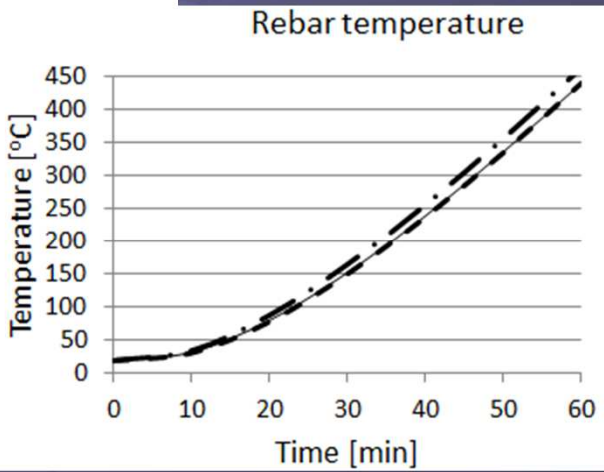
The results do not fulfill 2 criterion (from DIN 1991-1-2): fire resistance time and displacement for 60min.

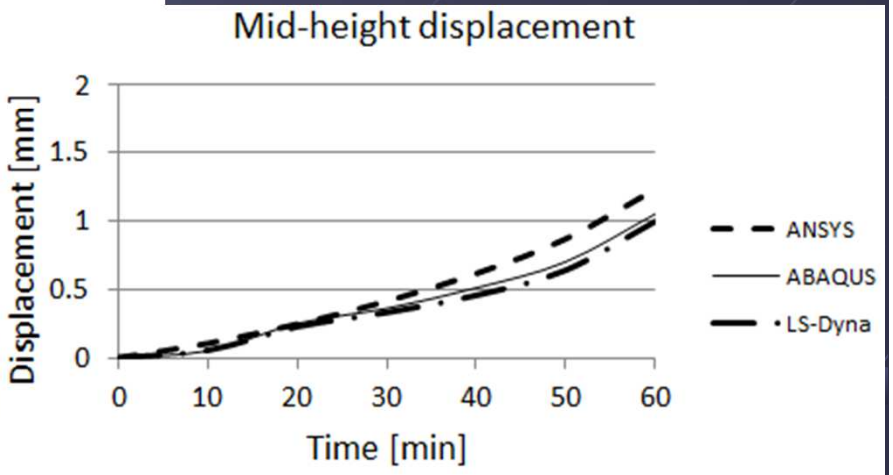
Complex material model

ABAQUS		Reference value X		Calculated value X′	Deviation [%]	Limit [%]
Failure time		92	>	87	-5.43	± 5
Displ. [mm]	30 min	4.40	<	4.56	+3.52	
	60 min	5.50	<	7.82	+42.16	









Simple material model

Conclusions

- The analysis of elements subjected to fire should start with simple models
- Minor disparities may appear even for simple models
- Complex input data may lead to large disparities of results
- New questions about behaviour and mechanical interaction between elements arise
  - Debonding
  - Concrete damage
  - Radiation

References

1. DIN EN 1991-1-2/NA (2010) National Annex - National determined parameter – Eurocode 1: Actions on structures – Part 1-2: General actions – Actions on structures exposed to fire, Deutsche Norm

2. Raul Zaharia, Thomas Gernay, Validation of the Advanced Calculation Model SAFIR Through DINEN 1991-1-2 Procedure, 10th International Conference on Advances in Steel Concrete Composite and Hybrid Structures Singapore, 2 – 4July 2012

3. Leslaw Kwasniewski, Application of grid convergence index in FE computation, Bulletin Of The Polish Academy Of Sciences, Technical Sciences, Vol. 61, No. 1, 2013

4. Abaqus' Theory Manual

THANK YOU !

Ioan Both, Dr.eng
ioan.both@upt.ro

“Politehnica” University of Timisoara