13th April, 2012

COST TU0904 Integrated Fire Engineering and Response

Training School, April 11 - 14, 2012, Sliema

TRAINING SCHOOL

FIRE ENGINEERING RESEARCH - KEY ISSUE FOR THE FUTURE

TRAVELLING FIRE IN MULTI-STOREY BUILDINGS

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Contents

- Travelling fire
  - Models of travelling fire
- Experimental study
  - Material testing
- Numerical simulation (FDS)
- Composite floor slab (FEM)
- Goals of project

Travelling Fire

- Complicated geometry of FC, large open spaces, atria, high ceilings

→ **Travelling of fire**

field with higher and lower temperature, long duration

uniform fire, localised fire – high temperatures in short time

- Traditional methods – limited!

↓

New methodology of travelling fire

- extend family of traditional methods
- closer to real fire
- different behaviour of construction

Windsor Tower

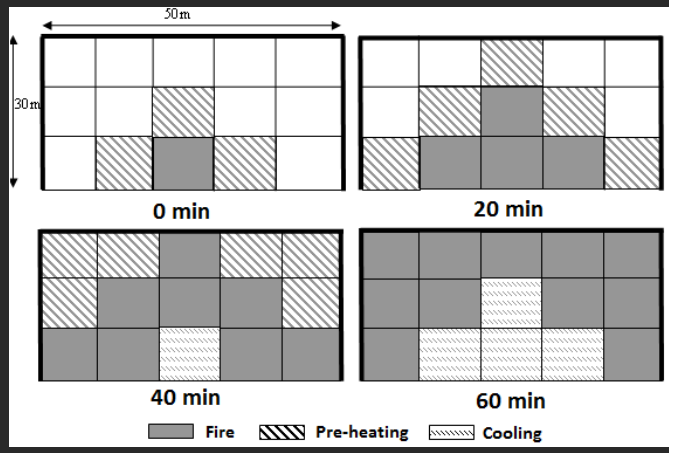
Travelling Fire

- Horizontally
  - beginning of the fire
  - depends on fire load distribution in FC, ventilation of FC
- Vertically
  - facade (window breakage in 3 min, 35 kW/m^2, VTT Finland)
  - Space in a facade
  - Via cabels (WTC – spread via phone lines)

Models of Travelling Fire

- **Clifton´s model, 1996**

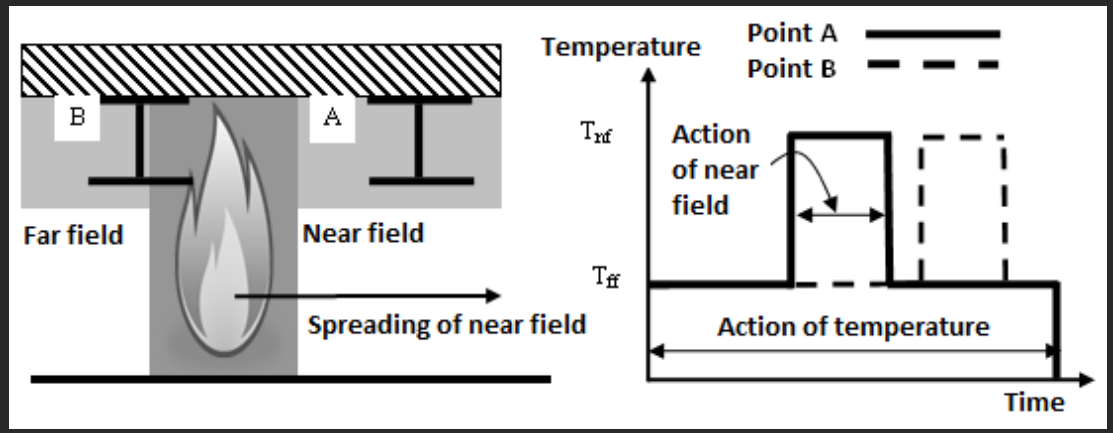
  uniform burning in small areas



- **Stern-Gottfried and Rein´s model**
- *Near field* and *Far field* temperatures

  influenced by Rate of Heat Release (RHR)

  in action about 19 min



Experimental Study

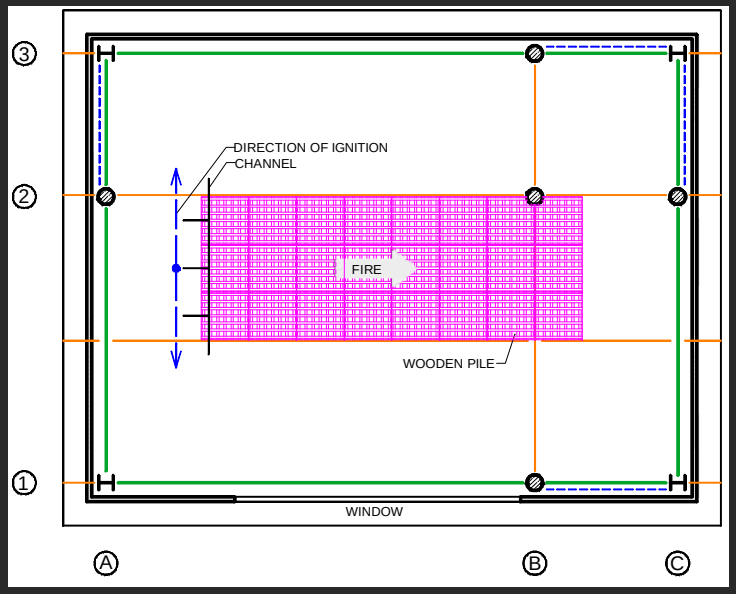
- 6th September 2011 Veselí n. L.
- Fire test on two floors administrative building
- Travelling fire scenario in upper floor

Compfire, RFCS
Design of joints to composite columns for improved fire robustness

- 10,4 x 13,4 x 4,0 m
- composite structure
- window 2,0 x 5,0 m

Experimental Study

- Fire load
  - 24 wooden piles on area of 24 m^2
  - 7 cribs of 50x50x1000 mm in 6 layers
- 2,52 m^3 of wood
  - Linear ignition source (U profile, mineral wool, paraffin)



Experimental Study

5.min

25.min

10.min

30.min

15.min

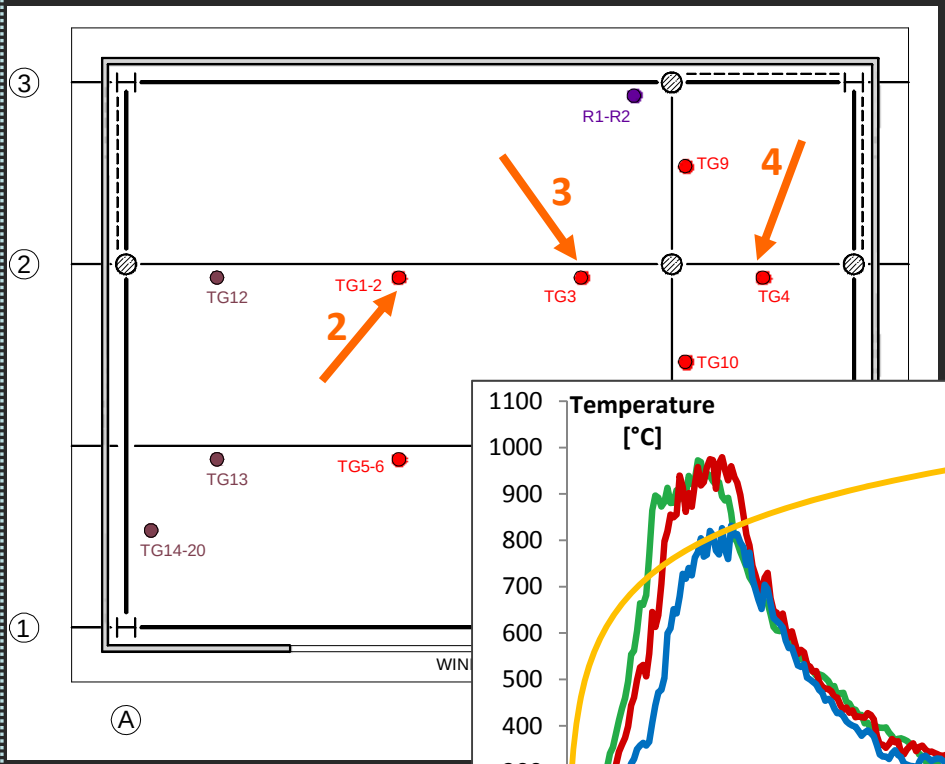
35.min

20.min

40.min

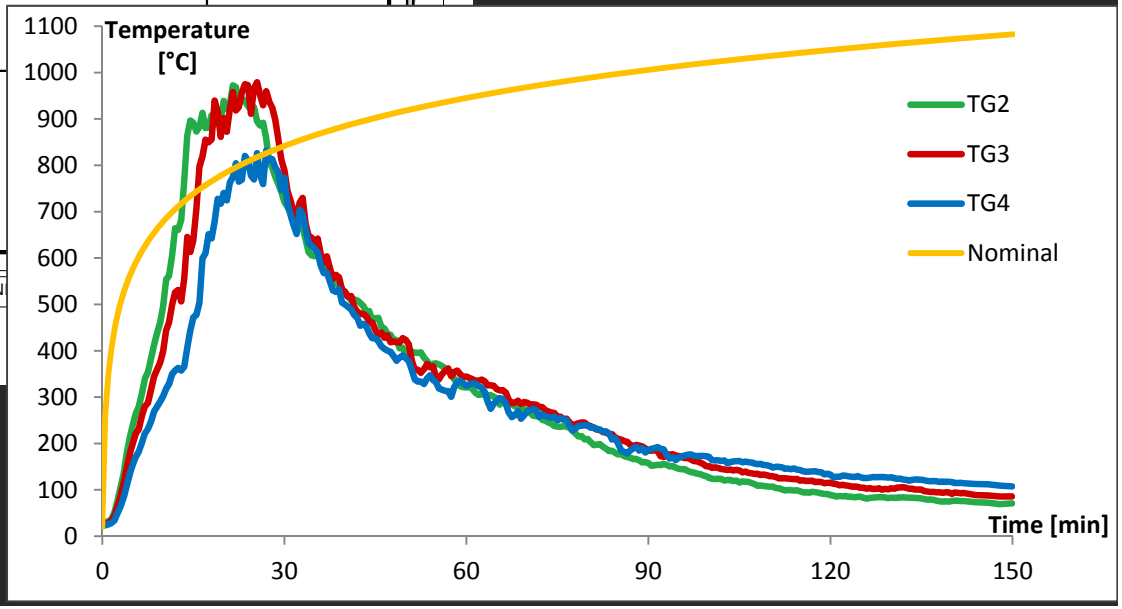
Experimental Study

- Gas temperature measurements
  - 20/97 thermocouples ø 3 mm



Fire time [min]	TG2 [°C]	TG3 [°C]	TG4 [°C]
1,0	32,29	29,46	25,68
5,0	238,49	199,48	153,31
10,0	495,32	398,94	301,71
15,0	891,56	639,31	471,85
20,0	938,74	901,64	740,21
25,0	925,08	966,34	769,57
30,0	721,32	788,65	773,57

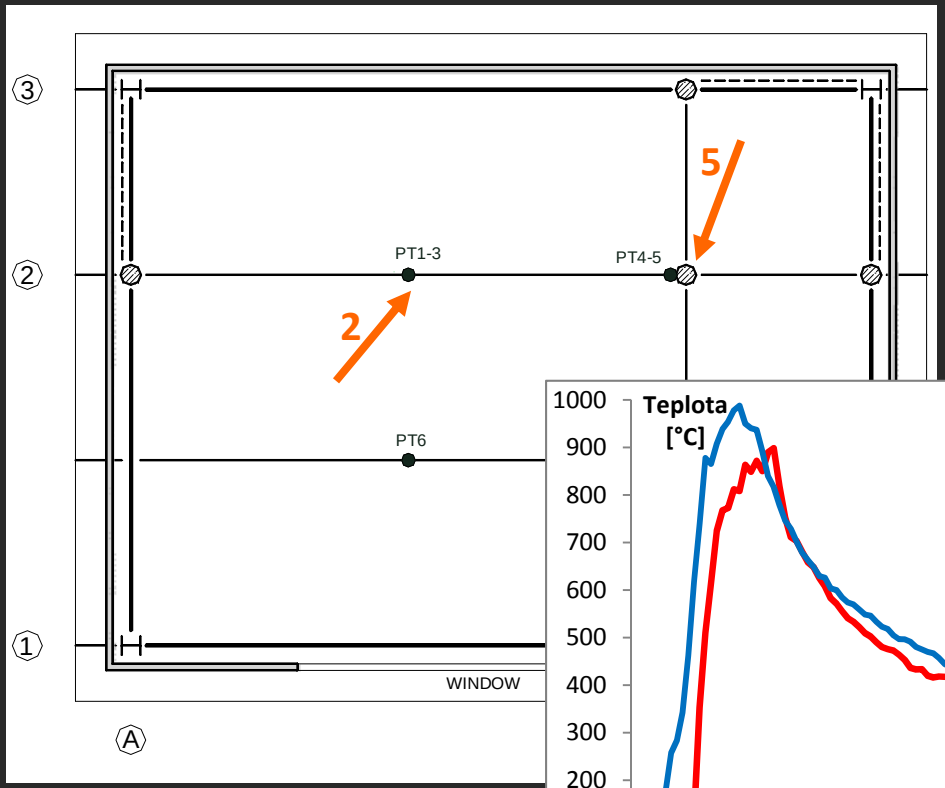
Temperature delay - 4 min



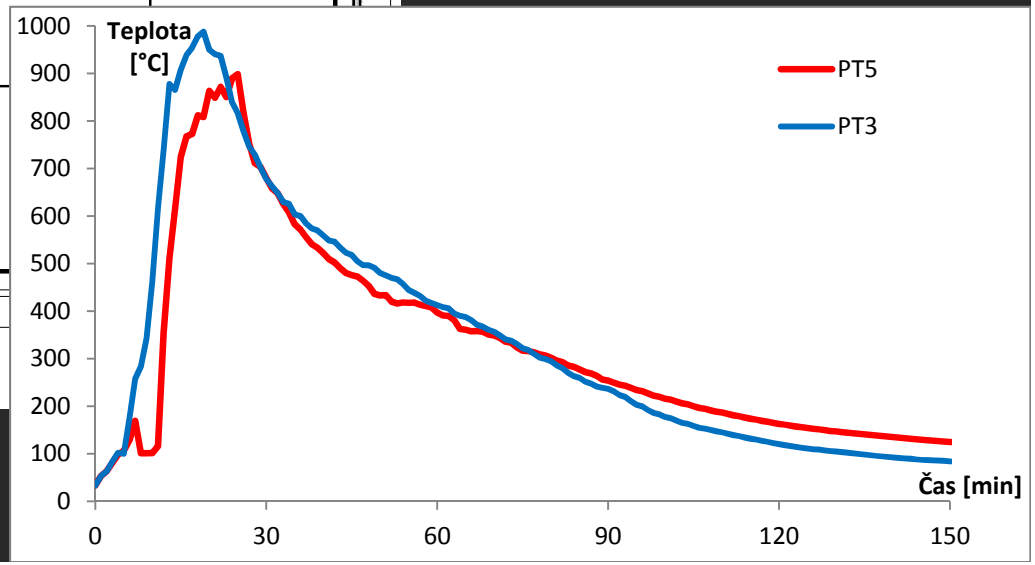
T_{max} in 26. min

Experimental Study

- Gas temperature measurements
  - 7 plate thermometers



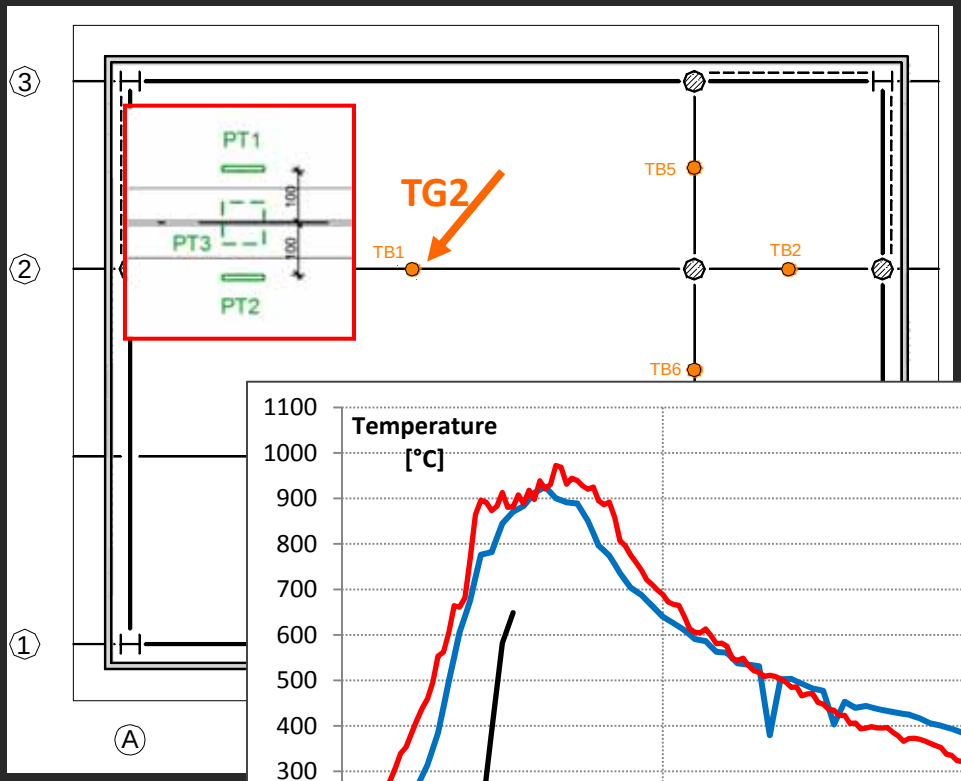
Temperature delay – 2,5 min

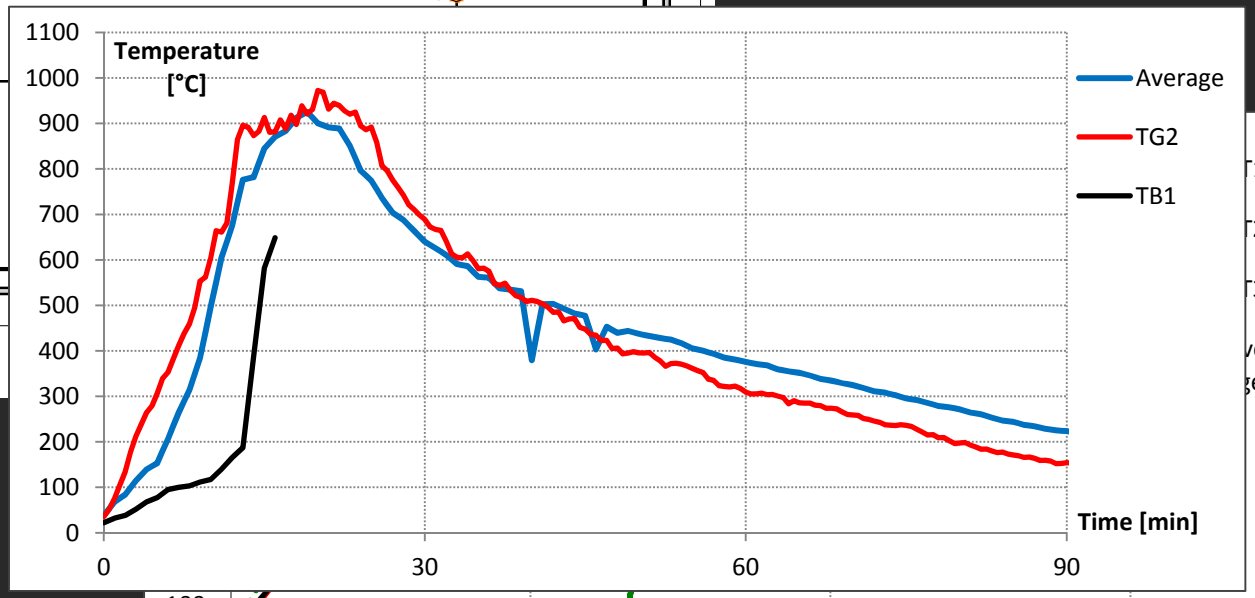


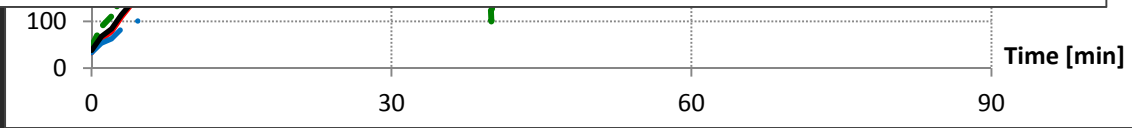
T_{max} in 19. min

Experimental Study

- Adiabatic surface temperature - PT







Experimental Study

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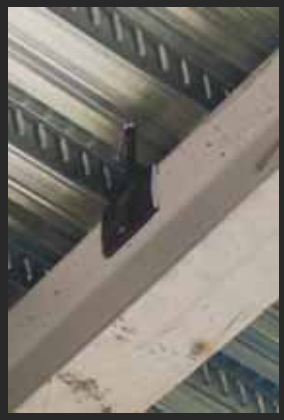
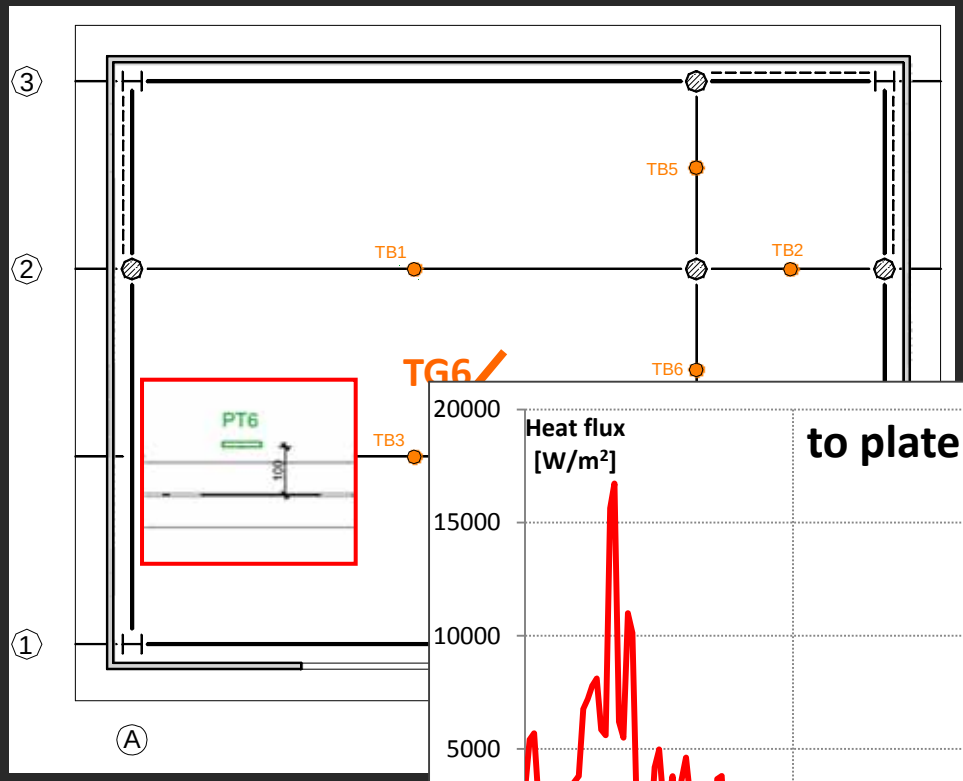
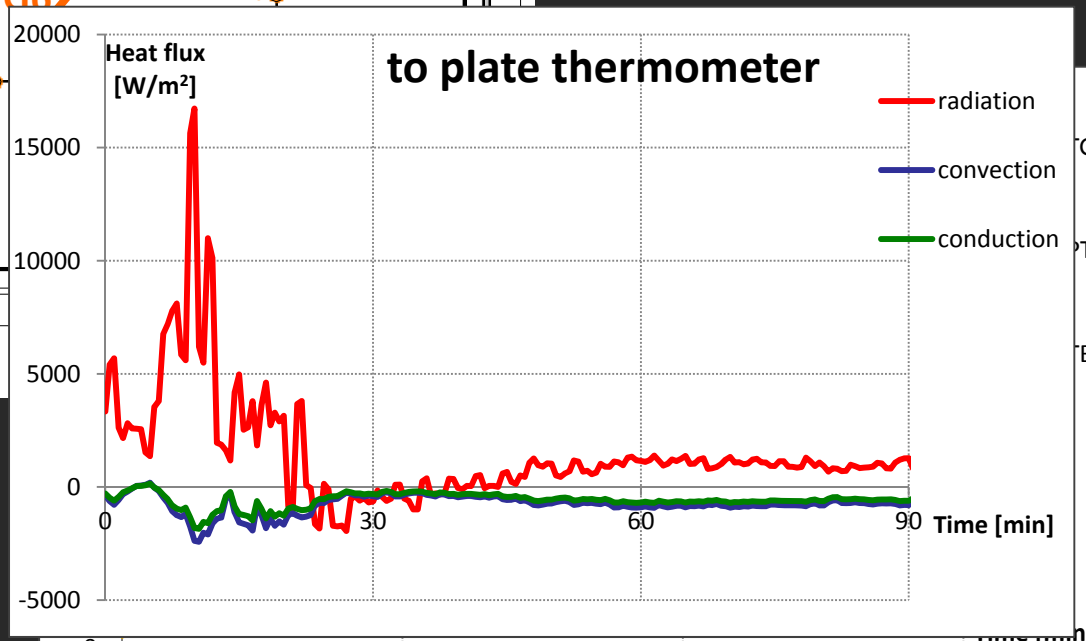






Material Testing

- Calorimetric method
  - Laboratory of TÚPO Prague
  - setting of RHR of wood

100 x 100 x 50 mm

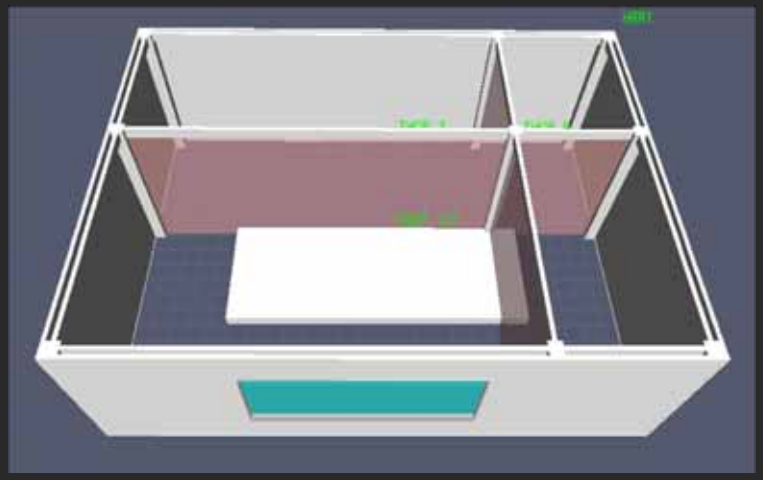
	1. test	2. test	3. test	Average
q´´ (180) [kW/m^2]	41,99	46,68	48,69	45,79
q´´ (300) [kW/m^2]	66,24	71,51	64,87	67,54
q´´ (max) [kW/m^2]	108,74	113,72	98,05	106,84

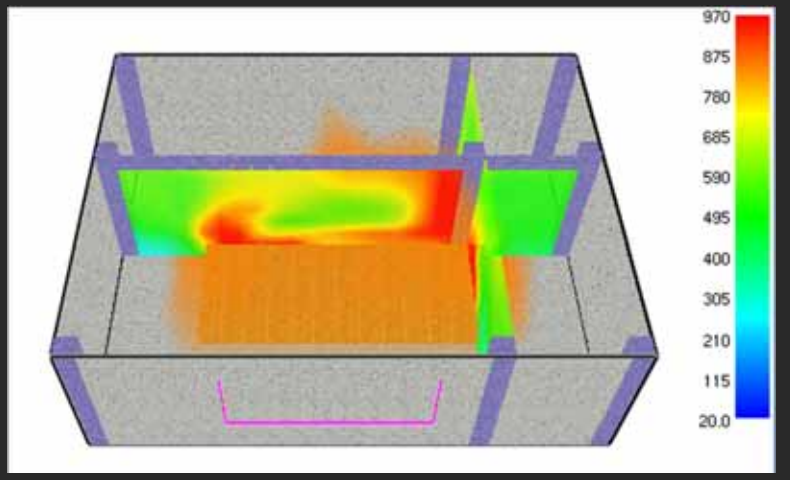
→ CFD

Numerical Simulation

Software FDS (Fire Dynamics Simulator)

- model of experimental compartment
- spreading of fire from left to right
- RHR input





Composite floor slab

- 3,0 x 4,5 m
- 40 mm thick slab in trapezoidal sheet TR40/160/0,75
- Connected by studs Ø12,5 mm
  70 mm length, spacing 300 mm

- Fibre concrete
  - Steel fibres HE 75/50
  - 70 kg/m^3
  - compresion strength of 46 MPa
  - tensile strength of 7,1 MPa

Goals of Project

- **Analytical model**
  - + comparison with numerical model
  - + modification of boundary condition of usage of traditional fire models
- **Numerical model (FDS)**
  - + parametrical study
  - + evaluation of model to data from Veseli n. L.
  - + analysis of fire load (RHR) → **CATALOGUE of RHR** → background of design
- Application to floor slab of multi-storey building
  - + global analysis (FEM)

THANK YOU FOR YOUR ATTENTION

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