Faculty of Safety Engineering
VSB – Technical University of Ostrava

Applications of Structural Fire Engineering

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Fire Simulation Application in Fire Safety Design for Tunnel Structures

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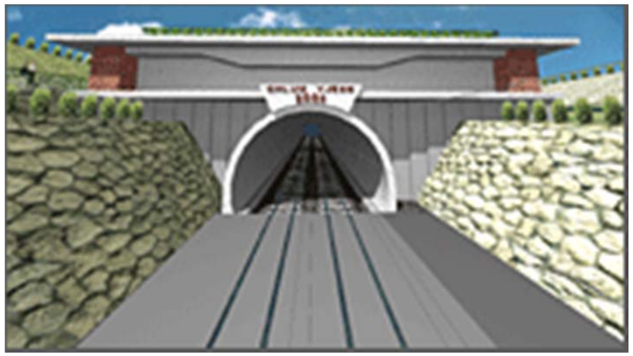
Utilization of Fire Engineering Method in Practical Example – Railway Tunnel

AIMS

- **safe evacuation of people in case of fire on a train in a railway tunnel:**
  - development of temperatures during a fire in a tunnel
  - smoke stratification during a fire in a tunnel
  - evacuation time assessment

TOOLS

- common available software
- using of empirical equations

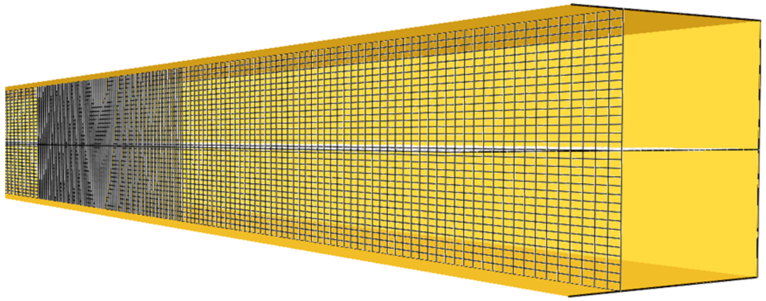


TOPIC 1:

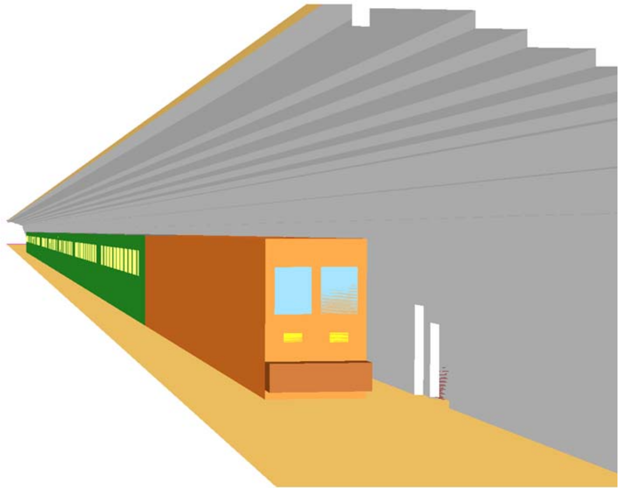
Modelling of temperature development and smoke stratification

Topic 1 – Fire Modelling in the railway tunnel

Input Parameters:



- **Basic parameters**
  - simulation time - 20 minutes
  - environment (temperature 10 °C, humidity 60 %,…)
  - others parameters (type of simulation LES,…)
- **Tunnel geometry**
  - computation space (610 m x 12 m x 8 m)
  - construction (tunnel lining, portal,…)
- **Definition of equipment**
  - **train set** – eight coaches and a locomotive (total length is 225 m)
  - other obstructions (entry to an escape shaft)



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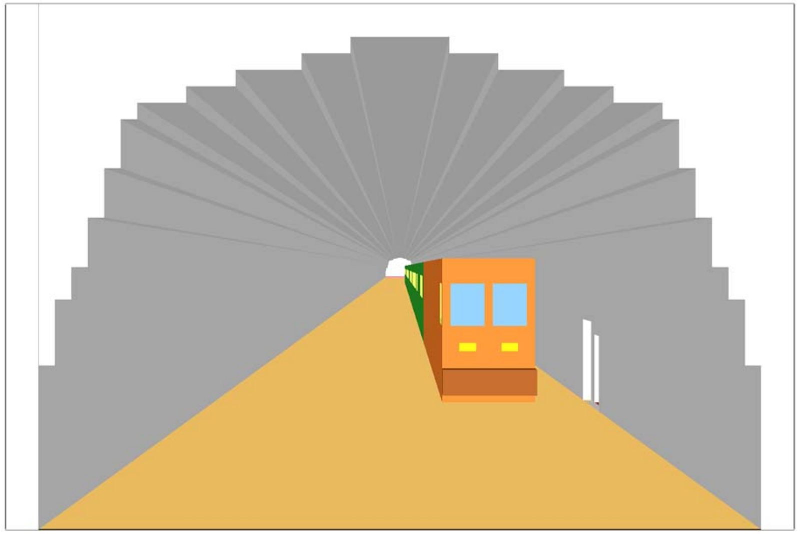
Topic 1 – Fire Modelling in the railway tunnel

Input Parameters:

- **Materials and surfaces**
  - physical properties of materials
  - definition of surface properties
- **Fire parameters**
  - fire initiation - first coach
  - heat release rate HRR (constant vs. variable)



HRR of passenger coach

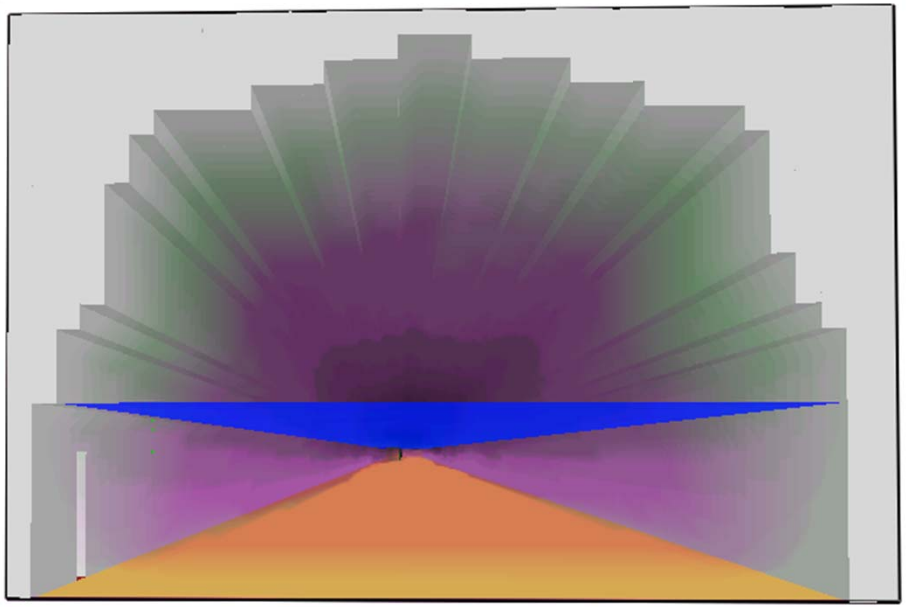
Time [min]	Heat release rate [kW]
0	0
5	1 800
10	6 000
15	14 000
20	21 000

Suitable mathematical model?

→ **Fire Dynamics Simulator**

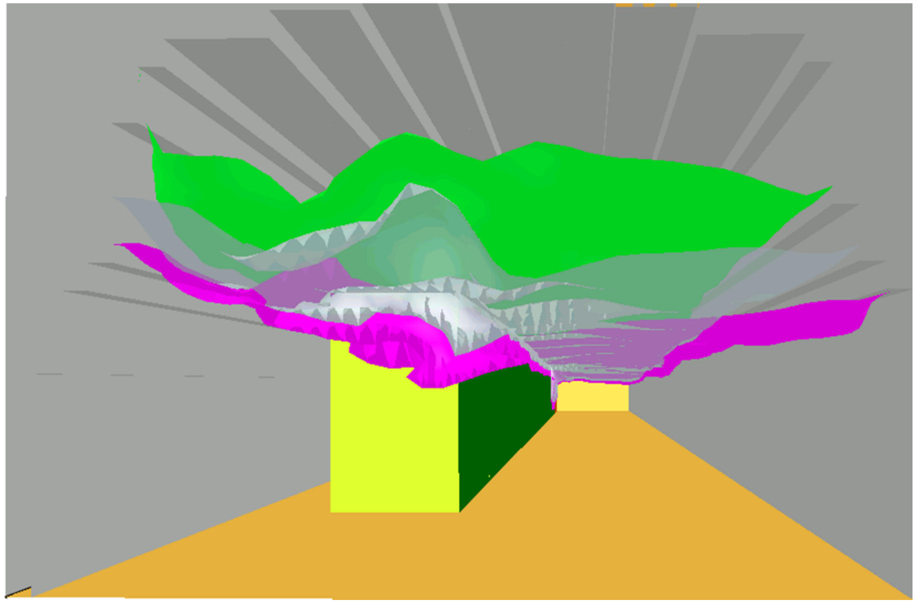
Topic 1 – Fire Modelling in the railway tunnel

Output parameters:



Smoke layer at the entry to the escape shaft in the 12th minute (line across the tunnel tube represents the 2.5 m height).

Note: Cooled smoke layer will diminish visibility on the escape walkway already at the end of evacuation; however, escaping people will not be endangered.



Isotherms just behind the train set at 40 °C (violet), 50 °C (grey) and 60 °C (green) in the 15th minute

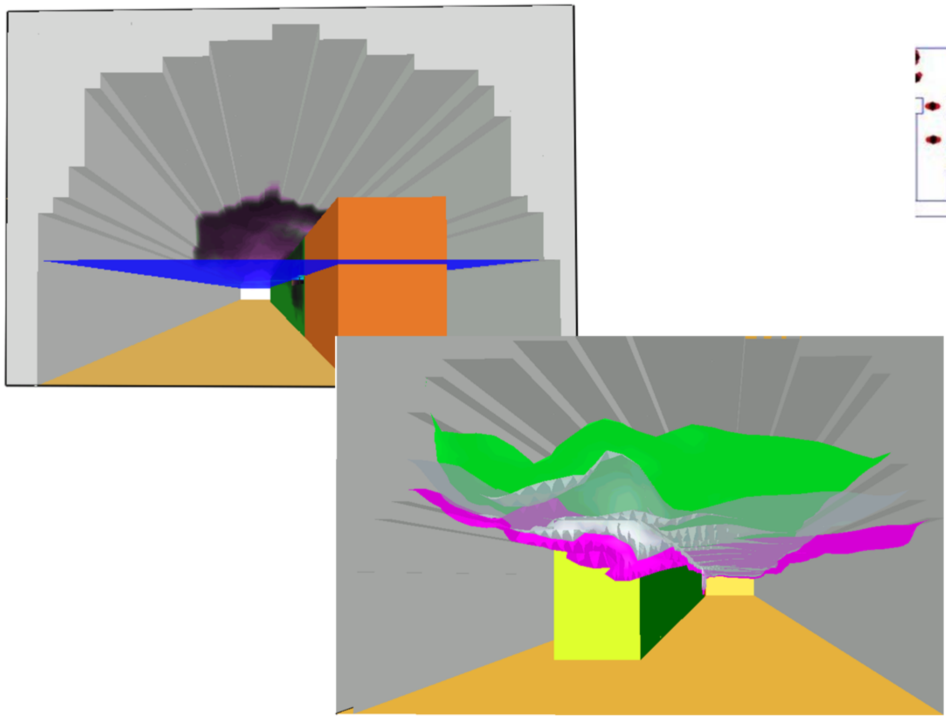
Note: These limit temperatures will not occur at heights less than 2.5 m on the walkway; they will not endanger in any way people escaping towards the entry to the escape shaft.Total evacuation time is about 12 minutes

TOPIC 2:

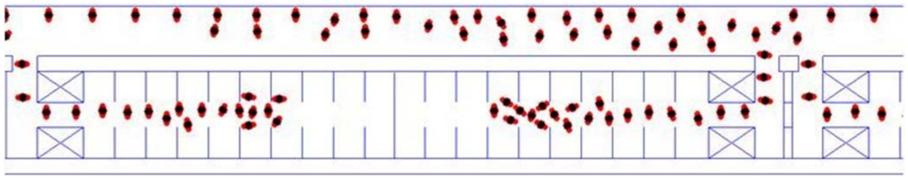
Evacuation time assessment in the railway tunnel

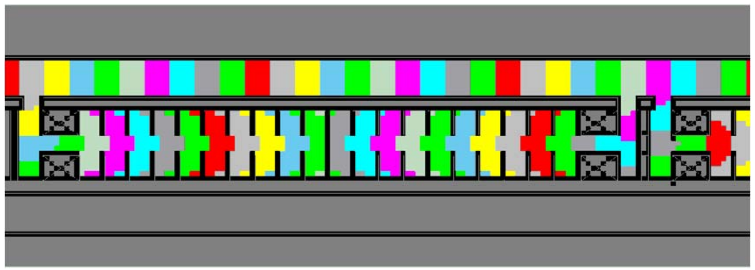
Topic 2 – Evacuation in the railway tunnel

Fire modelling



Evacuation

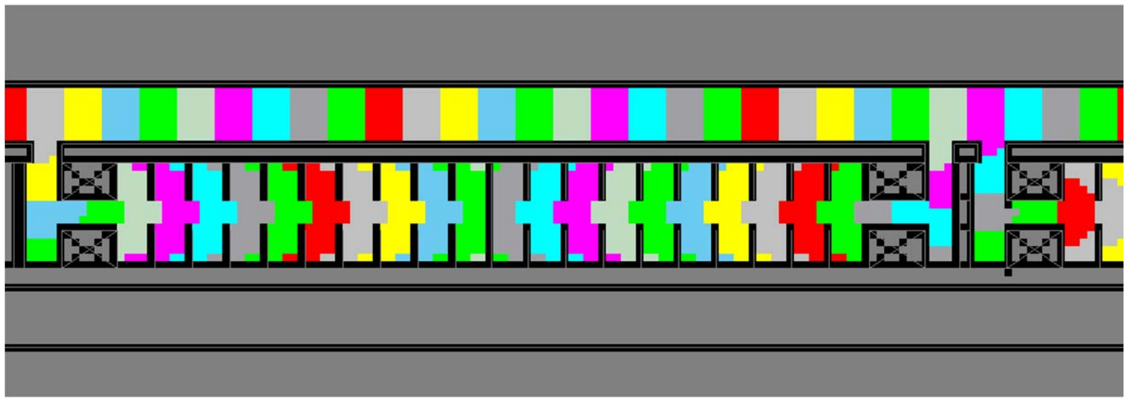




Input parameters:

- **Dimension of escape routes**
  - two directions along the **unprotected escape walkway** along the tunnel tube (toward the portal and entry to the escape shaft)
  - distance between the portal and the entry to the escape shaft is **605 m**
  - escape walkway width is **1.1 m**
  - width of door to the tunnel shaft is **1.4 m**

Distance map



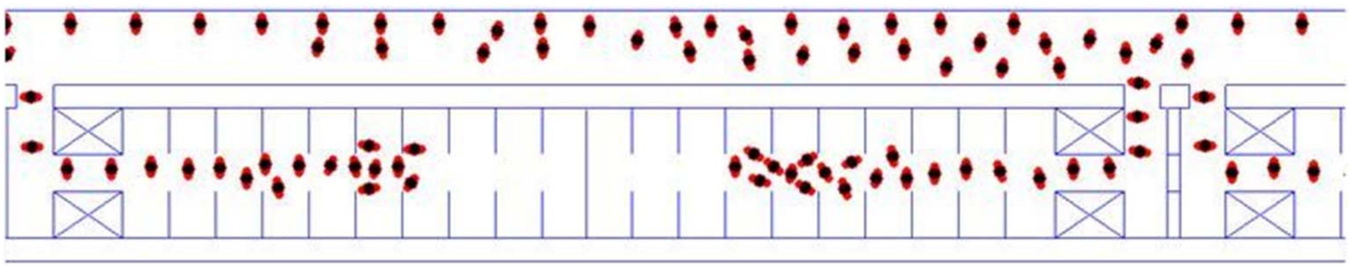
Topic 2 – Evacuation in the railway tunnel

Input parameters:

- **Definition of persons**
  - number of passengers – **640 pas.** (placement of people in a coach is even)
  - time delay before evacuation – **30 sec.**
  - average walking speed of people – **1.0 m/s**

- **Way of evacuation**
  - one half of the passengers (320 pas.) is designed to escape towards the portal and the other half of the passengers towards the entry to the escape shaft.

Programme SIMULEX



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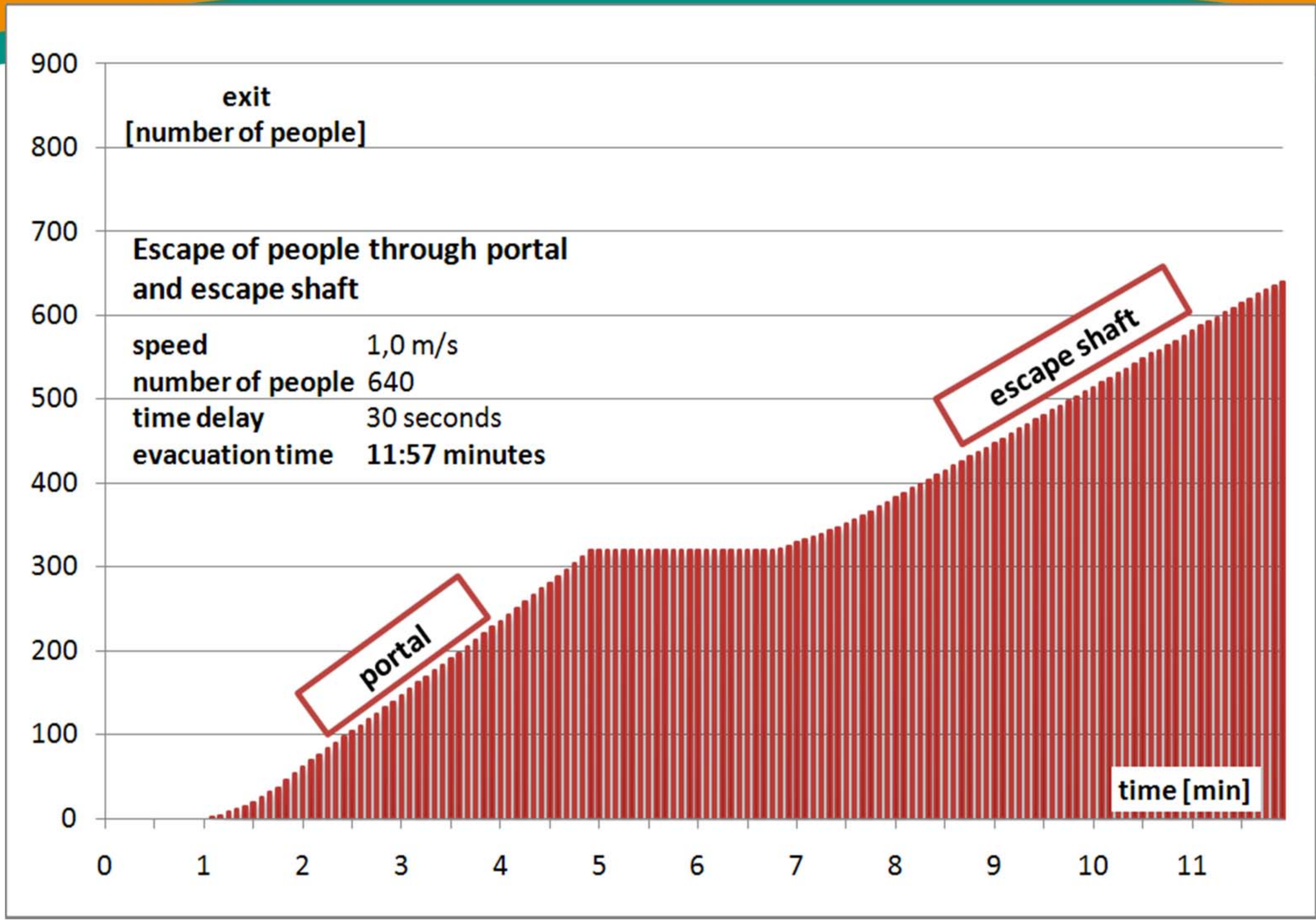
Topic 2 – Evacuation in the railway tunnel

RESULTS OF EVACUATION



In the course of evacuation they will not be endangered by high temperatures and smoke. Moreover, it has been verified that the visibility along the walkways is satisfactory.

THANK YOU FOR YOUR ATTENTION