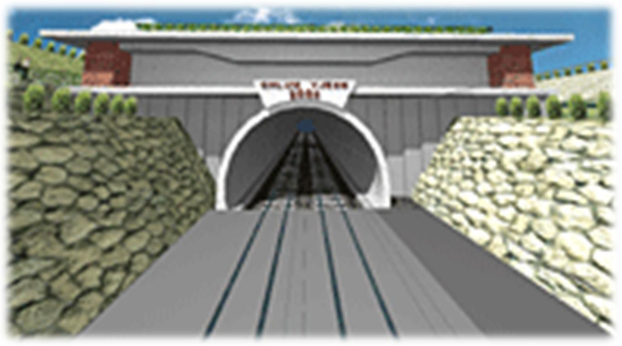
FIRE SIMULATION APPLICATION IN FIRE SAFETY DESIGN FOR TUNNEL STRUCTURES

Aleš DUDÁČEK – Isabela BRADÁČOVÁ – Petr KUČERA

VSB-TU of Ostrava, Faculty of Safety Engineering, Department of Fire Protection, Czech Republic



EVACUATION ANALYSIS

To verify the safe evacuation of people in case of fire on a train set in a railway tunnel, the following tasks were solved:

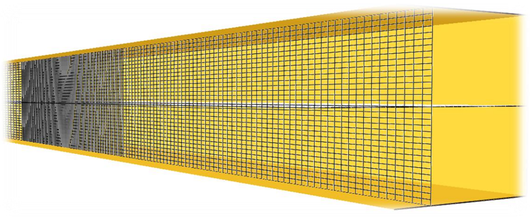
- development of temperatures during a fire in a tunnel
- smoke stratification during a fire in a tunnel
- evacuation time assessment

MODELLING OF TEMPERATURE DEVELOPMENT AND SMOKE STRATIFICATION

In the design of escape walkways, the worst variant is usually considered, namely a fire on a coach in the vicinity of entry into the escape walkway (cross-passage or escape shaft). People thus can escape merely along unprotected escape walkways leading to the entry to a neighbouring cross-passage or escape shaft or to the exit through tunnel portals. In addition, in the identification of the most unfavourable site of the fire it is necessary, in the case of a longitudinally inclined tunnel tube, to consider the stack effect owing to which people escaping in the direction chosen incorrectly may be directly exposed to the products of combustion.

Geometry of a Tunnel Model

People can escape along an unprotected escape walkway towards the entry to an escape shaft situated 605 m from a portal. The model tunnel length is selected at **610 m**, width at **12 m** and the maximum height of the tunnel arch at about **8 m**. Fire simulation time is **20 minutes**.

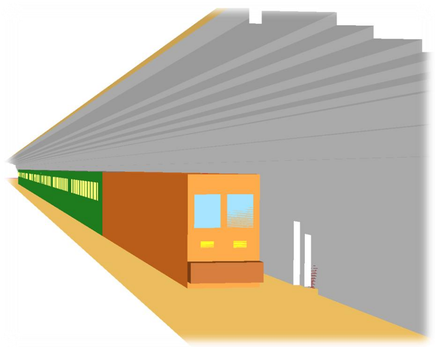


Geometry of a Train Set

For simulation, a passenger train set consisting of eight coaches and a locomotive of the total length of **225 m.** A fire in the first coach is assumed.

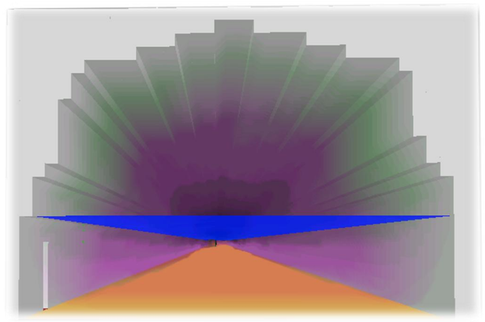
Definition of a Fire

A fire is defined by means of heat release rate.
Values of passenger train fire development during the first **20 minutes** grow gradually to **21 MW**.



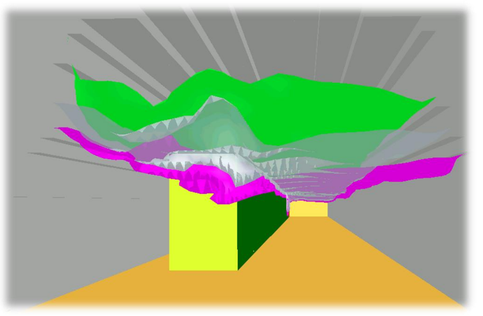
In the determination of temperature and smoke distributions in the tunnel, the program **FDS** (Fire Dynamics Simulator).

Graphic representation of results



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.

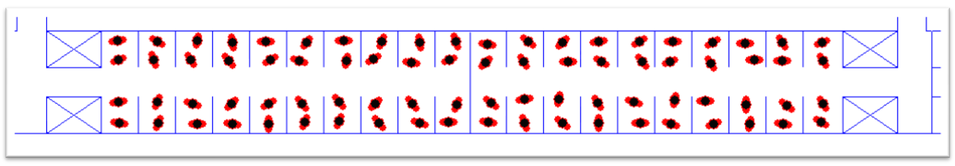
EVACUATION TIME ASSESSMENT

The aim of evacuation assessment using a **SIMULEX** model is to identify critical points for evacuation in the railway tunnel concerned, and to verify whether the designed escape walkways will enable people to leave through the tunnel escape shaft the space of affected tunnel tube in a sufficiently short time.

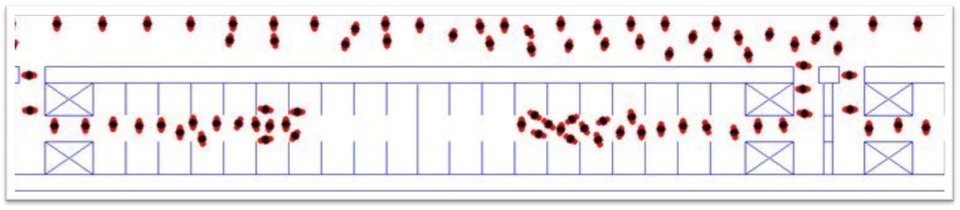
Geometry of the Tunnel Model and Preconditions for Evacuation

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**



Visualisation of placement of people in a coach (before evacuation)



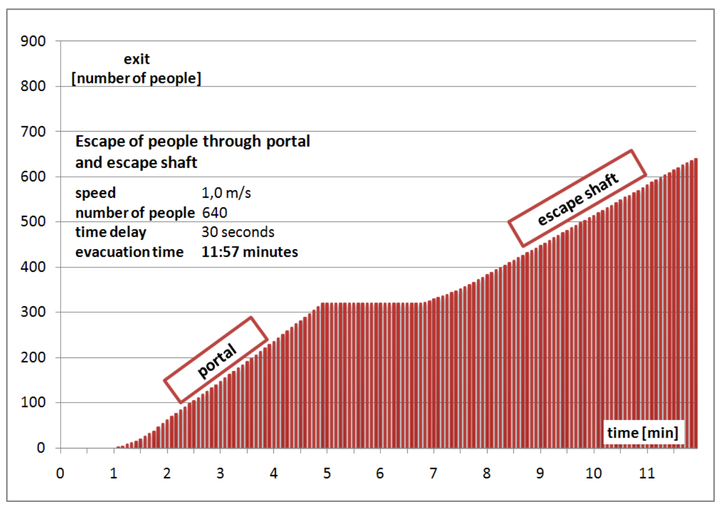
Visualisation of movement of people during evacuation

Definition of persons and Way of evacuation

- number of passengers – **640 passenger**
- time delay before evacuation – **30 second**
- average walking speed of people is **1.0 m/s**
- one half of the passengers (is designed to escape towards the portal and the other half of the passengers towards the entry to the escape shaft

Output data

Dependence of number of people escaping through the portal and the escape shaft on time



CONCLUSION

The evacuation of people towards the tunnel portal took only 5 minutes, whereas the evacuation towards the entry to the escape shaft lasted 11:57 minutes and was thus the factor decisive of the determination of total evacuation time.

Using the program FDS, the distribution of temperatures, the level of smoke layer and visibility during the fire on the train set in the tunnel were determined.

By modelling using the computer programs it has been verified that people will leave the tunnel within 12 minutes and that in the course of evacuation they will not be endangered by high temperatures and smoke. Moreover, it has been verified that the visibility (opacity) along the walkways is satisfactory.