FIRE RESISTANCE OF ROLLING STOCK ELEMENTS - 45545-3 STANDARD AND SPECIAL CASE OF TUNNELS

SUMMARY

- EN 45545-3
  - What is a fire barrier?
  - Requirements regarding fire resistance
  - Tests according to EN 45545-3
  - Examples

- Particular case of the tunnels
  - Tunnels: why and how?
  - 40 years of incidents
  - How to reduce the risks
  - Regulation in tunnels
  - Fire Engineering in tunnels.

EN 45545 -3:FIRE RESISTANCE REQUIREMENTS FOR FIRE BARRIERS

- According to EN 45545-1, a fire barrier is:

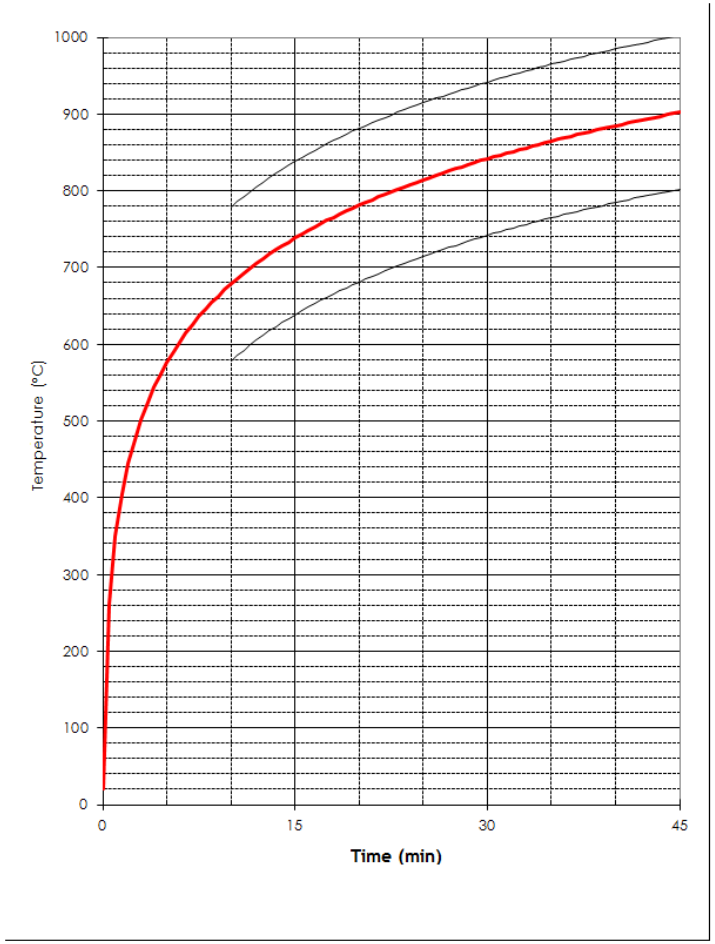
An element that is intended for use in maintaining separation between two adjacent areas of a railway vehicle in the event of a fire which resists to the passage of flame and/or heat and/or effluents for a period of time under specified conditions

- It can be:
- A wall
- A door
- A ceiling
- A floor
- A window
- A penetration system
- A battery
- A duct
- …

EN 45545 -3:FIRE RESISTANCE REQUIREMENTS FOR FIRE BARRIERS

- Tests according to EN 45545-3 are realized according to the general requirements of EN 1363-1 and specific requirements of EN standards, depending on the products:

- EN 1364-1
- EN 1364-2
- EN 1634-1
- …



EN 45545 -3:FIRE RESISTANCE REQUIREMENTS FOR FIRE BARRIERS

Three criteria are used for the classification:

-"E" criterion: Ability of a separating element, when exposed to fire on one side, to prevent the passage of flames and hot gases through and to prevent the occurrence of flames on the unexposed side.

-"I" criterion: Ability of a separating element, when exposed to fire on one side, to restrict the temperature rise of the unexposed face to bellow specified levels.

-"W" criterion: Ability of a separating element, when exposed to fire on one side, to reduce the probability of the transmission of fire as a result of significant radiated heat either through the element or from its unexposed surface to adjacent materials.

Penetrations through fire barriers (ducts, cables, …) should not reduce the fire resistance of the barrier.

Some fire barriers have a typical fire resistance performance according to the standard: E60 for a 2 mm thick steel sheet or E15 for a 5 mm thick aluminum sheet.

PARTICULAR CASE OF TUNNELS: WHY AND HOW?

- Historically, to avoid too important ramp impossible to use by vapour train and due to the low adherence of the contact wheel/rail (steel against steel).
- To cross an important geographic element (mountain, river, sea, …) and avoid the construction of a bridge.
- To conserve a straight railway (for High speed train especially).
- To avoid others problems (noise, …) and protect particular areas (patrimonial, safety issue, ..)

PARTICULAR CASE OF TUNNELS: WHY AND HOW?

- In the world, we list 78 tunnels longer than 12 000 m

Name	Length (m)	Date	Country
Tunnel de base du Saint-Gothard	57 104	2016	Switzerland
Tunnel du Seikan	53 850	1983	Japan
Tunnel under the Channel	50 450	1993	France - UK
Tunnel de base du Lötschberg	34 600	2005	Switzerland
Tunnel de Guadarrama	28 377	2007	Spain
Tunnel de Taihang	27 839	2008	China
Tunnel sous l'Hakkōda	26 445	2010	Japan
Tunnel d'Iwate-Ichinohe	25 810	2002	Japan
Tunnel du Qingyunshan	22 175	2013	China
Tunnel de Dai-shimizu	22 000	1982	Japan
Tunnel de Wushaoling	21 050	2006	China
Tunnel de Lüliangshan	20 800	2011	China
Tunnel de Geumjeong	20 323	2010	South Korea
Tunnel du Simplon	19 823	1905	Italy
Tunnel de la Vereina	19 042	1999	Switzerland
Tunnel Shin-Kanmon	18 713	1975	Japan
Tunnel de Vaglia	18 711	2009	Italy
Tunnel de base des Appenins	18 507	1934	Italy
Tunnel de Qinling	18 457	2000	China
Tunnel du Xuefengshan	17 892	2013	China

PARTICULAR CASE OF TUNNELS : WHAT ARE THE RISKS?

- Landslide, earthquake, avalanche
- Flooding

} **Natural risks**

- Accidents
- **Fire / Explosion**
- Toxic leaks
- Unadapted behavior/ Problems of comprehension

} **Technological risks**

- Problem of materials

} **Maintenance risks**

- Vandalism/Terrorism

} **Security**

PARTICULAR CASE OF TUNNELS : 40 YEARS OF INCIDENTS

- Tunnel of Simplon (1962)
- Tunnel of Crozet (1971)
- Tunnel of Vierzy (1972) -> 108 deaths and 111 injured
- Tunnel of Hokoriku (1972) -> 29 deaths and 703 injured
- London Underground (1975) -> 43 deaths and 100 injured
- Tunnel of Mexico (1975) -> 23 deaths and 55 injured
- Koln Subway (1978)
- Tunnel of San Francisco (1979) -> 1 deaths and 56 injured
- Tunnel of Hirschgraben (1991) -> 50 injured
- Bakou Subway (1995) : -> 337 deaths and 270 injured
- Tunnel under the Channel (1996) -> 8 injured
- Tunnel of Salerno (1999) -> 4 deaths and 9 injured
- Tunnel of the funicular of Kaprun (2000) -> 155 deaths
- Tunnel of Biogna (2003) -> 2 deaths
- Tunnel under the Channel (2006 and 2008)

PARTICULAR CASE OF TUNNELS : 40 YEARS OF INCIDENTS

Tunnel or subway	Time of smoke spread	Time of evacuation	Evacuated persons
SIMPLON	14	38	40
HOKORIKU	19	450 (7h30)	700
KOLN	11	5	8
SAN FRANCISCO	3	50	40
MUNICH	5	Empty	0
BERLIN	5	Empty	0
HIRSCHGRABEN	8	20	300
UNDER THE CHANNEL	10	30	34

PARTICULAR CASE OF TUNNELS : 40 YEARS OF INCIDENTS

- A number of persons potentially more important
- A higher length of the tunnels
- Smaller dimensions of the tunnels.
- A more difficult access to the incident site
- Longer fires (more materials to burn)
- In general, tunnels are older (less equipments, old standards, …)
- Socio-economic impact sometimes more important
- Means to use more important

The problematics are similar to the road tunnels, but at a bigger scale.

PARTICULAR CASE OF TUNNELS : HOW TO REDUCE THE RISKS?

- Modify the traffic
  - No crossing of trains inside the tunnel
  - Reduce the speed
  - Avoid any stop in the tunnel (no matter the reason)
- Reduce the risk at its origins
  - Reduce the calorific potential
  - Avoid the flammable material (reaction to fire)
- Provide efficient detection material in order to optimize the time of evacuation and the definition of the strategy to stop the fire.
- Provide evacuation materials (light, radio, protected evacuation way, …)
- Provide fixed and mobile adapted fire fighting materials (sprinklers, extinguishers, fans, …)
- Protect the tunnel in order to avoid any collapsing, facilitate the intervention and allow the reopening of the tunnel (resistance of fire)
- Development a training program, efficient and regularly used

PARTICULAR CASE OF TUNNELS : THE REGULATION

The objectives are:

- Assuring a minimal level of safety inside the tunnels:
  - Administrative procedures
  - Particular technical adapted materials
  - Operational procedures
- Define and harmonize the equipment level between the countries
- Impose to the exploitation society a continous improvement
  - Intervention trainings
  - Regular exchanges with all the security services
- Impose to the states to realize information campaigns

In a general way, the regulation dispositions are used for new tunnels

They can also be the basis for the evaluation of the existing elements (or in construction)

But the existing elements which should be modified are generally under an exemption (problem of feasability)

PARTICULAR CASE OF TUNNELS : THE REGULATION

- The international regulation is based on the International Union of Railways (IUR) rules, which describes the applicable test methods. This system is a minimum.

- For example, for the reaction to fire, the principal rules are:
  - Rule 564-2 : Relative to the trailed material. Each country has also the possibility to use its own reaction to fire test standards.
  - Rule 642 : relative to engine materials
  - Rule 779-9…

- On the European level, use of the Technical Specifications of Interopability provide by the Décision 2008/232/CE (21/02/2008)
- It covers: the safety, the signals, the gap between rails and rows, the electric systems, … They are edited by the European Rail Agency

And finally, use of the EN 45545 standards

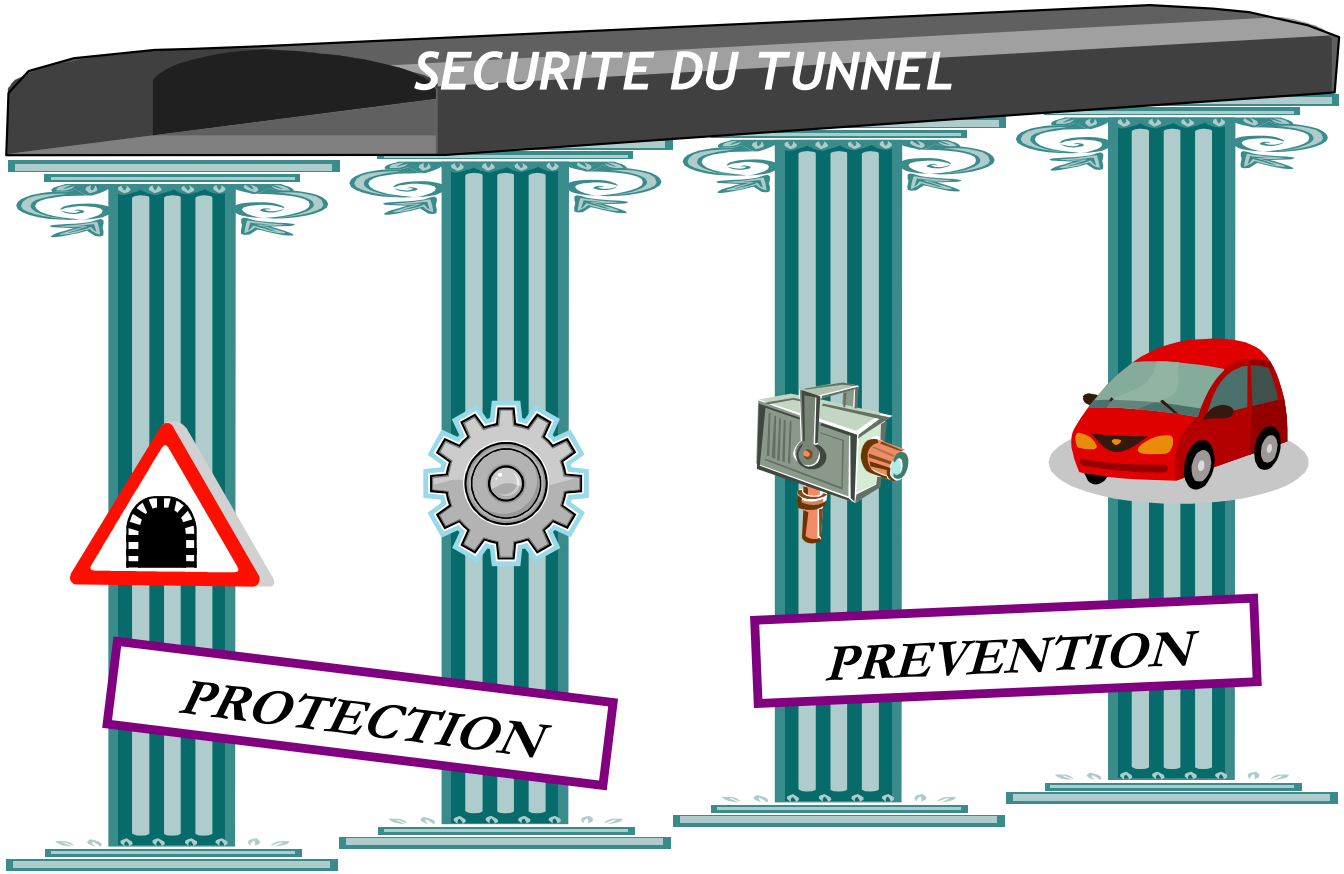
PARTICULAR CASE OF TUNNELS : THE SAFETY

1 : Configuration

2 : Level of equipments

3 : Exploitation

4 : Behavior of users

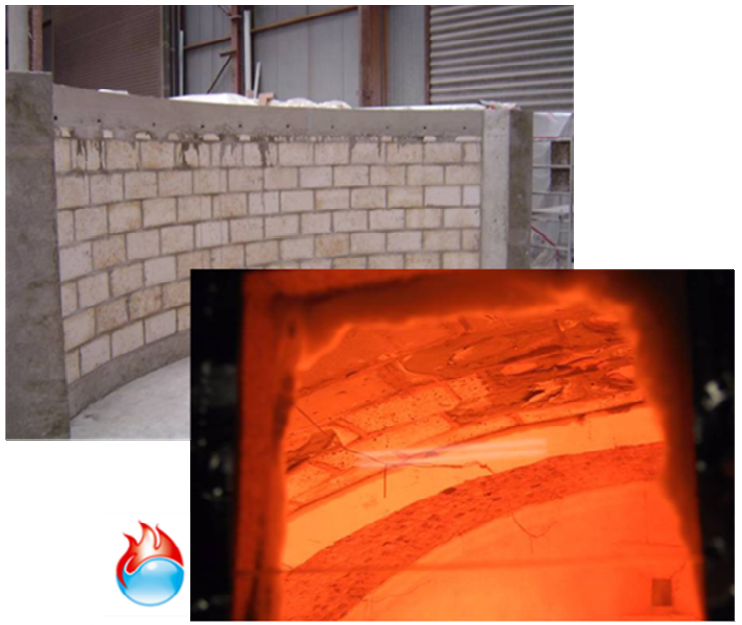


PARTICULAR CASE OF TUNNELS : REACTION TO FIRE

- Materials for the construction must be A1
- Materials of the infrastructure must be:
  - A2 s1 d0 for the covering or the ceilings
  - B s1 d0 for lateral covering only
- Cables must satisfy to the standards EN 50267-2-1, EN 50267-2-2 and EN 50268-2

PARTICULAR CASE OF TUNNELS : RESISTANCE TO FIRE

- The principal structure must be R 120
- The secondary structures (for example, ducts, technical room, …) has to be REI 120 or EI 120
- Doors must be EI 60
- Fans must be F200°C/120
- Escape ways must be EI 120



Eprouvette « voûte de tunnel » en test à la station d'essais d'EFECTIS France à Maizières-lès-Metz

PARTICULAR CASE OF TUNNELS : DISPOSITION FOR THE ROLLING STOCK MATERIALS (RM)

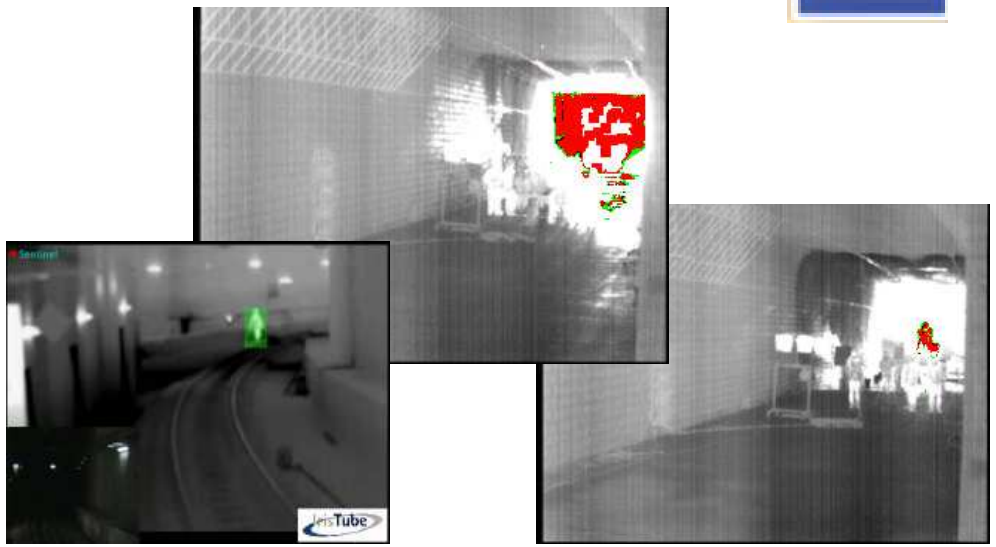
- A RM used for tunnels lower than 5 km, in which a lateral evacuation is possible, is called « category A ». In case of fire, the train will continue in order to reach a refuge in a delay lower than 4 minutes, at 80 km/h.

- For all the tunnels, the RM built to use all the european railways is called « category B ». Resistant to fire barriers are used to protect the persons during 15 minutes after the start of the fire. They are realized in order to allow the train to go out a 20 km tunnel at a speed of 80 km/h.

- If the train cannot go out the tunnel, the evacuation of persons will be done by the dedicated infrastructure means.

PARTICULAR CASE OF TUNNELS : DETECTION AND COMMUNICATIONS

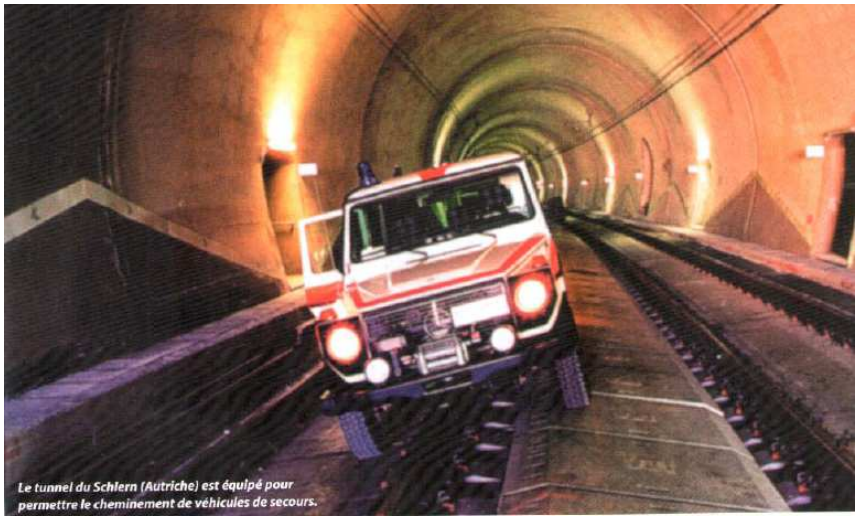
- The detection can be done on field or at the Control Office:
  - Thermometric cables
  - Opening of a door
  - Analysis of the air (CO for example)
  - Video-surveillance
  - Automatic detection of incident
  - …



- For the communications, two lines at least must exist
- The continuity must be kept during at least 1h
- The communication system must allow the localization of the RM

PARTICULAR CASE OF TUNNELS : FIRE FIGHTING

- Water providing and resistant to fire evacuation system
- Specific vehicles for the intervention



PARTICULAR CASE OF TUNNELS : FIRE FIGHTING (SPRINKLERS)

- Sprinkler systems in tunnel are not often used (principally in Japan).

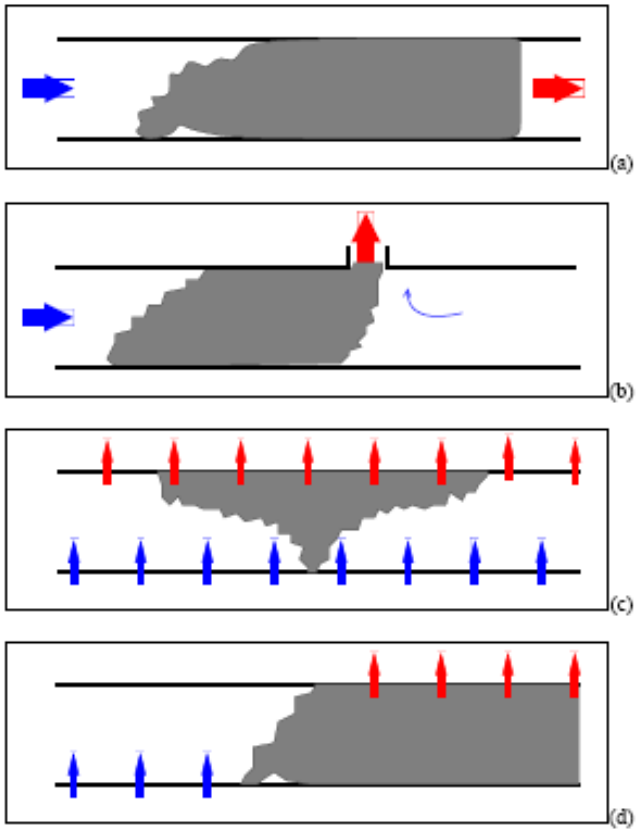
- Avantages :
  - Limit the temperature rise
  - Limit the spread of fire
  - Facilitatethe intervention of the firemen
  - Protect the infrastructure

- Inconvenients :
  - Important cost for the maintenance
  - Efficiency not proved regarding the personal safety
  - Loss of visibily inside the tunnel (water fog, unstratification of smoke + toxicity).

PARTICULAR CASE OF TUNNELS : VENTILATION

- Transversal ventilation : the aim is to keep the smoke at the top (stratification)
- Longitudinal ventilation : the aim is to « push » the smoke in only one direction in order to keep the other free of smoke (use of Jet Fans).
- Mix systems.

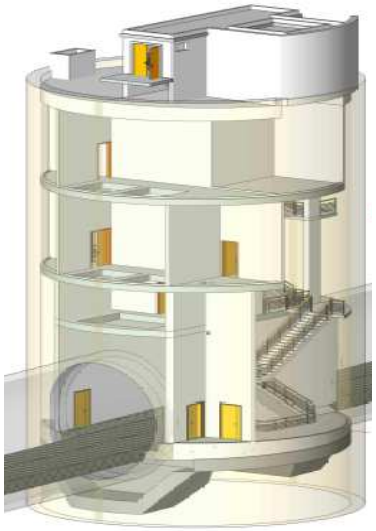
Préparation de l'essai de tenue au feu d'un accélérateur à la station d'essai d'EFECTIS France à Maizières-Lès-Metz



PARTICULAR CASE OF TUNNELS : EVACUATION

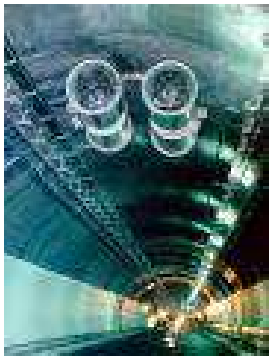
- Must be avoid at the maximum in tunnels!

- If there is no alternatives, the priority must be the evacuation by another train (lorries)

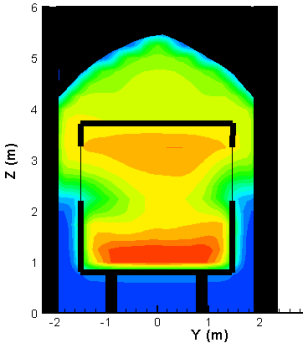


- The signalization and the safety exits must be clearly visible.

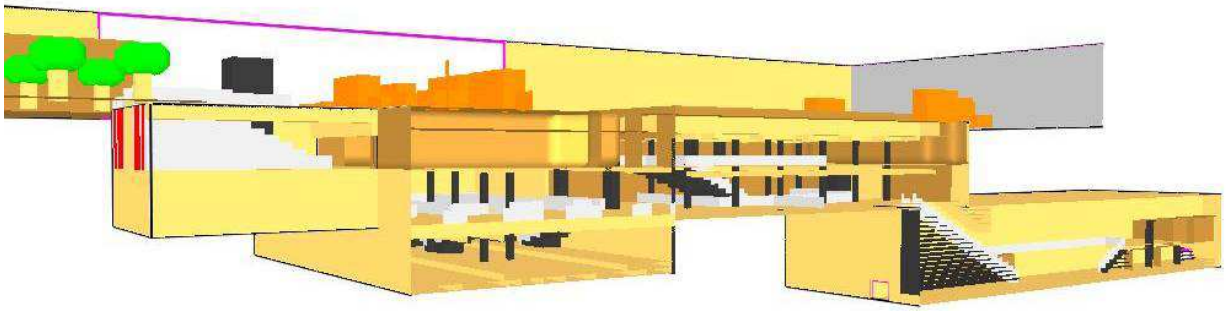
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING

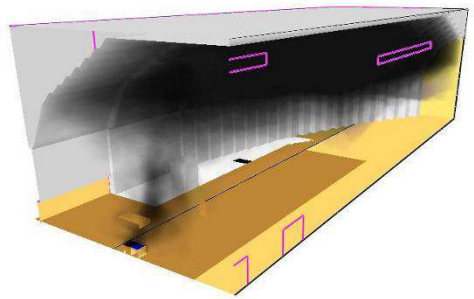


- Ventilation et smoke exhaust
  - Smoke engineering
  - Numerical simulation
  - Study of the ventilation system
  - On site fire tests



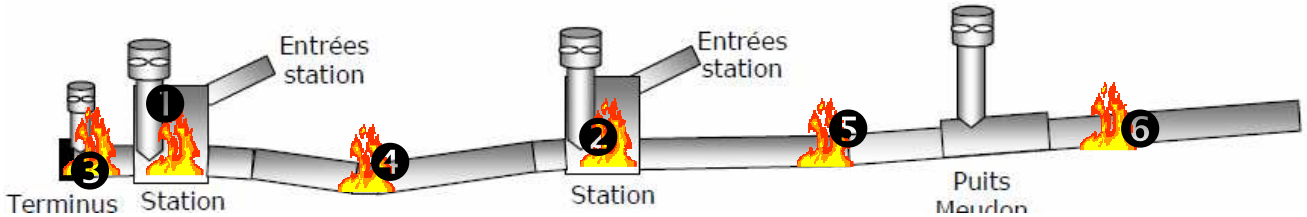
- Reaction to fire
  - Analysis of the fire behavior
  - Determination of the protection of structures
  - Calorific behavior of the RM





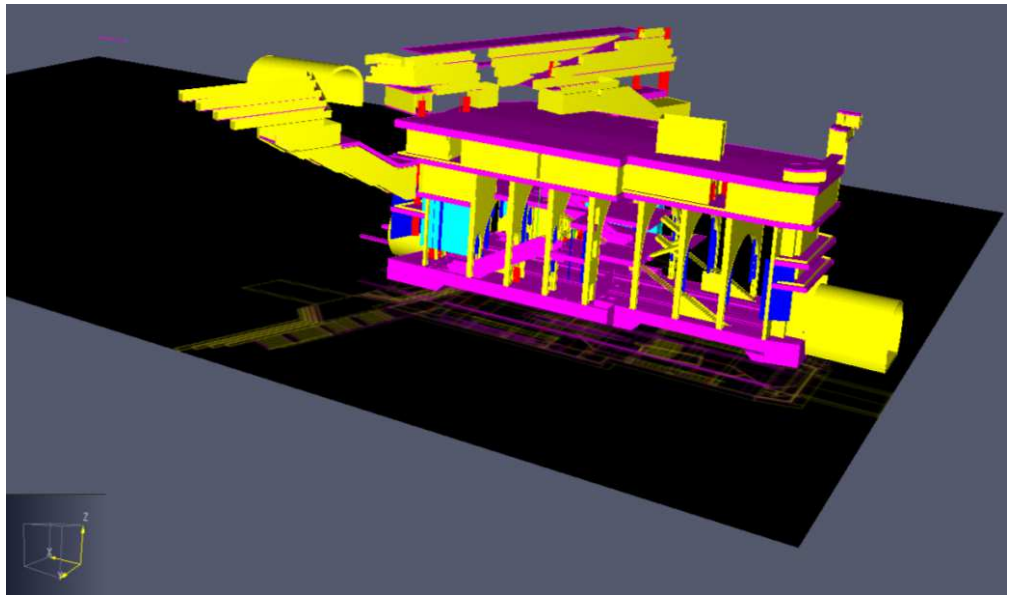
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING

- Caracterization of the fire (duration, localization, geometry, power, …)
- Modelization by « parts », with all the geometric informations



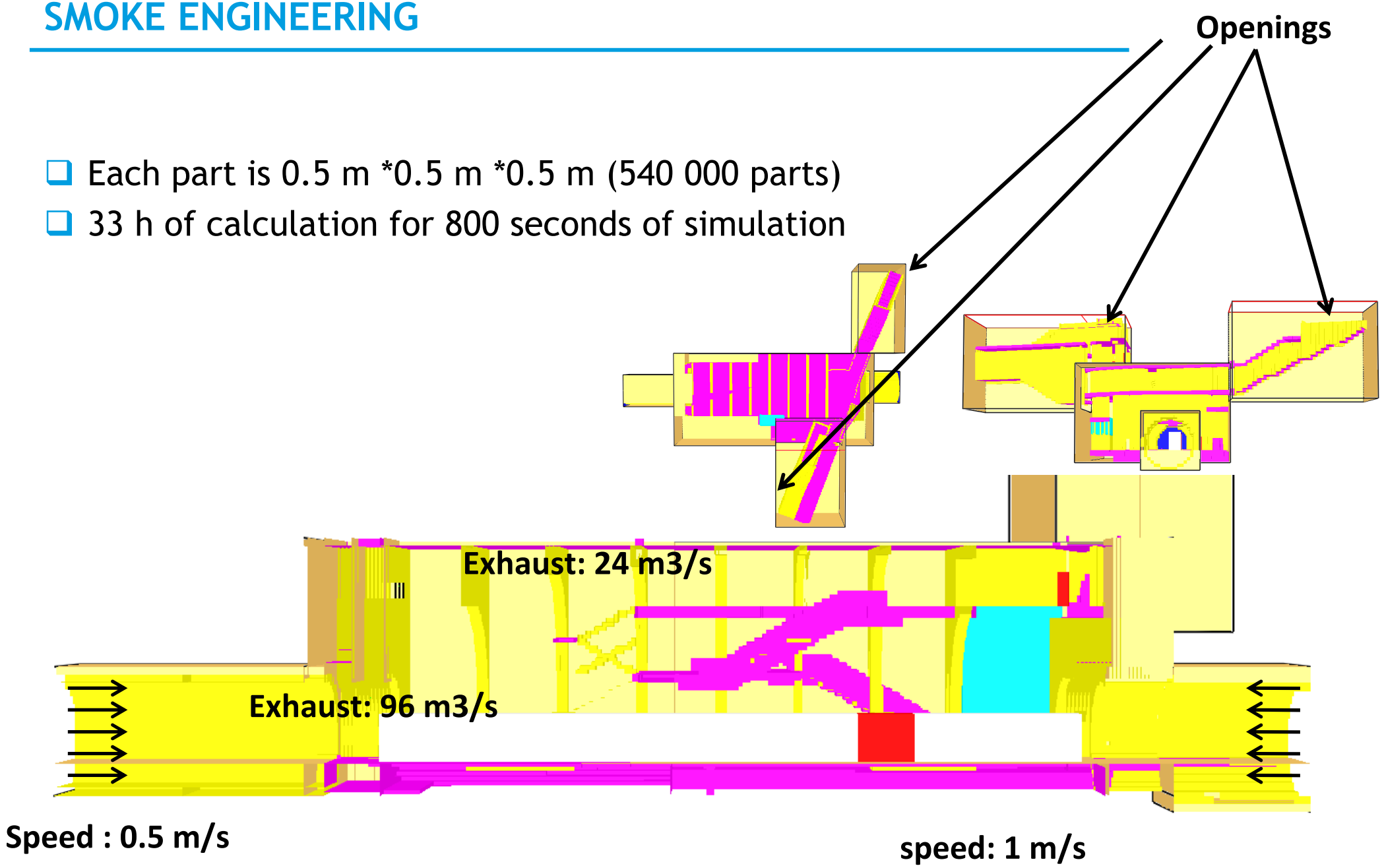
- Use of specific program (FDS, SAFIR, …)

PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING – EXAMPLE OF SMOKE ENGINEERING



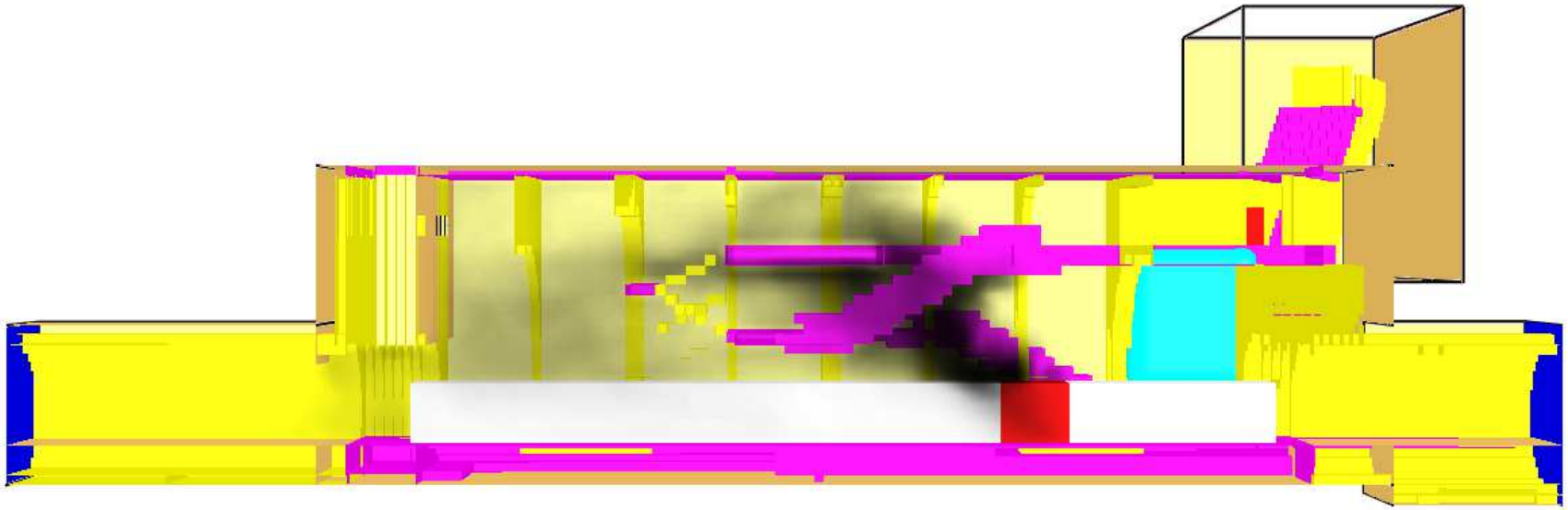
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING - EXAMPLE OF SMOKE ENGINEERING

- Each part is 0.5 m *0.5 m *0.5 m (540 000 parts)
- 33 h of calculation for 800 seconds of simulation

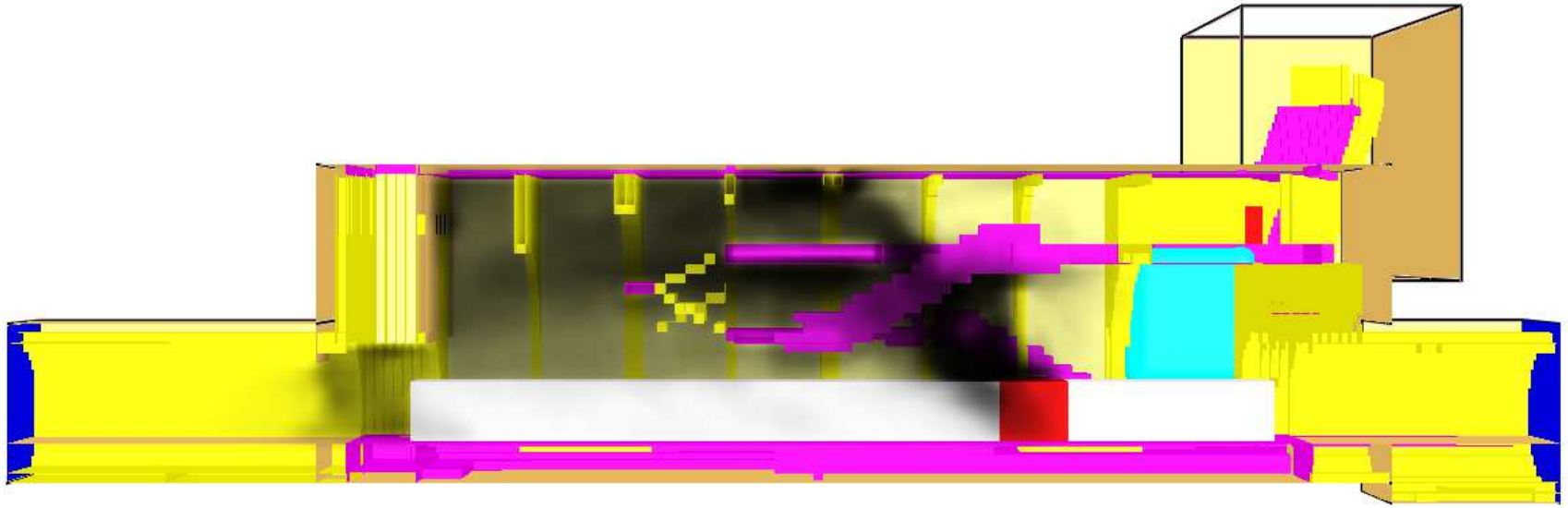


PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING - EXAMPLE OF SMOKE ENGINEERING

- t = 1 min



- t = 2 min



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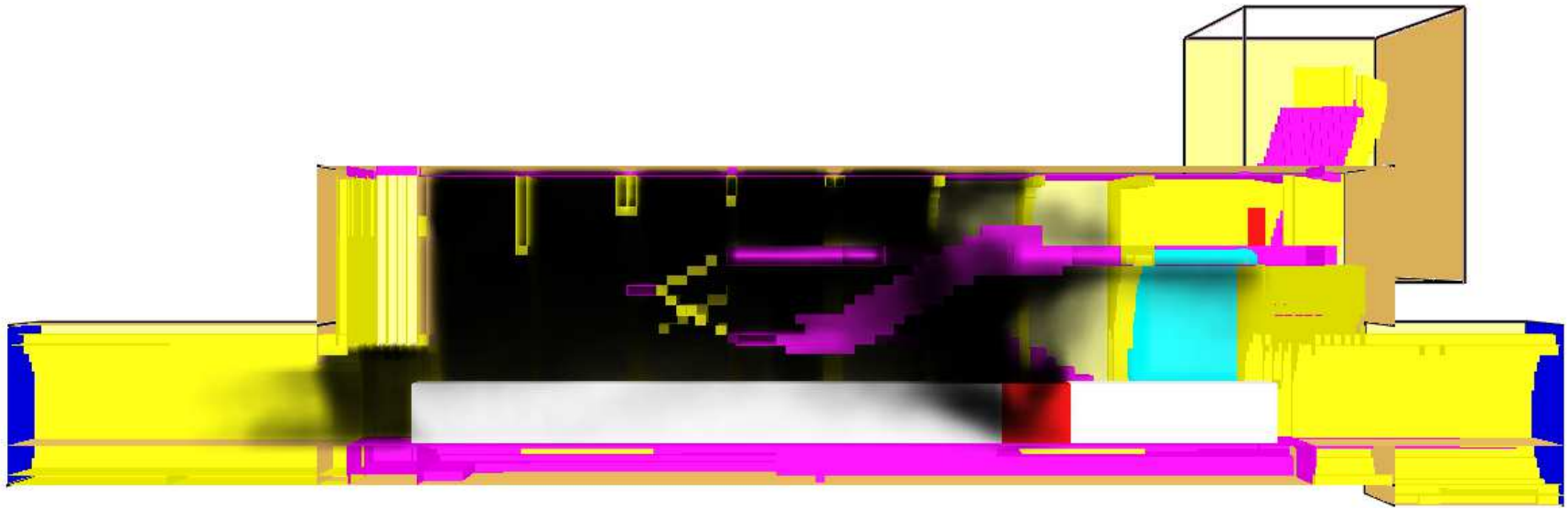
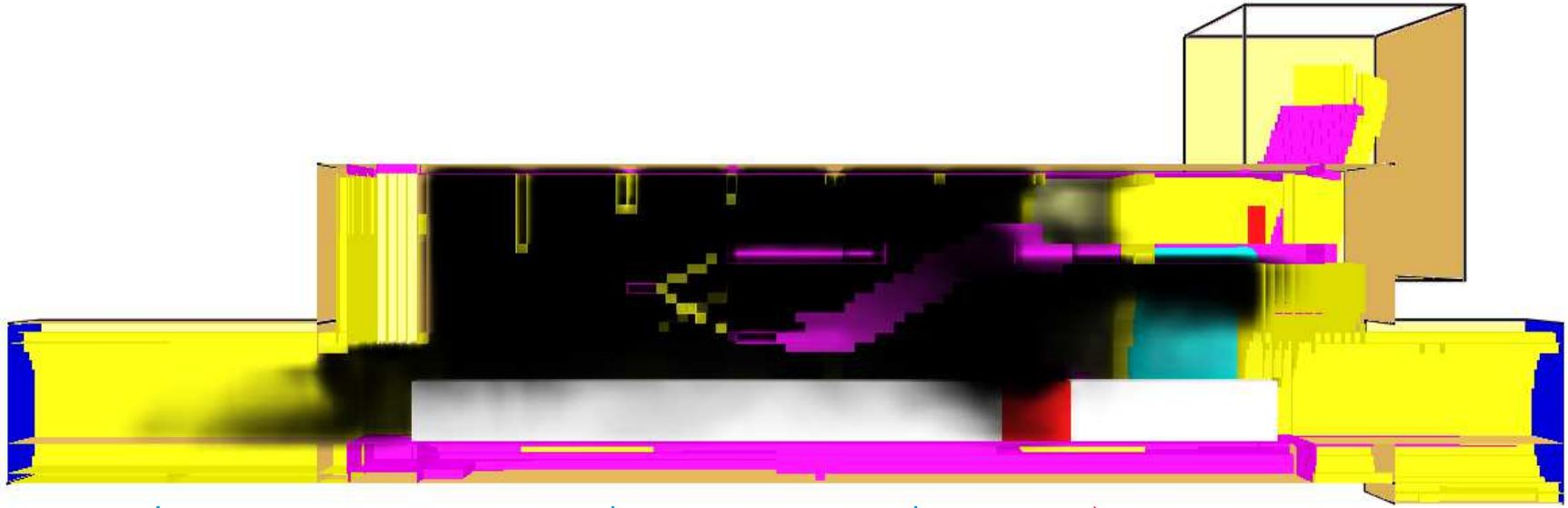
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING - EXAMPLE OF SMOKE ENGINEERING

- t = 5 min



- t = 10 min



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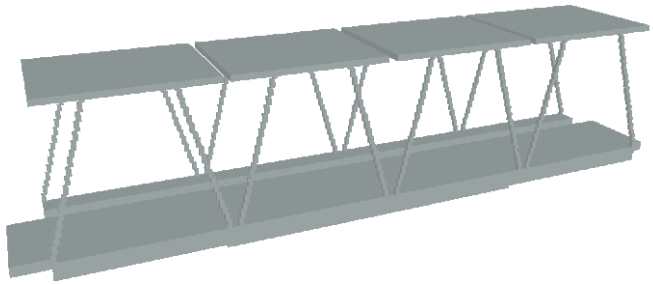
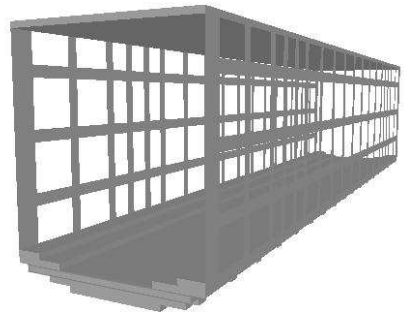
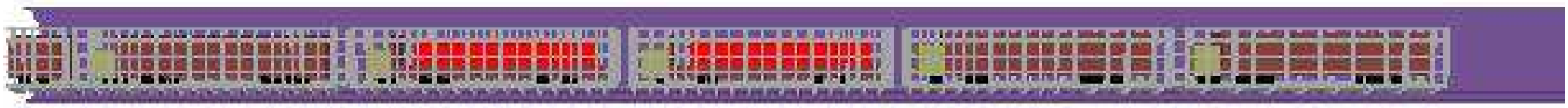
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING – EXAMPLE OF FIRE BEHAVIOR

- Request
  - Structural stability during 30 min

- Engineering
  - Verify the possibility for the train, in case of fire, to go out from the tunnel (30 min)
  - Modelization of the fire
  - Calculation of the thermal actions







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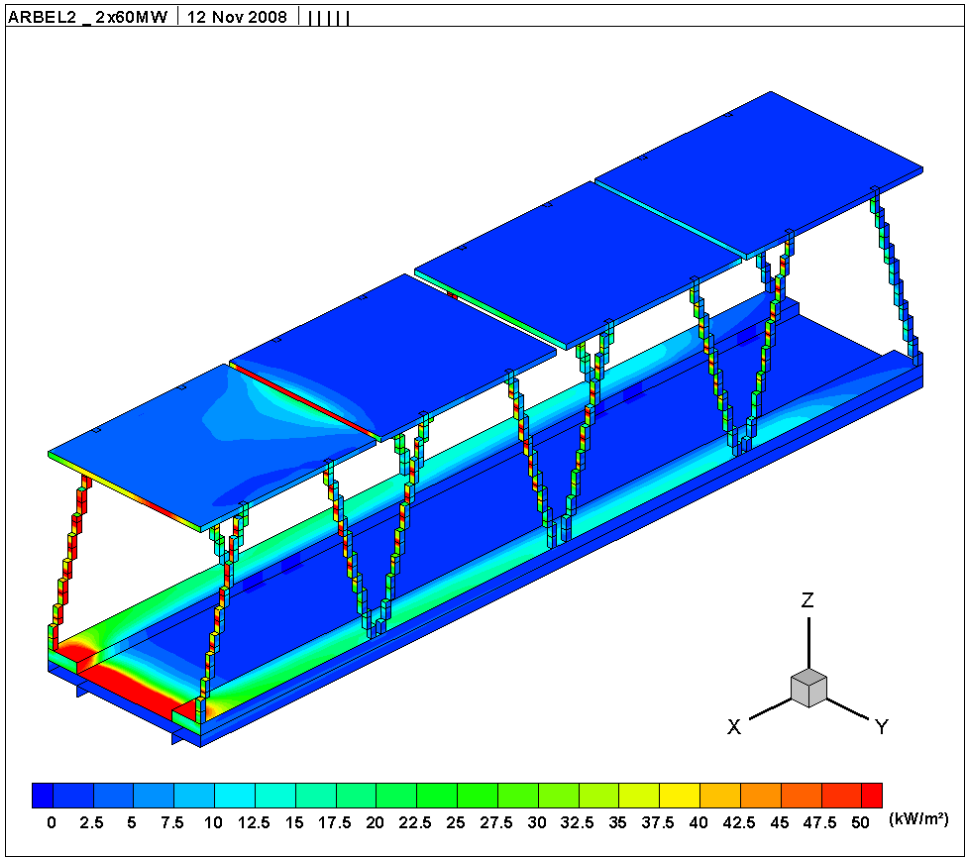
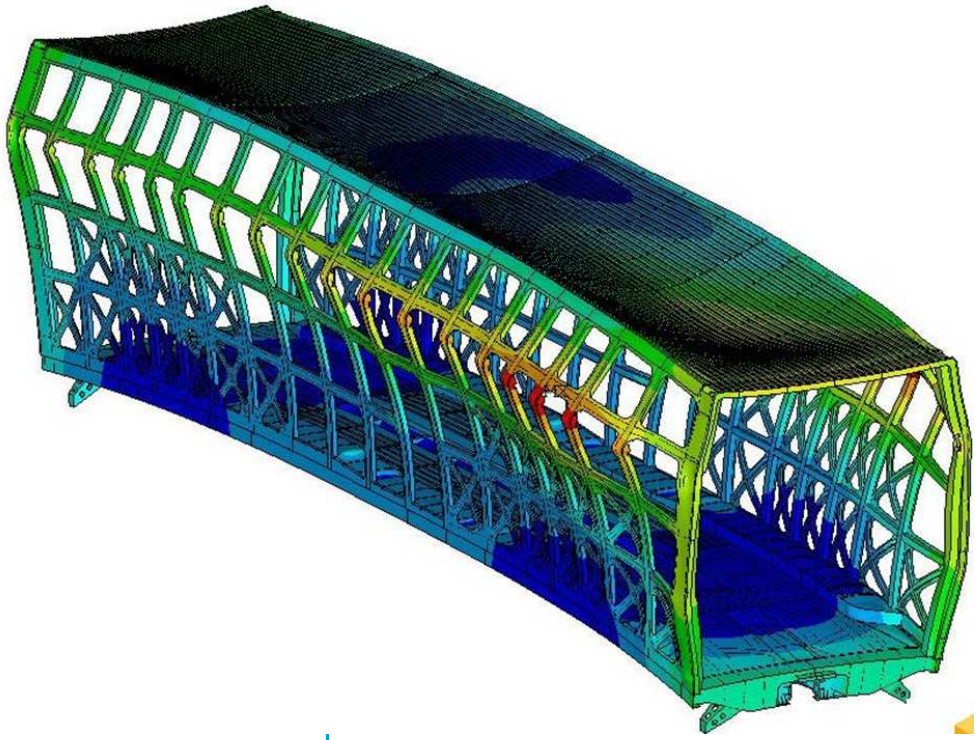
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING – EXAMPLE OF FIRE BEHAVIOR

Calculation of the thermal actions and the deflections





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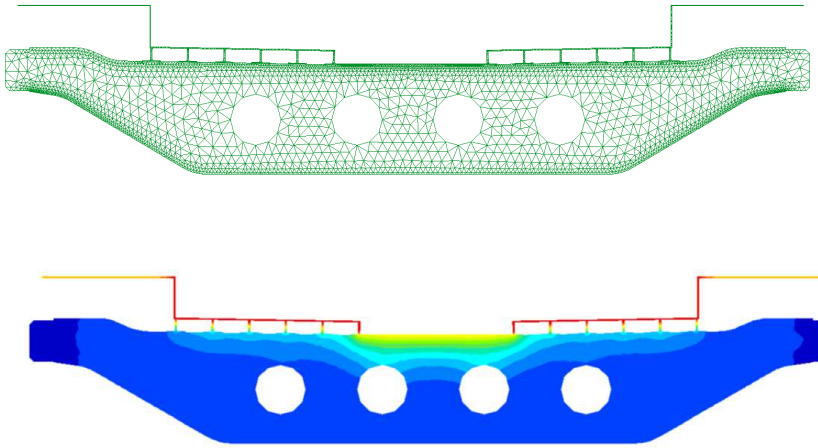
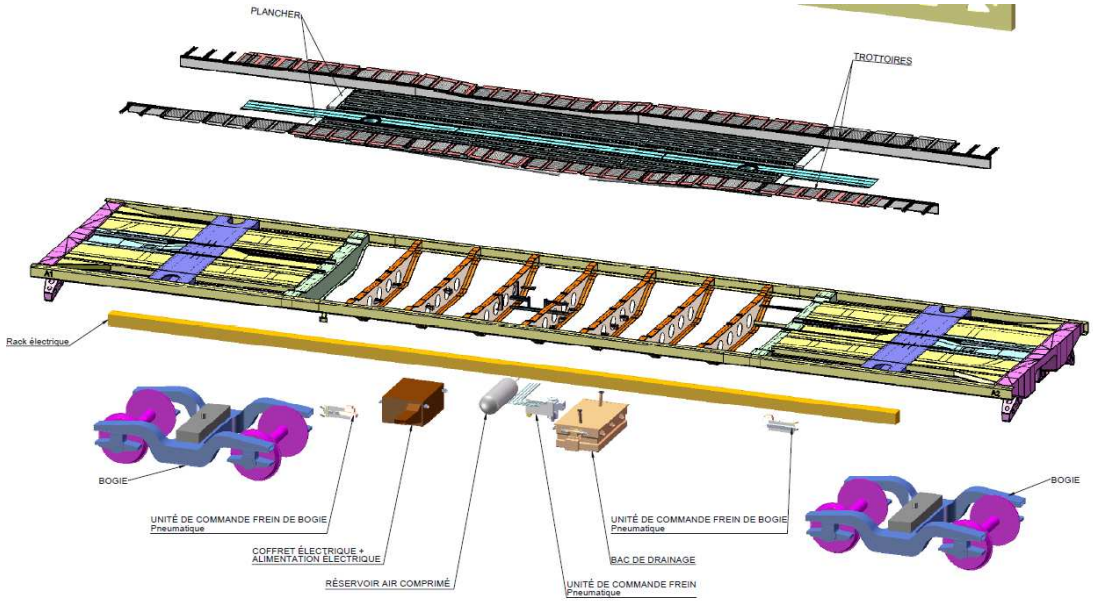
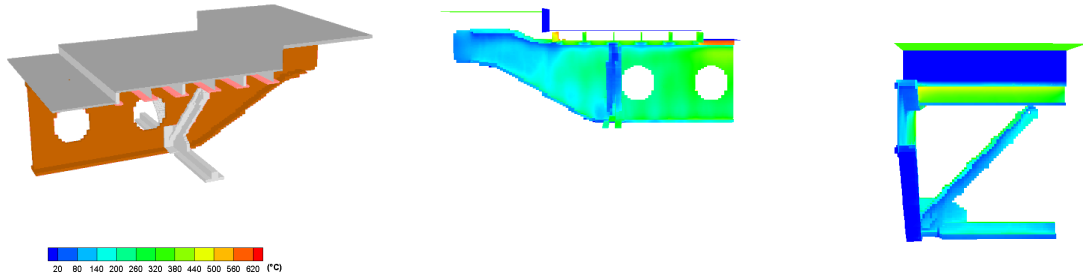
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING – EXAMPLE OF FIRE BEHAVIOR

Calculation of the thermal transfer in each part of the RM







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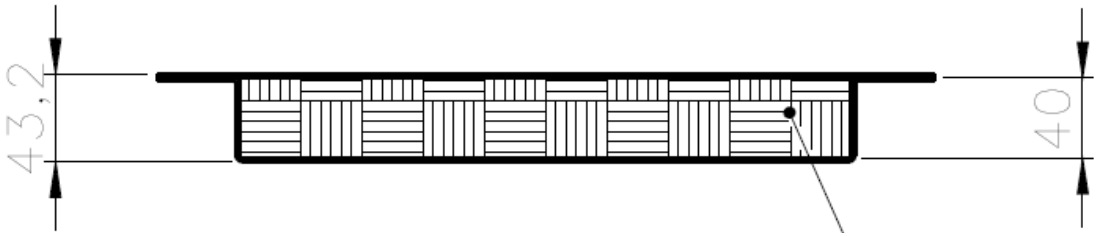
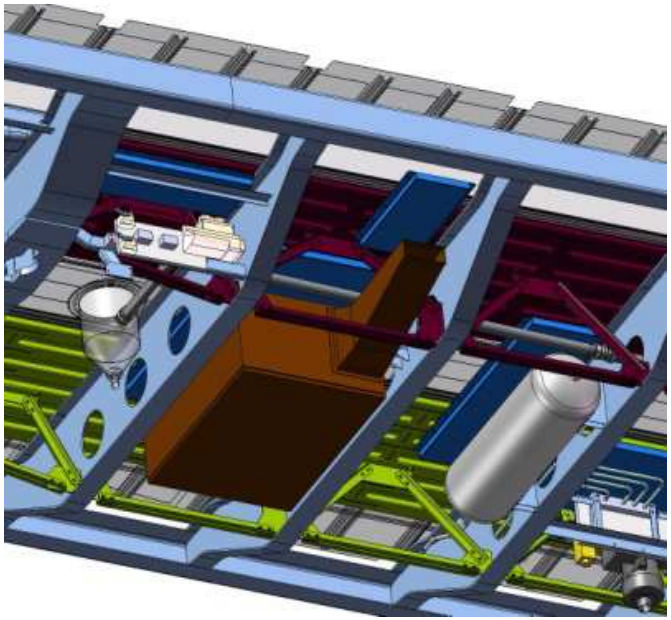
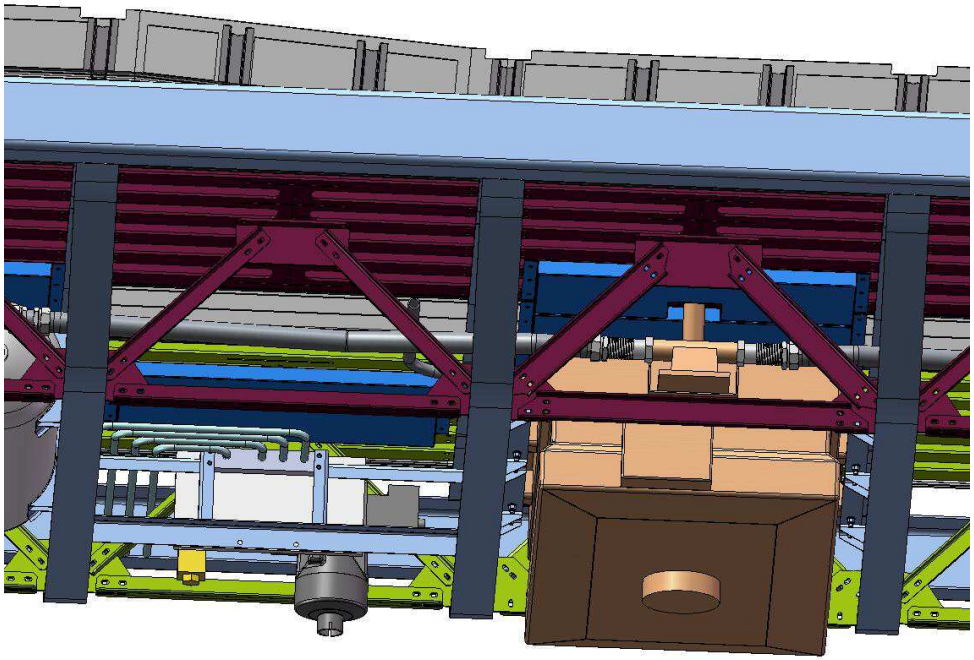
PARTICULAR CASE OF TUNNELS : FIRE ENGINEERING – EXAMPLE OF FIRE BEHAVIOR

Conclusion: Need of thermal protections







Thank you for your attention!