“Comparison of fire safety problems for the various transport modes in tunnels”

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Comparison of fire safety problems for the various transport modes in tunnels

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1. INTRODUCTION

1. Introduction

- All transport modes use tunnels:
  - -on a track: pedestrians, cyclists, skiers
  - -on a road: motorcycles, cars, vans, buses, small or large lorries…
  - -on rail: freight trains, passenger trains, metros, tramways, funiculars
  - -on water channel: commercial or pleasure boats
- The fire risk in a tunnel:
  - -concerns all the transport modes
  - -comes from the outside (vehicles)
  - -this is recalled by the recent disasters
- The fire problem is different according to the transport mode :
  - -infrastructure of the tunnel
  - -nature of traffic
  - -transportation safety
  - -operating mode
  - -response of the users and management

1. Introduction

- We examine the three transport modes which use most largely tunnels:

  road

  rail

  metro

- The paper aims at comparing the general fire safety problems for the three modes

- Afterwards, N.P. Hoj; P. Zuber and D. Gabay will present successively the compared fire safety features for road, rail and metro

2. General data on tunnels

2. General data on tunnels
Tunnel length

- in Europe,in cumulated length: several thousands km of road,rail or metro tunnels

- for road and rail lengths are most varying
  - from several m to several tens km
  - below 200m: minor risks

- for metro: the whole network is underground

2. General data on tunnels
Tunnel length

Maximal length of tunnels in Europe :

- **Road tunnels:**
  - **-urban:several km but high traffic (100000 veh/day)**
  - **-interurban: 10 to 20 km even 24.5 km but with 5 to 10 % of urban traffic, or less**
- **Rail tunnels:**
  - **-the longest at present:Channel tunnel - 50,5 km**
  - **-under project :Gotthard - 57 km and others**
- **Metro :**
  - **-underground line of 10 km and over**
  - **-but the stations cut the line into successive small tunnels of 500 m to 800 m**

2. General data on tunnels
Number of tubes

- Road tunnels:
  - -bi-tube for heavy traffic
  - -often mono-tube for very long tunnels

- Railway tunnels:
  - - mono-tube: the most common
  - - bi-tube for long recent tunnels

- Metro :
  - - mono-tube: the most common
  - - bi-tube in some cities

2. General data on tunnels
Cross-section

- Road tunnels:
  - -the vehicles are not guided: lanes are wide
  - -elevated lateral walkways are often available
  - -the cross-section is rather wide, except with a ventilation ceiling (transverse system)

- Railway and metro tunnels:
  - - the rolling stock is guided by the rail
  - - the tunnel width is optimised
  - - the cross-section is often smaller than for road

3. Place of tunnels in safety of the general operation for the 3 transport modes

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Road transport

- The accident rate is rather lower in tunnels than on open roads
- But road is the most dangerous of the three transport modes
- For some tens years the danger has been increasing: very high increase of traffic and transported tonnage
- Consequences in tunnels: additional safety arrangements
- Most european countries have minimal national regulations for safety

3. Place of tunnels in safety of the general operation for the 3 transport modes
Rail transport

- The safest transportation mode
- Important feedback on experience regarding operation
- The tunnel protects from the outside incidents
- The safety in tunnel is covered by the operating rules of the global network
- But the recent disasters show that the fire risk must be re-evaluated
- The national regulations are more disparate than for road

3. Place of tunnels in safety of the general operation for the 3 transport modes
Metro transport

- Also a very safe transportation mode
- Long operating experience entirely underground
- Safety arrangements specially adapted to the underground environment (rolling stock…)
- The stations play a large part for safety
- A severe problem – however very rare – is an incident between two stations
- The fire safety rules depend largely from each city or network

4. Traffic nature and potential fires

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Specific features of traffic and its management

Specific feature of trafic and signing:

- **Road: - numerous and individual vehicles**
  - no possibility of individual control
  - reinforced signing

- **Rail and metro : - convoys from about 100 to 800 m**
  - each train is surveyed in the CR
  - traditional network signing

- **High speed rail: reduced likelihood to stop inside the tunnel**

4. Traffic nature and potential fires
Specific features of traffic and its management

Specific features of vehicle driving:

- road: - permanent instinctive correction of the path
  - numerous drivers from various origines
  - high risk of accident

- rail and metro : - rail-guided path
  - professional drivers
  - very low risk of collision

4. Traffic nature and potential fires
Specific features of traffic and its management

Transported people :

- **Road :** - one or several persons per vehicle
  - but numerous and dispersed vehicles
  - crucial problem: presence of buses (40-60 people…)

- **Rail and metro :** -freight train : 1 or 2 people only
  -passenger train : hundreds, even more than thousand people in the same convoy

4. Traffic nature and potential fires

Specific features of traffic and its management

Potential fires:

The FIT web site provides values on the fire heat release rates for the 3 modes.

- Road: PC and HGV generally are mixed :
  - -each vehicle is easily flammable
    - about 30 to 1000 l. of fuel
    - plastic, rubber…
    - hot parts
    - electric circuits
  - no construction rules regarding the fire behaviour of vehicles
  - potential heat release rate from 2 to 200 MW unknown by the operator at fire starting time

4. Traffic nature and potential fires
Specific features of traffic and its management

Potential fires:

- **Rail:- the mixed passenger/freight trains are the most numerous and dangerous**
  - **the electric traction reduces risks**
  - **passenger trains:limited fire heat release rate (20 MW)**
  - **freight trains:**
    - **fire heat release rate of a wagon (100-200 MW)**
    - **problem of the fire transmission between the wagons**
    - **total fire load:10 à 50 times a HGV**

4. Traffic nature and potential fires
Specific features of traffic and its management

Potential fires:

-Metro: - only electric traction

- construction rules for the rolling stock to limit fire

-fire HRR from 7 to 20 MW

4. Action towards fires

5. Action toward fires
Vehicle on-board means for fire detection and fighting

- Road vehicles: - no specific detectors
  - some users have a portable extinguisher on board
- Trains - metros:- some trains have detectors
  - alarm signal for passengers: problem in case of stopping inside the tunnel
  - portable extinguishers
  - exceptionally extinguishing system on each coach or wagon

5. Action toward fires
Fixed means for fire detection

- Road : various equipment :
  - video surveillance
  - pollution sensors
  - specific detectors etc…
- Rail : generally no detection in the interior zone
- Metro : detectors in the station rooms

5. Action toward fires
Fxchange of informations with the users

- **Road :** - no direct exchange between the operator and the drivers
  - the users can sometimes be alarmed through the public radio channels
  - exceptionally loudspeakers inside the tunnel: problem of audibility
  - but the user can call the operator via the fixed emergency phones inside the tunnel

- **Rail and metro:** - ground/train radio connection (operator/driver)
  - sound-wiring of coaches
  - fixed operation phones

- **Metro stations / underground stations:** - stations sound-wiring
  - fixed emergency phones

5. Action toward fires
Ventilation and smoke control

- **Road :** - ventilation facilities in numerous tunnel
  - smoke control: a priority since 20 or 30 years
  - various systems: -longitudinal
    -transverse
    -mixed
- **Rail :** - a ventilation facility is exceptional
  - generally no smoke control
- **Metro :** - rather frequent smoke control system
  - longitudinal scavenging of tubes
  - extraction/blowing by shafts or stations

5. Action toward fires
Escape of users

- **Road :**
  - Problematics: the users are scattered
  - Arrangements for mono-tube: - evacuation through the tunnel
    - parallel emergency gallery
    - emergency ventilation duct
    - emergency staircases for cut-and-covers
    - shelters
  - Arrangements for bi-tube: inter-tubes communication galleries (200 to 400m)
  - Also: camera surveillance and proper lighting of the pavement

5. Action toward fires
Escape of users

Rail :

- Problematics:
  - crowd effect, congestion of emergency exits, panic
  - no platform in the interior zone (height difference of about 1 m)
  - narrow passage
  - ballast and rails non adapted for walking

- Arrangement for mono-tube: escape only through the tunnel

- Arrangement for bi-tube : space between inter-tubes generally larger than for road

- **Safety basic principle:** to make the train get out of the tunnel (but problem of the catenary fire behaviour)

5. Action toward fires
Escape of users

- **Metro :**

  - **Problematics: the same as for rail regarding an incident in the tunnel**

  - **Escape by the stations is well adapted (staircases, video surveillance, lighting…)**

  - **Basic safety principle: to drive the train to any platform in a station**

5. Action toward fires
Intervention of rescue services

- **Road:**
  - **all types of traditional emergency vehicles can have an access to the tunnel**

- **Rail :**
  - **the road vehicles cannot drive inside the tunnel**
  - **the rail-guided emergency vehicles are exceptional**

- **Metro :**
  - **multiple accesses by the stations, but by foot**

5. Action toward fires
Intervention of rescue services

- Intervention time of firemen (plausible order of magnitude):

  - road : 5 min to 1 h

  - rail : 1 h

  - metro: 5 to 10 min

The self-escape of the users must always be preferred.

6. Conclusion

Item	Metro	Rail	Road
Length	5 to 600 meters mean between 2 stations	30 m to about 50km	200 m to about 20 km
Location	city	city, country	city, country
Exits	stations	tunnel ends	tunnel ends, shelters with access to other tunnels
Possibilities to move from accident place to safe exit	very narrow pathways	narrow pathways	wider pathways
Intervention time of firemen	5 to 10minutes	10 to 60 minutes	5 to 10 (firemen at the end) to 60minutes
Fire heat release rate	7 to 20 MW fire load under control	10 to 200 MW(TMD) fire load depends on vehicles (their load)	2 to 200 MW (TMD) fire load depends on vehicles (their load)
People	100 to 250 per wagon	150 per wagon	1 to 100 (bus)
Traffic control	strict control	strict control	no control to individual drivers
Communication for alarm	driver or interphone	driver of the train	each driver of each vehicle
Materials	fire resistance standard	fire resistance standard	no standard
Firemen intervention	stations cannot use cars	ends of tunnel cannot use cars	ends of tunnel, special accesses

6. Conclusion

- The problem of fire safety in tunnel is different for the 3 modes of transport

- The feedback on experience and the operating cultures are different

- For road the fixed safety arrangements are rather more developed than for metro and especially for rail

- But the prevention and mitigation objectives show common cares… that we must tend to unify because…

... the fire never says in which type of tunnel it will start.

- The end -