ROAD TUNNELS : COMPLEX UNDERGROUND ROAD NETWORKS

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**Synthetic presentation of WG 5**

- **Present situation**
  - 28 members + AM + CM
  - 19 countries

- 3 working sessions / year essentially in Europe
- Visio-conferences with the members in Asia, Australia & America
Publications

- Publications at the end of the 2011/2015 cycle
  - Part A of the report “Case Studies” and preliminary recommendations
  - Monograph sheets of 17 “tunnels complexes” analysed
  - New chapter 1.7 of the “PIARC Road Tunnel Manual” dedicated to the “complex underground road networks”

- Publications planned for the 2015/2019 cycle
  - Part B of the report “specific analyses and recommendations”
  - 10 Additional monograph sheets and update of Part A
What are “complex underground road networks”?

- Underground infrastructures with numerous interchanges, accesses and exits
- Sequences of successive tunnels
- Multimodal tunnels: road, train, tram, pedestrians, bicycles, buses
- Service tunnels for supplying activities
- Tunnels with dual function: transit traffic – access to underground car park
- Tunnels with reduced clearance - access restricted to PC
Part A “Case Studies”

- Methodology
  - Definition of a list of existing “tunnels complexes”
  - Drawing up a questionnaire
  - Collect of information by interviews with owners, designers and operators
  - Analysis of the information gathered during the interviews
    - Statistical data
    - Identification of good and bad practices
    - Preliminary recommendations
  - Editing a monograph sheet for each “tunnel complex”
"tunnels complexes" investigated

- 27 "tunnels complexes" located in 17 countries
- representing 41 tunnel units

- Large part of the "complexes" investigated are in Europe
  - It is a picture of the existing real situation
  - Method with "interviews" could be carried out only in the countries with WG5 members of corresponding members
  - Additional investigations going on during present cycle in Australia (3), China (1), Japan (1), USA (2)
Main synthetic information

- Nominal length
  - 400 m to 16.4 km
- Overall length of the structures
  - 1.1 km to 32.8 km

Part A “Case Studies”
Main synthetic information

- **Date of commissioning**
  - 73% during last 30 years

- **Traffic volume**
  - 85% with AADT < 100,000 veh

- **Methods of construction**

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**construction methods**

- Cut & cover: 9%
- Drill & blast or NATM: 3%
- TBM or shield: 44%
- Immersed: 44%
Main synthetic information

- Horizontal alignment
  - *minimum radius*

- Vertical alignment - gradients
  - *ramps from 1% to 10%*
Main synthetic information

- Interchanges entrances & exits
  - 45 for M 30 in Madrid
  - ratio between 1 and 2 per km
  - particularity for service tunnels: Helsinki & Paris
- Area of accumulation of accidents
Part A “Case Studies”

Main synthetic information

- **Width of traffic lanes**
  - 60% with a width of 3.50m
  - width of 3.00m for tunnels with low clearance

- **Vertical clearance**
  - 39% between 4.00m and 4.50m
  - 44% between 4.60m and 4.80m
  - 4.80m in Prague, Stockholm & Seoul
  - 2.00m to 3.50m for French low clearance tunnels
Main synthetic information

- **Speed limit**
  - 60% with a limit at 70 km/h

- **Ratio of breakdowns**
  - \( \frac{\text{number of (breakdowns)}}{\text{(traffic volume x tunnel length)}} \)

- **Ratio of accidents**
  - very few injuries & fatalities
  - sinuous horizontal alignment
  - reduced visibility entrance & exit
  - high descending gradient
  - behaviour of the drivers
Main synthetic information

- **Fires**
  - 30% without any fires
  - 40% less than 0.75 fire / year
  - 30% more than 1 fire / year

- **Escape routes**
  - 40% with spacing 100m to 200m
  - 35% with spacing 200m to 300m
  - spacing 350m to 400m Japan
  - spacing < 100m Helsinki & Montreal
Part A “Case Studies”

Main synthetic information

Ventilation

- 27% with massive smoke extraction
- 33% with a smoke exhaust gallery
- 40% with a pure longitudinal ventilation

- short tunnels
- tunnels with a strict control of the traffic and closing of the access in order to avoid traffic jams

Aeraulic independency of the branches with doors, air or water curtains, jet fans
Preliminary recommendations are presented
- in Part A of the report
- in chapter 1.7 of the “PIARC road tunnel manual”
- They concern
  - Geometry
  - Cross section
  - Ventilation
  - Safety – emergency - firefighting
  - Signalling
  - Environment
  - Traffic conditions – traffic management
  - Operation

Impossible to present these recommendations in detail – Followings slides present only some examples
A global transverse approach is essential, in particular:

- function of the infrastructure
- occupation of surface and underground
- traffic volume, nature & evolution – traffic jam probability
- operational & safety conditions
- geological & geotechnical background
- environmental sensitivity
- construction methods – construction risks
- interfaces with other facilities

All these parameters have an impact on the geometry
Cross section is a major parameter on cost optimisation - transverse analysis is again mandatory in particular:

- function of the tunnel – nature of traffic => choice of:
  - vertical clearance
  - width of the traffic lanes
- traffic volume
  - number of lanes
  - length of exit and merging lanes
- ventilation & escape route =>
  - provisions within the cross sections
- geological & hydrogeological conditions =>
  - construction methods
  - shape of the cross section

until 30% of potential cost saving
Ventilation & safety of underground network are challenging major issues that require:

- realistic forecasts of traffic volume
- clear evaluation of the traffic jams probability
  - no basic postulate “no jam” & possibility to avoid them
- iterative analysis with risks & dangers statements
- environmental analysis with location of polluted air discharge points
- aeraulic independency of the branches with doors, air or water curtains, jet fans
Complex road network & escapes routes could be a kind of labyrinth with numerous people trapped

- quality of the positioning of an incident,
- performing signalling
- communication with users specific to each branch according to the incident & its location
- perfect knowledge of the network, the accesses, the facilities by emergency services
  - frequent training & exercises
  - access time could require “first line team”
To be investigated during works and operation periods

- Impact on the portals & ventilation shafts location
  - Regular operation conditions
  - In case of fire: smoke and toxic gases discharge

- Impact on construction methods & construction period of time =>
  Conventional methods ≠ TBM or shield
  - Surface required / noise / nuisances
  - Duration of daily works period - final deadline

- Decision for implementing air cleaning system to be investigated carefully
  - Real efficiency – financial balance cost / results
  - Numerous existing air treatment plants out of operation
Interfaces with other infrastructures and operators

- interactions are numerous
- specific analysis required for all the interfaces
- transmission of the information between all the operators
  - under normal operation – in case of emergency
- qualification, organisation & means could be very different
  - operator of the main traffic infrastructure (24 h/24h)
  - operator of a building or commercial facilities
- global emergency plan mandatory with definition
  - leading operator
  - priority actions of each operator
Thank you for attention