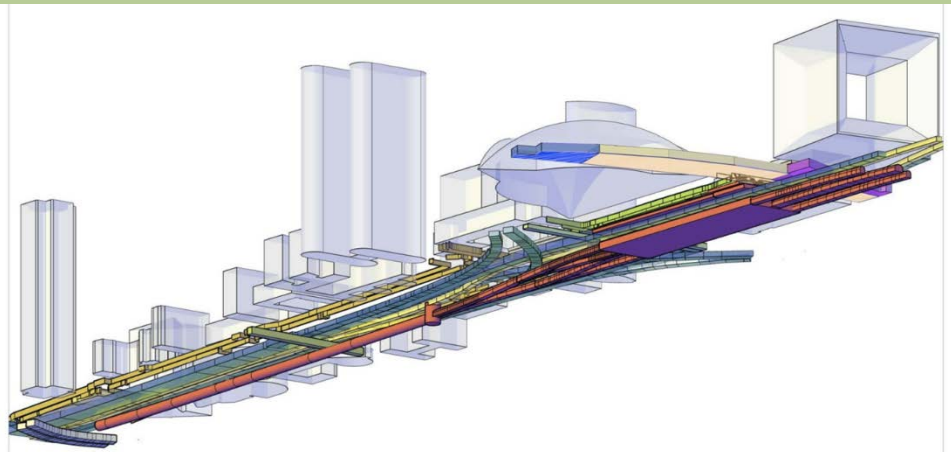
ROAD TUNNELS : COMPLEX UNDERGROUND ROAD NETWORKS

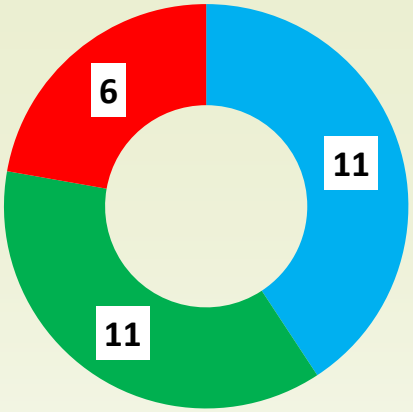


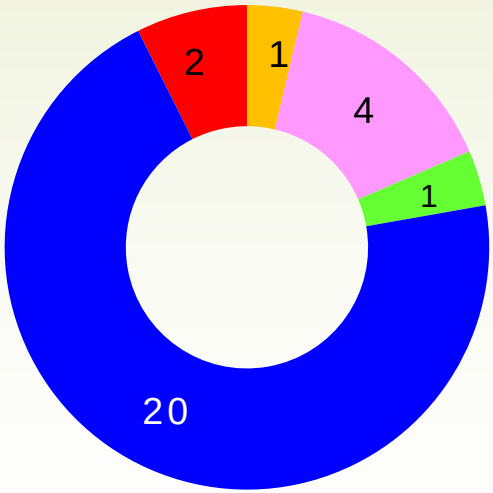
Bernard FALCONNAT - Frédéric WALET

Leader and coleader of WG 5 - PIARC TC Road Tunnel Operations

Membership

- **Synthetic presentation of WG 5**
- **Present situation**
  - 28 members + AM + CM
  - 19 countries





South Africa

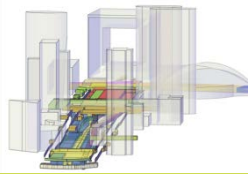
China
Japan
South Korea

Canada / Québec
USA

Austria
Belgium
Czech Republic
Denmark
France
Germany
Italy
Norway
Spain
Sweden
Switzerland
United Kingdom

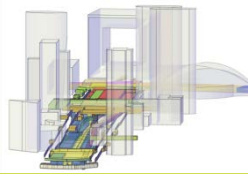
- 3 working sessions / year essentially in Europe
- Visio-conferences with the members in Asia, Australia & America

Publications



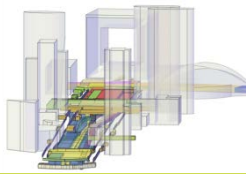
- **Publications at the end of the 2011/2015 cycle**
  - Part A of the report “Case Studies” and preliminary recommendations
  - Monograph sheets of 17 “tunnels complexes” analysed
  - New chapter 1.7 of the “PIARC Road Tunnel Manual” dedicated to the “complex underground road networks”
- **Publications planed for the 2015/2019 cycle**
  - Part B of the report “specific analyses and recommendations”
  - 10 Additional monograph sheets and update of Part A

Part A “Case Studies”



- **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, busses
  - Service tunnels for supplying activities
  - Tunnels with dual function: transit traffic – access to underground car park
  - Tunnels with reduced clearance - access restricted to PC

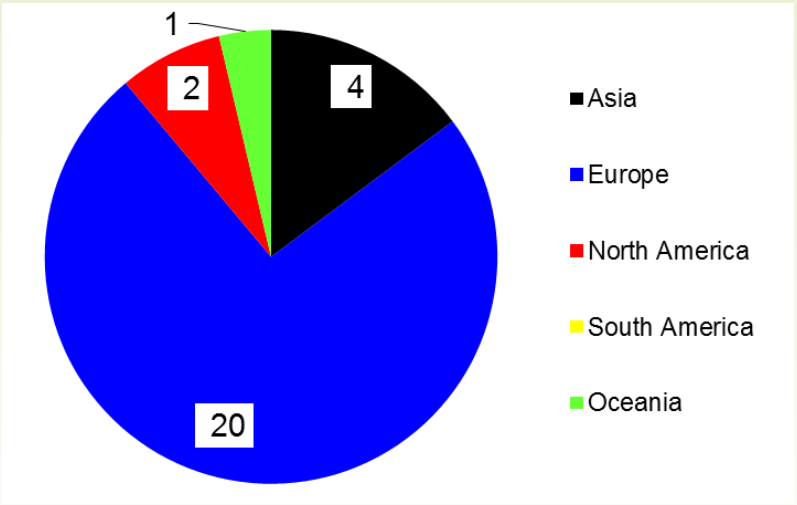
Part A “Case Studies”

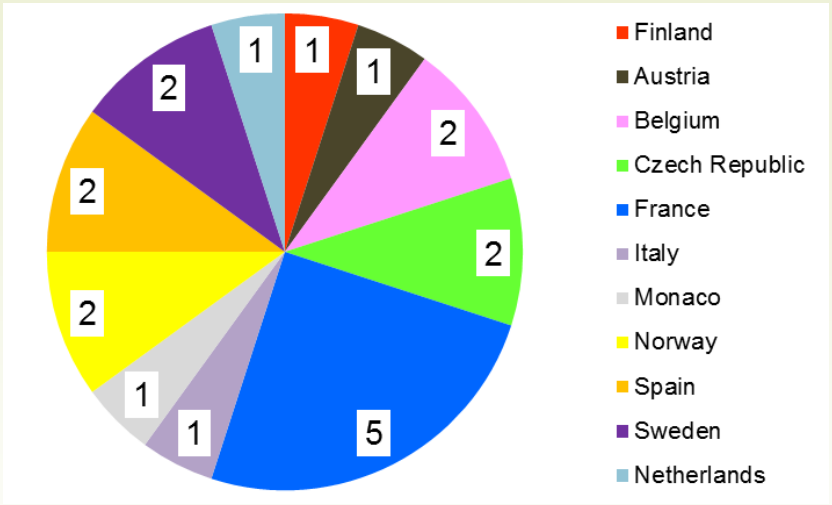


- **Methodology**
  - Definition of a list of existing “tunnels complexes”
  - Drawing up a questionnaire
  - Collect of information by interviews with owners, designers and operators
  - Analysis of the information gathered during the interviews
    - *Statistical data*
    - *Identification of good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

Part A “Case Studies”

- **“tunnels complexes” investigated**
  - 27 “tunnels complexes” located in 17 countries
  - representing 41 tunnel units

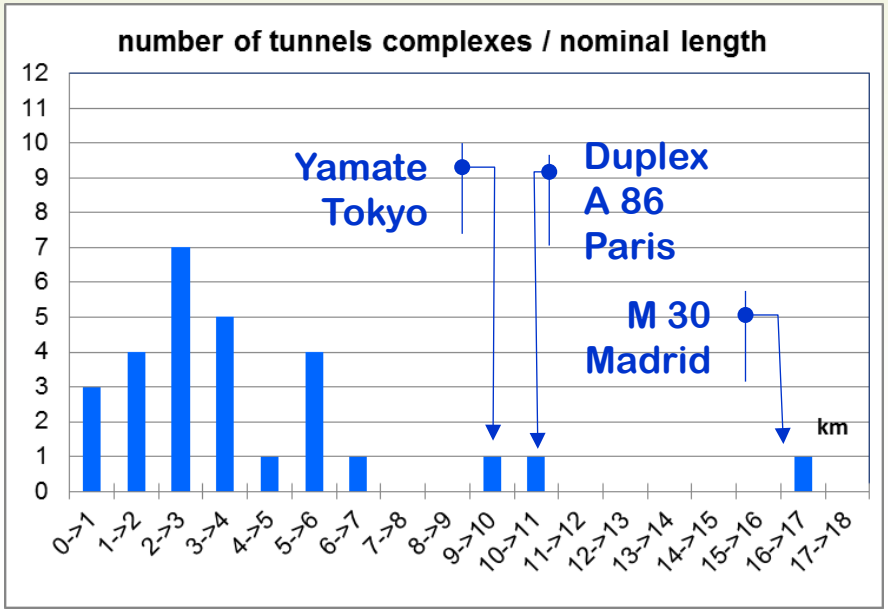


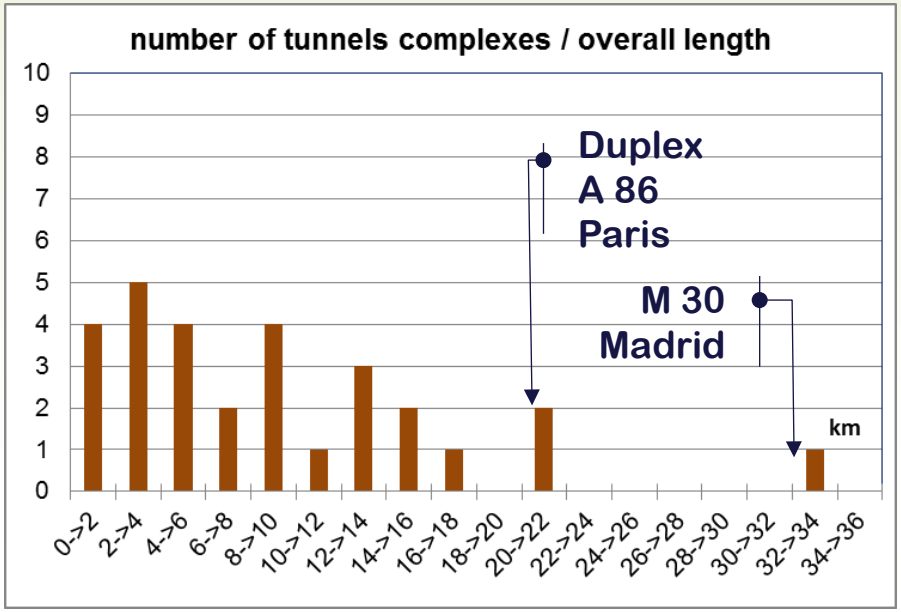


  - large part of the “complexes” investigated are in Europe
    - *it is a picture of the existing real situation*
    - *method with “interviews” could be carried out only in the countries with WG5 members of corresponding members*
    - *Additional investigations going on during present cycle in Australia (3), China (1), Japan (1), USA (2)*

Part A “Case Studies”

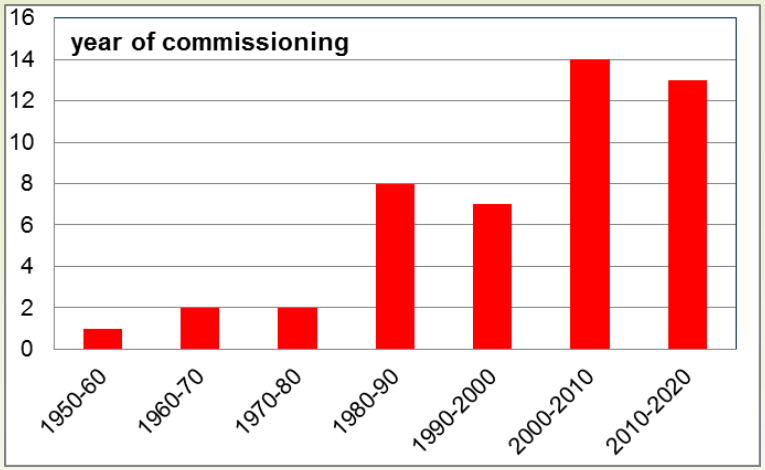
- **Main synthetic information**
  - Nominal length
    - *400 m to 16.4 km*
  - Overall length of the structures
    - *1.1 km to 32.8 km*

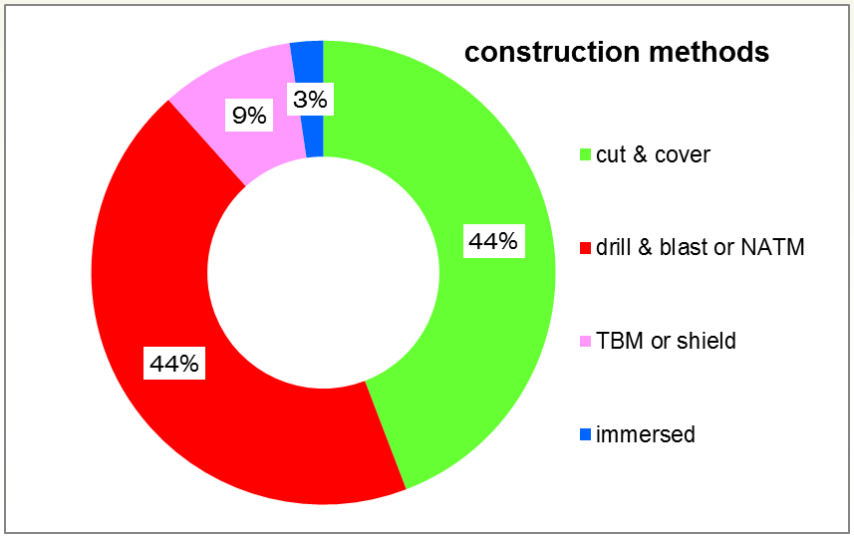


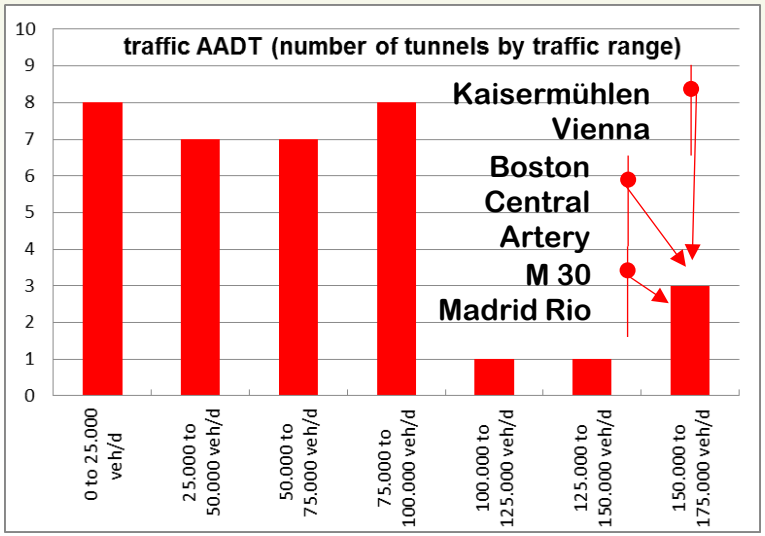


Part A “Case Studies”

- **Main synthetic information**
  - Date of commissioning
    - 73% during last 30 years
  - Traffic volume
    - 85% with AADT < 100,000 veh
  - Methods of construction

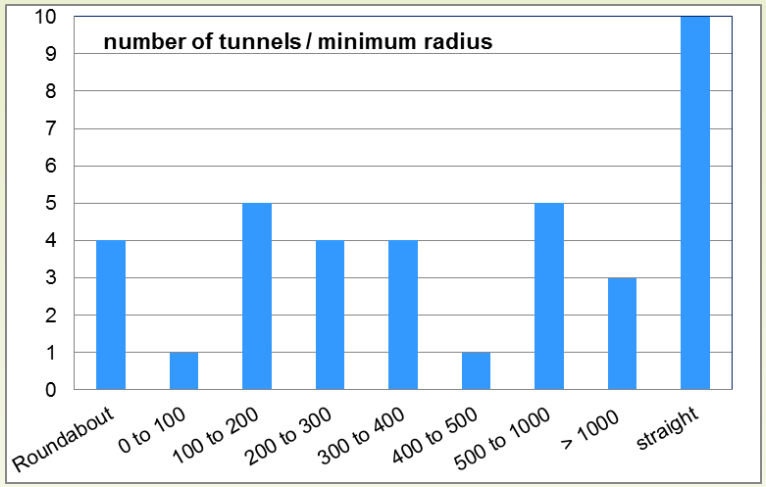


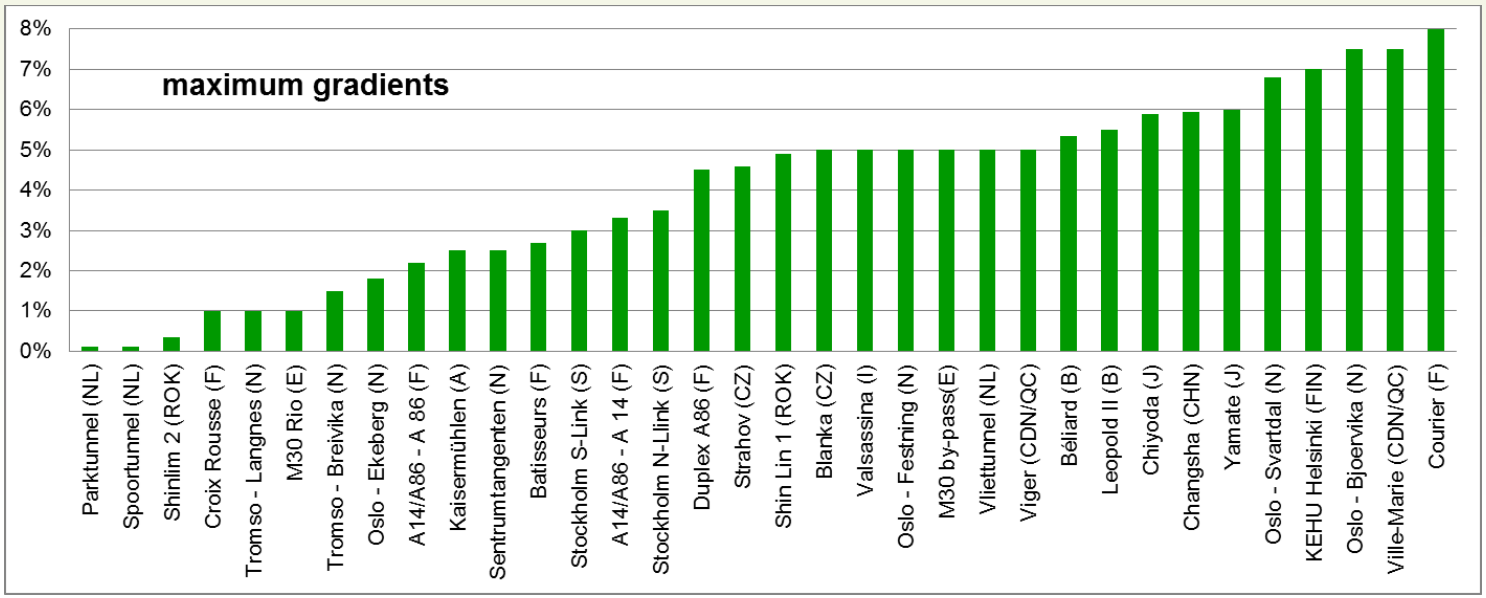




Part A “Case Studies”

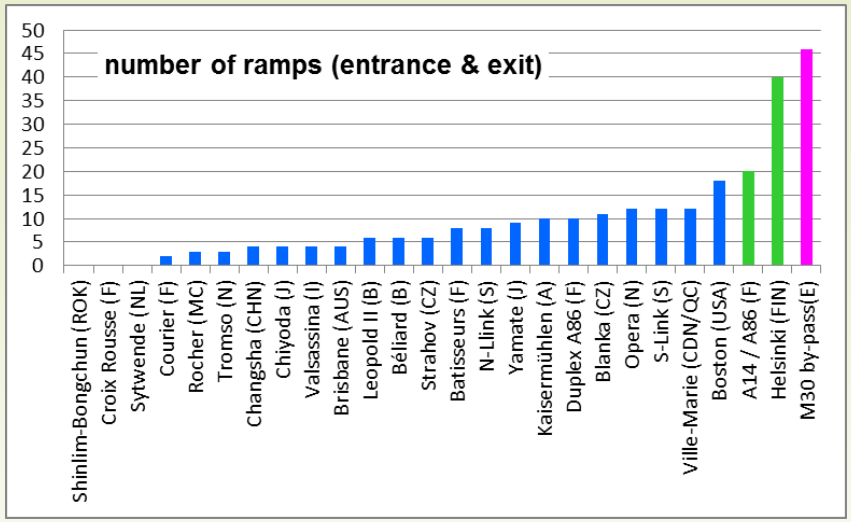
- **Main synthetic information**
  - Horizontal alignment
    - *minimum radius*
  - Vertical alignment - gradients
    - *ramps from 1% to 10%*

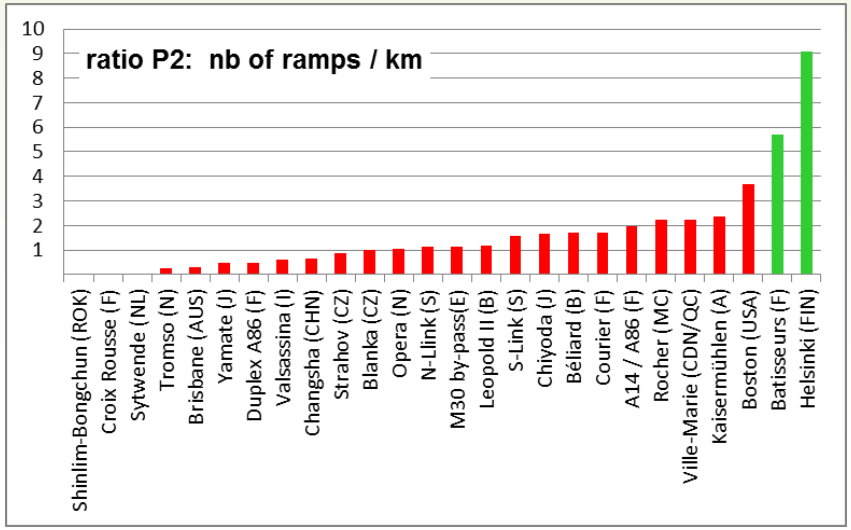




Part A “Case Studies”

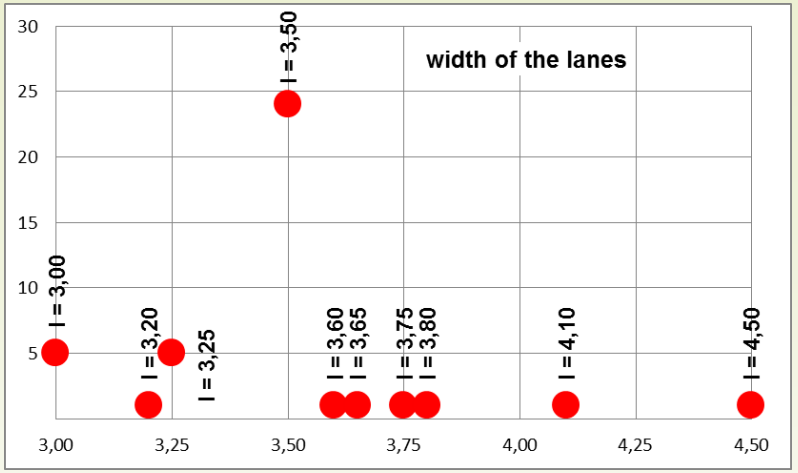
- **Main synthetic information**
  - Interchanges entrances & exits
    - *45 for M 30 in Madrid*
    - *ratio between 1 and 2 per km*
    - *particularity for service tunnels: Helsinki & Paris*
    - *area of accumulation of accidents*

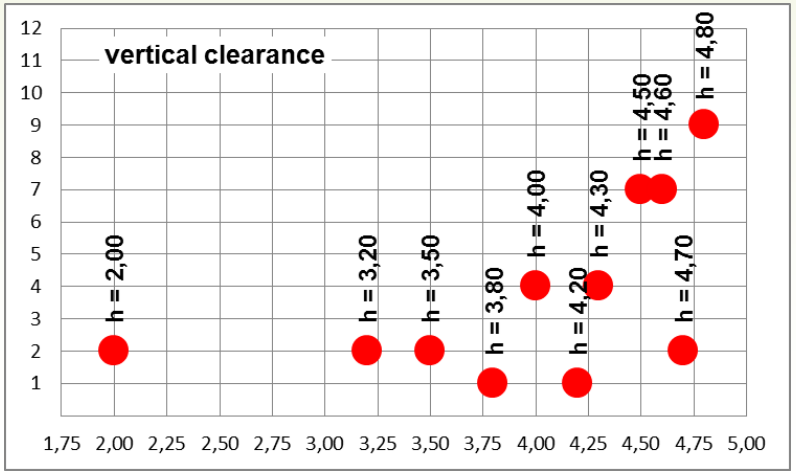




Part A “Case Studies”

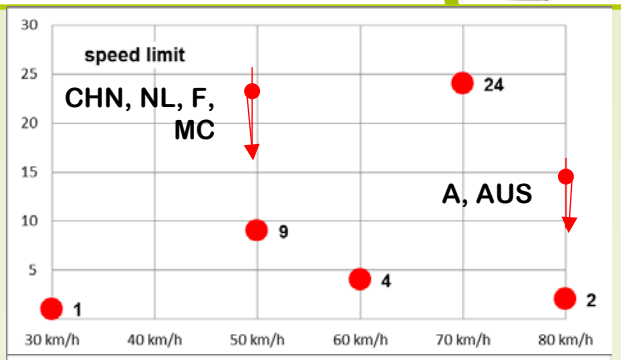
- **Main synthetic information**
  - Width of traffic lanes
    - *60% with a width of 3.50m*
    - *width of 3.00m for tunnels with low clearance*
  - Vertical clearance
    - *39% between 4.00m and 4.50m*
    - *44% between 4.60m and 4.80m*
    - *4.80m in Prague, Stockholm & Seoul*
    - *2.00m to 3.50m for French low clearance tunnels*

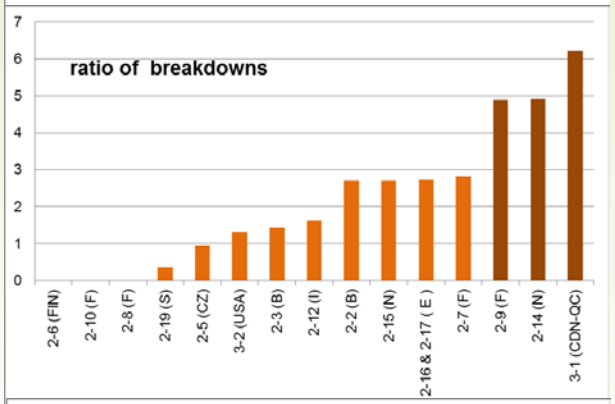


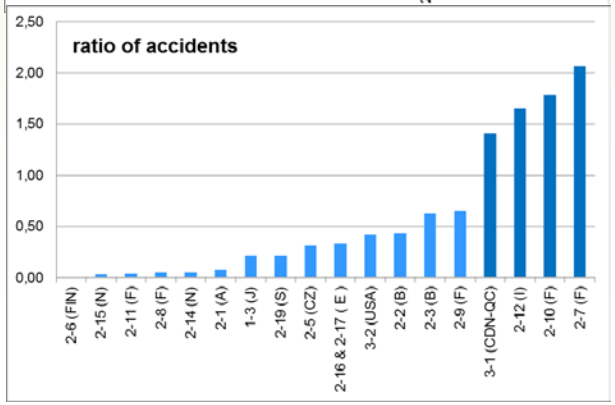


Part A “Case Studies”

- **Main synthetic information**
  - Speed limit
    - *60% with a limit at 70 km/h*
  - Ratio of breakdowns
    - *number of (breakdowns) / (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*

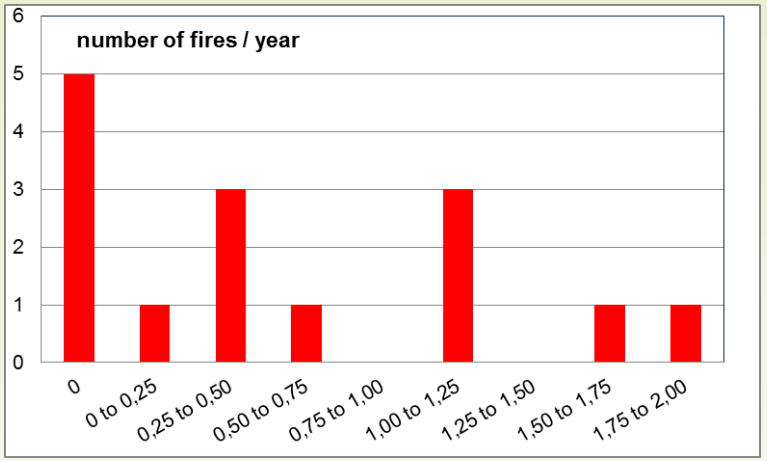


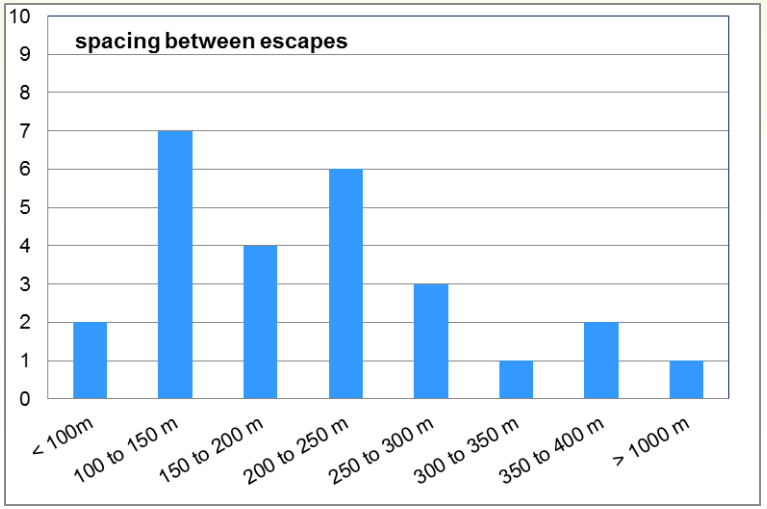




Part A “Case Studies”

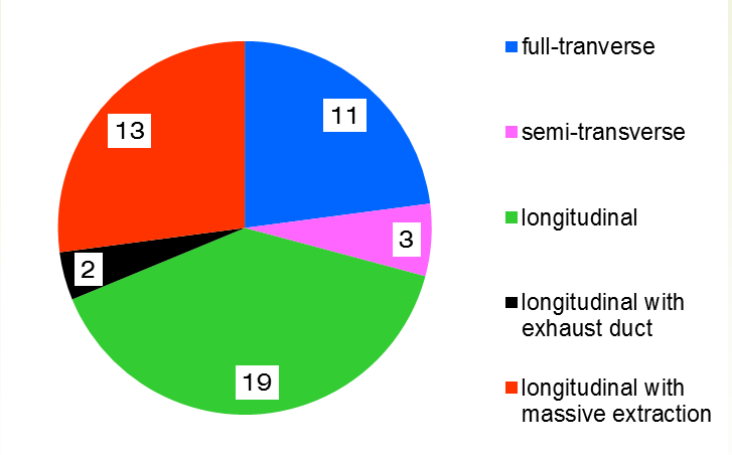
- **Main synthetic information**
  - Fires
    - *30% without any fires*
    - *40% less than 0,75 fire / year*
    - *30% more than 1 fire / year*
  - Escape routes
    - *40% with spacing 100m to 200m*
    - *35% with spacing 200m to 300m*
    - *spacing 350m to 400m Japan*
    - *spacing < 100m Helsinki & Montreal*





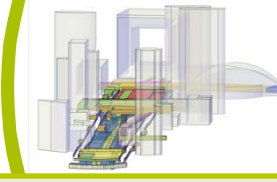
Part A “Case Studies”

- **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*



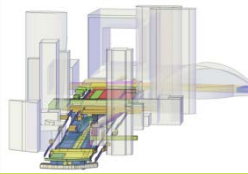
    - *Aeraulic independency of the branches with doors, air or water curtains, jet fans*

Preliminary recommendations



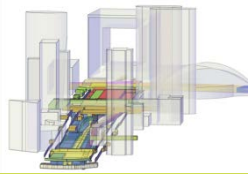
- **Preliminary recommendations are presented**
  - in Part A of the report
  - in chapter 1.7 of the “PIARC road tunnel manual”
  - They concern
    - Geometry
    - Cross section
    - Ventilation
    - Safety – emergency - firefighting
    - Signalling
    - Environment
    - Traffic conditions – traffic management
    - Operation
- **Impossible to present these recommendations in detail – Followings slides present only some examples**

Preliminary recommendations - Geometry



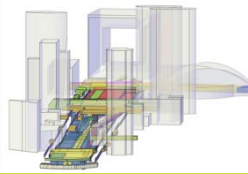
- **A global transverse approach is essential, in particular:**
  - *function of the infrastructure*
  - *occupation of surface and underground*
  - *traffic volume, nature & evolution – traffic jam probability*
  - *operational & safety conditions*
  - *geological & geotechnical background*
  - *environmental sensitivity*
  - *construction methods – construction risks*
  - *interfaces with other facilities*
- **All these parameters have an impact on the geometry**

Preliminary recommendations – Cross section

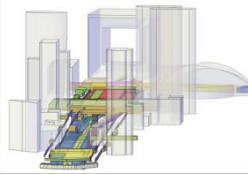


- **Cross section is a major parameter on cost optimisation - transverse analyse is again mandatory in particular:**
  - *function of the tunnel – nature of traffic => choice of:*
    - *vertical clearance*
    - *width of the traffic lanes*
  - *traffic volume*
    - *number of lanes*
    - *length of exit and merging lanes*
  - *ventilation & escape route =>*
    - *provisions within the cross sections*
  - *geological & hydrogeological conditions =>*
    - *construction methods*
    - *shape of the cross section*

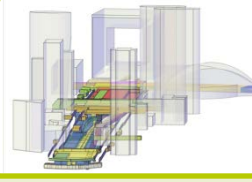
until 30% of potential cost saving



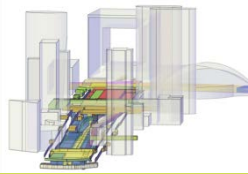
- **Ventilation & safety of underground network are challenging a major issues that require:**
  - *realistic forecasts of traffic volume*
  - *clear evaluation of the traffic jams probability*
    - *no basic postulate “no jam” & possibility to avoid them*
  - *iterative analysis with risks & dangers 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*

https://www.piarc.org/en/knowledge-base/road-tunnels/tunnels-manual/

https://www.piarc.org/en/order-library/25361-en-Road%20tunnels:%20complex%20underground%20road%20networks.htm