PROJEKTOVÁ PRÍPRAVA A REALIZÁCIA PODZEMNÝCH STAVIEB – DOPRAVNÝCH TUNELOV

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07. december 2010

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OBSAH PREZENTÁCIE

- Minulosť a súčasnosť výstavby dopravných tunelov
- Priestorové usporiadanie dopravných tunelov
- Konvenčné tunelovanie - princípy
- Navrhovanie a realizácia definitívneho ostenia dopravných tunelov
- Realizované stavby dopravných tunelov
- Pripravované stavby dopravných tunelov

Railway tunnels in Slovak republic

ITA
AITES

Železničné tunely Slovenska - tematická mapa SR, vydanie prvé, máj 2009

Vydavateľ: Slovenská tunelárska asociácia (STA) ..... www.sta-ita-aites.sk
Basler & Hofmann Slovakia, s.r.o. ..... www.bhb.sk
Železnice Slovenskej republiky ..... www.zsr.sk
Spracovateľ: © Obsahová a grafická úprava: Basler & Hofmann Slovakia, s.r.o.
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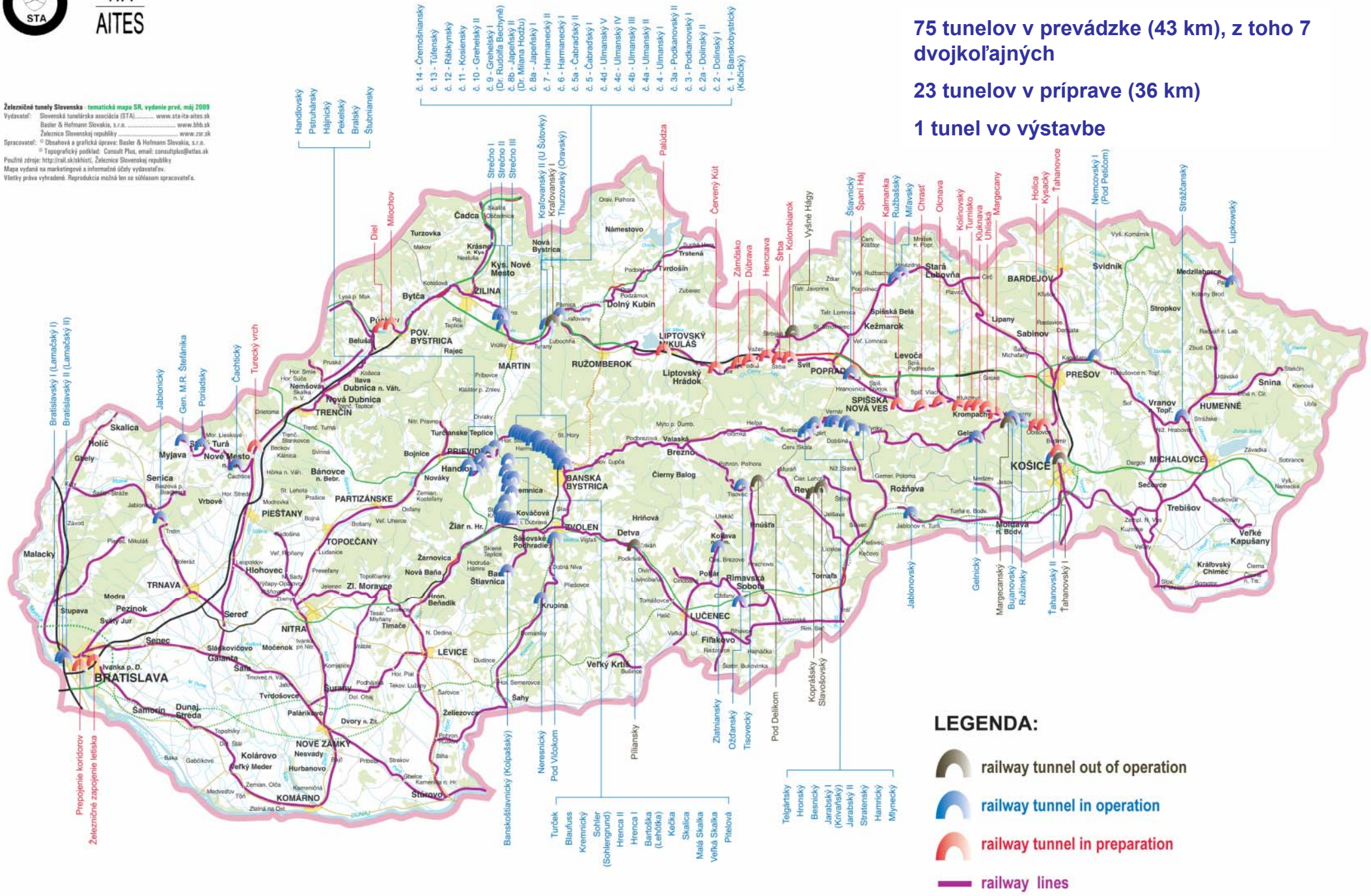
Použité zdroje: http://rail.sk/skhist/, Železnice Slovenskej republiky
Mapa vydaná na marketingové a informačné účely vydavateľov.

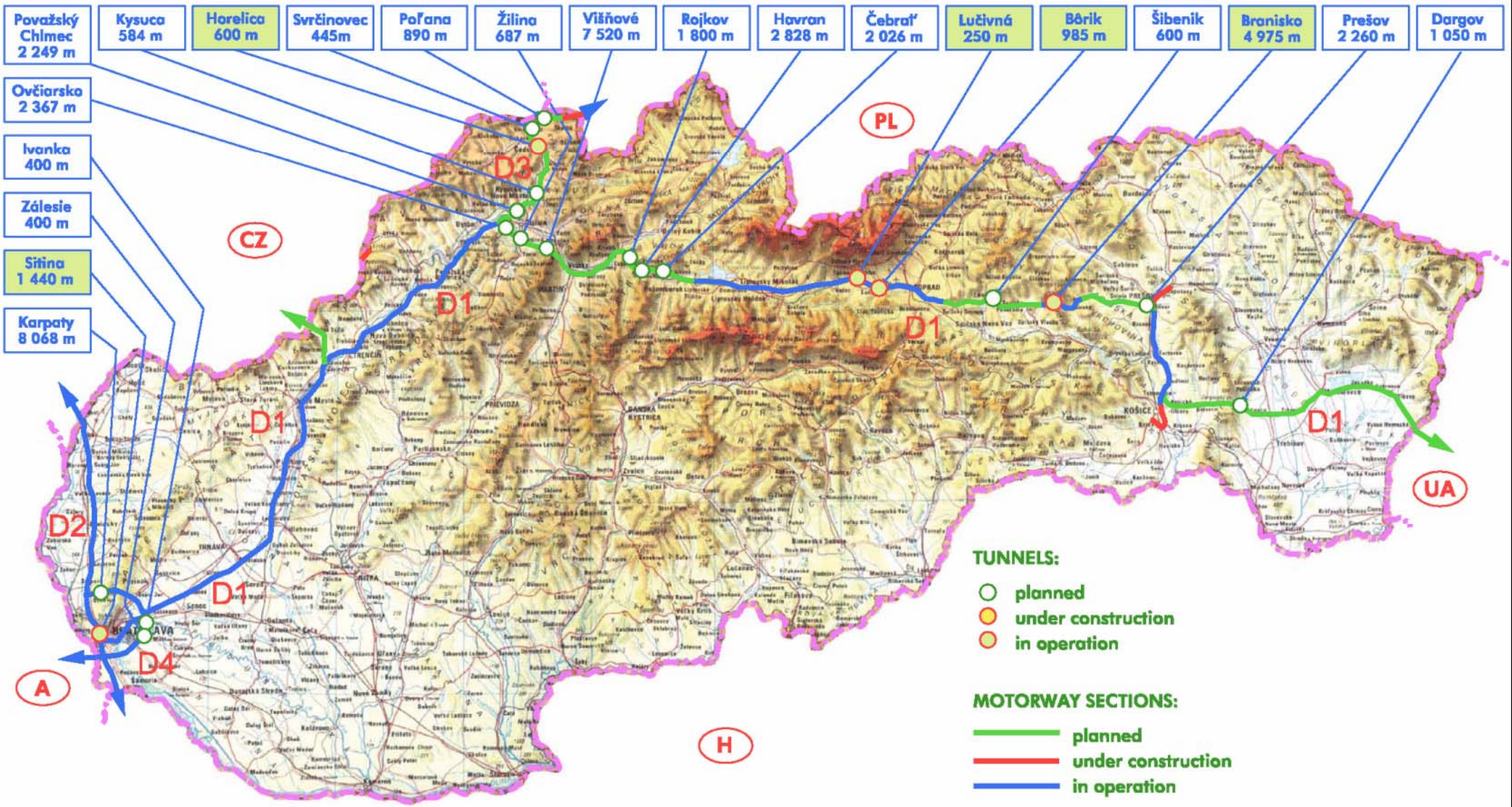
75 tunelov v prevádzke (43 km), z toho 7 dvojkoľajných

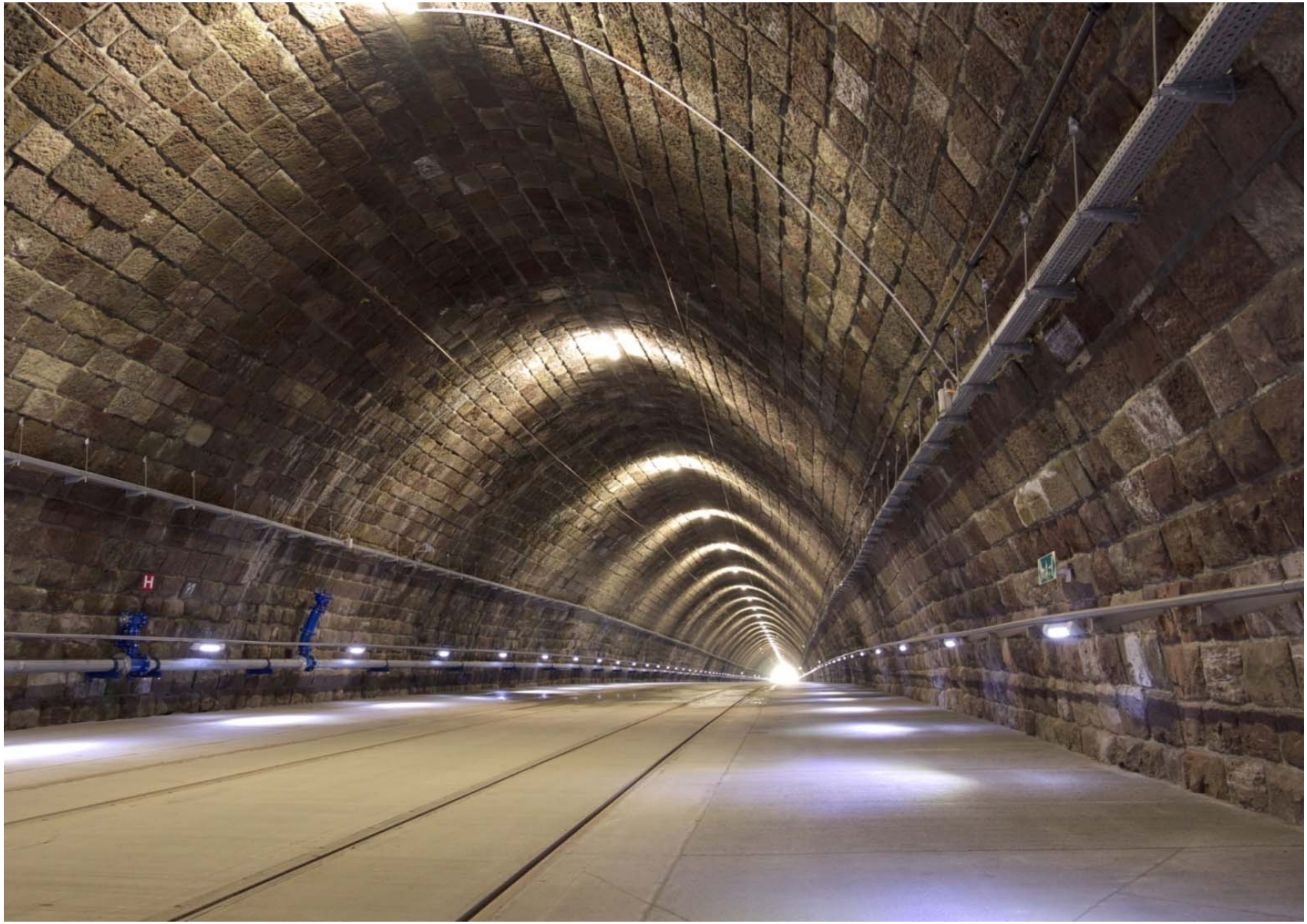
23 tunelov v príprave (36 km)

1 tunel vo výstavbe



TUNNELS ON THE MOTORWAY NETWORK IN THE SLOVAK REPUBLIC





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Električkový tunel Pod hradom (793 m) - pôvodne cestný tunel (1949)

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Cestný tunel Stratená (300 m)

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Tunel Branisko (4975 m) – prvý diaľničný tunel otvorený v 2003

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Tunel Horelica (600 m) otvorený v r. 2004

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Tunel Sitina (1440 m) – prvý tunel s dvomi rúrami, otvorený v r. 2007

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Tunel Bôrik (980 m) otvorený v r. 2009

Predpisy platné pre projektovanie dopravných tunelov - priestorové usporiadanie a bezpečnostné vybavenie

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Cestné a diaľničné tunely

Directive č.54/2004/EC on minimum safety requirements for the tunnels in the Trans-European Road Network

Nariadenie vlády SR č. 344/2006 Z.z. o minimálnych požiadavkach na tunely v cestnej sieti

STN 73 7507 Projektovanie cestných tunelov (2008)

TP 04/2006 Požiarna bezpečnosť cestných tunelov (2006) (revízia 2010, v schvalovaní)

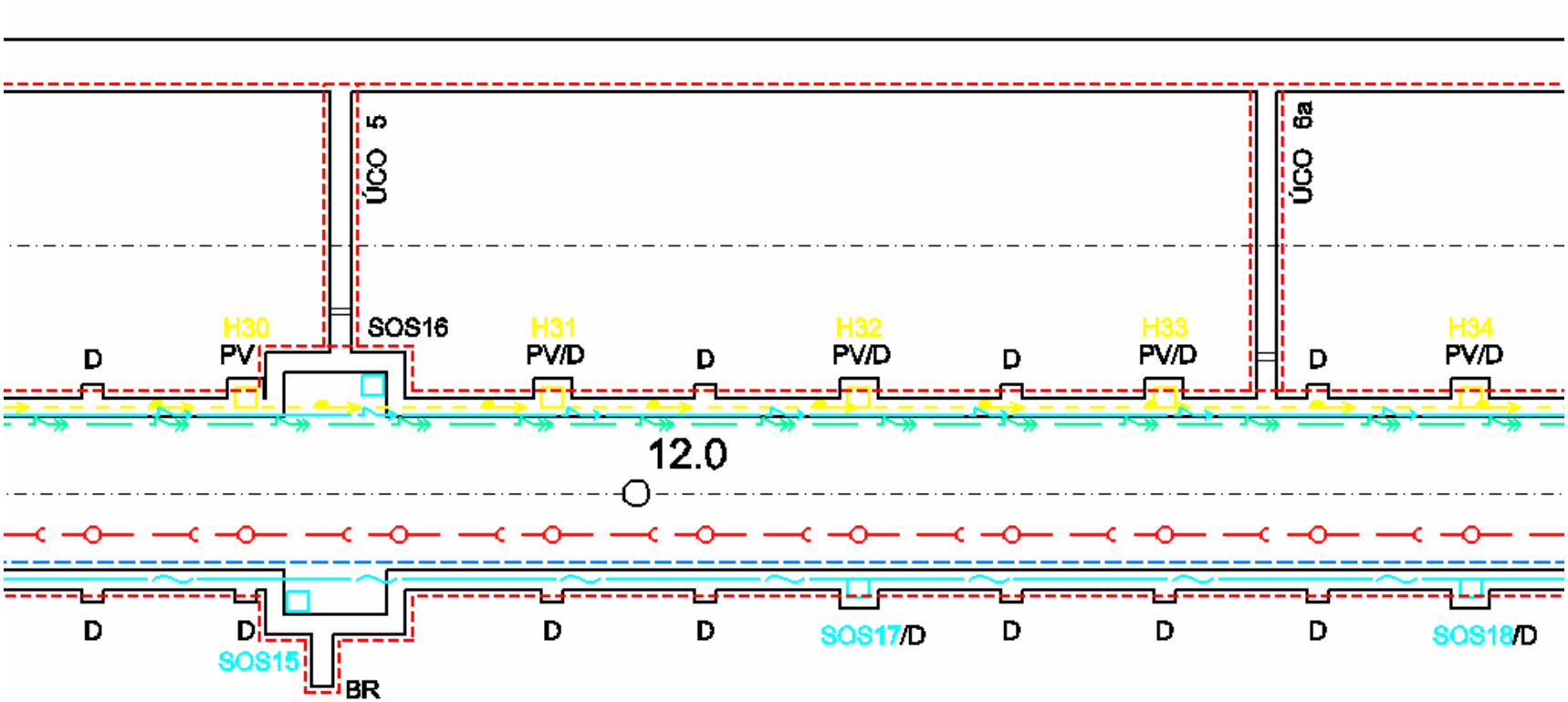
Železničné tunely

STN 73 7508 Projektovanie železničných tunelov (2010, v schvalovaní)

Rozhodnutie komisie č.186/2008 o technickej špecifikácii interoperability v súvislosti s aspektom „bezpečnosť v železničných tuneloch“ v systéme transeurópskych konvenčných a vysokorýchlostných železníc

Bezpečnostné stavebné úpravy cestných tunelov

- Núdzové pruhy
- Núdzové zálivy
- Únikové cesty pre osoby – priečne prepojenia
- Prístupové cesty pre zásahové jednotky – priečne prepojenia
- Výklenky tiesňového volania (SOS výklenky)
- Požiarne výklenky



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Technologické prevádzkové vybavenie cestných tunelov

- Vetranie
- Osvetlenie
- Dopravné značenie
- Bezpečnostné a komunikačné vybavenie:

  SOS hlásky, rádiové spojenie, evakuačný rozhlas, videodohľad
- Zásobovanie elektrickou energiou
- Elektrická požiarna signalizácia
- Centrálny riadiaci systém

Definícia a princípy konvenčnej výstavby tunelov

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Definition of conventional tunnelling:

- Any method of underground construction except methods using full profile TBM could be considered as conventional tunnelling
- As typical modern conventional tunnelling methods can be considered New Austrian Tunnelling Method (NATM) and Sprayed Concrete Lining (SCL Method)

Conventional tunnelling – principles:

- Ground around the tunnel is considered to be load bearing element
- Depending on the conditions the requirement of stiff or light deformable support is identified
- Type and quantity of support elements is adjusted in combination with development of ground reaction
- Stability is confirmed by monitoring of ground reactions mainly by deformation measurement

Typická skladba primárneho a sekundárneho ostenia

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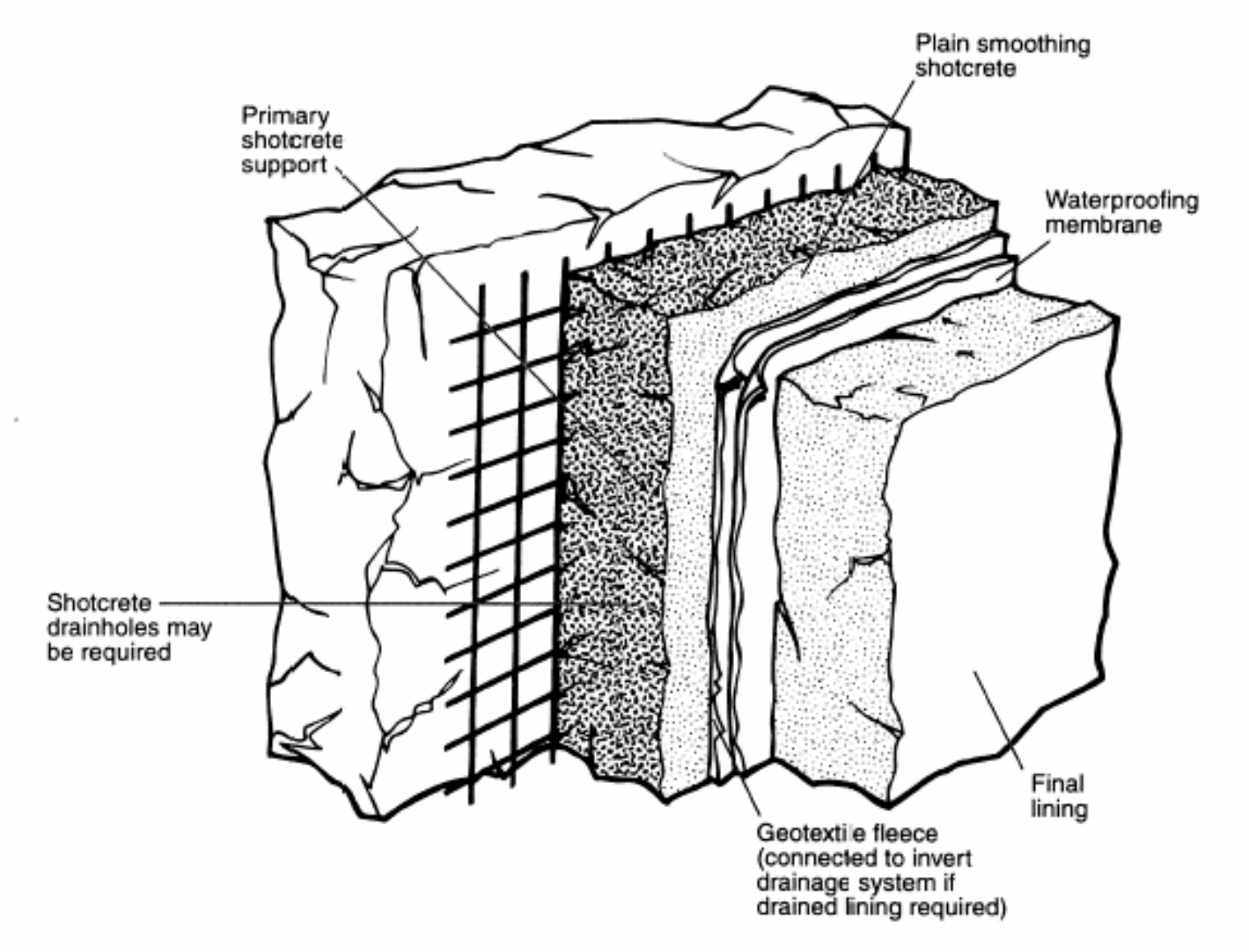
Primary lining - typical support elements

- Shotcrete lining of various width reinforced by steel mesh or steel fibres
- Rock bolts of various types (SN, frictional, selftapping etc.)
- Steel ribs or lattice girders
- Special measures ahead of the face (pipe roofs, forepoling, face bolts etc.)

Final (secondary) lining

- Cast in situ concrete – common for road and railway tunnels in Slovakia
- Shotcrete secondary lining – in Slovakia used only in special cases (emergency gallery, cross passages between tunnel tubes)

Typická skladba dvojvrstvového ostenia



Typical composition of two-layers tunnel lining

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Hard rock conditions – typical for most of transport tunnels in Slovakia

- Drill and blast excavation, partially mechanized excavation
- Support classes framework defines advance lengths, type and quantity of support elements
- Subdivision into top heading and bench
- Invert only in case of poor rock conditions
- Waterproofing system from membrane and drainage pipes on side of tunnel walls (umbrella system)
- Final lining from unreinforced or reinforced concrete

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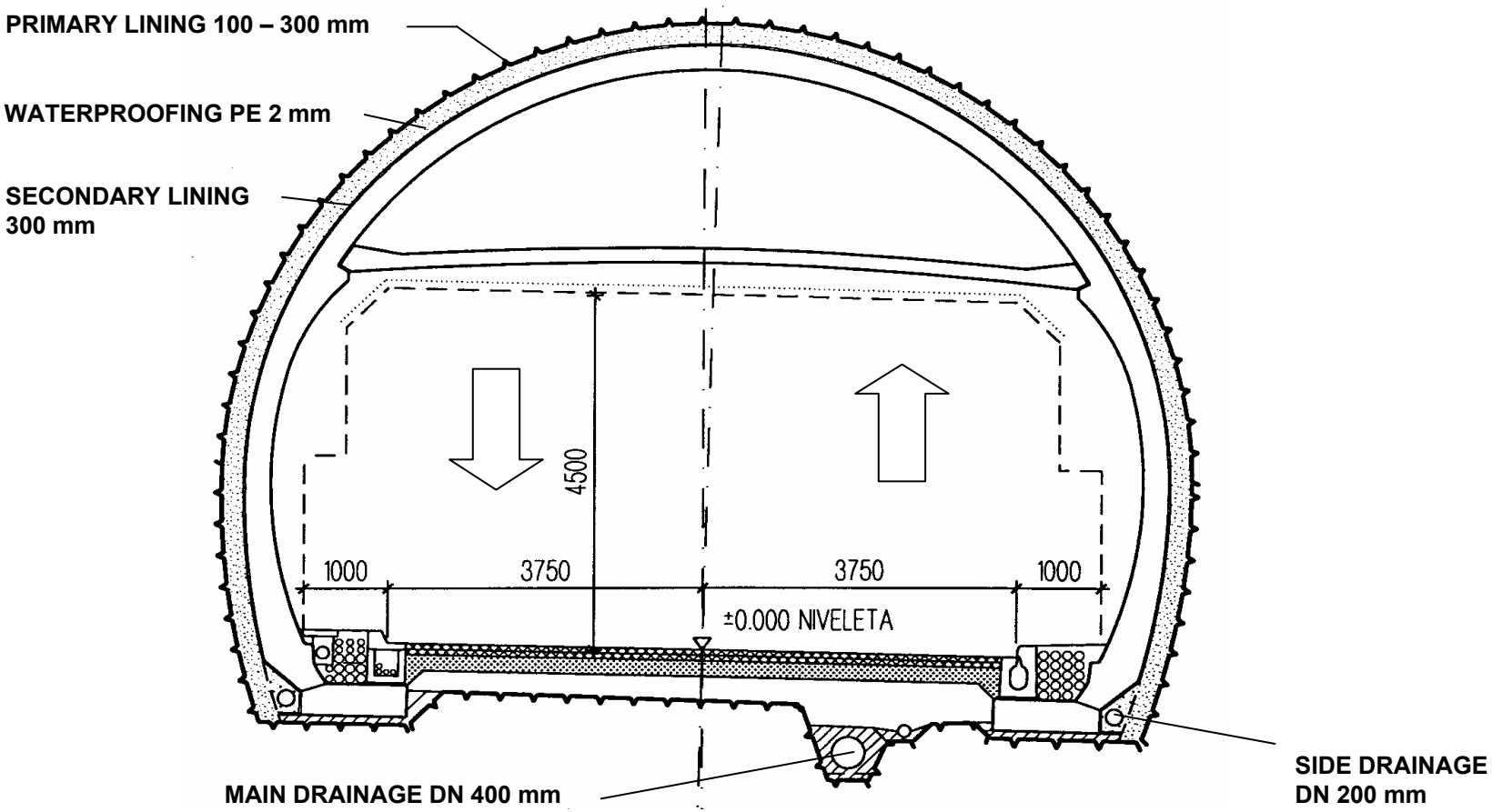

Example of road tunnel in rock conditions with open waterproofing system and side drainage pipes (Branisko Tunnel)

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Soft ground conditions without special requirements

- Without buildings on surface above tunnel
- Mechanized excavation
- Subdivision into top heading, bench and invert
- Special measures (e.g. pipe roofs, temporary invert, elephant feet)
- Shorter length of advance
- Waterproofing system from membrane and drainage pipes on side of tunnel walls (umbrella system)
- Final lining from reinforced concrete usually designed for full load of overburden without water pressure

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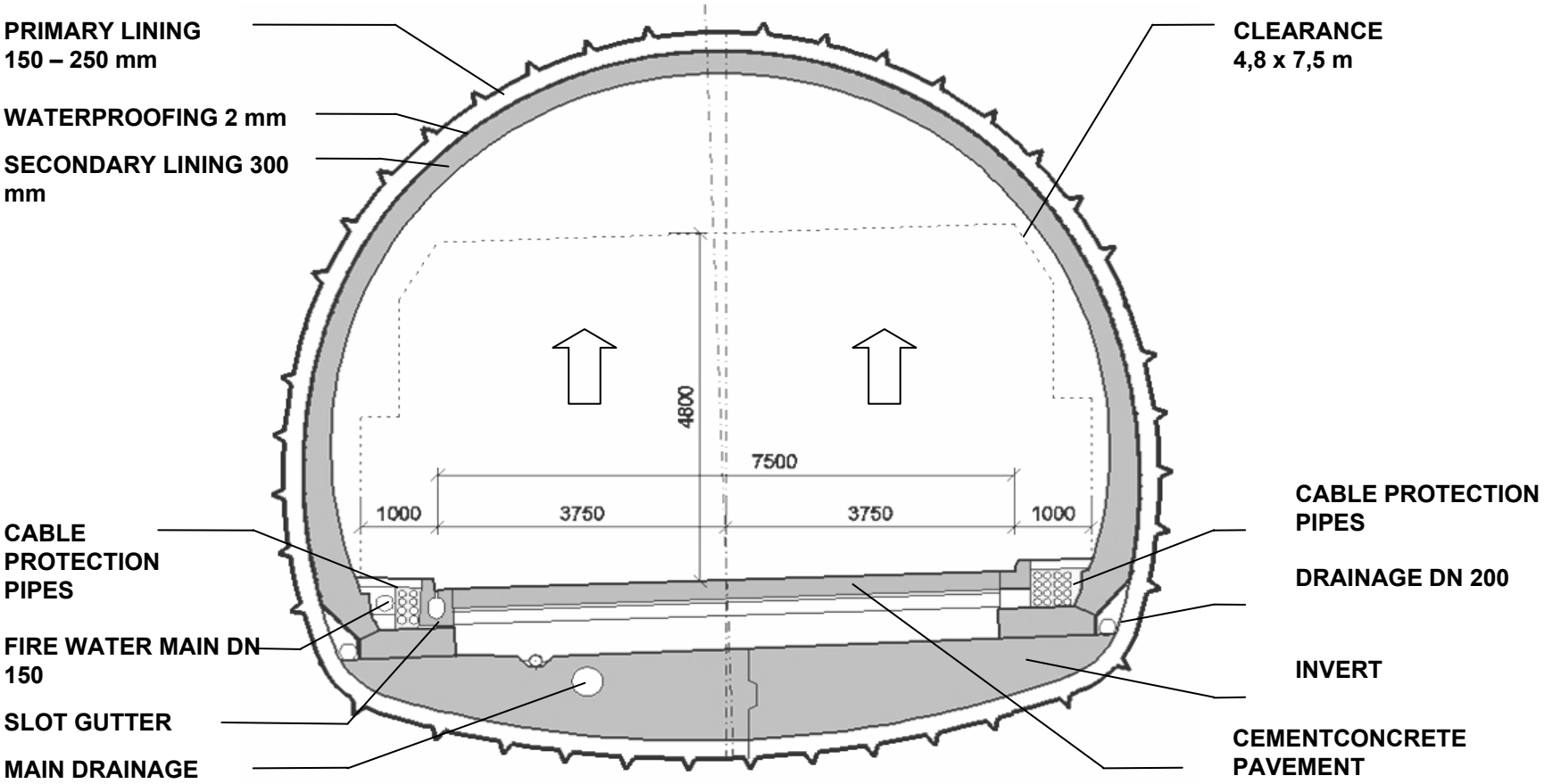

Example of road tunnel in poor rock conditions with open waterproofing system and side drainage pipes (Sitina Tunnel)

Podmienky zemín so zvláštnymi požiadavkami

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Soft ground conditions with special requirements

- Settlements on surface are restricted – urban areas with buildings or communications
- Subdivision of cross section with rapid ring closure
- Excavation of small sections of face with immediate support
- Short length of advance
- Rigid primary lining – deformations are not allowed
- Fully tanked lining system with or without membrane without permanent drainage
- Final lining from watertight reinforced concrete designed for the full water pressure

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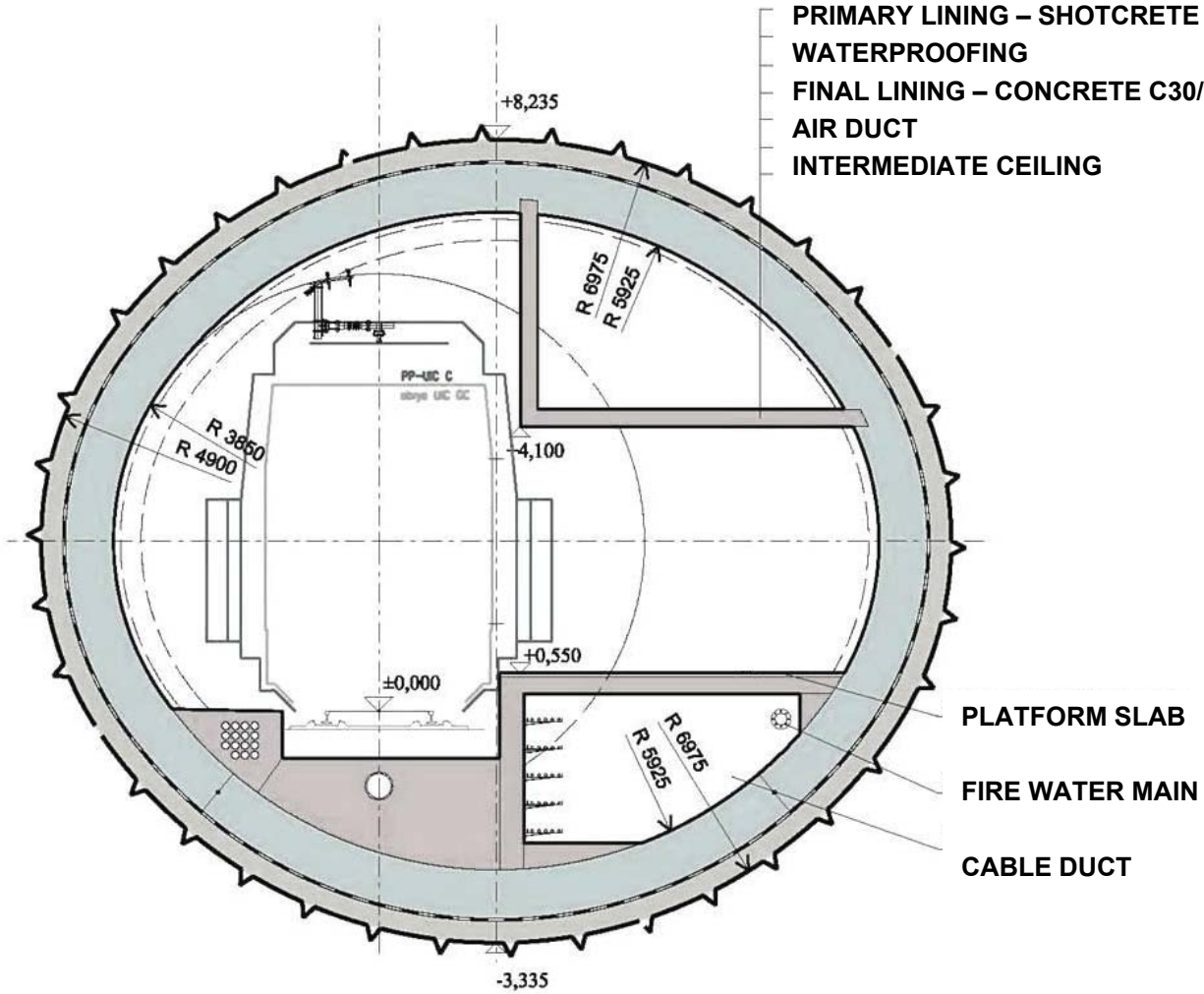

Example of railway station tunnel in soft ground with special requirements (TEN-T Railway Corridor Interconnection Project)

Princípy izolácie a definitívneho ostenia

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Protection against groundwater – waterproofing

- Open (umbrella system) – waterproofing membrane from PE or PVC protected with geotextile with permanent pipe drainage on sides of tunnel walls
- Fully tanked system (submarine) – waterproofing membrane without permanent pipe drainage in case when groundwater level should not be affected by tunnel
- Double waterproofing divided into the sections by cross and longitudinal waterstop profiles especially for tunnels under groundwater level

Final lining

- Unreinforced concrete – for hard rock conditions and for vault and circular cross sections
- Reinforced concrete – for soft ground conditions, poor rock conditions and for special shape cross section (niches, laybies, junctions with cross passages etc.)
- Reinforced watertight concrete with protection of working joints (e.g. waterstops) – for tunnels under groundwater level

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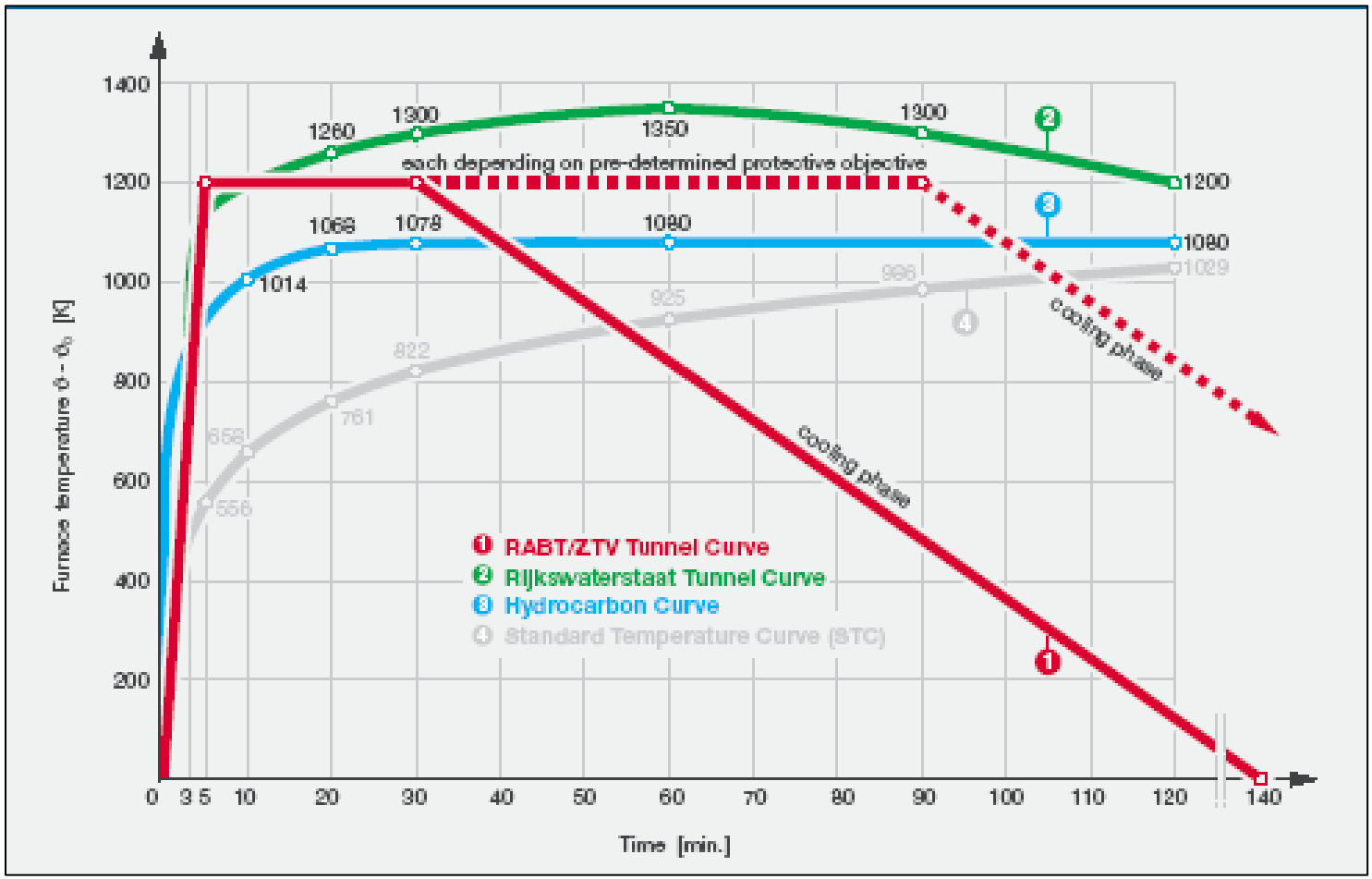
Standards for final lining structural design

- STN EN 1990 Eurocode 0 Basis of structural design
- STN EN 1992 Eurocode 2 Design of concrete structures
- STN EN 1997 Eurocode 7 Geotechnical design

According to EN 1990 structure of tunnel shall have 100 years service life time.

Load cases (actions) for final lining

- Rock pressure – division of loads to the primary and final lining in time is an important issue
- Self-weight of final lining
- Water pressure only in full tanked solution
- Thermal actions – winter and summer case
- Shrinkage of concrete
- Fire load



Fire curves used for fire resistance analysis of final lining

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Material specifications of final lining for motorway tunnels

(National Motorway Company specifications)

- Basic requirements on concrete mixture and production are defined by STN EN 206-1.
- Minimum compressive strength class of concrete for upper arch of final lining which is to shall be C25/30 with exposure classes XF2, XC3.
- Minimum cover of reinforcement shall be 40 mm on the air side and 30 mm on the rock side (if waterproofing is installed).
- Protection pipes (conduits) for cables of electro-mechanical equipment can be inserted into the final lining. Material of conduits shall meet requirements of fire protection specs.

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Construction requirements for final lining of motorway tunnels

- Length of the final lining block usually doesn´t overstep the value 12 m.
- Cross working joints of final ling elements (upper arch, basement strips, ceiling, invert) shall correspond.
- The same is recommended for slot gutters and cement-concrete carriageway.
- Construction of final lining (upper arch) can start after decreasing velocity of primary lining deformations to defined level (usually 1 mm per month).
- Concreting of upper arch shall be done in one operation without interruption.
- Demoulding of upper arch can start after concrete reaches sufficient strength. Minimum value of demoulding strength is 3 MPa.

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Pros and Cons of unreinforced final lining

+ lower construction costs

  (reinforced final lining is approx. 30 – 50% more expensive as unreinforced lining)

+ increased construction progress

+ lower risc of waterproofing damages

- possibility of cracks occurence (also in reinforced lining)

- in case of cracks structural consideration, monitoring of cracks, eventually sanation

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Parameters of final lining of Branisko tunnel

- Thickness of lining for typical profile: 300 mm
- Thickness of lining for lay-by profile: 350 mm
- Unreinforced lining C25/30: 4172 m (87%)
- Reinforced lining C25/30: 650 m (13%)

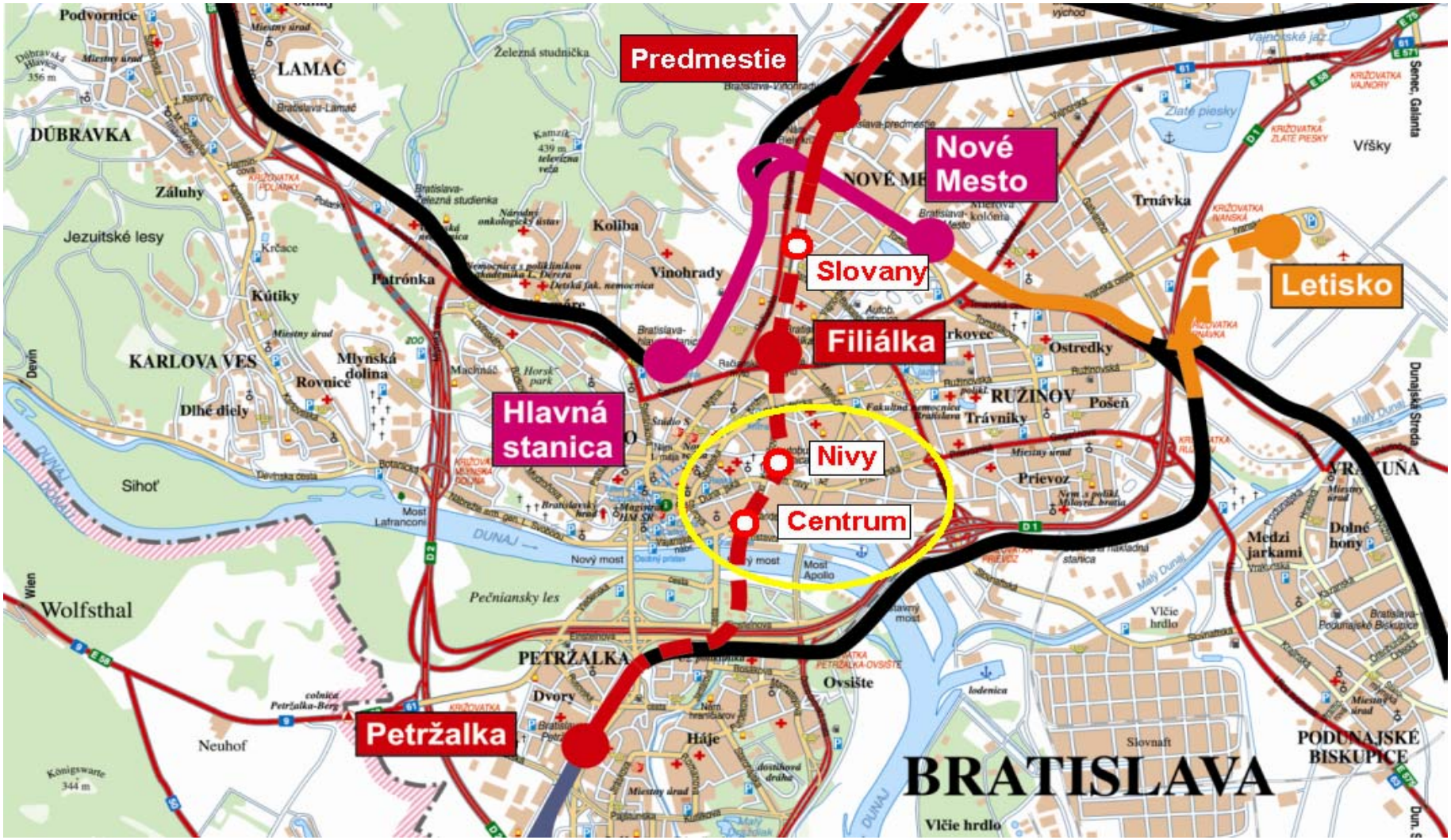
  (portal sections, sections with modified profile as lay-bies, niches etc.)
- Reinforcement quantity (upper arch): 113 kg/m3 concrete
- Formwork length: 10 m
- Fire resistance: 120 min (ISO fire curve)

Parameters of final lining of Sitina tunnel – mined tunnel sections

- Section without invert (both tubes) : 2 048 m (87%)
- Section with invert : 300 m (13%)
- Thickness of lining for typical profile: 300 mm
- Thickness of lining for lay-by profile: 350 mm
- Unreinforced lining C25/30: 1788 m (76%)
- Reinforced lining C25/30 560 m (24%)

  (portal sections, intermediate sections with low overburden, sections with modified profile – lay-bies, cross connections etc.)
- Reinforcement quantity (upper arch): 116 kg/m3 concrete
- Formwork length: 10 m
- Fire resistance: 120 min (ISO fire curve)

Železničné prepojenie TEN-T koridorov v Bratislave



Situácia železničného prepojenia na mape Bratislavy

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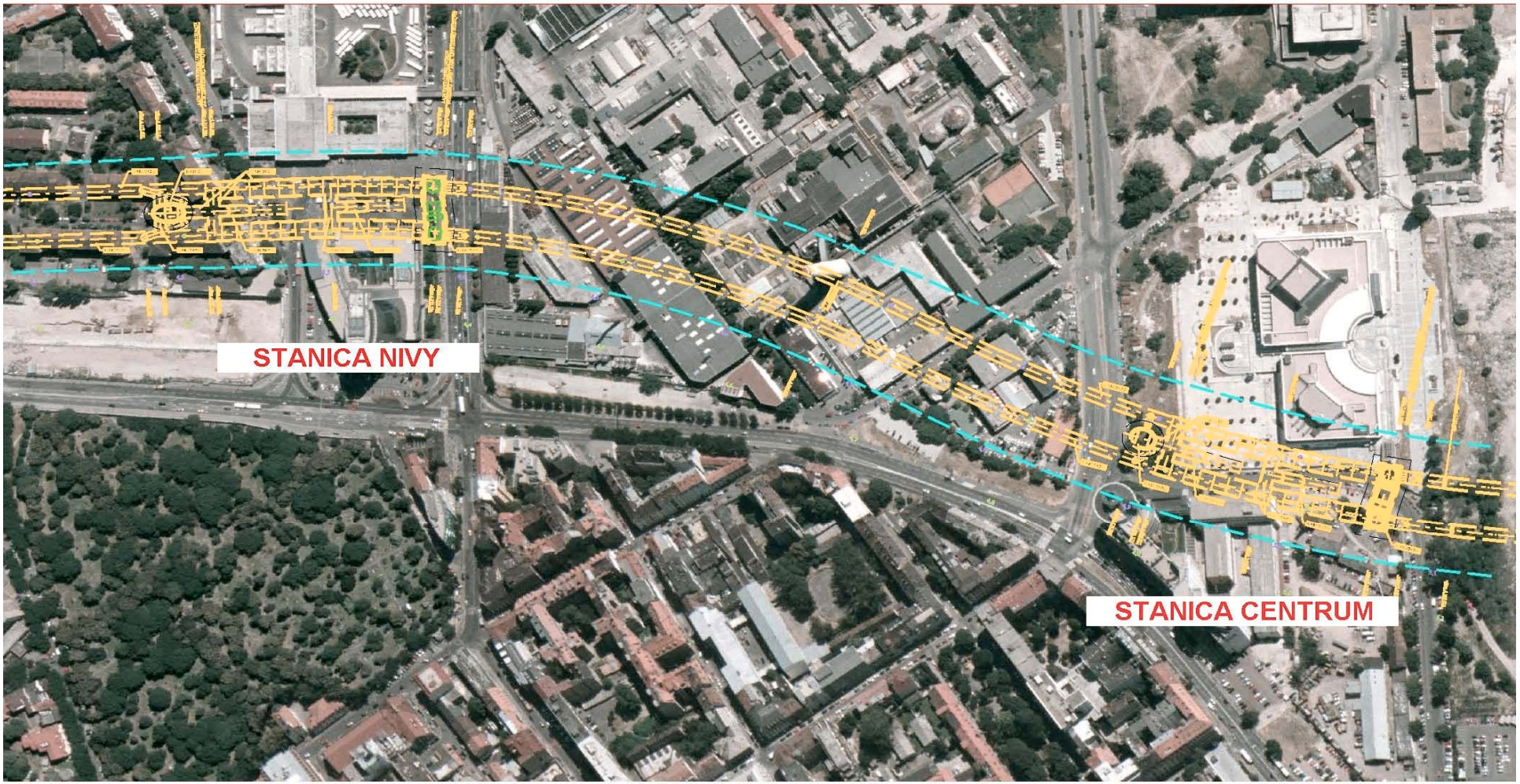

Situovanie staníc Nivy a Centrum v území s existujúcou a plánovanou zástavbou