

Current opportunities of sprayed waterproofing membrane



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What would we like to achieve?



What is desired?



...and what is not desirable !



Current technology: Conventional waterproofing concept with sheets

- Widely spread and accepted
- Installation precision is needed
- Leakage difficult to repair – need for compartments
- Precise welding
- Complex geometries are difficult



1st Stage: Sheet Formation



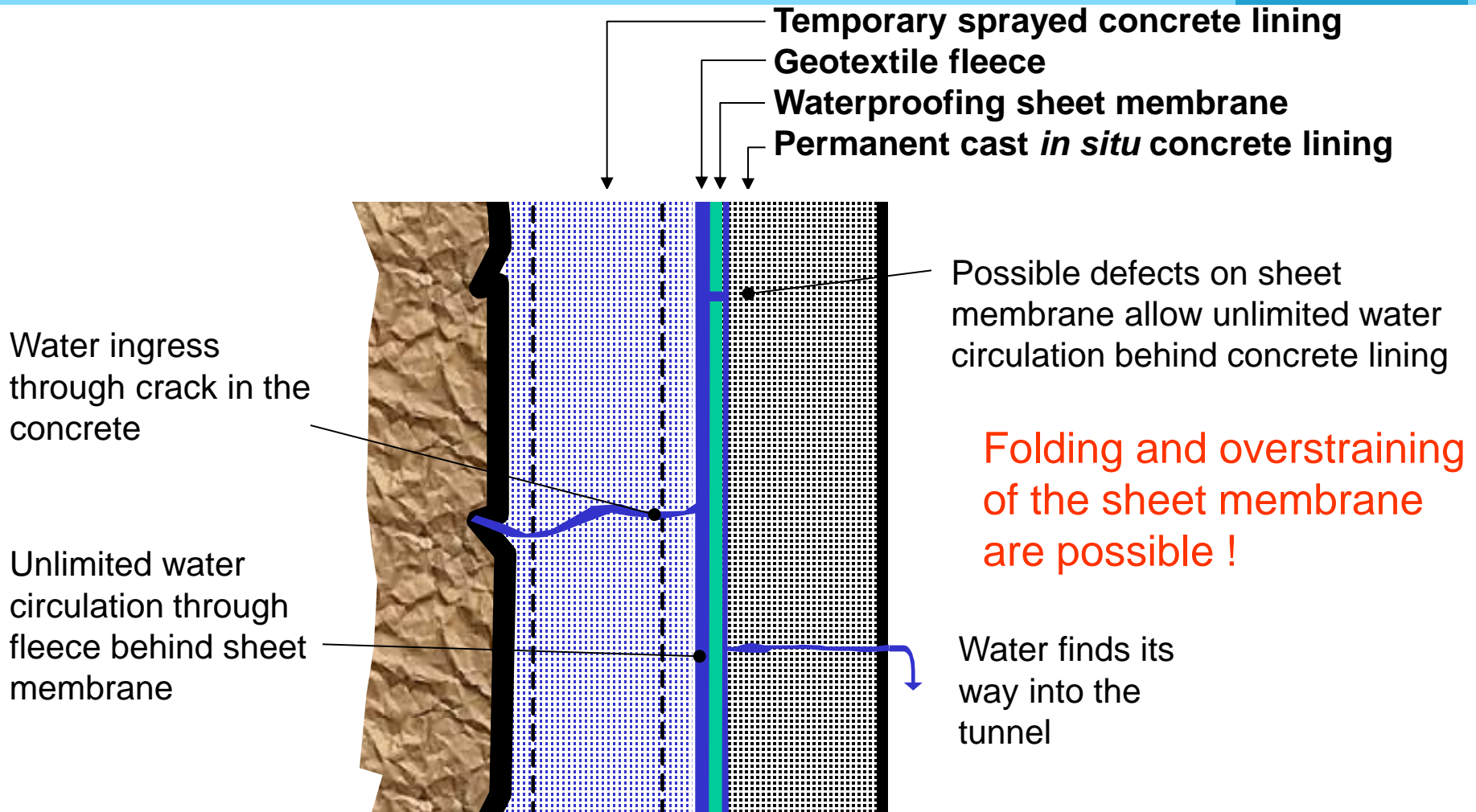
2nd Stage: Application

Current technology: Conventional waterproofing concept with sheets

- Installation of traditional waterproofing sheets is a real challenge !



Current technology: Conventional waterproofing concept with sheets



Innovative Waterproofing Concept with MASTERSEAL 345

- Waterproofing membrane
- Easy to apply
- No problem with complex geometry
- High application rates
- Easy to repair in case of water ingress.



One Stage: Sheet Formation & Application

Innovative Waterproofing Concept

Main Features (1)

- With MASTERSEAL 345 a waterproof, permanent CSL (Composite Shell Lining) is feasible
- Higher serviceability:
 - Permanent waterproofing
 - Improved safety and functionality
- Advantageous especially in complex sections, e.g. crossways
- Applicable for drained and undrained systems



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Main Features (2)

- MASTERSEAL 345 is compatible with other waterproofing systems, e.g. interfaces with conventional sheet membranes



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Main Features (3)

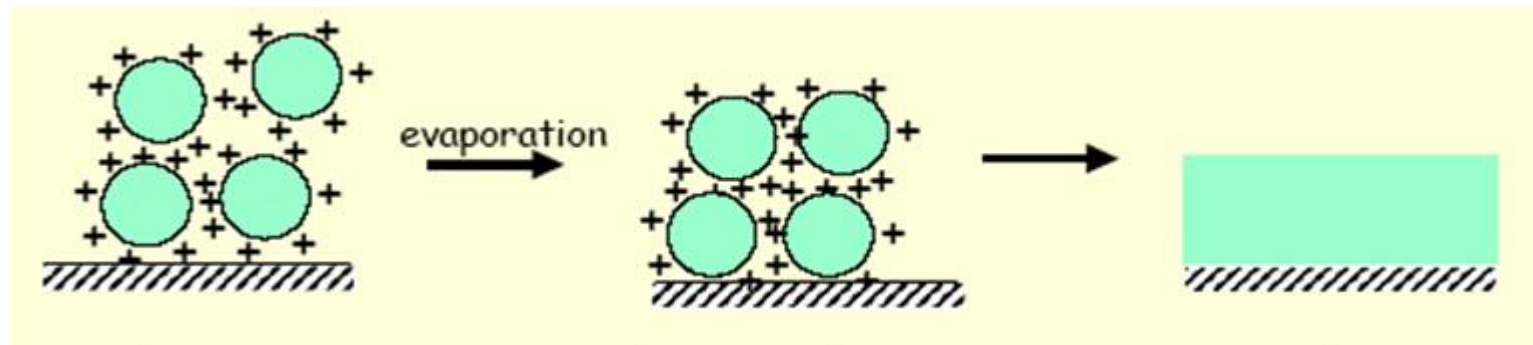
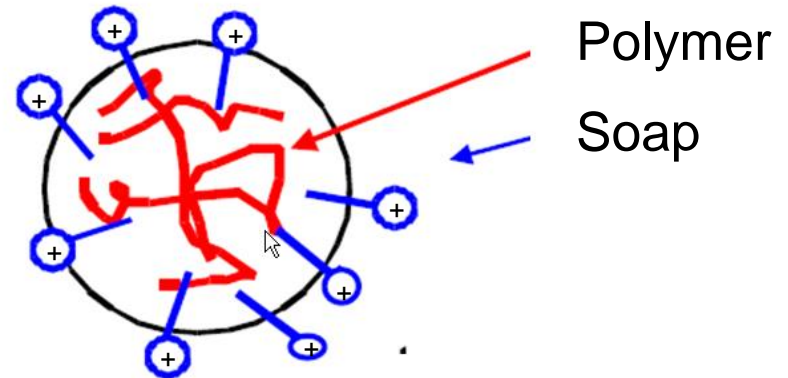
- Easy and rapid application:
 - 50 – 100 m²/h (2 - 3 workers)
 - Up to 180 m²/h (Robot application)
 - *Sheet membranes: approx. 25 m²/h*
- Inner lining may also be built with fiber reinforced sprayed concrete
- Continuous waterproofing:
 - No waterstops required
 - No compartmentalization of sections
- Application onto bolt heads possible



MASTERSEAL 345 chemistry: Polymer Colloid, Emulsion, Dispersion, Latex

- Small particles from water-insoluble polymer chains become water-soluble by addition of soap
- Static stabilization occurs:

10^{-4} mm



Why have we chosen EVA copolymers ?

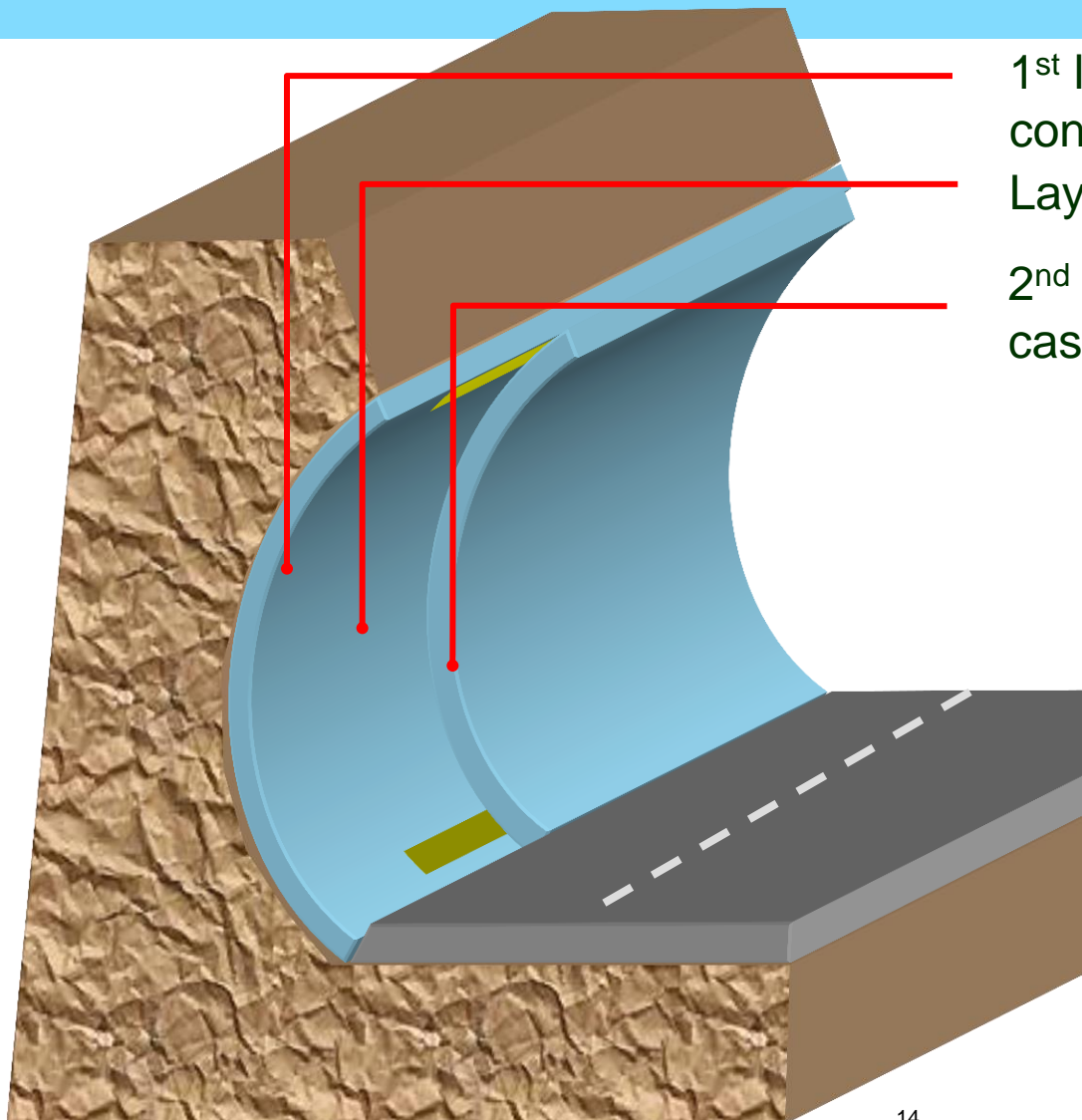


EVA is the abbreviation of **Ethylene Vinyl Acetate**. This film is used in the production of solar panels for the encapsulation of the cells. **EVA is hard-wearing, transparent, resistant to corrosion, and flame retardant.**

plasticizer free



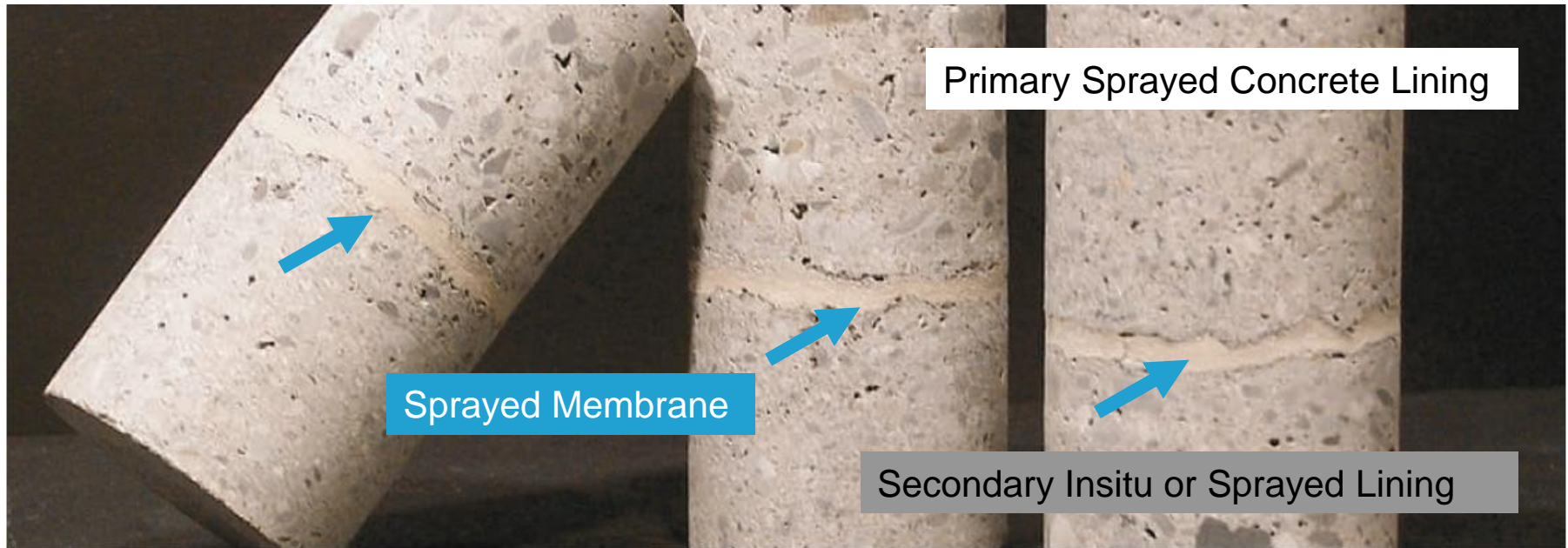
Composite Shell Lining: Double bonded concept



- 1st layer of permanent sprayed concrete lining
- Layer of MASTERSEAL membrane
- 2nd layer of permanent sprayed or cast concrete lining



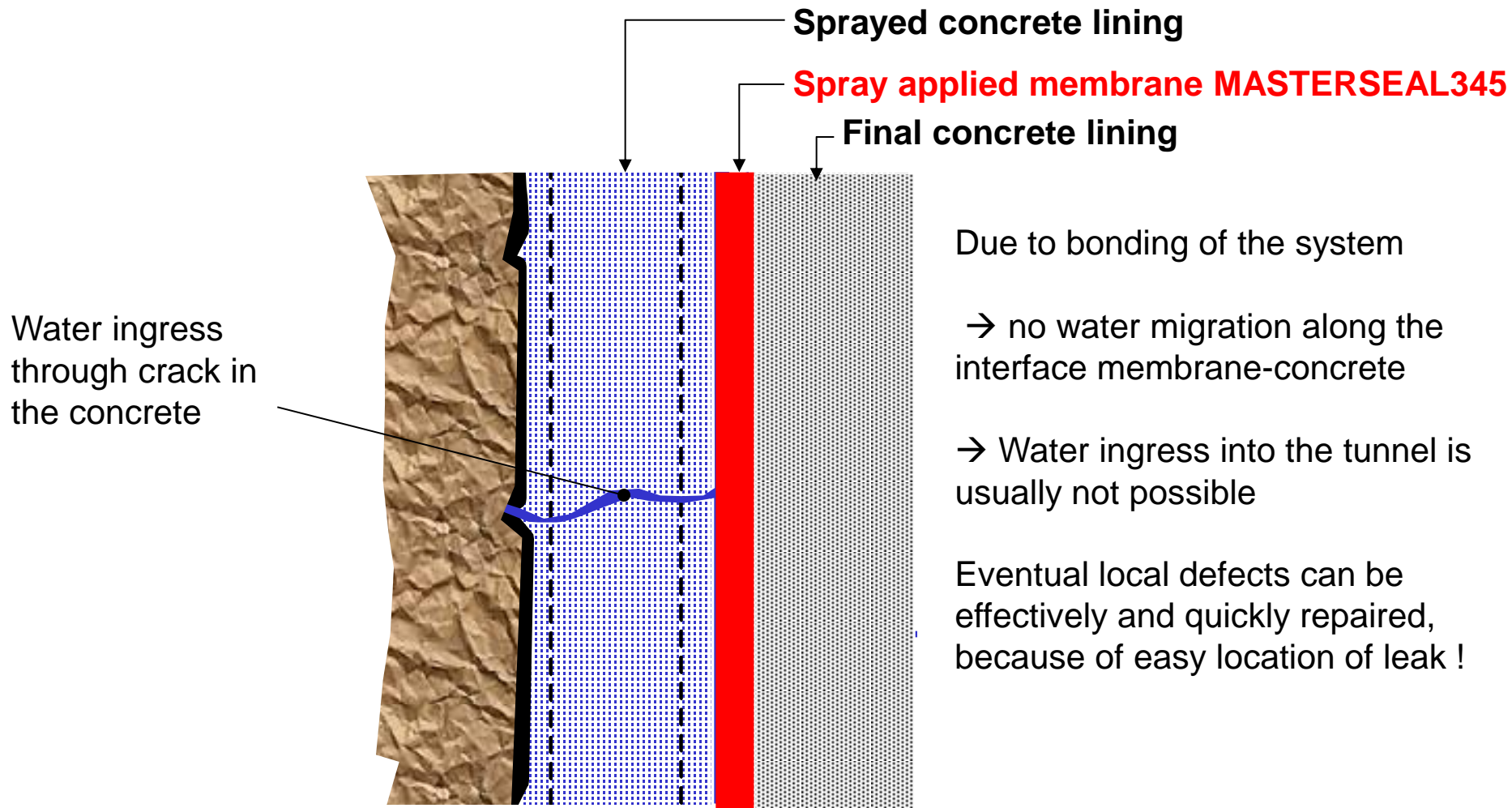
The fully bonded membrane in a composite SYSTEM



Spray-applied membrane 3mm

MASTERSEAL 345 has same bond on both sides allowing a composite system

Innovative Waterproofing Concept CSL and MASTERSEAL 345



Due to bonding of the system

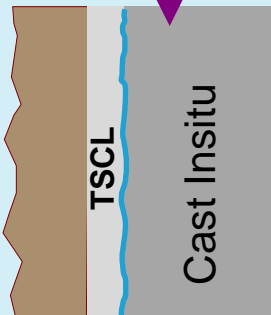
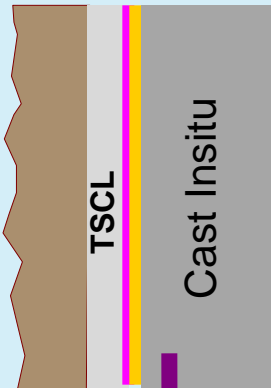
→ no water migration along the interface membrane-concrete

→ Water ingress into the tunnel is usually not possible

Eventual local defects can be effectively and quickly repaired, because of easy location of leak !

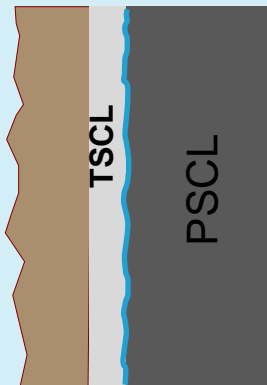
Advances in the design of concrete linings

Primary Lining seen as temporary only



Benefit from:

- Bond
- Easy placing of sprayed membrane & sprayed concrete

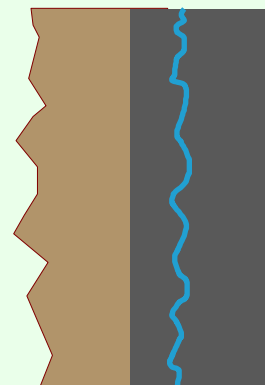


Benefit from: Bond and Placing spray. membrane

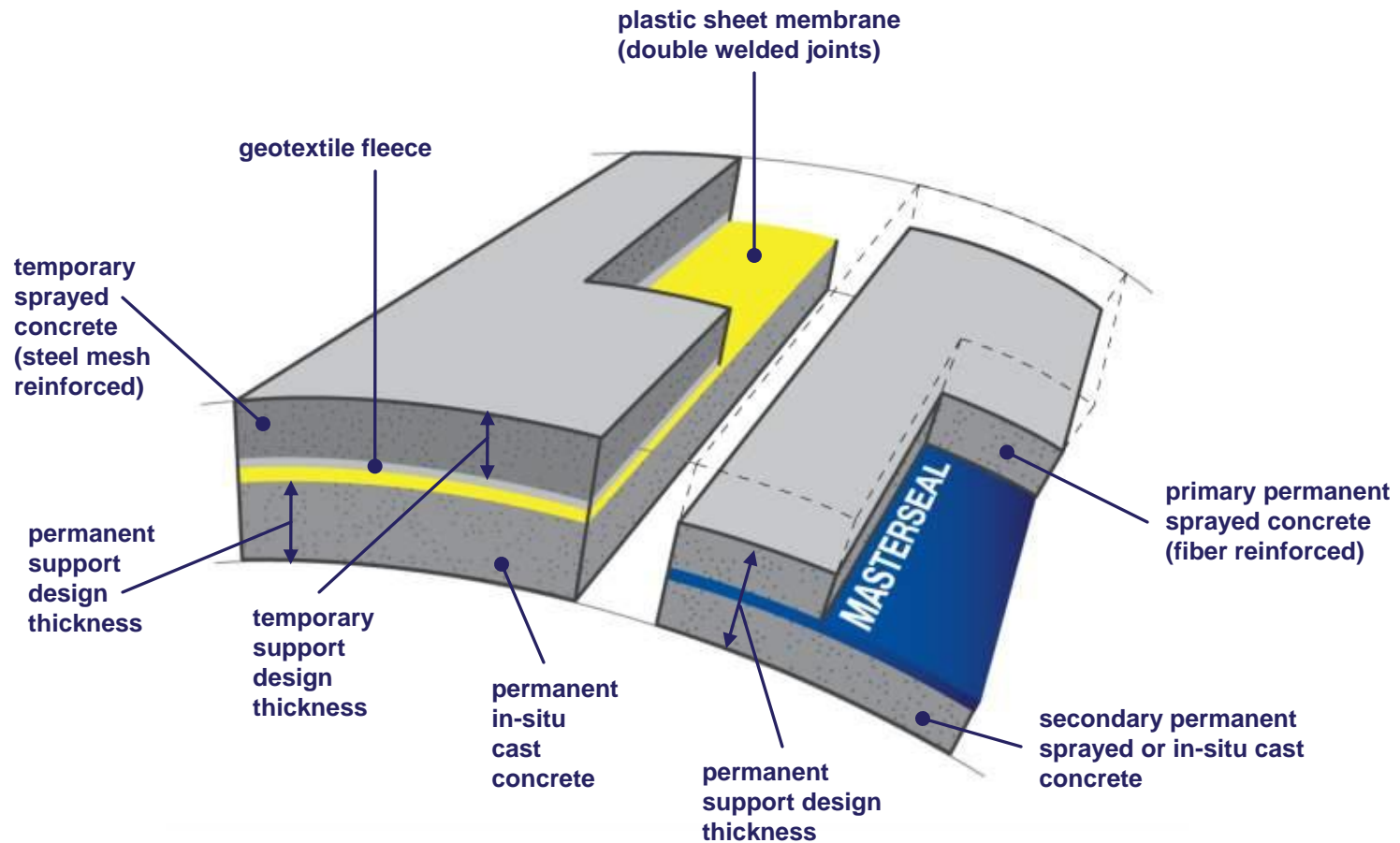
Primary Lining seen as permanent

Benefit from:

- Bond
- Easy placing of sprayed membrane & sprayed concrete
- **Reduced lining thickness through composite structure**



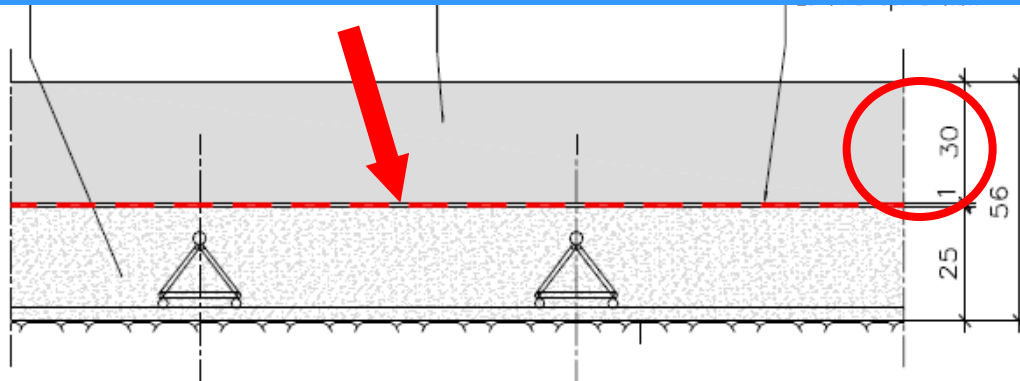
Full advantage of CSL



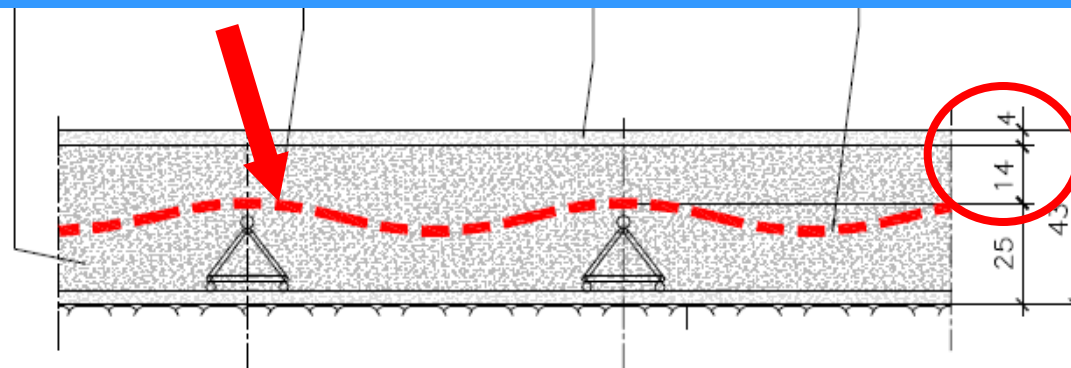
Lausanne M2

Advantage with CSL

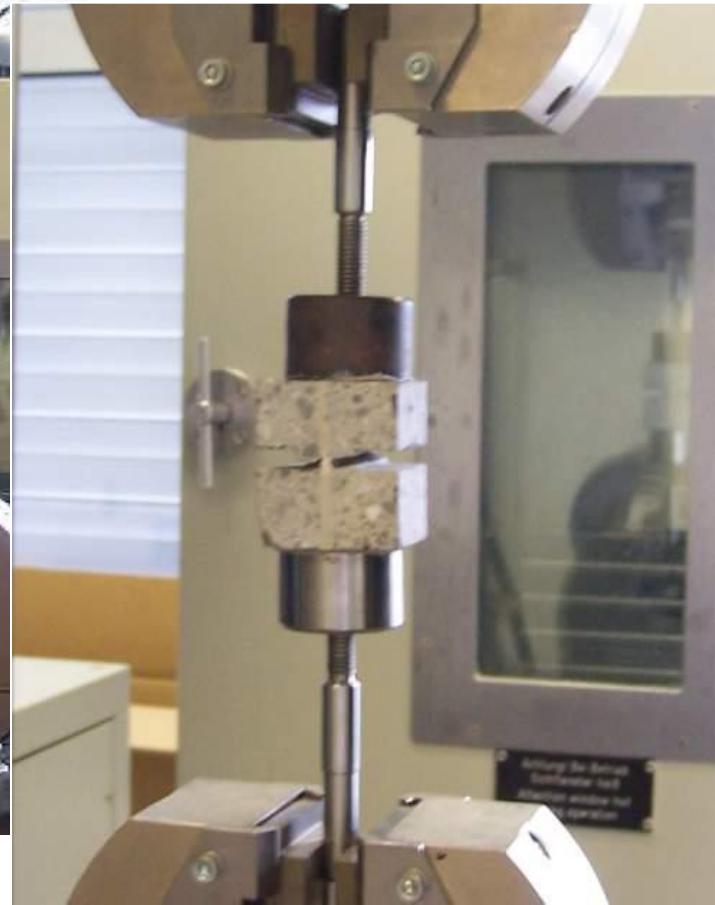
Original Design
Sheet Membrane & 300mm Concrete



Contractors Alternative Design
Sprayed Membrane & 140+40 mm Sprayed Concrete



Tests to evaluate parameters for CSL

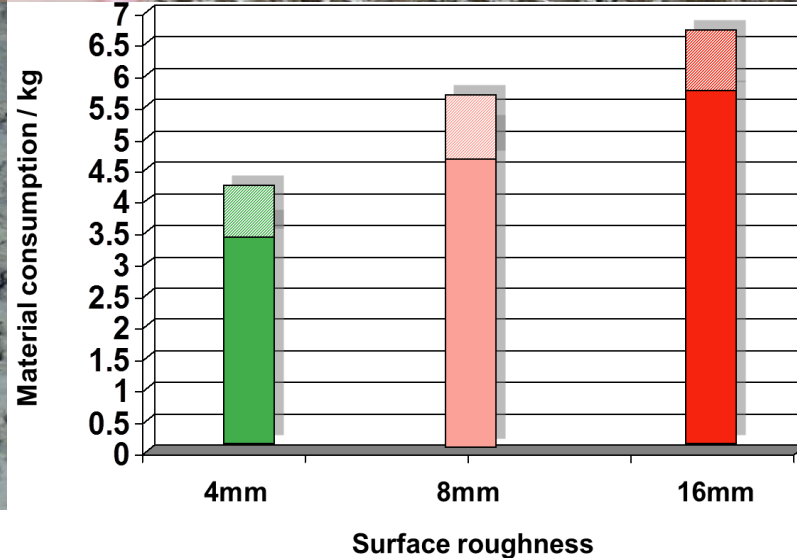


Innovative Waterproofing Concept Application Aspects (1)



Innovative Waterproofing Concept

Application Aspects (2)



Innovative Waterproofing Concept

Application Aspects (3)

- Substrate / Concrete surface must be thoroughly cleaned before application of MASTERSEAL 345:
 - Fresh and clean concrete substrate: with water (spraying nozzle)
 - Light dirty concrete substrate / “sanding”: high pressure cleaning
 - Old, dirty concrete substrate: very high pressure (> 250 bar)
 - Cleaning also with pressurized air and water possible
 - Avoid oil to come in contact with the air flow !
- Wetting of clean substrate just prior to application → good bond

Innovative Waterproofing Concept

Application Aspects (4)

- No application on standing water (e.g. tunnel invert) !
- Pre-treatment of water ingresses before application:
 - Damp spots without visible water ingress: no measures !
 - Running water: temporary stopped (injection) or drained
- Works must be adapted to local conditions and supervised
- Drainage measures should be handy and properly fixed on the substrate to avoid vibrations during application

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Application Aspects (5)

- Example of local drainage measures with half-pipe channels fixed on sprayed concrete:

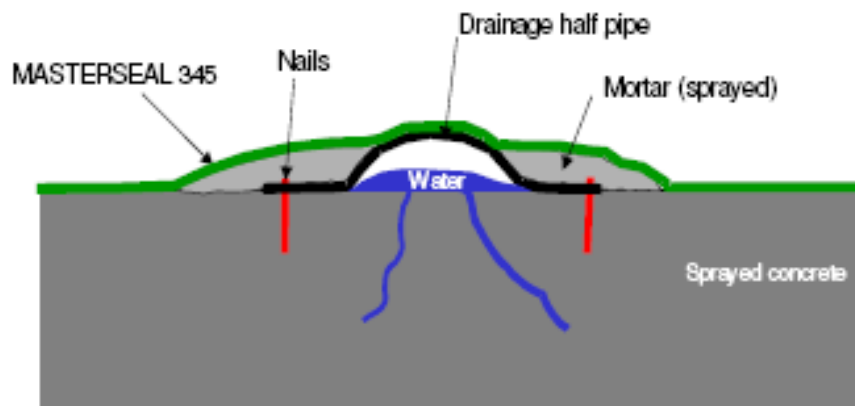


Figure 4: Installation detail of half-round drainage pipes



Innovative Waterproofing Concept

Application Aspects (6)

- Combination of local pressure relieve measures by means of boreholes (\varnothing 10 mm, $L < 1$ m) and chemical injection (packers) after curing of MASTERSEAL 345 or application of final lining:

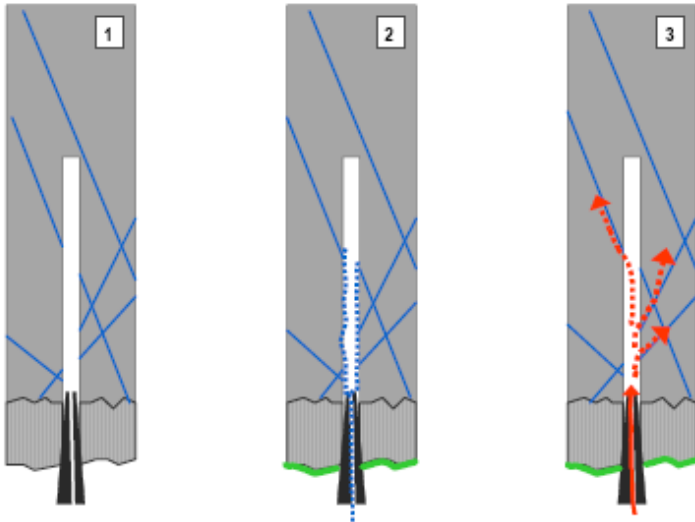


Figure 6. Temporary drainage of small seepages through 10 mm drillholes and jetpackers. The holes are injected either after the curing of the membrane or after the application of covering sprayed concrete.



Figure 7: Photo of drainage with 10 mm diameter drillholes fitted with jet-packers and hoses, prior to the application of MASTERSEAL[®] 345

References

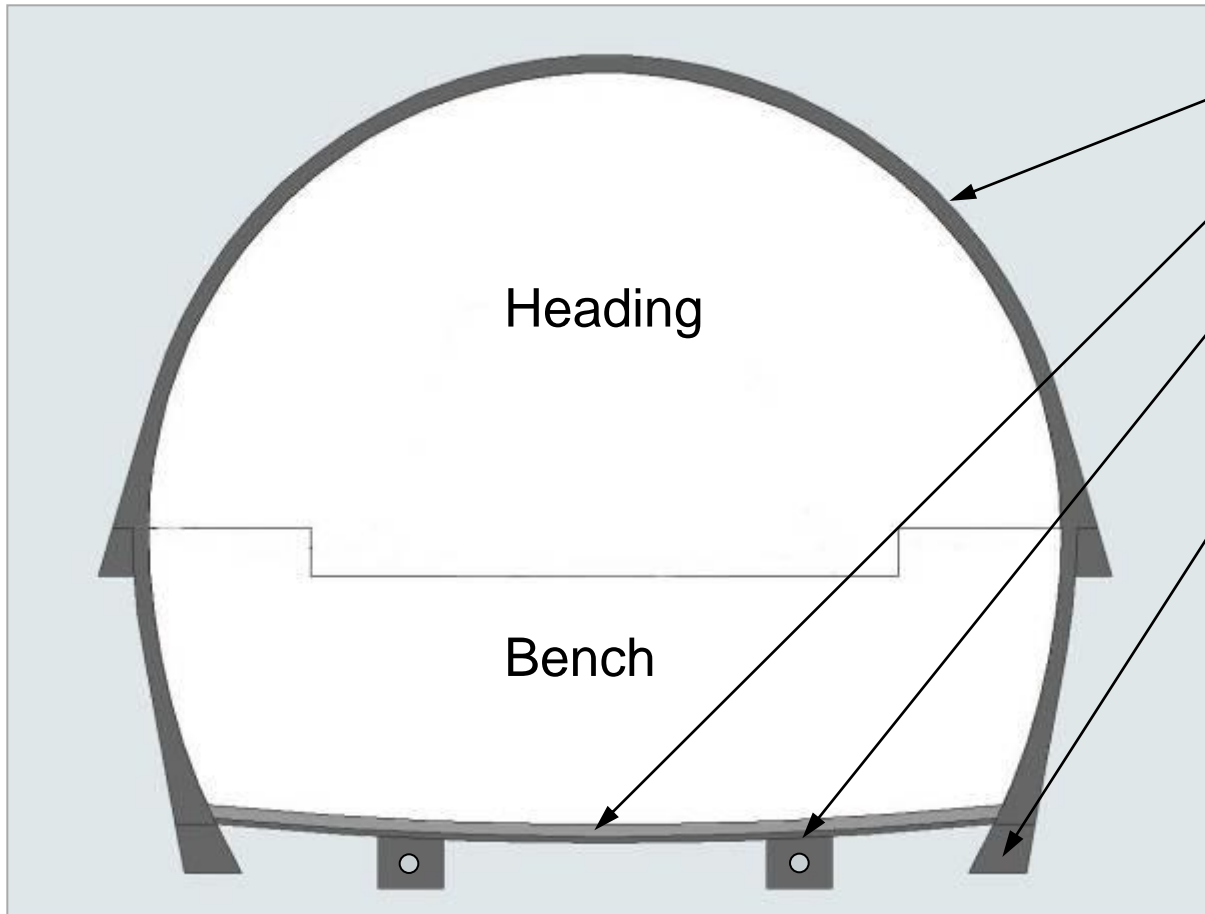
- New built tunnel using a CSL design
- Rehabilitation and upgrading existing tunnel

Hindhead A3

- 6.7 km dual carriageway
- 1.8 km twin bore tunnel
- Environmentally sensitive area
- Overall project cost £371 m
- Completion in 2011



Primary lining layout



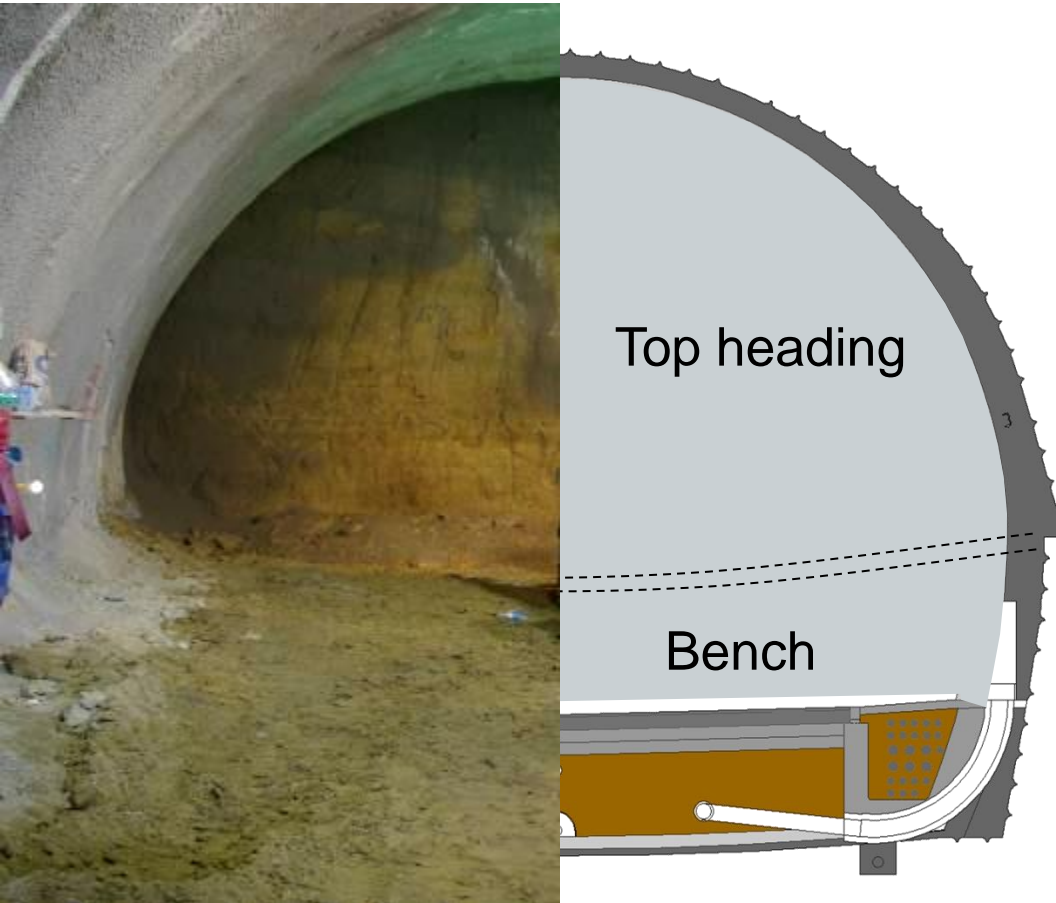
Primary lining

Flat invert (almost)

Groundwater
drainage

Elephants feet

Primary Lining

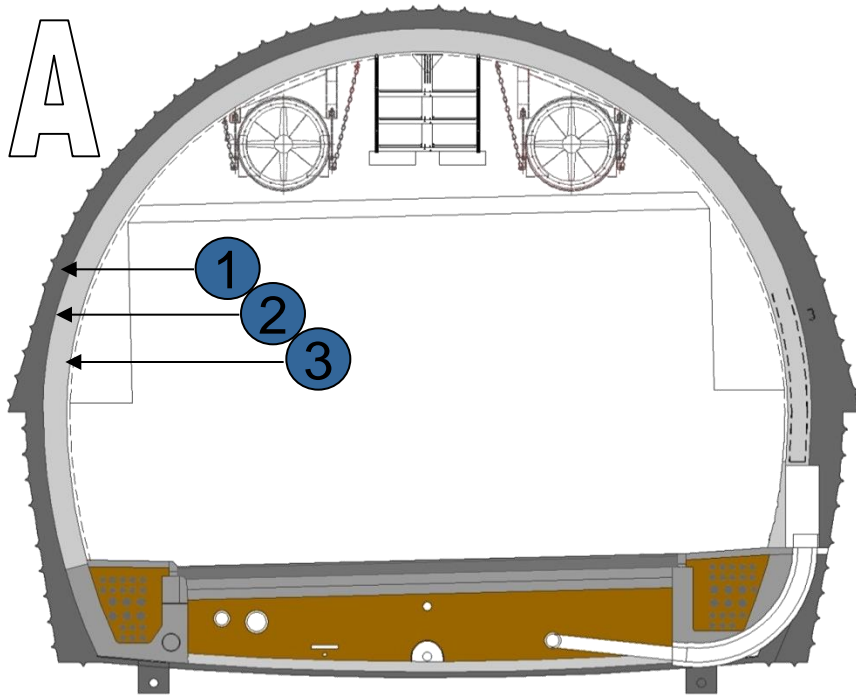


- 200mm sprayed concrete primary, permanent lining
- For durability, all steel elements designed out:
 - No lattice girders
 - No mesh
 - No rockbolts
- Steel / structural plastic fibre reinforced

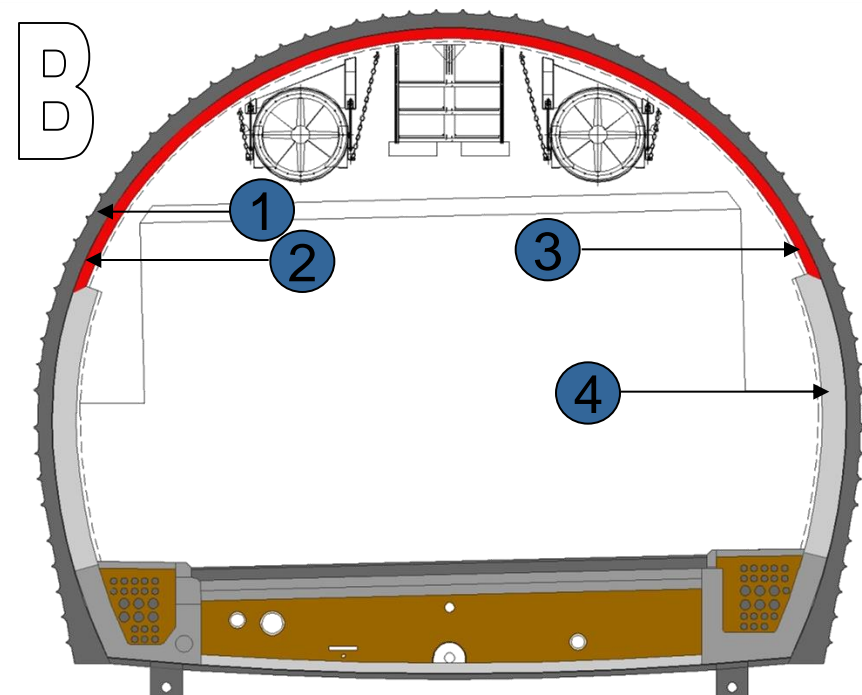
Base concrete and cross passages



Secondary Lining Value Engineering



1. SFRS Primary lining
2. PVC sheet membrane
3. Plain cast in-situ concrete Secondary lining



1. SFRS Primary lining
2. Spray applied membrane
3. Sprayed concrete Secondary lining
4. Plain cast in-situ concrete walls

Two, fully detailed design solutions

Spray applied waterproofing



Casting sidewalls

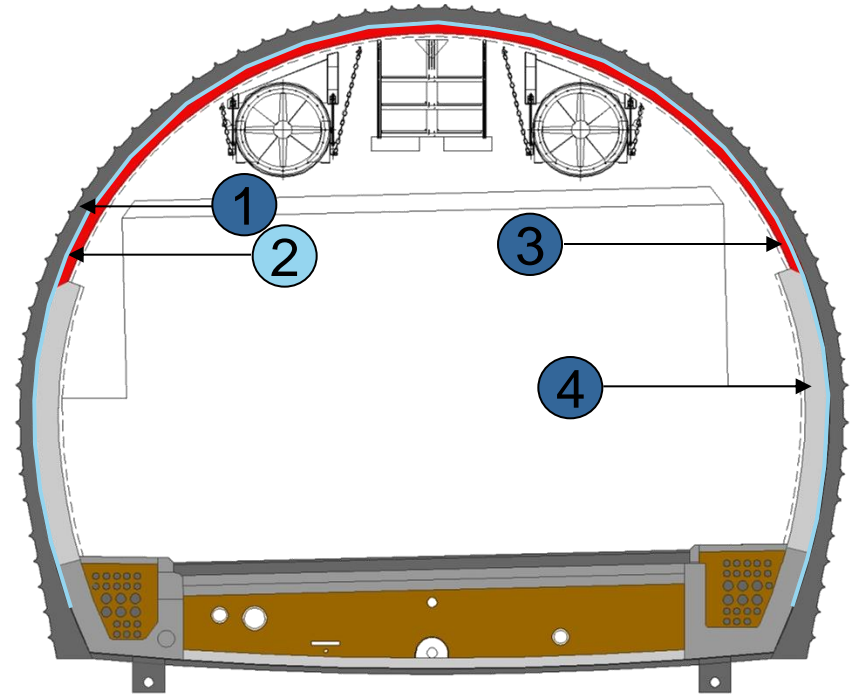


Hindhead

State-of-the-art SCL design

Key benefits:

- Same team, same equipment as for SCL
- Materials and Equipment Cost saving ~ £1.5M
- Programme saving 3 - 4 months
- Increased flexibility



1. SFRS Primary lining
2. Spray applied membrane
3. Sprayed concrete lining
4. Plain cast in-situ concrete lining

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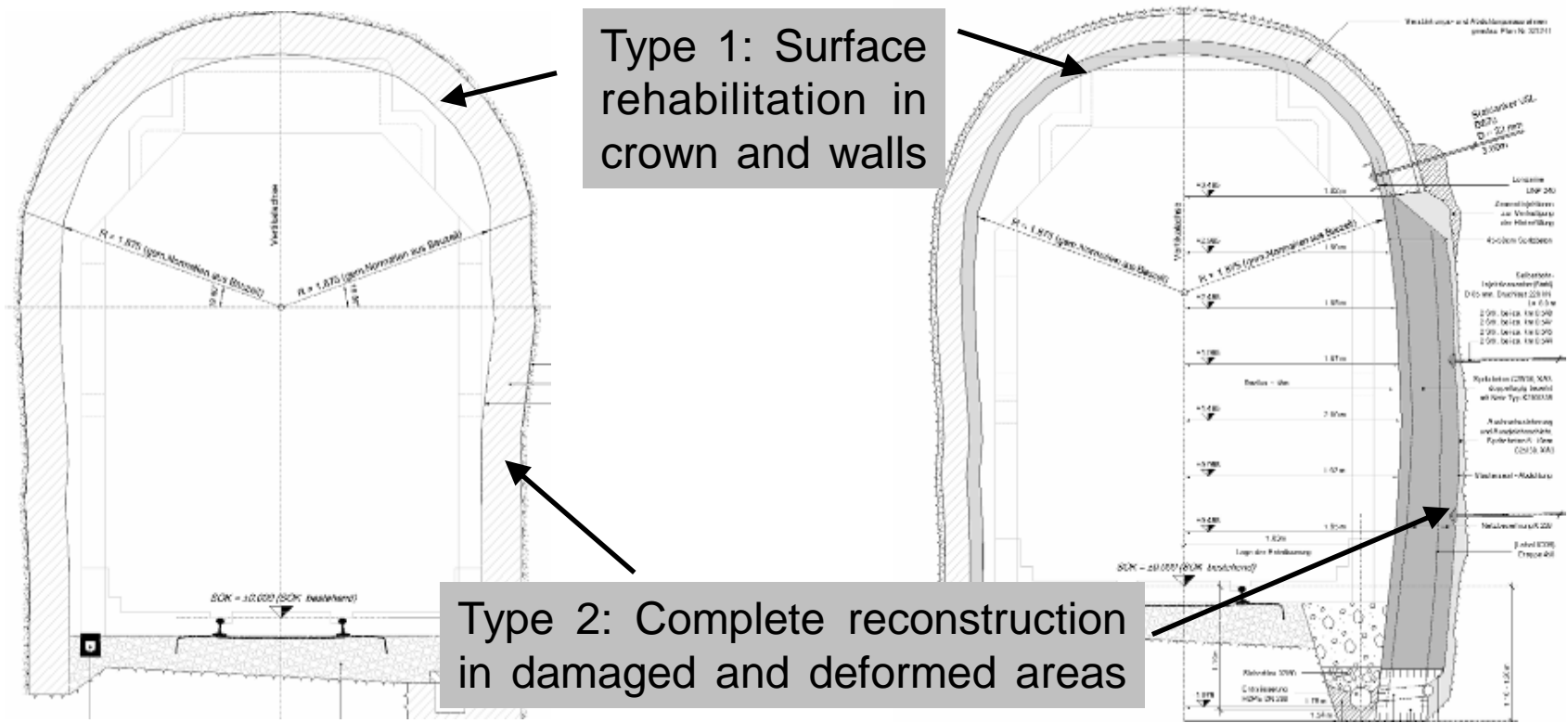
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The two main issues for the rehabilitation:



- Large deformations and structural instability of parts of the walls caused by ice pressure
- Minor seepage in the tunnel crown and walls, structural stability ok

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Type 1: Surface rehabilitation in crown and walls

Type 2: Complete reconstruction in damaged and deformed areas

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Rehabilitation type 1 - surface damage



Situation prior to rehabilitation:

- Water ingress through joints
- Partially deteriorated joint filling material (mortar) near tunnel surface
- In some places: formation of ice during winter

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Rehabilitation type 1 - surface damage



Rehabilitation efforts:

- Abrasive trimming of surface
- Singular seepage points collected in drainage features
- MASTERSEAL 345 spray applied membrane
- Steel fibre reinforced spray concrete 7 cm thickness

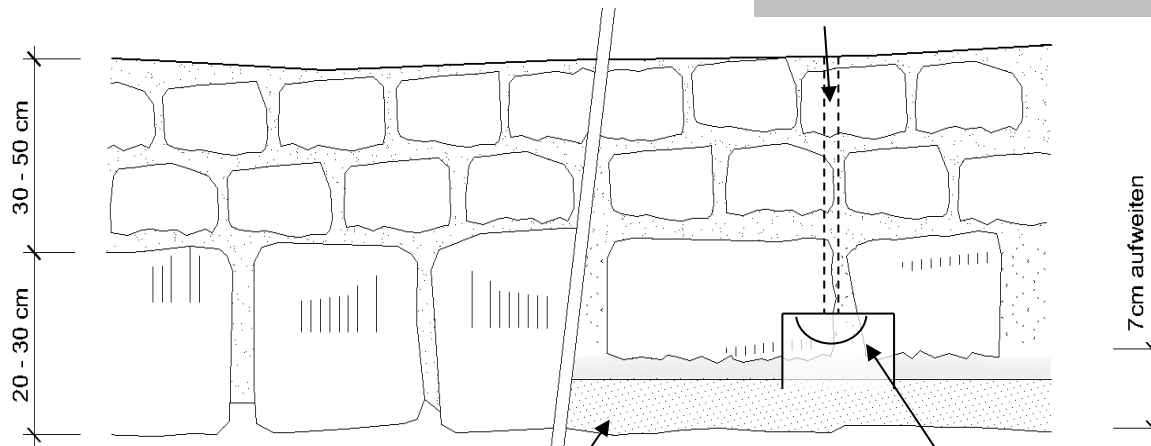
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Type 1: Section of system with drainage detail

Drillhole to collect seeping water



Removal of 7 cm of old lining
by abrasive trimming

Drainage feature with drainage
half-pipe placed in a groove

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Rehabilitation type 2 – serious damages



Situation prior to

- Formation of ice caused pressure and strong inwards deformation of the masonry lining
- Developing situation, immediate intervention was required
- Complete reconstruction of these sections

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Rehabilitation type 2 – serious damages



Rehabilitation efforts:

- Demolition and reconstruction of old lining in shorter sections
- Spray applied waterproofing in combination with sprayed concrete and mesh reinforcement

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Rehabilitation type 2 – serious damages



- Demolition of old lining in 3 meter sections step by step
- Rock support with wet mix sprayed concrete

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Rehabilitation type 2 – serious damages



Reconstruction:

- Primary support with sprayed concrete, MASTERSEAL 345 spray-applied waterproofing membrane and inner lining of mesh-reinforced sprayed concrete
- Formwork for overlapping joints of the next section

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Rehabilitation type 2 – serious damages



- Final lining with mesh-reinforced sprayed concrete

Conclusions

- Conventional water proofing systems is not always the best solution
- New concept with MASTERSEAL 345 is allowing CSL which can save risks, time and costs in a project
- New design approach is necessary when using MASTERSEAL 345 in a composite structure
- MASTERSEAL 345 has several design options
- Spray applied membrane is fast, easy and flexible
- MASTERSEAL 345 has shown its performance in numerous projects worldwide