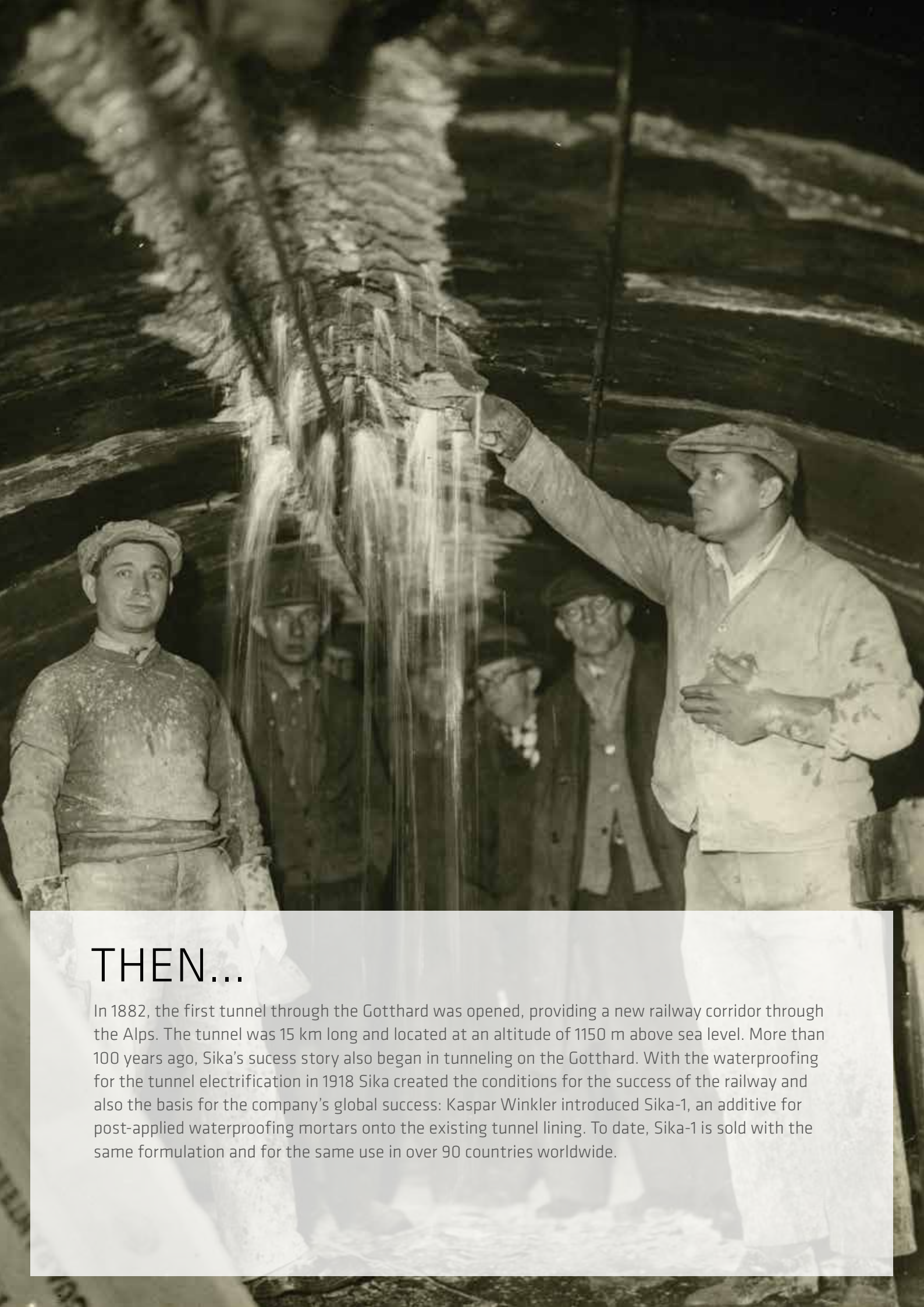
WATERPROOFING
SIKA SOLUTIONS FOR WATERTIGHT TUNNEL STRUCTURES

BUILDING TRUST



THEN...

In 1882, the first tunnel through the Gotthard was opened, providing a new railway corridor through the Alps. The tunnel was 15 km long and located at an altitude of 1150 m above sea level. More than 100 years ago, Sika's sucess story also began in tunneling on the Gotthard. With the waterproofing for the tunnel electrification in 1918 Sika created the conditions for the success of the railway and also the basis for the company's global success: Kaspar Winkler introduced Sika-1, an additive for post-applied waterproofing mortars onto the existing tunnel lining. To date, Sika-1 is sold with the same formulation and for the same use in over 90 countries worldwide.

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WATERPROOFING SOLUTIONS

WATERPROOFING SYSTEMS for tunnel structures are faced with very stringent requirements regarding durability, exposure and stress conditions, demanding construction methods and sequences, ease of application and total cost management. In addition, sustainable system solutions are becoming more important in order to save natural resources such as energy and water, reduction of CO_2, etc.

As the global leader in providing structural waterproofing solutions, Sika has a complete and comprehensive range of solutions and designed systems to meet the specific needs and requirements of owners, architects, engineers and contractors on site, consisting of highly flexible membrane systems, liquid applied polymeric membranes, waterproofing concrete admixtures, joint waterproofing systems, waterproofing mortars and coatings as well as injection grouts.
Today, operators request a service life for underground structures of 100+ years, but a lack of water tightness severely reduces the long-term durability of a tunnel structure and badly affects its planned use, as water ingress results in physical attack and deterioration of the concrete. Expensive repair works, damage and operational downtime are the results.
The selection of the appropriate waterproofing solution, the project specific design of the chosen waterproofing system and its safe application at site are the key elements to minimize the operation costs.
A waterproofing system typically amounts to a fraction of the total constructions costs. The selection of a high quality waterproofing solution may easily save an amount of its initial investment or more on future maintenance and repair costs during the entire service life of the structure.

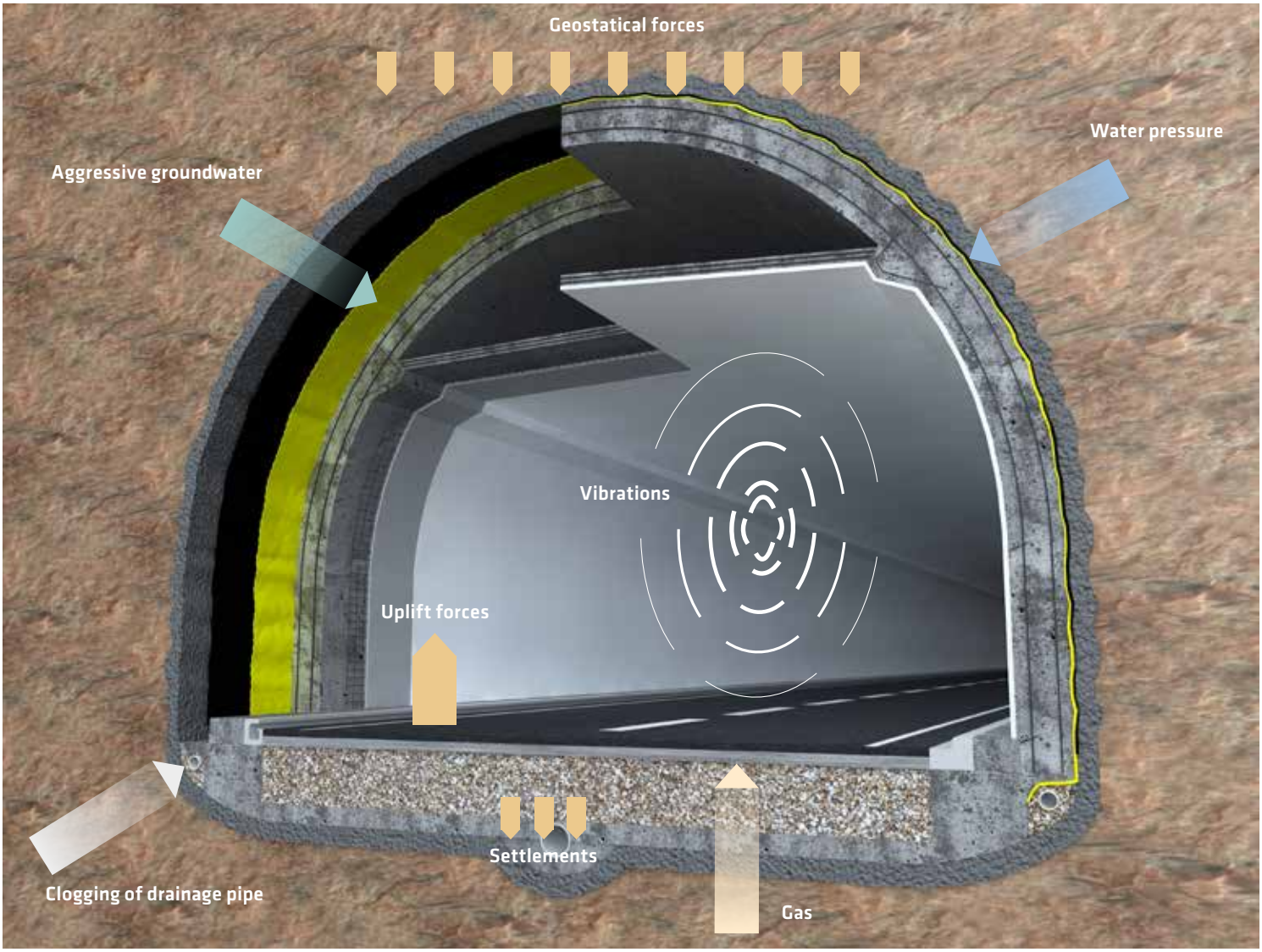
ROAD TUNNELS
Waterproofing of cut-and-cover structures and mined tunnels for roads and express ways.

RAILWAY TUNNELS
Waterproofing of cut-and–cover structures and mined tunnels for railways

METRO TUNNELS
Waterproofing of cut-and-cover structures, mined tunnels and shafts for subways tubes and metro stations.

PRESSURE GALLERIES
Waterproofing of high-pressure galleries, surge chambers and caverns to resist against hydraulic pressure.

TUNNEL STRUCTURES – EXPOSURE AND STRESS



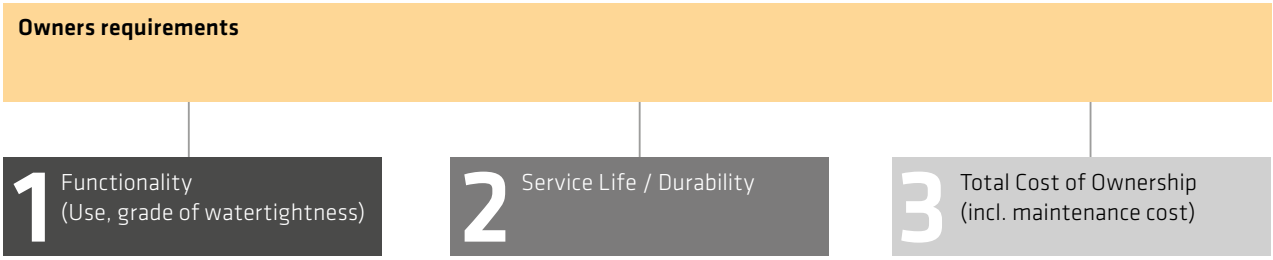
EXPOSURE IMPACT ON BELOW GROUND STRUCTURES

The following types of exposure may adversely influence the use, watertightness and durability of a tunnel structure, resulting in a reduced service life of the entire structure.

Exposure		Impact on structure
Water ingress	→	Damage to structure, wiring and electrical installations. Corrosion of steel reinforcement.
Aggressive chemicals	→	Concrete damage (due to sulphate attack), corrosion of steel reinforcement (due to chloride attack)
Unequal static forces	→	Structural cracking
Dynamic forces	→	Structural cracking
Temperature variations	→	Condensation, scaling or cracking of concrete
Gas penetration	→	Gas penetration and exposure for users
Fungal/bacterial attack	→	Damage to the waterproofing system, finishes or contents

OWNER'S PROJECT REQUIREMENTS

TO DEFINE THE APPROPRIATE WATERPROOFING STRATEGY AND TYPE OF SYSTEM for a specific project, it is important to consider not only the ground conditions but also the project requirements of the owner: Functionality and future use, the service life and the total cost of ownership.



1 FUNCTIONALITY (USE, GRADE OF WATERTIGHTNESS)

The future use defines the degree of watertightness and protection of a structure. The German tunnel standard Ril 853 describes different levels of watertighness which can be combined with additional protection requirements.

Class 1	Class 2	Class 3	Class 4
Completely dry	**Dry to slightly moist**	**Moist**	**Moist to wet**
No moist parts on the dry part of the tunnel surface permitted	Single failing parts permitted. No dropping water on the dry part of the tunnel surface permitted	Partly limited moisty parts and single dropping parts on the dry part of the tunnel surface permitted	Moisty parts and dropping parts permitted
■ Clean air rooms ■ Dry rooms ■ Energy supply rooms ■ Metro stations (presence of people)	■ Road tunnels highway ■ Road tunnels in frosty zones ■ High speed train tunnels ■ Parking areas	■ Regional railways ■ Metro lines ■ Escape tunnels	■ Sewage tunnels
Water infiltration in l/sqm within 24 h acc. STUVA report			
0	0 – 0.1	0.1 – 0.5	0.5 – 1.0

2 SERVICE LIFE / DURABILITY

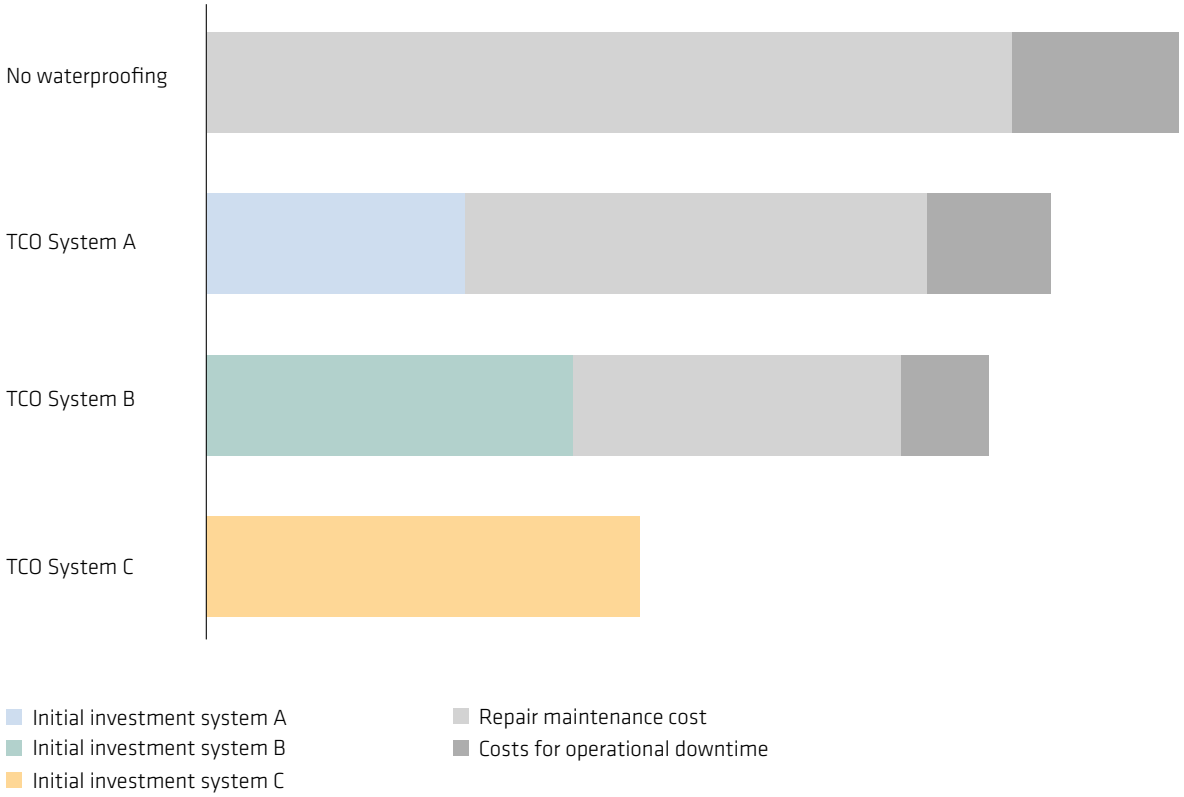
100+ years durability are common requirements nowadays for tunnels and underground structures. The following guidelines and standards used internationally describe material and system properties to be considered to achieve a service life of 100+ years:

- Austria
  ÖBV Guideline 'Richtline Tunnelabdichtung'
- Germany
  ZTV-ING, Ril 853
- Switzerland
  SIA 272

The requirements defined in those standards are not limited to initial physical properties, but include stringent long-term tests as well, such as exposure to hot water and specific chemicals, to simulate the ageing process of the waterproofing products.

3 TOTAL COST OF OWNERSHIP

The total cost of ownership (TCO) for the owner and investor includes all of the building costs for the entire service life of the structure, including the initial investment, the cost of any repair and maintenance, plus the cost of any downtime during any such works. The graphic below illustrates the total cost of ownership for a specific project (e.g. tunnelling structure) with a required service life of 100+ years.



EXCAVATION METHODS

MINED TUNNELS include all structures excavated underground by conventional methods or tunnel boring machines. Depending on the excavation method and the required watertightness, single or double linings are chosen. In case of single-shell tunnels, the primary lining is the waterproofing barrier in itself. In case of double-shell constructions, the waterproofing layer is provided between the first and the secondary lining.

CONVENTIONAL EXCAVATION

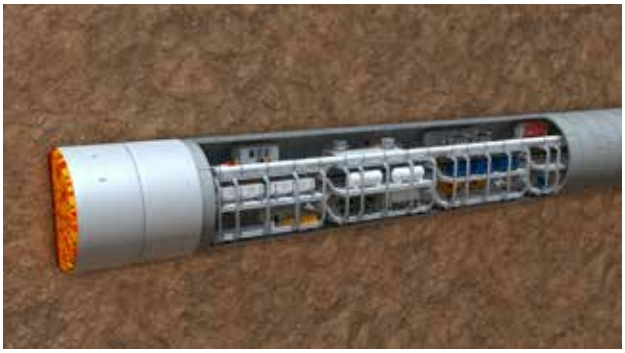
BY DRILL AND BLAST

Description:
By default, mined tunnels limit the selection of the waterproofing system to pre-installed membrane systems or integral waterproofing only. Externally or post-applied bonded waterproofing systems can not therefore be used.

Waterproofing systems:
Integral waterproofing systems:
- Sika White Box / Watertight Concrete System

Pre-installed waterproofing systems:
- Loose-laid prefabricated membrane systems, drained and pressurized

MECHANISED EXCAVATION



BY TBM

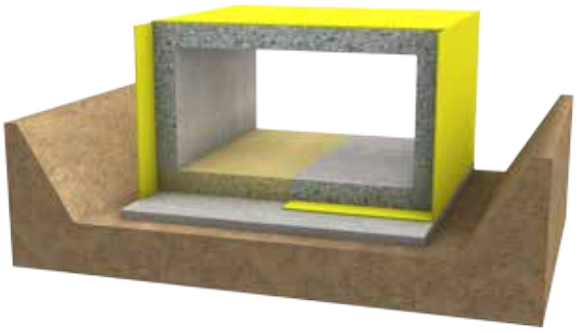
Description:
Single-shell tunnels with pre-fabricated segments or double linings are common. The type of TBM (shield or hard rock) defines the waterproofing system.

Waterproofing systems:
Integral waterproofing systems:
- Sika White Box / Watertight Concrete System

Pre-installed waterproofing systems:
- Loose-laid prefabricated membrane systems, as drainage or barrier system (double shell)

CUT-AND-COVER STRUCTURES describe buildings constructed in an open pit and then covered by soil again. The type of temporary pit support and excavation method defines the possible waterproofing systems to be used.

OPEN CUT EXCAVATION



WITH SLOPING SIDES

Description:
This basic excavation method using sloping sides allows an easy bottom-up construction method and has no impact on the selection or installation of the waterproofing system.

Waterproofing systems:
Integral waterproofing systems:
- Sika White Box / Watertight Concrete System

Externally applied waterproofing systems:
- Loose laid compartmentalized membrane systems
- Pre- and post-applied fully bonded sheet membranes
- Liquid applied membranes
- Waterproofing mortars and coatings (in combination with drainage systems)

CONSTRUCTION WITH PILED / DIAPHRAGM WALLS

CONSTRUCTION INSIDE PILED WALLS

Description:
The structure is normally built directly against the temporary pit support. Post- applied waterproofing systems can therefore not be used for these structures (except for podium and roof sections).

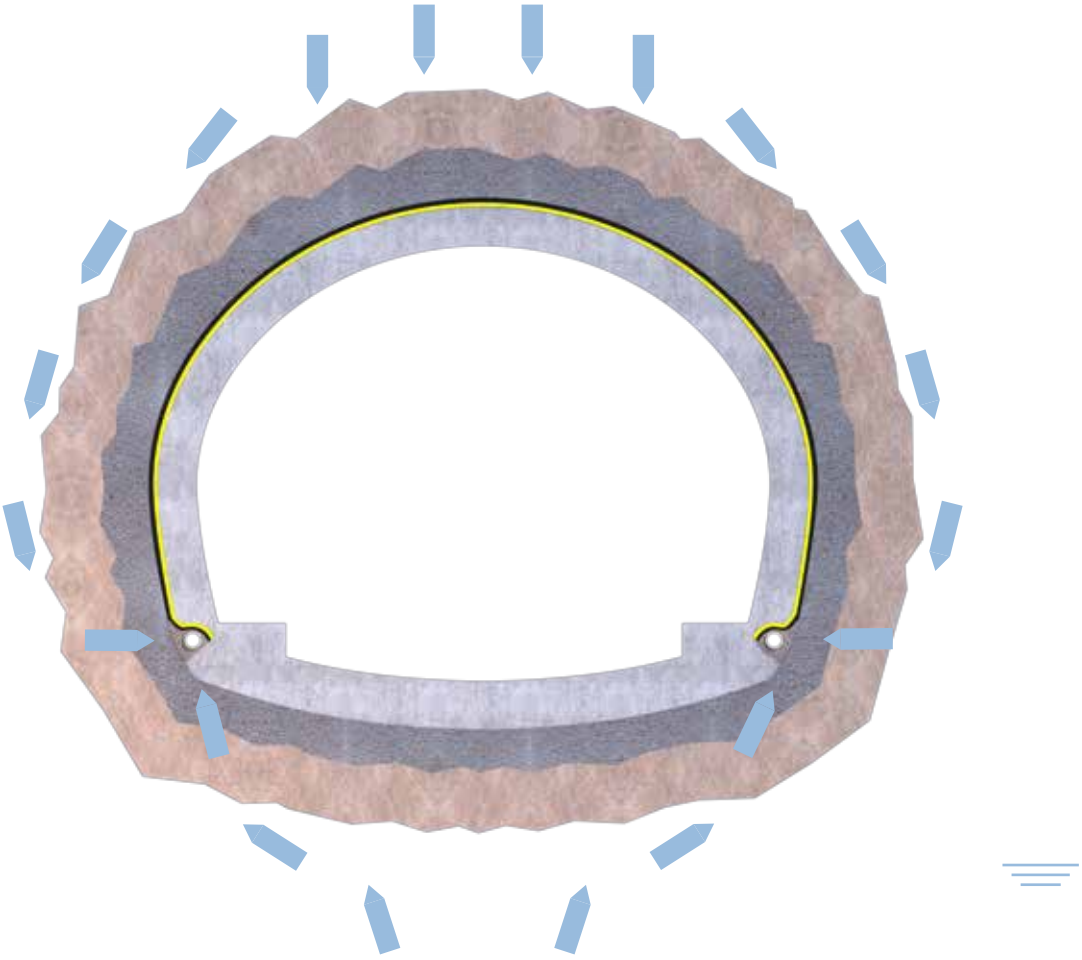
Waterproofing systems:
Integral waterproofing systems:
- Sika White Box / Watertight Concrete System

Externally applied waterproofing systems (base slab):
- Loose laid compartmentalized membrane systems
- Pre-applied fully bonded sheet membranes

GENERAL WATERPROOFING CONCEPTS

THERE ARE TWO BASIC WATERPROOFING CONCEPTS for the sealing of underground structures. Different factors such as location, groundwater conditions, overburden etc define the appropriate approach, which has to be selected by the designer prior to any definition of the construction layout and the waterproofing materials and systems.

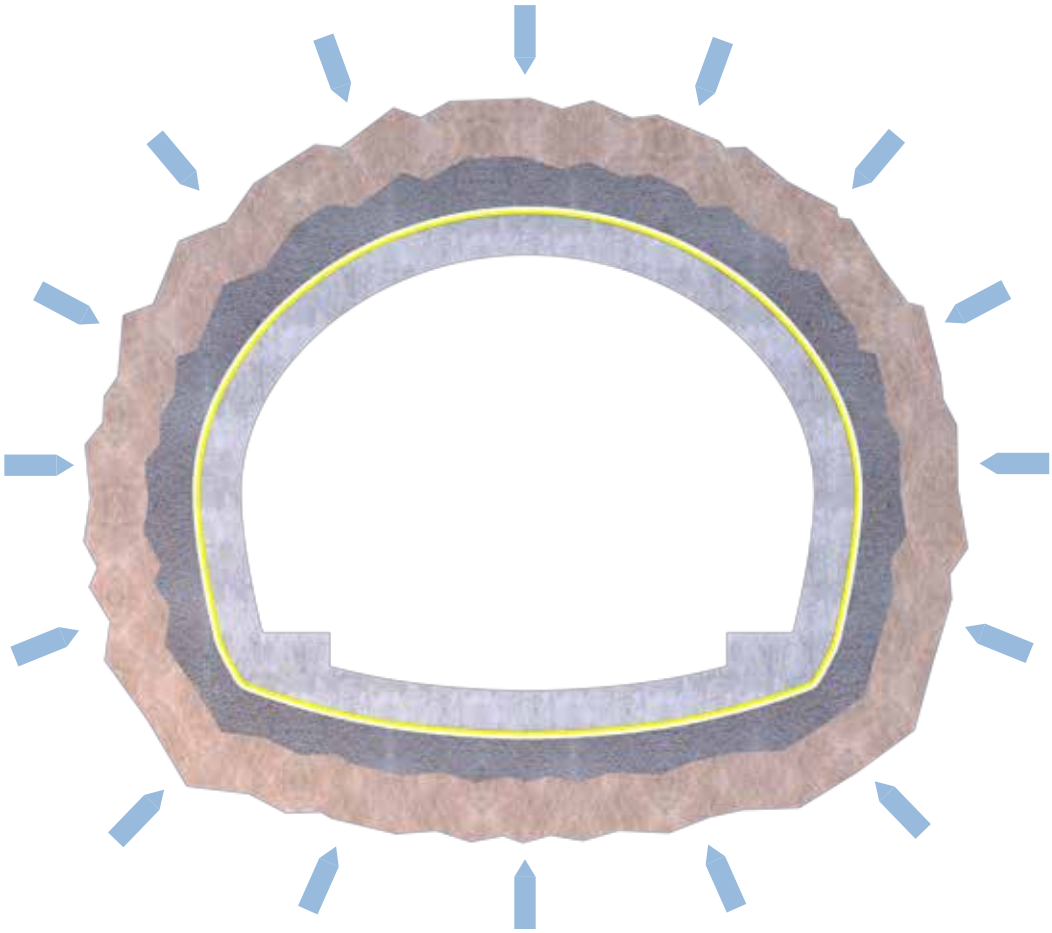
DRAINAGE SYSTEM



Description:
Permanent drainage of water keeps the ground water table below the raft. The concrete structure is not under water pressure.
The waterproofing lining protects the concrete in the arch and conveys water to the drainage pipes. The drainage pipes are the main element and must be checked and maintained regularly to avoid blocking (sintering) of the drainage system.

Pros & Cons:
- Reduction of concrete thickness possible
- Less waterproofing lining cost
- Allows tunneling under extreme conditions
- Higher maintenance cost (cleaning of drainage pipes)
- Traffic interruption during maintenance work
- Ground settlements above the tunnel area possible due to drainage

BARRIER SYSTEM



Description:
The entire tunnel is under full water pressure which must be considered in the structural design.
The waterproofing lining protects the complete concrete structure against water ingress and chemical attacks. Depending on the waterproofing technology, an in-built control and injection system can be established in order to have a redundant system.

Pros & Cons:
- No influence of water table after construction, no negative impact on environment.
- Strongly reduced risk for ground settlements
- Higher level of waterproofing system
- Allows easy control and repair of waterproofing function
- No maintenance cost
- Higher cost (concrete structure and waterproofing lining)

WATERPROOFING TECHNOLOGIES

SIKA PROVIDES A WIDE RANGE of different waterproofing systems and solutions. The selection of the best system for a specific project depends on many factors, incl. the local ground conditions. Waterproofing is closely connected with the structural design and construction of tunnels, therefore it is important for the designer to integrate the selected waterproofing system into the structural design at an early stage.

Due to the high cost but more in view of uninterrupted availability to traffic, tunnels are expected to have long service life expectations of 100 years and more without significant renovation work. All of the components in the multilayer tunnel construction must fulfill these expectations. Among these components the waterproofing layer is an important element. Leakages could reduce the tunnel service life, cause damage to electrical installations or lead to dangerous situations for the road traffic. The waterproofing layer is in the middle of the tunnel construction, therefore access to this layer for repair or replacement purposes is not feasible in most cases.

Each technology of waterproofing system has a specific durability, degree of security, of watertightness and reliability. For some technologies – such as synthetic sheet membranes – specific test methods for > 100 y durability are described in leading standards (ÖBV). For other technologies no standards exist (e.g. bitumen membrane) or tests are not applicable (e.g. watertight concrete and waterproofing mortars). A differentiation of the following technologies are shown on page 14/15.

1. SYNTHETIC SHEET MEMBRANE SYSTEMS

For nearly half a century polymeric membranes based on PVC have been used for the waterproofing of tunnels. The service life of the membranes is determined by the most comprehensive and standardized material testings, including accelerated aging procedures, therefore, they provide the highest security regarding durability.

2. LIQUID APPLIED, REACTIVE MEMBRANES (PUR/PUA)

These materials provide the highest chemical resistance. Regarding durability, no comprehensive tests and regulations are available so far.

3. FULLY BONDED SHEET MEMBRANES

The latest evolution of polymeric sheet membranes are advanced systems with a full bond to the structural concrete. The base material fulfills the highest durability tests, which have been used for loose-laid polymeric sheet waterproofing membranes, nevertheless, the bond itself and the overlaps are neither standardized nor investigated extensively regarding durability.

4. SIKA WHITE BOX CONCEPT/WATERTIGHT CONCRETE

The in-built waterproofing of the concrete structure makes this technology a very convenient approach for contractors but the durability highly depends on the groundwater quality, especially as salt water leads to corrosion and substantially reduces the durability.

5. WATERPROOFING MORTARS

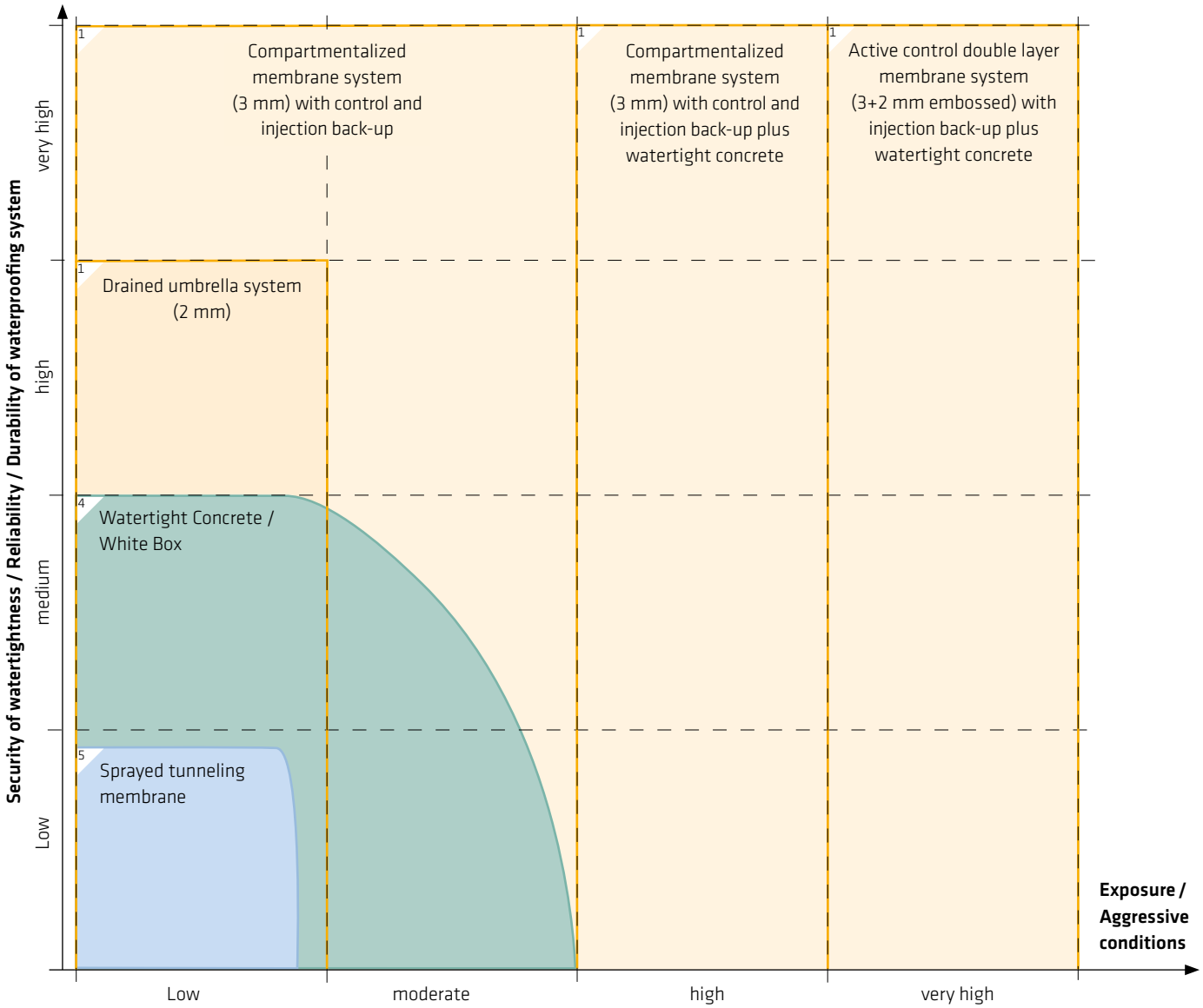
Manually or spray applied mortars provide a reasonable durability in fresh water. With increasing sulfate and magnesium contents, the durability is reduced drastically.

6. BITUMINOUS MEMBRANES

Bituminous membranes are one of the oldest waterproofing technologies, with limited durability even in non-aggressive ground-water conditions.

TECHNOLOGY SELECTION

MINED TUNNELS



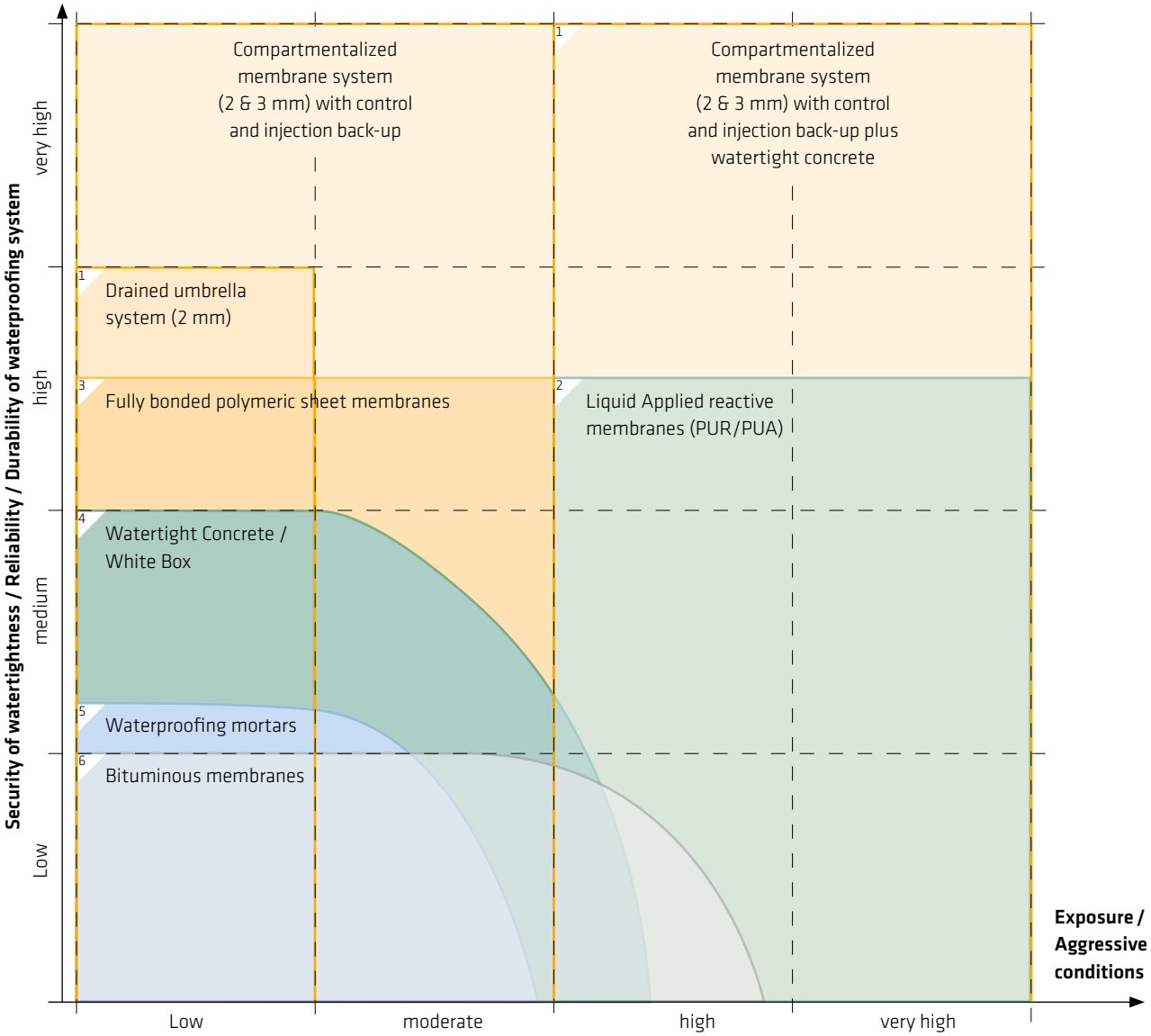
Durability / Reliability

Very high: High redundancy system / water completely under control / proven high durability.
High: Redundant system / low risk for water ingress / high durability.
Medium: No redundant system / limited risk for water ingress
Low: No redundant system / encreased risk for water ingress / limited durability

Exposure / Aggressive conditions

Very high: Water pressure > 60 m / high temperature > 35°C / very aggressive water.
High: Water pressure 30 – 60 m / aggressive water, cracks > 0.2 mm.
Moderate: Water pressure 5 – 30 m / cracks < 0.2 mm / no aggressive water.
Low: Water pressure < 5 m / no cracks / no aggressive water.

CUT- AND- COVER STRUCTURES



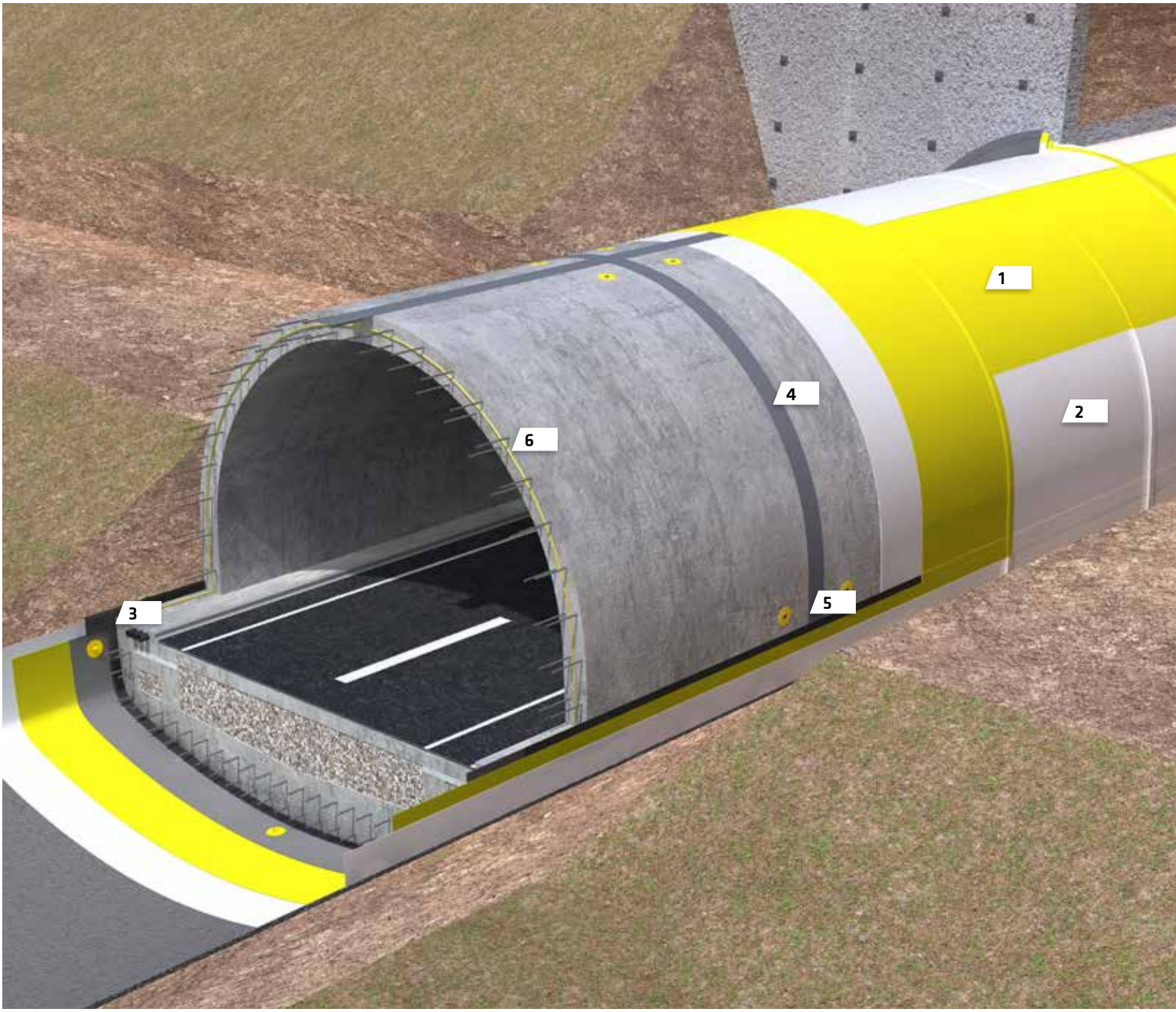
Durability / Reliability

Very high: High redundancy system / water completely under control / proven high durability.
High: Redundant system / low risk for water ingress / high durability.
Medium: No redundant system / limited risk for water ingress
Low: No redundant system / encreased risk for water ingress / limited durability

Exposure / Aggressive conditions

Very high: Water pressure > 30 m / high temperature > 35°C / very aggressive water.
High: Water pressure 15 – 30 m / aggressive water, cracks > 0.2 mm.
Moderate: Water pressure 5 – 15 m / cracks < 0.2 mm / no aggressive water.
Low: Water pressure < 5 m / no cracks / no aggressive water.

COMPARTMENTALIZED MEMBRANE SYSTEMS WITH INTEGRATED CONTROL AND INJECTION BACK-UP



1
Sikaplan® WP/WT

2
Sikaplan® W Felt or Sikaplan® W Tundrain or Sika® Drain

3
Sika® Waterbar WP/WT

4
Sika Dilatec E Tape or Sikaplan® WP Tape or Sikaplan® WT Tape

HIGH PERFORMANCE, CRACK-BRIDGING, WITH IN-BUILT REDUNDANCY FOR FUTURE REPAIR WORKS

Highly flexible state-of-the-art waterproofing systems using Sikaplan® PVC-based or FPO-based sheet waterproofing membranes are installed in mined tunnel structures or post applied on cut- and- cover tunnel structures to ensure completly dry tunnels and to fully protect the concrete lining against drained or pressurized water.

USE

- As waterproofing solutions to ensure completly dry conditions
- For high demands and harsh ground conditions
- For structures in aggressive groundwater like coastal areas
- For tunnels, portals, metro stations, cross passages etc.

MAIN ADVANTAGES

- Watertightness is controlled and secured at any time during service.
- All membranes and system components fulfil leading tunneling standards to achieve a service life of 100+ years

TYPICAL PROJECTS

- Road tunnels
- Railway tunnels
- Metro tunnels
- Cross passages
- Shafts
- Pressure water galleries

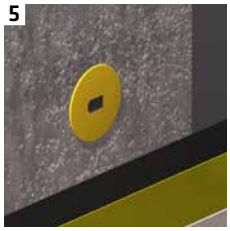
SIKA PRODUCTS AND SYSTEM SOLUTIONS

Sikaplan® WP 1100 and 2100 series	Homogeneous and plastisiced PVC sheet waterproofing membranes, for waterproofing of tunnels and cut-and-cover structures, membrane overlaps sealed by heat welding.
Sikaplan® WT 1200 series	Fleece stabilized FPO sheet waterproofing membranes, for waterproofing of cut-and cover tunnels, membrane overlaps sealed by heat welding.
Sikaplan® WT 2200 series	Homogeneous FPO sheet waterproofing membranes, for waterproofing of mined tunnels, membrane overlaps sealed by heat welding.

Accessories

Sika® Waterbar WP/WT	External waterstops, heat welded on installed Sikaplan® sheet waterproofing membrane to form a compartment network for pressurized systems.
Sika® Waterbar WP/WT Control Socket	Preformed flange welded on installed Sikaplan sheet waterproofing membrane as control and injection ports, connected with flexible pipes for leak detection access and injection.
Sikaplan® WP/WT Tapes Sika Dilatec E/ER Tapes	Adhesive sealing tapes based on PVC or FPO, bonded with Sikadur®-31 CF adhesive for terminations and sealing of joints.
Sikaplan® W Tundrain Sika® Drain	Drainage and protection boards for mined tunnels and open cut structures.

5



Sikaplan® WP/WT Control and Injection Socket

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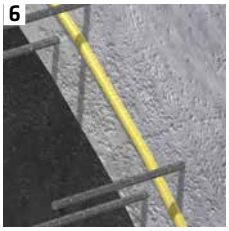
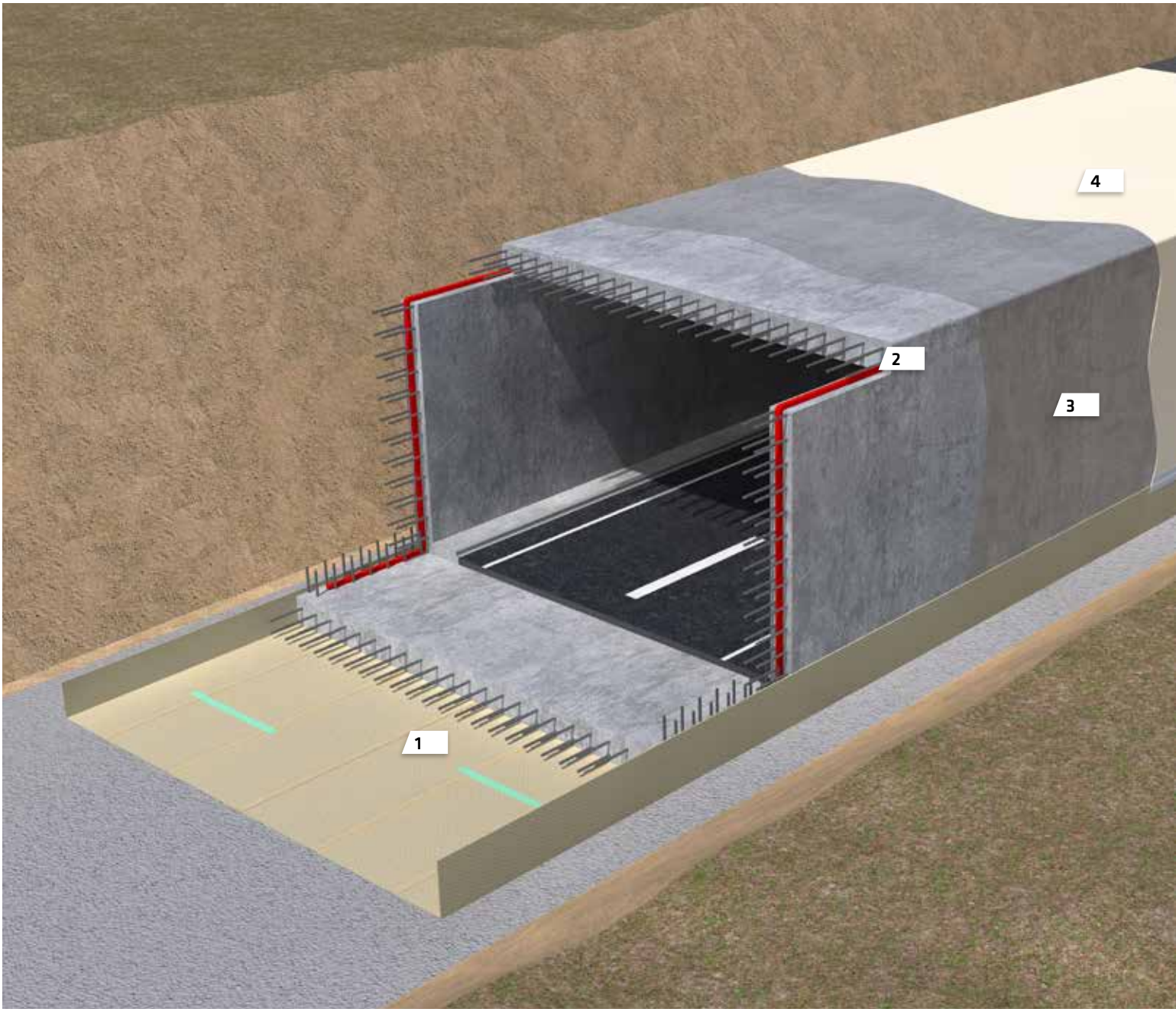
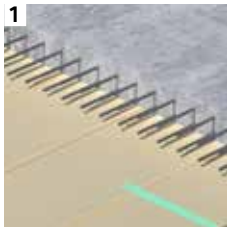


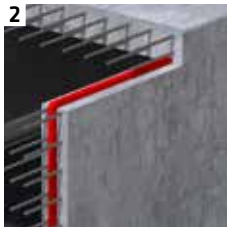
SikaFuko®

REACTIVE LIQUID APPLIED WATERPROOFING MEMBRANES

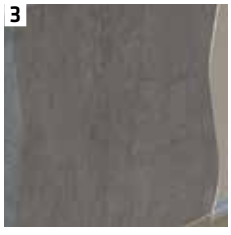




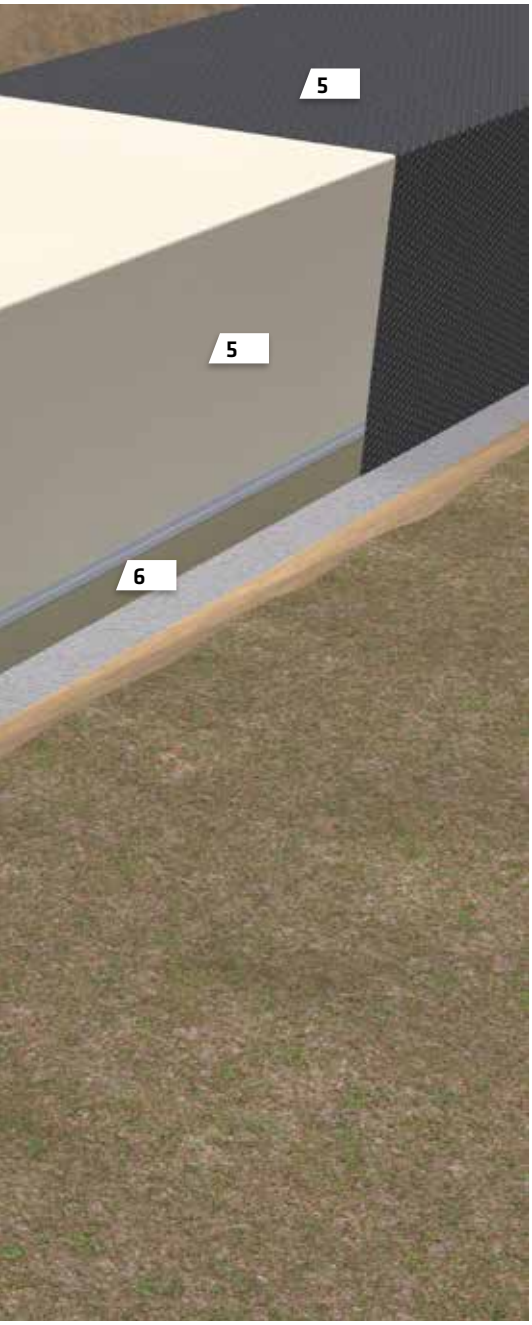
SikaProof® A-12



SikaSwell®



Sikafloor® Primer or Sika® Concrete Primer



FAST SETTING AND CRACK-BRIDGING

Reactive liquid applied membranes (LAM) are highly elastic and flexible polymeric systems based on polyurea or hybrids, with excellent technical properties for high performance applications. These materials are spray applied onto prepared / primed external concrete surfaces to provide excellent solutions particularly for complicated geometries. Liquid applied membranes will also prevent underflow of any lateral water in the event of local damage.

USE

- As post-applied waterproofing of retaining walls and roof sections to ensure dry conditions
- For high demands and harsh groundwater conditions

MAIN ADVANTAGES

- Fully-bonded solution
- Crack bridging
- Fast reacting
- High chemical and abrasion resistance
- Easy application at complex details

TYPICAL PROJECTS

- Cut- and cover tunnels for roads and railways
- Metro station boxes

SIKA PRODUCTS AND SYSTEM SOLUTIONS

Sikalastic®-851	Highly flexible, fast curing, two-component resin based on polyurea / polyurethane, spray-applied onto structural concrete for waterproofing of retaining walls and roof sections.
Sikalastic®-8800	Highly flexible, fast curing, two-component resin based on pure polyurea, spray-applied onto structural concrete for waterproofing of retaining walls and roof sections.
Sikafloor®-156 and -161	Epoxy primer
Sika® Concrete Primer	Two component fast reacting hybrid primer

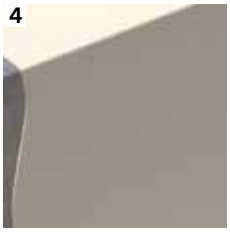
Complementary products for joint sealing

SikaSwell®	Ready to use gaskets for various purposes of concrete joint sealing, with hydrophilic properties.
SikaFuko®	Re-injectable injection hose for the waterproofing of construction joints.
Sika® Drain	Drainage and protection board

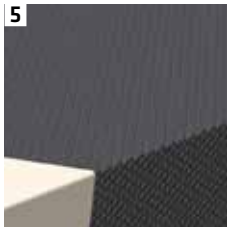
Raft waterproofing

Please note that it is not recommended to apply a liquid membrane onto blinding concrete, therefore, a prefabricated membrane system is to be selected under the structural slab:

Option 1	
SikaProof® A-12	Fully bonded membrane system, see page 20
Option 2	
Sikaplan® WP/WT	Compartmentalized membrane system, see page 16

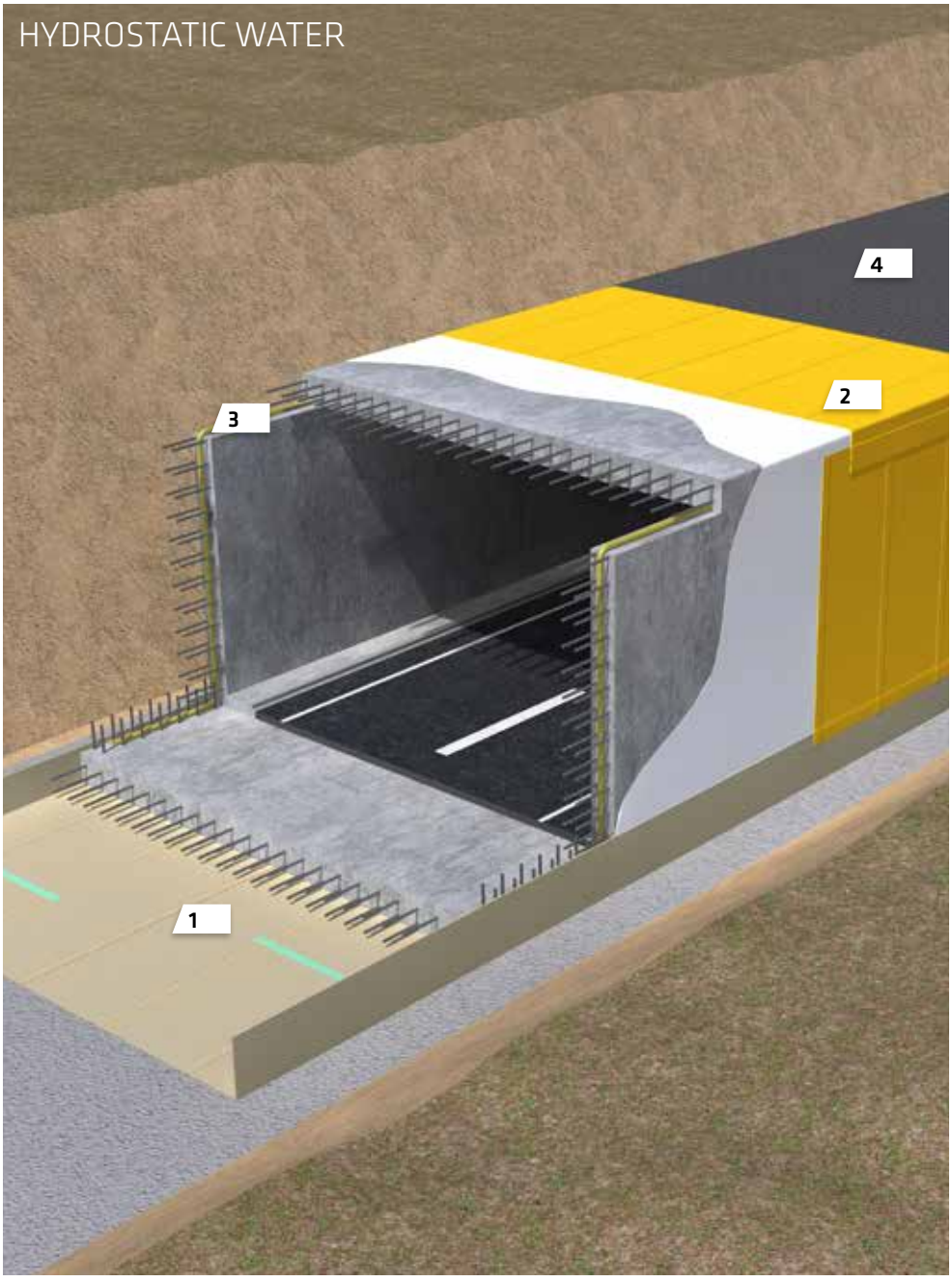


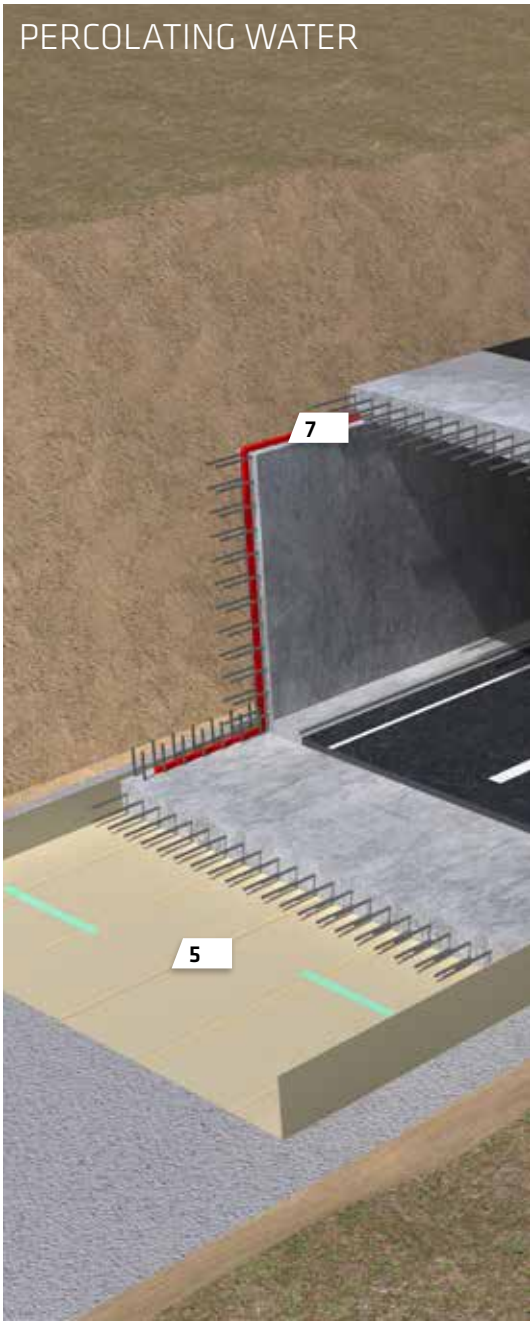
Sikalastic®-851 or Sikalastic®-8800

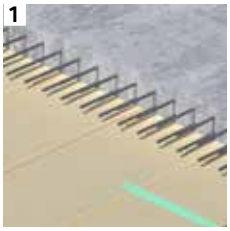


Sika® Drain

FULLY BONDED SHEET WATERPROOFING SYSTEMS

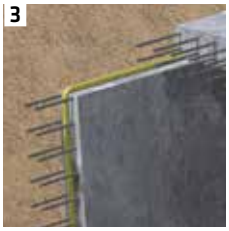




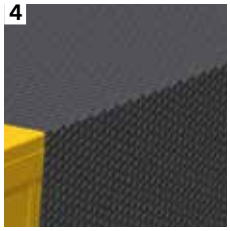


SikaProof® A

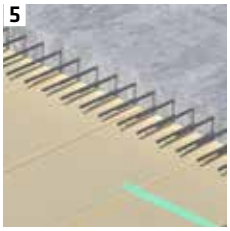
SikaProof® P-1201



SikaFuko®

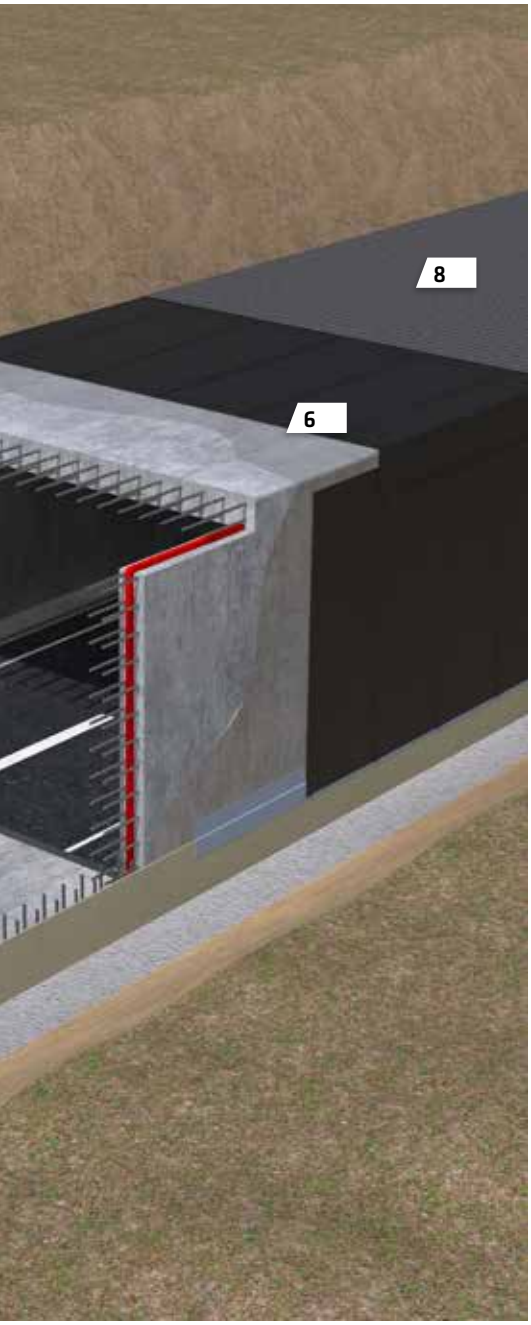


Sika® Drain



SikaProof® A-12

SikaBit® S-515



HIGH PERFORMANCE, CRACK-BRIDGING, FAST AND EASY TO INSTALL

Sika's pre- and post-applied fully bonded sheet waterproofing membrane systems can permanently prevent any lateral water underflow between the waterproofing and the structural concrete in the event of local damage, even when this has occurred below the base slab.
The SikaProof® and SikaBit® fully bonded sheet waterproofing membrane systems are simple and easy to use, making them fast and secure to install on site. The overlaps, butt joints and details are all connected and sealed very simply by bonding them together with sealing tapes or self-adhered overlaps. There are no welding procedures and no special equipment is required on site.

USE

- As pre- or post-applied waterproofing solution to ensure dry conditions
- For high demands and harsh ground conditions
- For structures in aggressive groundwater like coastal areas

MAIN ADVANTAGES

- Cost effective solution (Material + Application)
- High durability
- No lateral water underflow
- High flexibility and crack-bridging ability
- Approved detailings

TYPICAL PROJECTS

- Metro stations
- Cut-and-cover tunnels

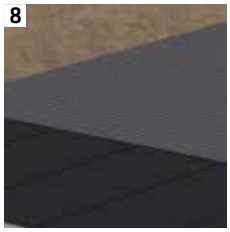
SIKA PRODUCTS AND SYSTEM SOLUTIONS

Pre-applied waterproofing (raft and walls)	
SikaProof® A-12	Pre-applied FPO sheet waterproofing membrane system for application below base slabs, plus on single faced formwork cast walls.
Post-applied waterproofing (walls and top)	
Option 1	
SikaProof® P-1201 System	**SikaProof® Adhesive:** High performance two-component PU adhesive for the bonding of SikaProof® P-1200 membrane.
	SikaProof® P-1200: Post-applied in-situ adhered FPO sheet waterproofing membrane, specially designed for roof slabs and double-faced formwork cast walls.
Option 2	
SikaBit® S-515 System	Self-adhesive prefabricated bituminous membrane (including primer) against percolating water.
Complementary products	
SikaSwell®	Ready to use gasket for various purposes of joint sealing, with hydrophilic properties.
SikaFuko®	Re-injectable injection hose for the waterproofing of construction joints.
Sika® Drain	Drainage and protection boards

7

SikaSwell®

8



Sika® Drain

WATERTIGHT CONCRETE, WHITE BOX SYSTEM

INTEGRAL WATERPROOFING SYSTEM

The Sika® White Box Concept involves optimum structural design and reinforcement together with an integral waterproofing solution, It consists of a waterproof concrete, combined with appropriate joint sealing systems for all construction and movement joints. The production of watertight concrete uses admixtures including superplasticisers and pore-blocking or active crystallization agents, to ensure optimum consistency, flow and easy compaction in a dense matrix with minimal voids. In addition, Sika can offer a wide range of joint sealing products such as PVC waterstops, hydrophilic gaskets and sealants, as well as injection hoses and adhesive tapes.

USE

- As a waterproofing solution to ensure dry conditions
- For high demands in soft groundwater conditions

MAIN ADVANTAGES

- Cost effective solution concerning material and construction works
- Reduced working procedures on site

TYPICAL PROJECTS

- Road tunnels
- Railway tunnels
- Metro tunnels
- Service tunnels

SIKA PRODUCTS AND SYSTEM SOLUTIONS

Sika® Viscocrete®	High Range Water Reducing admixtures for reducing pore volumes and improving rheology for self compacting concrete.
Sika® WT 100 **Sika® WT 200**	Pore-blocking and active crystalline admixtures to block pores against water penetration.
Sika® Waterbar	Cast in place external and internal waterstops based on PVC or rubber, cast into concrete for the waterproofing of joints.
Sikadur-Combiflex®	Adhesive sealing tape based on FPO, bonded with Sikadur®-31 CF adhesive for post applied joint sealing system.
SikaFuko®	Re-injectable injection hose for the waterproofing of construction joints.
SikaSwell®	Ready to use gaskets for various purposes of joint sealing, with hydroswelling properties.
Sika® Drain	Drainage boards

1

Sika® ViscoCrete®
Sika® WT 100/WT 200

2

Sika® Waterbar

WATERPROOFING MORTARS AND SPRAYED TUNNELING MEMBRANES

SikaCem®-711 Elastic

Sikalastic® 1K or
SikaTop® Seal-107

SikaSwell®

FAST TO APPLY

Sika® waterproofing mortars and cement based membranes in mined tunnels and cut-and-cover structures with good technical properties to seal against damp soil, seepage and percolating water. These materals are applied on prepared external concrete or shotcrete surfaces by manual application or by spraying. These waterproofing mortars are used in combination with joint sealing products.

USE

- As pre- or post-applied waterproofing of structures with low requirements regarding watertightness and reliability

MAIN ADVANTAGES

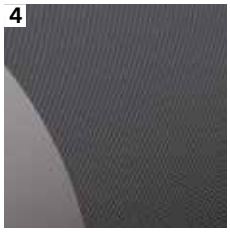
- Easy application
- Can be combined with Sika joint sealing systems

TYPICAL PROJECTS

- Escape tunnels with a maximum water pressure of 5 m

SIKA PRODUCTS AND SYSTEM SOLUTIONS

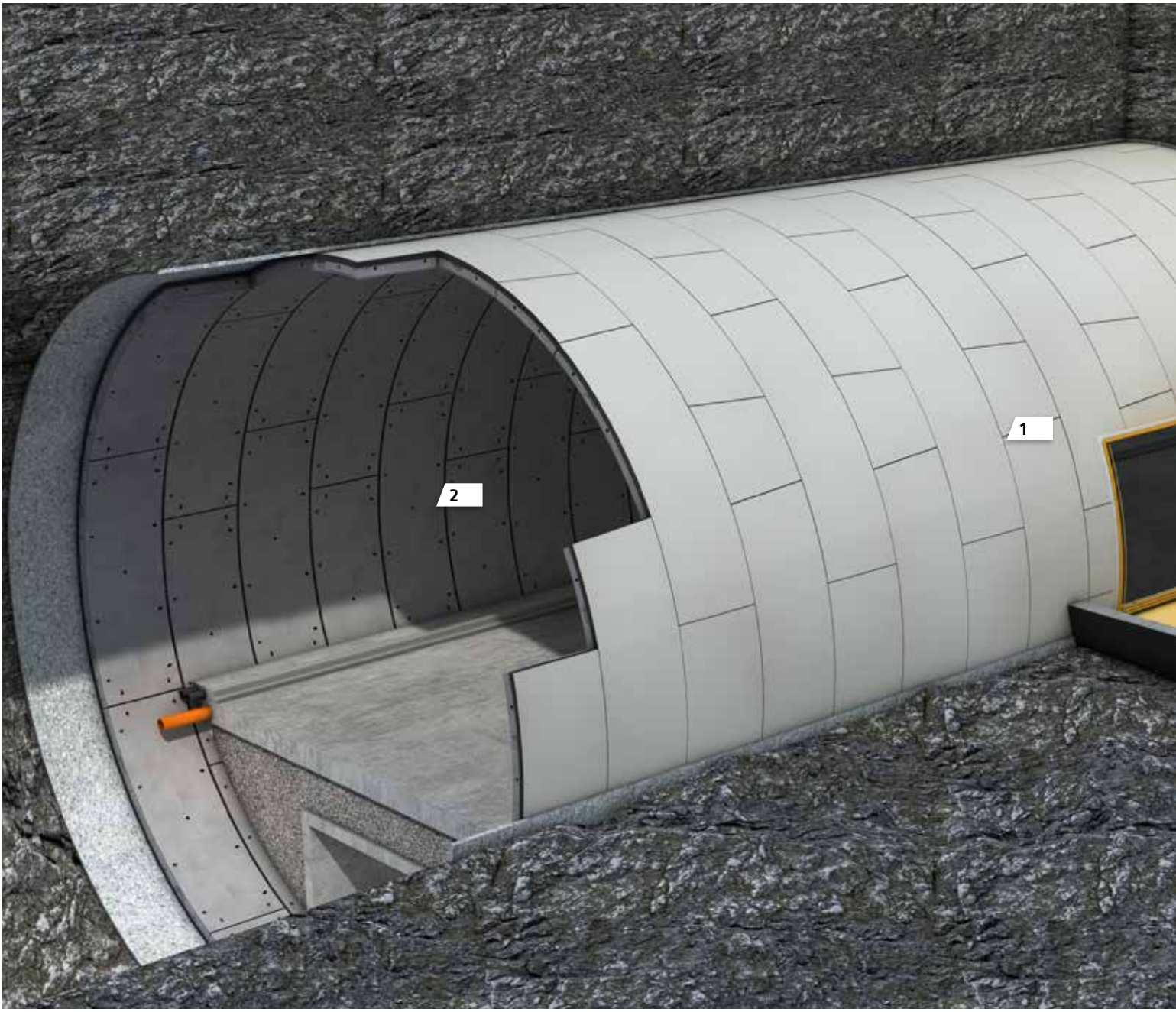
Sikalastic®-1K	One component, polymer modified cementitious waterproofing mortar with medium flexibility for application on concrete surface of cut-and-cover structures.
SikaTop® Seal-107	Two component, polymer modified cementitious waterproofing mortar with slight flexibility for application on concrete surface of cut-and-cover structures.
SikaCem®-711 Elastic	Spray applied cementitous, polymer modified, flexible waterproofing gunite, delivered in powder bags, to be applied by Shotcrete robot (Aliva 237) onto shotcrete linings underground.
Complementary products	
Sika® FlexoDrain	Channels for the free flowing drainage of groundwater penetrating through the shotcrete lining.
Sika® Shot-3	Highly accelerated ready-to-use gunite for the overspraying of damp and wet areas of shotcrete linings, or as surface preparation for liquid membranes.
Sikadur-Combiflex®	Adhesive sealing tape based on FPO, bonded with Sikadur®-31 CF adhesive for post applied joint sealing of construction and expansion joints.
SikaSwell® Hydrophilic profiles	Ready to use gaskets for various purposes of joint sealing, with hydrophilic properties.
Sika® Drain	Drainage and protection boards for cut-and-cover structures

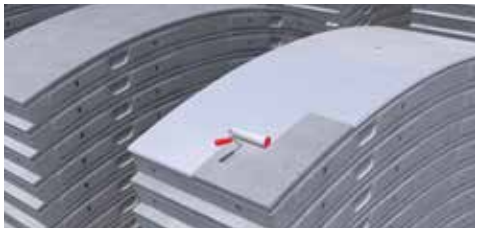


Sika® Drain

Lateral Drainage

WATERPROOFING SOLUTIONS FOR SINGLE SHELL TUNNELS WITH PRECAST SEGMENTS



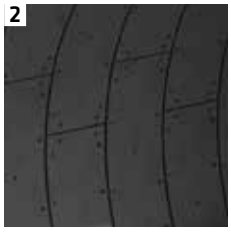


Sikagard® 65 WN application

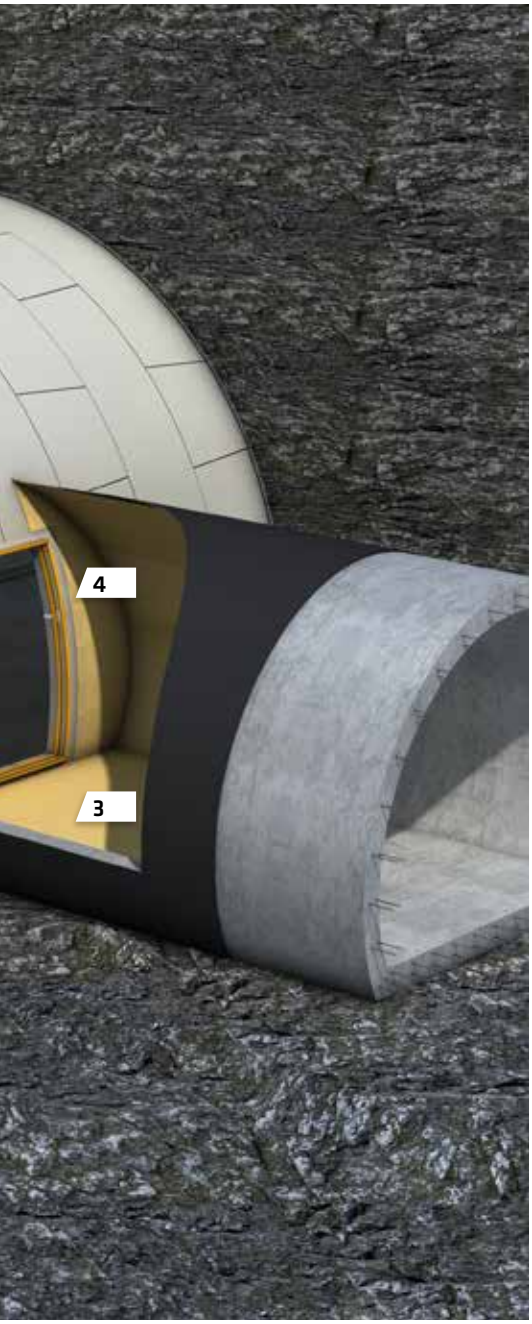
1

Sikagard® 65 WN

2



Sika® ViscoCrete®
Admixture



INTEGRAL, RIGID AND COST EFFICIENT SYSTEM

Prefabricated tunnel segments (tubbings) for use in shield TBM-tunnels. The system consists of a waterproof concrete segment combined with EPDM gaskets for the segmental joint sealing. The production of watertight concrete uses admixtures including superplasticisers in order to ensure optimum consistence, flow and easy compaction in a dense matrix with minimal voids, plus slump retention. The quality and durability of the segments are further improved by the use of a protective epoxy coating and curing compound.

USE

- Waterproofing and concrete protection for single linings made of tubbings (precast segments)

MAIN ADVANTAGE

- Cost effective solution concerning material and construction works
- Reduced working procedures on site

TYPICAL PROJECTS

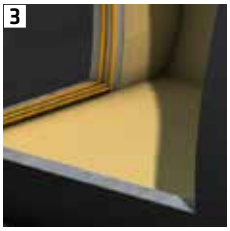
- Road tunnels
- Railway tunnels
- Metro tunnels
- Service tunnels

SIKA PRODUCTS AND SYSTEM SOLUTIONS

Sika® ViscoCrete® Admixure	High Range Water Reducing admixtures for reducing pore volumes and improving rheology for self compacting concrete.
Sikagard® 65 WN	Curing agent and protective epoxy coating to be applied onto the fresh (green) concrete on the outside of the segments. Improves the concrete quality and increases the durability of single shell constructions permanently exposed to groundwater.

Additional solutions for all cross passages

Sikaplan® WP/ WT Sheet membranes	Waterproofing membranes for the sealing of all cross-passages.
Sikaplan® WT Tapes **Sikaplan® WP** Tapes	Adhesive sealing tapes based on PVC or FPO, bonded with Sikadur®-31 CF adhesive for a watertight termination of cross passages at segmental linings.



Cross passages:
Sikaplan® WT/WP
Sheet membranes

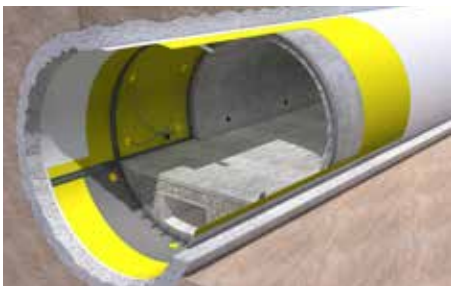
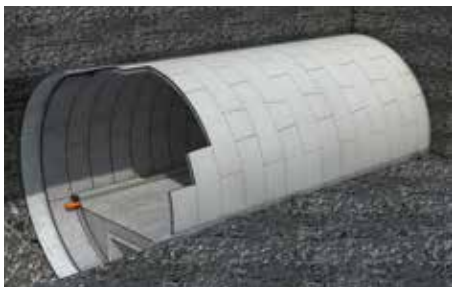
Cross passages:
Sikaplan® WT/WP Tape

SYSTEM SELECTION GUIDE FOR MINED TUNNELS

DRAINED SYSTEMS

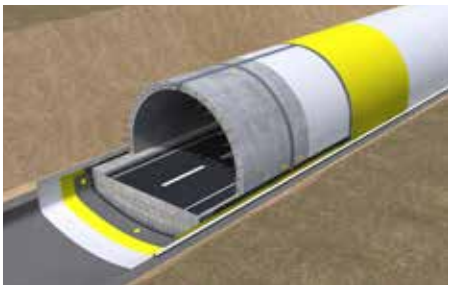
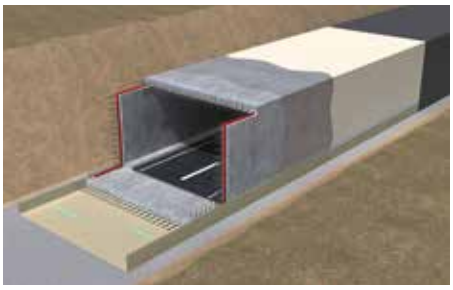
	UMBRELLA SHEET MEMBRANE SYSTEM	CHANNELED SYSTEM
Sika solution	**Sikaplan®**	**FlexoDrain® / SikaCem®**
Excavation method	– Conventional excavation – Hard Rock TBM – Shield TBM	– Conventional excavation (Drill and blast etc) – Hard Rock TBM
Lining(s)	Double-shell tunnel: – Primary lining: Shotcrete or segments – Secondary lining: Concrete or shotcrete	Single-shell tunnel with shotcrete or double shotcrete lining with liquid applied membrane in between
Waterproofing technology	Drainage layer plus loose-laid synthetic membrane (umbrella) made of PVC or FPO	FlexoDrain drainage channel system: Catching spot-wise ingress of water. Optional sprayed waterproofing membrane on top
Degree of water tightness	Class 1 (Completely dry)	Class 4 (Moist to wet)
Concrete protection	High	None or limited to secondary lining
Durability/Reliability	High	Low
Performance characteristic	Crack-bridging: +++ Water vapour tightness: n.a. Chemical resistance: ++ Gas barrier: n.a.	Crack-bridging: + Water vapour tightness: + Chemical resistance: + Gas barrier: n.a.
Repair in the event of leaks	– Local injection	– Crack injection – Soil injection
Conditions of application	Defined evenness of shotcrete lining	No special requirements for FlexoDrain. Very high requirements on substrate preparation required before membrane spraying: waterproofing through soil injection for dry substrate. Ventilation and humidity control on site
Advantages	Cost effective solution, full proof arch, drainage reduces criticality of application	Simple to install
Typical application fields	Road and railway tunnels in mountainous areas with high overburden	Escape tunnels, pedestrian ways, structures with no or very limited requirements regarding water tightness. Maximum water pressure 0.5 bar

BARRIER SYSTEMS

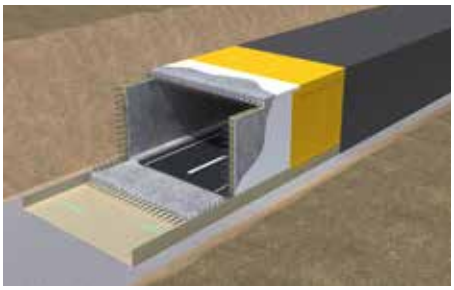
HYDROSTATIC MEMBRANE BARRIER	WATERTIGHT CONCRETE SYSTEM	SEGMENTAL LINING
		
Sikaplan®	**Sika® White Box**	**Sikagard®**
– Conventional excavation – Hard Rock TBM – Shield TBM	– Conventional excavation (Drill and blast etc) – Hard Rock TBM	– Shield TBM
Double-shell tunnel: – Primary lining: Shotcrete or segments – Secondary lining: Concrete	Double-shell tunnel: Primary lining: Shotcrete Secondary lining: Concrete	Single-shell tunnel: Primary lining: Tubbing segments
Loose laid membrane system made of PVC or FPO with compartments and integrated injection back-up. Membrane application in one or two layers	Sika White Box system: Watertight concrete plus joint sealing and structural design	Watertight precast segments, joint sealing by EPDM gaskets
Class 1 (Completely dry)	Class 2 (Dry to sligthly moist)	Class 2 (Dry to sligthly moist)
High	Limited, depending on concrete quality	Low to high depending on concrete quality and protective coating on segments
High	Medium	Medium – high
Crack-bridging: +++ Water vapour tightness: +++ Chemical resistance: +++ Gas barrier: +++	Crack-bridging: n.a. Water vapour tightness: + Chemical resistance: + Gas barrier: +	Crack-bridging: n.a. Water vapour tightness: n.a. Chemical resistance: ++ Gas barrier: +
– Injection of leaking compartments through injection ports inside of structure	– Crack injection – Joint injection	– Crack injection – Joint injection
Defined evenness of shotcrete lining	Controlled concreting on site required: casting, compaction, curing Crack widths limited to 0.2 mm max.	Segments production under controlled factory conditions, high-end mix design
High waterproofing security, in-built redundancy by compartment injection	Integrated waterproofing, limited waterproofing works at all joints	In-built waterproofing through industrialized process at segments factory
Road and railway tunnels in urban areas with no permission to change the groundwater conditions	Metro tunnels, road tunnels and railway tunnels with limited water pressure	Metro tunnels, railway tunnels, road tunnels

SYSTEM SELECTION GUIDE FOR CUT-AND- COVER STRUCTURES

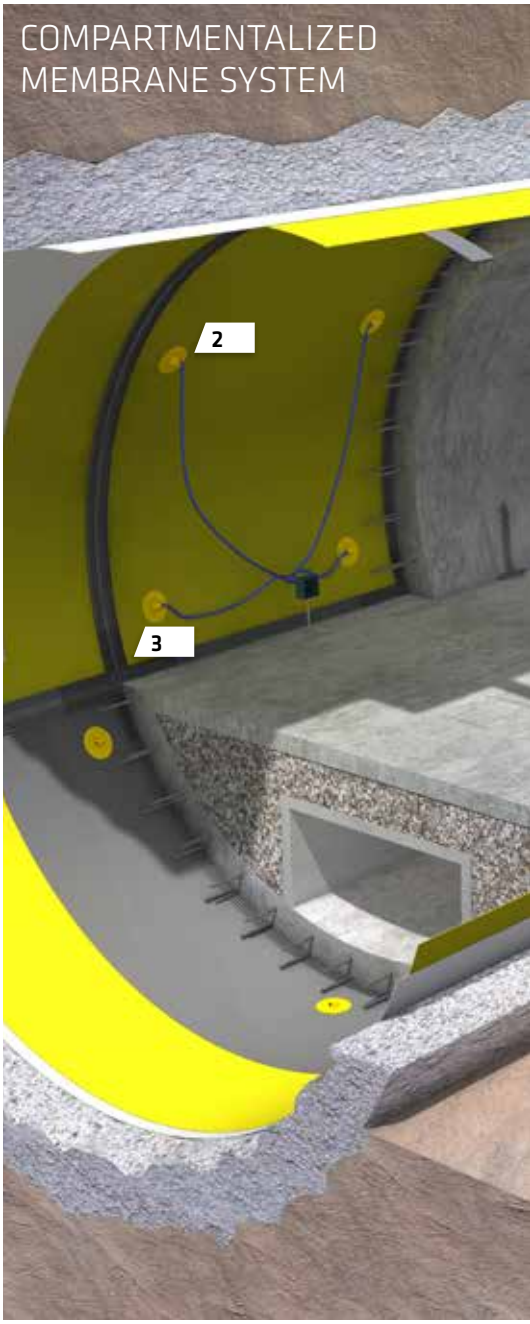
FLEXIBLE SYSTEMS

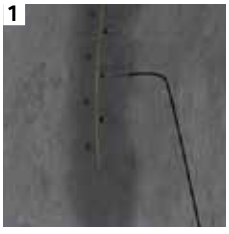
	COMPARTMENTALIZED SHEET MEMBRANE SYSTEM	**SPRAYED MEMBRANES**
		
Sika solution	**Sikaplan®**	**Sikalastic®**
Time of application	Pre-applied onto blinding concrete or temporary pit support Post-applied onto structural concrete	Post-applied onto structural concrete
Groundwater conditions	Percolating water or hydrostatic groundwater	Percolating water or hydrostatic groundwater
Waterproofing technology	Loose laid membrane system based on PVC or FPO, with compartments and integrated injection back-up. Membrane application in one or two layers.	Reactive 2K sprayed membranes based on Polyurethane and Polyurea
Degree of watertightness	Completely dry	Dry to slightly moist
Concrete protection	Very high	High
Durability/Reliability	Very high	High
Performance characteristic	Crack-bridging: +++ Water vapour tightness: +++ Chemical resistance: +++ Gas barrier: +++	Crack-bridging: +++ Water vapour tightness: ++ Chemical resistance: +++ Gas barrier: ++
Repair in the event of leaks	– Injection of leaking compartments through injection ports inside the structure	– Crack injection – Soil injection
Conditions of application	No special requirements	Substrate preparation (priming) required before membrane spraying. Dew point control on site mandatory.
Advantages	High waterproofing security In-built redundancy High durability	Easy detailing, seamless application, super fast setting time, fully bonded
Typical application fields	Station boxes, metro tunnels, road tunnels, railway tunnels	Retaining walls, podiums, roof sections of station boxes

RIGID SYSTEMS

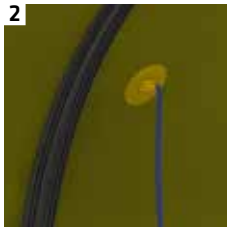
FULLY BONDED SHEET MEMBRANES	WATERTIGHT CONCRETE	WATERPROOFING MORTARS
		
SikaProof® / SikaBit®	**Sika® White Box**	**SikaTop® / SikaCem®**
Pre- and post-applied onto structural concrete	Integral waterproofing	Post-applied onto structural concrete
Percolating water or hydrostatic groundwater	Percolating water or hydrostatic groundwater	Percolating water
Pre-fabricated bituminous membrane sheets, torch-on or self-adhesive, applied in single or multiple layers. Or bituminous emulsions.	Sika White Box system: Watertight concrete plus joint sealing and structural design	Cementitous coating
Dry to slightly moist	Moist	Moist to wet
High	Limited, depending on concrete quality	Limited
High (for polymeric based sheets) Medium (for bitumen based sheets)	Medium	Low
Crack-bridging: ++ Water vapour tightness: ++ Chemical resistance: ++ Gas barrier: +	Crack-bridging: n.a. Water vapour tightness: n.a. Chemical resistance: + Gas barrier: n.a.	Crack-bridging: + Water vapour tightness: n.a. Chemical resistance: n.a. Gas barrier: n.a.
– Crack injection – Joint injection	– Crack injection – Joint injection	– Crack injection – Joint injection
Substrate preparation and primer required before membrane application	Controlled concreting on site required: casting, compaction, curing	No special requirements
Fast and easy to apply	Cost effective, integrated waterproofing Limited waterproofing works at all joints	Very cost effective Simple and fast to apply No specialist applicator required
Station boxes, escape tunnels, pedestrian ways, structures with limited requirements regarding water tightness and durability	Station boxes, metro tunnels, road tunnels, railway tunnels	Escape tunnels, pedestrian ways, structures with no or very limited requirements regarding water tightness

REMEDIAL WORKS BY INJECTIONS





Sika® Injection-101 RC
Sika® Injection-201 CE
Sika® Injection-307



Sikaplan® WP/WT control sockets

SIKA INJECTION SOLUTIONS FOR REPAIR AND REFURBISHMENT WORKS

In situations with water ingress due to localized damage of the waterproofing system, appropriate repair works have to be undertaken. This can only be done by injection to seal leaking areas, due to inadequate access to the waterproofing system itself in most underground structures. According to the type of leakage and if it is through joints or cracks in the structural concrete, the most suitable material has to be injected. The success factor for durable and tight injection work is a combination of Sika's materials and equipment selection, as well as application experience.

USE

Sealing and repairing of:
- Cracks
- All types of joints
- Sikaplan compartments
- Leaking sections by areal or curtain injections

MAIN ADVANTAGES

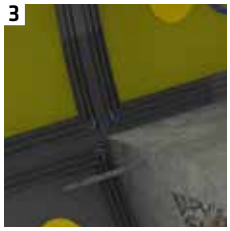
- No excavation required
- Localized repair works
- Durable repair

TYPICAL PROJECTS

- Suitable for all types of tunnels and underground structures

SIKA PRODUCTS AND SYSTEM SOLUTIONS

Packer Injection	
Sika® Injection-101 RC	Flexible, solvent-free, fast foaming polyurethane (PUR) foam for temporary water-stopping of high water intrusions through cracks, joints and cavities in concrete.
Sika® Injection-201 CE	Elastic, solvent-free PUR-Injection resin for permanent sealing of dry, damp or water-bearing cracks and joints in concrete.
Sika® Injection-307	Elastic, very low viscous polyacrylic injection resin with active passivation of steel reinforcement.
Compartment and Fuko® Injection	
Sika® Injection-306	Elastic, very low viscosity polyacrylic injection resin for the repair of damaged waterproofing membrane compartments and injection of SikaFuko® injection hoses. It is also used for the permanent sealing of water-bearing cracks, voids and joints in the concrete.
Sika® Injection-701	Low viscosity cementitious/polyacrylic hybrid injection resin for the repair of damaged waterproofing membrane compartments and injection of SikaFuko® injection hoses. It is also used for the permanent sealing of water-bearing cracks, voids and joints in the concrete.



Sika® Waterbar WP/ WT Inject

Sika® Injection-306 Sika® Injection-701

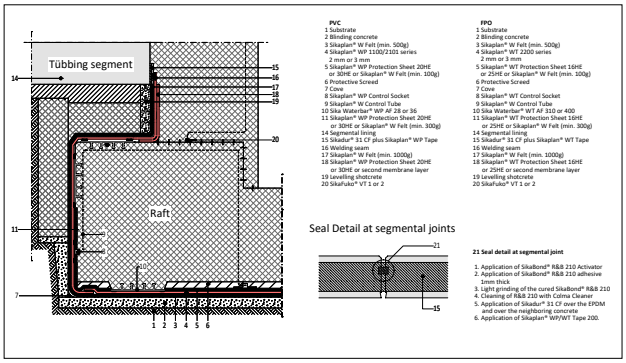
SIKA – THE GLOBAL LEADER IN STRUCTURAL WATERPROOFING

SIKA PROVIDES A WIDE RANGE of alternative waterproofing solutions for different requirements in new tunnel structures, or refurbishment of tunnels. With more than 100 years of experience in Structural Waterproofing, Sika is the reliable partner for all the parties involved on every project. Innovative Sika waterproofing solutions that include both, rigid and flexible systems, create added value for customers every day , and are the key driver for our global success and one of the key reasons why Sika is the clear number one in Structural Waterproofing. With a local presence all around the world, now in more than 90 countries, Sika is ideally positioned to support our customers everywhere, right from the initial project design and detailing, through to successful installation and completion on site.

DESIGN SUPPORT

- Selection of appropriate concept and system solutions
- Concrete mix design and control
- Engineering details, custom solutions
- Cost/Performance

SPECIFICATION SUPPORT



- Specifications, Method Statements, Bills of quantities
- Detail drawings (CAD + BIM)

ON SITE SUPPORT

- Application training on site
- Troubleshooting
- Quality control procedures
- Concrete quality control

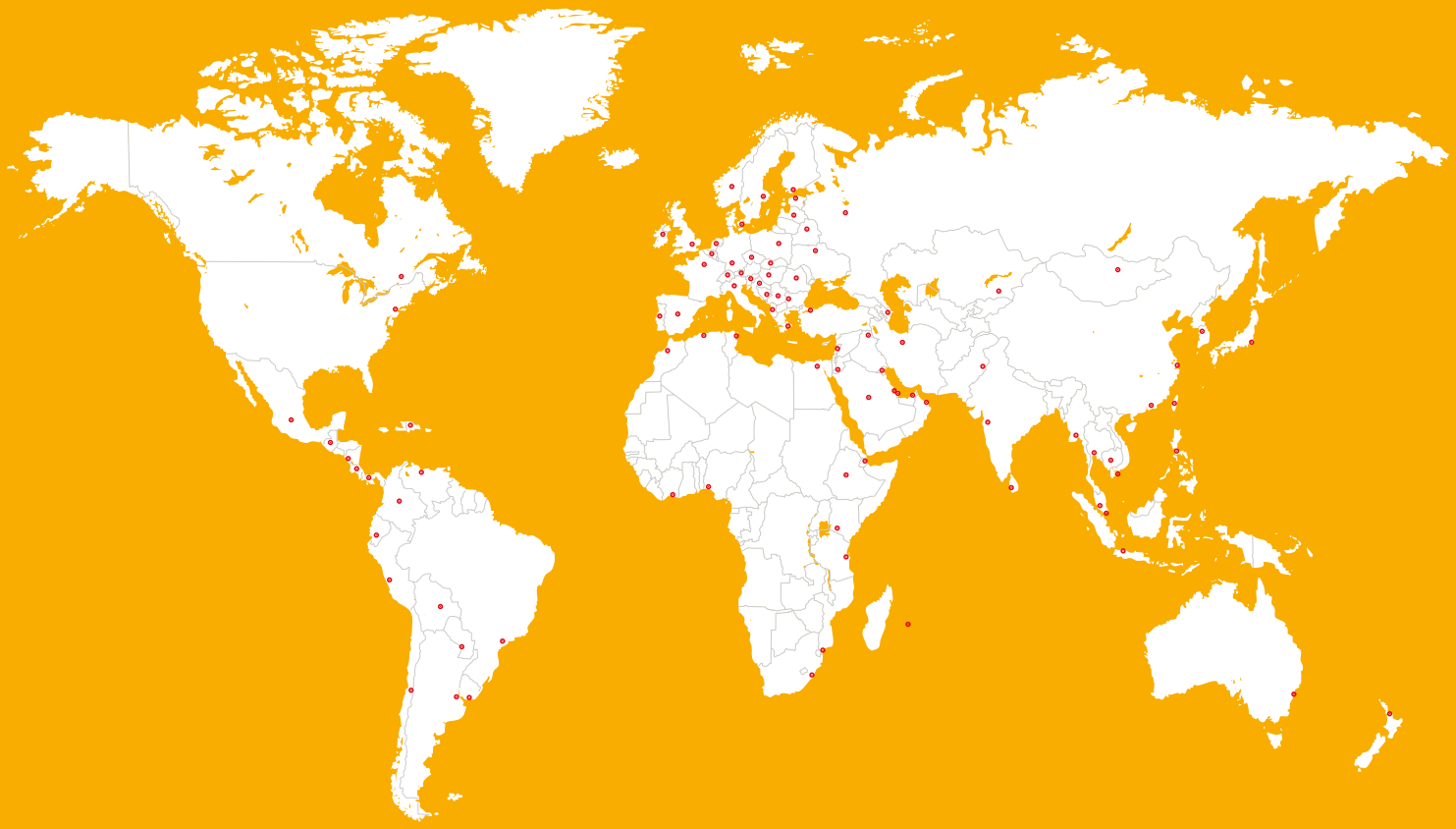
MAINTENANCE SUPPORT

- Maintenance Manuals
- Refurbishment systems
- Repair and refurbishment documentations
- Site visits and refurbishment proposals

... AND NOW

125 years after the completion of the first railway tunnel through the alps, the new Gotthard Base Tunnel was constructed, at an altitude of only 550 m above sea level, allowing a flat connection from North to South, without ramps, reducing the travel time and increasing the transportation capacity. The construction of the 57 km long double-tube tunnel had started in the year 2000 and took 15 years. Sika, with an experience of 100+ years in tunnel waterproofing, provided the entire water-proofing system with synthetic sheet membranes Sikaplan® WP based on PVC-p and Sikaplan® WT based on FPO.

GLOBAL BUT LOCAL PARTNERSHIP



FOR MORE INFORMATION:

WE ARE SIKA
Sika is a specialty chemicals company with a leading position in the development and production of systems and products for bonding, sealing, damping, reinforcing and protecting in the building sector and the motor vehicle industry. Sika's product lines feature concrete admixtures, mortars, sealants and adhesives, structural strengthening systems, flooring as well as roofing and waterproofing systems.

Our most current General Sales Conditions shall apply.
Please consult the Data Sheet prior to any use and processing.

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BUILDING TRUST

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