

WATERPROOFING Sikaplan® MEMBRANE SYSTEMS FOR TUNNELS

TECHNOLOGY & CONCEPTS

BUILDING TRUST



Sikaplan® MEMBRANE SYSTEMS – FOR ALL TYPES OF TUNNELS

TUNNEL CONSTRUCTIONS, exposed to statical and dynamic stress, as well as hydraulic influences of aggressive water, are designed to last for decades or centuries. This requires a reliable waterproofing system with sheet waterproofing membranes in order to protect the tunnel construction from water ingress and the concrete structure against harmful influences of aggressive groundwaters.

Sikaplan® solutions allow installation into mined tunnels and shafts, or on the external face of cut- and cover tunnels. This versatility also means compatible transitions between different application areas and construction elements. The highly flexible membrane allows waterproofing of structures below the groundwater table even after structural cracking by settlements or seismic movements. Depending on the requirements, drained or pressurized systems can be defined.

In order to secure the quality over expected service life, Sikaplan® sheet membranes are under permanent quality control and approved according to high demands of standardization. Experience since over 50 years with Sikaplan® membranes and an in-build repair and control system gives owners, specifiers and applicator trust in this type of waterproofing technology. Tunnel waterproofing with Sikaplan® sheet membranes means fast installation, even under wet conditions on site, independent from the substrate quality.

TYPICAL APPLICATION

MINED TUNNELS AND SHAFTS



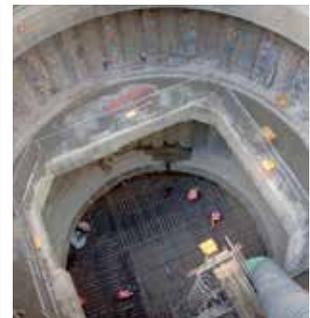
ROAD TUNNELS



RAILWAY TUNNELS



PRESSURE GALLERIES



SHAFTS

CUT-&-COVER TUNNELS



ROAD TUNNELS



ROAD GALLERIES

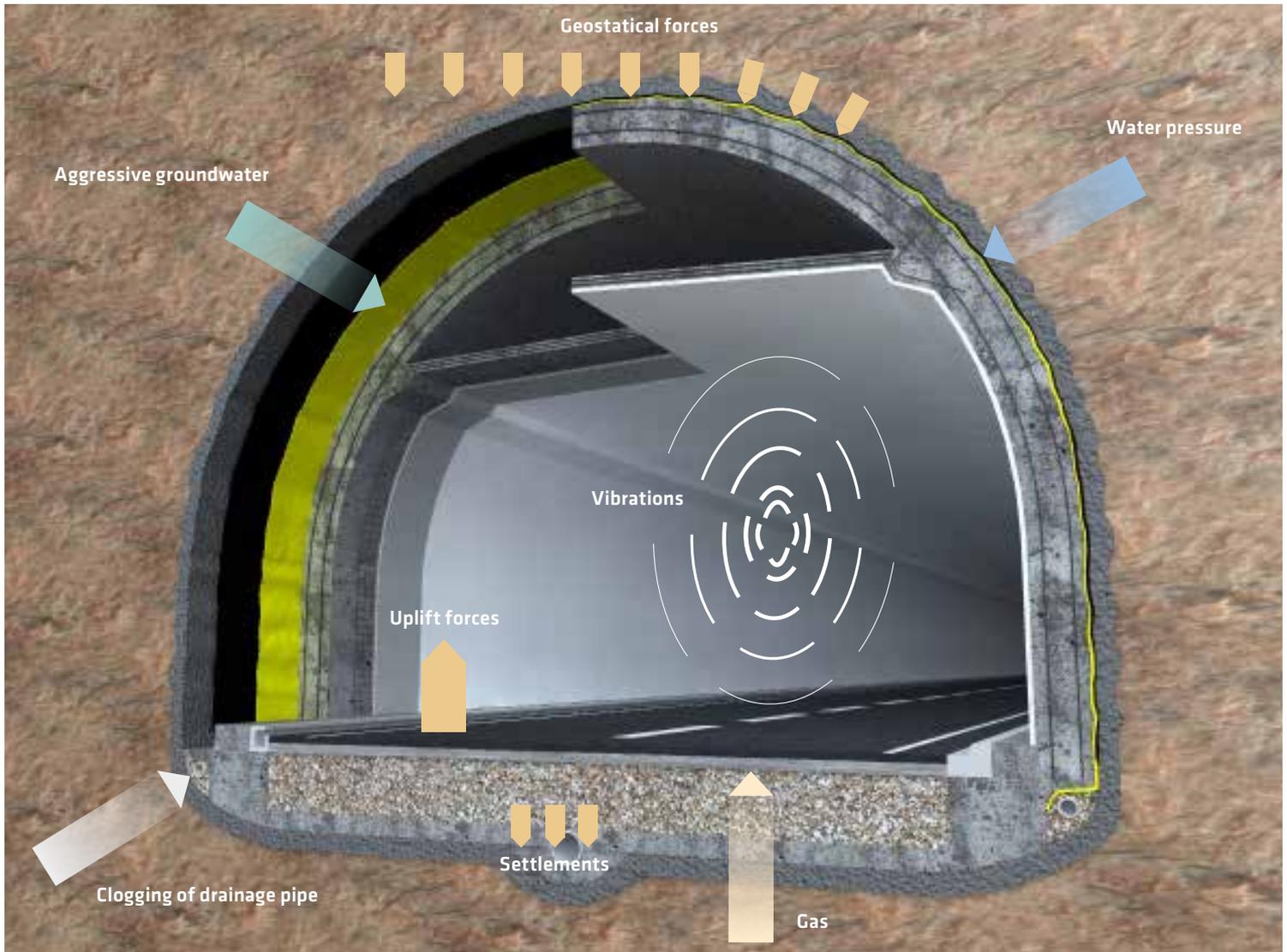


RAILWAY TUNNELS



METRO STATIONS

INFLUENCES ON TUNNEL STRUCTURES



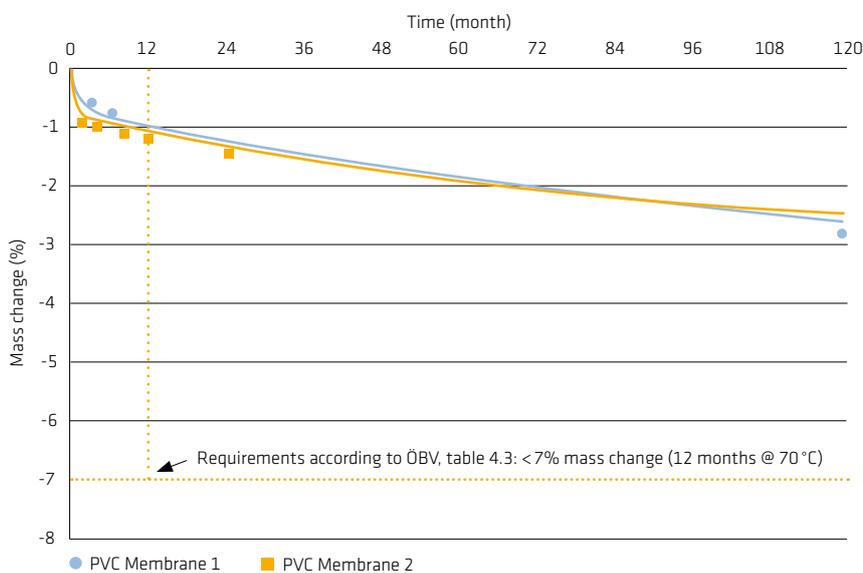
EXPOSURE IMPACT ON BELOW GROUND STRUCTURES

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

DURABILITY OF SHEET MEMBRANES

LAB-SIMULATIONS are necessary to predict the life time expectancy of a specific waterproofing membrane. The degradation process will be simulated at various temperatures and exposures times in the lab and physical characteristics such as tensile strength and elongation are measured after aging and compared with the initial performance. The end of the life time is defined in the relative change of the mechanical characteristics.



Behaviour after storage in hot water of 2 PVC membrane samples: stil conform with requirements according to ÖBV 4.7.

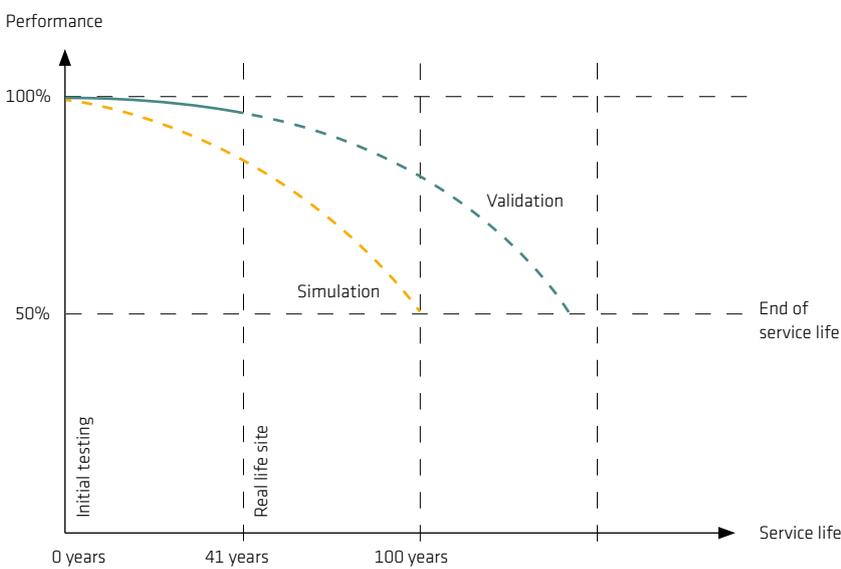
Determination of elongation and tensile strength of Sikaplan® PVC membrane after storage in hot water.

The actual most comprehensive durability tests are described in the Austrian ÖBV Tunnel Waterproofing guideline. There are several test methods described for both technologies – PVC-P and TPO membranes – to be met to achieve a service life of >100 years. The table below shows the most important test methods.

Behavior after storage in hot water (=Leaching) 360 days at 70 °C	EN 14415	Reduction of tensile strength and elongation: ≤ 25% Change of mass: ≤ 7%
Behavior after storage in saturated limewash 360 days at 50 °C	EN 14415	Reduction of tensile strength and elongation: ≤ 25% Change of mass: ≤ 7% Reduction of impact load (drop height): ≤ 40%
Behavior after storage in 5 – 6% sulphurous acid 120 days at 23 °C	EN 1847	Reduction of tensile strength and elongation: ≤ 25% Change of mass: ≤ 4% Reduction of impact load (drop height): ≤ 30%
Behavior after storage in 0.5% sulphuric acid 360 days at 50 °C	EN 1847	Reduction of tensile strength and elongation: ≤ 25% Change of mass: ≤ 7% Reduction of impact load (drop height): ≤ 40%

Austrian ÖBV 'Richtlinie Tunnelabdichtung', Table 4.7

REAL-LIFE VALIDATION is needed to check and proof the results of the lab-simulation and the predicted life time expectancy of a specific waterproofing membrane. This can be done by collecting real exposed membrane samples during maintenance works which allows accessibility to the exposed membranes. These samples will be tested again and compared with some retained samples from the same production batch.



Comparison of lab testing (simulation) with 41 years old real exposed samples (validation), taken from the Reussport tunnel in Switzerland.

Membrane sample from excavated niche of the Reussport tunnel in Switzerland.

Sika had the opportunity to analyze 41 and 44 years real exposed waterproofing sheet membranes from two tunnels in Switzerland which were built in 1968 and 1970. Both membranes still possess material properties that exceed the requirements for new membranes. Based on the outstanding test results the aged membranes can be regarded as good as new and will achieve the required 100 years durability.



Excavated niche during maintenance works allows accessibility to 44 years old exposed Sika membrane for durability testings.



Waterproofing of the excavated tunnel niche using Sikaplan® membrane, directly connected to the existing PVC membrane.

Sikaplan® MEMBRANE TECHNOLOGY SELECTION CRITERIA

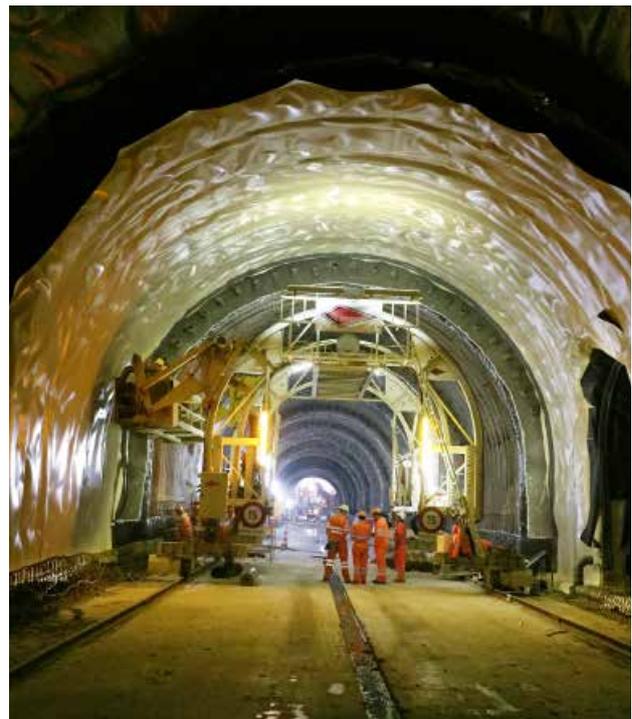
CONSIDERING THE APPLICATION of waterproofing membranes in tunnels, the long time experience of sealing, the practical welding behaviour, the economics and the technical characteristics of the wide plastic range, in general two technologies have excelled: Advanced plasticized PVC and highly flexible FPO (TPO) with an E1-2-Modulus < 55 N/mm². Both materials allow easy thermal welding without the necessity of extrusion seams.

Characteristics	PVC-P	FPO (TPO)
Durability	++	++
Ease of application	++	0
Welding properties	++	+
Thermal and chemical resistance	+	++
Detailing	++	+
Long-term experience	++	+
Flexibility	++	+
Fire behaviour	+	0
Smoke behaviour	0	+
Resistance to mechanical impact	+	+
Thermal expansion	0	+

++ excellent / + good / 0 fair



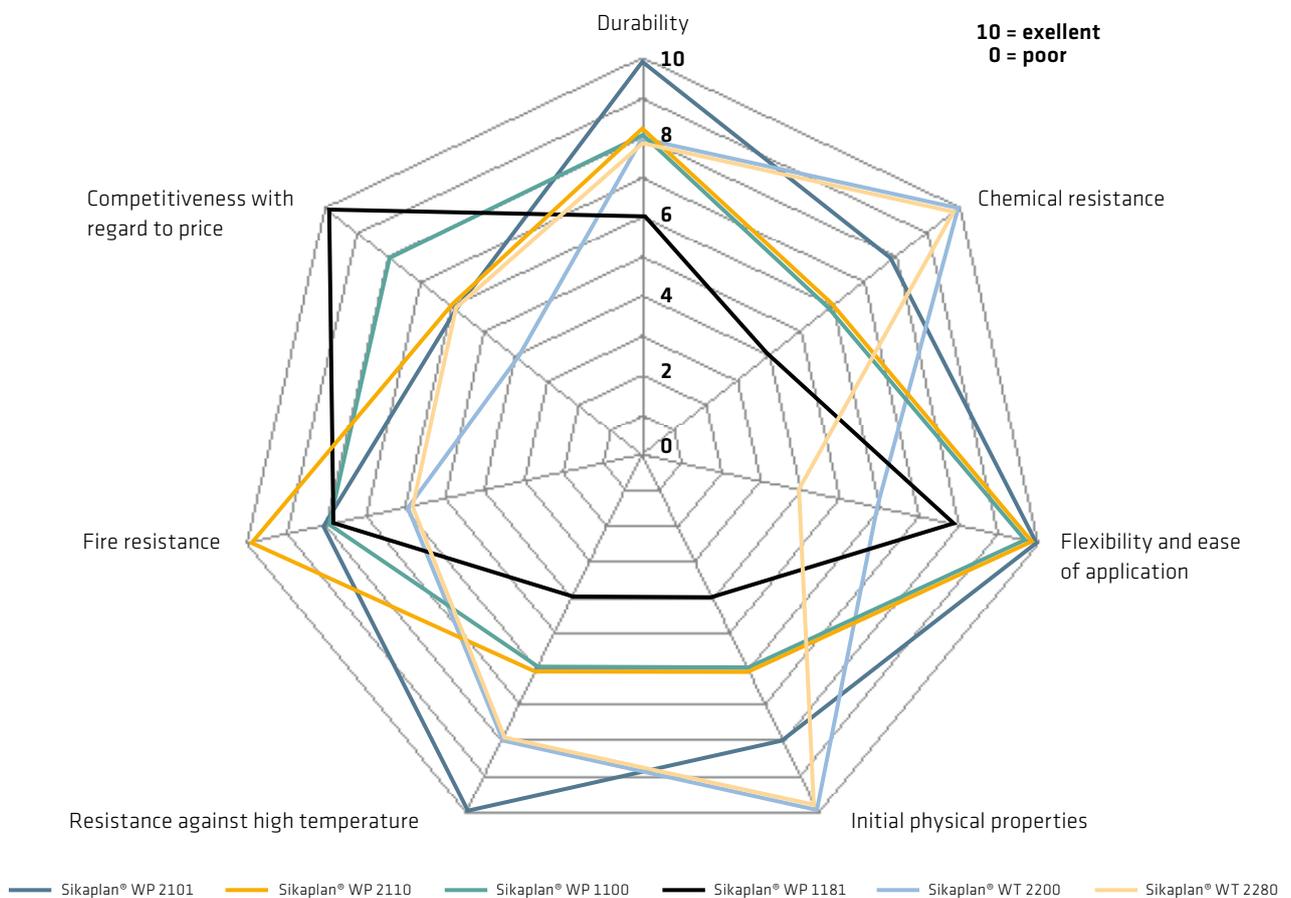
Sikaplan® WP 1100 (PVC-P)



Sikaplan® WT 2200 (FPO)

PRODUCT SELECTION

THE FOLLOWING SECTION gives an overview on the performance characteristics of different Sikaplan® membranes. Sikaplan® WP indicates products on base of plasticized polyvinylchloride (PVC-P), Sikaplan® WT products on base of flexible polyolefines (FPO).



CERTIFICATES FROM INDEPENDENT TESTING LAB

	ÖBV 4.6	ÖBV 4.7	SIA	ZTV-ING	REACH
Sikaplan® WP 2101	✓	✓	✓	✓	✓
Sikaplan® WP 2110	-	-	✓	-	✓
Sikaplan® WP 1100	✓	-	✓	✓	✓
Sikaplan® WP 1181	-	-	-	-	✓
Sikaplan® WT 2200	✓	✓	✓	✓	✓
Sikaplan® WT 2280	-	-	-	✓	✓

SUBSTRATE PREPARATION

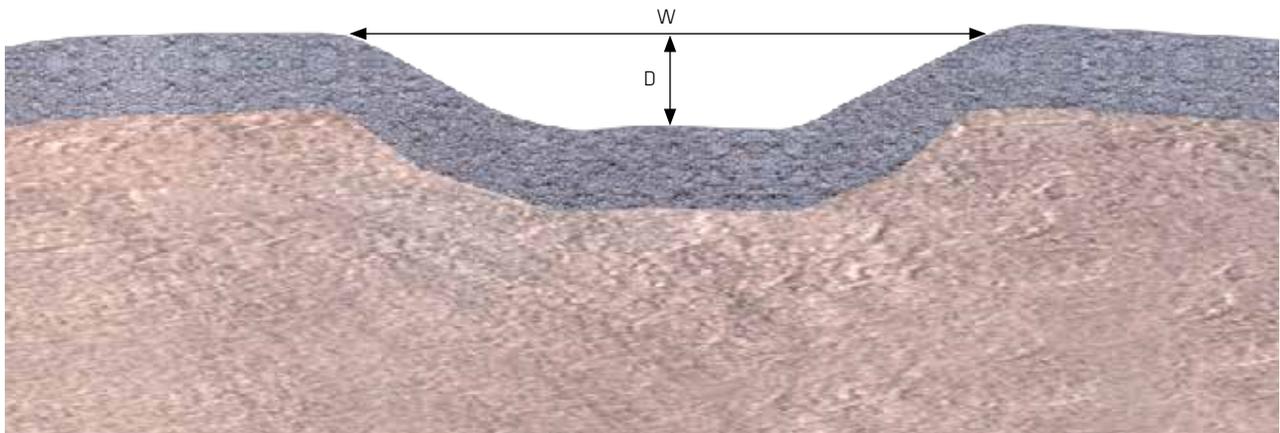
IN THE APPLICATION FIELD of tunnels and underground structures, the flexibility of the waterproofing membrane is the key element to avoid membrane failures during application and after concreting of the inner concrete liner on irregular shotcrete substrate.

Typical application failures are low quality welding of the membranes which is directly related to the main technical characteristic: the flexibility.

High flexible membranes not only avoid difficulties of machine welding in uncomfortable conditions such as niches and cross sections, but also reduce potential failures of hand welding applications like welding of patch repairs or connection welding of waterstops onto membranes. If the welding can not be carried out very carefully, the continuity of the waterproofing sheets can not be maintained. Any failure in the seam weld will then cause leakages in the tunnel with potentially fatal results particularly if hydrostatic water pressure is present. The flexibility of a material is described with the section elasticity module E_{1-2} according to EN ISO 527. The lower the

E-Modulus the more flexible the membrane is which makes substrate preparation less critical and application much easier. Because the stiffness of the membrane also affects the performance on uneven substrates, maximum values for substrate irregularities have been defined depending on the membrane technology.

The ratio of the max. diameter (W) to the depth (D) of irregularities shall be not less than 5:1 for PVC-P and not less than 10:1 for flexible TPO waterproofing membranes. Very stiff HDPE sheets require much stringent shotcrete evenness ratio of $W:D \approx 15:1$ which results in higher cost for substrate preparation.



Requirements of membrane flexibility in connection with shotcrete evenness

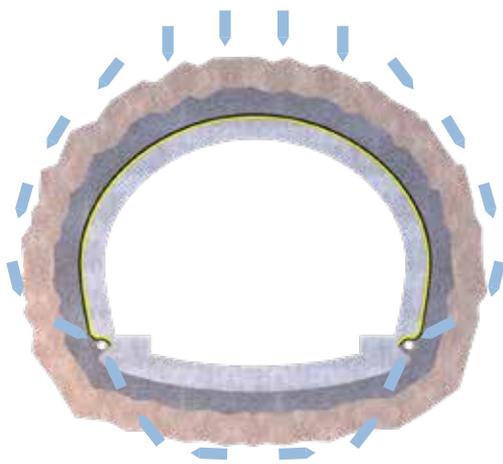
Material type	PVC-P	FPO	LLDPE
Section elasticity module E_{1-2} according to ISO 527	< 20 N/mm ²	< 65 N/mm ²	< 100 N/mm ²
Evenness of shotcrete W:D	≈ 5:1	≈ 10:1	≈ 15:1

CUSHION LAYER

SHEET WATERPROOFING MEMBRANES shall be protected adequately. Depending on the waterproofing concept (drainage or barrier system), appropriate cushion layer are recommended.

WATERPROOFING SYSTEM AND RELATED CUSHION LAYER

DRAINAGE SYSTEM

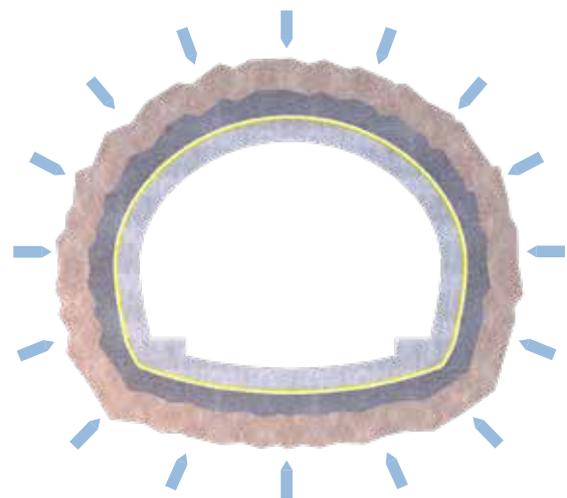


Cushion layer: Sikaplan® W Tundrain / SikaDrain®

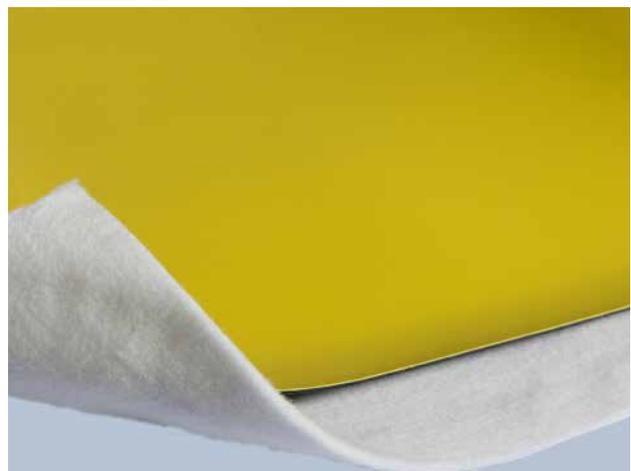


- Sikaplan® W Tundrain or SikaDrain® act in two ways:
- Membrane protection from the rough shotcrete liner in the case of mined tunnels and from the backfilling in the case of cut-and-cover structures
 - Highly effective drainage layer

BARRIER SYSTEM

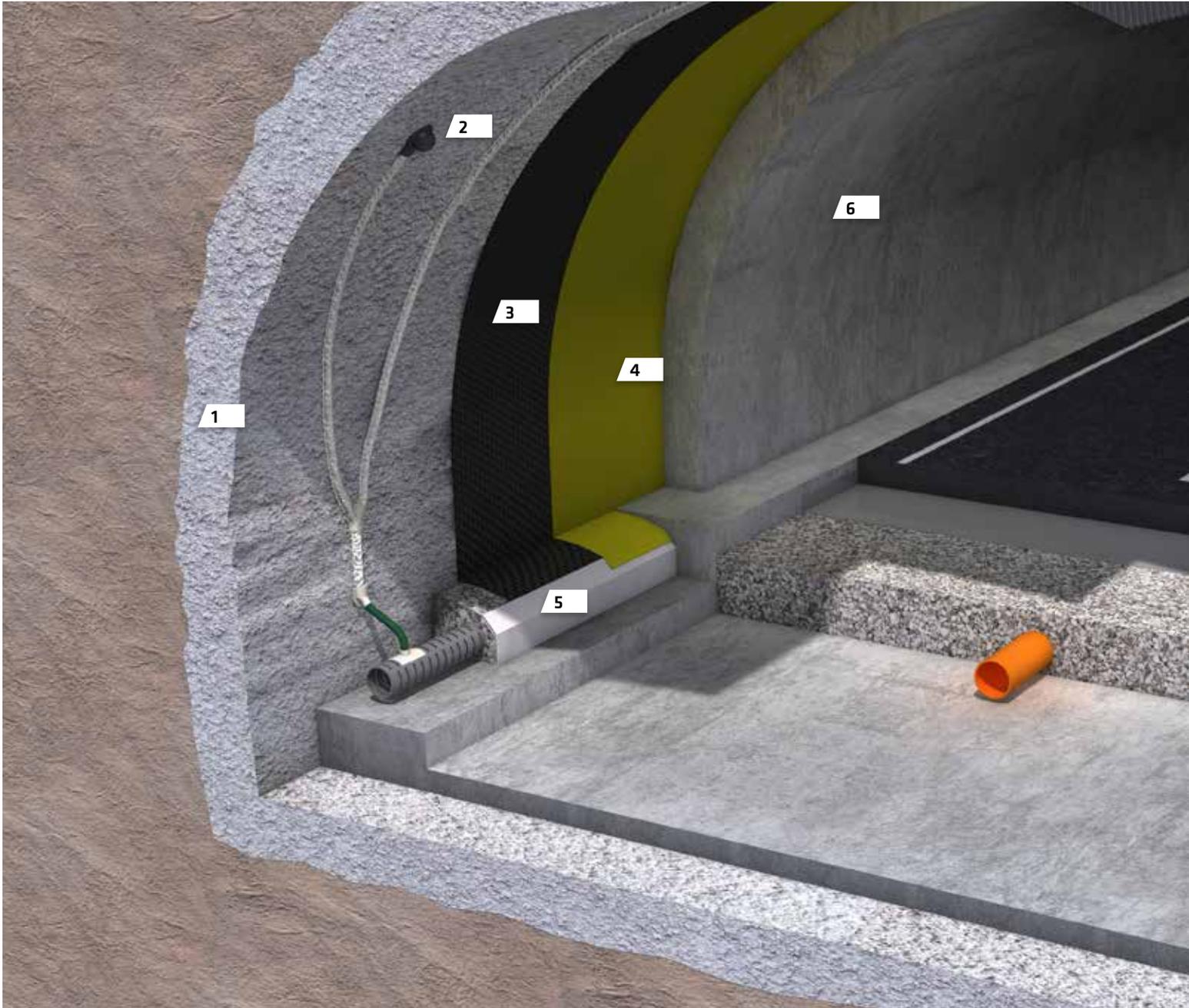


Cushion layer: Sikaplan® W Felt



- Sikaplan® W Felt polypropylene geotextile has one function:
- Membrane protection from the rough shotcrete liner in the case of mined tunnels and from the backfilling in the case of cut-and-cover structures

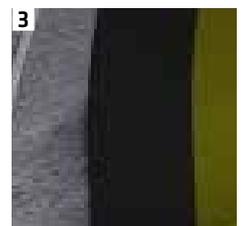
MINED TUNNEL – Sikaplan® DRAINAGE SYSTEM



1
Primary Shotcrete
lining



2
Sika® Flexodrain
system



3
Sikaplan® W Tundrain
Sika® Drain



SELECTION CRITERIA

DRAINAGE - SINGLE LAYER - PARTIAL WATERPROOFING

PVC

Sikaplan® WP 1100 sheet membranes are used to resist against drained waters up to temperatures of +35°C and Sikaplan® WP 2101 up to +50°C. The most suitable thickness of Sikaplan® WP sheet membranes is specified with 2.00 mm for drained water.

Rating for drainage system Sikaplan® WP (PVC) sheet membranes	1	2	3	4	5
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

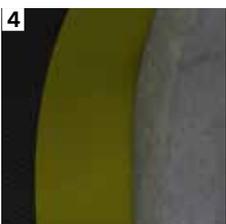
(1 poor - 5 excellent)

FPO (TPO)

Sikaplan® WT 2200 sheet membranes are used for waterproofing against clear groundwater and groundwater containing hydrocarbons at temperatures of up to +40°C. The most suitable thickness of Sikaplan® WT sheet membranes is specified with 2.00 mm for drained water.

Rating for drainage system Sikaplan® WT (FPO) sheet membranes	1	2	3	4	5
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor - 5 excellent)



Sikaplan® WP/WT

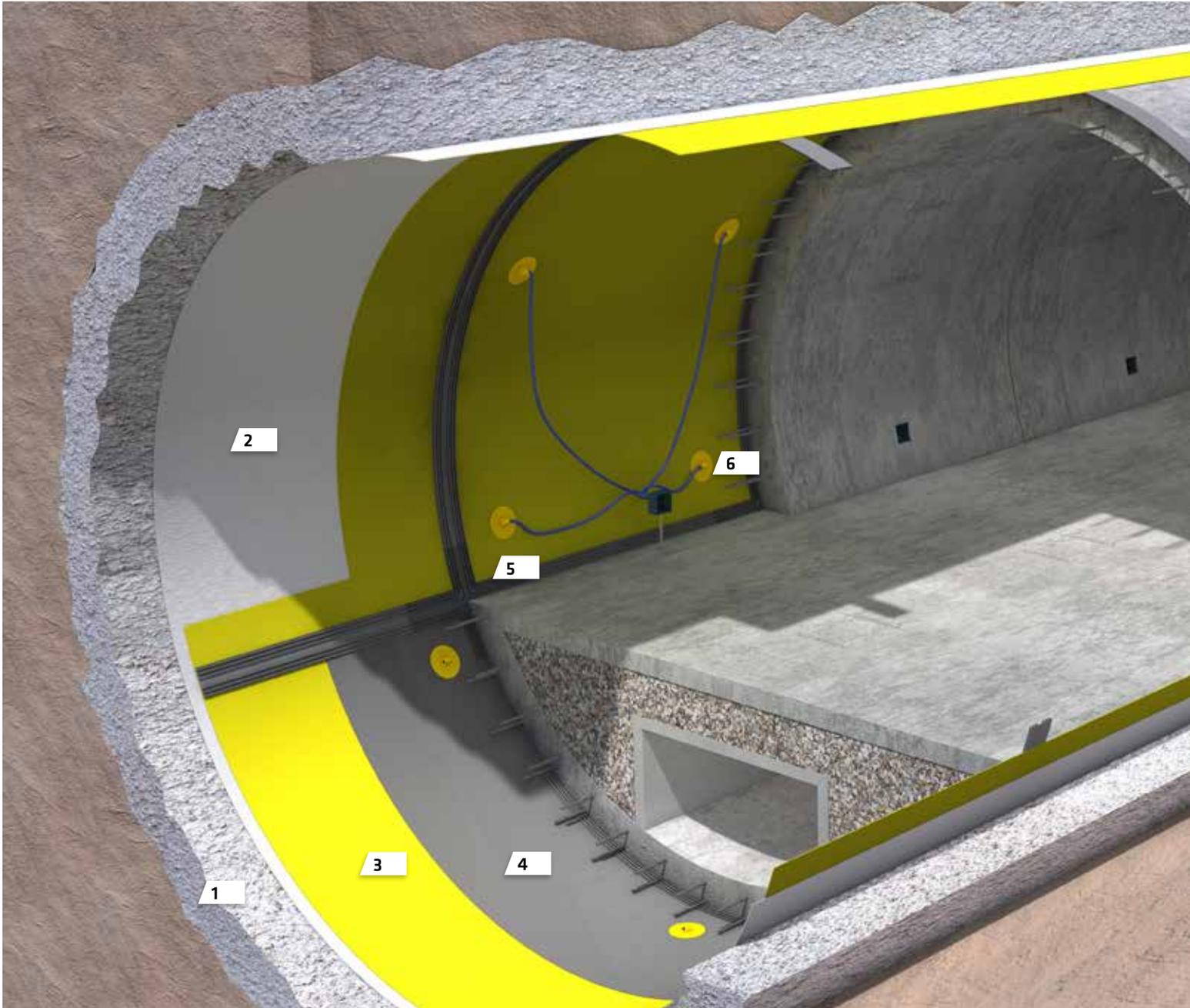


Sikaplan® WP
Drainage Angle

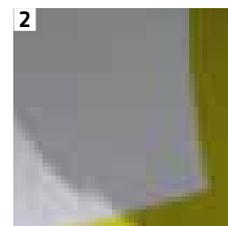


Secondary Concrete
lining

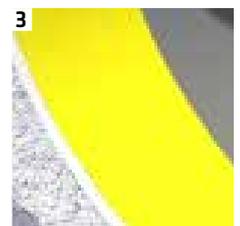
MINED TUNNEL – Sikaplan® BARRIER SYSTEM



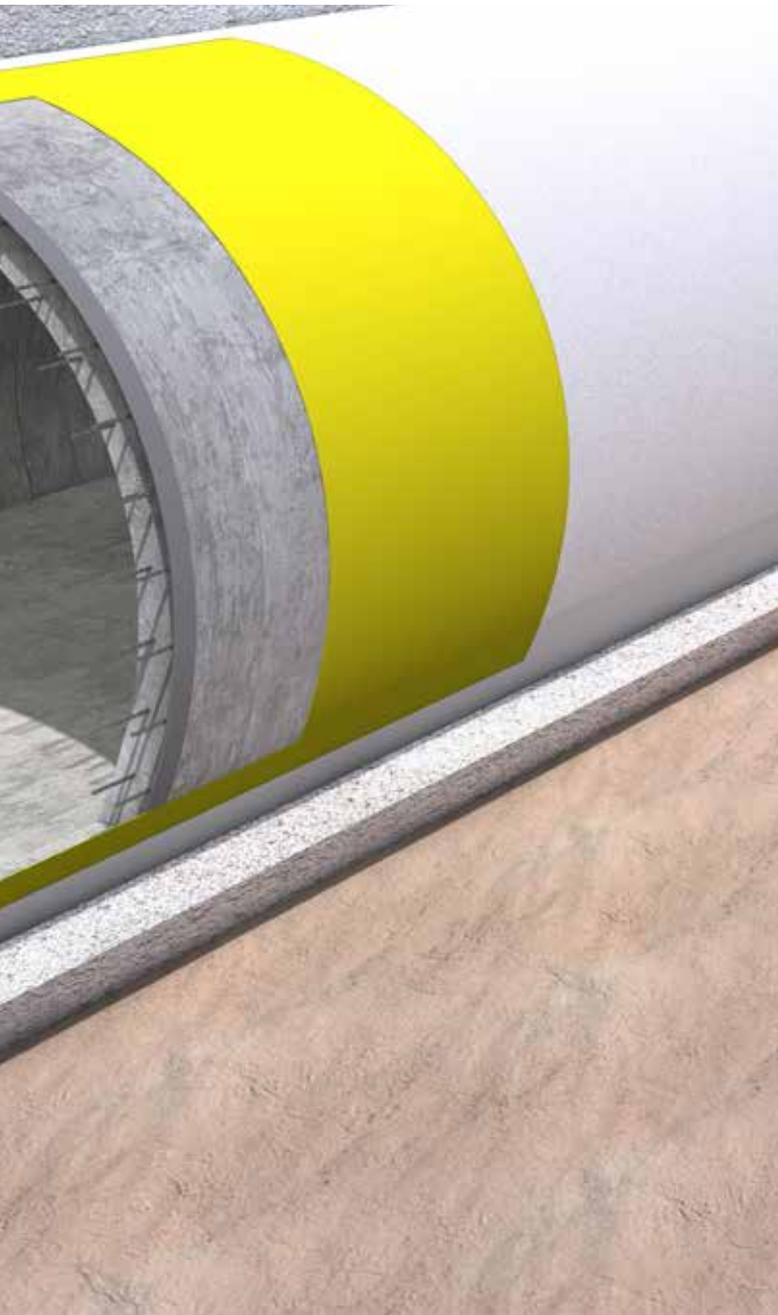
First Shotcrete lining



Sikaplan® W Felt



Sikaplan® WP/WT



SELECTION CRITERIA

BARRIER SYSTEM – SINGLE LAYER – FULLY ENCLOSED WATERPROOFING

PVC

Sikaplan® WP 1100 sheet membranes are used to resist against pressurised waters up to temperatures of +35°C, and Sikaplan® WP 2101 up to +50°C. The most suitable thickness of Sikaplan® WP sheet membranes is specified with 3.00 mm for hydrostatic pressure.

Rating for barrier system	1	2	3	4	5
Sikaplan® WP (PVC) sheet membranes					
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor – 5 excellent)

FPO

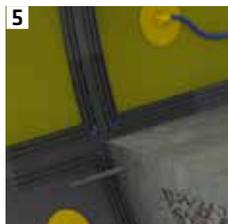
Sikaplan® WT 2200 sheet membranes are used for waterproofing against clear groundwater and groundwater containing hydrocarbons at temperatures of up to +40°C. The most suitable thickness of Sikaplan® WT sheet membranes is specified with 3.00 mm for hydrostatic pressure.

Rating for barrier system	1	2	3	4	5
Sikaplan® WT (FPO) sheet membranes					
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

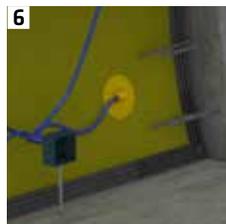
(1 poor – 5 excellent)



4
Sikaplan® WP/WT
Protection Sheet

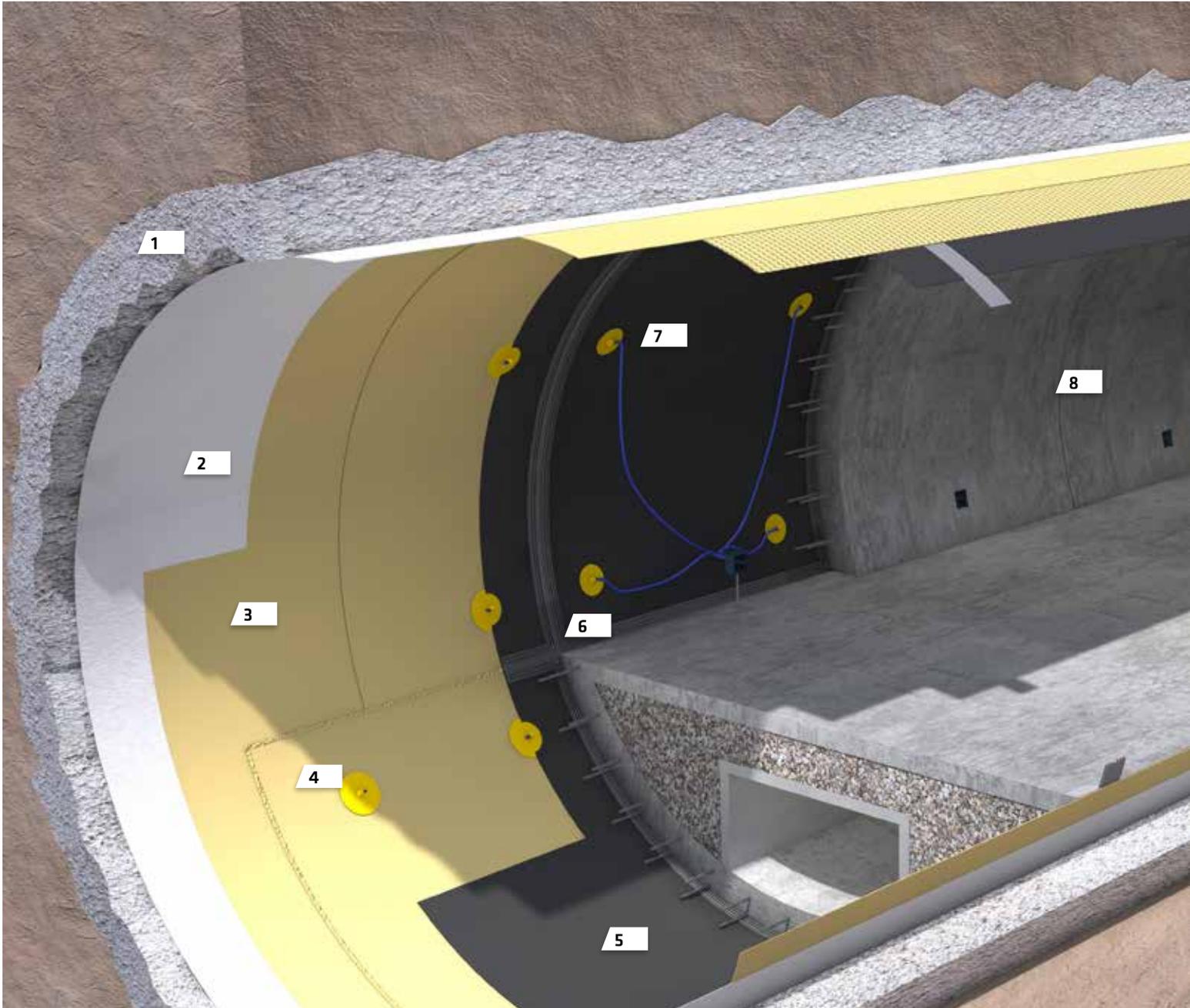


5
Sika® Waterbar
WP/WT, Injectable

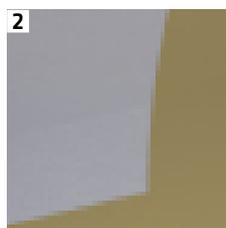


6
Sikaplan® WP/WT
Control Socket

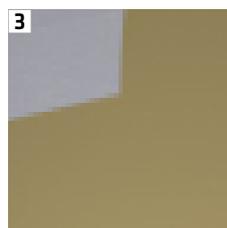
MINED TUNNEL – Sikaplan® ACTIVE CONTROL SYSTEM



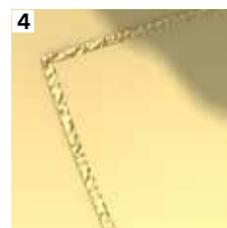
1
First Shotcrete lining



2
Sikaplan® W Felt



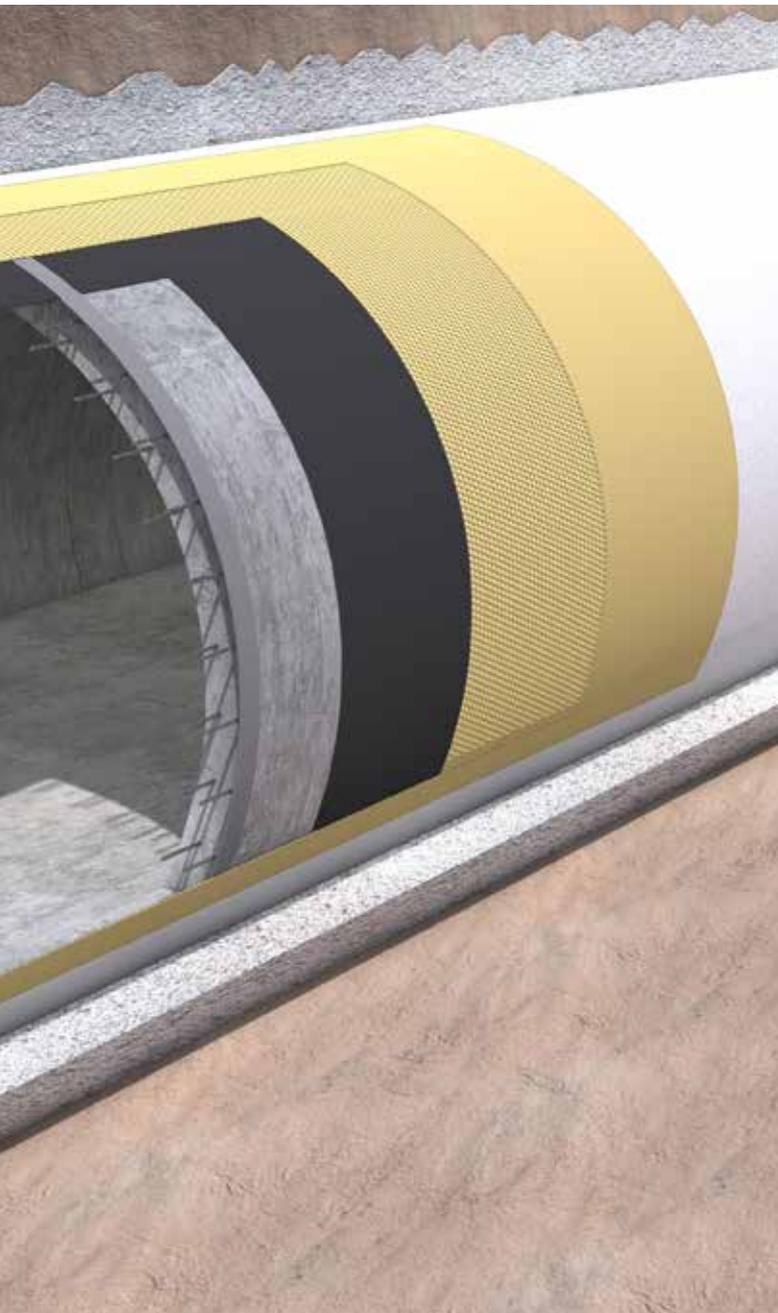
3
First Layer
Sikaplan® WT



4
Second Layer
Sikaplan® WT
Embossed



5
Sikaplan® WT
Protection Sheet



SELECTION CRITERIA

ACTIVE CONTROL SYSTEM- DOUBLE LAYER - FULLY ENCLOSED WATERPROOFING

FPO

Sikaplan® WT 2200 sheet membranes are used for waterproofing systems that can also resist chemically aggressive groundwater and hydrocarbons at temperatures up to +40°C. The double layer system meets the highest demands for security and control of watertightness. The most suitable thickness of Sikaplan® WT 2200 is specified with 3.00 mm (first layer) and 2.00 mm embossed (second layer).

Rating for active control system Sikaplan® WT (FPO) sheet membranes	1	2	3	4	5
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor – 5 excellent)



6
Sika® Waterbar WT,
Injectable

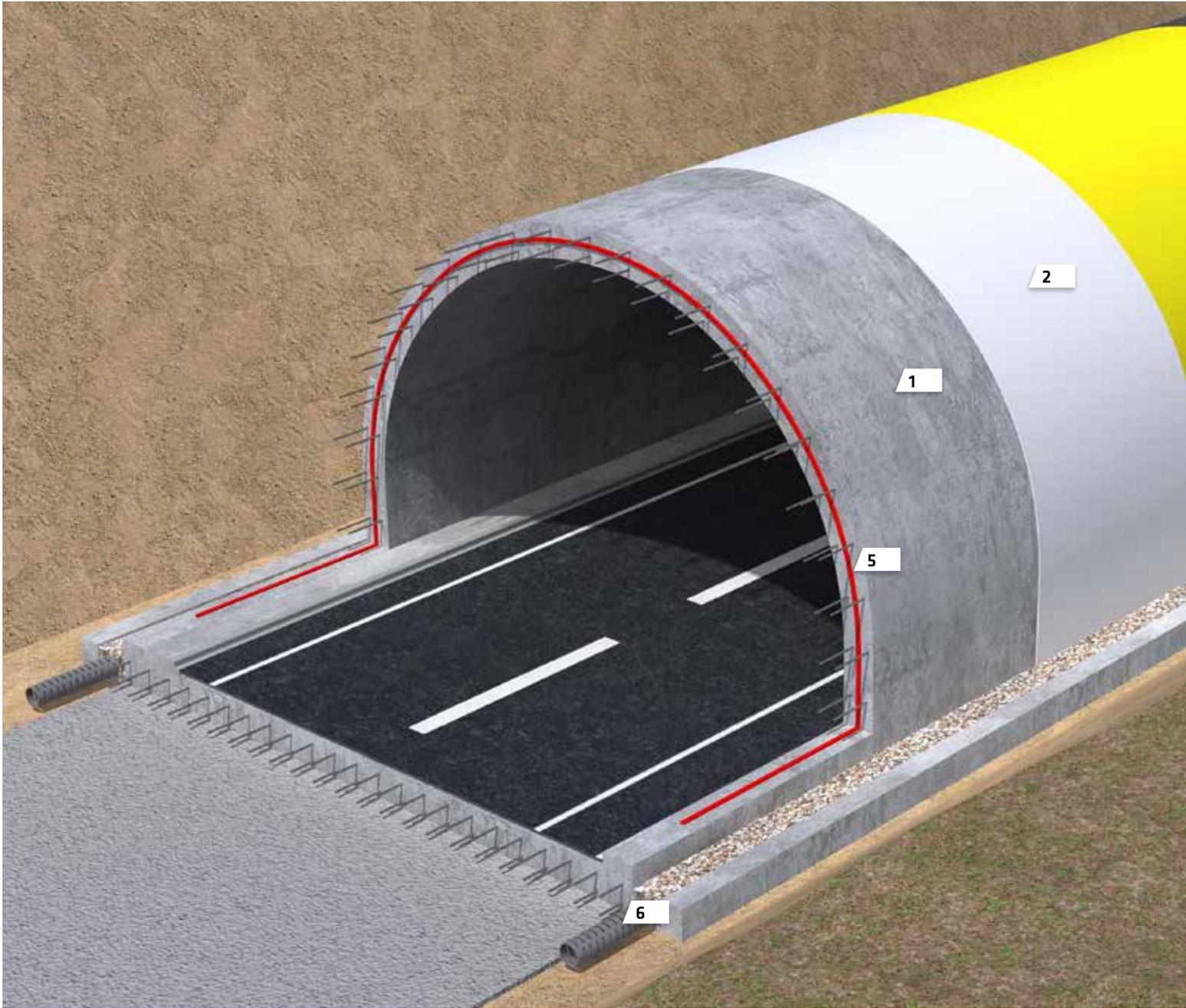


7
Sikaplan® WT
Control Socket



8
Secondary Concrete
Lining

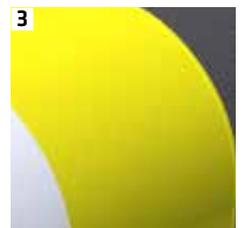
CUT-AND-COVER Sikaplan® DRAINAGE SYSTEM



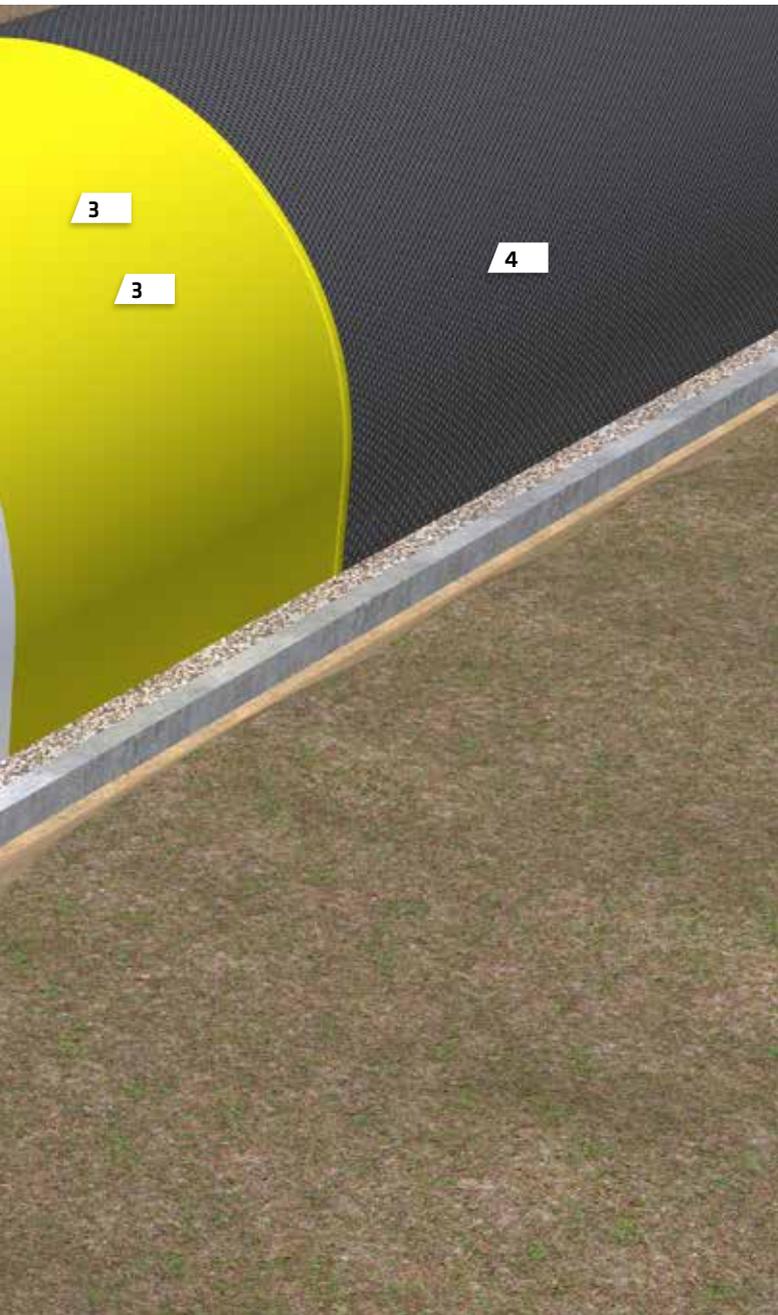
1 Structural Concrete



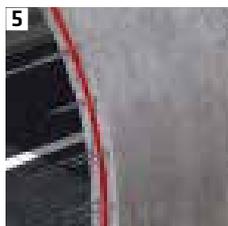
2 Sikaplan® W Felt



3 Sikaplan® WP/WT



Sika® Drain



SikaSwell®



Drainage Pipe

SELECTION CRITERIA

DRAINAGE - SINGLE LAYER - PARTIAL WATERPROOFING

PVC

Sikaplan® WP 1100 sheet membranes are used to resist against drained waters up to temperatures of +35°C and Sikaplan® WP 2101 up to +50°C. The most suitable thickness of Sikaplan® WP sheet membranes is specified with 2.00 mm for drained water.

Rating for drainage system Sikaplan® WP (PVC) sheet membranes	1	2	3	4	5
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor - 5 excellent)

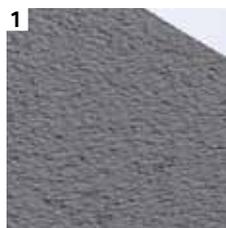
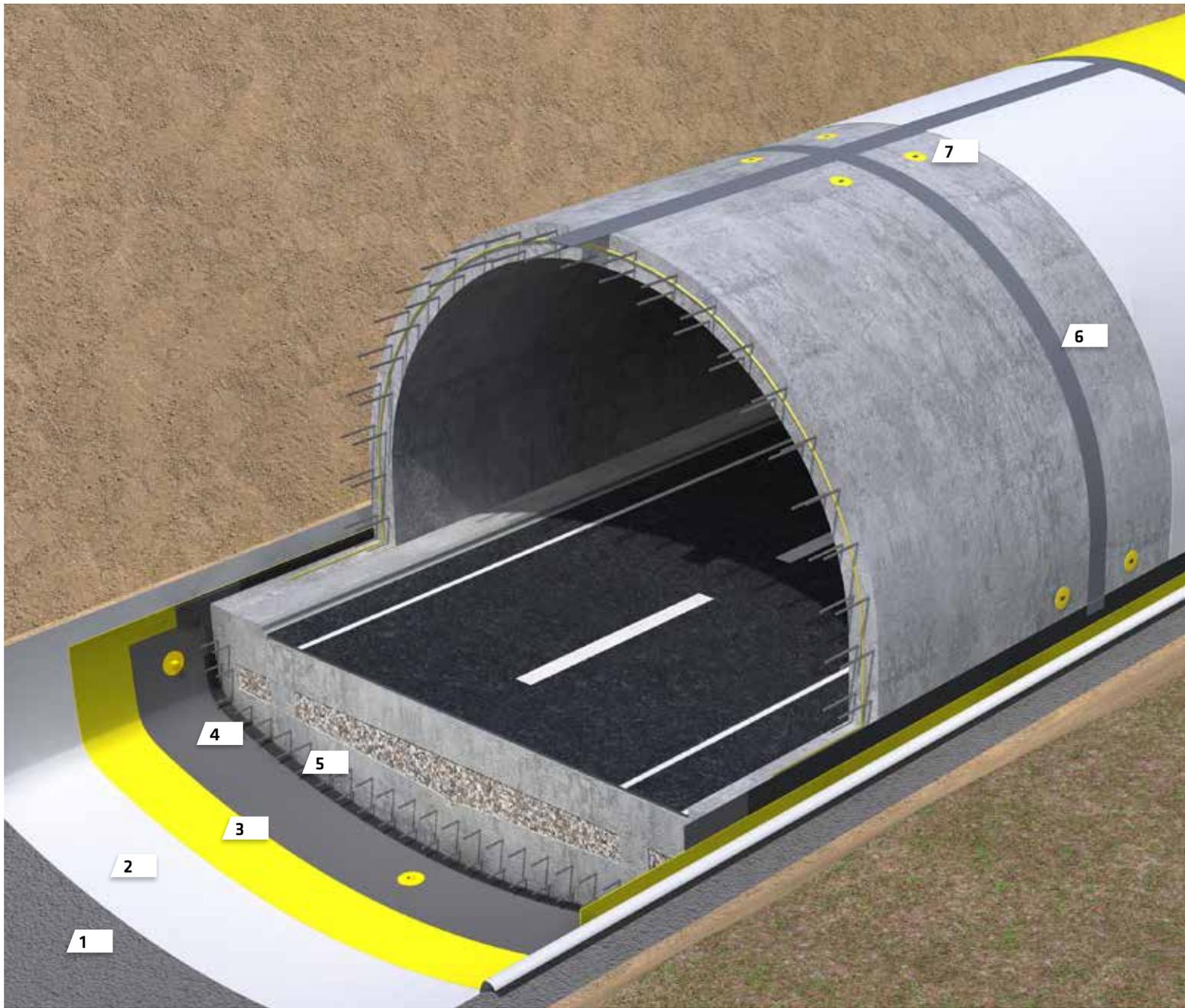
FPO

Sikaplan® WT 1200 reinforced sheet membranes are used for waterproofing against clear groundwater and hydrocarbons groundwater at temperatures of up to +40°C. The most suitable thickness of Sikaplan® WT sheet membranes is specified with 2.00 mm for drained water.

Rating for drainage system Sikaplan® WT (FPO) sheet membranes	1	2	3	4	5
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor - 5 excellent)

CUT-AND-COVER Sikaplan® BARRIER SYSTEM



Lean Concrete



Sikaplan® W Felt



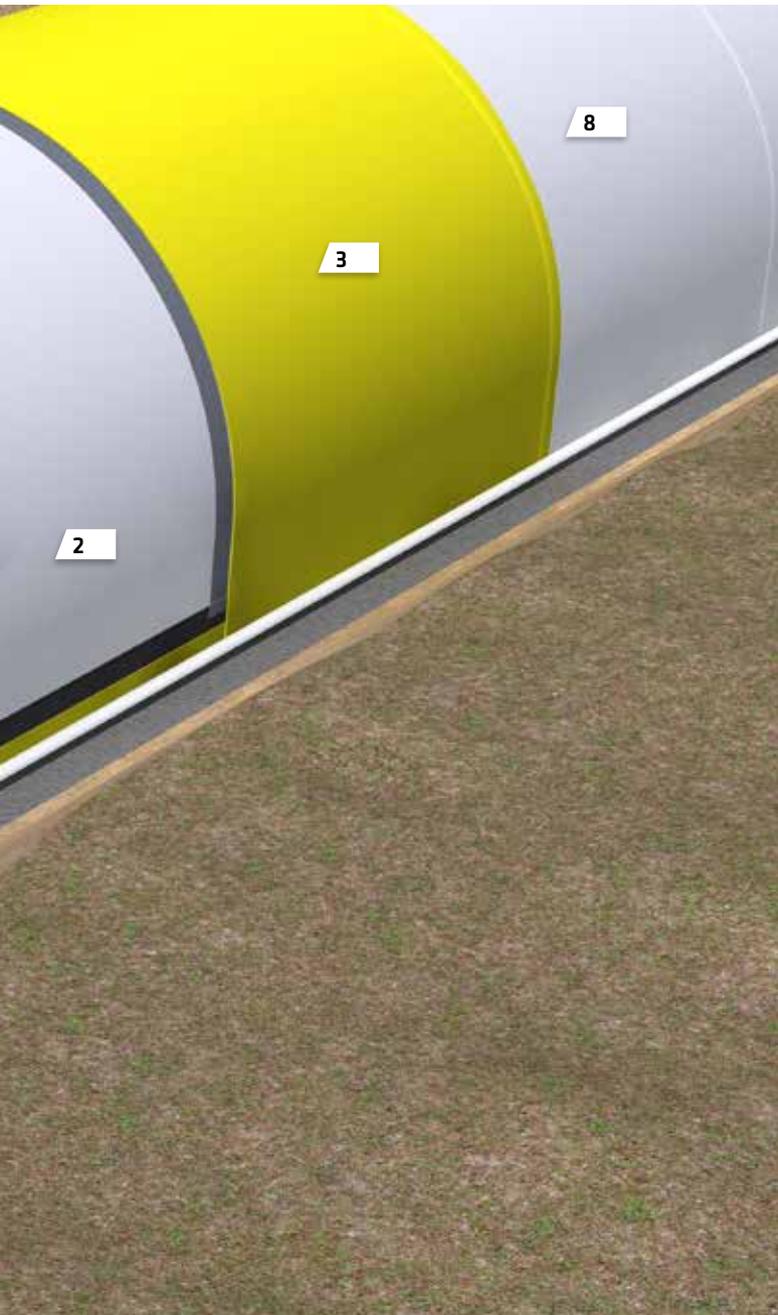
Sikaplan® WP/WT



Sikaplan® WP/WT
Protection Sheet



Sika® Waterbar
WP/WT



SELECTION CRITERIA

BARRIER SYSTEM – SINGLE LAYER – FULLY ENCLOSED WATERPROOFING

PVC

Sikaplan® WP 1100 sheet membranes are used to resist against pressurised waters up to temperatures of +35°C and Sikaplan® WP 2101 up to +50°C. The most suitable thickness of Sikaplan® WP sheet membranes is specified with 3.00 mm for hydrostatic pressure.

Rating for barrier system	1	2	3	4	5
Sikaplan® WP (PVC) sheet membranes					
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

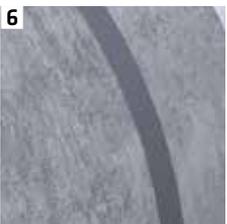
(1 poor – 5 excellent)

FPO

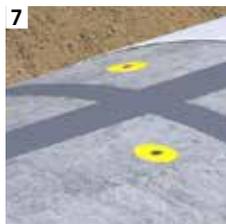
Sikaplan® WT 1200 reinforced sheet membranes are used for waterproofing against clear groundwater and hydrocarbons groundwater at temperatures of up to +40°C. The most suitable thickness of Sikaplan® WT sheet membranes is specified with 3.00 mm for hydrostatic pressure.

Rating for barrier system	1	2	3	4	5
Sikaplan® WT (FPO) sheet membranes					
Resistance to chemicals					
Resistance against high temperature of groundwater					
Controlability and redundancy level of the system					
Safety of waterproofing during service life					

(1 poor – 5 excellent)



Sikaplan® WP/WT Tape or Sika Dilatec



Sikaplan® WP/WT Control Socket



Sikaplan® W Felt Heavy

ANCILLARY PRODUCTS

DESCRIPTION

Fixing discs for the spotwise and temporary fixing of sheet membranes at vertical and overhead areas to be waterproofed.

Sikaplan® WP SERIES (PVC BASED)



Sikaplan® WP Disc PVC yellow

Sikaplan® WT SERIES (FPO BASED)



Sikaplan® WT Disc PE grey

Injection sockets or ports for the inspection and control of watertightness, and for the injection of compartments, are either spot welded on single layer membrane systems, or fully welded on double layer systems. These sockets are connected with special, highly elastic PU tubes to accessible injection ports on the inside concrete surface.



Sikaplan® WP Control Socket



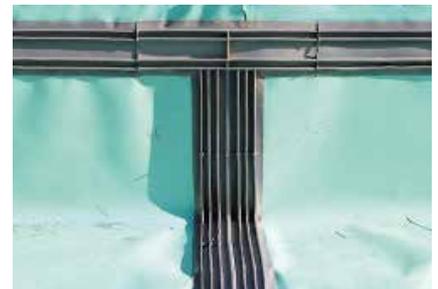
Sikaplan® WT Control Socket PE

Full range of waterbars, specially designed for use in combination with sheet membranes:

- Wide welding flanges for easy and watertight welding against the waterproofing membrane
- Injection channels to eliminate honeycombing, especially in overhead applications



Sika Waterbar® WP



Sika Waterbar® WT

Protection sheets over the installed waterproofing membrane are mainly used as protection measures against reinforced concrete or backfilling. In addition, if embossed, they allow the repair injection material to distribute easily.



Sikaplan® WP Protection Sheet



Sikaplan® WT Protection Sheet

FLEXODRAIN SYSTEM



Sika Flexodrain to lead drain water into lateral drainage:

- | | |
|-----------------------|--------------------------|
| 1 Halfpipe | 4 Hose collector |
| 2 Leakwater collector | 5 Drain-hose |
| 3 Y-connecting piece | 6 Drain-pipe inlet piece |

DRAINAGE ANGLE



Sikaplan® WP Drainage angle allows a fast and safe termination of the waterproofing membrane around the drainage pipe for umbrella systems, for Sikaplan® WP and WT.

QUALITY CONTROL OF WELDED MEMBRANES

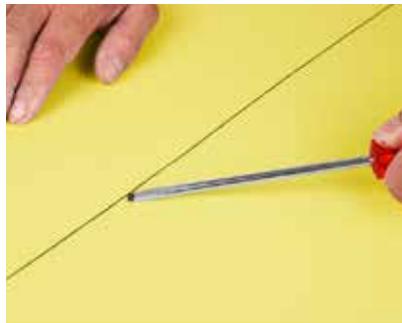
Completed tunnel structures that are waterproofed with Sikaplan® sheet membranes are intended to be exposed to water under hydrostatic pressure. It is therefore essential to test the watertightness of the completed membrane installation works, prior to covering and protecting the membrane from ongoing construction works. There are a variety of different methods to check and approve the welded seams and overlaps in particular on the installed membrane.

PEEL TEST



Peel tests have to be performed on separate membrane samples at the beginning of each membrane application to set the machine parameters, as well as at regular intervals during the application to adjust the welding setup according to the changing climatic conditions.

VISUAL INSPECTION



Visual checking with the aid of a broad screw driver to search for voids or misses at seam edges. The surface area can be visually checked by control of signal layer.

COMPRESSED AIR TESTING



Air pressure testing using an air pressure pump, reverse flow valve and test needle that is inserted into a test channel between the seams of double seam welding (suitable for double seams only).

VISUALLY WITH ELECTRICAL SENSOR



Area defect testing with an electrical copper wire brush holiday test. Electrical sparks signalizes capilarities in seams. Any defects in the membrane or at seam edges can be detected, if an electrical conductor is placed underneath.

VACUUM TESTING OF DETAILS BY VACUUM BELL



Vacuum testing using a vacuum bell and electrical vacuum pump for testing of details. After treating the seam edges with soap solution, the vacuum bell is firmly pressed over the area to be tested and the vacuum applied. Any leaks are clearly seen by bubbling of the soap solution under vacuum.

VACUUM TESTING OF COMPARTMENT OVER SIKAPLAN CONTROL SOCKETS



Vacuum testing of compartments of a double layer membrane system using vacuum pump. During the testing the vacuum should not drop less than 20% in 10 minutes to be completely watertight.

REPAIRING OF LEAKS

THE UNIQUE BENEFIT: LEAK CONTROL AND REPAIR BACK-UP

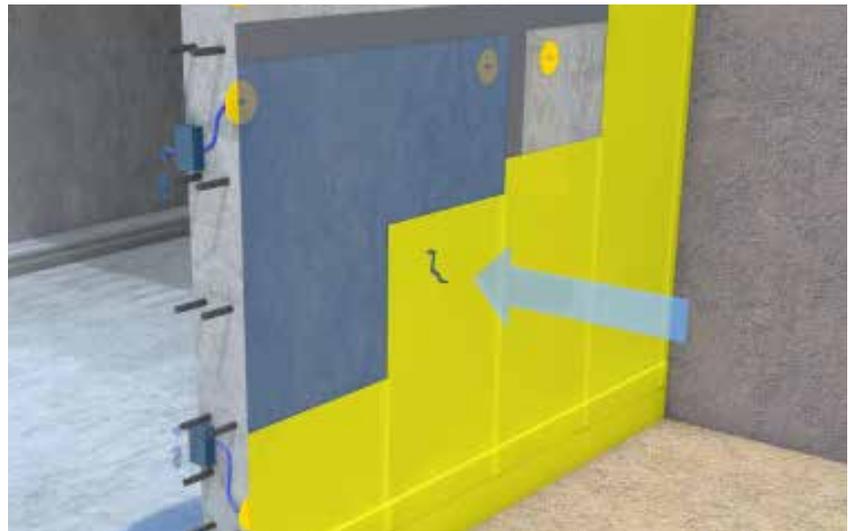
Tunnels under hydrostatic pressure are waterproofed with Sikaplan® sheet waterproofing membranes including compartments and injection backup. Each compartment with an area of approx. 150 m² is combined with four to five control sockets plus control tubes. The control tubes lead to a socket box on the inside of the structure, allowing easy access and quick repair at any time of the entire service life of the structure, in case of failures in the membrane.

Leaks can be easily detected as leak-water appears at the end of the control tube. Repairing of leaks can be performed by injecting Sika® Injection-306 resin through the Sika control

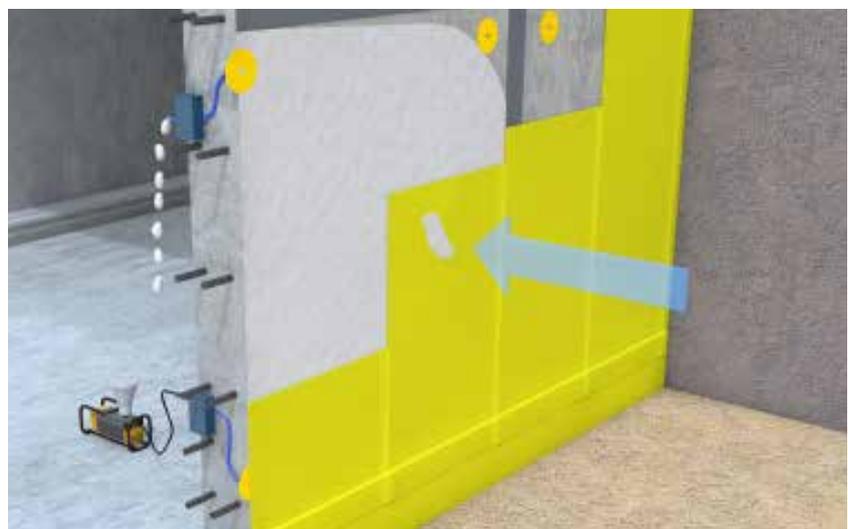
tube. Sika® Injection-306 is a low viscosity fast reacting polyacrylate injection liquid, which mixes with leak water during the injection process and reacts to form a solid, but highly elastic and expandable gel in the gap between the structural concrete and the membrane within a compartment area, or between the membrane layers in the case of double layer systems.

To complete the system, injectable Sika® Waterbars are highly recommended for mined tunnels, as the proper embedding of the ribs of waterbar is not guaranteed at crown areas, where the anchors are placed upside down.

- In case of damaged membrane, water can locally underflow the membrane but will then be limited by waterstops cast into the concrete to create compartments.
- Any leaking compartment can easily be detected though the control ports that remain accessible from inside the completed structure.



- Repairing any leaks in the membrane is achieved by injection of Sika® Injection-306 through the integral injection flanges accessible from inside the completed structure.
- The Sika injection resin reacts with water to form a solid but flexible, elastic gel in the void between the structural concrete and the membrane within the compartmentalized section to seal the damaged area.



SEGMENTAL LININGS CROSS PASSAGE WATERPROOFING

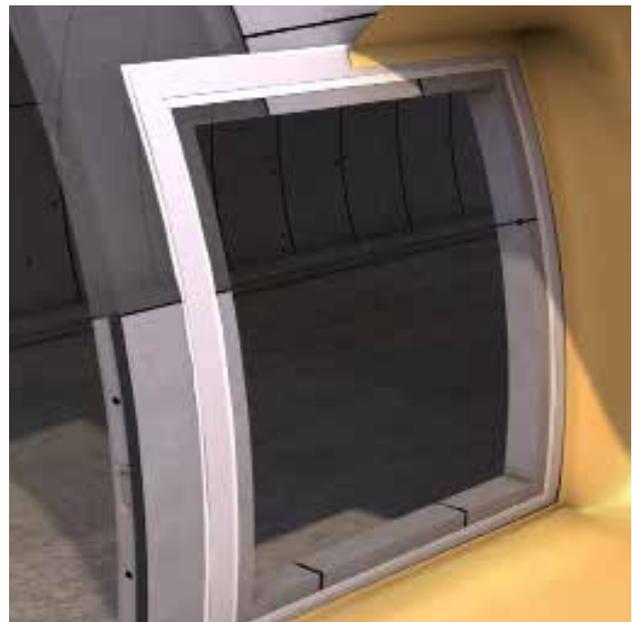
SIKA HAS DEVELOPED two high performance bonded tape sealing solutions that are both quick and easy to install, and with the same standard and level of watertightness as the whole cross section/transition waterproofing system (i.e. the Sikaplan Membrane Compartment System). Dependent on which membrane waterproofing system is selected for each project, Sika provides this bonded tape sealing solution based on a compatible formulation of either PVC – “The Sikaplan® WP Tape System”, or FPO – “The Sikaplan® WT Tape System”.

Uses:

- Watertight connection of crossings between parallel tunnels
- Watertight transitions between TBM driven tunnels to station boxes
- Forming compartment systems together with Sikaplan® tunnel membranes in Cut and Cover tunnels
- Watertight terminations of Sikaplan® WP/WT membrane systems

Main properties:

- The system cost is “highly” competitive in comparison to any clamped solution.
- No need for the costly mortar beds/build-ups required for mechanically clamped systems
- Proven durability:
 - The FPO based Sikaplan® WT Tape-200 has the same formulation as Sikaplan® WT 2200 Series with proven ageing behaviour >120 years and a well-documented track record
 - The PVC based Sikaplan® WP Tape-200 has the same formulation as Sikaplan® WP 1100 Series with proven ageing behaviour >100 years and a well-documented track record
- Full material/system compatibility and tested life expectancy
- Minimizes the risk of failures at critical details



See also brochure waterproofing Sikaplan® WP/WT tapes

Sikaplan® WP TAPE-200 AND Sikaplan® WT TAPE 200 are high performance waterproof sealing tapes for terminations and fixings of Sikaplan® WP and WT waterproofing membranes. The sealing tape is bonded to the substrate by epoxy and fully sealed by heat welding to the Sikaplan® waterproofing membranes. This solution is used to maintain a high quality, watertight seal at perimeter edges and terminations. It can therefore also be used in cross passages, waterproofed by Sikaplan® membranes, at the terminations to the segmental lining.

CHARACTERISTICS / ADVANTAGES

Sikaplan® WP Tape-200 based on PVC is a white/black tape modified on the black side to provide excellent adhesive properties with the Sikadur®-31 CF adhesive, for bonding to concrete and steel surfaces.

- Very good bond characteristics
- Long-term water resistance
- Optimized workability, heat weldable
- Optimized flexibility with high tensile strength and multi-axial elongation
- Elastomeric behaviour
- Flexible in cold temperatures
- Bonds the membrane tape securely to the concrete substrate at terminations and fixings
- No lateral water underflow



CHARACTERISTICS / ADVANTAGES

Sikaplan® WT Tape based on FPO is a grey/black tape modified on both sides. Both, black and grey sides have excellent bonding properties with Sikadur®-31 CF epoxy adhesives to concrete and steel.

- Excellent adhesion between the tape and adhesives means no solvent activation of the tape is required on site
- Fast and easy to install
- Suitable for installation on both dry and damp concrete surfaces
- Performs well within a wide range of temperatures
- Good adhesion to many different material substrates
- The adhesives are available in normal and rapid hardening grades to suit different conditions and requirements
- Root penetration resistant
- No lateral water underflow



SHOTCRETE ON SHEET MEMBRANE

It is common practice for the secondary linings in double-shell tunnels to use in-situ concrete. This is cast-in-place by large movable formwork assemblies on rails, which are usually between 10 m and 12.5 m long. This approach provides a fast and economical solution for the regular cross sections of long tunnels. However, there are technical and commercial limitations: In short tunnels, tailor-made formwork assemblies might not be cost effective.

- For changing diameters, widening sections, cross-passages etc., the formwork has to be modified or even completely replaced
- In these instances, a secondary lining made of shotcrete instead of in-situ concrete can provide the following advantages:
 - Lower complexity of construction operations
 - The possibility of saving time and money because of no need for costly formwork

The Sika®Anchor/BA-Anchor System is a hard synthetic shaft connected to a flexible Plastic flange made of Sikaplan® WP or WT membranes for steel mesh fixation.



When SikaFiber® is added to the shotcrete, there can be additional cost savings because of reduced reinforcement requirements and operations. This solution is therefore an ideal replacement for in-situ-poured / cast-in-place concrete linings and can be useful for short tunnels, and wherever the regular cross section changes, e.g. in widenings, junctions, openings and cross passages.

However, shotcrete does not adhere to smooth synthetic sheet membranes; therefore it is necessary to implement a rebound reduction system. A steel mesh is installed over the waterproofing membrane, reducing the rebound and/or taking over the static loads of the newly applied shotcrete while it is fresh. The mesh has to be anchored into the substrate behind the membrane, which without any additional measures, would create penetrations and potential leaks through the waterproofing system. This problem can readily be solved in two different ways:

The Sikaplan® WP or WT Trumpet Flange allows a watertight penetration of conventional rock anchors for fixing the rebound reducing steel mesh.





Bypass Lungern (CH), sprayed secondary lining over Sikaplan® WP membrane system at widening section, steel mesh penetration sealed with Sikaplan® WP Trumpet Flange.

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 most current local Product Data Sheet prior to any use.



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