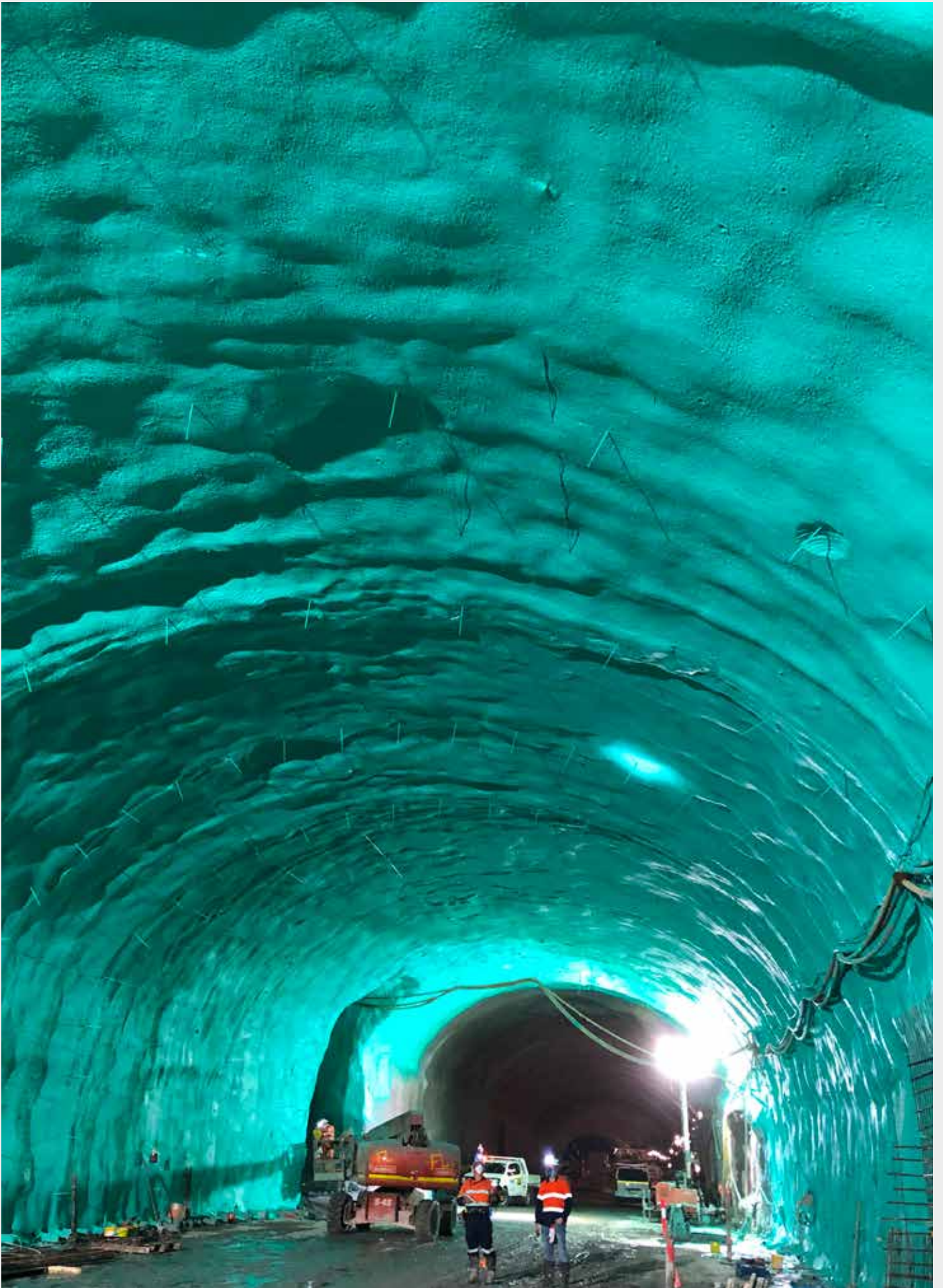


# TUNNEL METHOD STATEMENT FOR MAPELASTIC TU SYSTEM SPRAY APPLIED WATERPROOFING MEMBRANE





**NORTH CONNEX**, Sydney (Australia)

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## 1. MANUFACTURER PROFILE

Founded in Milan in 1937, MAPEI is today one of most affirmed world leaders in the production of chemical products for civil construction field, with a large worldwide development. In fact, MAPEI Group nowadays counts 90 subsidiaries with 83 production facilities in operation over 36 countries and 5 continents.

MAPEI has always devoted continuous and significant investments and a relevant number of its employees to the Research and Development of new products and technologies. Apart from 83 quality control laboratories, MAPEI also has 31 research laboratories. Furthermore, MAPEI has developed a sales and technical service network with offices all over the world and offers an efficient Technical Service that is valued by architects, engineers, contractors and owners.

### 1.1. INTRODUCTION TO UTT (UNDERGROUND TECHNOLOGY TEAM)

The Underground Technology Team (UTT) is the division of MAPEI dedicated to underground works. With more than 20 years of international on-site Underground Construction & Mining experience with a worldwide network of highly trained and professional technical service, able to handle the most unpredictable situations, thus ensuring the most appropriate technical and economic solution. The products and technologies manufactured by MAPEI have the goal in mind of completely satisfying every technical requirement of our customers, from applicator to client.

## 2. SCOPE AND REQUIREMENTS

This document is intended to serve as a basis for performance and installation requirements for the application of waterproofing systems, featuring a spray-applied watertight polymeric synthetic membrane layer, bonding to a cementitious based material.

This document covers the application of spray-applied membranes with an average thickness of 2 mm DFT (3 mm WFT) on the smoothing layer surface and the final application of a shotcrete/concrete layer. With this solution, the membrane is sandwiched between the smoothing layer and the shotcrete/concrete layer.

The following method is referred to both drained and undrained tunnels that require respectively crown/walls and full round membrane application.

### 3. MATERIAL AND SPECIFICATION

Waterproofing is one of the most important steps to build a safe and durable structure. It's possible to waterproof a structure with different methods and different products: MAPELASTIC TU SYSTEM is one of the most innovative.

MAPELASTIC TU SYSTEM is one component sprayable membrane. Once applied, MAPELASTIC TU SYSTEM forms a waterproofing barrier, avoiding the passage of water between the two cementitious layers (e.g. shotcrete-membrane-shotcrete, shotcrete membrane-poured concrete, etc.).

Moreover, MAPELASTIC TU SYSTEM is characterized by high flexibility, which allows stretch and deformation, guaranteeing the integrity of the lining, by high tensile strength and by excellent adhesive properties on cementitious substrates, even those with complex shape.

These properties make MAPELASTIC TU SYSTEM the ideal product for waterproofing underground structures.

MAPELASTIC TU SYSTEM is characterized by:

- High flexibility: it has a great ability to stretch and deform, thus maintaining coating integrity after substrate deformation;
- Good tensile strength;
- Excellent bonding properties to the cementitious substrate properly prepared (e.g. cement-based concrete, shotcrete, premixed grout etc.),
- Double colored version for an easy and proper checking of surface coverage.

## TECHNICAL CHARACTERISTICS

Characteristics	Value
Appearance	light green/white paste
Density (g/m <sup>3</sup> )	1.25 ± 0.05
Shore A Hardness (-) (DIN 53505)	≥ 40
Tensile strength (MPa) (EN ISO 527)	≥ 1.0
Elongation at break (%) (EN ISO 527)	≥ 150
Bond strength (MPa) (EN 1542)	≥ 0.75
Resistance to water pressure (EN 12390/8)	5 bar per 28 d
Crack bridging ability (EN 1062-7, method A) (µm)	A5 > 2500
Reaction to fire (EN 13501-1)	B, s2, d0
Packaging (kg/drum)	260

The Product shall have a nominal/average thickness of 3 mm WFT (2 mm DFT). A localized minimum of 2 mm can be accepted.

The product is durable even if exposed to groundwater condition.



MAPELASTIC TU SYSTEM drums

## 4. APPLICATION PROCEDURE

### 4.1. SURFACE CHECKLIST

The Surface checklist should be carried out following the procedure below:

- The substrate must be cleaned from any residual dust using, for example, compressed air, in order to improve the adhesion between the sprayed membrane and the surface. If the residual dust over the substrate requires a pressurized water washing, it is necessary to wait for the surface to dry before the application of the spray-applied membrane.
- Each part of the substrate must be solid and it's necessary to remove every loose parts before spraying the membrane.
- Any external curing agent applied onto the sprayed concrete, which is not compatible with the spray applied membrane, shall be thoroughly removed using a method approved by the Engineer, before application of the membrane.
- In case of surface irregularities of around 4 mm, the application of a fine-grade, sprayed, concrete smoothing layer is suggested to achieve the best results in terms of final performances and consumption. Substrates with major pittings are unsuitable, as they require excessive material consumption. A shotcrete panel shall be lined with the smoothing layer in the trial phase to act as a benchmark.
- The smoothing layer should be around 10 mm thick min. and it is suggested to use sand (with a grading of 0 to 4 mm) as aggregate. The use of a fast-reacting premixed grout with high mechanical and watertight proprieties (MAPEGROUT GUNITE FSD) is recommended.
- The use of an additional premixed, watertight, ultra-fast smoothing layer (MAPEGROUT GUNITE SHOTGUN) is highly recommended to properly treat possible damp areas over the substrate.
- Joints, breaks and penetrations through the system shall be covered with a shotcrete/smoothing layer. Any protruding bolt head needs to be free of water, dust and loose particles



and covered with a shotcrete/smoothing layer to satisfy the requirements (the product is designed to be sandwiched between two shotcrete layers). It is strongly suggested to check for voids behind the bolt head also prior to spraying concrete.

- Consumption shall be around 4-5 kg/m<sup>2</sup> per an average thickness of 2 mm DFT (3 mm WFT). Consumption depends significantly on the irregularities, on the roughness and undulations of the support.
- Before starting the application, the drum shall be checked to make sure it is properly sealed.
- During spraying, in order to quantify the quantity of MAPELASTIC TU SYSTEM to be consumed, and to calculate the average consumption, it is recommended to divide the area to be covered into approx. 60 m<sup>2</sup> sections.
- Is highly recommended, after the application of the smoothing layer, to wait until 7 days (85% of the final smoothing layer compressive strength) prior to the installation of the spray applied membrane.



Airless pump

## 4.2. EQUIPMENT

The equipment for the application of the MAPELASTIC TU SYSTEM shall consist of the following characteristics:

- The equipment to be used to spray MAPELASTIC TU SYSTEM shall be a high-pressure painting pump without air at the nozzle, also called "Airless". The pump is usually with a single-piston. This pump has an air-driven engine that must have a pressure ratio of about 45/60:1, which means that 1 bar of air for the engine provides 45/60 bar to the spray gun. The pressure applied to the gun allows to properly and constantly spray the material on the chosen surface. Normally input pressure shall not exceed 6 bar.
- In order to guarantee a complete filling of the cylinder of the high-pressure piston pump, it's better to use a transfer piston pump to be inserted directly in the 260 kg drum, with the outlet side directly connected to the inlet side of the main pump.



Fuel-powered screw pump

- Different kind of pumps like air/fuel engines or screw pumps can be used to apply the membrane according to the manufacturer recommendations. Application by using a screw pump is possible but the minimum output of the equipment has to comply with the average application flow rate (usually around 5 and 6 l/min).
- Material shall be applied using a proper gun and tip (or nozzle, if the application is carried out by using a screw pump). Common tip sizes are:
  - 439
  - 443
  - 445



Engine pump compatible with MAPELASTIC TU SYSTEM

Different tip sizes can be adopted according to features of the equipment, substrate characteristics and installation speed required.

Mapei recommends performing a site trial prior to the installation of the membrane to define the right tip size.



Guns and tip types (airless application)



Screw pump nozzle (for screw pump application)

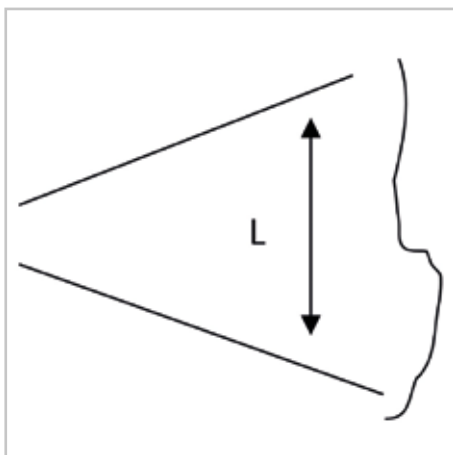
### 4.3. SPRAYING PROCEDURE

The spray procedure shall follow the criteria below:

- The product must be applied at a maximum distance of 1/1.5 meters from the surface, so, if required, it's necessary to prepare proper scaffolds or structures to approach the surface.
- However, with proper spray equipment, 1 m distance it's the average value.



Application phase (distance from the substrate)



Application distance from substrate



Application phases (gun fan direction)



Example of gaps (pinhole)

- The gun sprays the material in a single “fan”, allowing to direct the flow precisely where necessary, having at the same time a direct control of the sprayed area.
- The gap “L” increases or decreases with the proximity of the nozzle to the surface. The optimum distance, as said, is 1 meter from the surface. As the distance from the substrate increases, there is a risk that the material gets wasted into the air.
- It is not strictly necessary to cover the entire substrate surface in the first coat. Otherwise, the consumption would be too high. Gaps such as pinholes are easily filled with the second coating.

#### 4.4. FINAL LINING

MAPELASTIC TU works properly in a “sandwich” system, meaning that once the membrane has dried, it has to be completely coated with one of the two following systems:

- Cast in situ concrete layers;
- Shotcrete (recommended).

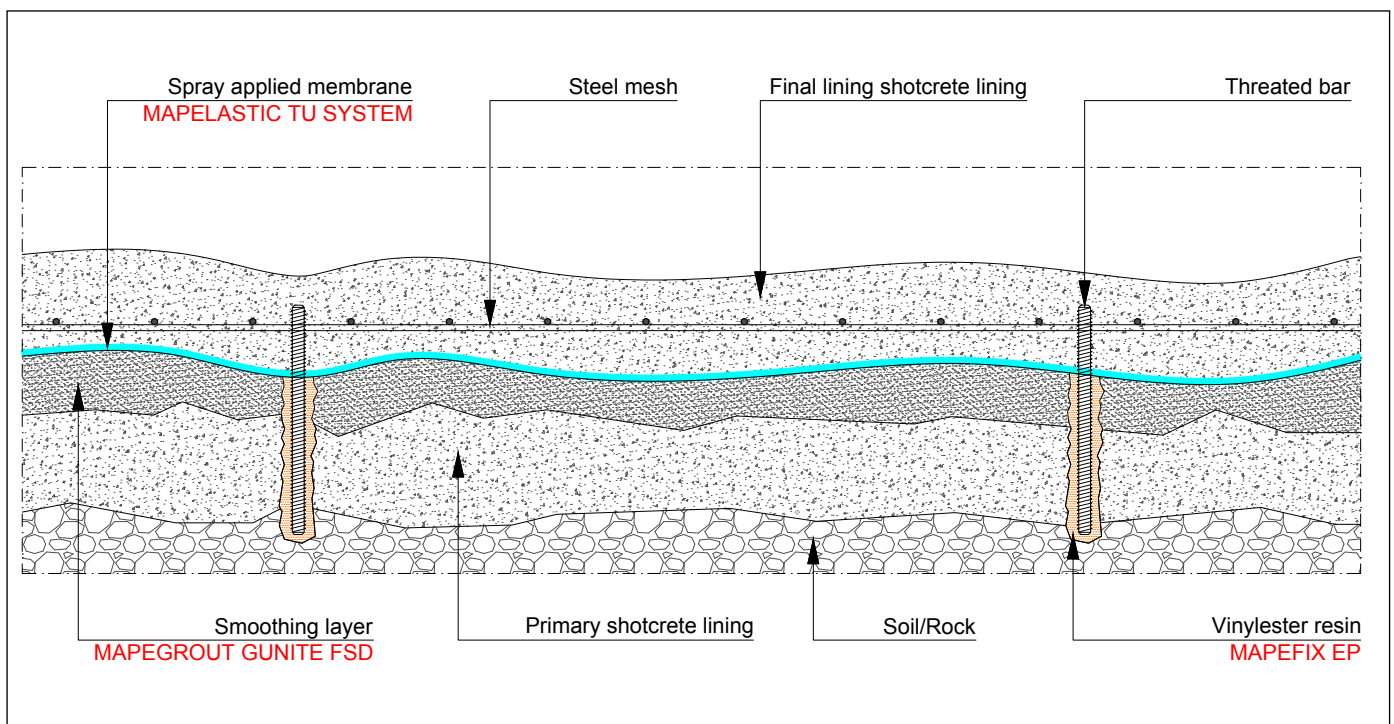
The following parameters shall be followed to achieve the proper performances of the composite lining:

- The entire membrane surface shall be fully covered with the final shotcrete/concrete lining, so that the material performs properly.
- It is recommended to spray a layer of shotcrete thicker than 5-10 cm onto the membrane to properly close the system.
- MAPELASTIC TU SYSTEM shall be correctly cured prior to spraying shotcrete onto it. Checks can be carried out using a Durometer (flatness and site condition permitting) to evaluate the Shore (A) Hardness. According to our laboratory testing, Mapei recommends achieving a Shore (A) Hardness  $\geq 25$  prior to the application of the final shotcrete lining. To avoid any surface membrane contamination (ex. powder) that could adversely affect the adhesion of the membrane with the final lining, it is recommended to apply the final lining within 72 hours after the prescribed Shore-A Hardness (25) has been achieved.
- If for any reason (other tunneling works, delay in the application of the final shotcrete lining, etc.) dust, powder or incoherent parts are detected on the membrane surface, they shall be removed using compressed air or (if necessary) high-pressurized water. After the washing operation, it is necessary to wait until the surface is completely dry and clean before applying the final shotcrete layer.
- If fiber-reinforced shotcrete is required, is recommended the use of PP fiber to minimize the picturing stress over the membrane.
- Any kind of rebar or threaded bar for future usage (anchor point, installation of steel mesh, etc.) shall be installed in



MAPELASTIC TU SYSTEM  
composite lining (“sandwich” system)

the primary shotcrete lining, prior to the application of the MAPELASTIC TU SYSTEM. Re-bars (or threaded bars) shall be fixed by using an appropriate adhesive approved by the supplier (for detailed re-bars installation see § 4.4.1).



Final cross-section of spray applied membrane system

#### 4.4.1. INSTALLATION PROCEDURE FOR RE-BARS OR THREADED BAR

Re-bars or threaded bars installation shall be carried out following the procedure below:

- Address the position of the fixing elements;
- Drill holes into the first shotcrete layer to fix the re-bars. The number of holes per m<sup>2</sup> has to be defined depending upon rebar size;

- Flush the borehole by using compressed air to clean the surface of the hole;
- Re-bars or threaded bars have to be fixed and sealed in each borehole and sealed with MAPEFIX VE SF;
- MAPELASTIC TU application can start (coverage over the threaded/reinforcing bar shall be around 50 mm).

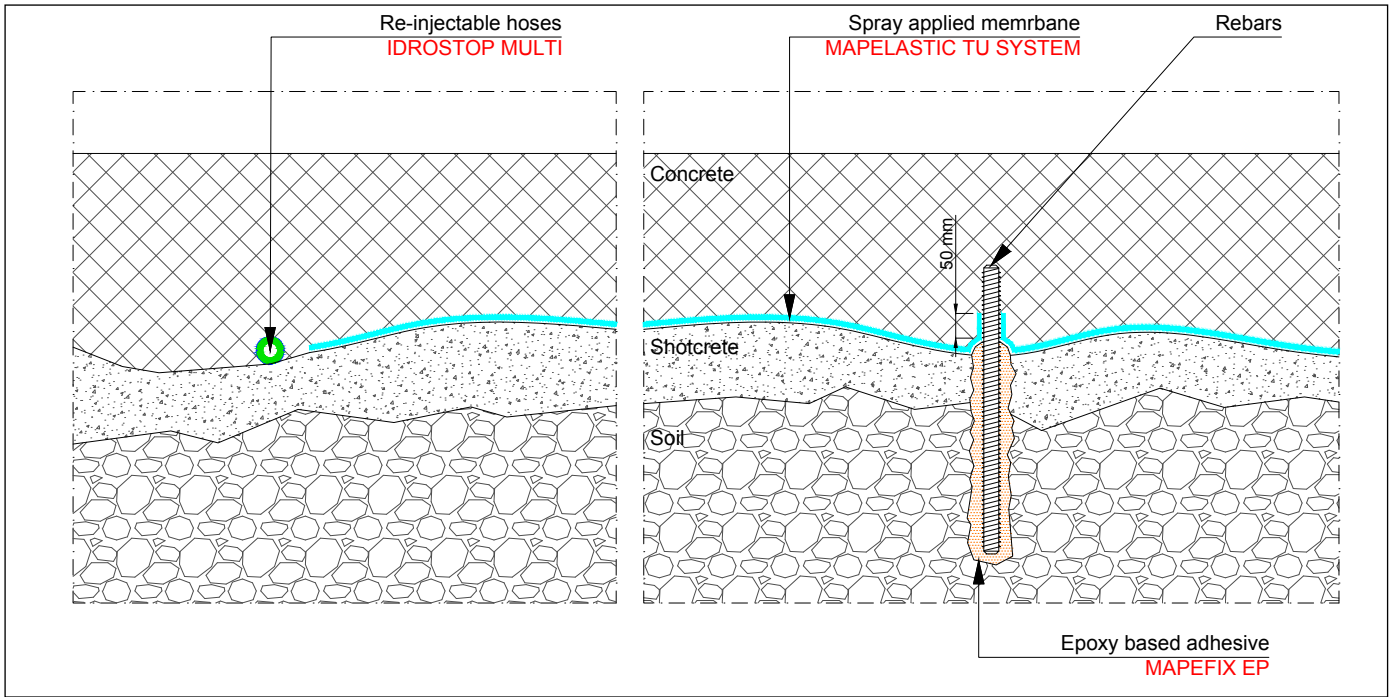


Example of re-bars installation

#### 4.4.2. MEMBRANE TERMINATION

Membrane termination shall be carried out just interrupting the continuous membrane layer. It is recommended to install IDROSTOP MULTI 11 backup system along the edge of the membrane termination.

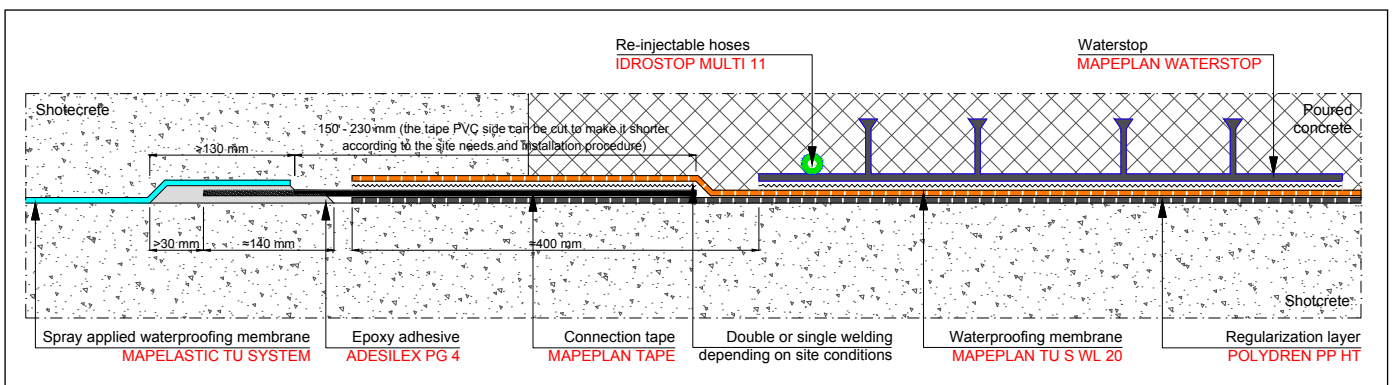




Membrane termination and fixing bar detail

#### 4.4.3. SHEET MEMBRANE TRANSITION

The transition between spray-applied waterproofing membrane and synthetic sheet membrane is possible. To achieve a watertight transition, a proper detail shall be adopted according to manufacturer recommendation.



Transition from MAPELASTIC TU SYSTEM and MAPEPLAN synthetic membrane



**TUNNEL MITHOLZ, LÖTSCHBERG BASIS TUNNEL** - Transition between MAPELASTIC TU SYSTEM spray applied membrane and MAPEPLAN synthetic waterproofing membrane

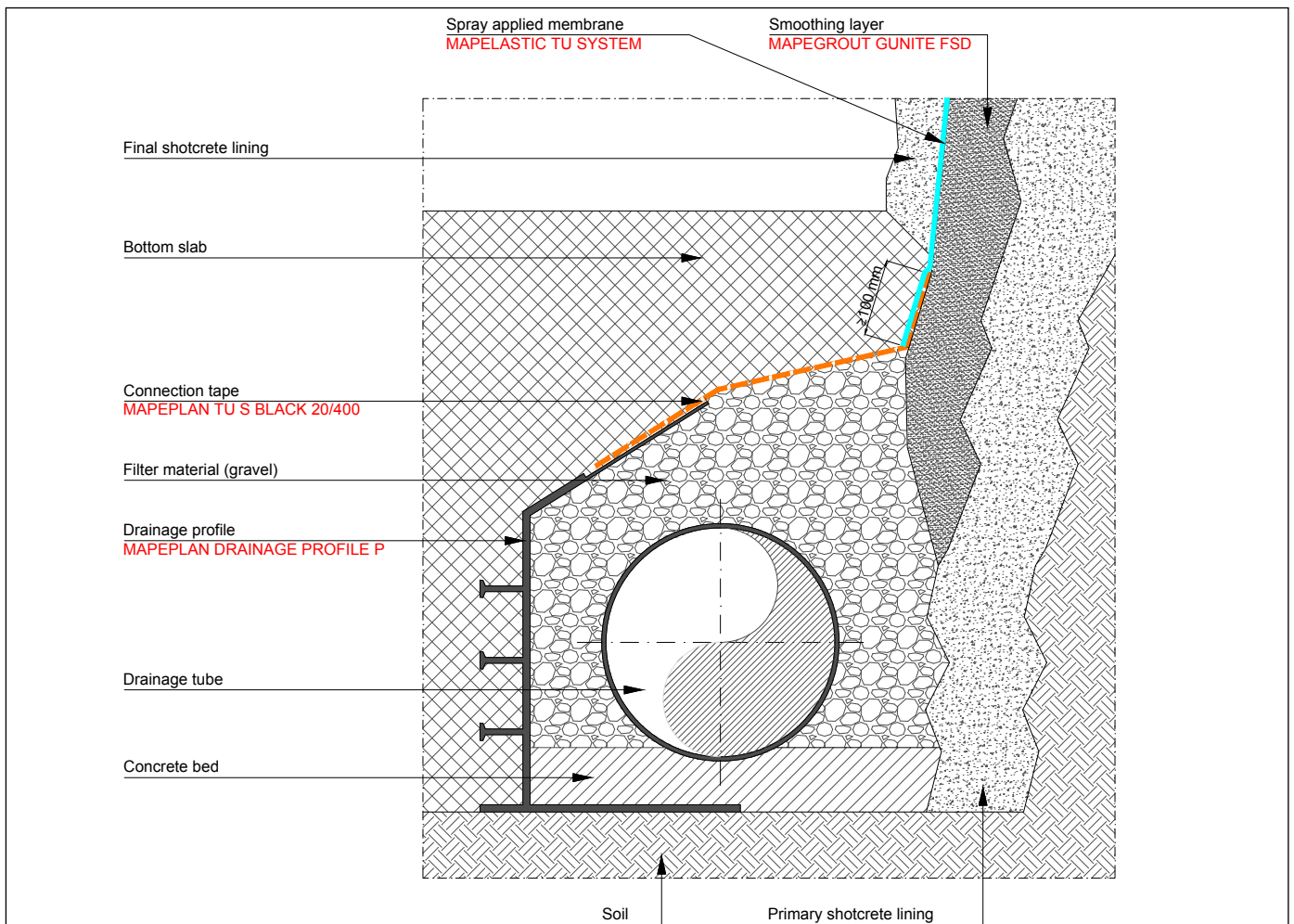


#### 4.4.4. DRAINAGE DETAIL

If a drained tunnel is waterproofed by using MAPELASTIC TU SYSTEM, a proper drainage system has to be designed and approved by the spray applied membrane supplier.

The drainage system shall consist of a prefabricated rigid profile able to:

- Separate the inverted arch/slab of the tunnel from the crown;
- Contain the drainage material and the drainage pipe;
- Properly overlapped with spray-applied membrane;
- Be easily and quickly installed.



Example of drainage system

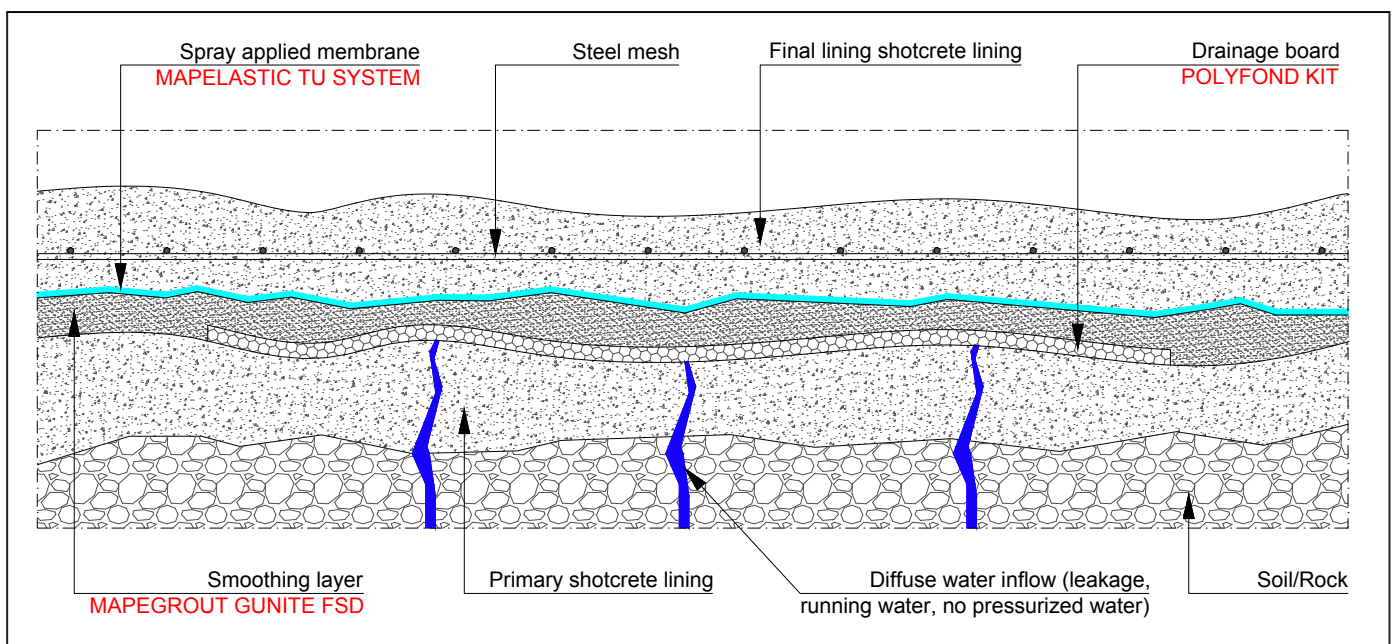
## 5. APPLICATION IN PRESENCE OF WATER

Spray applied membranes cannot be applied directly on running/dripping water. Any kind of water ingress shall be pre-sealed or managed by various systems prior to the application of the spray applied membrane and preferably before the application of the smoothing layer.

It is recommended to manage/treat the surface water before applying the smoothing layer to achieve a better quality of the smoothing layer. Allowing a constant and easy application of the membrane.

Any water inflow or surface running water, water leakage and damp areas shall be treated following the procedure below:

- Address the area that has to be treated.
- Adopt the following solution depending on the type of water ingress:
  - Concentrated and pressurized water inflow: injection of resins such as RESFOAM 1 KM HS and FOAMJET is recommended.

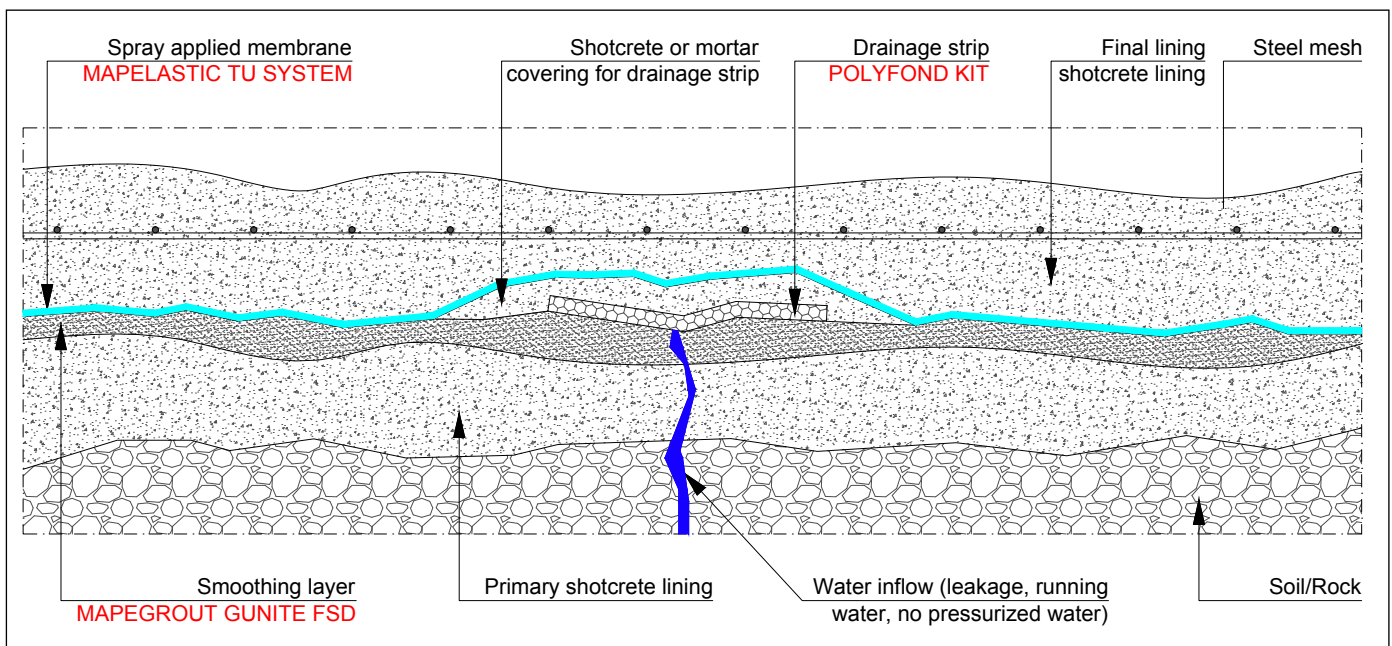


Diffuse water inflow solution - Drainage sheet

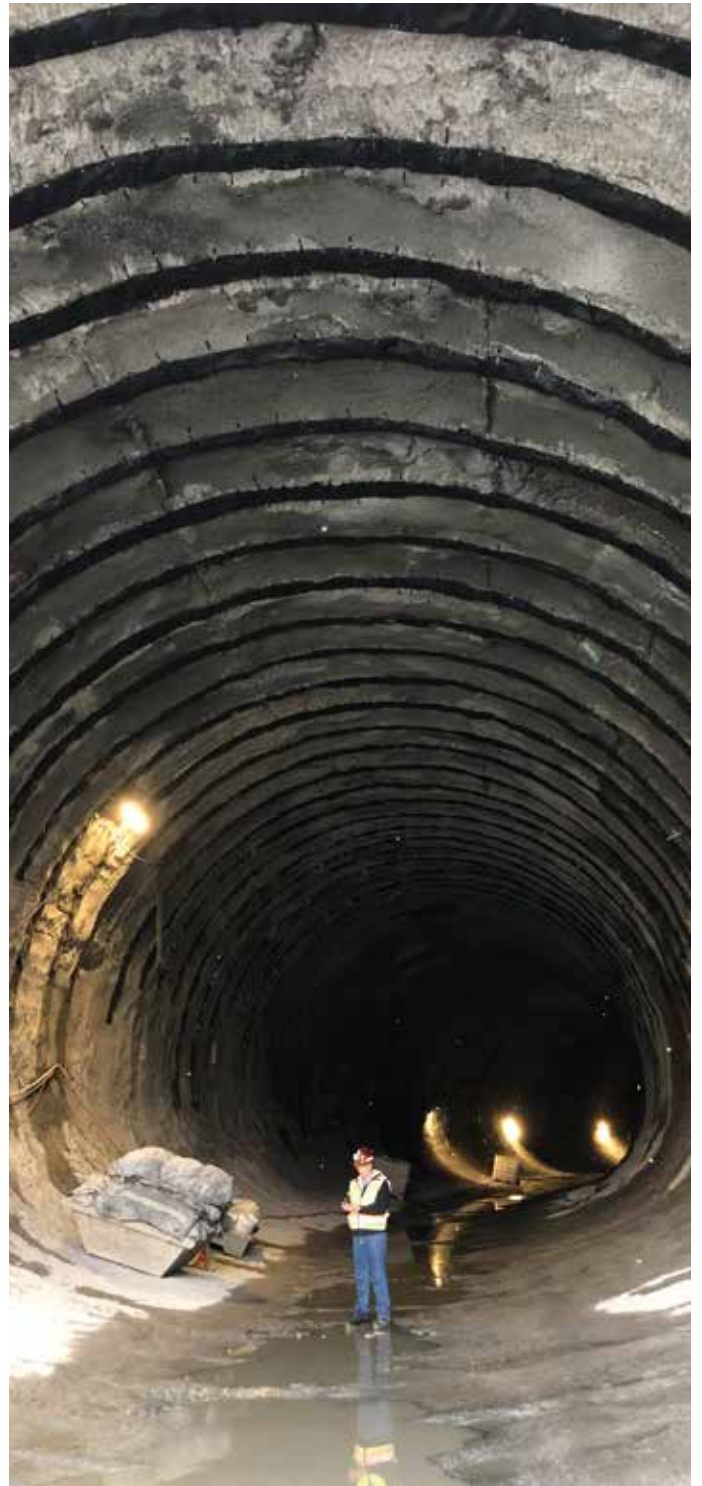
- Diffuse running water or water leakage: application of drainage sheet membrane (POLYFOND KIT or POLYFOND DRAIN PP) to collect the water from crown/wall to the bottom slab. The subsequent installation (over the drainage sheet) of the steel mesh is recommended to provide the right support where the smoothing layer should be sprayed.
- Concentrated running water or water leakage: application of drainage strip (POLYFOND KIT or POLYFOND DRAIN PP) to collect the water from crown/wall to the bottom slab.
- Diffuse damp area: application of ultrafast, reactive, dry shotcrete (MAPEGROUT GUNITE SHOTGUN).
- Concentrated damp area or soft dripping point: hand application of ultrafast binder (LAMPOSILEX).

If water is correctly treated before the application of the smoothing layer, the surface of the smoothing layer should be dry. If small leakages and/or damp areas occur over the smoothing layer, they can be treated by following point d. and e.

Strips drain and drainage board may also be applied on the smoothing layer in presence of running water or leakage, moreover they shall be covered with a cementitious layer.



Technical solution in case of concentrated running water - Drainage sheet



Example of drainage strips installation

## 6. QUALITY ASSURANCE

- Areas of the membrane which lack uniformity, exhibit lamination or cracking, lack adequate bonding, lack water tightness, or fail to meet the specified strength and toughness requirements shall be regarded as a defective membrane.
- Where an area is deemed defective, the section shall be removed, cleaned and re-sprayed with a minimum overlap of 100-200 mm from the boundaries of the defect. Damaged or tested areas shall be repaired.
- Where the membrane is sprayed in alternate ways, or there is an interruption in spraying of more than 6-8 hours, there shall be a minimum overlap of 100 mm with the existing membrane and the surface shall be cleaned prior to application.
- The membrane, once dried, has to be 'sandwiched', ideally soon after the Shore Hardness (A) of 25 is achieved. The actual timing depends on the temperature and humidity conditions within the tunnel. Even though the time required is long, it doesn't affect the product performances. Bond strength is guaranteed, but, in any case, it is important to make sure that the membrane is clean. To avoid surface membrane contamination (ex. powder) that can adversely affect the adhesion of the membrane to the final lining is recommended to install the final lining within 72 hours after the recommended Shore-A Hardness (25) is achieved.
- All tunneling works in proximity to the already applied membrane (or during its application) must not adversely affect the substrate (that should always comply with the manufacturer recommendation), the curing process of the membrane as well as the final cured membrane surface (settlements, dust or powder, etc.).
- Before the start of site works, a Site Trial should be carried out on an area of 40 m<sup>2</sup>. The area must meet the requirements and specifications of the project.
- Optimal conditions to spray MAPELASTIC TU SYSTEM are listed below. It is recommended to extend drying time in case the actual conditions considerably differ from those suggested.



- Humidity below 80%;
  - Temperature between +10°C and +35°C (under specific condition, the membrane can be applied at lower temperature, as long as the temperature is above +5°C. In such condition contact the UTT staff for technical support);
  - Good ventilation can significantly contribute to shorten the drying time.
- The staff in charge of the application of the membrane shall always pay attention to the proper coverage of the substrate (visual inspection) and shall conduct spot WFT measurement in a frequency established by the Test Production Plan (PTP) of the jobsite.



WFT evaluation

## 7. INVENTORY AND LOGISTIC PLANNING

To be checked depending on job site location and organization.

## 8. HEALTH & SAFETY STANDARDS

Background: the Manufacturer and Applicator recognizes the health of personnel, the safety of operations and environmental protection as the highest corporate priorities, and as a determinant key to sustainable development. The HSE management system is therefore integrated into the business as an essential element of management.

Employees of Applying agency shall:

- Know, understand, and comply with the Health, Safety and Environmental requirements as applicable to the work they perform.
- Report to their Supervisor any equipment malfunction that may affect the safe operation of the equipment.
- Advise their immediate Supervisor whenever unsure of the instructions for a task or when concerned about the safety status of any task.
- Participate in the training courses as scheduled.
- Collaborate with all accident/incident investigations as necessary.

Working at Site with MAPELASTIC TU Materials: anyone working at jobsite shall wear the project required safety equipment. A copy of the Safety Data Sheet (SDS) for any chemicals or other products being utilized for these works must be on-site and available for review. Any additional safety or protective equipment stipulated in the SDS must be worn and available.

To ensure the protection of the environment any protection measures as outlined in the SDS must be completed on-site to ensure materials do not damage the environment. Ensure materials are stored away from waterways and stormwater drainage systems. Also, ensure spill kits are maintained and readily accessible in the vicinity of spray membrane works at all times.



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UNDERGROUND  
TECHNOLOGY  
BY **MAPEI**

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