

WATER PROOFING CHALLENGES AND ISSUES

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Background

Watertightness of any hydraulic structure is naturally of the highest importance, however when considering a piece of structure and its long-term durability watertightness becomes even more vital in terms of improved constructability, longevity and serviceability.

The ongoing maintenance of a hydraulic structure, especially with relation to its waterproofing, must also be considered and must remain cost effective without needing to apply complex technical solution that can reduce the usability of the system.

MAPEI Group has nowadays more than 50 years of experience in synthetic membrane field and a large knowhow in the challenging world of hydraulic structure waterproofing and specifically canals waterproofing.

In order to provide the highest level of quality and service to its customers MAPEI develops and produces products on the following strong basis:

- Quality: MAPEI works in accordance to the most recent standard of quality and is certified in accordance to EN ISO 9001 and EN ISO 14001. MAPEI also redirect 5% of the total turnover in R&D.
- Environment respect: MAPEI certify environmental performances and impact of its membranes through their LCA (Life Cycle Assessment) providing the EPD (Environmental Product Declaration) certification in accordance to international recognized standard (ISO 14040 and ISO 14025).
- International specialization, experience and support: MAPEI provide a worldwide technical and commercial services that are able to support all the parties involved in the project along all the design and construction moments.

Canal waterproofing system

As indicated above, waterproofing new and existing water channels is an environmental and technical challenge. Several are factors which bring the need to recommend a system that can improve the channel watertightness:

- Increase of extreme weather phenomenon with higher risks for the structure to be damaged (heavy rain storms, winds, etc.).
- Longer and hotter dry seasons raise the need to better collect a store the water that must be carefully used for the expected purpose.
- Presence of vandalism which is almost impossible to be avoided if not limited by the construction system and materials.

MAPEI waterproofing system is trying to match all the need above. It is a simple but effective system and consists of the following stratigraphy and installation general procedure

1. Substrate (normally lean concrete or existing concrete)
2. Regularization geotextile layer (500 g/m²): POLYDREN PP HT 500

Regularization layer is laid directly onto the substrate and sheets are simply overlapped for approximately 10 cm.

3. 2,5 mm thick waterproofing PVC geomembrane (fleece backed with 500 g/m² geotextile): MAPEPLAN WT S 25/500

Sheets of waterproofing membranes are laid onto the regularization layer, overlapped and welded by using a double welding machine.

4. Prefabricated watertight M16 anchors installed by vinyl ester resin: MAPEPLAN ANCHORING + MAPEFIX VE SF

Prefabricated anchors are fixed through the membrane in the substrate by using the proper resin. This fixing point are used to install the final lining reinforcements and to structurally connect the substrate with the shotcrete final lining.

5. PP fiber reinforced permanent shotcrete lining: MAPEFIBRE IT 39 NV + MAPEPLAST SF + DYNAMON + MAPEQUICK AF

Technical advantages

Approaching the waterproofing of and new (or existing) canal with above system brings benefits not only in terms of structure longevity and integrity (materials characteristics), but also in terms of installation process.

System and installation advantages can be summarized below:

- Minimum substrate preparation.
- High production (application speed)
- The watertightness of the membrane can be tested (compressed air test on double welding seam between geomembrane sheets)
- Collaboration between the final shotcrete lining and the substrate due to the anchors.

The combined use of MAPEI products bring benefit on the whole system, however also the singles materials that made up the system own specific technical advantages and characteristics.

MAPEPLAN WT S 25/500 is a geomembrane with great mechanical performances and a life expectancy matching the structure requirements. Due to the collaboration between the fleece and the geotextile (bonded together) is possible at the same time to increase mechanical proprieties (tensile strength and puncturing resistance), protect the membrane during the final shotcrete lining installation phases and improve the adhesion between final lining and geomembrane. The specific PVC formulation improves the workability of the geomembrane, speeding up the waterproofing operation and making the material easy to install and weld.

PRODUCT	Mapeplan WTS 25/500
Product	Waterproofing membrane in PVC-P, without internal reinforcement, fleece

	backed with 500 gr/m ² polypropylene woven-non-woven.
Colour	Top layer: light grey Bottom layer: light grey
PROPERTIES - STANDARDS	
Thickness (geomembrane only) EN 1849-2	2,5 mm (±5%)
Mass per unit area (geomembrane only) EN 1849-2	3,25 Kg/m ² (-5/+10%)
Mass per unit area of geotextile EN ISO 9864	500 g/m ² (±10%)
Test performed on Geocomposite Sample Peak Value at Geotextile break: <ul style="list-style-type: none"> • Strength • Elongation Peak Value at Geotextile break: <ul style="list-style-type: none"> • Strength • Elongation EN ISO 527/4 (test speed 100 mm/minute)	 ≥ 31 kN/m ≥65% ≥ 23 kN/m ≥230%
Tear resistance (on nominal thickness of geomembrane) EN ISO 34 (specimen fig.2 speed 50 mm/min)	≥ 80 kN/m
Puncture resistance (CBR) EN ISO 12236 (kN)	≥ 4,5 kN
Low temperature flexibility EN 495/5	Not failure at -30°C
Dimensional stability (6 hours at 80°C) EN 1107/2	≤ 2,5%
Hydrostatic pressure resistance (72h at 10 bar) EN 1928 method B	Resistant
Thermal aging in water (maximum variation of weight after 56 days at 50°C, drying and reconditioning for 24 hours at 80°C) <ul style="list-style-type: none"> • General appearance • Dimensional stability, L&T • Variation of tensile strength, L&T • Variation of elongation at failure, L&T EN 14415 Method A	 No blister ≤ 2,5% ≤ ±20% ≤ ±20%
Weathering UV resistance (3000H – 350 MJ/m ²) EN 12224	No cracks

Table 1: Mapeplan WT S 25/500 main characteristics

MAPEPLAN ANCHORING is a prefabricated M16 threaded bar covered with a duty plastic case equipped with a PVC flange, weldable on the geomembrane. It allows to install fixing point (threaded bar) through the membrane without compromising the geomembrane watertightness. The product has been tested up to 7 bar of water pressure and a lot of pull off and shear test have been done in order to provide mechanical performances to designer and clients. The possibility to have a prefabricated unique piece helps to save time, speed up the installation process and keep constant the quality of the product; additionally the product offer a perfect protection against the corrosion effect of the threaded bar due to the plastic case.

Final shotcrete lining increases the longevity of the whole system offering a direct protection from possible mechanical damages coming from the surrounding environment, vandalism, etc.

Also is important to underline the benefits related to the use of the combined MAPEI products for the final shotcrete lining. The addition of silica fume enhances the properties of the concrete both at fresh state (pumpability, volumetric stability) and in the hardened state (higher impermeability and durability). The super-plasticizer allows to reduce the W/C ratio but keeping the right consistency necessary to pump the concrete to the nozzle. Keeping a low W/C ratio enhances the mechanical properties and the impermeability of the concrete. Structural polypropylene fibers enhance the ductility of the concrete and the ability to absorb deformation energy, increasing the durability of the structure. MAPEFIBRE IT39NV are able to resist the chemical attack from chemicals in the atmosphere and in the concrete itself. Shotcrete alkali-free accelerator enhances the properties of the hardened concrete if compared to sodium silicate-based accelerators (better strength development and an enhanced long-term durability).

Product	Quantity
CEM II A-LL 42,5R	450 kg/m ³
Silica fume (MAPEPLAST SF)	20 kg/m ³
Water (W/C ratio ≤ 0,45)	200 l
Graded aggregates 0-8 mm	1500-1700kg
Structural PP fibers (MAPEFIBRE IT 39 NV)	3 kg/m ³
Super plasticizer (DYNAMON)	0.6-1.5%
Alkali free accelerator (MAPEQUICK AF)	2-6% (on cement weight)

Table 2: typical shotcrete mix design

Conclusion

Approach of MAPEI system to canal waterproofing and refurbishment is to provide a complete product package (system). All the products of this system are designed and tested to work together to achieve the best results in terms of performances and structure longevity, being at the same time cost effective in a long-term view.

Some between the most prestigious and challenging hydraulics works has been successfully completed by MAPEI with this approach. New Panama Canal project is a great reference where MAPEI was proactive partner and supplier of 800 000 m² of geomembrane and additive for 5 500 000 m³ of concrete.



Figure 1: New Panama Canal (courtesy from Carpi)