Underground Construction
Project Profile - Waterproofing

MasterSeal® 345 sprayable membrane for undrained waterproofing of a 4 m diameter bored tunnel

Giswil Emergency Escape Tunnel, Switzerland

The Project

The 1960 m long Giswil road tunnel in Canton Obwalden in central Switzerland will provide a bypass for the town of Giswil. The project consists of a two-lane road tunnel and an emergency escape tunnel running parallel to the main tunnel. The main road tunnel is located in mica schist and excavated by drill-and-blast. The final structure consists of a double shell concrete lining with drained waterproofing by means of a PVC sheet membrane and a geotextile fleece for drainage.

The emergency escape tunnel was excavated by a 4 m diameter hard-rock TBM and supported by pattern rock bolting and sprayed concrete. A length of approximately 10 m in each end of the tunnel was excavated by drill-and-blast.

In the portal areas a cut-and-cover concrete tunnel was constructed.

The Challenge

The Engineer wished to achieve a waterproofing solution in the outermost parts of the escape tunnel in both ends which provided:

- No water ingress in the bored part of the tunnel
- A successful solution for waterproofing continuously from the bored tunnel, through the blasted part of the tunnel to the cut-and-cover concrete tunnel at the portal
- Compatibility between the waterproofing of the cut-and-cover concrete tunnel and the waterproofing of the rock tunnel.

For this reason the Engineer chose an undrained solution, with a waterproofing system that covered the entire profile, including the invert.
The Giswil road tunnel. Schematic cross-section with configuration of the main road tunnel (drained) and the emergency escape tunnel (undrained).

**The Solution**

BASF suggested the use of the sprayable waterproofing membrane Masterseal 345 for this purpose. The main advantages with this solution were:

- Due to the high bond strength to concrete, there would be no migration of water along the membrane/substrate interface, hence significantly reducing the risk of water seepage even by eventual damages or holes in the membrane.
- Feasibility of waterproofing of the invert
- Feasibility of waterproofing of the interfaces between bored tunnel and drill-and-blast excavated tunnel, as well as between drill-and-blast excavated tunnel and concrete cut-and-cover tunnel
- Compatibility with the PVC sheet membrane and Bikutop-system at the interfaces
- Injection rather than drainage for removal of water seepages due to the undrained solution

**Removal of the water seepages** around the tunnel profile which would otherwise cause problems with the bonding of the membrane to the substrate. This was done by means of one-component polyurethane injection (MasterRock MP 355 1K) and two-component acrylic injection (MasterRoc MP 308).

This operation was more extensive in this particular case due to the request from the Engineer for an undrained watertight structure.

**Application of a layer of sprayed concrete** to the substrate by wet mix with a 4 mm maximum grain size to provide a suitable substrate for cost effective spray membrane application.

**Temporary removal of the remaining water seepages** through the substrate by small scale acrylic injection (mainly sealing/filling of dripping bolt holes). These injection works were done successfully and with very limited effort using acrylic grout BASF MP 308.

Application; Working sequence

The undrained waterproofing solution in the entire tunnel profile imposed a careful planning for the sequence of the different parts of the application.

Temporary removal of water seepages before applying the sprayed concrete substrate
**Spraying of waterproofing membrane MasterSeal 345**, minimum thickness 3 mm. A BASF Piccola dry sprayed concrete machine was used. The modifications to suit spraying of membrane were a rotor with reduced height (90 mm) and trenchless output speed (air powered machine or electric powered with variator).

Frequent spot thickness controls with needle during spraying were done minimum every two to three minutes. The nozzleman was always kept updated as to the effective thickness which was sprayed. Average capacities of 70 – 80 m² per hour were achieved.

**Spraying of the unreinforced inner concrete layer, design thickness 10 cm.** The spraying of inner concrete took place 1 day after the application the membrane.

After the application of sprayed concrete in the walls and the crown, a thorough cleaning of the invert was necessary in order to facilitate spraying of membrane in the invert.

**Application of membrane in the invert by careful spraying.** An overlapping horizontal strip of membrane in the lower wall ensured a complete coverage of the tunnel perimeter. Finally the sprayed concrete could be applied in the invert.

Application of the inner concrete layer with wet-mix sprayed concrete. Note the horizontal stripe of membrane in the lower wall which is left uncovered. This ensured overlapping and a continuous membrane when applying the membrane in the invert.
Application of sprayable membrane in the invert to create a complete waterproofing of the entire tunnel profile

Results

Application of the inner concrete layer with wet-mix sprayed concrete. The unique features of the sprayed membrane system were clearly realised during the Giswil project. Its versatility in combining with other waterproofing systems and tunnel support linings were demonstrated. Furthermore, due to its bonding characteristic it offered the opportunity for economical permanent single shell sprayed concrete linings, and reduced the risk of uncontrolled water paths typically associated with sheet membrane systems.

Due to a few minor water seepage points in the invert during the application, a few repair injections were necessary. These were successfully rectified with BASF MP 308 low viscosity acrylic gel.

The information given here is true, represents our best knowledge and is based not only on laboratory work but also on field experience. However, because of numerous factors affecting results, we offer this information without guarantee and no patent liability is assumed.

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