



Flagon Tunnel Waterproofing System

Introduction

The Flagon Tunnel Waterproofing System has been used on numerous Underground and Metro projects both in the UK and around the World, including in the UK: The “cut & Cover” portals at the Hindhead Tunnel, SCL waterproofing at Tyne Tunnel, Shaft Pal 2 at Victoria Station for London Underground and the “Step-free-access” works at Green Park Station. Crossrail Projects: C300 Fisher Street Shaft, C305 Stepney Green Caverns, C310 Thames Tunnel Cross Passages, C360 Mile End Shaft, C360 Eleanor Street Shaft, C510 Whitechapel Station & Liverpool Street Station. LU – Victoria Station Upgrade, LU – Vauxhall Station Upgrade.

With regard to Deep Tube Tunnels and Shafts, the Flagon Tunnel Waterproofing System exceeds the level of water resistance required and achieves Grade 3 of BS8102.

Junctions between systems can be detailed at design stage in accordance with Soprema to ensure precautions are included to avoid leakage at junctions between new and existing waterproofing. The system incorporates protection geotextiles, waterproof membranes, waterstops, attachment rondels and a variety of accessories to ensure a watertight structure. We also have experience and methods of connecting with older systems and many variations of termination details to connect with the vast majority of new systems available.

The material components within the system meet the requirements the following BS and EN Standards: ISO 9001/CEN 29001, CE marked in accordance with EN13491, certificate no. 1085-CPD-0012, BS EN ISO 11925-2 : 2002 – Class E, EN 1849-2, EN 1849-2, EN ISO 527-3, EN ISO 527-3, EN 14150, EN 1928 (B), EN ISO 12236, DIN 16726-5.12, EN 12310/2, EN ISO 868, EN 495/5, CEN TS 14416, EN 14575

The system is designed to allow for long term ground movements and effects of ground water levels and seasonal variation. Waterbars can be included as part of the system to compartmentalise and injection pipes can be incorporated to further increase confidence and assist with long term maintenance by facilitating future repair possibilities.

Supporting element or substrate

This is the surface on which the layers of the waterproofing system will be placed. It should be as smooth as possible, free from debris and other irregularities that may puncture the waterproofing layers. In the case of natural tunnels, the substrate is usually made up of a gunite layer (sprayed concrete lining) sprayed on the excavation walls. In foundations or in man-made tunnels, the substrate is composed of a supporting foundation of lean concrete to the base and walls.

Definitions of System Elements

- Geotextile fleece - non-woven fleece fixed to the regulating layer.
- Fleece fixing disks - disks used to provide temporary anchorage of the membrane before the inner concrete lining is placed whilst preventing excessive stresses being applied to the membrane
- Sheet waterproofing membrane - polymeric waterproof sheet fixed over geotextile.
- Sheet membrane protection layer - reinforced sheet membrane designed to be attached to and completely cover the waterproofing sheet to protect it from damage during bar reinforcement installation and other construction activities potentially detrimental to the integrity of the sheet waterproofing membrane
- Water Barrier - Base seal waterstop welded to sheet waterproofing membrane, to prevent tracking of water along the interface with the sheet waterproofing membrane and the secondary lining.
- Re-injectable Grout Tubes - Grouting hoses made of synthetics equipped with a valve system, which excludes grout return flow from outside into the grouting hose. The grouting hose must allow multiple grouting passes
- Secondary lining - cast in-situ reinforced concrete lining, inside the waterproofing membrane.



MATERIALS

Geotextile Fleece – “Flagon Geotextile”

- Because membranes are sensitive to local mechanical damage, a geotextile layer must be installed between the substrate and the membrane, this to protect the membrane against puncturing. Another function of the geotextile is to create a sliding surface below the membrane to avoid tensions/stresses inside the membrane or to allow movement of the concrete structure caused by temperature, settlement, dynamic loads, etc. and therefore to avoid fine cracks inside the inner concrete shell. The geotextile protects the membrane during construction and operation of the tunnel. The geotextile is to be 100% polypropylene as these fibers provide superior protection from the chemical aggression caused in the curing process of the concrete. The geotextile should be laid in dry conditions with minimum 200mm overlap at the edges.



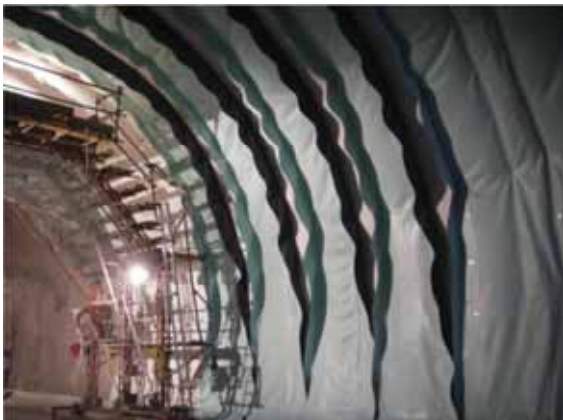
Fixing disks - "Flagon Rondels"

- The geotextile is fixed onto the substrate with PVC disks, a minimum 4 per m². The disks are secured through the geotextile and into the substrate with shot-fired nails. The disks are produced from the same compound as the waterproofing PVC membrane, so as to allow the welding of the membrane to the surface of the disks. The disks are specially designed to provide temporary anchorage of the membrane before the inner concrete ring is placed. At the same time preventing excessive stresses being applied to the membrane.
- The resistance to break of the nails and disks must be less than the resistance of the connection between the membrane to the disk so as to ensure that the membrane remains intact.
- The polymer disks are a minimum of 75mm in diameter and are capable of being secured through the geotextile and into the substrate with a single shot-fired nail and washer.



Sheet Waterproofing Membrane – "Flagon BSL 2.0mm"

- The sheet waterproof membrane shall consist of a continuous impermeable heat welded sheet of unreinforced soft polyvinyl chloride (PVC) manufactured by coextrusion.
- The sheet waterproofing membrane shall have a uniform thickness of 2.0mm and surface texture and shall be supplied in such dimensions that will result in the minimum of on-site seam welds.
- The sheet waterproofing membrane has a signal layer on the exposed surface of the waterproofing membrane, to give a visual indication of any mechanical damage.



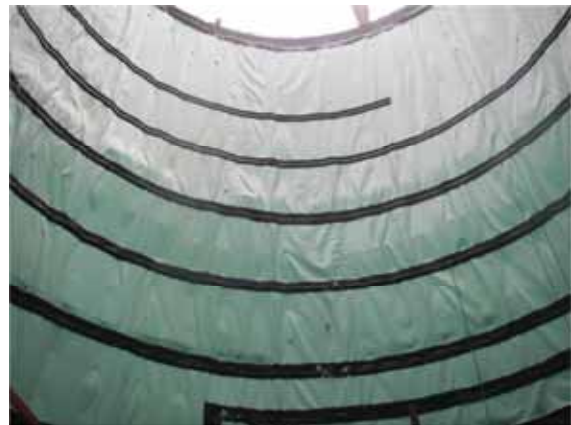
Sheet Membrane Protection Layer – “Flagon PZ”

- The unreinforced protection sheet membrane shall be installed against the waterproofing membrane where necessary.



Water Barriers – “Flagon Waterbar - W4”

- This enables the waterproofing project to be divided into sectors, allowing future repair operations to be carried out by injection of water-reactive resins. It is composed of shaped joints of the same type of material (PVC) and is easily welded to the waterproof liner.
- The waterstop prevents cross passage of water across the concrete joint from one compartment to the adjacent.



Injection Tube Systems – “Predimax 11 & 19”

- Injection tube systems shall be suitable for the grout adopted and be suitable for flushing and multiple re-injection.
- The injection tube system shall be complete and shall include tubes, junction boxes, pumps and all other items required for its installation and use.
- Coloured vent ends, junction boxes, anchor clips, closure plugs and all other accessories shall be as specified and supplied by the injection tube manufacturer.
- Injection tubes shall be a maximum of 10m long and be tough, flexible and chemically inert. Injection tubes shall be fixed such that there is intimate contact with the substrate along their full length. Injection tubes may be an integrated component of the waterbar.
- The internal diameter shall be sufficient to allow flow of proposed injection grout over the length of the tube.
- Terminal boxes shall be heavy duty plastic with water tight feed through connections and shall be a suitable size for housing and protection of the injection tube. Boxes shall be fitted with front covers mounted flush with the surrounding concrete surface and shall be securely fixed during concreting operations.
- Grout for injection tubes shall be compatible with the sheet waterproofing membrane and shall be low viscosity, suitable for re-injection, shall not clog the pipes and shall set to form a non-brittle compound.





INSTALLATION

Waterproofing System Installation General

- The sheet waterproofing membrane shall be installed only by the manufacturer or an applicator accepted by the Principal Contractor.

Substrate Preparation

- The substrate surface shall be prepared in accordance with the membrane manufacturer's instructions. All soil, debris, oils and grease shall be removed and any damaged or spalled surfaces, voids and cracks with depths greater than 25mm shall be repaired with regulating concrete.
- The substrate surface shall be free from protrusions or sharp edges and fibres which may lead to membrane puncture.
- Temporary fixings for construction purposes shall be removed and projecting portion of any support elements shall be cut off and patched so they are flush with the face of the regulating concrete.
- The profile of the substrate shall not have any irregularities that exceed a ratio of length to depth of 5:1 and the minimum radius shall be 200mm.
- The substrate shall be inspected and accepted by the waterproofing installer prior to commencement of installation of the waterproof membrane



Management of Water Ingress

- Where water ingress through the primary lining is such that it may affect the successful installation of the sheet waterproofing membrane, the Sub-Contractor shall use temporary water management techniques. This water management shall be maintained throughout the membrane placing process and secondary lining placing, and shall be so arranged that excess water pressure behind the membrane cannot develop.

Geotextile Fleece Layer

- The geotextile shall be fixed onto the substrate with a minimum of 4 fleece fixing disks per m². Sufficient fleece fixing disks shall be installed to ensure that when installed the fleece is in close contact with the substrate, the sheet waterproofing membrane is in close contact with the fleece and the system is securely supported.
- Joints shall be in accordance with the manufacturer's instructions and have a minimum overlap of 200mm.



Sheet Waterproof Membrane

- When placing the sheet waterproof membrane no other works shall be carried out in the vicinity which may cause personnel or equipment to adversely affect the installation process.
- The sheet waterproof membrane shall be welded to the fleece fixing disks installed with the geotextile.
- Joints between waterproof membrane sheets shall be welded using flat faced fillet double welds.



- The sheet membrane shall be compartmentalised on the inside face of the membrane. The dimensions of each compartment shall not exceed 15m horizontally or vertically.



Sheet Membrane Protection Layer

- Where required, the sheet membrane protection layer shall be attached to the sheet membrane according to manufacturer's recommendations. The method of attachment shall not be a system that involves puncturing the waterproofing membrane or affects the integrity of the sheet waterproofing membrane in any other way.



Water Barriers for compartmentalization

- Water barriers shall be installed on the inside surface of the membrane, to be cast into the secondary lining at the boundaries of each compartment.
- Water barriers are required at all construction joints of the secondary lining, and shall be placed centrally to such.
- At the time of placing water barriers, the Sub-Contractor shall ensure that the membrane surface is clean and free from ponded or running water
- Water barriers shall be installed so that they are securely held in their correct positions while the concrete is being placed. No holes shall be made through any water barrier except where provided for by the manufacturer.
- Concrete shall be fully compacted around the water barrier with no voids or porous areas.



Injection Tubes at Water Barriers

- Injection tubes shall be fixed in accordance with the manufacturer's instructions and shall be intimately fixed to the substrate to ensure a close fit. Before pouring of the secondary lining the injection tubes shall be tested by flushing with water. Individual injection tubes shall be overlapped by a minimum of 200mm.
- Injection points shall be located to avoid interference with rebar or embedded objects and permit easy future access and use.
- Injection shall only take place if water is leaking through the lining. Tubes shall be flushed with water after injection to enable re-injection at a later date, if required.





SUPERVISION AND TRAINING

Supervision of Sheet Waterproofing Works

- The Sub-Contractor shall have on site a dedicated waterproofing supervisor who shall have at least five years experience of, and training in, the installation of similar systems.

Training of Sheet Waterproofing Works Installers

- All waterproofing installers will have undergone installation training accepted by the manufacturer of the membrane and be experienced in the installation and testing of the waterproofing system.



A little on our History

The Soprema Group has been producing synthetic membranes for underground works since the mid 60's and has always been at the forefront of innovation. We are able to produce membranes for a vast number of different applications from single ply roofing membranes to underground construction projects and basements; from tunnel lining to drinking water reservoirs, canals and dams.

In the past 50 years Flagon membranes have been used for the most prestigious road and underground railway tunnels and also for the basements and foundations of some of the World's most celebrated buildings. Today we are one of the World's leading manufacturers of synthetic membranes for waterproofing major civil engineering works.

Our Underground waterproofing systems include tunnel waterproofing and basement structures. There are a wide range of solutions from the simple single layer system through to very technologically advanced systems for waterproofing below ground installations. The most advanced of these is the Vacuum System which is unique in enabling impermeability testing to be carried out not only during construction but also once completed. The Vacuum System also facilitates the localised repair of a damaged area without the need for costly excavation.

Recent projects include: the Shot Crete Lining sections at Tyne Tunnel; the sheet waterproofing for the Cut and Cover Sections of Hindhead Tunnel and the Step Free Access for Green Park Station and for Metro projects in St Petersburg, Sofia, Milan, Turin and Rome; for road and rail tunnels throughout the World and for some amazing foundation projects including the Burj Kahlifa and the International Airport in Dubai.

The Flagon membranes are manufactured in our Factories which have **UNI EN ISO 9001 and 140001** and the products fully comply with all relevant EU and DIN standards as well as having many other local accreditations.

Flagon Geomembranes (Sheet membranes)

FLAGON membranes have been designed, formulated and manufactured according to specific application needs.

Waterproofing with a geomembrane system provides major advantages:

- They can be laid in damp conditions
- Membranes bridge standard settlement and tension cracks in the substructure
- A suitable membrane can be selected from a wide range of off the shelf membranes with particular properties/characteristics such as Fire Retardants or Potable water.
- Geomembranes are chemical resistant; age resistant and possess high tear strength and elongation capacity
- If necessary, a suitable membrane can be tailored to exactly suit the particular requirements of the project

