A new system for water drainage in tunnels

Water leaks often create problems in tunnels, as they can result in icicles. To prevent this, water is drained from the tunnel roof and walls down to the ground, where it can be dealt with. Traditionally sheets of PE foam have been used, but they are difficult to fit and introduce large quantities of flammable material into the tunnel. A new drainage system, Rockdrain, has now been tested, both in the laboratory and in full scale in a railway tunnel. The project has been financed by the Swedish Transport Administration, and performed as a joint project by SP Fire Technology, CBI, IVL, Besab, Rockdrain and the Traffic Administration.

Rockdrain is a new system for drainage of inwardly leaking water in tunnels, based on a mesh of ducts secured to the roof and walls of the tunnel and then sprayed with a thin layer of conventional permeable shotcrete. The shotcrete is then covered by a special layer of sprayed concrete under the name of Solbruk, which is impermeable to water leakage and provides better thermal insulation than does conventional shotcrete. The addition of a small quantity of polypropylene fibres to the Solbruk produces a material that can withstand fire without spalling.

Full-scale tests in a railway tunnel
The system has been tested on full scale in a recently constructed 1.8 km long railway tunnel at Kattleberg, about 40 km north-east of Göteborg. The Rockdrain system has been constructed in the tunnel over a length of about 100 m where water leakage has been observed. The tunnel interior has been laser-scanned after each stage of application, i.e. first after the channel mesh was fitted, then after the spraying of conventional shotcrete, and finally between each spraying of Solbruk. These scans have made it possible to determine the thickness of each sprayed layer with very high accuracy. In addition to enabling the drainage performance of the system to be tested on full scale, the work has also revealed practical problems associated with application, such as insufficient thickness of Solbruk, which could then be rectified. In addition, energy input and the necessary working time for application have been measured to enable LCC/LCA analyses to be performed. The same measurements and comparisons have also been made for insulation of a conventional drainage system using foamed PE mats.

Laboratory tests
An extensive programme of testing has been carried out as part of the work of the project. CBI Betonginstitutet has investigated the mechanical properties of the various elements, their durability, the drainage performance and the tolerances required by the system for its application, i.e. the maximum distances that can be accepted between the mesh and the tunnel wall without the channels in the mesh being blocked by shotcrete. SP Fire Technology has tested the system’s fire resistance using the hydrocarbon curve (HC) test characteristic. The thermal conductivity and thermal diffusivity of Solbruk have also been determined.

The results show that the system works
The tests that have been performed show that, on the whole, Rockdrain works well for dealing with drainage in tunnels. Special measures may need to be taken to provide protection for certain functions such as frost resistance and fire resistance. Spalling of the material can be avoided by wet-spraying of Solbruk with an admixture of 0.5 kg/m³ polypropylene fibres. The tests show that the mesh must be mounted not more than 10 mm from the surface of the rock in order to prevent it from being clogged by shotcrete. The LCA/LCC analysis clearly shows that Rockdrain has definitely less environmental impact, and is cheaper, than the traditional method of drainage. A further important lesson from the project is that good training of operators, thorough knowledge of the system and proper inspection are required in order to ensure that the system is correctly applied.