

# Tunnelling Journal

The international journal for the tunnelling industry



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# DRAINING AWAY

**A new drainage system, under development and trial for a decade, is now ready to be launched on the world. We take a peek at this novel solution.**



Rockdrain being installed on the concrete lining

**SWEDISH ENGINEERS** have invented a new drainage system for hard rock and other self-supporting tunnels, which they say is safer, slimmer and lasts longer than traditional systems.

RockDrain is the brainchild of civil engineer Lars Jönsson, who began developing the concept back in 2007. Since then there have been a number of full-scale trials in Sweden and Finland, the latest of which was the rehabilitation of the Lundby road tunnel in Gothenburg, Sweden.

The 2km-long Lundby Tunnel was constructed by drill-and-blast in 1998. Extensive grouting of the granite before and after blasting aimed to limit water ingress, but over the years the amount of water leaking into the tunnel has increased causing a hazard in the

winter due to ice.

RockDrain was installed on a 100 sq m area of the tunnel, simulating a small-scale repair situation. One-and-a-half years after its installation in November 2014, the Swedish Transport Administration carried out checks on the RockDrain, awarding it a Class 0 rating.

"Class 0 is the best you can get, it indicates that no maintenance will be needed for at least 10 years," explains Morten Nesheim, CEO of Timer Solutions which signed an agreement to market and sell RockDrain around the world in 2013, as well as taking a stake in the business.

RockDrain uses a mesh of plastic half-pipes to form drainage channels within layers of



## INNOVATIVE TUNNEL ENGINEERING

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shotcrete. First a layer of shotcrete, around 30mm thick, is applied to the rock face; then the mesh is fastened on with Hilti nails, with the open side of half-pipe facing the walls, followed by a second 25mm shotcrete layer.

Finally, where frost is likely, a 60mm layer of specialist insulating shotcrete, Solbruk T-ISO, is applied or where there is no chance of frost a shotcrete with a waterproofing agent Solbruk ADD can be used. Where fire protection is required 0.5kg of polypropylene fibres for every cubic metre of shotcrete are added.

The RockDrain system was designed with both existing and new-build tunnels in mind. Traditionally, rock tunnels have been treated for water by extensive pre-grouting and post-grouting, however more recently drainage systems, suspended from ceilings and walls have been used.

In Sweden polyethylene foam sheets, around 50mm thick, are attached to the tunnel walls with bolts, leaving an air gap between wall and sheet, then covered with a layer of reinforced shotcrete between 60 and 80mm thick. In Norway a similar system is sometimes used, or alternatively a light concrete segment structure with sheet membrane or a combination of the two.

Sprayed waterproofing membranes, sandwiched between layers of sprayed concrete, are another relatively new solution for hard rock tunnels in some parts of Scandinavia. However, research into their longevity related to how the water moves through the membranes is ongoing and there have been some reported cases of debonding.

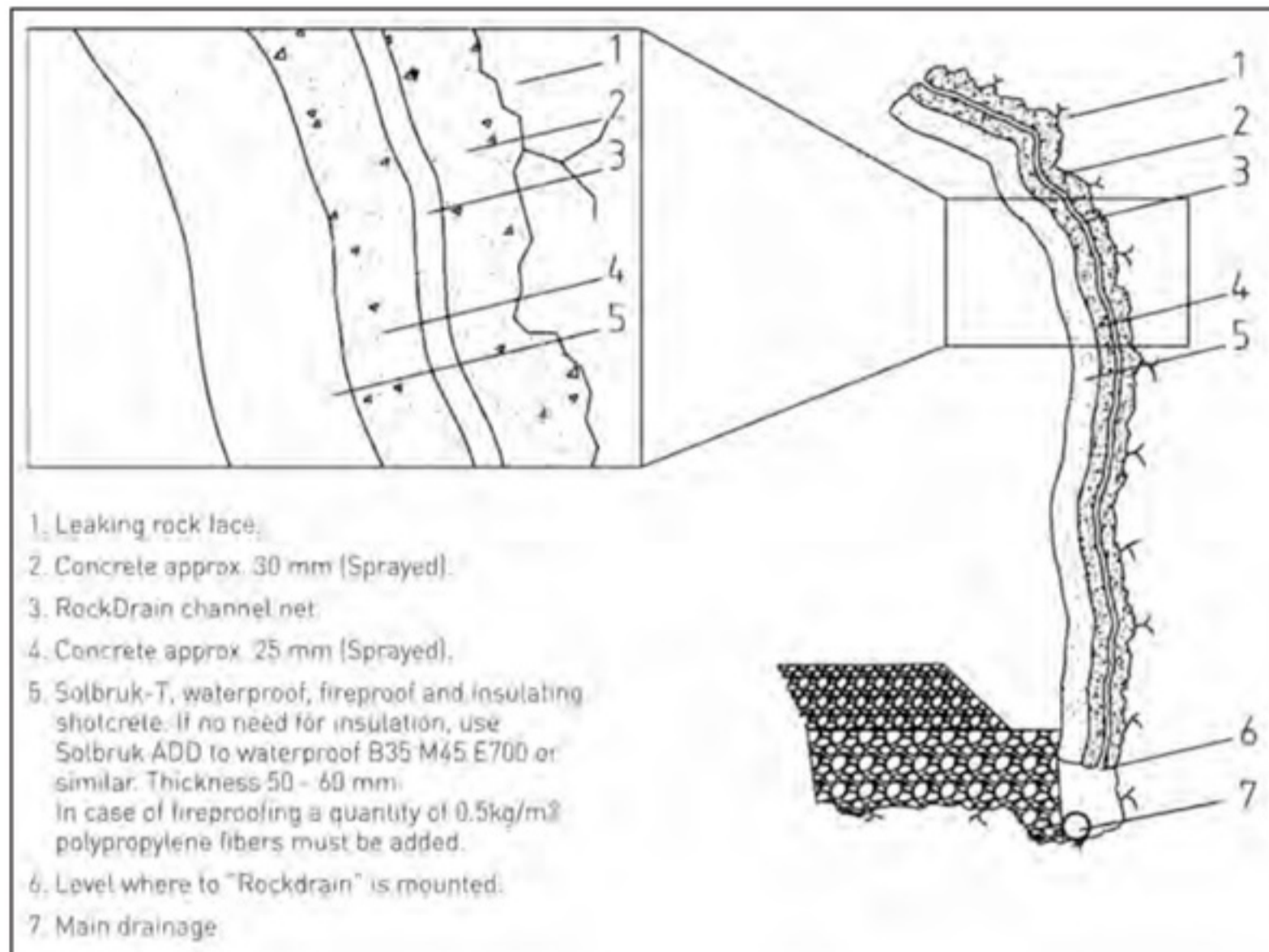
"The membrane may be compared with glue between the shotcrete layers," says Nesheim. "In my opinion it is not a question of if the membrane loses the binding power with

possible dangerous results, but when it will lose it."

Polyethylene foam is highly flammable, so that if the shotcrete coating on a conventional waterproofing

**Trials**

Prior to the Lundby Tunnel, RockDrain had been put through its paces in full-scale trials on the Länsimetro in Finland, and the Hallandsas tunnel and Kattleberg



**Above: Schematic illustrating the installation and layering of a typical Rockdrain waterproofing system**

**Left: System installation is simple and non labour intensive, here using a Hilti GX 120-ME**

system is damaged, there is a risk of fire. Repairs are also costly and can take a long time.

"We have seen accidents in Norwegian tunnels where the wall has caught fire and then the whole tunnel can burn," says Nesheim. "The RockDrain system is very safe and very easy to repair. Repair can be done within a few days, not months, when there is an accident."

The other challenge for traditional systems is that routine inspections or investigations when there are leaks are time-consuming and tricky, because one needs to look behind the shell.

For high-speed rail tunnels, a waterproofing system must cope with the suction forces imposed as the trains pass, causing movement in the bolts and eventually fatigue. RockDrain does not suffer due to these forces, according to its inventors, as it is a monolithic system.

rail tunnel in Sweden. The early trials revealed a few practical points related to its installation.

Researchers observed that the first layer of shotcrete must be reasonably smooth, within normal standards. If the flexible drain net is installed more than 10mm from the first layer of shotcrete, concrete from the next layer of shotcrete can run into the half pipes and block them. This is not a problem, says Nesheim, because the water will always find the easiest way in the drain system.

One of the early trials also experienced issues with the application of the Solbruk T special insulating and waterproofing layer. There were variations in strength and problems with de-bonding which Nesheim explains were due to poor installation: "Laser scanning before and after showed that less than 10mm was applied instead of the required 60mm.

"Our approach is to always be present to educate, control and follow up all projects under progress," says Nesheim. "That wasn't possible with one of the early projects."

Solbruk T can be applied using either the wet or dry shotcrete method, according to Nesheim: "For the dry method there is no special instruction. For the wet method, mix according to instructions and use a screw-pump instead of piston-pump. The 6cm screeds can be done in one layer."

On the most recent trial on the Lundby Tunnel, problems with the Solbruk T were not experienced by the contractor BESAB which used the dry spray method.

Research projects related to these trials by IVL, the Swedish Environmental Research Institute (reports referenced below) also looked at life cycle assessment (LCA) and life cycle cost (LCC) for RockDrain. Led by the IVL's Håkan Stripplé, the research concluded that RockDrain cost 55 percent less than conventional drainage over a 60 year period and used 43 percent less energy.

Timer Solutions is now talking to a number of projects around the world about possible RockDrain applications. "Over the last year we have been asked to quote on projects worth around £40million, in Europe and in Asia," says Nesheim.

"We are targeting projects world-wide: everywhere where tunnels or other underground constructions are being built and water has to be taken care of in the best and most long-lasting way."

**REFERENCES**

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