Sika at work
The Hallandsås ridge railway, Sweden
Waterproofing in varying geology and high groundwater pressure

More information:

Sika Sverige AB, a part of the global group Sika AG, is a leading supplier of specialty chemical products. Sika provides solutions, systems and products to the construction, building and manufacturing industries and is a leading supplier of materials that are used for sealing, bonding, damping, reinforcing and protecting.

Sika’s product range consists of high quality concrete admixtures, mortars, sealing & bonding, damping and reinforcing materials, structural strengthening systems, industrial flooring as well as roofing and waterproofing systems.

Our most current General Sales Conditions shall apply.
Please consult the Data Sheet prior to any use and processing.

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Building Trust
Rock grouting
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Segments
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Shotcrete
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Waterproofing
- Sikaplan® WT 2200-32HL2
- Sikaplan® WT Protection sheet-25HE
- Sikaplan® Felt PP 1000-1 BZ
- Sikaplan® W Tundrain Type A
- All kinds of membrane accessories
- Sika® Waterbar WT AF-500/34 MP
- Sikaplan® WT Tape 20D
- Sikadur®-31 CF Normal
- SikaSwell® products
- X-Plug (mechanical plug)

Shoring
- Sika® injektering 30 (injection cement)
- Sika® iFlow-1 (dispersing admixture)
- Sika® Acr-1 (accelerator)
- Sika®- SN40
- Sika® Intraplast-A
- SikaFuko® VF-1, VF-2 and Eco-1
- Sikadur®-52
- Sika® Injection-201 CE
- Sika Injection-306
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The tunnel is designed for a technical life time of 120 years, which put high requirements on the tunnel construction. Sika has continuously been involved in technical discussions about waterproofing, injection, shotcrete, concrete, etc.

**Waterproofing - membrane**

Since the ridge has a high groundwater level the construction of the waterproofing is made with “watertight full-around seal” or holding the head of water. This means that the construction has no influence on the water table. The TPO membrane (FPO, Flexible Polyolefin) system is installed on an inner-lining or on shotcrete with a surface evenness of 10:1 to provide adequate support. The system consists of geotextile fixed with discs which the membrane is welded to and divided into compartments to limit occurring leakages. The size of the compartments (in square meter) depends on construction type and they are created with watertops with integrated injection channels. In some parts protection sheet is installed as well to create a compartment and protection of the membrane. The system has been used in tunnel sections where there are no segments installed and with water leakages higher than the requirements.

**Waterproofing - connection between segments and membrane in cross tunnels**

Connection between membrane and segment has always been a challenge with flange construction in order to create a waterproofed connection. After investigation of reports, tests on-site and references the Sika joint tape sealing system was used to have a waterproofed system in the cross tunnels.

In the cross tunnels the joint tape (FPO, Flexible Polyolefin) was glued by epoxy adhesive directly on the backside of the segment. Afterwards, the waterproofing membrane was welded to the joint tape to create a waterproofed system. The joint tape has also been used to create compartments on the wet side of the cross tunnels. The system has been supplemented with swelling profiles/paste, injection hoses and by grouting to secure the waterproofing system.

**The Hallandsås Tunnel**

The 8.7 km long Hallandsås tunnel is the core piece of the west-link railway in Sweden. Due to the varying geology and high groundwater pressure the construction of the tunnel is complicated. The tunnel is scheduled to open for traffic in 2015.

**Why build a tunnel?**

The current railway line over the Hallandsås ridge comprises a single-line track that was completed in 1885. Due to its climbs and tight bends, the section over the ridge has always been a problem. Hallandsås restricts capacity and creates delays along the entire west coast of Sweden.

In the 1980s, when the Swedish government decided to expand and regenerate the Swedish railway network, the suggestion was also put forward for a tunnel to solve the problem of low traffic capacity on the stretch of track beyond Hallandsås. In 1991, the Swedish government decided to construct an 8.7 km long tunnel between Båstad and Förslöv.

A tunnel through the Hallandsås ridge increases capacity from the current rate of 4 trains per hour to 24, and the goods trains weight capacity will be double.

**History**

The construction of the tunnel suffered many serious setbacks in the period from 1992 to 1997. The first TBM (tunnel boring machine) used was not suitable to the demanding conditions in the ridge and switch was made to traditional drill and blast techniques. This time there were problems with water flowing into the tunnel which caused wells to run dry and the project’s environmental permit to be exceeded.

A chemical sealant was then used to make the tunnel water-tight. When it became apparent that toxic acrylamide leaked to the surrounding environment the work was stopped. The tunnel was then sealed and decontaminated and the ridge was given a clean bill of health. Completion of the project required, among other things, a resolution by the Swedish government and parliament, a construction permit and a new environmental permit. This was completed in 2004.
In the 19 cross tunnels connecting the two parallel single-line tunnels excavation is made in event of any stoppages or accidents in the railway tunnels. The cross tunnels are constructed with a distance of 500 meters and they have fire doors at both entrances which convert them into fire cells. The approx. 22 meter long cross tunnels are constructed using traditional drill and blast method from the east tube. These are carried out at the same time as the west tunnel is being constructed.

Waterproofing with membrane in insitu tunnels.

The major parts of the tunnels are segment lined tunnel (approx. 65%) drilled by TBM meanwhile the rest is done by traditional drilling, blasting and shotcrete application. However, since there is a high water inflow in some sections in the non-segment lining these sections have been concrete lined insitu with a membrane for waterproofing of the construction. The installed membrane is divided in compartments by waterstops and with injection devices.

The tunnel runs through varying geology and high groundwater pressure. The water pressure is 15 bars in some parts of the tunnel which means 150 m of groundwater above.

Environment and control

Executing a major infrastructure project without affecting the environment is impossible. However, the goal is to minimize the impact. The Hallandsås project has learned from earlier incidents during the tunnel construction and environmental initiatives are now a central part of the construction work. Several internal and external control systems are in place to look after the water, chemicals and ecology.
The tunnel construction - year by year
1885 - Railway over the Hallandsås ridge is inaugurated
1975 - SJ (Swedish railway) conducts the first tunnel investigation
1991 - The Swedish Parliament approves the construction of the tunnel.
1992 - Contractor Krafthyttan is selected as the contractor for the project.
1993 - The TBM Hallborr becomes stuck. Krafthyttan changed to more traditional method of drilling and blasting.
1995 - Contractor Krafthyttan is withdrawn from the project.
1996 - Skanska takes over as the new contractor.
1997 - The regulation of the Water Act was exceeded. Acrylamide (Rhoca Gil) is used to seal the tunnels. High levels of acrylamide are registered in seepage water. The leakage triggers a crisis in the immediate surroundings of the tunnels.
1999 - The government decides that Banverket (the Swedish Railway Authority, today Trafikverket, the Swedish Transport Administration) will investigate whether work on the tunnel is to be continued.
2001 - The Skanska-Vinci consortium is selected as the general contractor for the continued construction work on the tunnel.
2005 - Preparation of the TBM Åsa is initiated in the autumn.
2008 - The TBM Åsa breaks through the midway point in the east tunnel.
2010 - The TBM Åsa makes its breakthrough in the eastern tunnel.
2011 - The work on the 19 cross tunnels is started. The cross tunnels are linking the two tunnel tubes at approximately every 500 meter and act as escape routes among other things. The segment factory in Astorp is closing after having been producing more than 40 000 segments.
2013 - The TBM Åsa makes break through in the western tunnel 4 sep 2013.
2014 - The Skanska-Vinci contract will be completed, followed by the track installation.
2015 - The first train will pass through the Hallandsås Tunnel.

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**REQUIREMENTS AND SIKA SOLUTIONS**

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**PROJECT DESCRIPTION**

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Grouting and Injection
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Shotcrete
- Sigunit®-TBM

Concrete segments
- Sikament® 20 HE Åstorp
- Sikament® EVO 26
- Sikament®-5

Mortars and other products
- Sika FastFix®-4
- SikaQuick®-506 FG
- Sika®MonoTop®-910
- Antisol-E
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- Sika® AnchorFix-1
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