wassara

STRAIGHT FORWARD DRILLING

WATER-POWERED DRILLING FOR SECURING AN IMMERSED TRAIN TUNNEL IN STOCKHOLM

The City Line railway project builds a six km long commuter train tunnel under the central parts of Stockholm, Sweden. The tunnel will be built in bedrock. At one part it will be immersed.

The water-powered drilling technology was chosen as it is the faster alternative and gives a borehole surface that is optimal for the following grout process. It is also able to meet all environmental and accuracy demands.

A complex construction project

Plans for the City Line railway project in Stockholm, Sweden, has been developing since 1980. The Swedish Transport Administration, Trafikverket, kicked off the project in 2006 with environmental friendliness as a top priority. A six km long commuter tunnel will go under the central parts of Stockholm. When the project is completed in 2017, the track capacity in Stockholm will be doubled.

The tunnel

Most of the tracks will be located in Stockholm's bedrock, ideal for tunnel constructions. At one particular place, the underwater bedrock is too far below ground level to allow the tunnel to go through bedrock. The 330 meter stretch requires a very advanced tunnel construction method, comprising a concrete tunnel to be immersed.

The anchoring

The Southern end of the tunnel connects to Söder Mälarstrand and will be secured to the rock by a total of 69 anchors, each containing 19 strands, Ø 16 mm wide. 44 rock anchors are located in longitudinal direction of the tunnel and distributed conical around the cross section. These rock anchors overlap in the concrete structure with post-tensioning tendons that continues through all three immersed tunnel elements. The other 25 anchors are installed perpendicular to the tunnel axis to transfer high transverse forces into the rock in accidental load case of ship impact. Each anchor cable will be tensioned to about 300 tons, whereas the maximum allowed anchor load is around 400 tons.

In the Northern end, the tunnel will be able to vary a little in length as the water temperature shifts between winter and summer. A giant rubber gasket will keep it sealed.

Drilling for the anchors

Several factors made the drilling for the anchoring cables particular. The number of holes and the angle of each hole has been calculated to give optimal strength to the installation. Allowed borehole deviation was only 2%. On top of this, the drilling technology needed to be as environmental friendly as possible. The drilling was performed in three steps:

1. The first eight meters of each borehole was drilled with rotary drilling and a bit size of Ø 116 mm.
2. The water-powered DTH drilling then continued with a bit size of Ø 115 mm for the remains of the hole length. After this, the hole was grouted to seal off any water leakage.
3. Finally, the borehole was reamed with water-powered drilling and a Ø 165 mm reaming bit.

The water-powered drilling gave both high accuracy, high penetration speed and optimal borehole surface.

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CASE STUDY

WATER-POWERED DRILLING FOR SECURING AN IMMERSED TRAIN TUNNEL IN STOCKHOLM

Why water-powered drilling?

Wassaras water-powered DTH drilling technology is well-proven and well-known of its capabilities to meet environmental and accuracy demands. The measured borehole deviation was kept at 1.28% and below, well within limits. The drilling project was completed in good time. The water-powered drilling technology also gives optimal borehole surface. Core drilling would, if used alone, give a borehole surface too smooth for the following anchoring of the cables.

A pleased contractor

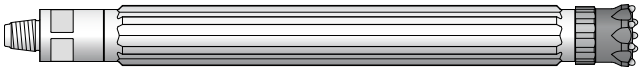
Johannes Glückert is Technical Manager at the contractor Züblin Spezialtiefbau.

- "The drilling with Wassara was straight forward. We were able to keep the time schedule and had no problem with meeting the accuracy demand. The borehole surface was optimal for the following anchoring process."

Project time for the drilling

January – February 2010

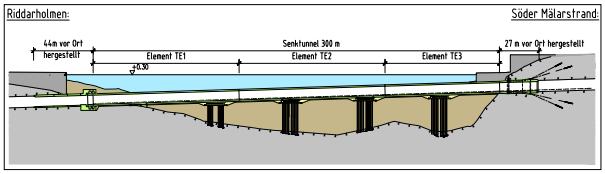
The W100 hammer



The W150 hammer

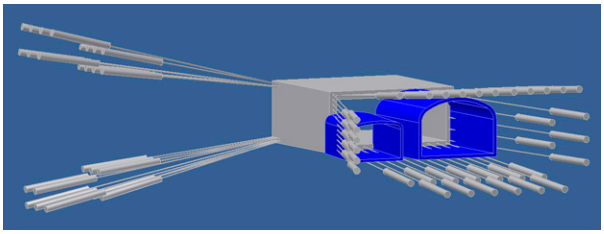
Equipment used	
DTH hammer	Wassara W100 for the pilot holes
	Wassara W150 for the reaming
Drill bits	Ø 115 mm (for W100)
	Ø 165 mm (for W150)
Rigs	Casagrande M9
Pump	Electric pump
Drilling fluid	Clean water
Drill pipe	88.9 - 121 mm
Borehole length	20 - 42 meters
Scope of drilling	1960 meters
Geologic formation	Gneiss and pegmatite

July 2014



Side view of the 330 m tunnel with the anchoring to the far right
(Illustration courtesy of Züblin Spezialtiefbau)

Aligning the drill rig for the next rock anchoring hole
(Photo by Hans Ekestang)



Axonometric view of conical and transverse rock anchors
(Illustration courtesy of Züblin Spezialtiefbau)

The joint between tunnel element 2 and 3 before being filled with concrete. The horizontal cable packages are clearly visible.