SmartMeasures

Tough projects call for smart measures.

AmbergSeismics

Norwegian Public Roads Administration
Coastal highway route E39
Rogfast tunnel project, Norway

Project

- Coastal highway route E39 - Rogfast tunnel project
- Access and maintenance tunnel E- 13 Arsvågen side tunnel.
- 26.7 km total project length
- The longest NATM undersea highway tunnel in the world

Contractor

- Contractor: NCC AS
- TSP Survey: Statens Vegvesen (project owner)

Duration

- 2018 - 2019; resumption expected in 2020

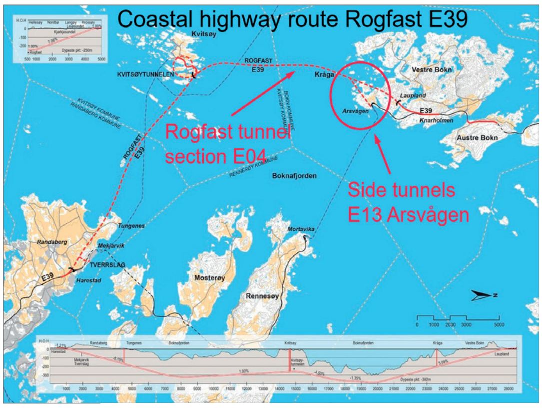
Task

- Detection of formation structures, shear zones, weak rock zones, water bearing areas.
- Reduction of the geological uncertainty to a minimum due to complex situations at some tunnel sections

The world's deepest and longest road tunnel in construction – subsea comes to that!

As part of the planned new coastal highway route E39 between Stavanger and Trondheim, the Rogfast subsea tunnel underpasses on its length of 26.7 km the Boknafjord from Harestad in Randberg to Laupland on Veste Bokn, passing the island Kvitsoy. The road tunnel with two tubes will be the deepest and longest undersea tunnel in the world.

Preliminary geological and geophysical investigations have shown that the Rogfast tunnel runs through an area of complicated geology with several thrust nappes and faults as well as many different types of rock. Along the section E04 between Kvitsøy and Bokn, distribution of the rock types is very uncertain.



TSP measurements have been done since the beginning of the excavation of the side tunnels E13-Arsvågen (L=1,980 m), predicting the geological conditions to obtain maximum structural information in addition to the "Measuring While Drilling" (MWD) method.

During the excavation, mainly gneiss alternating with phyllite was present and a shear zone near the intersection of E13 with the main tunnel section E04 was expected.

AMBERG TECHNOLOGIES

«The TSP 303 Plus system is a practical, cost-efficient and reliable prediction tool. By using it, we were able to detect several unfavourable rock conditions and water-bearing formations 150 m ahead of the working face. That led to cost-saving by optimizing the excavation rates and increased the safety of the working conditions. In addition, by implementing the TSP system during the excavation of the main tunnels, we are looking forward to reducing the amount of core drilling, thus cutting down on excavation costs.»

Ahmed Al-Samarray (right) and Erik Jensen (left), Engineering Geologists at the Norwegian Public Roads Administration

Challenges

- Excavation through high uncertainty of the rock type distribution and the risk of large water inflow at high pressure.

Products Used

- One Amberg TSP 303 Plus System
- 12 TSP campaigns performed so far

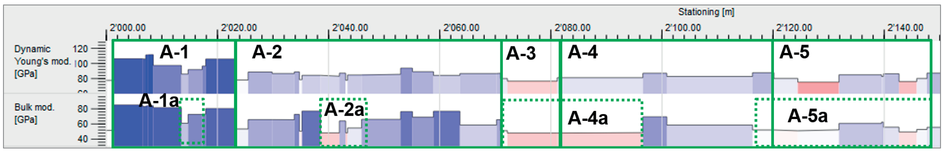
Forecast of shear and weak rock zones

Within the prediction range of 150 m, the TSP measurement identifies the following zones with changes in rock stiffness (RS) and rock compressibility (RC). The first based on the dynamic Young's modulus and the second by means of the reciprocal value of the bulk modulus:

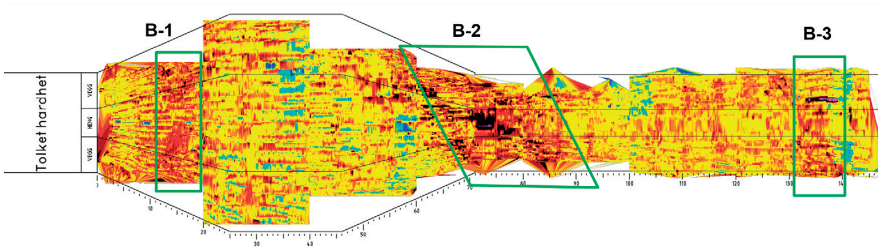
A-1 (2,000-2,024): High RS and low RC with local drop of RS at ST 2013-2018
A-2 (2,024-2,071): Moderate RS with a 8 m wide center zone of higher RC
A-3 (2,071-2,082): Shear zone with lower RS and higher RC
A-4 (2,082-2,120): Moderate RS with high to moderate RC (A-4a)
A-5 (2,120-2,148): Alternating moderate to low RS with mainly higher RC

The TSP results are consistent with the relative rock hardness obtained by MWD measurements in large parts such as the softer rock areas (B1 & B3). Due to the repetitive near-field investigation of MWD directly in front of the working face, the shear zone (B2) can be shown somewhat more clearly, but remains limited in its spatial extent. The 3D-TSP S-wave velocity model (C) shows the spatial distribution of the shear zone and further low velocity zones (A-3/B-2 & A-5/B-3).

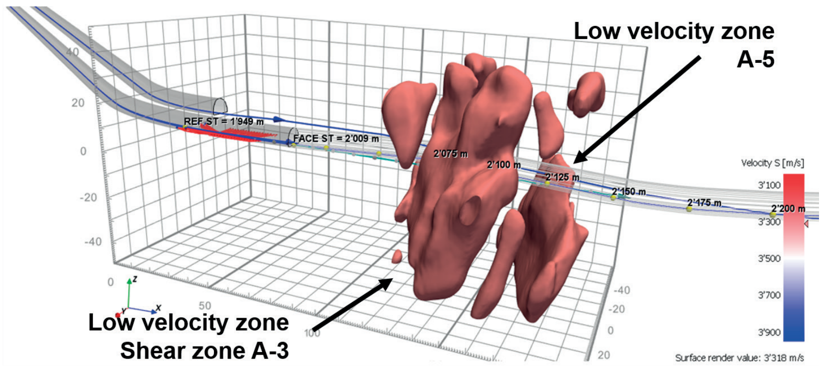
A) Dynamic Young's & Bulk modulus derived from TSP velocities



B) Relative rock hardness derived from MWD-Method

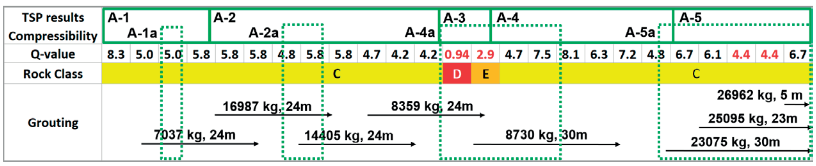


C) TSP 3D S-wave velocity model (surface rendering of low velocities)



Benefits of reduced uncertainty confirmed during construction

The interpretation of the rock properties for low velocity zones in combination with the elasticity and bulk modulus completed the previous knowledge of the geological situation during the excavation. Based on the gained knowledge, the TSP results supported the site management in estimating and selecting the quantity of grout and rock support types.



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