



Press Release

HERRENKNECHT

Milestone for hard rock tunnelling: Final double breakthrough Follo Line

March 19, 2019

Schwanau, Germany / Ski, Norway

The construction of Norway's longest railway tunnel marked a breakthrough for the use of tunnel boring machines in hard rock tunnelling. In Scandinavia long rail tunnels have hitherto been drilled and blasted rather than bored. In the Follo Line Project, the tunnel boring machines made a convincing case for themselves all the way through the extremely hard Norwegian rock. Four tunnel boring machines (TBMs) by Herrenknecht worked simultaneously to excavate the main part of two 20-kilometer railway tunnels between Oslo and Ski. On February 26, 2019, the final double breakthrough of the Double Shield TBMs "Anna" and "Magda" successfully completed the challenging mission and drew a spectacular close.

_____ The final double breakthrough of the two Herrenknecht tunnel boring machines "Anna" and "Magda" (Double Shield TBM, Ø 9,900 mm) in the Norwegian Ski completed the excavation of both 20-kilometer-long tunnel tubes of the Follo Line railway. This concludes the tunnelling work on what is currently the country's largest infrastructure project. The first two Herrenknecht-TBMs "Queen Eufemia" and "Queen Ellisiv" had already reached their destination in opposite Oslo on September 11, 2018.

The miners and the 350 invited guests cheered loudly when, on the afternoon of February 26, 2019, the sister machines cracked the last few centimeters of hard Norwegian rock with maximum precision after they had worked their way through it for about nine kilometers each. "Anna" and "Magda" had been chewing through extremely hard Norwegian gneiss since autumn 2016. This successful completion of the project represents an important milestone for tunnel boring machines in a country that has so far been relying primarily on conventional drill and blast tunnelling.

"If we want to stay fit for the future, we can't just say: we'll do it the way we've always done it," says Anne Kathrine Kalager, project manager for Bane NOR. "We must always keep looking for the best methods – and as it turns out, in this project TBMs

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have decisive advantages." With drill & blast it would have taken a total of seven construction sites in the metropolitan area, some of them difficult for trucks to access, which would have placed a great burden on traffic and residents. In contrast, the TBM solution gets by with only one central point of attack. Two 900 meter long access tunnels connect the large Åsland jobsite on the surface with two underground caverns. From there, two machines each bore south and north respectively to create the two tunnel tubes. Kalager is expecting the Follo Line to act as a signal for further projects in Norway.

Acciona Ghella Joint Venture is commissioned by the Norwegian government's agency for railway services (Bane NOR) to construct the main part of the tunnel at the Follo Line (EPC TBM). As of late 2022, high-speed trains are to drive through the new tunnel tubes at speeds of up to 250 kilometers per hour, halving the travel time between Oslo and the municipality of Ski 22 kilometers to the south from 22 to 11 minutes. The Follo Line represents a lifeline for the future of the Norwegian capital with its population of 600,000 and the region around Ski, which anticipates population growth of 30 percent by 2025.

To master the extremely hard rock with up to 300 MPa compressive strength, Double Shield TBMs by Herrenknecht were employed. The technically very sophisticated tunnel boring machines combine the functional principles of Gripper and Single Shield TBM in one machine. They can simultaneously bore and line the freshly bored tunnel with rings made of reinforced concrete segments - 140,000 of these segments were placed during the Follo Line Project.

The advance stands and falls with the quality of the disc cutters. The disc cutters made of special steel, 19 inches in diameter and each weighing up to 372 kilograms, are pressed against the extremely abrasive rock with up to 32 tonnes of pressure. "The wear of the disc cutters was enormous," stresses Matthias Flora, a specialist in hard rock at Herrenknecht. Up to 50 of Herrenknechts cutter experts in Schwanau professionally refurbished a total of around 8,000 worn disc cutters for reuse for the four machines in Norway over the entire project period. "In close cooperation with our customers we feel our way ever closer to the optimal parameters for the disc cutters," Flora explains about the special project challenges.

"Even the tiniest improvement to the discs counts. If optimal cutter management allows us to complete just one more tunnel ring per day and machine, this ultimately adds up to put us two to three months ahead of the planned project time." states Fernando Vara, Project Director of the Acciona Ghella Joint Venture. Thanks to regular maintenance and excellent teamwork, consistently high advance rates and peak performances of up to 155 meters per week were achieved in Norway. Such advance rates can only be achieved with particularly strong and robust machines. Each of the

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four cutterheads weighing 265 tons was driven by 13 engines with a drive power of 4,550 kW each, which corresponds to 475 hp each.

Discover more on the Follo Line in the Herrenknecht online magazine All Around #8 "Facing the toughest missions with grit and confidence":
<https://allaround.herrenknecht.com/en/issue-8.html>

Project data

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MACHINE-/ PROJECT DATA S-980, S-981, S-982 AND S-983 – FOLLO LINE

Machine type: 4x Double Shield TBM

- › Shield diameter: 4x 9,900 mm
 - › Drive power: 4x 4,550 kW
 - › Advance length: 1x 8,881 m
 - 1x 8,892 m
 - 1x 9,113 m
 - 1x 9,128 m
 - › Geology: Hard rock, gneiss
 - › Client: Bane NOR
 - › Contractor: AGJV Acciona Ghella Joint Venture
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Images

Milestone for hard rock tunnelling: Final breakthrough on the Follo Line



Photo 1

On February 26, 2019, the site crew celebrates the final double breakthrough of the two TBMs "Anna" and "Magda" at the Follo Line in Norway. This successful completion of the project represents an important milestone for tunnel boring machines in a country that has so far been relying primarily on conventional drill and blast tunnelling.

Photo: AGJV / Nicolas Tourenc



Photo 2

The new twin railway tube will run from the municipality of Ski in the south of Oslo right into the center of the metropolis. Thanks to the high advance rates of the double shield technology, all tunnelling work can be managed and carried out from one large central jobsite.



Photo 3

On September 11, 2018 around 25,000 spectators worldwide celebrated the breakthrough of the first two Herrenknecht machines "Queen Eufemia" and "Queen Ellisiv" by livestream.

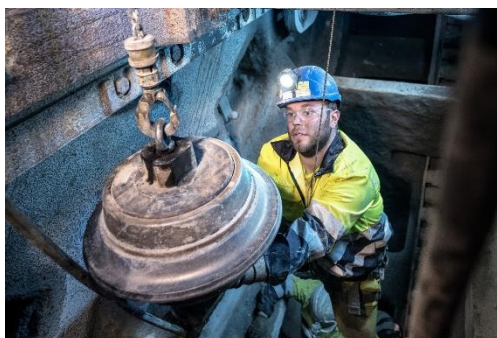


Photo 4

Regular maintenance and repair of the machines and their components are a prerequisite for consistently high advance rates in the complex Norwegian hard rock.

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**Photo 5**

On the basis of the experience gained daily on the jobsite, step by step the disc cutters are optimized for the Norwegian hard rock.

**Photo 6**

All four tunnel boring machines (Double Shield, Ø 9,900 mm) have successfully carved their way through the hard Norwegian rock for a distance of roughly nine kilometers each.

**Photo 7**

After about 9 kilometers each through tough gneiss, on Tuesday, September 11, 2018 the first two tunnel boring machines from Herrenknecht "Queen Eufemia" and "Queen Ellisiv" achieved an historic double breakthrough near the city center of Oslo.

Photo: AGJV / Nicolas Tourenc

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Herrenknecht AG

Herrenknecht AG is the only company worldwide to deliver tunnel boring machines for all geologies and in all diameters – ranging from 0.10 to 19 meters. The product range comprises tailor-made machines for traffic, supply and disposal tunnels, technologies for routing of pipe lines, as well as additional equipment and service packages. Herrenknecht also manufactures drilling equipment for vertical and inclined shafts as well as deep drilling rigs.

The Herrenknecht Group achieved a total output of 1,208 million euros in 2017. The independent family business employs about 5,000 people worldwide, from which 180 are trainees. With about 80 domestic and overseas subsidiaries and associated companies working in related fields, Herrenknecht provides comprehensive, fast and targeted services close to each project and contractor.

› <http://www.herrenknecht.com/en/references>

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