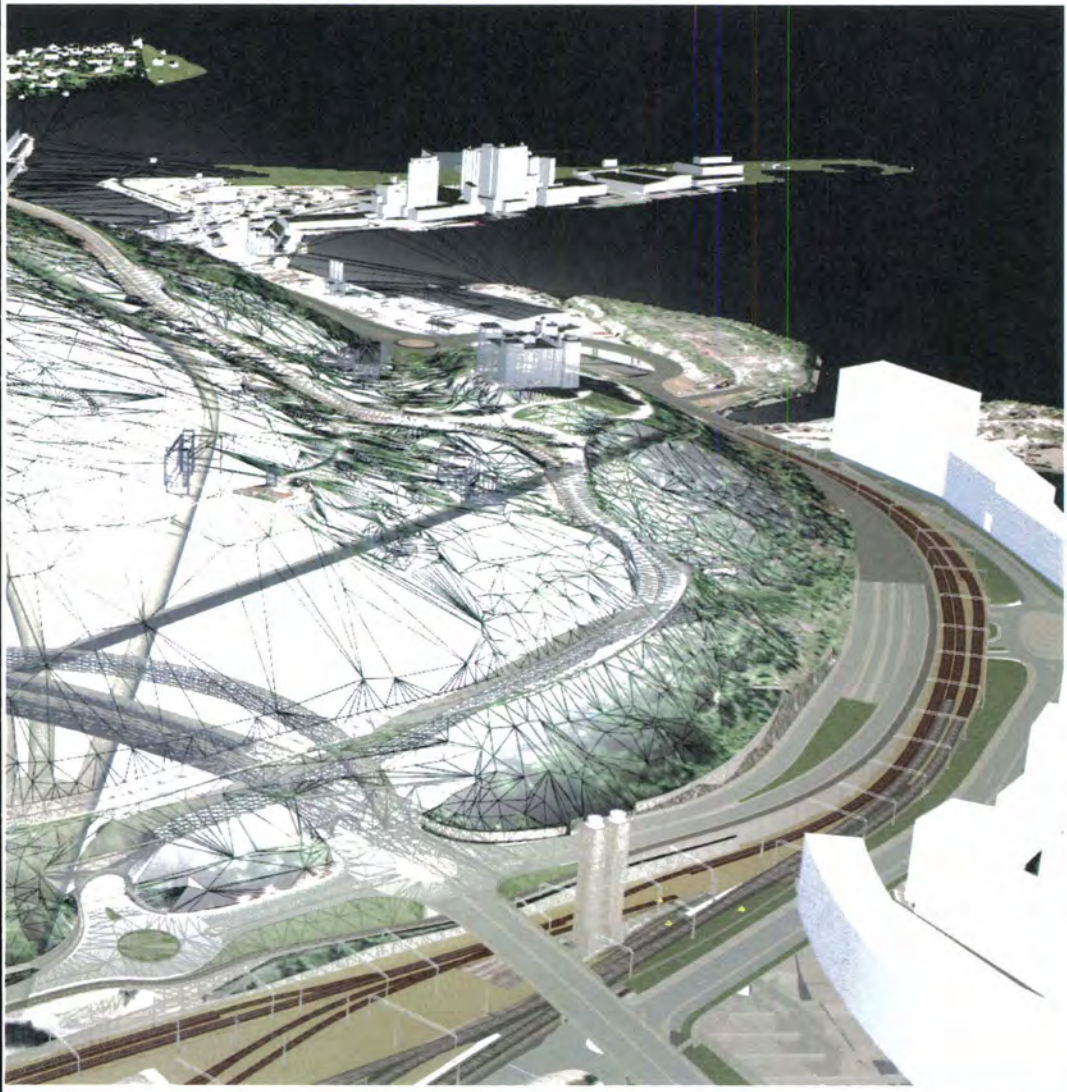
The Follo Line Project

NORWAY'S LONGEST RAILWAY TUNNEL



Norwegian National Rail Administration

Jernbaneverket

A tunnel with two bores

Norway's longest railway tunnel will be constructed using tunnel boring machines, as well as traditional drill and blast methods. This is the first time that tunnel boring machines will be used in Norway to build a railway tunnel.

Four large tunnel boring machines will excavate the Follo Line tunnel, which will have a total length of 19.5 km. From Åsland outside Oslo, two TBMs will bore southwards to the tunnel portal at Langhus, while a further two TBMs will bore northwards to Bekkelaget.

It has been provisionally planned to use traditional drill and blast methods for the final 2.8 km section towards Oslo Central Station. Traditional drill and blast methods will be utilised on a total of one-third of tunnel work on the Follo Line Project. Drill and blast will be used for all cross connections between the two tunnel bores, access tunnels to the main tunnel, a large mountain hall for construction work and a tunnel to the Østfold Line.

Tunnel boring machines – the right choice

In Norway, drill and blast has been the traditional method for constructing road and railway tunnels, while internationally it is common to use tunnel boring machines for long tunnels.

TBMs are well suited for construction of the Follo Line tunnel for a number of reasons, including:

- the tunnel's length
- the character of the rock
- generally adequate covering
- access to a large rigging area suitably located in relation to the tunnel (Åsland)
- built up areas – a limit to the number of cross cut tunnels using traditional drill and blast methods

This is the first time in Norway that a twin bore railway tunnel has been built. There are three main reasons why this solution has been adopted:

- future operation and maintenance

1 The Follo Line and the Østfold Line will run through the Ekeberg Hill, Oslo. (Jernbaneverket/ViaNova)
2 The Follo Line tunnel will be the first railway tunnel in Norway with two separate bores. (Jernbaneverket/ViaNova)

- optimum train/traffic handling
- safety

Preliminary works

Crucial preliminary works will start in 2013 before commencement of the main works in 2014. During 2013, the contract for construction of the long tunnel will be put out to tender both nationally and internationally. Suppliers and collaborating parties may now start preparing for the prequalification and tendering process.

The construction of the Follo Line's two tunnel bores is an extensive project, significantly larger than any previous railway project in Norway. The use of TBMs as the primary method of construction paves the way for major national and international participation in the construction of what will be Norway's longest railway tunnel to date.

Based on the size of the tunnel construction, a contract strategy has been formulated that involves alliance-building between Norwegian and foreign contractors and suppliers. The Norwegian National Rail Administration would like to encourage innovation and competence building that may benefit the development of the InterCity triangle and further strengthen Norwegian tunnel-building expertise on the international stage.

Comprehensive and innovative

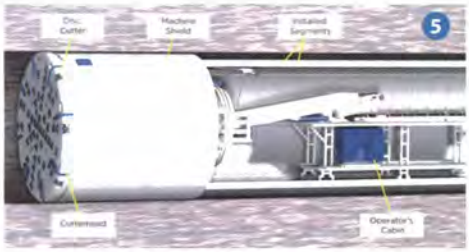
The Follo Line tunnel will have a life expectancy of at least 100 years. Consequently, there are strict requirements regarding the life expectancy of stability constructions and safety constructions. In a densely trafficked tunnel, access for maintenance work can be problematic and this must be taken into account in the selection of technical solutions.

Important criteria for the Follo Line tunnel:

- impervious and safe
- long service life
- minimum maintenance requirements
- maximum uptime (fewer closures means predictable traffic)
- minimum impact on the local environment during the construction phase and in normal operation
- willingness to embrace technological solutions, skills upgrading and development

3 The long tunnel will be constructed using tunnel boring machines – and drill & blast. (Jernbaneverket/Hilde Lillejord)
4 Exampel: Single shell lining, TBM
5 Exampel: TBM

Single shell lining



Norway has a long tradition of using TBMs

In the 1970s and 1980s the Norwegian tunnel construction sector was one of the world's leading players in the use of TMBs for hard rock tunnelling. TBM were primarily used to excavate tunnels for hydroelectric plants, but also in the excavation of sewage tunnels and a couple of road tunnels. When major hydroelectric projects were scaled down, the TBM lost ground in Norway and the tunnel construction sector gradually lost some of its expertise in TBM operations. However, a few Norwegian companies have been involved in international TBM projects right up to the present day.

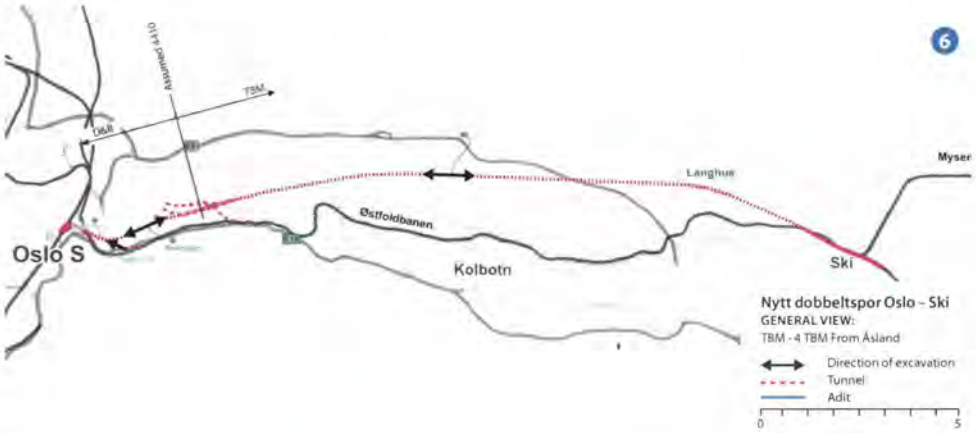
Quality for the future

The TBM is a system comprising pre-cast impermeable concrete elements installed in a closed loop to ensure protection from rock fall, as well as water and frost. The space behind the concrete elements is filled with shotcrete to seal the gap towards the rock face.

Production and installation of concrete elements will form part of an industrialised process. This will help ensure a high and consistent quality to components, as well as the actual installation process. From a life cycle perspective, precast concrete elements in a closed loop will require less maintenance than the more traditional form of rock fall protection using bolts.

Choosing machinery that is suited to the ground conditions and a crew well used to operating under similar rock conditions, is crucial. Extensive knowledge of ground conditions is an important prerequisite to success.

6 The Follo Line: Rig areas and attack points/TBM.



Major construction site for TBMs

At Åsland, by the E6 European highway southwards out of Oslo, a large rigging area will be established. Concrete elements, to be used for tunnel reinforcement, will be among a number of components manufactured here. Large areas will be required for this production work. Space will also be required for other tasks and other logistics.

At Åsland, three access tunnels and a mountain hall will be constructed utilising traditional drill and blast methods. Together, the three tunnels will cater for incoming and outgoing traffic, as well as transportation of spoil out of the tunnel via a conveyor belt. The tunnels are also important as a means of air supply to the main tunnel.

The four large TBMs will be installed inside the tunnel system. Two TMBs will excavate the two bores towards Ski, while the other two TMBs will excavate northwards towards Oslo. Tunnel spoil will be transported via conveyor belt to Åsland.

Spoil – a resource

Around 10 million tons of rock spoil will be removed during tunnel construction. Following an invitation to tender, the Norwegian National Rail Administration has established contact with various public and private sector parties who can make use of the spoil. It is important that the rock spoil is recycled in a socially and environmentally acceptable manner.

Safe transportation of spoil is also crucial in order to minimise the impact on the local environment. Once the respective options for the recycling of spoil have been determined, plans will be drawn up for the necessary transportation from the construction site. From an environmental perspective, it will be advantageous if most of the spoil ends up at Åsland, which has direct access to the E6 European highway, rather than being removed from eight cross cut tunnels and transported along local roads. Rock spoil, from what will be Norway's longest railway tunnel to date, will be removed over a period of around 3–3.5 years.

Facts about the Follo Line Project:

- Norway's largest transport project
- 22 km new double track line from Oslo Central Station to the public transport hub at Ski
- A total of around 64 km of new railway track
- At 19.5 km, it is Norway's longest railway tunnel to date
- The first railway tunnel in Norway with two separate bores for efficient and safe traffic
- The Follo Line tunnel will have a life expectancy of 100 years
- To be constructed primarily with four tunnel boring machines, as the first railway tunnel of its kind in Norway
- Ca. 1/3 of tunnel works will utilise the drill and blast method
- The project includes construction of a new station at Ski, extensive works at Oslo Central Station, and the necessary realignment of tracks to the Østfold Line on the approach to Oslo Central Station and between the tunnel and the new Ski station
- Forms the core part of InterCity development southwards from Oslo
- To be built for speeds of up to 250 km/h
- Will enable a 50% reduction in journey time between Oslo and Ski (to 11 minutes)
- Provides a significant increase in capacity to/from Oslo
- First transport project with its own environmental audit method (Pilot project for the Norwegian National Rail Administration in terms of the environment.)
- The new line is scheduled for completion towards the end of 2019
- May be combined with a possible high-speed line to the continent

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