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9. RV 13 Ryfast, world's longest subsea road tunnel combined with E 39 – Eiganes Tunnel

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Abstract

The Rv.13 Ryfast project is an undersea tunnel which will connect the city of Stavanger to the Ryfylke region. When completed, the tunnels will replace the existing vehicle ferries which operate between Stavanger and Tau, and between Lauvvik and Oanes. Currently the combined daily traffic volume for both ferry routes is 4,000 vehicles (AADT). Ryfast consists of two dual lane, subsea tunnels - The Hundvåg tunnel (from the new E39 Eiganes tunnel to the Island of Hundvåg), and the Solbakk tunnel (which extends from the Hundvåg tunnel to Strand, in Ryfylke). Construction time will be five and a half to 6 years, with an expected opening in 2018/19. Safety issues have played a major role during the initial planning phase of the project, with focus on integrating ideas and proposals from the emergency services and experts from various fields.

The tunnelling network will also reduce today's E39 bottlenecks in Stavanger, with traffic currently routed along heavily congested local roads. The E39 Eiganes tunnel will be the new 'North/South' main route through Stavanger, extending the existing motorway beyond the Stavanger central business district, and significantly reducing local traffic. The primary route for the project is 5km long, comprised of dual tunnels 3.7km long, and 1.3km of ground level, two lane carriageways. In addition to the primary North and South Bound tunnels, the project will also include tunnelled entry/exit ramps, and the connection to the Ryfast Hundvåg tunnel. As a result of geometric constraints, and the existing topography, a significant portion of the Eiganes tunnel will have 15-25 metres of rock cover to the surface.

As the south western connection to the Ryfast project, the E39 Eiganes tunnel will be constructed and managed jointly with the Ryfast project. Together, the Ryfast and Eiganes tunnel projects will produce 3.8 million cubic metres of rock, and finding a suitable use for this material has been a challenge. The solution has been to utilise this material for land reclamation at a number of sites adjacent to the project. Further project details and challenges will be discussed in the document.

KEYWORDS: strait crossing, subsea road tunnel, tunnel safety and security, cross city tunnel

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General Information

Project approved by the Norwegian parliament 12th June 2012.

Norwegian Public Roads Administration's role

The Norwegian Public Roads Administration (Statens vegvesen, or SVV) will manage the project through a traditional client role. As a result of the scope and size of the project, the management structure includes two sub-project managers for each of the two projects. They will be assisted by site managers and inspection engineers, making sure that the contractors follow the required procedures and maintain a high focus on the health, safety and the environment.

In addition to contract and project management personnel, the project organisation also includes a support team for communication, neighbour relations, environmental issues, health and safety, and a variety of additional tasks that are required to secure the overall quality of the project.

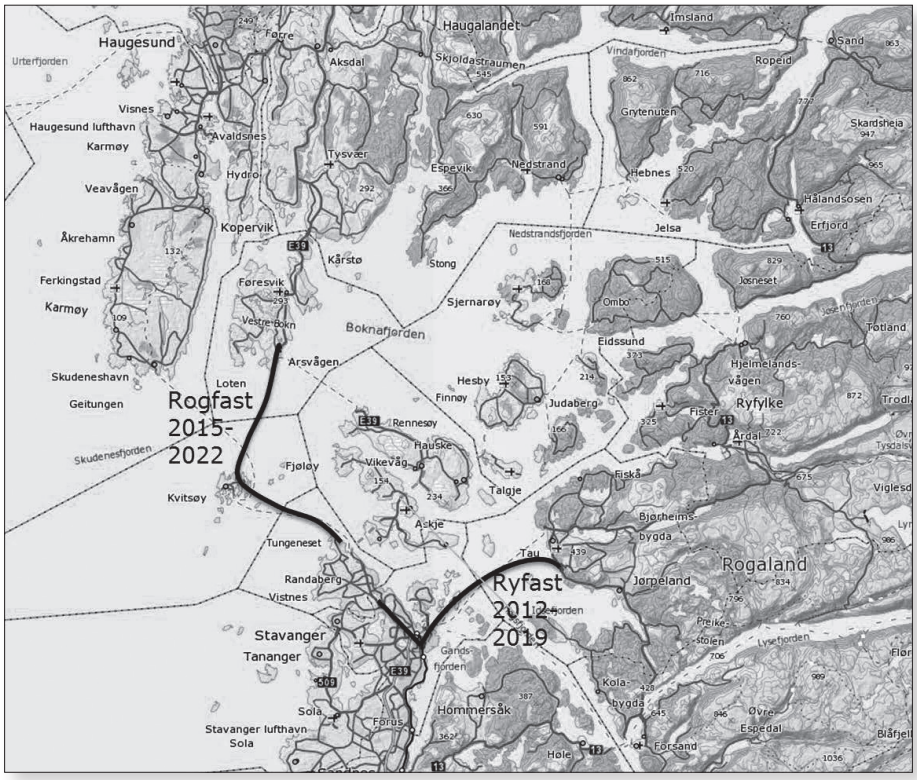

Figure 1 Map showing the location of the Ryfast project

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Construction method

In the early phases of the planning, alternative tunnelling options were assessed and evaluated. Among the assessed options, were different types of conventional drill and blast tunnelling technology (tunnels in Norway are almost exclusively constructed using drill and blast methods), and the use of tunnel boring machines.

Given the proximity of the tunnelling work to older urban areas, and a desire to secure an efficient and flexible construction program, conventional drill and blast tunnelling technology was seen as the best choice for the project.

Contract terms/choosing the contractor

The contracts will be announced as fixed price contracts, with price, experience and methodology / program as the key selection criteria.

Rough estimates

In total there will be between 10,000 and 15,000 blasts required to finish the projects. In urban areas these blasts will be adjusted to have a minimal impact on people's comfort and everyday life. An equivalent of 15,000 lorry loads of sprayed concrete will be used, together with approximately 250,000 bolts, to keep the tunnel secure during construction. Also, there will be a total of between 3.5 and 4 million cubic metres of excavated rock extracted from the tunnels. Finding the best solution for utilising the surplus rock has been a great challenge for the project. The geological properties / problems with the material make it unsuitable for use in road construction, but it can be used for land reclamation. Together with relevant local stakeholders, the project has identified 3 locations where the material will be utilised. Upon completion of the project, we will have approximately 50km of new road, with the asphalt, concrete, ground services and cabling that goes with it, together with new areas for industry and business.

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Rv. 13 Ryfast

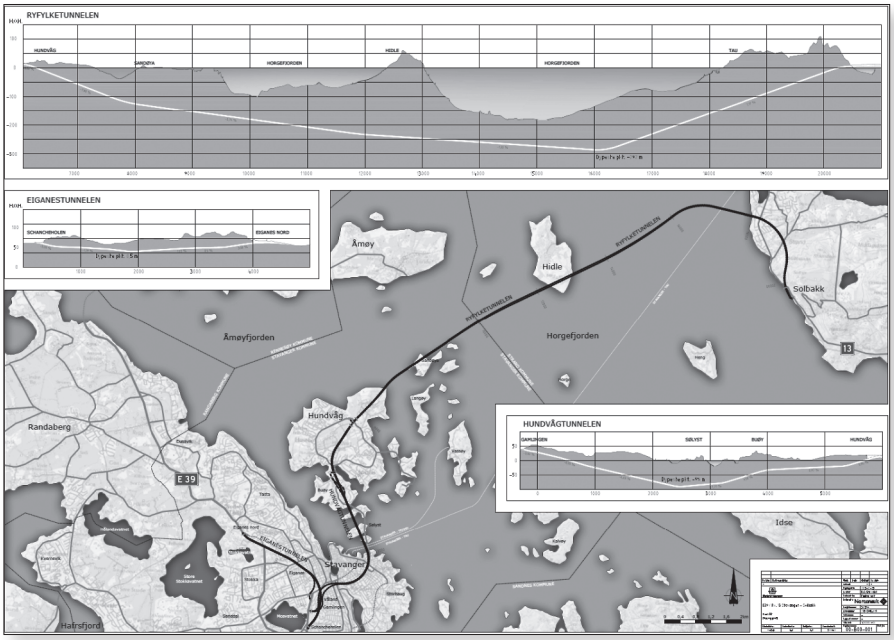

Figure 2 Plan view and longitudinal profiles of the Ryfast and Eiganes tunnels

Rv 13 Ryfast will connect Stavanger, eastwards, to the Ryfylke region, replacing the existing ferry connections between Stavanger and Tau, and between Lauvvik and Oanes. Currently, the combined daily traffic volume for both ferry routes is 4,000 vehicles (AADT). Preliminary construction works commenced in early 2013, with tunnelling programmed to begin in August 2013. General details for the Rv 13 Ryfast project are as follows:

The tunnels

Ryfast consists of two ‘dual lane’ tunnels, the Solbakk tunnel from Solbakk in Ryfylke, to the island of Hundvåg in the Stavanger municipal area, and the Hundvåg tunnel, which extends from Hundvåg to an underground (tunnelled) motorway interchange with the E39 Eiganes tunnel.

The Solbakk tunnel consists of two individual, parallel (dual lane) tunnels (or ‘tubes’), stretching 14.3km in length and reaching a depth of 290 meters below sea level. Traffic forecasts predict that upon opening in 2019, the Solbakk tunnel will carry 5,000 vehicles (AADT) daily. Each of the ‘tubes’ will be 8.5 meters wide, with emergency access tunnels connecting the two every 250 meters.

The Hundvåg tunnel is 5.5km long and 95 meters below sea level at its deepest. In addition to providing a link from the Solbakk tunnel to the E39 and Stavanger, the Hundvåg tunnel will provide an alternative route for commuters to the existing ‘City bridge’. Traffic forecasts predict that upon opening in 2019, Hundvåg tunnel will

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carry 10,000 vehicles (AADT) daily. The width for the tunnel tubes in the Hundvåg tunnel is 9.5 meters.

Assessment of safety and security

Throughout the planning and construction, we've maintained a high focus on evaluating the risks regarding the safety and security with the finished product. The solutions have been established accordingly to the latest standards for Norwegian tunnels, and are taken further through active involvement of the local Fire Service. There are particularly three centralised issues which we've regarded carefully. These are accessibility, ventilation, and access to extinguishing water. With regards to accessibility, we have worked jointly with the Fire Service to develop adequate procedures for evacuation of people in case of an emergency. There are, along the entire length of the tunnel, regular crossing sections, which are fully accessible for vehicles. This makes it possible to access all parts of the tunnel efficiently. The Fire Service has been actively involved in addressing the issues of how to make the tunnel as accessible as possible.

In the event of an accident, the Fire Service will access the location of the accident from the direction of the air flow. This measure is taken to avoid dangers related to meeting traffic, and exposure to toxic gases. Because of the length of the tunnel, there will be driveable crossing sections every 250 meters, which will be used as alternative routes to maintain good accessibility in both directions. All of these sections have a maximum of 5% gradient through the whole tunnel, and will also function as evacuation tunnels to the adjacent tube.

The ventilation systems are dimensioned for 100 MW fire and with an air flow of 4.5 m/s. This speed is more than enough to prevent the smoke from spreading towards oncoming traffic and people. Some areas, like the intertwining sections in the Eiganes and Hundvåg tunnels, have been specifically tested and evaluated through testing with experts from varied fields. As a result, we've designed the ventilation for the Eiganes and the Hundvåg tunnel with a system that will be handling situations with pre-programmed logic.

Regarding water supplies in case of fire, extinguishing water will be easily accessible every 250 meters, with a supply of 30 litres per second and a pressure between 4 and 10 bars. The difference in water pressure comes from individual solutions for each of the tunnels. Pressure enhancements will be given from the equipment used by the Fire Service.

Furthermore, all of the tunnels will have both automatic and manual traffic control. This system can be used to establish two-way traffic, in cases where we'll have to close down one of the tubes.

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Funding

The Ryfast tunnels are estimated to cost 5.5 billion Norwegian Kroner (650 million Euros), of this, 90% of the financing will be provided by the Norwegian government (with the addition of road tolls), and the remaining 10% provided by the local/municipal and regional authorities.

Today, the toll for the Solbakk tunnel is estimated to be 230 Norwegian Kroner (30 Euros) for light vehicles, and 30 Kroner (4 Euro) for light vehicles in the Hundvåg tunnel. The toll levied against trucks / heavy vehicles will be marginally higher. The estimated toll fee makes the project the most expensive in Norway for road users.

E 39 Eiganes Tunnel

Today's E39 bottlenecks in Stavanger, with traffic routed along heavily congested local roads. The E39 Eiganes tunnel will be the new 'North / South' trunk route through Stavanger, extending the existing motorway beyond the Stavanger central business district, and significantly reducing local traffic.

The tunnel is 5km long, and is comprised of two, dual lane tunnels, 3.7 km long, with 1.3 km of ground level, two lane dual carriageways. Similar to the Hundvåg tunnel, the width of the tunnel tubes is 9.5 meters. Traffic forecasts predict that upon opening in 2019, the Eiganes tunnel will carry approximately 20,000 vehicles (AADT) daily.

Figure 3 The map shows Eiganes North, the Eiganes Tunnel and the connection to Rv 13 Ryfast through The Hundvåg Tunnel

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The estimated cost for the project, including the tunnels and surface road construction is 2.2 billion Kroner (250 million Euros). The Norwegian government will provide the funding for the Eiganes tunnel, with 70% of the cost to be repaid via tolls from the existing 'North Jæren Toll Ring Road'.

The E39 Eiganes Tunnel will be constructed in conjunction with Ryfast, under the same project management. Construction time for the entire project, both Ryfast and Eiganes tunnels, is planned for five and a half to six years, with the expected opening in 2019.

Geology

Geologically, this part of Rogaland is comprised mainly of Precambrian autochthon / autochthonous rock units of Caledonian covers. The Ryfast tunnel will be constructed through the overlying Allochthonous / long-Caledonian rock layers, consisting mainly of phyllite and gneiss, which was pushed beneath the Caledonian orogeny for approximately 350 million years ago. From previous experience tunnelling in this region, the project expects to encounter small leaks while tunnelling through the phyllite, both below the ocean floor and on land.

By way of a local comparison, there were small leaks during the construction of the Mastrafjord tunnel (Rennfast project, completed in 1993). According to geology reports, these areas are geologically similar to the Solbakk tunnel. The areas where the sediment is thinnest are considered to pose the greatest risks of leakage along the Solbakk tunnel. These areas are located in Horgefjorden, close to Hidle. The project has in place, proven work methodology to rectify any leaks encountered during construction.

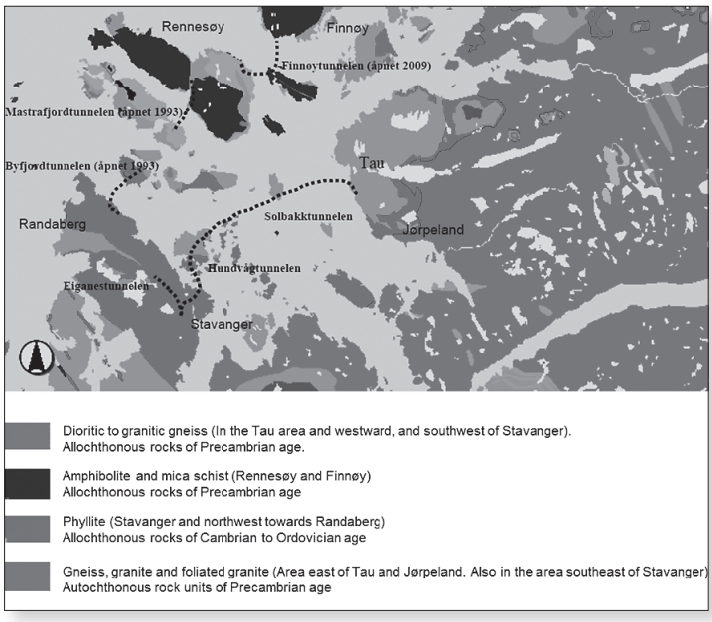

Figure 4 Geological map of the tunnel area

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Contracts

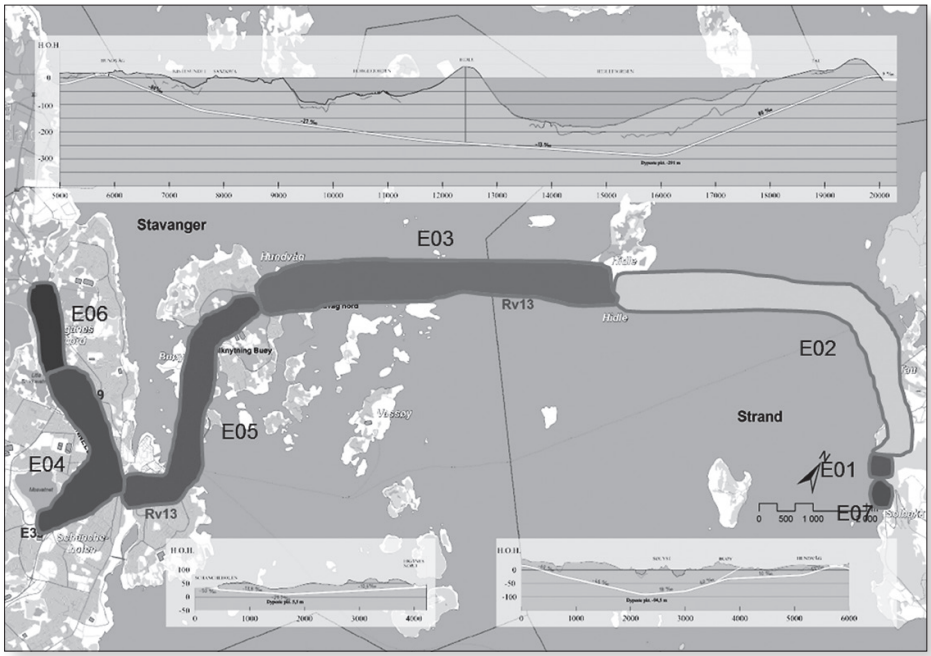

Figure 6 Allocation of various contract sections

E01: Preliminary work at Solbakk

The first construction contract for the Ryfast tunnel was signed on 9th November 2012, when a local contractor was awarded the tender for preliminary earthworks, and stabilisation for the tunnel portal at Solbakk in Strand municipality. These works were completed on 22nd April 2013.

Figure 7 3D-illustration of the entry point of the Solbakk tunnel at Solbakk

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E02: 7.6 km of Solbakktunnelen from Solbakk

On 30th April 2013, the first of the major tunnelling contracts was awarded to Marti Contractors Ltd, IAV and Marti Norway AS. This contract covers the civil engineering and tunnelling works for the first 7.6 km of the Solbakk tunnel, from Solbakk.

E03: 6.7 km of the Solbakktunnelen from Hundvåg

As of May 2013, the second major tunnelling contract, the remaining 6.7 km of civil engineering/tunnelling works for the Solbakk tunnel, was out to tender. This includes Hundvåg, together with the construction of the Hundvåg interchange, and portal for the Hundvåg tunnel.

E04: The Eiganes tunnel with parts of the Hundvåg tunnel

Part 4 of the project, The Eiganes tunnel (including the Hundvåg tunnel interchange), is expected to be the largest contract in the project. This contract includes all of the tunnelling for the Eiganes tunnel, the tunnelled interchange, and connection to the Hundvåg tunnel. It also includes additional entry/exit ramps for both tunnels, and the reconfiguration of the existing motorway, to provide the southern approach to the tunnel. This is a connecting route to both tunnels, and the E39 southbound, from the Stavanger CBD and western parts of the city.
This stage of the project will pose a variety of challenges for the chosen contractor, and is currently programmed to be tendered out in Summer/Autumn 2013.

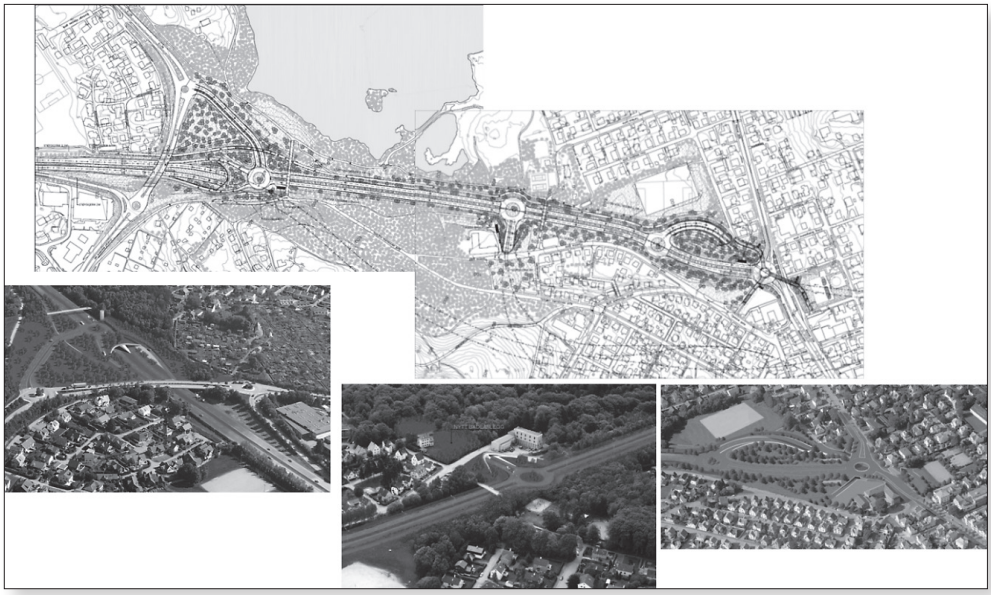

Figure 8 Early project sketches from the development phase

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E05: Hundvågtunnelen

The last of the tunnelling contracts is Part 5 of the project; The Hundvåg tunnel. This contract involves the tunnelling of entry/exit ramps for the Hundvåg tunnel from the Island – Buøy. This will also include the tunnelling of the Hundvåg tunnel to Stavanger, and to Hundvåg from Buøy. Currently, this stage of the project is planned to be tendered out in winter 2013/2014.

E06: Eiganes north

Part 6 of the project, the northern approaches and motorway interchange for the E39 Eiganes Tunnel, is currently planned to be tendered out in winter 2014/2015. This contract includes the upgrading of the existing highway to Motorway standard, as well as the construction of several bridges. During construction of this stage of the project, the contractors will need to maintain the existing traffic flow, construct 4 lanes of motorway (2 Northbound, 2 southbound), and provide for construction traffic from Eiganes tunnel. As a consequence of the accelerated program for the construction of the Rogfast project, the final scope of this project is currently being revised to optimise the construction of both projects.

E07: Mosvannet Land Bridge/Isthmus (which has now been included in E04 – Eiganes tunnel)

Figure 9 Southern portals to the Eiganes tunnel, and the Mosvannet Land Bridge.

In addition to the contracts presented, there will be separate contracts for electrical, pumping, ventilation and control systems.

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In summary, the project is a much needed measure for the people of Stavanger and inner Ryfylke. This infrastructure will improve traffic flow through the city, reduce congestion, and provide for the growth of the city of Stavanger. At the same time, thus providing a safe, reliable, and all-weather route between Stavanger, north Jæren and Ryfylke, which will only enhance the economic development of the region as a whole.

Find more about the projects at:
http://www.vegvesen.no/Vegprosjekter/e39eiganestunnelen
http://www.vegvesen.no/Vegprosjekter/ryfast.