Technology days 2016

E39 Tunnels


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General information on the tunnels

The tunnels on the E39 are designed on the basis of manuals and standards. Specific design requirements have not initially been established, but risk assessments have resulted in additional considerations in some of the tunnels.

• The majority of the tunnels are “normal”:
  – Within the manuals' tables in terms of length and traffic
  – The safety class may be derived directly from tables
  – Equipment is thereby a given
  – Upgrade projects/rehabilitation

• There are two longer subsea tunnels on the stretch:
  – Under Boknafjorden (Rogfast)
  – Under Romsdalsfjorden
  – These are two special cases

• Transition submerged floating tunnel to rock tunnel:
  – Not yet planned in detail
  – Presentation of possible solution
Various challenges on the E39 when building tunnels. Here, the E39 Eiganes tunnel, Stavanger
Modern tunnels

- Are earlier/current tunnels outdated?
- Investment
- Operation and maintenance
- Risk
E39 Kristiansand – Trondheim

- Two long subsea tunnels: Boknafjorden (Rogfast) almost 27 km in length and Romsdalsfjorden just over 16 km in length. Advance information on assessment/analysis
- Submerged floating tunnel/transition tunnel. Assessment for crossing of Bjørnafjorden
E39 Rogfast, review

Overview map subsea tunnel Bokna fjorden
E39 Rogfast

General targets

- The tunnel must have a high level of safety
- Traffic flow must have few interruptions
- Uptime must be high
Standard choices

- N-500 states that special assessments must be made concerning the standard of tunnels longer than 10 km.
- Viewed in relation to length, traffic volume and traffic composition.
- Remedial measures to reduce risk and the consequences of incidents are key issues in such an assessment.
- ROS analysis is the tool.

- N-500 (Road Tunnels)
- The agency project Modern Road Tunnels
- ROS analyses for the project
- Theme report on tunnel from consultant
- Recommendations from the Norwegian Public Roads Administration
E39 Rogfast (Boknafjorden)

- The tunnel was planned with a 7% climb from the sag and northwards.
- Changed to 5% in compliance with EU standard, approx. 1,500 metres longer
Instruments to achieve targets

- Measures from the ROS analysis
  - Crawler lane uphill (and downhill)
  - Shoulder width
  - Frequency of pedestrian cross–connections (emergency exits)
  - Cross–connections for traffic
  - Intersection solution (Kvitsøy intersection)
  - Caverns
Conclusions for standard choices

- Main tunnel; normal profile 2xT10.5
- Kvitsøy tunnel; normal profile T9.5
- An extra crawler lane will be established in the 7% climb towards Arsvågen – (not applicable)
- Distance between emergency exits will be 125 metres where the climb is 5% or more
- 4 caverns will be established in each direction to counter monotony
- 4 cross-connections for traffic will be established
E39 Rogfast
Tunnel profile 2 x T10.5
E39 Rogfast
Intersection in tunnel Kvitsøy
E 39 Rogfast
Kvitsøy intersection
Scope of work, challenges in tunnelling the Boknafjord tunnel

● Long steps, (arm to Kvitsøy important for implementation)

● High water pressure and extensive injection

● Long section with limited knowledge of rock composition

● Securing of zones with poor rock

● Large deposits in sea, areas exposed to weather – maintain YM

● Coordination between the contracts
Alternative tunnelling method

- TBM has been considered both on Ryfast (the Ryfylke connection) and Rogfast (the Boknafjord connection)
- Despite long tunnels > 10 km, TBM is not prioritised as an option
- The challenge is niches/turning points and technical structure/various sumps
- Extraction of large volumes of rock in the cross-section that must be transported out and refilled
E39 Romsdalsfjorden

- Vik – Julbøen zoning plan finished in 2016, planning can start when priority is in place
  - 16 km subsea tunnel with two courses and 5% climb
  - Approx. 2 km long suspension bridge with 1625 metre main span, four lanes and g/s lanes
  - Construction period 6 years
- Julbøen – Molde started municipal sub-plan in 2016
E39 Romsdalsfjorden

Cross-section T9.5 (T10.5)
Incidents

- Type of incident:
  - Accidents
  - Accident
  - Stopped vehicle
  - Fire in vehicle
  - Extinguisher removed
  - Electricity outage
  - Objects in road
  - Repair external cause

- Empirical data for frequency of each type of incident
  (e.g. incidents per million vehicle km)

- Assessment of closure time per incident type
## Basic analysis

## Incidents

<table>
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<tr>
<th>Hendelse</th>
<th>Sannsynlig frekvens pr mill kjtkm</th>
<th>Hendelser pr år</th>
<th>Varighet (timer)</th>
<th>Andel av hendelse som medfører stenging</th>
<th>Stengealternativ</th>
<th>Kommentar</th>
<th>Stengetid pr år (timer)</th>
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Basic analysis

Closure time

Operation/maintenance
Around 500 hours per year (average)

Technical rehabilitation (1.4 years)
(every 25 years):
Work: 5,000 hours (course closed)
Traffic restrictions without work: 7,400 hours (lane closed)
Total 12,400 hours

Structural rehabilitation (3.6 years)
(every 50 years, incl. technical rehab):
Work: 16800 hours (course closed)
Traffic restrictions without work: 15,100 hours (lane closed)
Total 31,900 hours

Incidents
Around 120 hours per year (average)
Submerged floating tunnel, alternative Bjørnafjorden

• Stord – Os: municipal sub-plan at mid 2017 (state). Crossing of Langenuen and Bjørnafjorden. Work on concept for Bjørnafjorden considered reduced to floating bridge and suspension bridge on TLP. Submerged floating tunnel will likely no longer be considered in this phase.
Illustration: Reinertsen, Olav Olsen, Norconsu