Technological Innovations; Road Tunnel in Norway

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Geographically speaking, Norway is an especially tricky place for motorists. With more than 1,100 fjords — the deep glacial water inlets that divide land masses — driving from point A to point B typically requires points C through Z, several bridges, and a couple of ferry rides. Some of the fjords have been declared World Heritage Sites by UNESCO.

To remedy the problem, Norway is undertaking an ambitious project to build a fully submerged floating traffic tunnel beneath the waves of the [Sognefjord](), a troublesome body of water that runs 3,000 feet wide and 4,000 feet deep.

The structure is officially called a submerged floating tube-bridge but is also known as a Archimedes Bridge.

http://www.livescience.com/55583-floating-underwater-tunnels-planned-for-norway.html

The first-of-its kind structure will be made up of two 1,200 meter (4,000ft) curved concrete tubes, floating up to 30 meters (100ft) below the surface. The tubes will be supported by pontoons on the surface and kept stable with connecting trusses. For extra stability, the construction might be bolted to the bedrock as well.

On the surface, there would be wide gaps between the pontoons to allow ferries to pass through.

http://www.roadtraffic-technology.com/projects/laerdal-tunnel/

The Archimedes principle is named after the Ancient Greek mathematician who came up with the buoyancy calculation, supposedly while sitting in the bathtub.

The principle denotes that the upward buoyant force that is exerted on a body immersed in a fluid, whether fully or partially submerged, is equal to the weight of the fluid that the body displaced.

In June 1992 the Norwegian Parliament decided to construct the world's longest road tunnel. The 24.5km-long stretch of tunnel stretches between Aurland and Laerdal on the new main highway connecting Oslo and Bergen.

The construction was approved to traverse a section of country with relatively poor levels of reliability in road transport due to the mountainous area and narrow roads combined with many fjord crossings.

The Laerdal tunnel is an important part of the extension of a ferry-free, reliable road link between the two largest cities in Norway. The decision to build a tunnel rather than refurbish existing roads was taken to avoid difficult terrain with high risks of rock falls. From an environmental perspective, the tunnel was seen as a justifiable investment to avoid destroying sections of the unspoiled natural landscape.

Construction

Operations during the construction of Laerdal tunnel was divided into four main phases: drilling, blasting, loading and transport and excavating and landscaping.

Drilling the tunnel was carried out using computer-controlled drilling jumbos as well as traditional drilling and blasting. To make sure that the tunnel sections met more than 10km into the rock and 1000 meters under the mountain, it was important that the drilling and blasting work were carried out with great precision.

Navigation satellites were used to determine fixed survey points on which other measurements inside the tunnel were based. Inside the tunnel, bearings were indicated using laser beams. A computer on the drilling jumbo captured the laser beams and positioned the drilling equipment automatically, according to a set pattern. Each drilling jumbo contained three automatic hydraulic drills.

Blasting was conducted using approximately 100 holes, 45 - 51mm in diameter and 5.2 meters deep, drilled for each blast. A detonator inside a small stick of Anolit dynamite was places in the bottom of each hole.

Wheel-mounted loaders were used for loading and transport in the tunnel. The excavated materials were transported out of the tunnel using dump trucks. Permanent roads were built in the tunnel, in parallel with the tunneling work, so that transport vehicles could run on a good, paved road base during the construction period. This improved efficiency and minimized pollution.

The disposal of 2.5 million cubic meters of excavated rock from the tunnel was one of the greatest challenges in planning the tunnel. To avoid major conflicts because of the cultural importance of the landscape and the productive agricultural land in the main valley, the Norwegian Public Roads Administration decided to build more than half of the tunnel from a 2.1km long access tunnel in Tynjadal. Tynjadal is a side valley, opening out about 8km east of the town of Laerdal. Here, the excavated materials were deposited with no visible effect on the main valley, and without any risk of hazardous run-off into the Laerdal watercourses.

Design

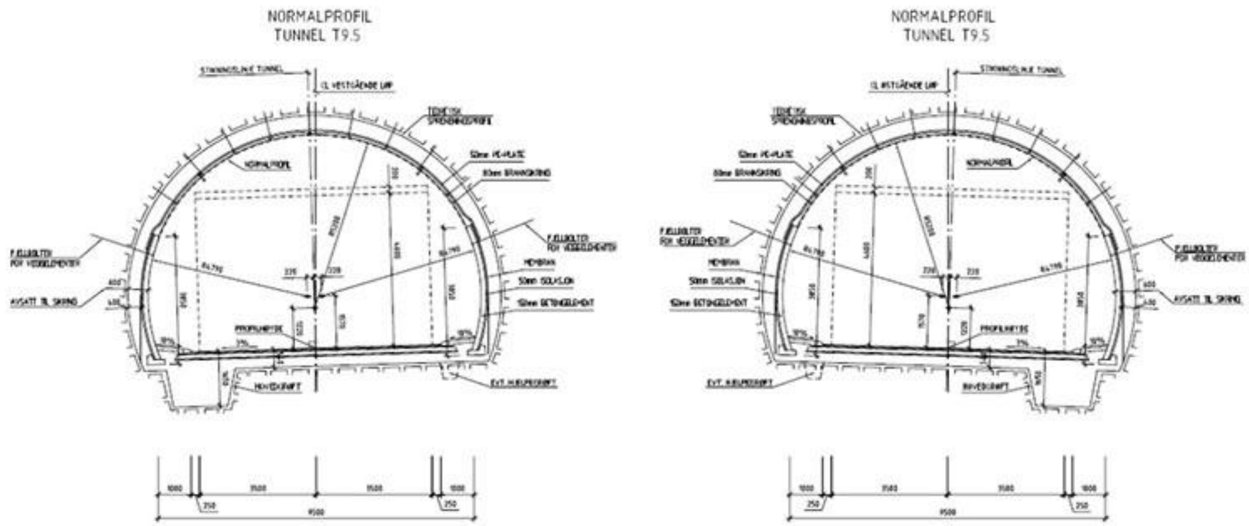
The Norwegian Public Roads Administration's (NPRA) challenge was to design the tunnel so that people did not find the 20-minute-long trip monotonous, thereby losing concentration during the long journey.

A working group led by experienced psychologists at SINTEF (the Industrial and Technological Research Association) worked closely with the NPRA to assess what could be done to make the journey through the tunnel a pleasant experience.

Simulators where used to find the best solutions as regards lighting levels and design and gentle curves and short straight sections make driving through the Laerdal tunnel less monotonous, without breaching the guidelines for safe viewing distance.

At any given point in the tunnel, the safe viewing distance will be 1000 metres or more.

The tunnel has been subdivided into four sections by means of specially widened areas which are large enough to allow coaches and trains to turn without having to reverse.



Ventilation

The tunnel is longitudinally ventilated through only one ventilation air exhaust shaft, 18km from the Aurland end of the tunnel. About 10km from the Aurland end of the tunnel, a cleaning plant for the tunnel ventilation air is installed in a short side tunnel. This plant cleans the passing air for critical polluting components, thus maintaining an acceptable air quality throughout the tunnel even during periods of heavy traffic and limiting the air volume and jet from power consumption which is required in order to ventilate the long tunnel.

The air quality in the tunnel will be continuously monitored, and the air cleaning system will automatically go into operation when required. The electrostatic precipitator will automatically be quenched for de-dusting at regular intervals, while maintenance of the gas filtration catalyst is expected to be required only at intervals of several years.

Safety

A great deal of investment was put into safety measures and equipment in the **Laerdal** tunnel.

Fire safety is the main priority in the construction of any tunnel. The Laerdal tunnel goes through dry rock with little need for sealing water seepage. In the few places where flammable plastic mats have been required for waterproofing, these methods were put to the test in a coach fire in the **Ekeberg** tunnel in 1996. The heat generation was around 35.000kW, and the temperature below the tunnel roof rose to more than 1000°C with no visible damage occurring to the tunnel cladding.

Even with little risk of accident and safe fire designs, the Laerdal tunnel has a large quantity of emergency equipment. Emergency telephones and fire extinguishers have been installed at closer intervals than is usual in other tunnels.

Several million Norwegian kroner where spent on equipment for monitoring and to check that the ventilation systems, radio connections, lightning systems, traffic lights, emergency equipment, etc., are in working order.

The Norwegian Public Roads Administration's monitoring center in Laerdal is responsible for monitoring and checking all tunnel systems in the region.

If any fault should occur in the ventilation system or if any queues should form, creating excessive volumes of exhaust fumes, the tunnel will automatically be closed to traffic.

If a traffic accident or some other situation should occur the tunnel can be closed with immediate effect from the monitoring center. All drivers who have entered the tunnel will be given information via radio about whether they should wait or possibly turn round and drive out of the tunnel.

Problems

Shortly before the opening of the tunnel a fan caught fire in a bus carrying about 50 people through the tunnel to the ceremony in Laerdal.

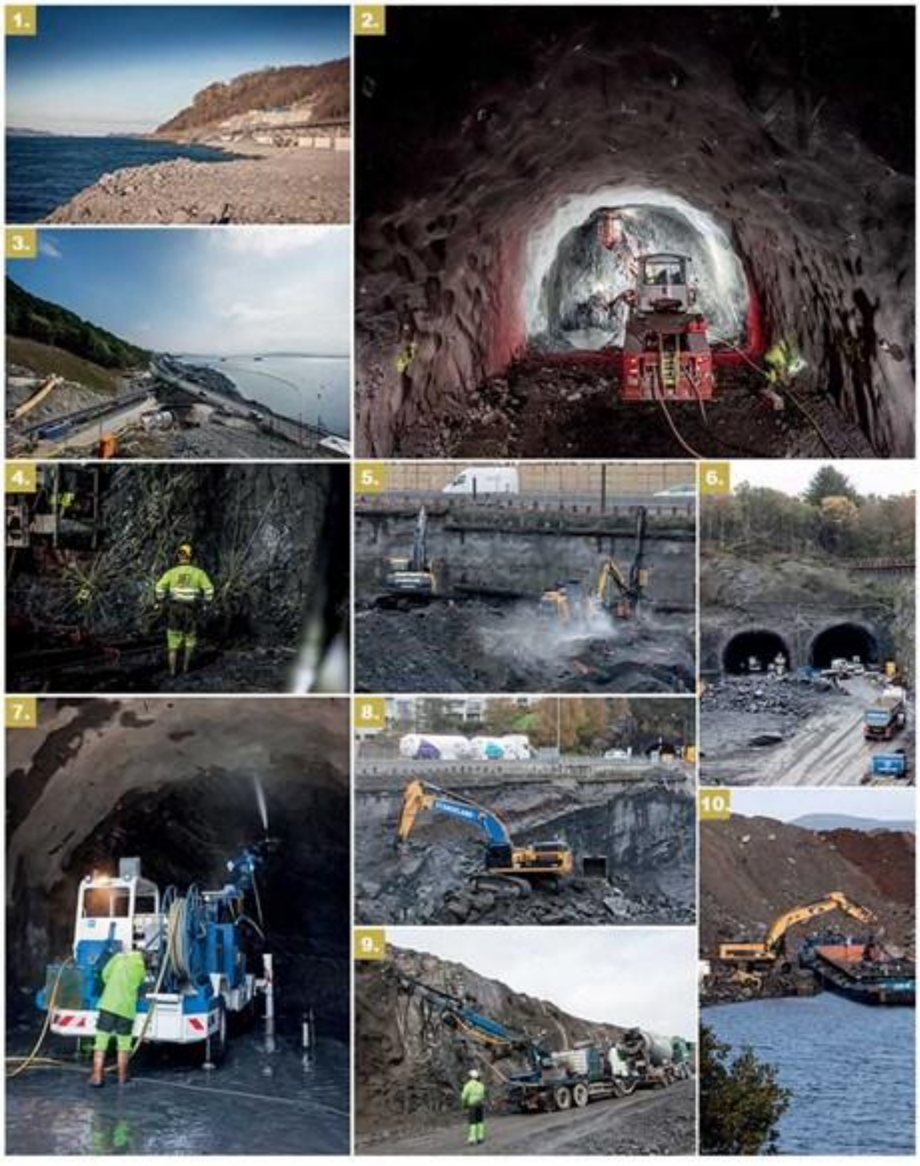
The bus filled with smoke, forcing passengers to evacuate while 8 miles inside the mountain. No one was hurt. Passengers re-boarded and drove on a few minutes later when smoke dispersed.

Contractors

Inter-consult a member of the Cowi Group was involved as electrification and automation consultant to design all electrical installations in the tunnel.

This includes electrical power systems, control systems (PLC) and emergency phone system. Inter-consult where also involved in the electrical construction of the tunnel ventilation system.

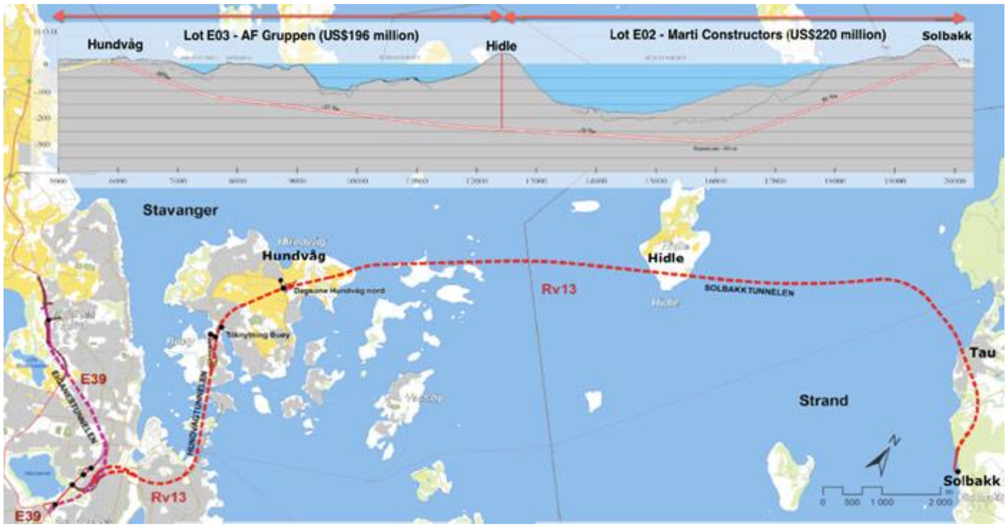
Inter-consult where instrumental in ensuring traffic safety was a key parameter in the design of the technical installations, including lighting designed to give the road user the impression of driving through several shorter tunnels instead of one long by making transition zones in the tunnel with an imitated sky (blue lighting).



1. The project will help connectivity along Norway's rugged coastline 2. Drill and blast techniques were selected as being the most suitable 3. Norway's scenic coastline may be a magnet for tourists but new road development is required 4. The blasting process has been carefully controlled to optimize safety 5. Work is being carried out on the approaches to the tunnels 6. Considerable work is needed for the approaches 7. The competent nature of the rock means that support needs are less intensive

than for some tunnel projects 8. Excavation work is being carried out from both ends of the tunnel 9. The walls of the approaches are also being shotly erected 10. Water transport plays a key role in removing spoil

The consideration and planning for tunneling was carried out keeping the fragile environment in mind. The tunneling would leave the mountains and water bodies un-polluted.



Overview	
Location	SognogFjordane, Norway
Coordinates	60°58′19″N 07°22′06″ECoordinates: 60°58′19″N 07°22′06″E
Route	E16
Operation	
Work begun	1995
Opened	2000
Operator	Norwegian Public Roads Administration
Character	Automotive
Vehicles per day	1,000
Technical	
Length	24.51 km (15.23 mi)
Highest elevation	265 m (869 ft)
Lowest elevation	5 m (16 ft)
Width	9 m (30 ft)
Grade	2.5%

Safety

The tunnel does not have emergency exits. In case of accidents and/or fire, many safety precautions have been made. There are emergency phones marked "SOS" every 250 metres (820 ft) which can contact the police, fire departments, and hospitals. Fire extinguishers have been placed every 125 metres (410 ft). Whenever an emergency phone in the tunnel is used or a fire extinguisher is lifted, stop lights and electronic signs reading: *snuogkøyrut* (English: turn and exit) are displayed throughout the tunnel and 2 other electronic signs on both sides of the entrance reading: tunnelenstengt (English: Tunnel closed). There are 15 turning areas which were constructed for buses and semi-trailers. In addition to the three large caverns, emergency niches have been built every 500 metres (1,600 ft). There are photo inspections and counting of all vehicles that enter and exit the tunnel at security centres in Lærdal and Bergen. There is also special wiring in the tunnel for the use of radio and mobile phones.[2][3]Speed cameras have been installed because of serious speeding (there are very few other completely straight roads in the region).

Air quality

High air quality in the tunnel is achieved in two ways: ventilation and purification. Large fans draw air in from both entrances, and polluted air is expelled through the ventilation tunnel to Tynjadalen. The Lærdal Tunnel is the first in the world to be equipped with an air treatment plant, located in a 100-metre (330 ft) wide cavern about 9.5 kilometers (5.9 mi) northwest of Aurlandsvangen. The plant removes both dust and nitrogen dioxide from the tunnel air. Two large fans draw air through the treatment plant, where dust and soot are removed by an electrostatic filter. Then the air is drawn through a large carbon filter which removes the nitrogen dioxide.[3]

http://international.fhwa.dot.gov/uts/uts_eu06_02.cfm

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