



Statens vegvesen

Norwegian Public Roads Administration

HARDANGER BRIDGE

INFORMATION



Golden Gate 1937 - Norwegian parliament 2006

It's 1937: The longest suspension bridge in the world, the Golden Gate Bridge, opens in San Francisco. The longest suspension bridge in Norway, the Fykkesund Bridge, opens in Hardanger. The inventor Aamund K. Bu (1972-1944) is inspired by these momentous events. In 1937, he writes in an article in the Norwegian daily Bergens Tidende that a suspension bridge could be built between Vallavik and his local village, Bu.

The following year, Hordaland County Roads Department engineer Ødegard states that a bridge of this kind is technically feasible.

Shorter ferry crossing

1969: Granvin Municipality Project Board submits a sketch of a tunnel between Kjerland and Vallavik and a suspension bridge between Vallavik and Bu.

In 1973, power development commences in the Inner Hardanger region. Road construction between Ulvik and Bruravik begins, with the aim of shortening ferry connections across the fjord. In July 1976 the ferry connection between Bruravik and Brimnes opens.

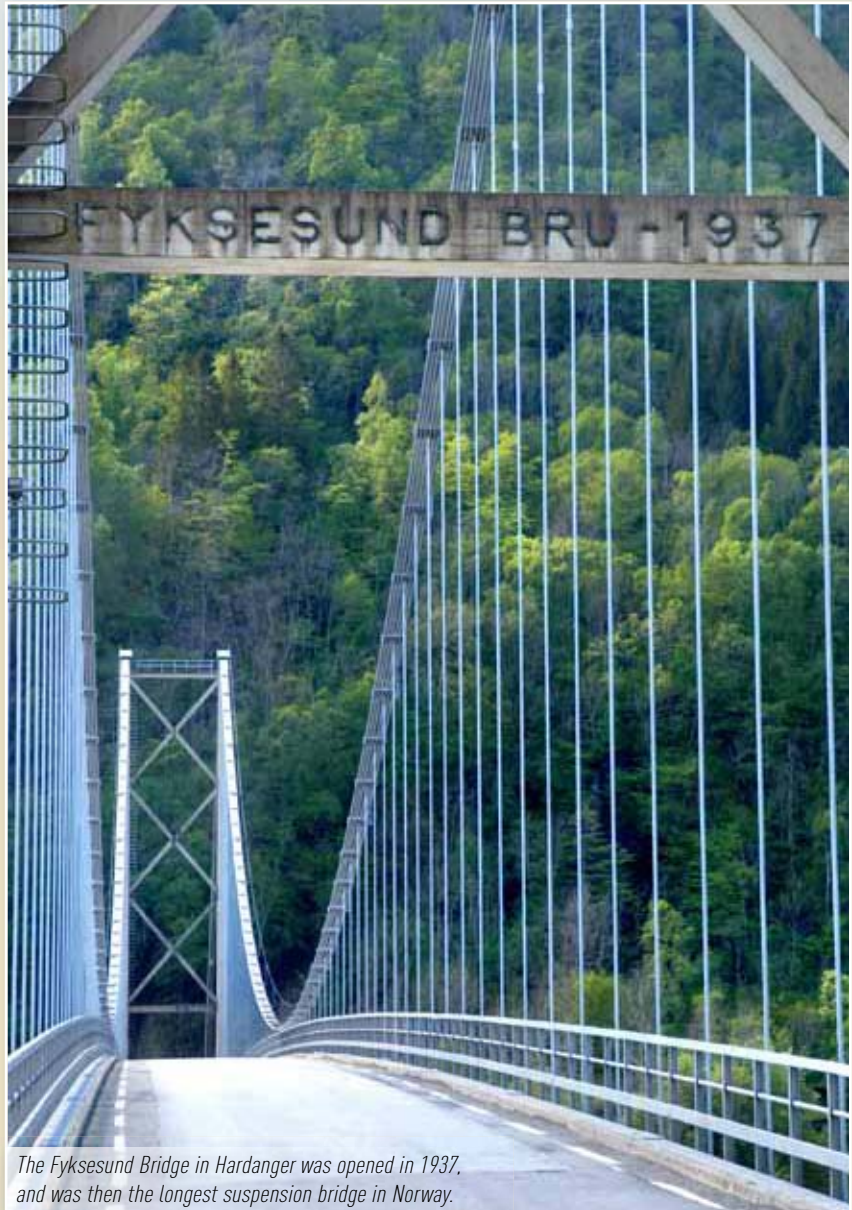
Shortly afterwards, planning of the 7510 m long Vallavik tunnel starts, and it is opened on 27 April 1985. At the same time, a working committee of the municipalities with interests in the project starts working on plans for a bridge. In 1986, the committee submits proposals for a new pilot project for the Hardanger Bridge. The following year the bridge company is formed.

NO changes to YES

On 10 April 1988, the Norwegian Public Roads Administration (NPRA) submits the main plan for the Hardanger Bridge, which is approved the following year.

In 1996 the Storting (Norwegian parliament) goes in for building the «triangular connection» and the Folgefonn tunnel in Hordaland County, but says no to the Hardanger Bridge.

Ten years later, the Hardanger Bridge is again the subject of debate in the Storting. On 28 February 2006 the Storting approves the application for toll collection, and NPRA can proceed with the engineering and in due course construction of the bridge. The Fykkesund Bridge in Hardanger was opened in 1937, and at the time was the longest suspension bridge in the country. The opening of the Vallavik Tunnel in 1985 speeded up the planning of the Hardanger Bridge.



The Fykkesund Bridge in Hardanger was opened in 1937, and was then the longest suspension bridge in Norway.

Photo: Geir Brekke



The opening of the Vallavik Tunnel in 1985 speeded up the planning of the Hardanger Bridge.

Photo: Odd Sæveraas

High tunnels

Work on the approach roads to the Hardanger Bridge commenced on 26 February 2009 in Vallavik and shortly afterwards at Bu. The Bu contract is for NOK 210 million and the Vallavik contract for NOK 190 million. Both contracts, totalling NOK 400 million, were awarded to AF Gruppen.

The assignment has covered construction of road and tunnel and blasting of a splay chamber and anchorage chamber for the bridge on both sides of the fjord.

Walkways and cycle paths were built first, and have functioned throughout the construction period as access roads for the contractors. This has saved the NPRA the need to construct separate access roads and therefore make greater incursions into the landscape during the construction period.

Architecture

A unique architectural solution has been found for the Hardanger Bridge, particularly the design of the tunnels leading up to the fjord crossing itself. At Vallavik, the roof of the tunnel rises from a height of 6 to 23 m in the last 100 m up to the portal, while the height of the tunnel mouth at Bu is 15 m.

When the Vallavik end of the tunnel was driven, there was work at several elevations at the same time, with hole-through to the fjord in April 2009. With a height of 23 m, the Vallavik tunnel up to the bridge is one of the highest road tunnel portals in the world.

At the very front, wire sawing has been used in working on the rock forming the tunnel walls, to secure the rock.

Roundabouts in the mountain

Both road tunnels have roundabouts with an external diameter of 55 m that distribute the traffic in three directions. The central island is a pillar 7 m in diameter that has been left in place. This method of leaving rock in place as a central island has also been used in other tunnel projects in Norway, and saves a great deal of blasting and not least maintenance in the future.

The stability of the pillars is assured by measuring deformation.

*Vallavik, March 2009:
Tunneling at the top
and unloading at
the bottom.*



The mouth of the Vallavik Tunnel is 23 m high.

Photo: Geir Brekke

Zone of weakness at Vallavik

The blasting at Bu took place in good quality rock. At Vallavik, however, NPRA encountered a weak zone, particularly in the area where the splay chamber was to be blasted. There were some soil-like masses that could be virtually excavated by hand in some parts of the left splay chamber.

Re-engineering took place here, and steel core piles were installed to secure the foundation for the splay saddle.

Landfills

A number of landfills were made of blasted rock. The largest is 140 000 m³, and is being used for road embankments and protection against landslides on National Highway 13 at Bugjelet. The other is about 100 000 m³ and has been used for a breakwater at Vallavik.

Photo: Geir Brekke

Breakwater at Vallavik.

Photo: Eivind Kolte



Securely anchored

The bridge is anchored in solid rock on both sides of the fjord. The terrain is steeper at Vallavik than at Bu, but both anchorage plates lie in rock caverns. Access during the construction period is through different tunnels from those that will be road tunnels up to the bridge.

The anchorage consists of two splay chambers and one anchorage chamber on each side of the fjord. The splay chamber at Bu is built into the terrain in a weak slope, while the splay chambers at Vallavik have been blasted into two rock caverns in the steep mountainside above Vallavik common.

Under the splay chambers lies the anchorage chamber, a rock cavern 40 m long and 15 m high.

Saddle and shoe

Uppermost in the splay chamber lies the cable bundle in the splay saddle, where it is split into 19 individual cables. Each of these is fastened in a cable shoe. The cable shoes are fastened in stays and plates, which in turn are fastened in the anchorage block at the lower end of the splay chamber.

The anchorage block in the splay chamber is fastened to the concrete plate in the anchorage chamber by means of a total of 76 tension cables. The tension cables pass through cement-filled holes drilled through 27 m of rock.

Three stages

The work of excavating and blasting the anchorage system started in spring 2009, and the concrete work started in the winter and spring of 2010. The steel contractor was given access to the construction site in spring 2011.



Photo: Geir Brekke

Splay chamber at Bu with walls and doors. Most of the structure will be covered with soils when the bridge is completed.

*Anchorage chamber at Bu.
These rock caverns are
40 m long and 15 m high.*



Photo: Håkon Matre



Photo: Geir Brekke

«Skyscraper»

The work on the pylons for the Hardanger Bridge commenced with the casting of the foundation at Bu in October 2009. Each foundation consists of 900 m³. Concrete pouring proceeded for 50 hours continuously on 7 and 8 October 2009. In January 2010, the foundation at Vallavik was poured. The pylon at Bu is 201.5 m high. The base of the foundation at Vallavik is 8 m higher, bringing the pylon height, including the top house, up to 193.5 m here.

Both pylons reached the 185 m contour in February 2011. In March 2011 the 4 pylon saddles were lifted into place on top of the pylons. The pylon house on the Hardanger Bridge is shaped as a 15 m high point, with completion scheduled for spring 2011.

Formwork moved 50 times

The pylon construction was carried out using climbing formwork on a total of 44 sections each representing 4 m of pouring. Climbing formwork was also adapted for the pouring of 6 shorter sections at the top of the pylons.

Construction cranes and lifts have been vital aids in the building of the pylons. At their highest point, the construction cranes along the pylons were up at over 210 metres. The cranes have solid foundations, and the two cranes by the bridge pylons were fastened into the pylon itself during the construction period.

Six transverse girders

Each pylon has three transverse girders between the pylon legs. The two lowest girders were cast in 6 stages. First the bottom, then the two walls in two parts, and finally the top. Casting of the uppermost girder, which is the smallest one, required four operations.

The greatest challenge presented by the work on the girder was getting the supporting steel trusses set up under the formwork.

Two steel framework girders were also set up between the legs of the pylon at different heights from the transverse girders as extra support during the building of the pylons.

Lifts and stairs

In March 2011, internal, permanent lifts, which are to be used for future maintenance of the Hardanger Bridge, were installed in both the bridge towers. Evacuation routes have also been installed alongside the lift. A staircase has been built in the other tower leg.

Veidekke won the concrete award for the Hardanger Bridge, where the building of the pylons was the main work activity. The formwork for the tower amounted to an area equivalent to about 4 football fields.



The Vallavik tower, viewed from Bu..

Photo: Geir Brekke



Photo: Håkon Maitre

Work on the formwork for the bridge tower at Vallavik.

Photo: Geir Brekke

The Vallavik tower.

Steel from all over the world

The steel work for the Hardanger Bridge has been in progress since autumn 2009 at different plants in both Europe and Asia.

The construction of the steel box girder started at Zhenhua Port Machinery Co., Ltd. in Shanghai, China, in summer 2010. The construction of the steel box girder which is to constitute the bridge deck between the bridge towers is part of the general contract for steel and assembly that is being performed by the Danish contractor MT Højgaard A/S.

All sections on one ship

The steel sections are first built in 12 metre long sections which are welded together into 60 metre lengths – a total of 23 sections. When the sections are completed, they receive surface treatment in the form of sand blasting and painting. The waterproofing will also be placed on the bridge deck before the whole delivery is loaded onto ships at the yard in Shanghai in January-February 2012 and then transported to Hardanger.

The actual assembly of the 23 sections will take place by lifting them from the deck of the ship by means of two cranes fastened on top of the cables. Each 60-metre section weighs 400 tons. It will take 5-6 hours to lift each section into place. After the complete bridge box girder has been lifted into position, the connecting up and completion of the bridge will start.

Cable with dehumidifier

The cable wire for the Hardanger Bridge has been manufactured by Bridon in Doncaster, England, and shipped to Norway in four deliveries.

When the scaffolding, or cat-walk, is mounted between the bridge towers in summer 2011, the cable spinning will take place from Bu, with the aid of a spinning device. In the course of about 4 months in autumn 2011, the strands will be combined into a cable with a diameter of 60 m3 between the two splay chambers on each side of the fjord and over the saddles at the top of the bridge towers. A completed cable consists of 19 cable bundles with 528 galvanized strands, each 5.3 mm in diameter. This means a total of 10 032 strands.

A separate dehumidifying system for the cable is to be established for the first time in Norway. The cable wire was also dehumidified in 2010 and 2011, when it was stored in containers on the construction site.

French hangers

In spring 2012 the hangers will be attached to the hanger clamps on the suspension cables. 120 of the in all 130 hangers in the main span of the Hardanger Bridge consist of one cable with a cast steel socket at each end. The hangers are suspended as 65 pairs on each side of the steel box girder.

120 of the hangers were made by ArcelorMittal in Bourg-en-Bresse, near Lyon in France.

Other deliveries

Højgaard has used subcontractors to manufacture anchor plates in Vietnam (IMECO in Ho Chi Minh City) and Poland (LUBSTA I AL. Jana Pawla). IMECO has made cable shoes for the splay chambers on the bridge, with subsidiary production at QILU south of Shanghai. Anchor rods were manufactured at OME in Milan, Italy.

Tower saddles, splay saddles, upper hanger clamps, the ten shortest hangers and cable terminals were produced by Goodwin Steel Castings Ltd in Stoke-on-Trent, England.

The saddles are heavy steel structures that are central elements in the suspension bridge concept.

The splay saddles weigh 23 tons each and the tower saddles 13 tons each.

Erection of the anchor rods and anchorage plates in the splay chambers started in autumn 2010.



Inspection at Stoke and finished tower saddle.

Photo: Gunnar Gundersen



Inspection of steel stays in Milan.

Photo: Ingar Fasteland

Welding in Shanghai.

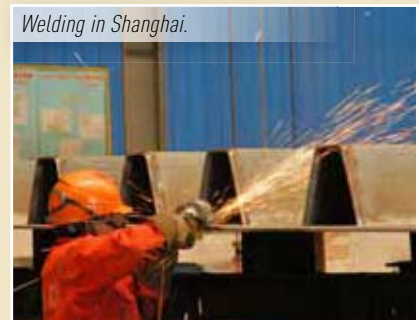


Photo: Geir Brekke

Manufacture of steel box girders in Shanghai.



Photo: Asbjørn Valen



How the bridge will look

The Hardanger Bridge will be the longest suspension bridge in Norway. It will stand out from other Norwegian suspension bridges because of its distinctive architectural features: the top houses with 15 m high, pointed terminations over the tower saddles combined with extra high tunnel mouths on both sides of the fjord. The tunnel opening will rise towards the viaducts on the bridge, with a further lift through the tunnel portals.

The tunnel opening at Vallavik will be 23 m high and that at Bu 15 m high, and it will be the only road tunnel of its kind in the world. The high openings will give road users an early view of the bridge and the fjord crossing on the way out of the tunnels.

Emphasis will be placed on good lighting in the roundabouts and the tunnel portals in the project.

Forum Arkitekter of Bergen has been responsible for the architecture of the Hardanger Bridge. The photographic illustrations on this page have been made by Forum Arkitekter, and show how the bridge will look after the opening in June 2013.





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FACTS HARDANGER BRIDGE

- **Building period:** February 2009-June 2013
- **Approach roads:** 2.4 km tunnel, 800 m road, 900 m walkway and cycle path
- **Bridge:** Suspension bridge with 1310 main span and 70 m side spans (45 m at Bu and 25 m at Vallavik) tower height 200 m, sailing height under bridge 55 m
- **Blasted material:** 350 000 m³ from tunnel, cuts and construction pits for towers
- **Amount of concrete work:** Concrete 22 400 m³, reinforcement 3 800 tons, formwork 50 000 m²
- **Amount of steel used:** 15 000 tons, about half each on the deck and suspension cables with hangers
- **Total cost:** NOK 2.3 billion (2011 NOK)
- **Funding:** 62 per cent toll, 23 per cent local government subsidies, 3 per cent saved ferry costs and 12 per cent central government funding (in the event of any additional costs, the share of government funding can be increased)

Contractor crew on the way to a new shift.

Photo: Geir Brekke

The brochure was produced in April 2011. Text: Geir Brekke, NPRA