Long span bridges in Norway, including future crossing of the Oslo Fjord

Børre Stensvold
Bridge Director
Norwegian Public Roads Administration
Directorate of Public Roads

NVF Annual Bridge Conference 2014
3rd and 4th of September, Reykjavik, Iceland
Norway is a country of bridges!

Norway’s topography is unique. Mountains, valleys, rivers and islands make bridges an integral part of our infrastructure. They are, in fact, a premise for freedom of movement and accessibility.

In short, Norway is a country of more than 17,200 bridges – you simply can’t get very far without them.

Raftsundet bridge (1991)
Cantilever, main span length 298 m, world record when built and lightweight concrete in the main span
The Norwegian Public Roads Administration

- Approx. 7,100 employees
- The total annual budget is approx. NOK 48 billion (US $: 7.8 billion)
- Two administrative levels: Directorate of Public Roads and five regions

Coastline: 28,953 km
Islands: 71,963 km
Total: 100,915 km

Population in Norway: 5,0 mill
«In–house» Bridge engineers

- In addition to the Bridge Section in the Directorate in Oslo, most of the major cities have bridge planning units
- Construction projects employees; bridge site manager
- Bridge management and maintenance expertise – throughout the country
- Emergency Preparedness Team – for rapid installation of temporary bridges when needed, for instance after a flood
Inside the concrete box girder

Height: 3,5 – 14,5m
The stiffening girder (bridge deck) consists of a truss girder and was the dominant design of suspension bridges for decades in Norway. Some examples:

- Varodd bridge (1956), main span 337 m
- Sotra bridge, (1972) main span 468 m
- Kvalsund bridge (1977) main span 525 m
- Nærøysund bridge (1981 m) main span 325 m

85 suspension and cable-stayed bridges, the oldest from 1844
Skarnsundet Bridge (1991)

Cable Stayed Bridge,
Main span 530 m (world-record when new)
Askøy bridge (1992) Bergen, Main span 850 m

Our first closed steel box girder suspension bridge
Our very first Floating Bridge
Bergsøysundet Bridge (1992), total length 931 m

• The superstructure: Steel truss and pipe junction.
• The bridge deck: orthotrop steel.
• 7 concrete pontoons – high strength lightweight concrete LC55
• At the opening, the bridge was the world's only floating bridge without any side anchoring
Our second Floating Bridge, Nordhordlands bridge (1994)

Total length 1614m, floating bridge 1246 m
- 10 lightweight concrete pontoons - lateral movement 0.5 m
- Max. fjord dept: 500m -> without side anchoring
A new box girder bridge, new challenges

• Osterøy Bridge (1997), main span 595 m, total length 1065 meter.
• Vortex–induce vertical movements gave the bridge a nickname ”The rocking bridge” when the wind was around 10 m/s (small breeze)
• Spoilers or vanes were set up on the underside of the box girder, and the movements was eliminated
In-house design team:
• 6 from Bridge Section, NPRA
• 2–3 consultants (Norconsult AS)
• Other specialists in wind engineering meteorology, geology and tunnelling, concrete technology

Hardanger Suspension Bridge (2013)
- main span length 1.310 m
Box girder cross section
Under construction: HÅLOGALAND BRIDGE (open 2017)

- Main span 1145 m
- Total length 1533 m
- Sailing height 40 m
- Main cables, diameter 0.48 m
HÅLOGALANDS BRIDGE
The Oslo Fjord crossings:

- A concept study as an early strategic analysis
The two transport routes across the Oslo Fjord

Cars

Heavy vehicles

Approx. 40% Østfold – Vestfold

All railway lines, and in fact also the main roads, are channeled towards Oslo
The starting point:

Oslo Fjord region with a population of nearly 2 million
- In addition: All of Østfold, Akershus and Vestfold, Grenland (IC Region)

The expected population growth in the Inter City region from 2.3 mill in 2010 up to 2.9 million in 2030

- The traffic increase in Oslo Fjord tunnel from about 7,000 in 2010 to about 18,000 in 2030
- The ferry could increase from about 4,500 in 2010 to approx. 6,500 in 2030

Today:
- Few social and educational contact
- The industry do not cooperate
A concept study

The actual assignment

Inspired by the process of ferry-free E39 has got politicians in Østfold and Vestfold counties to engage for a ferry-free Oslo Fjord Crossing since this is the largest ferry service in Norway;

✓ Investigate concepts for the overall transport system of the Oslo Fjord, not only in the corridor Moss – Horten
✓ Crossing with road, rail and better ferries
  – In cooperation with National Rail and The Norwegian Coastal Administration
✓ Regional effects – a common settlement and labor markets over the Oslo Fjord
✓ Environmental impacts: climate, nature, noise and air pollution

In addition:
The connection E6 – E18, Hwy 23, on the east side of the Oslo Fjord
A bridge as an alternative to new Oslo Fjord tunnel – max. gradient: 7%
We have considered many concepts

Screening based on the preliminary assessment of:

- Traffic impacts
- Costs
- Area conflicts
- Regional effects
Focus on in the final phase:

Four different concepts and a Hwy 23 Bridge

Hwy 23 New Bridge
- The planning of the second stage of a new tunnel started in 2011

The Hurum connection
- Road or road and railway

A better ferry connection (+ Hwy 19)

A bridge Moss – Horten

A tunnel Moss – Horten
An aerial view from the northwest
Bridge of Hwy 23 – road line Håøya north
Bridge East of Håøya
– a suspension bridge

Towers 200 m

Vertical ship clearance 72 m
National road 23 – bridge or tunnel?

Bridge West of Håøya
– curved bridge with pillars
Bridge West of Håøya
- curved bridge with pillars

Vertical ship clearance 55 m

÷ Many pillars
÷ Large superstructure

+ No high towers
+ Relatively low costs
National Road 23 – bridge or tunnel?

Bridge West of Håøya
– alternative with a suspension bridge
National Road 23 – bridge or tunnel?

Bridge West of Håøya
- alternative with a suspension bridge

Towers 140 m

+ Three towers and lower superstructure (3m) – less visual barrier
÷ Some more expensive than a cantilever box girder bridge
Crossing the Drøbak Channel to Hurum
Total length: $300 + 1500 + 300 = 2.100$ m
Main span length: $1.500$ m
Towers: $260$ m above sea level
The Hurum connection
- Road or road and railway

Total length: 2.470 m
2 x main spans length: 720 m
Towers: 300 m above sea level
Over fjorden 05.05.2014

75 m clearance

Concrete road deck

Steel girder
Moss – Horten connection
EU has stated new requirements for the gradient of road tunnels as shown below. This gives a subsea road tunnel a length of 16–20 km under the Oslo Fjord. A rail tunnel can here end up being nearly 50 km long! This makes it near to impossible to combine rail and road when building deep tunnels.

Gradient for road in tunnel: max. 5% (i.e. climbing 50 m/km.)

Gradient for rail in tunnel: max. 1.25% (i.e. climbing 12.5 m/km.)
Oslofjord Seismic Survey - HORTEN BASIN

Depth to Bedrock [m]
(below sea level)
3D Model
Preliminary findings

Currently, the technological feasibilities

- Undersea tunnels can be 16–18 km long (today 7.3 km). A bridge is twice the cost of an undersea tunnel in the same "track"
- Bridges south of Hurum require very long span – up to 1900 meters
- Bridge at Filtvet with span 1400 m
- Long bridge span means high tower – in a flat landscape
- Hurum connection and a bridge Moss – Horten may require 3–4 km long tunnels on land (to avoid land area conflicts)
- Possible to pass Jeløya in a rock tunnel, while thick soils further south makes this difficult
- Suspension bridges with long spans or tube bridge is not suitable for trains.
- Railway means long bridges trough the landscape
- Railway Moss – Horten is not relevant
Recommendation?
Comprehensive assessment!

- Road–benefit
- Regional effects
- Investment costs
- Operation and maintenance
- Increased emissions of greenhouse gases
- Natural Interventions
- Local environment
The concept study of the Oslo Fjords Crossings

MORE INFORMATION ON: 

- [http://www.vegvesen.no/Vegprosjekter/oslofjordkryssing](http://www.vegvesen.no/Vegprosjekter/oslofjordkryssing)
Thank you for your attention

Tana Bridge (1948) in Northern Lights
Main span 194 m