Grenland Bridge

Contract Period
1992-1996

Completion
June 1996

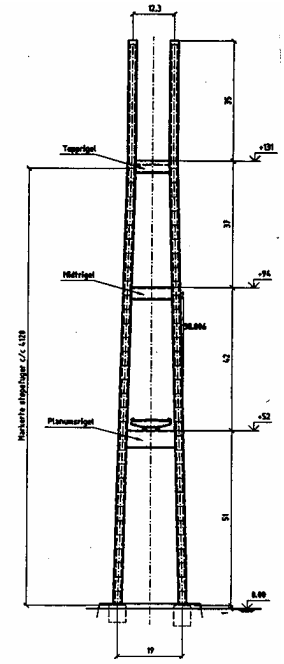
Construction cost
NOK 180 mill

Services rendered
(In association with the Bridge Department of the Public Road Administration)

- Preliminary design and Cost Estimates
- Establishment of dynamic wind climate including site measurements
- Dynamic Wind Analysis
- Detailed Design and Specifications
- Tender documents
- Construction Engineering
- Construction Drawings

Client
Norwegian Public Roads Administration

The Grenland Bridge consists of a single pylon main high level cable-stayed bridge across the Frier fjord, with a ship channel of 50 x 100 m, a back span area of approx. 67 m between the rock abutment/anchorage structures and the pylon on the north side, and an approach viaduct of total length 236 m on the south side. The main span of the cable-stayed bridge is 305 m. This is designed with a steel/LWA concrete composite deck structure. The rest of the deck is designed with a ND concrete slab in composite with the steel box. The pylon is H-shaped with a top elevation of +166 m. Most of the back stays are anchored directly to the solid rock via a steel transition structure and rock anchors to an accessible cavern on each side of the road.


Tverrrigel
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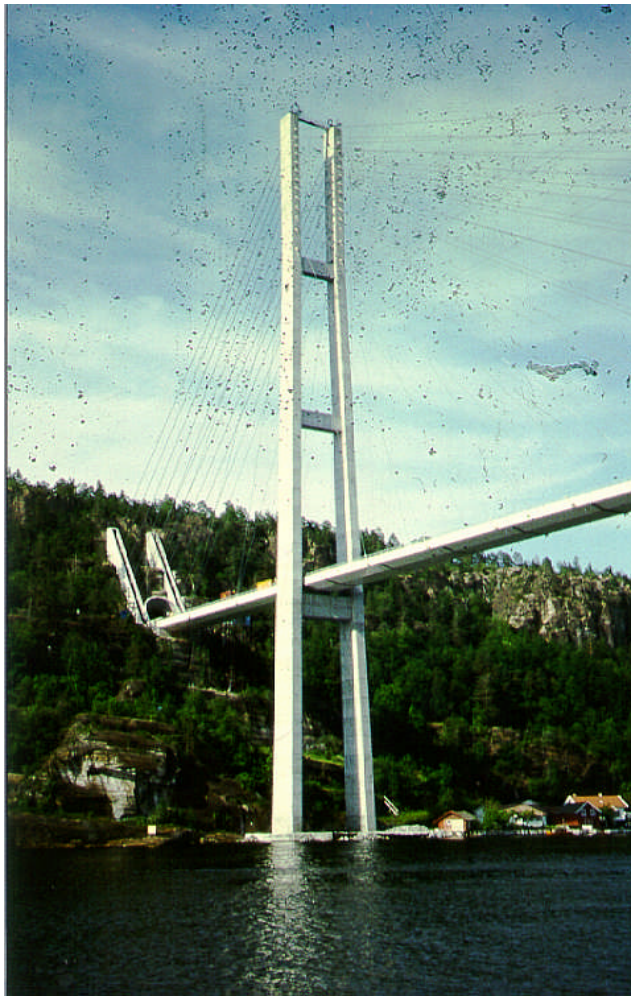
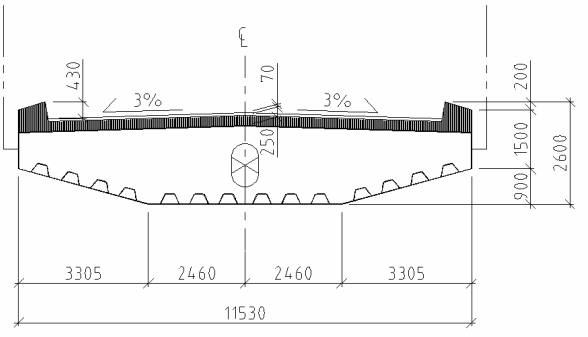
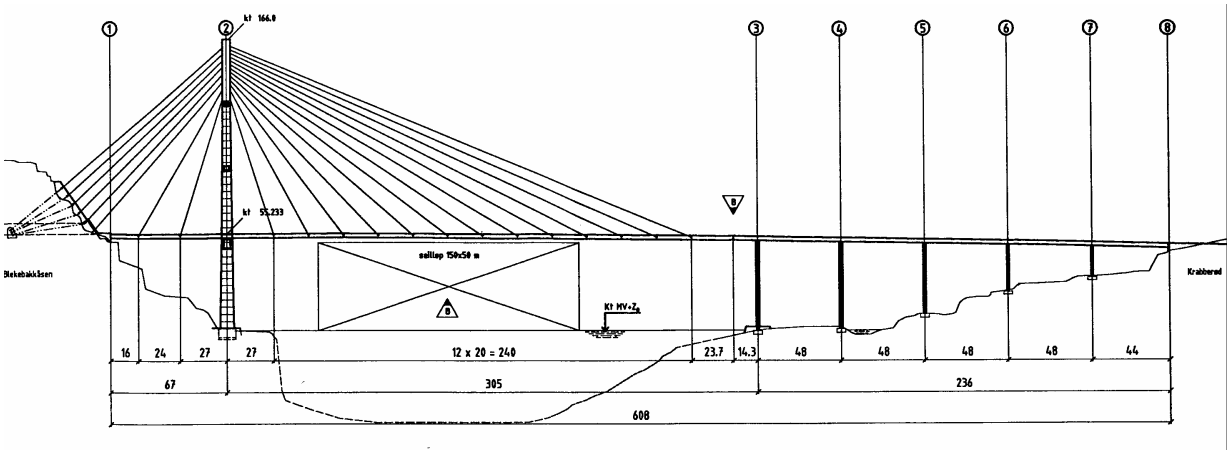
Planumsrigel




430
3%
70
3%
200
250
1500
900
2600
3305
2460
2460
3305
11530


kt 166.0
kt 51.233
seilløp 150x50 m
Kt HV+Z
Krabberød
16
24
27
27
12 x 20 = 240
23.7
14.3
48
48
48
48
44
67
305
236
608

Grenland Bridge, cont'd

Time Schedule:

Contract award, design:	Oct. 1992
Contract award, pylon:	June 1994
Contract award, steel:	Dec. 1994
Completion:	June 1996

Materials:

Stays: Ø7 - Ø131 mm lock coil ropes
High strength LWA-concrete in main span slab: LC55
ND-concrete in viaduct slab: C55
ND-concrete in pylon, etc.: C45

Geometry:

Main span: 305 m
Back spans: 67m + rock anchor abutment
Viaduct: 44 + 4 x 48 = 236 m
Width overall: 11.53 m
Top of pylon: 166 m
Ship Channel: H x B = 50 x 100 m

Climate:

Temperature: -22 to +35oC
Wind: 10 min. mean at elevation 10 m: V10,10 = 23.0 m/s
Turbulence intensity, horizontal: 0.20 V10,z
Turbulence intensity, vertical: 0.13 x V10,z

Mix design for LWA-concrete LC55:

Cement HS65:	430 kg
Silica fume:	22 kg
Sand 0-4 mm:	652 kg
Leca 800, 4-12 mm:	567 kg (exp. clay)
Water total:	214 l
Plasticizers/superpl.:	6 l
Water absorption in LECA 800:	7.5%
W/c + s (efficient):	0.39

giving the mechanical properties:

Mean strength fc,mean = (100 mm cubes)	67.4 MPa
Characteristic strength fck =	61.1 MPa
Standard deviation:	4.5 MPa
Modulus of elasticity Ec =	26100 MPa
Density =	1904 kg/m3

Design considerations

The bridge design was the winning proposal in an architectural competition. It was considered to be the most elegant bridge in harmony with the dramatic bridge site. However, it was clearly recognised that a design with two pylons would have given a more economic design.

For the single pylon bridge the anchorage of the back stays in the existing steep rock face in combination with the rock tunnel entrance is a major visual and structural element. The design of the main span with a steel box in composite with an LWA-concrete LC55 slab and edge beams was found to give the minimum cost. The slab itself was designed with LWA elements, thickness 130 mm, and a composite cast-in-place LWA-concrete LC55 topping, t = 120 mm min. Composite action with the steel box was provided by welded studs in the joints. An expansion joint was provided in the main span 14.0 m from axis 3.

Construction methods

The following construction methods were used:

- Pylon by self-climbing jump forms.
- Viaduct, span by span steel box lifted by a big crane barge and launched from span 3-4 towards the abutment. The slab was cast when the steel box was fully erected from axis 3 to 8.
- Main span by 20 m long steel segments in free cantilever lifted by a derrick travelling on the completed steel structures. The permanent stays were connected and tensioned before lifting the next segment. The concrete slab was also completed for the segment behind the derrick before the next segment was lifted. The erection procedure for the main span involved four stay tensioning steps for each pair of stays during erection and one possible final adjustment after continuity.

The effect of the somewhat varying E-modulus of the lock coil ropes was incorporated by checking the global level of the bridge beam against theoretical level for each stage.

Team involved

All field connection in the steel box was done by welding.

Client:	Public Roads Administration (PRA), County of Telemark
Design:	PRA, Bridge Department in ass. with Dr.Ing. A. Aas-Jakobsen AS
Architect:	Lund & Slaatto, Lunde & Løvseth, Hindhammar – Sundt - Thomassen
Contractors:	Pylon, etc.: Selmer A/S Steel structures, etc.: Excon A/S
Concrete supplier:	Norbetong AS, Aker Betong
LWA supplier:	Norsk Leca