Multispan suspension bridge on floating foundations

Technology Development Status
Green circles shows fjord crossings where the Multispans Suspension Bridge on TLP Foundations are concluded to be feasible solutions. In addition, Sulafjorden also shows potential for a TLP solution.
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HALSAFJORDEN BRIDGE

LENGTH: 2.5KM
SPANS: 2 x 1200M
FJORD DEPTH: 500M
BRIDGE GIRDER WIDTH: 30.6M
BRIDGE DECK HEIGHT: 3.92M
SPECIAL FEATURES: MULTISpan system, Floating support (TLP) and use of top cable
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BJØRNAFJORDEN BRIDGE

LENGTH: OVER 5KM
SPANS: 1385M + 1325M + 1385M
FJORD DEPTH: 550M
BRIDGE GIRDERS WIDTH: 30.6M
BRIDGE DECK HEIGHT: 3.92M

SPECIAL FEATURES: Multi span system, Floating support (tLP) and use of top cable
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Crossing of Bjørnafjorden

Highway E39 with Bridge
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Consept overview

Material take off:

Steel floater alternative:
127.000 ton steel
67.000 m³ concrete

Concrete floater alternative:
96.000 ton steel
146.000 m³ concrete
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Reference to other bridges

Bjørnafjorden

Akashi Bridge

Golden Gate
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**Steel Hull**
- Buoyancy through its volume

**Key Figures:**
- Outer diameter (center tether porch) 90m
- Draught as TLP 50m
- Steel weight: 16500 t
- Displacement (metric tonnes) 111 753 t

**Concrete Hull**

**Key Figures:**
- Outer diameter (center tether porch) 90m
- Draught as TLP 47.5m
- Concrete volume: 39 000m³
- Displacement (metric tonnes) 173 000 t
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ANCHOR SYSTEM

- The vertical force from the tension legs are secured to the seabed through the weight of the anchor, provided by the mass in the top of the anchor and suction forces from the part of the anchor that penetrates the seabed.

KEY FIGURES:
Tether pretension: Approx 300 MN in total
Tethers: 12 (16 concrete alternative) Pipes Ø1118x38 mm
Tether lengths: 500 and 400 m, axis 5 and 6 respectively
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Anchor block

Concrete: 15 000 m^3
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Bridge girder

* Aerodynamic steel box girder
  - Transverse truss components every 4 meters
  - Road consists of 2 vehicle lanes and a footpath
  - Total width of girder 30.6 meters
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Steel floater

Central towers
- Diamond shape and made of steel
- Lightweight, easy constructable and durable
- The towers on land are conventional A-shaped towers of concrete
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Hanger system

- The hangers are connecting the bridge girder to the main cable
- Connected every 24 meters along the bridge
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Top and Main cable sections

**Top Cable**

**Main Cable**

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Transverse stiffness

The system provides high stiffness in the vertical direction and for rotation of the two horizontal axes.

For transverse displacements the tension in tethers, suspension cables and top cables provide a restoring force which limits the maximum dynamic transverse displacements from wind, wave and current to about 30 m.
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Use of top cable instead of stiff towers
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Dynamic eigenmodes

**Plan view**

**Mode 1:**
*Half sine wave TC ~ 110 s, TS ~ 80 s*

**Mode 2:**
*Sine wave TC ~ 70 s, TS ~ 60 s*

**Side view**

**Vertical mode:**
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Construction methods 0 – 36 mths
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Construction methods 36 – 52 mths
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Construction methods 52 – 60 mths
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Construction methods 60 – 72 mths
The Bjørnafjorden suspension bridge is a combination of known technology put together in a new way. The buoyancy is provided by the TLPs and the bridge is of a suspension type. This bridge will be the first of its kind, i.e. there will not be any matching reference of the combination of the technologies, upon which the project can rely.

With a conceptual onset as a classical suspension bridge, its extraordinary features are:

• its length is beyond normal
• it is a multi-span suspension bridge for which only few references exist
• it has top cables between pylon tops (very few existing references)
• it is supported on somewhat flexible supports (TLPs)
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Summary phase 2

The Phase 2 study emphasized the following items:

• technical feasibility
• structural stability (system stability)
• in–service performance (movements and accelerations on bridge deck)
• overall risks and accidental impacts (ship collision etc.)
• main structural component sketch designs and dimensions
• operation and maintenance
• construction principles including working conditions (movements and accelerations)
• indicative quantity estimates
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Conclusion. Phase 2

The overall conclusion is that the proposed bridge performs well for the environmental conditions in Bjørnafjorden, has a large safety margin with respect to vessel impact, can be constructed with known technology, has acceptable up-time and predictable maintenance costs.
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Consultant group, phase 2, finished summer 2016
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THANK YOU FOR YOUR ATTENTION.