About the Network Arch Bridge

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Topics

1. History of Network Arch Bridges
2. Concept
3. Bridges around the world
3. Case study
Network arches

Network arch

Nielsen bridge
Idea

Per Tveit, dr. Eng, Docent Emeritus, Norway, per.tveit@ui.a.no

http://home.ui.a.no/pert/index.php/Home
History of Network Arch Bridges

193 t

132.6 m

679 t
General recommendations

1. The arch
2. The hangers
3. The lower chord
The arch

- steel, often circular
- American wide flange – easy to find
- Longer spans – box section
The arch

b/t = 31.25, A=69696 mm^2
The arch shape

Brunn and Schanack, 2003
Arch rise

15 – 17 % of the span
The hangers

- Wires or rods
- No compression
- Hangers can relax – network ≠ truss

Increase in the bending moments
The hangers

A 25\times 3.9\text{m} \quad 24\times 4.1\text{m} \quad B

12\times 3.9\text{m} \quad 12\times 4\text{m}
The hangers

The radial arrangement
The hangers

Φ = 40-60mm
Protection
Lower chord = deck
{}
Why?

Fig. 28. Åkviksund Bridge. Designed in year 2001.
Why?

Fig. 29. Steel weight in various arch bridges.
Comparison of weight per m² of useful bridge area

<table>
<thead>
<tr>
<th>Material</th>
<th>100%</th>
<th>Reduction</th>
<th>58%</th>
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</thead>
<tbody>
<tr>
<td>Structural steel incl. prestressing steel</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reinforcement</td>
<td>100%</td>
<td></td>
<td>34%</td>
</tr>
<tr>
<td>Concrete</td>
<td>100%</td>
<td></td>
<td>24%</td>
</tr>
<tr>
<td>Min. weight to be moved during erection</td>
<td>100%</td>
<td></td>
<td>46%</td>
</tr>
<tr>
<td>Pillars are the same for both bridges</td>
<td>100%</td>
<td></td>
<td>33%</td>
</tr>
<tr>
<td>Savings in cost are probably 35 - 45% per m² of useful bridge area.</td>
<td></td>
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</tbody>
</table>
Fig. 7. Bridge at Steinkjer, Norway, built 1963-1964
Bridges around the world

Fig. 13. Details in arch at Steinkjer.

Fig. 15. Fastening of a hanger to the arch.

Fig. 16. Joint in wind-bracing.
Fig. H5. The Bolstadstraumen Network Arch seen from the south
Bridges around the world
Waikato River Network Arch

Figure 1. Waikato River Network Arch. Span 100 m. Built 2010. Opened 2011.

Figure 3. Waikato River Bridge Top Chord Sections
Bridges around the world

Fig. 40e shows a two track railway bridge spanning 100 m designed by Brunn and Shanack

Fig. 40f. Reinforcement for a tie in the railway bridge in fig. 40e
Bridges around the world
Flora Bridge over the Mitteland Canal in Germany
Network arch over B6 at Halle
NETWORK ARCH BRIDGE OVER THE RIVER LUZNICE (Czech Republic) Built 2005
Designer: Ladislav Šašek, PhD, Mott MacDonald, Prague

Fig. 96a. Longitudinal section
Bridges around the world

- Covered street lights
- Stainless rods Ø 40
- Steel bridge railing
- Pavement waterproofing 2.5%
- Ties 2xC 180
- Tendons 2x15 Ø 0.67
- C35/45

Dimensions:
- 290
- 1340
- 545
- 7930
- 3600
- 545
- 1340
- 290
- 580
- 180
- 2.5%
- 85
- 300
Bridges around the world
Bridges around the world

Fig. 101. The Brandanger Sound Bridge was lifted onto the pillars on the 7th of September 2010

THE BRANDANGER BRIDGE IS THE WORLD’S MOST SLENDER ARCH BRIDGE
Fig. 100. Final design of the Brandanger Bridge
TROJA BRIDGE IN PRAGUE
Fig. 4 Precast transversal beams stored on the site prior to assembly
“Palma del Río” bowstring arch Bridge. Córdoba. Spain.
Bridges around the world
Bridges around the world
Blennerhassett Island Bridge, 268m
Fig. 3 – Typical Section at Floorbeam

Fig. 4 – Network Tied Arch Elevation

Fig. 5 – Rib Bracing
Cross-section

ARCH PLANE

13.30
9.30
7.80
3.50
3.50
40
75
25
1.50
1.00
1.50
2.5
2.5
45
24
22

ARCH PLANE

77.00
Case study

The arch – HD 400x634
Case study

The hangers – Full locked coil strands

The tie – concrete beam C40/50
Case study

The model
Live load: LM1 + pedestrians 3 kN/mp – 1 sidewalk

Banda nr. 1
- $Q_1 = 300\text{kN}$
- $q_1 = 9\text{kN/mp}$

Banda nr. 2
- $Q_2 = 200\text{kN}$
- $q_2 = 2.5\text{kN/mp}$

Banda nr. 3
- $Q_3 = 100\text{kN}$
- $q_3 = 2.5\text{kN/mp}$

Suprafata ramasa
- $q_f = 2.5\text{kN/mp}$
Load cases:
- Dead load
  - Structure
  - Asphalt, railings, etc.
- Live load
  - LM1 – TS + UDL
  - Pedestrians
- Wind
  - Wind x
  - Wind y
  - Wind z

Load combinations:
- Dead load
  - SLS
  - ULS.
- Dead + Live+Wind
  - SLS
  - ULS
Hangers – tension vs no tension
- deflection - dead weight

Equivalent Loads - Free Body Diagram (Concentrated Forces in KN, Concentrated Moments in KN-m)
- Dist Load (2-dir): 46.73 KN/m at 74.44167 m (Positive in -2 direction)
- Shear V2: 289.662 KN at 74.72000 m
- Moment M3: 477.0737 KN-m at 6.75429 m
- Deflection (2-dir): 0.278936 m at 33.50000 m (Positive in -2 direction)
Tension in the hangers vs. no tension
- deflection - dead + live

Equivalent Loads - Free Body Diagram (Concentrated Forces in KN, Concentrated Moments in KN-m)

- Dist Load (2-dir)
  53.85 KN/m at 74.44167 m
  Positive in -2 direction

- Shear V2
  811.370 KN at 74.72000 m

- Moment M3
  1250.4149 KN-m at 6.75429 m

Deflections

- Deflection (2-dir)
  0.748973 m at 40.12875 m
  Positive in -2 direction
Tension in the hangers

**deflection** - TS vs UDL

**Equivalent Loads - Free Body Diagram** (Concentrated Forces in KN, Concentrated Moments in KN-m)

- **Dist Load (2-dir)**
  - 0.00 KN/m at 77.00000 m
  - Positive in -2 direction

- **Resultant Shear**
- **Shear V2**
  - 511.718 KN at 74.72000 m

- **Resultant Moment**
- **Moment M3**
  - 683.386 KN-m at 6.75429 m

- **Deflections**
- **Deflection (2-dir)**
  - 0.307817 m at 42.82313 m
  - Positive in -2 direction
Forces – tension
- Axial force in the **TIE** + bending moment
- dead load

**Resultant Shear**

**Shear V2**
- 429.104 KN at 74.72000 m

**Resultant Moment**

**Moment M3**
- -575.6799 KN-m at 74.72000 m

**Resultant Axial Force**

**Axial**
- 6593.375 KN at 76.43000 m
Forces – no tension
- Axial force in the TIE + bending moment
- dead load
Forces – tension
- Axial force in the **TIE** + bending moment
- DEAD + LIVE
Case study

Forces – NO tension
- Axial force in the **TIE** + bending moment
- DEAD + LIVE

**Resultant Axial Force**

- **Axial**
  - 17752.956 KN at 58.81000 m
  - 16640.489 KN at 58.81000 m

**Resultant Shear**

- **Shear V2**
  - 1333.884 KN at 74.72000 m
  - -1325.380 KN at 2.28000 m

**Resultant Moment**

- **Moment M3**
  - 2295.6678 KN-m at 6.75429 m
  - 1661.6396 KN-m at 6.18714 m
Forces – tension
- Axial force in the ARCH + bending moment
- DEAD

Resultant Axial Force

Axial
-8044.668 KN
at 5.59151 m

Resultant Shear

Shear V2
-92.791 KN
at 0.00000 m

Resultant Moment

Moment M3
-313.0838 KN-m
at 0.00000 m
Forces – NO tension
- Axial force in the ARCH + bending moment
- DEAD

- Resultant Axial Force: Axial
  -7581.644 KN
  at 5.59151 m

- Resultant Shear: Shear V2
  -146.978 KN
  at 0.00000 m

- Resultant Moment: Moment M3
  -417.3206 KN-m
  at 0.00000 m
Forces – NO tension
- Axial force in the ARCH + bending moment
- DEAD + LIVE
Forces – tension
- Axial force in the ARCH + bending moment
- DEAD + LIVE
LM1 – static vs moving load
Deformed shape – relaxed hangers

Dead

Dead + live
Welcome to my homepage

The network arch bridge is an arch bridge with inclined hangers. Some of the hangers cross each other at least twice.

If you are not familiar with network arches and have 4 minutes, you can read the first page of The Network Arch.

If you want more information you might start reading Preliminary Design of Network Arch Road Bridges with two examples spanning 93 m and 120 m. You can find it here.

If you would like to have a good general updated knowledge on network arches, read "On Network Arches for Architects and Planners".

There is a lot of information in the 18 pages in "About The Network Arch". It can be found here.

A lot of information on network arches can be found here. These 15 pages were presented at NSBA World Steel Symposium in San Antonio, USA, November 2009.

If you are looking for information on a specific piece of information, it might be best to look at the index on page 2 of "Systematic Thesis"

Bibliography
http://home.uia.no/pert/index.php/Home
Thank you for your attention!

Questions?