Telford, Brunel and British Metal Forms

1780’s to 1880’s British Structural Engineering

New materials and new forms
Form, forces, and efficiency in long span bridges
Saltash vs. Britannia bridges and struggles with the discipline of economy
Iron Bridge (100 ft [30.5 m]) - Abraham Darby - 1779
Telford’s Buildwas Br. - 1795

Darby’s Iron Bridge - 1779
Pont y Cysyllte Aqueduct - 1805
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Exercise:
Write down at least one point under each ‘s’ for the Llangollen aqueduct
Tour de France
Telford/Eiffel video
1810 Telford proposal for Menai Straits
DRAFT for the SUSPENDED STRUCTURE for the proposed IRON ARCH over the RIVER at SYVY-HOCH.
Still in 1810…
Craigellachie Bridge - 1814 - 150 ft [46 m]
Minute “paper”:

- Draw an alternative arrangement of members to connect the deck and arch of the Craigellachie bridge
- Compare your results with your neighbor. Explain why you chose your arrangement
Telford \textit{proposal} for Runcorn Gap (1000 ft [305 m] span!, developed 1814 to 1818)
Telford’s most famous work: Menai Straits
CROESO I BORTHWAETHWY
WELCOME TO MENAI BRIDGE
Menai Straits Bridge - 1826 - 580 ft [177 m] (longest in the world at completion)
Runcorn Gap proposal 1000 ft [305 m]

Menai Straits completed 580 ft [177 m]
Clifton Bridge - I.K. Brunel - 1864
702 ft [214 m] (vs 580 ft [177 m] for Menai)
Without calculations or research, what issues in the design do you think would affect the economy of these alternative bridge designs?
Britannia Bridge - Stephenson - 1850
460 ft [140 m] spans
Brittania today
Saltash Bridge - Brunel - 1859 - 455 ft [139 m]
<table>
<thead>
<tr>
<th></th>
<th>Britannia</th>
<th>Saltash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency</td>
<td>Hollow box</td>
<td>Lenticular</td>
</tr>
<tr>
<td></td>
<td>460 ft span</td>
<td>455 ft span</td>
</tr>
<tr>
<td></td>
<td>7000 lb/ft</td>
<td>4700 lb/ft</td>
</tr>
<tr>
<td>Economy</td>
<td>£ 198 /ft</td>
<td>£ 102 /ft</td>
</tr>
<tr>
<td>Elegance</td>
<td>Form not expressive</td>
<td>Form ambiguous</td>
</tr>
</tbody>
</table>

1 ft = 0.305 m
1 lbf = 4.45 N
What considerations may have led to the very different (lenticular vs. suspension) bridges built at the same location? 

List as many as you can.
Circling back to Brunel’s 1864 world’s longest Clifton Suspension Br.
702 ft [214 m] main span, vs. 580 ft [177 m] at Menai
Eiffel Tower Structural Study

introduction to statics
Tools and methods for structural analysis

Free body diagrams
Equilibrium
Load path
Free Body Diagrams
gravity
- Top Platform: 340 ft
- Intermediate Platform: 444 ft
- Second Platform: 380 ft
- First Platform: 106 ft
- Bottom Section: 300 ft
- Tower Height: 984 ft
$F h = M$
$P = wH$

$P = (2.6)(984)$

$P = 2600 \text{ kips}$

$p = 2.6 \text{ k/ft}$

$H = 984 \text{ ft}$
gravity

reactions
wind = TC

wind

T

C

reactions

M

reactions
Wind force $P$

Stretching (tension)

Shortening (compression)
Civil Engineering Units

• Lots of imperial units..
• The kip? kip = kilopound = 1000 lb
• The psf? a pound per square foot
  – say you weigh 150 lb and are standing on a part of the floor which is 1ft x 1ft, you are = 150psf
  – other way – say a constant wind of 40 psf is blowing on a building which is 100ft x 100ft across – the force is 40psf X 100ft X 100ft = 40,000 lb
  – 40,000 lb = 40 kips
• Also… psi and ksi, pound/sq. in, and kip/sq. in
  – Materials may be described as having limit stresses in psi or ksi, e.g., typical yield stress of steel = 50 ksi
Equilibrium
\[ \Sigma M_{\text{section}} = 0 \Rightarrow M - p(H-h)(H-h)/2 = 0 \]
\[ \Sigma M_{\text{section}} = 0 \rightarrow M - p(H-h)(H-h)/2 = 0 \]

\[ M = p(H-h)(H-h)/2 = P(H-h)/2 \]
\[ M = [p(H-h)][(H-h)/2] = P(H-h)/2 \]

\[ C = -T = M/w \]
\[ M = [p(H-h)][(H-h)/2] = p(H-h)^2/2 \]
Load path

or, how the load travels to the ground
All forces or loads must eventually get to the ground. Can we trace the path of tension of compression?
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**locomotive**

**Secondary load path**