Cable-Stayed Bridges
History, Aesthetics, Developments

Lecture Themes
- Germany rebuilds, role of technology & society in creating new forms
- Understanding cable-stayed bridge form: cable, pylon, deck, material
- Contrasting cable-stayed bridges with suspension bridges
- Unique challenges and solutions in multi-span cable-stayed bridges
- National experiences beyond Germany: America, Japan, China
- Potential for play and future forms for cable-stayed bridges

Collapse of the Salle River Bridge
1818 reconstruction

Navier
1823
Memoir on Suspension Bridges
1830, Scotland, still in service

L, Bucknell perspectives professor; R, W. McCosh current owner

1873

(a) deck axial forces

www.structurae.de Nicolas Janberg
Germany rebuilds

F. Dischinger
1887-1953

1955 Stromsund Br
(Dischinger designed, 1st modern cable-stayed)

1957 Theodor Heuss Bridge

F. Leonhardt

1961 Severinsbrücke

www.structurae.de
German cable-stayed bridges 1955-1979
Dischinger, Leonhardt, Holmberg, others.

How do innovations arise?
Pressing social need (15,000 bridges destroyed in the war) and a system that ultimately proved economical for intermediate spans.

How are innovations related to the culture in which they arise?
Truss bridges also would have worked (cheaper too!). Germans rejected old forms on aesthetic grounds, instead had an expressed desire for elegance (technic?) which led to experiments in new forms. Also, German design competitions led to innovation in systems.

How did new technology influence the development?
Structural analysis innovations allowed for new confidence, but new technology came primarily from construction desires: high strength wire, hydraulic jacking, cantilever construction to name a few.
Usually if we speak of cable-stayed bridge design parameters, we have their cable-arrangement, pylon-geometry, the cross-sections and the materials of their deck etc. in mind. But the overall layout is considered to be more or less invariable: a three-span arrangement with two pylons, a main-span and two holding down side-spans, and occasionally half of that with one pylon.

Schlaich, J.
cable-stayed pylons/towers

suspension bridge towers

cable-arrangement: fan or harp, single or multiple

pylon-geometry: portal, A, tower, inverted Y (λ)

deck cross-sections: rigid ➔ flexible, continuous

materials: almost exclusively steel

German examples 1955-1979
Dischinger, Leonhardt, Holmberg, others.

cross-sections

<table>
<thead>
<tr>
<th>Arrangement</th>
<th>Deck cross-sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin girders</td>
<td><img src="image1" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Single rectangular box girder</td>
<td><img src="image2" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Central box girder and side single web-girders</td>
<td><img src="image3" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Single twin cellular box girder and sloping struts</td>
<td><img src="image4" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Single trapezoidal box girder</td>
<td><img src="image5" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Twin rectangular box girder</td>
<td><img src="image6" alt="Deck cross-section" /></td>
</tr>
<tr>
<td>Twin trapezoidal box girder</td>
<td><img src="image7" alt="Deck cross-section" /></td>
</tr>
</tbody>
</table>

the exception to the German rule

1962
Maracaibo Br.
by
R. Morandi
Challenges in multi-span cable-stayed bridges

Figure 1 - Structural concept of the Maracaibo Bridge

1962
Maracaibo Br.
by
R. Morandi

2004
Milau Viaduct
by
M. Virlogeux
Temporary wind restraints for Ting Kau during construction
Fred Hartman Bridge (Houston Ship Channel) 1995
image courtesy www.engr.uky.edu

Stay Cable Vibrations

Stay Cable Vibrations
Hitsuishijima and Iwagurojima

Great Seto Bridge (some projects are on a grand scale!)

Meiko Nishi Br.

Yokohama Bay Br.
“experiments” in cable-stayed forms

Usually if we speak of cable-stayed bridge design parameters, we have their cable-arrangement, pylon-geometry, the cross-sections and the materials of their deck etc. in mind. But the overall layout is considered to be more or less invariable: a three-span arrangement with two pylons, a main-span and two holding down side-spans, and occasionally half of that with one pylon.

However, the cable-stayed bridge concept offers more and can adapt to very special boundary conditions… the outcome may be e.g. one out of a large number of feasible multi-span arrangements, or a combination of cable-stayed and cable-supported. Other situations may call for cable-stayed bridges, where the deck is not straight in plan but curved, or even for convertible or folding decks.

Schlaich, J.
Tension in architecture vs. engineering in Cable-stayed bridges - Calatrava
where do we go from here?

7 of the 10 longest cable-stayed bridges are now in China.

Since 2000 over $\frac{1}{2}$ of all long-span cable-stayed bridges (>2000m) have been completed in China.

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Span (m)</th>
<th>Traffic</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Toara Bridge</td>
<td>800</td>
<td>Road</td>
<td>Japan</td>
<td>1999</td>
</tr>
<tr>
<td>2</td>
<td>Normandie Bridge</td>
<td>856</td>
<td>Road</td>
<td>France</td>
<td>1996</td>
</tr>
<tr>
<td>3</td>
<td>Qingdao Minjiang Br.</td>
<td>605</td>
<td>Road</td>
<td>China</td>
<td>1996</td>
</tr>
<tr>
<td>4</td>
<td>Yangpu Bridge</td>
<td>602</td>
<td>Road</td>
<td>China</td>
<td>1993</td>
</tr>
<tr>
<td>5</td>
<td>Meke Chao Bridge</td>
<td>599</td>
<td>Road</td>
<td>Japan</td>
<td>1997</td>
</tr>
<tr>
<td>6</td>
<td>Xupu Bridge</td>
<td>590</td>
<td>Road</td>
<td>China</td>
<td>1996</td>
</tr>
<tr>
<td>7</td>
<td>Skarosund Bridge</td>
<td>530</td>
<td>Road</td>
<td>Norway</td>
<td>1991</td>
</tr>
<tr>
<td>8</td>
<td>Tsurumi Fairway Bridge</td>
<td>519</td>
<td>Road</td>
<td>Japan</td>
<td>1994</td>
</tr>
<tr>
<td>9</td>
<td>Øresund Bridge</td>
<td>490</td>
<td>Road/Rail</td>
<td>Denmark/Sweden</td>
<td>2000</td>
</tr>
<tr>
<td>10</td>
<td>Iguchi Bridge</td>
<td>490</td>
<td>Road</td>
<td>Japan</td>
<td>1991</td>
</tr>
</tbody>
</table>

Table 1. The ten longest cable-stayed bridges at the turn of the millennium.

(2008 Sutong Br. in China, 1088m became the longest)
UMass notes

• Journal entry due midnight 3/25
• Exam next week Thursday, study guides available on course website ce.jhu.edu/perspectives
• HW7 makeup due March 27th

Lecture Themes
Germany rebuilds, role of technology & society in creating new forms
Understanding cable-stayed bridge form: cable, pylon, deck, material
Contrasting cable-stayed bridges with suspension bridges
Unique challenges and solutions in multi-span cable-stayed bridges
National experiences beyond Germany: America, Japan, China
Potential for play and future forms for cable-stayed bridges
Ancillary and Superseded Slides

Swiss cable-stayed
Christian Menn’s designs
(we will learn more about Menn...)

Mathis – www.structurae.de
a. Rigid deck, with different possible types of connection between deck and piers.

b. Intermediate solutions, with rigidity distributed between piers deck and pylons.

c. Rigid pylons and flexible deck, with a transmission of moments between pylons and piers.

a. Static configuration.

b. Loading the main span.

c. Loading a side span.
Fig. 3 Dischinger’s proposal for a bridge between Köln and Mühlheim.