Cable-Stayed Bridges

History, Aesthetics, Developments

Load path: cable stayed v. suspension
Cable stayed bridges in postwar Germany
Visual/structural elements of a cable stayed bridge
Stiffness in cable stayed bridges
American, Japanese, and Swiss cable stayed bridges
Saale River Bridge, Nienburg.
Source: Walther, René Ponts haubanées

1818 reconstruction
Navier
1823
Memoir on Suspension Bridges
Germany rebuilds

F. Dischinger
1887-1953
1955 Stromsund Br.
Theodor Heuss Bridge

F. Leonhardt

www.structurae.de
1961 Severinsbrücke
1969 Kniebrücke

Janberg - www.structurae.de
1967 Rees Br.
1974 Köhlbrand

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

How do innovations arise?

How are innovations related to the culture in which they arise?

How did new technology influence the development?
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.
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.
Load Paths in Cable Stayed Bridges during construction

Plot of total deck compression

Weight of deck section
Load Paths in Cable Stayed Bridges during use

live load
cable-arrangement
cable-arrangement

1961 Severinsbrücke
cable-arrangement

1961 Severinsbrücke

1957 Theodor Heuss Bridge
cable-arrangement

1955 Stromsund Br.
cable-arrangement

1955 Stromsund Br.

1967 Rees Br.
pylon-geometry
pylon-geometry
Fig. 1.31  Space positions of cables
(a) Two vertical planes system  (c) Single plane system
(b) Two inclined planes system  (d) Asymmetrical plane system
<table>
<thead>
<tr>
<th>Arrangement</th>
<th>Deck cross-sections</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Twin girder</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>2 Single rectangular box girder</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>3 Central box girder and side single web girders</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>4 Single twin cellular box girder and sloping struts</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>5 Single trapezoidal box girder</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>6 Twin rectangular box girder</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
<tr>
<td>7 Twin trapezoidal box girder</td>
<td><img src="#" alt="Diagram" /></td>
</tr>
</tbody>
</table>
German examples 1955-1979
Dischinger, Leonhardt, Holmberg, others.

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
the exception to the German rule

1962
Maracaibo Br.
by
R. Morandi
Figure 1 - Structural concept of the Maracaibo Bridge
a. Static configuration

b. Loading a central span

c. Loading an adjacent span
1962
Maracaibo Br.
by
R. Morandi
2004
Milau Viaduct
by
M. Viogoleux
a. Intermediate support: every second span.

b. Head-cables.

c. Long cables from a pylon head to an adjacent pylon at the deck level.

d. Cable-stays coming from both adjacent pylons to support the central part of each span.
Temporary wind restraints for Ting Kau during construction
The American Experience
The Japanese Experience
1977 Rokko Br.
Hitsuishijima and Iwagurojima
Meiko Nishi Br.
Swiss cable-stayed
Christian Menn’s designs
(we will learn more about Menn...)
“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._
Fig. 2: "Obere Argen Bridge": Proposal
Fig. 16: Folding Bridge, Kiel, completed 1998
Fig. 12: Model of the Railroad Bridge, Bad Cannstatt (under design)
where do we go from here?
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Span</th>
<th>Traffic</th>
<th>Country</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Tatara Bridge</td>
<td>890 m</td>
<td>Road</td>
<td>Japan</td>
<td>1999</td>
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<tr>
<td>2</td>
<td>Normandie Bridge</td>
<td>856 m</td>
<td>Road</td>
<td>France</td>
<td>1995</td>
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<tr>
<td>3</td>
<td>Qingzhou Minjiang Br.</td>
<td>605 m</td>
<td>Road</td>
<td>China</td>
<td>1998</td>
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<tr>
<td>4</td>
<td>Yangpu Bridge</td>
<td>602 m</td>
<td>Road</td>
<td>China</td>
<td>1993</td>
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<tr>
<td>5</td>
<td>Meiko Chuo Bridge</td>
<td>590 m</td>
<td>Road</td>
<td>Japan</td>
<td>1997</td>
</tr>
<tr>
<td>6</td>
<td>Xupu Bridge</td>
<td>590 m</td>
<td>Road</td>
<td>China</td>
<td>1996</td>
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<tr>
<td>7</td>
<td>Skarnsund Bridge</td>
<td>530 m</td>
<td>Road</td>
<td>Norway</td>
<td>1991</td>
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<tr>
<td>8</td>
<td>Tsurumi Fairway Bridge</td>
<td>510 m</td>
<td>Road</td>
<td>Japan</td>
<td>1994</td>
</tr>
<tr>
<td>9</td>
<td>Øresund Bridge</td>
<td>490 m</td>
<td>Road+rail</td>
<td>Denmark/Sweden</td>
<td>2000</td>
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<tr>
<td>10</td>
<td>Iguchi Bridge</td>
<td>490 m</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)
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 (>20) have been completed in China.
Announcements

- Modeling HW due next Tuesday
- Modeling help session Monday 6:00 in 211
  Marston