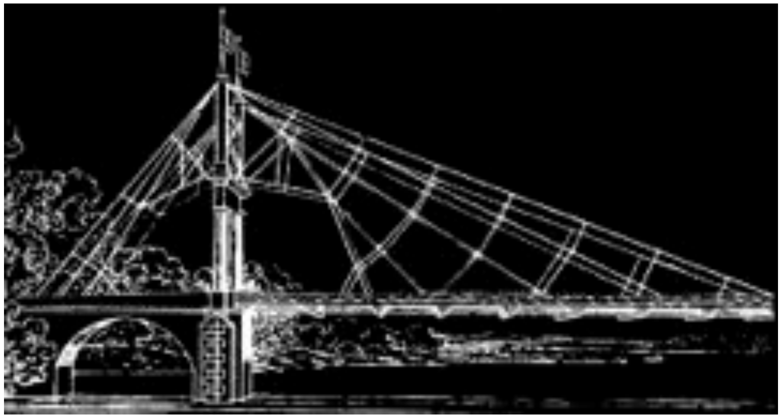
Cable-Stayed Bridges

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



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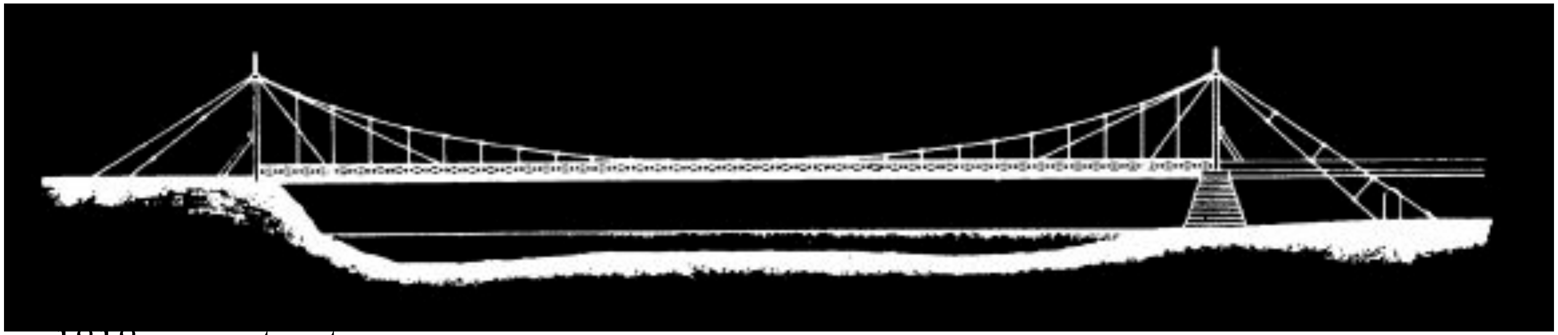
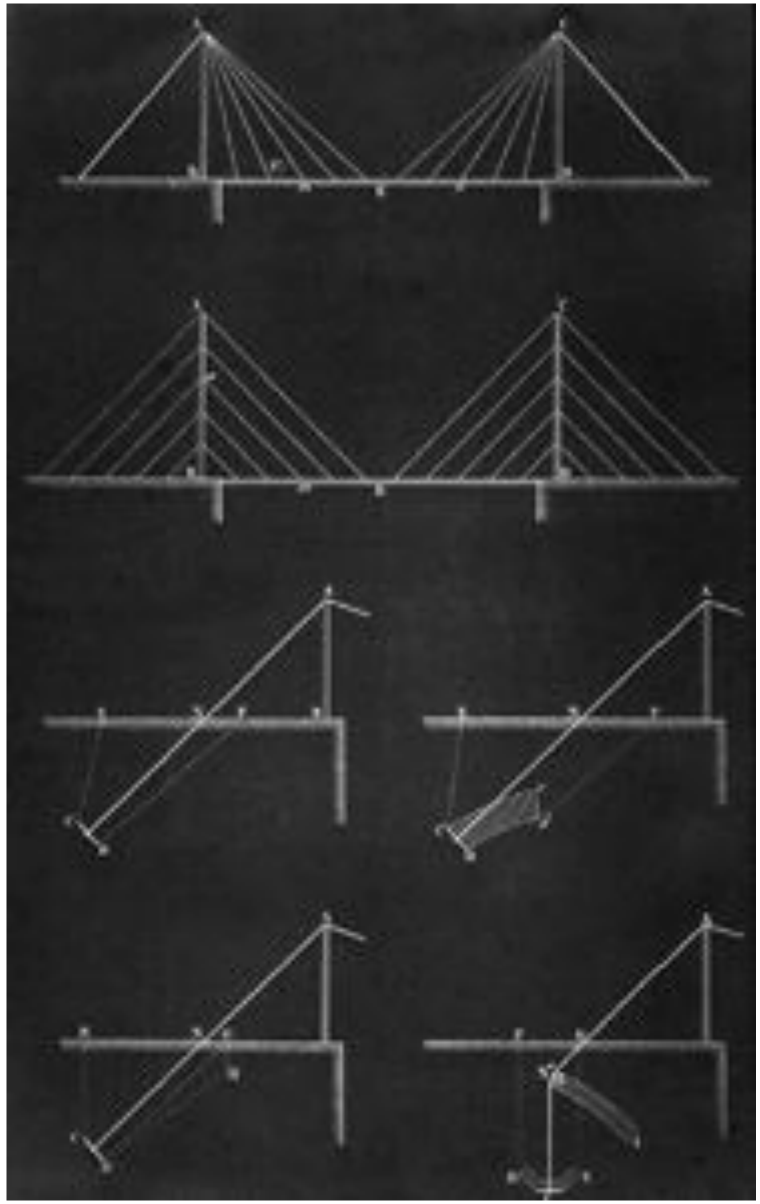
Saale River Bridge, Nienburg.

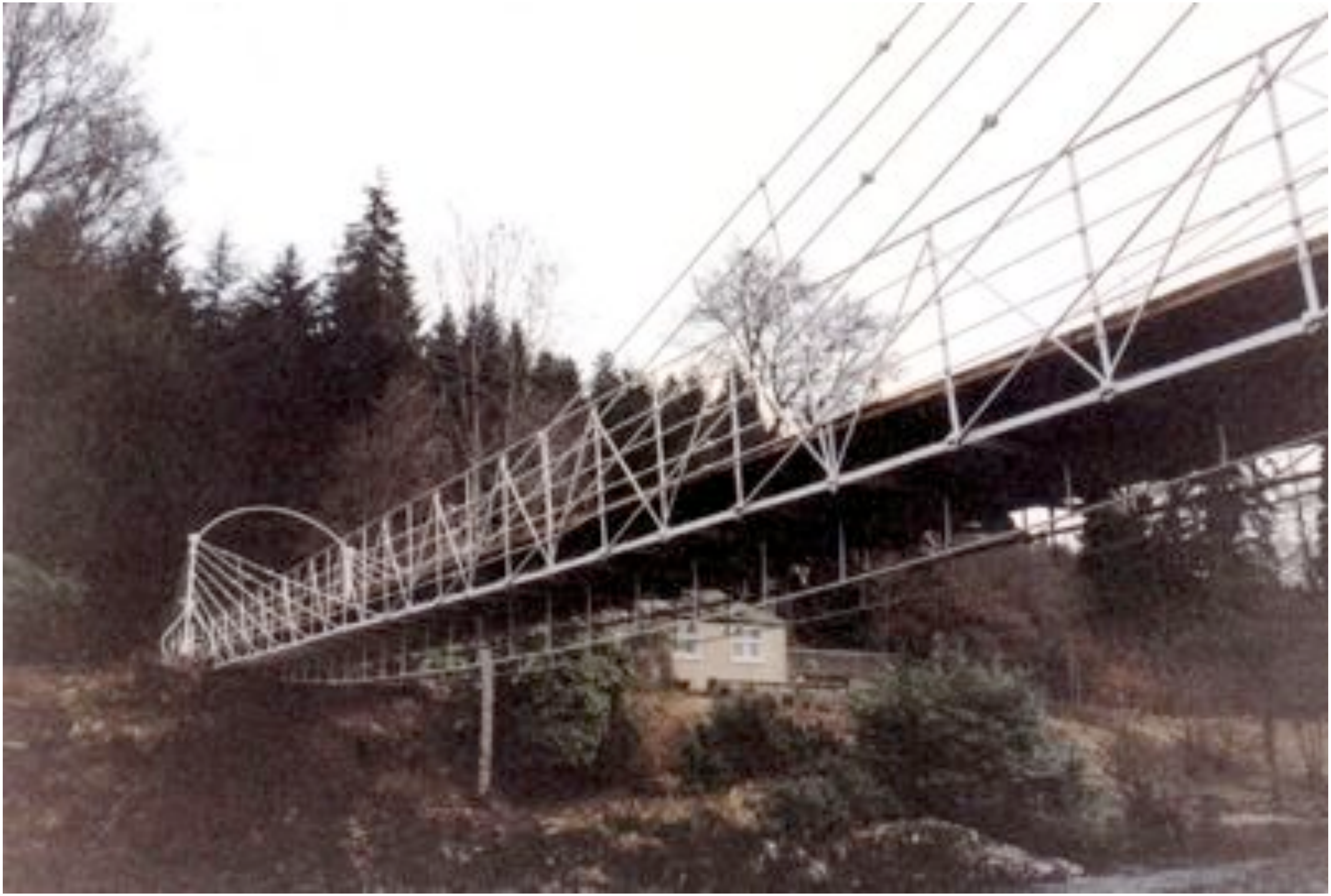
Source: Walther, René Ponts haubanées

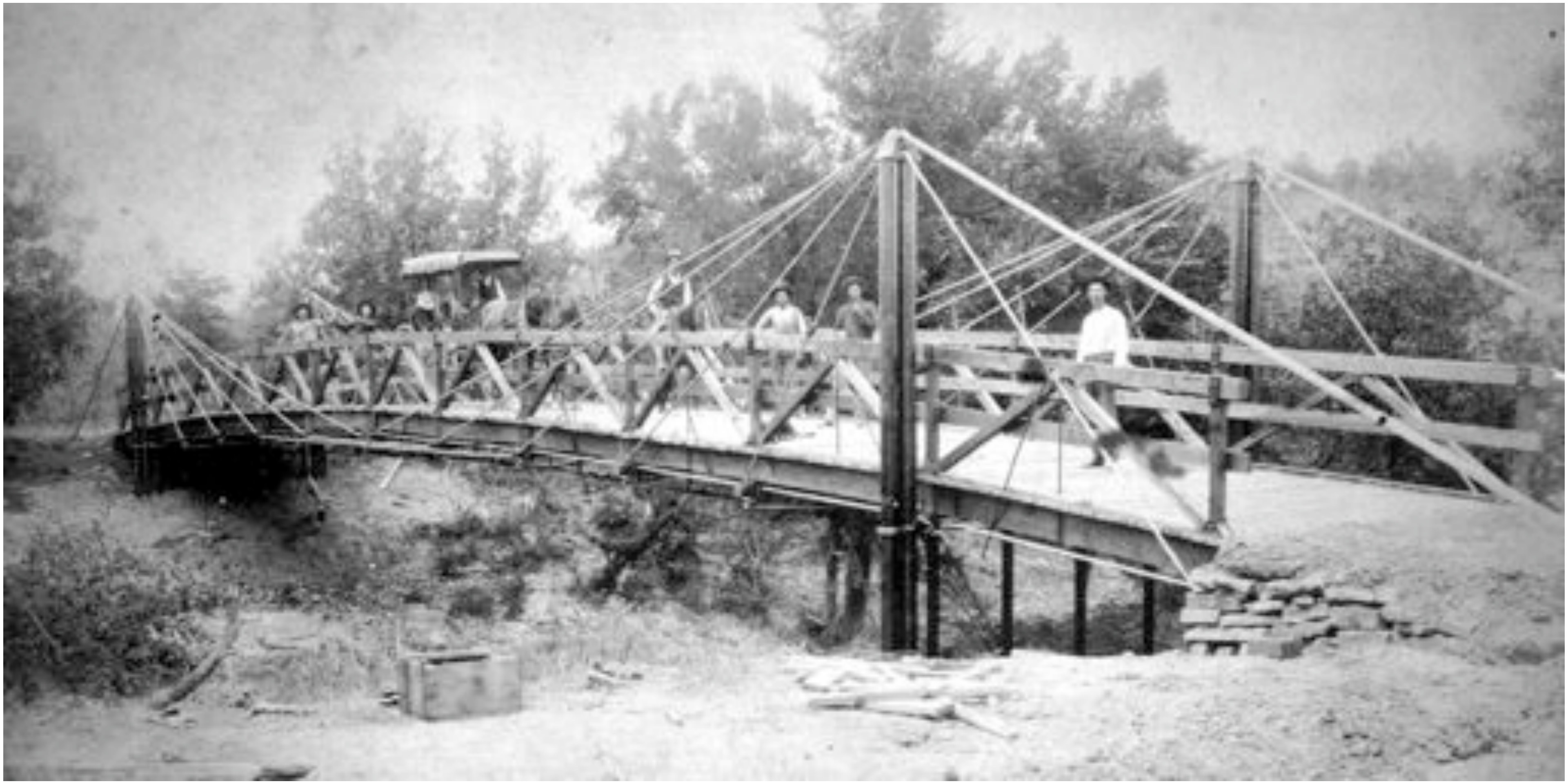


1818 reconstruction

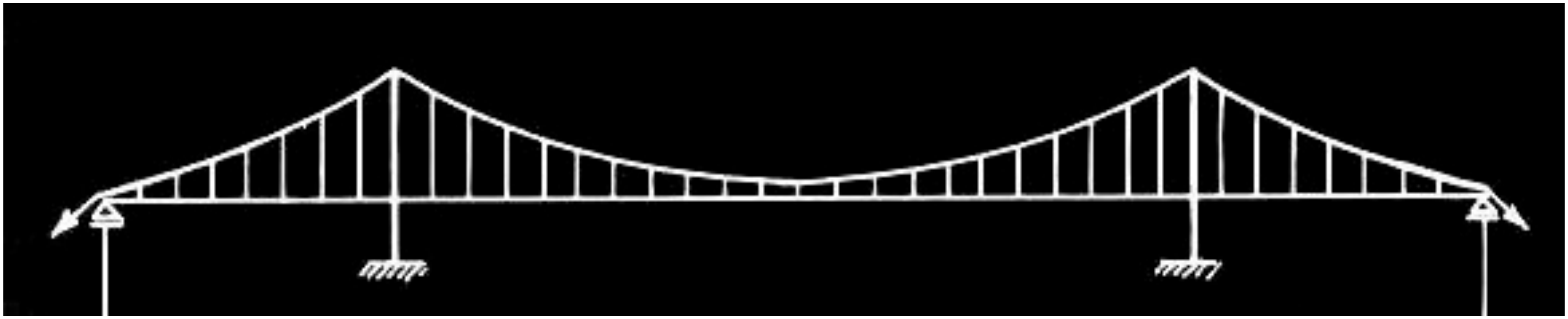


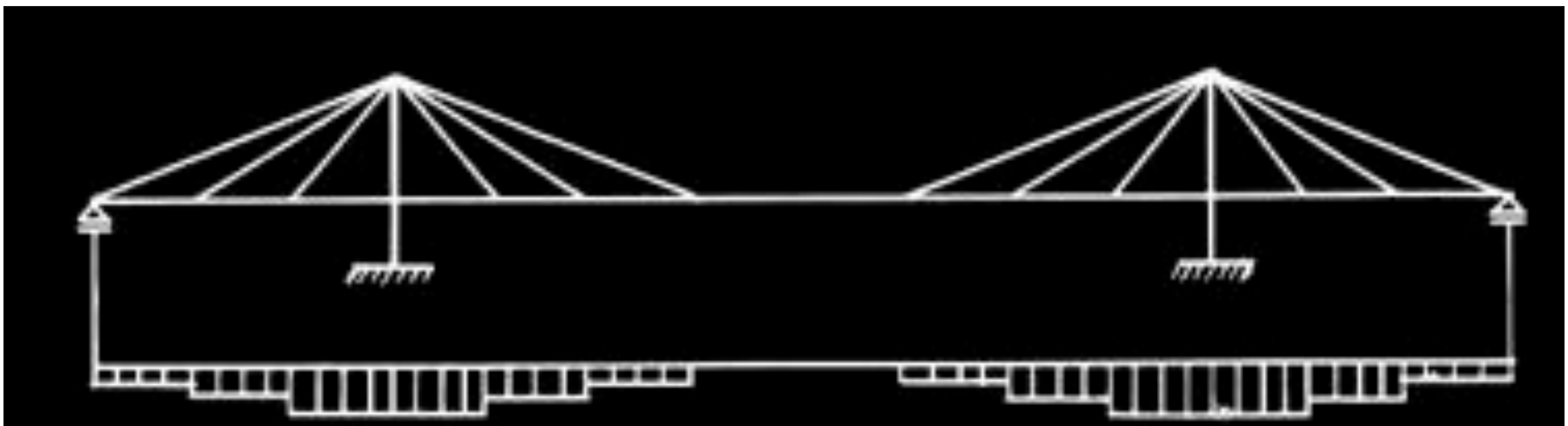
Navier
1823
Memoir on
Suspension Bridges



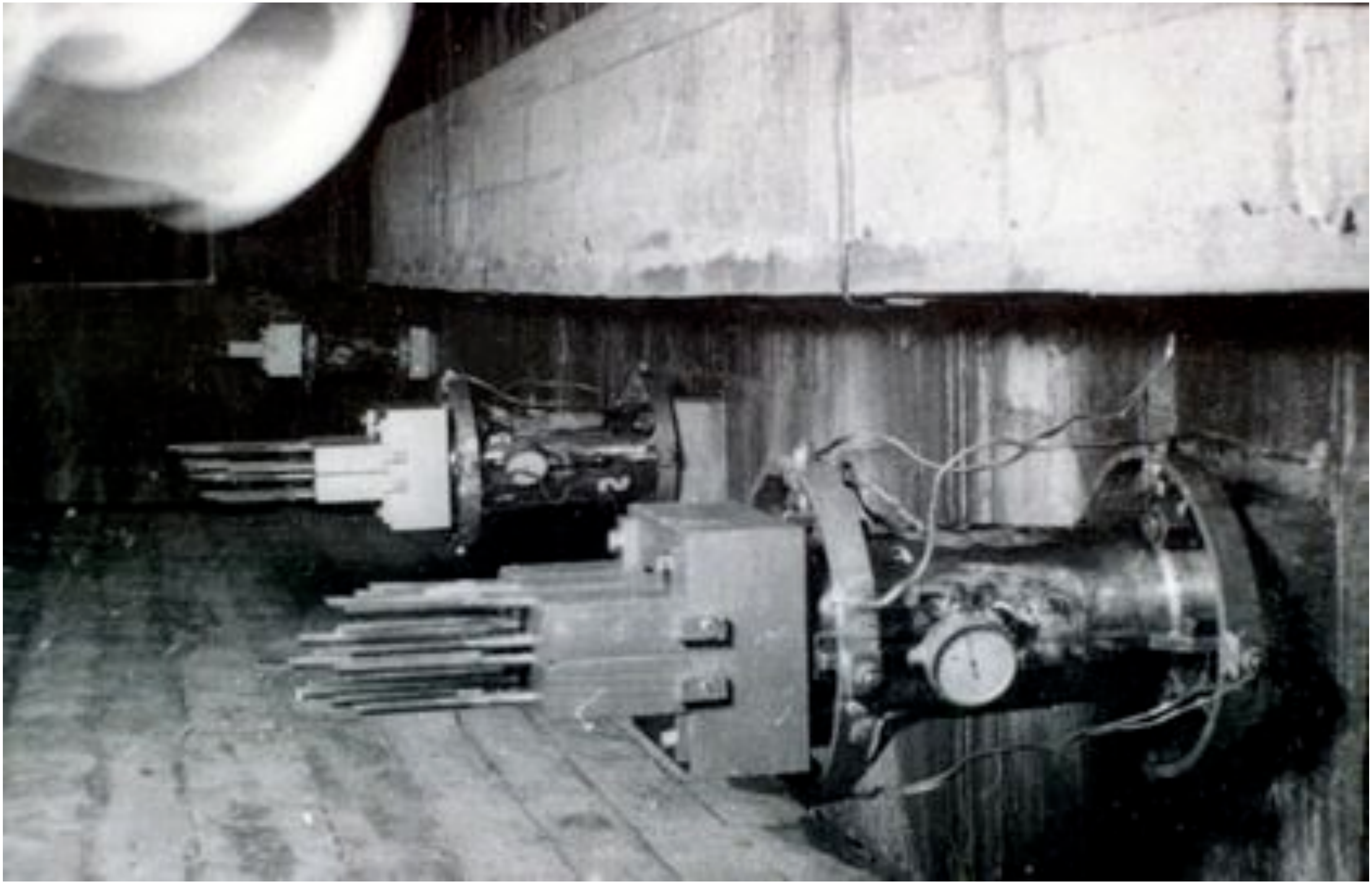


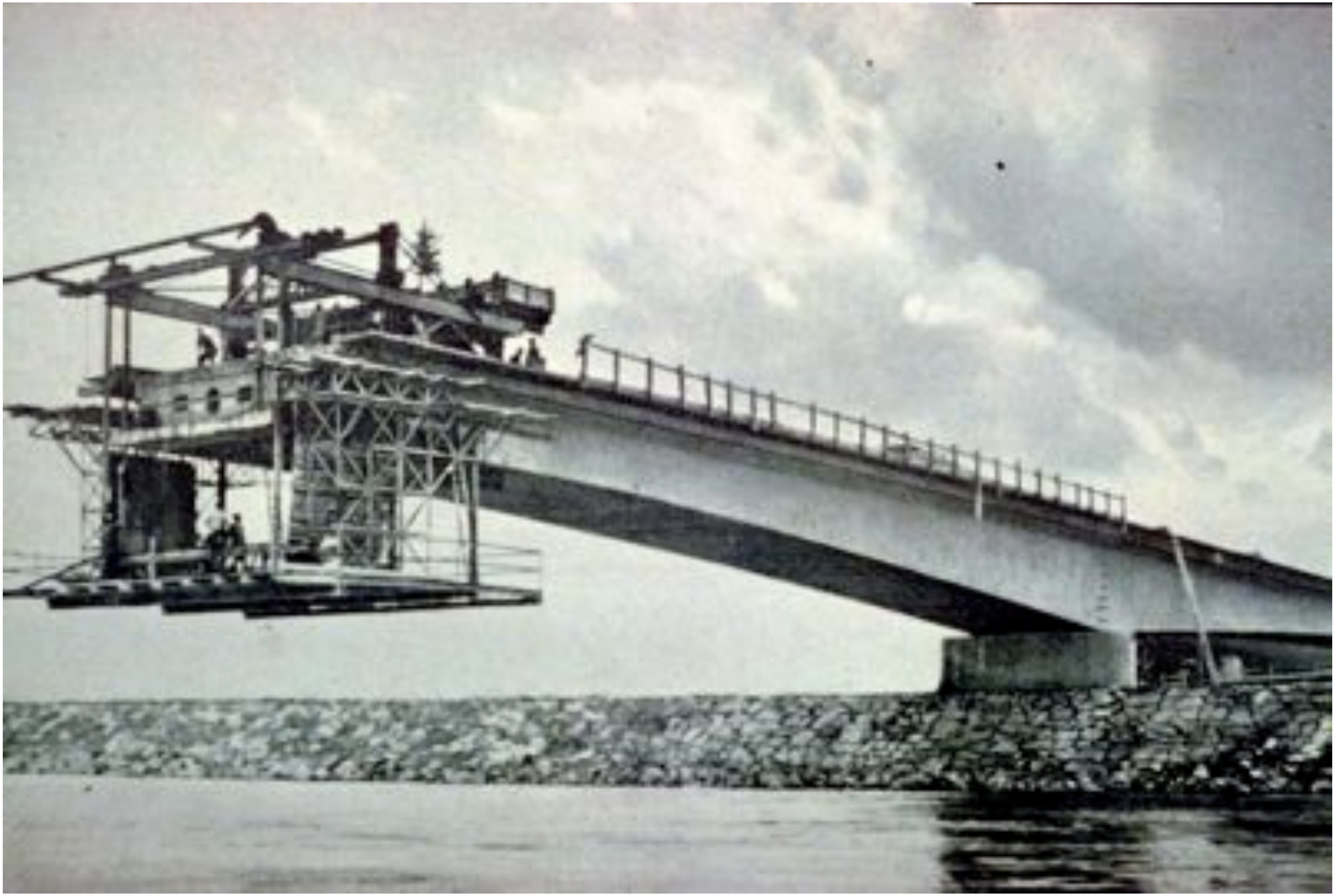
www.structurae.de Nicolas Janberg





(a)





Germany rebuilds

F. Dischinger
1887-1953

1955 Stromsund Br.

○

Theodor Heuss Bridge

F. Leonhardt

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1961 Severinsbrücke

1962 Norderelbe Br.

Janberg - www.structurae.de

1969 Kniebrücke

1967 Rees Br.


Holzmann – www.structurae.de

1974 Köhlbrand

Janberg – 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?

German cable-stayed bridges 1955-1979

Dischinger, Leonhardt, Holmberg, others.

How do innovations arise?

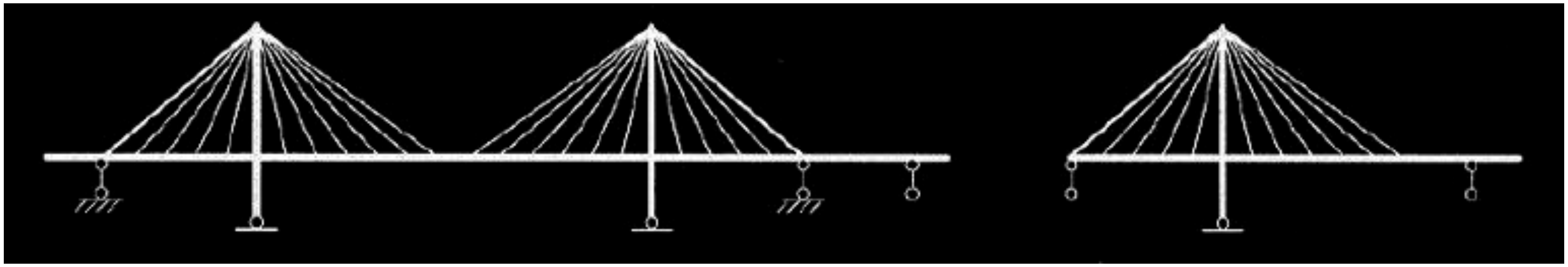
Pressing social need (15,000 bridges destroyed in the war) and a system that ultimately proved economical for intermediate spans.

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..



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

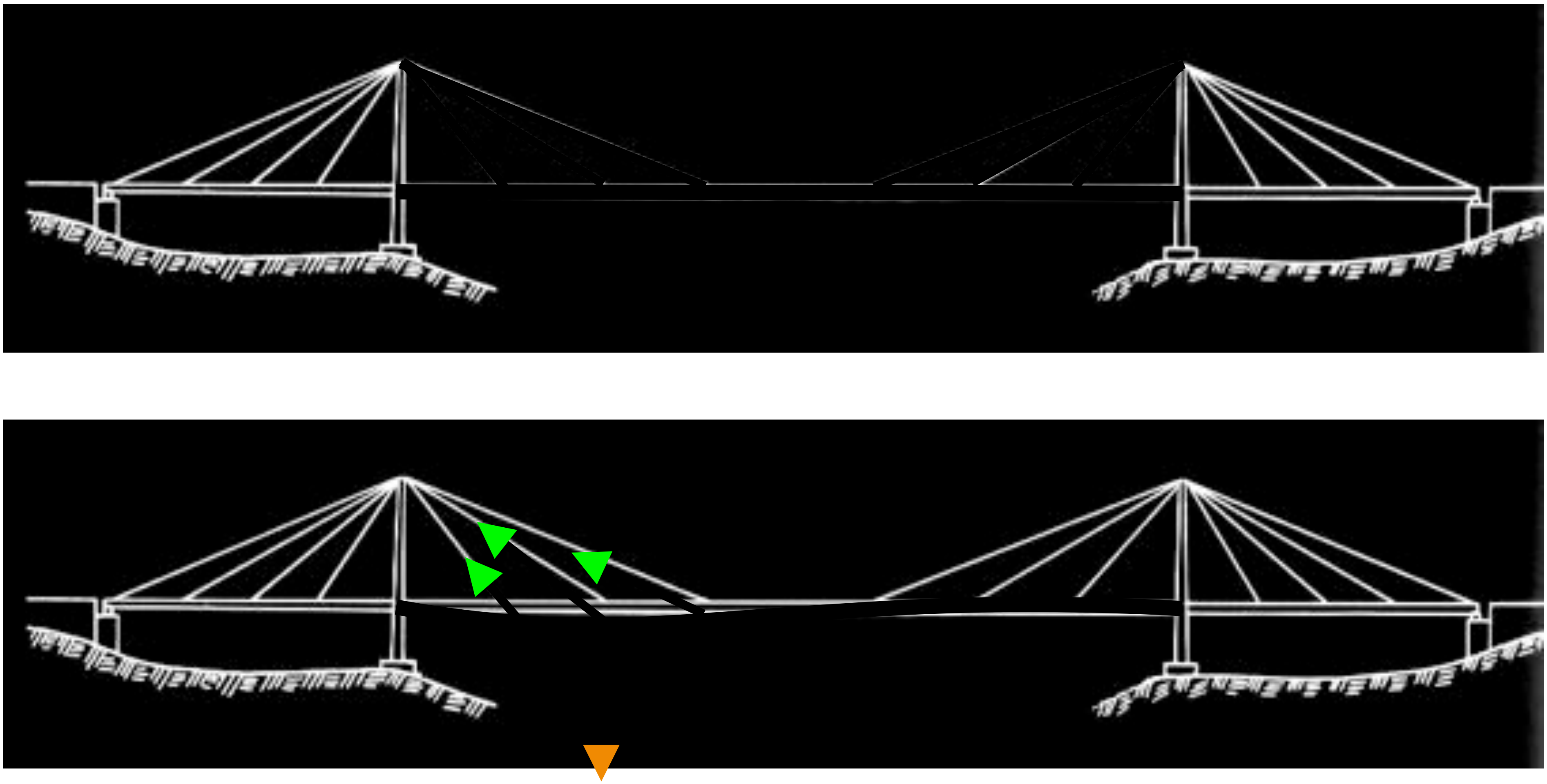
e

ht of
deck section

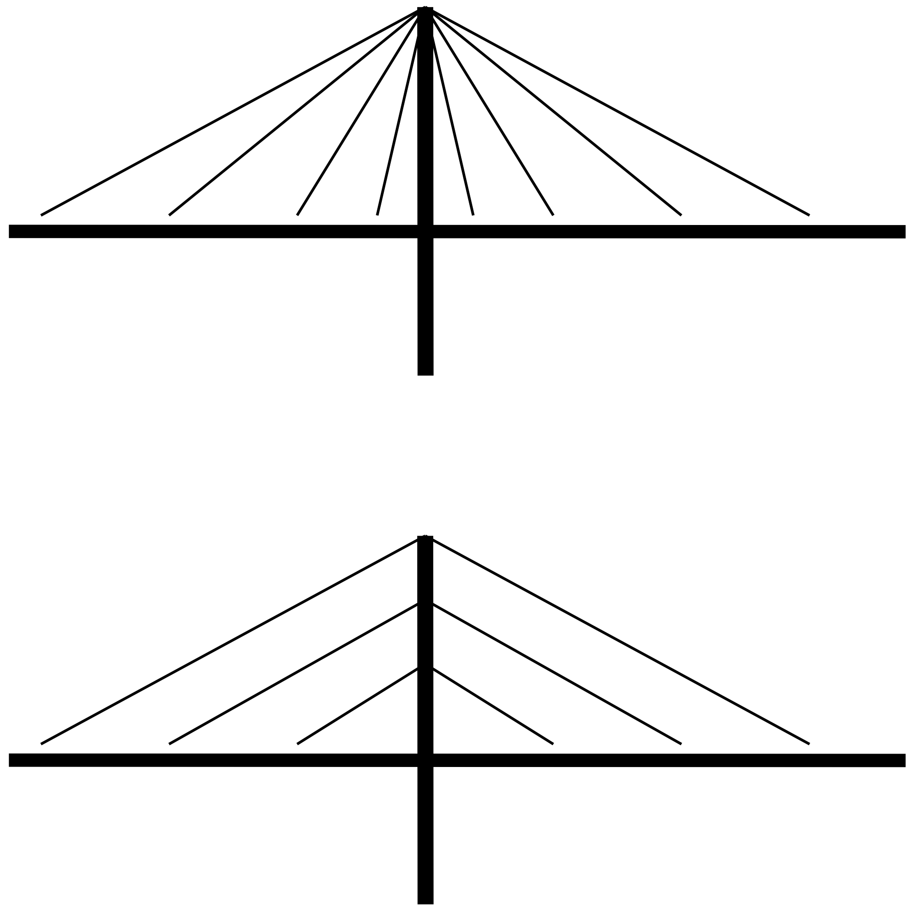
plot of total deck compression

Load Paths in Cable Stayed Bridges

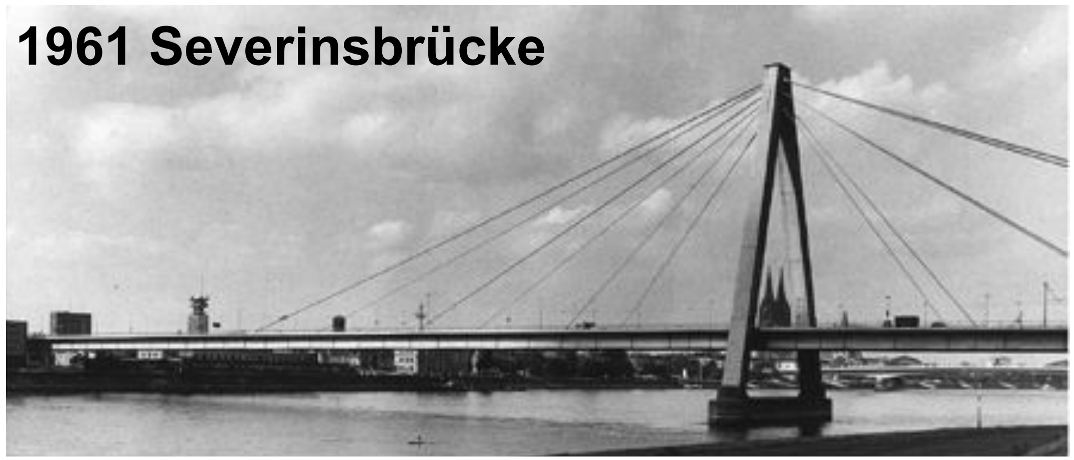
during use

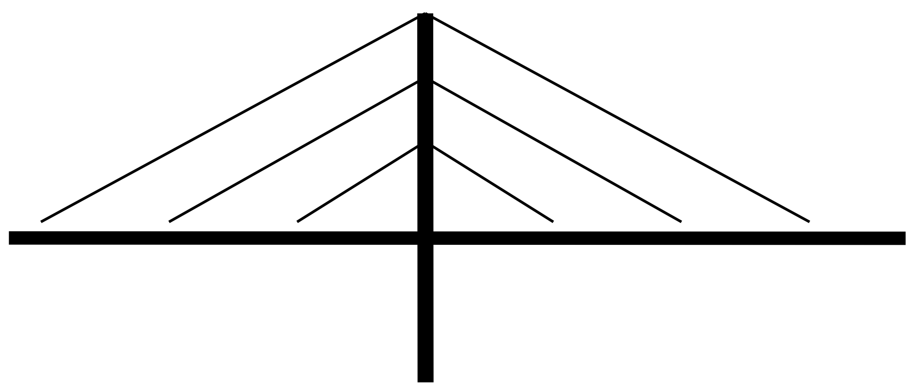


cable-arrangement

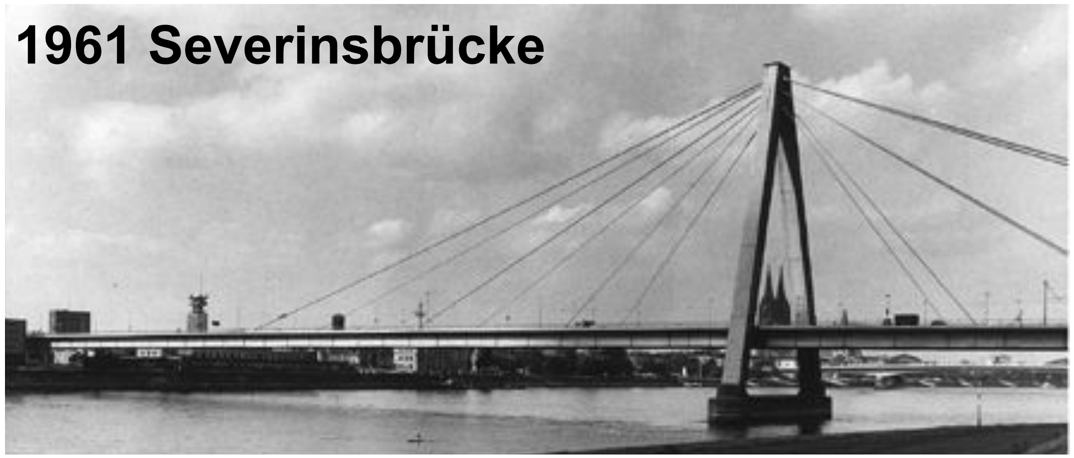


cable-arrangement

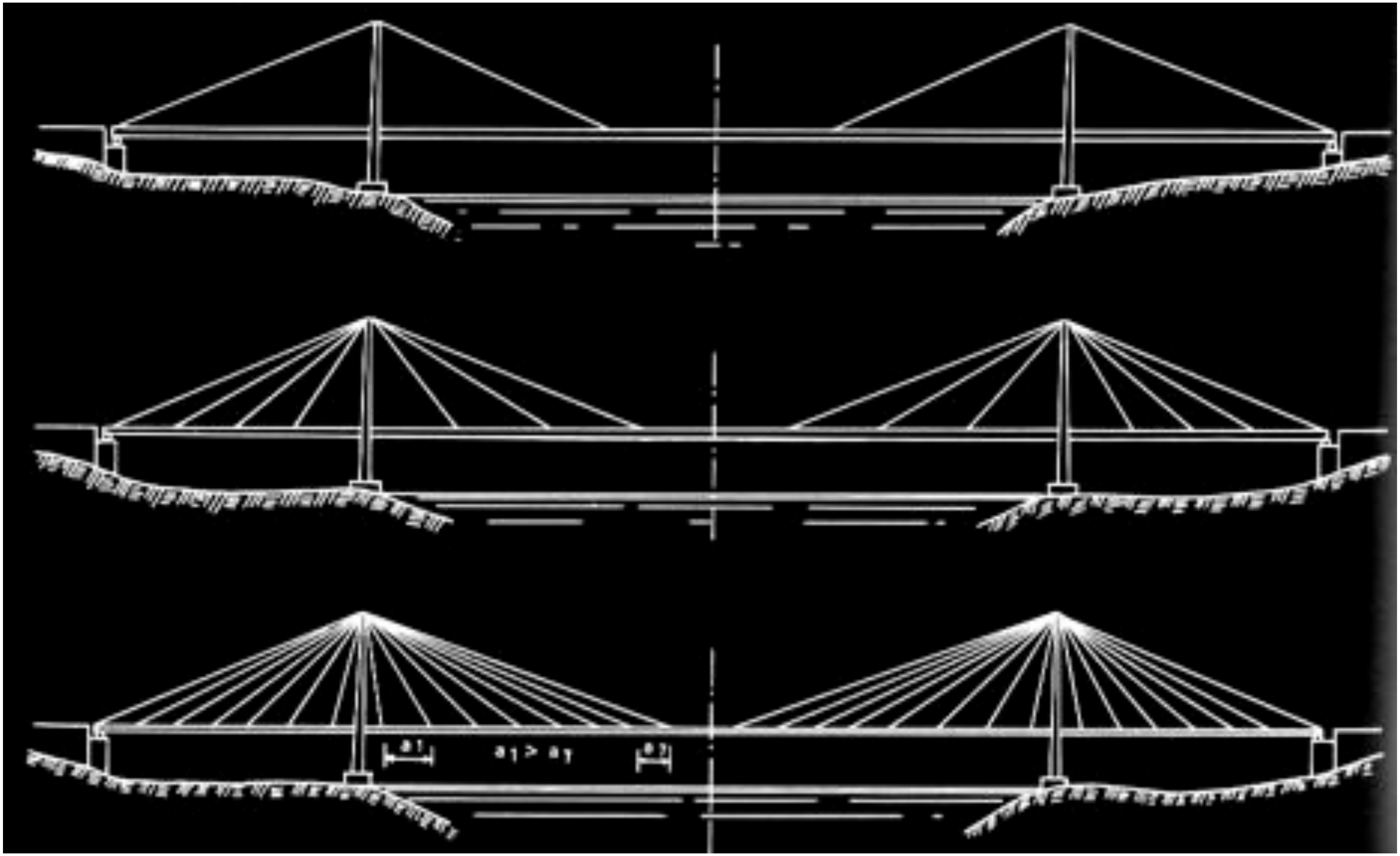




cable-arrangement

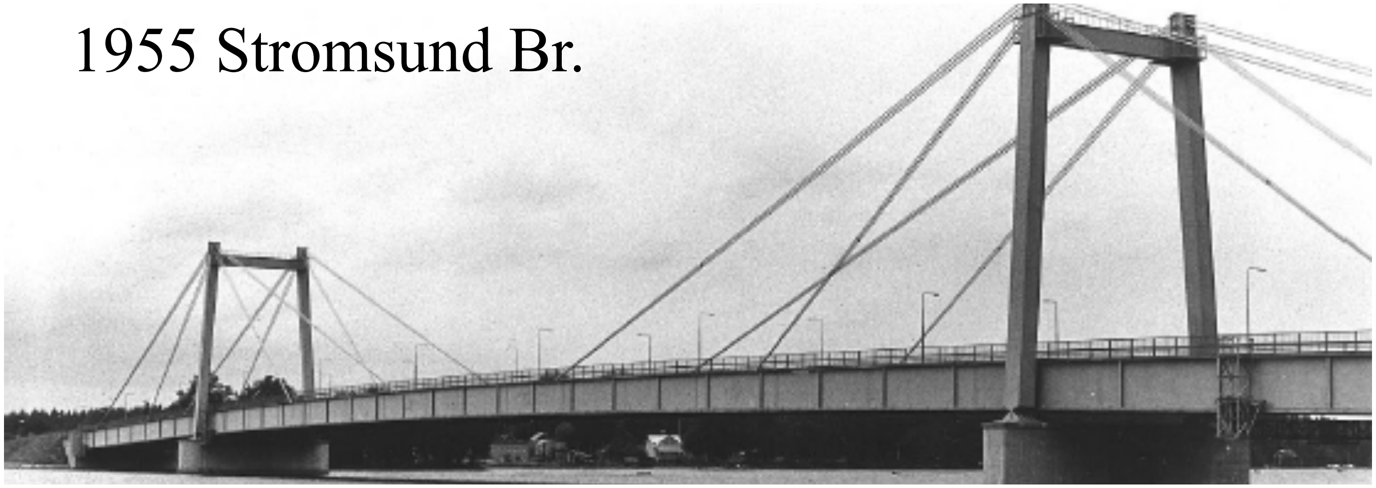


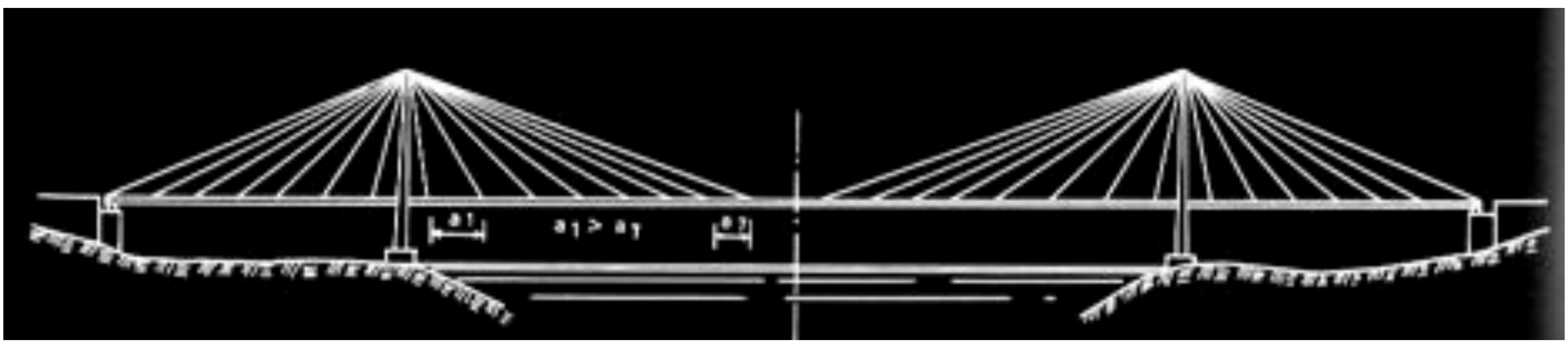
cable-arrangement



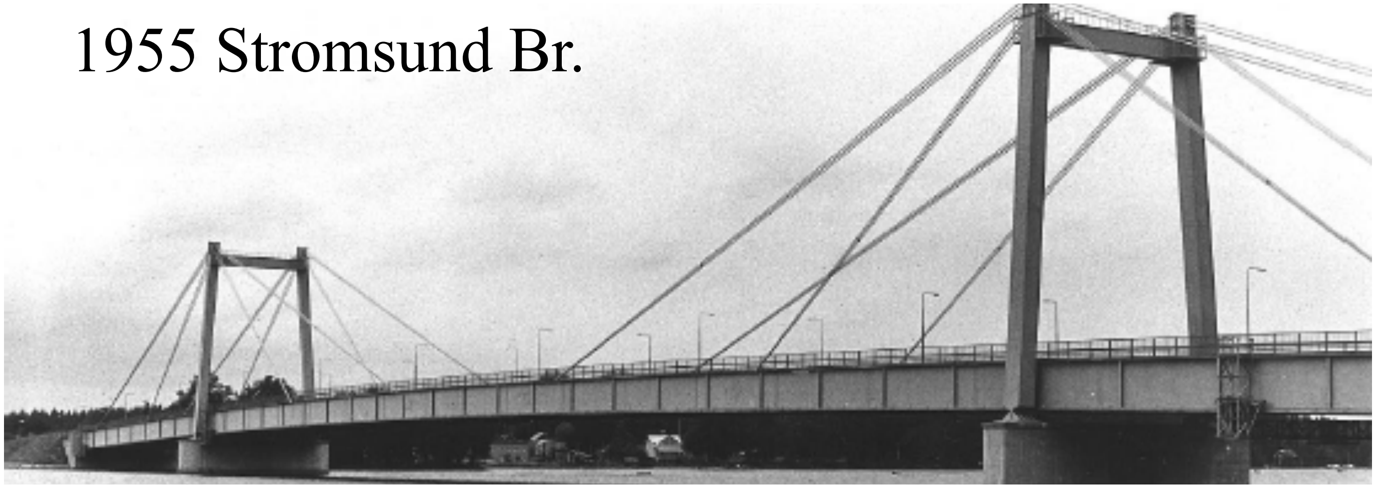
cable-arrangement

1955 Stromsund Br.

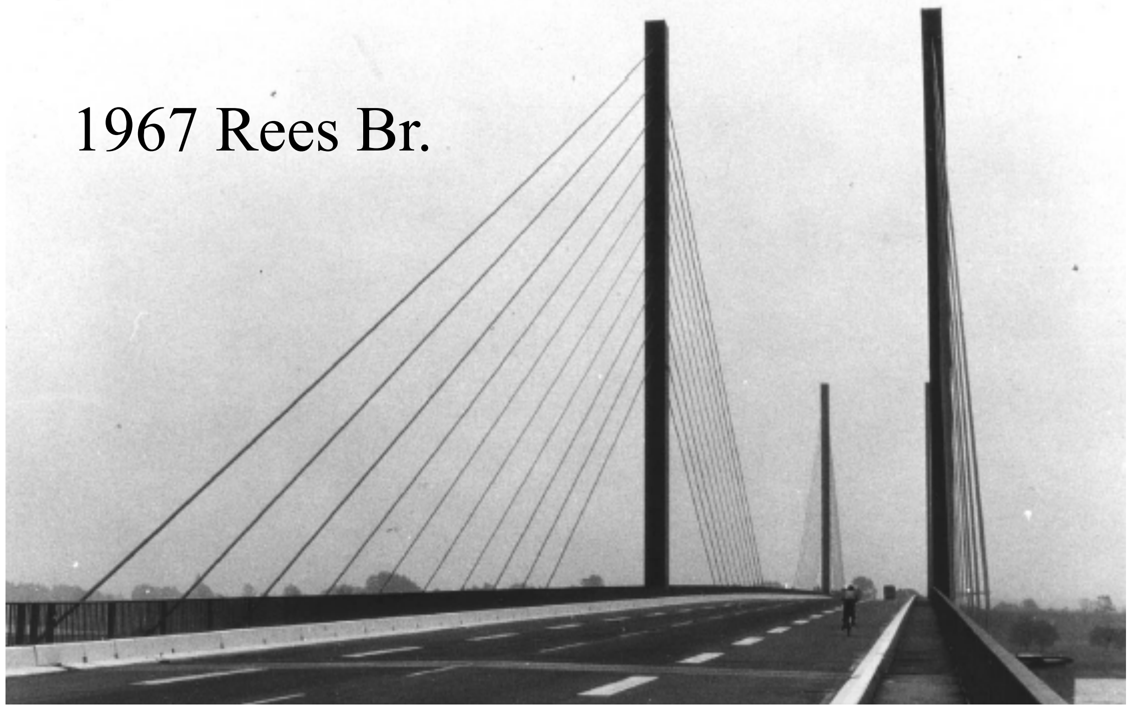




cable-arrangement

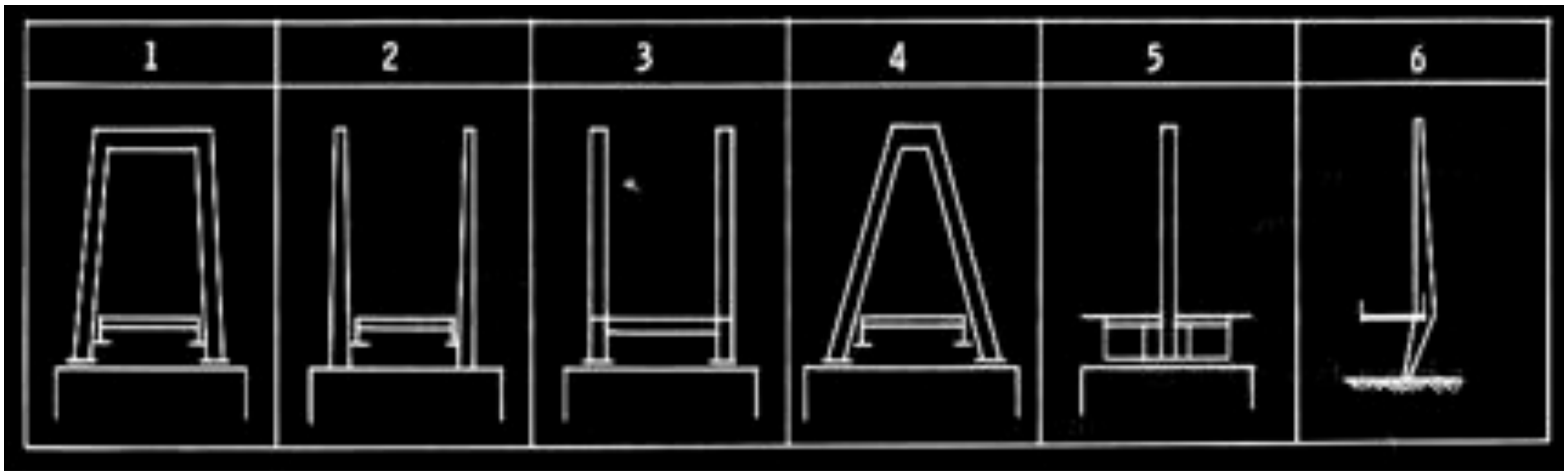


1955 Stromsund Br.

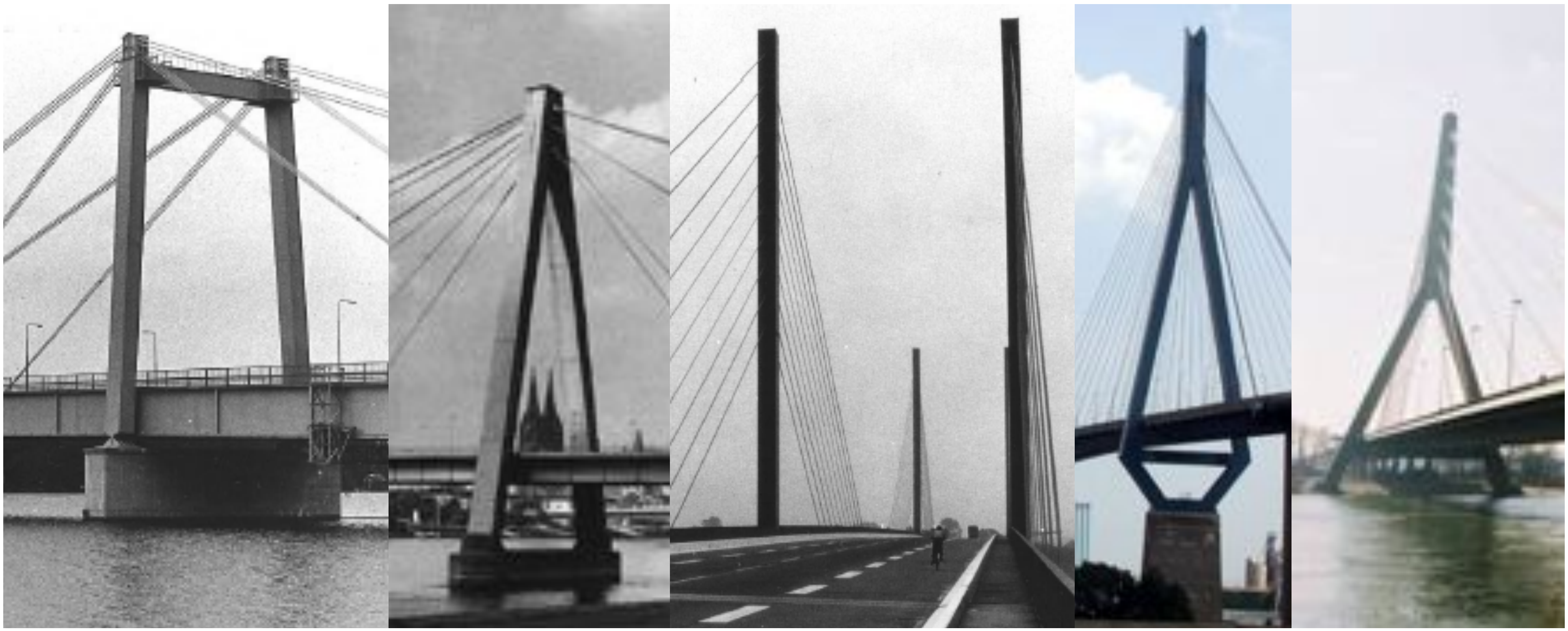


1967 Rees Br.

pylon-geometry



pylon-geometry



pylon-geometry

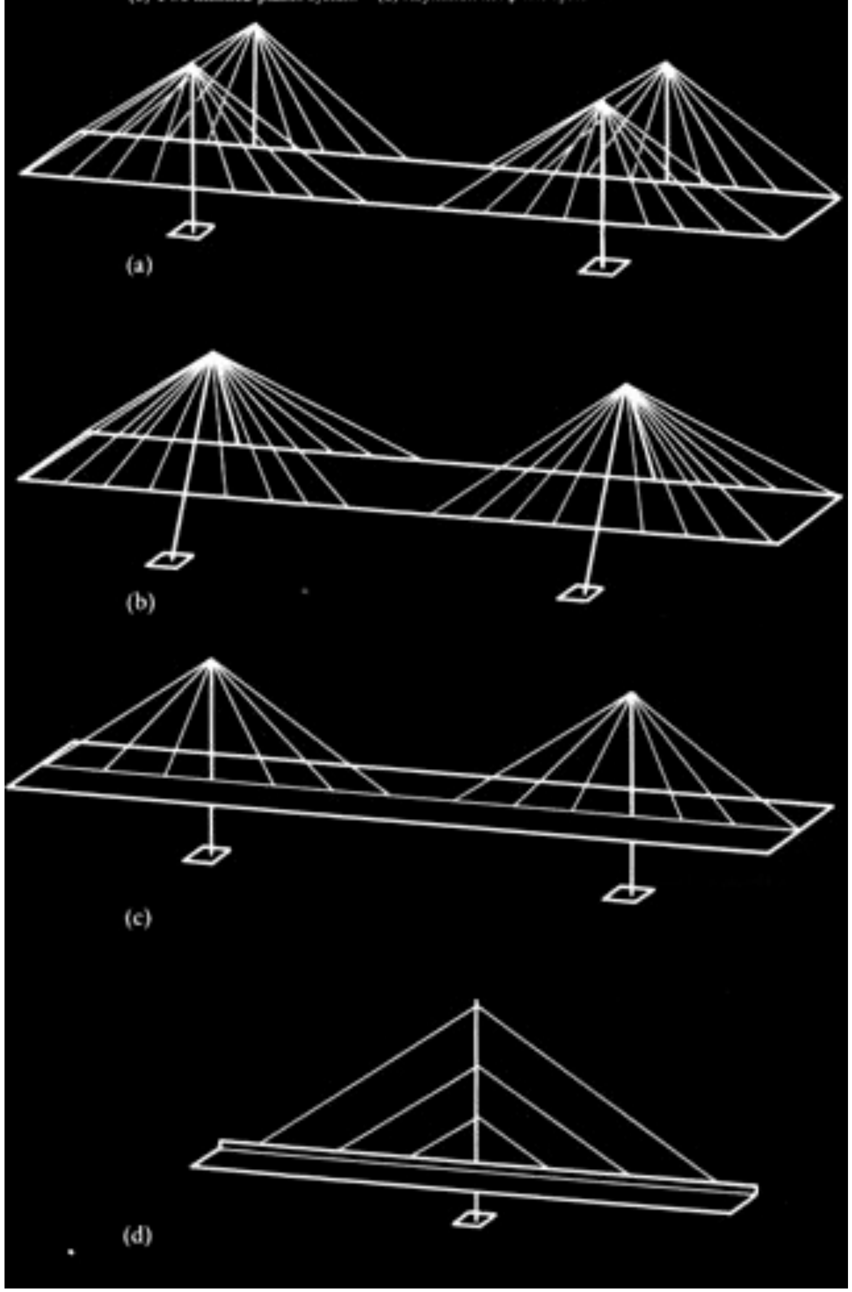
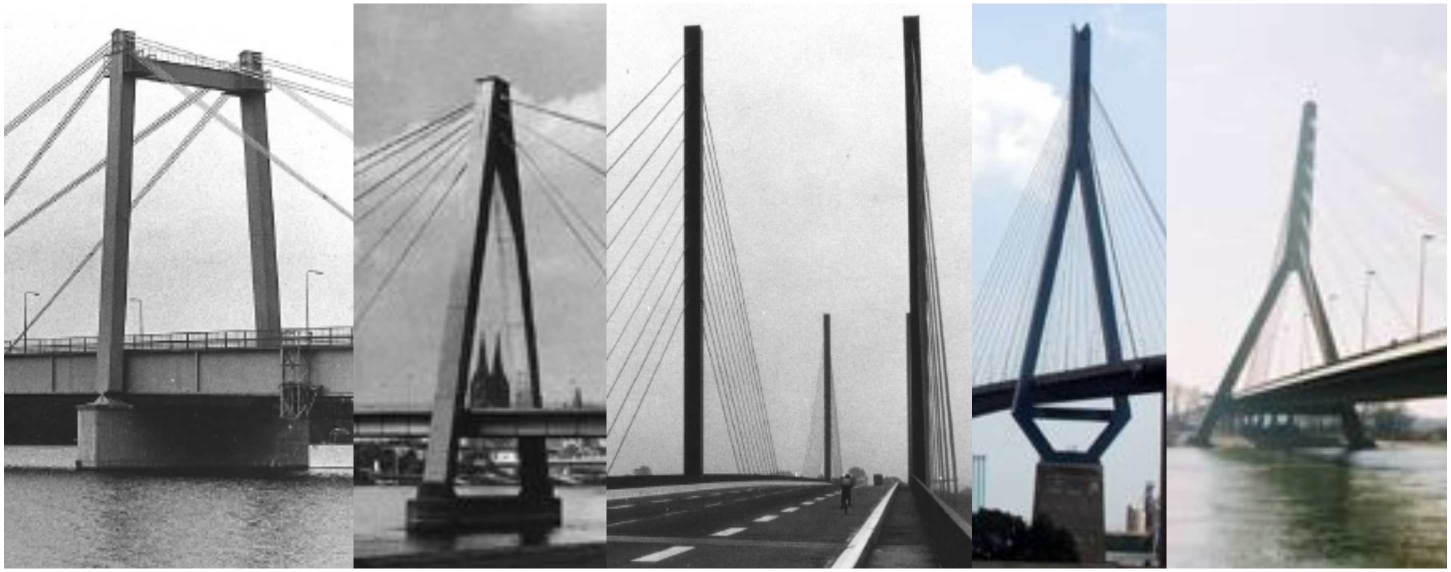
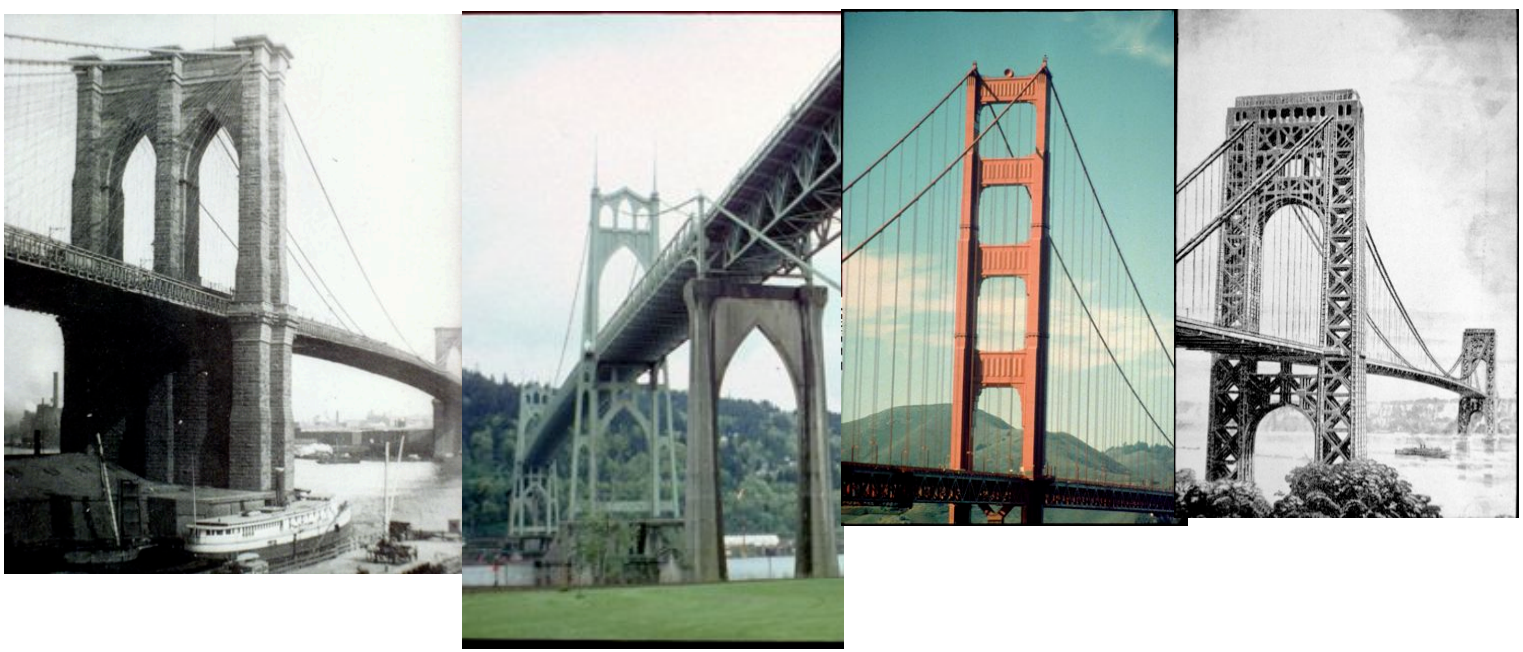


Fig. 1.31 Space positions of cables
(a) Two vertical planes system (c) Single plane system
(b) Two inclined planes system (d) Asymmetrical plane system

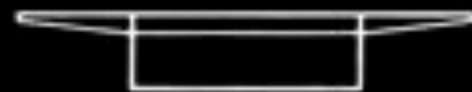
cable-stayed pylons/towers



suspension bridge towers



cross-sections

Types of main girder		
	Arrangement	Deck cross - sections
1	Twin I girder	
2	Single rectangular box girder	
3	Central box girder and side single web girders	
4	Single twin cellular box girder and sloping struts	
5	Single trapezoidal box girder	
6	Twin rectangular box girder	
7	Twin trapezoidal box girder	

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

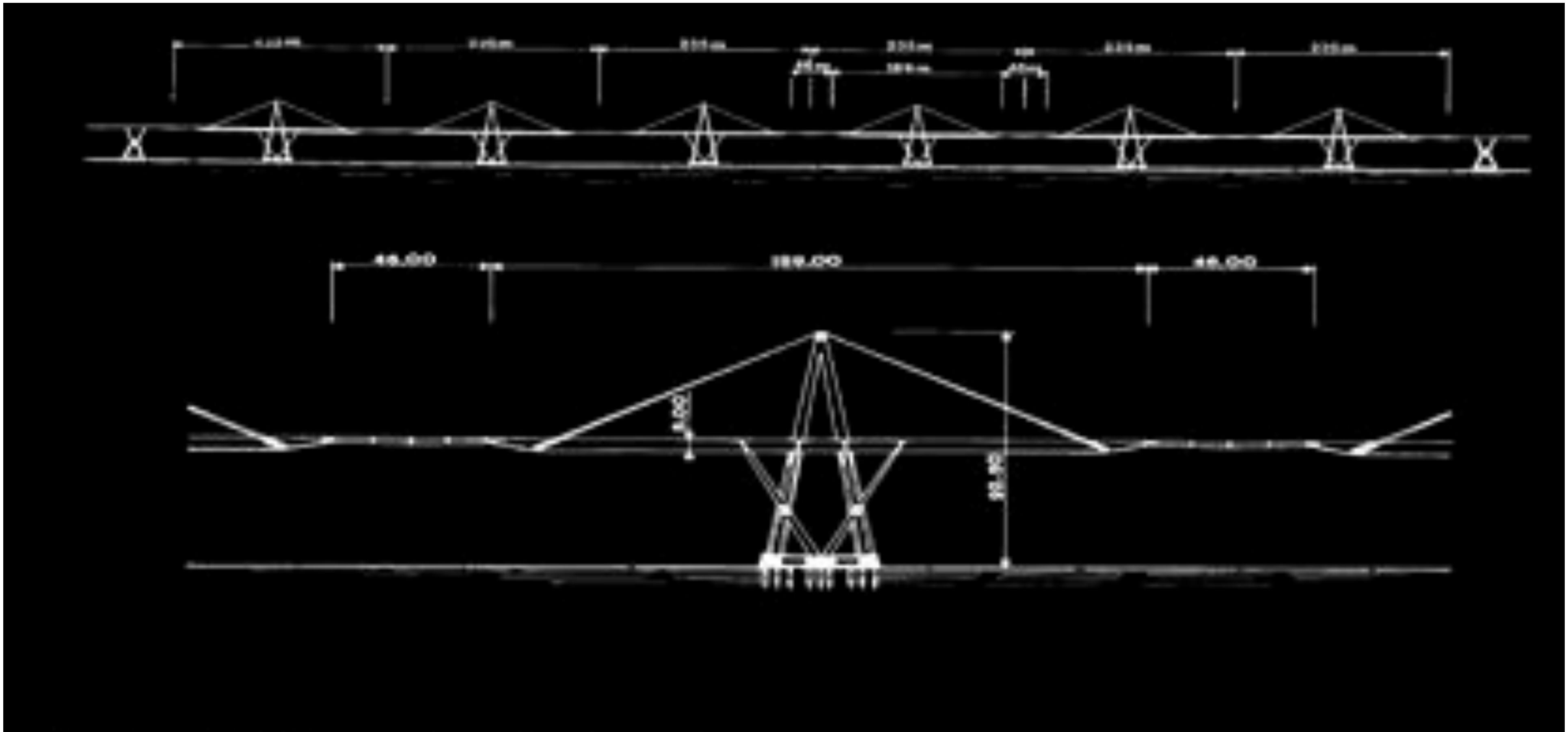
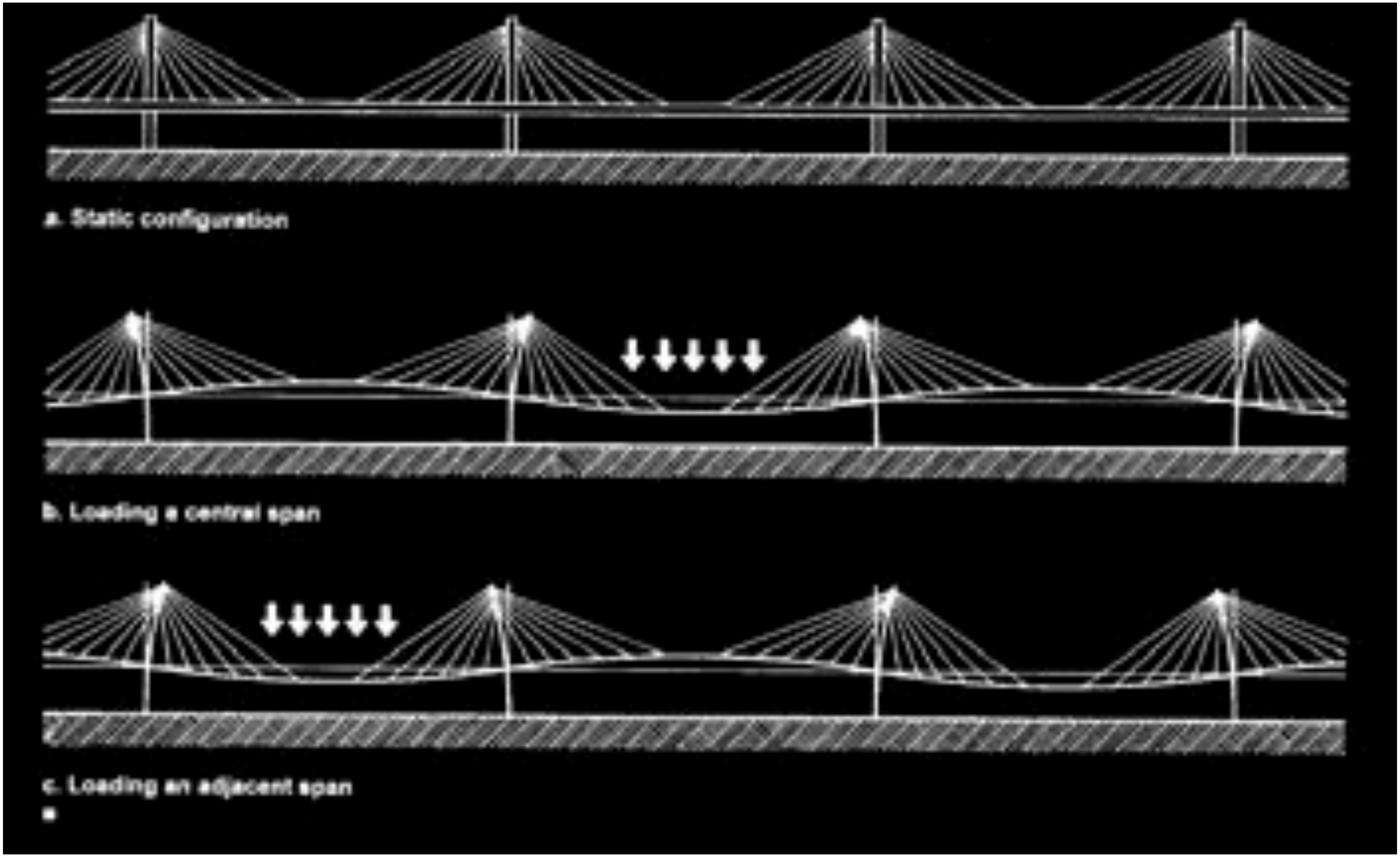


Figure 1 - Structural concept of the Maracaibo Bridge


a. Static configuration
b. Loading a central span
c. Loading an adjacent span

1962
Maracaibo Br.
by
R. Morandi

2004
Milau Viaduct
by
M. Virogleux

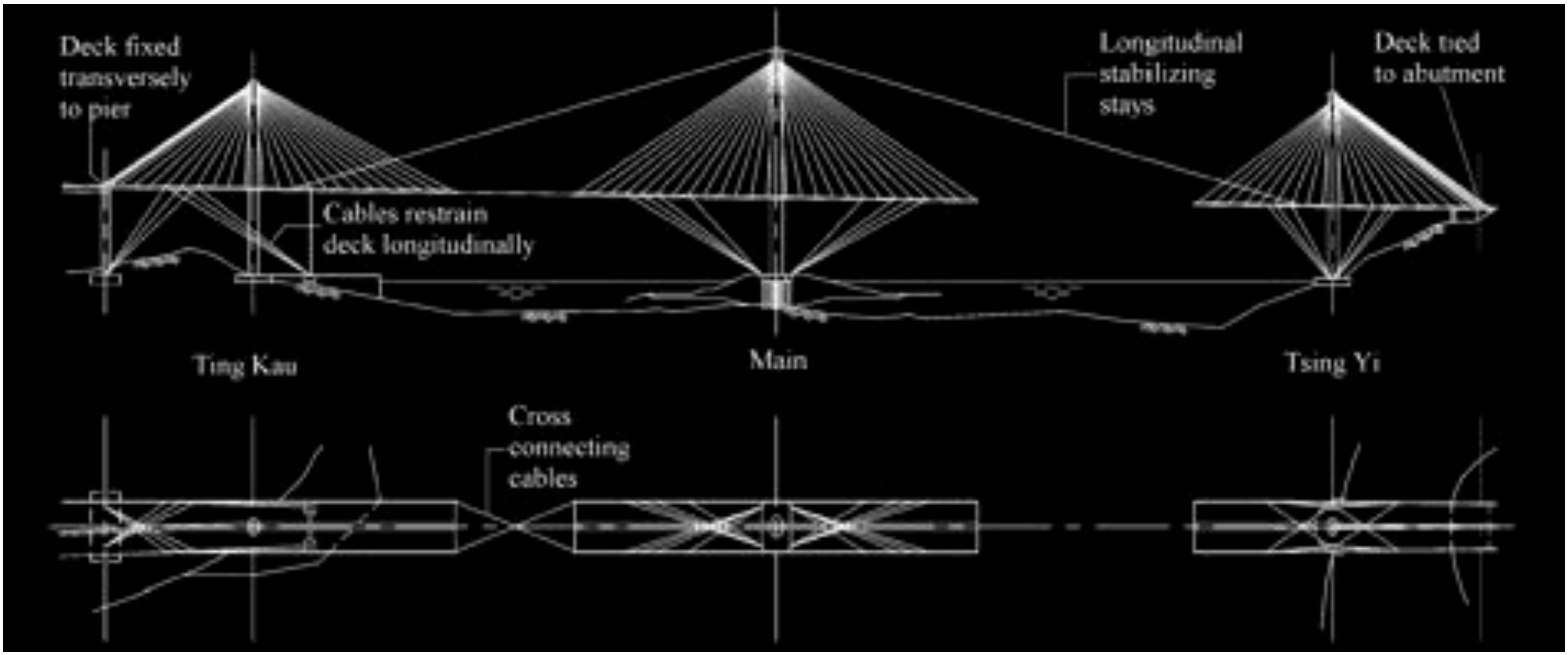
a. Intermediate support every second span.

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.

Yokohama Bay Br.

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

Mathis – www.structurae.de

“experiments” in cable-stayed forms

J. Schlaich

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

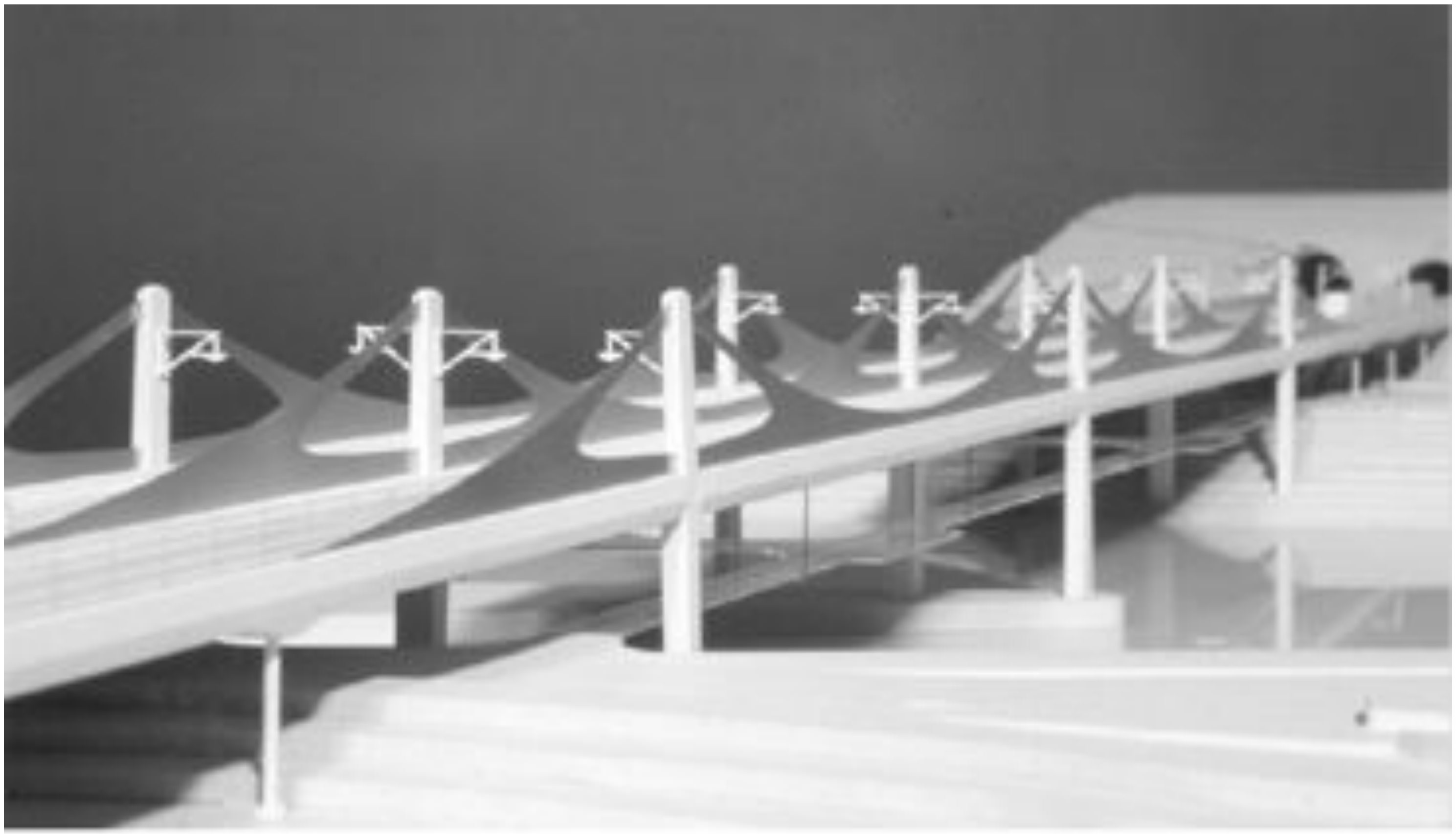


Fig. 12: Model of the Railroad Bridge, Bad Cannstatt (under design)



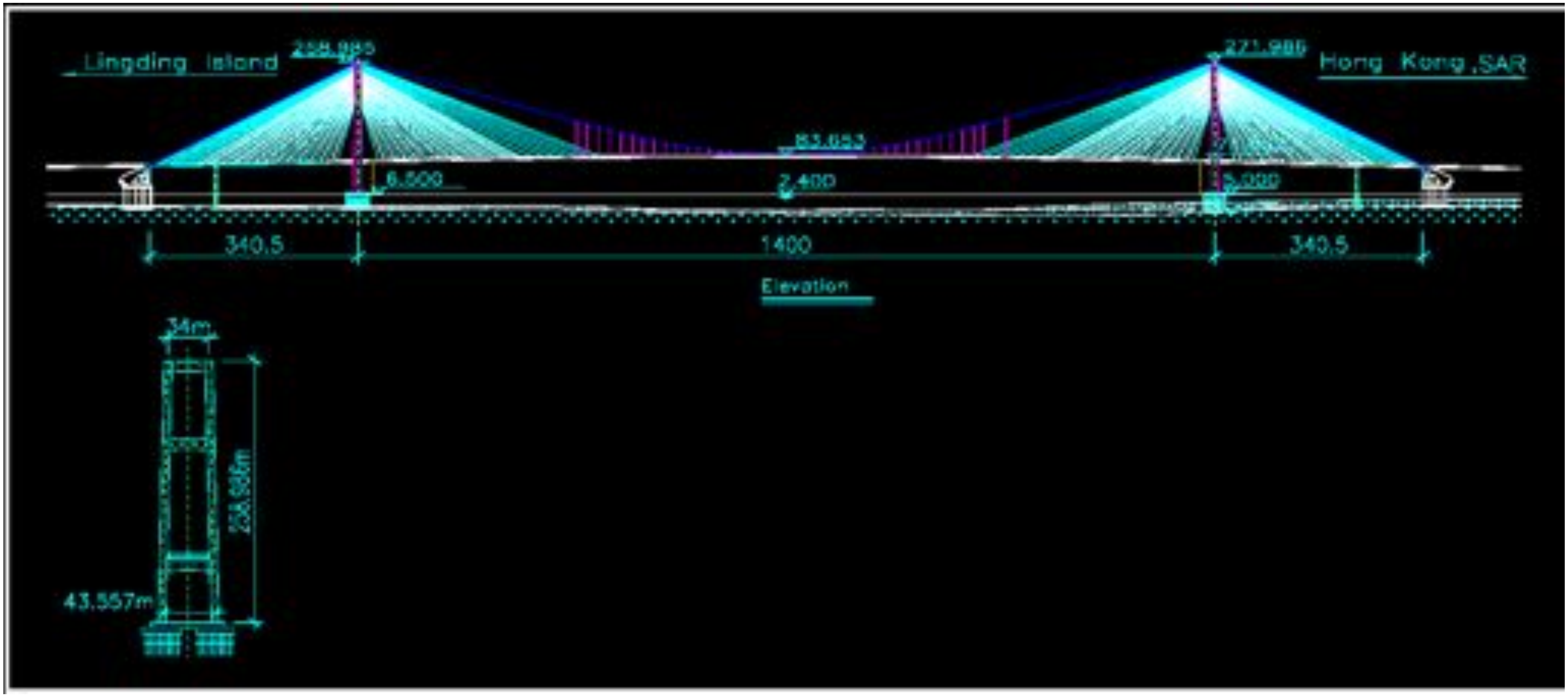

where do we go from here?

Longest cable-stayed bridges in the year 2000

No.	Name	Span	Traffic	Country	Year
1	Tatara Bridge	890 m	Road	Japan	1999
2	Normandie Bridge	856 m	Road	France	1995
3	Qingzhou Minjiang Br.	605 m	Road	China	1998
4	Yangpu Bridge	602 m	Road	China	1993
5	Meiko Chuo Bridge	590 m	Road	Japan	1997
6	Xupu Bridge	590 m	Road	China	1996
7	Skarnsund Bridge	530 m	Road	Norway	1991
8	Tsurumi Fairway Bridge	510 m	Road	Japan	1994
9	Øresund Bridge	490 m	**Road+rail**	Denmark/Sweden	2000
10	Iguchi Bridge	490 m	Road	Japan	1991

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 ½ of all long-span cable stayed bridges (>20) have been completed in China.


Québec
Trois-Rivières
Sherbrooke
Maine
New Hampshire
Massachusetts
Rhode Island

Announcements

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