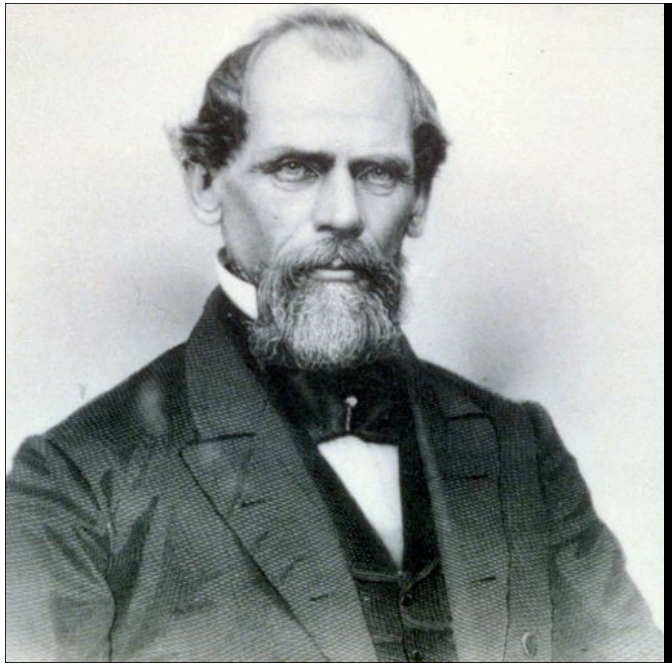
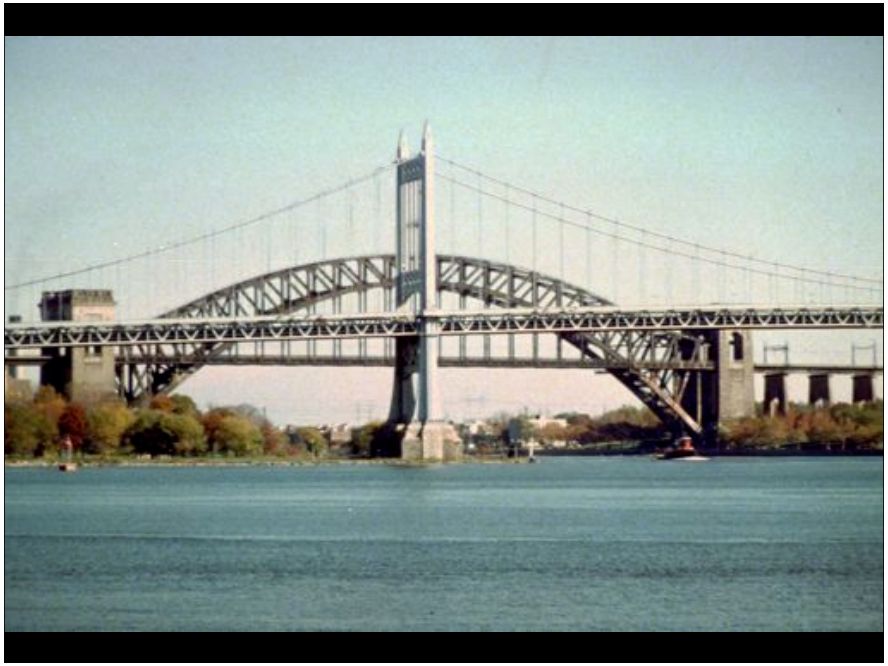
History and Aesthetics in Suspension Bridges

(Othmar Ammann, NYC Bridges, and 20th century bridge engineering)

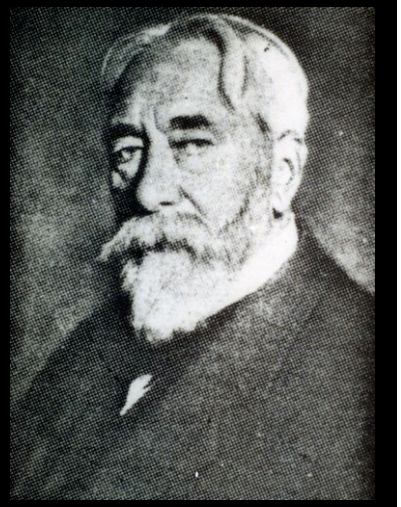
Social role of Ammann's bridges in New York
The Hellgate Arch: form and forces
Stiffness in suspension bridges (cont.)
Lindenthal and the RR vs. Amman and the automobile
Form, function, and aesthetics in suspension bridge towers



Othmar H. Ammann



Gustav Lindenthal (1850-1935)



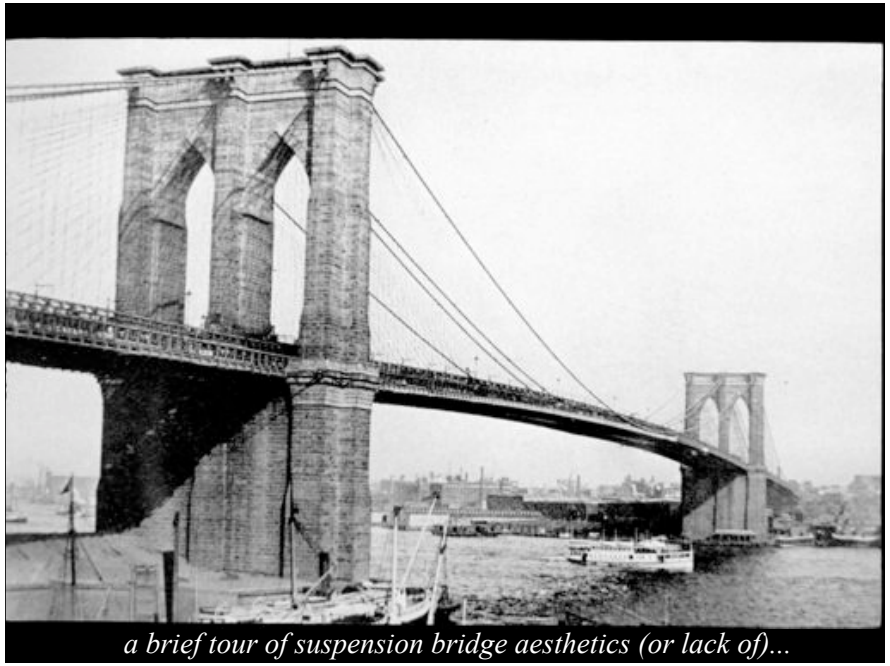
Hellgate Bridge - Gustav Lindenthal - 1916 - 977 feet

contrast with Sydney Harbor Bridge...

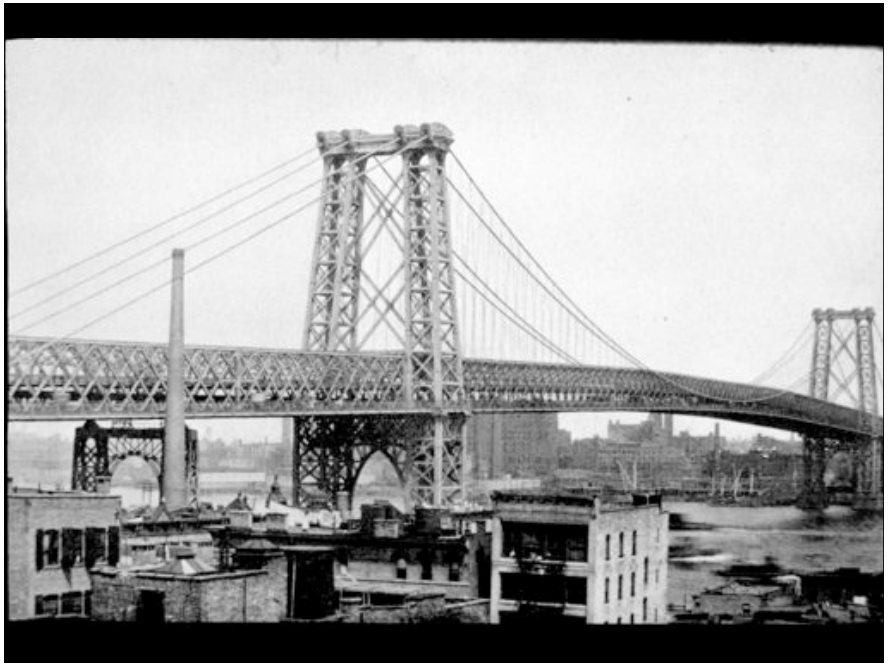
http://en.structurae.de/photos/index.cfm?JS=3089
Katrin Janberg

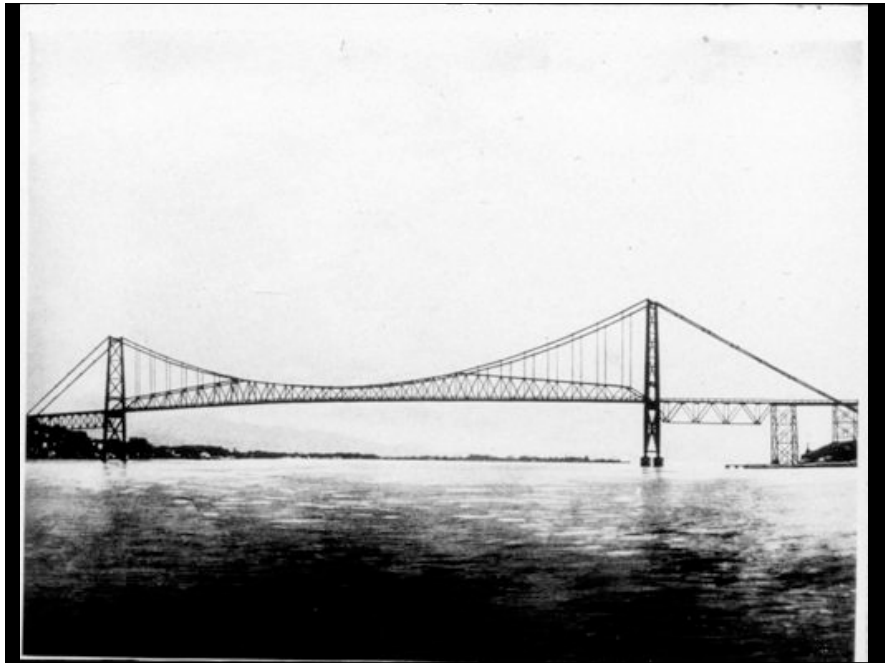
Amman - Bayonne Bridge - 1675 feet (proposal)

Amman - Bayonne Bridge - 1675 feet (as built)



a brief tour of suspension bridge aesthetics (or lack of)...





returning now to Lindenthal, Amman, and the design and development of the GWB

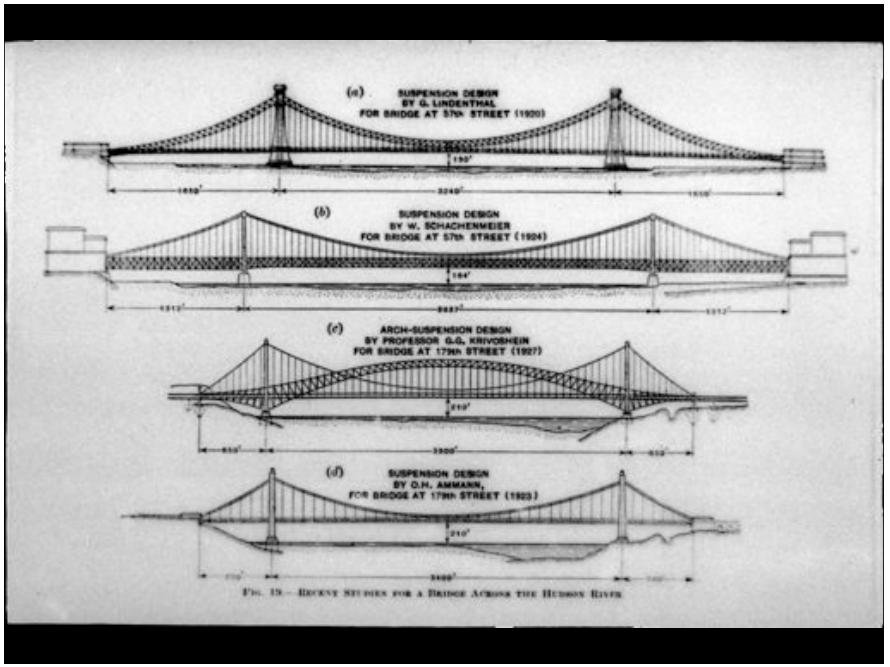
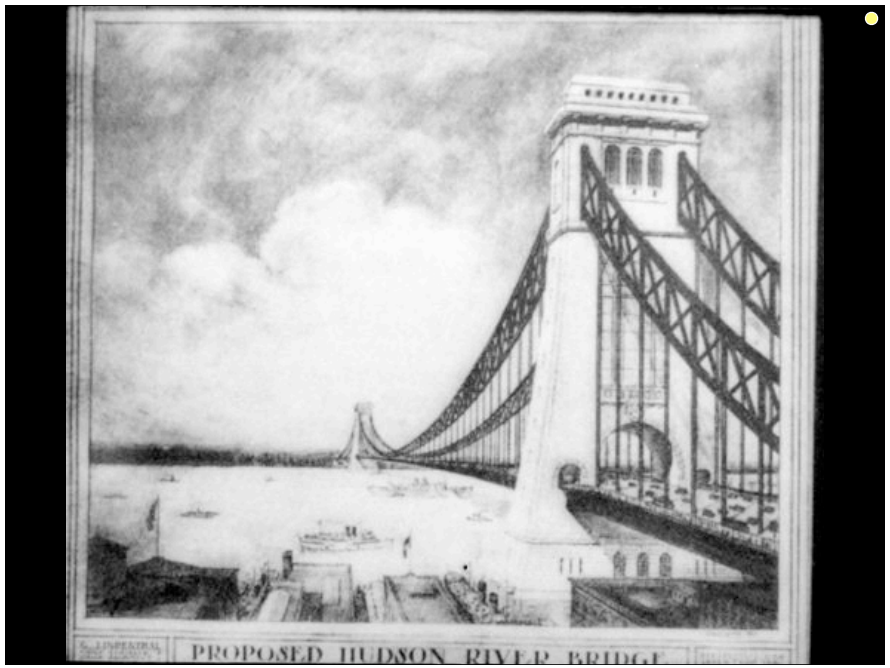
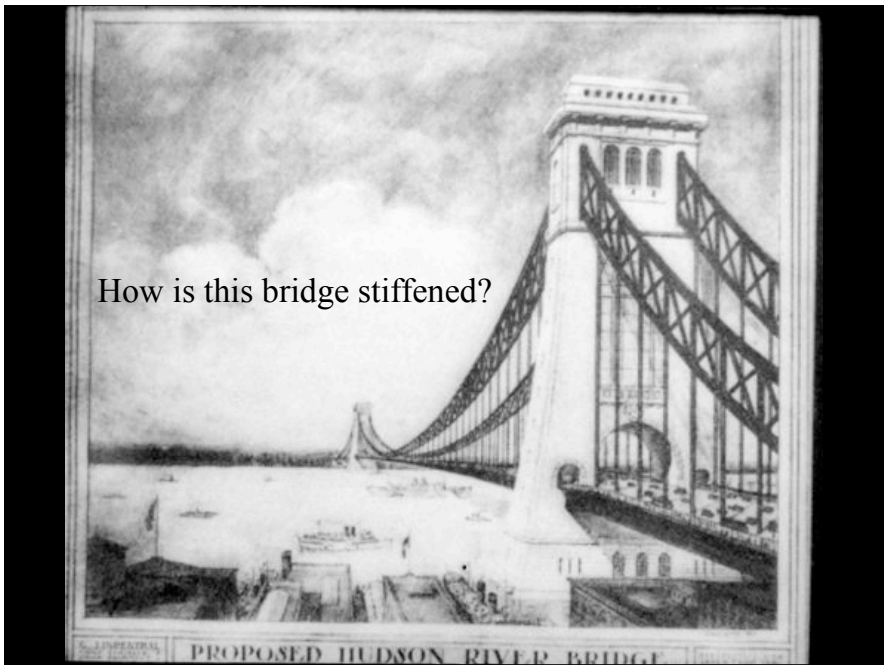
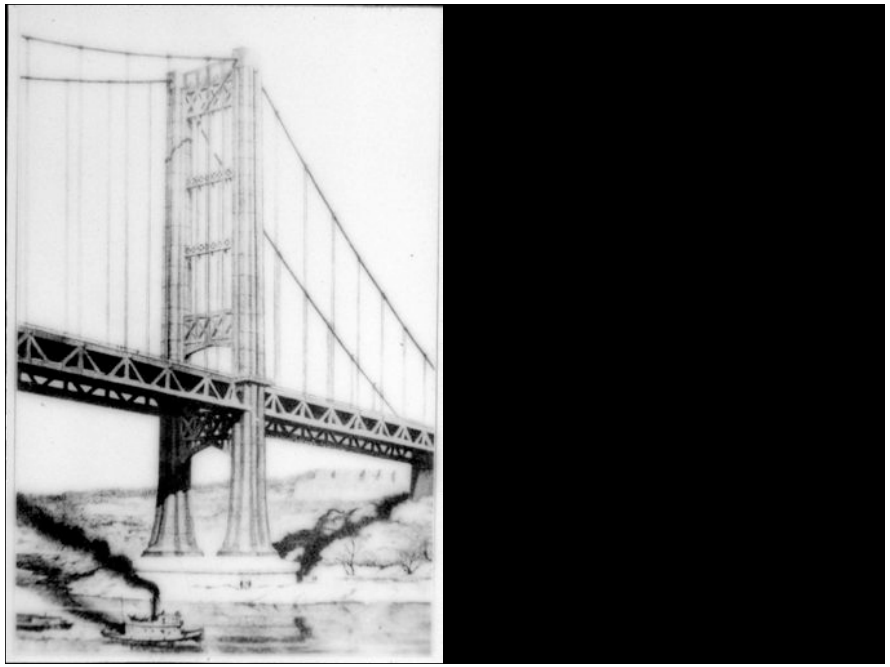


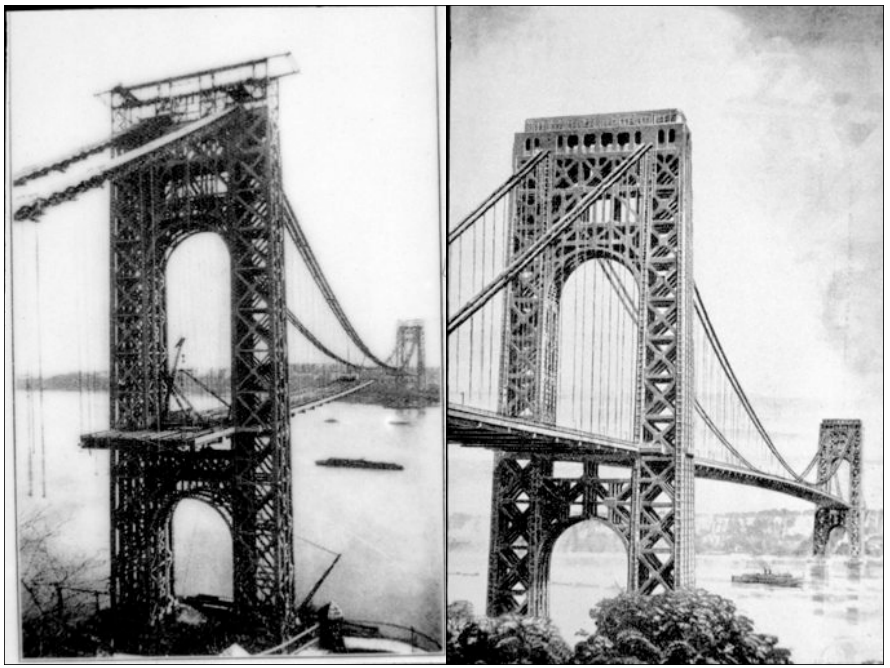
FIG. 19.—RECENT STUDIES FOR A BRIDGE ACROSS THE HUDSON RIVER


PROPOSED HUDSON RIVER BRIDGE

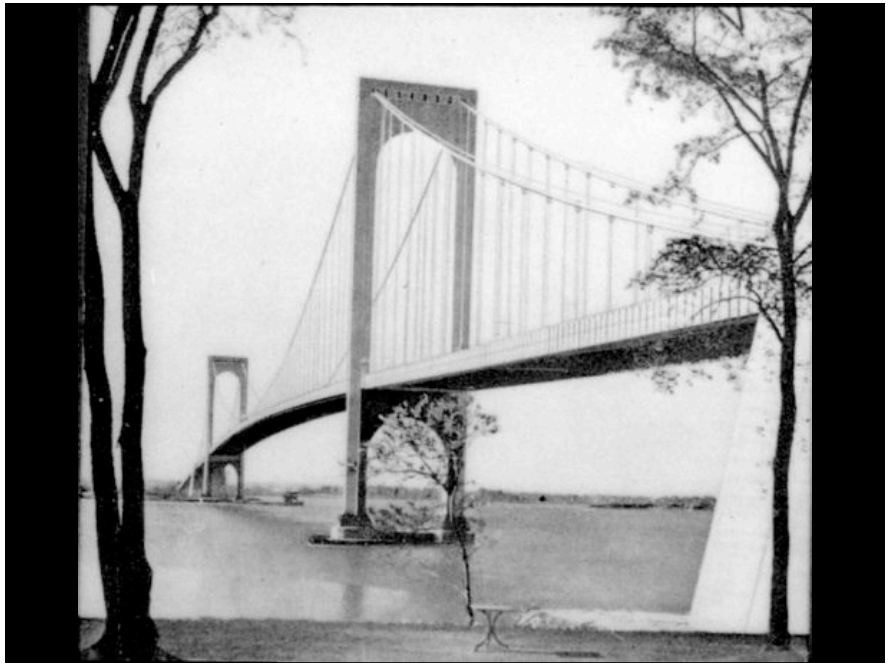

How is this bridge stiffened?
PROPOSED HUDSON RIVER BRIDGE



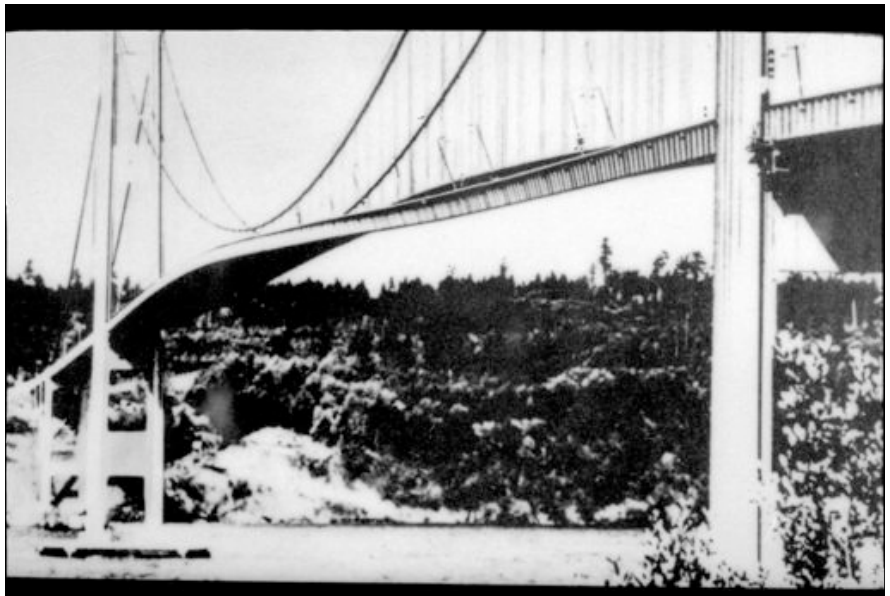
George Washington Bridge - Othmar Ammann - 3500 feet - 1931



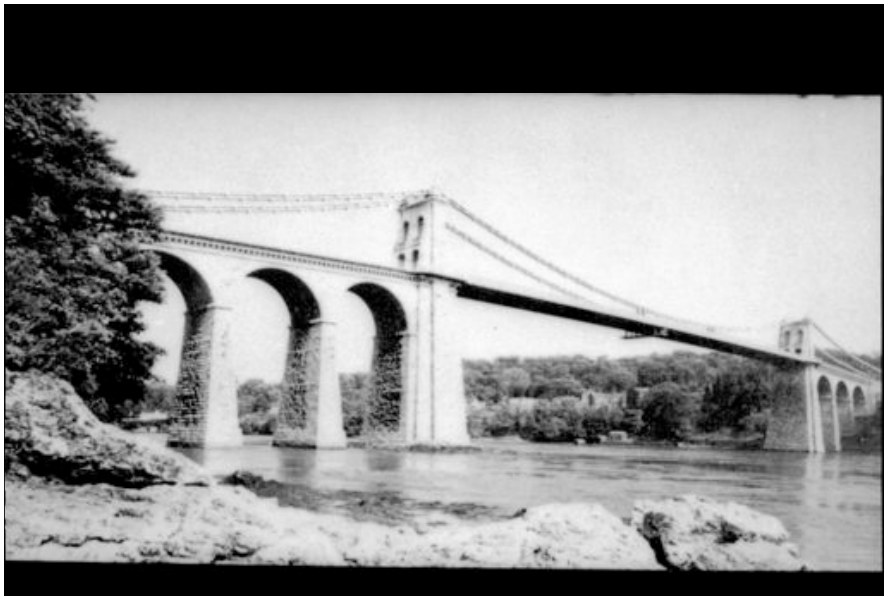
Deer Isle Bridge - David Steinman

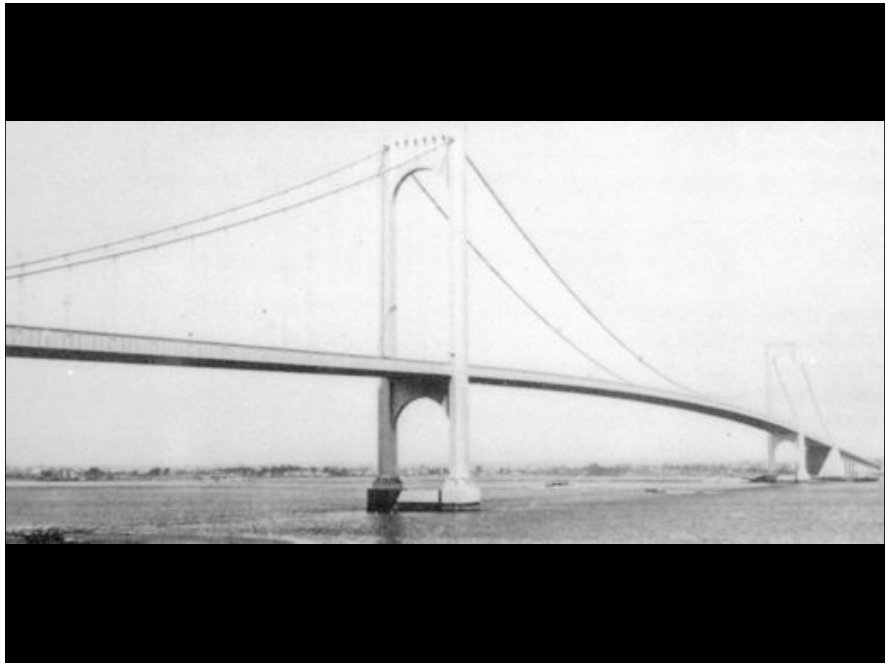


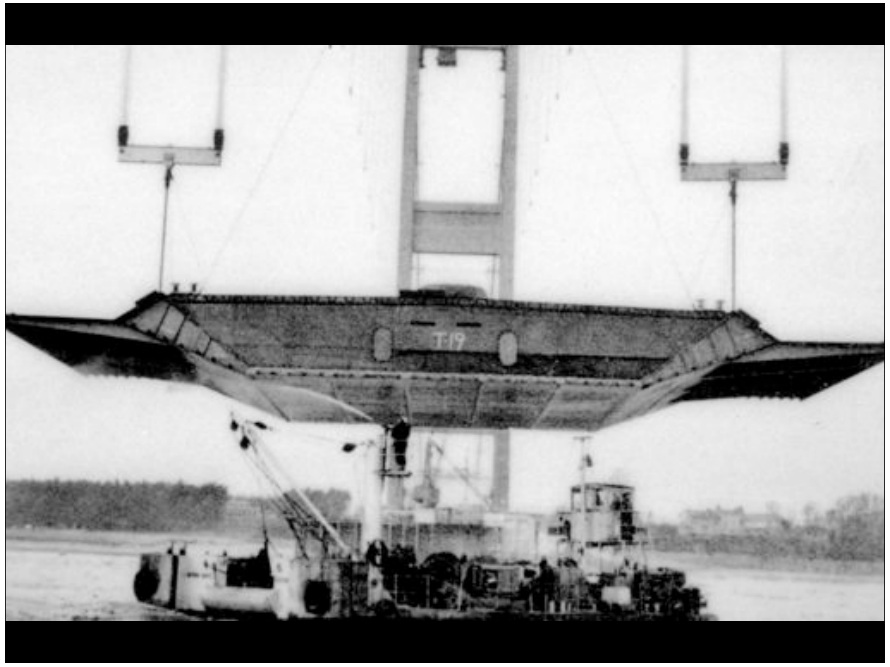
Tacoma Video

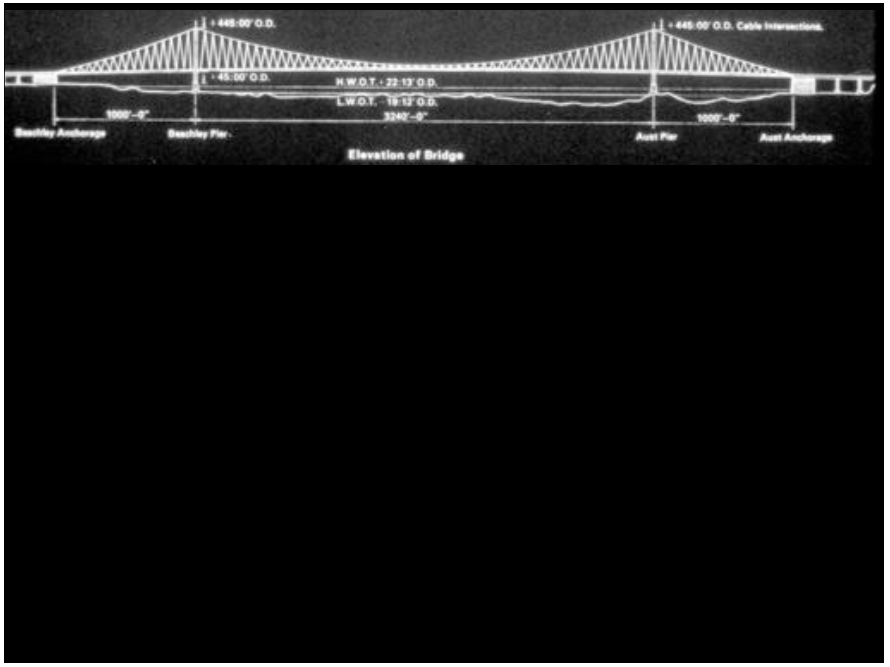


First Tacoma Narrows Bridge

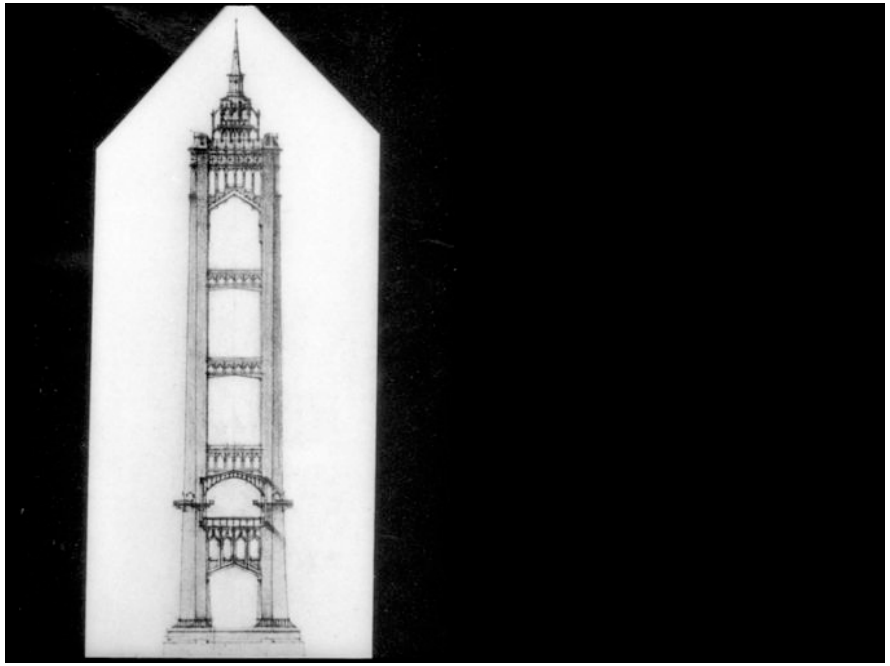


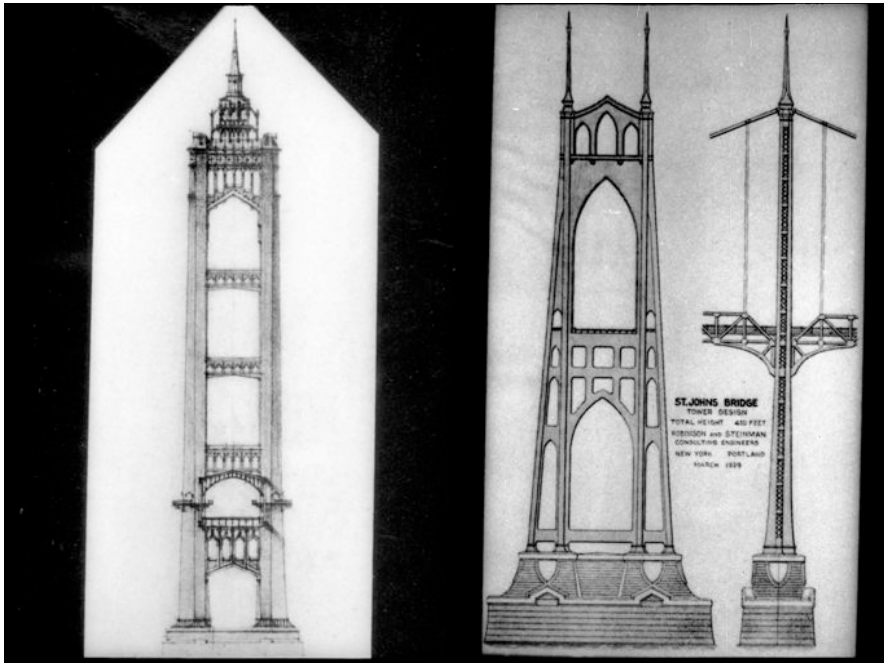


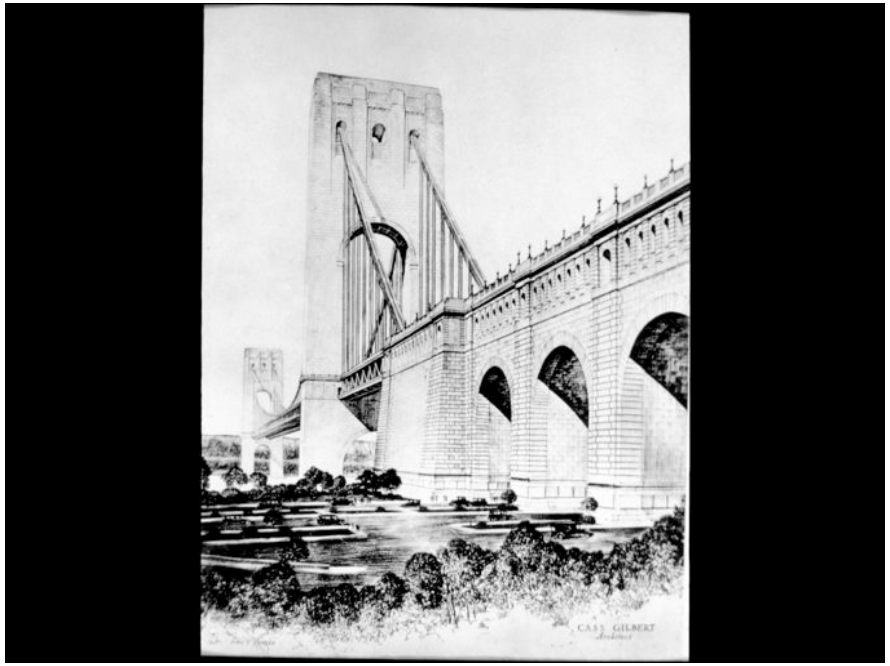


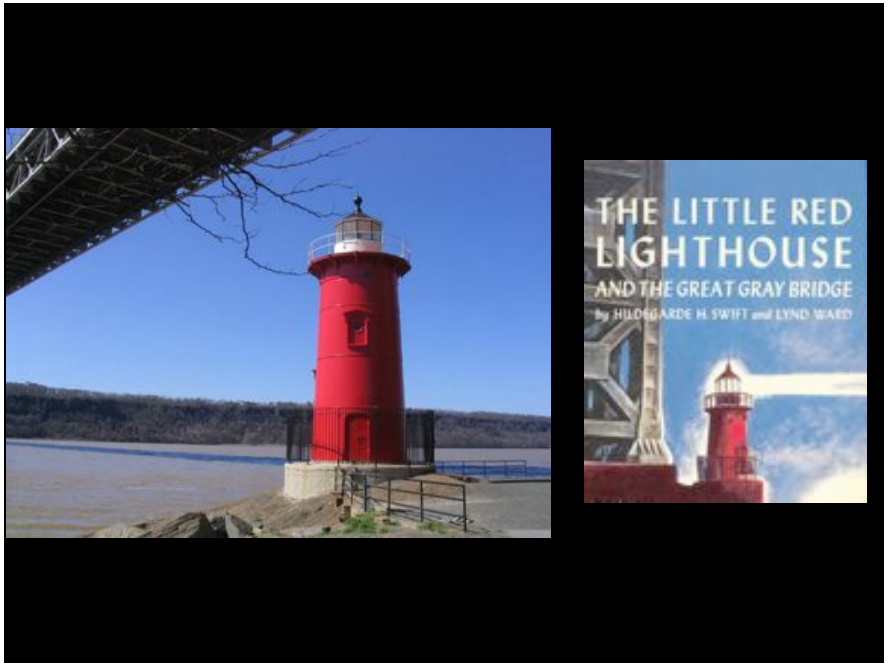

+ 445.00' O.D.
+ 445.00' O.D. Cable Intersections
+ 45.00' O.D.
H.W.O.T. + 22.13' O.D.
L.W.O.T. - 19.12' O.D.
1000'-0"
3240'-0"
1000'-0"
Beshlay Anchorage
Beshlay Pier
Aust Pier
Aust Anchorage
Elevation of Bridge

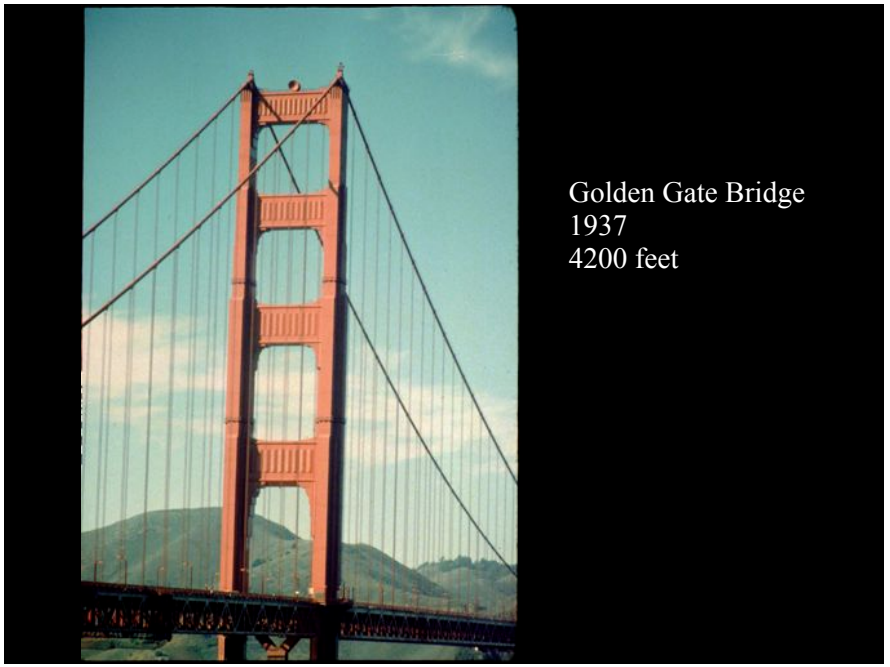
Consider the aesthetics and scientific function of towers particularly Ammann's vs. Steinman's towers



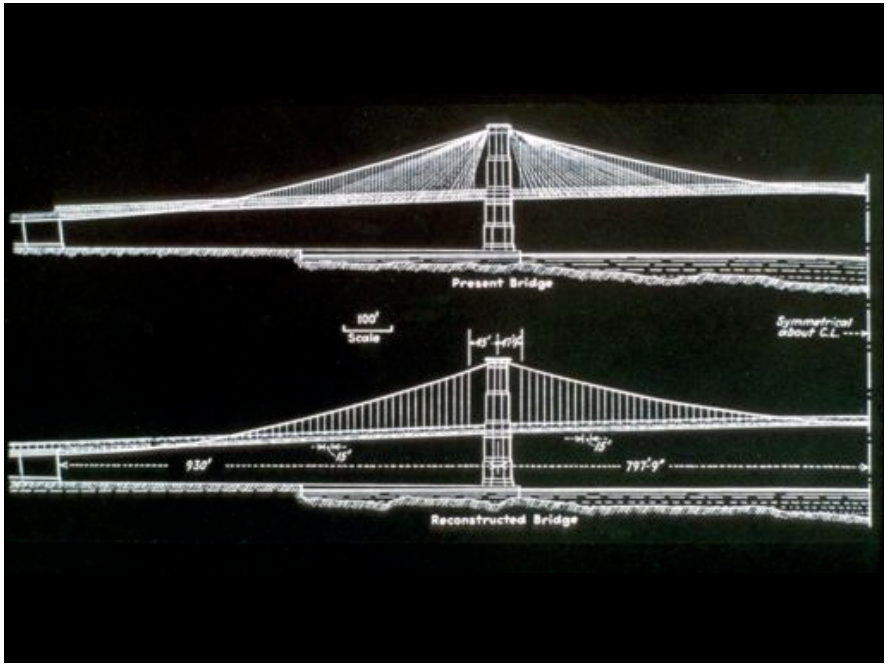

ST. JOHNS BRIDGE
TOWER DESIGN
TOTAL HEIGHT 400 FEET
ROBINSON AND STEINMAN
CONSULTING ENGINEERS
NEW YORK PORTLAND
MARCH 1928

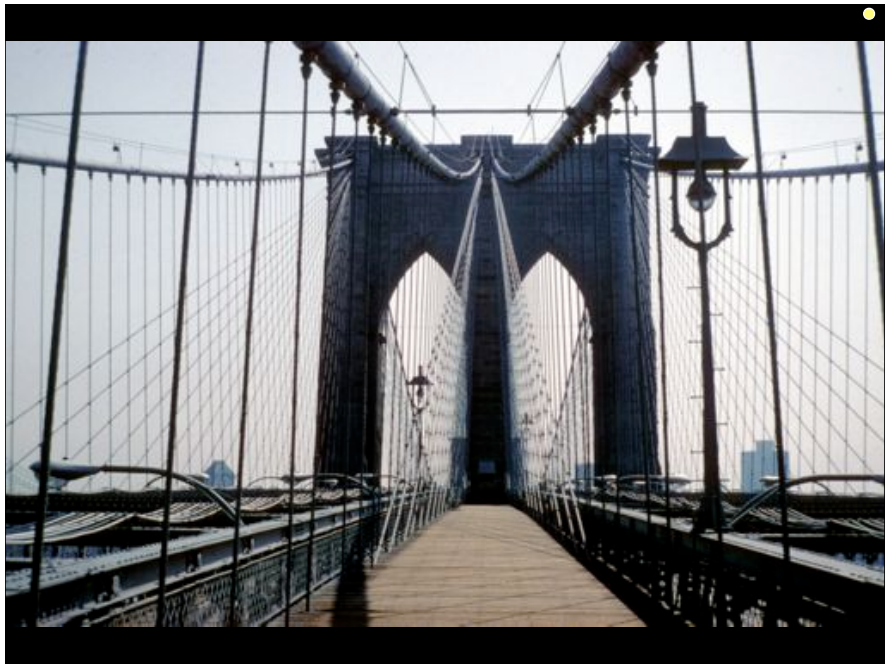


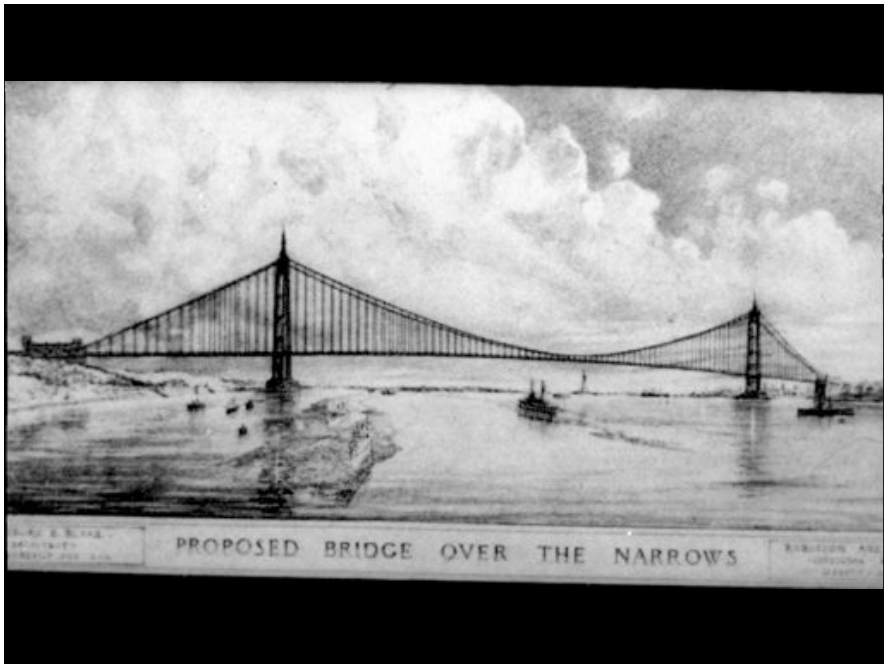


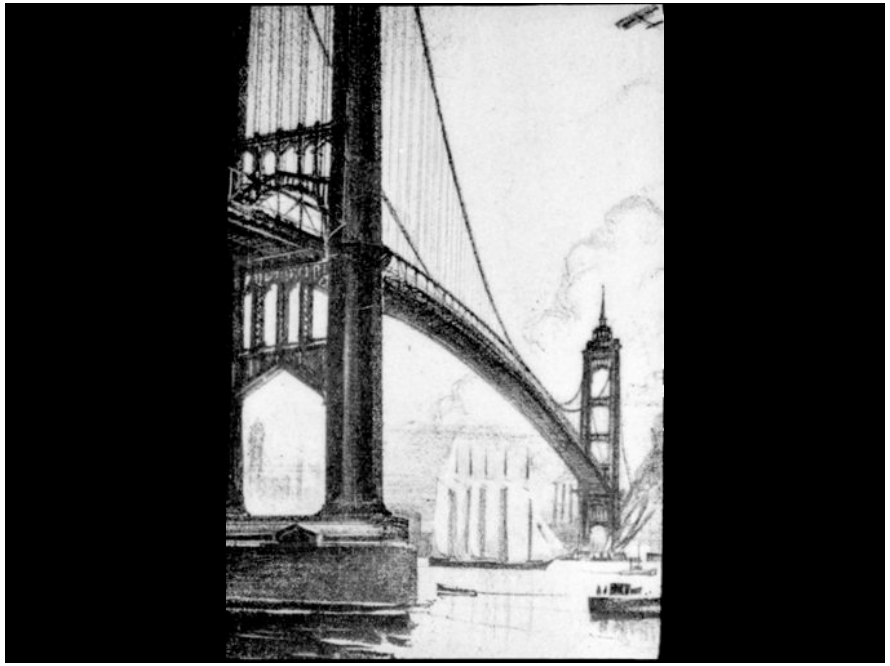


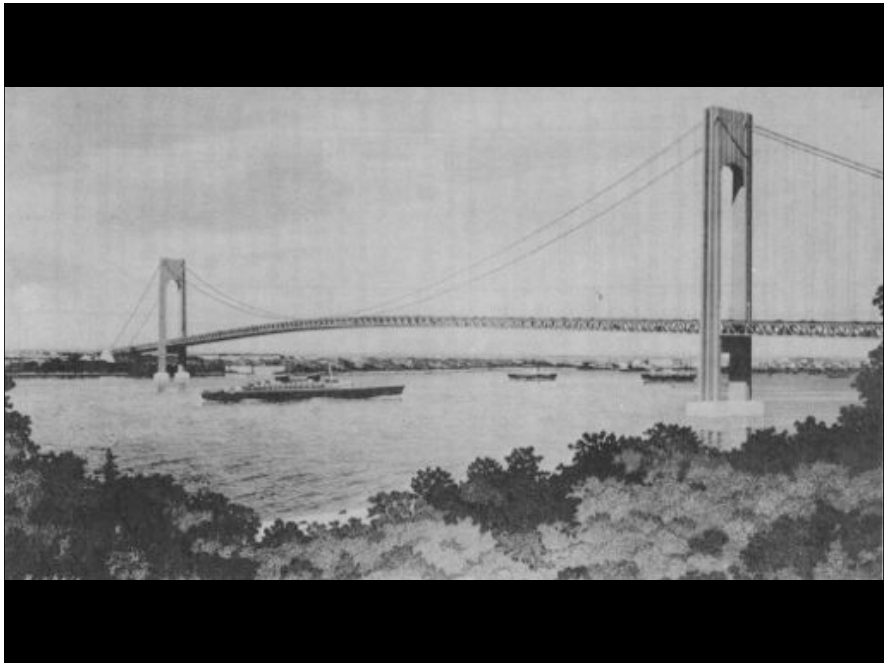
Golden Gate Bridge
1937
4200 feet


Present Bridge
100'
Scale
Symmetrical
about C.L.
930'
Reconstructed Bridge




PROPOSED BRIDGE OVER THE NARROWS





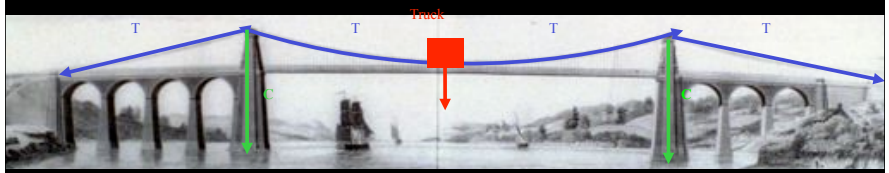
Othmar Ammann (1879 - 1965)

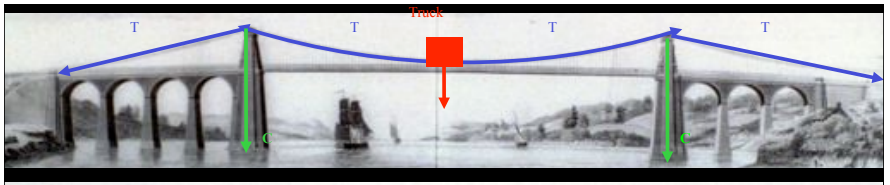
"For a half-century of distinguished leadership in the design of great bridges which combine beauty and utility with bold engineering concept and method."

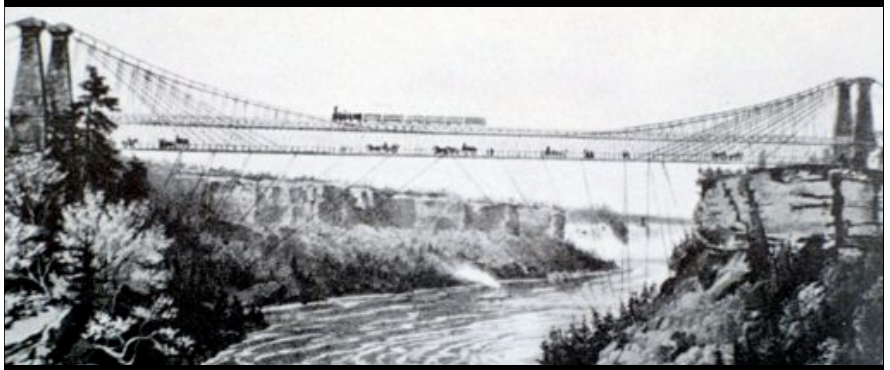
Suspension Bridge Statics

Load Path

All forces or loads must eventually get to the ground.
Can we trace the path of tension of compression?



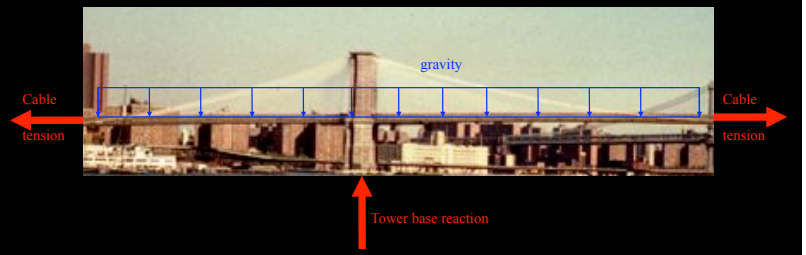


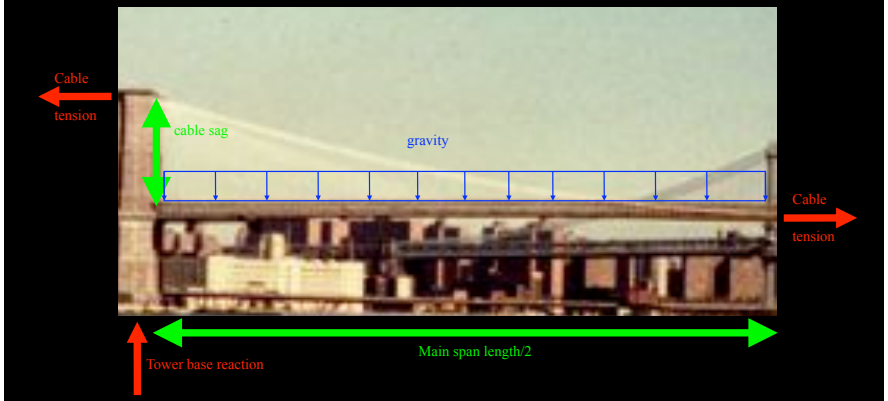


How does Roebling's introduction of diagonal stays introduce ambiguity to the load path?

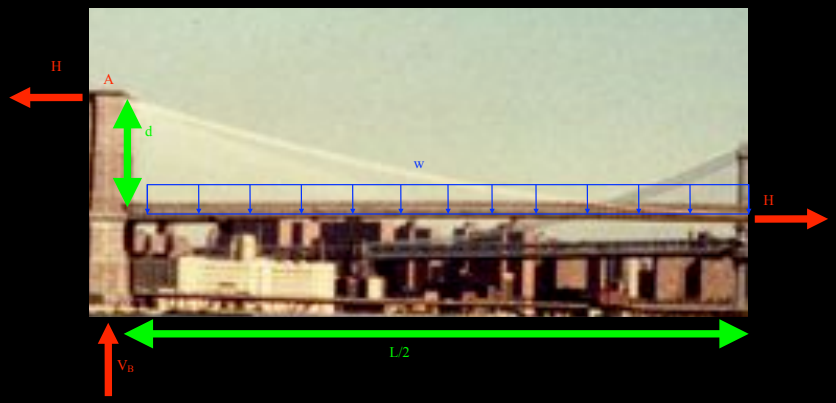
Free Body Diagrams

A sketch of all or part of a structure, detached from its support

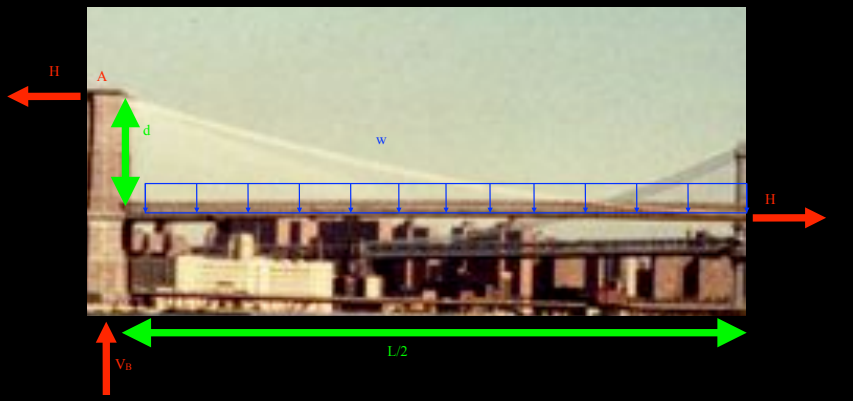




Notation

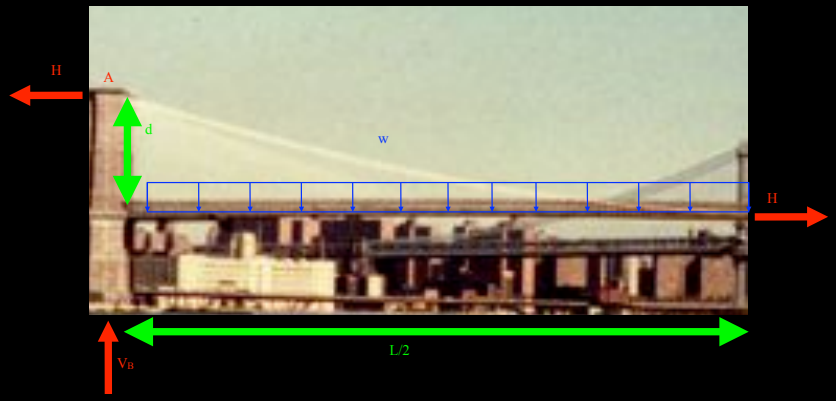


Equilibrium



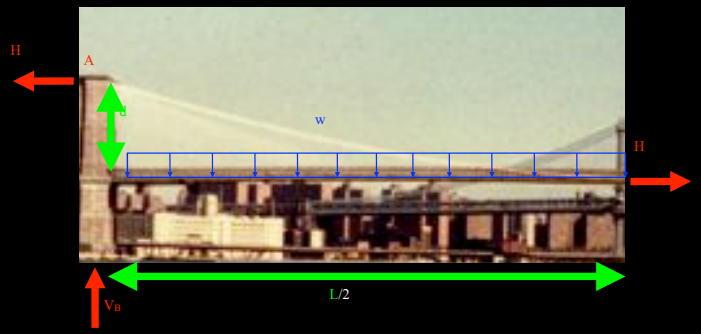
$\Sigma M_A = 0$

Equilibrium



$\Sigma M_A = 0, \quad Hd - wL^2/8 = 0, \quad H = wL^2/8d$

Cable tension



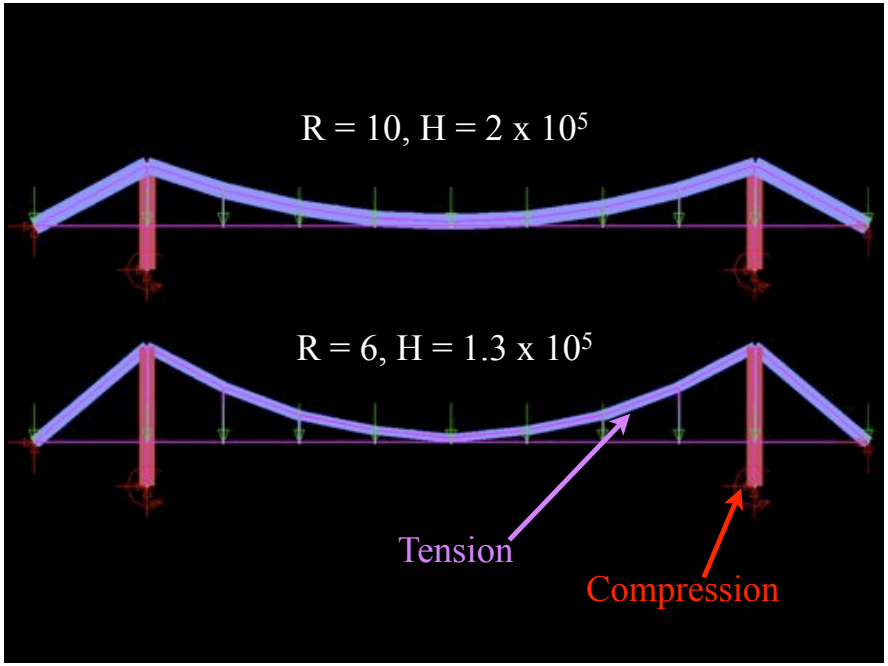
$H = wL^2/8d$

$R = L/d$

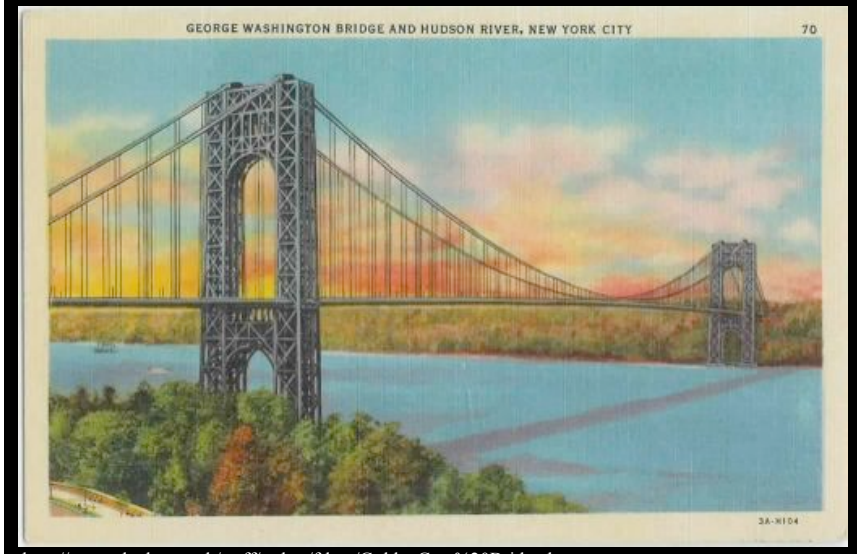
$H = wLR/8$

w = load
L = size
R = form
H = function

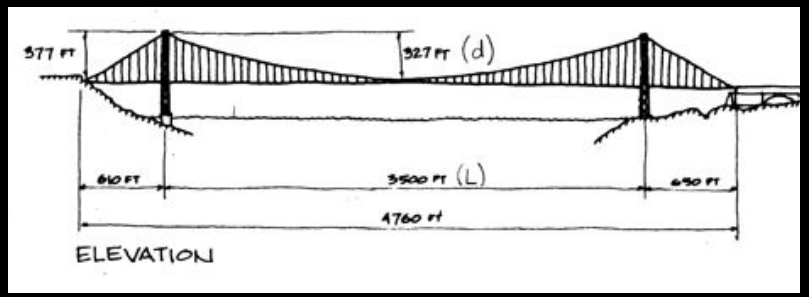
R,L transform w into H

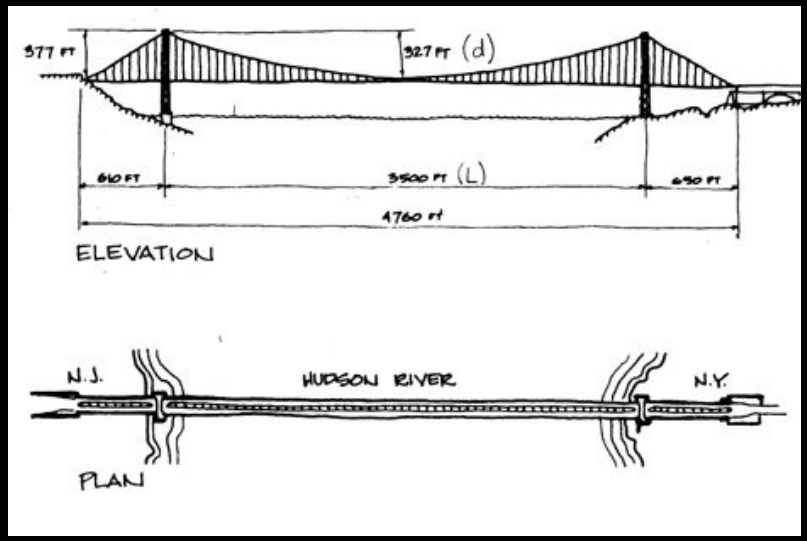


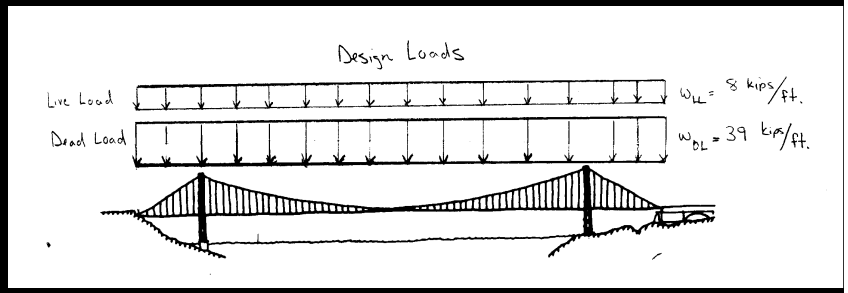
George Washington Bridge Study



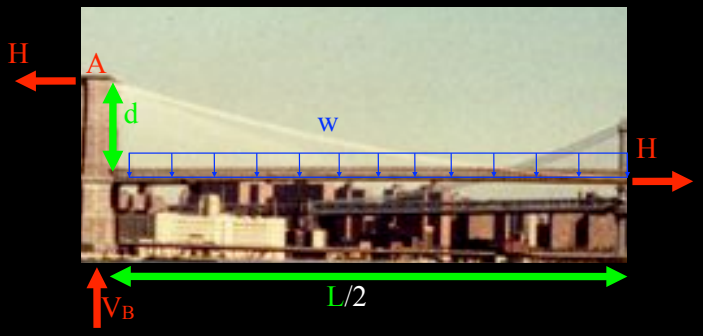
http://www.sbe.hw.ac.uk/staff/arthur/frbpc/GoldenGate%20Bridge.htm







Cable tension



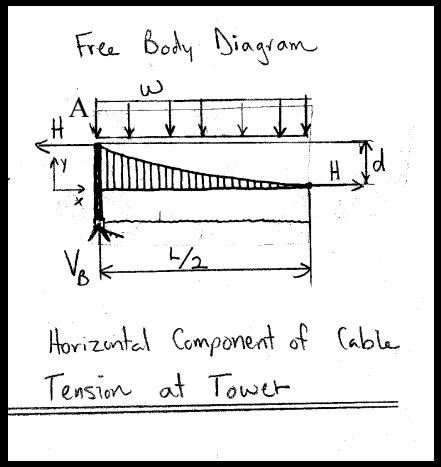
$H = wL^2/8d$

$R = L/d$

$H = wLR/8$

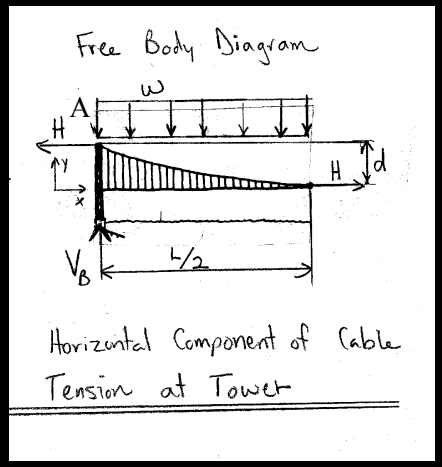
w = load
L = size
R = form
H = function

R,L transform w into H



$$H = \frac{wL}{8}R$$

$$R = \frac{L}{d}$$



$$H = \frac{wL}{8}R$$

$$\text{cable stress} = \frac{\text{cable tension}}{\text{cable area}}$$

$$\sigma = H/A$$

$$\text{safety factor} = \frac{\text{allowable stress}}{\text{cable stress}}$$

safety factor > 1 ?

safety factor < 1 ?

safety factor = 1 ?

efficiency versus safety