Brooklyn Bridge

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History

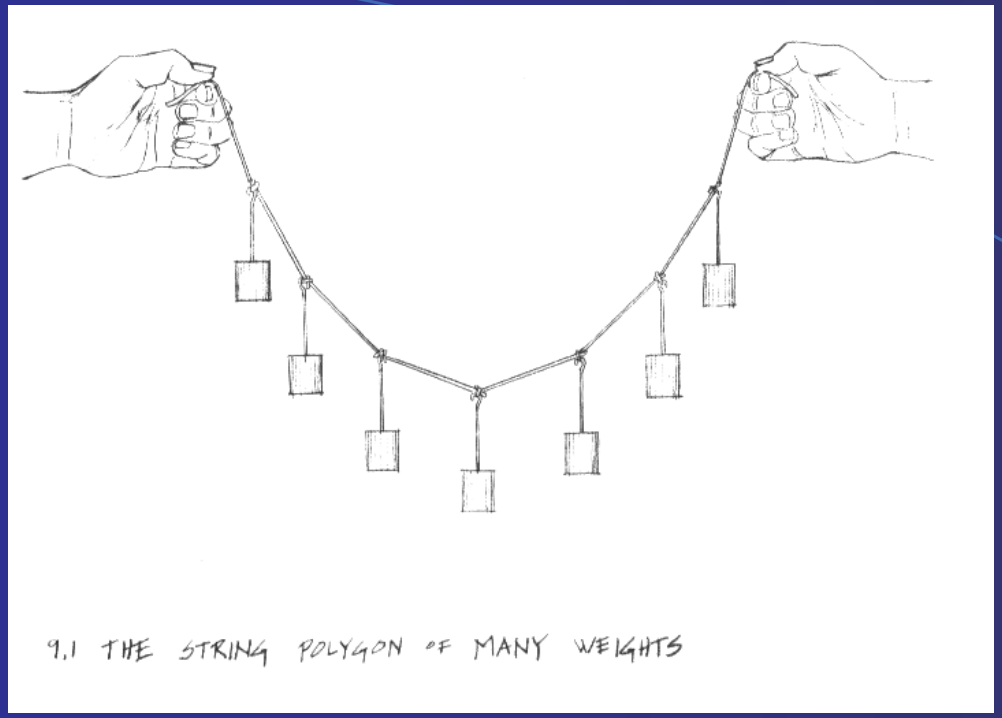
Engineers: John A. Roebling
Washington A. Roebling
Emily Warren Roebling

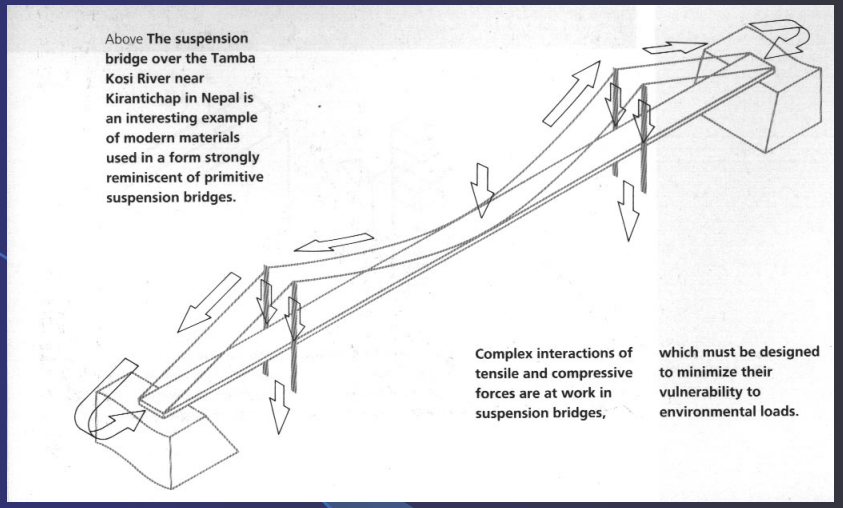
Date of Construction: January 2, 1870 - May 24, 1883

Location: Brooklyn and Manhattan, New York

Bridge Type: Suspension Bridge

Importance: <u>World Record Status at Time of Completion:</u>
Fifty percent longer than any suspension bridge
First use of pneumatic caissons
First Steel Cable Suspension Bridge





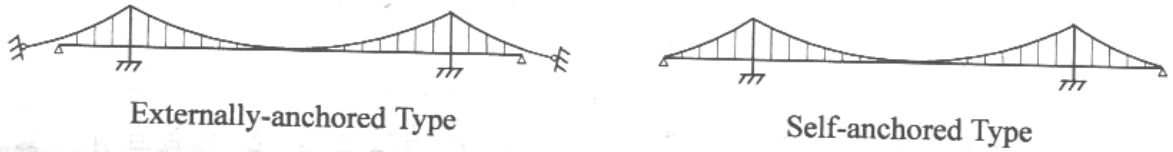
Principles / Load Paths

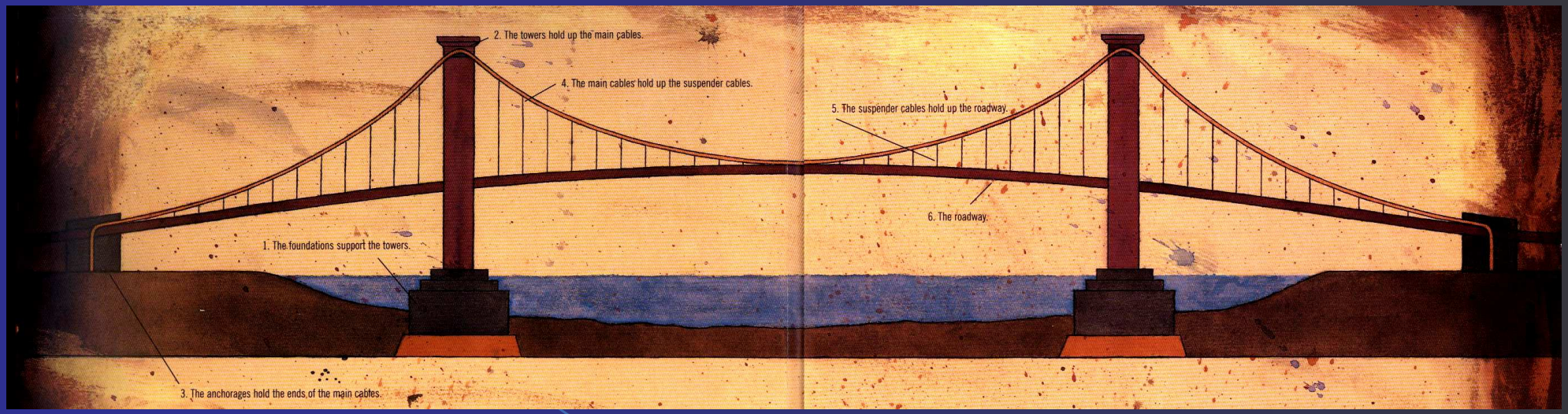
Types of Suspension Bridges

FIGURE 18.2 Types of suspension bridges.

FIGURE 18.3 Types of stiffening girders.

FIGURE 18.4 Types of suspenders.





Components

Brooklyn Bridge East River Span - 1595.5 feet
Supported land span - 930 feet.
Length of Brooklyn Approach - 971 feet
Length of New York Approach - 1562½ feet
Official Length end-to-end - 5,989 feet, 1.13 miles.

Total Weight of Bridge, excluding caissons, towers, anchorages - 14,680 tons

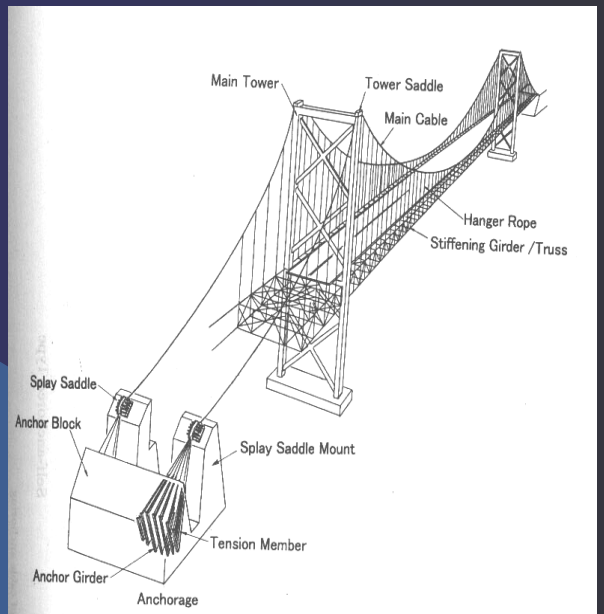
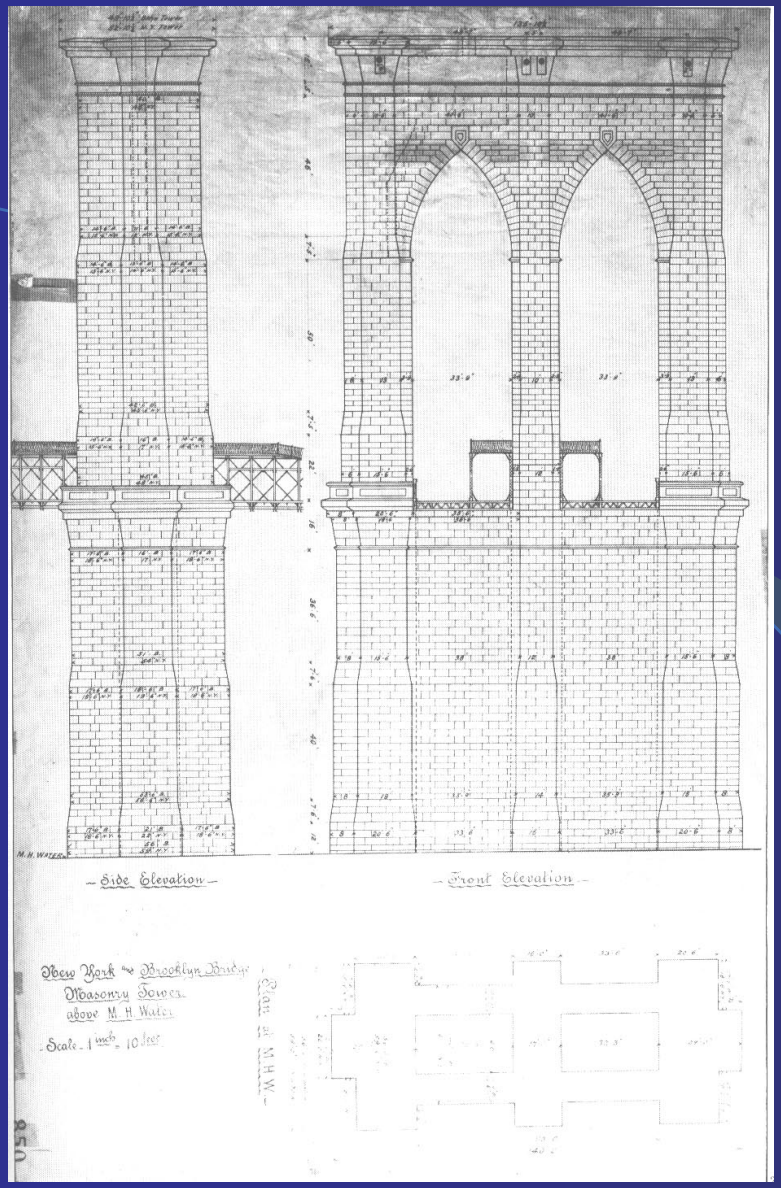


FIGURE 18.1 Suspension bridge components.



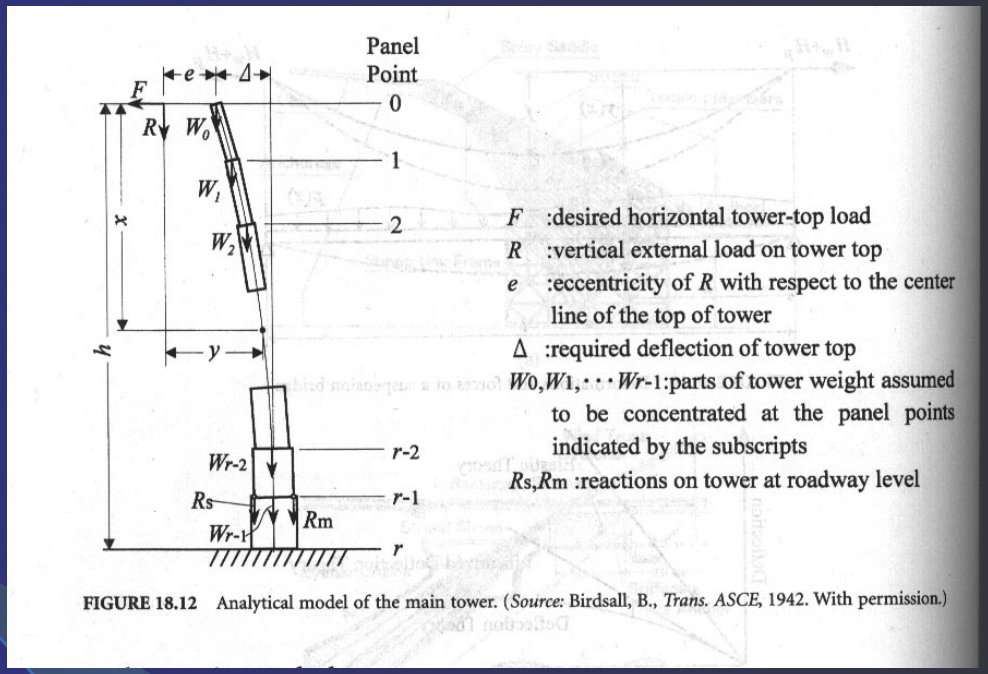
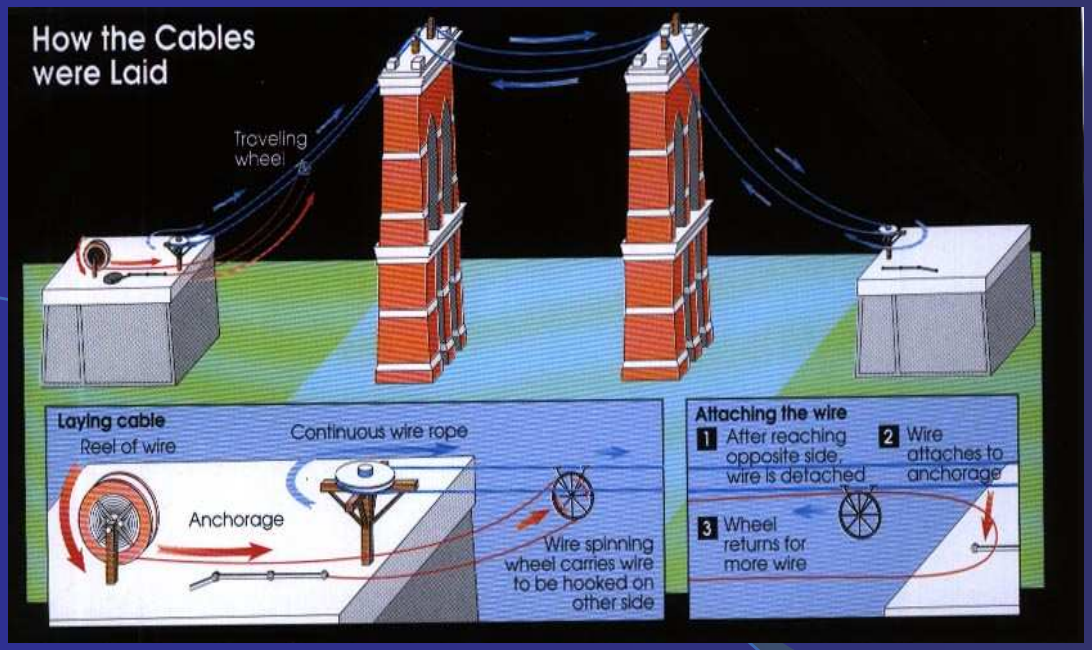


FIGURE 18.12 Analytical model of the main tower. (*Source:* Birdsall, B., *Trans. ASCE*, 1942. With permission.)

Height of Towers above high water- 276½ feet
Height of Towers above roadway - 159 feet
Height of Tower Arches above roadway - 117 feet
Tower Structure - Stone masonry



Suspension Cables
- four 15 3/4" diameter wire ropes.

Number of Strands in each cable
- 19

Total Length of Wire in cables
- approximately 3600 miles

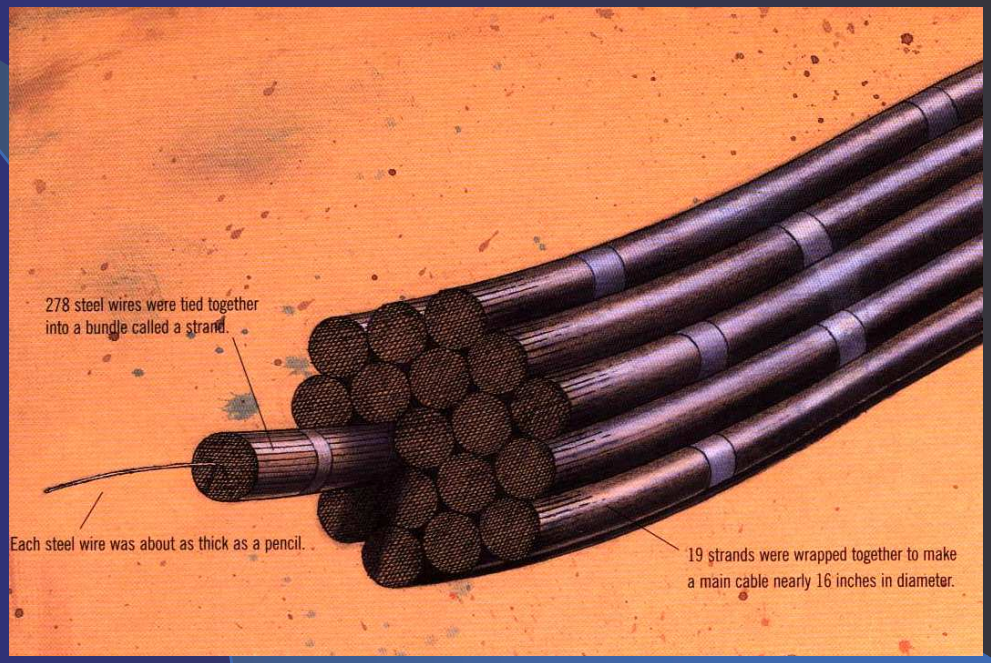
Miles of wrapping wire on each cable
- 243 miles 943 feet

Inventor and manufacturer of steel wire cable - John A. Roebling

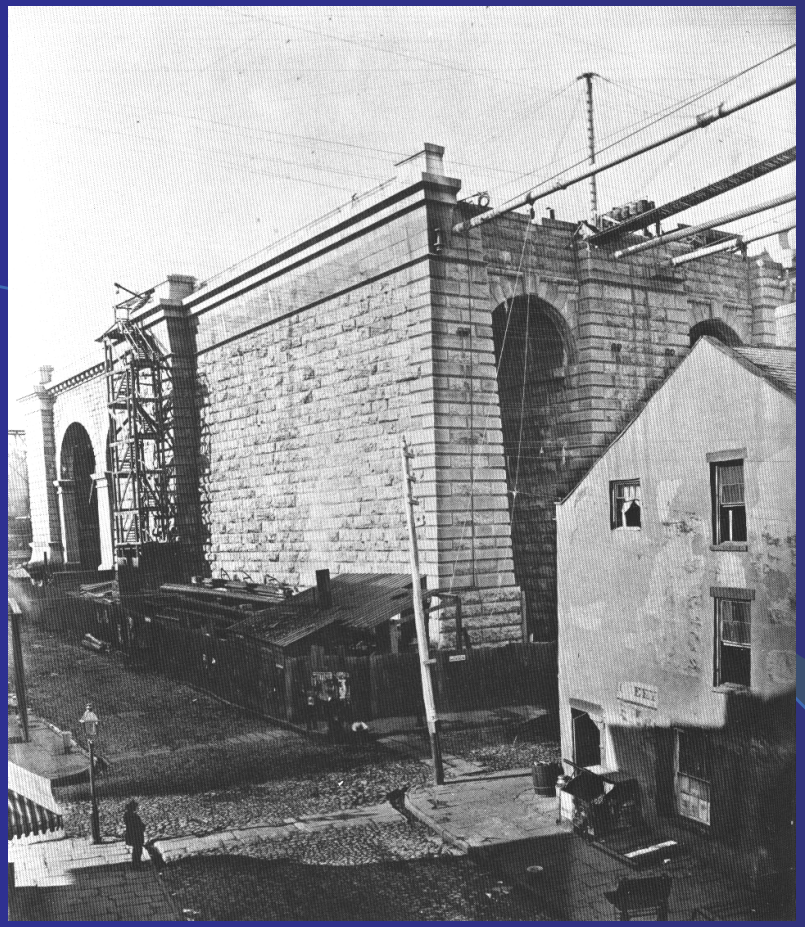
Tested cable wire strength - 160 ksi

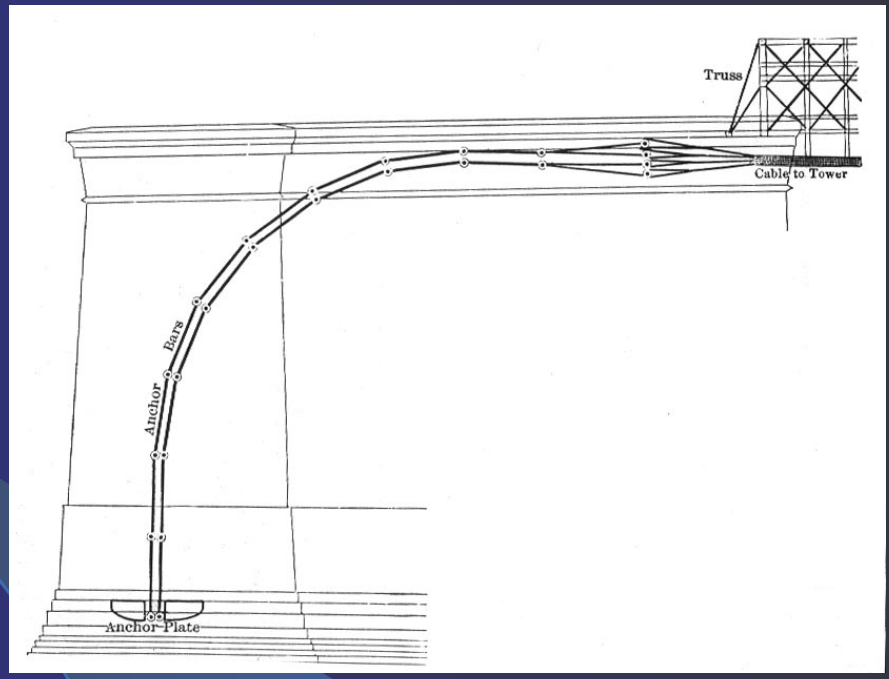
Dead weight of deck and suspenders - 13,240 kips - 3,410 kips per cable.

Maximum load on single cable (Live and Dead Load) - 6,000 kips



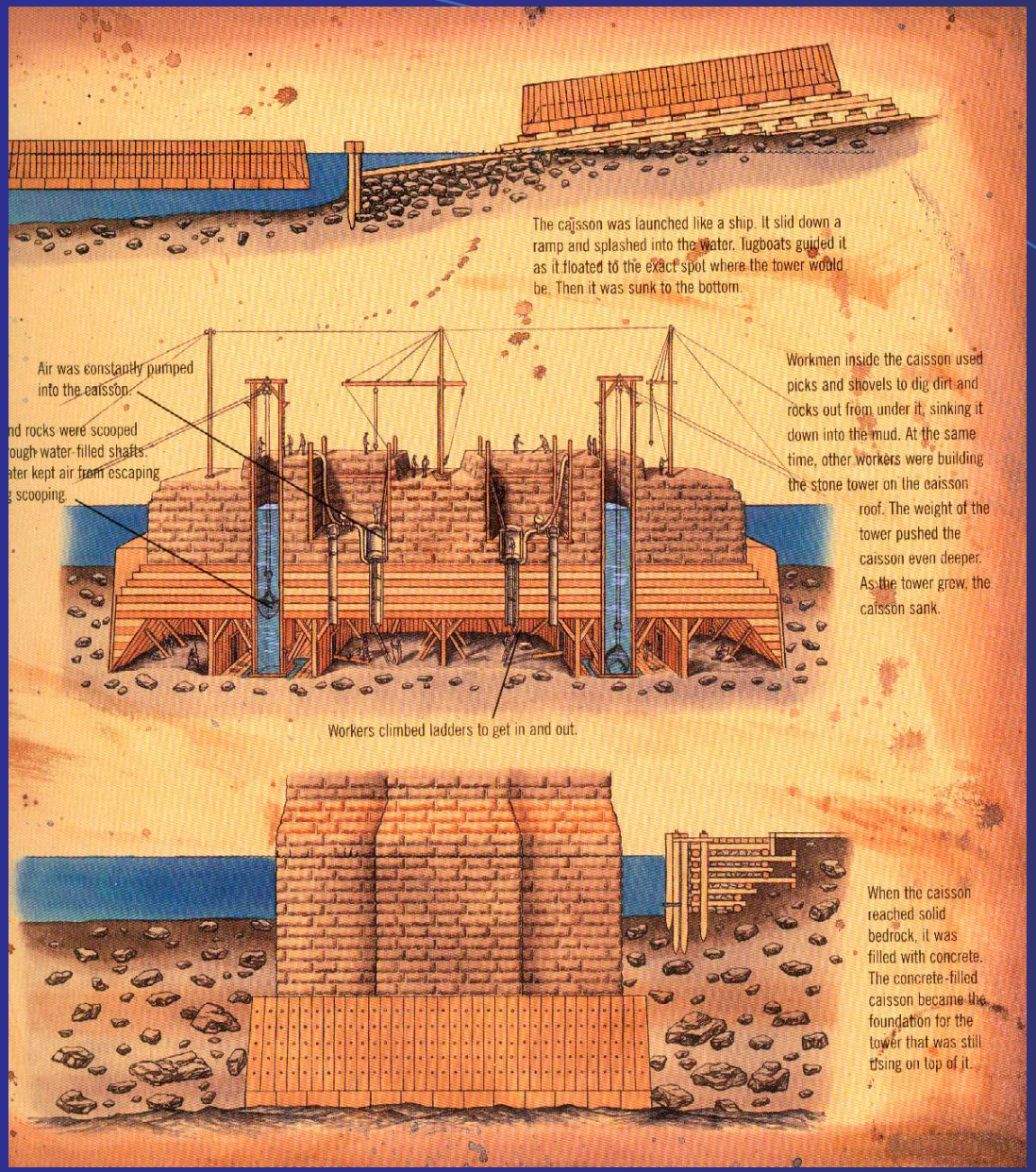
Cable Anchorage





Size of each anchorage at base - 129 x 119 feet
Size of each anchorage at top - 117 x 104 feet
Height of each anchorage in front - 89 feet
Height of each anchorage in rear - 85 feet
Weight of each anchorage - 60,000 tons

Caissons



Depth of Brooklyn caisson - 44'-6" feet below mean high tide

Design weight supported by Brooklyn Caisson - 80,000 tons
Depth of New York caisson - 78 feet, bearing on sand

Launching Size of Brooklyn Caisson - 168' x 102' x 14½'
Launching Weight of Brooklyn Caisson - 3000 tons

Holes in the top of the Brooklyn caisson –
(2) water shafts
(2) man shafts
(2) supply shafts

Determining the Distributed Load

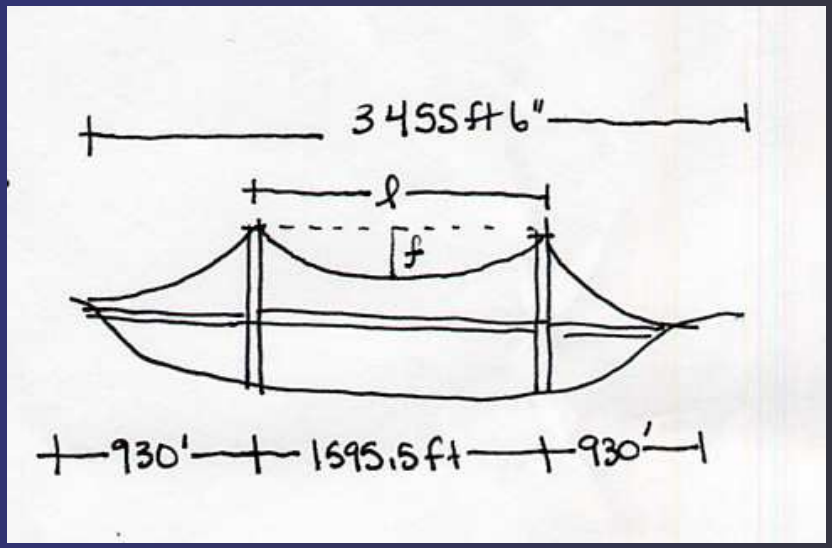
$T = (ql^2/8f)*\text{sqrt}[l + 16(f/l)^2]$

T = tension T = 6000 kips
l = span (ft) l = 1595.5 ft
f = sag (ft) f = 130 ft
q = load (lb/ft) q = ?

Solved for q:

q = 61.36lb/ft

Because of redundant engineering practice, the design for the bridge is more than adequate for the load.



Determining the Factor of Safety of Cables

Ultimate strength of cables – 24,600 kips
Maximum load on a single cable – 6,000 kips
Cable factor of safety – 24,000/6,000 = 4.1

Determining the Length of the Cable

$S = l[1 + (8/3)*(f/l)^2 - (32/5)*(f/l)^4]$

S = length of cable (ft) S = ?
l = span (ft) l = 1595.5 ft
f = sag (ft) f = 130 ft

***S* = 1623.3ft**

John A. Roebling's Death –
July 22, 1869, of Lockjaw, an infection
resulting from the accident in which his foot was crushed.

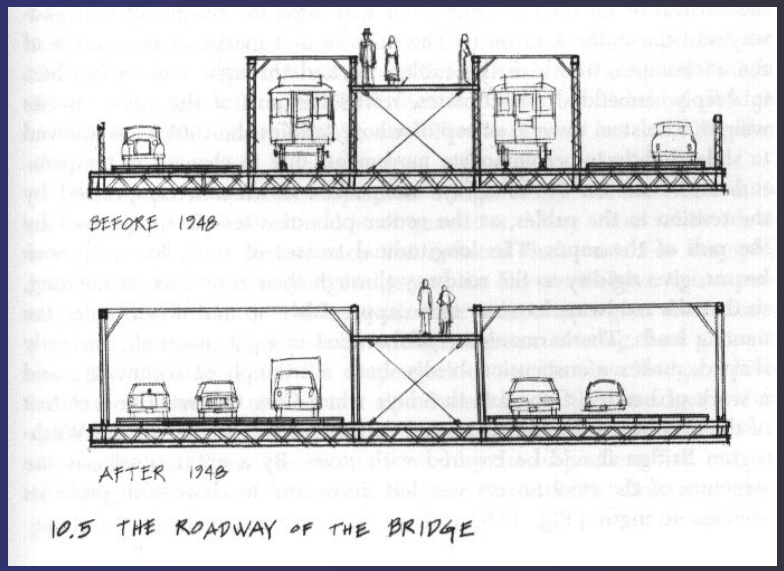
How tough was John Roebling? –
Declined anesthetic for the amputation of his toes crushed in the 9 July 1869 accident.

Bridge Construction Calamities:

- John A. Roebling's death
- Explosion
- Caisson Fire
- Steel Cable contractor fraud
- Illness and debilitation of Washington A. Roebling
- 20-30 Deaths

Notable parcel under NY anchorage -
1 Cherry Street, home of George and Martha Washington from 1789 to 1790 when New York was the capital of the US.

Scandal over the supply of faulty wire – 1887
People crossing the bridge on opening day - 150,300
Vehicles charge on Opening Day - 5 cents



"Report" to the New York Bridge Company September 1, 1867 - Plan and Details of Anchorage, Approaches, Towers, and Steel Cable. "The contemplated work, when constructed in accordance with my design, will not only be the greatest bridge in existence, but it will be the great engineering work of the Continent and of the age. Its most conspicuous feature - the great towers - will serve as landmarks to the adjoining cities, and they will be entitled to be ranked as national monuments. As a great work of art, and a successful specimen of advanced bridge engineering, the structure will forever testify to the energy, enterprise, and wealth of that community which shall secure its erection."