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: World Record Status at Time of Completion:
Fifty percent longer than any suspension bridge
First use of pneumatic caissons
First Steel Cable Suspension Bridge
Principles / Load Paths

9.1 The String Polygon of Many Weights

Above: The suspension bridge over the Tamia Keal River near Kirtanshah in Nepal is an interesting example of modern materials used in a form strongly reminiscent of primitive suspension bridges.

Complex interactions of tensile and compressive forces are at work in suspension bridges, which must be designed to minimize their vulnerability to environmental loads.

Suspension
Types of Suspension Bridges

**FIGURE 18.2** Types of suspension bridges.

- Single-Span
- Three-Span
- Multi-Span

**FIGURE 18.3** Types of stiffening girders.

- Two-hinged Stiffening Girder
- Continuous Stiffening Girder

**FIGURE 18.4** Types of suspenders.

- Vertical Hangers
- Diagonal Hangers
- Combined Suspension and Cable Stayed System

- Externally-anchored Type
- Self-anchored Type
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
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

\[ T = \left( \frac{q^2}{8f} \right) \sqrt{l + \frac{16f^2}{l^2}} \]

- \( T \) = tension
- \( l \) = span (ft)
- \( f \) = sag (ft)
- \( q \) = load (lb/ft)

Solved for \( q \):

\[ q = 61.36 \text{ lb/ft} \]

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 – \( \frac{24,600}{6,000} = 4.1 \)

Determining the Length of the Cable

\[ S = l \left[ 1 + \frac{8}{3} \left( \frac{f}{l} \right)^2 - \frac{32}{5} \left( \frac{f}{l} \right)^4 \right] \]

- \( S \) = length of cable (ft)
- \( l \) = span (ft)
- \( f \) = sag (ft)

\[ S = 1623.3 \text{ ft} \]
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."