The Great Bridge [Brooklyn] by David McCullough (1972)

John Roebling [JR 1806-1869] was a man of vision & his son, Washington [WR 1837-1926], was a great engineer. A bridge over the East River [NYC-Brooklyn] would be safer than ferries in bad weather and would allow horizontal expansion [not thinking of taller buildings yet]. It would be the largest suspension bridge in the world. The steel wires were in tension while the stone towers were in compression. The bridge would carry trains, cars & pedestrians [elevated walk would allow uninterrupted views].

1860s were a great time for man's accomplishments. Among them were: Suez Canal, Trans-continental railroad & Grand Central Depot. There was great public apprehension to suspension bridges. 1870's one out of four bridges failed. Learning from others, stiffness was the key to a bridge's success. It was designed 6x as strong as it needed to be, to allow for error. And error came when the wire company was sending inferior wire to the site [$300,000 illegitimate profit].

In 1869 if you wanted anything done in NYC, you went through [& paid fees to] William Tweed. He made off with $30M from the people of NY before he was deposed in 1872. He was paid millions in corruption from the County Courthouse & had his eyes on the bridge as another endless coffer. The courthouse cost $13M in 1871 [500% over-budget & twice what was paid for AK]. Kingsley would buy 1600 shares of stock & give it to Tweed. In return Tweed got him appointed as superintendent & was paid $175,000 for doing nothing. Tweed flaunted his wealth at his daughter's wedding and people began to wander where he got his money. And then when the county auditor & Tweed's trusted bookkeeper died it all fell apart.

A caisson is a huge bottomless box filled with compressed air to keep water out. The roof of the 14' tall caissons were covered with 12 layers of alternating 12x12 timbers [yellow pine]. It is driven into the earth until it reaches a firm foundation. Then it is filled with concrete to support the weight from the masonry tower above. The V-shapes [8"@bottom & 9'@top] sidewalls create surface friction [900psf]. The caisson itself weighed 3000 tons & was divided into six chambers. The exterior was coated with coal tar, hydraulic cement, tin & a layer of creosote-saturated yellow pine. Sea worms cause damage between low-tide mark & mud line so the caisson needed to be well below that. Boulders would have to be removed to continue driving the caisson down.

Atmospheric pressure is 14.7 psi & they will range from 20-35 psi inside the caisson [more reqd deeper]. They had water shafts [filled with water & stayed afloat by barometric pressure] to bring in supplies & carry out dirt. And they had air chambers for the men to come & go. Men were impaired, hospitalized & some died from the bends [nitrogen bubbles released into the body & blocks oxygen in the blood]. The cure was known at the time, but most didn't believe it would work [slowly coming back to normal air pressure (1 minute per pound of pressure)].

Fire had been discovered in the Brooklyn caisson & was put out quickly. But it traveled inside the timbers & made huge cavities. The caisson was flooded with 1.35M gallons of water, then dried out & the cavities were filled with 600 cf of concrete. The NY caisson was then lined with boiler plate [prevent fire] & whitewashed to reflex more light. It was unfortunately located on

the city's dumping ground and near street sewer outlet. There was more sand on the NY side & the caisson drove down faster. The compressed air in the caisson would shoot sand & water up 400' in the air [to remove it from below].

The Brooklyn caisson had a spiral stair to exit after the air lock, but it was fatiguing to climb. The NY caisson had a steam elevator installed. They worked 24/6 [no work on Sundays] for $2 a day [8 hr shift] but stopped for winter outside the caissons. It was 80 dF in the caisson & men would easy catch colds when they exit sweaty to the cold outside. They hired a doctor to review the men & he had the right idea, but they were inadequate to do any good.

Much of WR time was spent on administrative reports to the directors & politicians. A combination of the bends & stress caused severe damage to his health [nervous system was shattered]. He nearly died in 1872 & was house bound most of the rest of his life. His wife became his connection to the world. Emily did a great job at understanding & explaining the engineering. His mind was still sharp & he would dictate ideas he worked out in his head. His brothers died & at 84 he took over the wire mill again.

It would take 10 minutes to carry a new 1/8" wire from shore to shore & there were about 400,000 trips. 19 of these wires would be wrapped into a hexagon section, 278 sections in a strand, and then the 19 strands were compressed & encased in wire [16" diameter total]. 1176 of suspender ropes hung from the four 16" main cables to hold the deck & diagonal stays radiated from the towers to give more stability.

NYC stopped paying their share & brought construction to a near halt. The courts ordered them to pay up & construction resumed. Toward the end of construction electric lights & telephone had been introduced [that would have helped in the caissons] so lights were added. Greatness comes from an absolute confidence in their ability to do the job at hand. Our strengths can also be our weakness.

1841 Roebling began making wire rope [1" steel would replace 9" hemp]
1844 JR built the 1st suspension aqueduct [canal over the Allegheny]
1855 JR built the 1st suspension railroad bridge at Niagara Falls
1867 charter approved for the bridge & WR was sent to Europe to study caissons
1869 John Roebling died from not following doctor's orders after getting his foot crushed
1870 construction began with the Brooklyn caisson
1871 Brooklyn caisson finished & New York [NY] caisson began
1872 NY caisson finished & the Tweed ring collapsed
1873 Brooklyn anchor began
1875 NY anchor began, Brooklyn tower & anchor finished
1876 NY tower & anchor finished, wires began
1878 cable spinning finished
1883 Brooklyn Bridge [BB] completed
1944 trains quit running on the bridge & it was inspected [it only needed more paint]
1948 RR tracks replaced with a 3rd lane in each direction.
1964 The bridge became a National Historic Landmark

Stats: the roadway is 130' above the water & the 2 towers [140' x 59'] reach 276' [1595' apart], with a total length of 5989'. 168' x 102' caissons were set at 44' & 78' [Brooklyn & NY

respectively] deep. 119'x85'x129' [WHL] masonry anchors weighed 60,000 tons each to hold cables. Total cost of $15 million.

Trivia: The stone towers were mad of limestone below water & granite above. Roebling Wire Co had a great reputation & was lowest bidder, but politics gave the contract to another [ultimately went bankrupt]. Weight of boats did not add to total weight carried by the aqueduct since it displaced its own weight. Roebling's bridges made them famous, but their wire company made them rich. The triangle is the only unchangeable figure known in geometry. Henry Ward Beecher [brother to Harriet], preacher for Plymouth Church in Brooklyn, was paid $20,000/yr [same as the US President][Roebling was only paid $8,000/yr]. Roebling Wire was used to build the Golden Gate Bridge, the Panama Canal & elevators. WR mineral collection [included all but 4 known minerals] was donated to the Smithsonian. BB was the 1st & last monumental stone gateway in North America. The BB gets a new coat of paint every 5 yrs.

Books: Johnston Flood (David McCullough); Dairy of my Journey [immigration] (John Roebling); The Gilded Age (Mark Twain);

1857 Economic panic
1869 Fisk & Gould tried to corner the gold market [govt flooded the market to bring it back]
1913 Income tax began
1940 Tacoma Narrows Bridge collapse [to light & flexible in high wind]