**The Building of the Brooklyn Bridge**

Brooklyn boasts many things. They include the best pizza on the planet and the original Nathan’s (at Coney Island). It was also the home of the legendary Brooklyn Dodgers, where “Jackie” Robinson--the first black major-league player--debuted in 1947.

The second largest borough of New York City (the first is Queens) has also been justifiably stigmatized for its infamous Brooklyn accent, which butchers commonplace words beyond recognition: “tawks” (talks), “tirty” (thirty), “tird” (third), “quarder” (quarter), “nawmal” (normal) and of course, “duh” (the).

But Brooklyn is also home to the historic BrooklynBridge. Completed in 1883,

the bridge is an architectural tour de force and an enduring monument of brilliant project management. Over the past couple of years I’ve written about PMs responsible for historic projects ranging from the building the Alaskan Pipeline to managing the creation of the atomic bomb, which brought World War ll to a speedy end.

The building of theBrooklynBridge also belongs in that august category because it had all the ingredients of a project fraught with drama, tragedy, hardship, problems, lessons and astounding triumphs.

It’s not hard to understand why the spectacular structure still draws thousands of tourists each year, compelled to be able to say that they walked the awesome suspension bridge that crosses the East River and links Brooklyn and Manhattan. Even cynical, hard-edged New Yorkers are proud of the monumental structure. Every day thousands of cars and bikes cross the bridge, and pedestrians walk it going to and from work.

**Historic firsts**

The BrooklynBridge was the first suspension bridge to use steel for its cable wire and underwater explosives in its construction. When completed, the 3,460-foot bridge was the longest suspension bridge in the United States. With a main span of 4,260 feet, the Verrazano-NarrowsBridge--linking Brooklyn and Staten Island--took that No. 1 slot upon its completion in 1964. The second longest suspension bridge in the nation today is San Francisco’s 4,200-foot Golden GateBridge, completed in 1937.

**Why the bridge was built**

Prior to the construction of the BrooklynBridge, getting to Manhattan from Brooklyn (and vice versa) was difficult--a nightmare during the winter because the frozen East River was impossible to cross by boat. In the mid-1860s, it took less time to go from the state capital ofAlbany to New York City by train than to go from Brooklyn to Manhattan.

The view from the 1-mile-plus suspension bridge--with its elevated pedestrian promenade and its two imposing towers sunk deep in the river’s rocky surface--would make the surrounding skyline a tourist attraction not to be missed.

**A triumph of persistence over adversity**

Like many extraordinary projects that finally came to fruition, the BrooklynBridge was plagued with crippling problems before and during its construction. The two engineers/PMs responsible for the building of the bridge were John A. Roebling and his son, Washington A. Roebling. Unfortunately, John was only involved in the initial planning stage. When he was surveying the construction site, his foot was smashed in a freak accident. He died of tetanus, a rare but often fatal disease that affects the central nervous system. (Today, it’s easily preventable with a tetanus vaccination.)

John not only designed the BrooklynBridge, but is also the inventor of the steel wire rope used in bridge suspension cables. After emigrating from Germany to Pittsburgh, the elder Roebling was considered a legend in his time who achieved the American dream. While he was penniless when he arrived, his creativity and drive motivated him to achieve greatness. He was known as a pioneer farmer, inventor, spiritualist and philosopher and above all an inventor and brilliant architect.

But it was Roebling’s 1840 patent for the spinning of wire rope, which was considered a major breakthrough in suspension-bridge technology, that made him an innovator in bridge construction. The patent opened doors for Roebling that initially led to a commission to build a cable-suspended, wooden aqueduct over the Allegheny River in 1845.

He went on to build a number of aqueducts before receiving two major bridge commissions. The first was an 821-foot-span Niagara rail bridge (built 1841-1855), and the second was the 1,000-foot-span CincinnatiBridge (built 1856-1867). Both bridges served as prototypes for the BrooklynBridge.

Even though the BrooklynBridge project had the support of New York City’s political boss, William Tweed, it took two years for the project to be funded. In June 1869, the New York City Council and the Army Corps of Engineers finally approved Roebling’s plan, and the initial stages of laying the foundations for the twin masonry support towers 78 feet below the water level began.

John A. Roebling and his son Washington A. Roebling, engineers and PMs on theBrooklynBridge project, knew that building a suspension bridge linking the boroughs ofBrooklyn and New York would be a difficult project. But they had no idea how difficult it would be and what hardships awaited them.

Like the beginning of any massive construction project, the two engineers poured over stacks of blueprints, numbers and specifications before the first cable was even cut. Here are few of the equipment numbers the Roeblings agonized over during the first weeks of construction:

* Length of river span: 1595.5 feet
* Total length of bridge: 5989 feet
* Width of bridge floor: 85 feet
* Suspension cables: four, each: 15.75 inches in diameter and 3578.5 feet long, containing 5434 wires each, for a total length of 3515 miles of wire per cable
* Foundation depth below high water: Brooklyn: 44 feet 6 inches  
  Foundation depth below high water, Manhattan: 78 feet 6 inches
* Buttressed gothic towers’ material: Granite
* Foundation depth below high water, 276 feet 6 inches  
  Roadway height above high water: 119 feet (at towers)
* Total weight, not including masonry: 14,680 tons

To put a few of these awesome numbers in perspective: The roadway platform was to be hung on two-inch diameter steel suspenders strung from two pairs of cables (called catenaries), 16 inches in diameter. Each cable was composed of 5,296 steel wires (the length of the wire was 14,357 miles).

From building prior bridges and constantly testing cable strength and durability, according to John A. Roebling’s calculations, each of the four cables was capable of sustaining loads of 12,000 tons.

**Construction begins**

Groundbreaking for the BrooklynBridge began on Jan. 3, 1870. The project’s first goal was to anchor the bridge’s two towers on solid bedrock, which was under layers of mud below the East River. Huge wooden 3,000-ton caissons, which looked like giant boxes, were assembled on land and towed to the construction sites on the Brooklyn and Manhattan sides so the foundations could be built. It took three years to complete the bridge’s foundations. For the first time in bridge construction, dynamite was used to expedite the placement of the caissons.

The caissons were large airtight cylinders that enclosed the workers so they could clear away the layers of silt underneath the riverbed. They were sunk 78½ feet below the river on the Manhattan side and 44½ feet below the river on the Brooklyn side. The caisson’s false floor was then ripped out, allowing workers to dig up the river bottom.

The huge bell-shaped caissons were pumped full of compressed air to keep the water from entering it from below. There was a room on the top of the caisson called the “material chamber” where the dirt and mud dug out of the river passed up and was carted away. Another room on the side of the caisson called the “air-lock” was where the workers went so they could be “compressed.” When the compressed air was admitted into the room, the blood absorbed the gasses of the air until the tension of the gasses in the blood equaled that of the air. When the equilibrium was reached, the men were able to work in the caissons for hours without suffering discomfort (but only if enough pure air is pumped in). It was the foul air, however, that did enormous harm.

Working in the caissons was hard, dreary, miserable and dangerous work. The published reports of the construction of the bridge at the time--the problems and obstacles--read better than fiction. Immigrant workers, desperate for work, risked their lives to earn $2.25 a day. In the early stages of building the bridge, the men had no idea what dangers awaited them. They quickly found out that they were working in deathtraps.

In the article “In Sandhog: Building the BrooklynBridge, 1871,” published on website [Eyewitness to History](http://www.eyewitnesstohistory.com/), working conditions were vividly described. They were likened to Dante’s *Inferno*. Here’s an account of what they were like: “The tremendous pressure, the suffocating heat, the lack of oxygen and the noise all combined to limit a worker’s time within the caisson to a maximum of two hours.”

Veteran construction workers warned new men about the dangers of the bends. A worker remembers the good advice: “The men told me no one could do the work for long without getting the bends; the bends were a sort of convulsive fit that twisted one’s body like a knot and often made you an invalid for life.”

He went on to describe what happens when you breathe foul air. “It was the foul air that did the harm. If they’d pump in good air, it would be okay; but that would cost a little time and trouble, and men’s lives are cheaper.”

In [Part 2](http://www.gantthead.com/content/articles/243511.cfm), we described how construction workers risked their lives every day they went to work on the BrooklynBridge. Picking up where we left off, a worker describes what it was like going in and out of the airlocks. The account, “In Sandhog: Building theBrooklynBridge, 1871,” was published on the website[Eyewitness to History](http://www.eyewitnesstohistory.com/).

*“When we went into the air-lock and they turned on one air-lock after another of compressed air, the men put their hands to their ears and I soon imitated them, for the pain was very acute. Indeed, the drums of the ears are often driven in and burst if the compressed air is brought in too quickly. I found that the best way of meeting the pressure was to keep swallowing air and forcing it up into the middle ear, where it acted as an air-pad on the innerside of the drum.”*

If that daily torture wasn’t enough, the worker described what it was like working in the claustrophobic caisson:

*“Six of us were working naked to the waist in a small iron chamber with a temperature of about 80 degrees Fahrenheit: In five minutes the sweat was pouring from us, and all the while we were standing in icy water that was only kept from rising by the terrific air pressure. No wonder the headaches were blinding. The men didn’t work for more than 10 minutes at a time.”*

At the time, in an issue of *Modern Architecture* magazine, reporters Kenneth Framtpon and Yukio Futagawa also described working conditions in the caissons. Life in the caissons was miserable and conditions were hazardous. Without telephones or electricity, the men were practically prisoners. There was no way to efficiently deal with emergencies that practically cropped up every day.

E.F. Farrington, the master mechanic working under Washington Roebling, described the inner workings of the caissons as follows: “Inside the caisson everything wore an unreal, weird appearance. There was a confused sensation in the head, like the rush of many waters. The pulse was at first accelerated, and then sometimes fell below the normal rate. The voice sounded faint and unnatural and it became a great effort to speak.”

The worker went on to describe a surreal working space--flaming lights, deep shadows, confusing noise of hammers, drills and chains and half-naked forms flitting about--that he compared to Dante’s *Inferno*. Yet time passed quickly in this living hell. Twenty men died as a result of fires, explosions and caisson’s disease took the lives of 20 men. Caisson’s disease--which is caused by changes in air pressure that affect nitrogen levels in the bloodstream--left Washington Roebling paralyzed.

With the assistance of his wife Emily, a bedridden Roebling used a telescope to direct the construction of the bridge from his apartment. He dictated instructions to his wife, who relayed the orders to the workers. Emily taught herself to be a combination engineer and project manager. She studied higher mathematics and bridge engineering and visited the construction site every day in order to supervise her husband’s staff of engineers and builders.

Despite problems--a sudden explosion wrecked one caisson, a fire damaged another and a cable snapped and crashed into the water--construction continued at a brisk pace. Fourteen years after ground was broken, Roebling and his wife guided the completion of theBrooklynBridge. On May 24, 1883, at 2 p.m., the bridge was opened to the public, and 150,300 people walked over it. Each person paid one cent to walk across. Three hours later, at 5 p.m., 1,800 cars crossed the bridge, paying five cents a piece to drive across. In 1884, entrepreneur P.T. Barnum demonstrated the safety of the bridge by parading across it with a herd of 21 elephants.

Washington Roebling, strained to his physical and emotional limits after years of being confined to his apartment, became reclusive and refused to attend the opening celebration honoring his extraordinary achievement. By then, he was physically able to leave his apartment.

Today, the bridge is praised as a brilliant, groundbreaking project. It’s still standing because John A. Roebling, Washington’s father, designed it six times stronger than it needed to be. Most of the bridges that were built around the same time have collapsed or have been replaced. With diligent maintenance, it’s likely the great bridge--which stands as a testimony to man’s persistence and driving obsession to achieve the impossible--will be around for centuries.