PDHonline Course C570 (8 PDH)

Spanning the Golden Gate

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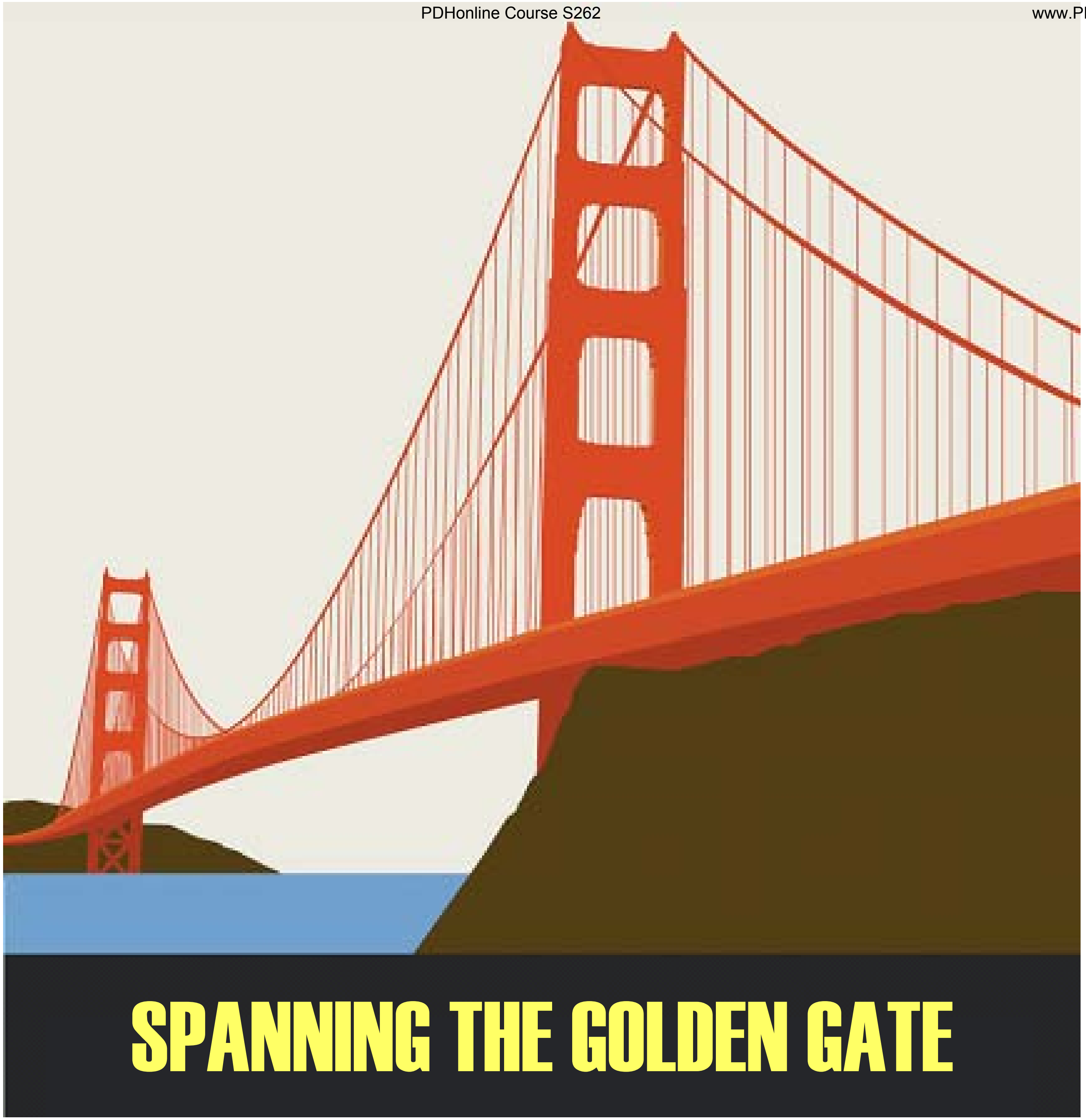
SPANNING THE GOLDEN GATE

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Part 1

Chrysopylae

Wide thy Golden Gate stands open to all nations of the world
Free beneath its stately portals
All flags are in peace unfurled

Beauteous Gate, when loitering sunset covers thee with burnishing gold

Mighty Gate, when surging ocean thy strong cliffs alone withhold

Treacherous Gate, deceiving many with a name most fair-blessed Gate, where millions find the golden boon of liberty

Poem, 1884

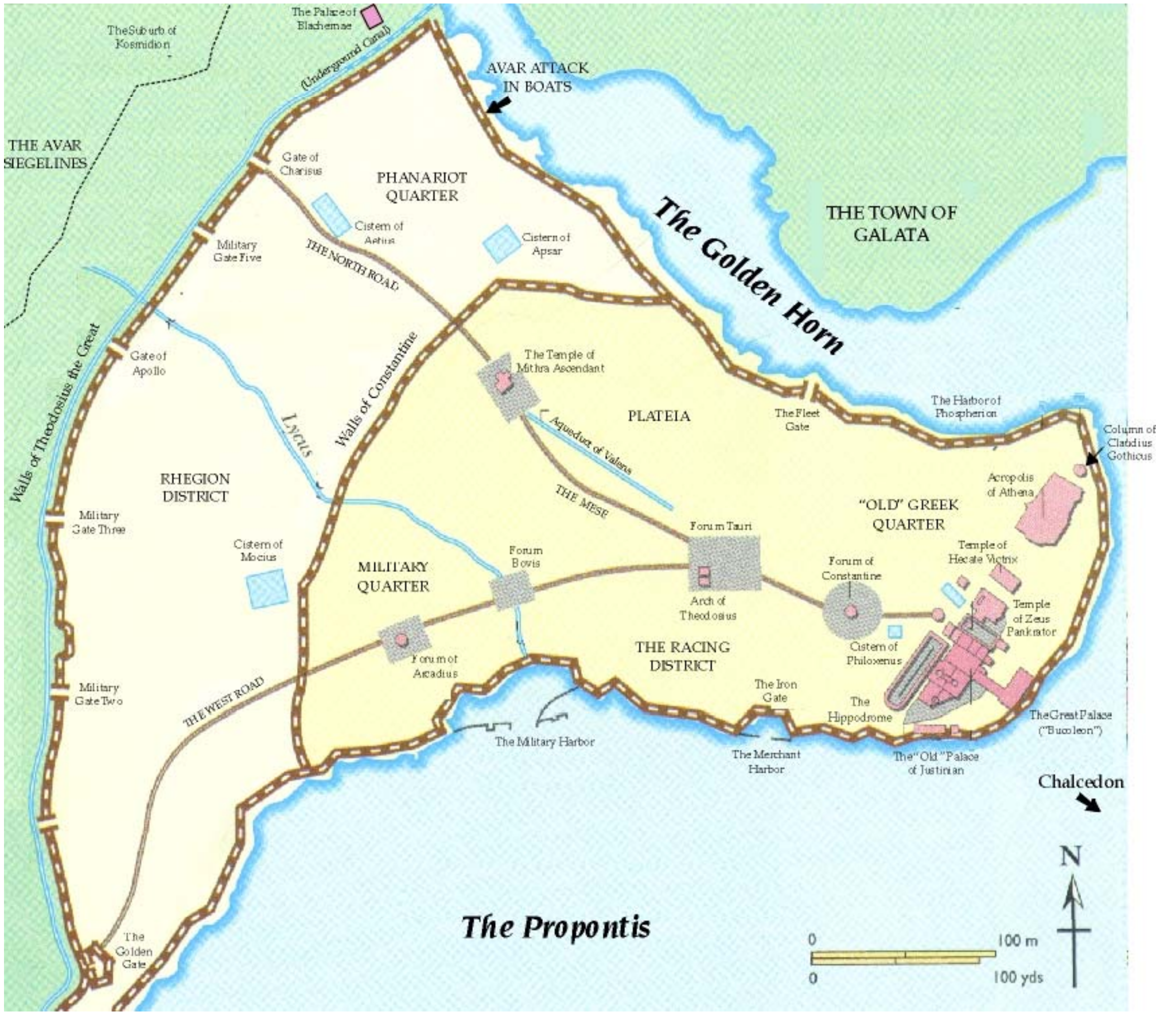
"…is caressed by breezes from the blue bay throughout the long golden afternoon, but perhaps it is loveliest at the cool end of the day when, for a few breathless moments, faint afterglows transfigure the gray line of the hills."

Irving Morrow – Architect, 1919

RE: the natural beauty of the Golden Gate

The Pathfinder

The Golden Gate strait is approximately one mile wide by three miles long, flowing between the Marin County headlands (to the north) and the San Francisco peninsula (to the south). It was formed by the scouring action of the Sacramento and San Joaquin Rivers during the last ice age. Tidal currents are strong through the strait, ranging from 4.5 to 7.5 knots. Since the strait is often obscured by heavy fog, it was missed by several early European explorers such as Sir Francis Drake. In 1775, the Spanish ship *San Carlos,* sailed through the strait and weighed anchor in a cove behind Angel Island. On July 1st 1846, U.S. Army Captain *John C. Fremont* first gazed upon the magnificent strait. Engineer, geographer and explorer, Fremont earned the nickname: "The Pathfinder." It was from his service in Byzantine Constantinople (now Istanbul) where he observed the "Golden Horn" (*Chrysoceras,* in Greek) strait. Fremont, who declared California's independence from Mexico (also in 1846), named the strait in honor of the Golden Horn of Byzantium.

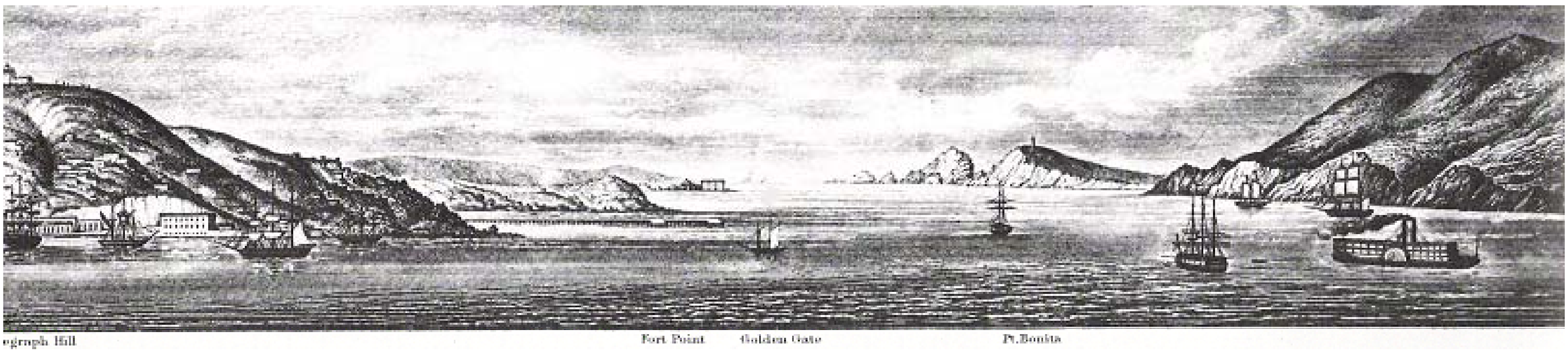


Constantinople and the Golden Horn
(ca. 622 A.D.)

"To this Gate I gave the name of 'Chrysopylae' or 'Golden Gate' for the same reasons that the harbor of Byzantium was called 'Chrysoceras,' or 'Golden Horn'…it is a Golden Gate to trade with the Orient."

Captain John C. Fremont

RE: excerpt from his *Geographical Memoir*, submitted to the U.S. Senate on June 5, 1848. Also in 1848, the name "Golden Gate" appeared on Charles Preuss' map of the western U.S. Previously, the strait was called: *Boca del Puerto de San Francisco* (Mouth of the Port of San Francisco)



View of the Golden Gate from Yerba Buena Island

(entrance to San Francisco Bay)

(ca. 1870)

Prior to the discovery of gold in Northern California, San Francisco was a sleepy village of about four-hundred people named *Yerba Buena*. With the gold rush came a population explosion and by 1849, the first year of the rush, the population was 35K. The first ferry service began ca. 1820. By the 1840s, there was scheduled ferry service whose prime purpose was the transport of water to San Francisco. By 1867, the ferry *Princess* linked San Francisco with Sausalito in Marin County. To encourage settlement, the *Sausalito Land and Ferry Company* – owners of the Princess (later the *Golden Gate Ferry Company*), offered free ferry passes to anyone purchasing a lot in Sausalito. The *Southern Pacific Railroad* owned and operated the highly profitable Golden Gate ferry service (at one time it was for the exclusive use of SPRR customers only). By the 1920s, it was the largest ferry service in the world with two routes; Hyde Street Pier (San Francisco) to Sausalito (Marin County) which took about twenty minutes and/or Sausalito to the Ferry Building (Embarcadero) which took about twenty-seven minutes.

San Francisco
(ca. 1849)

Norton I, Emperor of the United States and Protector of Mexico

Englishman *Joshua Norton* arrived in San Francisco in 1849 determined – like so many other *'49ers*, to get rich as quickly as possible. By 1869, he was bankrupt and no longer in control of his mental faculties. He declared himself *"Norton I, Emperor of the United States"* and began issuing decrees. Tolerated and even encouraged by his neighbors, he called for bridges to be built across the strait and bay, the first person to publicly do so. His reign as Emperor of North America ended with his death in 1880.

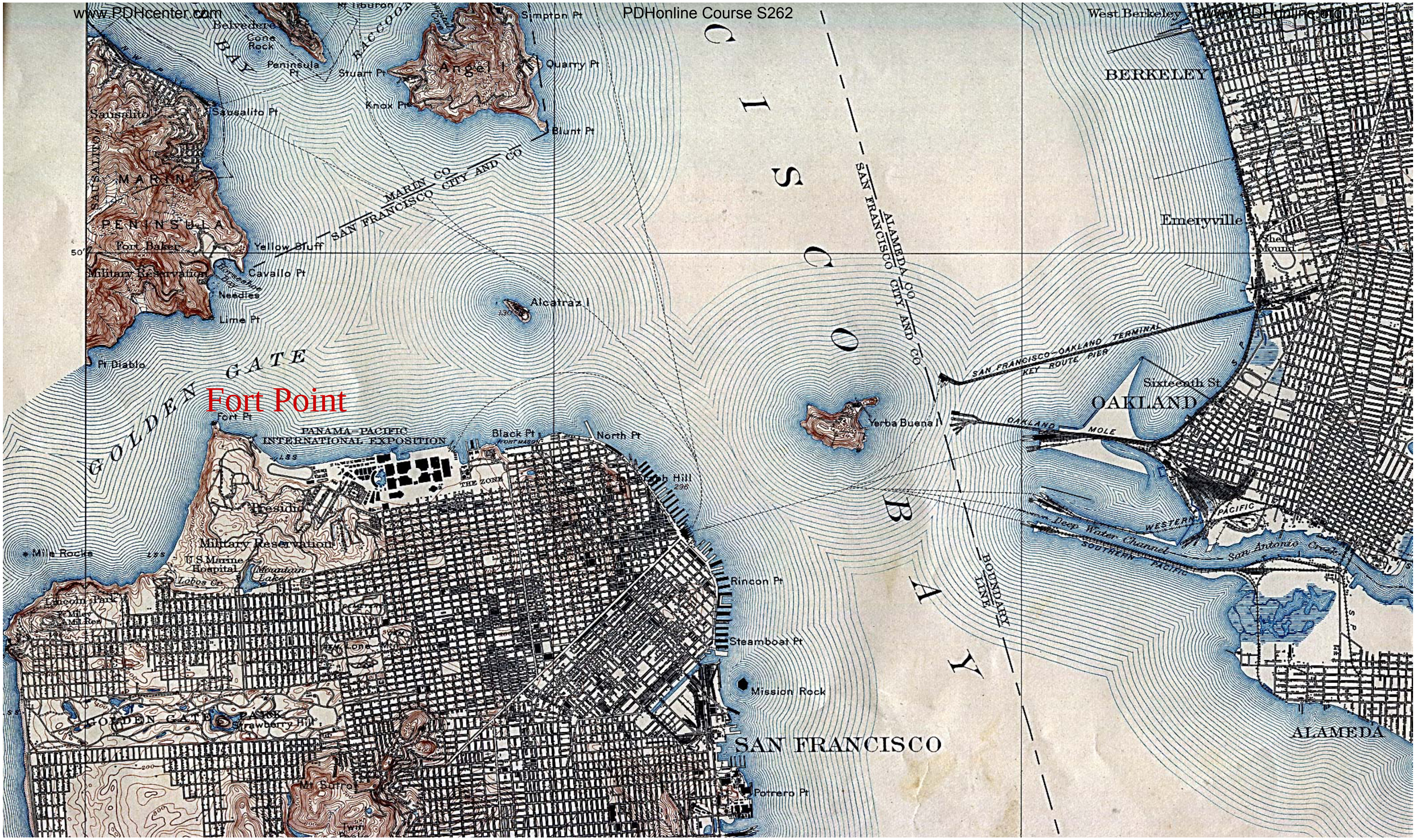
In 1869, the trans-continental railroad was completed linking east with west. In 1872, *Central Pacific Railroad* executive and entrepreneur *Charles Crocker* announced to the *Marin County Board of Supervisors* that his engineers had prepared plans and cost estimates for a suspension bridge design (with rail lines) that would span the Golden Gate.

Gibraltar of the West

"The key to the whole Pacific Coast"

Inspector General Joseph F.K. Mansfield – U.S. Army Corps of Engineers, 1853

RE: Fort Point

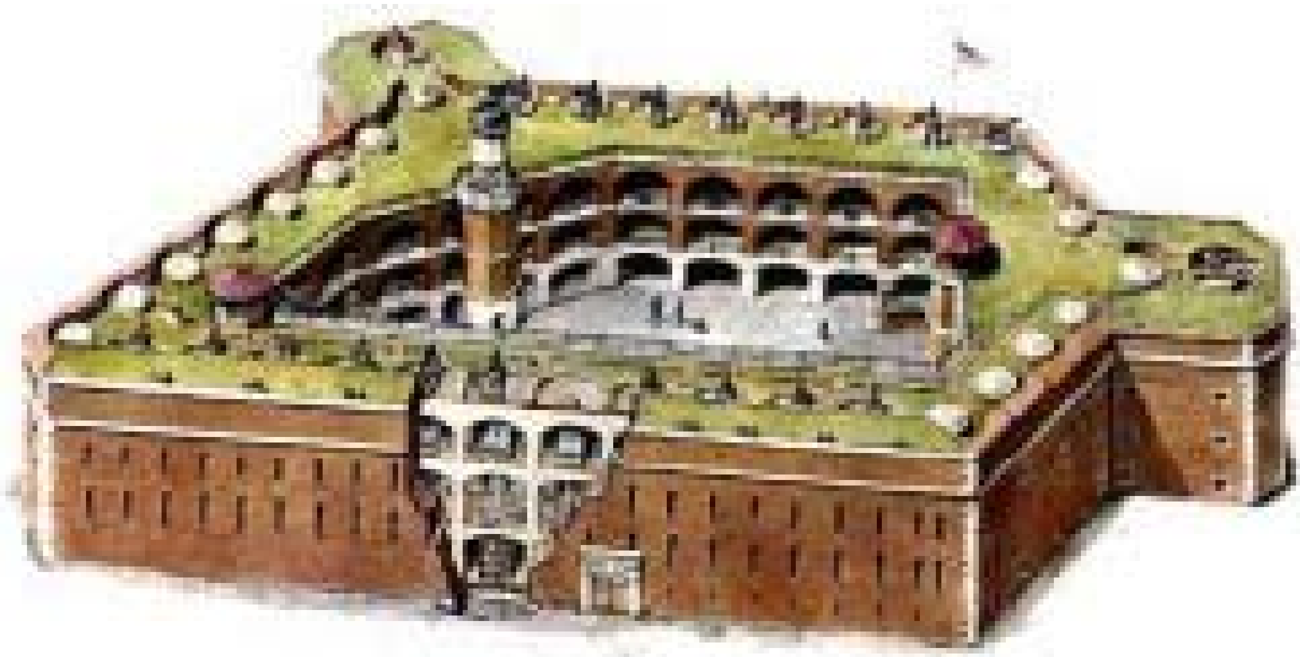


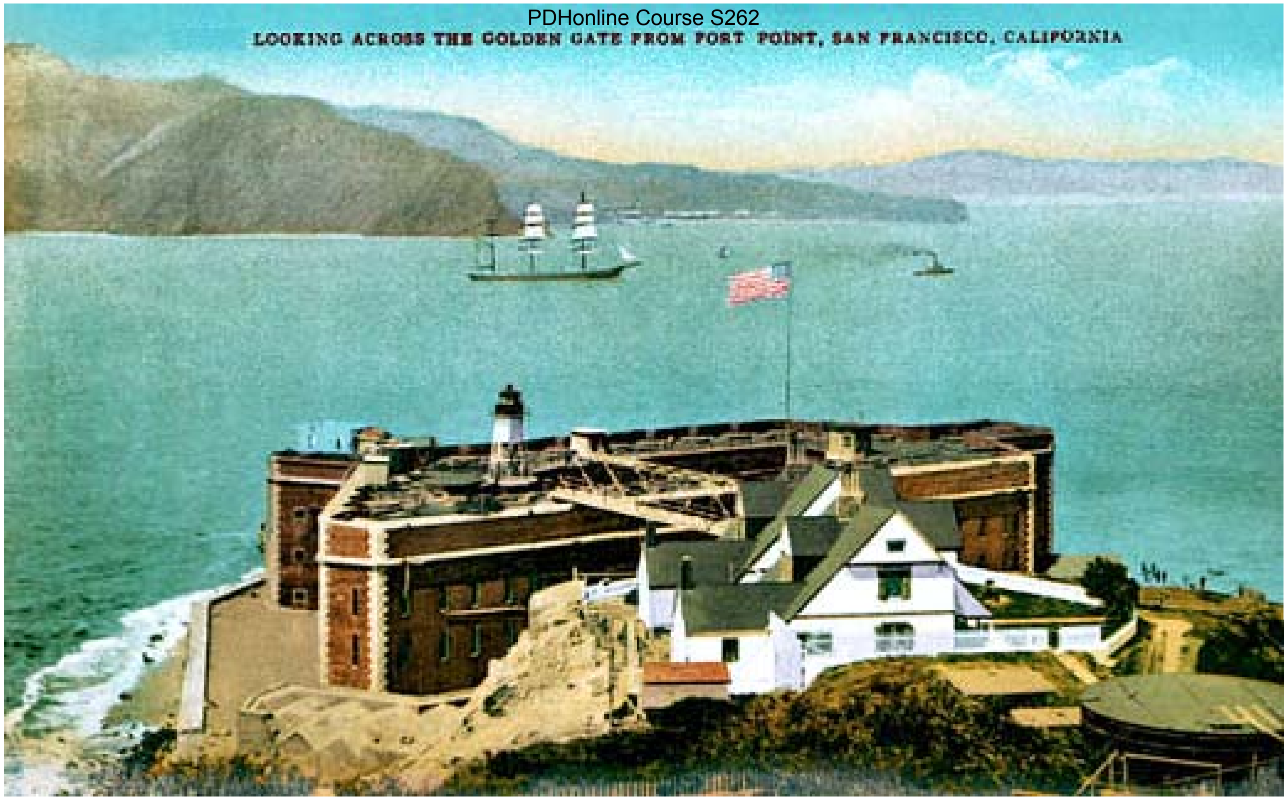
Map of San Francisco

(ca. 1915)

In 1850, California achieved statehood. With it came the need to improve the defenses in and around the "Inland Sea" that was/is San Francisco Bay. The key to the defense was in the Golden Gate strait itself, at *Fort Point* on the San Francisco peninsula – the narrowest point in the strait. The fort would be modeled on the "Third System Design" and would be the only one of its kind ever built on the west coast. This design, like that of *Fort Sumter*, featured seven-foot thick walls and three tiers of "casemates" (vaulted rooms). It required eight-million bricks to construct and was built by two-hundred workmen (many failed gold miners). Begun in 1853 and completed in 1861, it was manned by a garrison of five-hundred Union soldiers during the Civil War. With a compliment of 141-cannon, it was a formidable obstacle for any would-be attacker, though it never fired a shot in anger. The 1861 attack on Fort Sumter had demonstrated the vulnerabilities of masonry forts to rifled artillery. After the war it fell into a state of disrepair, being moderately damaged in the April 1906 earthquake. In 1882, it was renamed *Fort Scott* in honor of Union Army General *Winfield Scott*.

Fort Point
(ca. 1861)

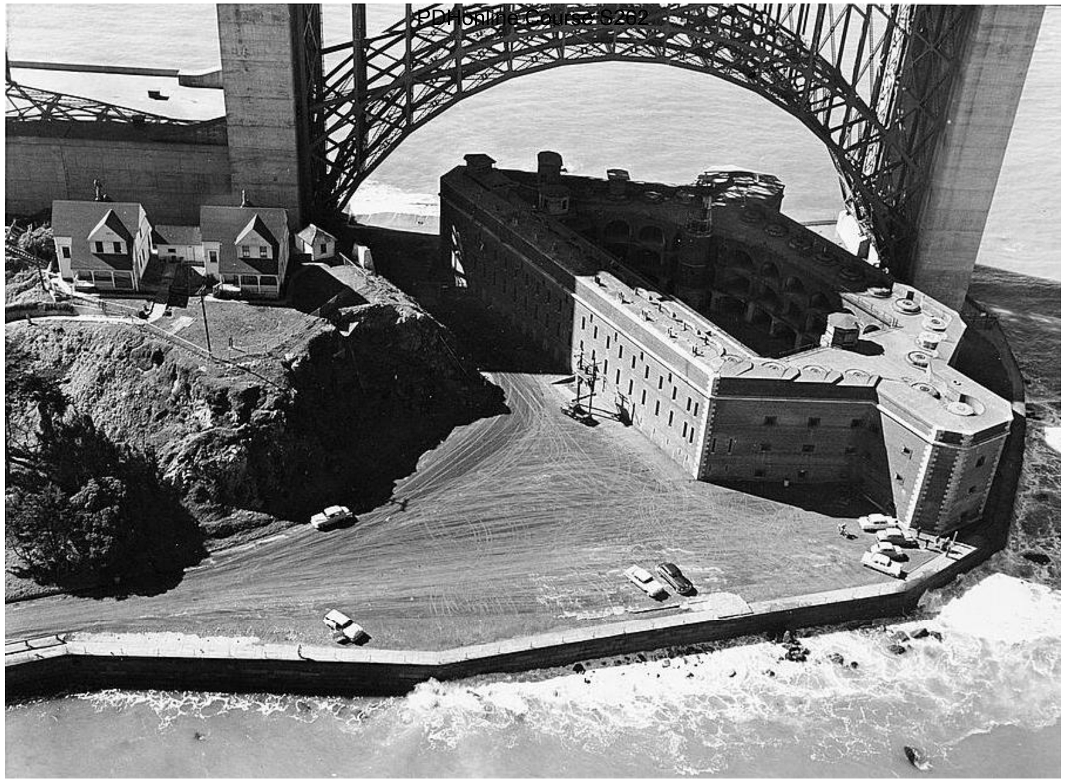




Being situated on the tip of the narrowest point in the Golden Gate strait made the site of the old fort the ideal location for a suspension bridge anchorage. As such, it was scheduled for demolition per the original bridge plans. In 1926, the *American Institute of Architects* (AIA) took up the cause of preserving the old fort with little success. However, they did get the attention of Chief Engineer Joseph Strauss who recognized the historic significance of the fort and its site (old lighthouse in foreground).

"While the old fort has no military value now, it remains nevertheless a fine example of the mason's art…it should be preserved and restored as a national monument."

Joseph Strauss – Chief Engineer, Golden Gate Bridge



To preserve the old fort while still taking advantage of the Fort Point site for the southern anchorage, Strauss' engineers designed a graceful steel arch to support the approach roadway (flanked on either end by a pair of art deco-style pylons). The arch vaults over the western half of the fort and allows the bridge cables to pass over the arch and into the anchorage situated behind (south) of the arch. On October 16th, 1970, President Richard M. Nixon declared the old fort a national Historic site.

Part 2

The Bridge That Couldn't Be Built

"It is possible to bridge San Francisco Bay at various points. But only at one point can such an enterprise be of universal advantage – at the water gap, the Golden Gate, giving a continuous dry-shod passage around the entire circuit of our inland sea."
***San Francisco Bulletin*, 1916**

Forty-four years after Charles Crocker proposed a suspension bridge to span the Golden Gate, structural engineer and newspaper editor (*San Francisco Bulletin*) James H. Wilkins campaigned in the court of public opinion for a bridge across the Golden Gate. America's entry into WWI the following year (April 1917) deferred any immediate planning for a bridge, but after the armistice in late 1918, San Francisco Board of Supervisors member Richard Welch asked Congress to authorize the taking of soundings in the Golden Gate strait, specifically in the channel between the Marin headlands and the *Presidio* – a military reservation inclusive of Fort Point. Wilkin's campaign had caught the attention of San Francisco City Engineer *Michael O'Shaughnessy*. In 1919, with the blessings of the Board of Supervisors, O'Shaughnessy was given the green light to proceed with a feasibility study for bridging the strait. In January 1920, O'Shaughnessy requested that the *U.S. Coast and Geodetic Survey* take soundings of the channel bottom. The *U.S.S. Natoma* completed the survey in May of 1920.

"In such a product of the Great Golden West, America could build a Peace Memorial that would fitly commemorate the close of the World War…Aside from its commercial value and financial attractiveness, and its great practical value, it will represent a crowning achievement of American endeavor and will constitute the greatest structure in point of magnitude and span ever erected."

Frederick Jackson Turner

The results of the 1920 census shocked San Franciscans when they learned that Los Angeles had replaced their city (still served primarily by ferry boats) as the state's most populous. Unlike San Francisco, which was bounded on three-sides by water, the Los Angeles basin left plenty of room for expansion. Without a bridge across the Golden Gate to allow for northward expansion, San Francisco would remain bottled-up on its narrow peninsula. When the *Natoma* completed its survey, O'Shaugnessy sent the survey to three prominent bridge engineers: *Francis C. McMath* of the *Canadian Bridge and Iron Company* in Detroit, *Gustav Lindenthal* in New York and *Joseph B. Strauss* in Chicago. Most of the speculation over the cost of the bridge was +$100 million, due to the "open ocean conditions" and geology of the strait, not to mention the length of the span required. McMath never responded and Lindenthal's minimum estimate was $56 million. On June 28th 1921, Strauss, unaware of his competition, submited to O'Shaughnessy and Mayor Rolph's secretary – *Edward Rainey*, preliminary sketches of a hybrid cantilever-suspension design costing +$17 million.

PROPOSED GOLDEN GATE BRIDGE
SAN FRANCISCO, CALIF.

Estimated Cost, Proposed Golden Gate Bridge

The estimated quantities and cost of the structure are as follows:

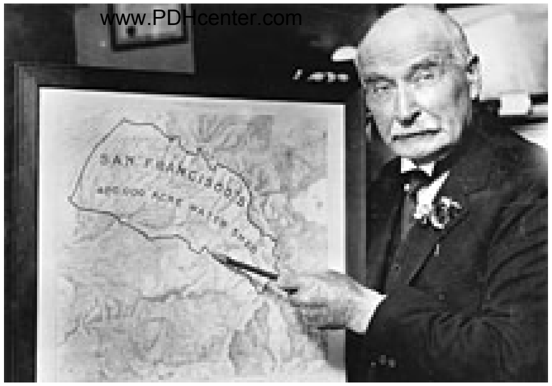
SUPERSTRUCTURE

Cable erected	5,250 tons	@	$460.00	$ 2,415,000.00
Structural Steel (Nickel steel)	74,000 "	@	150.00	11,100,000.00
Rails	400 "	@	60.00	24,000.00
Railing	500 "	@	200.00	100,000.00
Lumber	1,675 M. ft. BM.	@	80.00	134,000.00
TOTAL SUPERSTRUCTURE				$13,773,000.00

SUBSTRUCTURE

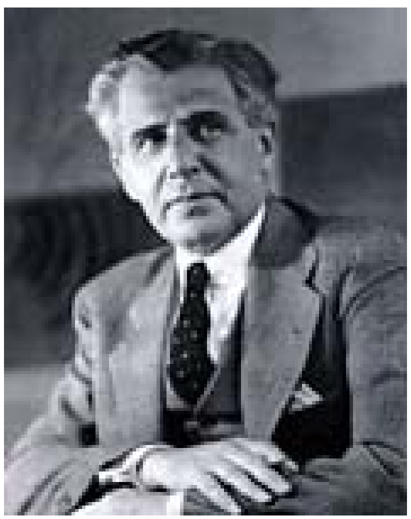
Concrete	114,000 cu. yds.	@	12.00	1,368,000.00	
Reinforcement	1,460 tons	@	60.00	88,000.00	
2 caissons		@	260,000.00	520,000.00	
2 abutments including steel (anchorage, etc.)				440,000.00	
Miscellaneous				61,000.00	
TOTAL SUBSTRUCTURE					2,477,000.00
TOTAL COST					$16,250,000.00
ENGINEERING, SURVEYS, GENL. MISC.					1,000,000.00
GRAND TOTAL					$17,250,000.00

Strauss' Cost Estimate for his hybrid *Cantilever-Suspension* design (1921)



"Everybody says it can't be done. And that it would cost over $100 million if it could be done."

Michael O'Shaugnessy, San Francisco City Engineer



"I think it can be done."

Joseph B. Strauss, Bridge Engineer

The *troika* of *Joseph Strauss*, *Edward Rainey* and *Michael O'Shaughnessy* proposed, in 1922, that a special political entity be established for the Golden Gate Bridge project. They argued that a special district is necessary to manage the financing, design and construction of the bridge. As well, such an entity would allow the many surrounding counties affected by the special district to have a voice in the goings-on. At the same time, Strauss put on his bridge promoter's hat and, using his original design, traveled throughout Northern California advocating for the bridge to communities and civic leaders. He argued that the bridge was entirely feasible and the toll revenue alone could/would pay for the bridge in whole. Accurately anticipating success in his promotional efforts, in 1921 Strauss hired Charles Ellis, Professor of Structural and Bridge Engineering at the University of Illinois, and soon promoted him to VP of *Strauss Engineering Corp*., (in charge of bridge design and construction supervision) to further develop plans for the bridge. On December 7th 1922, nearly one and one-half years after receiving Strauss' original plans, O'Shaughnessy made the plans public.

"…considered a wild flight of imagination, has become a practical proposition"

RE: excerpt from a 1922 promotional pamphlet entitled: *A Wild Flight of the Imagination.* Its authors were Joseph Strauss and Michael O'Shaughnessy. In later years, O'Shaughnessy and Strauss would become bitter foes when O'Shaughnessy became an active opponent of the bridge. San Francisco's growth rate prior to the *Golden Gate* (and *San Francisco-Oakland Bay*) *Bridge* was well below the national average. The new bridge/s (and WWII) would reverse that decline.

"…to help stimulate public interest in building a bridge and to determine what financial and political support really existed for the project"

Joseph B. Strauss

RE: his promotional efforts in Northern California in 1922 on behalf of his proposed hybrid cantilever-suspension bridge spanning the Golden Gate Strait

"An upside-down rat trap"

RE: critique of Joseph Strauss' hybrid cantilever-suspension bridge design. The idea of the bridge was widely accepted by the public, but Strauss' design was panned in the press as ugly and unworthy of the Golden Gate's great natural beauty. At the same time, the need for the bridge was evidenced by the growing lines of cars at the ferry terminals as the decade of the 1920s advanced the motor age.

In 1925, Strauss had Ellis hire Professor *George F. Swain* (of Harvard University) and *Leon S. Moisseiff* (designer of the *Manhattan Bridge*) as consultants. Both Swain and Moisseiff reviewed Strauss' plans for a hybrid cantilever-suspension design and concurred that it was feasible, from an engineering point-of-view. However, in November 1925 Moisseiff submitted to Strauss a report entitled: *Report on Comparative Design of a Stiffened Suspension Bridge over the Golden Gate Strait in San Francisco, CA.* The report expressed concerns over the hybrid design and compared it with a traditional suspension design. Despite this, Strauss continued promoting his own symmetrical cantilever-suspension design as late as 1929. On August 15th 1929, the District's Board of Directors appointed several prominent engineers to serve on an *Advisory Board of Engineers*. Strauss served on the board as Chairman and appointed Ellis its Secretary. Moisseiff was appointed to the board along with *Charles Derleth, Jr.* of the UC Berkeley Engineering School, and *Othmar H. Ammann*, Chief Engineer of the *Port of New York Authority.*

DESIGNERS OF GATE SPAN

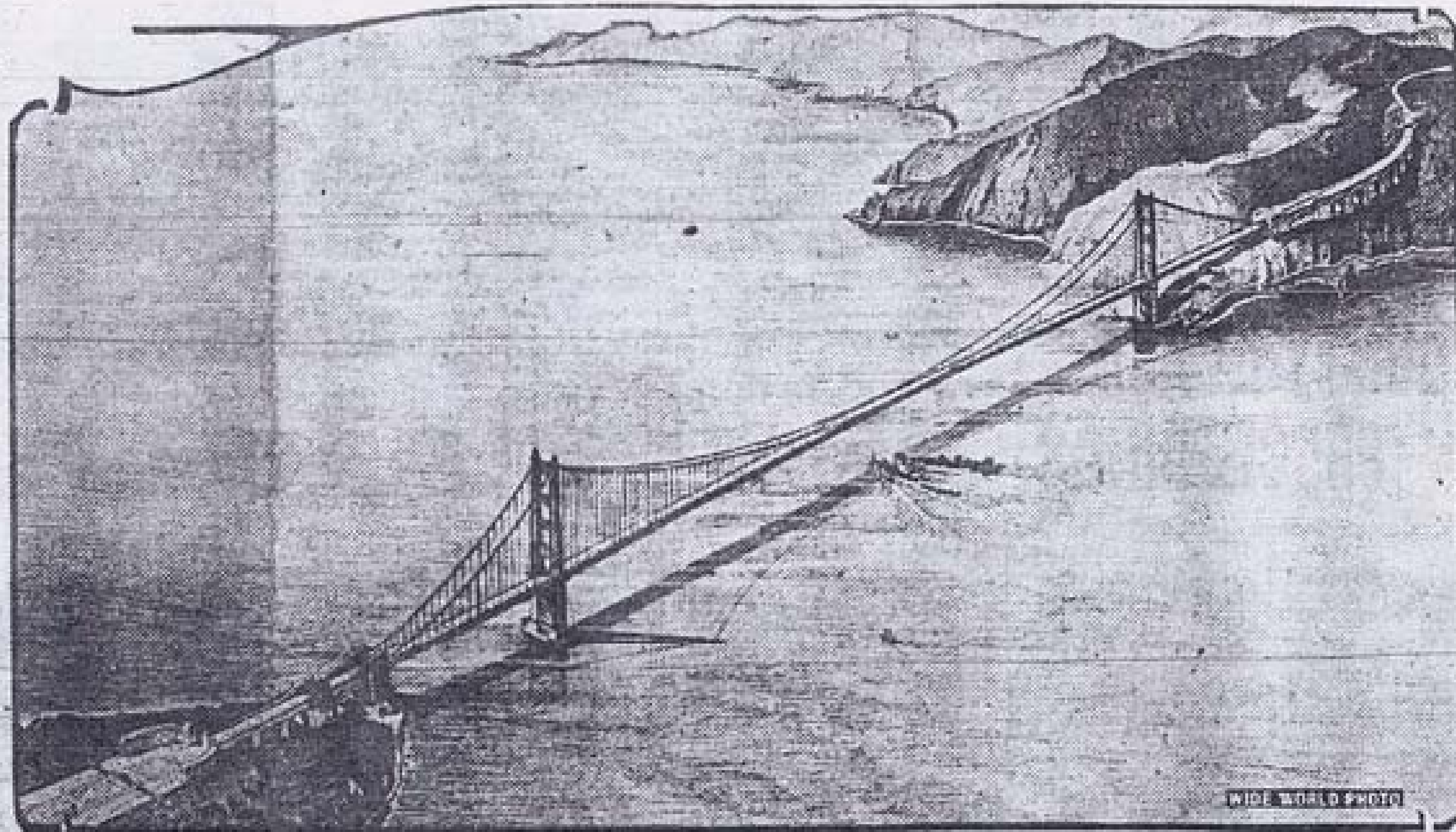
Chief Engineer Joseph B. Strauss and his staff of consulting engineers. Left to right are: A. H. Ammann chief engineer for the New York Port Authority, designer of the Hudson River Bridge; Dean Charles Derleth, Jr., of the College of Engineering, University of California; Mr. Strauss, and Leon S. Moisseiff, advisory engineer for the New York Port Authority. In the rear is Professor Andrew C. Lawson, former Dean of the College of Mining, University of California, and consulting geologist for the Golden Gate Bridge.

"…In the interval which had elapsed any advantages possessed by the cantilever-suspension type bridge had practically disappeared and on recommendation of the Chief Engineer, the cantilever-suspension type was abandoned in favor of the simple suspension type."

RE: excerpt from: *The Golden Gate Bridge, Report of the Chief Engineer, September 1937*. It's not exactly clear, even in Strauss' own report, when exactly the decision was taken to abandon the hybrid design in favor of the simple suspension design, but it's safe to assume it occurred sometime between the November 1925 release of Moisseieff's report and the first meeting of the advisory board on August 27th 1929. The negative public and press reaction to the hybrid design's aesthetics no doubt played a role in the decision, but there were other factors (i.e. economics).

:OTA COUNTY, MINN., FRIDAY, AUGUST 8, 1930.

How the Great Golden Gate Bridge Will Look



"A great city with water barriers and no bridges is like a skyscraper with no elevators. Bridges are a monument to progress."

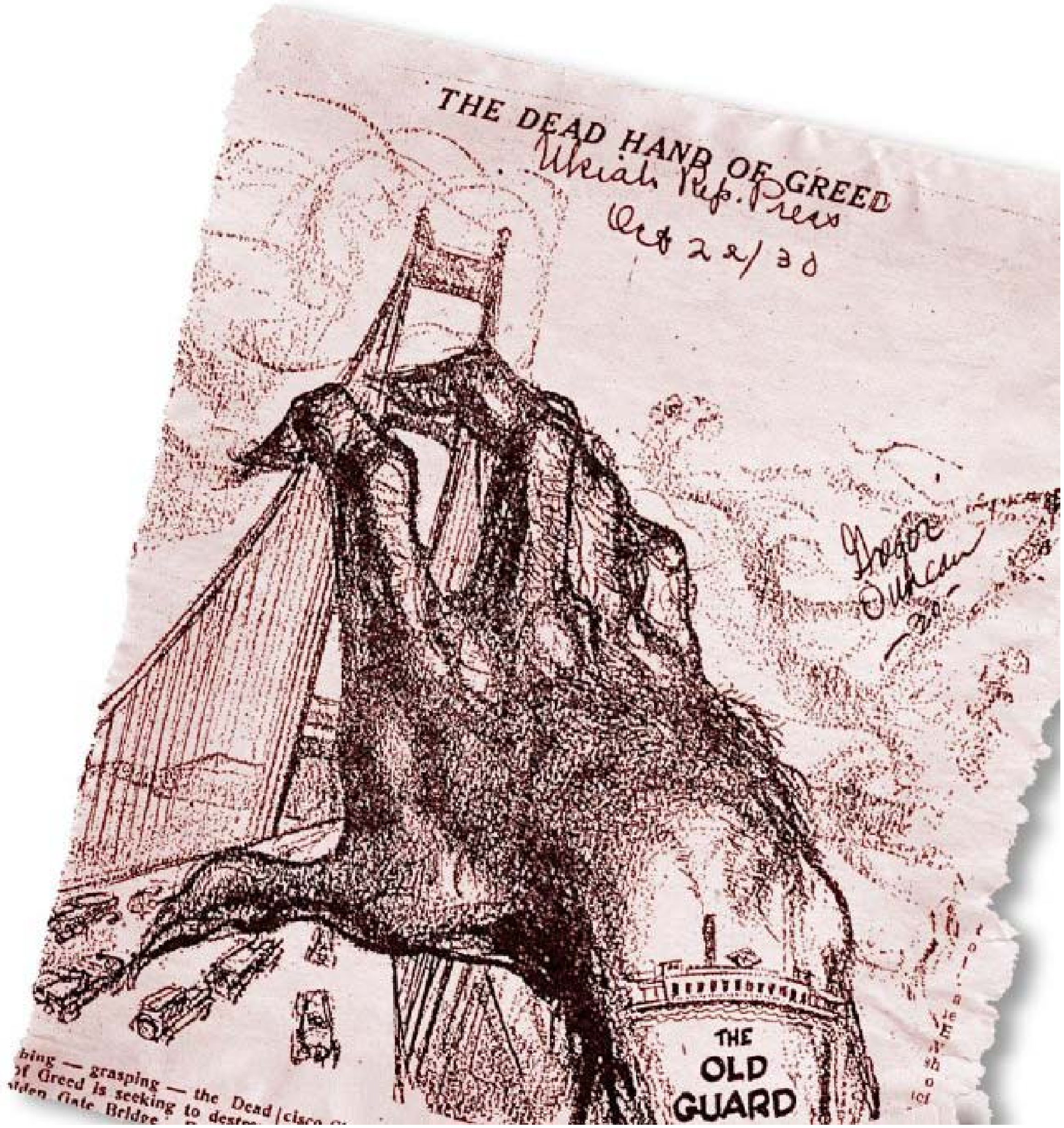
Joseph B. Strauss – Chief Engineer, Golden Gate Bridge

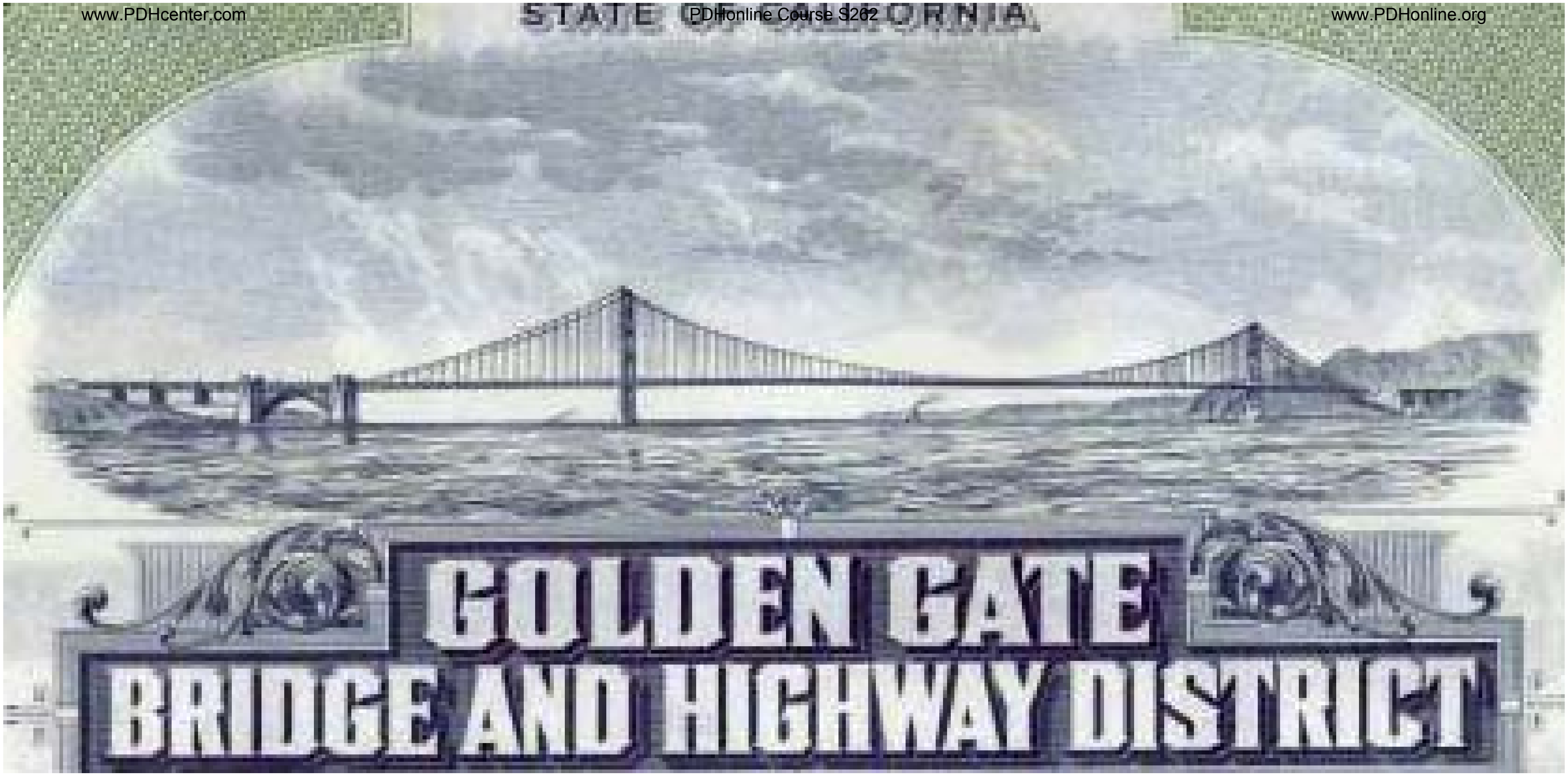
On January 13th 1923, an historic meeting took place whereby representatives of twenty-one counties formed the *Bridging the Golden Gate Association.* The association had two parallel goals: promote the idea of the bridge through their "Bridge-the-Gate" campaign and securing of enabling legislation for the project. On May 25th 1923, with the sponsorship of state Assemblyman *Frank L. Coombs*, the *Golden Gate Bridge and Highway District Act of California* (a.k.a. "Coombs Bill") was signed into law. This act gave the Golden Gate Association power to create a special district, assume powers of taxation, eminent domain and control over the bridge and roadway construction and maintenance. However, the land on either side of the strait was owned by the *War Department*. As such, the War Department had oversight and jurisdiction over any/all harbor construction that might have effected shipping traffic and/or military logistics. In May of 1924, San Francisco and Marin counties filed a joint permit application to the War Department for permission to build the bridge.

On May 16th 1924, *Colonel Herbert Deakyne* held a hearing concerning the bridge permit application (on behalf of the *Secretary of War*). Two main issues were discussed; available financing sources and hindrance/s to navigation that the bridge might create. On December 20th 1924, in light of the overwhelming testimony in favor of the bridge, Secretary of War *John W. Weeks* issued a provisional permit allowing construction of the bridge to proceed (including transfer of land and roads necessary to construct the bridge).

The Old Guard

With the War Dept. permit came a storm of protest from vested interests led by the *Southern Pacific Railroad* whose lucrative *Golden Gate Ferry Company* would be adversely affected by a bridge. These well-financed and powerful special-interests launched an aggressive campaign to stop the bridge construction and/or the formation of the special district that would build, operate and maintain the bridge. In the interim, Joseph Strauss set-up shop at San Francisco's Palace Hotel and became the bridge project's self-appointed main proponent. Leading petition drives from San Francisco to the Oregon border, he was relentless in his efforts to get as many of the twenty-one Northern California counties to join the Bridge and Highway District. Ultimately, only six counties would vote in favor of joining: *San Francisco, Marin, Sonoma, Del Norte, Napa* and *Mendocino.* By August 1925, all six counties had formally approved joining the District. The "Old Guard" (bridge opponents) launched a vigorous campaign in court to stop the formation of the District that would last for nearly six years. By the end of 1928, a total of 2,307 protests against forming of the District had been filed.

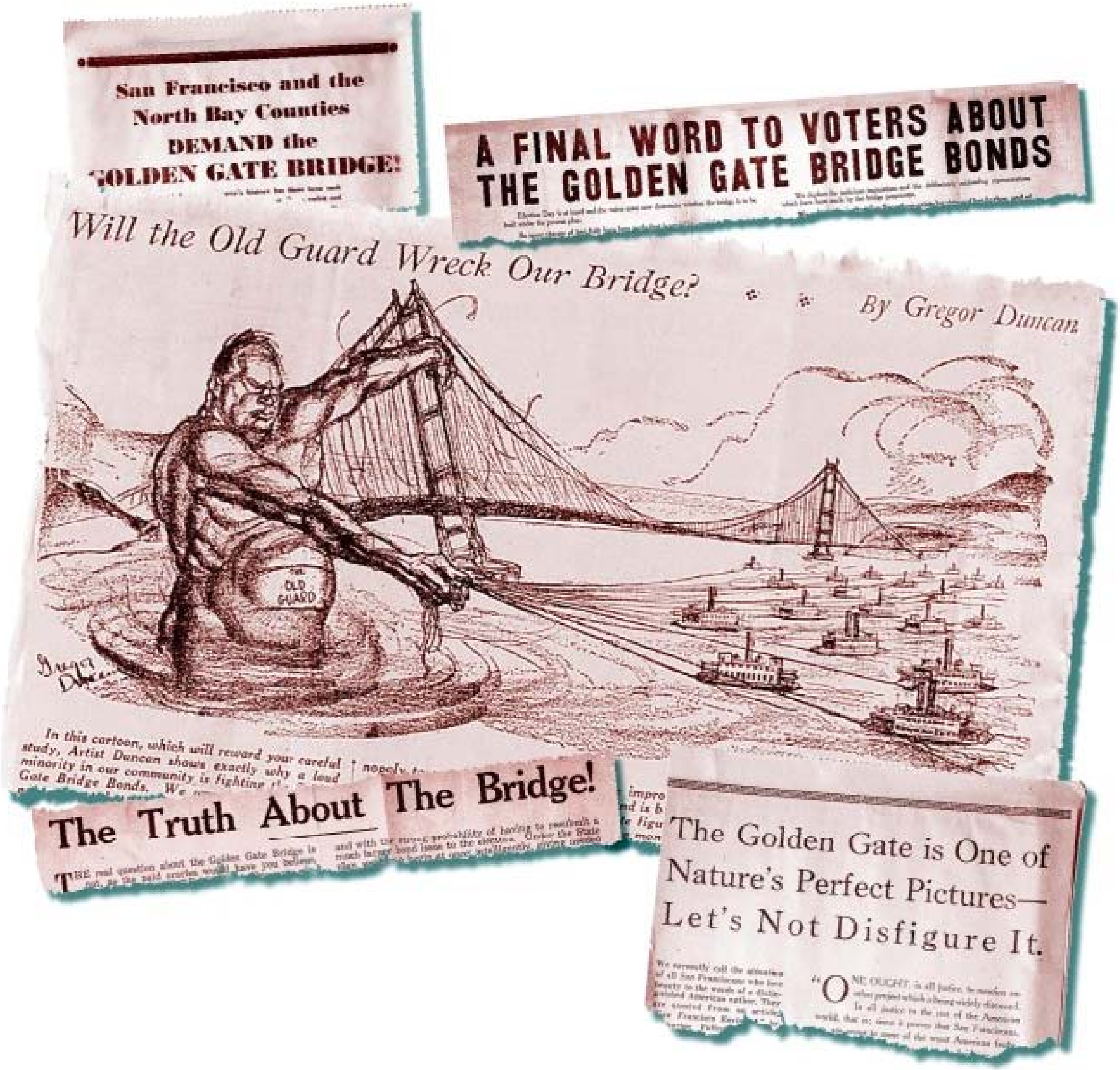

THE DEAD HAND OF GREED
Ukiah Rep. Press
Oct 22/30
THE
OLD
GUARD



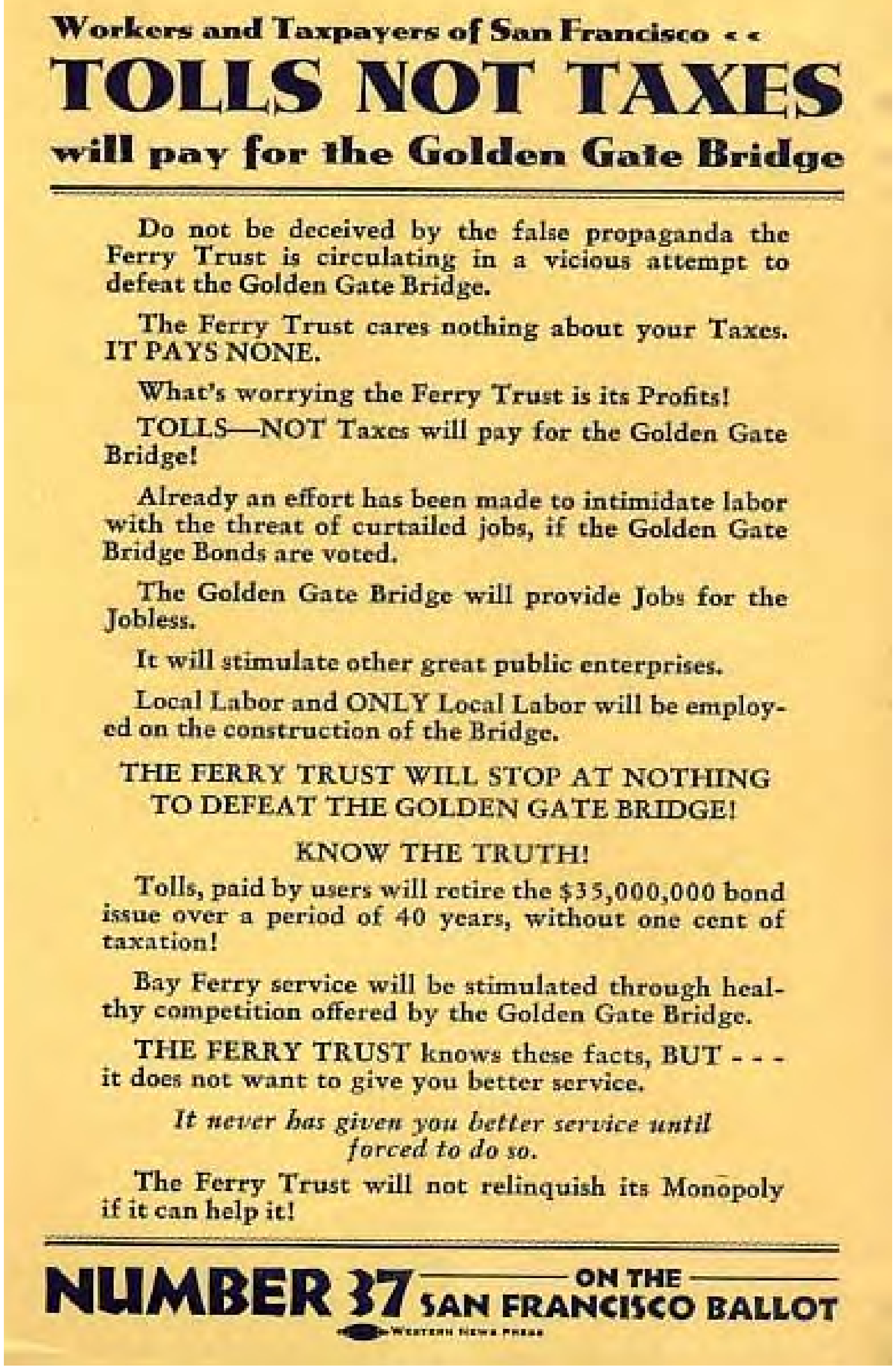
On December 1st 1928, Superior Court Judge *C.J. Luttrell* denied all 2,307 protests against forming the Bridge & Highway District (his decision was later affirmed by the Supreme Court). On December 4th 1928, California Secretary of State *Frank Jordan* signed the District's Certificate of Incorporation. On August 11th 1930, Secretary of War *Patrick Hurley* issued the construction permit.

It Ain’t Over ‘til It’s Over

Even with the incorporation of the District and issuance of a construction permit, opposition to the bridge continued unabated. *The Golden Gate Bridge and Highway Act of 1928* stipulated that funds to construct the bridge could be raised via taxation on properties within the District for preliminary expenses. By July 1930, this levy yielded $465K. The Strauss team estimated the total cost of the bridge to be $27 million. The District's Board of Directors concluded that a $35 million bond issue would satisfy the construction costs and provide sufficient funds for administration, engineering and other miscellaneous costs. As such, it was determined that the bond issue should be presented to the six county's voters for their approval on the November 1930 ballot (Proposition No. 37). An opposition group: *Citizens' Committee Against the Golden Gate Bridge Bonds*, was formed consisting of businessmen, taxpayers and others convinced that the bridge was not feasible for a variety of reasons. Ironically, Michael O'Shaughnessy was a member of this group. Other opponents included the *Commonwealth Club* and ship owners associations.


San Francisco and the
North Bay Counties
DEMAND the
GOLDEN GATE BRIDGE!
A FINAL WORD TO VOTERS ABOUT
THE GOLDEN GATE BRIDGE BONDS
Will the Old Guard Wreck Our Bridge?
By Gregor Duncan
THE OLD GUARD
In this cartoon, which will reward your careful study, Artist Duncan shows exactly why a loud minority in our community is fighting the Golden Gate Bridge Bonds.
The Truth About The Bridge!
The Golden Gate is One of Nature's Perfect Pictures—Let's Not Disfigure It.


BRIDGE
The GATE
Vote YES No 37



The Citizens' Committee was well organized and used every means at their disposal to plant seeds of doubt in the public's mind. The bridge would cost more than $35 million, the Pacific Fleet (based in San Francisco) would be trapped if the bridge were sabotaged, the floor of the Golden Gate Strait could not support the weight of the San Francisco pier and tower and, most disturbing to the public, the bridge could not withstand an earthquake and would surely collapse. After all, only a fool would buy bonds for a bridge that was doomed to failure from its inception by the forces of nature.

"It was disconcerting to be caught halfway between professors."

Joseph B. Strauss – Chief Engineer, Golden Gate Bridge

RE: conflict between geologists concerning the stability of the ground for the foundations of the Golden Gate Bridge. The dire warnings of Professor of Geology *Bailey Willis* scared away federal funding and some public support. The devastating earthquake of 1906 was still within living memory of many Bay Area residents and whether founded or unfounded, the opposition played on those fears.

"If I knew that there was to be an earthquake in San Francisco tomorrow and I couldn't get into an airplane and had to remain in the city, I think I should get a piece of clothesline about 1,000 or 2,000-feet long, and a hammock, and I would string it from the tops of the tallest Redwoods I could find, get into the hammock and feel reasonably safe. If this bridge were built at that time, I would tie me to the center of it, and while watching the sun sink into China across the Pacific, I would feel content with the thought that in case of an earthquake, I had chosen the safest spot in which to be."

Charles Ellis – Design Engineer, Golden Gate Bridge

To counter the slanderous campaign of the Citizens' Committee, the District Bard of Directors established a *Bureau of Information*. Many pro-bridge organizations including trade unions, civic organizations, automobile clubs, the San Francisco *Chamber of Commerce* and the *Redwood Empire Association* campaigned in support of the bond measure. On November 4th 1930, voters from the six counties of the District put up their homes, farms and businesses as collateral for the bonds and voted a plus two-thirds majority in favor of the bond issue. Marin county declared November 12th a holiday and celebrated the passing of the bond issue with a parade and fireworks. To some, it was foolish to even propose a bond issue is such hard economic times, to others it was just what was needed to create much-needed jobs as the depression deepened. There were no federal and/or state funds available for the project since the nearly simultaneous *San Francisco-Oakland Bay Bridge* project (costing $77 million) depleted most available funds. With President Hoover (a SF native and engineer) and the public behind it, the SF-OB Bridge was the favorite son of public financing.

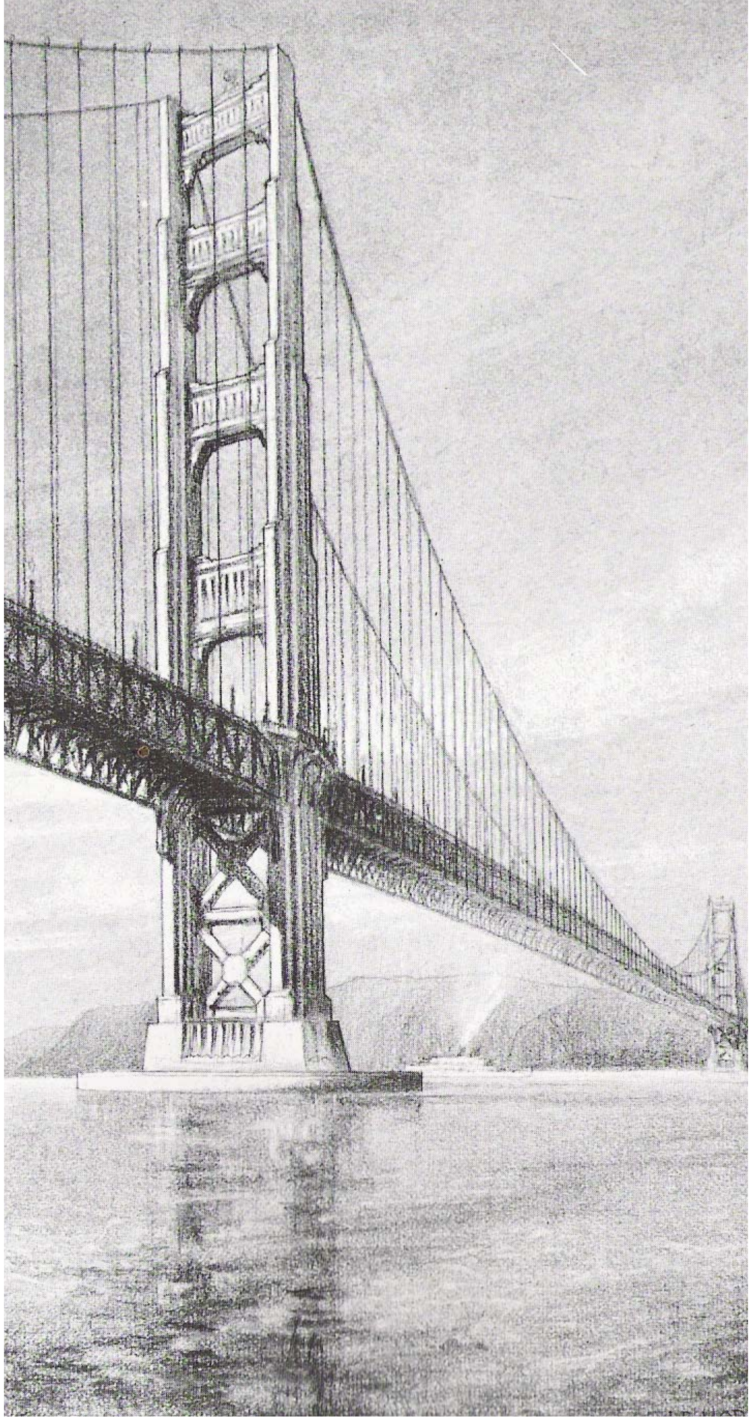
"I'll build a bridge to Hell if they give me enough money to do it"

Joseph B. Strauss

"The Golden Gate Bridge is a fact today because the Fort Lee bridge was built yesterday. It was the latter project that attuned the public mind to the possibility of financing such huge enterprises."

Engineering News Record **(ENR), 1937**

RE: the passing of the $35 million bond issue on Nov. 4th 1930 making possible the construction and completion (May 1937) of the *Golden Gate Bridge* without public financial support. The "Fort Lee" bridge is a reference to the *George Washington Bridge* (1931) which connects upper Manhattan (Washington Heights) with Fort Lee, NJ. (spanning the Hudson River). That earlier bridge was financed via the issuance of bonds thus it set a precedent. The GWB was also more than 2x the length of any previous bridge (3,500-foot main span) and proved that long-span suspension bridges were indeed possible and practical (the Golden Gate's main-span is 4,200-feet). Because of the October 1929 stock market crash and its aftermath, the District was unable to raise the required funds privately.



"I did not intend to attempt to construct the longest span in the world. On the contrary, I tried to make the span length as short as possible."

Joseph B. Strauss – Chief Engineer, Golden Gate Bridge

RE: simple suspension plan for the *Golden Gate Bridge* pursuant to the War Department's specifications;

- **4,200-foot main span**
- **210-foot vertical clearance at towers**
- **220-foot clearance at mid-span**

The GGB remained the longest suspension bridge in the world until 1964, when the *Verrazano-Narrows Bridge* (4,260-feet) opened in NYC.

Prior to the letting of the construction contracts, another problem arose concerning the bonds. A syndicate bidding on the first offering of bonds elevated the interest rate on the bonds to 5.25%. The District's Board of Directors had asked the voters to vote on the bond issue based on a 5% interest rate, not 5.25%. Litigation ensued concerning the legality of the bonds (since they exceeded 5%). Fearing having to levy new taxes and/or delay the start of construction due to litigation, in early 1932 Strauss led a group of officials and board members in an effort to secure the support of the *Bank of America*. Meeting with Chairman of the Board *A.P, Giannini*, he pledged his support and Bank of America formed a new syndicate that bought the first block of bonds ($3 million worth) for the legal interest yield rate of 5%. BOA also committed to buy a second $3 million block of bonds by March 1st and advanced the District $184K to meet their operating expenses. By 1971, the $35 million principal and $39 million in interest payments on the bridge bonds had been paid back in full, entirely from toll revenues.

"San Francisco needs that bridge. We'll take the bonds."

A.P. Giannini – Chairman of the Board, *Bank of America*

RE: to his everlasting credit, A.P. Giannini and BOA's 11th hour financial support of the bridge proved critical in making the bridge a reality


GOOD TIMES
UNEMPLOYMENT
Now-all together!
ON TO GOOD TIMES
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"Strauss' secretary told me that every month someone would show up, pick up a paper sack with $400 in it. Well, $400 in those days was the equivalent of about $2,000 today."

Charles Kring, Bridge Cable Supervisor

RE: bribing of San Francisco Board of Supervisors members by political fixer H.H. "Doc" Meyers who was hired by Joseph Strauss to ensure their support for the bridge project. Strauss was a determined man and would let nothing stand in his way.

"A thirteen years' war…a long and tortuous march."

Joseph B. Strauss – Chief Engineer, Golden Gate Bridge

“The Golden Gate Bridge, the bridge which could not and should not be built, which the War Department would not permit, which the rocky foundation of the pier base would not support, which would have no traffic to justify it, which would ruin the beauty of the Golden Gate, which could not be completed within my cost estimate of $27,165,000, stands before you in all its majestic splendor, in complete refutation of every attack made upon it.”

Joseph B. Strauss – Chief Engineer, Golden Gate Bridge
RE: excerpt from his May 27th 1937 opening day speech

Part 3

The Little Bridge Builder

Joseph Baermann Strauss **was born January 9th 1870 in Cincinnati, Ohio. He came from a creative, artistic family. His mother was a concert pianist and his father –** ***Raphael Strauss*****, a writer and prominent painter. From an early age, Strauss was attracted to the arts, poetry in particular. At only five-feet tall, he had to struggle with his slight physical stature from an early age – but his sharp mind, creative ability, powers of persuasion and bulldog determination would serve him well throughout his life. Attending the** ***University of Cincinnati*****, he was seriously injured after trying out for the football team. While recovering, his hospital window gave him a direct view of the** ***Cincinnati-Covington Bridge*** **(a.k.a.** ***Roebling Bridge*****). It spanned the Ohio River linking Cincinnati, Ohio with Covington, Kentucky. Begun before the Civil War and completed in 1867, it was the design/construction forerunner of the** ***Brooklyn Bridge*** **(1869-1883), both designed by** ***John A. Roebling*****. Strauss was fascinated by the bridge and determined then-and-there that if he couldn't be a gridiron hero, he would make his mark on the world by building great bridges, just like his hero John Roebling did.**

Cincinnati-Covington Bridge
(1867)

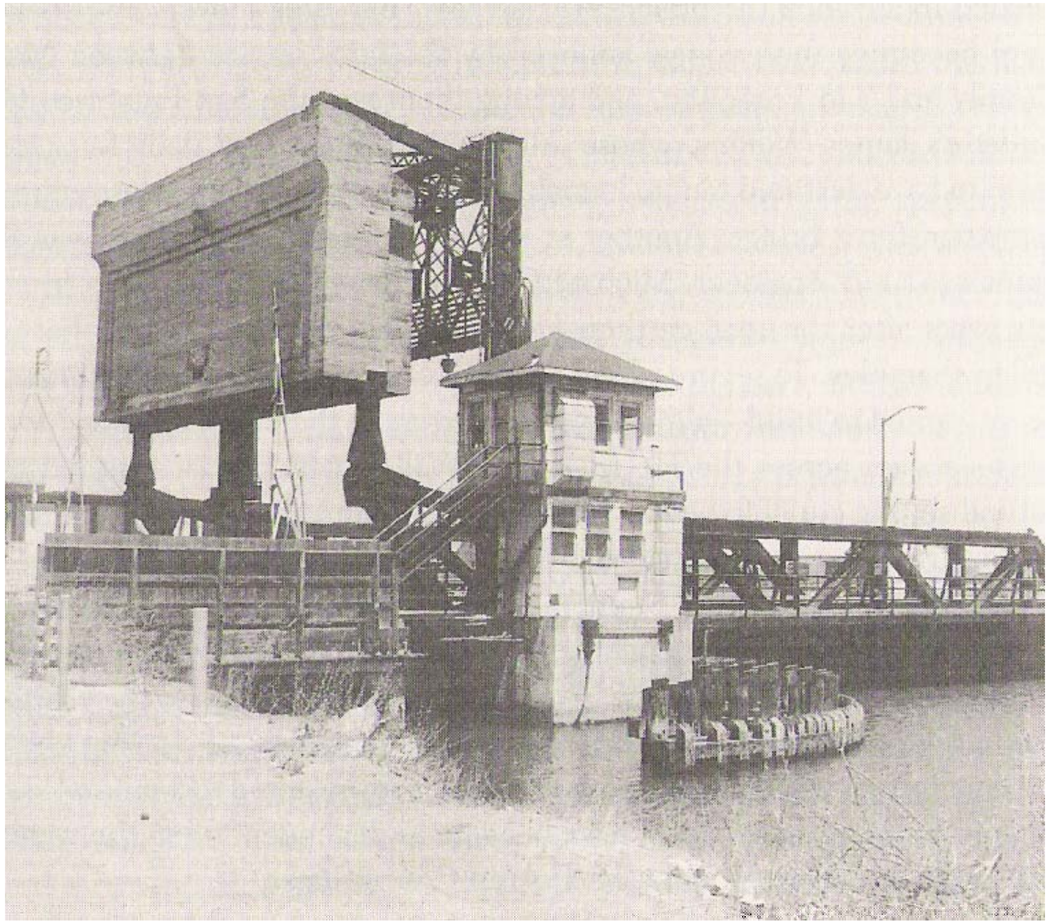
"Before a crowded house, a bewildered faculty, and a distinguished group of visitors and speakers, this modest, soft spoken young graduate unfolded his utopian dream."

Alfred K. Nippert

RE: Strauss' ***University of Cincinnati*** **fraternity brother recalling Strauss' commencement address to the graduating class of 1892. Strauss presented his senior thesis to the audience; a proposed railroad bridge across the Bering Strait linking Alaska with Russia. Though skeptical, the audience admired his boldness. As both class president and class poet, Strauss also read aloud his poem entitled:** ***Reveries***

The Bascule Bridge King

Upon graduation, Strauss went to work as a draftsman, first for the *New Jersey Steel and Iron Company* and later for the *Lassig Bridge and Iron Works Company* in Chicago. A few years later, he was working for *Ralph Modjeski* – a prominent Chicago engineer, where he was promoted to principal assistant engineer. While working for Modjeski, he became interested in *Bascule Drawbridges*. They were utilitarian, unattractive structures but highly functional and in great demand. In 1904, Strauss left Modjeski's firm and struck out on his own forming the *Strauss Bascule Bridge Company of Chicago* (later *Strauss Engineering Corporation*). He built over four-hundred bridges around the world and revolutionized the movable bridge type, but Strauss dreamed of greater things.



Fourth Street Bridge
San Francisco, CA
(1916)

Burnside Bridge
Portland, Oregon
(1926)

Lewis and Clark Bridge

Over the Columbia River - between Longview, WA and Rainier, OR (1930)

Cherry Street Strauss Trunnion Bascule Bridge
Toronto, Ontario, Canada
(1931)

NOTE: The *Strauss Trunnion Bascule Bridge* design was awarded a patent in 1904

Aside from his Bascule Bridges and poetry, Strauss' fertile imagination and engineering skill made him a prolific inventor. Among his inventions was a tubeless tire, a glass-washing machine (for soda fountains), a concrete railroad car, an anti-aircraft searchlight (used in WWI), a bascule door for aircraft hangers and a safety net to prevent automobiles from crossing train tracks while trains were approaching. In 1915, for the Panama-Pacific Exposition held in San Francisco, Strauss designed the "aeroscope" ride; a glass-enclosed platform attached to a crane which lifted people 150-feet into the air. In 1930, his alma mater (the *University of Cincinnati*) awarded Strauss an honorary *Doctor of Science* degree for his contributions to the science of bridge engineering.

"…to build the biggest thing of its kind that a man could build."

Joseph B. Strauss

RE: when San Francisco City Engineer Michael O'Shaughnessy contacted him in 1919 about a bridge spanning the mile-wide Golden Gate Strait, Strauss saw his chance for glory and would not be deterred. Though his hybrid design was rejected and the classic suspension design of Leon Moissieff and Charles Ellis would be the actual bridge built, Strauss' ego would not let him share credit as creator of the great bridge with anyone, including subordinates. As such, he alienated a wide variety of people in his quest to become "The Man Who Built the Bridge."

"Our world today revolves around things which at one time couldn't be done because they were supposedly beyond the limits of human endeavor, don't be afraid to dream…when you build a bridge, you build something for all time"

Joseph B. Strauss

"Mr. Strauss gave me some pencils and a pad of paper and told me to go to work."

Charles Ellis – Design Engineer, Golden Gate Bridge, 1930

RE: After overseeing test borings, Ellis returned to Chicago on March 1st 1930 to refine the design and cost estimates. At the same time, he maintained contact with Leon Moisseiff and Othmar Ammann. He had a tremendous responsibility including preparation and oversight of all calculations, computation of stresses and preparation of stress sheets, construction documents, contracts, proposals etc. Ellis and Strauss' personalities were completely opposite, whereas Strauss sought the limelight, Ellis shunned it and worked tirelessly at his assigned tasks. On December 5th 1931, Strauss insisted Ellis take a vacation. A few days before he was to return, Ellis received a letter from Strauss instructing him to turn over all his work to his assistant and take a permanent, unpaid vacation thereafter. Ellis was never to receive the official credit he deserved. He joined the engineering faculty at *Purdue University* in 1934, retiring as Professor Emiritus in 1947. He died in 1949.

"The structure was nothing unusual and did not require all the time, study and expense…"

Joseph B. Strauss – Chief Engineer, Golden Gate Bridge

RE: reason given for the firing of Chief Design Engineer Charles Ellis. By October 1931, Strauss was insisting Ellis complete his design work for the bridge. In response, Ellis asked Strauss' patience and cooperation, he needed more time to be certain that the complex calculations for cables, suspenders, towers, floor beams etc. ensured a safe design. By November 1931, Strauss had lost patience with his very meticulous design engineer. In his 1949 obituary, Ellis was credited as the Golden Gate Bridge's designer. Ironically, in death he finally received the credit for his many years of precise design work (starting in 1921) that he never enjoyed in his lifetime. Ellis produced ten volumes of calculated dimensions, loads, wind stresses etc. prior to his termination (in December 1931) by Strauss.

During construction of the bridge, Strauss became exhausted both physically and mentally from the long effort to get the bridge built. For over six months he was absent from the site, causing rumors to spread that he had a nervous breakdown. During this time, he divorced his long-time wife and married a young singer. After the bridge opened on May 27th 1937, he moved to Arizona to rest and recuperate after the long struggle. On May 16th 1938 – less than a year after the opening of the bridge, Strauss was dead at the age of 68, the result of a stroke.

A statue of Joseph Strauss was proposed for the bridge plaza, but it was blocked by Strauss' many enemies. On May 29th 1941, a bronze statue of Joseph B. Strauss was unveiled by his widow, Annette Strauss who provided funding for the memorial. In 1949, the statue was mounted on a grandiose concrete pedestal at the same location (adjoining Highway 101). The statue (placed on a simple round pedestal) was later moved to the SE Visitor Area (near the *Round House* Restaurant/Gift Shop).

Joseph B. Strauss
1870-1938
'The Man who Built the Bridge'

Here at the Golden Gate is the eternal rainbow that he conceived and set to form, a promise indeed that the race of man shall endure unto the ages

Chief Engineer of the Golden Gate Bridge
1929-1937

RE: inscription on the statue of Joseph B. Strauss

Part 4

Dream Team

Gone, But Not Forgotten

Charles Alton Ellis **wrote the standard textbook for structural design in use at the time, but he did not earn a formal Civil Engineering degree from the** ***University of Illinois*** **(where he was a Professor of Engineering prior to earning his degree). Rather, he was a Mathematician and Greek scholar who became an expert in structural design. He spent the last twelve years of his career as Professor Emiritus at** ***Purdue University*****. On the occasion of the bridge's 70th Anniversary (May 2007), in their formal report of their seventy year stewardship, the** ***Golden Gate Bridge District*** **gave Charles Ellis major credit for the detailed design of the Golden Gate Bridge.**

Though Ellis was officially "off the team," he nonetheless maintained his obsession with making the bridge safe. He spent five months after his dismissal calculating and recalculating the design. By the middle of 1932, Ellis had completed his self-appointed critical review and determined that the bridge, based on his own *preliminary* design work, was unsafe and required revisions to make it safe. To call attention to his findings and make his position known to the District and Advisory Board, Ellis wrote a very long explanatory letter on January 4th 1933 chronicling key events to journalist *George Cameron* of the *San Francisco Chronicle.* The letter outlined his tenure as design engineer of the Golden Gate Bridge from March 1930, through his dismissal (at the end of 1931) to the completion of his personal review in April 1932.

"…There were two problems in particular which, to me at least seemed at first insoluble with our present knowledge in the theory of structures…They arose at critical points and solutions were necessary. After several weeks of intensive study they yielded to a solution…Please remember that I was thoroughly acquainted with the towers when I started this work, and with previous studies at my command I anticipated that a month would be ample time for a complete review. I now know how erroneous was my estimate for I worked on the problem continually over ten hours a day, seven days a week, for nearly five months and the work was completed in October…"

RE: excerpt from Ellis' chronological, explanatory letter to George Cameron (for April 1932)

"…Why should revisions to my original design be necessary? ***Due to Mr. Strauss' insistence the towers have no diagonal bracing above the floor, each tower is therefore what is known as a statistically indeterminate structure. The moments, shears and resulting stresses cannot be determined by the principles of statics alone, and additional data must be obtained from the behavior of the structure under stress, by taking into account the distortion of the members and the corresponding deflections of the various joints…The amount of work is greatly reduced if the number of unknown quantities is kept at a minimum…Such a procedure can be justified in a preliminary study when speed is urged, but always at the expense of accuracy. The computations for the preliminary design and estimate were of this latter character…in a structure of this size, so novel and extraordinary, any assumptions are attended by considerable sacrifice of accuracy…I realized that the final design for construction purposes was an entirely different matter…These were the facts that gave me worry…"***

RE: excerpt from Ellis' letter to George Cameron (for April 1932)

"…Having these facts in mind I decided when I began my study last April to eliminate all assumptions, that could possibly have any influence on the structure, and to solve for each unknown that would have the slightest importance. I set up algebraic expressions for 38 unknowns as against 13 in the preliminary work, which means that 25 assumptions appearing in the preliminary design were eliminated in my final computations. The correct result instead of an assumed value which was only approximate (and in some instances hardly that) in 25 instances can easily account for considerable differences between the preliminary and the final designs. In other words the preliminary design is superficial and approximate: the final design is thorough and correct… All this work has been done on my own time and expense…I have worked three years and more on this job; I personally made all the computations and design and wrote the specifications. Naturally, it is very close to my heart, and I cannot face the possibility of having the work start off on a design which my five months intensive study has convinced me needs revisions…"

RE: excerpt from Ellis' letter to George Cameron (for April 1932)

Leon Moissieff **had remained silent when his friend and colleague Charles Ellis was dismissed by Strauss. When Ellis' letter reached the Advisory Board, Moissief reviewed it but found Ellis' concerns over the perceived design flaws unsubstantiated thus, they were essentially ignored. Ellis was replaced by Strauss Engineering Corporation's managing engineer,** ***Clifford Paine*****. All references to Charles Ellis were expunged from all materials and documents pertaining to the Golden Gate Bridge.**

Charles Ellis
Professor Emiritus, Purdue University
(ca. 1935)

Moisseiff

Leon S. Moissieff **was born November 10th 1872 in Riga, Latvia. He attended the** ***Baltic Polytechnic Institute*** **for three years and when he was 19yo (in 1891), he emigrated to the United States with his family. In 1895, he graduated from** ***Columbia University*** **with a degree in Civil Engineering. He became a naturalized American Citizen and was so pleased with his new country, he named his daughter** ***Liberty*****. He joined the New York City Bridge Dept. where he would gain a national reputation as an able bridge designer. He was one of the designers of the** ***Manhattan Bridge*** **(1909) and assisted Ralph Modjeski with the** ***Benjamin Franklin Bridge*** **(1926) spanning the Delaware River between Camden, N.J. and Philadelphia, PA. Moissieff was an advocate of all-steel bridges and "Deflection Theory." This theory stated, generally, that the more flexible the roadway, the greater the reduction of stress by transmitting forces (via suspension cables) to the towers. Moissieff took this theory to an extreme a few years later with the** ***Tacoma Narrows Bridge*****. Ellis would apply and expand many of Moissieff's Deflection Theory ideas to his design work for the Golden Gate Bridge.**

Manhattan Bridge
(1909)

Benjamin Franklin Bridge
(1926)

When Strauss had Ellis hire Moissieff as a consultant, Ellis gained an invaluable source of information on Deflection Theory of which Moissieff was the leading proponent among prominent bridge engineers. With Ellis in Chicago and Moissieff in New York, telegrams became the means by which they communicated their ideas for the Golden Gate Bridge. In particular, Moissieff contributed greatly to the wind-force calculations. Exploring a practical application of Deflection Theory, the pair made the design of the Golden Gate Bridge light, long and narrow yet flexible enough to withstand the gale-force winds of the Golden Gate Strait. With Moissieff and Ellis resolving successfully the suspension bridge design, Strauss began to come around to its practicality versus his hybrid cantilever-suspension design. The classic suspension bridge design would use less steel thus it would cost less to build. Also, it would be quicker to build. The cost and time factors along with the growing outcry of his "ugly duckling" hybrid design defacing the natural beauty of the Golden Gate strait sealed the deal for a suspension bridge design.

"Moissieff believed that up to half the stress caused by winds could be absorbed in a suspension bridge by the bridge cables and suspender ropes, and transmitted to the bridge towers and abutments. So if a bridge were designed all to bend and sway with the winds, the suspended structure – the roadbed – would act as a counterweight and restore the bridge to equilibrium."

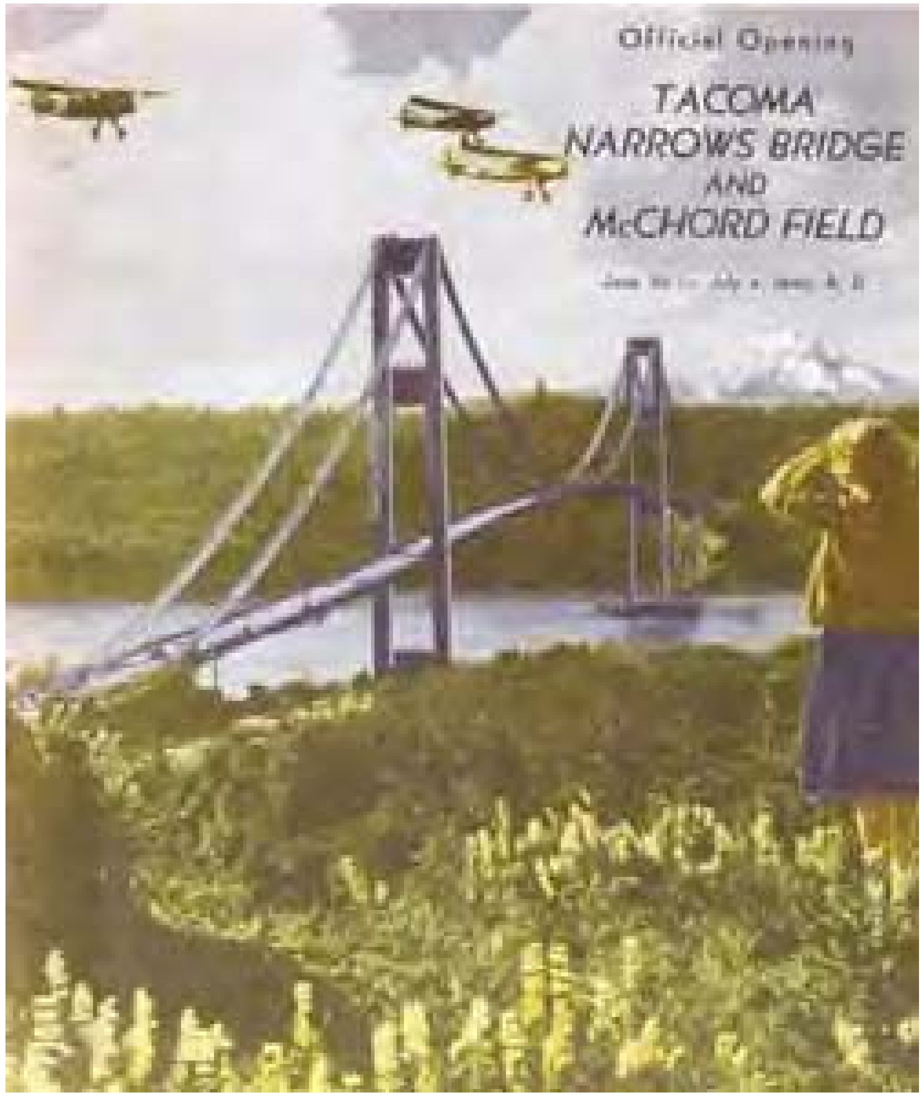
John Van Der Zee, Author

Wind Won't Imperil Bridge At Golden Gate

Winds could sway the center of the Golden Gate Bridge across the entrance to San Francisco Bay more than twenty feet in either direction without danger, according to the Bethlehem Steel Company, largest contractor on the giant span.

The Most Beautiful Bridge in the World

With America's entry into WWII on the horizon, there was a need to link *Tacoma Field* with the *Bremerton Naval Station* in Washington State. Separating them was the Tacoma Narrows. Leon Moissieff would be called upon to be the lead superstructure engineer, a first for him whereas previously he was a consultant and/or member of a design team. His long, narrow design for the bridge made it the third longest in the world (at the time) and he considered it to be "The Most Beautiful Bridge in the World" because of its slender profile. At a span-to-width ratio of 72:1, it was extremely narrow and unstable in the wind. Moissieff minimized the wind bracing and used a plate-girder stiffening truss. This solid steel girder caught the wind and created excessive movement (a.k.a. "Gallop") of the deck, thus the bridge which opened on July 1st 1940, came to be known as *Galloping Gertie.* On November 7th 1940, just four months after it opened, the bridge began to twist tortionally in a sustained 40mph wind, eventually collapsing into the Narrows below. Moissieff's long career as a bridge engineer was over. He died a broken man three years later of a heart attack on September 3rd 1943.


Official Opening
TACOMA
NARROWS BRIDGE
AND
McCHORD FIELD

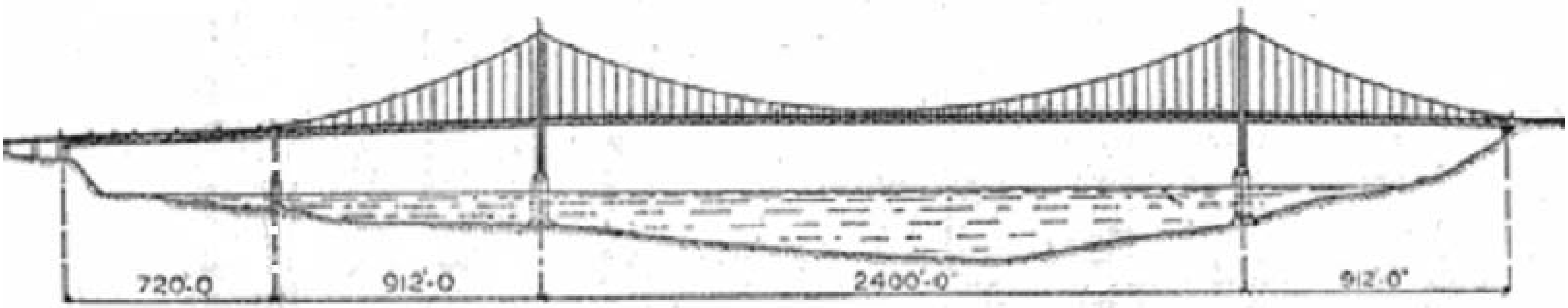
"…I therefore, feel that with the exception of the unusual narrowness of the bridge with reference to its span length, the super-structure design is technically sound. It is probably technically sound not withstanding its narrowness, but there are several reasons why it would be of material advantage if the bridge could be widened at a reasonable increase in the cost, and therefore, I recommend that serious consideration be given to the possible increase in the width of this structure, before the contract is let out or work begun."

Theodore L. Condron – Advisory Engineer for the *Reconstruction Finance Corporation* (RFC)

RE: report to the RFC whereby Condron voiced his concerns over the narrowness of the bridge and recommended it be widened to 52-feet wide (from 39-feet) to decrease the *span-to-width ratio* from 72:1 to 53.8:1

"It might seem to those who are not experienced in suspension bridge design that the proposed 2,800-foot span with a distance between stiffening trusses of 39-feet and a corresponding width of span ratio of 72, being without precedent, is somewhat excessive. In our opinion this featureof the design should give no concern."

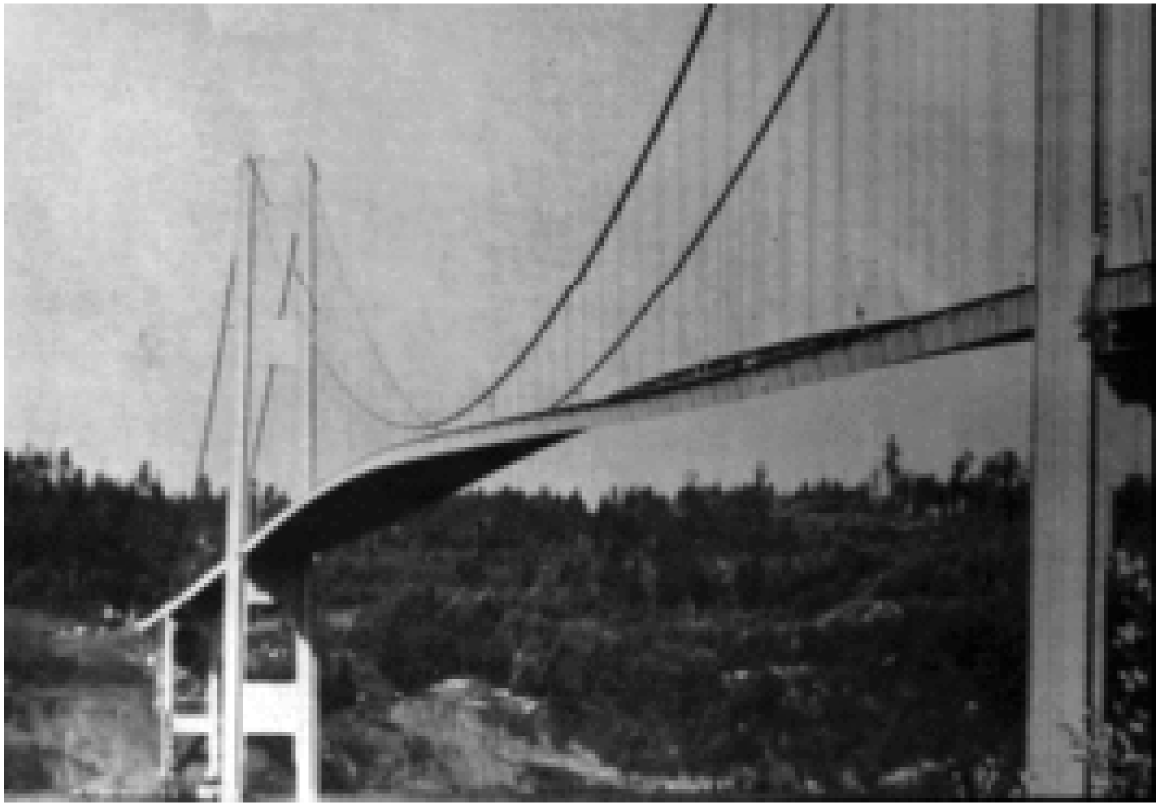
RE: report of the consulting engineers to the RFC on behalf of the *Washington State Toll Bridge Authority* (WSTBA) whereby a loan of $3 million was granted and construction bids received by October 1938


720-0
912'-0
2400'-0"
912'-0"

"There seemed to be almost no recognition that wind created vertical movement…historical perspective seemed to have been replaced by a visual preference unrelated to structural engineering"

David P. Billington, Bridge Historian

RE: the "blind spot" in engineers' thinking concerning the power of the wind in the 1920s & '30s



"These long-forgotten difficulties with early suspension bridges, clearly show that while to modern engineers, the gyrations of the Tacoma bridge constituted something entirely new and strange, they were not new – they had simply been forgotten."

J.K. Finch - Columbia University Professor of Civil Engineering

RE: excerpt from his 1941 article in *ENR* entitled: *Wind Failures of Suspension Bridges or Evolution and Decay of the Stiffening Truss*

"We knew from the night of the day the bridge opened that something was wrong. On that night the bridge began to gallop…We watched it, and we said that if that sort of motion ever occurred on the real bridge, it would be the end of the bridge"

Professor F.B. Farquharson, University of Washington RE: hired by WSTBA to conduct tests and recommend corrective measures for the *Tacoma-Narrows Bridge* "bounce." Wind tunnel studies on a 1:200 scale model (54-feet long) of the *Tacoma-Narrows Bridge* demonstrated a "twisting motion," observable under certain conditions.

"…the Tacoma-Narrows Bridge was well designed and built to resist safely all static forces, including wind, usually considered in the design of other structures…It was not realized that the aerodynamic forces which had proven disastrous in the past to much lighter and shorter flexible suspension bridges would effect a structure of such magnitude as the Tacoma-Narrows Bridge"

RE: *Federal Works Agency* (FWA) investigation/report (five months after collapse) by three prominent engineers;

- ***Theodore Von Karmen* – Director: Aeronautical Laboratory at the *California Institute of Technology***
- ***Glenn B. Woodruff* – Design Engineer: *San Francisco-Oakland Bay Bridge***
- ***Othmar H. Ammann*: Chief Engineer: *Port of New York* Authority (PNYA)**

"came as such a shock to the engineering profession that it is surprising to most to learn that failure under the action of wind was not without precedent in the history of suspension bridges…much old information long forgotten was once again made available to the profession"

Professor F.B. Farquharson, University of Washington

RE: the myopia of suspension bridge designers in the 1930's concerning the many suspension bridges destroyed by the wind between 1818 and 1889 (25% of those built)

"Regrettable as the Tacoma-Narrows Bridge failure and other recent experiences are, they have given us invaluable information and have brought us closer to the safe and economical design of suspension bridges against wind action."

Othmar H. Ammann – Chief Engineer, PNYA

"The one great disappointment in Mr. Moisieff's career was the failure of the Tacoma-Narrows Bridge, the design of which he had originated and guided…it would be improper for his fellow professionals to put the blame for that failure entirely upon Mr. Moisieff's shoulders for he followed a trend in long-span suspension bridge design which appeared justified at the time."

Othmar H. Ammann – Chief Engineer, PNYA

RE: letter in *Engineering News Record* (ENR) upon the death of Leon Moisieff – his friend and colleague

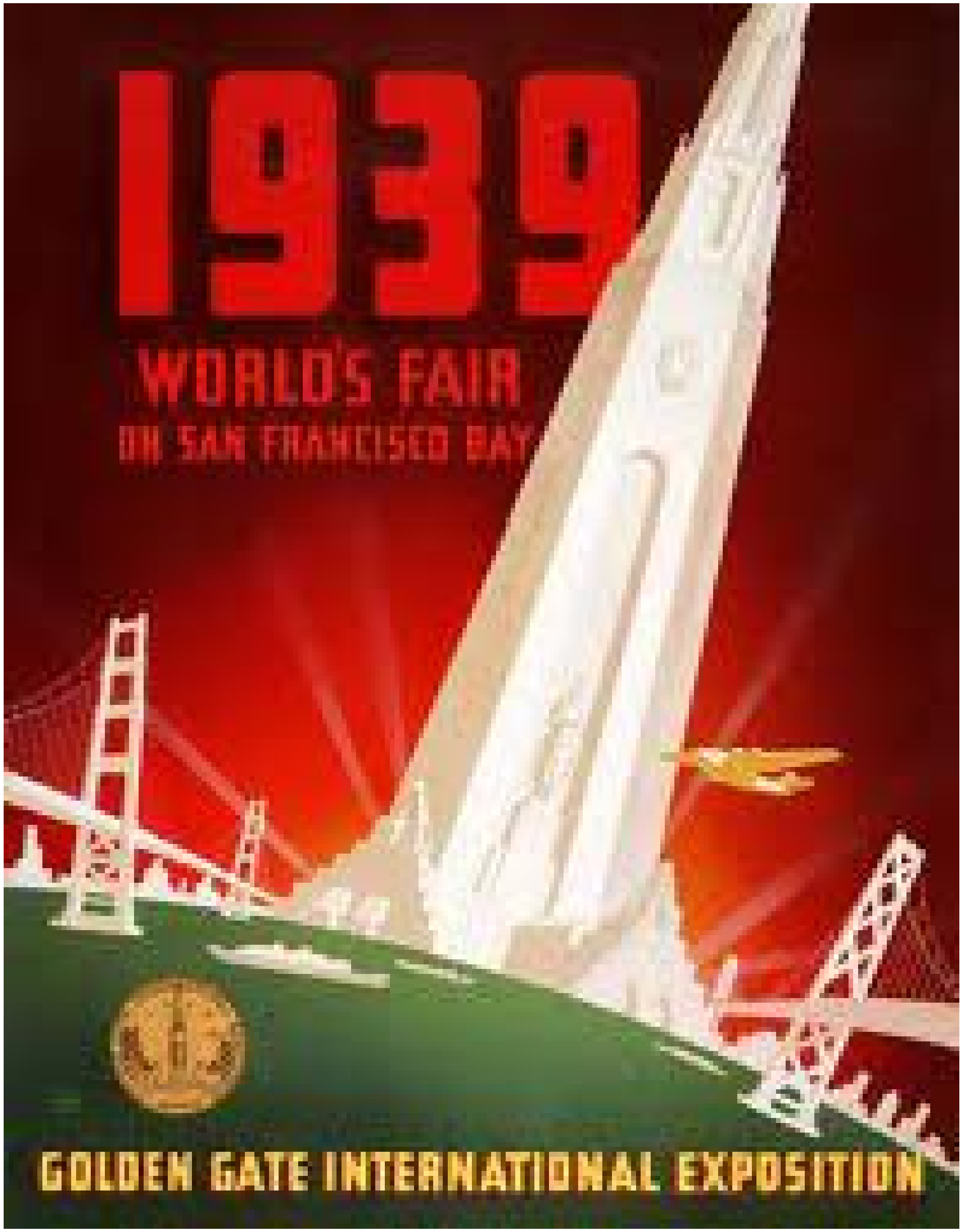
Morrow

Irving Foster Morrow **was born in 1884 and graduated with a degree in architecture from UC Berkeley in 1906. From 1908 to 1911, he attended the prestigious** ***Ecole nationale superieure des Beaux-Arts*** **in Paris. He designed a variety of buildings; banks, schools, hotels, theatres, commercial and residential buildings. Morrow practiced with architect** ***William I. Garren*** **as** ***Garren & Morrow*** **from 1916 to 1925. He married fellow architect and UC Berkeley graduate** ***Gertrude Comfort*** **and they practiced together as** ***Morrow & Morrow*** **from 1925 until Irving Morrow's death in 1954. Most notably, they designed the** ***Alameda-Contra Costa County Building*** **for the 1939/40** ***Golden Gate International Exposition*****. The GGIE was an extravagant "coming-out" party for San Francisco and a celebration of the city's two new bridges:** ***San Francisco-Oakland Bay*** **(1936) and** ***Golden Gate*** **(1937).**

GGB (foreground) / SF-OB Bridge (Background)
Yerba Buena & Treasure Island (upper left)

"Bridge, ha! That's no bridge, that's a trestle."

RE: Joseph Strauss' opinion of the SF-OB Bridge as expressed at its opening on November 12, 1936, six months ahead of the GGB 125


1939
WORLD'S FAIR
ON SAN FRANCISCO BAY
GOLDEN GATE INTERNATIONAL EXPOSITION

Visitor’s Map

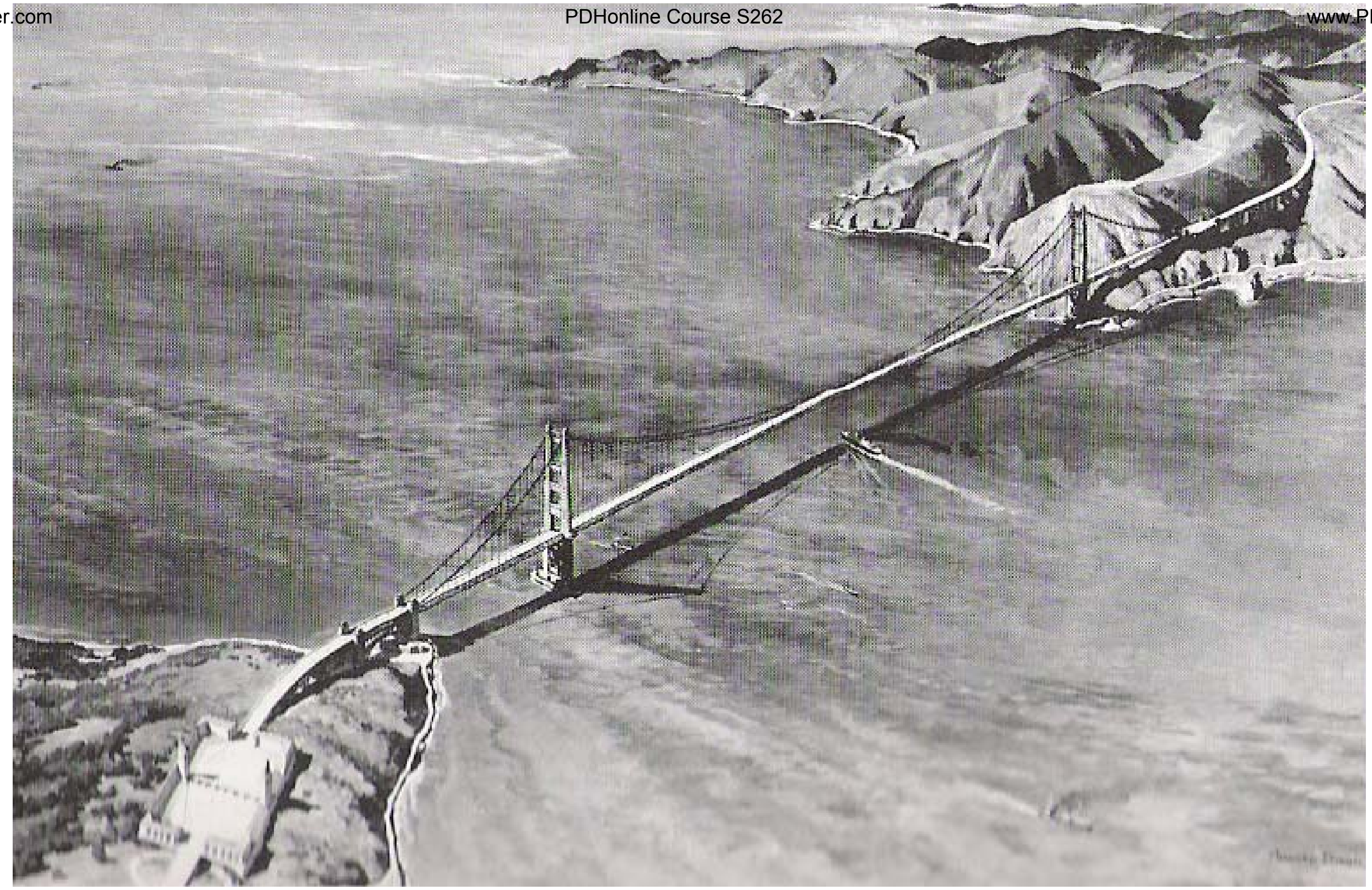
Golden Gate International Exposition of 1939/40

The exposition was held on *Treasure Island*. It was a man-made island made from the “spoil” of digging the half-mile long tunnel through Yerba Buena Island (part of the SF-OB Bridge project).

Perspective Rendering
by Irving R. Murrow, Architect

Strauss wanted the bridge to be a fusion of *form-following-function*. To this end, he sought out a talented architect and, at first, found Austrian native and "thematic" architect *John Eberson* - a theater architect based in New York. Eberson had a national reputation as a talented designer. Strauss hired Eberson to work on the towers and the approaches. Essentially, his design for the tower/s was the basis for Morrow's design, with some modifications by Morrow such as a gradual narrowing of the tower/s as they rose. Eberson wanted more money to complete the work but Strauss was not buying, Eberson had established the design criteria through his work-to-date and Strauss needed someone who could work well with the planning commission. On the recommendation of artist *Maynard Dixon*, Strauss replaced Eberson with local architect *Irving F. Morrow* in early April 1930. As a native, Morrow knew the local political, cultural and artistic climate well. In fact, many of Morrow's early drawings of the bridge were heavily influenced by Maynard Dixon's own vision of the bridge.

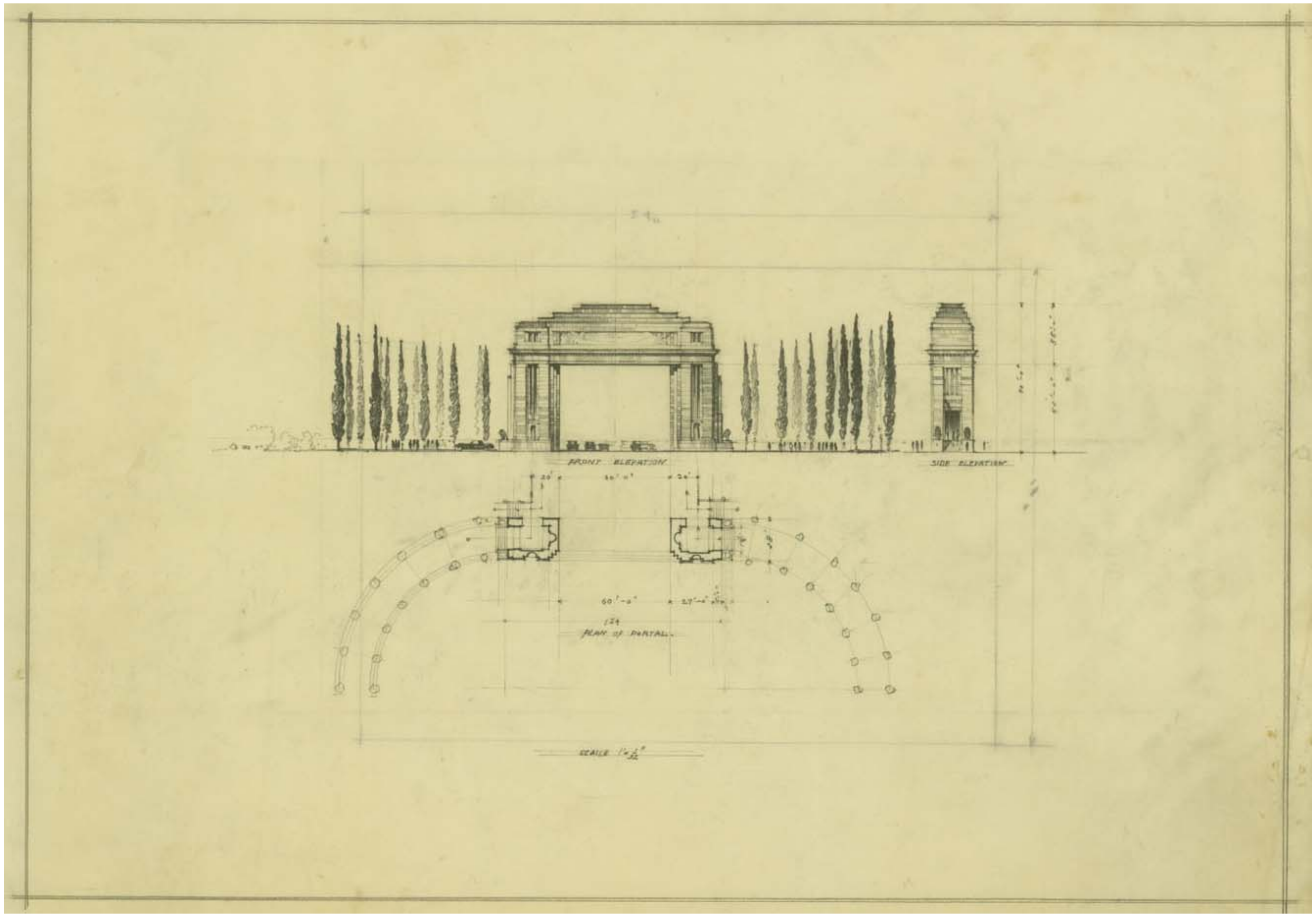
Conceptual Painting of the Golden Gate Bridge
by Maynard Dixon
(1930)



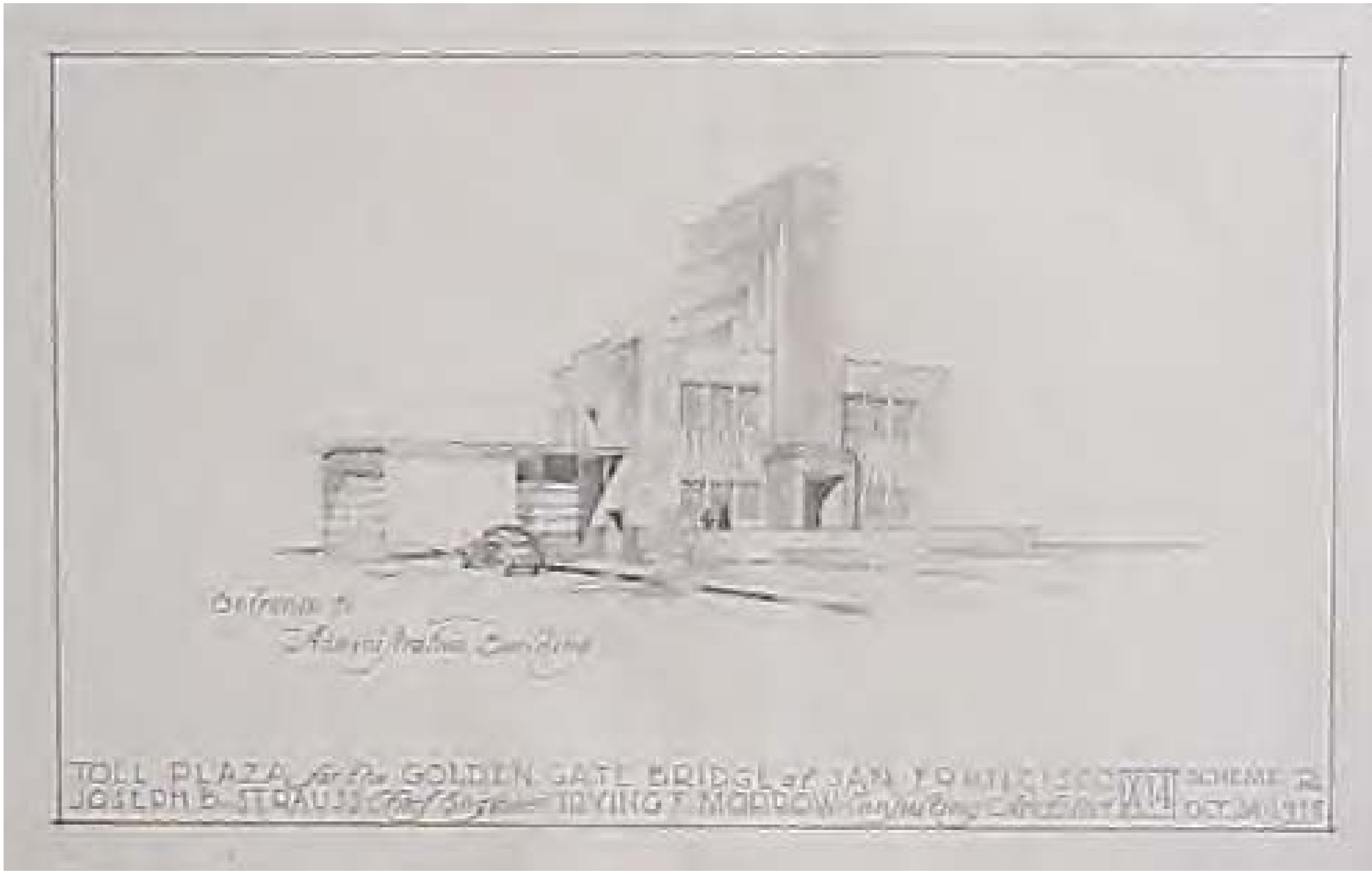
This rendering by artist *Maynard Dixon* appeared in an August 1930 article (about plans for the bridge being approved by the District) in the *San Francisco Chronicle.* It's purpose was to dispel opponents of the bridge – including environmentalists/naturalists (i.e. San Francisco native *Ansel Adams*), who claimed the bridge would ruin forever the natural beauty of the Golden Gate.

"Sentimentalists tell you it would be a desecration of natural beauty to bridge the Golden Gate. The point is not whether bridging the Golden Gate will destroy its beauty but whether the particular bridge proposed will destroy it."

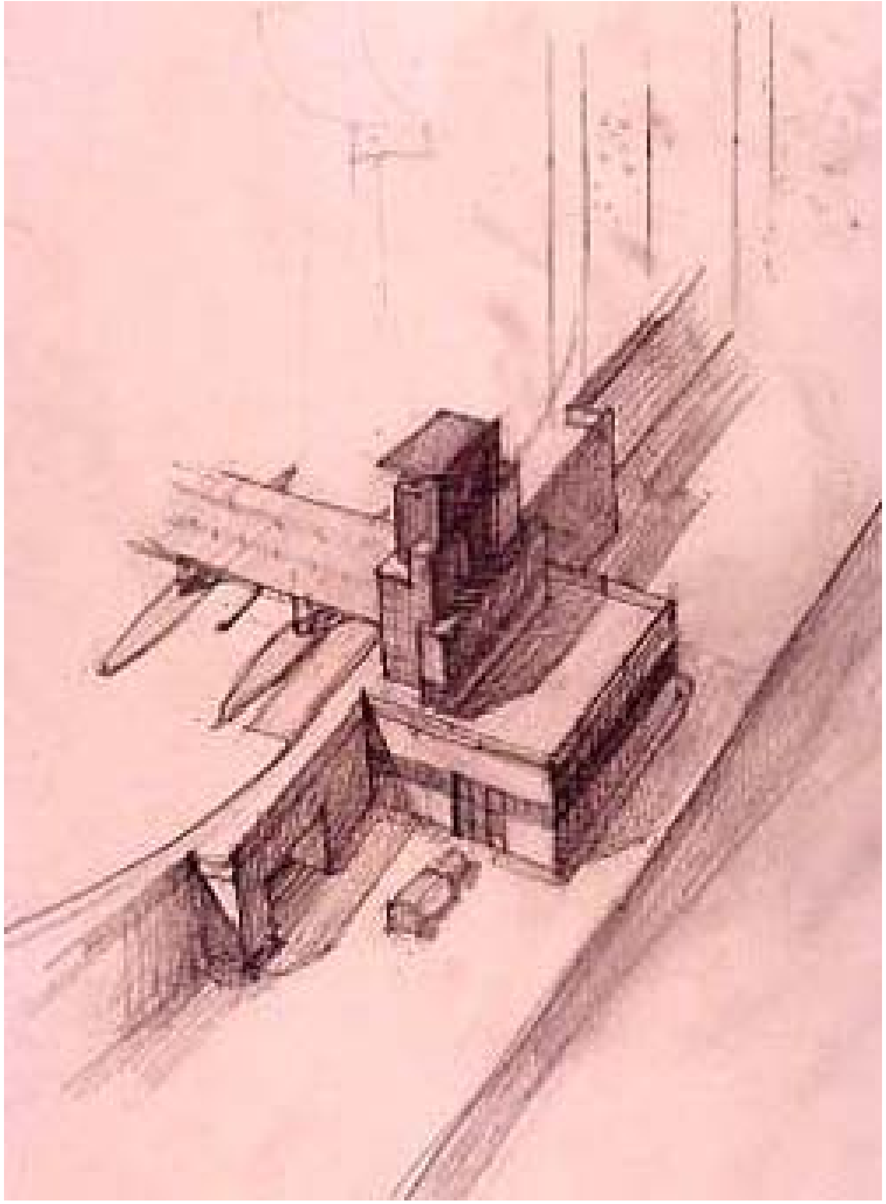
Irving Morrow - Consulting Architect, Golden Gate Bridge

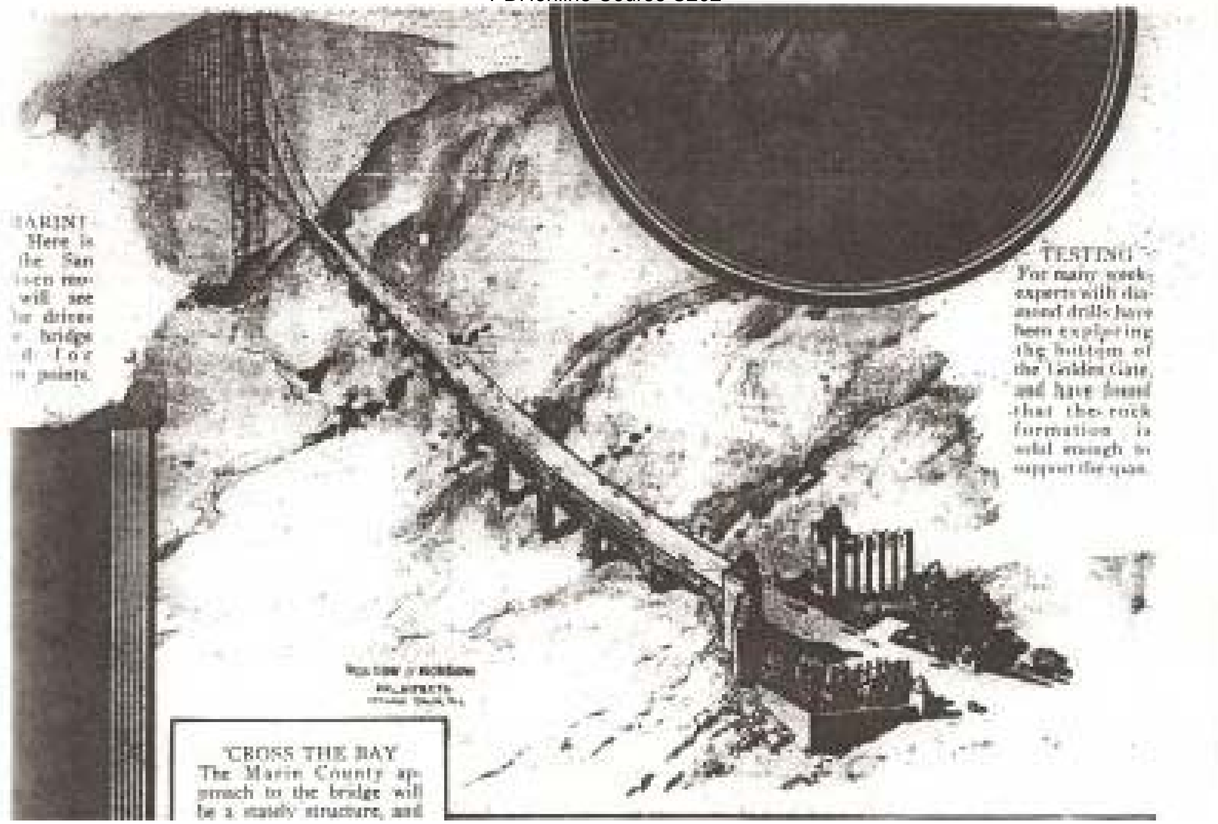


Elevation/Plan Study of the Northern Approach
(reminiscent of the *Brandenburg Gate*, Berlin)
by John Eberson
(ca. 1930)



"Toll Plaza for the Golden Gate Bridge of San Francisco"
Irving Morrow, Architect



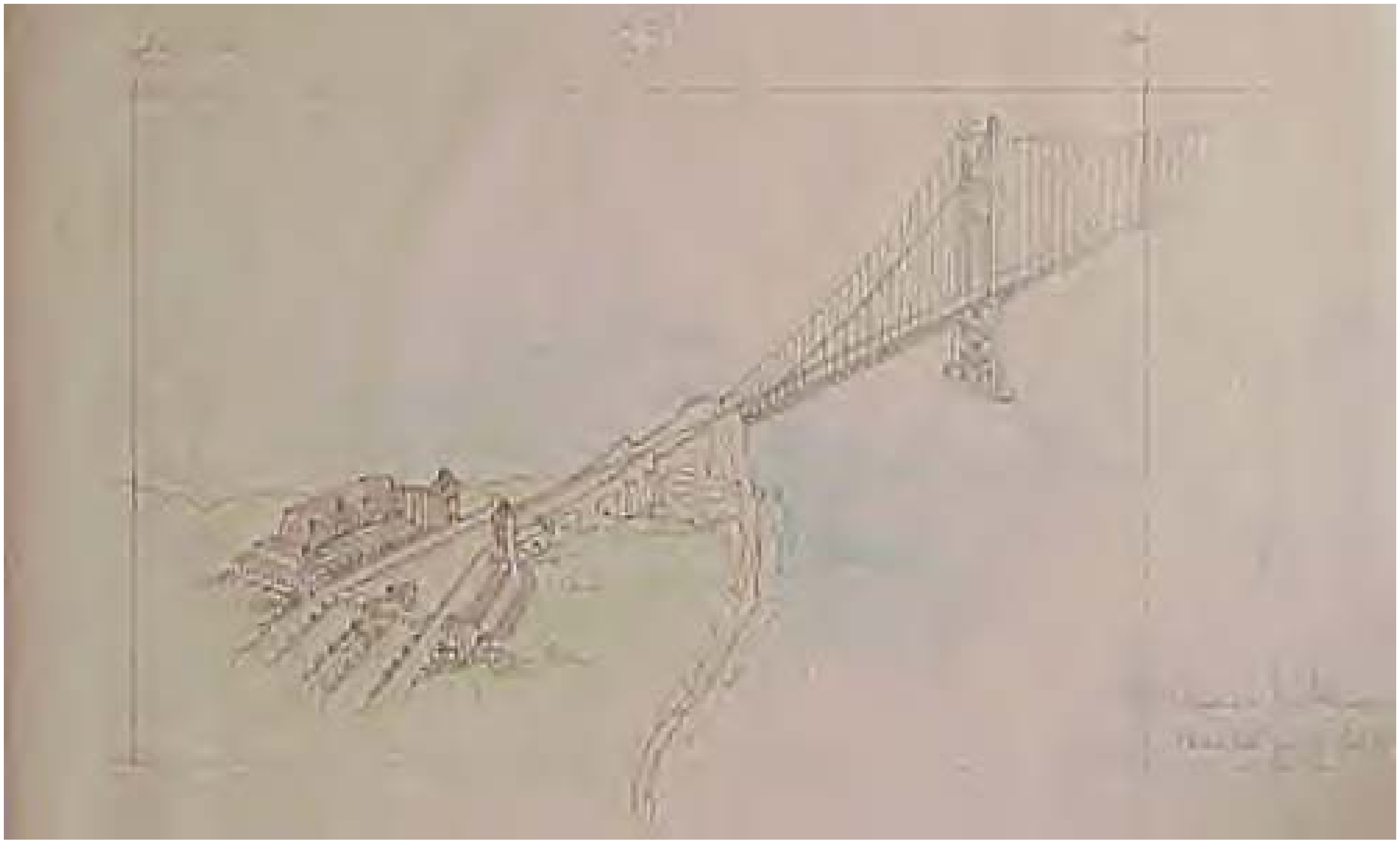


On October 5th 1930, this drawing of "The World's Greatest Span" (by *Morrow & Morrow*) appeared in the *San Francisco Chronicle's* Sunday edition. It is somewhat reminiscent of both Eberson's neo-classical approach design/s and Bernini's colonnade in St. Peter's Square (Vatican City). The design featured an exhibition hall and a large plaza with high walls (to act as a wind barrier). A roadway realignment and cost concerns ended this scheme.

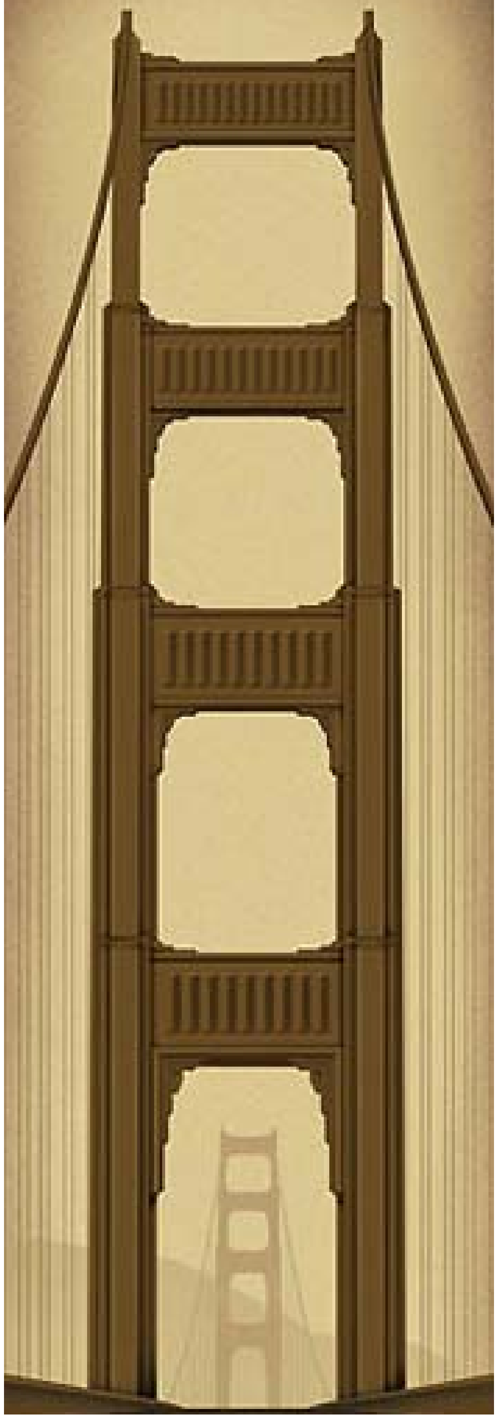
"When the wide road over the Presidio territory has old trees fringing both sides of it and lower bushes to break the ocean winds, it will become a favorite drive…it is necessary to awake the attention of the traveler before he gets on the bridge…"

Bernard Maybeck, Architect of the *Palace of Fine Arts*

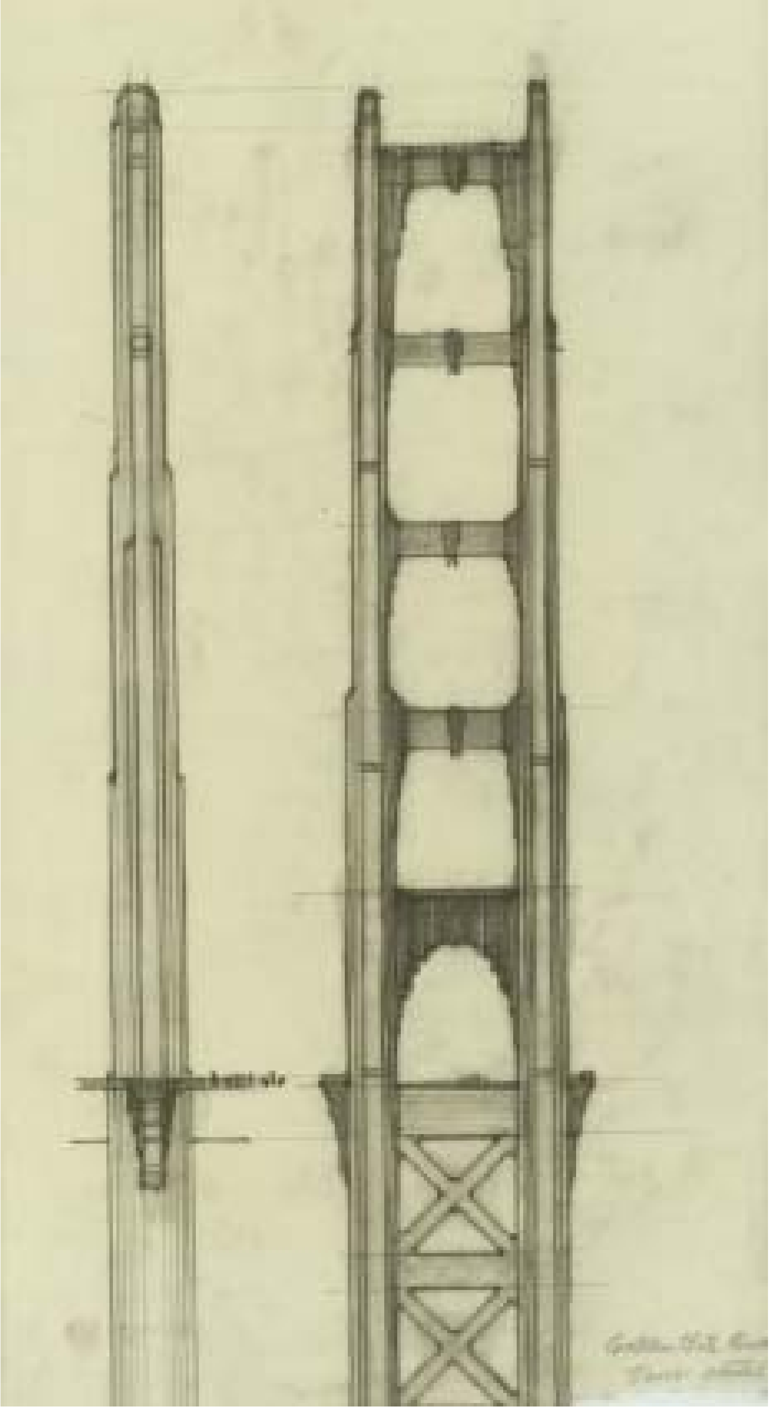
RE: excerpts from a letter to *Chesley Bonestell*, renderer of the proposed monumental approaches and toll plaza for the *Golden Gate Bridge*. Strauss used these grandiose designs to help sell the bridge to the public in the 1920s, but they were never realized due to the onset and deepening of the depression by the time construction began in 1933. Irving Morrow's more contemporary art-deco design for the toll plaza was however, realized. Bonestell is most famous for his "space art" and for having designed many of the decorative features (i.e. eagle gargoyles) of the *Chrysler Building* (1930), in New York City.



The World's Tallest Art Deco Sculpture



Strauss instructed Irving Morrow and his wife, Gertrude to "Make it Beautiful." To do this, Morrow had to emphasize the strong vertical elements of the two towers, the bridge's most conspicuous feature/s. Angular concrete pylons frame the towers upon approach (from the Presidio) and the soaring towers come into full view. The four rectangular portals decrease in width while the stepped-back towers rise from the deck in ascent to the sky. Between the tower legs, Morrow used stamped vertical fluting (on the housing of the bracing struts). The many variations in the tower/s geometry catches the sun's light creating a play of light and shadow. To emphasize the height of the towers, Morrow used lighting very effectively by focusing less light at the top than at the deck, making the tower seemingly soar limitless into the night sky.



"The very fact that Strauss initially chose Eberson to stylize the towers and other aspects of the bridge underscores Strauss' sense of the Golden Gate Bridge as, in part, a theatrical production orchestrating site, structure and atmospheric into a unified aesthetic statement"

Kevin Starr, Author

RE: John Eberson's rendering of the bridge's suspension tower, ca. 1930 (left)

"Eberson's design of the towers was very influential I believe. His tower design was changed very little after Morrow took over as consulting architect."

Jessica Hough, Curator

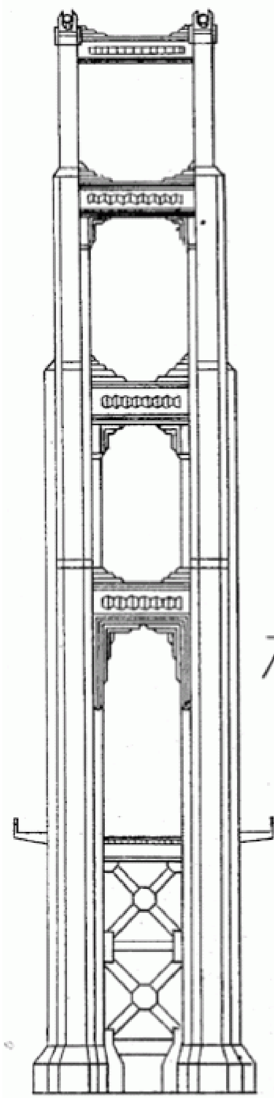


Fig. I.

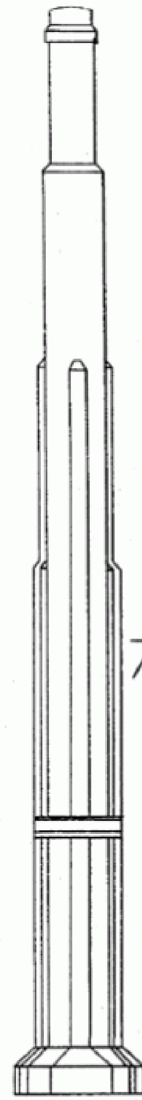
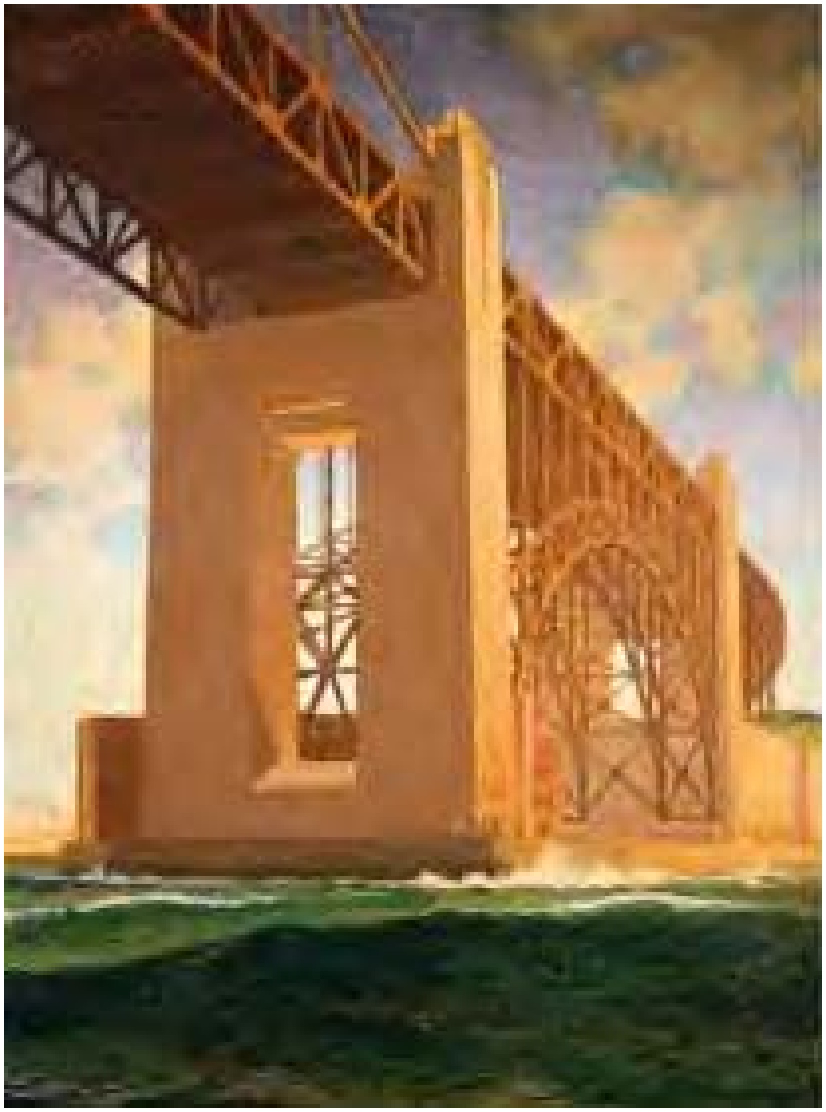
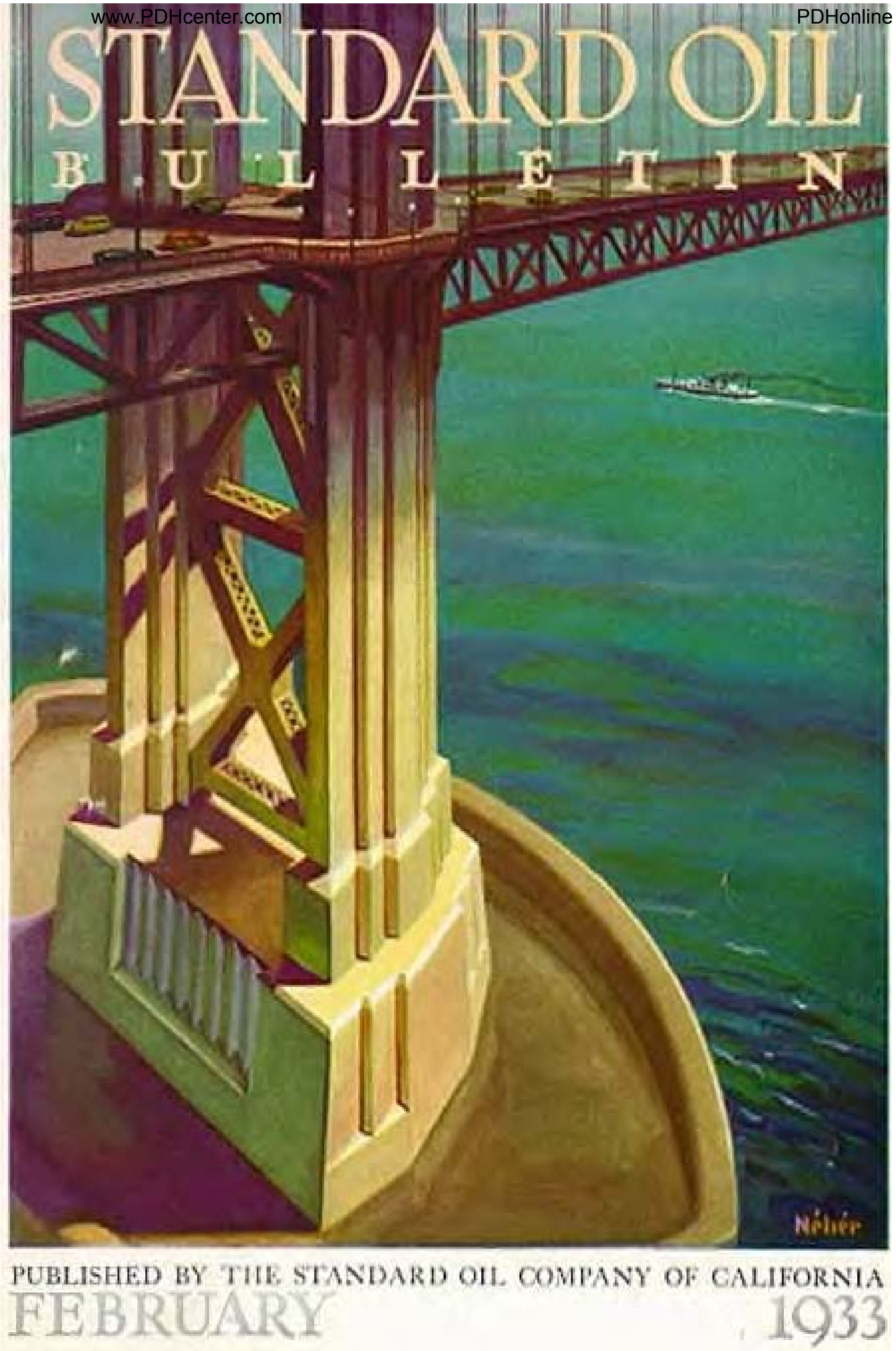


Fig. II.

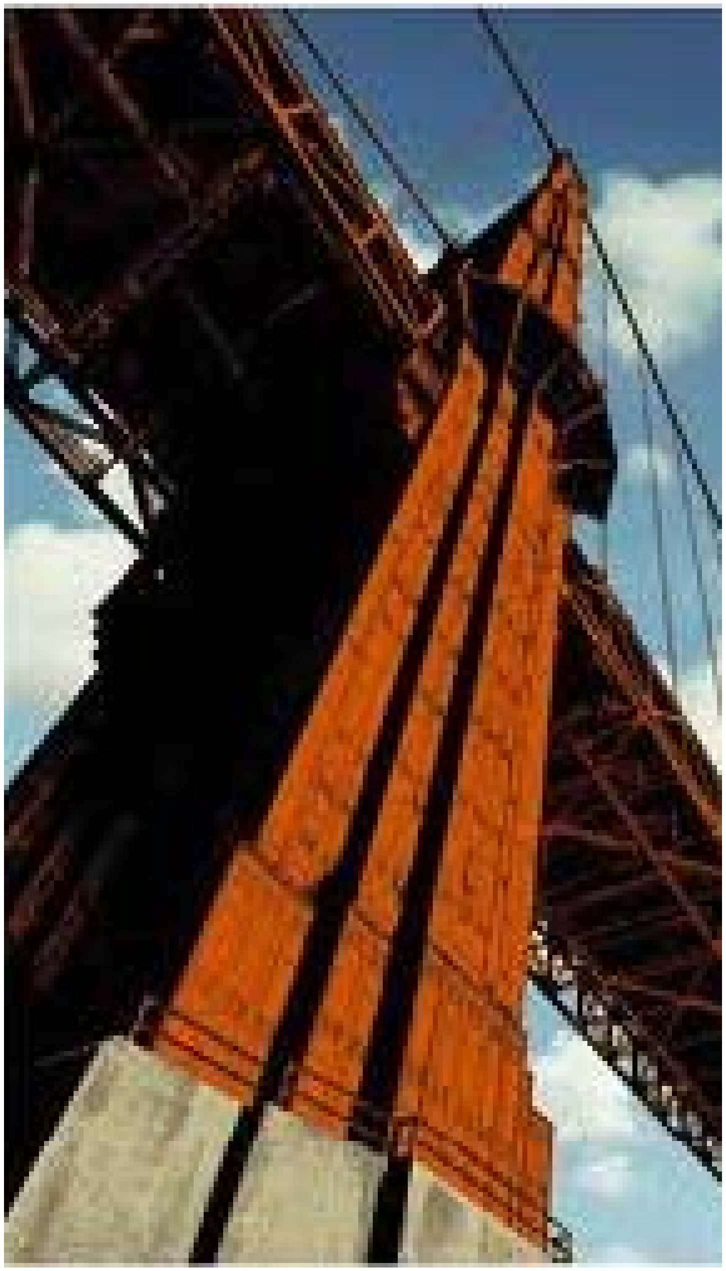
INVENTOR.
JOSEPH B. STRAUSS
BY C. L. [signature]
ATTORNEY




NO
STOPPING
OR
TURNING
ON BRIDGE



The *Standard Oil Company of California* commissioned talented artists to create several covers featuring the GGB under construction for their monthly *Standard Oil Bulletin.* This cover illustration for the February 1933 issue lacked the bridge's distinctive *International Orange* coloration since it had not been decided on at that point in time. Standard Oil also assigned employee *Ted Huggins* the task of photographing the bridge during construction (for three years). He was prolific producing hundreds of photographs which appeared in news outlets of the day.

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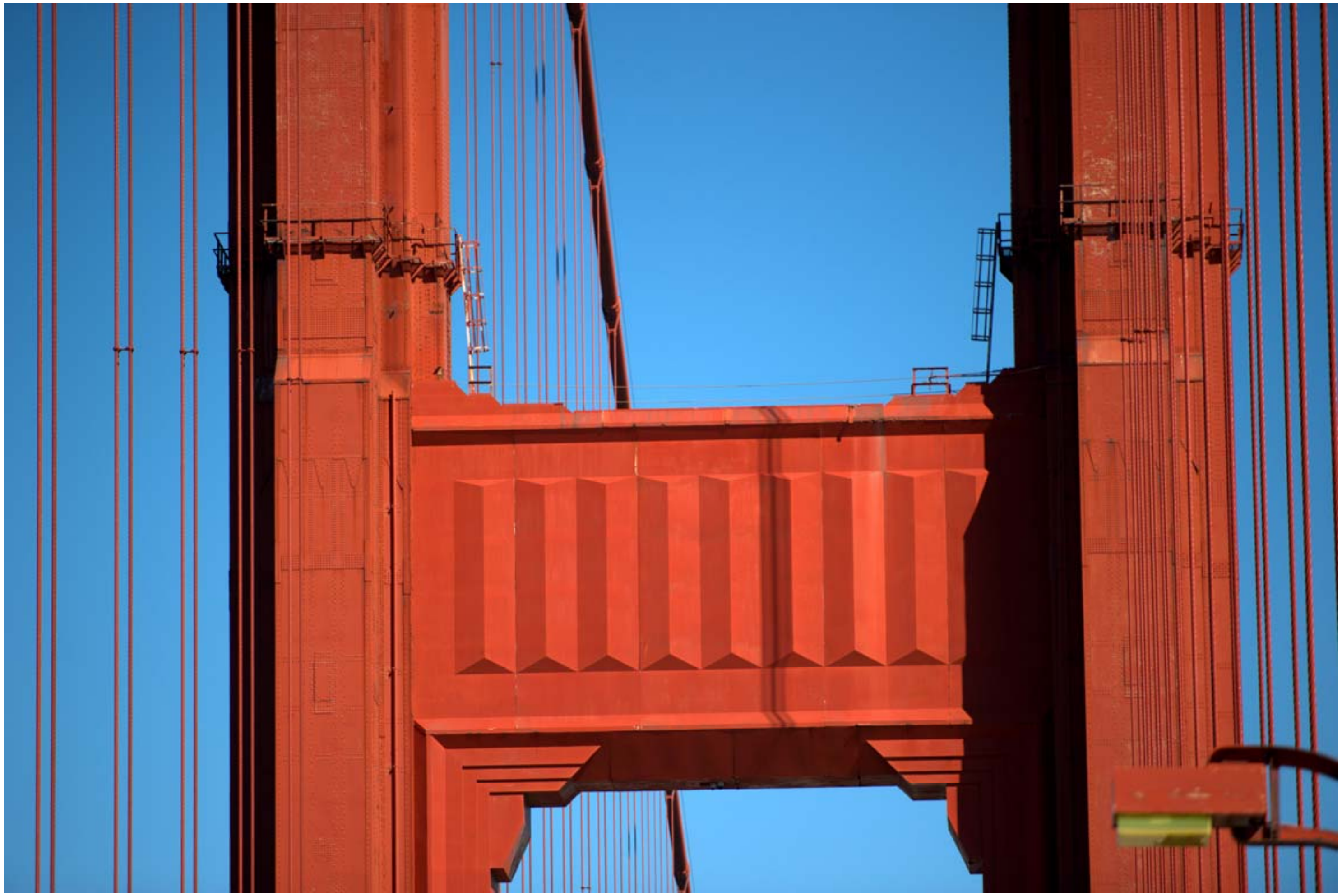
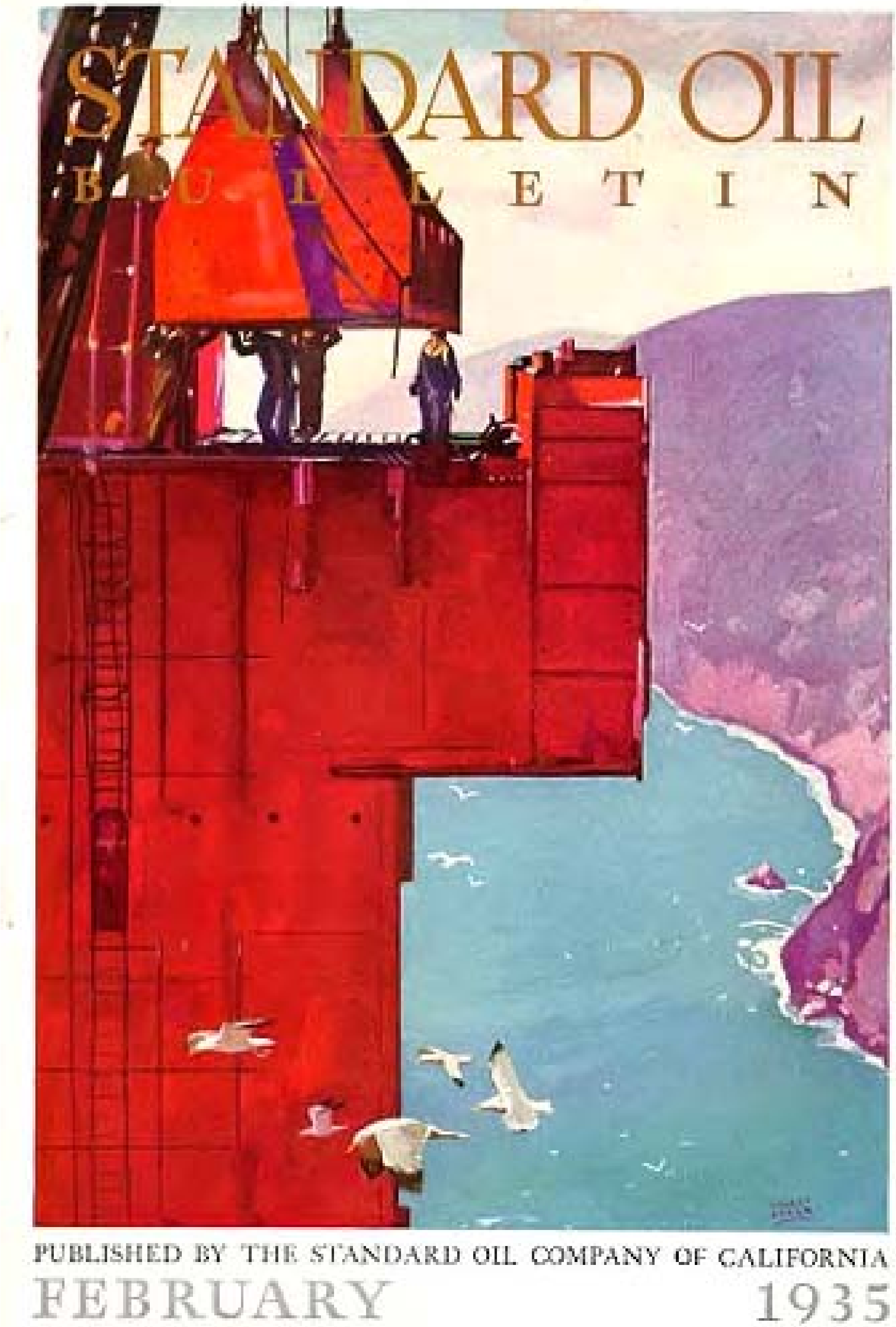


International (Airways) Orange

"Preliminary to discussion of particular colors, a decision must be made on a matter of policy – is it desired to emphasize the bridge as an important feature on the landscape, or to make it as inconspicuous as possible."

Irving Morrow – Consulting Architect, Golden Gate Bridge

Irving Morrow played a key role in the selection of the "burnt red-orange hue" paint used on the Golden Gate Bridge, known as *International Orange*. As a daily commuter on the ferry from his home in the East bay to the bridge site, he took note of the red-lead primer used by Bethlehem Steel to coat the steel at the foundry. He found the color inspirational and began color studies to see which color-mix blended best with the surrounding hills and bay. Some wanted the bridge to be painted a dull grey, others wanted it to be painted aluminum (like the SF-OB Bridge). The Navy wanted the bridge to be as visible as possible, considering the fog conditions of the bay and their fleet anchorage (near the foot of the tandem suspension bridge of the SF-OB Bridge), so they suggested a highly visible yellow with black stripes. It was also widely believed that a red-based paint could not stand up to the weather conditions in the strait. "International Orange" existed then and now as a high-contrast paint (to set things apart from their surroundings), but this version – similar to "safety orange," has a deeper tone of red.



This February 1935 cover illustration of the *Standard Oil Bulletin* features the cable saddle sections being hoisted into place atop the Marin Tower. It also highlights the red-lead primer Bethlehem Steel applied to the tower sections which impressed and influenced Irving Morrow in deciding on a reddish-hued topcoat.

"The tone is beautiful under all light conditions"

U.S. Forest Service

Morrow's color studies included black, grey and aluminum. He and his group of advising architects, engineers, painters, sculptors etc. found black to be worst, reducing the scale of the bridge and very unattractive. Aluminum was thought to give the bridge an aircraft-like quality, but Morrow felt it would minimize the scale of the towers. Both *Battleship Grey* and *Warm Grey* were considered, with the latter a runner-up to *Vermillion Orange*. In the end, *International Orange* was chosen not only for its beauty, but also because it was highly visible (which made the Navy happy) and would require less frequent reapplication than the other color choices.

THE DUTCH BOY QUARTERLY

Practical and Technical Discussions of Paint Materials, Lead and Related Products

INDEX GUIDE

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VOLUME 15 1937 NUMBER 2

New Color Adds to Beauty of Golden Gate Bridge

FROM an architectural and an engineering standpoint there are any number of things about the new bridge spanning the Golden Gate at San Francisco which set it apart as an achievement of world-wide interest and importance. Two aspects of the project, however, stand out particularly above all others. One is the unprecedented size of the structure which gives it top ranking among the single-span bridges of the world. The other is its unusual color—a brilliant orange vermilion, similar in appearance to red-lead—which, contrasting sharply with the prevailing blues and grays of the water and sky, makes the bridge appear even larger than it is.

Among technical paint men, the color of the new structure is known as "international orange." It is the same color which was selected a year or so ago by the nations of the world as the standard for airway marking purposes. It is available in the Dutch Boy color in oil line as Basic Lead Chromate (International Airways Orange) and its use as an aid to safer air navigation was discussed at some length in the Dutch Boy Quarterly, Vol. 14, No. 3.

Although "international orange" thus serves primarily a special purpose, it is a handsome, practical and useful color in its own right. With the San Francisco structure as a precedent, it will undoubtedly find a broader application in future engineering undertakings. For on this bridge, as Irving F. Morrow, its architect, has pointed out, the primary consideration in the selection of color was an aesthetic one, and the fact that the color finally chosen matched the standard for airway marking was merely a happy coincidence.

According to Mr. Morrow, the decision to use "international orange" was reached after observing the towers under construction painted with pure red-lead as the priming coat. With reference to the selection, he writes in the March, 1937, issue of a

Courtesy of Standard Oil Co. of Calif.

"For a definite aesthetic reason, the color known as 'international airways orange' has been selected for the final coat of paint on San Francisco's huge Golden Gate Bridge. Incidental to its color, but also of great importance, is the fact that this paint is extremely durable under adverse exposure conditions. It is made of basic lead chromate and has a brilliant vermilion color remaining bright and free from fading for a long time."

Benjamino Benvenuto Bufano, Italian-American Sculptor

"The effect of International Orange is as highly pleasing as it is unusual in the realm of engineering"

Irving Morrow – Consulting Architect, Golden Gate Bridge

"I have been watching very closely the progress of the towers on the Golden Gate Bridge in its structural beauty, its engineering and architectural simplicity – and of course its color that moves and molds itself into the great beauty and contours of the hills – let me hope that the color will remain the red terra-cotta because it adds to the structural grace and because it adds to the great beauty and the colorful symphony of the hills – and it is because of this structural simplicity that carries to you my message of admiration."

Benjamino Benvenuto Bufano, Italian-American Sculptor
RE: comments to Irving Morrow


San Francisco

"No span of steel will tolerate neglect. But if service by generations who use it and sparred man-made hazards, such as war, it should have life without end."

Joseph Strauss – Chief Engineer, Golden Gate Bridge

A Never Ending Job

"The largest item in the maintenance budget is for painting of the structural steel. The past fiscal year, the sum of $112,431.84 was expended for painting of the Bridge structures…The exposure to salt-laden fog is more severe at the Golden Gate than any other bridge in the Bay Area. Not only is the fog extremely active in attacking the paint film but it also limits the hours when painting can be done. Over 30% of the working hours during the last fiscal year could not be utilized for outside painting because of weather conditions. The condition of the paint on the steelwork was so critical at the time of the bridge opening that an acceleration of the original painting program was necessary…On steel structures erected subsequently to the Golden Gate Bridge, steel surfaces have been treated with sandblasting or flame cleaning prior to erection. Failure to use either of these special treatments has added greatly to the cost of maintenance painting. The six months' delay in the construction of the Bridge also contributes to this additional cost since, at the time the bridge opened, the main towers, or over 40% of the tonnage had already a year's exposure…"

RE: excerpt from the GGB's 1938/39 Annual Report

"…Prior to the completion of the Bridge, contractors and the District found it necessary to expend over $130K for paint maintenance on the towers and main span. Immediately after the steel contractor completed his work in December 1937, the District organized a small crew of painters…the crew starts at the bases of the towers where the rust had attacked the rivet heads and surfaces. The steel was thoroughly cleaned and a hot application of coal tar paint made at these points. The majority of paint failures has been caused by mill scale. Rusting progresses under the loosened mill scale so that soon much of the surface is involved and it is necessary to remove most of the paint and thoroughly clean the metal surfaces…After the rust and scale have been removed by chipping hammers, a flame dehydration torch is passed over the metal. The flame effectively dries out the moisture between the plates and around rivet heads and also removes all remaining traces of scale leaving a warm, dry surface to receive the priming coat. This surface is thoroughly wire-brushed and immediately primed while still warm and dry."

RE: excerpt from the GGB's 1938/39 Annual Report

All bridges require on-going paint maintenance – it's the prime maintenance function on the GGB. Without its protective coat of paint, the bridge's steel would corrode rapidly in the salt-air environment of the Golden Gate Strait. The original paint-job included a lead-based primer and top-coat. Until 1968, the bridge was "spot-painted" as required. However, by then thirty-plus years of exposure demanded a more systematic and thorough approach to the advancing corrosion. By 1995, all the lead-based primer and top-coat was replaced with a zinc silicate primer and a vinyl topcoat. The topcoat was changed from vinyl (a *Volatile Organic Compound*) to an acrylic emulsion in 1990 to meet air quality requirements. Inspections assist greatly in identifying areas of the bridge where corrosion is a problem and there are always one or more major painting projects on-going at the GGB.

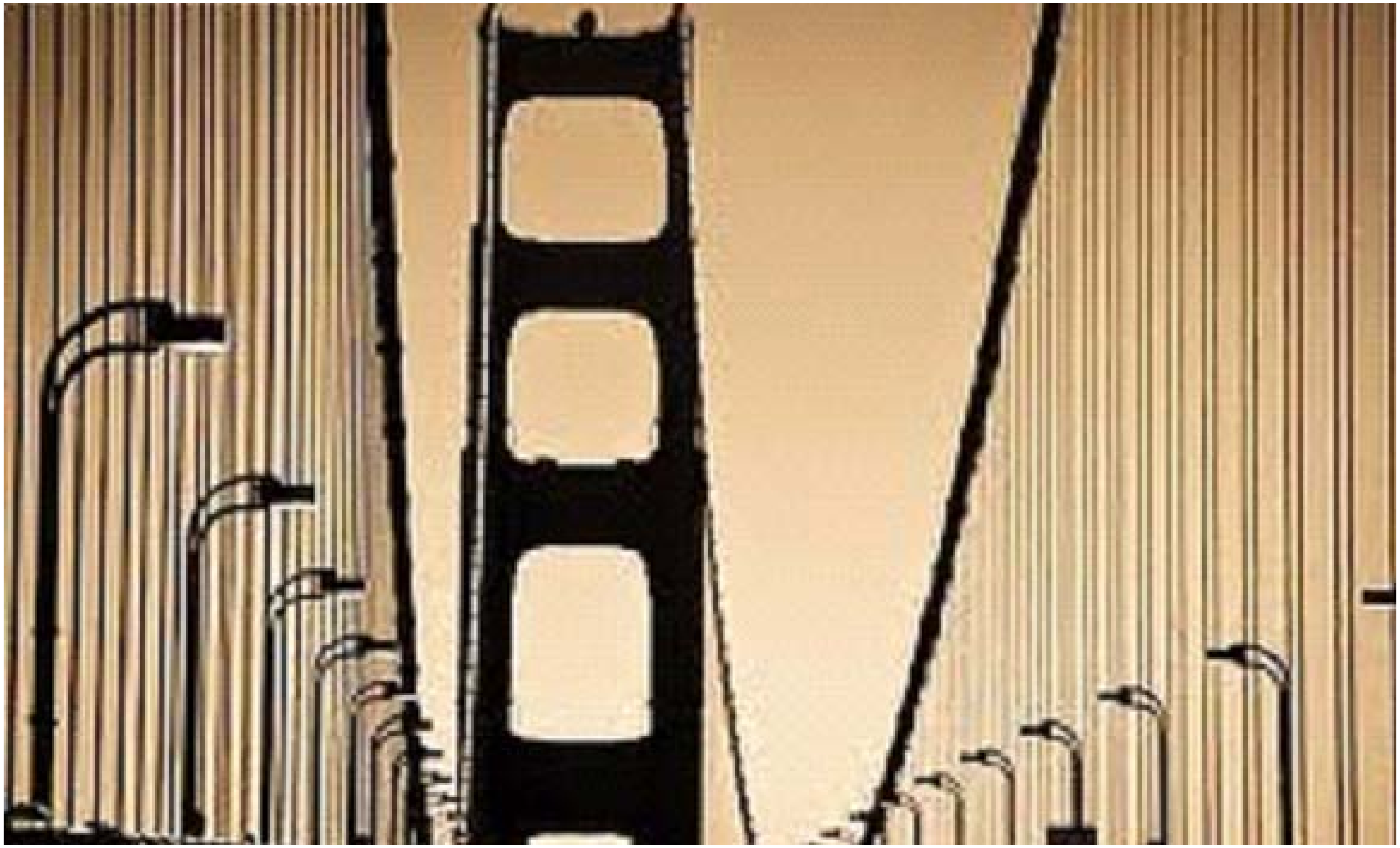
"Forever"

Joseph B. Strauss – Chief Engineer, GGB

RE: his reply when asked, in 1932, how long the bridge would last

Morrow was also involved in the design of the railings, pedestrian walkways and lighting fixtures, giving them a modernistic look with an art-deco flourish. For the lighting, he took into consideration two important factors; the shear size of the project and the dignity of its scale. As such, he varied the intensity of the lighting on its parts (i.e. towers). A subdued yet dignified effect was called for, not searchlight-like lighting that would diminish the great structure's proportions. Morrow chose low-pressure sodium vapor lamps to light the roadway. In 1982, they were replaced with high-pressure sodium vapor lamps with amber lens' (to maintain the original warm glow). Though Morrow planned to light the towers at night (with a reduction of intensity toward the top), funds were not available at the time of construction and not until the bridge's 50th Anniversary (in 1987) were the towers lit at night per Morrow's original scheme. PG&E provided most of the $1.2 million required.

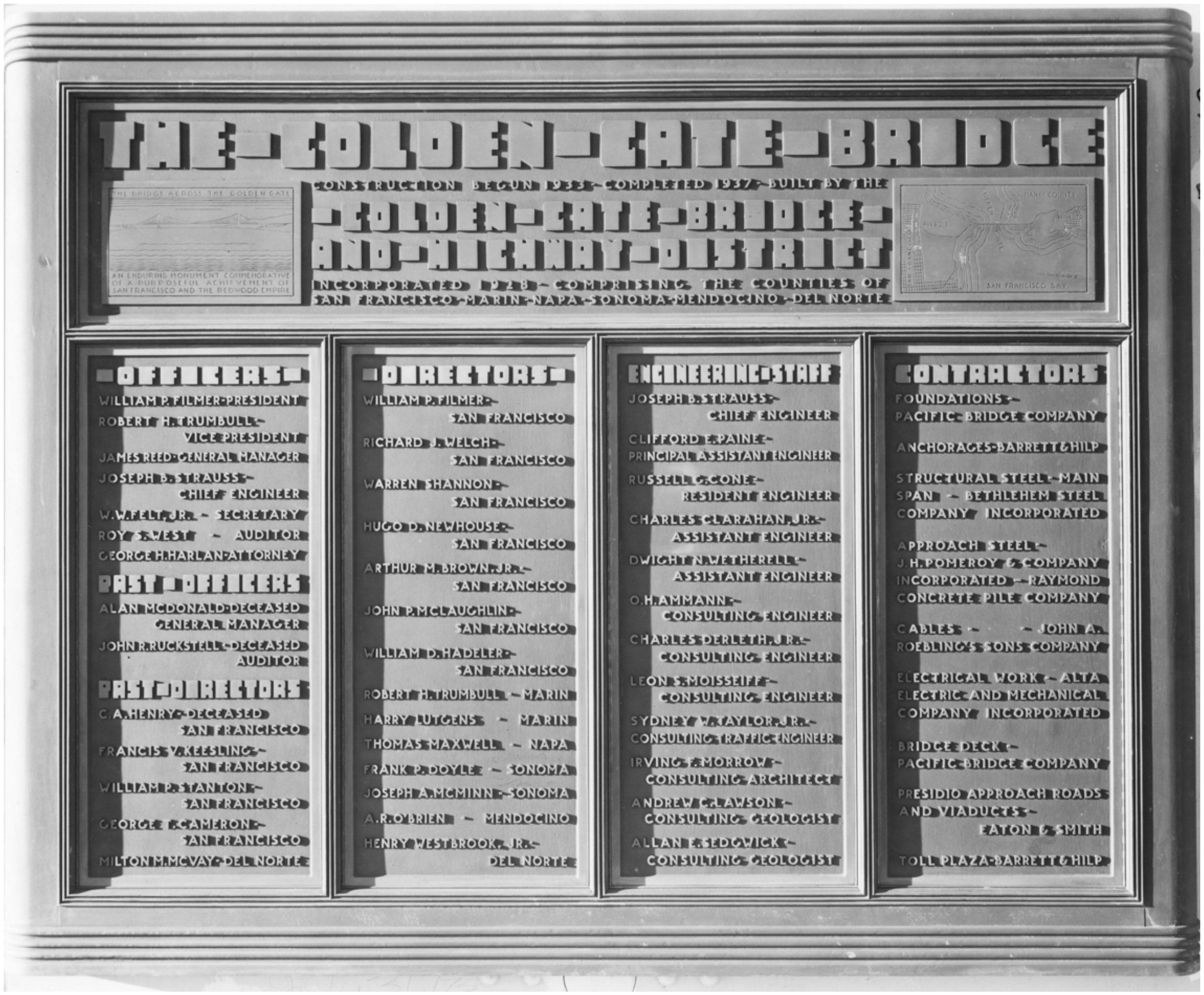
ca. 1937



Post-1982

Aside from *Charles Ellis* (who served as Design Engineer from 1922 to 1931), a dedication plaque on the San Francisco tower includes the following members of Strauss' Golden Gate Bridge team:

- ***Clifford Paine* (VP *Strauss Engineering Corp*.) - Served as Principal Assistant Engineer during final design and construction**
- ***Russell G. Cone* - Resident Engineer during construction**
- ***Charles Clarahan, Jr*. and *Dwight N. Wetherell* – Assistant Engineers**
- ***O.H. Ammann, Prof. Charles Derleth, Jr*. and *Leon S. Moisieff* – Served on Advisory Board of Engineers**
- ***Sydney W. Taylor, Jr*. – Consulting Traffic Engineer**
- ***Irving F. Morrow* (*Morrow & Morrow Architects*) – Consulting Architect**
- ***Andrew C. Lawson* and *Allan E. Sedgwick* – Consulting Geologists**


THE GOLDEN GATE BRIDGE
CONSTRUCTION BEGUN 1933 - COMPLETED 1937 - BUILT BY THE
GOLDEN GATE BRIDGE AND HIGHWAY DISTRICT
INCORPORATED 1928 - COMPRISING THE COUNTIES OF
SAN FRANCISCO - MARIN - NAPA - SONOMA - MENDOCINO - DEL NORTE
THE BRIDGE ACROSS THE GOLDEN GATE
AN ENDURING MONUMENT COMMEMORATIVE OF A PURPOSEFUL ACHIEVEMENT OF SAN FRANCISCO AND THE REDWOOD EMPIRE
SAN FRANCISCO BAY
OFFICERS
WILLIAM P. FILMER - PRESIDENT
ROBERT H. TRUMBULL - VICE PRESIDENT
JAMES REED - GENERAL MANAGER
JOSEPH B. STRAUSS - CHIEF ENGINEER
W. W. FELT, JR. - SECRETARY
ROY S. WEST - AUDITOR
GEORGE H. HARLAN - ATTORNEY
PAST OFFICERS
ALAN MCDONALD - DECEASED GENERAL MANAGER
JOHN R. RUCKSTELL - DECEASED AUDITOR
PAST DIRECTORS
C. A. HENRY - DECEASED SAN FRANCISCO
FRANCIS V. KEESLING - SAN FRANCISCO
WILLIAM P. STANTON - SAN FRANCISCO
GEORGE T. CAMERON - SAN FRANCISCO
MILTON M. MCVAY - DEL NORTE
DIRECTORS
WILLIAM P. FILMER - SAN FRANCISCO
RICHARD J. WELCH - SAN FRANCISCO
WARREN SHANNON - SAN FRANCISCO
HUGO D. NEWHOUSE - SAN FRANCISCO
ARTHUR M. BROWN, JR. - SAN FRANCISCO
JOHN P. MCLAUGHLIN - SAN FRANCISCO
WILLIAM D. HADELER - SAN FRANCISCO
ROBERT H. TRUMBULL - MARIN
HARRY LUTGENS - MARIN
THOMAS MAXWELL - NAPA
FRANK P. DOYLE - SONOMA
JOSEPH A. MCMINN - SONOMA
A. R. O'BRIEN - MENDOCINO
HENRY WESTBROOK, JR. - DEL NORTE
ENGINEERING STAFF
JOSEPH B. STRAUSS - CHIEF ENGINEER
CLIFFORD E. PAINE - PRINCIPAL ASSISTANT ENGINEER
RUSSELL G. CONE - RESIDENT ENGINEER
CHARLES CLARAHAN, JR. - ASSISTANT ENGINEER
DWIGHT N. WETHERELL - ASSISTANT ENGINEER
O. H. AMMANN - CONSULTING ENGINEER
CHARLES DERLETH, JR. - CONSULTING ENGINEER
LEON S. MOISSEIFF - CONSULTING ENGINEER
SYDNEY W. TAYLOR, JR. - CONSULTING TRAFFIC ENGINEER
IRVING F. MORROW - CONSULTING ARCHITECT
ANDREW C. LAWSON - CONSULTING GEOLOGIST
ALLAN E. SEDGWICK - CONSULTING GEOLOGIST
CONTRACTORS
FOUNDATIONS - PACIFIC BRIDGE COMPANY
ANCHORAGES - BARRETT & HILP
STRUCTURAL STEEL - MAIN SPAN - BETHLEHEM STEEL COMPANY INCORPORATED
APPROACH STEEL - J. H. POMEROY & COMPANY INCORPORATED - RAYMOND CONCRETE PILE COMPANY
CABLES - JOHN A. ROEBLING'S SONS COMPANY
ELECTRICAL WORK - ALTA ELECTRIC AND MECHANICAL COMPANY INCORPORATED
BRIDGE DECK - PACIFIC BRIDGE COMPANY
PRESIDIO APPROACH ROADS AND VIADUCTS - EATON & SMITH
TOLL PLAZA - BARRETT & HILP

The Engineering Staff

JOSEPH B. STRAUSS
Chief Engineer

CLIFFORD E. PAINE
Principal Assistant Engineer

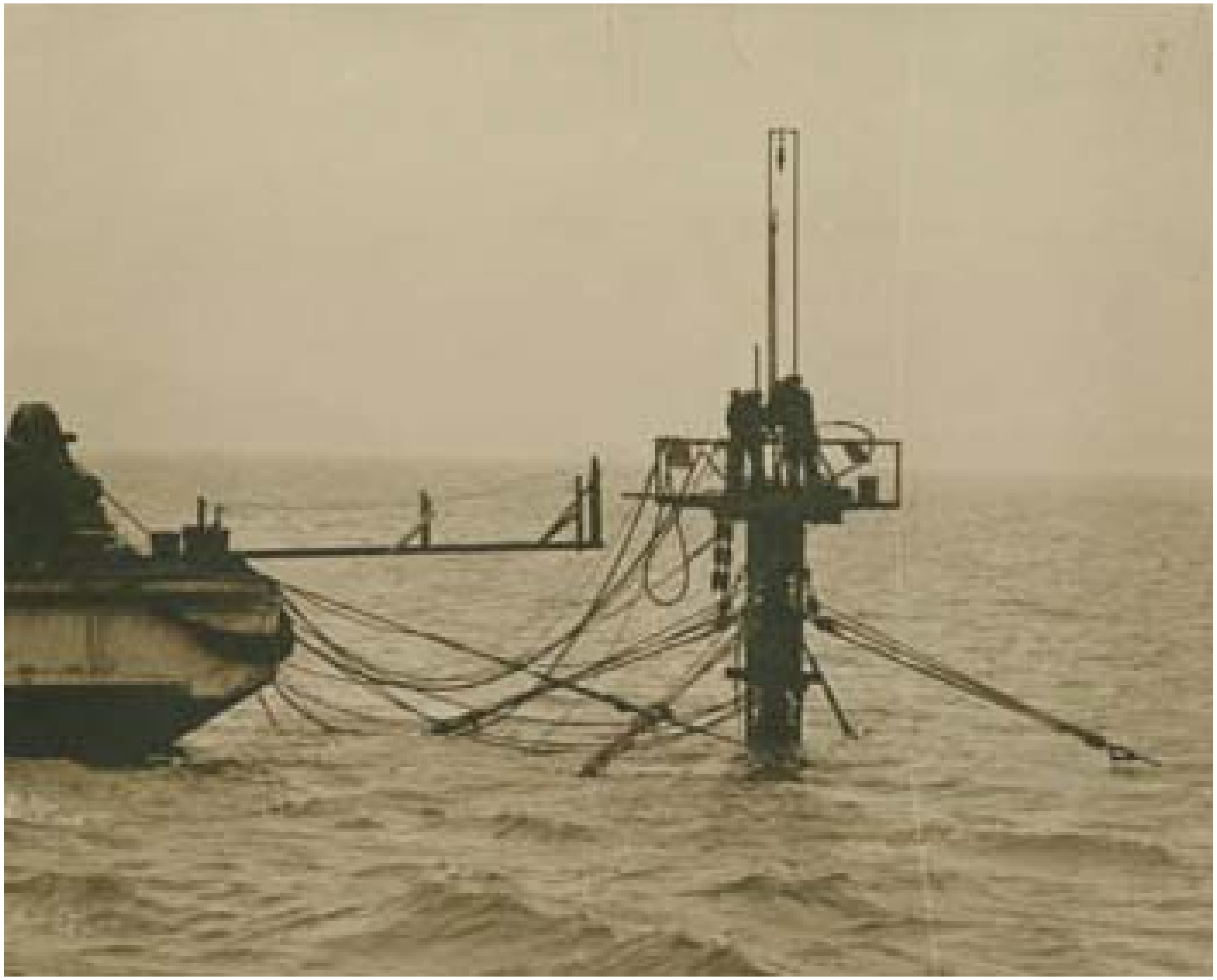
RUSSELL CONE
Resident Engineer

Below, center—O. H. Ammann, New York, consulting engineer; Prof. Charles Derleth, Jr., Berkeley, consulting engineer; Andrew C. Lawson, Berkeley, consulting geologist; Leon S. Moisseiff, New York, consulting engineer.

Part 5

Breaking Ground

In February 1930, Strauss submitted a formal report to the District's Board of Directors outlining all changes, including the decision to use a pure suspension configuration. Starting in March 1930, Ellis oversaw the test borings and, upon returning to Chicago, he worked for four months strait, typically fourteen-hours per day, on the preliminary design and cost estimate. He was communicating with Moissieff by telegram during this time and in June, Moissief, Ammann and Professor Derleth (the Advisory Consultants) reviewed Ellis' work. In August, the War Department issued a final construction permit for a suspension bridge with a 4,200-foot main span and vertical clearances of 220-feet and 210-feet at mid-span and side-span/s respectively. Also, in late August (two months behind schedule) Strauss submited a 285-page comprehensive final plan to the Board of Directors. After the victory of the bond issue in the November 1930 election, Strauss had instructed Ellis to begin the very detailed calculations for the bridge's various components. By November of 1931, Ellis was still not complete on the calculations and Strauss summarily relieved him of his duties in December.



Test Borings
(for the South Pier)

Fort Point

Fort Scott (left), site of San Francisco Anchorage (right)


PIOMBO BROS
GRADING
NORTHWEST

In November 1932, the *Golden Gate Bridge and Highway District* awarded contracts totaling $23,843,905.00. Final construction cost for the bridge structure would be $27,125,000.00, but this included several supplemental costs;

- **Toll Plaza - $450K**
- **Toll Collection Equipment - $72K**
- **Tower Elevators - $60K**
- **Misc. Equipment - $45K**
- **Military Replacements and Improvements - $575K**

The final *total cost* of the bridge would be in-line with the amount of the bond issue ($35 million). It broke down as follows;

- **Bridge Structure - $27,125,000.00**
- **Engineering and Inspection - $2,050,000.00**
- **Administrative and Preliminary Expenses - $423K**
- **Financing - $4,068,000.00**
- **Surplus - $1,334,000.00**

Contract bids for the bridge structure were solicited and received by mid-October 1932. Eleven leading bridge engineering firms tendered proposals. Contracts totaling $23,843,905.00 broke down as follows;

- **<u>Contract I-A</u>: Steel Superstructure (structural steel of suspension span and towers). Awarded to *McClintic-Marshall Corp*. (a subsidiary of *Bethlehem Steel Corp*.) in the amount of $10,494,000.00.**
- **<u>Contract I-B</u>: Steel Cables, Suspenders & Accessories (main cables). Awarded to *John A. Roebling's Sons* in the amount of $5,855,000.00.**
- **<u>Contract II</u>: San Francisco Tower Pier and Fender, Marin Tower Pier. Awarded to *Pacific Bridge Company* in the amount of $2,935,000.00.**
- **<u>Contract III</u>: Anchorages and Piers of Approach Spans. Awarded to *Barrett & Hilp* in the amount of $1,859,855.00.**
- **<u>Contract IV</u>: Steel Superstructure for San Francisco and Marin Approaches. Awarded to *J.H. Pomeroy & Co*. and *Raymond Concrete Pile Co*. in the amount of $934,800.00.**
- **<u>Contract V</u>: Presidio Approach Road (a.k.a. Doyle Drive). Awarded to *Eaton & Smith Construction Co*. in the amount of $996,000.00.**
- **<u>Contract VII</u>: Pavement for Main Spans and Approaches. Awarded to *Pacific Bridge Co*. and *Barrett & Hilp* in the amount of $555K.**
- **<u>Contract VIII</u>: Electrical Work. Awarded to *Alta Electrical & Mechanical Co*. in the amount of $154,470.00.**

Contract VI was for the *Sausalito Approach Road* (a.k.a. *Sausalito Lateral*), but it was not awarded ($59,780.00) as part of the initial contract letting. Known today as *Alexander Avenue*, it would be built in 1936 by the *Works Progress Administration* (WPA). As a WPA project, it has the distinction of being the only part of the bridge paid for with public (federal) funds.

To San Rafael
Sausalito/ Marin City Exit
Harbor Rd.
Molly Stones
Marin Ship Way
Schoonmaker Marina
85 Liberty Ship Way
P
Beach
Turn at 7/11 Store Traffic lights
Bridgeway
Sausalito
Waldo Tunnel
Downtown Sausalito
N
W
E
S
101
Alexander Ave. Exit
San Francisco Bay
Golden Gate Bridge
To San Francisco

Construction of the *Golden Gate Bridge* officially began on January 5th 1933 when workers began to excavate and remove 3.25 million cubic-feet of dirt and debris for the bridge's two anchorages. The official ground breaking ceremony took place on February 26th 1933 at nearby *Crissy Field* (now part of the *Golden Gate National Recreation Area*). The festivities went on for hours with approximately 100K people in attendance. A parade was held in the *Marina District*, Navy planes flew in formation overhead and engineering students carried an 80-foot long replica of the bridge-to-be. President Hoover sent a congratulatory telegram, Mayor Rossi, Governor Rolph and District Board President Filmer made speeches and Major General Craig turned over to Rossi and Filmer the right-of-way grants, then the golden spade was used for "the turning of the sod" ceremony. The Golden Gate Bridge was no longer a dream in the minds of men, it was now becoming a reality in steel and concrete via the determination, skill, daring and raw courage of the thousands of men who would build it.

"Two hundred and fifty carrier pigeons, Provided by the San Francisco Racing Pigeon Club to carry the message of groundbreaking to every corner of California, were so frightened by the surging human mass that small boys had to crawl into their compartments in the bridge replica to shoo them out with sticks."

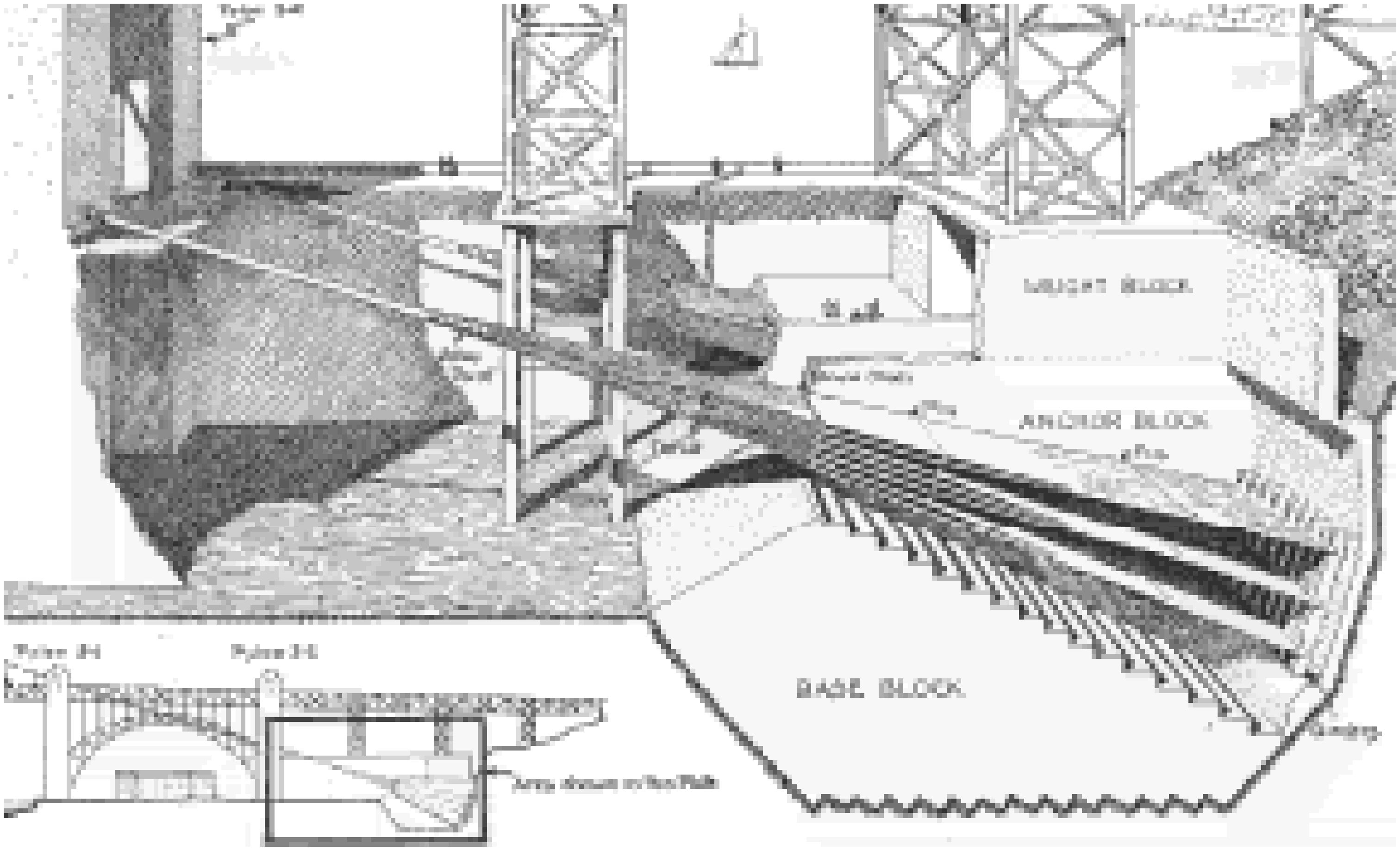
San Francisco Chronicle

Contract III

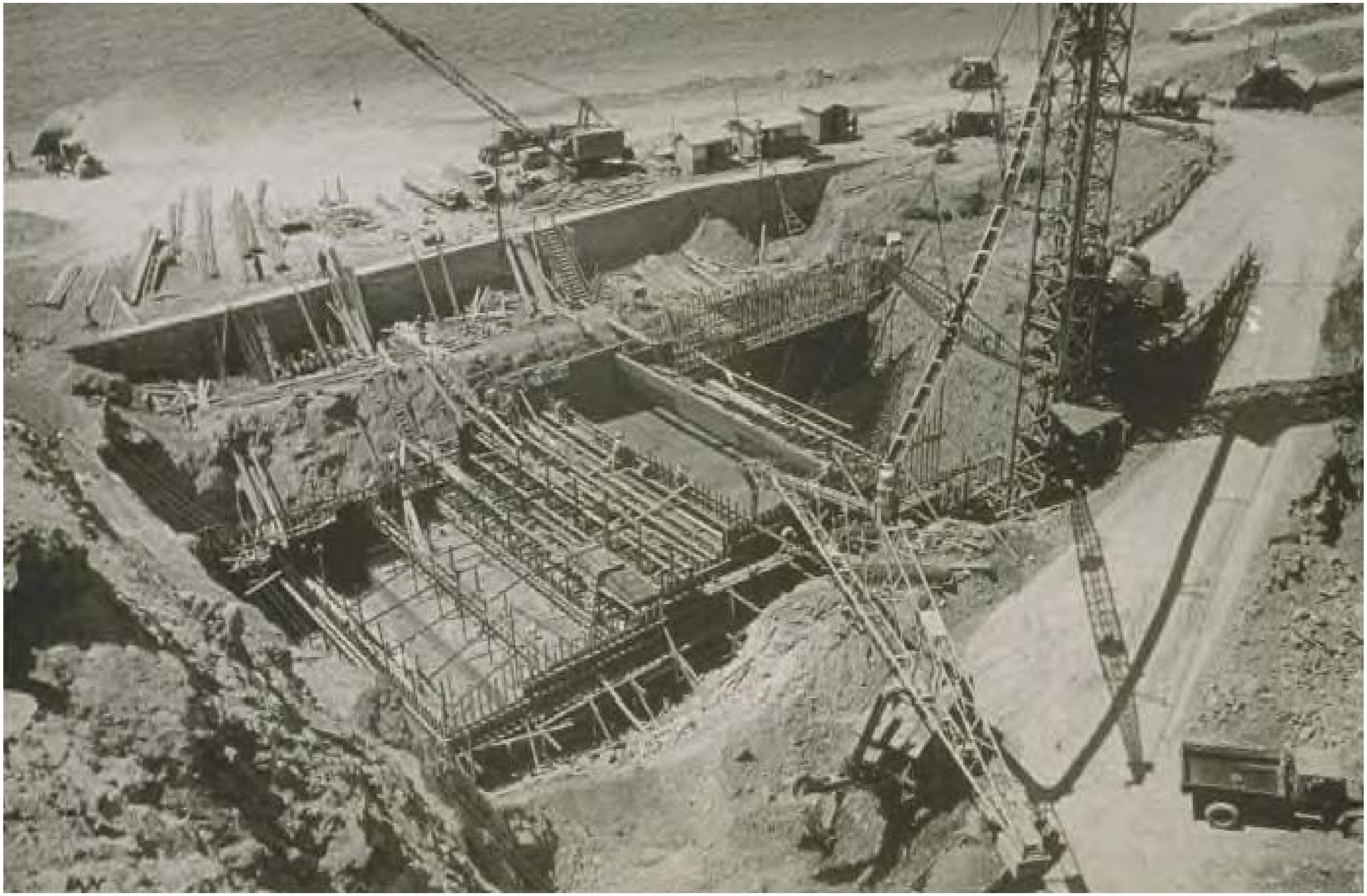
Anchorages & Approach Piers

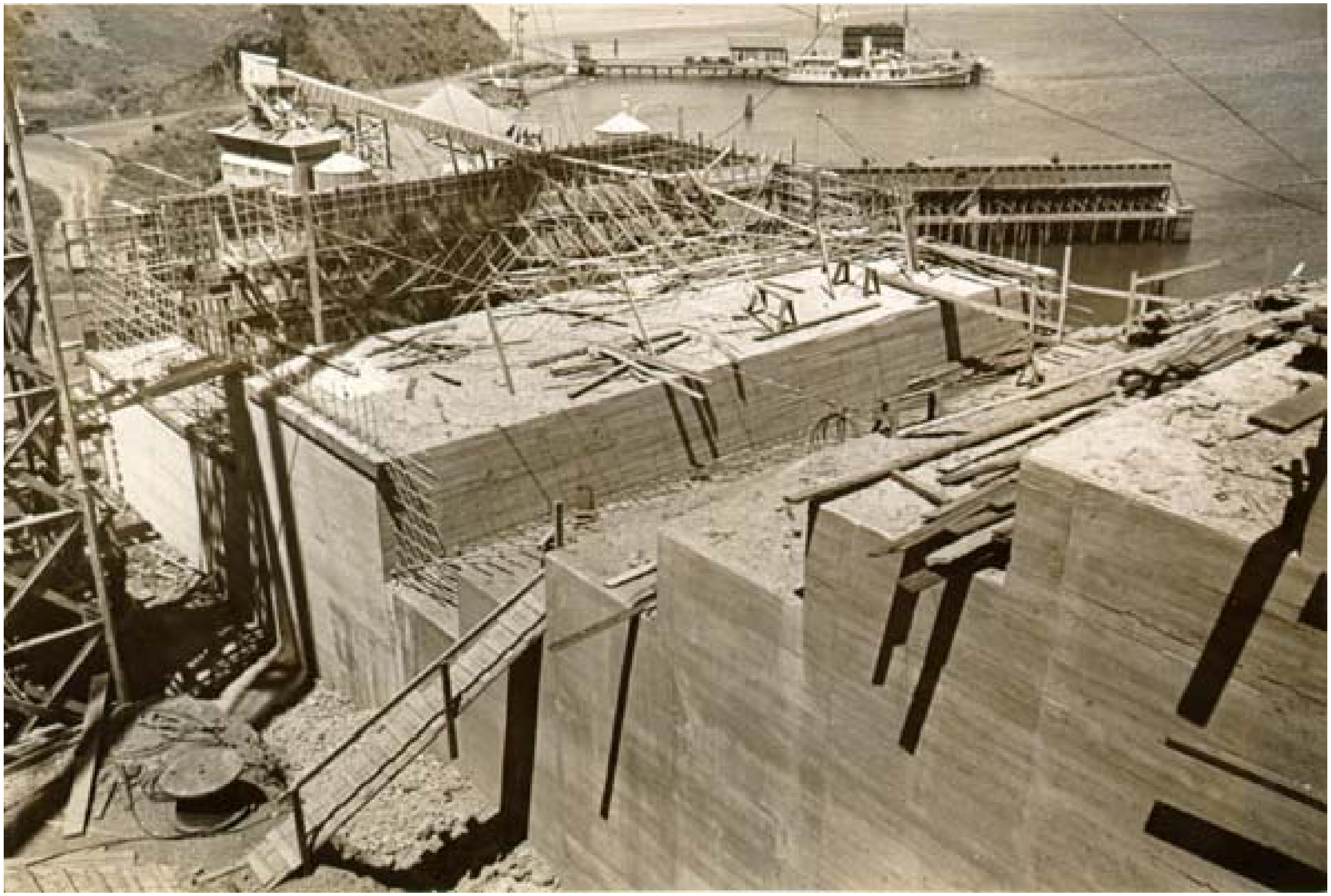
San Francisco Anchorage

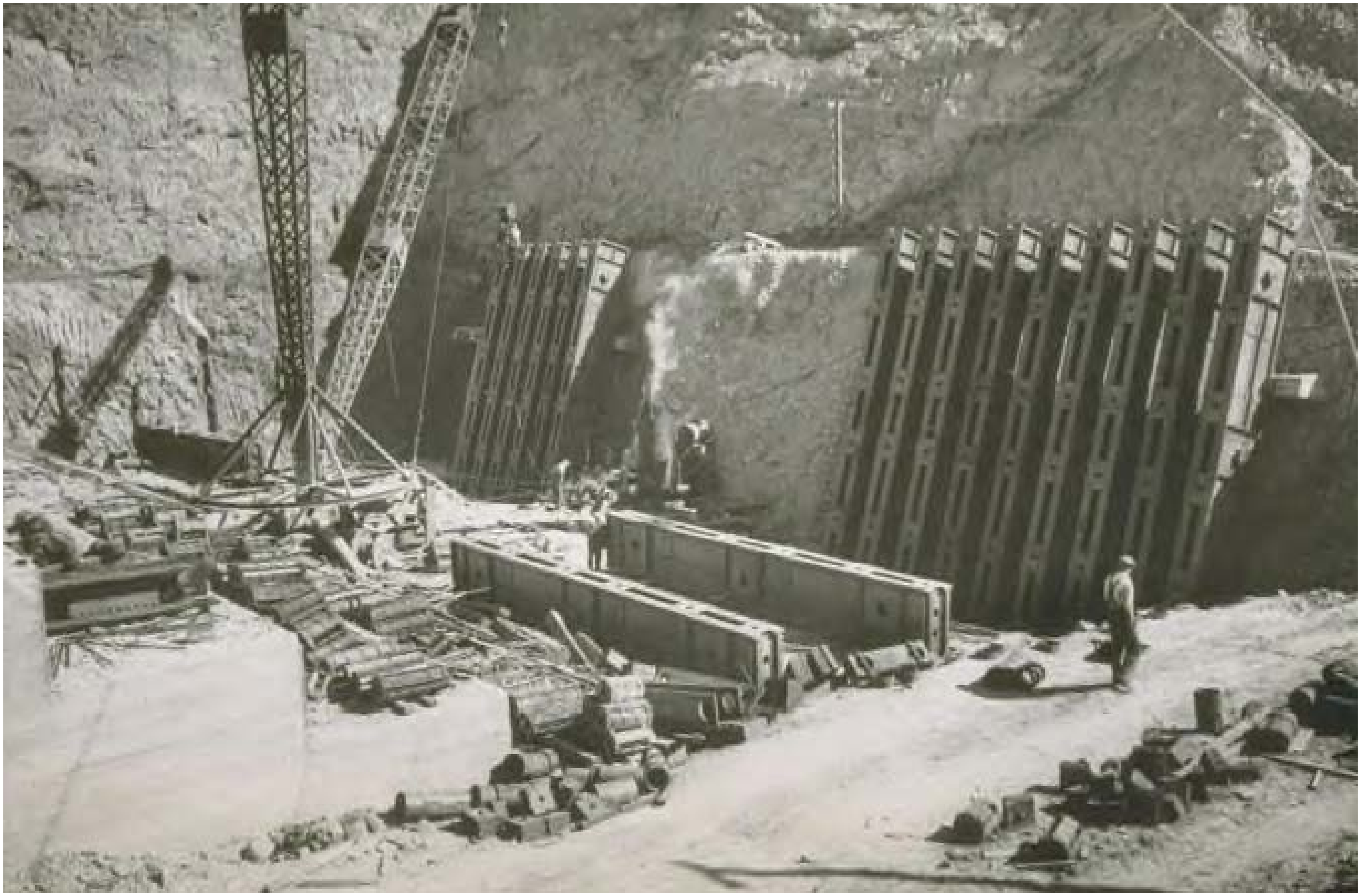
The San Francisco anchorage began construction in January 1933 and was completed in May of 1935. It occupied all of Fort Point and was inherently more complex than the Marin anchorage since in included construction of the reinforced concrete piers/pylons (between the steel arch vaulting over Fort Scott) which the cables had to pass through on their way to the anchorage. The embedded eye-bars at the rear of the anchorage would restrain the tremendous "pull" of the cables allowing the tension in the cables to be converted to compression in the towers. The embedded eye-bars allowed the force of the cable's pull to be spread out (akin to a tree's roots). Each individual strand of the cable was attached to an individual eye-bar. Including the Marin anchorage, 182K cubic-yards of concrete were used to create the anchorages and pylons.

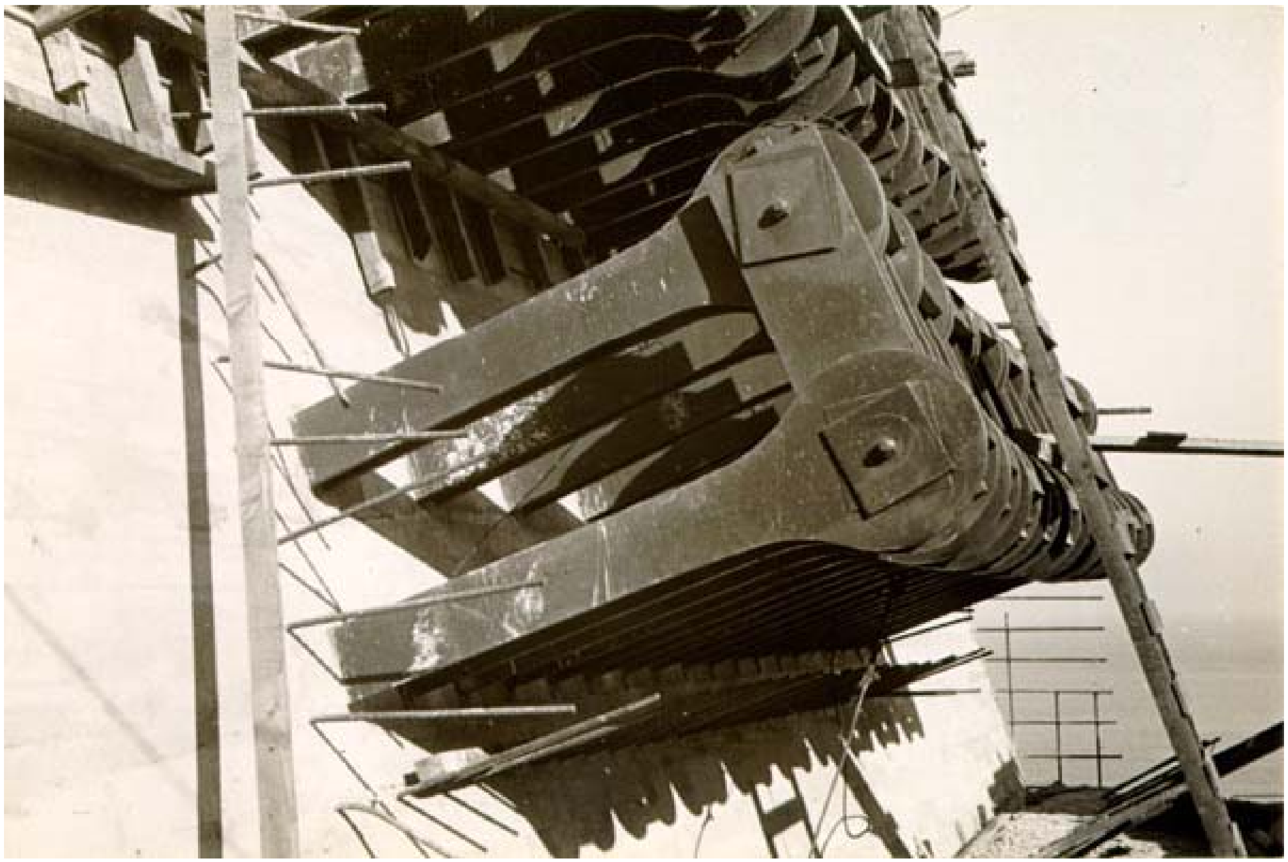

WEIGHT BLOCK
ANCHOR BLOCK
BASE BLOCK

Prior to the pouring of concrete for the southern anchorage, Strauss – an 1892 graduate of the *University of Cincinnati*, placed a brick from the façade of his alma mater's demolished *McMicken Hall*.

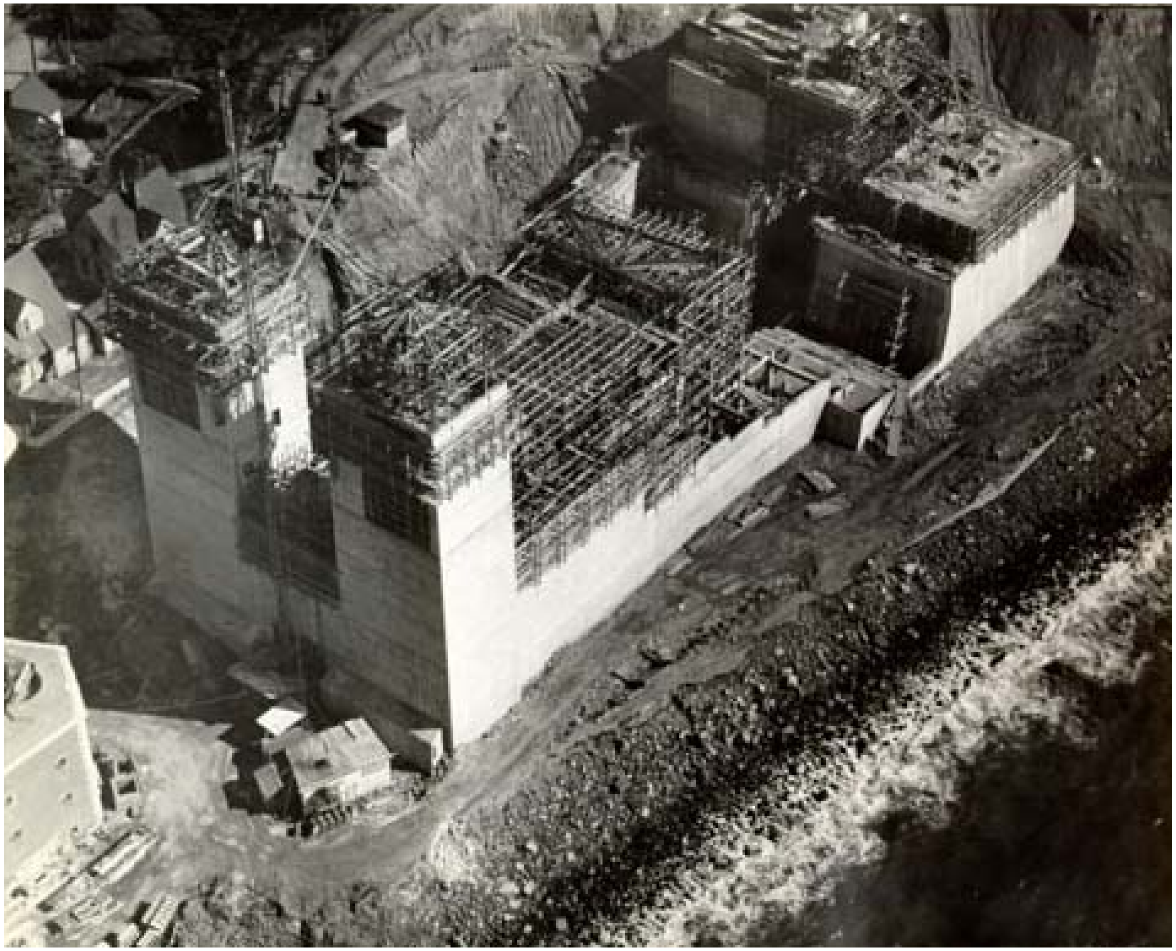


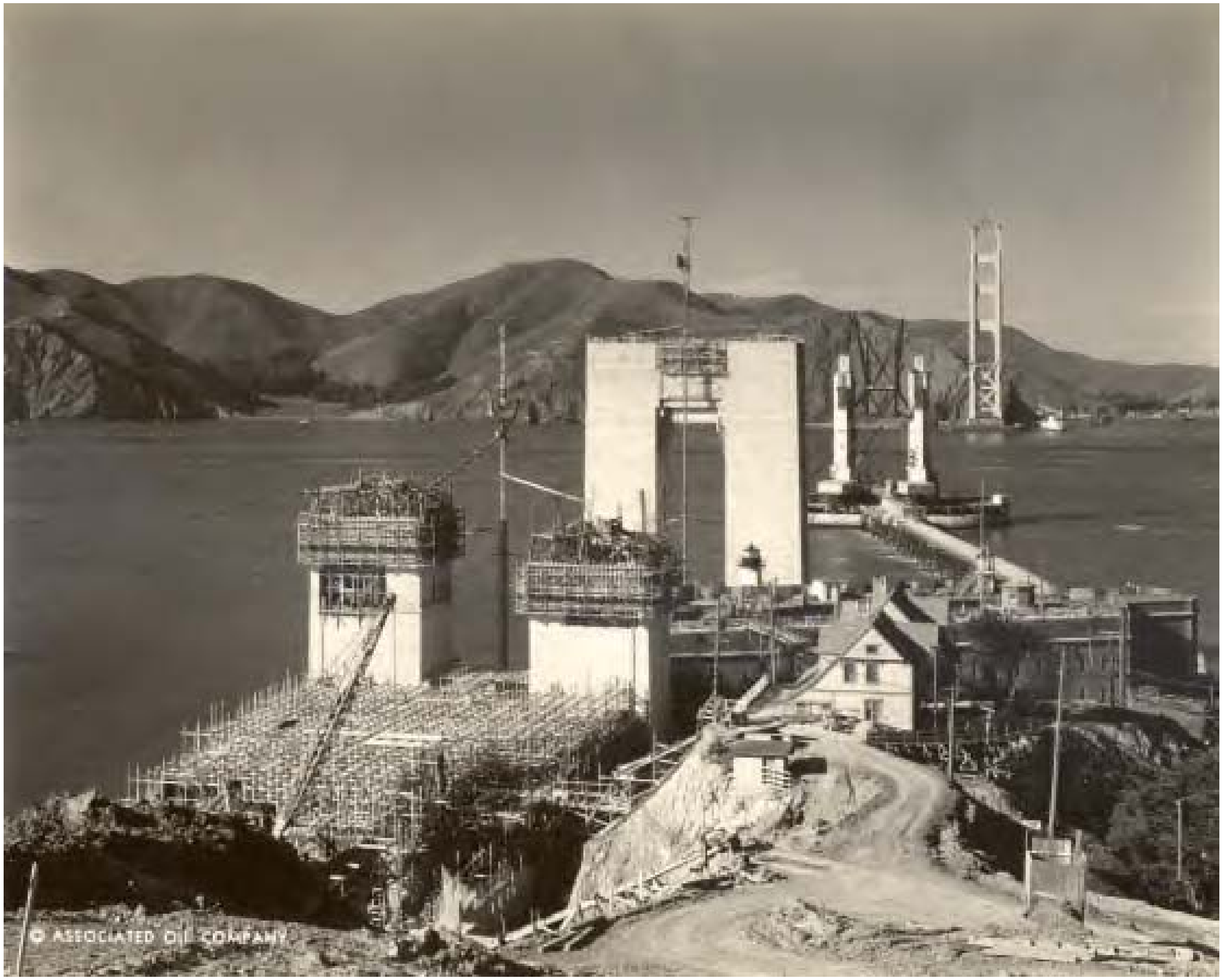


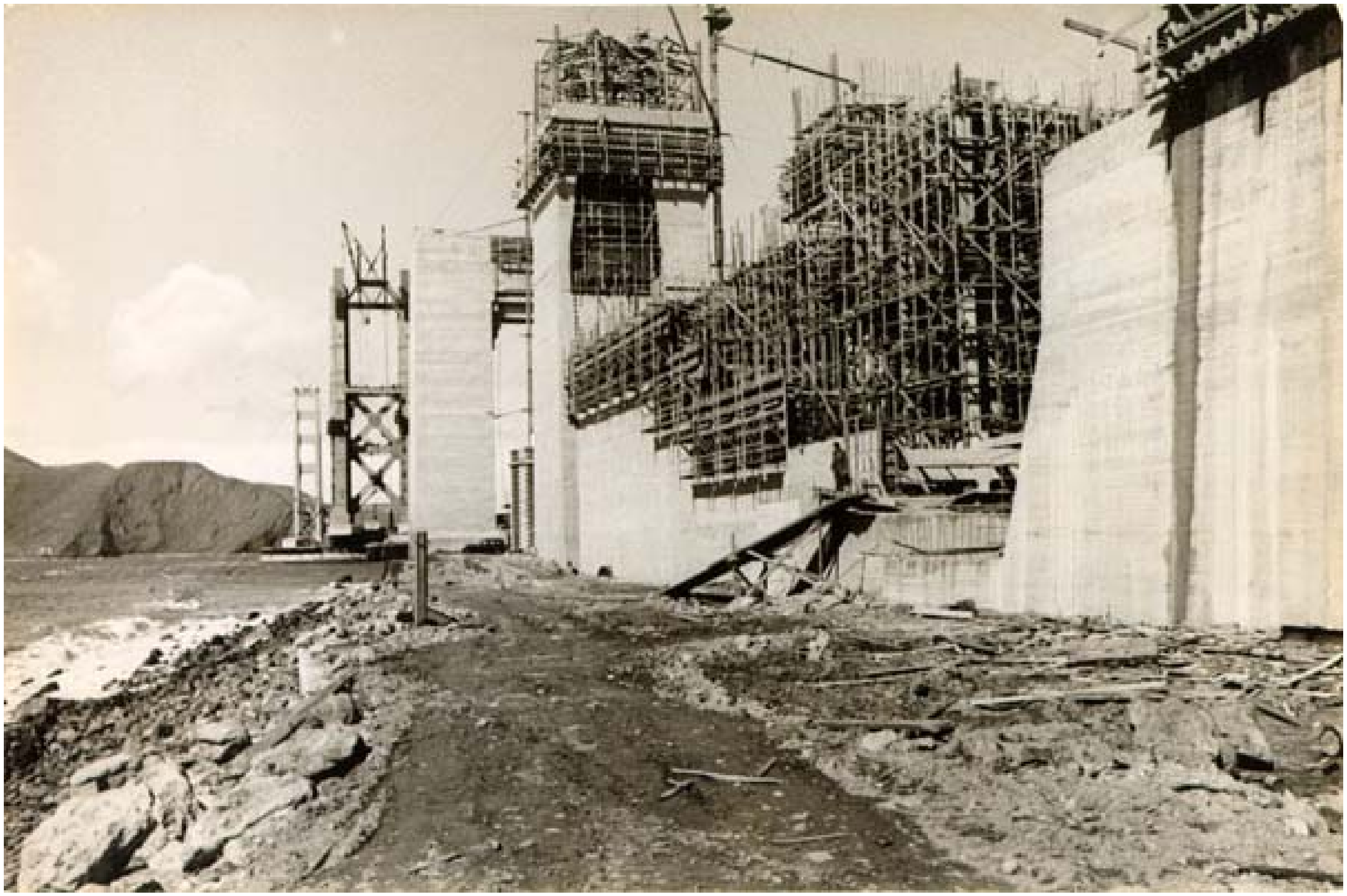


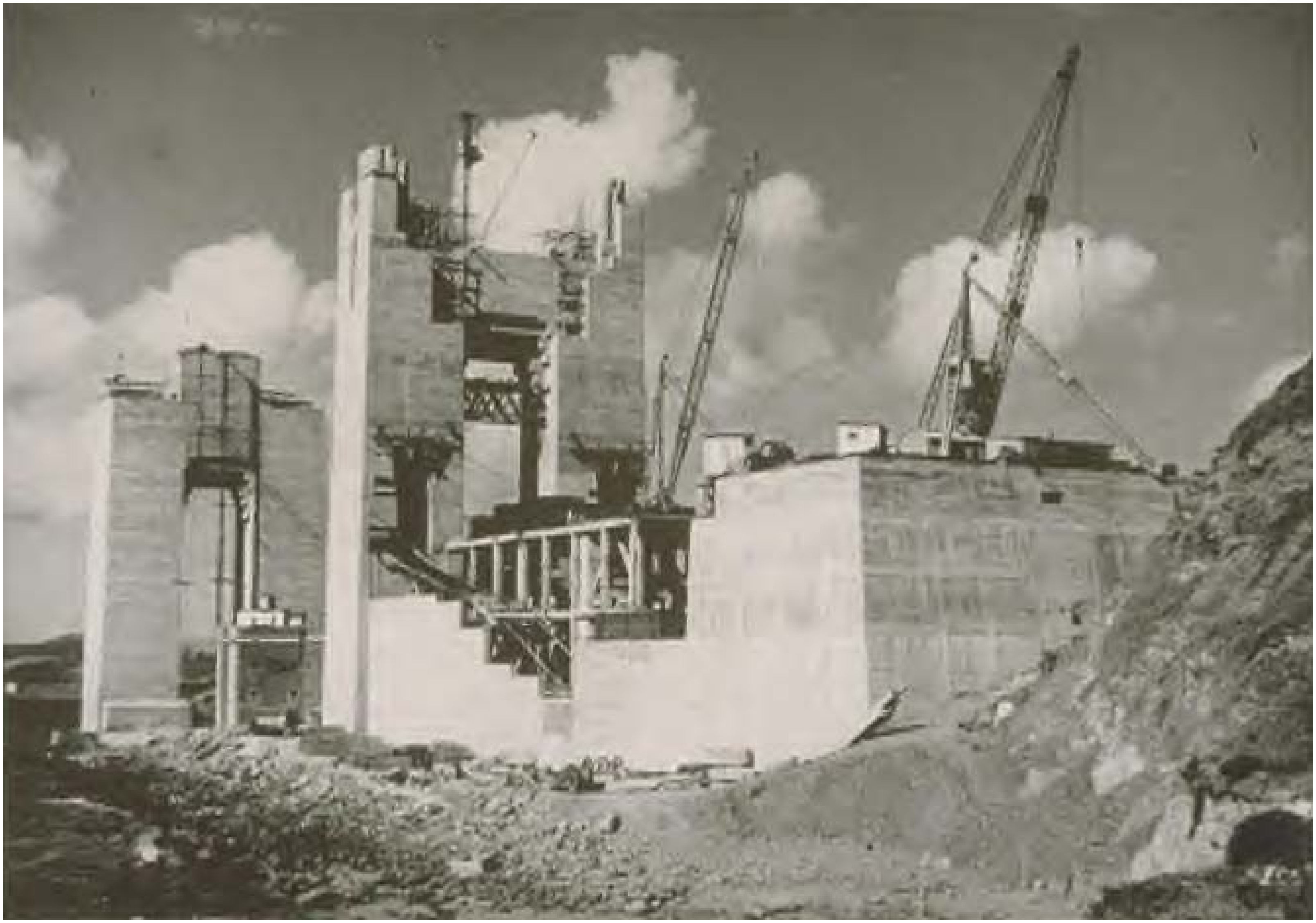


San Francisco Approach Piers/Pylons

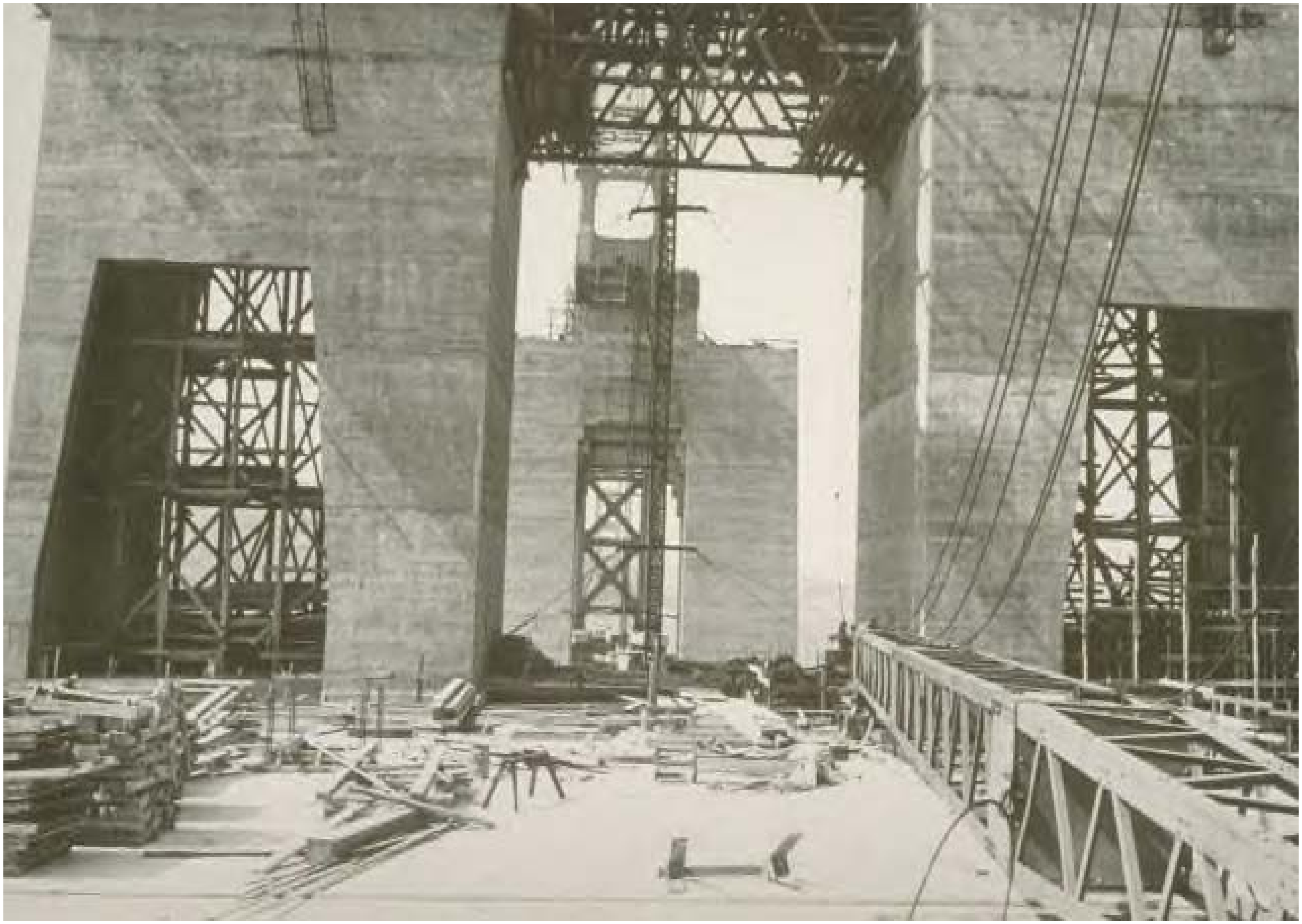



© ASSOCIATED OIL COMPANY



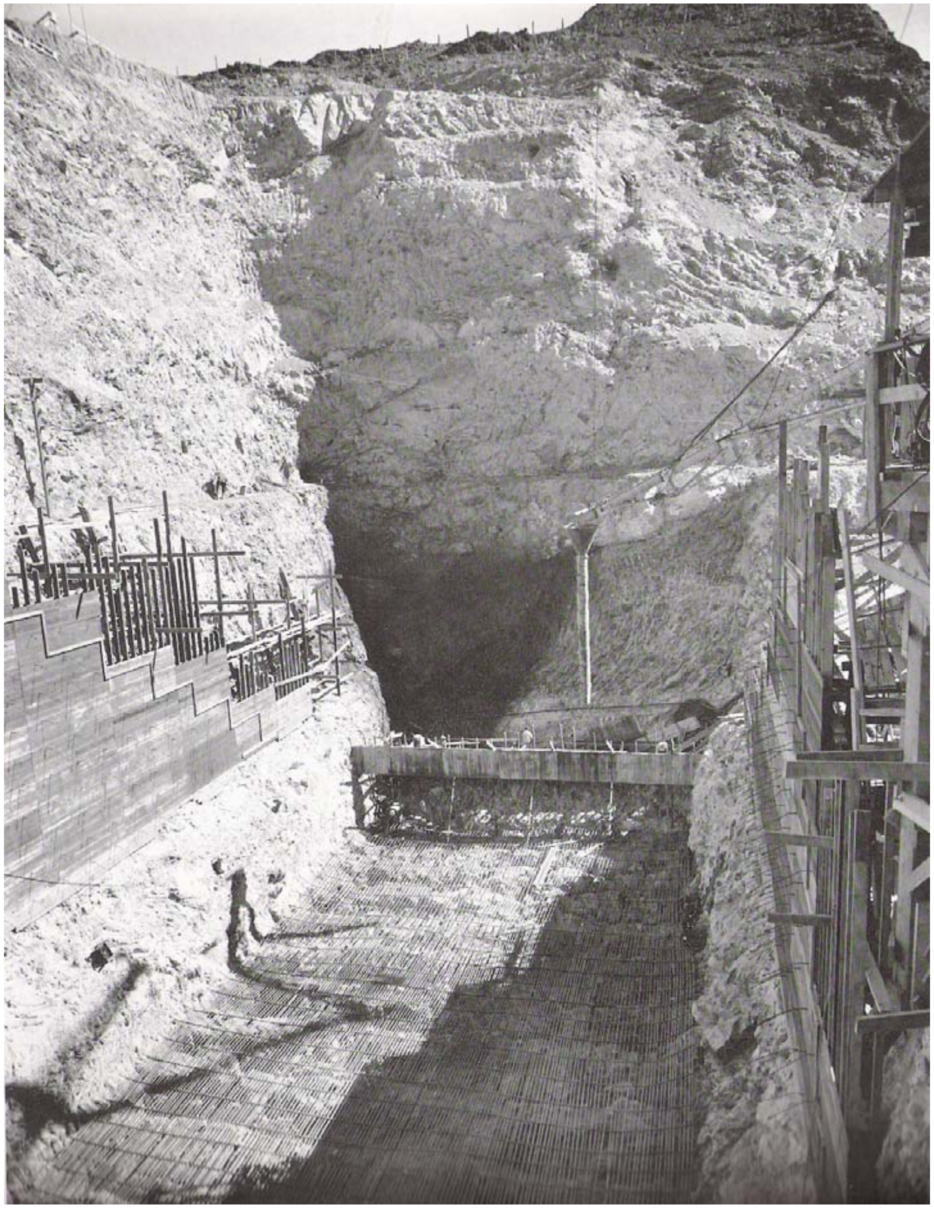


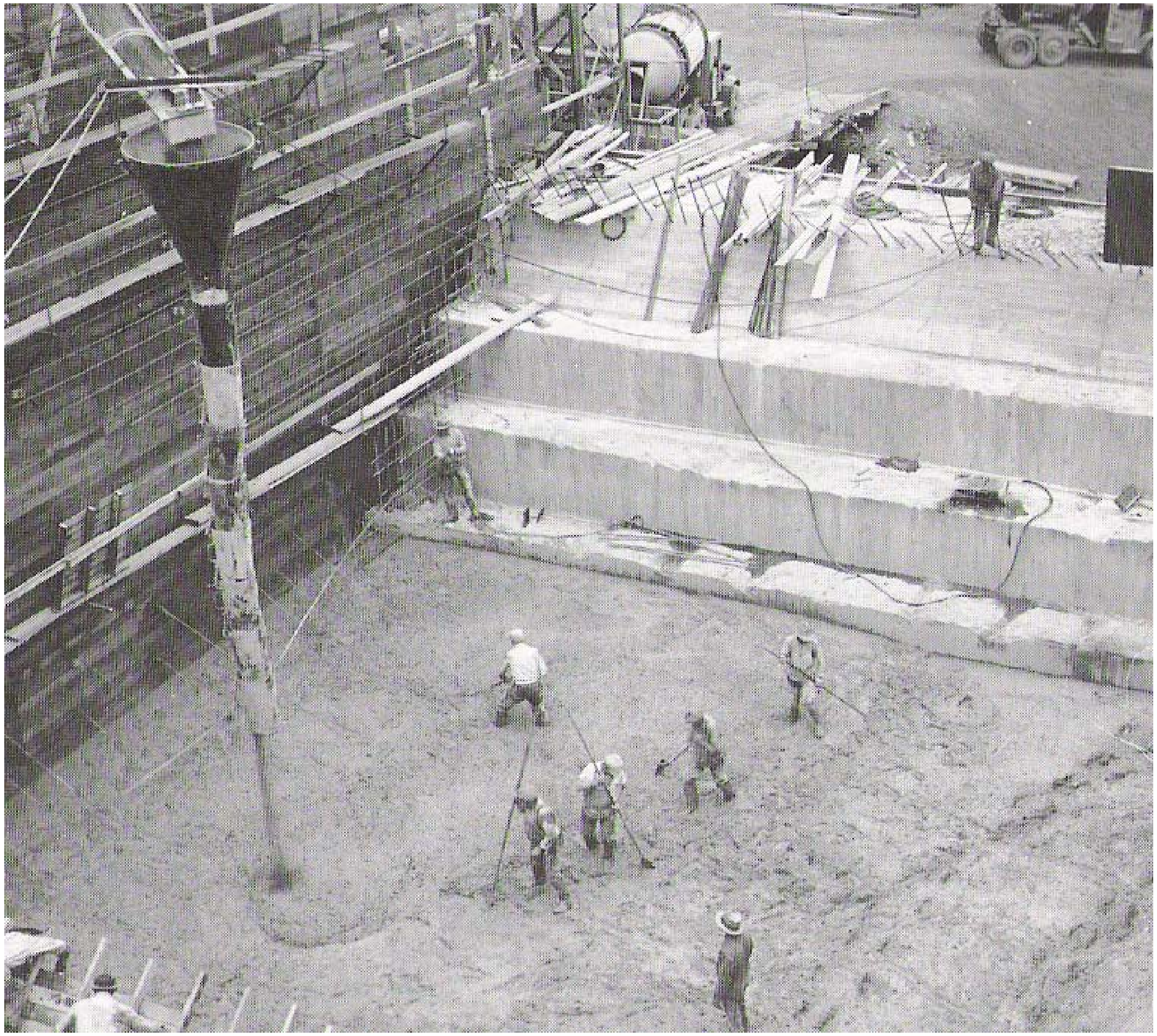
President Roosevelt chose this 1934 painting of the Golden Gate Bridge under construction to hang in the White House as a fitting tribute to "The Triumph of American Engineering." Looking north, artist *Ray Strong* depicted Fort Point in the foreground (with Fort Scott and the approach pylons under construction) and the Marin hills and tower (rising) in the distance. The painting now resides at the *Smithsonian American Art Museum*.

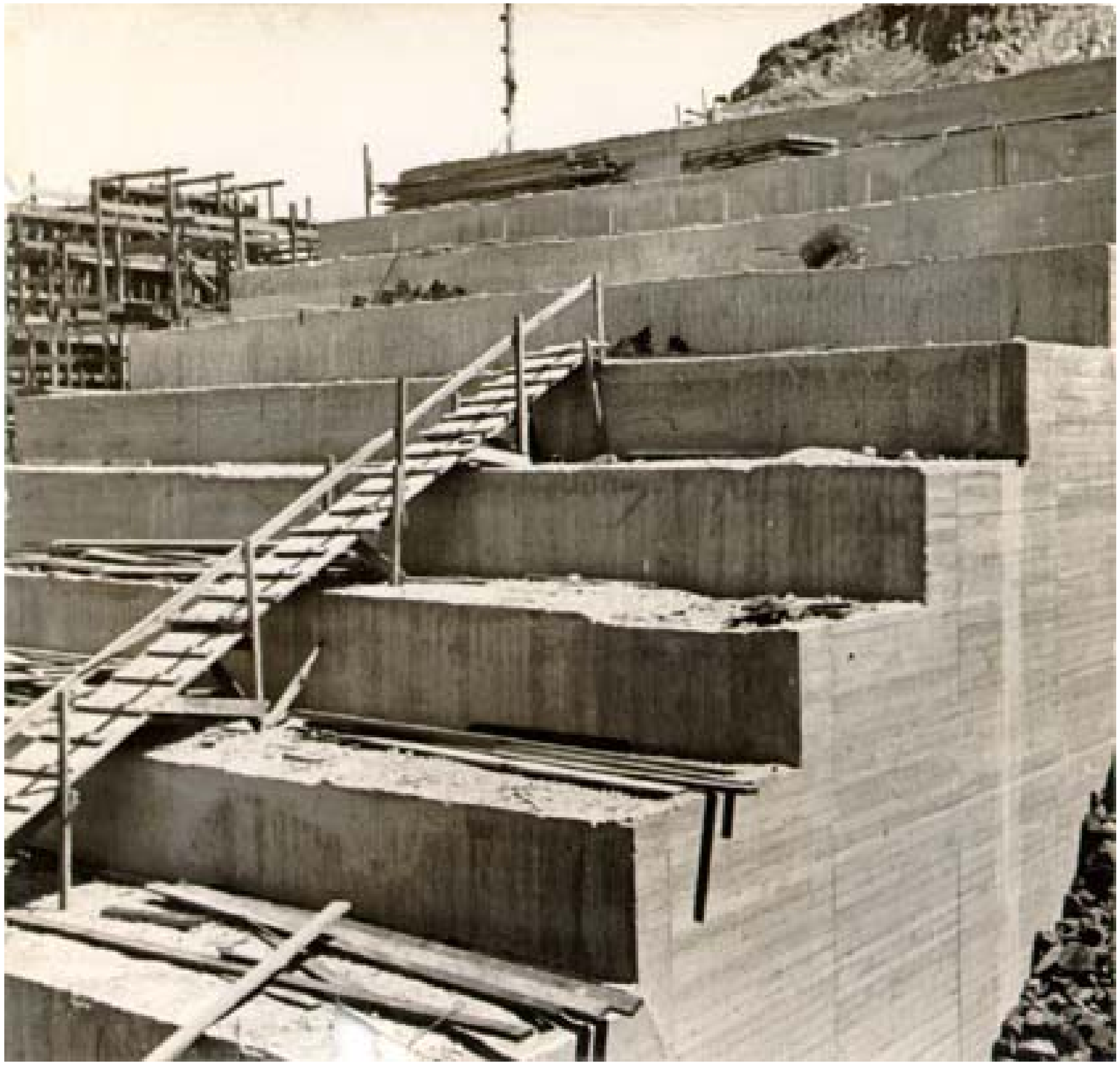


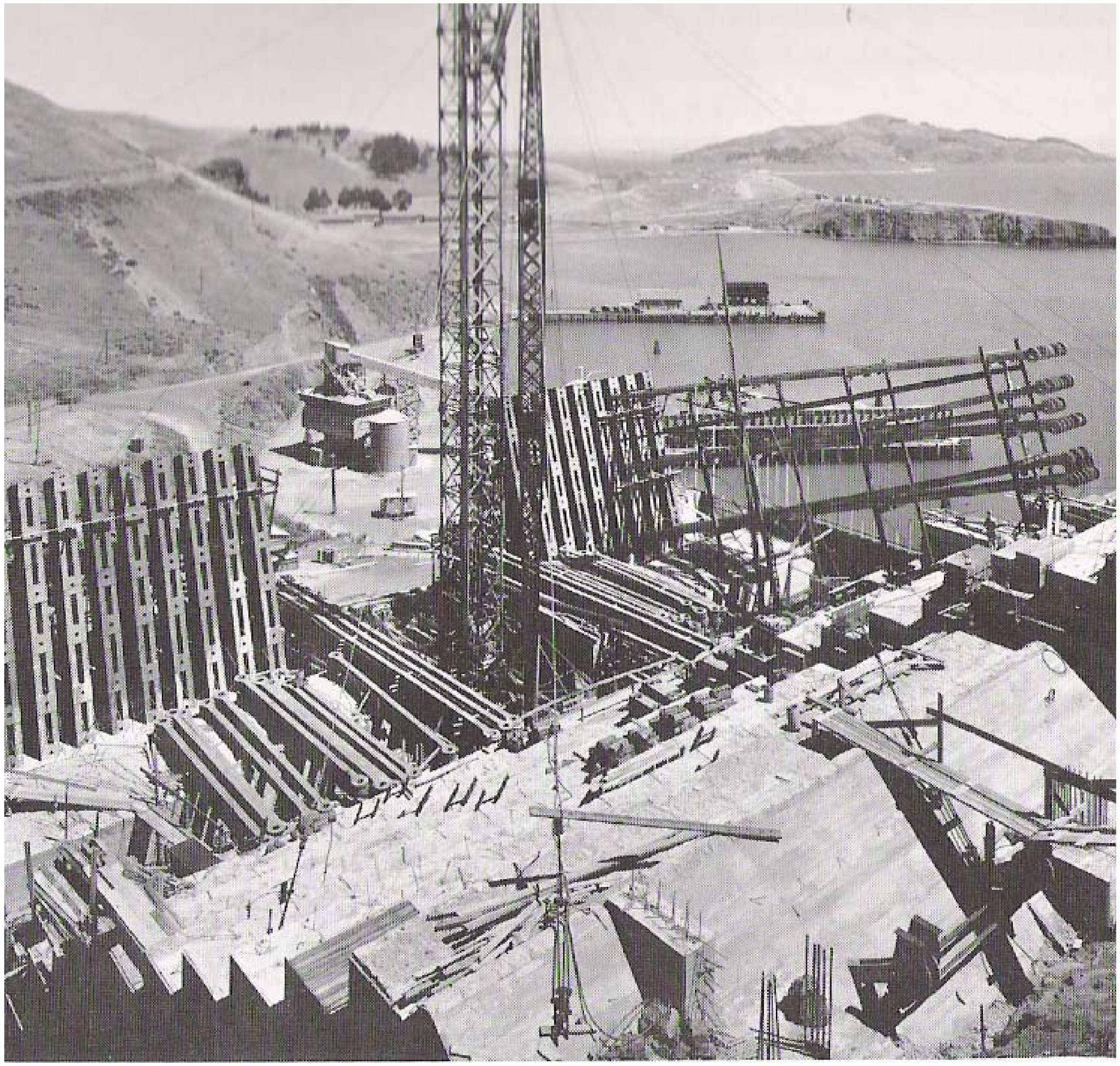
Marin Anchorage

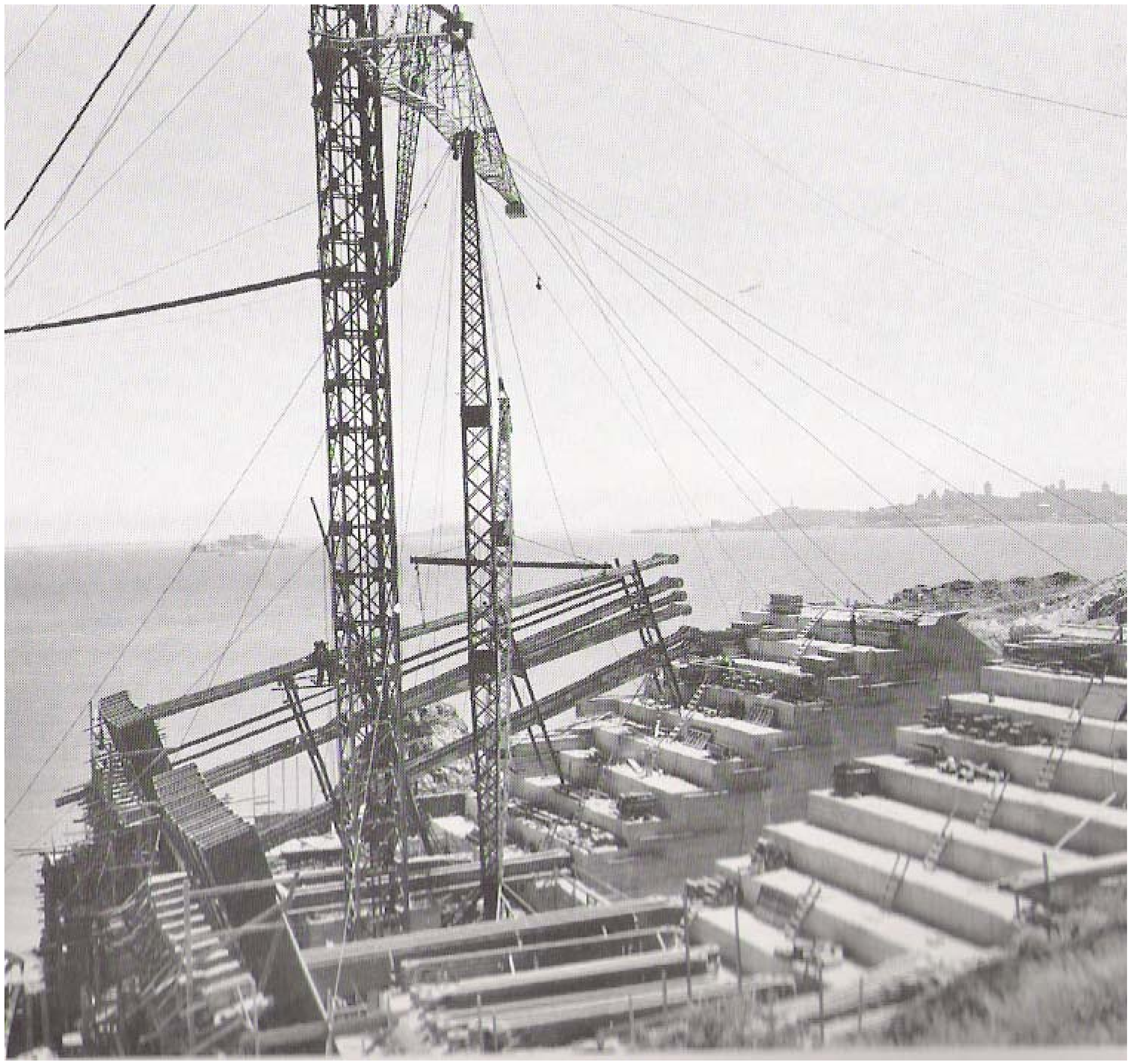
Like its opposite-number across the bay, the Marin Anchorage was begun in January 1933 but it was completed in June of 1935, one month later than the San Francisco anchorage. In a suspension bridge, its critical that the pair/s of anchorages and towers on either side of the span be completed at or near the same time, otherwise cable-spinning will be delayed. Each anchorage weighed-in at 60K-tons.

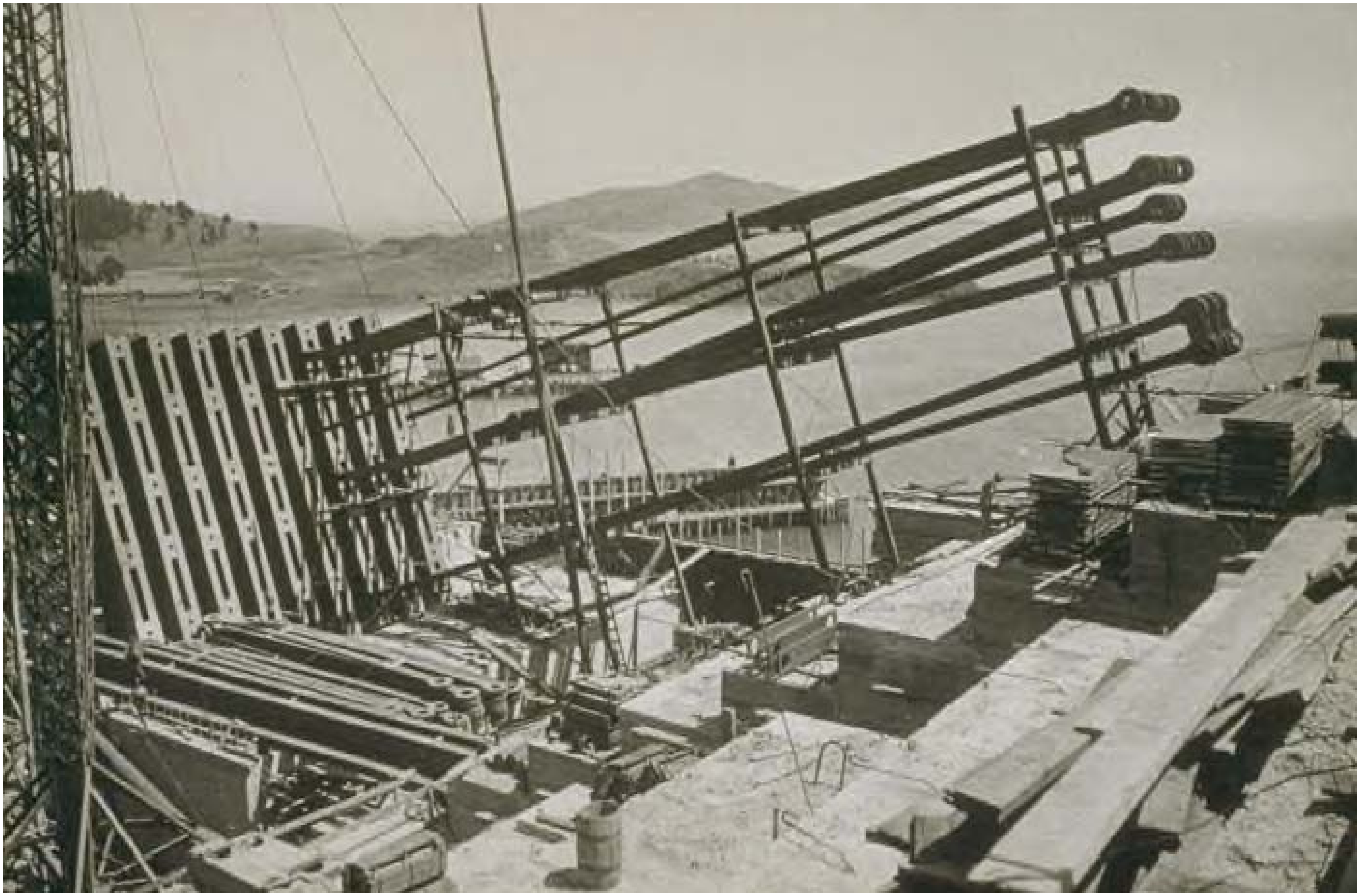


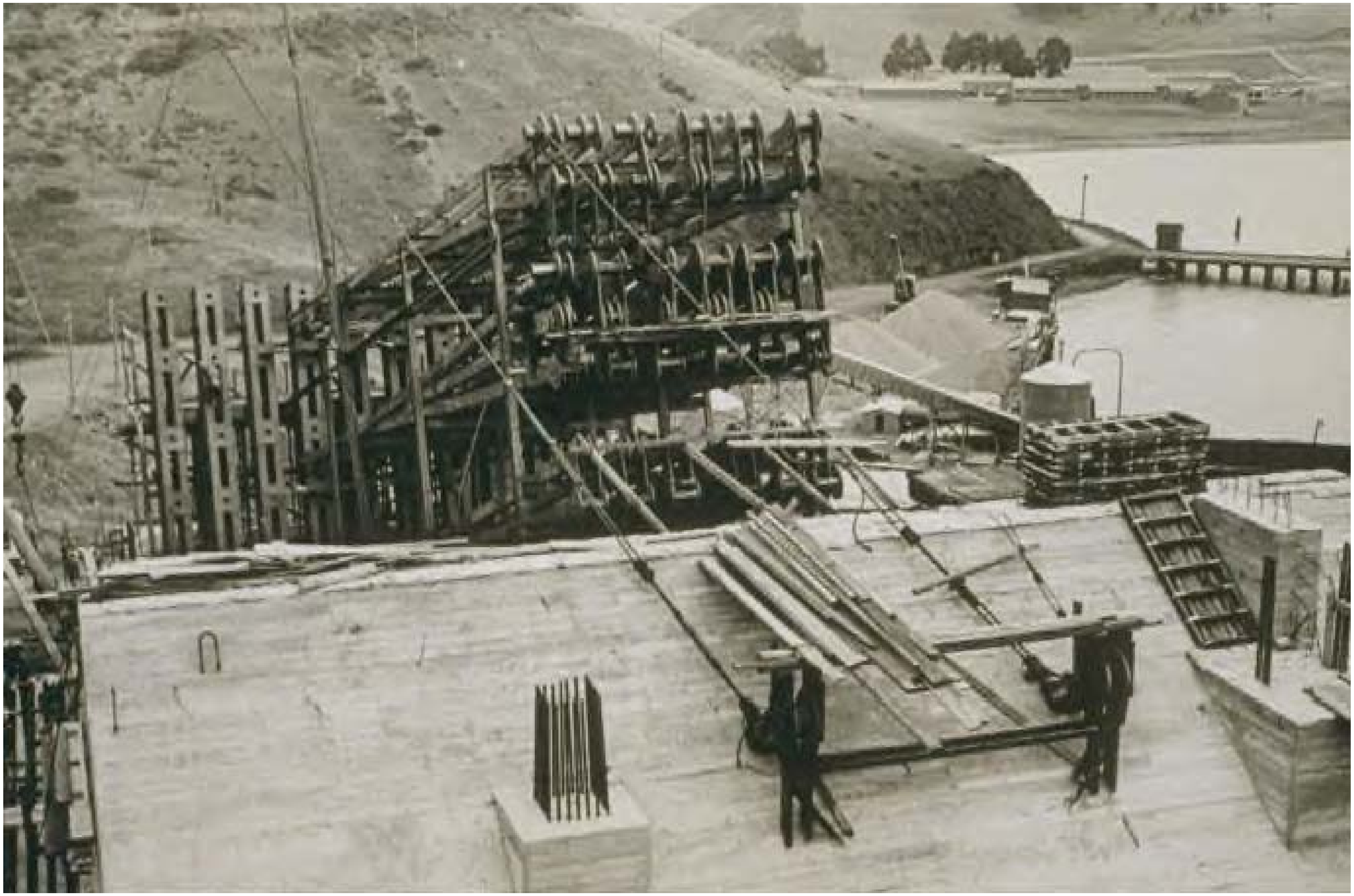


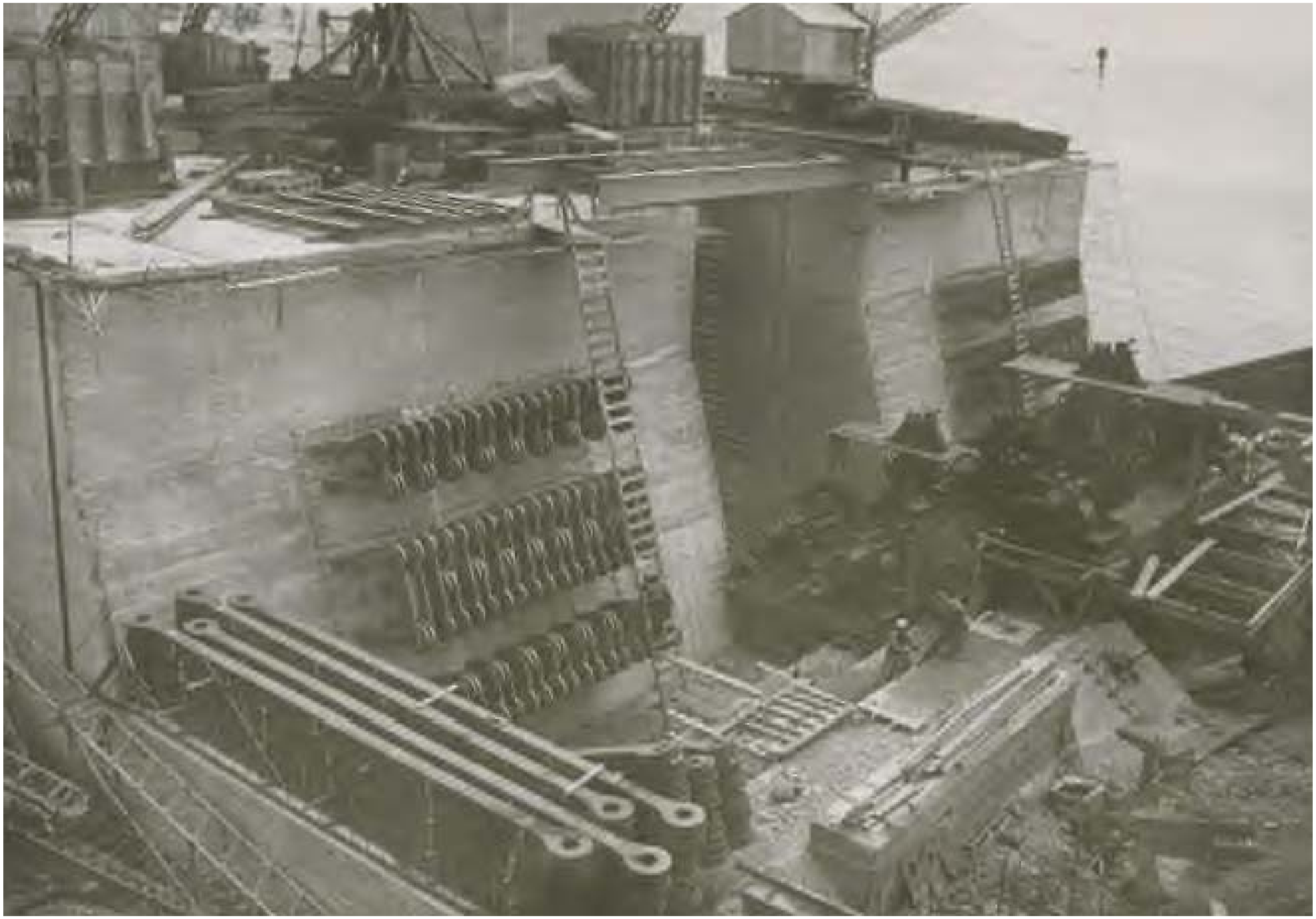


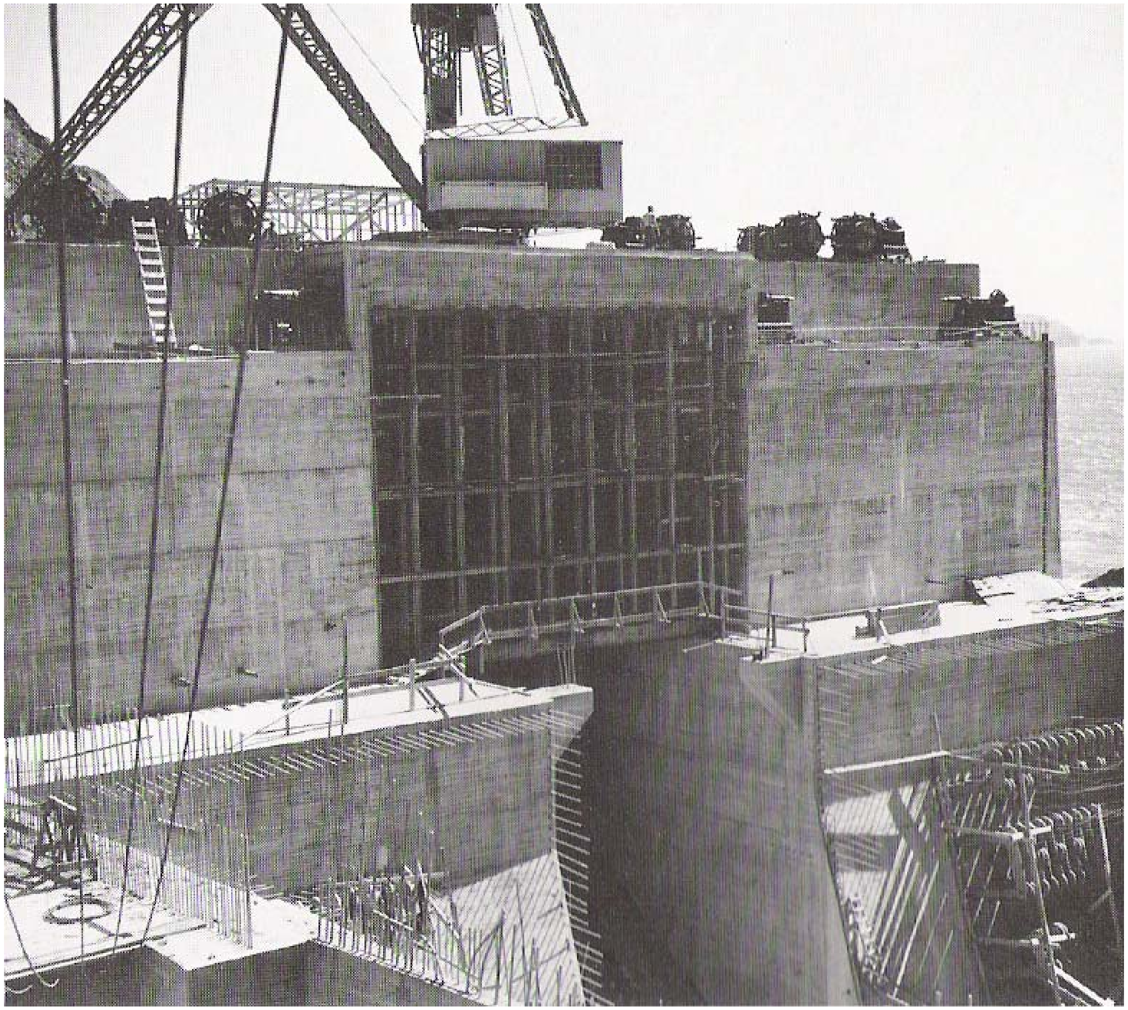


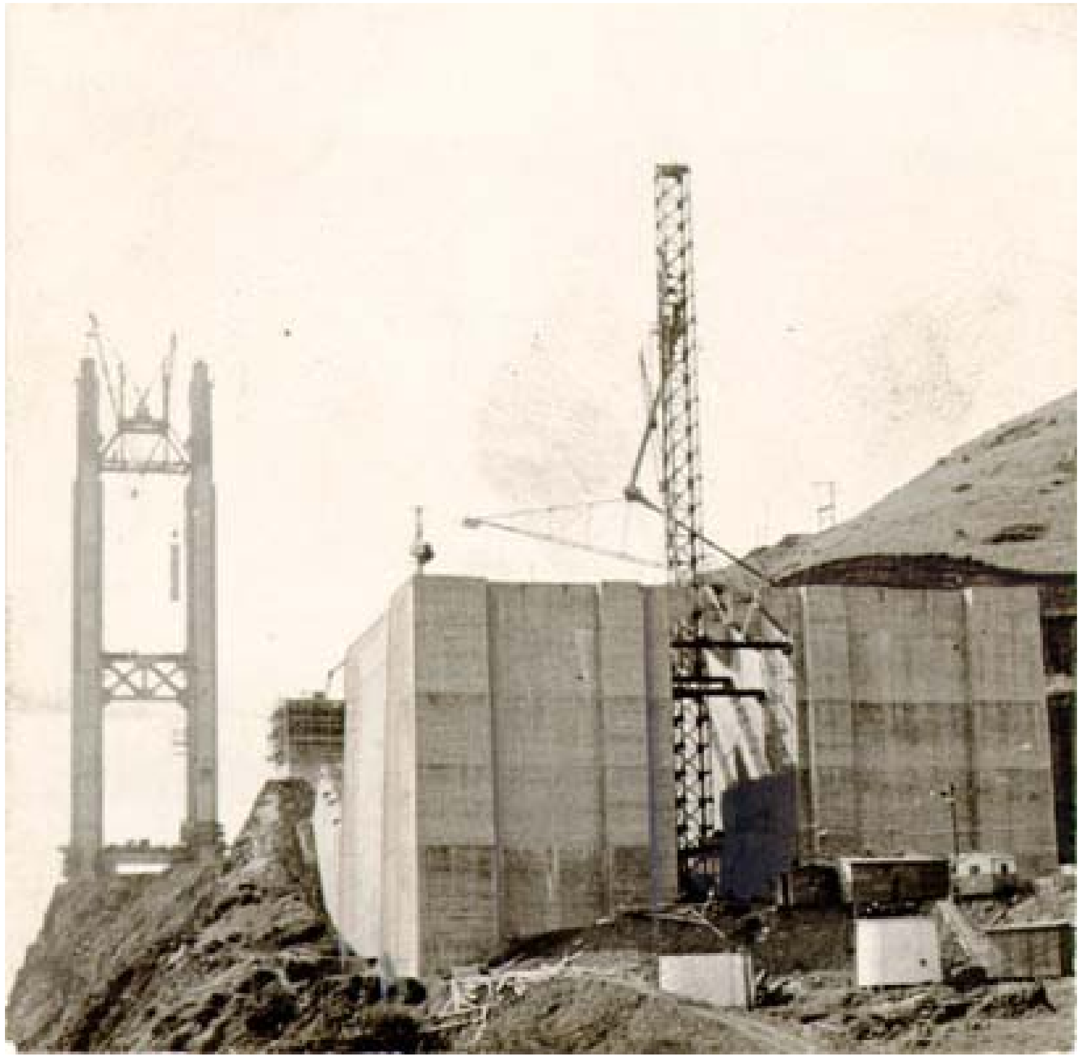












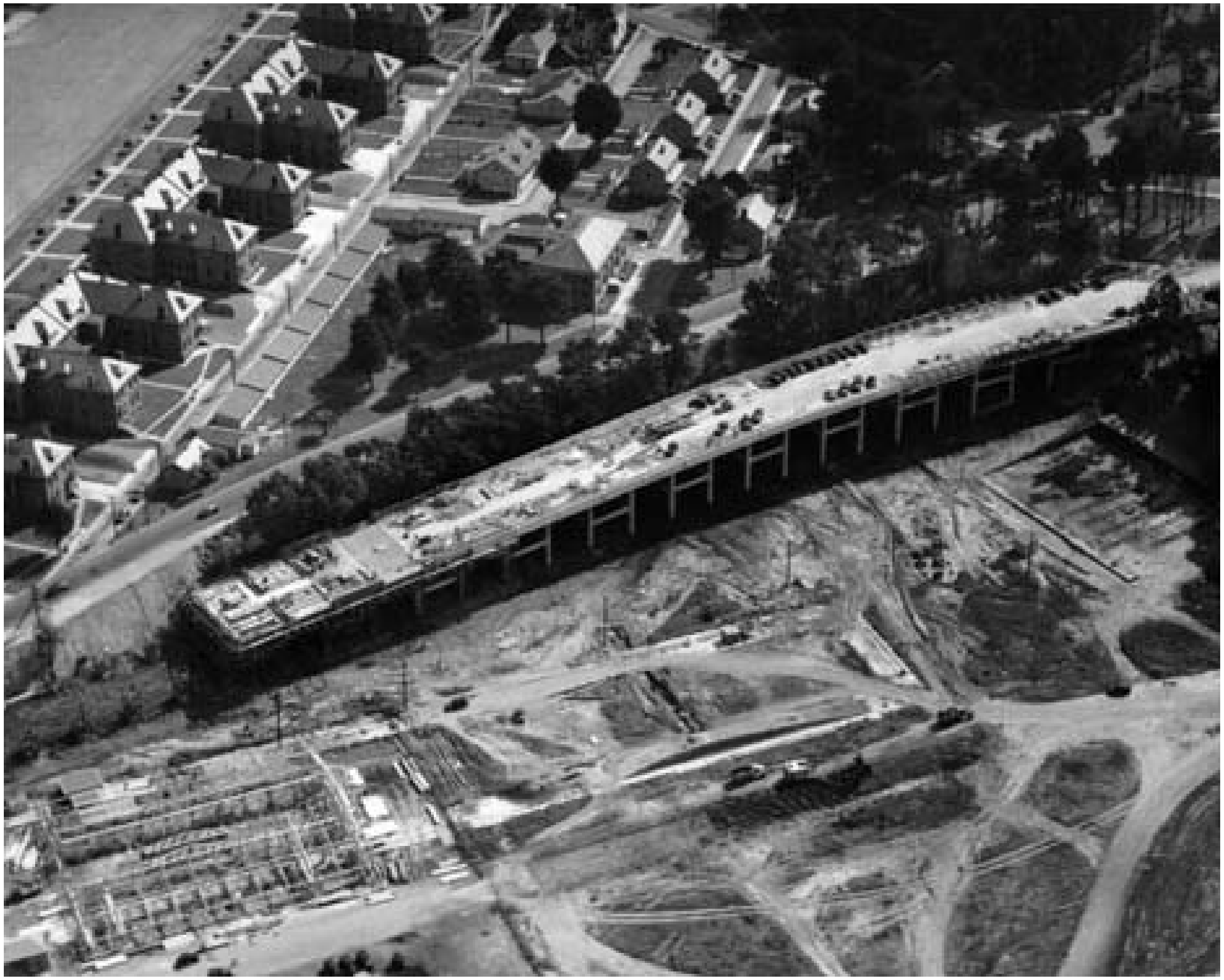
Contract V

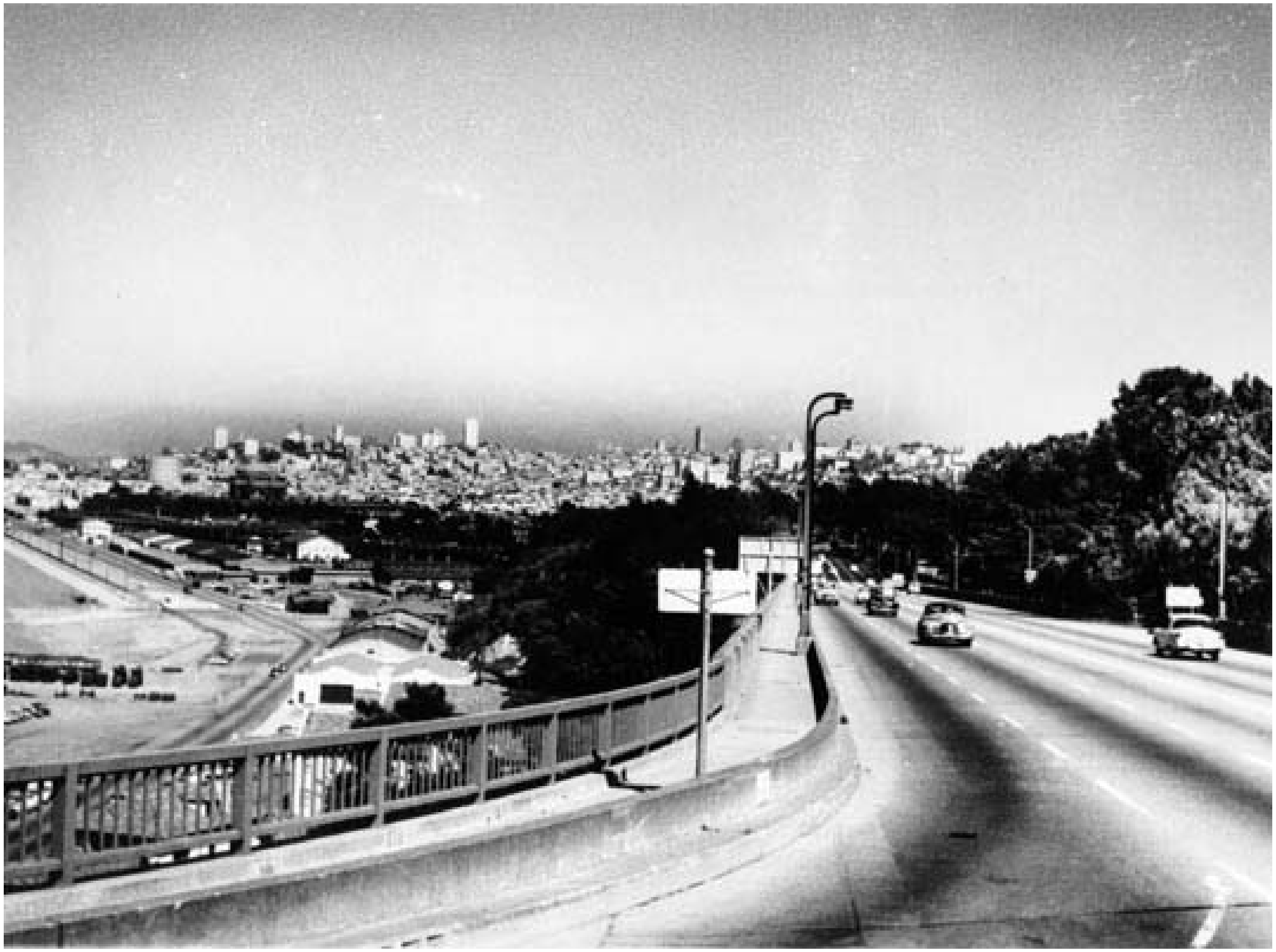
Presidio Approach Road

Contract IV

Steel Superstructure for Approaches

The arch spanning over Fort Scott (a.k.a. *Fort Point Arch*) began on July 12th 1936. The steel superstructure for the San Francisco (Presidio) approach viaduct began construction on July 21st 1936.





Marin Approach

On December 22nd 1932, construction commenced for a 1,700-foot long road extending from the end of the existing road (at Fort Baker) to the Marin Pier (adjoining the Lime Point Lighthouse).

On March 19th 1936, work began on the Marin approach viaduct.

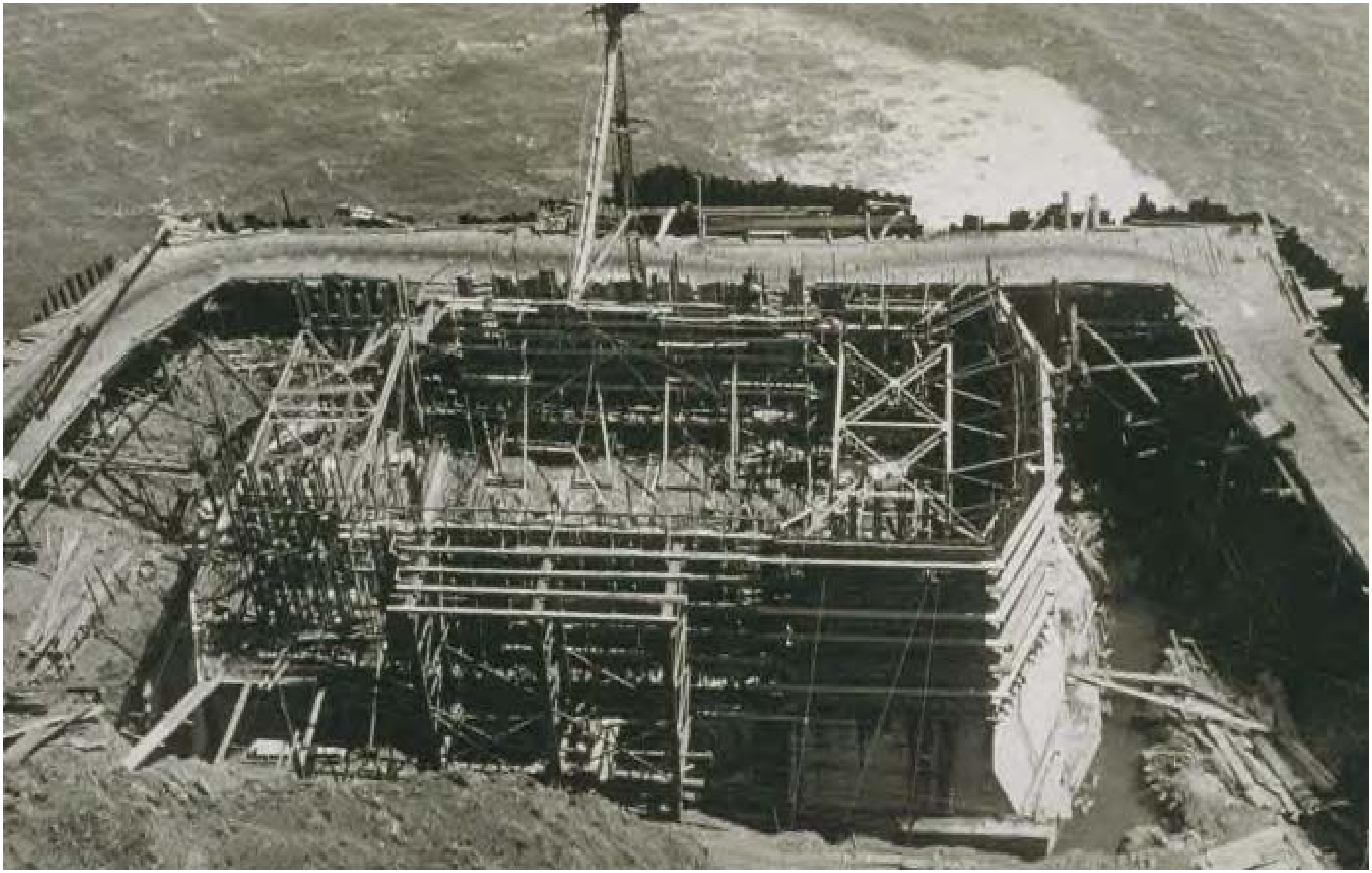
Part 6

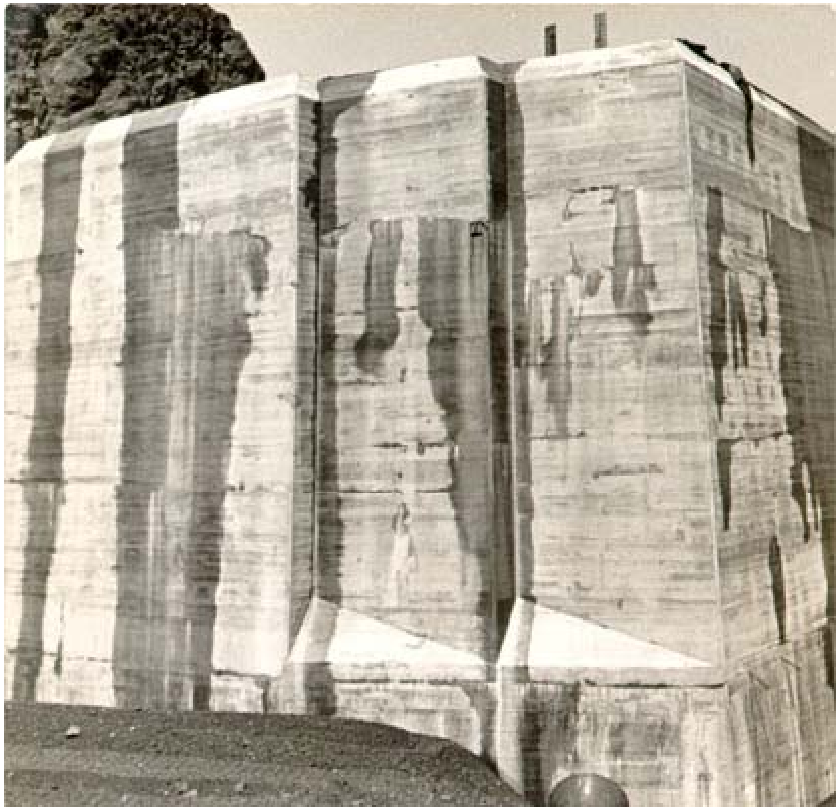
Piers

<u>Contract II</u>

Marin Tower Pier
San Francisco Tower Pier and Fender

Begun in January 1933, the Marin (north) pier was built on the Marin Shore and extends 44-feet above the waterline of the Golden Gate Strait. It was completed in June of 1933, requiring 23,500 cubic-yards of concrete.





San Francisco Tower Pier and Fender

"Building a bridge is a war with the forces of nature"

Joseph Strauss – Chief Engineer, Golden Gate Bridge

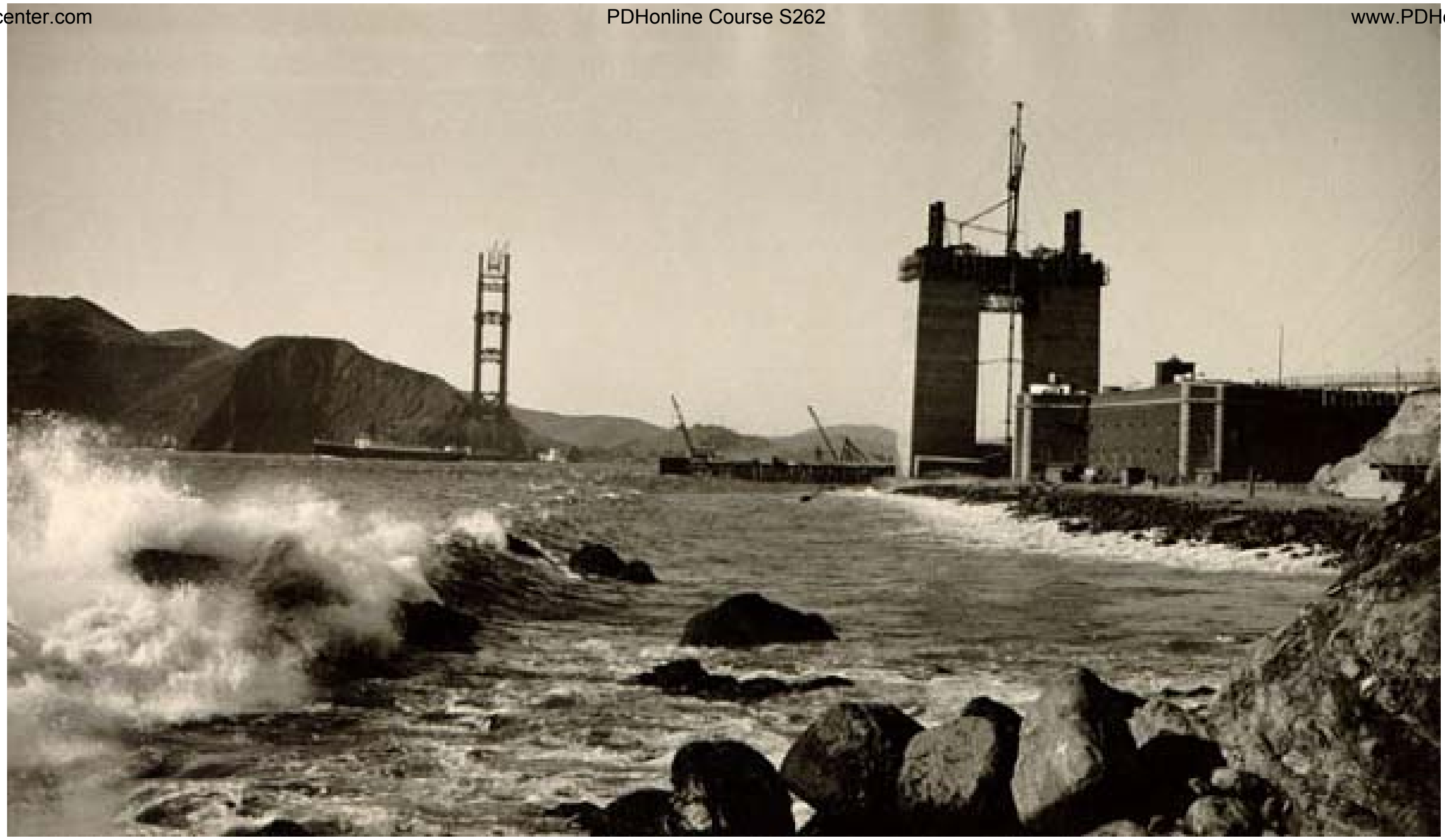
GOLDEN GATE SPAN TO STRETCH 4200 FEET OVER OCEAN

First Tower to Be 1200 Feet Out From Shore — To Be Beautiful But All For Utility

San Francisco, Sept. 11—Only a myth creator of the past could have envisioned architecture on the scale of the Golden Gate bridge.

The bridge when completed will have a tower 1200 feet out from shore. It is the first time anything like this has been attempted in the open sea. It will sweep across an expanse of blue, from San Francisco to Marin, with the dry California hills in the backgronud.

In January 1933, work began on the south (San Francisco) tower pier, it would prove to be the most difficult task encountered in building the bridge. The north (Marin) tower pier was located on land and built "in the dry," that would not be the case for the south pier. To achieve the 4,200-foot main span, the south tower needed to be built 1,125-feet off of Fort Point, exposed to the narrow shipping channel of the Golden Gate Strait which is subject to powerful and unpredictable currents. The strait is deep – up to 335-feet, and only about a 1.25 miles wide. The ocean entrance to the strait is the widest along the California coast, permitting the Pacific Ocean to surge into the strait. Alternately, many northern California rivers deposit fresh water into San Francisco Bay. When this Fresh Water (flowing west) meets the salt water of the Pacific, the result is violent and complex currents concentrated in the strait. On a daily basis, 2.3 million cubic-feet per second of San Francisco Bay water (17%) is pumped through the strait and into the Pacific Ocean. This would be the first time a bridge pier was built in *open ocean conditions* and its creation set precedents still followed today.



"If you go out to the bridge site, you can see the waves crashing over the south shore. And those waves are only the surface manifestation of a big energy pump underneath the water."

Mark Ketchum, Civil Engineer

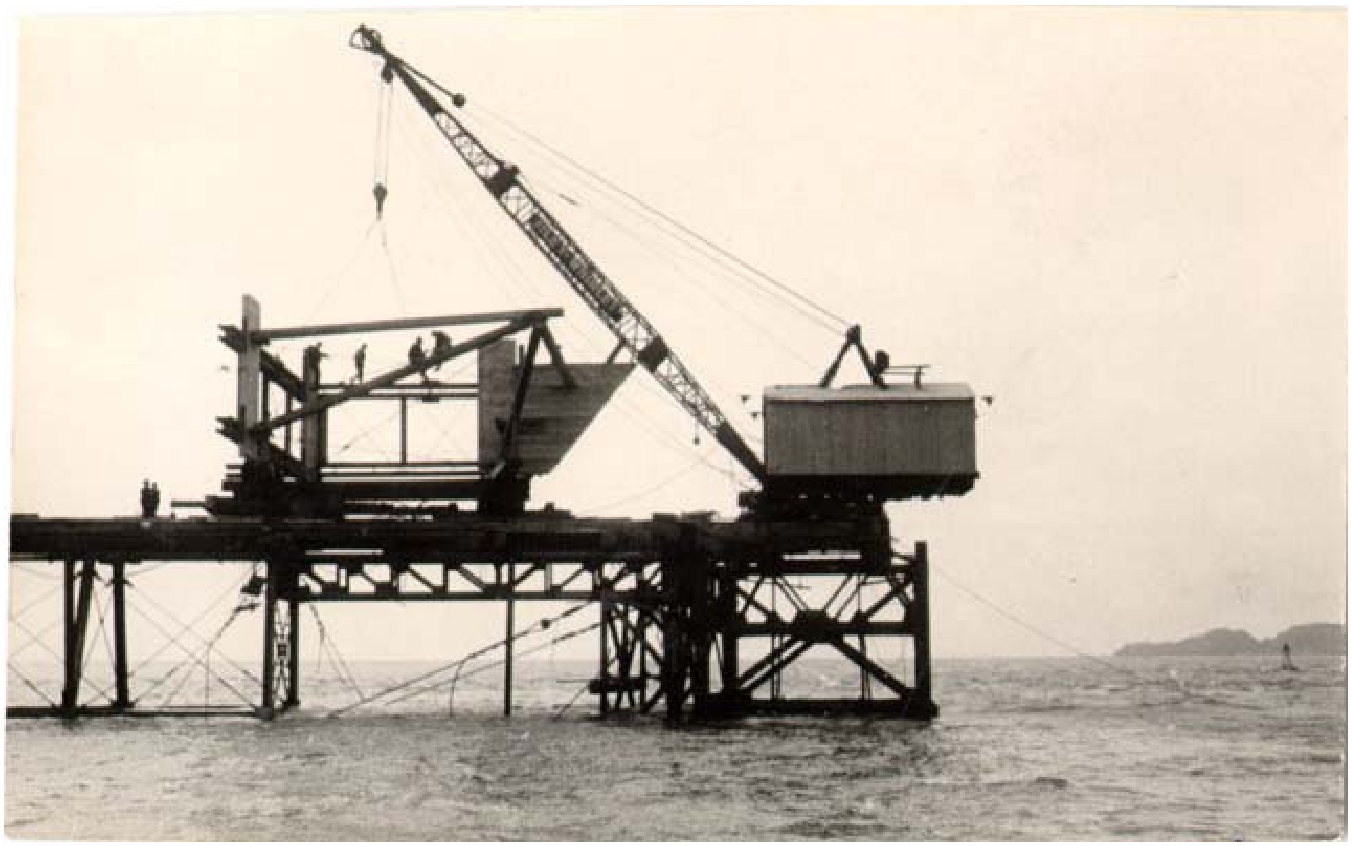
"Without question, the most difficult engineering feat men have ever tackled was the south pier, rising 1,000-feet from shore on a rocky ledge 65-feet below the waves. I know of no place on the globe which has more violent conditions of water and weather than the Golden Gate. For eleven months it was an unequal battle of man against sea."

Joseph Strauss - Chief Engineer, GGB

RE: the many difficulties encountered in creating a foundation for the south tower

Access Trestle

It took a whole year, from March 1933 to March 1934, to construct a fifteen-foot wide access trestle extending 1,125-feet off of the Fort Point shoreline to the site of the south pier/tower. Nearly complete, on August 14th 1933 the steamship *Sidney M. Hauptman*, lost in a thick fog, crashed into the trestle and carried away four-hundred feet of it. On October 31st 1933, with five of twenty-two sections of the fender complete, a storm destroyed three of the five completed sections and the trestle's end, with the loss of all equipment. After repairs from the collision were finished, starting on December 13th 1933, for two days a southwest gale battered the trestle destroying eight-hundred feet of it. First the ship collision and then the storm/s damage gave the bridge's opponents still another opportunity to cry "*told you so.*" Nevertheless, Strauss and his team rebuilt the trestle for the third and last time, completing repairs on March 8th 1934. This time, they used timber piles rather than steel I-beams. They found that the I-beam shape created tremendous turbulence in the strong currents of the strait causing violent shaking of the trestle. The round shape of the timber pilings caused less turbulence.



Aftermath of the December 1933 Storm

Rebuilding the access trestle after the storm (with timber piles)

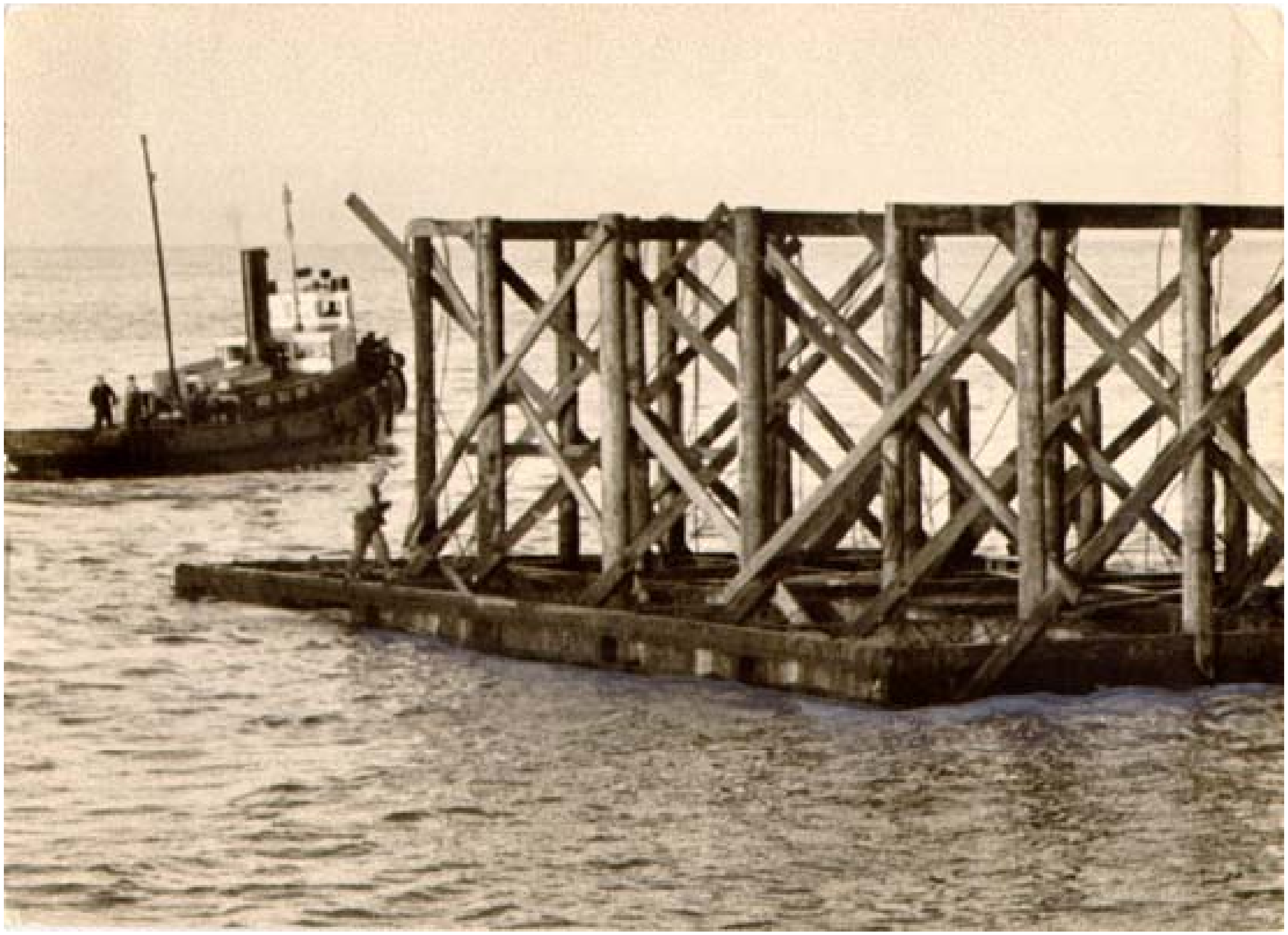
Access Trestle Complete

The Bathtub

"We got the caisson in at four o'clock in the morning. It loomed up as big as a house, we edged it in very nicely and were all relieved. At 8 o'clock that night, I got a message to come out to the pier. Heavy swells had come in from the sea; the caisson was tossing around like a cork and acting like a ramrod and a catapult upon the fender. It looked as if it would batter it to pieces. It was necessary to make a quick decision and to find a substitute procedure which would be just as satisfactory. We finally hit upon a plan and, after discussion with the new contractor, arrived at a decision about midnight to adapt a new procedure and take the caisson out. This operation was just as ticklish a job as getting it in. It was successfully accomplished, however. The caisson was edged out about 9 o'clock in the evening, and later taken out to sea and sunk."

Joseph Strauss - Chief Engineer, Golden Gate Bridge

RE: loss of the $300K, 10K-ton caisson for the south pier in a storm surge. The caisson was towed fifty miles out to sea and blown up.

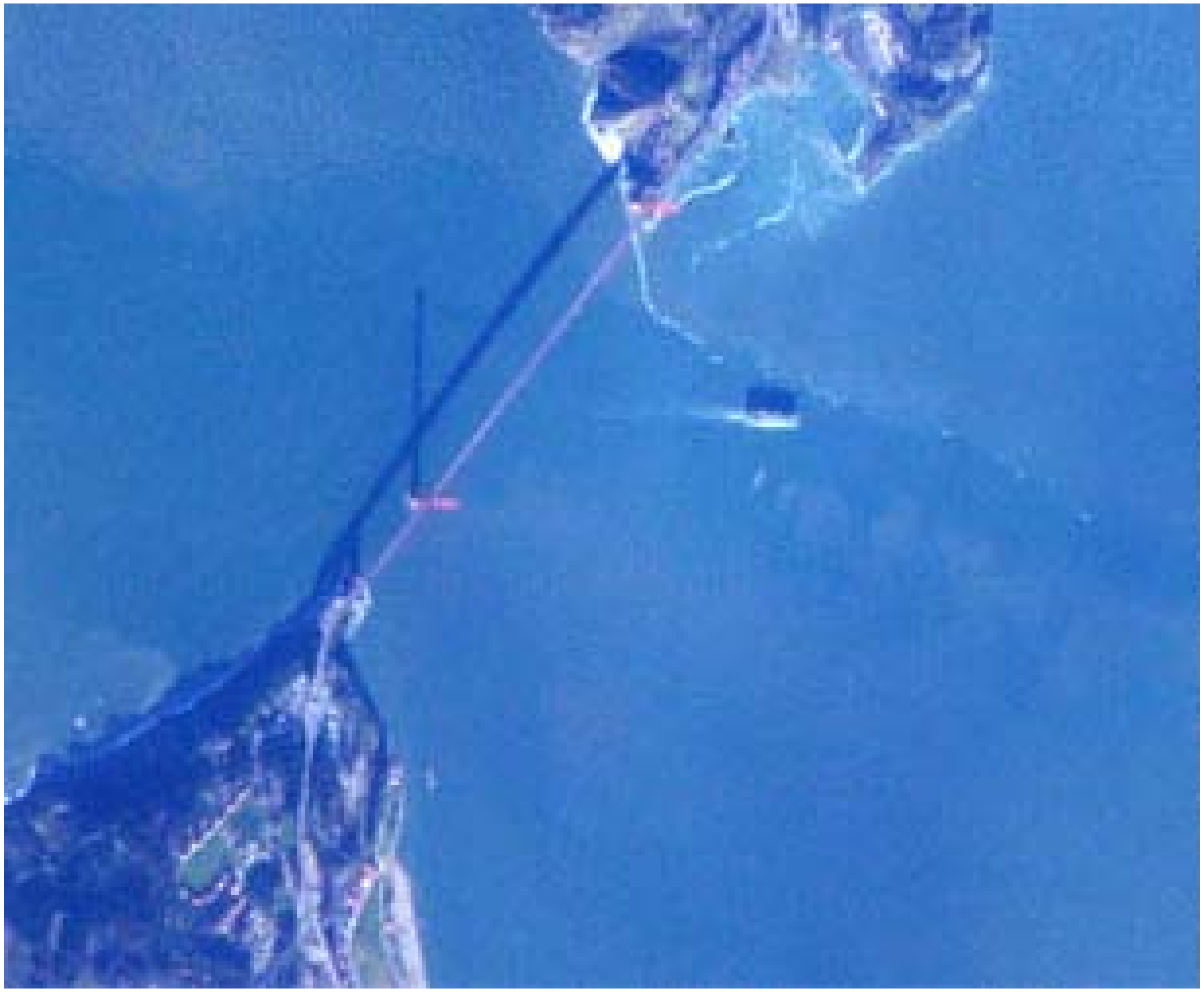


Strauss' plan called first for the construction of a giant concrete "fender" to prevent damage to the pier/tower from errant and/or stray fog-bound ships. The concrete pier for the south tower would be built in the area inside the fender (about the size of a football field) after the water was pumped out. The walls of the fender were forty-feet wide and filled with water (to give it strength against the current, until it was filled with concrete). Working inside the fender was risky since it could collapse from the intense pressure of the currents of the strait and/or be destroyed by a ship running into it (as happened to the access trestle). Divers would do the brunt of the work inside the fender, going as far down as ninety-feet (to remove detonation debris) into the murky depths where visibility was zero (they had to "feel their way" most of the time). Aside from the dangers without, the dangers within were great too. Because of the strait's varying currents, there were only four, twenty minute periods each day when the divers could work. This meant that they were often forced to the surface without sufficient time to decompress properly, resulting in *The Bends.*

"I hadn't figured on building a bridge in the middle of a river"

J.E. "Jack" Graham, *Pacific Bridge Company*

RE: 4.5 to 7.5-knot tides and rough water of the Golden Gate Strait. The tidal action of the bay/strait dumps (2x daily, within a six-hour time frame) into the Pacific Ocean approximately 3.5x the volume of water the Mississippi River deposits into its delta.

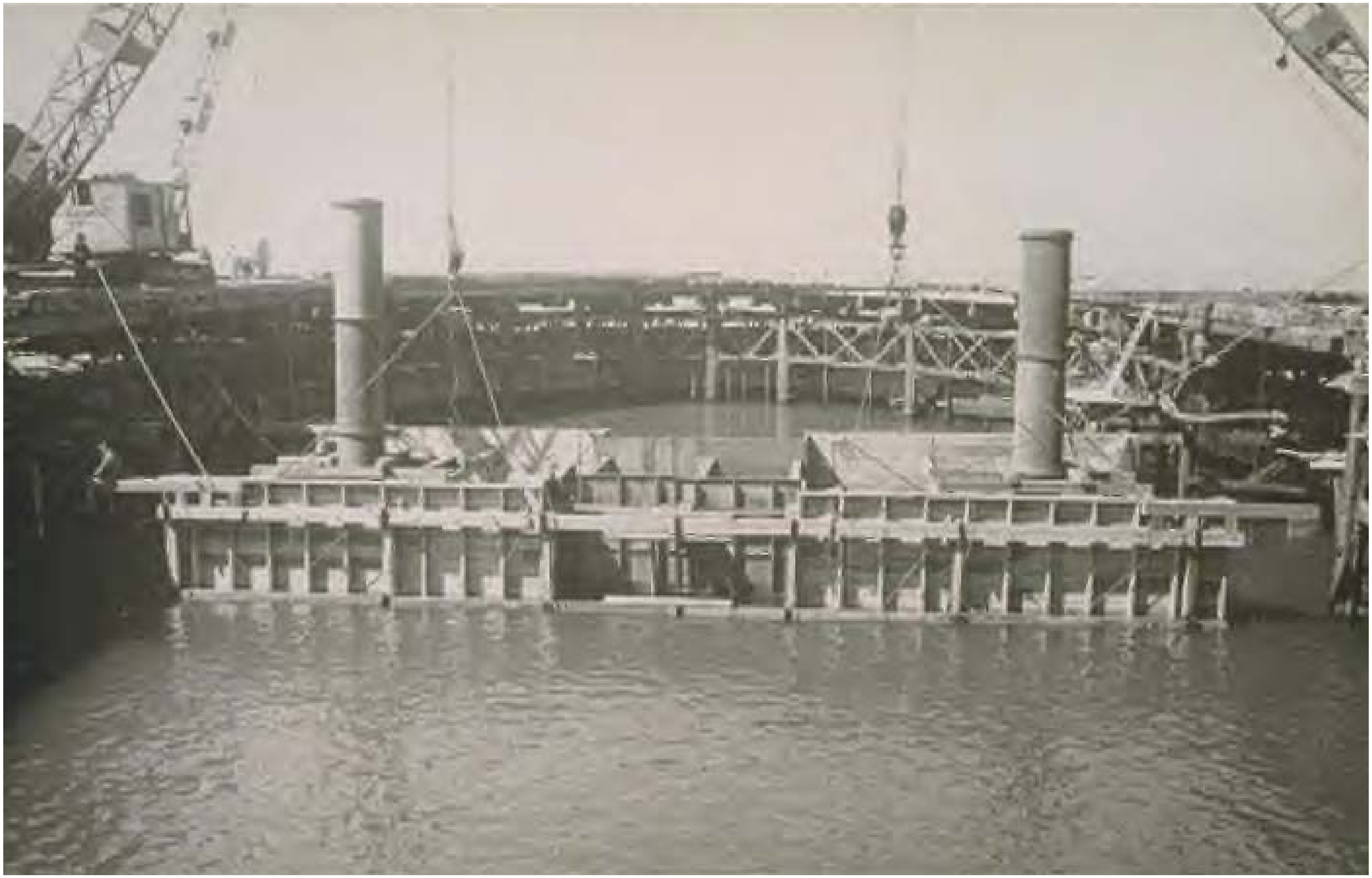


The Bathtub fender contained 9.41 million gallons (35.6 million liters) of water prior to being pumped-out (dewatered) and replaced with concrete.

"When we took off the wooden forms after the concrete had set, they went right to the bottom although they'd been as buoyant as cork three days before. That shows what the pressure is down there. An hour's about as long as you can stay at that depth. Longer than that is at your own risk. The deeper you go and the longer you stay, the greater the risk of the bends, or caisson disease, caused by over-rapid relief from air pressure which has built-up within the diving suit to counteract the water pressure without. The bends causes terrific pain, and sometimes temporary or even permanent paralysis in the part it hits you in. It gets me in the arms, it hits Bacon in the knees. A good tender is everything in diving. You have to trust him more than you would your mother. Your life depends on his keeping his head. My tender saved me from death once. The boom of a crane, above, broke and if he hadn't kept his head and yanked my air supply hose out of the way, the boom would have fallen on it, and I'd have been permanently out of breath."

Bob Patching - *McClintic-Marshall Company's* main diver

RE: working in "The Giant Bathtub" of the South Pier



"We were down damn near fifty-feet, and every time you go down twenty-nine feet you double your atmospheric pressure. Well that's strong enough it can hold you smack against a wall, and you can't move."

Bob Patching, Diver

Diving Bell

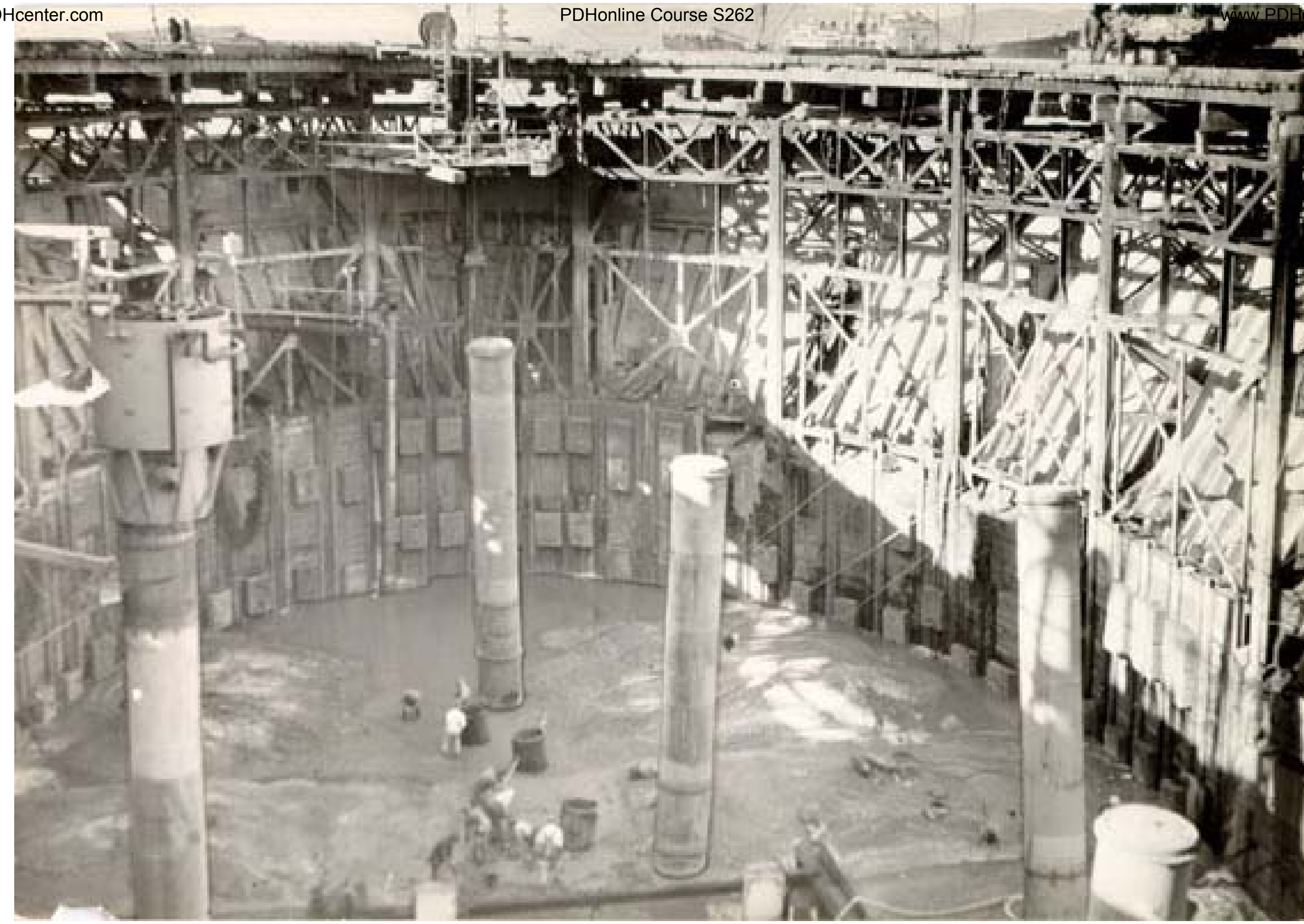
For their dangerous work, the divers were paid very well. With forty-ton steel forms and blasting tubes guided into position by the divers, black powder bombs were shot through blasting tubes into the bedrock below. The bombs exploded with such force as to throw fish as far back as the shoreline. After detonation, the divers used 500-PSI hoses to clear the debris and smooth the floor's surface.

"We then poured a forty-foot mat of concrete, underwater, over the entire area inside the fender **(November 27th 1934)** ***and used it as a cofferdam and built in the dry"***

Joseph Strauss - Chief Engineer, Golden Gate Bridge

RE: change in plan whereby the fender – completed on October 28th 1934, was made an integral part of the south pier which was completed on January 8th 1935. Combined, the south pier and fender consumed 130K cubic-yards of concrete.

On October 24th 1933, the south pier (a.k.a. "*The Bathtub*") fender wall was completed and on November 27th 1934 the area within the fender wall (for the tower pier) was dewatered.



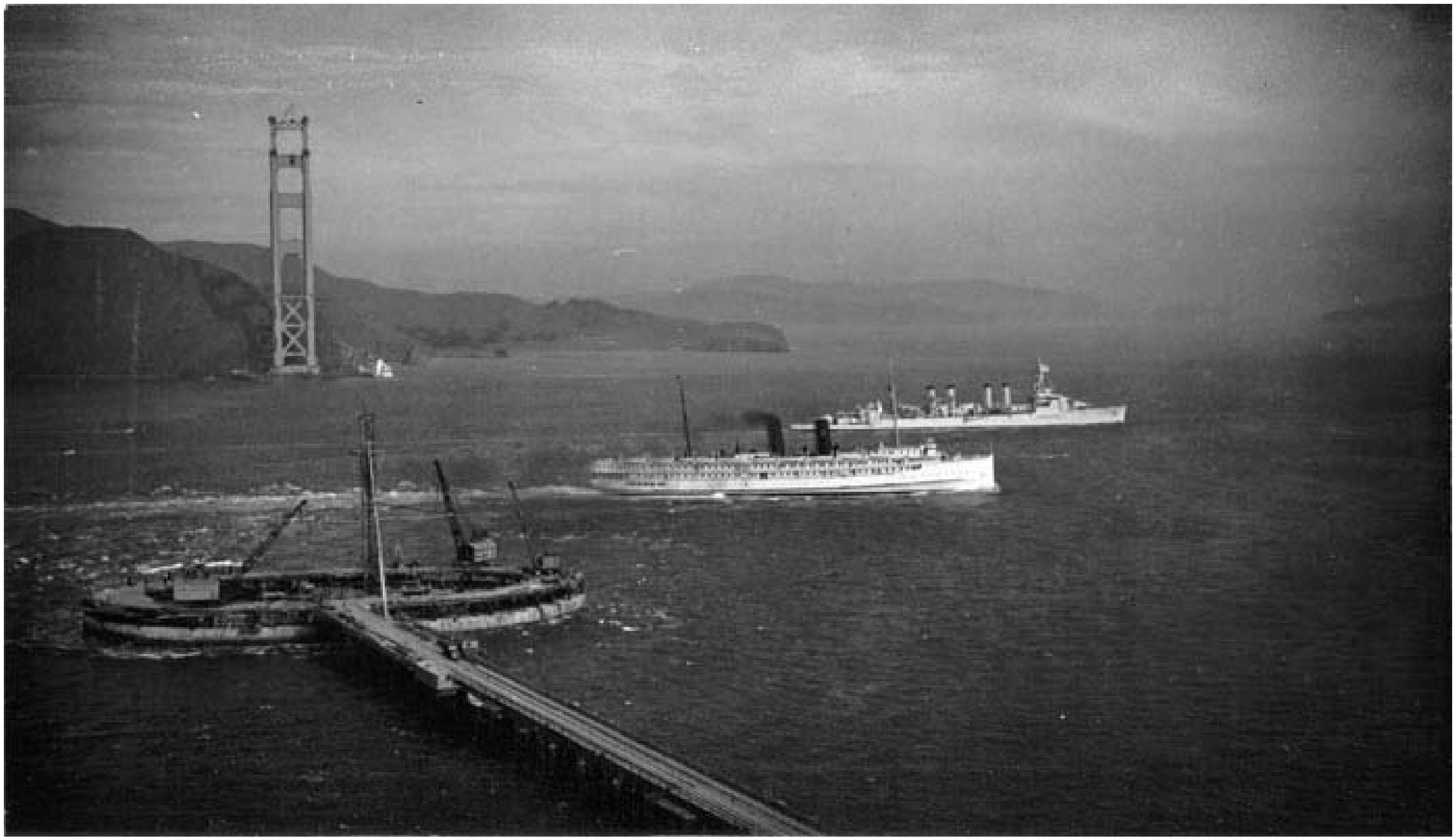
"The Wall was found to be remarkably tight, and very little pumping was needed to keep the bottom dry."

RE: excerpt from: ***Report of the Chief Engineer*** **– GGB, 1937**

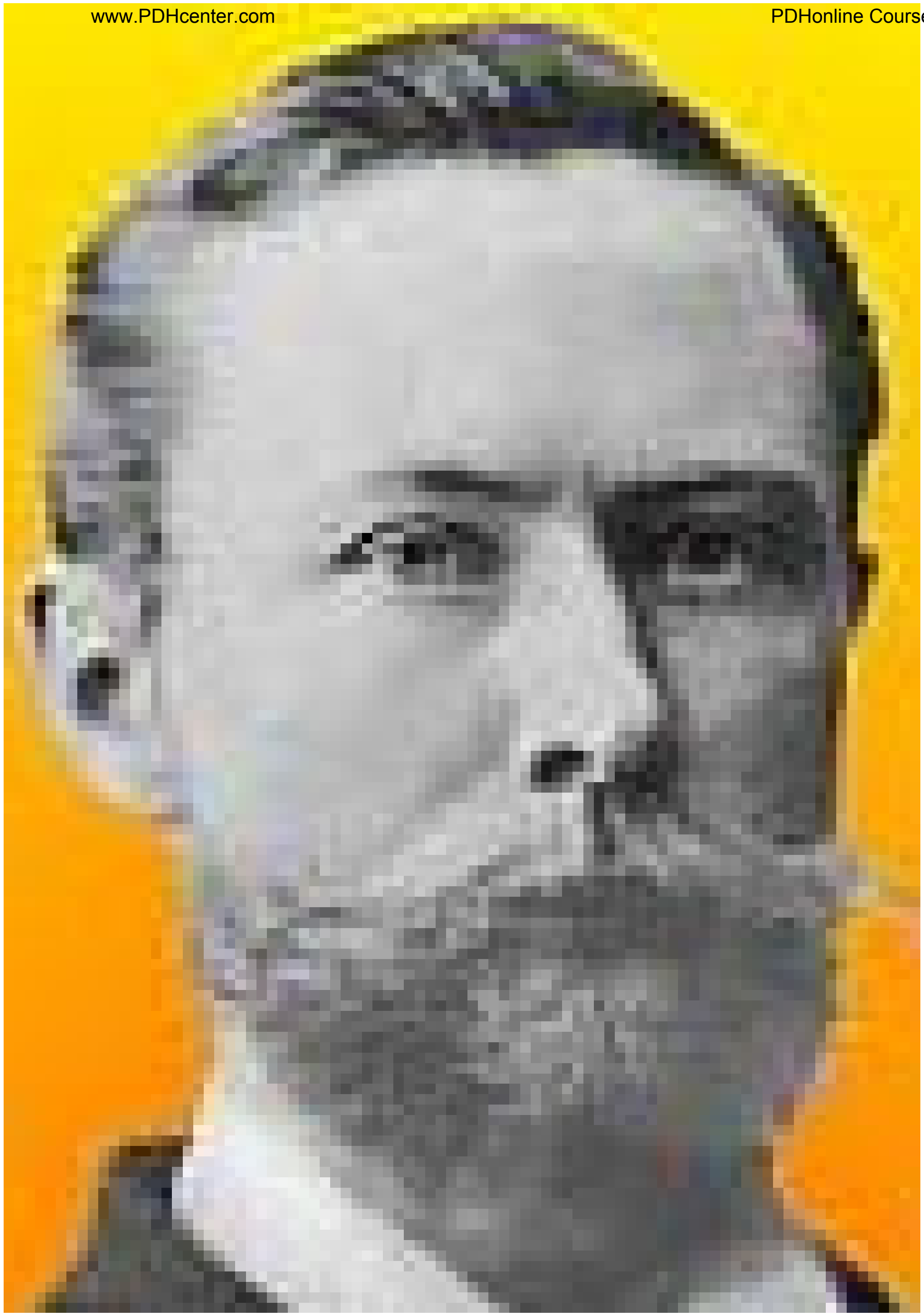
"Early one morning in a heavy fog, after the fender had been pumped out, a great freighter loomed up only a few feet away. Had it hit the fender in that condition, all would have been lost. Fortunately, it just cleared, and we finished the pier without further alarms."

Joseph Strauss - Chief Engineer, Golden Gate Bridge

RE: last narrow escape of the "jinxed" south pier

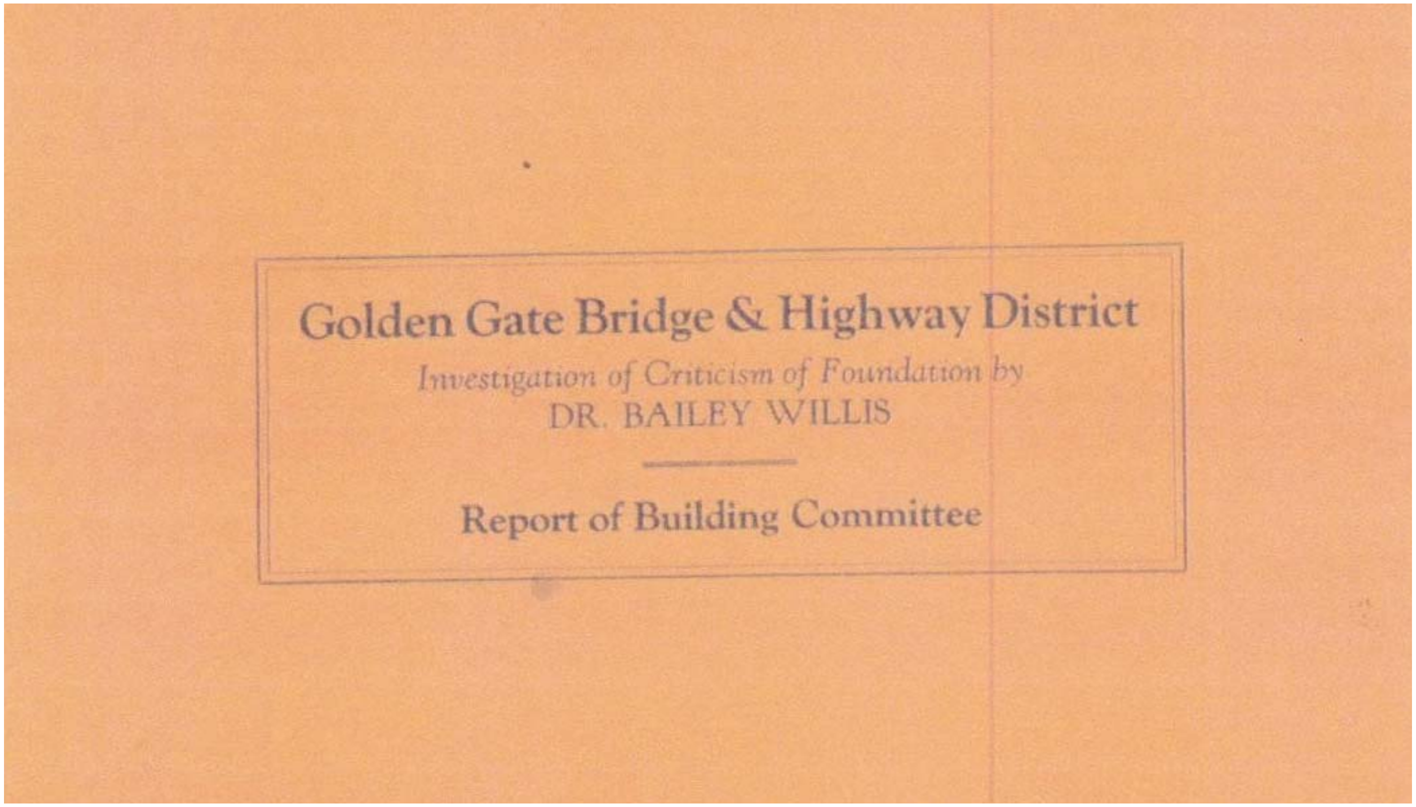


Bailey “Earthquake” Willis



Bailey Willis (1857-1949)

As a geologist, Bailey was recognized for his *geomorphological* and structural analysis of Mt. Ranier and the Appalachian Mountain range. He studied *denudation* (a form of erosion) chronology in North and South America and Africa and modeled experiments of *deformation* and *folding*. He also developed theories of d*ifferentiation* of the earth's crust. His interest in California geology caused him to doubt the safety of the site chosen for the south pier/tower


Golden Gate Bridge & Highway District
Investigation of Criticism of Foundation by
DR. BAILEY WILLIS
Report of Building Committee

"On August 22, 1934, Bailey Willis, Professor Emiritus of Geology, Stanford University, addressed himself to Joseph B. Strauss, Chief Engineer, as follows:

…certain observations in the geology of the South Pier rock…were referred to you and members of your board…I now write to inquire what measures, if any, have been taken or are proposed to obviate the dangers inherent in the geologic conditions described...

…the Chief Engineer responded …informing the Professor that the facts related to the south pier were public records, and the latter (Willis) requested opportunity to examine the records, particularly as related to *'Soundings and borings and to the design of the pier with special reference to any facts that bear upon the condition of the rock under the pier or that illustrate measures taken to guard against landslides which may endanger the structure…'"*

RE: excerpt from: *Building Committee Report*, Nov. 27th 1934

"…The Chief Engineer took the position that he would not discuss engineering problems with Professor Willis, that the subject was outside Professor Willis' experience and had been, and was satisfactorily being solved by the consulting engineers and himself…was transmitted to the Chairman of the Building Committee with the suggestion that *'it might be desirable to bring the matter to a head…to compel him to state the cause and purpose of his interest…'*

…Professor Willis telegraphed the Board of Directors urging that operations at the south pier site be suspended until further consideration could be given to conditions which he said endangered the permanent security of the bridge…

'…Serpentine is a treacherous and uncertain rock, and that it is one which should be carefully investigated before any load is put on it…'"

RE: excerpt from: *Building Committee Report*, Nov. 27th 1934

"…he concluded that the safety of any structure placed on a knob of rock out in the bay was subject to very grave question…he consulted Col. Wilder, the California representative of PWA, and stated:

'...there was a loan pending – an application for a loan – before the PWA, and he and I both felt that they should know the facts…'

…This knob of rock Professor Willis characterizes as 'pudding stone' in statements appearing in the press and elsewhere…Professor Willis has never done any construction work or any designing nor has he engaged in preparation of specifications as it relates to construction…

'…I think you will have to go down into the rock with your foundation to the level of the bottom of the channel…You would have to go about 250-feet below where you are now…'

RE: excerpt from: *Building Committee Report,* Nov. 27th 1934

"…Professor Willis has supported his recommendation by his concept of the geology in the area. It seems his concept has changed from time to time…

'1. There is no geological reason to assume that earthquake vibrations may probably cause the structure of the Golden Gate Bridge to oscillate in a manner likely to cause its failure. It is about six miles from the San Andreas rift and about twelve miles from the Hayward rift, and there is no nearer fault of such character and magnitude as would react with sufficient violence to affect the structure.'

2. The southern anchorage and the south pier are founded upon a mass of sheared rock involved in a system of minor faults and consequently unstable to a degree likely to endanger the structure. The rock is serpentine and subject to landslides…Such a slide would…block the entrance to San Francisco harbor, change the tidal prism, and the level of the tides…as well as loss of the bridge…'

3. This danger can be overcome provided the foundation be carried in the rock to the depth of the adjacent channel or below it…'"

RE: excerpt from: *Building Committee Report,* Nov. 27th 1934

"…Professor Willis was concerned with the condition of the serpentinized peridotite in the mass and under water…He describes the serpentine underlying the foundation as having two weaknesses, it is under an internal stress which reacts with an external force to produce rupture, and it is also transversed by planes of concentrated shear which are irregular and result in open fissures as a consequence of displacement, and that landslides are characteristic…

'…It would appear that there is reasonable ground to fear that a structure thus supported must sooner or later be destroyed by landslide, either as a result of prolonged stress and fatigue of material or as a result of earthquake shock, or both…in the mass it squeezes and slips, producing very smooth, slippery fractures which are known by the old Cornish mining term as slickenslides'"

RE: excerpt from: *Building Committee Report*, Nov. 27th 1934

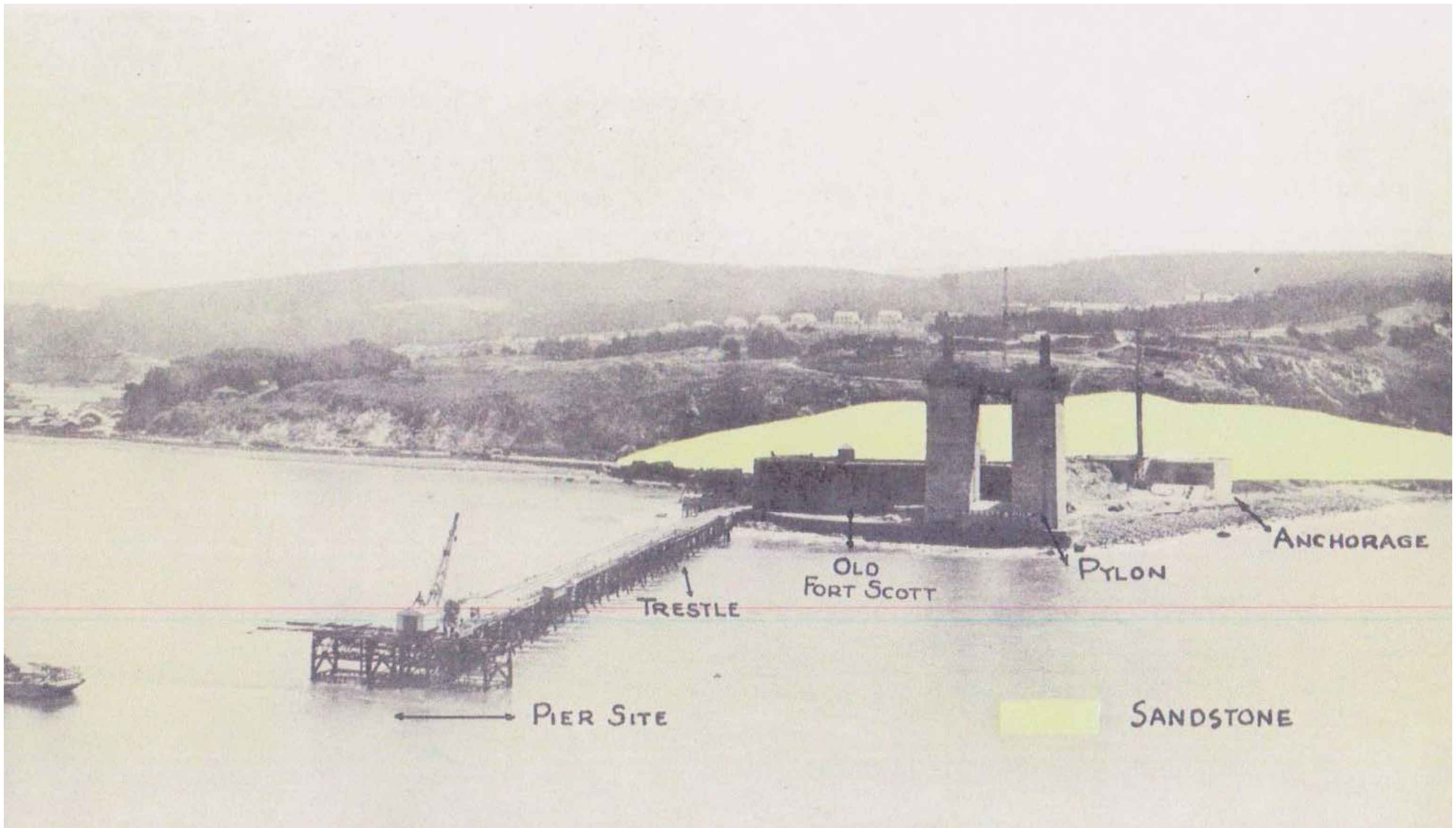
"…The Professor has proceeded by analogy and by use of Coast and Geodetic Survey sheets to establish his claims. Maintaining that serpentine is unstable and subject to slides, he states that this is demonstrated by slides which have occurred on the bluffs of the shore west of the Presidio reservation…It is Professor Willis' claim that if the formation slides in one place, it will slide in another and there have been slides from the formation in the vicinity northwest of the south pier…In his process of analogy, he points to contact between sandstone and crushed slate and serpentine at Marshall Beach, which is some 1,500 feet south of the Fort…and contends that it extends out beyond the south pier between the serpentine and the sandstone…Neither the serpentine nor the fault has been traced underwater…"

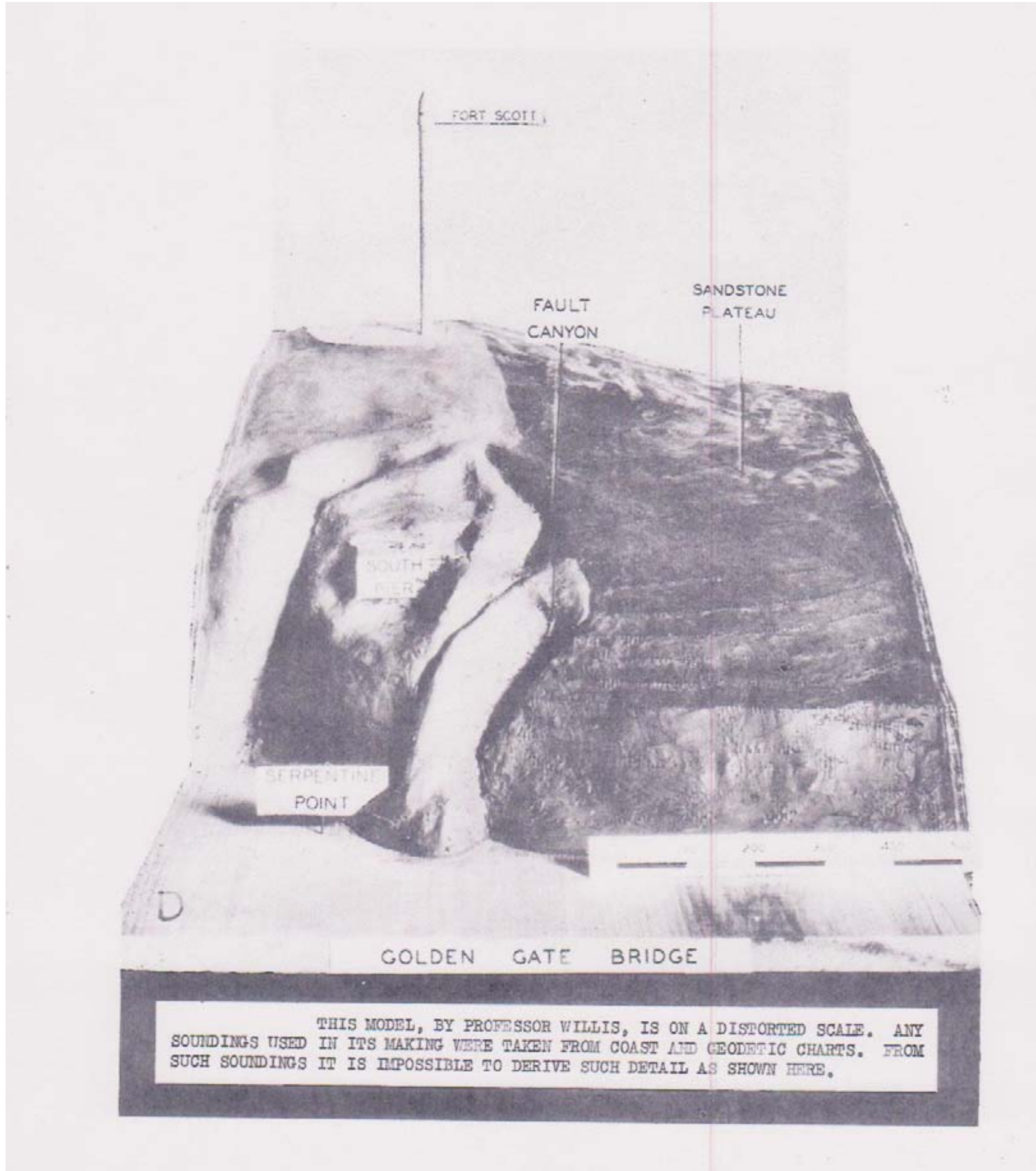
RE: excerpt from: *Building Committee Report,* Nov. 27th 1934

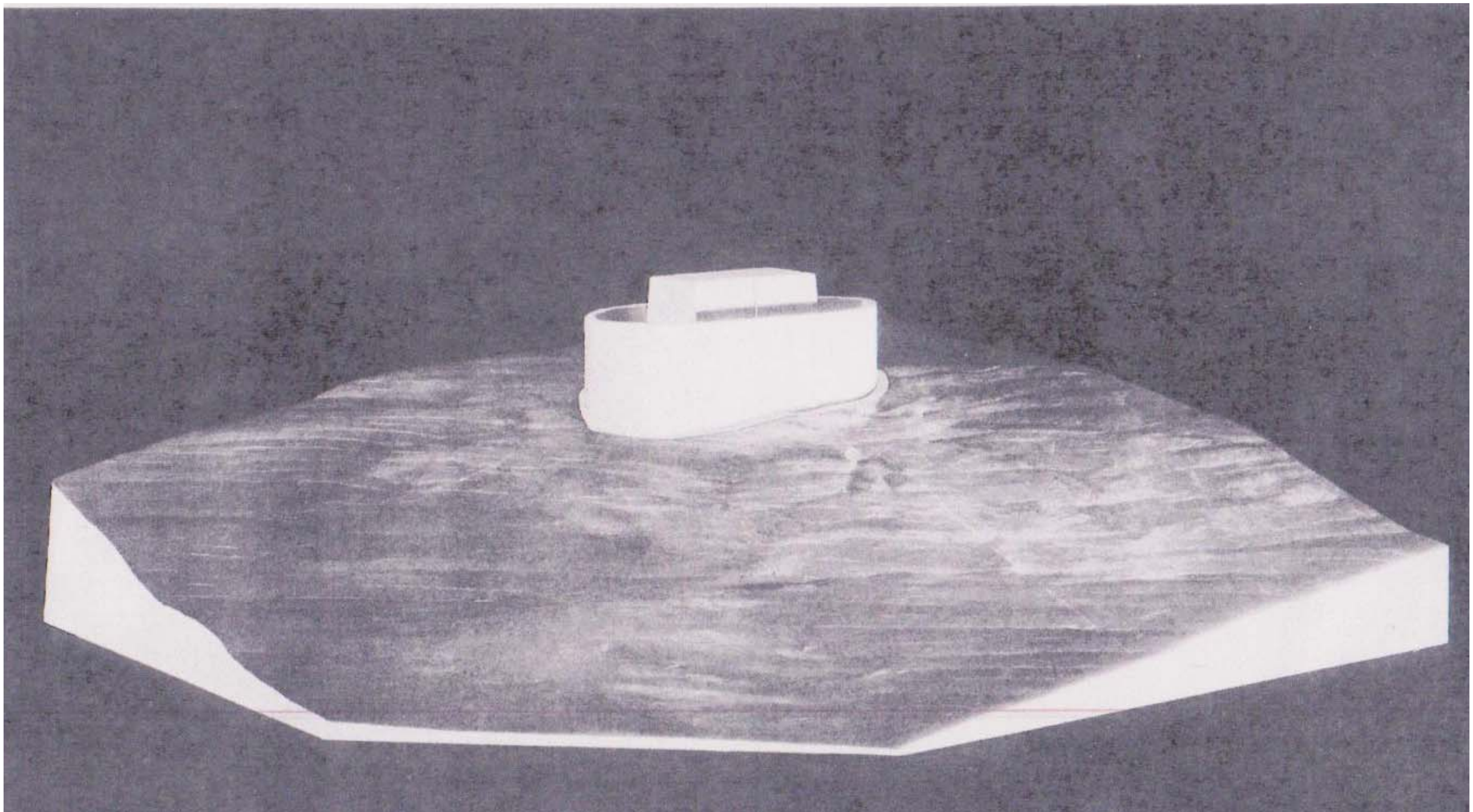
"…Professors Lawson and Sedgwick have reported with reference to the photo of this fault near Marshall Beach: ***'When we examined it in the field, the alleged fault proved to be merely a narrow dike of serpentine, exceptionally decomposed and partially silicified with sandstone on both sides of it. The width of the dike is about five or six feet. It is merely a narrow, intrusive tongue of serpentine in the sandstone…'***

…it is unfortunate that Professor Willis did not avail himself of data which is available…He was unaware of the extensive exploration of the area about the south pier which was made under the supervision of the District Engineers to determine exactly the shape and character of the structure on which the south pier is located…Professor Willis also exhibited a model of the formation on which the pier is located…but with a peculiarity that the vertical was exaggerated 5 to 1…effect of increasing the slope…" 349

RE: excerpt from: ***Building Committee Report*****, Nov. 27th 1934**


ANCHORAGE
PYLON
OLD
FORT SCOTT
TRESTLE
PIER SITE
SANDSTONE


FORT SCOTT
FAULT CANYON
SANDSTONE PLATEAU
SERPENTINE POINT
D
GOLDEN GATE BRIDGE
THIS MODEL, BY PROFESSOR WILLIS, IS ON A DISTORTED SCALE. ANY SOUNDINGS USED IN ITS MAKING WERE TAKEN FROM COAST AND GEODETIC CHARTS. FROM SUCH SOUNDINGS IT IS IMPOSSIBLE TO DERIVE SUCH DETAIL AS SHOWN HERE.



THIS MODEL IS AN EXACT REPRODUCTION ON A NATURAL SCALE OF THE SAN FRANCISCO PIER AND FENDER AND ROCK SURFACE UPON WHICH THEY ARE BASED. PIER AND FENDER MADE FROM CONTRACT PLANS. THE RELIEF MAP FROM THE 600 SOUNDINGS TAKEN BY DISTRICT FORCES.

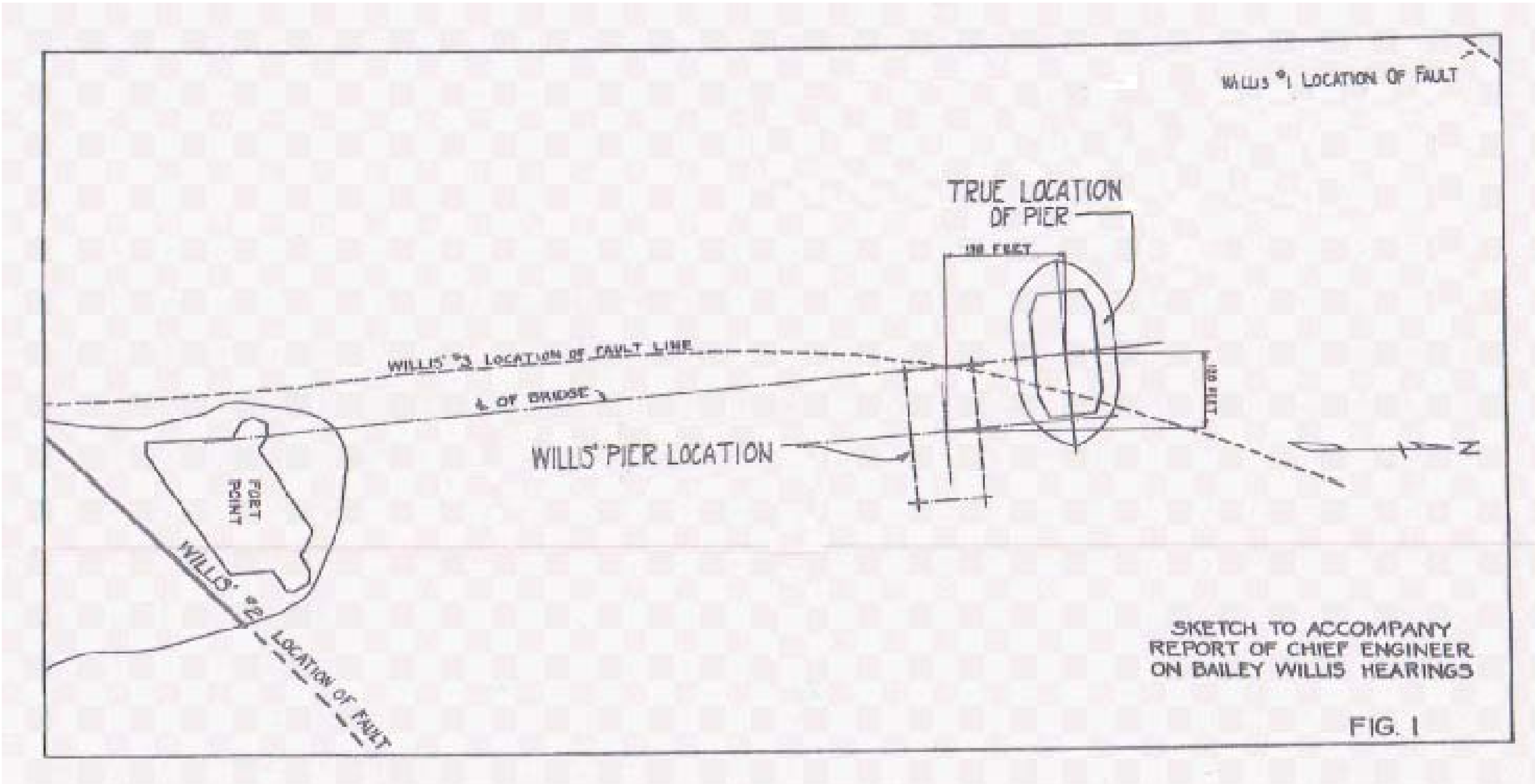
"…This report is not intended as an arraignment of Professor Willis, it is merely a statement of facts…The newspaper clippings of his public pronouncements give evidence…with berthing of the caisson as a motif, he issued statements to the press…addressed a letter to Charles Blyth, of Blyth and Company, a member of the bond syndicate…

'…This information is submitted to you in order that the banks and the public may not be misled into the purchase of bonds whose value depends on the completion of the bridge on a stable foundation. As the Bridge is now designed that foundation does not exist…'

Professors Lawson and Sedgwick submitted a joint report:

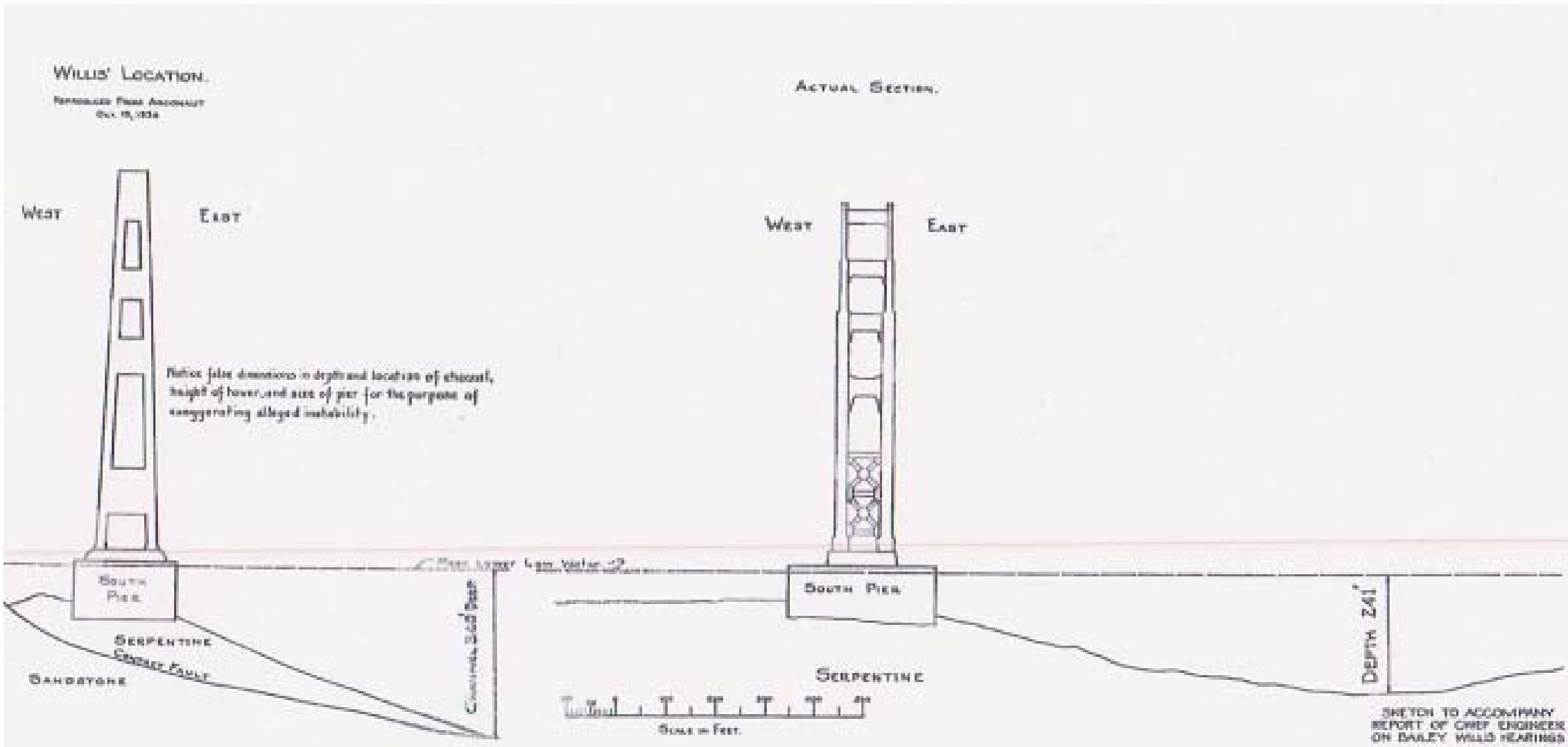
'...there is nothing in any of the numerous and discordant statements made by Professor Willis which would lead us to modify our original opinion as to the stability and integrity of the rock foundation upon which you are at present building the south pier…'"

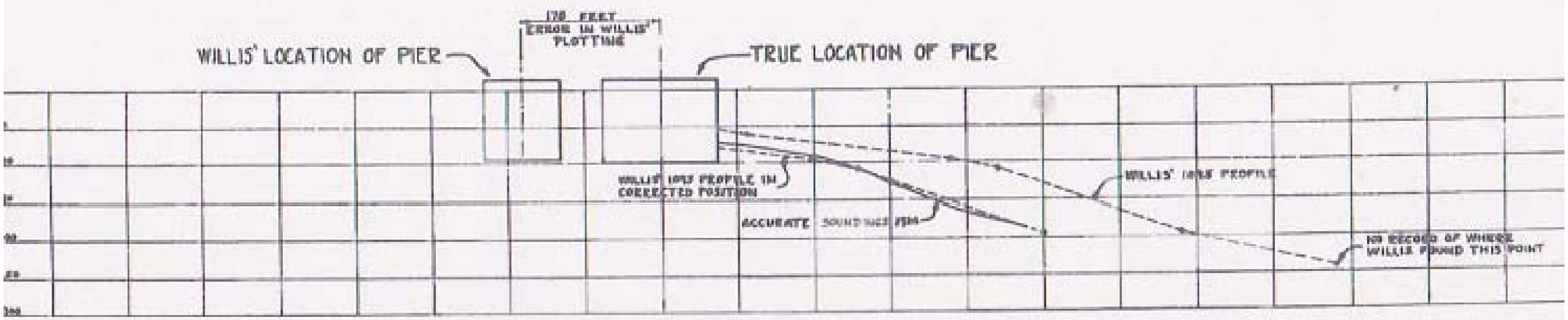
RE: excerpt from: *Building Committee Report,* Nov. 27th 1934



SKETCH TO ACCOMPANY
REPORT OF CHIEF ENGINEER
ON BAILEY WILLIS HEARINGS

FIG. 1


Willis' Location.
West
East
Notice false dimensions in depth and location of channel, height of tower, and size of pier for the purpose of exaggerating alleged instability.
South Pier
Serpentine
Sandstone
Actual Section.
West
East
South Pier
Serpentine
Depth 241'
Scale in Feet.
Sketch to accompany report of Chief Engineer on Bailey Willis hearings



PROFILES ALONG ℄ OF BRIDGE

HORIZONTAL SCALE SAME AS VERTICAL

SKETCH TO ACCOMPANY
REPORT OF CHIEF ENGINEER
ON BAILEY WILLIS HEARINGS

"'…Every statement, which, if left unchallenged, might alarm the general public regarding the safety of the bridge, has been carefully scrutinized, checked and analyzed and found erroneous as to the fact or inference…'

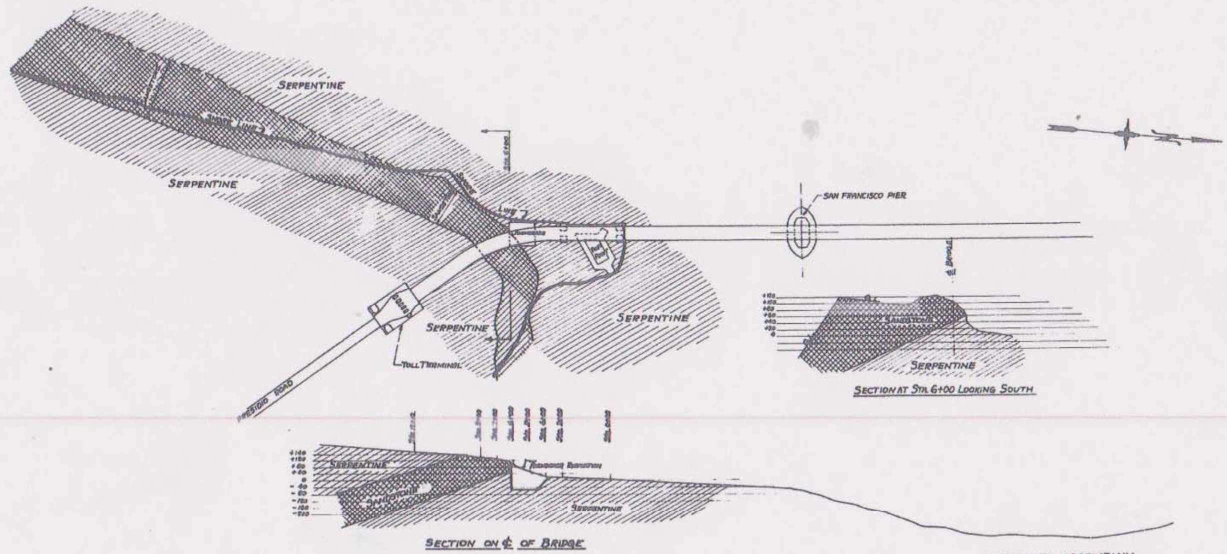
To determine the existence of any sandstone under the pier a hole was drilled into the foundation…immediately inside the fender wall…The drilling proceeded to a depth of 251.62 feet below sea level and 159.37 feet below the base of the pier. Professor Lawson reports:

'The cores recovered show that the hole for the entire 159.37 feet passes through serpentine and through nothing else. To the limit of the depth reached there is no sandstone and no fault. The information yielded by this drilling effectively and completely negates the statements which Professor Willis has published so widely, so persisitently, and so maliciously…it is in my opinion unnecessary to do any further drilling into the foundation rock of the south pier…'"

RE: excerpt from: *Building Committee Report*, Nov. 27th 1934[357]

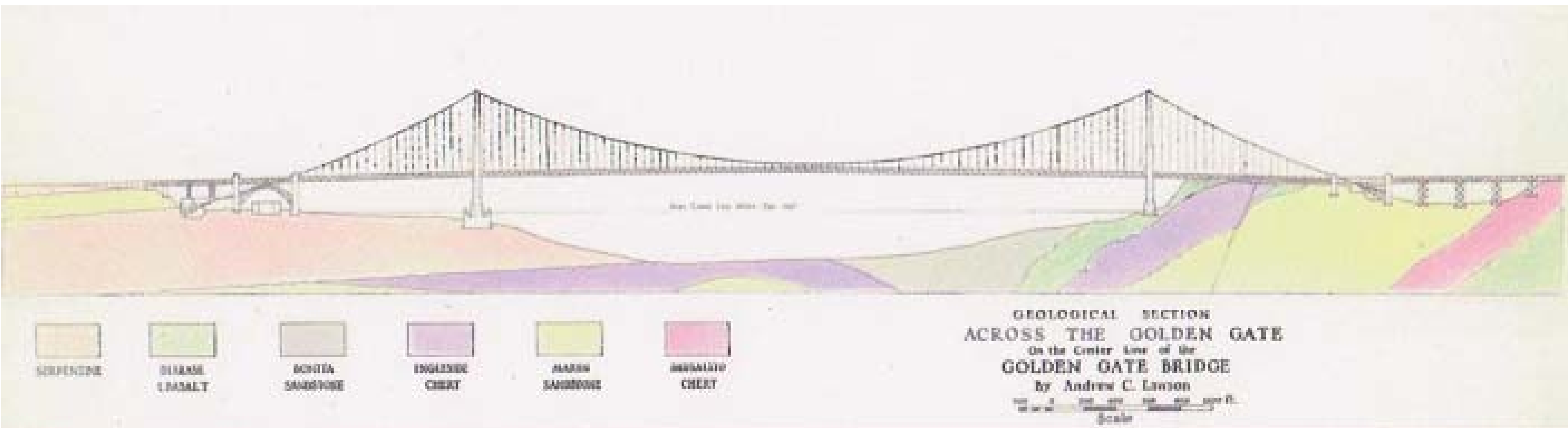
"…Professor Willis was inaccurate in locating the pier and he did not avail himself of the facts which were accessible, and his reasons for not doing so are mere pretext. It was his duty as a man of science, contemplating a report of the type which he transmitted to Washington, to investigate all the facts. This he did not do. The conclusions of the Committee are not based upon what may be the misconduct of Professor Willis but are based upon the facts. Professor Willis has not substantiated his conclusions. The Committee is satisfied that the serpentine structure is sufficient and that there is no sandstone within any range which should concern the Board of Directors. The Committee recommends, therefore, that the Board of Directors disregard the recommendation of Professor Willis."

RE: excerpt from: ***Building Committee Report,*** **Nov. 27th 1934**



SKETCH TO ACCOMPANY
REPORT OF CHIEF ENGINEER
ON BAILEY WILLIS HEARINGS

FIG. 2


SERPENTINE
GEOLOGICAL SECTION
ACROSS THE GOLDEN GATE
On the Center Line of the
GOLDEN GATE BRIDGE
By Andrew C. Lawson
Scale

Dr. Bailey "Earthquake" Willis' attempts to derail the building of the south pier/tower of the Golden Gate Bridge via faulty and misleading information ultimately failed, but he did succeed in casting the seed of doubt in the mind of the public and, more importantly, government officials. The *Public Works Administration* (forerunner of the *Works Progress Administration*) grant the District was seeking from the federal government (for expediting the construction of the southern approach and for purchasing large amounts of District bonds) never materialized as a result of Willis' report to Colonel Wilder, California representative of the PWA. Willis was an academic with degrees from *Columbia University* in Mining Engineering (1878) and Civil Engineering (1879). He played fast and loose with the facts and appears to have been unaware and/or indifferent to much of the technical data gathered by Professors *Andrew C. Lawson* – a Geologist, and Professor *Allan E. Sedgwick* of USC – a Consulting Geologist, concerning the south pier that was comprehensive and public record. His motivations and actions were highly suspicious, given the facts of the affair.

On December 3rd 1934, Chief Diver *Chris Hanson*, Resident Engineer *Russell Cone* and pier superintendent *Jack Graham* descended into an inspection well. At 107-feet below the waves of the strait, they inspected the bedrock and found it to be ideal for founding the south tower's pier

ENGINEERS EXAMINING ROCK STRUCTURE, SAN FRANCISCO PIER,

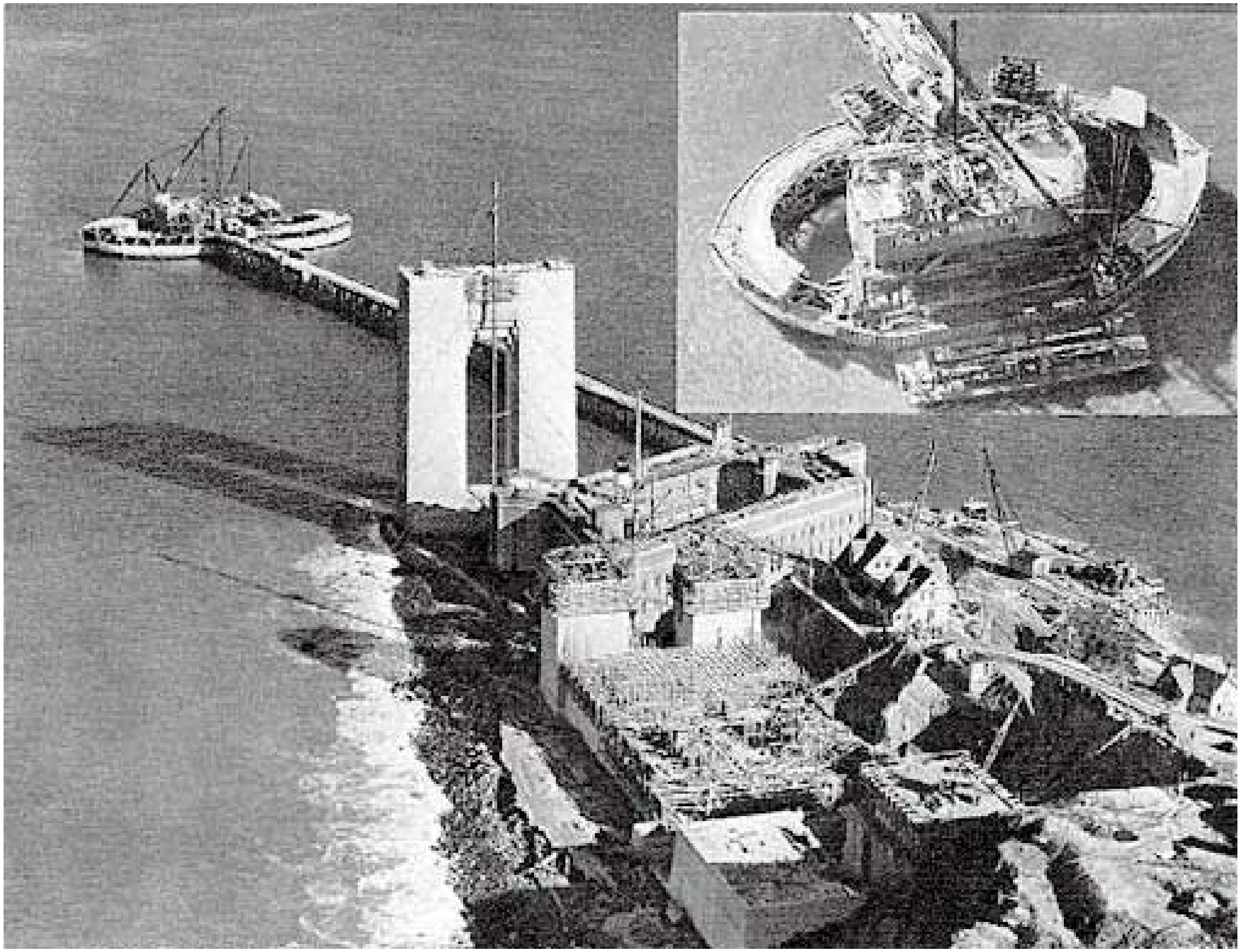
BOTTOM INSPECTION WELL, 108' BELOW SURFACE.

"The rock of the entire area is compact, strong serpentine remarkably free from seams…When struck with a hammer, it rings like steel."

Andrew Lawson – UC Berkeley Geologist, December 1934

The bottom of the south pier rests 110-feet (34-meters) below the mean low water-line.

Atop the completed pier



Part 7

Tale of Two Towers

Contract I-A

Steel Superstructure (Towers)

RECORD STEEL ORDER NEEDED FOR BRIDGE

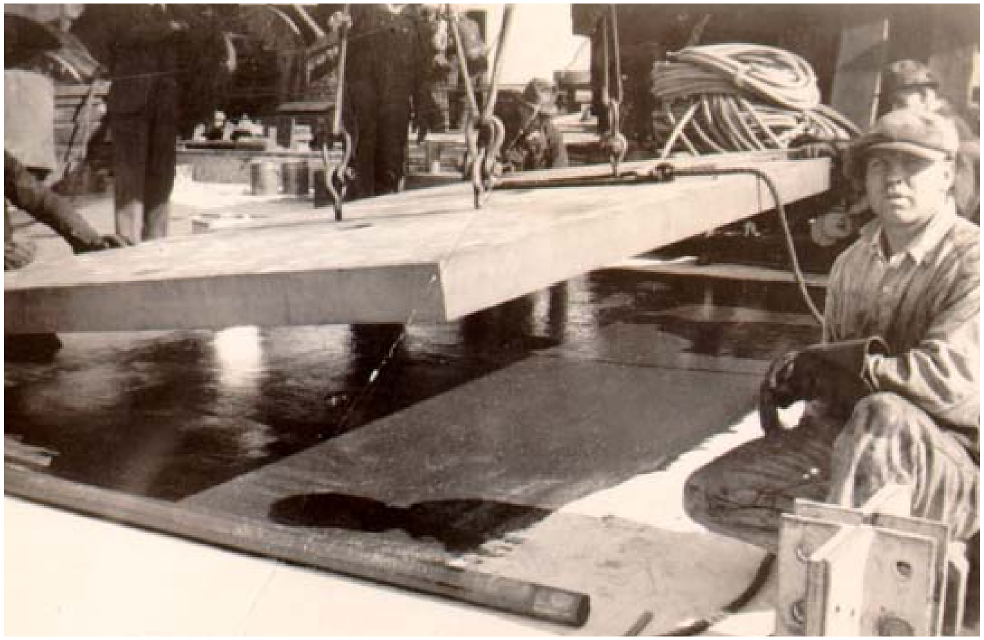
55,000 Tons Will Be Required for Span Over Golden Gate Bay

(By International News Service)

Philadelphia, June 3. — Fifty-five thousand tons of steel, constituting the largest single consignment of its kind ever to leave an American port and destined to be linked together to form the $33,000,000 Golden Gate bridge at San Francisco, will be shipped from Philadelphia within the next three years.

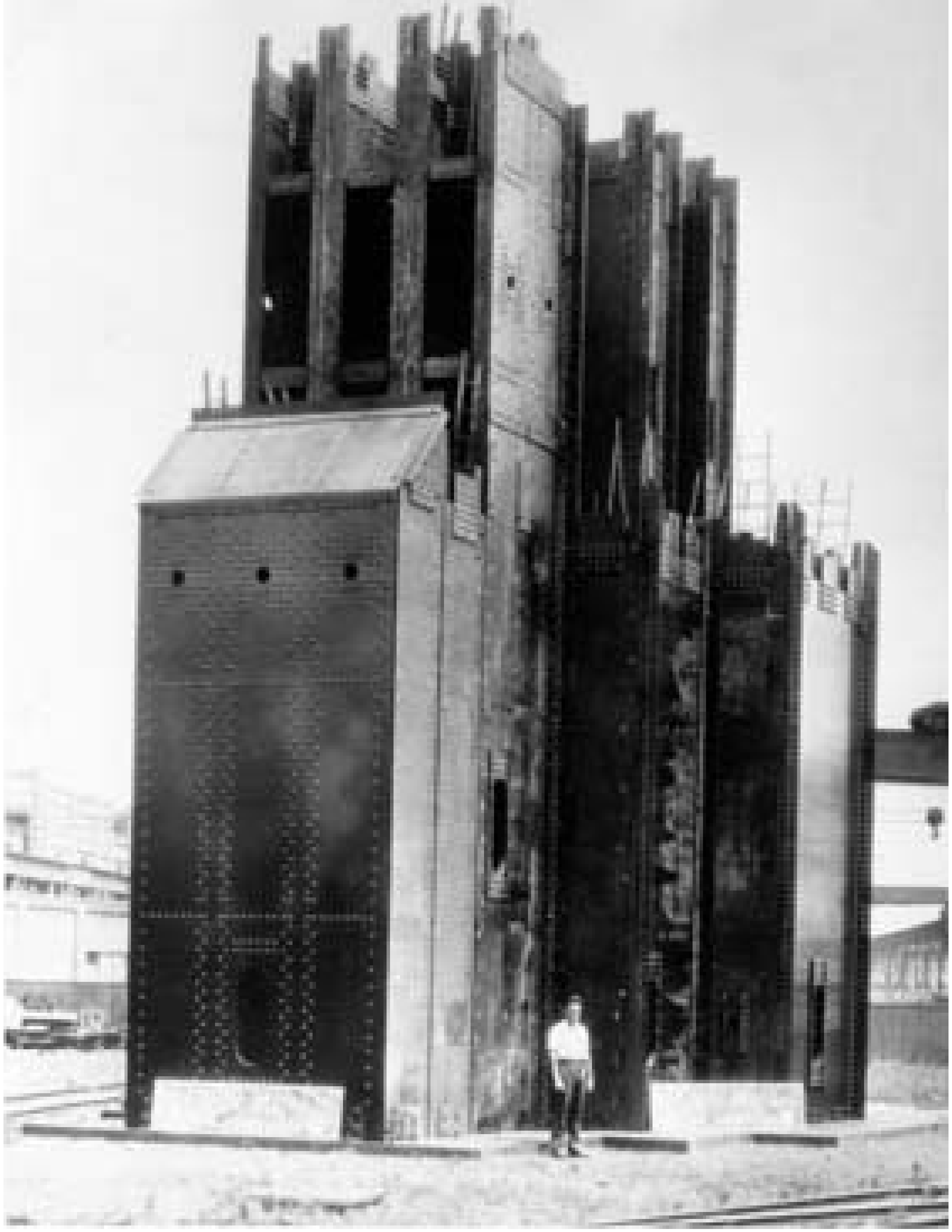
Marin Tower

On November 7th 1933, steel base plates for the Marin tower were laid atop the pier, marking the beginning of tower construction for the Golden Gate Bridge. Pre-fabricated “honeycomb” sections were lifted into place by a “creeper crane” that rose between the two legs of the tower. Four-man rivet gangs would then join the sections together with 800-degree white-hot rivets.



Installing Tower Base Plates

The pre-fabricated steel sections for the tower "cells" were fabricated by the *Bethlehem Steel Corp*. at their Pennsylvania foundry. To make sure everything fit (before shipping), test assemblies were used effectively. Once assured of proper fit, the sections were taken by rail to Philadelphia and from there loaded onto freighters to be transported by sea (through the Panama Canal) to San Francisco. The sections were off-loaded (into a storage yard) and, when needed, brought to the tower site by barge where they were hoisted by crane into position.



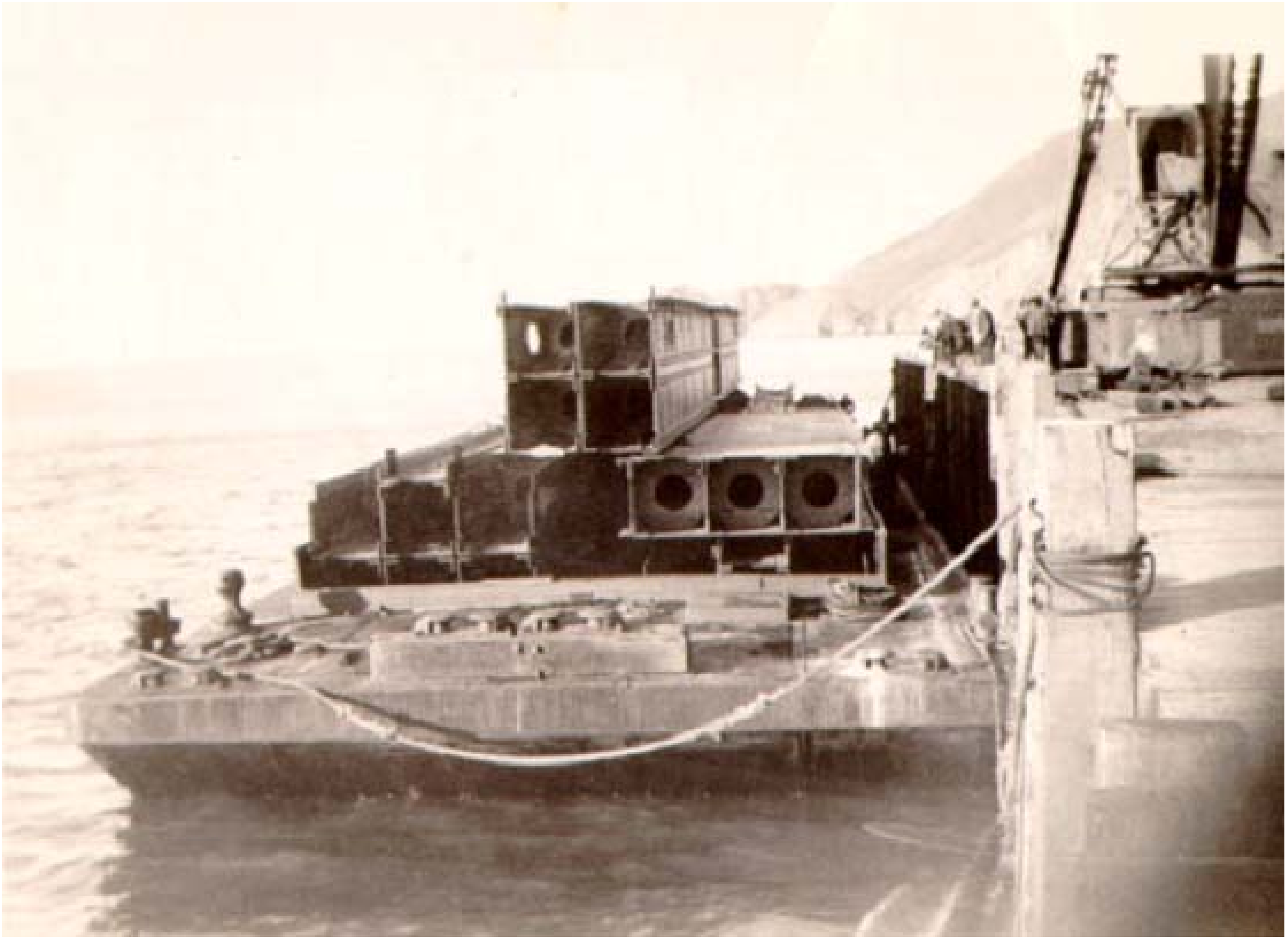
Tower Test Assembly (at PA foundry)

Loading Tower Sections
(onto rail cars at foundry)

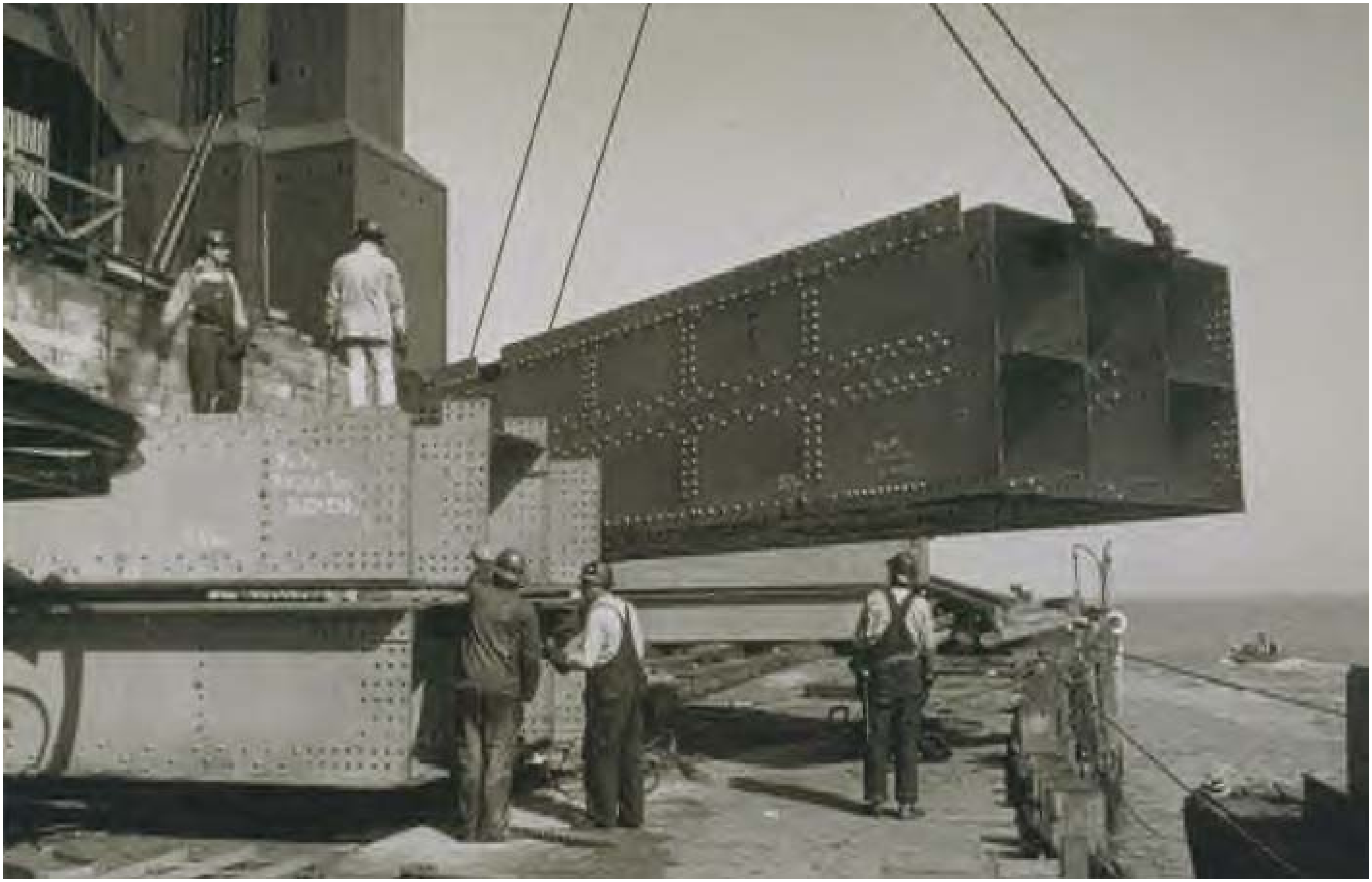
Tower Steel Sections
(being transported by rail to Philadelphia)

Tower Steel Sections
(being loaded onto freighter)

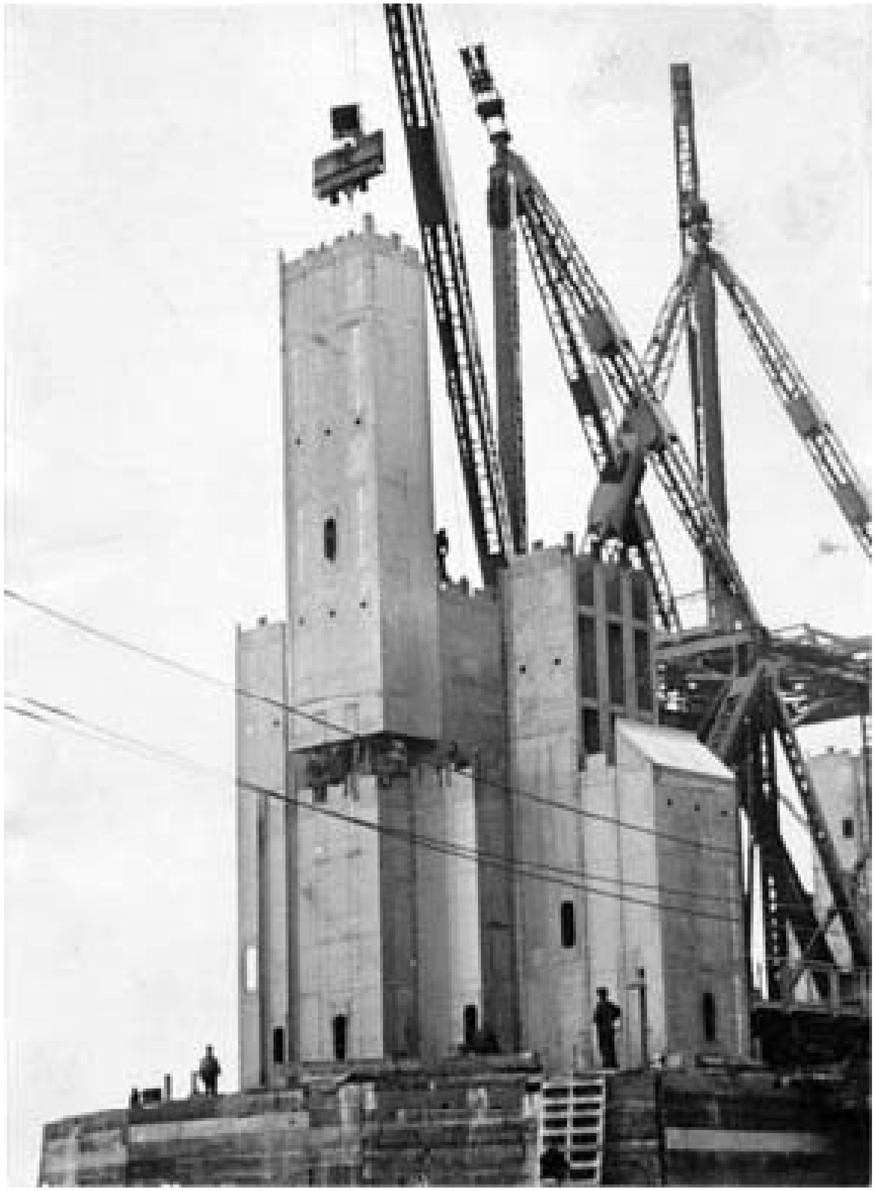
Off-Loading Tower Sections
(San Francisco)

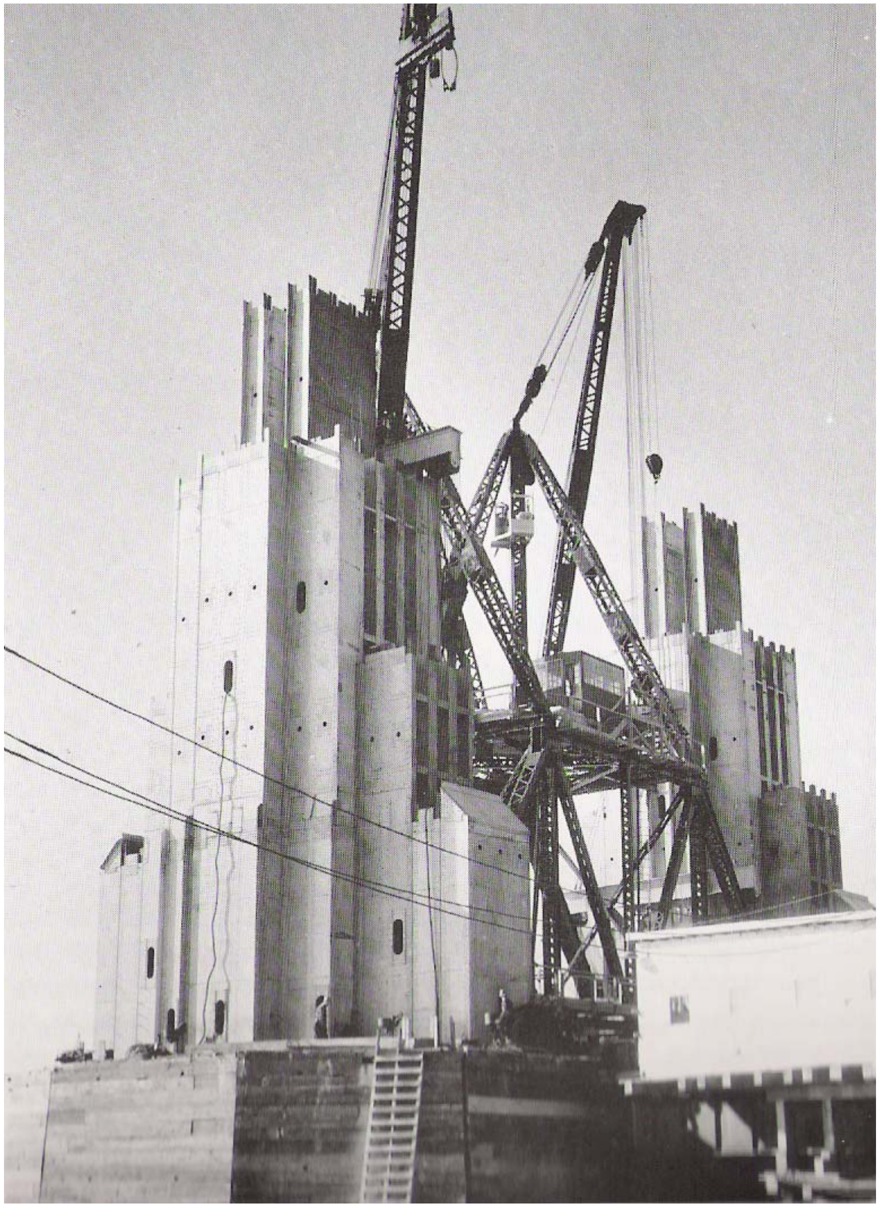


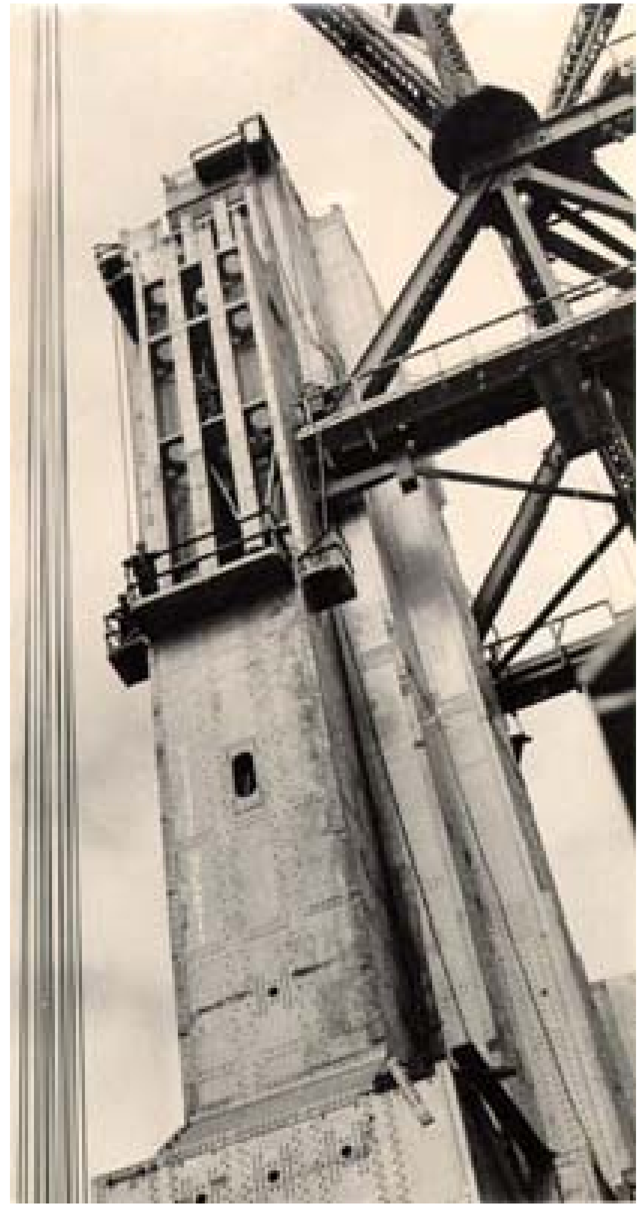
Barge with Steel Sections
(adjoining pier)

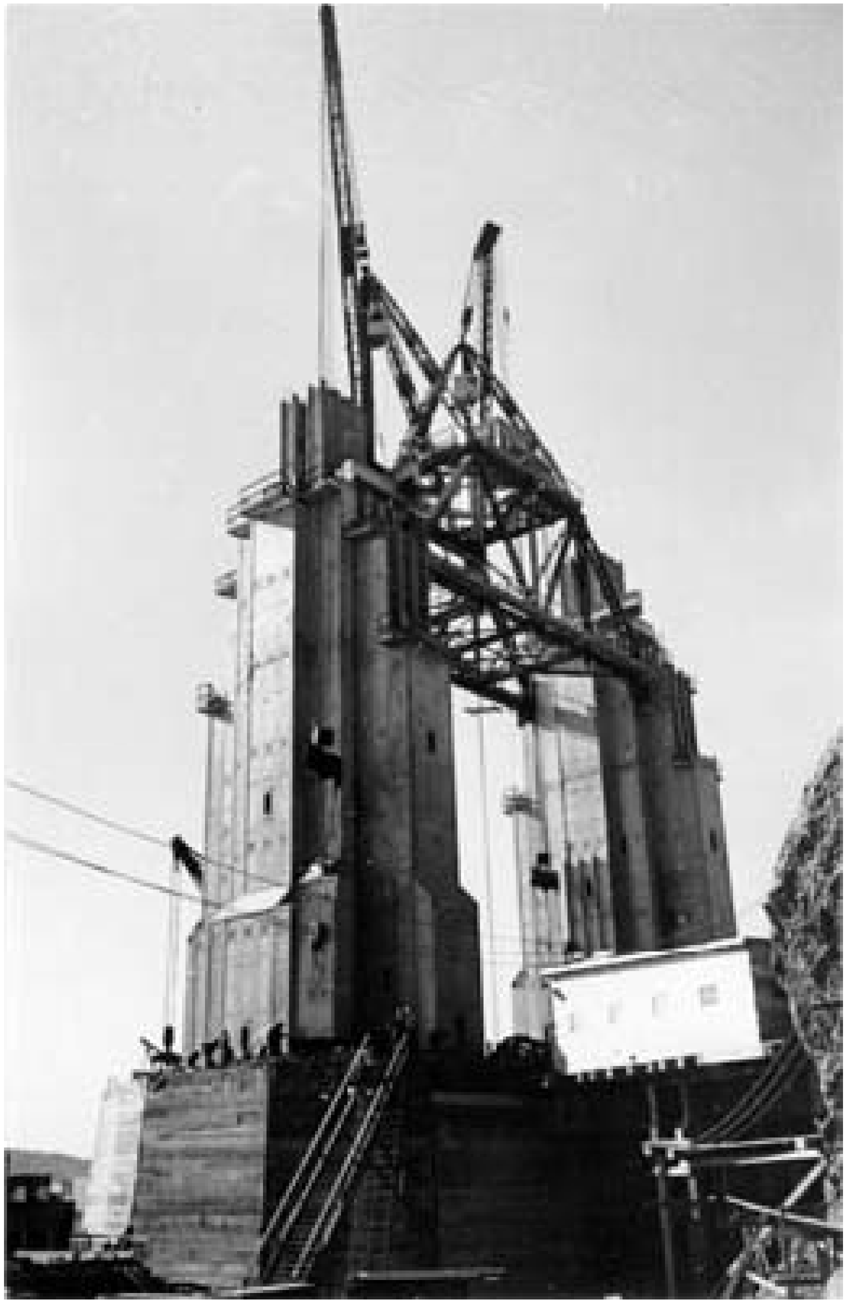


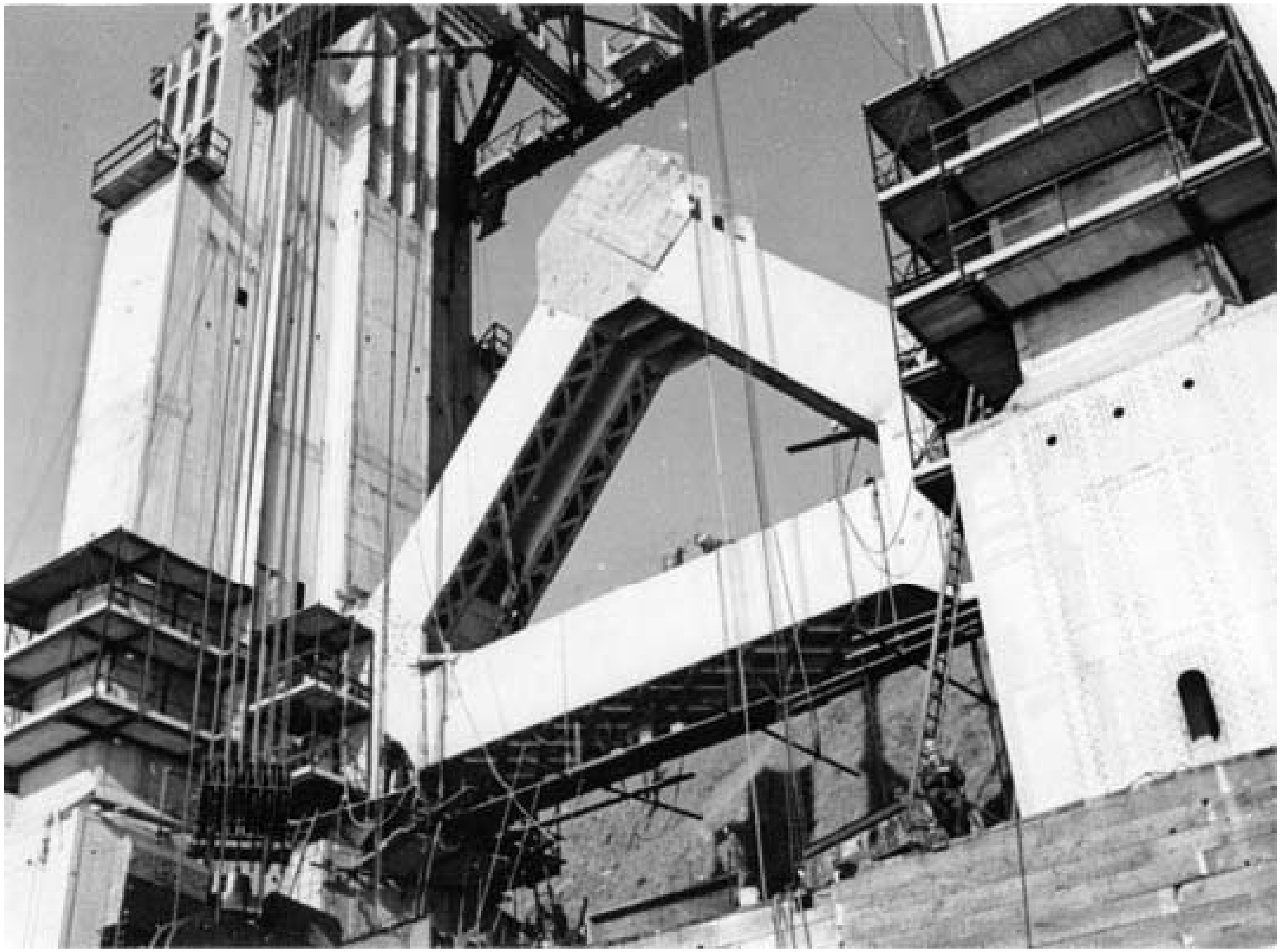
Tower Section on Pier
(being lifted into position by creeper crane)

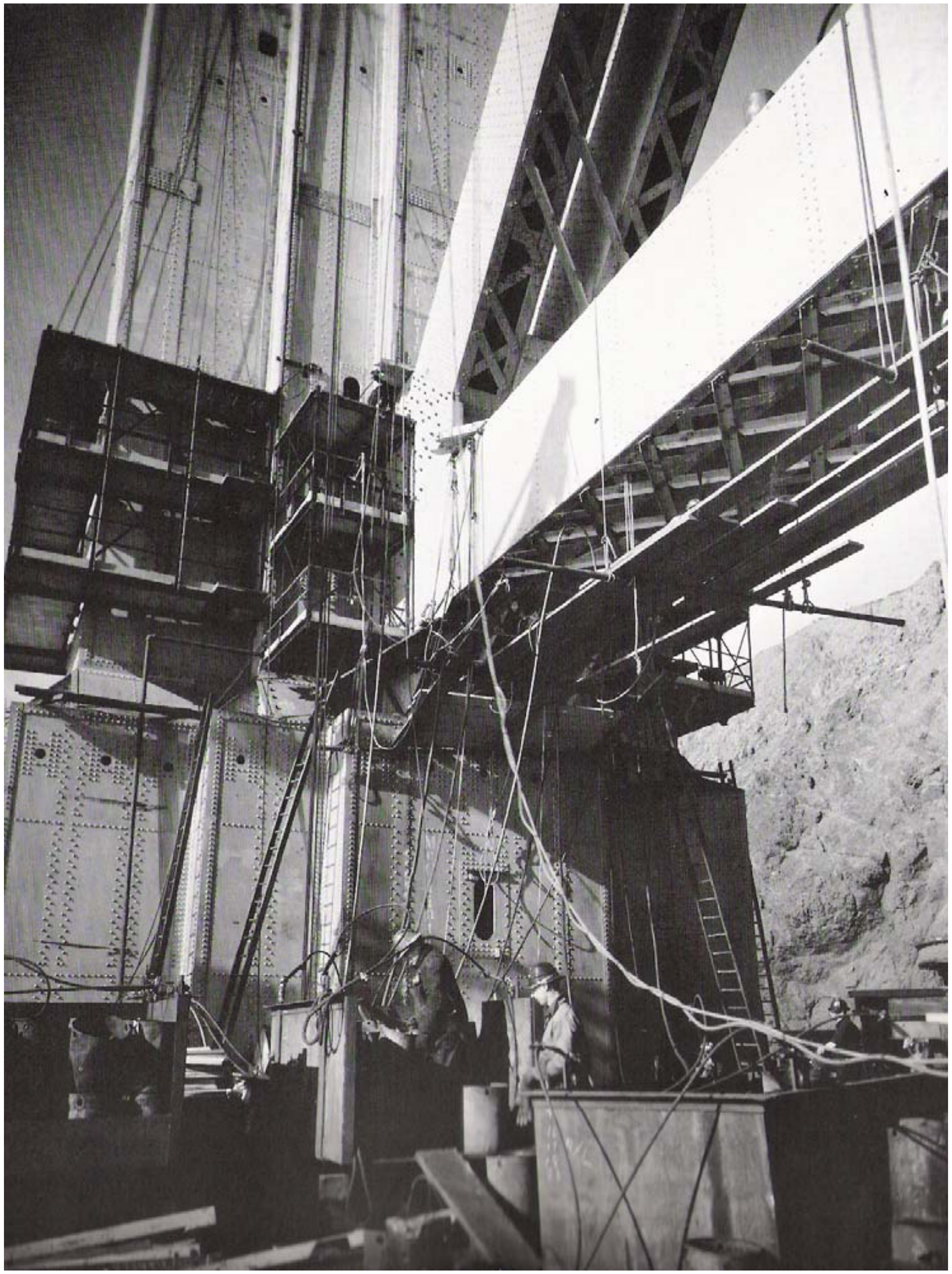








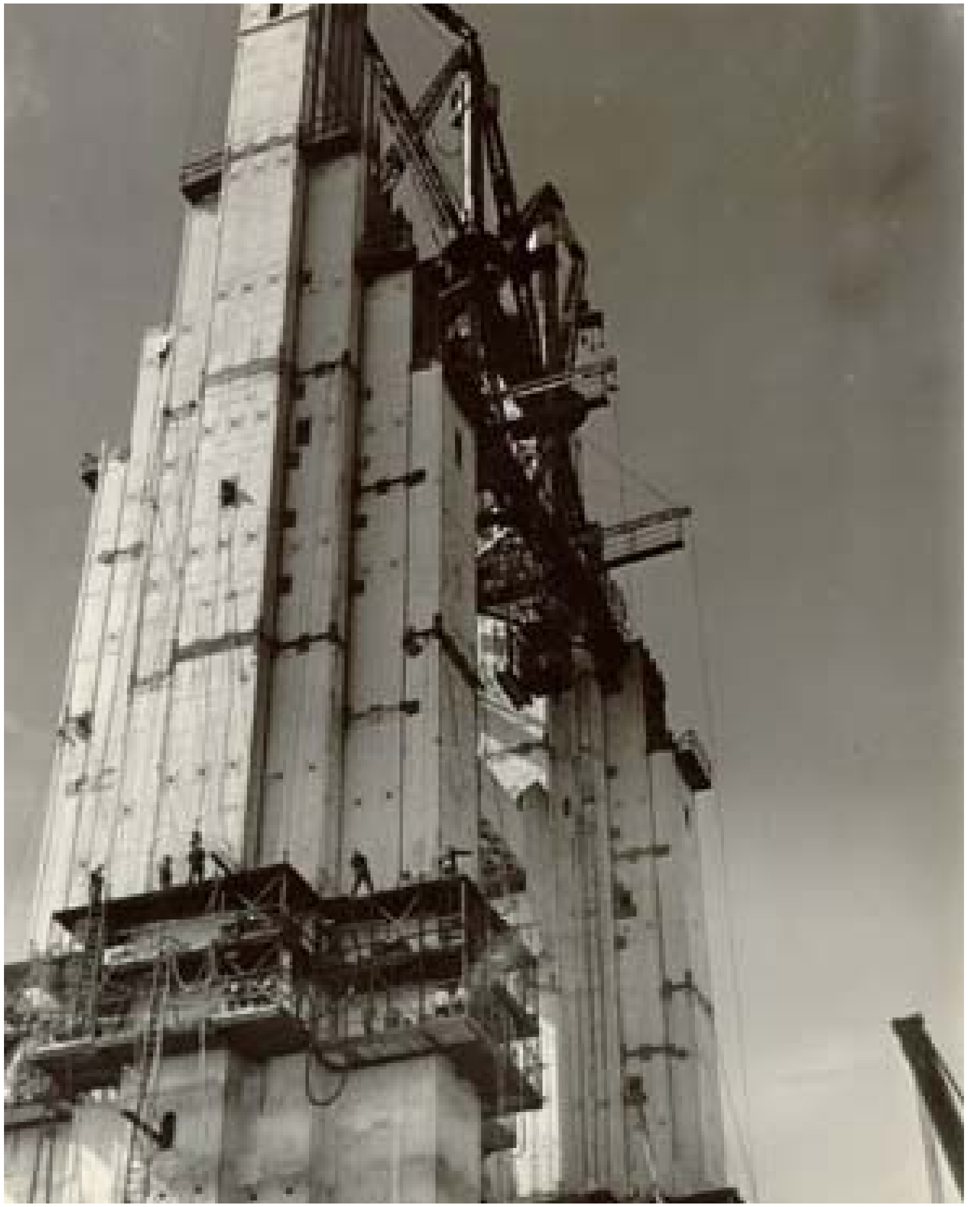


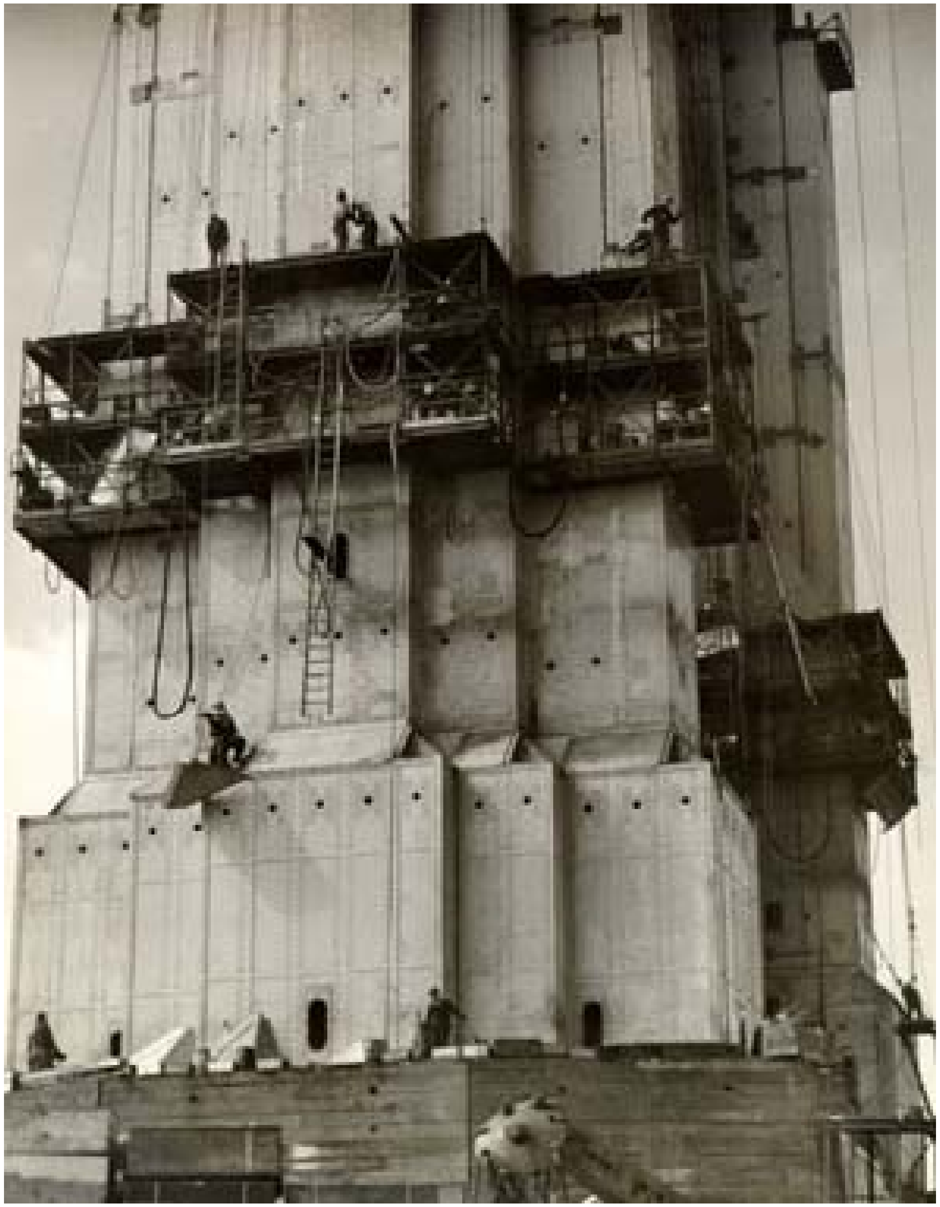


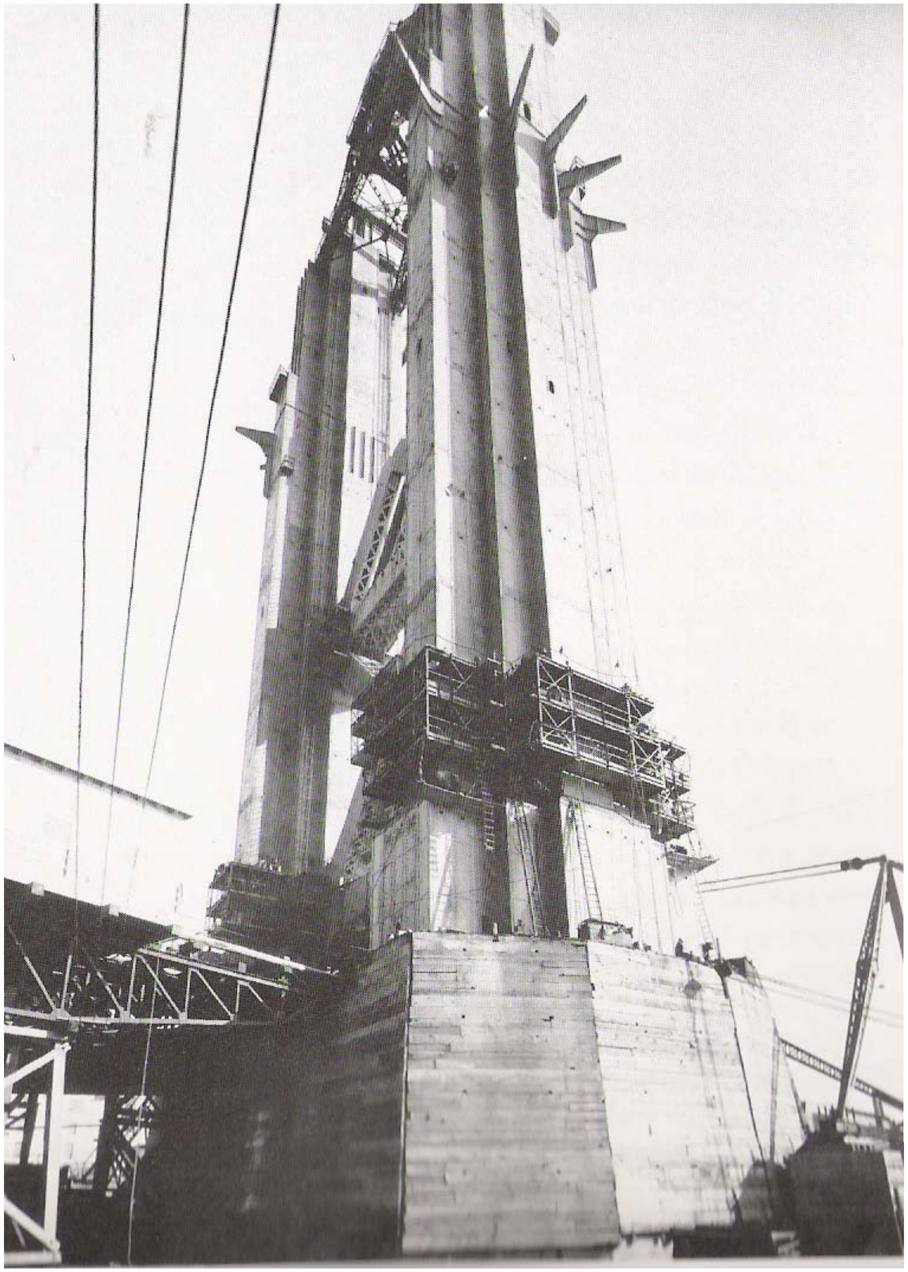
"Although I designed this weird labyrinth, I doubt if I could find my way out of it, even with the aid of the twenty-six page manual issued to direct the watchmen who inspect the towers over the twenty-three miles of ladders that connect the cells"

Joseph Strauss – Chief Engineer, Golden Gate Bridge

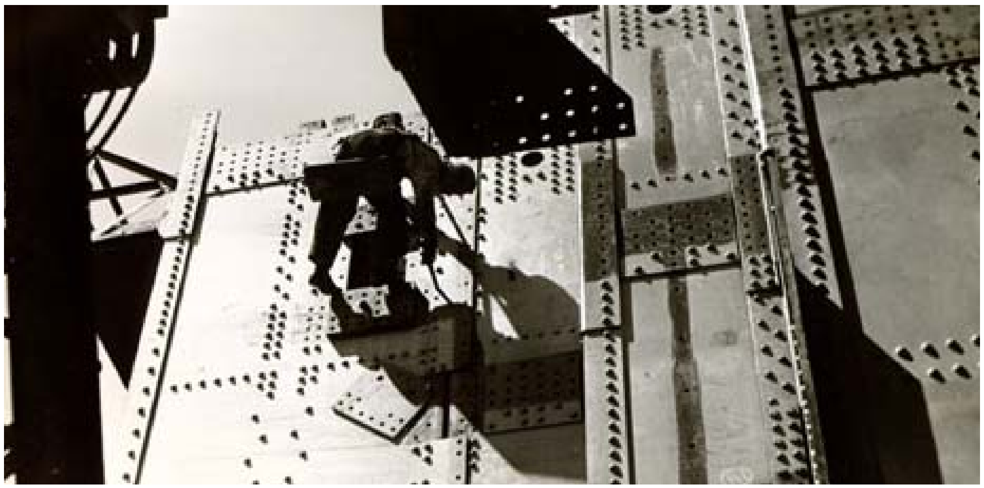
RE: ninety "routes" through the mass of honeycomb cells that made up the structure of the two towers – accessed via holes







Creeper Crane
(lifting steel sections into position)

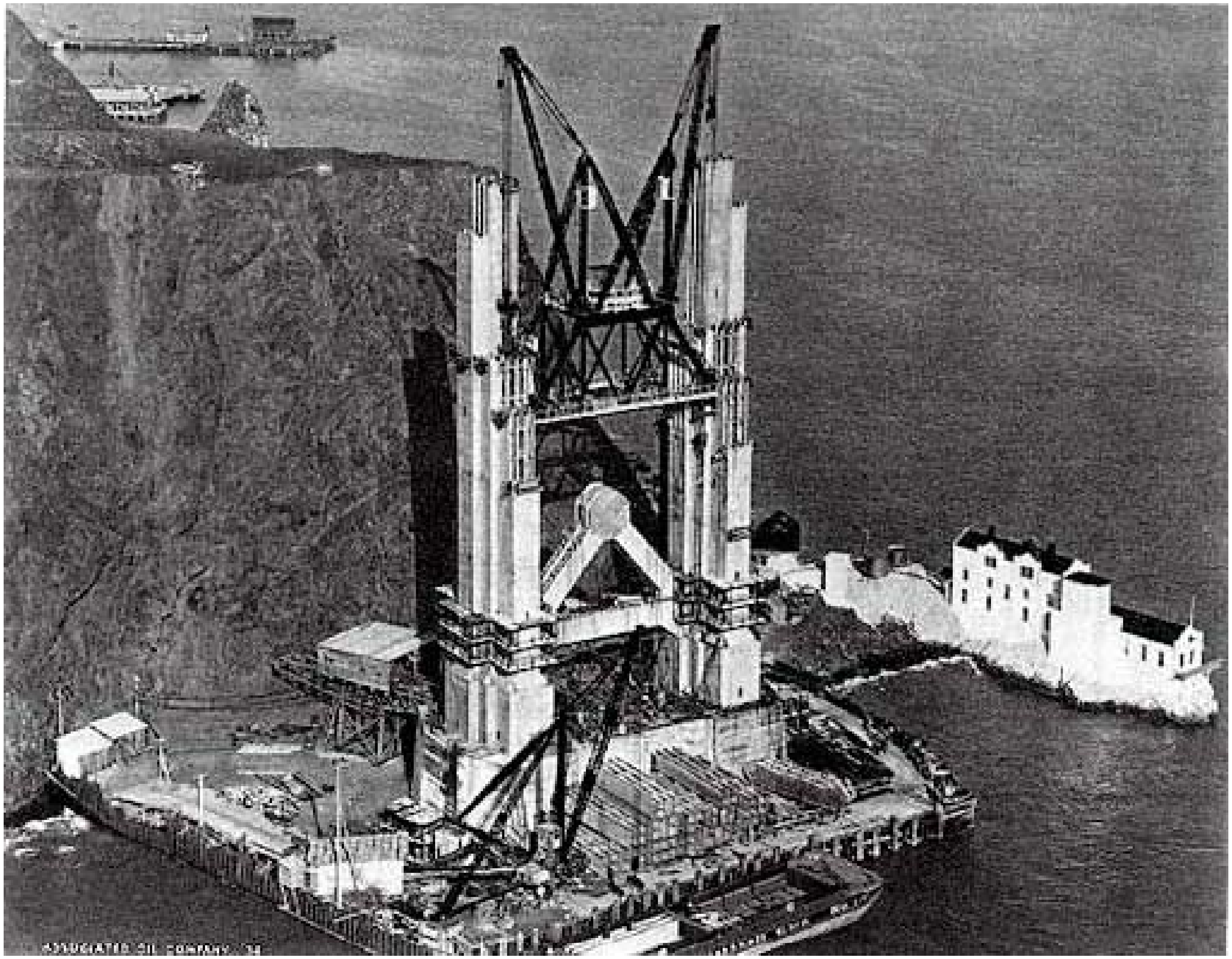


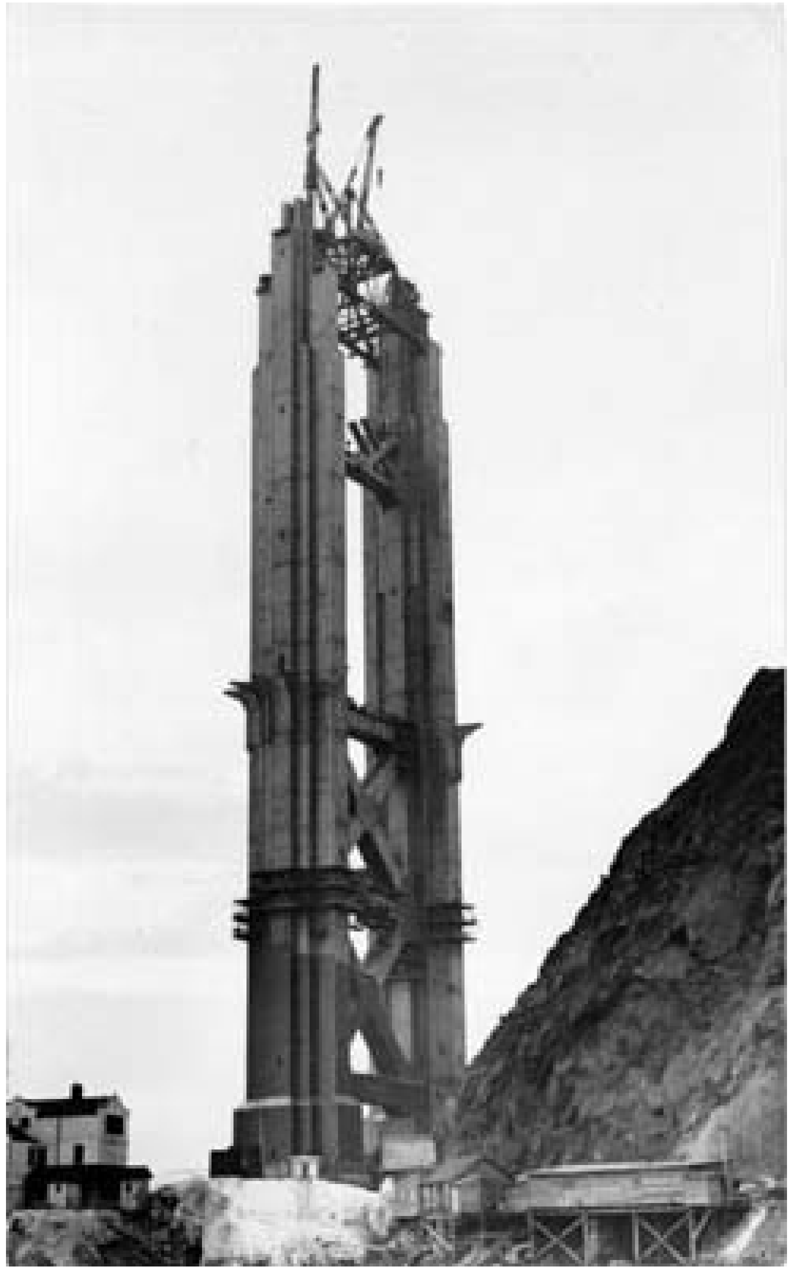
"They went 'Zing' just like a bullet…and you best catch it, and take it out, and you had to put it in fast"

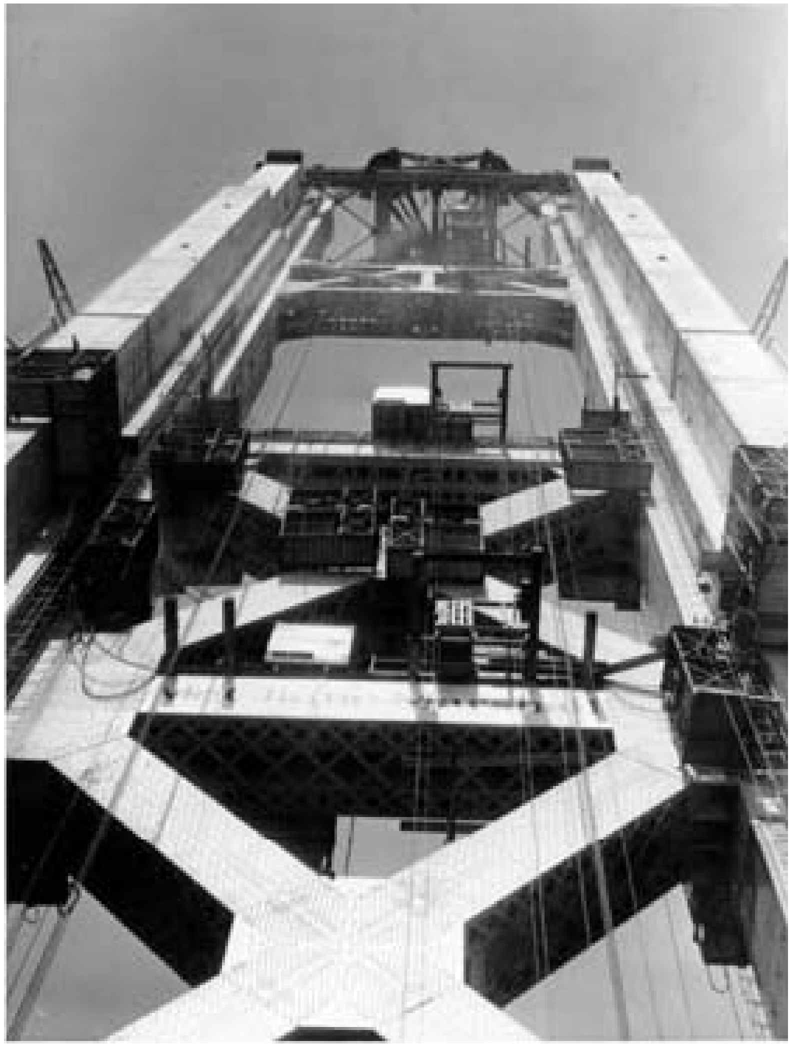
Walter Vestnys, Ironworker

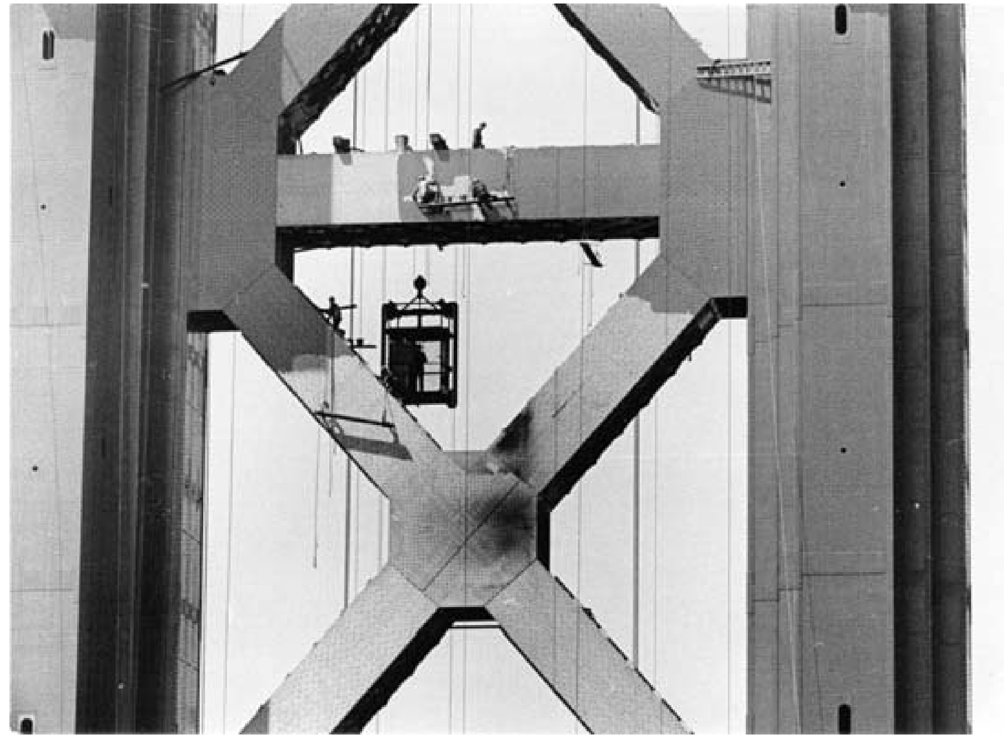
RE: Riveting

Approximately 1.2 million rivets were used to construct the GGB









Personnel Hoist
(top)

Safety, Safety, Safety

At the time of the bridge's construction, the rule of thumb for building suspension bridges was that one workman would die for every million dollars of cost, Strauss set out to change those odds by making safety a priority. A Bay Area manufacturer of safety equipment – *Edward W. Bullard*, modified the pickled-leather mining helmet he developed into an industrial hard-hat that Strauss insisted be worn at all times. Bullard also developed a sand-blast respirator.

Pickled-Leather Hard-Hat
(w/Lantern)

Sand-Blast Respirator

Suspecting lead poisoning among the riveters in the tower cells, he made them;

- **wear glasses and respirators (the men didn't always comply – they would typically remove them once inside the tower cells and put them back on when exiting)**
- **take physical exams – including blood counts, every two weeks**
- **demanded clean hands, to prevent hand-to-mouth infection**
- **changed from red-lead to iron-oxide paint when his fears of lead poisoning were confirmed (the 800-degree rivet/s would vaporize the lead in the paint/primer on contact)**

Respirator

"On the Golden Gate Bridge, we had the idea we could cheat death by providing every known safety device for workers. To the annoyance of the daredevils, who loved to stunt…we fired any man caught stunting on the job."

Joseph Strauss - Chief Engineer, Golden Gate Bridge

RE: excerpt from the *Saturday Evening Post*, 1937. His obsession with safety included;

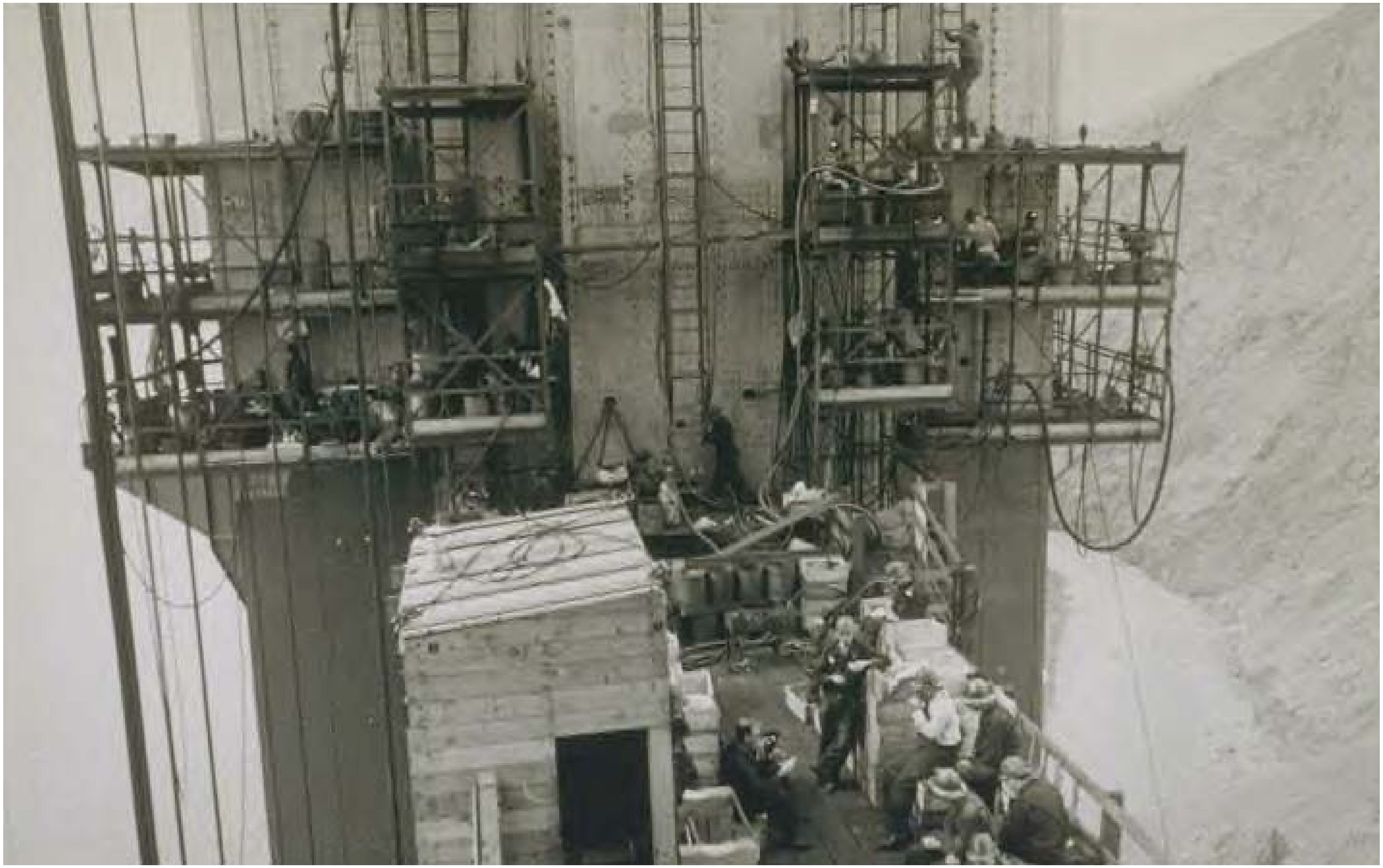
*** Doctor and nurse present on construction wharf at all times**

*** Mandatory wearing of 3/8-inch diameter by ten-foot long safety belt, rope and leather hard-hat**

*** Tinted safety goggles to avoid snow blindness from white fog banks**

*** Served "sauerkraut juice" to workers with hangovers on Monday mornings**

*** Fired any man who "stunted" on the job**



The Golden Gate was not the first big job to feature hard hats and safety lines as some have claimed. But it was the first to enforce their use with the threat of dismissal."

Stephen Cassady, Author

RE: Strauss' safety obsession paid good dividends by reducing serious injuries and/or saving workers lives. The safety program was expensive, but it served publicity conscious Strauss well in presenting a positive image of the GGB to the public. Most worker injuries were caused by falling objects thus mandatory wearing of hardhats was a critical component of the program. Resident Engineer Russell Cone was a strict enforcer of Strauss' safety program, in particular wearing of hardhats at all times and dismissal for "stunting." In April 2012, Jack Balestreri – the last surviving GGB workman, passed away.

The Golden Gate is the largest (and lowest) gap in the coastal range of California. As such, in the summer it was often shrouded in a heavy, chilly fog propelled by strong winds surging through the strait. In just a few hours, the temperature could drop up to thirty-degrees, the result of the cold Pacific meeting the humid air of the Bay. When the bridge was completed in 1937, *Anemometers* and *Accelerometers* were placed on the bridge to record wind velocities/angles and span movement, which was considerable in a strong wind. On several occasions, strong, sustained winds have forced the temporary closing of the bridge to traffic due to excessive up and down movement (gallop) of the road deck. On February 9th 1938, a storm caused the deck to deflect up to ten-feet and in 1941, a 60mph wind caused the towers and deck to bend nearly five-feet. Both these events were within design tolerances. However, in December 1951 a severe storm caused the deck to "ripple" and officials decided to invest $3.5 million to add additional stiffening to the road deck.

"The fog would come in and go out, come in, go out, all day long. When it's wet, the iron is just like ice…pretty chancy when you have to walk around so much…a gust could come along and literally blow you right off"

Skip Lambert, Ironworker

I'd never been so cold in my life…A guy brought me an overcoat, and I put it on…Eventually I worked standing in half a barrel."

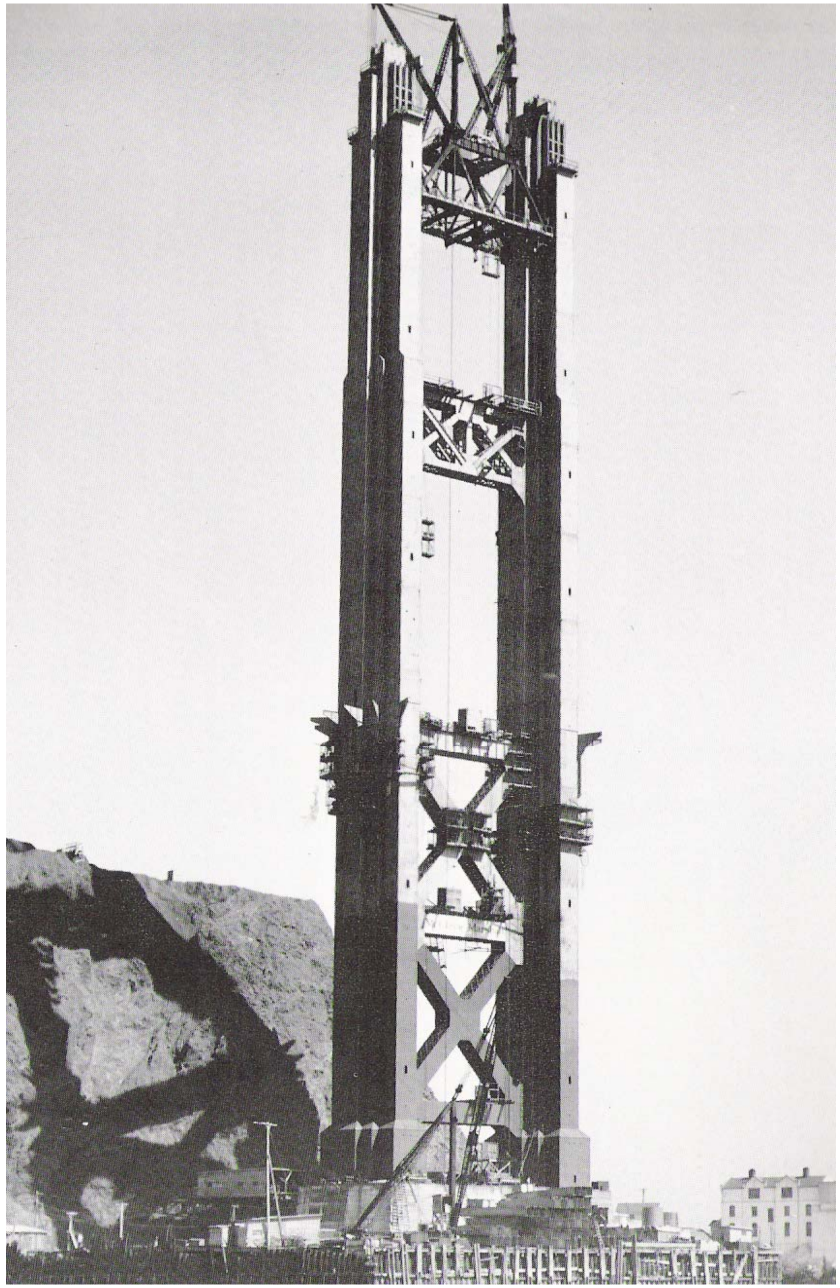
Harold McClain, Signaller

"You'd wonder what the hell you were doing out there. Fog, cold, wind in your face. Gusting winds and rain caused days of work delays."

George Albin, Bridgeworker

"…One would think it next to impossible to find men to take risks. But the very reverse is true. Bridgemen are a breed to themselves, strange migratory birds with an uncanny ability to sense the next big bridge job..."

Joseph B. Strauss – Chief Engineer, GGB



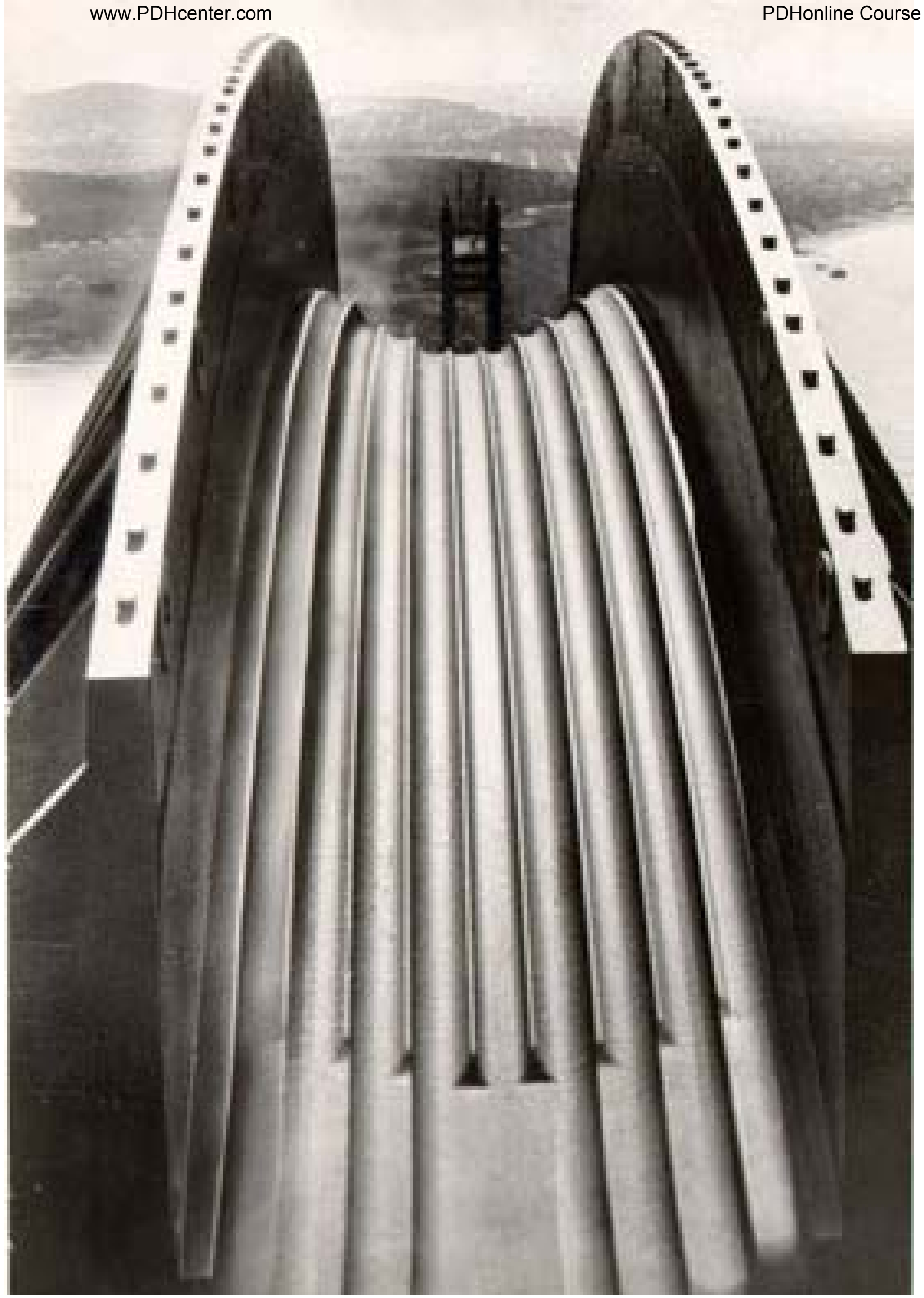
The Marin tower was "topped-off" on June 28th 1934 and completed in May of 1934. However, it would not be ready for cable spinning until November 1934.

Hoisting Cable Saddle Sections
(to top of tower)

Cable-Saddle Sections
(atop tower)

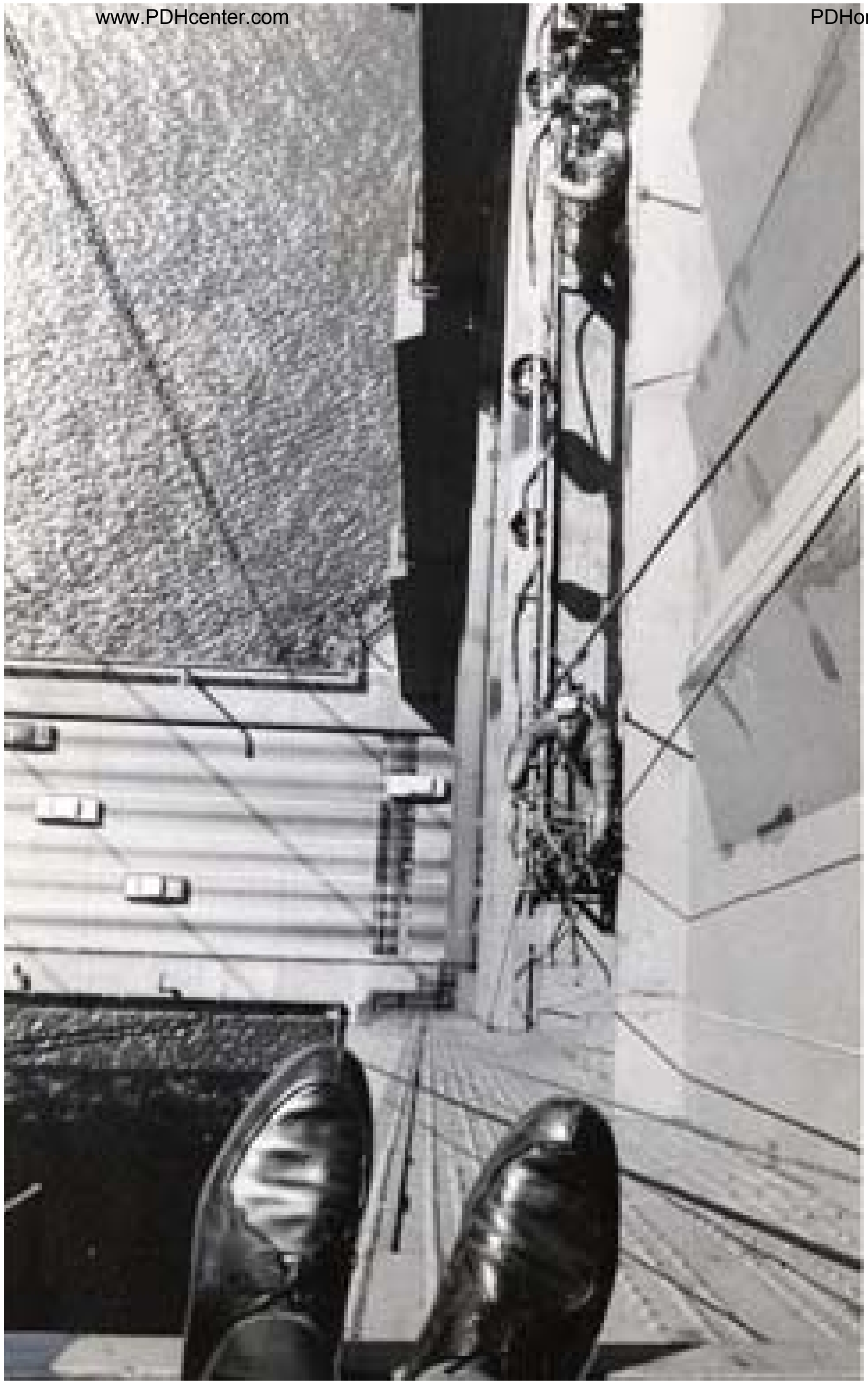
Cable-Saddle
(nearly complete)

Cable-Saddle (complete)



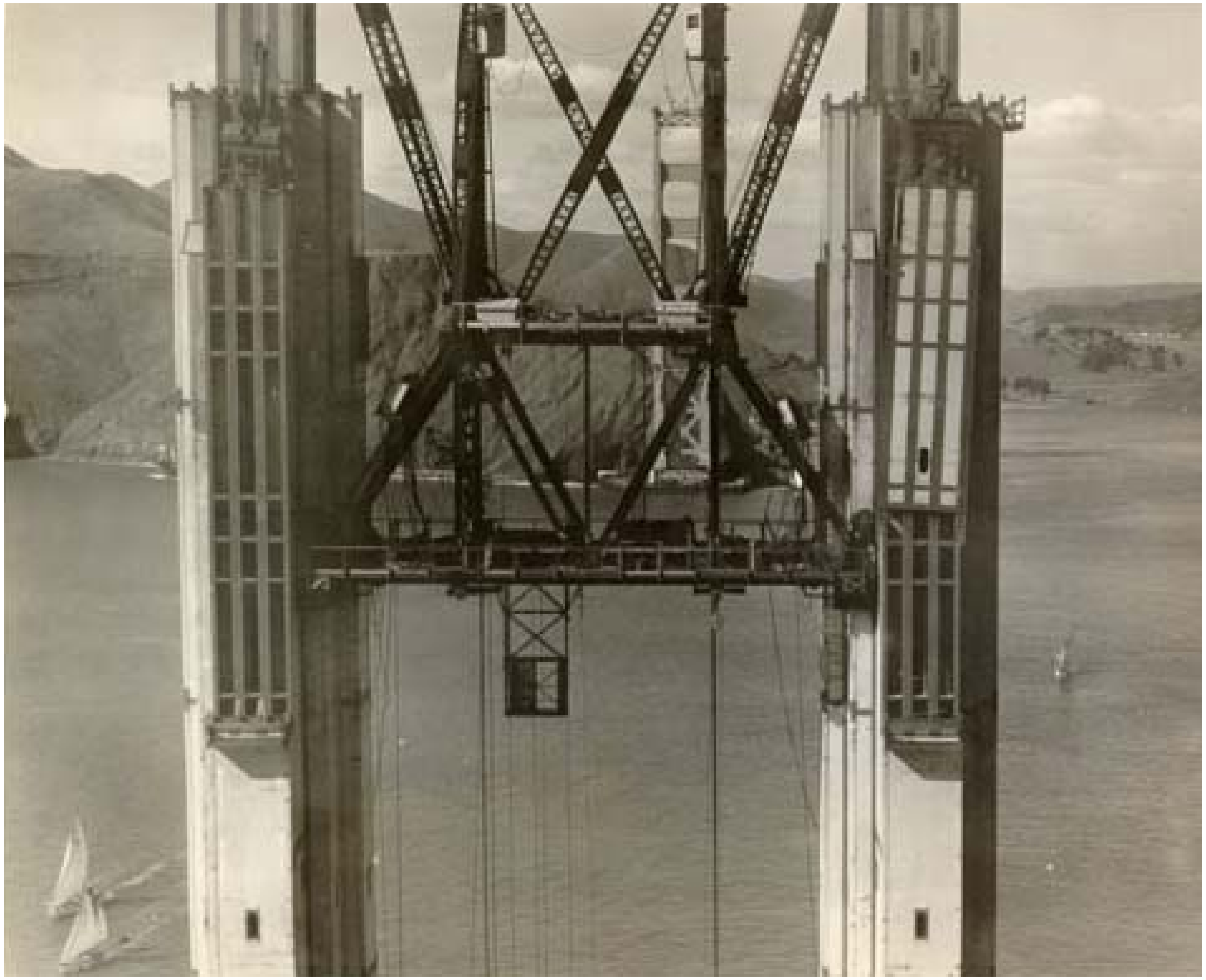
View Inside Cable Saddle. The grooves within the curvilinear base of the saddle are for the first nine cable strands to rest in (after being spun)

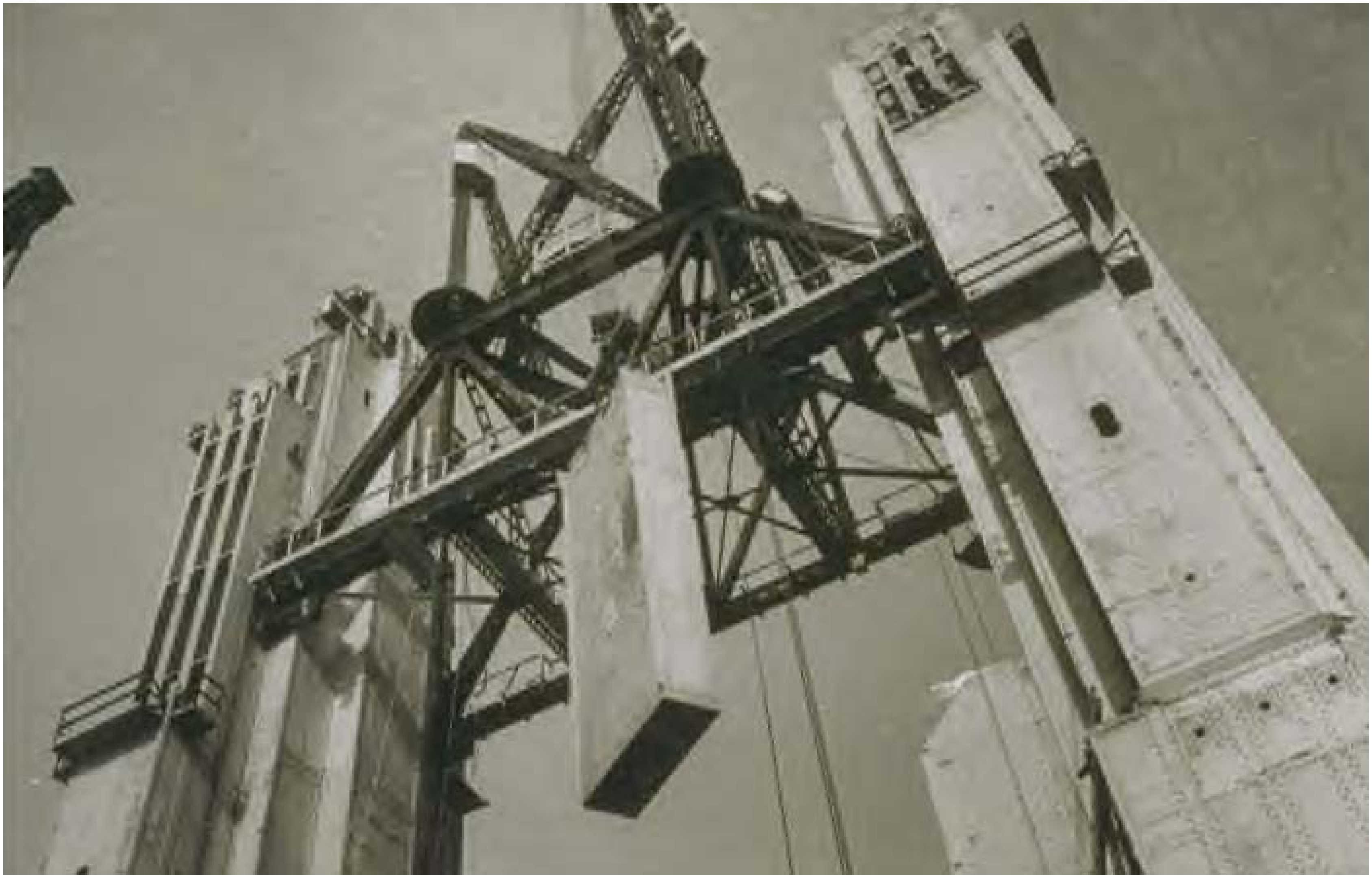
San Francisco Tower



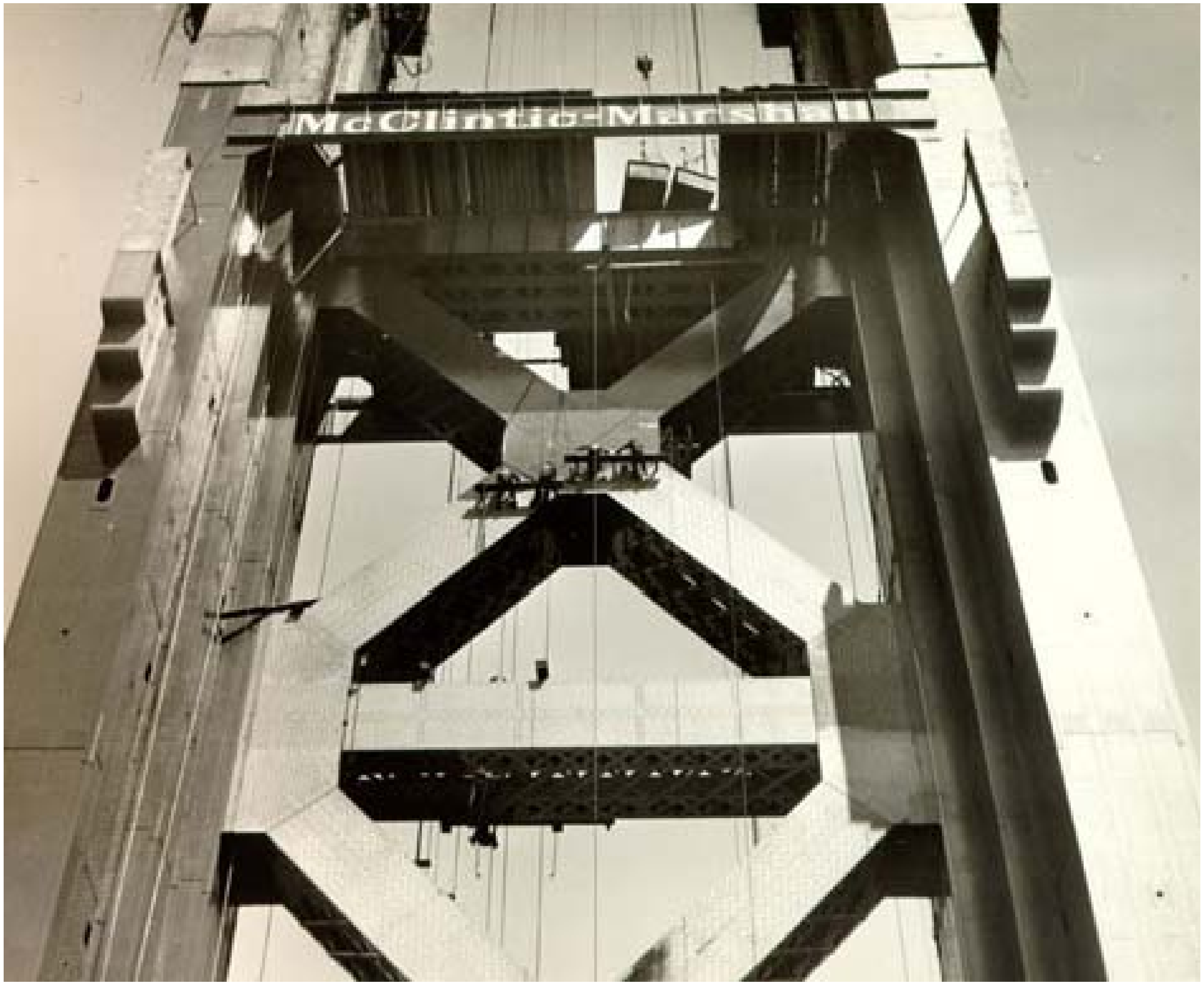
On January 8th 1935, the south pier was completed and erection of the San Francisco (south) tower could begin. It was finished on June 24th 1935, just six months later. Each tower rises 746-feet above the water-line and 500-feet above the road deck. Each leg of the tower/s measures 33-feet by 54-feet (at tower base). Combined, both towers weigh a total of 44K-tons. Each tower can deflect both in the transverse and/or longitudinal direction, 12.5-inches for the former and 22-inches for the latter.

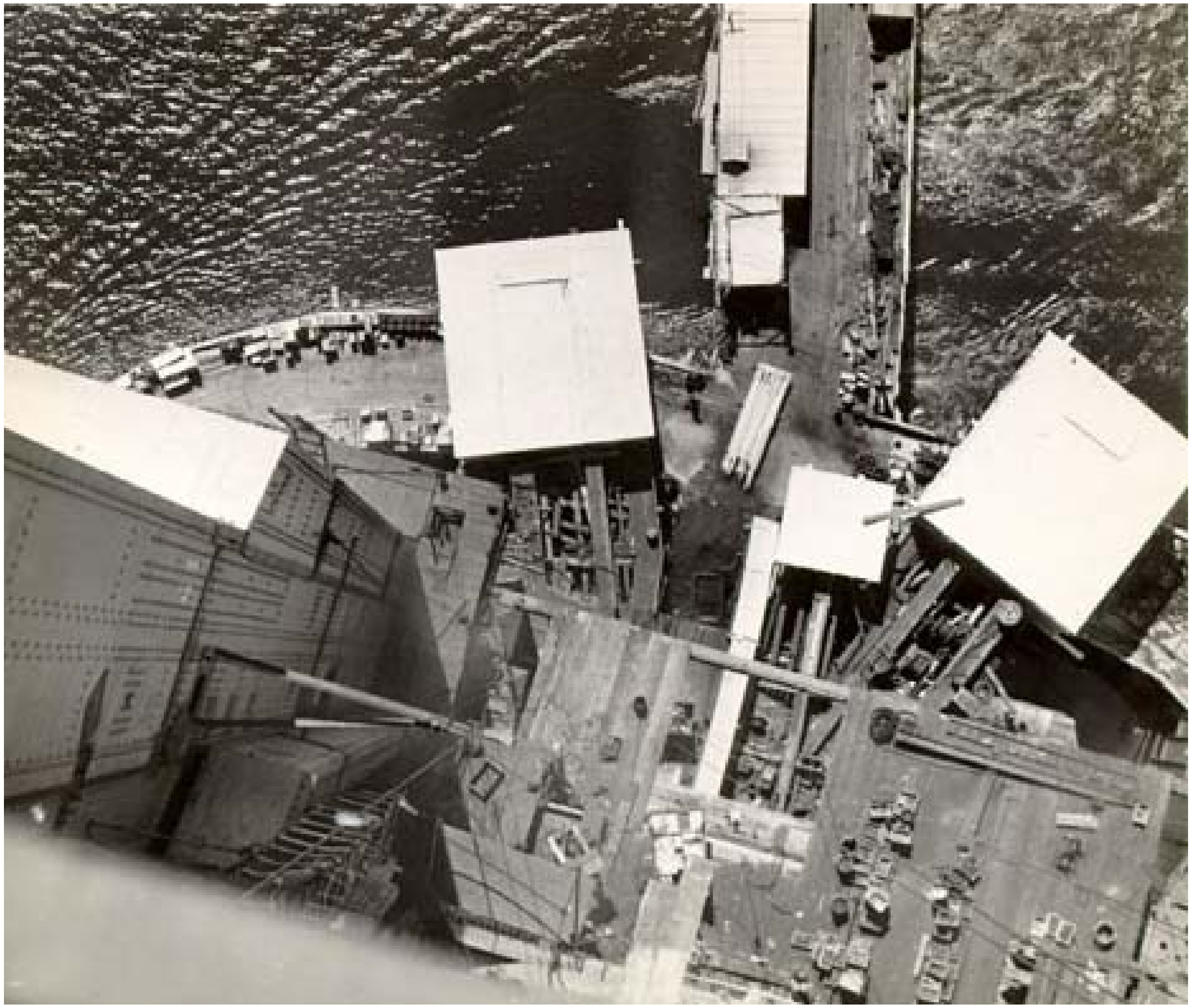

PACIFIC BRIDGE CO

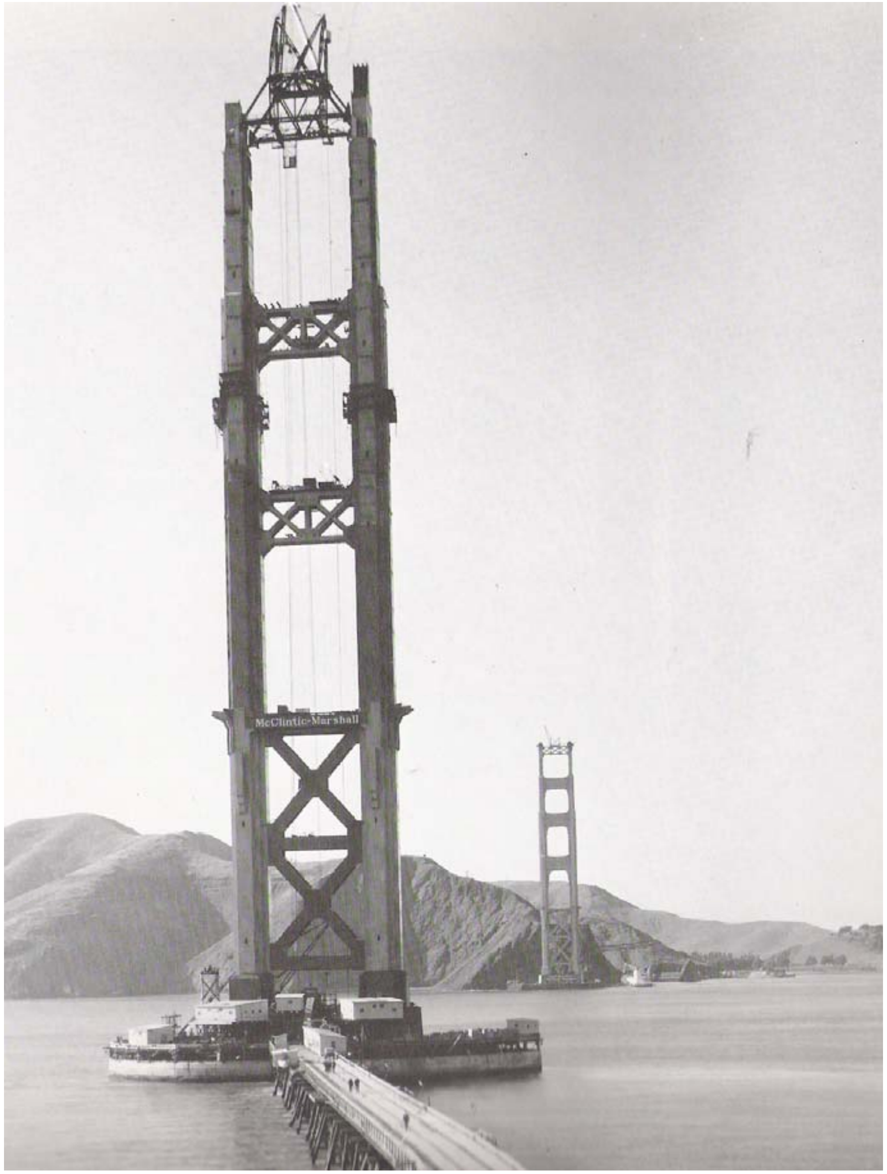





PACIFIC BRIDGE CO.


McClintic-Marshall




McClintic-Marshall

Part 8

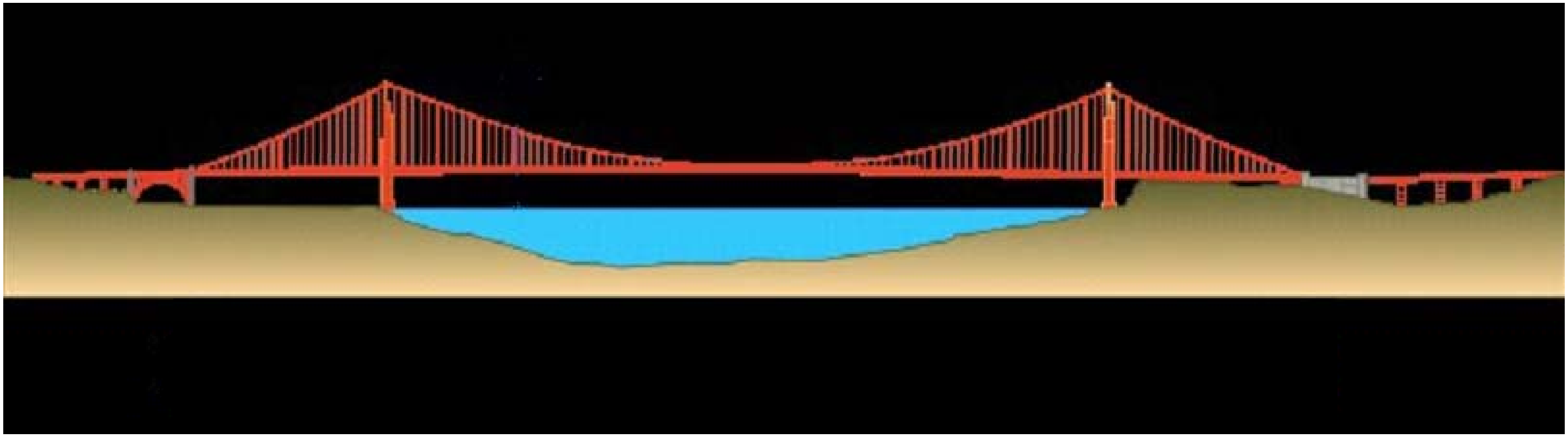
Cables

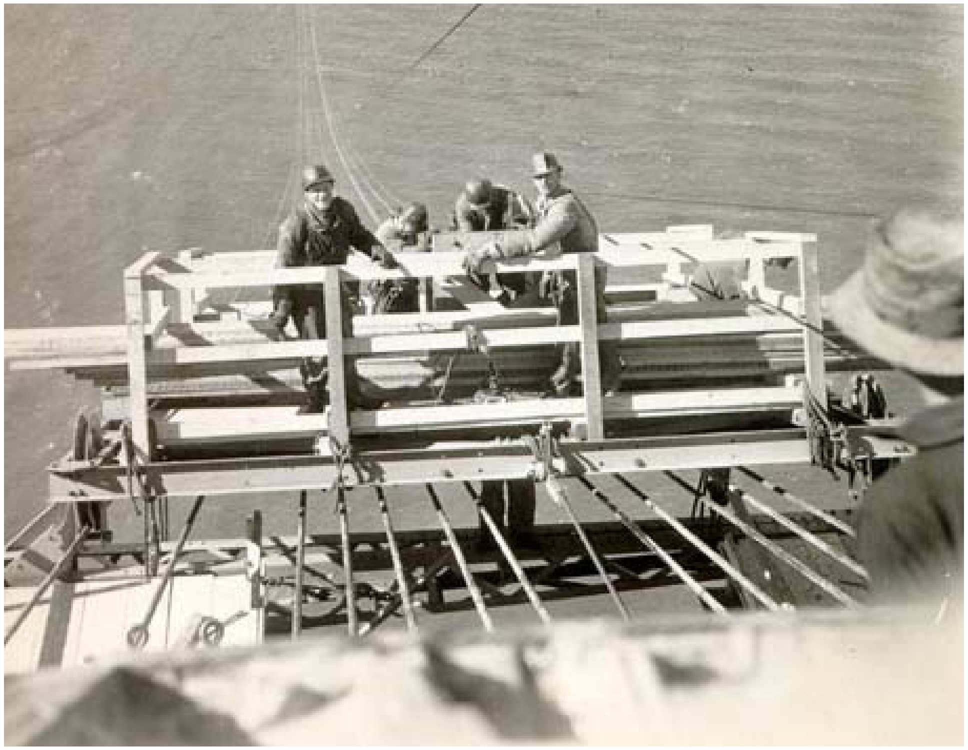
Contract I-B

Steel Cables, Suspenders & Accessories

Catwalks

With the towers complete, the *John A. Roebling & Sons Company* could commence aerial spinning operations. On August 2nd 1935, the *Harbor Tug and Barge Company* laid the first wire across the strait for support of the *Catwalk/s* (a.k.a. *Footbridge/s*). The Golden Gate Strait had to be closed to shipping traffic for fifteen minutes while the cable was transported between the towers. A barge played-out a one-inch cable to the bottom of the channel (at 372-feet) and it was then hoisted to its position between the towers. Laying of the Catwalk/s cable supports concluded on September 27th 1935. The Catwalk/s follow the same Catenary curve of the main cable/s in a position three-feet below the bottom of each cable. The floor/s of the Catwalk/s were made of redwood slats with gaps between (to allow the wind to pass through).






BARRETT & HILP

Aerial Spinning

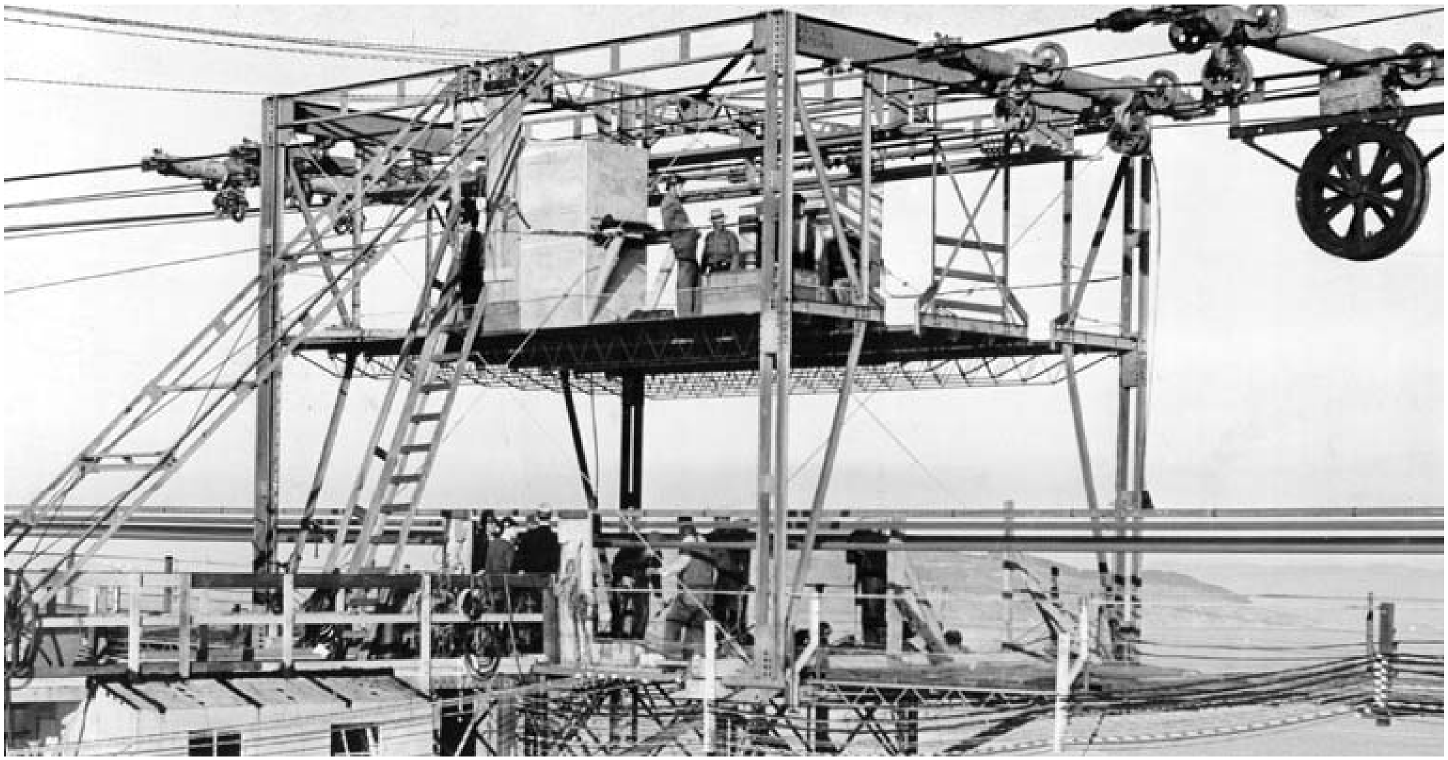
"The cable system is really the lifeline of a suspension bridge. That big cable, that looks so solid when we see it today, was spun in place from individual wires that are each about the size of a pencil."

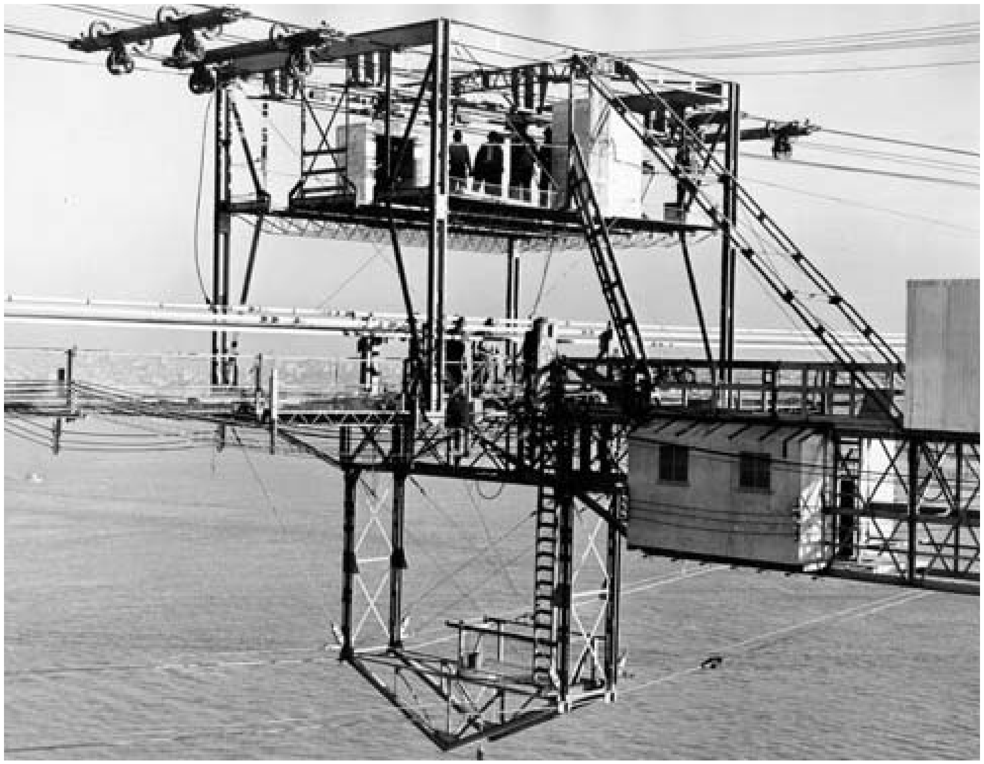
Mark Ketchum, Civil Engineer

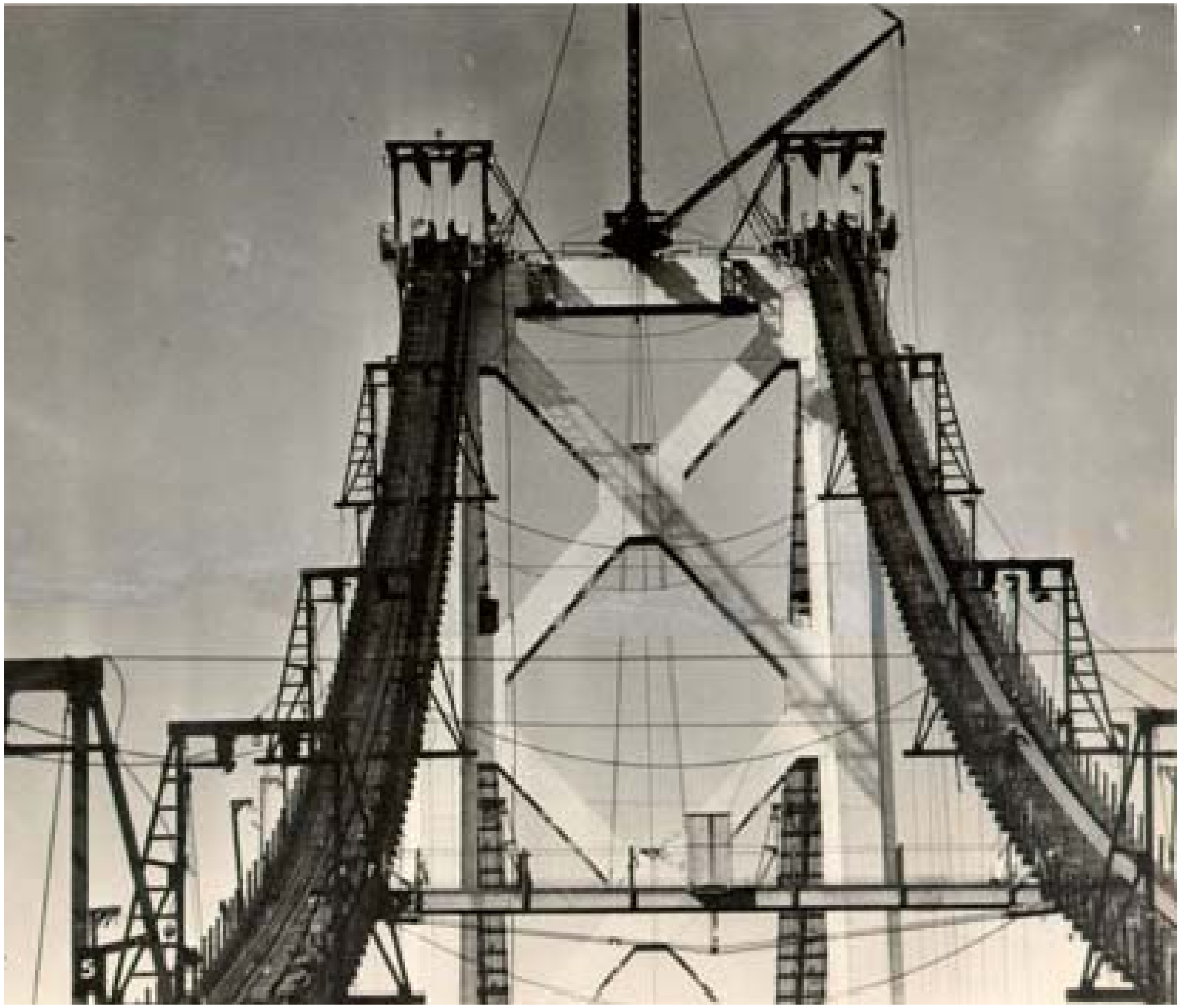

GOLDEN GATE BRIDGE
MAIN SPAN
4200 FEET

John A. Roebling and Sons **were the innovators of aerial spinning of wire cables. Founded by** ***John Augustus Roebling*****, a brilliant German immigrant engineer, artist, linguist and philosopher, the company was world famous for their "wire rope" and suspension bridges. Just fifty-two years earlier (in 1883), Chief Engineer** ***Washington A. Roebling*** **had completed the** ***Brooklyn Bridge*****, taking over after his father's tragic death at the beginning of construction (in June 1869). JAR&S had mastered both the art and science of cable spinning, providing the most efficient strength-to-rigidity ratio for on-site aerial spinning of wire cables. The advantage of on-site wire cable spinning are long-length and flexibility (the GGB cables can bend up to twenty-seven feet laterally). With the Catwalks complete in late September 1935, cable spinning of the 80K-miles of steel wire began in October 1935.**

Spinning Apparatus





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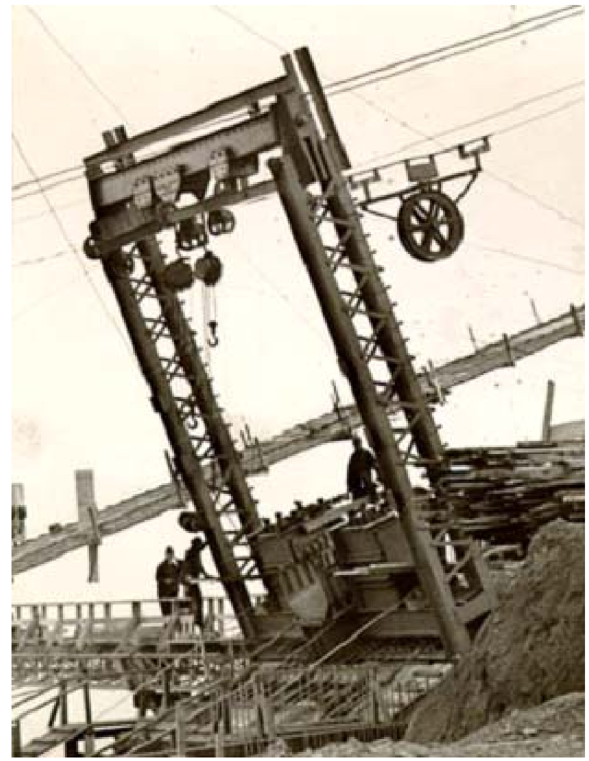
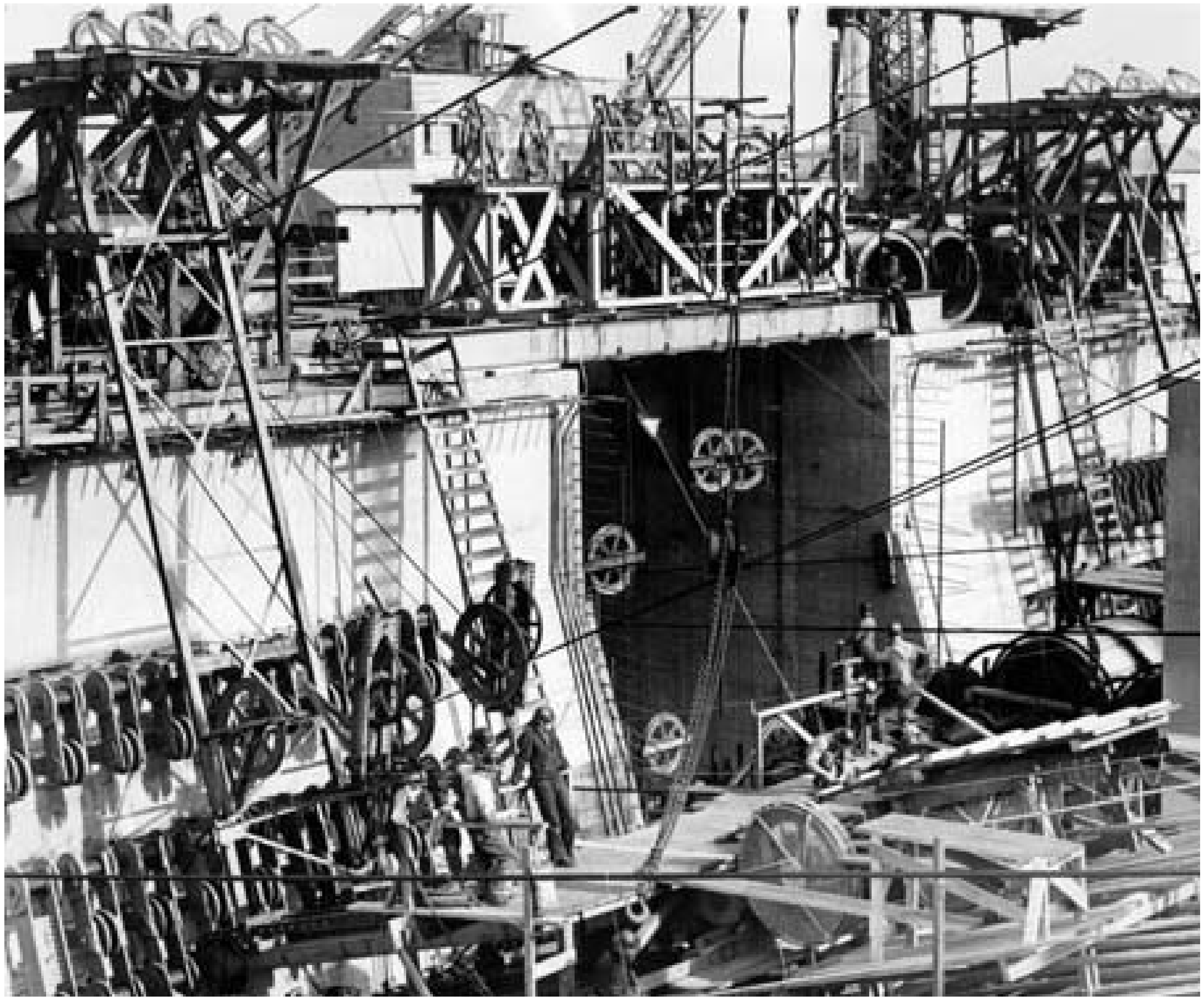


Spinning

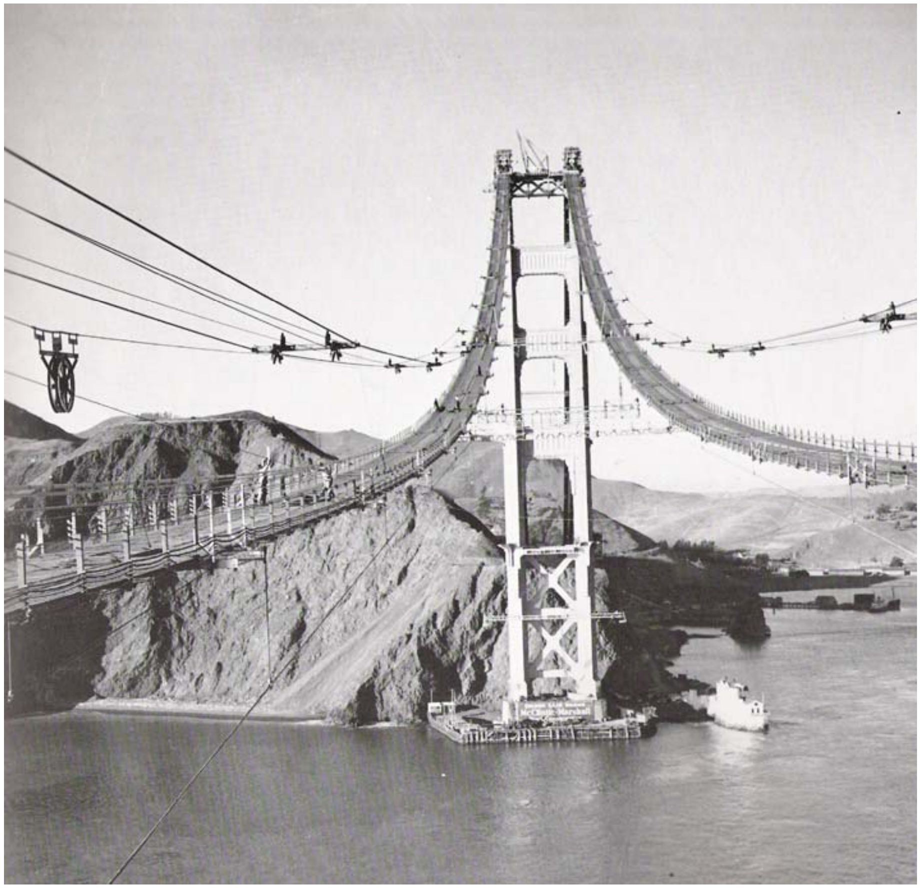
Sixteen-hundred pound spools of 0.192-inch diameter carbon-steel wire (YS=182,600 PSI) were secured atop one anchorage. Similar to a loom, a "dead wire" was attached to a *strand shoe* while the *Traveler Wheel* played-out a "live wire" to the opposite anchorage where it was looped around a corresponding strand shoe and then returned via the Traveler. This back and forth repetition was repeated until 452-wires were in-place to form an individual *strand*. Then, the end of the dead wire was attached to the end of the live wire and the strand was complete. Sixty-one strands were required to form each main cable. Thus, each main cable contains 27,572 individual wires for a total length of 7,650-feet. With suspender cables and accessories, each cable weighs 24,500-tons and transforms the tension in the cables to compression via the cable saddle/s atop each tower. The strand shoe/s are attached (via pin connection) to an embedded eye-bar's end (protruding from the face of the anchorage/s) and secured. The "pull" of the cables is resisted by the distribution of cable strands into the anchorage. Complete, the overall diameter of each cable was 36.38-inches.

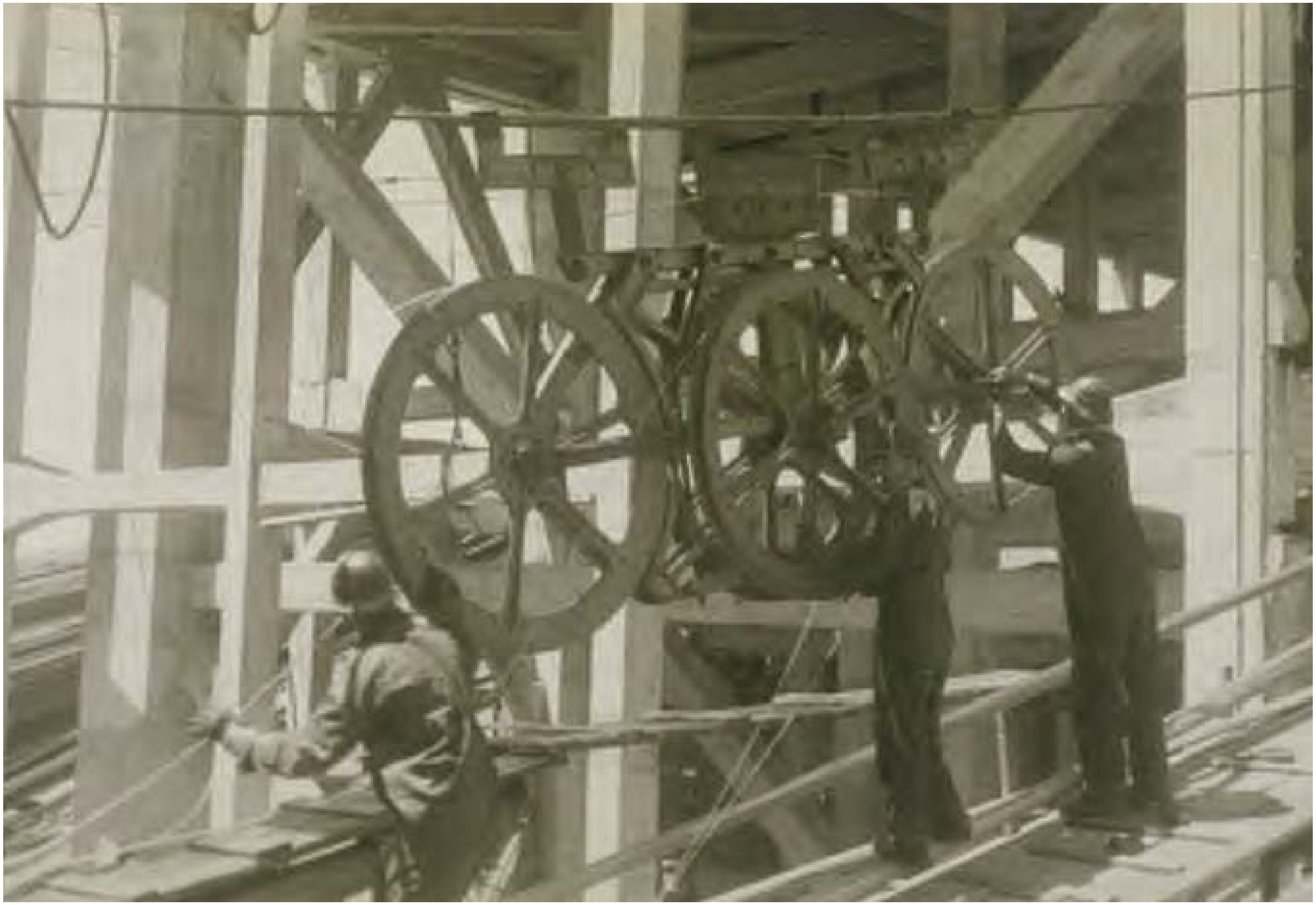


Splicing the Wire

Individual Cable Strands
(distributing to eye-bars within anchorage)

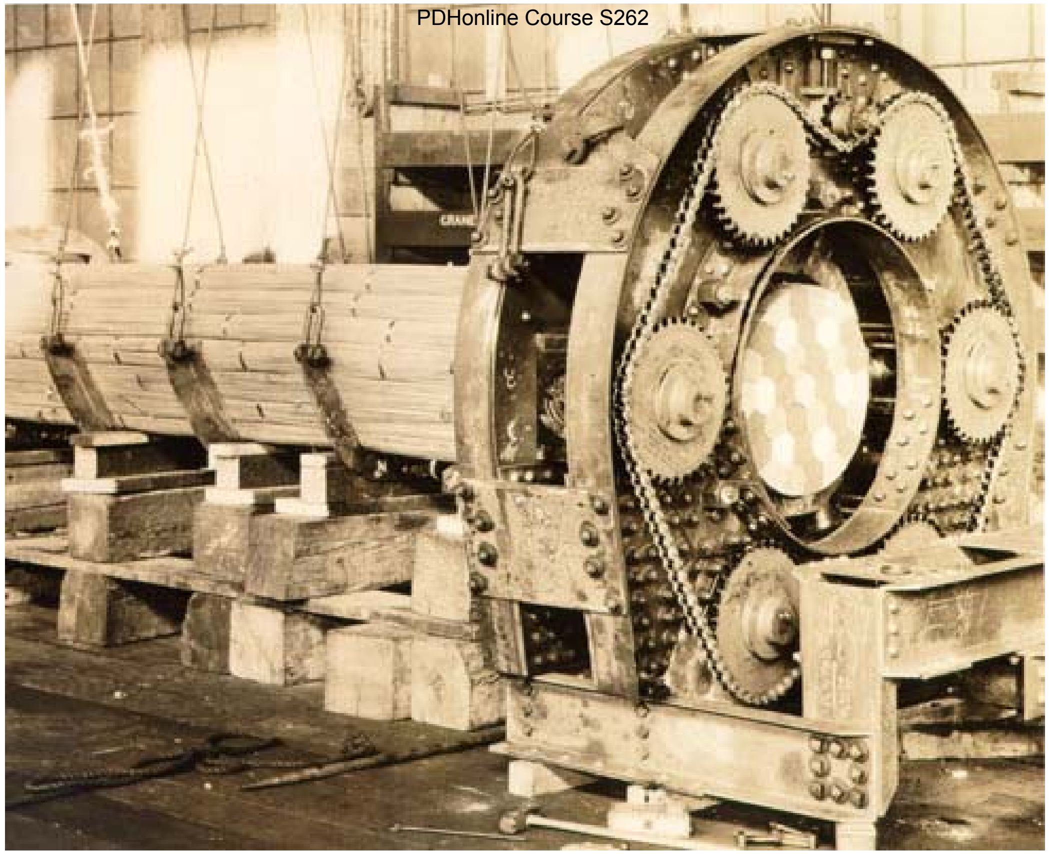
Cable-spinning needed to be done in a precise sequence in order to ensure that the cable's design could withstand wind pressures as calculated by Charles Ellis. JAR&S had a tight budget and even tighter schedule, having to complete the cables in just fourteen months. To meet this demanding schedule, JAR&S first devised a "split tram" whereby a second spinning wheel met the first wheel mid-span. This helped, but they further refined the process by spinning six wires simultaneously via triple-wheeled travelers (operating in opposite directions). To avoid confusion, wire for each traveler was color coded. Just as for the Brooklyn Bridge fifty-plus years earlier, a cow's bell attached to the traveler alerted the workmen of the traveler's approach. In good weather, it took about six and one-half minutes for the traveler to reach mid-span. With this innovative system, up to 1K miles of wire could be spun in an eight-hour shift. On May 20th 1936 – just six months and nine days after commencing operations and eight months ahead of schedule, the last wire was pulled across the bridge. The cables of the GGB have enough wire in them to circle the equator +3x.






ROEBLING

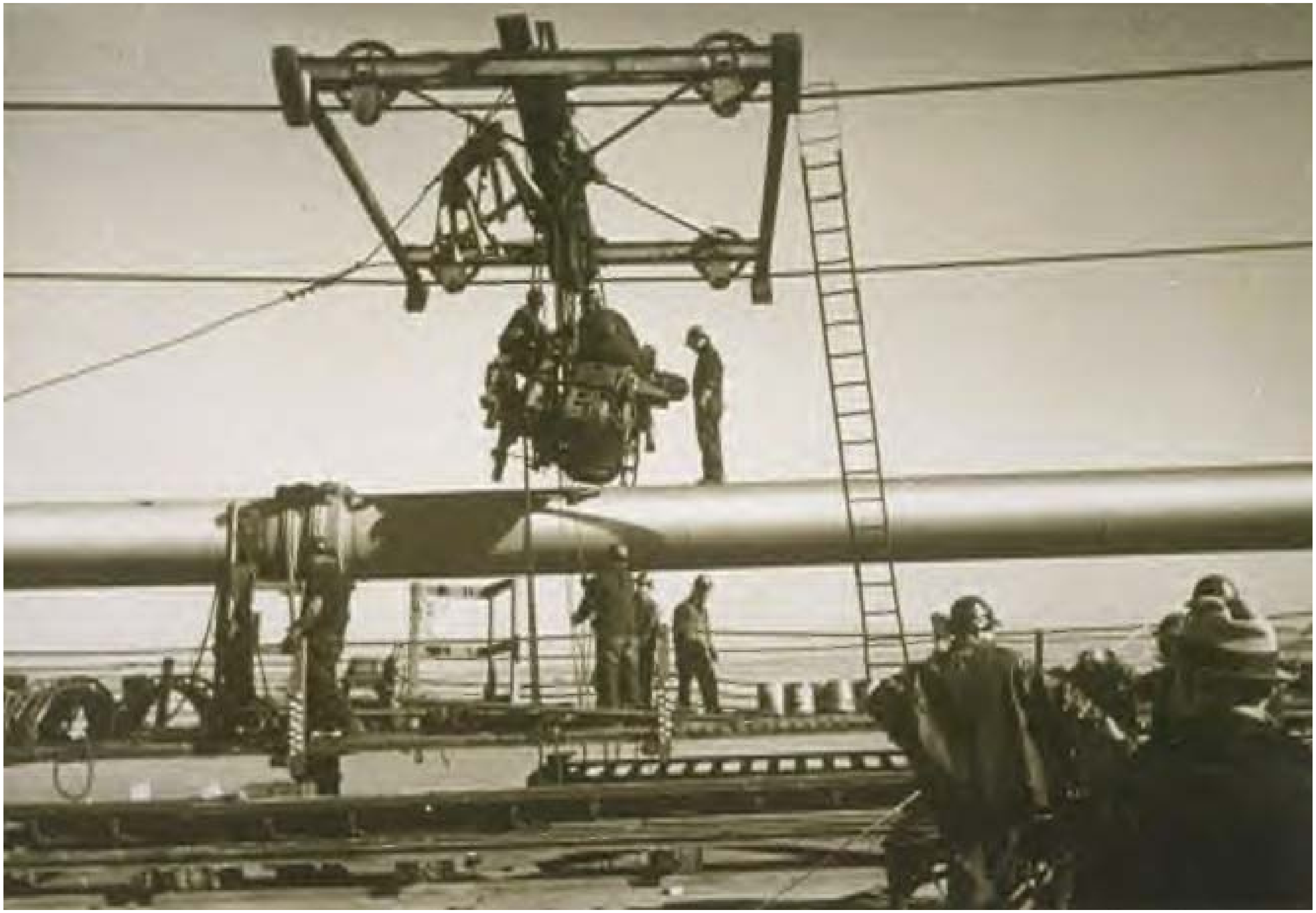
The Big Squeeze



With the completion of the aerial spinning of the main cables on May 22nd 1936, compression of the main cables (from a hexagonal to a round configuration) could begin. At the *Lime Point* (Marin) dock, six cable compressors were delivered and made ready for the cable compressing and wrapping operations. After the cable was squeezed round and bound, it was wrapped with a fine galvanized wire spun around the bound cable/s.

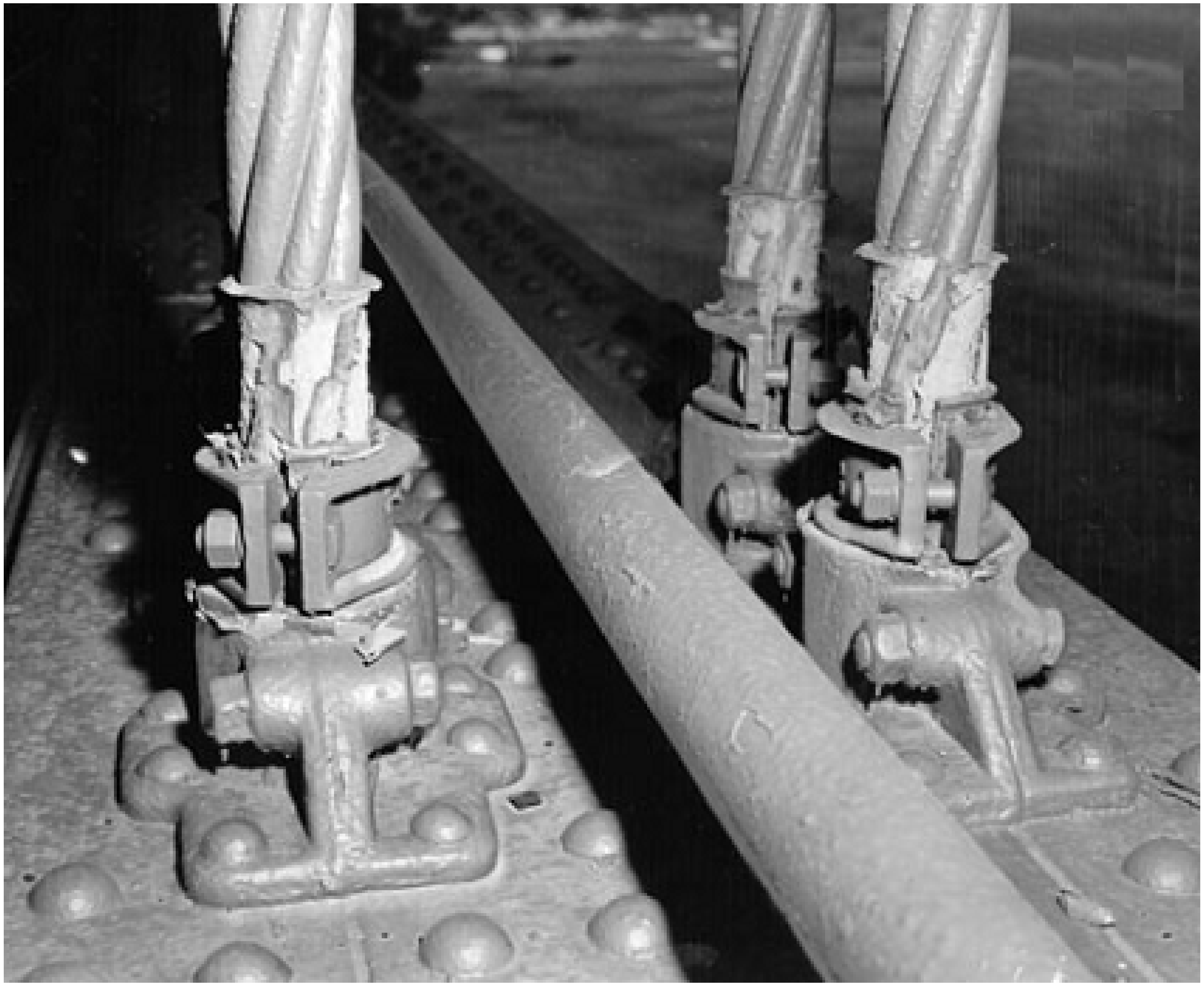

F5

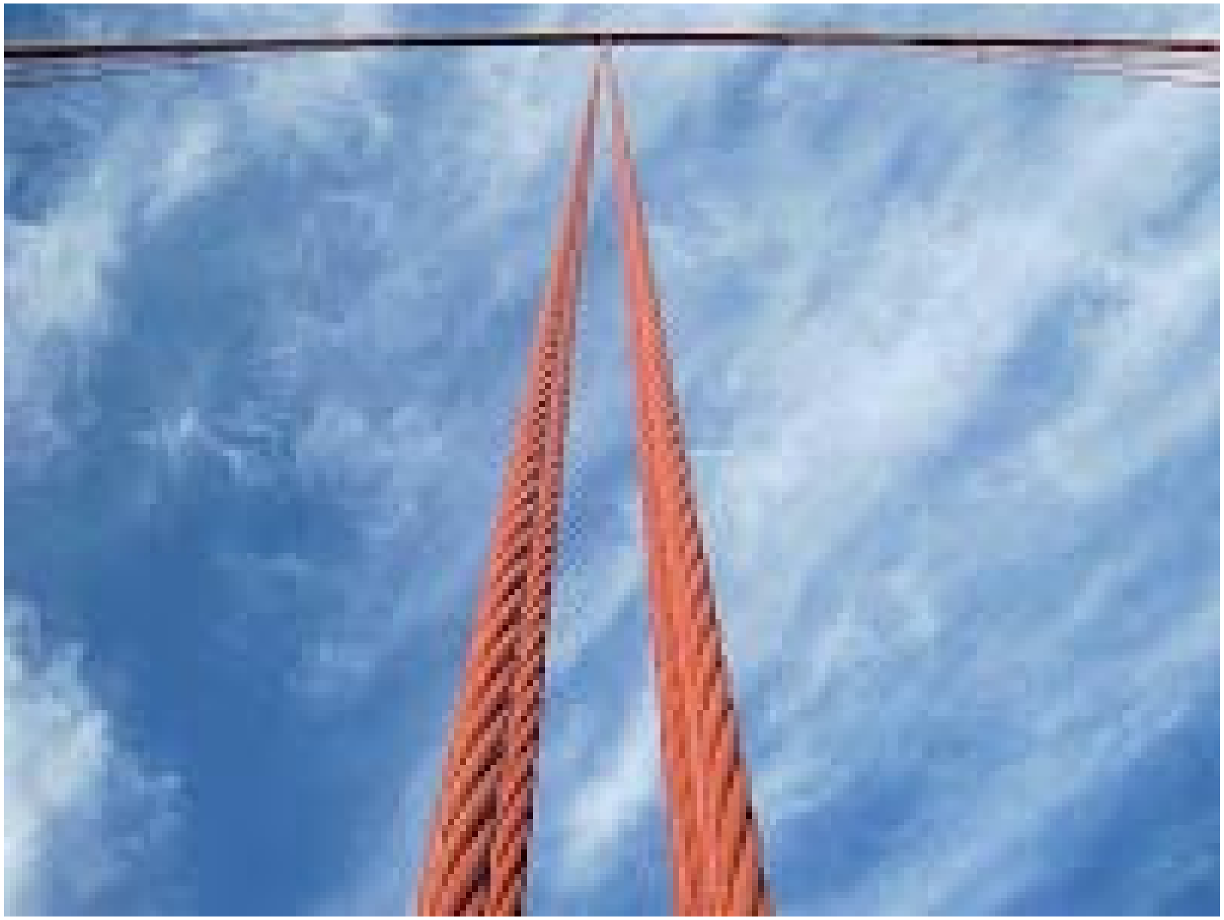
Consisting of two halves bolted together, the *cable bands* are spaced fifty-feet apart along the length of each main cable, in corresponding positions. With the additional lateral bracing retrofit project of 1953/54, it was discovered that the additional weight of the bracing system and the normal daily workload of the bridge caused the cable bands to lose up to 50% of their specified tension. In 1954, the main cable band bolts were re-tensioned via calibrated impact wrenches – the first time this was done for a suspension bridge's cable band bolts. Again in the 1970s (during the suspender rope replacement project), the cable band bolts were re-tensioned (using a *Biach Hydraulic Bolt Tensioner*) to 90K-pounds. Because of constant temperature and load changes on the main cable, minute changes in the cable diameter can/does occur. Also, the cable band/s are subject to thermal expansion/contraction. Alone and/or combined, these changes can cause the tension in the cable band bolts to "relax" (loosen). Random, on-going inspections of the cable band bolts calls for occasional retightening/tensioning.

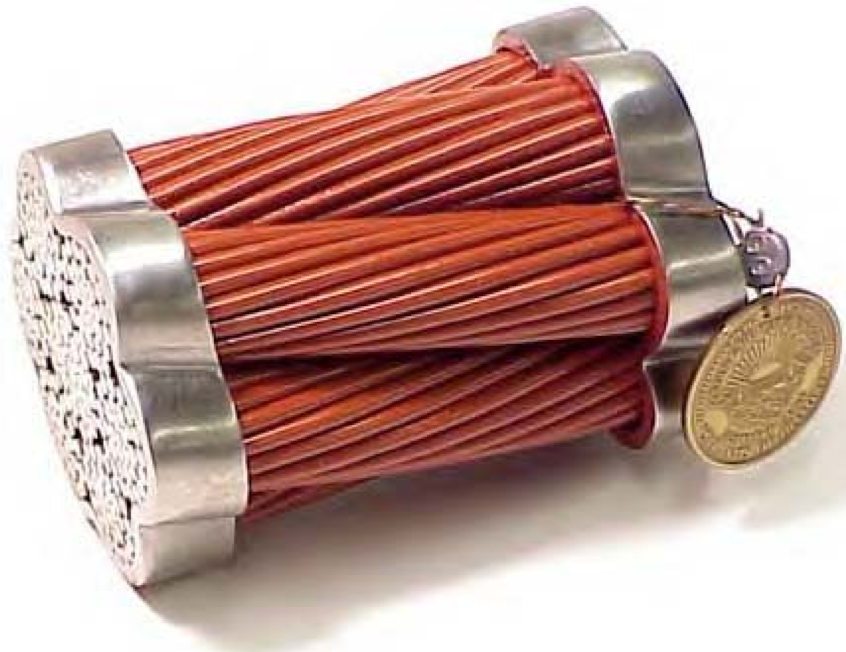


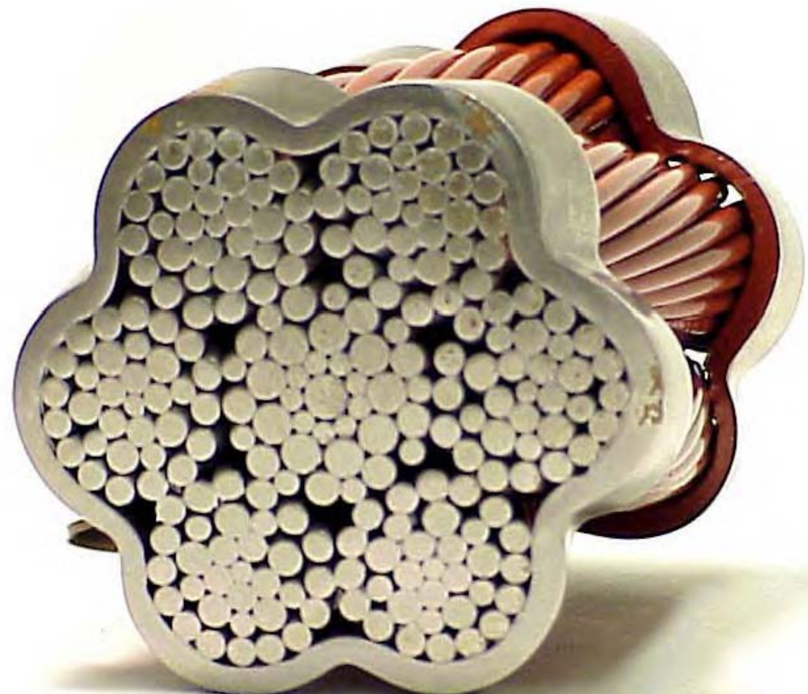
Hanging By A Wire (Rope)

Looping over each cable band and supporting the road deck are 250 pairs of 2.69-inch diameter suspender ropes. From 1967 to 1969, the engineering consulting firm founded by Othmar Ammann (1879-1965) – *Ammann & Whitney*, conducted a comprehensive inspection of all structural elements of the GGB. The inspection found that most suspender rope connection points (to the road deck) were severely corroded. Using traveling platforms spanning between the two main cables and suspended high above the roadway (to allow for uninterrupted traffic flow), all 250 pairs of suspender ropes were replaced. On only four occasions was the bridge briefly closed to traffic (to relocate the traveling platforms). This was the first time all suspender ropes of a suspension bridge were replaced while remaining open to traffic.









Part 9

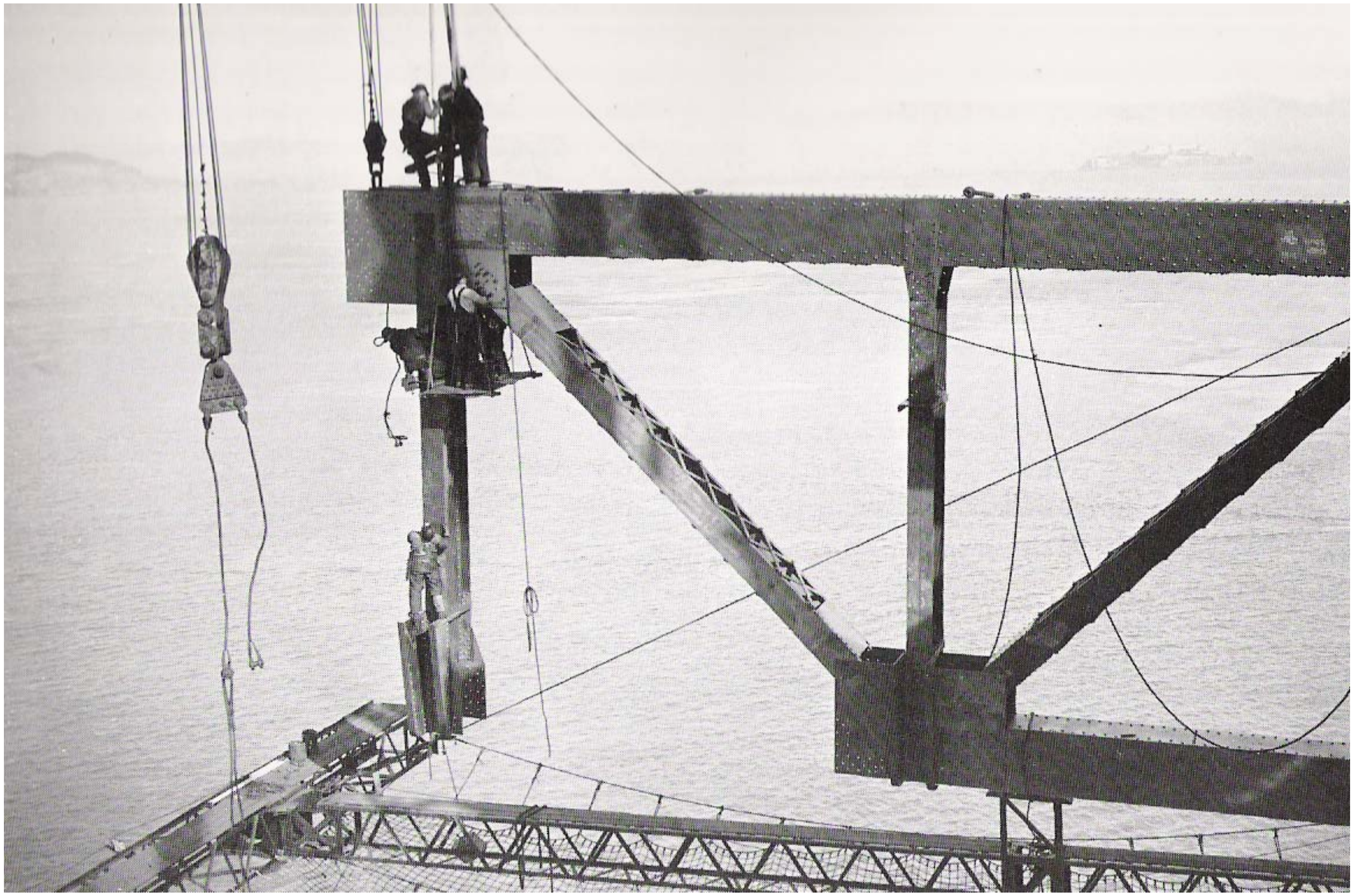
Suspended Structure

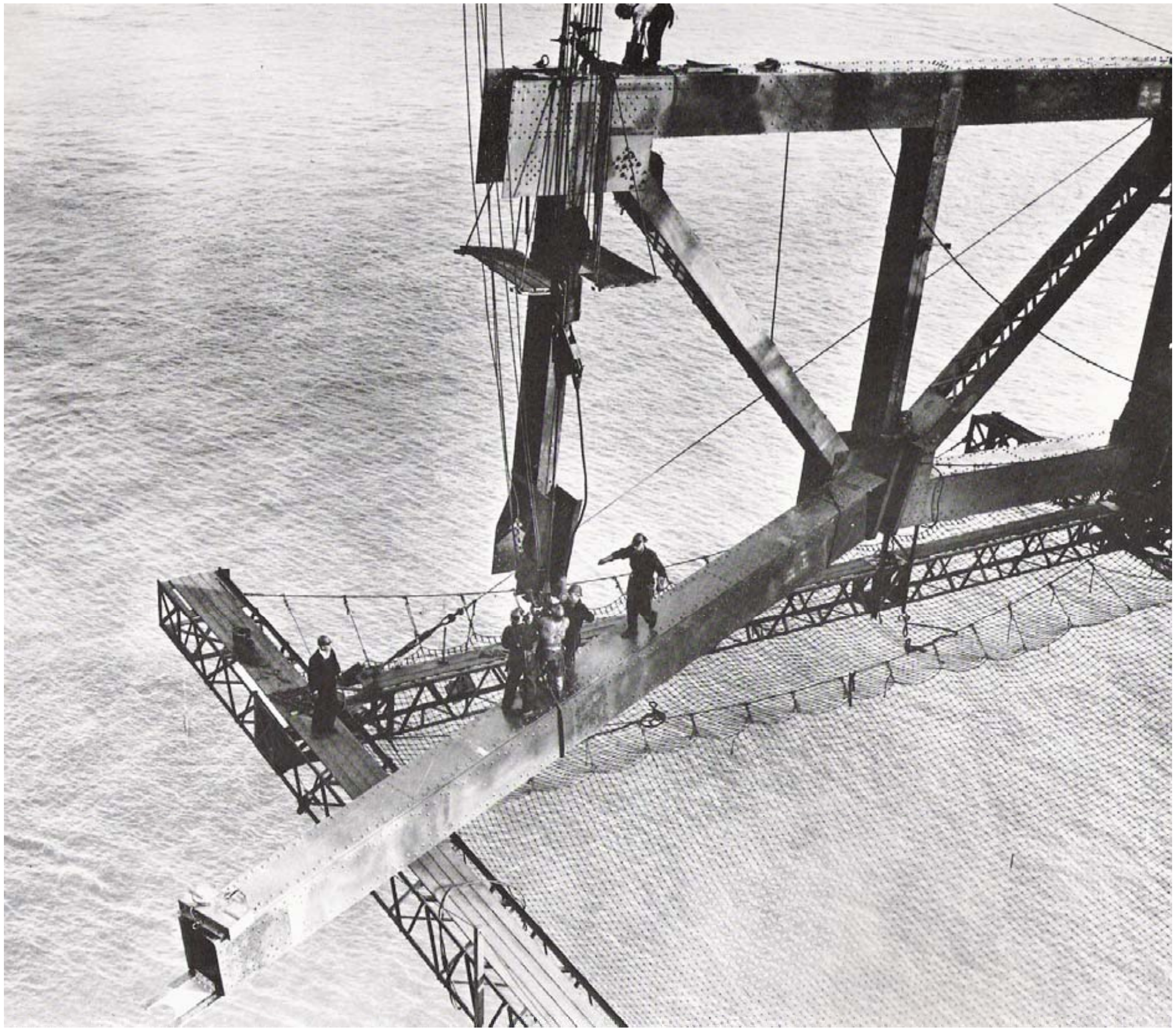
Contract I-A

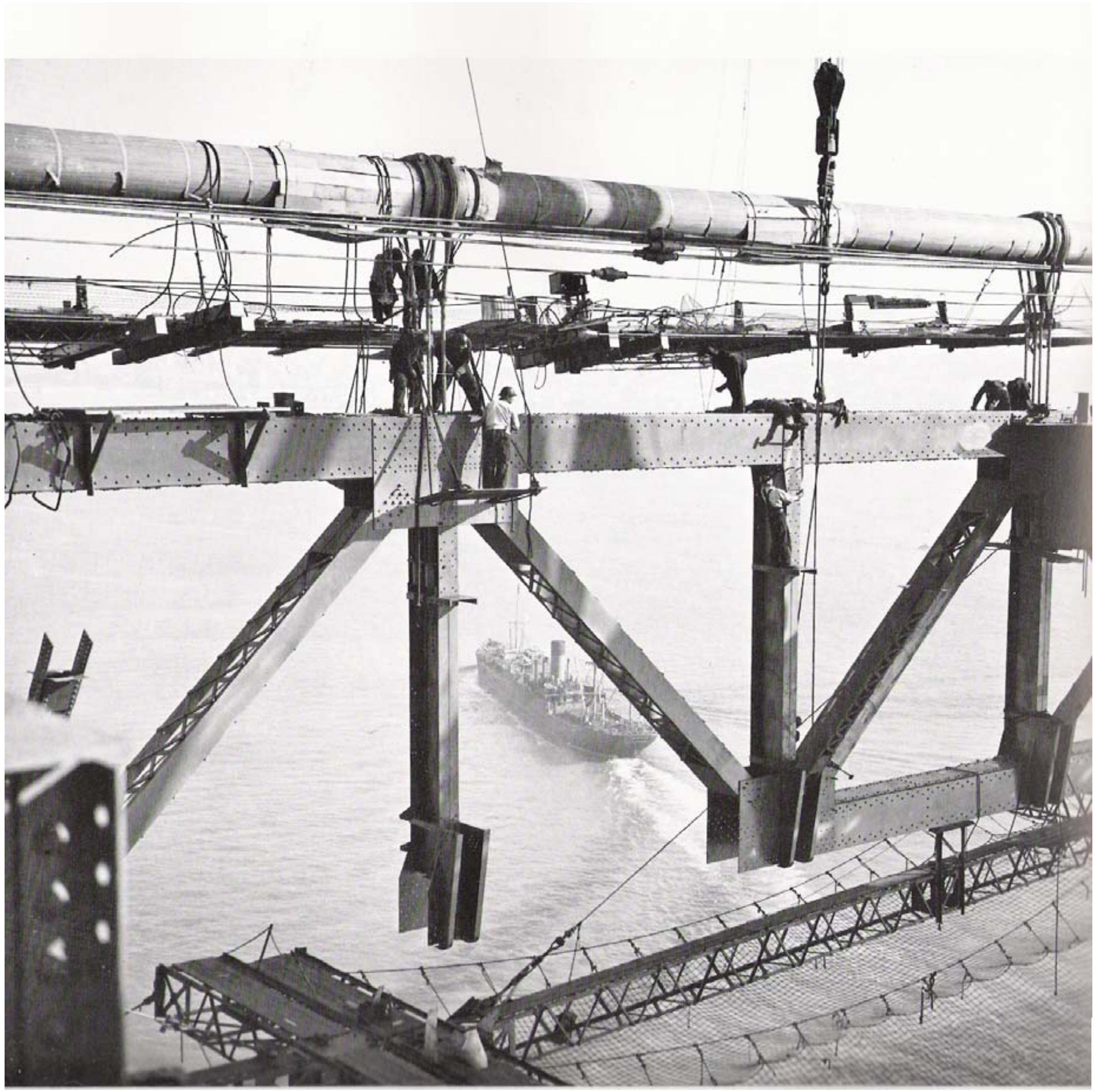
Steel Superstructure (Suspension Span)

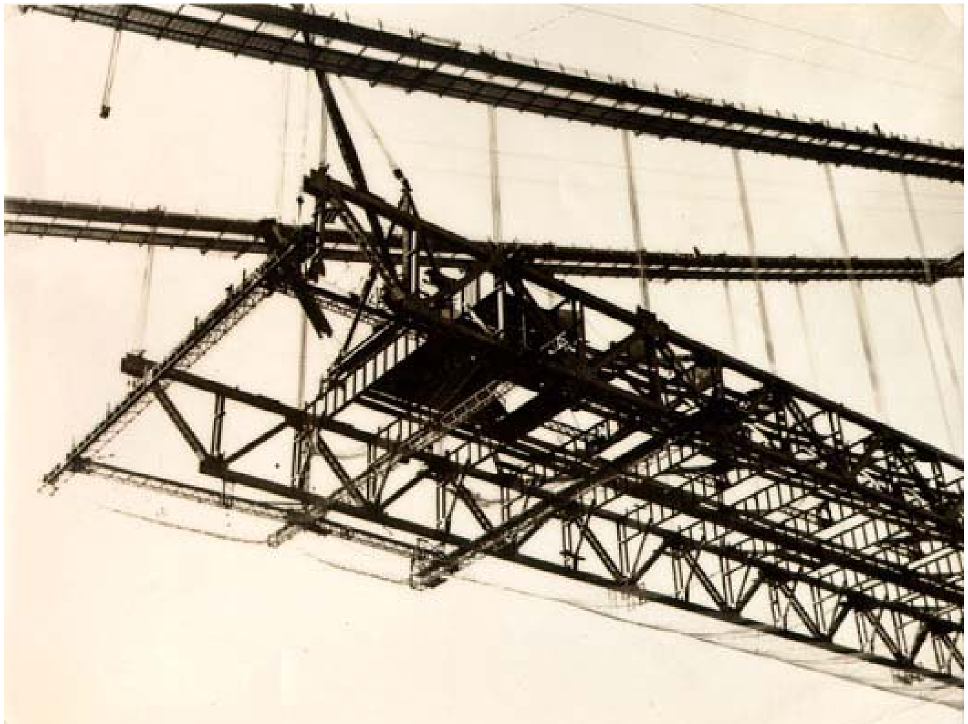
On June 18th 1936, erection of the suspended structure (90-foot wide road deck/stiffening truss) began. Working outward from the towers (towards the anchorage/s for the side-spans, towards mid-span for the main span), cranes would lift the steel sections off of barges below and hoist them into place where they would be attached progressively to the sockets at the end/s of the 250 pairs of suspender ropes, then the girders, truss etc. would be riveted together in-place. The deck was designed for a live-load of 4K-pounds per linear foot and, at mid-span, can deflect up to 27.7-feet (conditions allowing). Depending on temperature, maximum upward and/or downward deflection is 5.8-feet and 10.8-feet respectively. Between curbs, the roadway is 62-feet wide and the pedestrian walkway/s are 10-feet wide. Overall (main plus side spans), the length of the suspended structure is 6,450-feet or 1.2 miles and weighs-in at 24K-tons. From approach abutment (San Francisco) to approach abutment (Marin), the total length of the bridge is 8,981-feet or 1.7 miles. In its original configuration (1937), the total weight of the bridge was 894,500-tons (887K-tons total as of 1986, due to the re-decking project).

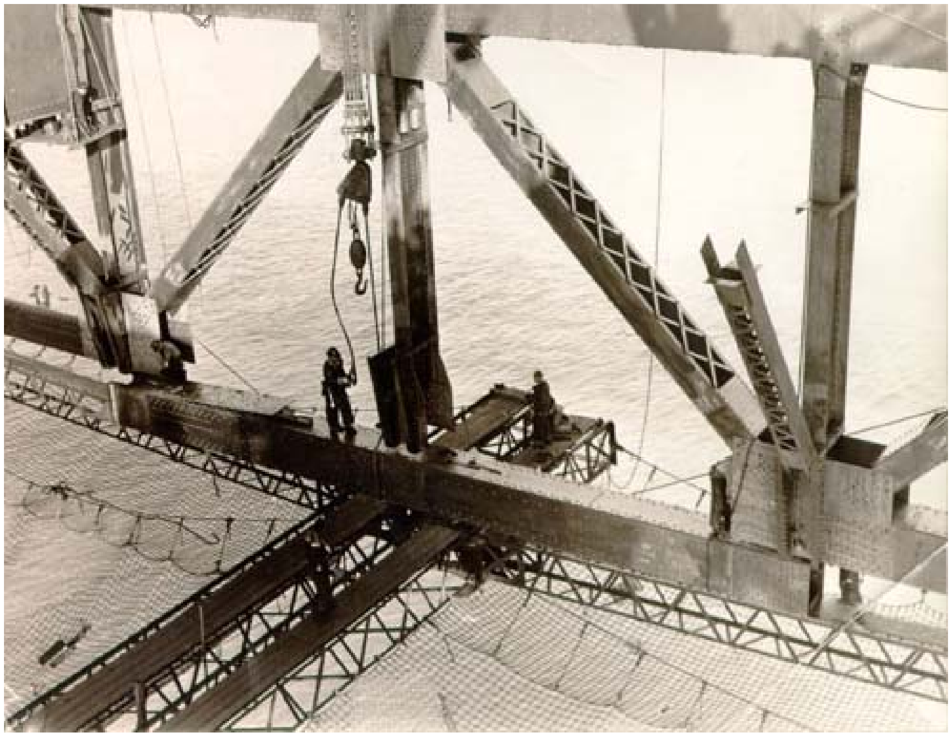

GOLDEN GATE BRIDGE

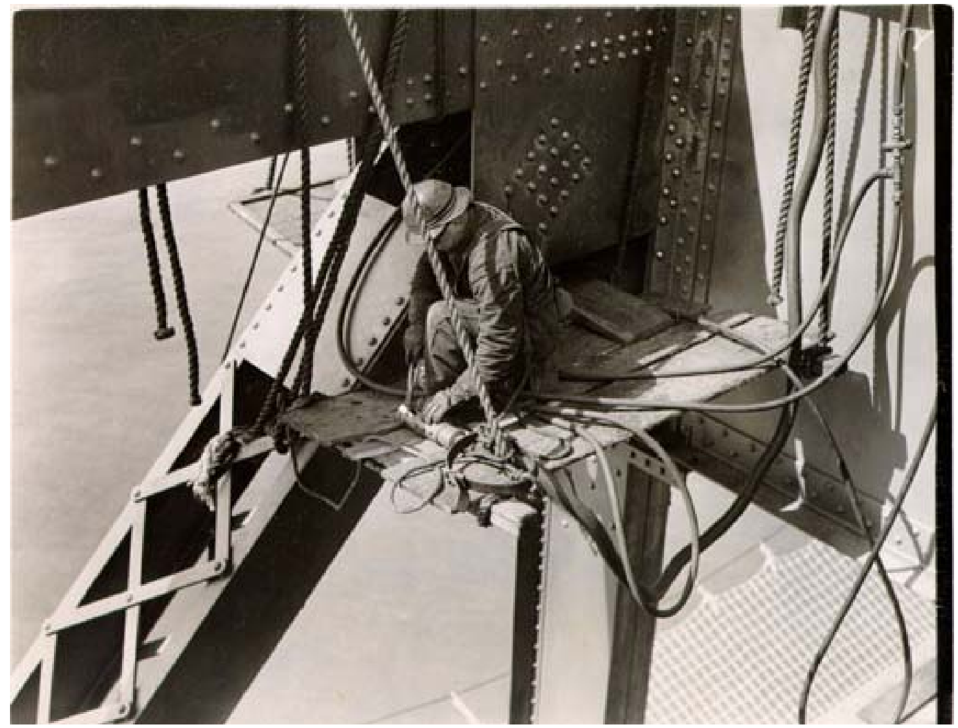




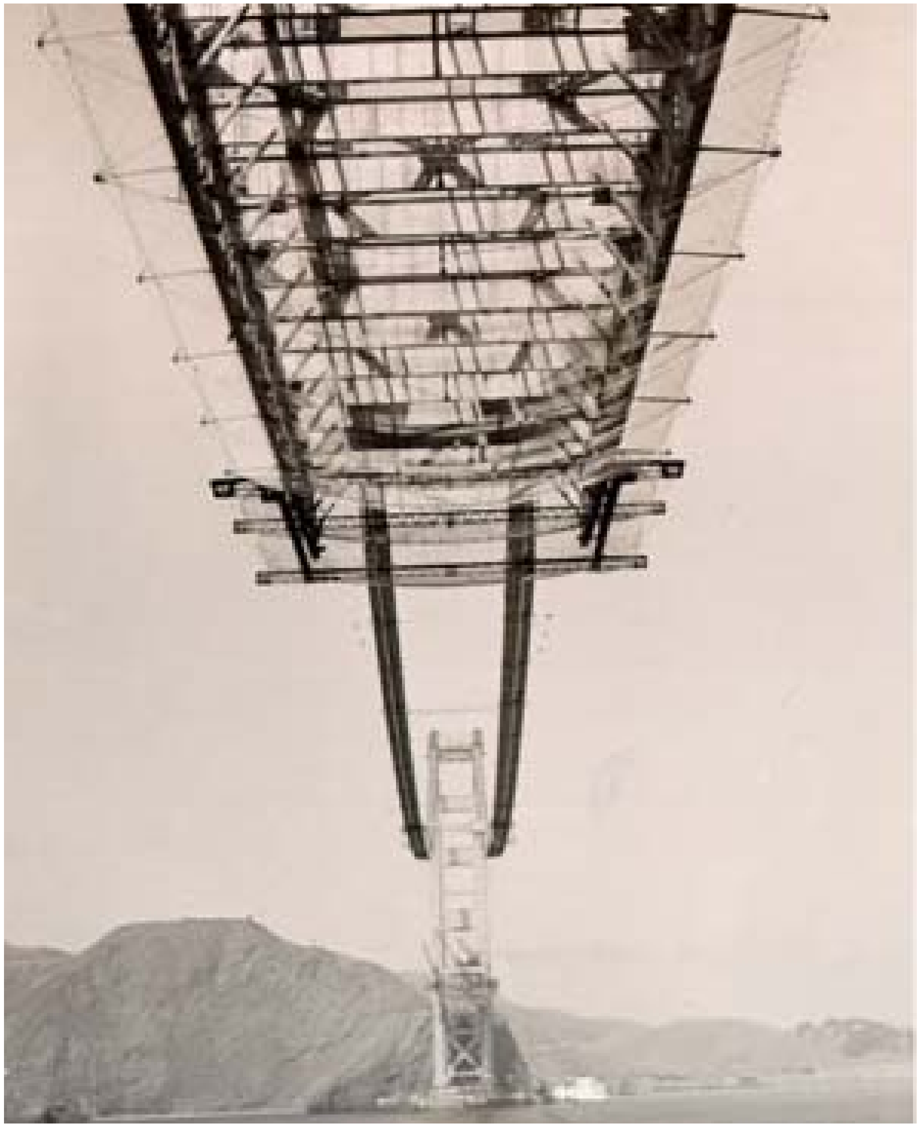


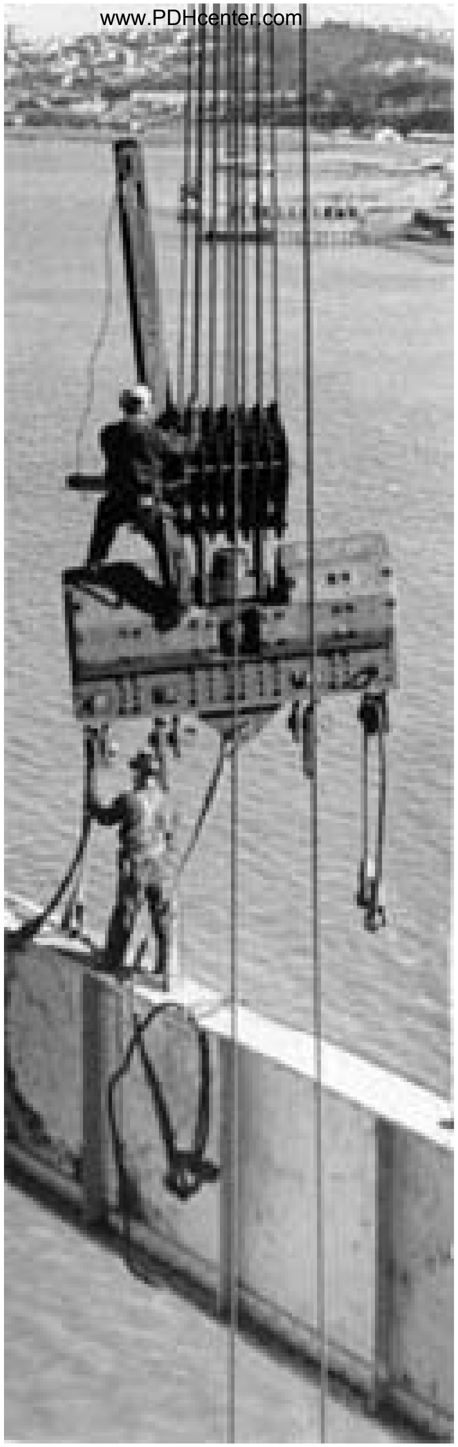






Strauss' greatest (and most expensive) safety innovation was the use of a \$130K trapeze-style circus net placed under the work area and extending ten-feet forward and to the side/s. Manufactured by the *J.L. Stuart Company*, it was made of 3/8-inch diameter manila rope in a six-inch square mesh pattern. Ultimately, it would save the lives if nineteen men who cheated death by falling into the net rather than the treacherous strait below. These men, who dubbed themselves "*The Halfway to Hell Club*," were an exclusive fraternity. Besides the lives it saved, the net increased worker productivity since a fall no longer meant certain death (the men often jumped into the net just for fun). The net was in-place on August 31st 1936.





"There's no doubt the work went faster because of the net"

Lefty Underkoffler, Bridgeman

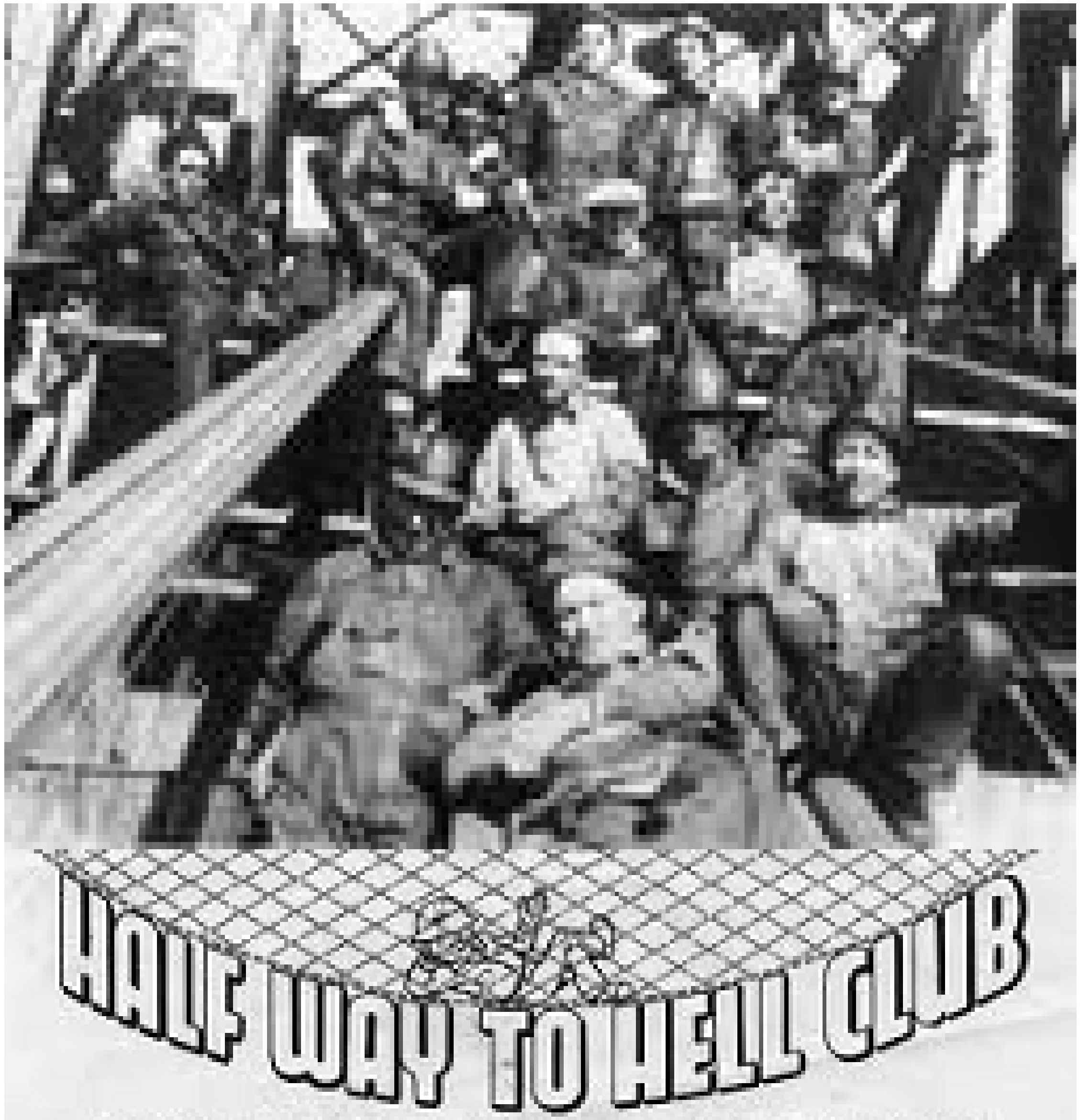
Golden Gate Bridge Fallers Organize Halfway Club

Six young men who almost got their feet wet in falls from the deck of the Golden Gate bridge during the last several months gathered yesterday to celebrate their survival.

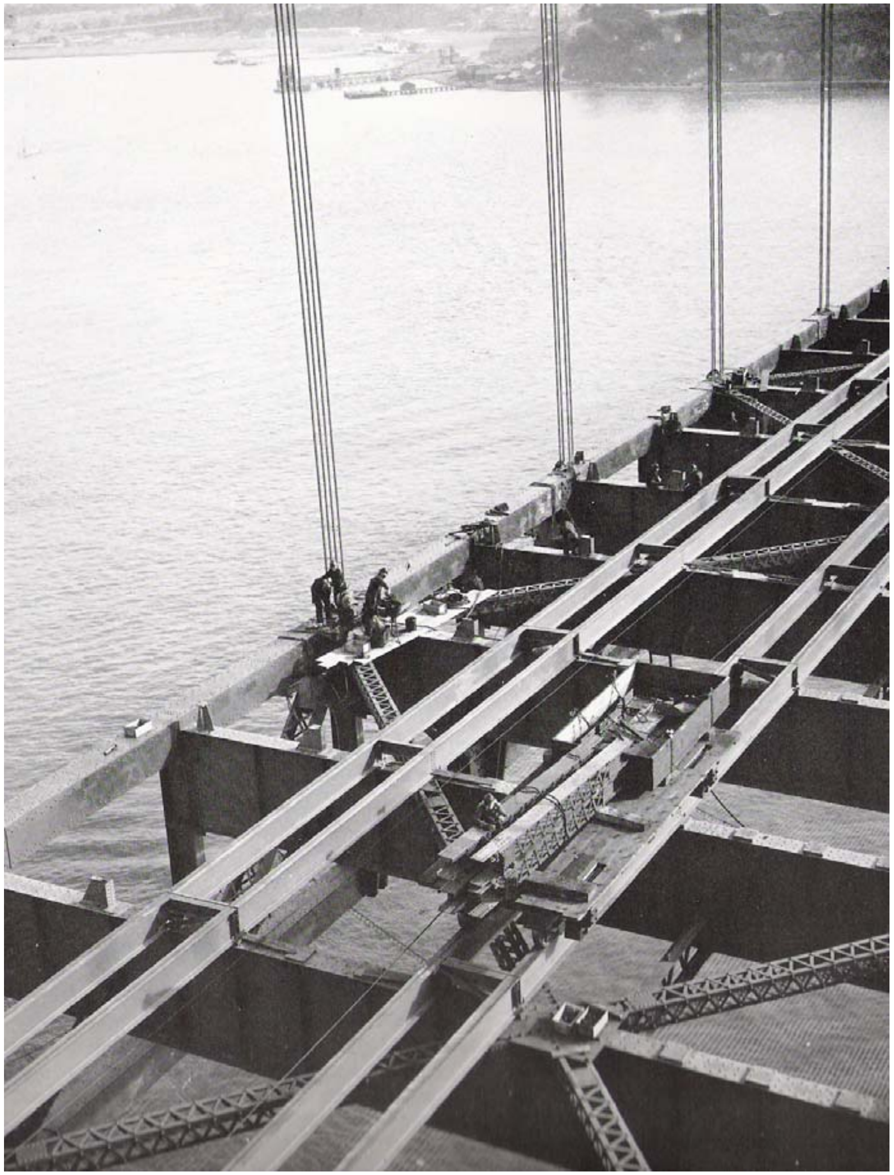
The six were bridge workers saved

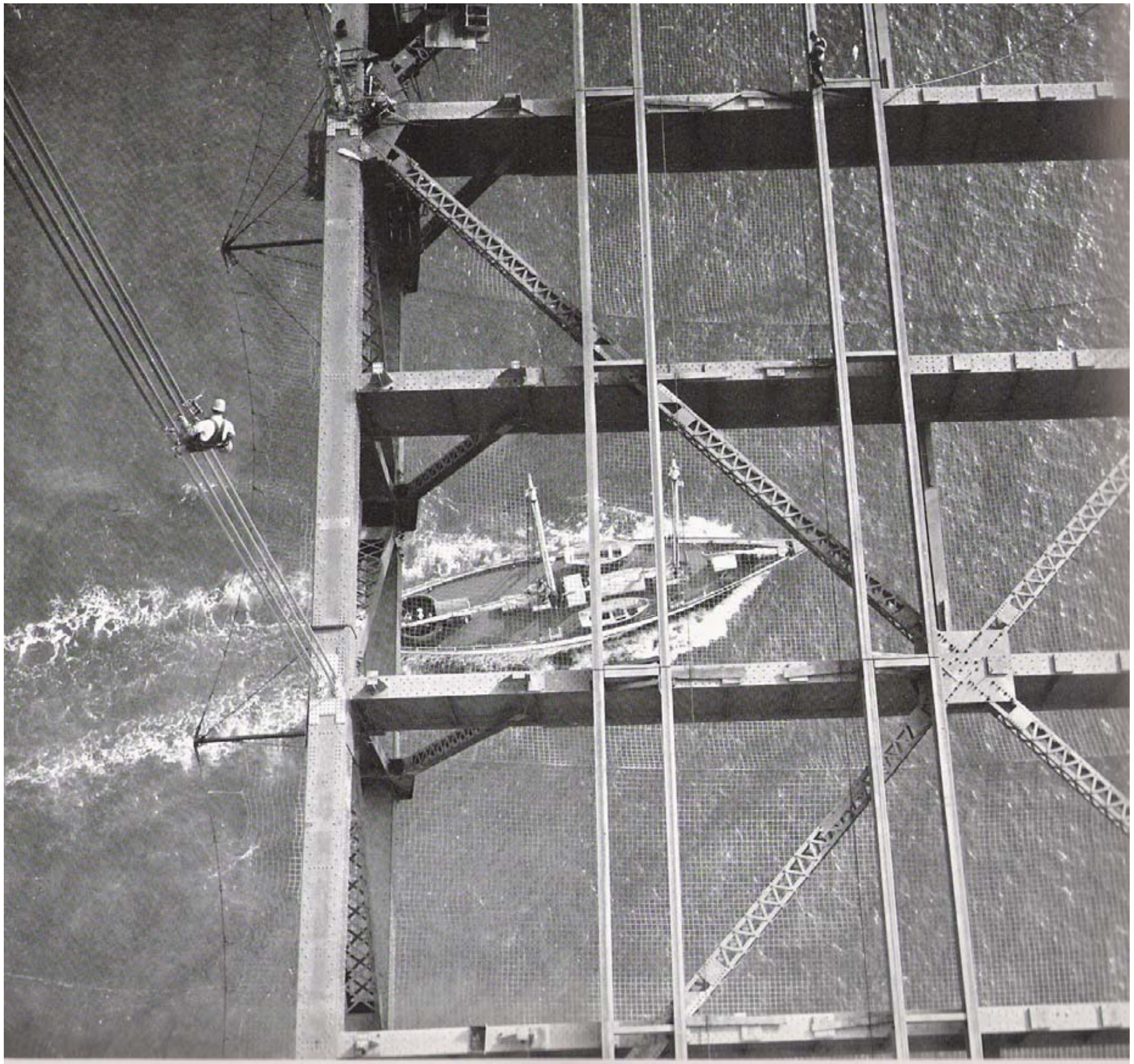
Stanley, 22, of 424 Fourteenth street, San Francisco.

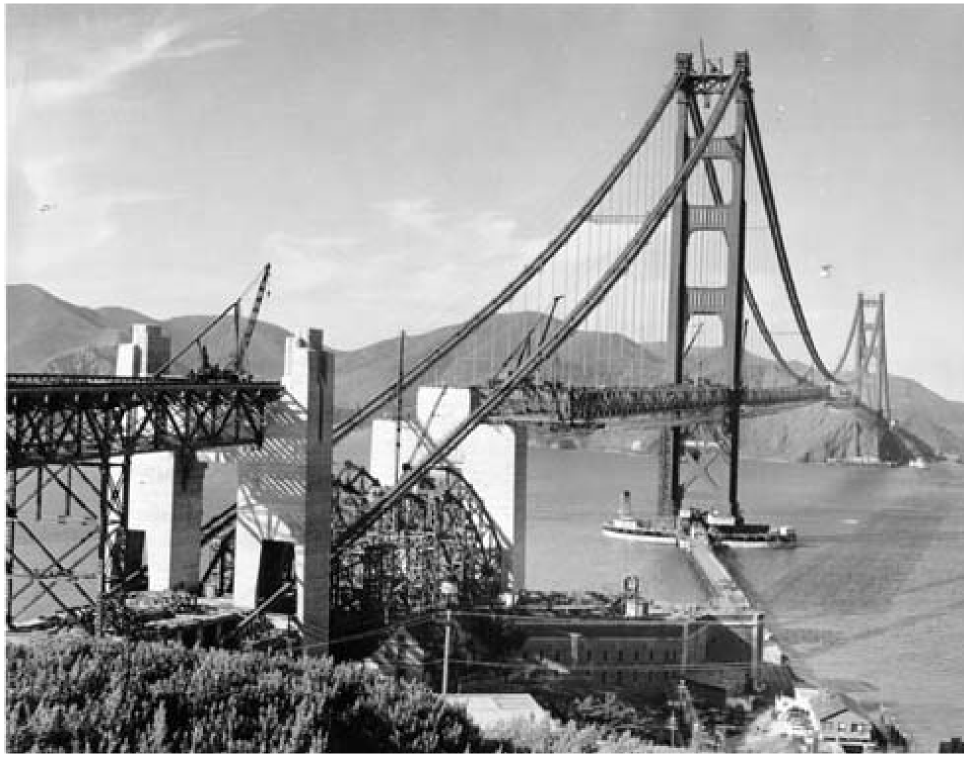
Ward Chamberlain, 26, of 7 Alameda way, San Anselmo; George B. Murray, 38, of 6300 California street, San Francisco; Albert Zampa, 31, of Crockett, and John Perry, 33, of 1278 Market street, San Francisco.

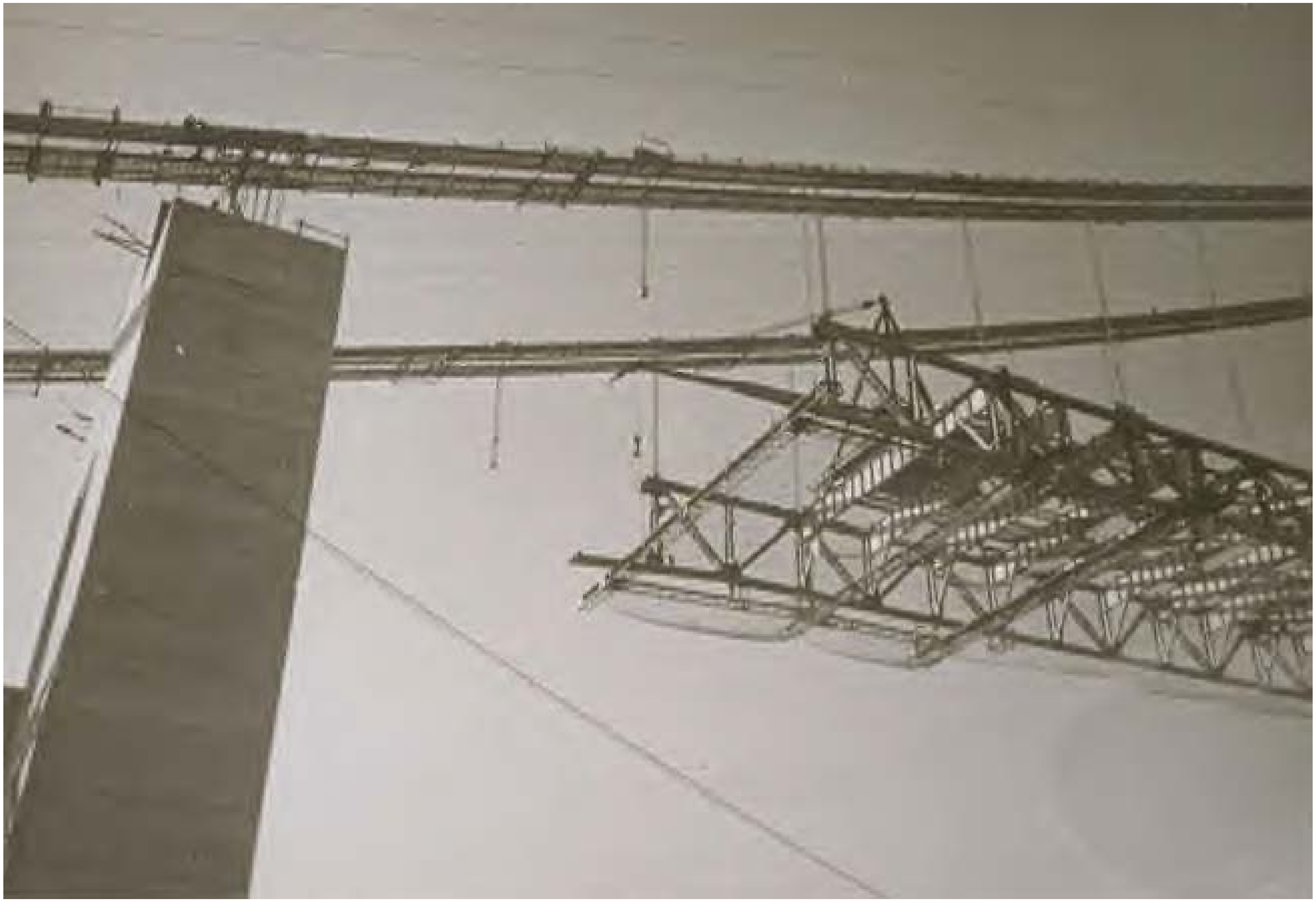

HALF WAY TO HELL CLUB

By September 1936, employment at the GGB peaked reaching one-thousand men. On October 21st 1936, the first fatality occurred when a traveling derrick toppled over killing *Kermit Moore*. Despite this gruesome milestone, work continued and on November 20th 1936, the main-span sections met mid-span and were joined. A brief, informal ceremony marked the occasion.

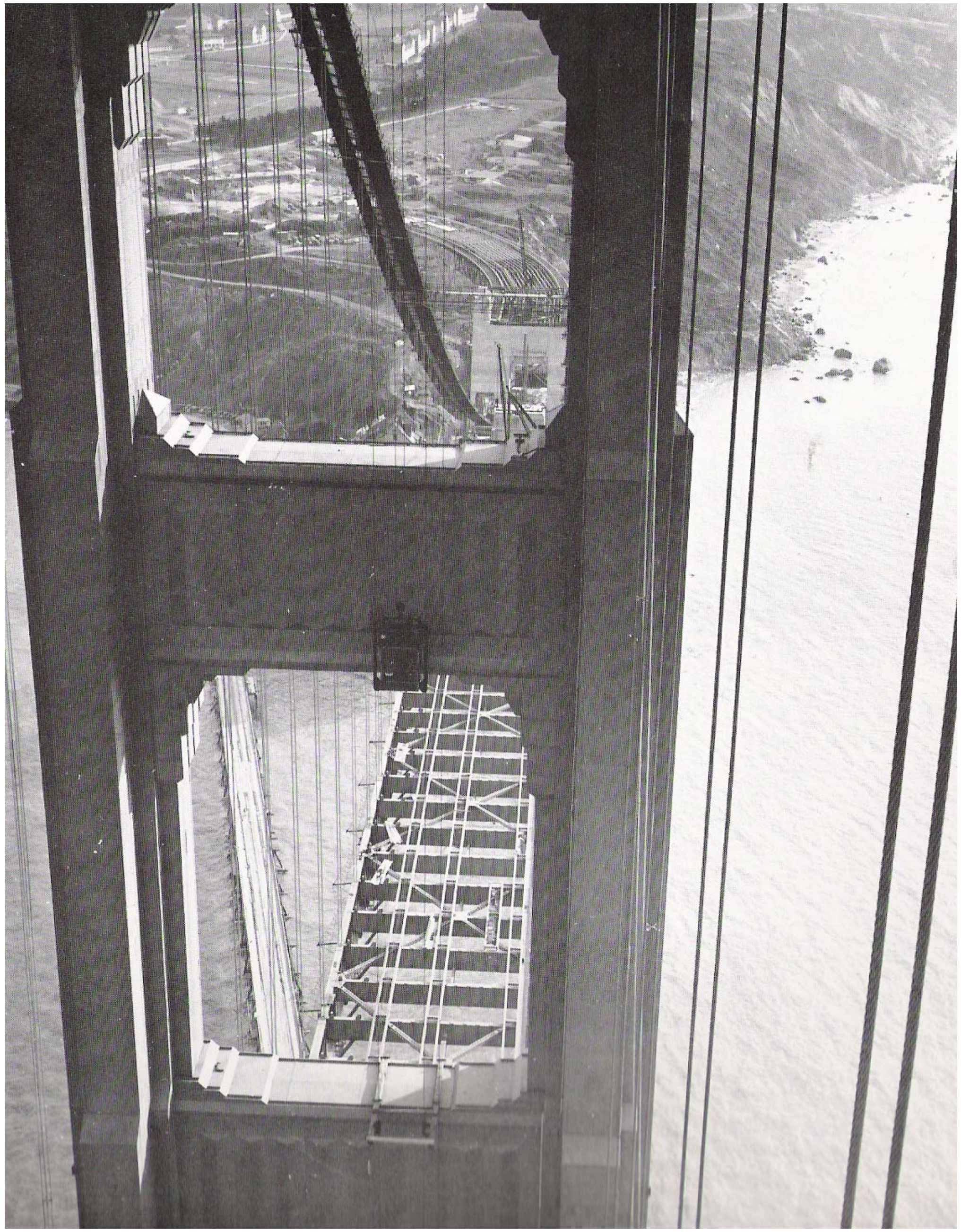






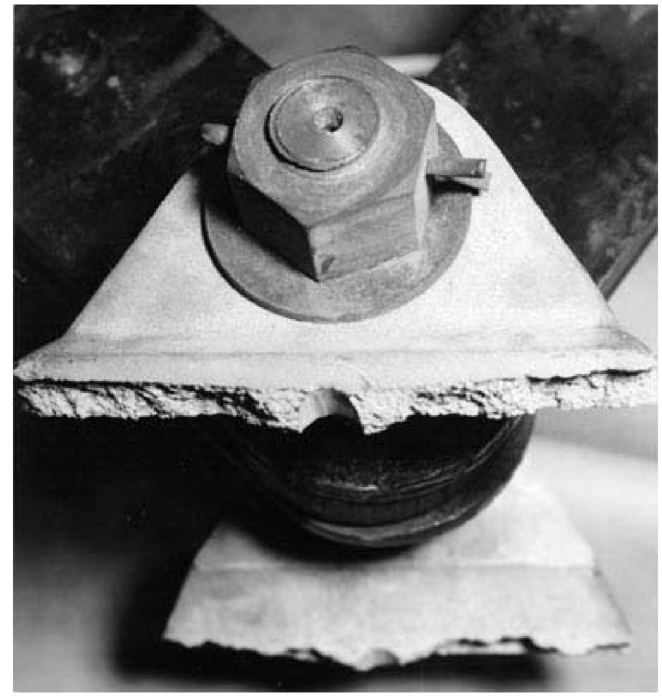


Battleship *U.S.S. California*
(passing under nearly completed suspended structure)



Calamity

With an impressive worker safety record, Strauss' luck was bound to run out. So it did for ten men who died in a single accident on February 17th 1937. Thirteen men were removing timber planks from the underside of the roadway via a movable scaffold. A set of wheels (supporting the west-end of the scaffold) slid off its support rail and the unbalanced weight of the stripper scaffold released the other wheels from their rails. One man – *Tom Casey*, jumped onto a nearby girder, but the others clung to the net which could not support the weight. Two men – crew foreman *Slim Lambert* and *Oscar Osberg (*a 51yo carpenter), survived the 220-foot fall. Osberg suffered a broken leg, fractured hip and massive internal injuries. Lambert, who desperately tried to save the life of another man, suffered a broken neck, back, ribs and severely twisted ankles.



"I felt the tower tremble as though there was an earthquake. I could see the net falling, accompanied by a sort of subdued chatter. I could hear faint baby-like cries. When the net hit the water, the men seemed like little blots of ink on the surface. The net looked like a rapidly sinking raft, with the tiny men entangled, fighting to get free. Then some of the inky blots disappeared. Some drifted out the gate and out of sight."

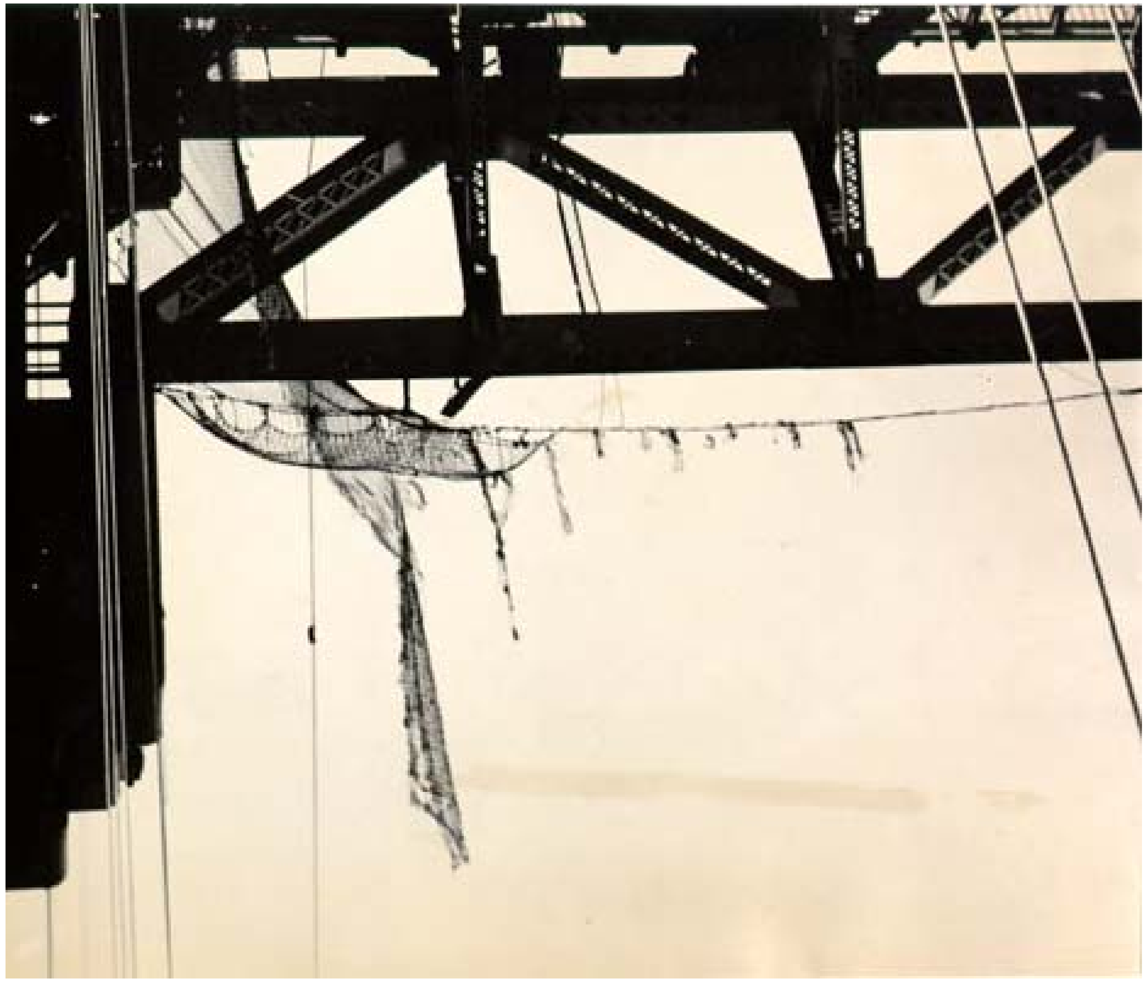
RE: eyewitness account of *Tex Leaster*, a GGB ironworker atop the south tower at the time of the scaffolding collapse on 02/17/37

"I felt everything slipping. There was nothing to hang on to. So I hollered to the rest of the fellows and jumped into the net…I must have acted instinctively, because I don't remember thinking. I landed in the safety net. A moment later, I heard a sound like thunder as the ten-ton stripper ripped from its hangers…Men were screaming and falling all around me. The whole net, about 1,200 feet of it, tore like tissue paper. I didn't realize until later that I was one of the few who missed being struck by the stripper. I was only conscious of being hurtled suddenly into the water. As I was falling, a piece of timber fell on my head. I was almost unconscious…I don't remember a thing except just before I hit the water with the net. Then I tried to jump. I think I succeeded because I wasn't fouled in the net. I went down in the water, not very deep, I think, because I came right up again… The icy waters of the channel brought me to. I'm a strong swimmer and I tried to get clear of the rigging net and wreckage…I saw some timber and grabbed on…"

Evan C. "Slim" Lambert, Crew Foreman

"It always bothered my father that he was regarded as a hero, because he said; 'I did nothing heroic. I wanted to save my best friend's life, and I did the best that I could.'"

Skip Lambert (son of Slim Lambert)



"…inexperienced laborers, ignorant of the hazard, were used to move the scaffold. It is the duty of Engineer Strauss to enforce terms of contracts. The affidavits of our brother workmen and the statements of Engineer Strauss, who, it is reported, will receive $1 million for his services, show that Engineer Strauss failed to enforce the contracts in such manner as to prevent the use of the dangerous scaffolding."

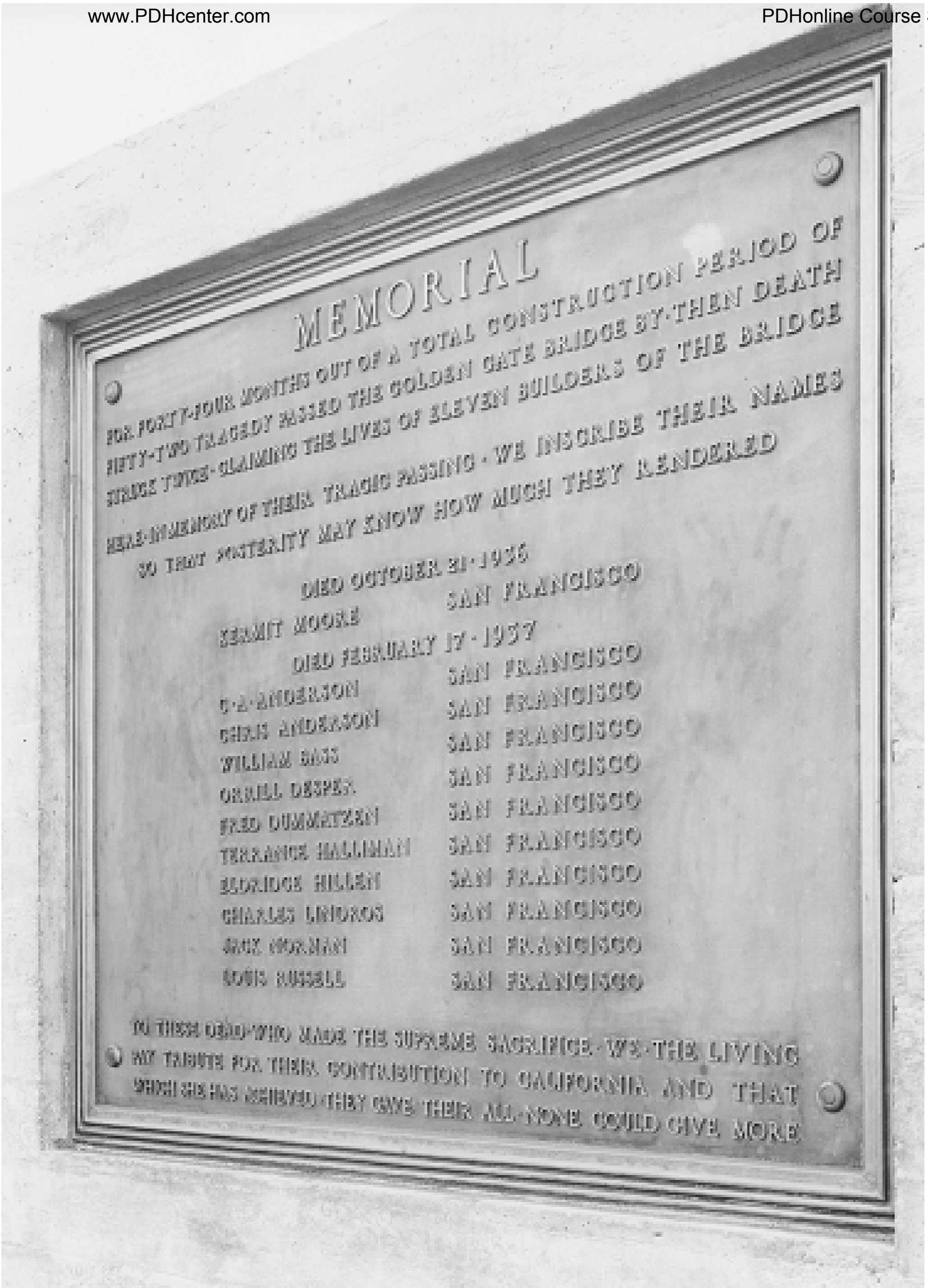
San Francisco Building Trades Council - Investigating Committee

RE: findings concerning the February 17th 1937 accident which killed ten GGB workmen. The committee pinned the blame squarely on both Strauss and the contractor – ***Pacific Bridge Company.*** **They severely criticized both for not heeding the warnings of California State (*Industrial Accident Commission*) inspectors who had warned them that the scaffold was unsafe.**

MEMORIAL

For forty-four months out of a total construction period of fifty-two, tragedy passed the Golden Gate Bridge by. Then death struck twice, claiming the lives of eleven builders of the bridge…To these dead, who made the supreme sacrifice, the living pay tribute for their contribution to California and that which she has achieved. They gave their all. None could give more.

RE: plaque on the San Francisco abutment honoring the eleven men who lost their lives constructing the Golden Gate Bridge



The eleven men who died building the Golden Gate Bridge:

- **Kermit Moore**
- **O.A. Anderson**
- **Chris Andersen**
- **William Bass**
- **Orrill Desper**
- **Fred Dummatzen**
- **Terence Hallinan**
- **Eldridge Hillen**
- **Charles Lindros**
- **Jack Norman**
- **Louis Russell**

"…It's like a terrible dream. It couldn't have happened. Yet I know it did. Ten of my friends were dead. I saw them die all around me and couldn't do anything about it…I didn't remember much more. I don't know any of the details of what happened. I only know I keep hearing the cries of my friends. They were frightened. It's hell to die like that."

Evan C. "Slim" Lambert, Crew Foreman

The Last Rivet


THE LAST RIVET
of the
GOLDEN GATE BRIDGE
A rivet of California gold was driven at this spot
PRESENTED TO THE
GOLDEN GATE BRIDGE and HIGHWAY DISTRICT
by

"Every span is something that 'can't be done' until the men in steel helmets have driven in their last rivet."

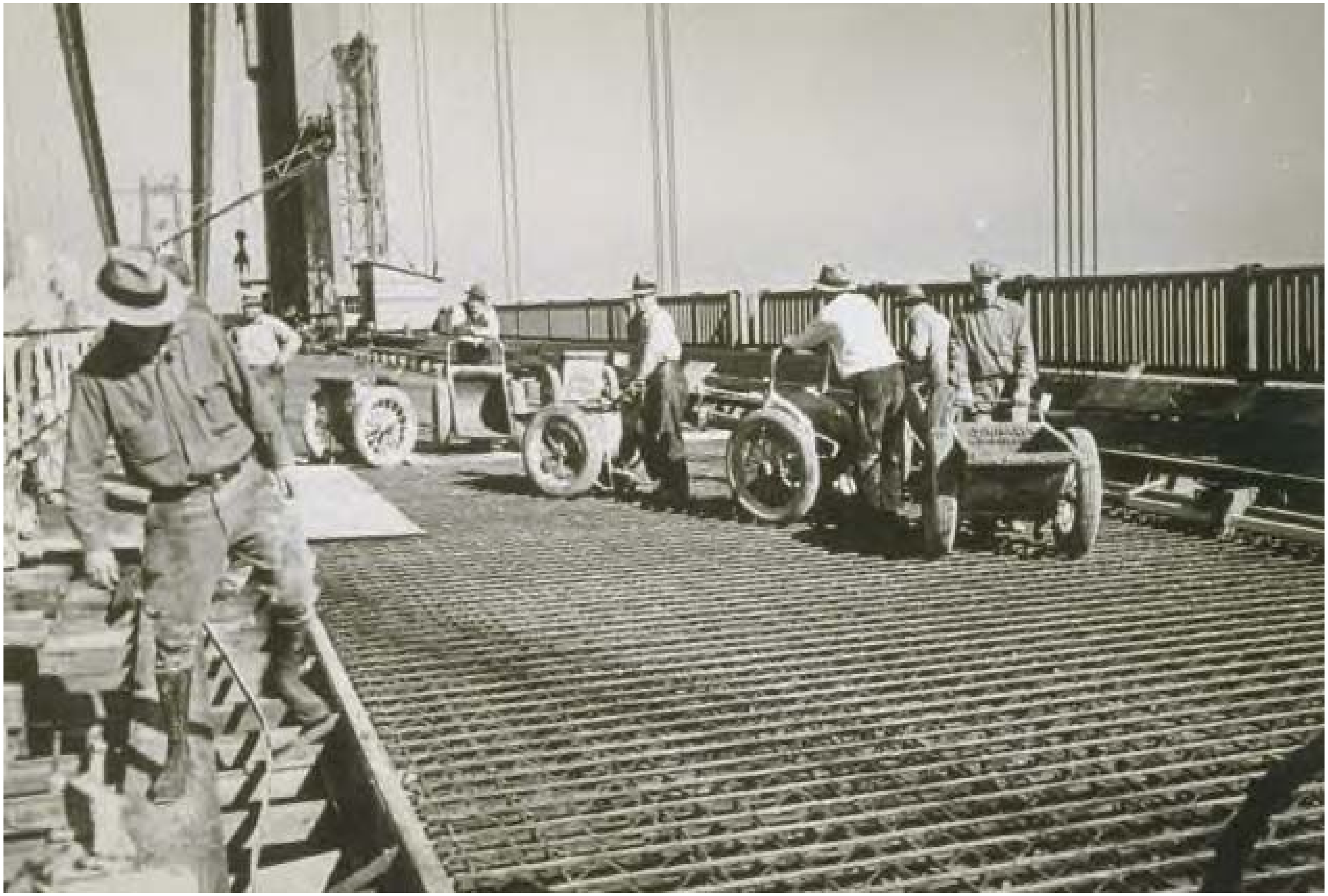
Joseph B. Strauss – Chief Engineer, GGB

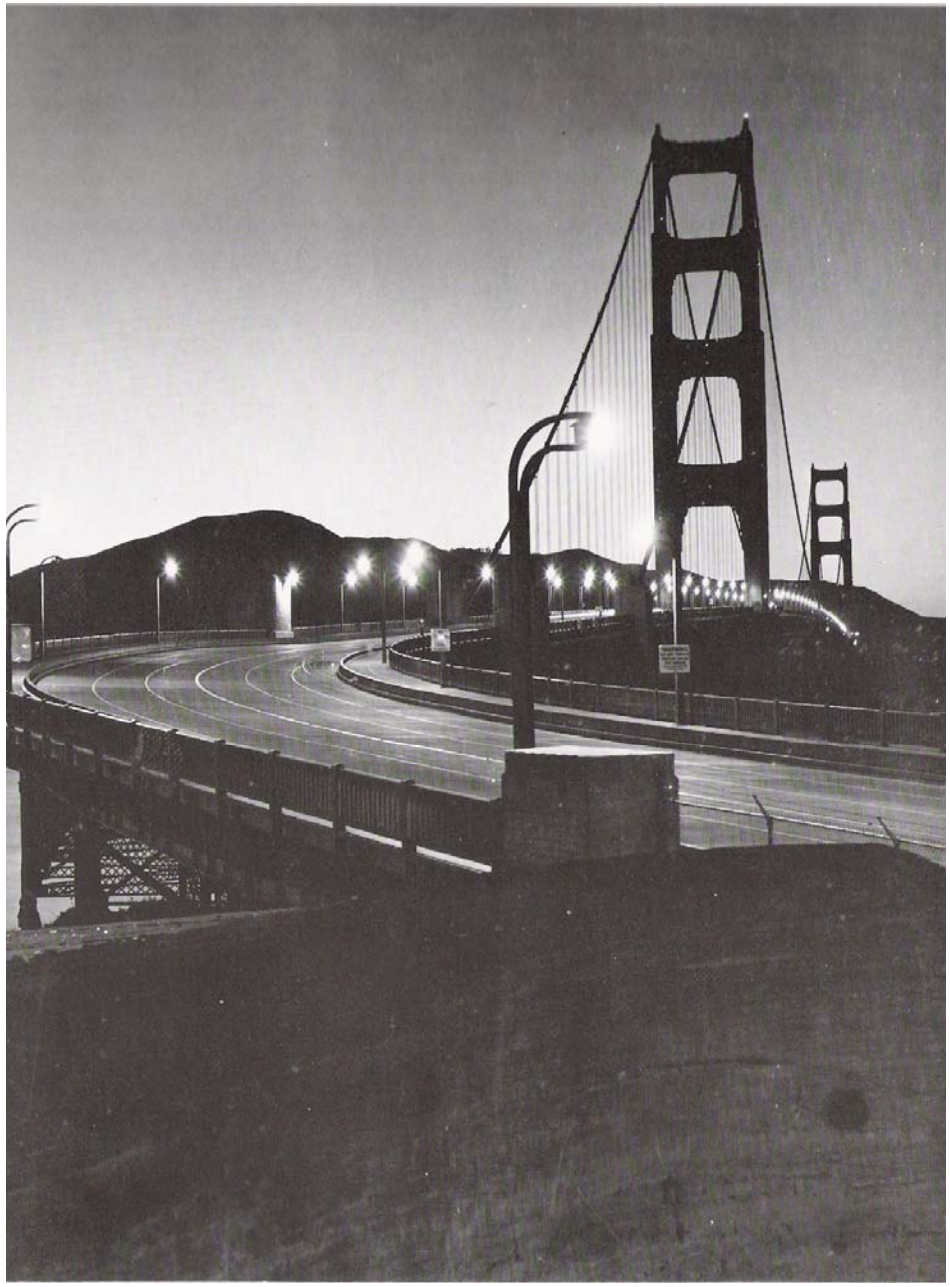
RE: on April 19th 1937, road deck paving was completed and on April 27th 1937, a "Ceremony of Completion" was held whereby the last rivet (gold) was driven in by Edward "Iron Horse" Stanley (who drove in the first rivet).

<u>Contract VII</u>

Paving for Suspension Spans and Approaches

Starting on January 19th 1937, the roadway paving was completed in exactly four months; on April 19th 1937.



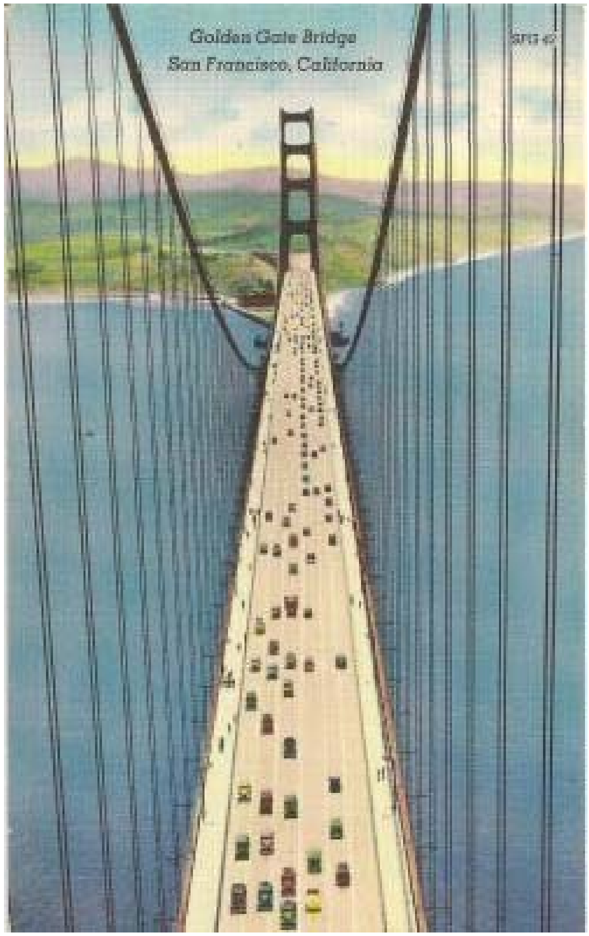


"Since all operations on the bridge at this time began to feel the scarcity of skilled workmen of all crafts, the rule for employment of residents was waived, when necessary, to minimize delay"

Joseph Strauss - Chief Engineer, Golden Gate Bridge (April, 1937)

RE: combination of the 02/17/37accident and near completion of the bridge created a labor shortage. The six counties rule for employment was over-ruled as a consequence.

The largest retrofit project for the GGB occurred between 1982 and the summer of 1985 when all original (747) concrete deck and steel stringer support sections were replaced with a lighter, stronger *Orthotropic* steel deck. *Ammann & Whitney* designed and oversaw the comprehensive retrofit – the first ever of its kind, which took 401 nights to complete (without having to close the bridge to traffic). The roadway was widened by two-feet (from 60-feet to 62-feet) allowing for wider outside lanes (in each direction) for trucks and buses (from 10-feet originally to 11-feet). After the new Orthotropic deck was in place, a two-inch thick epoxy asphalt was laid down. The harsh environmental conditions of the strait had deteriorated the original deck requiring its replacement.


Golden Gate Bridge
San Francisco, California

Rendering for Proposed Lower Deck
(ca. 1965)

"It took two decades and 200 million words to convince people that the bridge was feasible; then only four years and $35 million to put the concrete and steel together"

Joseph Strauss – Chief Engineer, GGB

RE: his fifteen year struggle to get the Golden Gate Bridge built. About 115K vehicles cross the GGB daily.

Part 10

The Mighty Task is Done

At last the mighty task is done;
Resplendent in the western sun
The bridge looms mountain high…

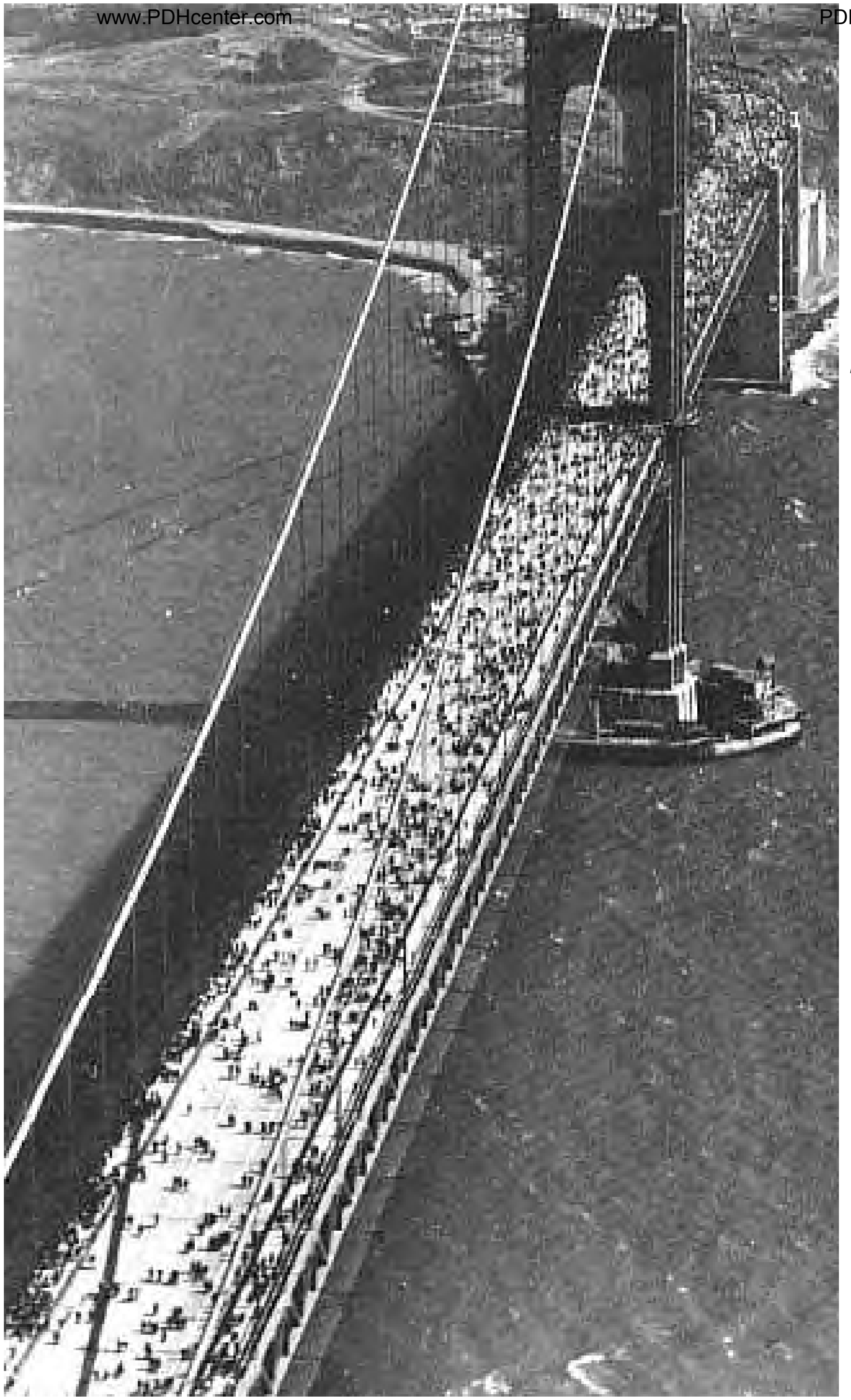
…On its broad decks in rightful pride,
The world in swift parade shall ride
Throughout all time to be…

…Launched midst a thousand hopes and fears,
Damned by a thousand hostile sneers.
Yet ne'er its course was stayed…

…But ask of those who met the foe,
Who stood alone when faith was low,
Ask them the price they paid…

…High overhead its lights shall gleam,
Far, far below life's restless stream,
Unceasingly shall flow…

Poem: excerpts from: *"The Mighty Task Is Done"* by Joseph B. Strauss

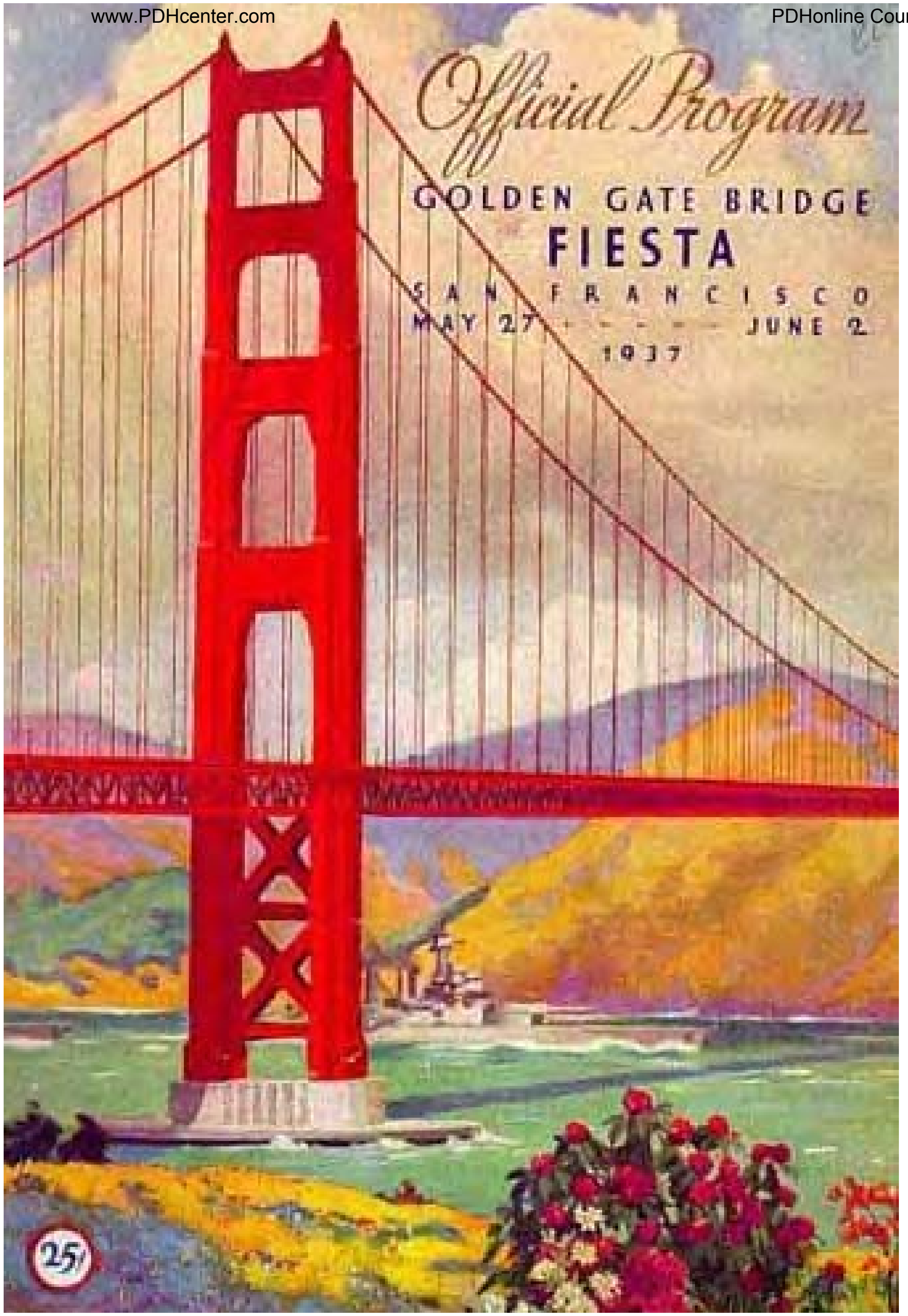


"A necklace of surpassing beauty was placed about the lovely throat of San Francisco yesterday"

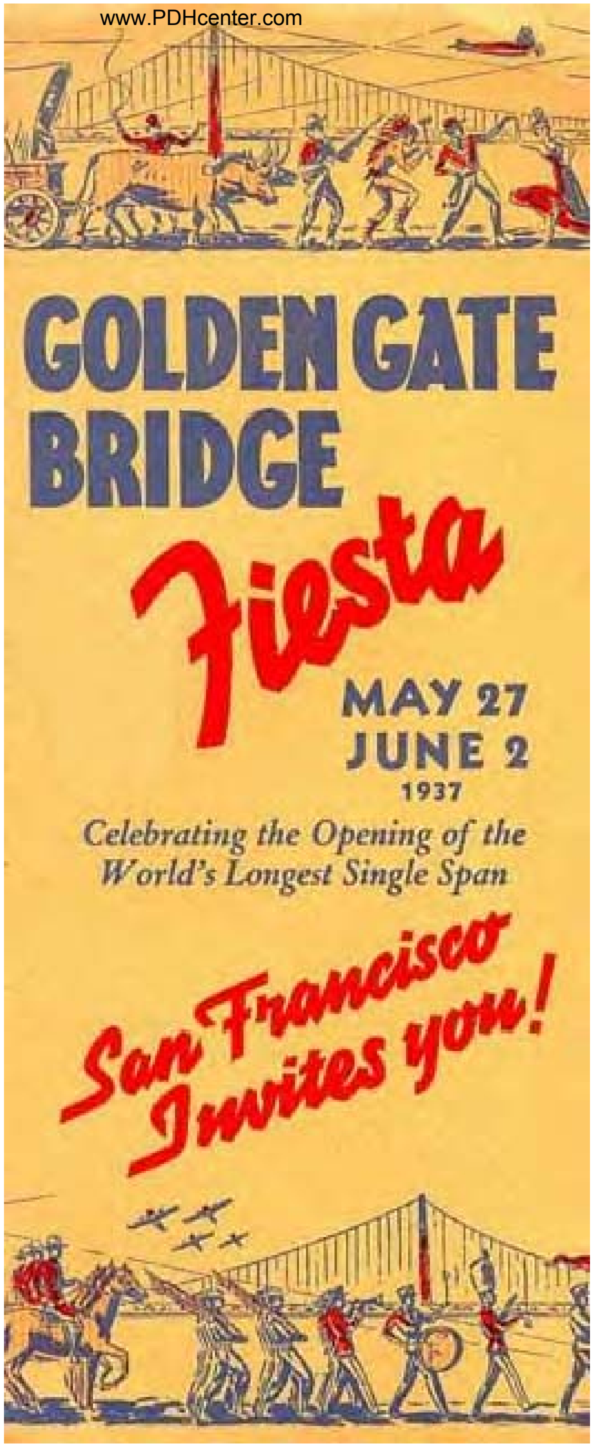
Willis O'Brien – Reporter, *San Francisco Chronicle*

RE: on May 27th 1937, the GGB opened to pedestrian traffic. The next day, Pres. Roosevelt pressed a telegraph key at noon and the bridge was opened to vehicular traffic, to the accompaniment of every church bell, siren and boat whistle and fog horn within earshot of San Francisco. The bridge was completed under budget (+$1.3 million) and ahead of schedule.


GOLDEN GATE BRIDGE FIESTA
San Francisco
OFFICIAL
PEDESTRIAN DAY
MAY 27, 1937
8020
Souvenir
25c
PRESIDENT GOLDEN GATE BRIDGE AND HIGHWAY DISTRICT



Fiesta Week **(May 27th to June 2nd 1937) celebrated the opening of the GGB with fireworks, parades, entertainment and a nightly pageant at nearby Crissy Field. During the week-long celebrations, most area schools were closed and businesses closed or reduced hours so that San Franciscans could partake in the memorable festivities. It began at 6:00 AM on May 27th with** ***Pedestrian Day*** **when an estimated 15K people per hour paid $0.25 to have the honor of saying they crossed the bridge on opening day (about 200K crossed the bridge that day).**



"I was in the parade, and I walked across the bridge. It was never just a job to me. I loved the work."

Harold McClain, Bridgeman

RE: *Pedestrian Day* festivities

The Fiesta's second day (May 28th) was devoted to automobiles and speeches. In the morning, San Francisco Mayor *Anjelo J. Rossi* read a proclamation and a chain-cutting ceremony was held at the Marin Tower. A flyover by five-hundred Navy planes occurred at 11:00 AM and the official opening ceremonies (at Crissy Field) took place at 11:30 AM. At 3:00 PM, the U.S. Pacific fleet arrived with the Battleship *U.S.S. Pennsylvania* leading forty-one other warships in salute of the GGB. At 10:00 PM there was a fireworks display and then a dedication address was given by *Francis K. Keesling:*

"We dedicate the Bridge to local, national and international service. It commands faith and integrity…We wish that this Golden Gate Bridge may remind the traveler as he leaves or approaches his native shore…of the liberty and glory of his country..."

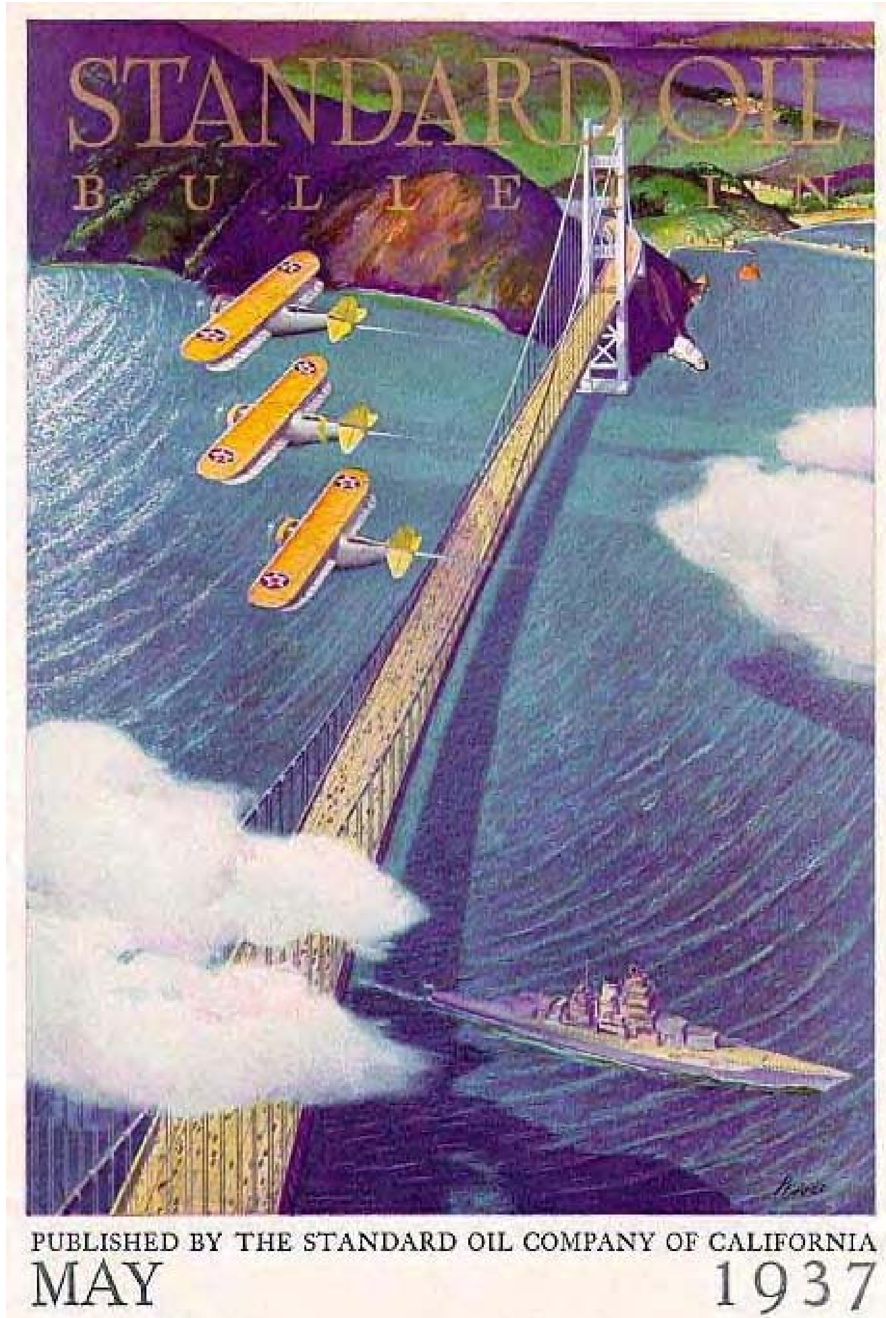
Planes and Fleet Help Opening of GoldenGateSpan

Autos Streaming Across New Bridge at Rate of 3,000 an Hour After F.D.R. Gives Go Signal

Pedestrians Rush

Tin Buckets Are Needed to Collect Fees From Those Going on Foot

SAN FRANCISCO, Calif., May 28 (AP).—Automobiles began streaming across the Golden Gate Bridge at an estimated rate of 3,000 an hour Friday as the great span opened to vehicular traffic with spectacular salutes from 300 fighting planes, the United States fleet and uncounted thousands who watched and cheered.


STANDARD OIL
BULLETIN
PUBLISHED BY THE STANDARD OIL COMPANY OF CALIFORNIA
MAY
1937

May 28th 1937

32,300 vehicles and 19,350 pedestrians cross the GGB [622]

I Like A Bridge

I like a bridge
It cries, "Come on, I'll take you there from here and here from there and save you time and toil."

I like a bridge
It breathes romance; "There's new adventure on the further side and I will help you cross."

I like a bridge
It makes me think that when a worry comes my mind will find somewhere a friendly bridge

RE: remarks at conclusion of *Pedestrian Day* – May 27th 1937, by California Governor *Frank F. Merriam*

"This bridge needs neither praise nor eulogy…It speaks for itself."

RE: excerpt from Strauss' opening ceremony speech

A Splendid Suicide

When the *Brooklyn Bridge* opened in 1883, *The Brooklyn Eagle* suggested that would-be suicides would have "A Splendid Suicide" by jumping off the bridge. It's one of the sad facts concerning the GGB that it immediately drew people bent on ending their own life and nowhere else on earth have so many people been successful in doing so (about two per month since 1937). "Jumpers" - as they are referred to, have easy access to the pedestrian walkway/s and their six-foot railing/s. It takes a jumper about four seconds to hit the water at +/-80mph. Most (98%) die from the impact, but some have survived the fall only to drown or die of hypothermia (the water gets as cold as 47-degrees Fahrenheit). Sometimes the body is recovered, but the strong currents can easily take the body out to sea. Not all suicides are witnessed and bodies of suspected jumpers are often found. Police prevent many suicides each year and there are special suicide prevention signs and telephones. Some people travel from all over the world to commit suicide from the GGB. They'll take a cab or bus or leave a rented car behind after they jump to their death.


CRISIS COUNSELING
THERE IS HOPE
MAKE THE CALL
THE CONSEQUENCES OF
JUMPING FROM THIS
BRIDGE ARE FATAL
AND TRAGIC


GOLDEN GATE
JUMPERS

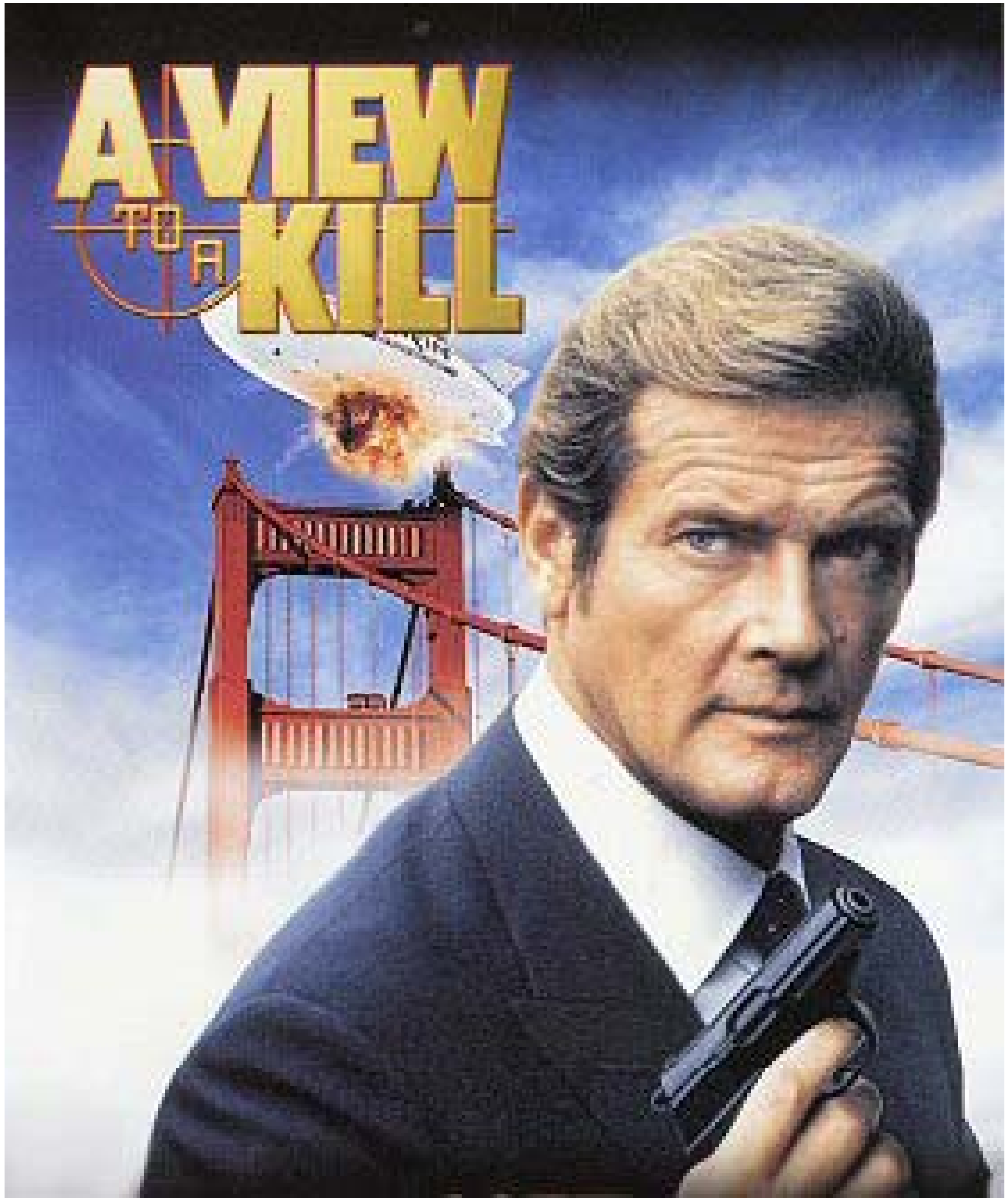
After years of debate and controversy (i.e. cost, aesthetics), in 2010 GGB officials approved construction of a *Suicide Barrier.* In the rendering above, a continuous net runs twenty-feet below the pedestrian walkway.

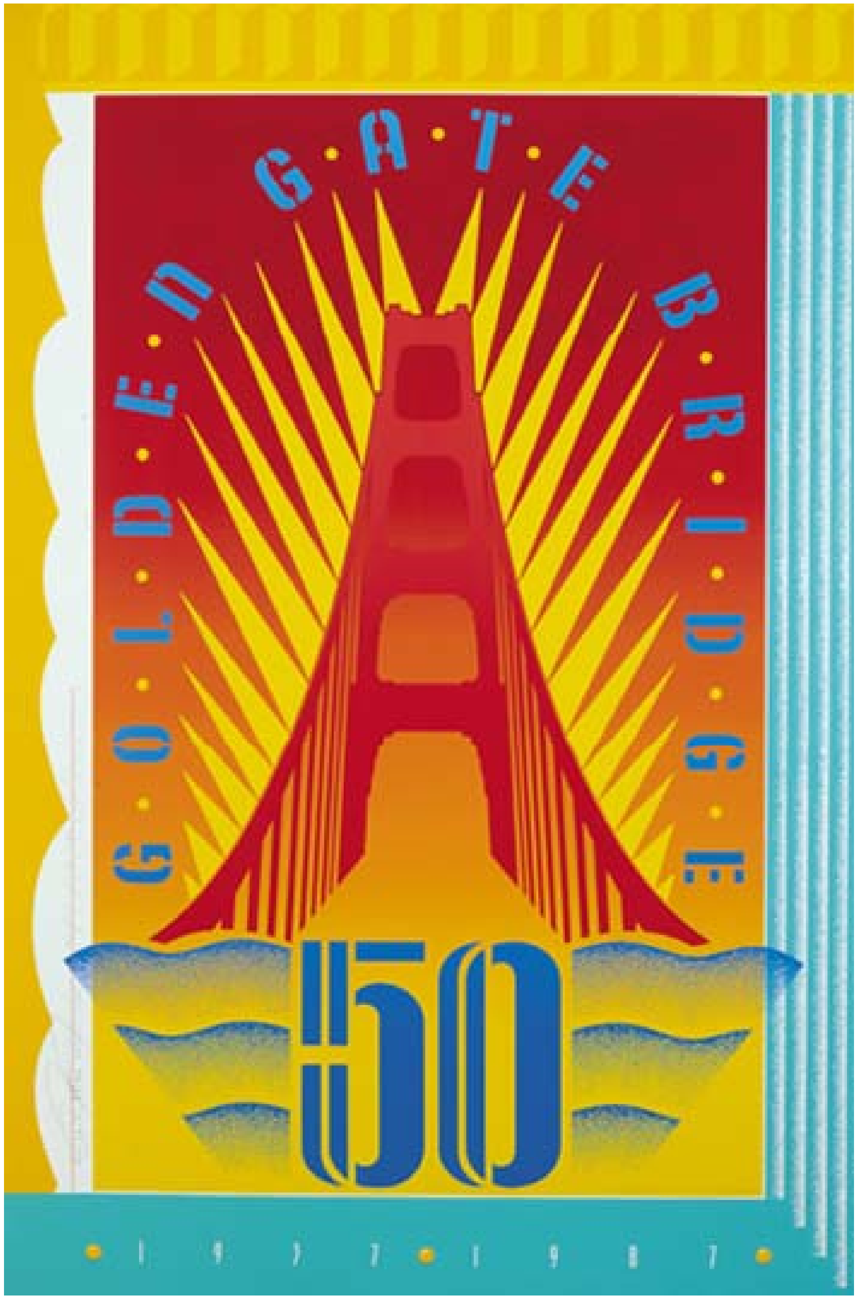
Milestones

- **July 25th 1938 – *Southern Pacific-Golden Gate Ferries*, Ltd. suspends all operations**
- **March 22nd 1957 – a 5.3 earthquake hits the Bay Area and the GGB is seen to "undulate as in a fierce gale"**
- **February 26th 1960 – in the interest of public safety, the pedestrian walkways are closed between sunset and sunrise**
- **August 15th 1970 – Golden Gate ferry service resumes between San Francisco and Sausalito**
- **July 1st 1971 – all the original bonds issued for constructing the GGB are retired**
- **1980-1982 – Both the Marin and San Francisco approaches are retrofitted to comply with Caltrans retrofit design standards for existing structures**
- **September 29th 1984 – filming of a new James Bond movie: *A View to a Kill*, takes place high atop one of the main cables**
- **February 22nd 1985 – the one billionth car crosses the GGB**
- **May 1987 – GGB celebrates its 50th Anniversary**

continued….

- **February 16th 1994 – *The American Society of Civil Engineers* (ASCE) names the GGB one of the *Seven Civil Engineering Wonders of the United States***
- **August 5th 1997 – Phase I of the seismic retrofit of the GGB begins**
- **September 3rd 1998 – the USPS unveils a Golden Gate Bridge commemorative stamp**
- **May 11th 2001 – a contract is awarded for Phase II of the GGB's seismic retrofit**
- **May 30th 2001 – the ASCE names the GGB a *Civil Engineering Monument of the Millenium***
- **April 2008 – Phase 3A of the seismic retrofit began (anchorage housing and pylons)**
- **May 2012 – the GGB celebrates its 75th Anniversary**
- **2014 – Phase 3B of the seismic retrofit scheduled to begin (main span and towers)**


A VIEW TO A KILL

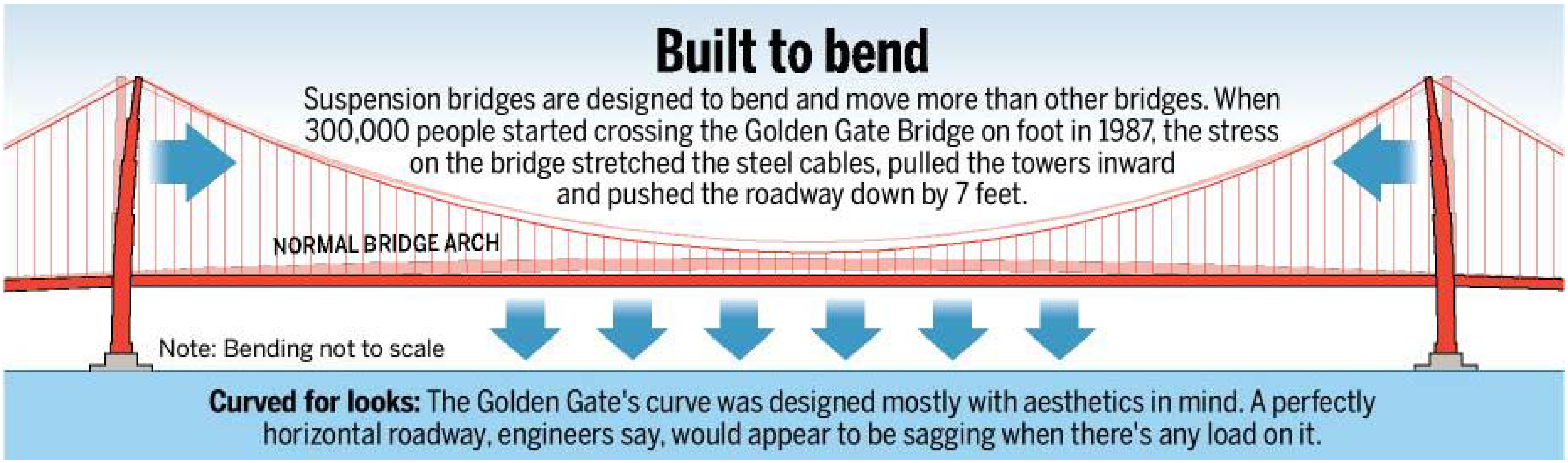

GOLDEN GATE BRIDGE
50
1937 1987

For the Golden Anniversary of the GGB, on May 24th 1987, bridge officials closed the bridge to traffic for an expected 50K pedestrians to cross the 1.7 mile long bridge (much as they did fifty-years earlier on *Pedestrian Day*). With 300K people stuck in human gridlock on the bridge (and another 500K waiting for their chance), bridge officials closed the bridge. The great weight of all that humanity caused the center of the bridge to sag seven feet. Downward deflections of up to ten-feet are within the GGB's design criteria and the bridge was never in danger of collapsing. The original design called for a live-load allowance of 4K-pounds per linear foot. Assuming an average weight of 150-pounds and 2.5 square-feet of occupied space per person (in such a densely packed crowd), that adds up to 5,400 pounds per linear foot (double that of bumper-to-bumper traffic). Fortunately, the Orthotropic Deck retrofit completed in 1985 had boosted the live-load capacity to 5,700 pounds per linear foot and the bridge was designed with a safety factor of 150% (for additional weight). Thus, the actual original live load capacity was 6K-pounds per linear foot.

Normal “Camber” (upward curve) of Main Span

Flattening of Deck (at center)

May 24th 1987


Built to bend
Suspension bridges are designed to bend and move more than other bridges. When 300,000 people started crossing the Golden Gate Bridge on foot in 1987, the stress on the bridge stretched the steel cables, pulled the towers inward and pushed the roadway down by 7 feet.
NORMAL BRIDGE ARCH
Note: Bending not to scale
Curved for looks: The Golden Gate's curve was designed mostly with aesthetics in mind. A perfectly horizontal roadway, engineers say, would appear to be sagging when there's any load on it.

"Then it got kind of scary, because we realized we were trapped. We were standing there, and then I said to my friend, 'Dude, this bridge is moving.'"

Barbara Schnur

"It was probably the biggest load the bridge had ever seen. But it did not exceed the design load capacity of the bridge."
Mark Ketchum, Civil Engineer


GOLDEN GATE BRIDGE
1937
2012
75TH ANNIVERSARY


32
USA
Golden Gate Bridge


GREETINGS
CALIFORNIA

"…they admire its living grace, and its magnificent setting. They respond to its many moods – its warm and vibrant glow in the early sun, its seeming play with, or disdain of, incoming fog, its retiring shadowy form before the sunset, its lovely appearance in its lights at night. To its familiars it appears as the 'Keeper of the Golden Gate.'"

RE: the Golden Gate Bridge


GOLDEN
GATE
BRIDGE