**San Francisco – Oakland Bay Bridge**

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| **San Francisco – Oakland Bay Bridge** |
|  |
| Western Span of the bridge at night |
| **Carries** | 10 lanes (5 westbound on upper level, 5 eastbound on lower) of [I-80](http://en.wikipedia.org/wiki/Interstate_80_%28California%29) |
| **Crosses** | [San Francisco Bay](http://en.wikipedia.org/wiki/San_Francisco_Bay) via [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island) |
| **Locale** | [San Francisco](http://en.wikipedia.org/wiki/San_Francisco) and [Oakland](http://en.wikipedia.org/wiki/Oakland%2C_California) |
| **Maintained by** | [California Department of Transportation](http://en.wikipedia.org/wiki/California_Department_of_Transportation) |
| [**ID number**](http://en.wikipedia.org/wiki/National_Bridge_Inventory#ID_numbers) | ++++++34+0003 |
| **Designer** | [Charles H. Purcell](http://en.wikipedia.org/w/index.php?title=Charles_H._Purcell&action=edit&redlink=1) |
| **Design** | Double-decked [Suspension](http://en.wikipedia.org/wiki/Suspension_bridge), [Truss](http://en.wikipedia.org/wiki/Truss_bridge) & [Cantilever Bridges](http://en.wikipedia.org/wiki/Cantilever_Bridge) and [Tunnel](http://en.wikipedia.org/wiki/Tunnel) |
| **Material** | Steel, concrete |
| **Total length** | West: 10,304 feet (3,141 m)East: 10,176 feet (3,102 m)Total: 4.46 miles (7.18 km)excluding approaches |
| **Width** | 5 traffic lanes totaling 57.5 feet (17.5 m) |
| **Longest span** | West: two main spans2,310 feet (700 m)East: one main span1,400 feet (430 m) |
| **Vertical clearance** | Westbound minimum 14 feet (4.3 m), with additional clearance in some lanes |
| **Clearance below** | West: 220 feet (67 m)East: 191 feet (58 m) |
| **Beginning date of construction** | July 8, 1933 |
| **Opened** | November 12, 1936 |
| **Toll** | Cars $4.00 (westbound only) |
| [**Daily traffic**](http://en.wikipedia.org/wiki/Average_daily_traffic) | 280,000 |
| **Connects:The eastern side of the city of San Francisco, CA with the western side of the city of Oakland, CA** |  |
| [**Coordinates**](http://en.wikipedia.org/wiki/Geographic_coordinate_system) | [37°49′5″N 122°20′48″W﻿ / ﻿37.81806°N 122.34667°W﻿ / 37.81806; -122.34667](http://toolserver.org/~geohack/geohack.php?pagename=San_Francisco_%E2%80%93_Oakland_Bay_Bridge&params=37_49_5_N_122_20_48_W_type:landmark_region:US-CA)[Coordinates](http://en.wikipedia.org/wiki/Geographic_coordinate_system): [37°49′5″N 122°20′48″W﻿ / ﻿37.81806°N 122.34667°W﻿ / 37.81806; -122.34667](http://toolserver.org/~geohack/geohack.php?pagename=San_Francisco_%E2%80%93_Oakland_Bay_Bridge&params=37_49_5_N_122_20_48_W_type:landmark_region:US-CA) |
| Map of the original bridge and the eastern span replacementSan Francisco – Oakland Bay Bridge (California) |

The **San Francisco – Oakland Bay Bridge** (known locally as the **Bay Bridge**) is a series of bridges in the [San Francisco Bay Area](http://en.wikipedia.org/wiki/San_Francisco_Bay_Area) of [California](http://en.wikipedia.org/wiki/California), in the [United States](http://en.wikipedia.org/wiki/United_States). Forming part of [Interstate 80](http://en.wikipedia.org/wiki/Interstate_80_%28California%29) and of the direct road route between [San Francisco](http://en.wikipedia.org/wiki/San_Francisco) and [Oakland](http://en.wikipedia.org/wiki/Oakland%2C_California), it carries approximately 270,000 vehicles per day on its two decks. It has one of the longest spans in the world.

The [toll bridge](http://en.wikipedia.org/wiki/Toll_bridge) was conceived as early as the [gold rush](http://en.wikipedia.org/wiki/California_Gold_Rush) days, but construction did not begin until 1933. Designed by Charles H. Purcell, and built by [American Bridge Company](http://en.wikipedia.org/wiki/American_Bridge_Company), it opened for traffic on November 12, 1936, six months before the [Golden Gate Bridge](http://en.wikipedia.org/wiki/Golden_Gate_Bridge). It originally carried automobile traffic on its upper deck, and trucks and trains on the lower, but after the closure of the [Key System](http://en.wikipedia.org/wiki/Key_System), the lower deck was converted to road traffic as well.

After being temporarily closed on October 27, 2009 due to failure of the recently repaired eastern span, the Bay Bridge reopened on November 2. For more information, see [October 2009 eyebar repair failure and bridge closure](http://en.wikipedia.org/wiki/San_Francisco_%E2%80%93_Oakland_Bay_Bridge#October_2009_eyebar_repair_failure_and_bridge_closure#October_2009_eyebar_repair_failure_and_bridge_closure).

In 1986, the city of San Francisco unofficially renamed the bridge to *The* [*James "Sunny Jim" Rolph*](http://en.wikipedia.org/wiki/James_Rolph) *Bridge*.

**Composition**

The bridge consists of two major crossings connecting each shore with [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island), a natural outcropping located mid-bay. The western crossing, from San Francisco to the island, consists of two [suspension bridges](http://en.wikipedia.org/wiki/Suspension_bridge) end-to-end with a center anchorage, along with three shorter truss spans connecting the San Francisco landing to the western cable anchorage located on [Rincon Hill](http://en.wikipedia.org/wiki/Rincon_Hill). The eastern crossing between Yerba Buena Island and Oakland consists of a double-tower [cantilever span](http://en.wikipedia.org/wiki/Cantilever_bridge), five medium-span truss bridges, and a 14-section truss causeway. These East Bay structures are scheduled to be replaced by an entirely new crossing, which is under construction. On Yerba Buena Island, the double-decked crossing consists of a 321 foot (98 m) concrete [viaduct](http://en.wikipedia.org/wiki/Viaduct) east of the west span's cable anchorage, a 540 foot (160 m) [tunnel](http://en.wikipedia.org/wiki/Tunnel) through the island's rocky central hill, another 790.8 foot (241.0 m) concrete viaduct, and a longer curved high-level steel truss viaduct that spans the final 1,169.7 feet (356.5 m) to the cantilever bridge. The viaduct sections east of the tunnel are at present being modified, bypassed and replaced as part of the seismic safety work that will eventually transition traffic onto and off of the self-anchored suspension (SAS) bridge of the new eastern bay crossing.

The toll plaza on the Oakland side (since 1969 for westbound traffic only) has eighteen toll lanes, of which six are dedicated [FasTrak](http://en.wikipedia.org/wiki/FasTrak) lanes. Mainline metering signals are located approximately 600 feet west of the toll plaza. Two full-time bus-only lanes bypass the toll booths and metering lights around the right (north) side of the toll plaza; other high occupancy vehicles are permitted to use these lanes during weekday morning and afternoon commute periods. The two far-left toll lanes are operated as [high-occupancy vehicle lanes](http://en.wikipedia.org/wiki/High-occupancy_vehicle_lane) during weekday morning and afternoon commute periods. During the morning commute hours, traffic congestion on the Oakland approach stretches back onto the three [feeder highways](http://en.wikipedia.org/wiki/MacArthur_Maze), Interstate 580, Interstate 880, and [Interstate 80](http://en.wikipedia.org/wiki/Interstate_80_in_California) toward [Richmond](http://en.wikipedia.org/wiki/Richmond%2C_California), [California](http://en.wikipedia.org/wiki/California). Since the number of lanes on the San Francisco approach is structurally restricted, [backups](http://en.wikipedia.org/wiki/Traffic_congestion) are frequent in the eastbound direction during evening commute hours. The bridge is currently restricted to motorized freeway traffic. Pedestrians, bicycles, and other non-freeway vehicles and devices are not allowed. However, a [California Department of Transportation](http://en.wikipedia.org/wiki/California_Department_of_Transportation) (Caltrans) bicycle shuttle operates during peak commute hours for $1.00 each way.

**History**

**Pre-construction**

San Francisco, located at the mouth of the bay, was in a perfect location to prosper during the [California Gold Rush](http://en.wikipedia.org/wiki/California_Gold_Rush). Almost all goods not produced locally arrived by ship. But after the [first transcontinental railroad](http://en.wikipedia.org/wiki/First_transcontinental_railroad) was completed in May 1869, San Francisco found itself to be on the wrong side of the bay, separated from the new rail link. The fear of many San Franciscans was that the city would lose its position as the regional center of trade. The concept of a bridge spanning the San Francisco Bay had been considered since the Gold Rush days. Several newspaper articles during the early 1870s discussed the idea. In early 1872, a "Bay Bridge Committee" was hard at work on plans to construct a [railroad](http://en.wikipedia.org/wiki/Railroad) bridge. The April 1872 issue of the *San Francisco Real Estate Circular* contained an item about the committee:

The Bay Bridge Committee lately submitted its report to the Board of Supervisors, in which compromise with the Central Pacific was recommended; also the bridging of the bay at Ravenswood and the granting of railroad facilities at Mission Bay and on the water front. Wm. C. Ralston, ex-Mayor Selby and James Otis were on this committee. A daily newspaper attempts to account for the advice of these gentlemen to the city by hinting that they were afraid of the railroad company, and therefore made their recommendations to suit its interests.

The self-proclaimed [Emperor Norton I](http://en.wikipedia.org/wiki/Emperor_Norton_I) saw fit to decree several times that a suspension bridge be constructed to connect Oakland with San Francisco. Later in 1872, frustrated that nothing had happened, Norton decreed:

WHEREAS, we issued our decree ordering the citizens of San Francisco and Oakland to appropriate funds for the survey of a suspension bridge from Oakland Point via Goat Island; also for a tunnel; and to ascertain which is the best project; and whereas the said citizens have hitherto neglected to notice our said decree; and whereas we are determined our authority shall be fully respected; now, therefore, we do hereby command the arrest by the army of both the Boards of City Fathers if they persist in neglecting our decrees.

Given under our royal hand and seal at San Francisco, this 17th day of September, 1872.

Sketch drawing of proposed Trans-Bay Suspension Bridge (1913)

Unlike most of Emperor Norton's eccentric ideas, his decree to build a bridge had wide public and political appeal. Yet, the task was too much of an engineering and economic challenge since the bay was too wide and too deep there. In 1921, over forty years after Norton's death, an underwater tunnel was considered, but it became clear that one would be inadequate for vehicular traffic. Support for a trans-bay crossing finally grew in the 1920s with the increasing popularity and availability of the automobile. In 1929, the California Legislature established the [California Toll Bridge Authority](http://en.wikipedia.org/w/index.php?title=California_Toll_Bridge_Authority&action=edit&redlink=1) with the responsibility of connecting San Francisco and [Alameda County](http://en.wikipedia.org/wiki/Alameda_County%2C_California) with a bridge.

To make the bridge design feasible, its route was chosen to pass through [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island), significantly reducing the amount of material and construction labor needed to build a trans-bay crossing. Yerba Buena Island was a [U.S. Navy](http://en.wikipedia.org/wiki/U.S._Navy) base at the time (and through 1997). So the approval of the U.S. Congress, which regulates the armed services and supervises all naval and military bases, was necessary for this island to be used. After a great deal of lobbying, California received Congressional approval to use the island on February 20, 1931.

**Construction**

The Bay Bridge under construction at [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island) in 1935

Construction began on July 9, 1933. The western span of the bridge between San Francisco and Yerba Buena Island presented an enormous engineering situation. The bay was up to 100 feet (30 m) deep in places and the soil required new foundation-laying techniques. At the time of construction, suspension bridges could not be made with more than a pair of towers because of stability considerations, and a two-tower span would have been longer than was practical. The solution was to construct a massive concrete anchorage halfway between San Francisco and the island and to build two complete suspension bridges, one on either side of the middle anchorage.

The eastern span was a marvelous engineering feat as well. The crossing from Yerba Buena Island to Oakland was spanned by a 10,176-foot (3,102 m) combination of double cantilever, five long-span through-trusses, and a truss causeway, forming the longest bridge of its kind at the time, with the cantilever portion being the most massive one yet constructed.

Much of the original eastern span is actually founded upon treated wood. Because of the very deep muds on the bay bottom it was not practical to reach bedrock, although the lower levels of the mud are quite firm. Long wooden pilings were crafted from entire old-growth [Douglas fir](http://en.wikipedia.org/wiki/Douglas_fir) trees which were driven through the soft mud to the firmer bottom layers.

**Yerba Buena Tunnel**

Traveling through the westbound Yerba Buena tunnel

Connecting the two halves of the bridge is Yerba Buena Tunnel, measuring 76 feet (23 m) wide, 58 feet (18 m) high, and 540 feet (160 m) long. It is the largest diameter transportation bore tunnel in the world. The huge amount of rock and dirt excavated from the tunnel was used in part to create [Treasure Island](http://en.wikipedia.org/wiki/Treasure_Island_%28California%29) in the Bay, immediately north, and connected to, Yerba Buena Island.

Reminders of the long-gone bridge railway survive along the south side of the lower Yerba Buena Tunnel. These are the regularly-spaced "Deadman holes" along the wall, into which track workers could duck, in case a train came along while they were in the tunnel.

**Opening day**

The bridge was opened to traffic on November 12, 1936, at 12:30 p.m. Among those in attendance were the former [U.S. president](http://en.wikipedia.org/wiki/President_of_the_United_States) [Herbert Hoover](http://en.wikipedia.org/wiki/Herbert_Hoover), Senator [William G. McAdoo](http://en.wikipedia.org/wiki/William_G._McAdoo), and the [Governor of California](http://en.wikipedia.org/wiki/Governor_of_California), [Frank Merriam](http://en.wikipedia.org/wiki/Frank_Merriam). Governor Merriam officially opened the bridge by cutting gold chains across the traffic lanes with an [acetylene](http://en.wikipedia.org/wiki/Acetylene) [cutting torch](http://en.wikipedia.org/wiki/Oxy-fuel_welding_and_cutting). The [*San Francisco Chronicle*](http://en.wikipedia.org/wiki/San_Francisco_Chronicle) report of November 13, 1936, read:

"the greatest traffic jam in the history of S.F., a dozen old-fashioned New Year's eves thrown into one — the biggest and most good-natured crowd of tens of thousands ever to try and walk the streets and guide their autos on them — This was the city last night, the night of the bridge opening with every auto owner in the bay region, seemingly, trying to crowd his machine onto the great bridge.

And those who tried to view the brilliantly lighted structure from the hilltops and also view the fireworks display were numbered also in the thousands.

Every intersection in the city, particularly those near the San Francisco entrance to the bridge, was jammed with a slowly moving auto caravan.

Every available policeman in the department was called to duty to aid in regulating the city's greatest parade of autos.

One of the greatest traffic congestions of the evening was at Fifth and Mission Streets, with downtown traffic and bridge-bound traffic snarled in an almost hopeless mass. To add to the confusion, traffic signals jammed and did not synchronize.

Police reported that there was no lessening of the traffic over the bridge, all lanes being crowded with Oakland- or San-Francisco-bound machines far into the night."

The total cost of construction for the bridge was $77 million. Prior to its opening, the bridge was blessed by [Cardinal Secretary of State](http://en.wikipedia.org/wiki/Cardinal_Secretary_of_State) [Eugene Cardinal Pacelli](http://en.wikipedia.org/wiki/Eugene_Cardinal_Pacelli), who later became [Pope Pius XII](http://en.wikipedia.org/wiki/Pope_Pius_XII). At completion, the bridge became the longest suspended-deck bridge in the world and the longest cantilever bridge in the world. Because it was in effect two bridges strung together, the western spans were ranked the second and third [largest suspension bridges](http://en.wikipedia.org/wiki/List_of_longest_suspension_bridge_spans). Only the [George Washington Bridge](http://en.wikipedia.org/wiki/George_Washington_Bridge) had a longer span between towers.

**Roadway plan**

Two double-deck [suspension bridges](http://en.wikipedia.org/wiki/Suspension_bridge) with a common central anchorage connect [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island) to [San Francisco](http://en.wikipedia.org/wiki/San_Francisco)

A double balanced [cantilever bridge](http://en.wikipedia.org/wiki/Cantilever_bridge), five [truss bridges](http://en.wikipedia.org/wiki/Truss_bridge), and a truss causeway currently connect [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island) to [Oakland](http://en.wikipedia.org/wiki/Oakland%2C_California) (to be replaced by new construction)

The original western approach to (and exit from) the upper deck of the bridge was a long ramp which began at Fifth and Bryant streets. There were also ramps for the upper deck on [Rincon Hill](http://en.wikipedia.org/wiki/Rincon_Hill) at Fremont Street, and ramps for the lower deck at Essex and First Streets. The lower-deck ramps, utilized mainly by trucks, were terminal points for the lower-deck highway. Beyond them, the tracks of the bridge railway also left the lower deck, curving northward into a loop through the [Transbay Terminal](http://en.wikipedia.org/wiki/Transbay_Terminal).

There were three original eastern approaches: a viaduct from the end of Cypress Street ([State Route 17](http://en.wikipedia.org/wiki/State_Route_17_%28California%29)) in Oakland; a viaduct from the end of 38th Street ([U.S. Route 50](http://en.wikipedia.org/wiki/U.S._Route_50_%28California%29)) at San Pablo Avenue in Oakland; and the [East shore Highway](http://en.wikipedia.org/wiki/Eastshore_Highway) which carried [U.S. Route 40](http://en.wikipedia.org/wiki/U.S._Route_40_%28California%29) along the shoreline of [Albany](http://en.wikipedia.org/wiki/Albany%2C_California), [Berkeley](http://en.wikipedia.org/wiki/Berkeley%2C_California) and [Emeryville](http://en.wikipedia.org/wiki/Emeryville%2C_California).

When the Bay Bridge first opened, the upper deck carried three lanes of traffic in each direction and was restricted to automobiles only. The lower deck carried three lanes of truck and auto traffic on the north side. The middle of these three lanes was reversed according to the commuting direction by utilizing traffic lights, but with no divider. Two railroad tracks were built on the south side of the lower deck for the electric commuter trains of the [Southern Pacific](http://en.wikipedia.org/wiki/East_Bay_Electric_Lines), the [Key System](http://en.wikipedia.org/wiki/Key_System), and the [Sacramento Northern](http://en.wikipedia.org/wiki/Sacramento_Northern) railroad, although train service across the bridge did not begin until September 23, 1938. An overhead [catenary](http://en.wikipedia.org/wiki/Catenary) supplied power to the Southern Pacific and Sacramento Northern trains while a [third rail](http://en.wikipedia.org/wiki/Third_rail) was utilized by the Key trains. After 1941, only the Key System used these tracks. All railroad service on the bridge ended in April 1958.

The Bay Bridge was reconfigured to have five westbound lanes on the upper deck and five eastbound lanes on the lower deck on October 12, 1963. Tolls continued to be collected in both directions until September 1969, when one-direction toll collection for westbound traffic only began.

The Federal highway on the bridge was originally [U.S. Highway 40](http://en.wikipedia.org/wiki/U.S._Route_40_%28California%29) and [U.S. Highway 50](http://en.wikipedia.org/wiki/U.S._Route_50_%28California%29). The highways were redesignated [Interstate 80](http://en.wikipedia.org/wiki/Interstate_80_%28California%29) in 1964, and U.S. 40 and U.S. 50 in this area were "de-mapped".

The off-ramps for [Treasure Island](http://en.wikipedia.org/wiki/Treasure_Island%2C_California) and [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island) are unusual in that they are on the left-hand side both in the eastbound and westbound directions. Eastbound and westbound on-ramps are on the usual right-hand side, but they are tricky since the on-ramps do not have dedicated merge lanes, and they can require acceleration from a dead stop to freeway speeds in a short distance.

**Modifications**

Daytime view of the [Oakland Bay Bridge](http://en.wikipedia.org/wiki/Oakland_Bay_Bridge) and San Francisco seen from [Yerba Buena Island](http://en.wikipedia.org/wiki/Yerba_Buena_Island)

Automobile traffic increased dramatically in the ensuing decades while the [Key System](http://en.wikipedia.org/wiki/Key_System) declined, and in October 1963, the Bay Bridge was reconfigured with five lanes of westbound traffic on the upper deck and five lanes of eastbound traffic on the lower deck. Trucks were allowed on both decks and the railroad was removed. Owing to a lack of clearance for trucks through the upper-deck portion of the Yerba Buena tunnel, it was necessary to lower the elevation of the upper deck where it passes through the tunnel, and to correspondingly excavate to lower the elevation of the lower portion. This work was done while the Bay Bridge was in use by using a movable temporary span over the portion being lowered. On the lower deck of the tunnel and its eastern viaduct extension, it was necessary to remove central supports, with each transverse beam (of reinforced concrete) being doubled to take the load across all lanes. It was also necessary to further reinforce each beam supporting the upper deck throughout the entire span, modifications still visible to the traveler.

On February 11, 1968, a [U.S. Navy](http://en.wikipedia.org/wiki/United_States_Navy) [T-33 Shooting Star](http://en.wikipedia.org/wiki/T-33_Shooting_Star) training aircraft, flying out of the nearby [Naval Air Station Alameda](http://en.wikipedia.org/wiki/Naval_Air_Station_Alameda), crashed into the eastern span of the bridge, killing both officers. One of the truss sections of the bridges was replaced due to damage from the impact.

The series of lights adorning the suspension cables was added in 1986 as part of the bridge's 50th-anniversary celebration.

**Earthquake damage and subsequent upgrades**

See also: [Earthquake engineering](http://en.wikipedia.org/wiki/Earthquake_engineering)

Collapsed section of roadway deck, 1989

During the October 17, 1989, [Loma Prieta earthquake](http://en.wikipedia.org/wiki/Loma_Prieta_earthquake), which measured 6.9 on the [moment magnitude scale](http://en.wikipedia.org/wiki/Moment_magnitude_scale), a 50-foot (15 m) section of the upper deck of the eastern [truss](http://en.wikipedia.org/wiki/Truss_bridge) portion of the bridge at Pier E9 collapsed onto the deck below, indirectly causing one death. The bridge was closed for just over a month as construction crews repaired the section. It reopened on November 18 of that year.

**Western span retrofitting**

The western suspension span has undergone extensive [seismic retrofitting](http://en.wikipedia.org/wiki/Seismic_retrofit). During the retrofit, much of the [structural steel](http://en.wikipedia.org/wiki/Structural_steel) supporting the bridge deck was replaced while the bridge remained open to traffic. Engineers accomplished this by using methods similar to those employed on the [Chicago Skyway](http://en.wikipedia.org/wiki/Chicago_Skyway) reconstruction project.

The entire bridge was fabricated using hot steel rivets, which are impossible to heat treat and so remain relatively soft. Analysis showed that these could fail by shearing under extreme stress, and so at most locations each was removed by burning out with an [oxygen cutting](http://en.wikipedia.org/wiki/Oxy-fuel_welding_and_cutting) torch, the hole precision [reamed](http://en.wikipedia.org/wiki/Reamer) and the old rivets replaced with heat-treated high-strength locator bolts and nuts. This work had to be performed with great care as the steel of the structure had for many years been painted with [lead](http://en.wikipedia.org/wiki/Lead) based paint, which had to be carefully removed and contained by workers with extensive protective gear.

Obsolete hot riveted [laced ties](http://en.wikipedia.org/wiki/Lattice_girder) (left, eastern span) and bolted box beam retrofit (right, western span)

Most of the beams were originally constructed of two plate I-beams joined with lattices of flat strip or angle stock, depending upon structural requirements. These have all been reconstructed by replacing the riveted lattice elements with bolted steel plate and so converting the lattice beams into box beams. This replacement included adding face plates to the large diagonal beams joining the faces of the main towers, which now have an improved appearance when viewed from certain angles.

Diagonal box beams have been added to each bay of the upper and lower decks of the western spans. These add stiffness to reduce side-to-side motion during an earthquake and reduce the probability of damage to the decking surfaces.

Analysis showed that some massive concrete supports could burst and crumble under likely stresses. In particular the western supports were extensively modified. First, the location of existing reinforcing bar is determined using magnetic techniques. In areas between bars holes are drilled. Into these holes is inserted and glued an L-shaped bar that protrudes 15 to 25 centimeters (6 to 10 inches). This bar is retained in the hole with a high-strength [epoxy](http://en.wikipedia.org/wiki/Epoxy) adhesive. The entire surface of the structure is thus covered with closely spaced protrusions. A network of horizontal and vertical reinforcing bars is then attached to these protrusions. Mold surface plates are then positioned to retain high-strength concrete, which is then pumped into the void. After removal of the formwork the surface appears similar to the original concrete. This technique has been applied elsewhere throughout California to improve freeway overpass abutments and some overpass central supports which have unconventional shapes. (Other techniques such as *jacket and grout* are applied to simple vertical posts; see the [seismic retrofit](http://en.wikipedia.org/wiki/Seismic_retrofit) article.)

**Eastern span replacement**

Main article: [Eastern span replacement of the San Francisco – Oakland Bay Bridge](http://en.wikipedia.org/wiki/Eastern_span_replacement_of_the_San_Francisco_%E2%80%93_Oakland_Bay_Bridge)

New and old approach spans (May 2008)

The replacement span has undergone a number of design evolutions, both progressive and regressive, with increasing cost estimates and contractor bids. Separated and protected bicycle lanes are a visually prominent feature on the south side of the new east span. The [bikeway](http://en.wikipedia.org/wiki/Segregated_cycle_facilities) will carry transportation and recreational cyclists back and forth from Oakland to Yerba Buena and Treasure Islands.

During the 2009 Labor Day weekend closure for the retrofit, a major crack was found in an [eyebar](http://en.wikipedia.org/wiki/Eyebar), significant enough to close the bridge on its own. Working in parallel with the retrofit, [California Department of Transportation](http://en.wikipedia.org/wiki/California_Department_of_Transportation) (Caltrans), and its contractors and subcontractors, were able to design, engineer, fabricate, and install the pieces required to repair the bridge, delaying its planned opening by only 1½ hours. The repair was not inspected by the [Federal Highway Administration](http://en.wikipedia.org/wiki/Federal_Highway_Administration), who relied on state inspection reports to ensure safety guidelines were met.

**October 2009 eyebar repair failure and bridge closure**

On October 27, 2009, during the evening commute, the steel crossbeam and two steel tie rods repaired over [Labor Day](http://en.wikipedia.org/wiki/Labor_Day) weekend snapped off the Bay Bridge's eastern span and fell to the upper deck. The cause may have been due to metal-on-metal vibration from bridge traffic and wind gusts of up to 55 mph causing failure of one rod which broke off, which then led to the metal section crashing down. Three vehicles were either struck by or hit the fallen debris, though there were no injuries. On November 1, Caltrans announced that the bridge would probably stay closed at least through the morning commute of Monday, November 2, after repairs performed during the weekend failed a stress test on Sunday. [BART](http://en.wikipedia.org/wiki/BART) and the [Golden Gate Ferry](http://en.wikipedia.org/wiki/Golden_Gate_Ferry) systems added supplemental service to accommodate the increased passenger load during the bridge closure. The bridge reopened to traffic on November 2, 2009.

The pieces which broke off on October 27 were a [saddle](http://en.wikipedia.org/wiki/Saddle_%28disambiguation%29#Other_uses), [crossbars](http://en.wikipedia.org/wiki/Crossbar), and two tension rods. The failure of the repair was caused by two design defects: first, the tie rods closely fit the holes in the cross pieces over the saddles and second, wind caused vibrations in the rods, which in turn caused wear and bending at the through holes, eventually causing a rod fracture. The catastrophic dropping of the cross pieces was caused by a lack of structural attachment to the saddle, being retained only by [tack welds](http://en.wikipedia.org/wiki/Welding), [friction](http://en.wikipedia.org/wiki/Friction) and the [tension](http://en.wikipedia.org/wiki/Tension_%28physics%29) of the tie rods. The rework of the design was planned to include six significant modifications:

1. Structural welding of the cross pieces to the saddles to avoid catastrophic disassembly
2. Enlargement of the through holes to avoid contact with the tie rods
3. Addition of a spherical seat and matching tie rod tensioning nut to eliminate concentrated bending loads at the nut
4. Addition of tie rod cross ties between the rods and the eyebar at three locations to reduce wind induced vibrations and to secure the rods from falling in case of failure.
5. Installation of protective sleeves to prevent direct contact of tension rods where they cross other structural members
6. Addition of [strain gauges](http://en.wikipedia.org/wiki/Strain_gauge) and associated instrumentation to continuously monitor component loading

Proper fitting proved difficult, requiring the disassembly of the new components to gain access for rework. CALTRANS installed a more permanent repair in December 2009. The fix involved cutting away the cracked end of the eyebar, and a new end was bolted onto the undamaged portion of the original eyebar using a pair of [gusset plates](http://en.wikipedia.org/wiki/Gusset_plate). The new end was attached to the large bolt the original eyebar was attached to. The permanent repair was inspected by CALTRANS and FHWA engineers before the temporary supporting structures were removed.

* [Detailed diagrams of the repair scheme](http://baybridgeinfo.org/sites/default/files/pdfs/eyebar_repair_web.pdf)
* [An overview of the repair process](http://www.sci-experiments.com/BrokenBridge/BrokenBridge.html)

**Official name**

An unofficial name of the bridge is The [James "Sunny Jim" Rolph](http://en.wikipedia.org/wiki/James_Rolph) Bridge — but this name has rarely been used, and it was not widely recognized until the bridge's 50th-anniversary celebrations in 1986. The official name of the bridge for all functional purposes has always been the San Francisco – Oakland Bay Bridge, and by most local people, it is widely referred to as simply "The Bay Bridge."

James Rolph, a [Mayor of San Francisco](http://en.wikipedia.org/wiki/Mayor_of_San_Francisco) from 1912 to 1931, was the [Governor of California](http://en.wikipedia.org/wiki/Governor_of_California) at the time construction began. He died in office on June 2, 1934, two years before the bridge opened, leaving the bridge to be named for him out of respect. However, due to the opposition of [Joseph R. Knowland](http://en.wikipedia.org/wiki/Joseph_R._Knowland), publisher of the [*Oakland Tribune*](http://en.wikipedia.org/wiki/Oakland_Tribune) at the time, recognition of Rolph was withheld. In 1932, with an inability to finance the bridge, Joseph R. Knowland, (a former US Congressman) travelled to Washington and helped to persuade President [Herbert Hoover](http://en.wikipedia.org/wiki/Herbert_Hoover) and the [Reconstruction Finance Corporation](http://en.wikipedia.org/wiki/Reconstruction_Finance_Corporation) to advance $62 million for the building of the bridge. Many people in [Oakland](http://en.wikipedia.org/wiki/Oakland) and [Alameda County](http://en.wikipedia.org/wiki/Alameda_County) felt the Bay Bridge was the East Bay's Own, especially since San Franciscans claimed the [Golden Gate Bridge](http://en.wikipedia.org/wiki/Golden_Gate_Bridge). [Emperor Norton](http://en.wikipedia.org/wiki/Emperor_Norton)'s early work at promoting a bridge between the city and county of San Francisco and the city of Oakland and Alameda County was commemorated on December 14, 2004, when the [San Francisco Board of Supervisors](http://en.wikipedia.org/wiki/San_Francisco_Board_of_Supervisors) approved a resolution calling for the new eastern span of the bridge to be named "The Emperor Norton Bridge". The resolution was introduced by San Francisco County Supervisor [Aaron Peskin](http://en.wikipedia.org/wiki/Aaron_Peskin). Neither the city of Oakland nor Alameda County passed any similar resolution.

Plaques honoring the contributions of both Rolph and Norton exist. The Rolph plaque, originally placed at the west end of the bridge in San Francisco, was moved to the corner of Fifth and Bryant Streets in 1986 and removed entirely by Caltrans in 2006. The plaque honoring Emperor Norton for the original idea graced the western archway of the Transbay Terminal, the public transit depot, and the Greyhound bus depot at the west end of the bridge in downtown San Francisco.

**Financing**

When the Bay Bridge opened in 1936, the toll was 65 cents, collected in each direction. Within months, the toll was lowered to 50 cents in order to compete with the ferry system, and finally to 25 cents since this was shown sufficient to pay off the original revenue bonds on schedule. As with other bridges of the era, passage was supposed to become free after completion of the repayment of the original bonds.

In the interest of reducing the cost of collecting tolls and of building additional toll booths, all bridges in the Bay Area were converted to collect tolls in only one direction, with the toll amount collected doubled.

Tolls were subsequently raised to finance improvements to the bridge approaches, required to connect with new freeways, and to subsidize public transit in order to reduce the traffic over the bridge.

[Caltrans](http://en.wikipedia.org/wiki/Caltrans), the state highway transportation agency, maintains seven of the eight San Francisco Bay Area bridges. (The Golden Gate Bridge is owned and maintained by the [Golden Gate Bridge, Highway and Transportation District](http://en.wikipedia.org/wiki/Golden_Gate_Bridge%2C_Highway_and_Transportation_District).)

The basic toll (for automobiles) on the seven state bridges was raised to $1 by Regional Measure 1, approved by Bay Area voters in 1988. A $1 seismic retrofit surcharge was added in 1998 by the state legislature, originally for eight years, but since then extended to December 2037 (AB1171, October 2001). On March 2, 2004, voters approved Regional Measure 2, raising the toll by another dollar to a total of $3. An additional dollar was added to the toll starting January 1, 2007, to cover cost overruns concerning the replacement of the eastern span.

The [Metropolitan Transportation Commission](http://en.wikipedia.org/wiki/Metropolitan_Transportation_Commission_%28San_Francisco_Bay_Area%29), a regional transportation agency, in its capacity as the [Bay Area Toll Authority](http://en.wikipedia.org/wiki/Bay_Area_Toll_Authority), administers RM1 and RM2 funds, a significant portion of which are allocated to public transit capital improvements and operating subsidies in the transportation corridors served by the bridges. Caltrans administers the "second dollar" seismic surcharge, and receives some of the MTC-administered funds to perform other maintenance work on the bridges.

As of July 2009[[update]](http://en.wikipedia.org/w/index.php?title=San_Francisco_%E2%80%93_Oakland_Bay_Bridge&action=edit), the toll for autos is $4, collected only for westbound traffic, at a toll plaza on the eastern (Oakland) side.

In October 2009, the Bay Area Toll Authority announced three proposals for further increasing the bridge toll. Two of the plans would raise the toll to $5 at all times, while the third would keep it at the current $4 for much of the day, but raise it to $6 during peak commute times. The agency is scheduled to vote on the proposals in January 2010, with any approved toll increases to take effect on July 1, 2010.

The Bay Area Toll Authority is made up of appointed officials put in place by various city and county governments, and is not subject to direct voter oversight.

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