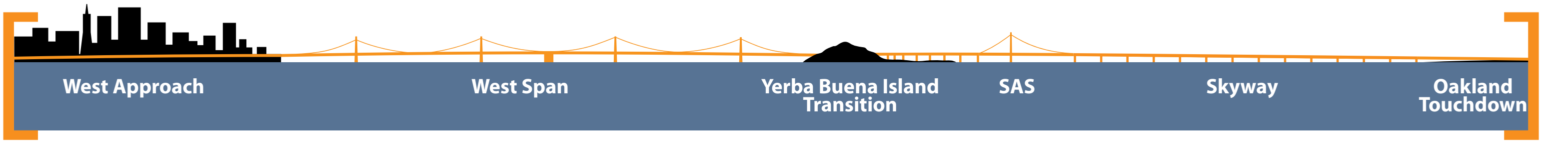
THE SAN FRANCISCO-OAKLAND
BAY BRIDGE SEISMIC SAFETY PROJECTS
CALTRANS BAY AREA TOLL AUTHORITY CALIFORNIA TRANSPORTATION COMMISSION



FACT SHEET

Seismic Innovations & Enhancements

The seismic retrofit of the entire Bay Bridge includes numerous cutting-edge and state-of-the-art features that make the bridge more resilient in an earthquake.

Project Overview

We have not forgotten the lessons of the 7.1-magnitude Loma Prieta earthquake, or that the clock is always ticking. When a 250-ton section of the East Span's upper deck collapsed during the earthquake, the bridge quickly reopened within a month. Yet a critical question lingered: how could the Bay Bridge be strengthened to withstand the next major earthquake? Any answer had to ensure that the Bay Bridge would survive heavy seismic activity and provide access for emergency services and rebuilding efforts.

After performing an exhaustive study, seismic experts determined that to make a bridge of this size seismically safe, the work must be divided into numerous projects, each presenting unique challenges.

The design, engineering and construction crews have met that challenge with cutting-edge seismic innovations and enhancements that are transforming the Bay Bridge into a state-of-the-art structure, which will be resilient against powerful earthquakes while aiding seismic scientific research.

Crews have made tremendous progress in making the Bay Bridge safer. Among those milestones are the completion of all seismic retrofit work on the western half of the bridge (the West Span and West Approach), the completion of the 1.2-mile-long Skyway (the longest section of the new East Span), and the successful connection of the Yerba Buena Island detour.

HINGE PIPE BEAMS, such as this one being inserted into the Skyway, are found throughout the new East Span. The center of the beams functions like a replaceable fuse, absorbing seismic energy to protect the rest of the bridge. After an earthquake, crews can replace the damaged fuses.

For more information about the Seismic Innovations & Enhancements, visit www.baybridgeinfo.org

West Span

The West Span required extensive retrofit work to strengthen its twin suspension bridges while allowing a wider range of movement. Crews installed 96 viscous dampers that act like shock absorbers to isolate, absorb and diffuse seismic energy. Crews also replaced half a million original rivets with twice as many high-strength bolts.

New bracing was added under both decks, and all of the "laced" diagonal crossbeams connecting the upper and lower decks were replaced with perforated steel; in all, 17 million pounds of structural steel was added to the West Span.

Piers were encased in heavy concrete jackets and additional anchor bolts were installed to fasten tower legs to pedestals. The span's main suspension cables were fastened by cable bands to the deck to allow uniform movement during an earthquake. Concrete keys cast into the bridge supports were added to keep the road deck from slipping sideways, and steel wind tongues will prevent sideways movement of the span itself. Finally, in perhaps the most astonishing maneuver, crews lifted the entire 3-million ton span to install massive bearings between the roadway and bridge supports to allow the deck to slide on top of the supports without significant damage to the bridge.

West Approach

Work on the West Approach, a 1-mile stretch of Interstate 80 in San Francisco, involved completely demolishing the entire existing structure, a retrofit-by-replacement. The key difference between the two structures that makes the new one seismically safe is that the east- and westbound roadways from 3rd Street to the bridge's anchorage at Beale Street now have independent columns and foundations. Prior to the replacement, the double-deck roadways shared a single foundation system that supported both decks. The roadways between 3rd and 5th streets are parallel concrete decks.

Skyway

Unlike the West Span, the entire East Span is being completely rebuilt and will look nothing like the original span. The first section to be completed is the 1.2-mile-long Skyway, the longest section of the new East Span, which also houses some of the most amazing seismic innovations.

INDEPENDENT COLUMNS AND FOUNDATIONS support the retrofitted West Approach. Prior to the retrofit, the west- and eastbound decks shared a single foundation system that supported both decks.

To build the Skyway's foundations, 160 rebar and concrete-filled steel piles were driven up to 300 feet below the water's surface to anchor into stable soils. The piles are driven into the soil at an angle, through a process called "battering" to create greater stability. This method has been used to create secure foundations for oil rigs for more than two decades, but has not been used for bridge construction of this scale.

Hinge-pipe beams are another amazing state-of-the-art innovation, as they are designed to move within their sleeves during expansion or contraction of the decks during minor events, such as changes in temperature, to major ones, such as an earthquake. Twenty of these 60-foot-long devices are placed between deck sections, as well as where the Skyway and Self-Anchored Suspension Span will meet. The beams are designed to absorb the energy of an earthquake by deforming in their middle or "fuse" section. This will minimize the damage to the bridge's main structure. The damaged fuses can then be quickly removed and replaced.

Self-Anchored Suspension Span

Hinge pipe beams are not the only innovation in the iconic signature span of the new bridge, the Self-Anchored Suspension Span (SAS). The single, 525-foot tall tower is made up of four separate steel legs connected by shear link beams, which allow the legs to move independently. The beams are designed to absorb most of the seismic energy during an earthquake and protect the tower from catastrophic damage. The damaged beams can later be removed and replaced.

Two massive marine foundations provide solid support for the tower and eastern end of the SAS, while a land-based foundation on Yerba Buena Island supports the western end. The tower's foundation includes 13 concrete piles

SHEAR LINK BEAMS connect the four sections of the iconic, single 525-foot-tall tower of the Self-Anchored Suspension Span. The beams are designed to move separately from the tower during an earthquake to absorb most of the seismic energy. The damaged beams can then be replaced.

that extend 196 feet below water to anchor into bedrock. The 16 piles in the eastern support reach down nearly 340 feet to reach bedrock, while the western support's foundations extend down 80 feet through the island's solid rock.

Yerba Buena Island

Hinge pipe beams can also be found at that western foundation where the SAS connects to Yerba Buena Island Transition Structure (YBITS), which will transition the East Span's parallel decks to the West Span's double deck configuration. To build the YBITS, crews connected a temporary detour that re-routes traffic around the original approach to the Yerba Buena Island tunnel. This allows for demolition of nearly a half-mile of the original bridge structure to make way for the YBITS.

Oakland Touchdown

At the other end of the East Span is the Oakland Touchdown (OTD), which connects the Skyway to Interstate 80 in Oakland. Many of the seismic innovations in the OTD can be found in its foundations. Columns are pinned at the top to reduce severe motion from being dispersed to the foundations and to the road-decks. The foundations use flexible vertical piles to absorb seismic forces more effectively. The OTD also features hinge pipe beams where it connects to the Skyway.

Original East Span

The East Span's seismic upgrade began not with the first piles being driven for the Skyway but with an interim retrofit of the original span that echoes much of the permanent work on the West Span. Original rivets were replaced with high-strength bolts, and viscous dampers, steel plates and steel lateral braces were added. At the section that collapsed, expanded hinge seats were added to allow greater movement in that area.

The Future of Earthquakes

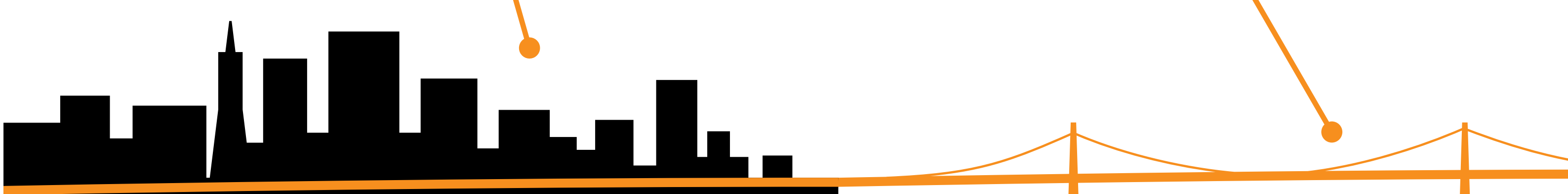
The seismic innovations throughout the bridge do more than just protect it from earthquakes; they will also help provide vital data to better understand earthquakes. Embedded throughout the bridge is monitoring equipment that will collect information on ground motion for the California Geological Survey. These devices, called accelerographs, will monitor and measure how the bridge responds to ground motion in an earthquake. There are 86 sensors in the SAS, 80 in the West Span, 73 in the Skyway, 28 in YBITS and 12 in the OTD.

After an earthquake, the sensors will transmit the data to create a digital map showing the location and intensity of seismic activity and ground motion. Crews can use the maps to determine potential damage to infrastructure including roads and water lines.

SEISMIC FEATURES ON

The West Approach's double-deck roadways now have **independent columns and foundations**. Prior to the retrofit, the roadways shared a single foundation system that supported both decks.

The West Span's main suspension cables are fastened to the deck with **cable bands** to allow uniform movement during an earthquake.



West Approach
(COMPLETED)

West
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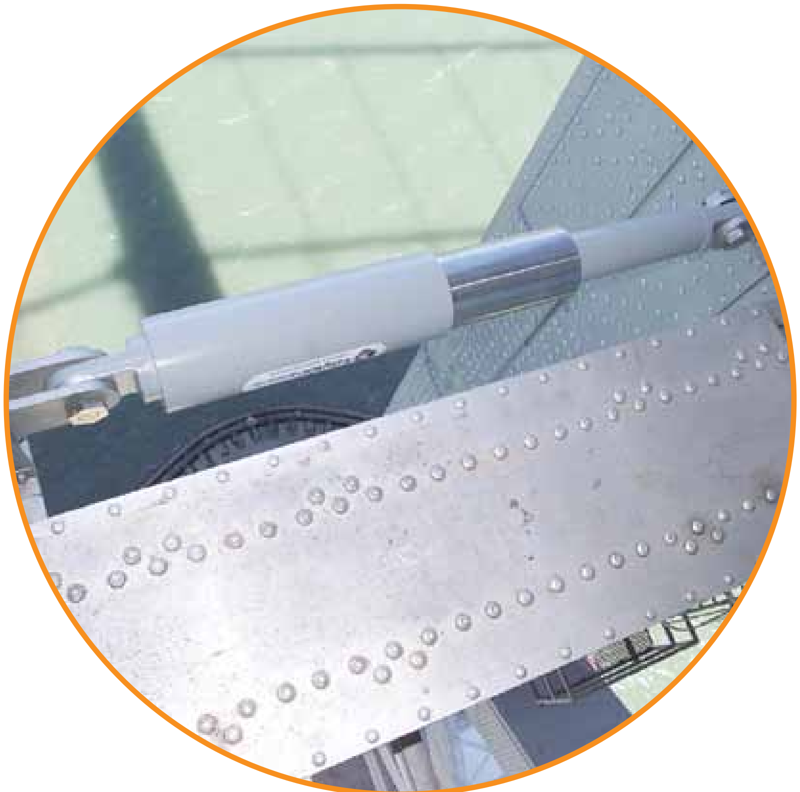
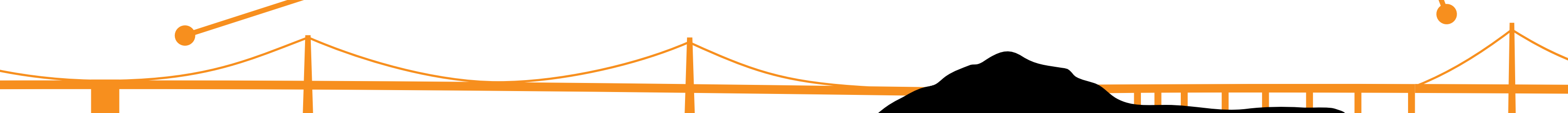
THE BAY BRIDGE

The Self-Anchored Suspension Span's single, 525-foot tall tower is made up of four separate steel legs connected by **shear link beams**, which allow the legs to move independently. The beams are designed to absorb most of the seismic energy during an earthquake and protect the tower from catastrophic damage. The damaged beams can later be removed and replaced.



Viscous dampers on the West Span act like shock absorbers to isolate, absorb and diffuse seismic energy.



Span
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Yerba Buena Island Transition

SAS

One hundred and sixty rebar and concrete-filled steel piles were driven up to 300 feet below the water's surface to anchor into stable soils. The Skyway's piles are driven into the soil at an angle, through a process called **"battering"** to create greater stability.

Hinge pipe beams are designed to move within their sleeves during expansion or contraction of the decks during an earthquake. The beams will absorb the energy of an earthquake by deforming in their middle or "fuse" section. This will minimize the damage to the bridge's main structure. The damaged fuses can then be quickly removed and replaced. Hinge pipe beams can be found throughout the new East Span.

Skyway
(COMPLETED)

Oakland Touchdown