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MEGA ENGINEERING PROJECTS

BIG CHALLENGES REQUIRE INNOVATIVE SOLUTIONS. USING NEW DESIGNS AND TECHNIQUES, BUILDERS WORLDWIDE ARE PUSHING THE LIMITS OF THE POSSIBLE.

BY JEFF WISE

PHOTOGRAPH BY PHILLIP TOLEDANO

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FOR 15 SECONDS ON OCT. 17, 1989, a magnitude 7.1 earthquake shook Northern California. The quake shifted the east span of the San Francisco-Oakland Bay Bridge by 7 in. on its Oakland side, causing a 50-ft., 250-ton section of the bridge’s upper deck to collapse, killing one motorist. The structural failure was a disturbing and highly visible sign of the vulnerability of one of San Francisco’s major transportation links. The collapsed section was repaired and reopened a month later, but engineers knew that returning the bridge to its pre-earthquake state wouldn’t be enough. They needed to come up with a solution that could
withstand some of the worst that California's fault zones are capable of dishing out.

In fact, the new bridge's designers faced two challenges: earthquakes and the demanding Bay Area public. In engineering terms, the simplest solution would have been to build a more robust version of the existing structure, a series of low trusses supported by piers that extends 2.2 miles between Yerba Buena Island and Oakland. But the public wanted a high, visually striking signature span to grace the bay. “The Bay Area is known for its spectacular bridges,” says Bart Ney, a spokesman for the California Department of Transportation (Caltrans). “It's part of our DNA, so naturally the aesthetics are a key part of the project.”

Caltrans ultimately decided to create a two-stage bridge, marrying a 1.3-mile Skyway to the first ever single-tower Self-Anchored Suspension (SAS) bridge. This revolutionary new structure hangs 1860 ft. of roadway from a single central tower, with the shorter western side rising from Yerba Buena Island, and the longer eastern side extending to meet the Skyway.

Most of us think of a bridge as a stationary, immobile object. But a bridge in Northern California has to be designed like a machine that moves. The U.S. Geological Survey estimates there is a 62 percent chance that a magnitude 6.7 or larger quake will hit the area by 2032. The Bay Bridge is flanked on the west by the San Andreas Fault and on the east by the Hayward Fault—putting it right in the strike zone. Since the new bridge's design specifications require that it last for 150 years, the engineers had to build in state-of-the-art seismic defenses (see "How to Quakeproof a Bridge," at right). The SAS tower, for instance, incorporates deformable structural elements to absorb quake forces, much as a car's crumple zone takes the brunt of a head-on collision. Thanks to this innovation, the structure should be able to accommodate seismically induced movement of up to 1 yard.

The conflicting demands of aesthetics and physics required engineers to come up with some clever solutions. Officially, the Bay Bridge is designated as a "life line" structure, meaning it needs to be able to serve emergency vehicles immediately after even the most powerful predicted earthquake. "The community representatives were very excited about a single tower," says Brian Maroney, who oversaw the project's engineering design for Caltrans. "But if you think about the size of such a structure, I didn't see how we could realistically repair it in the event of a quake."

To dissipate quake forces, Maroney's team designed the main SAS tower as four columns that function as one support system, but can move independently. And all of the bridge's shock-absorbing elements can be replaced within a day of quake damage to get the bridge up and running. But perhaps the most difficult engineering challenge involved the suspension cable system. Normally, suspension bridges require multiple towers, from which the roadway is hung like a hammock. The new Bay Bridge works more like a sling, suspending its twin roadways on a single tower. One long cable loops under the eastern end of the SAS span, then crosses over itself at the top of the tower and is fastened at the western end.

The project's design, approval and construction has been delayed by lengthy political bickering, which helped boost the estimated cost from $1.3 billion to over $6 billion. But when it opens to traffic in six years, the Bay Area will have a bridge worthy of the region's engineering legacy—an icon of both beauty and strength.
Temporary supports hold up the Bay Bridge Skyway, heading west toward Yerba Buena Island, while workers build a pier (above). Workers prepare the footing box for the bridge's 525-ft.-tall tower (below).