New Bay Bridge's earthquake challenges and fixes

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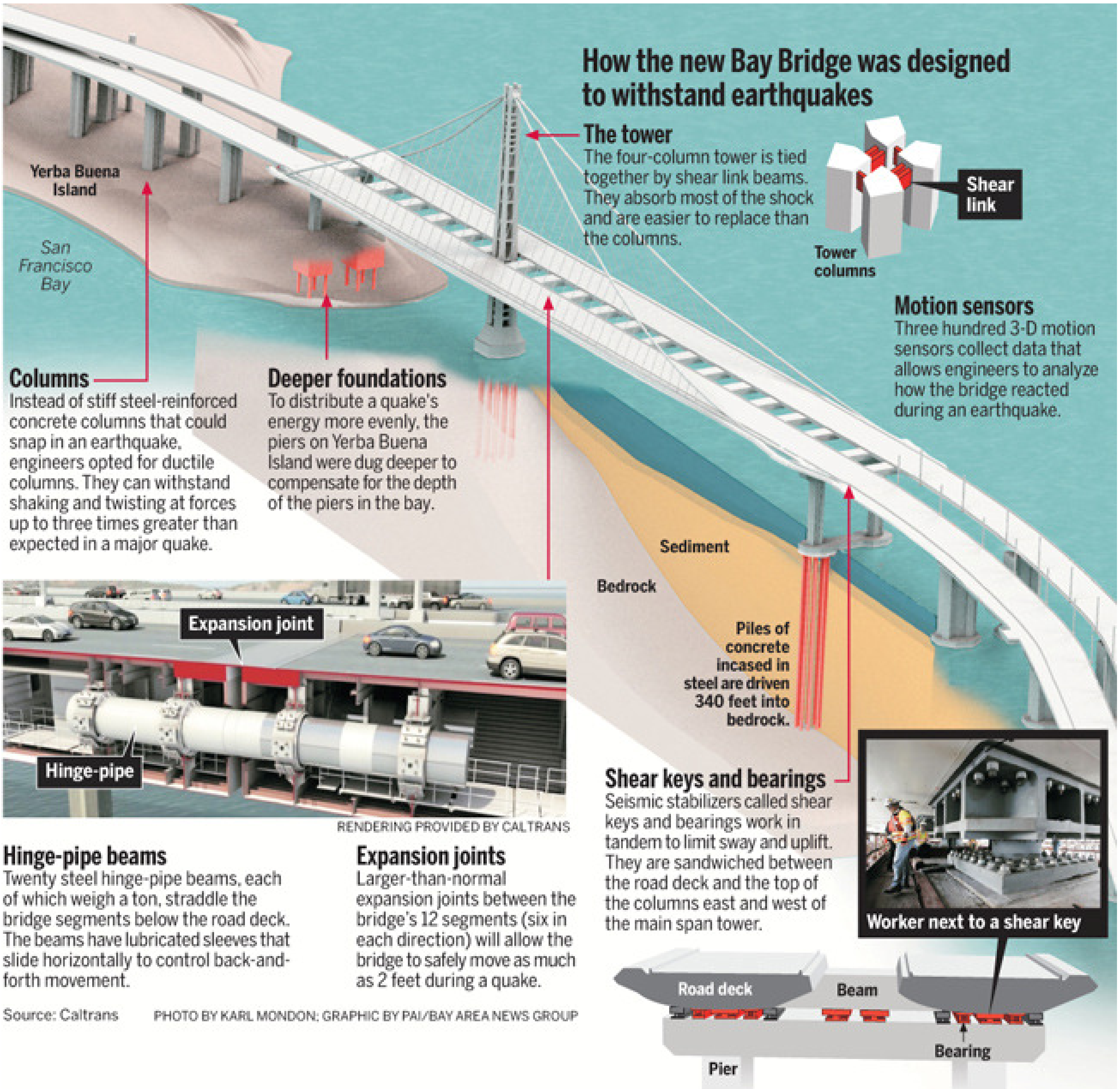

OAKLAND -- Building the new Bay Bridge to the highest seismic safety standards in California history presented engineers with numerous challenges.

In a recent bridge tour, Caltrans principal bridge engineer Brian Maroney explained how designers tackled difficult seismic scenarios and what he expects to see on the bridge after a big earthquake.

Expansion joints

- The problem: Every bridge must have spaces between its segments that allow sections of the span to expand and contract with the changing temperature and traffic loads. But in earthquake country, expansion joints sized only for normal movements would slam together.

- The solution: Install much larger joints between the bridge's 12 segments that allow the bridge to move up to 3 feet.

- After the quake: If needed, Caltrans will place steel plates over any damaged rubberized baffles that shield the joints on the travel deck. If any of the bridge segments shift out of alignment, Caltrans can use portions of the extra room on the shoulders of the five regular travel lanes and re-stripe.

Hinge pipes

- The problem: Much like we need fuses in our homes to protect appliances from electrical current fluctuations, the Bay Bridge's superstructure needs a buffer when the Big One hits.

- The solution: Install 20 hinge-pipe beams that consist of 2,000-pound, 60-foot-long steel pipes up to 5 feet in diameter. The pipes straddle the bridge's segments below the roadway and within the deck, resting in lubricated sleeves that allow them to move back and forth. The "fuse" is a section of thinner steel in the pipe that will take the brunt of the impact. By directing the quake's energy into an accessible area, it protects the superstructure and allows for repairs.

- After the quake: If the pipe is bent, crews would attempt to reheat and straighten the pipe in place. If it cannot be straightened, it could be cut out and replaced.

Columns

- The problem: Steel reinforced concrete columns and piers cannot be too stiff or they will snap in an earthquake. Even one broken column could leave the entire bridge impassable.

- The solution: Build columns that will bend, rebound and still carry the load. To test the designs, Caltrans built full- to half-scale columns and sent them to university labs, where they were shaken, contorted and subjected to forces up to three times greater than expected in an earthquake.

- After the quake: Exterior concrete column facets and architectural features are expected to crack or chip and will require cosmetic and light to moderate repairs.

Tower

- The problem: The largest of its kind in the world, the 525-foot steel tower supports a saddle that cradles a mile-long looped cable, which allows the bridge to hold itself up. The tower and saddle are too big to lift up for repairs using jacks, and in any case, if they fail during a quake, the bridge will collapse.

- The solution: Tie together the four-part tower with shear links. By directing the damage into accessible and repairable links, it will spare damage to the tower.

- After the quake: If necessary, replace or repair damaged links.

Shear keys and bearings

- The problem: The massive pier that supports the eastern end of the self-anchored suspension span will sway during a big quake, which could jeopardize the critical load-sharing balance between the east and west piers.

- The solution: Sandwich seismic stabilizers between the top of the pier and the bottom of the deck. Shear keys are 11-foot steel squares threaded with steel anchor rods and bolted down. Bearings are similarly sized giant steel rockers. The components work together to provide limited and controlled movement. (Two of the shear keys were where a third of 96 bolts snapped in early March and will require up to a $10 million repair before the bridge can open.)

- After a quake: Repair or replace.

Rock

- The problem: The steep elevation change underneath the water between the suspension span's eastern and western piers meant the columns on Yerba Buena Island would be much shorter than those on the other end. Columns of unequal heights don't equitably share a temblor's energy. But the bedrock is incredibly strong.

- The solution: Deploy a super-powerful rock ripper and deepen the piers on the island, which will allow for the construction of taller columns to more equitably share a quake's punch. Similar practices were used at the east end of the new bridge where piers are closer to the Oakland shoreline.

- After the quake: Much like the columns on the adjacent skyway, they have been designed to bend and recover. But the exterior column facets and architectural features will likely crack and chip and require modest repairs.

Motion sensors

- The problem: The earth moves beneath our feet every day and a bridge's reaction to even modest movements could provide clues to how it will behave in a big shaker.

- The solution: Install more than 300 three-dimensional motion sensors in key places throughout the replacement span, compile and analyze the data.

- After the quake: Compare the bridge's actual response with what engineers predicted.