Bay Bridge's old span risky, engineers say

Engineers sound alarm over risky condition of old eastern section

Jaxon Van Derbeken, San Francisco Chronicle, 5-25-13

Every day the old eastern span of the Bay Bridge remains in use is a day motorists face the risk of catastrophe, Caltrans engineers say.

Caltrans and the Metropolitan Transportation Commission must weigh that risk in deciding whether to delay the scheduled Labor Day weekend opening of the new eastern span while dealing with suspect steel rods - something Gov. Jerry Brown and other state officials have suggested might happen.

Caltrans will tell the commission this week what it intends to do. Any delay in the opening of the $6.4 billion bridge will push the timetable closer to the 24th anniversary of the Loma Prieta earthquake, which revealed to the world the seismic problems with the existing eastern span.

Bridge officials have asserted that even with questions about the integrity of more than 2,300 steel rods, the new span is more likely to withstand an earthquake than the one that opened in 1936.

'Biggest problem'

"This old bridge is the biggest problem we've got," said Steve Heminger, the transportation commission's executive director. "There is no fix to it, other than moving traffic onto the new span. That's why we feel such a sense of urgency."

The seismic threat to the existing bridge is undeniable. The structure - considered an engineering marvel when it opened during the Great Depression after just three years of construction - was stretched beyond its limits when the San Andreas Fault ruptured outside Santa Cruz on Oct. 17, 1989, unleashing a 6.9-magnitude earthquake.

One motorist died when a 50-foot section of the upper deck broke at the juncture of the incline and the cantilever section and collapsed onto the lower deck. Experts say the upper deck fell off its steel supports- or seats - because they were not wide enough to handle the violent movement that the quake caused.

Caltrans later addressed the problem, but experts say making the bridge quake-proof is another matter.

Near-disaster

The toll from Loma Prieta could have been much worse, said Caltrans' chief engineer on the eastern span project, Brian Maroney. "We came very close to a multi-span collapse," he said.

The 15-second quake snapped five other connections linking the bridge to piers at the eastern end of the truss section. One part came close to collapse. Had the quake lasted longer, Maroney said, more of the bridge might well have fallen.

Joe Nicoletti, a seismic engineer who served for years on Caltrans advisory panels, agreed that Loma Prieta nearly broke the bridge into pieces.

"There were several other sections that were about ready to fail," he said. "The bridge is so flexible."

Flexibility on bridges is a good thing. It's what enables a span to support thousands of cars and trucks in daily use, and to swing very gently in a windstorm - or an earthquake. But too much of it can cause a structure to break apart.

'It can't stay together'

The current eastern span is "so flexible and the vibrations are so large that it can't stay together," Nicoletti said. In an earthquake, he said, the bridge is likely to come apart from its supports.

After the bridge's flaws became obvious in 1989, Caltrans considered retrofitting the eastern span. But "it kept getting more and more complicated," Nicoletti said.

Among the bridge's design flaws are its foundations, which Maroney said are too weak to resist the forces that a powerful earthquake centered in the Bay Area could generate.

The bridge is anchored with treated Douglas fir trees, driven 85 to 120 feet down into clay and mud. Some penetrate the mud and are anchored into three giant, hollow concrete boxes that serve as supports.

Abrupt shifts

The mud can become like Jell-O during a quake, a process known as liquefaction. If that happens, quake forces exerted on nearby solid rock could be amplified by two times against the eastern span's supports.

That could cause a shift of several inches in the foundations, which would translate into several feet by the time the disruptions traveled 200 feet to the road deck. The likely result would be that the bridge would shake apart, Nicoletti said.

"You need very large expansion joints to take care of the displacement of the trusses," the steel latticework that begins at the western end of the incline, Nicoletti said.

Countering those seismic forces would require digging much deeper and larger foundations and retrofitting the bridge with bigger expansion joints - which Caltrans decided was unfeasible.

The foundations, Nicoletti noted, consist of 200 timber piles, roughly 10 stories tall, topped by large concrete caps. "How are you going to stiffen that?" he asked.

On the new bridge, the skyway is supported by foundation piers that are driven 300 feet down into strong soil. The span's tower is also built on pilings, secured into bedrock.

Maroney cited another problem on the old span - its reliance on 1,860 eyebar connectors that are similar or identical to one that cracked and failed near Yerba Buena Island in 2009.

Prone to cracking

Eyebars carry the load at steel truss connections, but they are prone to wind and thermal fatigue cracking, Maroney said. The Federal Highway Administration bans them on new bridge construction.

The bottom line, Maroney says: Whatever the problems are on the new eastern span, that bridge is still safer than the existing one.

One critic of Caltrans isn't convinced.

UC Berkeley engineering Professor Abolhassan Astaneh said the old span could have been retrofitted to modern standards. In fact, he studied such a retrofit for five years for Caltrans after the Loma Prieta quake.

He insists the span is more robust than many American bridges because, he says, it was designed to carry tanks and troops to respond to a wartime invasion.

"This is the only bridge I know of in the country that was designed for a row of tanks to cross it," Astaneh said.

The foundations would need "some help" by being buttressed with additional pilings and concrete, but the Douglas fir has not rotted, Astaneh said. In fact, he said, the pilings and surrounding clay combine to form a mass "like very solid rock," Astaneh said.

Foundations did well

Astaneh says that the bridge's performance in the Loma Prieta quake showed that its foundations fared well. Although it failed at one point, he said, its ability to flex prevented more sections from collapsing.

As for the eyebars, Astaneh pointed out that the Bay Bridge's western span still has 1,600 of them and that they anchor the cables. He said problems with the eyebar connections are usually due to a lack of maintenance.

Astaneh, however, is in the minority. Ahmad Itani, a civil and environmental engineering professor at the University of Nevada in Reno who has studied the span, says the eyebar crack in 2009 proves that the bridge is not worth retrofitting. Three-quarters of the span's steel members do not meet modern seismic standards, he said.

"The age of the bridge is very close to the fatigue limit," he said. "I have said it before: The faster we can move away from that bridge, the better we are."

Nicoletti noted that Caltrans' first response to Loma Prieta had been to attempt a retrofit.

"Caltrans struggled almost a year to try to come up with a scheme - I was on the seismic advisory board at the time," he said. "We told them, 'It doesn't look like you will be able to do it.' And finally, Caltrans agreed and started to design a new bridge."