Seismic Retrofit Design proves successful on double-deck bridge tested by structural engineers at UCSD

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SEISMIC RETROFIT DESIGN PROVES SUCCESSFUL ON DOUBLE-DECK BRIDGE

A revolutionary concept designed to provide additional strength to double-deck bridges during a major earthquake has been sucessfully tested by structural engineers at the University of California, San Diego for the California Department of Transportation (Caltrans).

"We have pushed the technology right to the limit and it performed extremely well," said M.J. Nigel Priestley, professor of structural engineering at UCSD who developed the strengthening concept.

The series of tests, conducted during the past several weeks in the Charles Lee Powell Structural Systems Laboratory at UCSD, was designed to confirm that the proposed retrofit technique would perform as predicted.

As part of the tests, the UCSD researchers tested or stressed a retrofitted, half-scale bridge model with forces greater than a magnitude 8.0 earthquake on the San Andreas fault- -which is the maximum credible earthquake for San Francisco. These conditions were created by 13 computer-controlled hydraulic jacks, each capable of producing 260,000 pounds of force.

The results showed only minor, cosmetic damage to the external concrete surface of the structure.

"The minimal damage really occurred where we designed it to occur," said Frieder Seible, professor of structural engineering at UCSD and the project's co-investigator.

"It was very predictable, it was controlled and it was all repairable," he said.

Added Priestley: "In the event of an earthquake, the cost of repair would be minimal and would not require the closing of the freeway at all."

Funding for the UCSD double-deck research came from Caltrans following the October 1989 Loma Prieta earthquake.

James E. Roberts, chief of Caltrans' Division of Structures, said the successful completion of the tests will allow department engineers to move ahead with confidence to use this retrofit technique on older double-deck concrete bridges like the Central Viaduct (Highway 101) and Southern Viaduct (1-280) in San Francisco that have been closed since the Loma Prieta earthquake.

"We recognize the fact that damage cannot be prevented in a major earthquake," said Roberts. "Our goal is to minimize damage to structures so that they can be easily repaired while remaining in service."

He added: "UCSD has produced a proven, safe and cost- effective design that we can use to provide additional strength for double-deck bridges. The retrofit techniques we are developing in California will be the model for the rest of the world."

The Central Viaduct is scheduled to reopen next year and the Southern Viaduct (1-280) is expected to return to service in late 1993.

The new design features a maximum eight-foot-deep, fourfoot-wide steel reinforced concrete "edge beam" located on the outside of the structure. This edge beam--framed into circular columns each reinforced by a steel cage surrounding a concrete inner core--provides additional flexibility and strength. A prestressed cap beam, nine-feet deep by eight-feet wide, runs transversely between the columns. In addition, the joints between the columns and beams were redesigned.

Aside from proving its ability to withstand major earthquakes, the new design also is cost effective.

"Ours is probably 20 to 30 percent less conservative than other designs Caltrans currently is considering in San Francisco," said Seible. "So we can say that what Caltrans is proposing to do with the San Francisco double-deck bridges not only is technically safe and sound, it's on the conservative side."

Added Roberts: "The UCSD research has tremendous ramifications because it clearly demonstrates that we can save money without sacrificing safety in developing seismic retrofit plans for bridges."

Captions for photos:

1. Double-deck bridge before testing

2. Following tests, Frieder Seible (right) and M.J. Nigel Priestley (left) highlight outline of cracks under bridge. Surface layer of concrete at upper part of column has peeled away, revealing steel cage and concrete core underneath.

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