Berkeley quake trial shows bridge safety ideas

David Perlman, San Francisco Chronicle, 5-27-10

A mock-up bridge and a mock-up rail car shook, rattled, but never rolled Wednesday as earthquake engineers from UC Berkeley demonstrated a system designed to keep bridge traffic moving even in the strongest of seismic shaking.

The 30-foot, scale-model bridge, designed and built in three jointed segments by researchers at the university's Pacific Earthquake Engineering Research Center, was erected on a huge "shake table" that created the same violent ground motions that have marked major quakes in California, Japan and Chile.

As each simulated quake struck, the three bridge segments rattled and shook separately with a huge clatter, but they never separated. Nor did the roadbed on the bridge, while railroad tracks running the length of the roadbed remained precisely in line, and the wheels of a model flatbed rail car never left the tracks.

The demonstration took place at the university's Richmond Field Station, where the 400-foot computer-controlled shake table is used to mimic the effects of a quake on experimental models of concrete buildings, columns, earthquake "isolators" designed to keep skyscrapers from tumbling, and other structures likely to fall victim to major seismic motions.

Wednesday's series of simulated quakes severely stressed the railroad bridge as it withstood successive ground motions of a half-dozen historic quakes, among them Loma Prieta in 1989, that struck with a magnitude of 6.9; Northridge, 1994 (6.7); Kobe, Japan, 1995 (6.9); and February's devastating temblor off the coast of Chile (8.8).

Stephen Mahin, director of the earthquake engineering research center, said the concept of building segmented bridges with seismic isolators between the segments would be particularly useful for long stretches of elevated freeways, high-speed rail lines that often run on elevated tracks, and spans like the Carquinez and Dumbarton bridges.

"Bridges like this will bend in an earthquake, but they won't break," he said.

Mahin pointed to three major innovations on the scale-model bridge that are designed to protect its three segments, and that could be included, three segments at a time, to longer future bridges or freeway spans.

One new concept, Mahin said, are the steel "lockup guides" between each bridge segment that keep the center line of the bridge's roadway continually aligned during a quake, and even after the shock, when the ground beneath the bridge may be settling.

Then there are devices called "linear isolators" installed on the abutments on both ends of the bridge. Teflon coated, they allow the bridge itself to slide briefly in any direction during a quake, Mahin said.

The third new idea is that each column supporting the bridge is equipped with what the engineers call "triple pendulum isolators," which are automatically activated one at time as shaking from an earthquake increases. Their job is to keep the bridge deck from moving violently.

"We're confident," Mahin said, "that bridges like this won't collapse in damaging earthquakes, and that we can protect life."