



Caltrans Division of Research,  
Innovation and System Information

# Research



# Results



Seismic

## MARCH 2014

**Project Title:**

The Effect of Live Load on the Seismic Response of Bridges

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## Developing Seismic Criteria to Account for Bridge Traffic

Study finds that bridge traffic can have a neutralizing effect in an earthquake

### WHAT IS THE NEED?

Seismic design specifications for bridges generally do not address live load—moving traffic—criteria, in part because earthquake-related damage directly associated with live loads has not been observed. With the increase of traffic over the past few decades, it is likely that far more vehicles will be on a bridge during an earthquake than was previously predicted. Design criteria for long-span bridges have been developed on a case-by-case basis, but no current seismic criteria address live-load effects for ordinary standard bridges in California. The effect of vehicles on bridges during large earthquakes has been a contentious issue because it is not well understood. Reliable research is needed to understand the influence of traffic on bridge performance during an earthquake.

### WHAT WAS OUR GOAL?

The goal was to study how live loads affect highway bridges during an earthquake.

### WHAT DID WE DO?

Caltrans, in partnership with the University of Nevada, Reno Department of Civil and Environmental Engineering, studied the effect of live loads on the seismic response of bridges. Researchers conducted multiple shake table tests on a large-scale model of a three-span steel girder bridge with a high degree of curvature. Six trucks were loaded on the model, which spanned four shake tables. The performance data was compared against a benchmark experiment without live loads. Analysts developed a 3-D finite element model of the bridge and live load and calibrated it against the experimental results. The model was then used to determine if the observations extended to bridges and trucks of varying mass.



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## WHAT WAS THE OUTCOME?

For the bridge tested, the study shows that live load can beneficially change the behavior of a bridge during an earthquake. Live load reduced the demand in the structure, as indicated by a decrease in displacements, accelerations, and internal forces. The presence of live load also delayed the formation of cracks and concrete spalling in the columns, reduced column damage, and lessened girder uplift at the abutments and degradation of column stiffness. However, study results also showed the beneficial effect of live load diminished as the shaking amplitude increased.

The 3-D finite element model for vehicle-bridge interaction replicated this behavior well. Although this model could be further refined, it is considered sufficiently accurate for use in live-load effect studies. The study resulted in recommendations concerning the influence of live load on seismic response and how these effects can be included in the seismic analysis and design of bridges. More importantly, it demonstrated that current design guidance is adequate because the bridges do not suffer adverse effects from the live load.

## WHAT IS THE BENEFIT?

Bridges built in seismically prone regions in major population centers carry more traffic than decades ago—much of it heavy commercial trucks. Yet seismic design specifications generally do not include the effect that live loads has on bridges, because few studies have focused on this issue. Reliable experimental studies that test live load effects on various types of bridges under varying conditions will lead to improved understanding, resulting in refined bridge seismic design specifications. Because this work verified the adequacy of current guidance material regarding live load traffic on a standard bridges, no additional design or construction costs are needed.

## LEARN MORE

To view the complete report:  
[www.dot.ca.gov/hq/esc/earthquake\\_engineering/Research\\_Reports/vendor/un\\_reno/59A0695/59A695\\_Final%20 Report.pdf](http://www.dot.ca.gov/hq/esc/earthquake_engineering/Research_Reports/vendor/un_reno/59A0695/59A695_Final%20Report.pdf)

## IMAGES

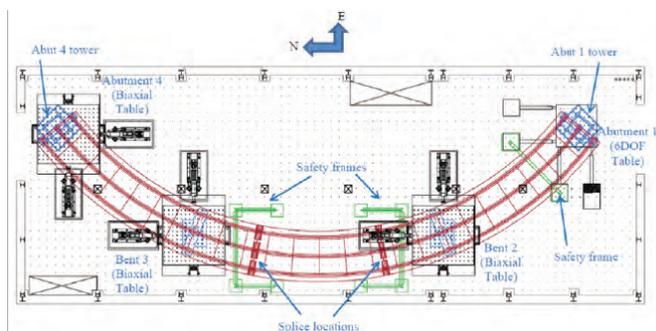


Figure 1: Horizontally-curved bridge model plan