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Caltrans Division of Research, Innovation and System Information

Research Results

Instrumenting Bridges to Capture Seismic Activity

Sensors advance the understanding of how bridges react to major seismic events

Seismic

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Archive Toll Bridge ADINA Models

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WHAT IS THE NEED?

Since the 1989 Loma Prieta earthquake, Caltrans has expanded efforts to install bridge sensors and downhole arrays throughout the state to assess bridge performance during a major earthquake and evaluate bridge conditions following the event. Motion sensors record the magnitude and duration of shaking over time. Downhole geotechnical arrays, which are buried at varying depths and geologic layers near bridge piers, measure acceleration to gather local site amplification data.
The number of sensors installed at each structure ranges from up to 200 for long-span toll bridges to as few as 6 for small bridges. Each sensor is a complex electronic device, networked within a system equipped with amplifiers, batteries, and recording devices. If the electrical grid is not working, the system runs on battery power. The batteries must be replaced every three or four years. The bridge sensors are robust and weather-resistant, and many have been operating for more than 20 years. However, vandalism, particularly copper wire theft, and equipment damage from nearby construction does occur. A comprehensive, ongoing program of oversight and vigilant maintenance is critical to keeping the seismic instruments functional at all times.

WHAT WAS OUR GOAL?

The goal was to monitor and maintain the existing inventory of seismic instruments installed on the state's bridges and to continue installations on bridges and tunnels.

WHAT DID WE DO?

Caltrans, in partnership with the California Geological Survey, placed strong-motion bridge sensors on highway and toll bridges to record deck torsion, column deflection, vertical

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roadway movement, rocking of large footings, and the opening and closing of hinges during a strong earthquake. The researchers compared longitudinal and transverse motion data with current modeling techniques to improve future modeling assumptions. They also assessed the functional health of the strong-motion sensors and geotechnical arrays installed on more than 100 bridges throughout the state. The instrumented bridges are checked every few months via phone lines. When problems are detected, repair teams are dispatched to the site to restore the system to full operational capacity.

WHAT WAS THE OUTCOME?

All toll bridges located in densely populated areas near active faults were instrumented. The sensor readings are now part of a database to assist in quickly assessing bridge conditions following an earthquake. The data has also been used to calibrate and refine computer modeling techniques to better capture the true structural response of large bridges and overcrossings. The readings help pinpoint the structural members that have yielded during a strong shaking event, movement that might not be apparent during a routine inspection but can be important for large underwater piers. In addition, existing sensors, recorders, and system batteries were monitored, replaced, and repaired. Vast amounts of data collected from previously recorded seismic motions were processed and archived for future design use.

WHAT IS THE BENEFIT?

An inventory of seismically monitored bridges is critical to maintaining public safety in a state prone to earthquakes. Using instrumention to observe how different types of bridgesâ€”from simple two-span overpasses, large single-column connectors, to multimillion dollar toll bridgesâ€”react to major seismic events gives seismologists and bridge engineers a better understanding of how various structural configurations respond to strong seismic shaking. Strong motion data also reveals valuable near-real-time information on ground-shaking levels and loss assessment for emergency responders. The collected data leads to improved design and build practices and analytical approaches for seismic modeling.

IMAGES

Figure 1: Location of bridges and downhole arrays

Figure 2: Drilling a downhole array at the Napa River bridge

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