DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Assessing In-Service Seismic Response Modification Devices

New algorithm evaluates the performance of viscous dampers and isolation bearings

Seismic

JANUARY 2014

Project Title:
Assessment and Reliability of Seismic Response Modification Devices In-Service

Task Number: 2041

Start Date: June 25, 2008

Completion Date: January 31, 2013

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WHAT IS THE NEED?

Caltrans has pursued a comprehensive program of bridge seismic retrofit over the past three decades to ensure public safety, bringing bridges up to the latest seismic standards to prevent collapse during an earthquake. As part of that retrofit effort, a separate program was established for long-span toll bridges, which present unique challenges as the state's largest and most complex bridges structures. Although the retrofit program for conventional bridges is technically feasible for toll bridges, it would be costly as well as create long-term traffic disruption to the public.

An innovative strategy that is more efficient for toll bridges was implemented using seismic response modification devices, such as viscous dampers and seismic isolation bearings. As part of this implementation, Caltrans sponsored the development of a unique facility to test commercially available response modification devices at the loads and speeds—70 inches per second—expected during an earthquake. Since then, numerous devices have been tested, and an extensive library of basic performance characteristics has been developed. However, the tests conducted were limited to new devices. What was lacking was performance data during a seismic event after the device had been in service for 10 or more years.

WHAT WAS OUR GOAL?

The goal was to develop and validate an approach for monitoring the performance of devices in service and develop deterioration models to improve the correlation between device performance and bridge structure performance.

WHAT DID WE DO?

Caltrans, in partnership with University of California, San Diego and Texas A&M University, developed a structural health

monitoring (SHM) algorithm to detect changes in seismic response modification devices installed on bridges. The algorithm assesses the performance degradation of conventional structural components and installed isolators and energy dissipaters based on changes in the structureâ€™s modal characteristic. Evaluating performance change is a two-step procedure. First, suspected damage or a change in response is located on the structure, which is then followed by quantifying the change. The researchers validated localization results through data obtained from numerical models and limited data sets collected from these bridges. The results have been promising in terms of localizing changes in both the structure and the seismic response modification device.

To further improve the reliability of the approach, the researchers studied the durability and wear characteristics of rod bearings and seals in viscous dampers. Many laboratory tests on different devices provided a large data set that was analyzed to identify the critical performance parameters of devices under realistic loading conditions. Similar studies were completed on friction pendulum
and lead rubber bearings to increase the limited knowledge available for full-scale devices. This included a comprehensive numerical study to investigate the effects of vertical load, velocity, and repetition of motion for these devices.

WHAT WAS THE OUTCOME?

Applying the structural health monitoring procedure to recorded data from bridge networks confirmed the suspected changes of the performance of the installed dampers. The evolution of the degradation in time and the forensic study of the involved devices suggested the existence of a critical combination of device characteristics and service-loading conditions that requires more careful monitoring and development of specific inspection and maintenance plans. The proposed models, validated during laboratory tests for friction pendulum and lead-rubber bearings, indicate the need for improved testing protocols for device characterization and updated acceptance criteria.

WHAT IS THE BENEFIT?

Caltrans bridge engineers have a tool to monitor bridge and device performance on properly instrumented structures. This information will aid engineers in developing better project and material specifications.

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