DRISI

Caltrans Division of Research, Innovation and System Information

Research Results

Validating Buckling-Restrained Brace Performance for Long-Span Bridges

Buckling-restrained braces offer an alternative to viscous dampers for mitigating seismic damage to long-span bridges and reduce maintenance costs

Seismic

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Project Title:
The Feasibility of Using Buckling-Restrained Braces for Long-Span Bridges

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WHAT IS THE NEED?

Buckling-restrained braces (BRB) may be a viable alternative to improve the seismic performance of bridges in active seismic areas, replacing the viscous-fluid dampers used to retrofit long-span bridges. When subjected to ambient bridge motion, viscous dampers tend to deteriorate faster due to the continuous movement of the bridge from traffic, raising questions about their reliability during a significant seismic event.

BRBs consist of a slender steel core supported by a concrete casing to prevent buckling under axial compression. While they are reliable at dissipating energy as demonstrated by protocols developed for the building industry by the American Institute of Steel Construction (AISC), those requirements are insufficient for bridge applications.

WHAT WAS OUR GOAL?

The goal was to investigate the feasibility of replacing viscous-fluid dampers with buckling-restrained braces on long-span bridges and develop acceptance criteria for BRBs.

WHAT DID WE DO?

Given the complexity of long-span steel truss bridges and bridge-specific design guidelines for these types of structures, the researchers performed extensive analytical modeling to identify the expected structural response during an earthquake. Bilinear BRB elements replaced viscous damper elements as part of a parametric study to identify the BRB parameters required for seismic response mitigation.

The bridge used in the case study is situated directly over a major fault, causing the pre-established site-specific design earthquake to be a near-fault, pulse-type ground motion, which is common for many long-span bridges in California. This scenario presents an important new structural application and seismic environment for BRBs. A near-fault event is characterized by a pulse of high ground velocity that results in inelastic cyclic demands on a bridge. These demands are explicitly neglected in existing AISC provisions.

The researchers physically verified the ability of BRBs to sustain these near-fault demands and validated the new loading protocols. The test matrix included braces fabricated with A304 stainless steel to utilize the superior ductility and corrosion properties and specimens tested at high strain rates to investigate the dynamic effect on BRB performance.

WHAT WAS THE OUTCOME?

The analytical results show that replacing viscous dampers with BRBs is economical, feasible, and beneficial for bridge applications. However, retrofitting other bridge structural elements might still be required. Loading protocols for qualifying BRBs for use on many existing near-fault, long-span bridges have been developed. Using these protocols, full-scale testing of six commercially available BRBs demonstrated their ability to deliver the large strain (= 0.05 in/in) demand under both pseudo-static and dynamic rates.

WHAT IS THE BENEFIT?

The need for economical solutions that require low maintenance, yet provide sufficient structural resistance for bridge structures is critical. Agreement between the analytical studies and the full-scale testing results has demonstrated the feasibility of using existing BRB technology on long-span bridges. Additional work is required to confirm whether BRBs can replace viscous-fluid dampers without the need for additional bridge retrofitting.

LEARN MORE

To view the complete report:
www.dot.ca.gov/research/researchreports/reports/2011/final_report_ca12-2149.pdf

IMAGES

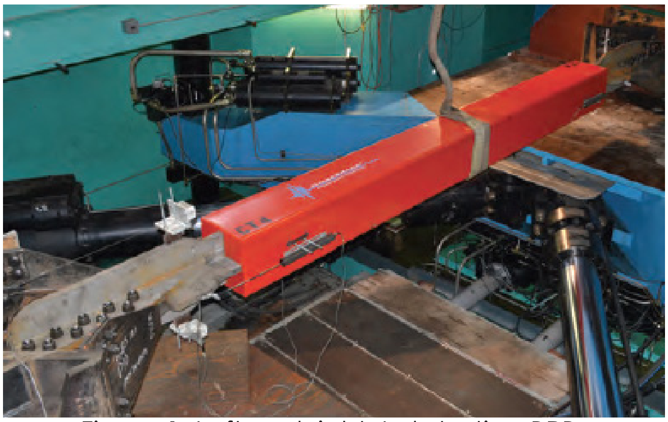

Figure 1: Left and right: Lab testing BRBs