DRISI
Caltrans Division of Research, Innovation and System Information

Research Results

Buckling-Restrained Brace Protocols for Truss Bridges

Bridge models retrofitted with buckling-restrained braces were studied to generate aprequalifying test loading protocol from earthquake induced brace demands.

Geotechnical/ Structures

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Project Title:
Buckling-Restrained Brace Protocols for Truss Bridges

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WHAT IS THE NEED?

Buckling restrained braces (BRBs) were originally developed in the 1970s in Japan but did not gain acceptance in buildings until after the 1995 Kobe Earthquake. These braces are capable of withstanding large seismic motions, during which they soften so as not to overload the rest of the structure. Therefore, they act as a type of fuse while still maintaining the stability of the structure during the earthquake. Since 1995, BRBs have become very popular in building seismic designs, however their use on bridges has remained almost nonexistent. Building designers have a comprehensive design guide for BRB frames and a substantiated component testing protocol provided in the AISC Seismic Provisions for Structural Steel Buildings. However, these tools have not been validated for bridge design and there is a need to investigate the application of BRB for bridges including the development of acceptance test protocols.

WHAT WAS OUR GOAL?

The immediate goals of this project were to:

- Identify characteristics and configurations of BRBs on steel truss bridges that improve structural seismic performance
- Subsequently produce a test protocol which can be used to prequalify BRB components for use on steel truss bridges. Prequalifying protocols statistically represent the expected seismic demands for a component, which acts as a fuse, within a structure and serve as a quality control measure to ensure it can perform as expected.

WHAT DID WE DO?

Two steel truss bridge models, one arched truss and one multi-span straight deck truss, were created from as-built drawings, as shown in Image 1 and 2. The bridges varied in truss configuration, span sizes, and number of spans. They were investigated for hypothetical seismic retrofit using BRBs as replacements for truss members that were identified as failing during a design earthquake. A parametric approach was used to determine the BRB sizes and configurations within the bridge structures. This retrofitted bridge model was then subjected to a suite of over 20 ground motions that generated BRB deformation demands that were used to develop a new loading protocol.

WHAT WAS THE OUTCOME?

Of the two bridges studied, only the arched truss bridge was found to be a suitable candidate for retrofitting with BRBs. This meant that the addition of a BRB significantly reduced the estimated damage during the design earthquake. Despite many different brace layouts and sizes attempted, the straight deck truss bridge did not experience a reduction in damage. This bridge will be studied more in the future as part of an effort to directly design BRBs for bridges, since this parametric strategy was unsuccessful.

The arch bridge was therefore used in the development of the protocol. The resulting protocol compared well with that provided by AISC for a BRB applied to building frames as shown in Figure 3. The similarities included the maximum brace deformation, number of deformation cycles (as the structure experiences shaking, the brace is compressed and stretched), and in terms of accumulated damage. Therefore, it was concluded that the existing AISC protocol could be directly used to qualify a BRB for use on steel truss bridges.

WHAT IS THE BENEFIT?

This study represents one of few studies addressing the use of BRBs on bridges and provides an additional data point for bridge engineers considering BRBs in their designs. The developed protocol provides insight into the expected demands on these braces with a somewhat conventional bridge type. Moreover, the AISC protocol has been used for well over 10 years to prequalify many existing BRB component designs.

Based on limited numerical results, it appears the AISC protocol can be used on steel truss arch bridges. However, this work should be expanded to include other bridge types and BRB configurations. Further, the results of this and subsequent studies should be utilized to develop a design process, including acceptance test protocols for BRBs on bridges.

IMAGES

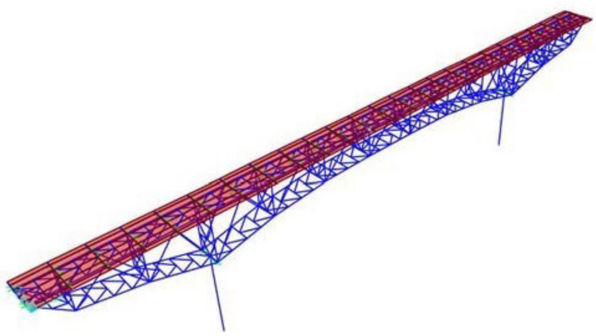

Image 1: graphic of arch deck truss

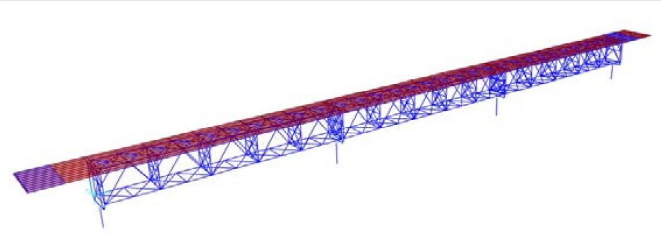

Image 2: graphic of straight deck truss

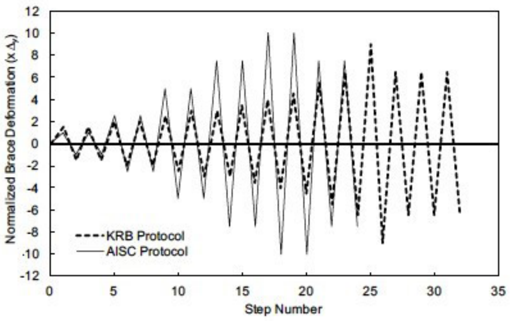

Image 3: Comparison of AISC protocol with proposed bridge protocol