Seismic Design, Analysis and Retrofit

Problem: Failure of Existing Structures and New Structures During a Seismic Event

Although widely believed to be unique to the western part of the country, earthquakes can and do occur throughout the United States. In fact, it is estimated that 31 states contain areas where the potential ground shaking from earthquakes could be sufficient to cause damage or failure of highway bridges.

Prior to the 1971 San Fernando Earthquake in California, bridge design codes gave minor attention to seismic design and detailing. This 6.4 magnitude earthquake collapsed or damaged 60 bridges and two hospitals in southern California. This event triggered the development of today's modern seismic design codes over the following decades. Bridges that were constructed prior to 1971, and even years after, lack proper seismic detailing and are vulnerable to damage or collapse even from a moderate earthquake. For the safety of the traveling public, these structures must be retrofitted to prevent collapse during a seismic event. In conjunction, new structures being designed and built must use current seismic technology, design codes and seismic detailing.

Putting it in Perspective

- Research by the U.S. Geological Survey (USGS) estimates that there is a 40% to 60% probability of an earthquake of magnitude 6 or greater in the central or eastern United States within the next 30 years. On the West Coast, the USGS and other scientists estimate a 62% probability of at least one magnitude 6.7 or greater earthquake striking before 2032, which would result in widespread damage.
- The damage to a key structure spanning a major river crossing would impede emergency traffic and disrupt regional and national commerce.
- Many engineers recognize the potential that an earthquake will damage their bridges, but they have made little effort to correct the seismic deficient areas and are not familiar with special seismic provisions that are required for new structures.

Solution: Offer training for seismic design/analysis, retrofitting and detailing.

What kind of design/analysis training?

Seismic training can soon be taken on three different levels. It can offer the very basic seismic requirements to engineers designing structures in low seismic zones. For structures in moderate zones, the training will be more complex and include higher level of analysis effort and detailing. Structures located in zones considered high seismic would be offered with additional effort and detailing for design.

What are the advantages of seismically retrofitting bridges?

Structures that have been properly retrofitted are better able to resist seismic forces and have been shown to sustain less damage and are less likely to fail during seismic events. Depending on the seismic zone the structure is located; the retrofit could be as simple as securing girders to the substructure with cable restrainers or extending the seat lengths. For structures in higher seismic zones, the retrofit may be more involved and can include column jacketing, base isolation bearings and foundation modifications.

Successful Applications: States' Results Demonstrate Success

Some States have been very active in implementing modern seismic codes and seismic retrofit programs which enhanced structure performance during seismic events:

California

The California DOT pursued a comprehensive seismic retrofit program following the 1971 San Fernando Earthquake. As a result, during the 1994 Northridge Earthquake in southern California, which had a magnitude of 6.7, almost all seismically retrofitted structures were undamaged or only sustained minor damage which were quickly repaired.

Washington

Similarly Washington State DOT completed their seismic retrofit program prior to the 2001 Nisqually Earthquake, which had magnitude 6.7. As a result, many retrofitted structures were undamaged or sustained only minor damage which were quickly repaired.

In contrast, damage and structural failures from recent earthquakes in countries where current seismic philosophy for retrofit and design has not been followed, was much more severe and widespread. Similar failure could occur in some parts of the United States if proper seismic retrofit and seismic design is not performed.

Georgia and New Jersey

Recently, the State DOT engineers attended a 2-day seismic seminar to become familiar with detailing, analyses, retrofit, and design.

Other states have conducted seismic design and retrofit training in the past for their personnel and consultants to familiarize them with new seismic codes and good detailing practices.

Benefits:

- Damage and collapse of bridges can be prevented with proper seismic design and detailing.
- Understanding plastic concepts can produce more economical foundations.
- Utilizing the latest seismic guidelines produces safe and state-of-the-art designs.
- Traffic congestion and interruption to commerce can be minimized if bridges remain in service following a seismic event.

Additional Resources:
To learn more, visit:
www.fhwa.dot.gov/resourcecenter

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