Impact of New Seismic Design Provisions on Bridges in Mid-America: A Pilot Pooled Funds Project

Background

In 1998, the National Cooperative Highway Research Program (NCHRP) initiated a study to develop a new set of seismic design provisions for highway bridges (NCHRP Project 12-49) for possible incorporation into the future AASHTO LRFD bridge design specifications. These recommended specifications provided the technical basis for a stand-alone set of provisions entitled "Recommended LRFD Guidelines for the Seismic Design of Highway Bridges" developed by a joint venture of the ATC and MCEER. The NCHRP project 12-49 was intended to reflect experience gained during recent damaging earthquakes and the results of research programs conducted in the US and elsewhere over the prior 10 years. The project was to incorporate the latest information regarding design, performance criteria, seismic hazard, site effects, and component design and detailing. Studies have shown that direct application of the proposed specifications may involve large number of bridges requiring seismic design, resulting in more cost for the states in the Central and Southeastern United States (CSUS). This project is to study the detail ground motion characteristics, site response models and bridge performance criteria to improve or evolve the latest specifications are a major improvement over previous versions – particularly as it pertains to bridges in the Central and Southeastern United States.

Objectives

The objectives of this research project are to apply a comprehensive methodology to design bridges in the CSUS – using the NCHRP 12-49 as a basis. The methodology would address

(1) current source models and maps used for ground motion in the CSUS
(2) current site response models
(3) fragility models and network assessment to determine required level of seismic protection
(4) Detailed analysis to derive retrofit design forces and deformations

The ground motion characteristics, site response models, and bridge performance fragility curves will be developed for representative states in the Central and Southeastern United States. Additional investigation into advanced analysis methods for bridges before and after retrofitting, and the use of network models will also be performed. It is believed that by addressing these four components using the latest tools and knowledge in seismology, geotechnical engineering, transportation and structural engineering, the impact of the codes on seismic design might, in fact, be minimal.

Task Statement

Task 1

Provide a state-of-the-art summary of the recent research on source models and site response models for the central and southeastern United States.

Task 2

Using the latest tools from the MAE Center, and the results of Task 1, develop ground motion intensity maps (rock motion) for representative regions in Mid-America for a suite of return periods.

---Interim Report (Month 3)

Task 3
Develop uniform hazard response spectra for representative regions in Mid-America area using DEEPSOIL, a nonlinear site response code that includes the significant effect of confining pressure on the nonlinear soil properties of soils in the Embayment and using an alternative approach based on soil attenuation relationships. Compare results with ground motions calculated by the USGS for regions in Mid-America

---Interim Report (Month 6)

Task 4
Develop fragility curves which represent the inherent capacity of bridges in Mid-America for use in the Analysis.

Task 5
Provide an example of the network solution to determine priorities and number of retrofitted bridges, and compare with traditional selection methods.

---Interim Report (Month 9)

Task 6
Perform refined analysis with soil-structure interaction of a sample bridge to determine forces and deformations for retrofit design, and compare with forces and deformations obtained from conventional analysis-for-design methods according to AASHTO and NCHRP.

Task 7
Provide recommendations on source, site, fragility models, retrofit prioritization and retrofit design, for future use for DOT's in central and southeastern United States.

-----Final Report (Month 12)

Deliverables

1. State-of-the-art summary of source models and site response models for central and southeastern United States.

2. Revised ground motion intensity maps (rock motion) for representative regions in the Mid-America for a suite of return period.

3. Uniform hazard response spectra for representative regions in Mid-America using DEEPSOIL, and comparison of results with USGS.

4. Fragility curves for typical bridges in Mid-America region (approximately 9 bridge types will be provided, consistent with those found in Hazus).

5. Refined analysis with soil-structure interaction of a sample bridge.

6. Example of network analysis used to determine lifelines, and prioritization of bridge retrofit.

7. Recommendation document on source, site, fragility models, and retrofit prioritization and retrofit design for future use for DOT's in central and southeastern US.

Budget Summary (12 Months)

FHWA : 100K ($70K available on FY05, $30K subject to availability on FY05/06)
State DOTs: $250K **(Subject to availability of State DOTs listed above)**

Total cost: $350,000