MPC-383

January 1, 2012 – December 31, 2012

Project Title:
Seismic Performance of Highway Embankments

University:
Colorado State University

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Research Needs:
Resilient transportation networks are essential component for post-earthquake relief and recovery missions. Large emphasis is placed on roads, highways, and bridges to provide rescue team with access to disastrous areas where essential needs including medical care can be provided to those affected.

Currently, the general approach for conducting a consequences based seismic risk assessment (SRA) hinges on assessing the degree at which bridges in the region in question are damaged due to a seismic event (Padgett and DesRoches, 2007). The approach includes selecting a region and a route to be investigated, identifying bridges that exist in the route, evaluating their performance under earthquake loading, assigning a level of functionality of the route based on bridge performance, and finally using a simulated traffic flow for assessing losses. In other words, the current approach solely depends on bridge damage in determining whether or not a particular route can be utilized for post-earthquake relief and recovery missions. Evidence has shown earthquakes to cause large damage and failure of road embankments (USGS, 2010). As a result of such, both the resiliency and reliability of a particular transportation network is impaired. It is therefore essential to assess the seismic resistance of highway embankments such and integrate the information in a planning for post-earthquake missions.

Research Objectives:
The objective of this study is to develop an approach for assessing the performance of embankments under seismic loads. The project seeks to highlight the various observed failures in highway embankments and the importance of including their behavior in post-earthquake recovery and relief missions. Finite element models of highway embankments will be developed and used to conduct nonlinear dynamic time-history analysis. The result of the analysis will be compared against specific performance levels. A methodology will be proposed for estimating the potential and degree of damage to highway embankments, which can be used by decision

makers in determining if a particular route can be utilized for post-earthquake relief and recovery missions.

Research Methods:
The objective will be met through conducting a comprehensive literature review on the damage sustained by pavement and embankment in previous earthquakes. The identified damage will be correlated to damage classifications, which will account for the observed mode of failure. Finite element models for each of the observed failure modes will be proposed with clear identification of the model geometry, material properties, loading scenarios, and the boundary conditions imposed on the embankment.

Expected Outcomes:
The project is expected to enhance the knowledge of vulnerability of highways to damage resulting from seismic events. The result of the studies can be used for planning for post-earthquake missions.

Relevance to Strategic Goals:
The outcome of the project is expected to address the strategic goal of the "State of Good Repair" as the result can be used to enhance the performance of highway embankments under seismic loading, which will result in minimizing the associated full life cycle cost.

Educational Benefits:
A graduate student will be hired as a research assistant on this project. The findings of the project will be utilized in a graduate course on Earthquake engineering (CIVE 767) which is taught by Dr. Mahmoud at the Civil and Environmental Engineering Department at Colorado State University.

Work Plan:
The objective will be met through various tasks which will include

Task 1: Conduct literature review

Comprehensive literature review will be carried out on the damage sustained by pavement and embankment in previous earthquakes. The identified damage will be correlated to damage classifications, which will account for the observed mode of failure.

Task 2: Selection of Prototype Highway/Embankment configurations

The outcome of the literature review will be used to determine the highway/embankment configurations to be used in the analytical studies and the critical parameters to be varied in the analysis.

Task 3: Conduct Nonlinear Dynamic Time-history Analysis

Finite element models of the prototype highway/embankment segments will be developed and nonlinear dynamic time-history analysis will be conducted to evaluate the response under seismic loading. The result of the analysis will be evaluated against certain performance levels.

Task 4: Propose a Methodology for Estimating the Damage

The results of the finite element analysis will be used for estimating the potential and degree of damage to a highway/embankment segment.

Task 5: Reporting and Dissemination

A final report will be produced describing the results of the research. The results of the study will also be disseminated in the form of scholarly papers which will be published in reputable journals.

Time Line:

	Months							
Task	1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24
1								
2								
3								
4								
5								

Project Cost:
Total Project Costs: $92,000
MPC Funds Requested: $46,000
Matching Funds: $42,000 Source of Matching Funds: CODOT

TRB Keywords:
Road, Embankments, Earthquake, Hazard Assessment, slope stability, slope failure

References:

Jamie E. Padgett and Reginald DesRoches, (2007) “Bridge Functionality Relationships for Improved Seismic Risk Assessment of Transportation Networks”, Earthquake Spectra, Volume 23, No. 1, pages 115–13.

United States Geological Survey (USGS), (2010b) “U.S. Geological Survey Photographic Library”. U.S. Geological Survey Open-File Report 90-547

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