Identifying Number MPC-342

Project Title:

Seismic Vulnerability Analysis of Bridges in Mountainous States

University:

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Description of Research Problem:

Seismic hazard, along with other natural hazards, has posed serious threats on bridges. Similar to other hazards, the performance of a bridge under seismic loading depends on site characteristics, seismic hazard in the area, and of course the structure itself. Mountainous states, such as Colorado, Wyoming and Utah, are not traditionally deemed as high seismic regions. Existing studies on the seismic vulnerability of bridges in mountainous states are very limited. In recent years, greater concerns have arisen to elevate seismic resistance of bridges in this region since there is the possibility of an earthquake which would be quite disruptive. The unique soil conditions, specific bridge designs and service load conditions, all underscore the need to have better knowledge of the vulnerability of existing bridges subjected to earthquakes. As an initial effort, the study will provide esssential knowledge which can be integrated into the future designs of these critical components of Colorado (and the Mountain states) infrastructure.

Research Objectives:

The objective of this study would be to conduct the vulnerability analysis of a typical bridge in a mountainous state by considering site-specific environmental, load and structural conditions. Through characterizing specific environmental conditions, a detailed analytical bridge model will be developed. The dynamic analysis of a prototype bridge subjected to earthquake along with other possible adverse environmental conditions will be conducted. The dynamic performance as well as possible damage of the bridge can be predicted. Finally, the probability-based vulnearbility analysis

of the bridge as well as impacts on the transportation service will be conducted.

Research Approach / Methods:

The propsoed study will include following tasks:

Task 1. Literature review
Extensive literature review will be conducted on the related government reports and existing studies on seismic analysis. Particular attention will be paid to existing studies in mountainous states. The historical damage of bridges due to earthquake will be evaluated to find out the vulnerable bridge types and environmental conditions.

Task 2. Characterization of site-specific conditions
Based on the findings in Task 1, one typical prototype bridge will be selected. Specific soil conditions and traffic conditions will be defined. Other adverse conditions will be considered, such as the pier conditions (e.g. types, buried depth etc). Different scenarios will be selected for the analysis by combining all possible hazardous conditions.

Task 3. Bridge dynamic analysis subjected to seismic
Opensees will be adopted to develop the analytical model and conduct the seismic analysis. For each scenario, dynamic simulation will be conducted which consider different service load conditions along with earthquake. Both global and local damage analysis will be conducted. For vulnerable portion, refined analysis will be further conducted.

Task 4. Vulnerability analysis
A vulnerability assessment of the whole prototype bridge will be conducted in this task. Specifically, the vulnerability analysis will include (1) local damage analysis and (2) risk of the structural collapse of the whole bridge.

MPC Critical Issues Addressed by the Research:

1. Improved infrastructure design.
2. Infrastructure longevity.
3. High-risk rural roads.

Contributions / Potential Applications of Research:

Hazard mitigation is a national concern and earthquake hazard is critical with regard to the safety and economy of a modern society. The findings from this study will be discussed with the related people in many agencies, such

as regional and local DOT and emergency management. Better insight about the seismic risk and furthermore, vulnerability of the example bridge in the region, will be achieved. By carefully selecting the representative bridge type in the region as the example, the observations made from this example bridge can be applied to many similar bridges in the region. This study will lay an important foundation for many further studies which can improve the current design and protection of bridges.

Potential Technology Transfer Benefits:

Through communicating with some stakeholders, the PI believes the proposed study has potential to be incorporated into the bridge design, emergency management and policy making by the related agencies in the future.

Time Duration:

July 1, 2010 – June 30, 2011

Total Project Cost:

$94,036

MPC Funds Requested:

$52,000

Source of Matching Funds:

In kind and hard match: $42,036

TRB Keywords: Rural bridges; seismic; risk