MPC-483 (Year 2)
March 29, 2016

Project Title:
Interaction Analysis of Girder Bridges and Traffic System subjected to Earthquakes

University:
Colorado State University

Principal Investigators:
Suren Chen
Associate Professor
schen@rams.colostate.edu
970-491-7722

Research Needs:
Due to the limitation on current seismic forecasting techniques, people usually have very short warning time for traffic to be evacuated from a bridge before seismic strikes. As a result, it is very likely that normal traffic still remain on the bridge when seismic occurs. Bridge seismic analysis typically does not consider the presence of traffic and the dynamic interactions. In recent years, some studies have been carried out on the bridge seismic performance when traffic is included and existing studies suggest that traffic has some influence on bridge seismic performance, which should not be neglected. In addition to the bridge safety concern, the moving vehicles may also experience some safety risks under seismic. However, most of existing studies considered one or several individual vehicles without appropriate modeling of dynamic interactions. In order to evaluate the performance of the bridge and traffic system, the dynamic performance of the coupled bridge and traffic system needs to be rationally predicted.

Research Objectives:
This study aims at developing the advanced coupled analysis and congestion/safety assessment model of a typical medium-span girder bridge and traffic system subjected to earthquake.

Research Methods:
The proposed study will develop a fully coupled analytical framework to study the bridge/traffic system subjected to seismic. Such a framework will include improved traffic flow simulation and fully coupled dynamic interaction analysis of the bridge and multiple vehicles of the traffic.

Expected Outcomes:
The study will provide following outcomes:

1) Improved stochastic traffic flow simulation considering driving behavior under seismic.
2) The fully coupled interaction analytical model, which is appropriate for typical medium- to short-span girder bridges.

Relevance to Strategic Goals:

The proposed study can help evaluating the post-seismic performance, which is important for the strategic goal of "State of Good Repair and Safety" for transportation infrastructures. Some findings may also help engineers to design safer and more economic bridges, serving the goals of "economic competitiveness" and "livable communities" as well.

Educational Benefits:
The graduate student will be involved in this study. Some findings from this study may be incorporated in the future bridge engineering classroom education.

Work Plan:
Task 1 Literature review

A comprehensive literature review will be conducted on the bridge resilience, bridge/traffic interaction and seismic design. The state-of-the-art on the bridge resilience to seismic hazard will be reviewed and documented. This task has been finished (100%).

Task 2 Improved stochastic traffic flow simulation (Yr 1)
The existing stochastic traffic flow simulation techniques on bridge system will be improved by incorporating appropriate driving behavior under seismic. As a result, more realistic traffic scenarios before, during and after seismic impact can be simulated. The basic simulation code is finished and we are now working on advanced features (Original task 85% finished)

Task 2P Extended traffic flow simulation model for traffic safety study (Yr 2)
The model developed in Year 1 will be extended to also accommodate different vehicle operational conditions (e.g. accelerating/braking). As a result, the new can be used for traffic safety study under both normal and emergency situations.

Task 3 Development of girder bridge/traffic/seismic interaction model (Yr 1)
The existing bridge/traffic interaction model was primarily developed for long-span bridges with box girders, which cannot be applied on girder bridges with medium and short spans. In this task, the new interaction model of the bridge/traffic/seismic interaction model is developed, which can be applied to thousands of girder bridges around the country. During the modeling process, the site-specific seismic effects can also be appropriately characterized and applied.
The framework is established and we are conducting validation and improvements. 70% finished.

Task 3P Development of integrated traffic congestion and safety prediction model (Yr 2)
Based on the advanced traffic flow simulation model developed in Task 2, the integrated traffic congestion and safety prediction model will be developed. With the model, the possible congestions and safety risks during and following earthquake will be assessed.

Task 4 Numerical analysis of Prototype Bridge
1-2 typical bridges in the mountainous region will be selected as the prototype ones. Detailed numerical analysis will be conducted to disclose some nature about the dynamic interaction of traffic, bridge and seismic. The impacts of traffic on the bridge seismic and possible mitigation

efforts will be discussed. In the mean time, the vehicle response on the prototype bridge under seismic will also be discussed.
The numerical analysis is over halfway. 60% finished.

Task 4P Numerical demonstration of traffic flow and safety assessment on prototype bridge (Yr2)
With the models developed in Task 2P and Task 3P, numerical demonstration is carried out to assess the associated congestion and traffic safety risks on the prototype bridge.

Project Cost:
Total Project Costs: $60,000.00
MPC Funds Requested: $30,000
Matching Funds: $30,000 Source of Matching Funds: In-kind

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

TRB Keywords: Girder bridge; traffic; seismic; dynamic interaction; resilience