MPC-461
April 1, 2014- July 31, 2017

Project Title:
Analytical Modeling for Progressive Failure Assessment of Curved and Skewed Highway Bridges Subjected to Seismic Hazards

University:
Colorado State University

Principal Investigators:
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Research Needs:
Curved and/or skewed bridges are very common on highways across the country. These bridges are more vulnerable to seismic than typical straight ones. The current specifications do not provide enough coverage for the curved and skewed bridges on progressive failure risk. Under the joint impact from post-seismic traffic and partial damage of some members from seismic, the progressive failure risk will increase depending on the intensity of seismic and traffic at the time. It is thus important to evaluate the progressive failure risk of vulnerable curved and skewed bridges immediately after the seismic occurrence. However, such a simulation tool which can enable progressive analysis of curved and skewed bridges subjected to traffic and seismic is not available.

Research Objectives:
This study will develop an analytical framework of modeling progressive failure risk of typical curved and skewed bridges subjected to seismic and traffic.

Research Methods:
The study will firstly start from more realistic traffic flow simulation before and after seismic with advanced agent-based traffic flow simulation techniques. Secondly, the FEM-based simulation framework will be developed to study the performance of curved and skewed bridge before and after seismic including the interactions with traffic. Finally, a prototype bridge will be numerically studied.

Expected Outcomes:
This project will develop (1) improved traffic flow simulation after seismic occurs including consideration of panicking driving behavior, and (2) the simulation tool to assess progressive failure risk of curved and skewed bridges. It will lay important methodological foundation toward future reliability-based progressive risk assessment, and vulnerability analysis. In the future, possible progressive risk of existing curved and skewed bridges can be rationally assessed and the bridges can be prioritized for the emergent repair immediately after the seismic before comprehensive monitoring checking is conducted. The findings from this study may also be used by engineers to improve the future bridge design and the current design guidelines.

Relevance to Strategic Goals:

The study is directly related to the goals of State of Good Repair and Safety.

Educational Benefits:
A graduate student will involve conduct this study and work toward the dissertation. In addition, some findings can be introduced in advanced bridge class for graduate students in the future.

Work Plan:

Task 1. Literature review
Extensive literature review will be conducted on the related studies. Particular attention will be paid to existing studies on progressive failure simulation on bridges as well as seismic studies on curved and skewed bridges. Some problems and conclusions already made in the existing studies will be gathered for the present study.

Task 2. Develop improved agent-based traffic flow simulation
Advanced agent-based traffic flow simulation will be conducted to model the traffic on curved and skewed bridges before and after seismic, including consideration of change of traffic driving behavior and pattern.

Task 3. Develop FEM-based progressive analytical simulation model
Hybrid simulation framework will be developed based on both commercial FEM software and in-house analytical software. Such a framework can carry out time-history analysis and the following progressive analysis including dynamic interactions with traffic and seismic. The simulation model will be primarily used to study the critical time durations during and immediately after the seismic occurrence. Such a model will be able to analyze different representative scenarios with different traffic and seismic intensities.

Task 4. Numerical example on a prototype bridge
One numerical example will be made to demonstrate the developed methodology with a prototype bridge in moderate seismic zone.

Time Line:

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

Project Cost:

Total Project Costs: $116,850
MPC Funds Requested: $ 57,000 (Pay one student and small portion for faculty summer)
Matching Funds: $ 59,850 Source of Matching Funds: Faculty and student time, CSU.

TRB Keywords: bridges, seismic, progressive failure