MPC-534
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Project Title:
Traffic Performance Assessment of Disrupted Roadway Networks Following Earthquakes

University:
Colorado State University

Principal Investigators:
Suren Chen
Associate Professor
Colorado State University
Phone: (970) 491-7722
Email: suren.chen@colostate.edu
ORCID: 0000-0002-3708-5875

Research Needs:
Earthquakes can cause catastrophic damages to infrastructures in urban areas, such as buildings, bridges, pavements, communication, and energy infrastructures etc. A degraded or disrupted transportation system following a major earthquake may involve different levels of reduced functionality caused by (1) physically damaged infrastructure, (2) partially blocked roads due to debris, falling trees, poles or other facilities, or (3) limited mobility due to serious congestion and/or possible accidents under hazardous driving conditions (Sullivan et al. 2009; Mattsson and Jenelius 2015). To rationally predict the performance of degraded transportation systems before, during and following earthquakes is crucial to smooth emergency response, effective recovery and developing optimal hazard mitigation strategy. However, post-hazard performance of disrupted transportation network has been primarily studied in a large scale and simplified manner without capturing the detailed disrupted nature caused by different hazards, considering the impacts from the damage and failure of other infrastructure and predicting the corresponding impact on transportation performance.

Research Objectives:
1. Characterization of disrupted roadway scenarios following earthquakes
2. Develop a multi-scale simulation tool for transportation performance assessment
3. Demonstration of the proposed traffic performance assessment

This study will develop an analytical framework of studying traffic performance of roadways in a transportation network following earthquakes through modeling the reduced functionality from various sources with the objectives listed above.

Research Methods:
The study will firstly start with comprehensive literature review of related studies on disrupted transportation infrastructure modeling. Secondly, representative disrupted scenarios of a typical city road network are identified, including possible transportation infrastructure damage and

debris caused by damages of other infrastructures. Thirdly, advanced agent-based traffic flow and safety simulation technique is applied to simulate the traffic performance, including both congestion and potential safety threats on the disrupted transportation system following earthquakes. Finally, the improvement strategy of transportation system to optimize the post-hazard performance of the disrupted network is studied.

Expected Outcomes:
This project will develop (1) a basic framework to characterize representative scenarios of disrupted transportation network following earthquakes by considering interdependent impacts from other infrastructure categories, and (2) the simulation tool to assess traffic performance of road network at both road and network levels. In the future, more resilient hazard mitigation strategy may be developed based on this study through predicting possible outcome and the optimal strategy to minimize the impact on post-hazard network.

Relevance to Strategic Goals:
- State of Good Repair
- Safety

The proposed study can improve traffic performance assessment of highways following earthquakes, 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 highway systems, serving the goals of "economic competitiveness" and "livable communities."

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

Tech Transfer:
This study will be shared with the research community through publications, conference and presentations.

Work Plan:
1. Literature review
2. Develop representative scenarios of disrupted transportation system
3. Develop a multi-scale simulation tool to assess transportation performance
4. Transportation performance assessment following earthquakes

Task 1 – Literature review
Extensive literature review will be conducted on the related performance and risk studies on bridges, pavements, and other infrastructure systems under earthquakes. These models will be selected for the following tasks to consider the impacts on debris, traffic control equipment and light conditions on the roads.

Task 2 – Develop representative scenarios of disrupted transportation system
For the prototype transportation network along with other infrastructure data in a city, possible representative disrupted scenarios of road segments will be identified based on site-specific conditions and also earthquake conditions. These scenarios include possible bridge failure, damage, road pavement damage, different debris scenarios and driving conditions through the network.

Task 3 – Develop a multi-scale simulation tool to assess transportation performance
In this task, advanced agent-based traffic flow simulation techniques and network modeling will be conducted on the network following hazards. With the simulation tool, both traffic congestion and possible safety risks can be assessed at both road and network levels. Such models can consider possible driving behavior change, different traffic demands, impacts from possible failures of other infrastructures (e.g. buildings, traffic control devices and energy infrastructure) following hazards.

Task 4 – Transportation performance assessment following earthquakes
Several different stages following earthquakes will be studied with the developed tool, including emergency response, early recovery and long-term recovery stages. For each stage, different disrupted nature of the transportation network will be modeled and the traffic performance will be assessed accordingly.

Project Cost:

Total Project Costs:	$114,000
MPC Funds Requested:	$57,000
Matching Funds:	$57,000
Source of Matching Funds:	Faculty and student time, CSU

References:

Mattsson L.G., Jenelius E. (2015). "Vulnerability and resilience of transport systems – a discussion of recent research." *Transp Res Part A Policy Pract*;81:16-34.

Sullivan, J., Aultman-Hall, L. and Novak, D. (2009). "A review of current practice in network disruption analysis and an assessment of the ability to account for isolating links in transportation networks," *Transportation Letters*, 1:4, 271-280.