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Project Title

Modeling Disrupted Transportation Infrastructure System Due to Multiple Hazards

University

Colorado State University

Principal Investigators

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Research Needs

A transportation system, consisting of roads and bridges, experiences various types of disruptions subjected to different hazards, including long-term, short-term and temporary ones. Due to the complex nature and different causes, disruptions can be very hard to predict with high uncertainty. Different from normal traffic conditions with intact transportation system, actual field data is often lacking, preventing from developing some data-based models.

Although travel time for normal traffic system and conditions has been well studied, there is no rational travel time prediction for disrupted traffic systems caused by different hazards. As the key step toward developing rational travel time prediction, disrupted traffic system needs to be appropriately modeled. Given the complex nature and high uncertainty of all possible impacts on traffic system due to different hazards, the prediction of possible disruption scenarios remains challenging and has not been addressed in existing studies. This is especially true for partially-blocked roads and bridges caused by partial lane closure due to structural damage, accidents or falling debris from nearby buildings, trees or others. In addition to these causes, the failure of interdependent infrastructure systems may also cause disruptions on transportation systems, such as partial blockage.

Research Objectives

As a key step toward predicting travel time of disrupted traffic system due to several representative hazards, this project tries to achieve following research objectives in order to support the preparation, response and recovery of modern community before and following natural hazards:

1. Appropriately define various natural hazards and incidents, which may cause transportation disruption in urban and rural settings;
2. Develop a general method to model the caused disruptions on transportation system, particularly roads and bridges, due to full or partial blockage.

Research Methods

The proposed work will integrate stochastic hazard modeling techniques, traffic finite element modeling and agent-based simulation techniques to conduct this study.

Firstly, typical natural hazards considering site-specific conditions, such as earthquake, hurricane and flooding will be modeled by considering site-specific and stochastic nature. In addition to natural hazards, major incidents such as accidents and failure of interdependent infrastructure systems are also modeled.

Based on the modeling of natural hazards and incidents, debris modeling will be conducted with advanced finite element modeling and other simulation techniques.

Agent-based modeling technique will be applied later to model different representative disruptive scenarios on both urban streets and interstate highways considering uncertainties.

Finally, a case study is conducted to demonstrate the proposed technique.

Expected Outcomes

An important missing link between hazards and traffic performance modeling following hazards is the characterization of disrupted scenarios of traffic systems. Based on the proposed methodology, future site-specific and hazard-specific studies can adopt the proposed model and further customize with specific data and basic calibration. With the proposed study, more accurate prediction of the disrupted scenarios, and in turn, traffic performance prediction, can greatly help developing more resilient traffic system and community.

Relevance to Strategic Goals

The proposed study specifically addresses USDOT strategic goal: Livable Communities.

This study helps developing more resilient transportation infrastructure system, which can improve the life quality and the economic development of communities under various hazards.

Educational Benefits

A graduate student will involve in conducting this study. Some selected findings and research outcome will be incorporated in the transportation engineering class for graduate students and senior students in the future.

Technology Transfer

Technology transfer will be conducted through publishing papers on technical journals and also present in major conferences, such as ASCE TRB and Structure Congress and EMI conferences. Results will also be reported on website and news articles.

Work Plan

Task 1. Literature review

Extensive literature review will be conducted about 1) existing research on modeling disruptions due to different representative hazards; and 2) existing traffic time prediction of the disrupted traffic system.

Task 2. Modeling of typical hazards and incidents

For each representative hazard, appropriate parameters to quantify the impact of hazards will be studied and selected, such as hazard intensity, temporal variables and site-specific variables. Uncertainties of the hazard modeling will be incorporated in the modeling in this task. In addition to natural hazards, some incidents such as traffic accidents, work zone on bridges and roads or failure of other interdependent infrastructure systems in the community will also be simulated.

Task 3. Modeling of debris caused by some hazards

This task will adopt finite element modeling and hazard analysis to find out potential debris generation and distribution, such as tree debris caused by strong wind and building debris during earthquakes.

Task 4. Modeling of disrupted scenarios of transportation systems

Simulation techniques will be developed to study the possible disrupted scenarios under three typical natural hazards and also incidents. This task will adopt agent-based simulation technique to model possible disruptions due to possible infrastructure damage, debris distribution modeling and further partial blockage prediction of the transportation system. Preliminary analysis of impact on traffic performance due to the disrupted traffic system is also conducted.

Task 5. Demonstrative study

A case study will be conducted to demonstrate the proposed technique. Some basic parametric study will be conducted to provide more insights.

Project Cost

Total Project Costs:	$116,000
MPC Funds Requested:	$ 58,000
Matching Funds:	$ 58,000
Source of Matching Funds:	Colorado State University