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Project Title

Resilience-Based Recovery Planning of Transportation Network Following Earthquakes

University

Colorado State University

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Research Needs

Earthquakes can cause severe damages to infrastructures and significantly affect the entire community (Coburn et al. 1992). Transportation networks support critical post-hazard emergency response and recovery efforts of the whole community. A degraded transportation network may cause traffic congestion and delay and even impact travel safety on the degraded system during the recovery process. The extensive repairs of degraded transportation infrastructures usually take months or even years following earthquakes to finish, making the transportation network in the region remaining partially disrupted over an extended time during the long-term recovery stage. In addition, the reconstruction of partially damaged transportation infrastructures such as bridges will create work zones, which may significantly increase travel time and travel safety risks. It is critical to have a systematic framework to study the recovery planning for a traffic system following hazards to optimize the time-dependent resilience performance.

Many existing studies focused on the performance and resilience modeling of transportation networks under hazards, including those based on the connectivity and accessibility of the transportation networks (Guo et al., 2015; Kondo et al., 2012; Mahmassani et al., 2013) and those on travel time of transportation networks (e.g. Alipour and Shafei 2016; Chang et al. 2012; Zou and Chen 2019; Zhang et al. 2019). All these studies contributed to the post-disaster transportation network performance evaluation and also reconstruction planning during the recovery stage. Most of the studies considered either fully closed or fully opened roads or bridges following hazards. Since the varying travel demand and origin-destination (OD) matrix considerably affect the travel time and safety, to incorporate the time-dependent OD demand and time-transient process of recovery process into the resilience assessment becomes essential.

Research Objectives

This study will develop a new analytical framework of assessing the transportation network resilience during the recovery periods following an earthquake. With the framework, the time-dependent population recovery, partially functional infrastructures, traffic efficiency and safety will be considered for the recovery period. The proposed methodology will help building improved resilience assessment and more optimized recovery planning efforts following earthquakes.

Research Methods

The proposed work will integrate stochastic hazard modeling techniques, resilience analysis, traffic network modeling and agent-based simulation techniques to tackle this problem.

Firstly, fragility analyses of various infrastructures including both transportation infrastructures and other infrastructures in the community will be conducted to develop the needs of emergency response, long-term recovery and the impacted capacity of traffic system.

Secondly, resilience indicators are developed for the recovery needs by capturing both traffic efficiency and safety.

Thirdly, some optimal strategies in terms of recovery prioritization of infrastructures will be developed to meet the needs of effective and prompt recovery.

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

Expected Outcomes

An important missing link between hazards and recovery plan following hazards is a rational model which can characterize the disrupted scenarios of traffic systems on both capacity and demand ends. Based on the proposed methodology, an improved holistic analytical approach covering the recovery of the traffic system in a community can be made. As a result of this study, the economic loss from the hazards can be minimized, and more lives can be saved based on more rational and accurate planning strategies.

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 TRB and ASCE Structure Congress 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) current progress on resilience modeling of disrupted traffic network following hazards; and 2) existing studies on the recovery planning of traffic system following earthquakes.

Task 2. Fragility analysis of related infrastructures

This task will conduct fragility analysis of transportation infrastructures and also residential infrastructures which may affect population change and traffic mobility. For different earthquake hazards, parametric analyses will be conducted to assess the potential impact on the transportation system disruption, building damages and population variations in the region.

Task 3. Modeling of long-term recovery planning strategy following earthquakes

This task will develop a new methodology of assessing the transportation network resilience during the recovery period following an earthquake. The model will consider time-dependent population recovery, partially functional infrastructures, traffic efficiency and safety impact. A resilience indicator will be introduced to assess the time-dependent transportation performance and help on reconstruction planning by considering both traffic efficiency and safety. Some new recovery planning and pre-hazard prevention measures will be investigated.

Task 4. Demonstrative study

A case study will be conducted on an urban traffic network to demonstrate the proposed technique, including parametric studies of some key parameters.

Project Cost

Total Project Costs:	$118,900
MPC Funds Requested:	$ 58,000
Matching Funds:	$ 60,900
Source of Matching Funds:	Colorado State University, faculty and student time

Reference

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