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Project Title

Reliability-Based Traffic Safety Risk Assessment of Traffic System in Hazardous Driving Conditions to Promote Community Resilience

University

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Research Needs

Traffic crash risk is significantly increased on bridges and connecting roadways under various hazardous driving conditions before and following some natural hazards, such as earthquakes, hurricanes, and snowstorms. During different phases of natural hazards, appropriate preparation, response and recovery efforts to improve the community resilience all depend on safe and efficient transportation even under hazardous driving conditions. To help conduct realistic traffic network analysis and planning, such as route choices, emergency response and retrofitting repair prioritization, appropriate traffic safety performance assessments of the traffic network become essential. Currently, however, there is no appropriate traffic safety risk function which can be used in quantifying the associated safety risks in these hazardous driving conditions.

Research Objectives

This project will develop a basic framework to model traffic safety risk functions based on reliability theory by considering various adverse driving conditions, potential vehicle safety risks and associated uncertainties. This project tries to address two important research questions in order to support the preparation, response and recovery of modern community before and following natural hazards:

1) *How to assess safety risks of realistic traffic in hazardous driving conditions?* Currently, there is lack of appropriate traffic safety function for traffic systems, which can quantify the associated crash risks in complex hazardous conditions with various uncertainties. This study will propose a new risk-based traffic safety performance function considering uncertainties, which can be used in many related studies.
2) *How to adopt the advanced traffic safety risk information, if available, in future traffic engineering practice?*

This study will also explore the feasibility of the application of the proposed new traffic safety performance function in traffic planning, including route choices and decision-making to support community resilience.

Research Methods

The PI has developed advanced deterministic traffic safety assessment simulation model in adverse driving conditions in recent years (Chen and Chen 2010, 2011; Hou et al. 2017). The proposed study will be conducted based on the recent advances of the simulation works and extend to the realistic traffic scenarios in several typical hazardous conditions, such as windy, partially obstructed and curving and/or wet/snowy/icy road surfaces. The proposed work will focus on following tasks: (1) to identify several typical hazardous driving conditions following some natural hazards; (2) to conduct detailed sensitivity analysis to identify key parameters to the problems, which need to be incorporated as random variables in the reliability-based analysis; (3) to develop the reliability-based model and measures to quantify safety risks in various hazardous driving conditions; and (4) to carry out feasibility study of its application in traffic network planning. A prototype traffic network will be studied as a demonstration.

Expected Outcomes

A new general methodology to model traffic safety functions based on reliability theory will be proposed for various adverse driving conditions. Based on the proposed methodology, any future site-specific and hazard-specific study can adopt and customize the proposed model with specific data and basic calibration. With improved traffic planning and emergency response efforts based on the proposed model, people will experience lower traffic safety risks even under the adverse driving conditions throughout different phases of natural hazards. As a result, it is expected that future communities can have safer and smoother traffic on traffic networks even when the driving conditions become adverse or even hazardous.

Relevance to Strategic Goals

The proposed study specifically addresses two USDOT strategic goals: Safety and Livable Communities.

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 traffic safety research before, during and following natural hazards; 2) existing traffic safety assessment techniques in adverse driving environment; and 3) current traffic planning practice related to traffic safety for community resilience.

Task 2. Modeling of typical adverse driving conditions with uncertainties

Based on existing traffic safety deterministic models, sensitivity studies will be conducted for all typical parameters of adverse driving conditions. Selected parameters will be modeled as random variables with appropriate characterization based on literatures and available data. Time-dependent variations of the driving environment conditions will also be characterized.

Task 3. Reliability-based traffic safety risk function modeling

Firstly, different traffic flow microscopic simulation will be conducted at different phases of hazard preparation, response and recovery stages with appropriate adverse driving conditions. Secondly, reliability-based traffic safety modeling of different typical traffic scenarios will be conducted. Thirdly, the safety risk functions for adverse driving conditions will be introduced based on the simulation results.

Task 4. Feasibility study of traffic network planning

A preliminary feasibility study will be conducted based on the proposed traffic safety risk function to demonstrate the potential application on a real traffic network to provide safety-based route planning and travel advices during different phases of natural hazards. This is expected to provide valuable information for many community-resilience related studies.

Project Cost

Total Project Costs:	$112,000
MPC Funds Requested:	$ 56,000
Matching Funds:	$ 56,000
Source of Matching Funds:	Faculty and student time, CSU

References

Chen, F. and Chen, S. R. (2011). "Reliability-based assessment of vehicle safety under adverse driving conditions", *Transportation Research Part C: Emerging Technology*, 19,156-168. doi:10.1016/j.trc.2010.05.003

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Hou, G., Chen, S., Zhou, Y. and Wu, Jun (2017). “Framework of microscopic traffic flow simulation on highway infrastructure system under hazardous driving conditions”, *Journal of Sustainable and Resilient Infrastructure,* 2 (3), 136-152.