Research Project Name: Analytical Approach for Transportation Assets Risk and Resilience Analysis (TAMU)

Improving the Durability and Extending the Life of Transportation Infrastructure

Principal Investigator:
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Project Partners: n/a

Research Project Funding:
Federal: $75,000 Match: $37,500 (TAMU)

Project Start Date: 09/01/2023 **Project End Date**: 05/31/2025

Project Description: Flood risk assessment for urban road infrastructure faces significant challenges, particularly due to the scarcity of historical inundation data and the computational inefficiencies of traditional hydrodynamic models. This study addresses these challenges by leveraging 592 modular 2D hydrodynamic flood simulations to assess both direct agency costs (infrastructure repair) and user costs (travel time delays) resulting from flood events. The methodology integrates hazard scenario generation, hazard-asset pairing, vulnerability assessment, and impact analysis to develop a holistic framework for flood risk and resilience assessment. Harris County, TX, a flood-prone region that includes the Houston metropolitan area, serves as the testbed for this analysis. High-resolution flood simulations are paired with geospatial road network data to estimate inundation depths and associated damages for over 21,000 road segments. Depth-damage functions are applied to quantify the direct economic costs of road infrastructure damage, while a transportation resilience model calculates the societal impacts in terms of travel time delays across flood scenarios.

The results demonstrate that flood-induced infrastructure damage and travel disruptions exhibit spatial heterogeneity and nonlinear relationships with inundation depth, highlighting critical road segments that require targeted resilience interventions. By combining direct and societal costs into a unified monetary metric, this study provides stakeholders with a robust decision-support tool for prioritizing flood mitigation investments and enhancing urban resilience. The framework's computational efficiency and scalability make it adaptable for application in other flood-prone regions, offering a valuable resource for policymakers, planners, and engineers.

US DOT Priorities:
Improving the resilience of transportation assets is a national imperative in transportation planning and asset management. This project will create and test new quantitative methods and models that enable transportation organizations to effectively integrate resilience into their transportation planning, asset management, and project selection procedures.

Outputs:
The proposed Transportation Risk and Resilience method will be documented in the final report in an intuitive manner to ensure that it is well utilized and referenced when DOTs develop and implement their own resilience plans and actions. The team will present and disseminate the research outcomes extensively to facilitate its implementation. To this end, the research outcomes will be shared during the TRB annual conference. The team will also participate and present the manual at the TRB Asset Management and Transportation Resilience Conferences. We will also present a webinar as part of the UTC webinar series.

Also, as part of our research report, we would suggest pilot projects with interested agencies in the UTC (as a possible next phase to this project).

Outcomes/Impacts:
The project will yield new quantitative methods and measures for integrating resilience in transportation planning and asset management. Based on the knowledge and experience of the research team, we are confident that the research results will yield explicit and directly applicable results for DOTs and other local transportation agencies across the nation. The results will center on quantitative, effective, and easy to implement methods and procedures to integrate R&R assessments into various transportation planning, infrastructure prioritization, project selection and screening, and project scoping processes. The quantitative R&R assessment procedures for transportation assets will assist DOTs in proactively specifying highly critical assets within their transportation networks during transportation planning, evaluating the extent of risks and impacts in highly critical assets during prioritization and project selection, evaluating various hazard mitigation alternatives during project development, and monitoring the status of the system R&R during strategic performance assessment.

Final Research Report:
https://rosap.ntl.bts.gov/view/dot/82618