

PROJECT SUMMARY REPORT

0-7233: Incorporating Resilience Considerations in Transportation Asset Management Planning and Project Selection Process

Background

Texas transportation infrastructure is exposed to a wide range of hazards, including extreme heat, winter storms, inland flooding, and drought. The effects of these hazards vary substantially across the state and across different types of transportation assets, including roadways, pavements, bridges, culverts, and retaining walls.

Transportation Asset Management (TAM) provides TxDOT with a systematic approach for managing asset condition, performance, risk, life-cycle cost, and investment needs. However, conventional asset-management and risk-based approaches do not always distinguish between an asset's vulnerability to a hazard and its broader ability to recover functionality after disruptions. An asset may have an acceptable current condition but limited ability to withstand a particular hazard or quickly return to service. Conversely, maintenance or rehabilitation work undertaken primarily to improve asset conditions can also improve resilience.

Resilience addresses this additional dimension by considering how well assets can withstand disruptions and recover afterward. Incorporating resilience into TAM can help TxDOT identify assets that may warrant additional inspection, maintenance, adaptation, or more detailed engineering analysis.

What the Researchers Did

- Reviewed existing TAM approaches, resilience measures, state DOT practices, data requirements, and asset management and vulnerability assessment tools.
- Compiled transportation asset, condition, criticality, climate, and hazard information and developed a Weather Projection App to support processing of projected hazard indicators.
- Conducted statewide, planning-level vulnerability assessments for roadways, bridges, and bridge-class culverts using hazard exposure and asset sensitivity. Representative retaining walls were evaluated using a weighted engineering scoring method because statewide retaining-wall data were limited.
- Developed a general resilience framework, which was adapted to individual asset types based on available data and their characteristics.
- Developed a project selection framework that connects candidate projects with nearby asset resilience needs and evaluates projects according to resilience need, criticality, and expected project effectiveness.
- Developed an ArcGIS Pro Resilience Toolbox that allows

TxDOT users to prepare asset data, calculate resilience measures, and map results.

- Conducted pilot studies, including sensitivity analysis and comparison of conventional risk-based and resilience-based asset rankings, in the Wichita Falls District for roadway segments and in the Houston District for bridges.



Fig. 1 Resilience-Informed TAM Framework

What They Found

Statewide analyses showed that transportation vulnerability is strongly dependent on both location and hazard type. Northern Texas, including the Panhandle and High Plains, showed higher vulnerability to extreme cold for roadways, bridges, and bridge-class culverts. Central, southern, and western Texas showed greater vulnerability to extreme heat, while eastern and southeastern Texas showed greater vulnerability to inland flooding. Coastal and major metropolitan areas may face multiple hazards

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simultaneously because high hazard exposure coincides with dense transportation infrastructure, population, freight activity, ports, and other critical functions.

The research also found that asset condition and resilience are related but are not the same measure. Assets in poorer condition may experience greater performance loss or require longer recovery, but condition alone does not capture hazard exposure, drainage, structural configuration, redundancy, criticality, or recovery characteristics. Therefore, resilience provides additional information beyond conventional condition assessment.

Additionally, the pilot studies demonstrated that risk-based and resilience-based prioritization do not always identify the same assets as highest priority. Conventional risk-based screening emphasizes vulnerability and the consequences associated with disruption. Resilience-based screening additionally considers an asset’s ability to maintain and restore functionality after disruption.

In the Wichita Falls roadway pilot, baseline functional performance had the greatest influence on roadway resilience. Extreme heat caused more substantial changes between risk-based and resilience-based priorities than extreme cold. This indicates that maintenance or rehabilitation that improves pavement condition and service performance may also provide resilience benefits under temperature-related stresses

In the Houston bridge pilot, inland flood vulnerability had the greatest influence on flood resilience, while deck, superstructure, and substructure condition also contributed. Of the 849 bridges evaluated, 83 moved substantially higher in priority when resilience was considered together with criticality. These bridges represent assets that could be underemphasized if project screening relied only on conventional flood-risk rankings.

The research further found that resilience needs by itself should not determine project priority. Projects are stronger candidates for resilience-focused investment when three

conditions occur together: the affected assets have a meaningful resilience deficiency, the location or service is operationally important, and the proposed project is expected to materially improve performance.

What This Means

The results support using resilience as an additional screening layer within TxDOT’s existing TAM and project selection processes, instead of replacing risk-based analysis, safety, life-cycle cost, or engineering judgment.

The framework can help TxDOT identify assets that may otherwise receive insufficient attention because their conventional risk ranking does not fully reflect their resilience against disruptive events. Depending on the source of resilience deficiency, the appropriate response may include targeted inspection, preventive maintenance, pavement rehabilitation, drainage improvements, bridge component improvements, scour mitigation, structural improvements, or other resilience-enhancing actions.

The project also demonstrates that TxDOT can begin resilience-informed screening using data already available through asset inventories, inspection records, condition assessment, and hazard datasets. The resulting resilience scores are intended as planning-level indicators and should not be interpreted as substitutes for site-specific hydraulic, structural, or cost-benefit analyses.

Overall, this project provides TxDOT with a practical framework for connecting hazard exposure, asset condition, vulnerability, robustness, recovery, criticality, and project effectiveness. Resilience-informed TAM can help TxDOT make more defensible investment decisions while using routine maintenance, rehabilitation, and capital improvements to improve both day-to-day asset performance and the transportation system’s ability to withstand and recover from future disruptions.

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