

## PROJECT SUMMARY REPORT

# 0-7177: Identifying Pavement Improvement Projects for Enhanced Safety

## Background

Traffic crashes and the associated injuries and fatalities remain a major public safety concern in Texas and across the United States. Crashes are complex events influenced by a wide range of factors related to the driver, vehicle, roadway, traffic stream, and weather. Understanding how these factors contribute to crash occurrence is essential for identifying effective safety improvements.

This project focused on evaluating the impact of pavement-related factors on crash occurrence to support the Texas Department of Transportation (TxDOT) in identifying candidate sites for pavement safety improvements. Pavement surface condition factors are of particular interest to highway agencies because these factors fall directly within their control and can be addressed through maintenance and rehabilitation (M&R) treatments.

While several studies have attempted to explain the relationship between pavement conditions and crash occurrence, their findings have been inconsistent. A large-scale study is needed to assess pavement susceptibility to crashes by considering multiple pavement condition indicators along with other influencing factors, using a statewide, multi-year dataset. Accordingly, the objectives of this project were to develop:

- Predictive models for assessing pavement susceptibility to crash occurrence.
- An online geographic information system (GIS) tool to identify candidate pavement sections for safety improvement.

## What the Researchers Did

Researchers assembled an integrated dataset covering 18,843 on-system roadbed miles across Texas, incorporating pavement condition, roadway geometrics, traffic, precipitation, and crash data for fiscal years 2021–2023, with a total of 24,873 crashes.

To predict pavement crash susceptibility (defined as the probability of crash occurrence) and quantify the effects of contributing factors, logistic regression models were developed for four pavement types:

- Asphalt concrete pavement (ACP) without surface treatment (ST).
- ACP with ST.
- Continuously reinforced concrete pavement (CRCP).
- Jointed concrete pavement.

Each model predicts the probability of crash occurrence on a given pavement segment in a given year as a function of five to eight independent variables (risk factors) related to pavement condition, traffic, roadway geometry, and precipitation.

Researchers also conducted a hydroplaning risk analysis. Using a large language model applied to crash narratives, researchers identified 627 crashes as hydroplaning events. The water film thickness (WFT) at the time and location of these crashes was computed using four existing empirical models. In addition, crash distributions were analyzed across different pavement mean profile depth (MPD) and skid number (SN) categories to establish threshold values aimed at minimizing crash risk.

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### Project Completed:

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Finally, a web-based GIS tool was developed to visualize crash susceptibility predictions and related data at the segment, district, and statewide levels, facilitating the identification of candidate pavement sections for safety improvement.

### What They Found

The crash susceptibility models showed consistent patterns across pavement types. The annual average daily traffic (AADT) and precipitation were positively correlated with pavement crash susceptibility across all pavement types. As the exposure variable, AADT had the strongest association with crash susceptibility across all pavements. In terms of pavement conditions, pavement roughness (measured by the International Roughness Index) and skid resistance (measured by SN) were significant in most cases. In addition, MPD showed a negative association with crashes for CRCP and ACP without ST, and pothole presence showed a positive association only for ACP with ST. Other pavement surface distresses such as rut depth, raveling, flushing, and failures for ACP and punchout for CRCP showed no significant effect on crash susceptibility.

For the hydroplaning analysis, 90 percent of confirmed hydroplaning crashes occurred at model-averaged WFT values below 0.05 inches, substantially lower than the traditionally cited threshold of 0.095 inches. About 61 percent of hydroplaning crashes occurred during light or light-to-moderate rain ( $\leq 0.1$  inches/hour), and 38.7 percent occurred in moderate or heavy rain ( $> 0.1$  inches/hour). Pavement surfaces with high macrotexture (MPD  $> 0.03$  inches) and high friction (SN  $> 40$ ) had a positive impact on reducing crashes under both wet and dry conditions.

### What This Means

Based on the results of this project, TxDOT districts can use the crash susceptibility models to identify pavement condition indicators that influence the likelihood of crash occurrence and to select M&R measures that target these risk factors. Specifically:

- Crash susceptibility can be incorporated into TxDOT's pavement management processes as a proactive safety indicator that links crash likelihood to measurable risk factors.
- Pavement safety improvement efforts should prioritize maintaining adequately high levels of surface friction, macrotexture, and smoothness. Such efforts are likely to reduce crash risk under both dry and wet weather conditions.
- Pavement M&R measures related to pavement macrotexture and geometry should attempt to keep the WFT below 0.05 inches during wet conditions.
- For macrotexture and skid resistance, thresholds of 0.03 inches for MPD and 40 for SN are recommended to minimize crash risk under both wet and dry conditions.
- The GIS-based tool can support pavement improvement project selection by incorporating crash susceptibility and hydroplaning risk alongside pavement condition. The tool can be implemented on a pilot basis in at least one TxDOT district, with subsequent refinements and development of guidelines to support broader adoption across other districts.

### For More Information

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