LOUISIANA TRANSPORTATION RESEARCH CENTER

Technical Summary

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Develop a Methodology for Pavement Drainage System Rating

Introduction

In pavement engineering, managing the presence and movement of water is crucial for maintaining infrastructure longevity. Water infiltration can cause a range of roadway damage, from visible distresses such as potholes to less apparent issues like weakening of subsurface materials. Water typically enters pavements from surface sources, such as rainfall and runoff, through joints, cracks, pavement shoulders, or backed-up ditches, as well as subsurface sources like a rising groundwater table or capillary action. To mitigate moisture-related damage, engineers design drainage systems comprising surface, subsurface, and roadside components. While the importance of drainage has long been recognized in design manuals and maintenance practices, network-level drainage condition ratings remain limited. Most state Departments of Transportation (DOTs) assess drainage only at isolated problem locations. At the Louisiana Department of Transportation and Development (DOTD), the Highway Needs Database, owned and maintained by the planning section, includes a drainage condition field that has not been updated in over 20 years. Although DOTD's maintenance division once proposed a drainage Level of Service (LOS) metric, it was never implemented. These gaps highlight the need for a practical, scalable, and data-driven framework to evaluate drainage conditions at the network level, supporting proactive management and more effective integration with pavement performance monitoring.

Objective

The objective of this study was to explore the use of existing DOTD Pavement Management System (PMS) and Light Detection and Ranging (LiDAR) data to develop a pavement drainage condition rating index for Louisiana, with the goal of integrating drainage evaluation into the Pavement Management System (PMS) as part of the overall pavement condition assessment.

Scope

This study focused on developing a practical, network-level methodology for evaluating pavement drainage conditions using existing data from DOTD's Pavement Management System (PMS). The framework assessed three components (pavement surface drainage, roadside/shoulder drainage, and ditch drainage) based on PMS datasets and imagery. Five roadway sections (LA 441, LA 15, US 167, LA 12, and LA 397) were analyzed to demonstrate implementation potential and highlight correlations with pavement performance. The scope was limited to identifying operational deficiencies in existing infrastructure, not regional flood risk or hydraulic capacity. Exploratory use of United States Geological Survey (USGS) LiDAR and Interferometric Synthetic Aperture Radar (InSAR) data was also considered, though limitations were noted for narrow, vegetated ditches. The emphasis was on creating a scalable, fine-resolution (0.1 mile) rating system that can be integrated into PMS workflows, with potential future enhancement through AI and LiDAR technologies.

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Methodology

The study developed a practical framework for evaluating pavement drainage conditions at the network level using existing data from DOTD. First, district offices across the state were surveyed to identify common drainage issues and gauge the relative importance of different drainage elements. The methodology then focused on three components: (1) pavement surface drainage assessed using PMS data such as cross-slope, longitudinal grade, and rutting; (2) roadside/shoulder drainage evaluated using PMS edge drop-off data and imagery to detect erosion, vegetation growth, and debris; and (3) ditch drainage assessed from PMS imagery to identify sediment accumulation, erosion, and obstructions. The framework was applied to five roadway sections across Louisiana, with drainage ratings generated at a fine scale (0.1 mi. resolution) to capture localized deficiencies. Additionally, exploratory analyses using publicly available LiDAR datasets and InSAR technology were conducted to evaluate their feasibility for roadside ditch condition evaluation.

Conclusions

- The proposed rating system offers actionable insights for pavement maintenance and can be implemented immediately using existing PMS Datasets.
- The pavement surface drainage condition rating exhibited a strong correlation with actual pavement performance, suggesting its value as a stand-alone monitoring indicator applicable to both rural and urban roadways.
- Sediment accumulation, vegetation/debris, and erosion reduce ditch capacity. While flooding cannot be fully prevented during major rainfall events, proper maintenance facilitates faster water recession, reducing roadway closures and structural damage.
- The water ponding/presence index in this study depends on the timing of PMS image collection, recent rainfall, and precipitation intensity. To improve reliability, this information can be supplemented with input from DOTD districts, as district personnel are most familiar with recurring ponding issues along their roadways.
- Fine-scale (0.1 mi.) analysis is critical, as small areas of poor drainage can disproportionately impact roadway serviceability.
- The proposed framework identifies operational deficiencies in roadside and pavement drainage but does not account for hydraulic capacity limitations or regional flood risk. In such cases, the condition rating should be treated as the first stage of analysis, with follow-up investigations required to address watershed-scale drainage and flood mitigation.
- Exploratory use of USGS 3DEP LiDAR and InSAR highlighted limitations: low point density and vegetation effects prevent reliable ditch geometry assessment.
- AI-powered image analysis and high-resolution LiDAR-based ditch surveys could enable more automated, repeatable, and comprehensive drainage evaluations.
- Consistent collection of cross-slope, longitudinal grade, and horizontal curve data across many years is essential for the successful implementation of the proposed rating methodology.

Overall, this study demonstrates that drainage conditions can be integrated into network-level pavement management. While the methodology does not replace hydraulic design or flood risk modeling, it provides a practical and scalable means of monitoring how well the existing drainage infrastructure is functioning. Used as an early-stage screening tool, it can help DOTD prioritize maintenance, identify critical sections, and implement proactive drainage improvements.

Recommendations

- Adopt the proposed pavement drainage rating framework to systematically assess operational deficiencies in pavement surface, roadside/shoulder, and ditch drainage at the network level. This framework provides actionable insights for maintenance prioritization and early-stage screening.
- Implement the rating system in a phased approach:
  - **Phase I – Immediate Implementation:** Incorporate the pavement surface drainage rating into the PMS as part of the overall pavement condition assessment, using existing datasets (cross-slope, longitudinal grade, rutting). This component has demonstrated a strong correlation with actual pavement performance and can serve as a stand-alone monitoring tool to identify sections at higher risk of deterioration.
  - **Phase II – Expanded Implementation:** Incorporate additional operational insights by manually reviewing PMS imagery to evaluate erosion, sediment accumulation, vegetation, and debris. Include these ratings in the overall drainage system assessment to guide targeted maintenance activities. At this stage, only the visual condition (Dvisual) is considered.
  - **Phase III – Advanced Implementation:** In future stages, integrate AI-powered image analysis and high-resolution LiDAR surveys to enable automated, repeatable, and comprehensive evaluations of drainage conditions. This will improve efficiency, consistency, and network-level monitoring.
- Conduct ratings at a 0.1 mi. resolution to capture localized drainage deficiencies, which can disproportionately affect pavement performance and serviceability.
- Maintain consistent PMS data collection. Ensure accurate and repeatable measurement of cross-slope, longitudinal grade, and horizontal curves across many years, as these are critical for the successful implementation of the rating methodology.
- Plan for periodic updates. Regularly update the drainage ratings to track changes over time, inform maintenance planning, and proactively mitigate operational deficiencies before they affect pavement performance.
- Use drainage ratings as an early-stage diagnostic tool. While the methodology identifies operational deficiencies, it does not account for hydraulic capacity or broader flood risk. For areas with potential regional flood impacts, complementary hydrologic and hydraulic analyses should be conducted.