Center for Transportation Research and Education

Iowa Pavement Preservation Guide

tech transfer summary

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RESEARCH PROJECT TITLE
Iowa's Pavement Preservation Guide

SPONSORS
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The mission of the Center for Transportation Research and Education (CTRE) at Iowa State University is to conduct basic and applied transportation research to help our partners improve safety, facilitate traffic operations, and enhance the management of infrastructure assets.

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Understanding the performance of pavement preservation treatments can help Iowa decision-makers select the most cost-effective treatments and establish long-term pavement preservation strategies across the state's highway network.

Objectives

The overarching aim of this research was to enhance the understanding of pavement preservation effectiveness in Iowa by (1) quantifying the performance of commonly used preservation techniques across different metrics and (2) evaluating the costs and benefits of those techniques.

Building on the data-driven decision-making approach developed in Phase I of this research, this second phase sought to overcome the limitations in Iowa performance data and continue transitioning the Iowa Pavement Preservation Guide into a dynamic, AI-powered decision-support system. Specific objectives included the following:

- Implement a hybrid data processing framework and apply transfer learning to overcome limitations in Iowa data
- Develop a modeling architecture that enforces engineering constraints
- Quantify uncertainty in the predicted performance of preservation treatments
- Enhance benefit-cost ratio calculations using improved performance predictions

Background

To support pavement preservation decision-making, the Iowa Department of Transportation (Iowa DOT) sponsored Phase I of this research to evaluate the performance and cost-effectiveness of commonly used preservation treatments.

The analysis relied on pavement preservation effectiveness data in Iowa's Pavement Management Information System (PMIS), which includes detailed measurements of distress, traffic information, and pavement history. Project details and treatment cost information were obtained from historical bid tabulations through the Bid Express portal.

Treatments included microsurfacing, patching, slurry seal, crack sealing/filling, seal coat, and hot-mix asphalt (HMA) overlay. Performance was evaluated using life extension (LE)—the additional service life gained from treatment—and index benefit (IB)—the improvement in pavement condition after treatment. The analysis considered flexible and composite pavements and examined performance under different pavement and traffic conditions.

The result was a set of deterministic models for preservation treatment performance and decision matrices for selecting the optimal treatment in terms of LE, IB, and benefit-cost ratio (BCR) given pavement and traffic conditions. A Pavement Preservation Treatment Guide toolbox for use in ArcGIS was also developed to help Iowa DOT decision-makers seamlessly apply the decision matrices to any PMIS dataset.

Problem Statement

Improved understanding of the pavement preservation techniques used in Iowa, with a focus on pavement performance over time, is needed.

Limitations in the quality of PMIS data include differing data collection practices among vendors, changes in condition rating metrics over time, inconsistencies in project records, a skew toward commonly used treatments, and limited analysis periods for many road segments. Pavement performance models that rely on these data must address these challenges.

Research Methodology

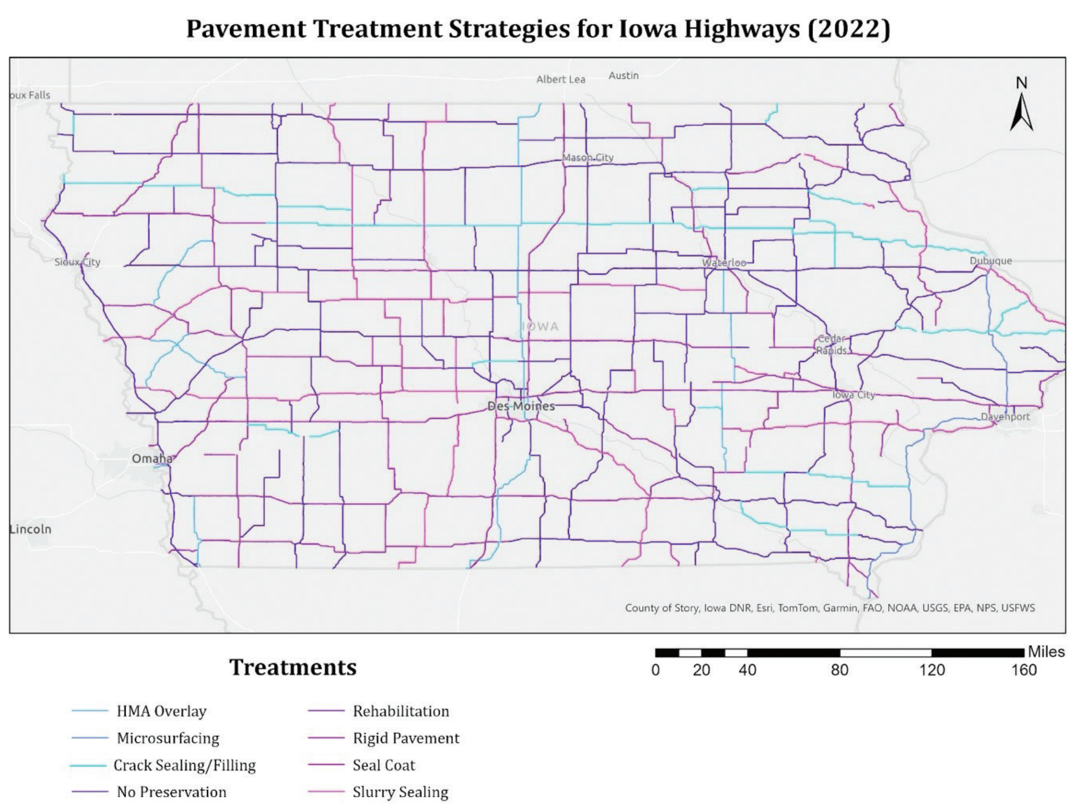
To address the limitations in Iowa performance data and strengthen the modeling framework developed in Phase I while preserving its interpretability and engineering relevance, Phase II introduced a hybrid data processing and AI-enhanced modeling framework. The outputs for Phase II remained consistent with the core performance metrics calculated in Phase I (LE, IB, and BCR).

The deterministic approach used in Phase I was augmented by incorporating systematic denoising procedures, engineering realism constraints, and machine learning–based modeling methods capable of leveraging additional contextual information such as traffic, climate, and pavement characteristics.

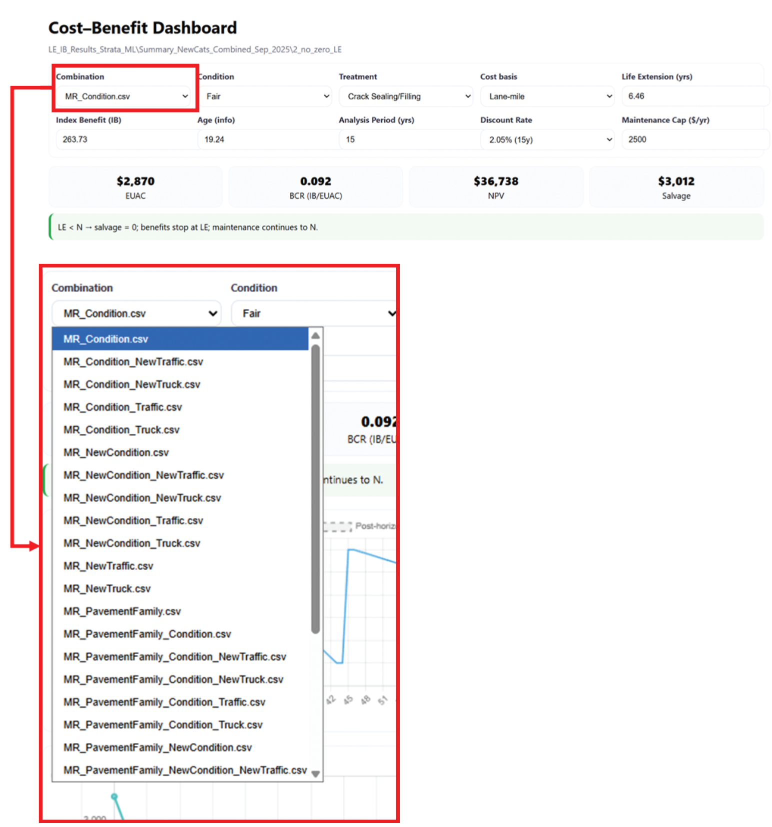
Transfer learning techniques were also used to supplement the Iowa PMIS dataset with nationally collected pavement performance data from the Long-Term Pavement Performance (LTPP) program to improve model generalization in treatment categories with limited local observations.

The modeling results were translated into practical decision matrices that identify cost-effective preservation treatments for different combinations of pavement type, condition, and traffic level. Six matrices each for flexible and composite pavements were developed that show the optimal treatment under two traffic indicators (annual average daily traffic [AADT] and annual average daily truck traffic [AADTT]) and three analysis periods (10, 15, and 20 years).

To extend the accessibility of the analysis beyond the ArcGIS tool developed in Phase I, a standalone, browser-based Cost-Benefit Dashboard was created in Phase II.



Screenshot of ArcGIS toolbox showing treatment strategies for Iowa highways based on 2022 PMIS data



Screenshot of the Cost-Benefit Dashboard

Key Findings and Outcomes

- Phase II results provided more stable deterioration curve estimations, better representation of treatment variability across pavement and traffic conditions, and more reliable predictions for treatment categories with historically limited observations.

- Structural treatments such as HMA overlay generally provide the largest improvement in pavement condition and the greatest life extension, although they also involve higher costs.

- Preventive treatments such as microsurfacing, slurry seal, and crack sealing/filling provide smaller improvements but can be highly cost-effective when applied at appropriate pavement condition levels.

- The findings confirm that treatment effectiveness depends strongly on pavement condition at the time of application, highlighting the importance of applying preservation treatments before severe deterioration occurs.

- All six decision-support matrices for flexible pavements yielded identical recommendations for both traffic indicators across all analysis periods. This stability indicates that the relative cost-effectiveness of the evaluated treatments is robust with respect to the assumed analysis horizon and traffic metric.

- For composite pavements, all decision-support matrices based on AADT resulted in identical treatment recommendations across all analysis periods. For the matrices based on AADTT, the recommended treatment when the traffic level is low/medium and the pavement is in fair/poor condition shifts from crack sealing to HMA overlay.

Decision matrix for flexible pavements

Traffic Indicator	Traffic Level	Good Condition	Fair/Poor Condition
AADT	Low/Medium	HMA Overlay	Slurry Seal
	High	HMA Overlay	HMA Overlay
AADTT	Low/Medium	HMA Overlay	Slurry Seal
	High	HMA Overlay	HMA Overlay

Decision matrix for composite pavements

Traffic Indicator	Traffic Level	Good Condition	Fair/Poor Condition
AADT	Low/Medium	HMA Overlay	Crack Sealing/Filling
	High	HMA Overlay	Microsurfacing
AADTT	Low/Medium	HMA Overlay	HMA Overlay
	High	HMA Overlay	Microsurfacing

Implementation Readiness and Benefits

This study resulted in a data-driven framework to support pavement preservation decision-making. The results and tools developed through this research can help the Iowa DOT select cost-effective treatments and establish long-term pavement preservation strategies across the state's highway network.

The improved decision-support matrices developed in Phase II provide a practical reference that can help engineers and pavement managers select preservation treatments during project planning and programming.

The browser-based Cost-Benefit Dashboard requires no specialized software or external data connections. Treatment effectiveness values computed from the historical PMIS analysis are embedded directly within the tool, allowing any decision-maker to conduct cost-benefit evaluations from a standard browser.

Note that this research focused solely on treatments for flexible and composite pavements. Future proposed improvements to the selection guidance include the incorporation of preservation treatments and a treatment selection process for rigid pavements.