

# JOINT TRANSPORTATION RESEARCH PROGRAM

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## Strategic Scheduling of Infrastructure Repair and Maintenance

*Volumes 1, 2, and 3*

### Introduction

INDOT seeks to apply appropriate treatments for its bridge and pavement assets at the right time. Even for the right treatment, improper timing can have consequences: premature application (treatment is applied too early) could mean wasteful spending even if users enjoy the benefits of higher asset condition; deferred or delayed application (treatment is applied too late) could result in higher user costs due to poor condition, and even reduced asset longevity.

The objectives of this research were to establish the optimal condition or timing for each of the standard maintenance and rehabilitation (M&R) treatment types typically used by INDOT; quantify the consequences of departures from such optimal conditions or timings; and establish the optimal M&R treatment schedule for each asset family. The study focused on:

1. Painting of steel bridges
2. Bridge deck maintenance and rehabilitation
3. Pavement maintenance, rehabilitation, and replacement

### Findings

1. The study established a cost-effective way of timing the painting of steel highway bridges.
  - a. Deterioration models were developed for painted steel superstructures of highway bridges on routes of various functional classes.
  - b. A painting cost model was developed using INDOT's painting contract records. Scenario analyses were

conducted by varying the relative weights of agency and user costs.

- c. A painting decision tree was developed to serve as a framework that would enable INDOT to consider other paint maintenance treatment types—namely, spot repair/painting and overcoating. Based on the results, it would be appropriate for INDOT to continue applying complete recoating at trigger value 4, or to include spot repair and overcoating for its highway bridge steel superstructures.
2. The study established appropriate performance thresholds for triggering bridge deck M&R activities.
  - a. Statistical models were developed to describe bridge deck and wearing surface deterioration, and performance jump (condition improvement) due to deck overlays. The agency cost models for latex-modified concrete (LMC) and polymeric overlays took into account the pre-treatment deck condition and the impact of scale economies. Two types of bridge user costs were considered: travel time costs due to work zone delays and the incremental vehicle operating costs (VOCs) during normal operations due to the increased roughness of the bridge deck surface.
  - b. A life-cycle cost analysis optimization framework was proposed. The analysis used data for bridges on the state-owned routes in Indiana. Various weights were assigned to the agency and user costs for sensitivity analysis purposes. The results indicated that different weighting would have an impact on the optimal trigger or the threshold associated with the lowest equivalent uniform annual

cost. In addition, the life-cycle condition-based deck M&R strategies based on different triggers were presented.

- c. Some modifications are recommended to be made to the original decision tree (DTREE) used in the Indiana Bridge Management System (IBMS) in order to incorporate the triggers for specific deck overlay treatments in the DTREE flow paths.
3. The study established a framework for determining the appropriate (condition-based) performance triggers for pavement maintenance, rehabilitation, and replacement activities.
    - a. Fourteen types of treatments were considered. Statistical models were developed in terms of performance jump due to each maintenance and rehabilitation (M&R) treatment. Models were also developed for post-treatment performance, agency costs, and user costs.
    - b. An optimization approach was proposed to determine the optimal International Roughness Index (IRI) trigger for each type of treatment on different families of assets that maximize the cost-effectiveness. The life-cycle cost analysis incorporates both agency cost (AC) and user cost (UC). Sensitivity analysis indicates that changing the relative weights of agency and user costs has a significant impact on the optimal trigger. The results of sensitivity analysis in terms of other important variables (e.g., AC:UC ratio, traffic load, discount rate, IRI upper bound, and pre-treatment performance) are also provided. The results show how the change in these factors can influence the optimal condition trigger results. This provides asset managers with greater flexibility in making M&R decisions.
    - c. The study established a framework to determine the optimal schedules for multiple treatments and recommended appropriate long-term M&R strategies

for flexible and rigid pavements on different road functional classes.

## Implementation

The methodologies used in this study can help INDOT and other agencies enhance their M&R decisions in terms of the performance threshold of individual assets, as well as long-term M&R scheduling. The findings for each of the three parts of this study provide INDOT asset managers with an enhanced basis for making programming decisions and estimating the consequences of premature or delayed treatments. Possible limitations are:

1. The optimal triggers for pavements are given for surface roughness (IRI). Other important performance indicators such as rutting and cracking are not considered in this study due to the lack of data availability.
2. The lack of quality data limited this study to finding only general relationships between the variables. As more accurate and reliable data become available, the models can be refined, creating a stronger basis for optimal triggers and long-term M&R strategies.

## Recommended Citation for Volume 2

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