CONSTRUCTION MANAGEMENT AND TECHNOLOGY

# Holding Strategies for Low-Volume State Routes – Phase I

tech transfer summary

**Low-cost, short-term "holding" strategies for severely deteriorated pavements may increase the flexibility of rehabilitation and reconstruction funds and improve the overall condition of Iowa's highway network.**

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**RESEARCH PROJECT TITLE**
Holding Strategies for Low-Volume State Routes

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## Problem Statement and Background

The overall pavement condition of Iowa's highway network has been deteriorating in the past decade, primarily due to aging facilities, increasing traffic, and limited financial resources for maintenance. Maintenance for low-volume roads that are due for rehabilitation or reconstruction is sometimes postponed due to insufficient funding.

Some lower cost, shorter term treatments, including thin asphalt overlays, in-place recycling technologies, and chip seals, have been considered inappropriate for use with severely deteriorated pavement. However, these treatments could be used as holding strategies to postpone rehabilitation or reconstruction using treatments that are more aggressive than preventive maintenance but cost less while likely having shorter service lives in comparison to traditional rehabilitation measures. The pavement can then be rehabilitated or reconstructed when funding is available.

## Objective

The objective of this research was to evaluate the six-year performance of various holding strategies and their cost-effectiveness. Treatments included combinations of thin hot-mix asphalt (HMA) overlays, in-place recycling technologies such as cold in-place recycling (CIR) and full-depth reclamation (FDR), and thin surface treatments.

## Research Description

In August and September 2013, various holding strategies were applied to nine test sections on a 13 mile segment of IA 93, a low-volume asphalt road on the Iowa primary road system. The original road was a two-lane full-depth asphalt highway in a primarily agricultural area with average annual daily traffic (AADT) of 1,040 vehicles per day (vpd) in 2011. The pre-construction pavement had a rough surface and was suffering from various surficial distresses.

*Condition of pre-construction pavements*

The nine sections were all rural sections.

*Nine holding strategy sections constructed*

| Section | Base Treatment | Surface Treatment | Length (miles) |
|---|---|---|---|
| 1 | 1 in. scarification | 1.5 in. HMA overlay | 1.3 |
| 2 | 1 in. scarification | 1.5 in. HMA overlay and single chip seal | 2.0 |
| 3 | 1 in. scarification and 1 in. interlayer course | 0.75 in. ultrathin HMA overlay | 2.2 |
| 4 | 8 in. FDR | 1.5 in. HMA overlay | 1.0 |
| 5 | 8 in. FDR | Double chip seal | 0.4 |
| 6 | 2.5 in. CIR | Double chip seal | 1.4 |
| 7 | 2.5 in. CIR | 1.5 in. HMA overlay | 1.6 |
| 8 | None | 2 in. HMA overlay | 1.4 |
| 9 | 1 in. leveling and strengthening course | Single chip seal | 1.9 |

*Cold in-place recycling train with milling machine (top left), crushing and screening unit (top right), pug mill (bottom left), and oil tank trailer (bottom right)*

The test sections were evaluated through pavement condition surveys, structural evaluation, and surface characteristics tests. A lifecycle cost analysis (LCCA) was also conducted to quantify the cost-effectiveness of each treatment method.

The pavement condition surveys involved inspecting surficial distresses such as transverse and longitudinal cracking, fatigue cracking, raveling, and rutting. Five pavement condition surveys were conducted—one before construction (July 2013) and six after construction (September 2013, April 2014, November 2014, April 2015, December 2018, and October 2019).

The pavement structural capacity was evaluated using falling weight deflectometer (FWD) and laboratory dynamic modulus ($E^*$) tests. The FWD tests were performed by Iowa Department of Transportation (DOT) staff in October 2012, November 2013, and September 2015. The $E^*$ tests were performed on field cores taken in 2015.

The surface characteristics were evaluated using a dynamic friction tester (DFT), the sand patch test (SPT), and a smartphone-based international roughness index (IRI) measuring system. The tests were conducted in May 2015, 20 months after construction.

For the LCCA, the life expectancies of the holding strategy treatments were estimated based on the performance of the test sections. Preplanned maintenance activities were included as part of the holding strategy alternatives.

The cost-effectiveness of each holding strategy was compared to that of a conventional mill and fill rehabilitation. The test section construction costs were used to estimate the costs of the alternatives. The maintenance costs were estimated from the bid prices for several maintenance projects in Iowa and neighboring states.

## Key Findings

- The post-construction pavement condition surveys showed that the holding strategy treatments successfully corrected longitudinal cracking, raveling, edge breaks, and rutting. The predominant early-age distress type found after construction was transverse cracking, which formed during the winter after construction. The post-construction crack densities did not change considerably during the six-year monitoring period.
- Field core samples suggested that the transverse cracks in the CIR sections were new cracks in the surface layers. Field cores also confirmed that the transverse cracks in the other sections were reflective cracks from the original pavement crack patterns.
- Recycling technologies (CIR and FDR) were the most effective treatments for mitigating reflective cracking, reducing cracks by more than 95%. The effectiveness of the treatments in preventing reflective cracking, from most to least effective, were CIR or FDR, high-quality asphalt material (including interlayer), 2-inch asphalt concrete (AC) overlay, leveling course and chip seal, and 1.5-inch mill and fill—with and without a chip seal surface.

- A chip seal applied to an FDR or CIR layer in this investigation was susceptible to damage from snow plowing and traffic and may require frequent maintenance activities resulting in higher lifecycle costs. Providing a better bond between the chip seal and FDR or CIR surface would mitigate this concern. Also, some areas of delamination were observed near bridge approaches where subgrade support may be inadequate. While this method provides lower construction costs, the projected need to maintain the surface with further chip seals increase the equivalent annual cost so that it exceeds those of other treatments.

- The DFT results indicated that the dry friction coefficient of the asphalt surfaces was higher than that of the chip seals. The friction coefficient of a wet asphalt surface was similar to that of a chip seal. The SPT results showed that chip seal surfaces have greater macro-texture than asphalt surfaces.

- The holding strategy treatments considerably improved rideability. All sections exhibited good surface roughness. The IRI values of the FDR with the double chip seal treatment and with the 1-inch milling with chip seal treatment were higher than those of the other test sections.

- The FWD results indicated that aged pavement with severe surficial distresses on low-volume roads can retain a high structural capacity due to their high stiffness, which likely results from the compaction of materials by traffic loading and oxidization of the asphalt.

- Newly constructed pavement layers can decrease the pavement's average stiffness and thus its structural capacity. Increased layer thickness can effectively offset this influence. However, treatments that include a recycled layer, such as CIR or FDR, may lower the pavement load carrying capacity considerably. Stiffness increased two years after the test sections were constructed, with the FDR sections showing the greatest improvements.

- The projected lifecycle costs of the various holding strategy treatments were estimated and compared to that of a traditional 3-inch overlay method. The LCCA results indicate that the equivalent annual cost (EAC) of the CIR and FDR and double chip seal methods are higher than the EAC of the 3-inch overlay strategy. The lifecycle costs of the other holding strategies are lower than or equal to the lifecycle cost of the 3-inch overlay method. However, with more information on longer term performance and maintenance costs, the LCCA cost estimates may change considerably.

- All of the holding strategies extended provided life extension to IA 93 from 2013 through 2020. Construction costs ranged from $94,000 to $181,900 per road mile in 2013 dollars. Projected equivalent annual costs including maintenance ranged from $10,100 to $13,200 per road mile, except for the FDR with a double chip seal which was projected at $15,800. Projected life extensions ranged from 10 to 25 years.

## Conclusions and Recommendations

- From a safety perspective, a chip seal functions similarly to an asphalt surface. However, a chip seal has higher macro-texture than an asphalt surface, which can lead to increased noise levels and tire wear.

- CIR or FDR with a thin asphalt overlay were projected to provide the longest life extension, since they have developed few cracks, so far. Also, negligible rutting was observed in these test sections. The CIR treatments have relatively low construction costs and projected lifecycle costs.

## Implementation Readiness and Benefits

Based on the results of this investigation, all of the holding strategies tested postponed the need for rehabilitation for at least six years. Decision makers can select the appropriate strategy from the alternatives investigated by considering funding availability, current material prices, and stakeholder needs.

These holding strategies have the potential to increase the flexibility of funding allocation and improve the overall condition of Iowa's highway network. Caution should be exercised regarding heavy traffic loads shortly after construction.