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Reflective Crack Mitigation Guide for Flexible Pavements Final Report

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Abstract
Reflective cracks form in pavements when hot-mix asphalt (HMA) overlays are placed over jointed and/or severely cracked rigid and flexible pavements. In the first part of the research, survival analysis was conducted to identify the most appropriate rehabilitation method for composite pavements and to evaluate the influence of different factors on reflective crack development. Four rehabilitation methods, including mill and fill, overlay, heater scarification (SCR), and rubblization, were analyzed using three performance indicators: reflective cracking, international roughness index (IRI), and pavement condition index (PCI). It was found that rubblization can significantly retard reflective cracking development compared to the other three methods. No significant difference for PCI was seen among the four rehabilitation methods. Heater scarification showed the lowest survival probability for both reflective cracking and IRI, while an overlay resulted in the poorest overall pavement condition based on PCI. In addition, traffic level was found not to be a significant factor for reflective cracking development. An increase in overlay thickness can significantly delay the propagation of reflective cracking for all four treatments. Soil types in rubblization pavement sites were assessed, and no close relationship was found between rubblized pavement performance and subgrade soil condition. In the second part of the research, the study objective was to evaluate the modulus and performance of four reflective cracking treatments: full rubblization, modified rubblization, crack and seat, and rock interlayer. A total of 16 pavement sites were tested by the surface wave method (SWM), and in the first four sites both falling weight deflectometer (FWD) and SWM were conducted for a preliminary analysis. The SWM gave close concrete layer moduli compared to the FWD moduli on a conventional composite pavement. However, the SWM provided higher moduli for the rubblized concrete layer. After the preliminary analysis, another 12 pavement sites were tested by the SWM. The results showed that the crack and seat method provided the highest moduli, followed by the modified rubblization method. The full rubblization and the rock interlayer methods gave similar, but lower, moduli. Pavement performance surveys were also conducted during the field study. In general, none of the pavement sites had rutting problems. The conventional composite pavement site had the largest amount of reflective cracking. A moderate amount of reflective cracking was observed for the two pavement sites with full rubblization. Pavements with the rock interlayer and modified rubblization treatments had much less reflective cracking. It is recommended that use of the modified rubblization and rock interlayer treatments for reflective cracking mitigation are best.

Keywords
Acceptance tests, Crack and seat treatment, Flexible pavements, Life cycle costing, Pavement design, Pavement management systems, Reflection cracking, Subgrade (Pavements), Mechanistic-Empirical Pavement Design Guide, asphalt mixture, composite pavement, modified rubblization treatment, pavement performance, pavement rehabilitation, reflective cracking, rock interlayer treatment

Disciplines
Civil Engineering

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tech transfer summary

Using Iowa's Pavement Management Information System (PMIS) and site investigations, a variety of crack mitigation strategies were analyzed to assess their intended design life.

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RESEARCH PROJECT TITLE
Reflective Crack Mitigation Guide for Flexible Pavements

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Background

Reflective cracking of asphalt mixtures is a common distress that results in a loss of pavement ride quality and service life. Several strategies exist to mitigate reflective cracking depending on the pavement structure, including the use of crack relief layers in the form of membranes and specialty asphalt mixtures (e.g., Strata), crack and seat, rubblization, cold in-place recycling (CIR) of existing asphalt overlays, and full-depth reclamation (FDR). Depending on the pavement structure, pavement condition, and traffic level, varying strategies exist that improve the performance of the pavement economically.

Problem Statement

The Iowa Department of Transportation (DOT) currently does not have a guideline or specification for reflective cracking control and mitigation in conventional composite pavement. A standard technical guide is needed for Iowa to provide detailed guidance on choosing the optimal reflective cracking mitigation strategy for a project.

Objectives

- Use Iowa's Pavement Management Information System (PMIS) to select reflective cracking mitigation strategies at the network level
- Perform project-level pavement site investigations to evaluate existing treated composite pavements

Rubblization using a multiple-head breaker

Research Description

A survival analysis was conducted to identify the most appropriate pavement rehabilitation methods for composite pavements and to evaluate the influence of different factors on reflective crack development. Four composite pavement rehabilitation methods, including mill and fill, overlay, heater scarification (SCR), and rubblization, were analyzed using three pavement performance indicators: reflective cracking, international roughness index (IRI), and pavement condition index (PCI). Data on pavement structure, traffic, and field performance were collected.

In addition, the modulus and performance of four reflective cracking treatments were evaluated at 16 pavement sites in Iowa using pavement condition surveys, pavement structural moduli testing by falling weight deflectometer (FWD), and surface wave method (SWM) testing. Treatments included full rubblization, modified rubblization, crack and seat, and rock interlayer.

Because of a steady increase of CIR for pavement rehabilitations, an analysis of CIR data for 100 CIR projects was also completed.

Key Findings

The results of the survival analysis, which involved the development of a treatment selection guideline, showed the following:

- A Kaplan-Meier estimator clearly illustrated that pavement rubblization can significantly retard reflective cracking development in composite pavements, more than the other three methods. The mill and fill treatment also exhibited better performance than hot-mix asphalt overlay in terms of reflective cracking mitigation.
- The general trend of a hazard/failure function for reflective cracking followed a lognormal distribution, with an early-time increase followed by a constant or decreasing probability of failure. The corresponding survival function showed a sharp initial drop with a long tail in later service life.
- No significant differences in PCI were seen in the survival analysis among the four rehabilitation methods. The hazard function for the PCI, however, is best described by a Weibull distribution, which has an accelerated failure time pattern.
- The SCR method showed the lowest survival probability in terms of reflective cracking and IRI. Higher initial IRI values were found for the SCR and mill and fill treatments in the database. This finally led to lower IRI survival probabilities for the two treatments.
- According to a multivariate analysis, traffic level was not a significant factor for reflective cracking. Higher trafficked roads even demonstrated a lower probability of reflective cracking failure.

The results of the project-level analysis, which focused on the structural condition of existing reflective cracking treatments, showed the following:

- SWM was a viable method for in situ material characterization of pavement systems. Portland cement concrete (PCC) modulus values from the SWM compared well with the FWD results on traditional composite pavement.
- The effect of SWM low-strain amplitude was evident in the measurement of the modified rubblization layer. The SWM moduli were typically two to three times higher than the values predicted by the FWD.
- SWM was used effectively to determine the moduli of thin rock interlayers, while the FWD method had difficulty in measuring and back-calculating the thin layer moduli.
- Among the four treatment methods, the crack and seat treatment had the highest moduli, followed by the modified rubblization layer. The full rubblization layer and the rock interlayer give similar, but lower, moduli.
- Field performance data showed that the traditional composite pavement site had the highest amount of reflective cracking. A moderate amount of reflective cracking was observed for the full rubblization projects. Poor subgrade soil properties could be the reason to use rubblization.
- CIR clearly exhibited an overall performance improvement for the first 12 to 14 years post-rehabilitation. Data are currently insufficient because the PMIS does not contain projects greater than 14 years old.

Implementation Readiness and Benefits

This project demonstrated that increasing the new pavement thickness was effective in retarding reflective cracking propagation for all four treatments. The removed pavement thickness did not significantly affect the survival probability.

Although the literature showed that subgrade soil properties can influence the use of rubblization in the field, this project did not observe these properties because modifying the rubblization pattern to compensate for weaker subgrades is already commonly performed by practitioners.

After assessing both the modulus and pavement performance of the existing reflective cracking mitigation treatments, this project recommends that the rock interlayer and modified rubblization methods be used in the field.

A steady increase in the use of CIR for pavement rehabilitation has highlighted the need for a performance review of the CIR pavements on the Iowa network. CIR performance data show an overall improvement in pavement performance post-rehabilitation. This information can be used to aid future decision making for pavement rehabilitation at the network level.