TECHBRIEF

Results of Long-Term Pavement Performance SPS-3 Analysis: Preventive Maintenance of Flexible Pavements

FHWA Publication No.: FHWA-HRT-11-049

FHWA Contact: Larry Wiser, HRDI-30, (202) 493-3079, larry.wiser@dot.gov

This document is a technical summary of the Federal Highway Administration report, *Impact of Design Features on Pavement Response and Performance in Rehabilitated Flexible and Rigid Pavements* (FHWA-HRT-10-066).

The Long-Term Pavement Performance (LTPP) program is a 20-year study of in-service pavements across North America. Its goal is to extend the life of highway pavements through various designs of new and rehabilitated pavement structures, using different materials and under different loads, environments, subgrade soil, and maintenance practices. LTPP was established under the Strategic Highway Research Program and is now managed by the Federal Highway Administration.

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology

Turner-Fairbank Highway Research Center

6300 Georgetown Pike

McLean, VA 22101-2296

http://www.fhwa.dot.gov/research/tfhrc/programs/infrastructure/pavements/ltpp/

Introduction

Rehabilitation and pavement preservation represent the majority of pavement construction activity in the United States. Preventive maintenance includes treatments that are applied to pavements primarily to delay development of and mitigate existing distresses. These treatments focus on improving pavement functional performance and prolonging pavement life, not on improving the structural capacity. Selecting the appropriate maintenance technique and treatment application timing form the basis of a concrete preventive maintenance practice.

Experimental Design

In addition to a nontreated control section, the Specific Pavement Study (SPS)-3 experiment included the following four maintenance treatment alternatives:

1. Thin hot mix asphalt overlay (typically 1 inch (25.4 mm) or less).
2. Slurry seal.
3. Crack seal.
4. Chip seal.

Additionally, each site was categorized according to the following five design factors:

1. Moisture (wet or dry climate).
2. Temperature (freeze or no-freeze zone).

3. Subgrade type (fine grained or coarse grained).
4. Traffic loading (low or high).
5. Existing pavement condition (good, fair, or poor).

This experimental design resulted in 48 different experimental combinations of factors. In total, 33 States and Canadian Provinces participated in the experiment, and 81 sites were constructed and monitored for the assessment.

Performance Indicator

To evaluate the effectiveness of preventive maintenance treatments regarding the performance of pavement sections, the alternatives at each site were compared to each other and the control section using a set of performance measures developed from Long-Term Pavement Performance (LTPP) monitoring data. Performance was evaluated as the deterioration measured by fatigue cracking, rutting, and roughness using the International Roughness Index (IRI).

When selecting the performance indicator, the objective was to find a parameter that could represent the pavement performance over the monitoring period. The indicator also needed to provide a simple, stable, and comparable parameter that could minimize the effect of survey measurement errors. The selected indicator was the weighted average of the distress normalized over the monitoring period. The weighted average represents the total area under the distress versus time curve divided by the total time period between the first and last surveys. As such, it is a measure of pavement performance relative to the specific distress over the entire survey period, and it allows for comparisons of pavement sections monitored for different periods.

Statistical Analysis Approach

The statistical test selected for the analysis was the Friedman test, which is a nonparametric test (distribution-free) for comparison of paired observations. Using paired observations, the performance of pavement sections subject to preventive maintenance treatments was compared to the performance of the control sections without the treatment as well as to the different treatment types. The Friedman test was applied to all design factors (moisture, temperature, subgrade type, traffic loading, and existing condition) for each distress type. The values used were the weighted average distresses normalized for the analysis period. The results of the test were used to determine whether statistically significant differences existed in pavement performance between any pair of treatments.

Analysis Results

SPS-3 pavement performance data were used to identify whether different climate conditions, subgrade material, traffic level, or initial pavement condition influences the effectiveness of a selected preventive maintenance treatment.

All four treatments were considered. The results showing preferred treatments based on pavement performance are presented in table 1 for different categories of design factors. The table summarizes the results of the statistical analysis for each distress type evaluated. Each cell represents a comparison between the treatments and the control section. When pavement performance for the treatment was found to be statistically significant compared to the control section, the treatment code was inserted in the cell. If no statistical significance was identified between the treatments and the control section, “None” was entered in the cell.

The overall results indicate that thin overlays and chip seals have superior performance, compared to slurry seal and crack seal. In the majority of the cases, the latter treatments had performance comparable to the control section.

Fatigue Cracking

Chip seal and thin overlay are recommended treatments for freezing temperature zones, wet climates, and pavements with coarse subgrade. Under these conditions, chip seal performance was superior to thin overlay. If the pavement was initially in poor condition, both treatments were effective; however, thin overlay was superior compared to chip seal.

Table 1. Preferred treatments.

Distress	Preferred Treatment	Temperature: Freeze	Temperature: No Freeze	Precipitation: Dry	Precipitation: Wet	Subgrade: Fine	Subgrade: Coarse	Traffic: Low	Traffic: High	Pavement Condition: Good	Pavement Condition: Fair	Pavement Condition: Poor
Fatigue cracking	1st choice	CH	CH	CH	CH	CH	CH	CH	CH	CH	None	TH
	2d choice	TH	—	—	TH	—	TH	—	TH	—	—	CH
Rutting	1st choice	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH	TH
	2d choice	CH	—	CH	—	—	—	—	—	—	—	—
Roughness	1st choice	TH	None	None	None	TH	TH	None	TH	None	None	TH

CH = Chip seal; TH = Thin overlay.
— Indicates that no data were available.
Note: Chip seal is not included as an option for roughness because it was never the preferred treatment method.

In no-freeze zones, dry climates, pavements with fine subgrade, low traffic conditions, and pavements initially in good condition, chip seal is the recommended treatment. For pavements in fair condition, none of the treatments were statistically superior to the control section.

Rutting

As shown in the table, thin overlay was an effective treatment option under all design circumstances with respect to rutting. As an alternative treatment, chip seal can be used in freeze zones and dry climatic regions.

Roughness

Thin overlay is the only treatment that was found to delay roughness progression. It was effective in freeze zones, heavy trafficked roads, and pavements initially in poor condition. Subgrade material and precipitation were not found to be the determinant factors. None of the treatments performed statistically different from the control section in no-freeze zones, on low traffic roads, or on pavements in good or fair conditions with respect to roughness.

Timing

One of the basic questions when planning preventive maintenance is when to implement it. Some pavements may be too deteriorated for effective repair and maintenance. The SPS-3 analysis consisted of comparing the performance of sections submitted to treatments at different preexisting levels of distress and conducting hypothesis testing to find if there were differences in performance. It was found that thin overlay can only perform better compared to other treatments if the IRI level is higher than 7.34 ft/mi (1.39 m/km). For lower IRI levels, the sections performed similarly, and there was no advantage of applying thin overlays.

When comparing the effect of timing on rutting, regardless of the level of preexisting rutting, thin overlays outperformed the other treatments, followed by chip seal. For cracking, thin overlays and chip seals outperformed the other treatments and the control section, when the initial cracking was lower than 232.13 ft^2/mi (13.4 m^2/km). For higher levels of cracking, every treatment outperformed the control section, with chip seal being the best, followed by thin overlay.

Conclusions

Based on the analysis of LTPP SPS-3 sites, the following conclusions were drawn:

- Thin overlay and chip seal were more effective than slurry seal and crack seal treatments and performed better than the control section for fatigue cracking.
- Thin overlay mitigated and slowed the progression of rutting under all circumstances. There were no significant differences between slurry seal, crack seal, and the control with respect to rutting.
- Chip seal effectively reduced the development of rutting in no-freeze zones and wet regions.
- Only thin overlay was effective in mitigating and delaying the progression of

roughness; however, it was only effective for pavements in freeze zones, under high traffic, or in poor condition.

- Thin overlays outperformed other treatments only when the existing level of IRI was higher than 7.34 ft/mi (1.39 m/km).
- For any existing level of rutting, thin overlays outperformed the other treatments followed by chip seals.
- Thin overlays and chip seals outperformed other treatments when the existing section had minimal cracking prior to the treatment and higher levels of preexisting cracking. All treatments were effective to some degree relative to the performance of the control section.
- Maintenance costs are a critical factor when deciding which mixture type to use. Cost analysis is an important step in selecting the optimum preventive maintenance treatment; however, this research only considered pavement performance.

Researchers—This study was performed by Applied Research Associates, Inc., Elkridge, MD.

Distribution—This TechBrief is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Availability—This TechBrief may be obtained from FHWA Product Distribution Center by e-mail to report.center@dot.gov, fax to (814) 239-2156, phone to (814) 239-1160, or online at http://www.fhwa.dot.gov/research/.

Key Words—Pavement treatment, Preventive maintenance, Pavement preservation, Chip seal, Slurry seal, Crack seal, Thin overlay, LTPP data, Data analysis, and SPS.

JUNE 2011 FHWA-HRT-11-049
HRDI-30/06-11(1.5M)E