TECH BRIEF

Expected Service Life and Performance Characteristics of HMA Pavements in LTPP

LTPP

The Long Term Pavement Performance (LTPP) program is a 20-year study of inservice 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.

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Background

A primary objective of the Long Term Pavement Performance (LTPP) program was to develop improved design methodologies and strategies for the new flexible pavements. Those experiments designed to address this objective include General Pavement Study (GPS) 1 and 2. The GPS 1 experiment includes existing flexible pavements without stabilized base layers, while the GPS-2 experiment includes those with stabilized base layers. The Special Pavement Study (SPS) 9 experiment and control sections within the SPS-5 experiment can also be used to achieve this objective.

This Technical Brief summarizes the results of a study of the GPS-1 and 2 and SPS-9 experiments and the control sections in the SPS-5 experiment, entitled "Expected Service Life and Performance Characteristics of HMA Pavements in LTPP." The study documents the performance trends and characteristics of these test sections, each 500-ft wide by one-lane wide, using distress data extracted from LTPP database version 13.1/NT3.1 released in January 2002. A total of 372 test sections were included in this study. The age of the pavements ranged from 3 to 33 years, with an overall median age of 17 years. Of the 372 test sections, 109 sections are older than 20 years. The test sections represent a diverse range of conditions and pavement structures.

Distresses Considered in Study

Six distress types or performance indicators were used to evaluate the performance characteristics of the LTPP test sections. They include fatigue cracking, longitudinal cracking in the wheel paths, longitudinal cracking not in the wheel paths, transverse cracking, rutting, and roughness (as measured by the International Roughness Index [IRI]). The extent of these distresses was divided into different categories for relative comparisons. The different levels of distress used in the study are defined in table 1 on the following page.

The level of distress defined as a "moderate" was used to determine the age to an unacceptable condition of distress. These values defined as moderate will generally result in some type of structural rehabilitation. Table 2, also on the following page, shows the percentages of the test sections having different levels of distress. As table 2 shows, almost half of the test sections have no fatigue and longitudinal cracking in the wheel path and very few have excessive levels of distress, with the exception of longitudinal cracking not in the wheel paths.

Table 1. Magnitude of distress for each category used in the performance evaluations

Distress Type	Categories of Distress Magnitude			
	Initiation or Nominal	Low	Moderate	Excessive
Fatigue Cracking, % of wheel path area	1-10	11-20	21-50	>50
Longitudinal Cracking in Wheel Path, m	1-10	11-50	51-150	>150
Longitudinal Cracking not in the Wheel Path, m	1-10	11-50	51-150	>150
Transverse Cracking, m	1-10	11-50	51-100	>100
Rut Depths, mm	NA	6-12	12-20	>20
Smoothness or Roughness, m/km	NA	1.5-2.0	2.1-2.5	>2.5
NA = Not Applicable				

Table 2. Percentages of test sections with respective levels of distress

Distress Type	Levels of Distress				
	None, %	Nominal, %	Greater Than Nominal, %		
			Low	Moderate	Excessive
Fatigue cracking	48	24	14	8	6
Longitudinal cracking in wheel paths	45	24	20	10	1
Longitudinal cracking not in wheel paths	26	14	19	12	28
Transverse cracking	25	20	23	28	4
Rutting	NA	35	43	18	4
Roughness	NA	38	38	12	12

Fatigue and Longitudinal Cracking in Wheel Paths

Almost half of the test sections have no load related cracking. More importantly, only 14 percent of the test sections have a moderate or greater level of fatigue cracking and only 11 percent have a moderate or greater level of longitudinal cracking in the wheel path. Most of these test sections have performed well past 15 years with little to no load related cracking.

Longitudinal Cracking Not in Wheel Path

Forty percent of the test sections have a moderate or greater amount of longitudinal cracking not in the wheel path, while 40 percent have none to nominal levels of longitudinal cracking not in the wheel paths. Of the distresses included in this study, longitudinal cracking outside the wheel paths had the greatest percentage of sections with excessive levels. Included in this distress type are construction joints that open up due to low density, as well as reflective cracking caused by shrinking of underlying clays or fine-grained soils. These reflective cracks from shrinking soils can reach high severity levels rather quickly.

Transverse Cracking

Forty-five percent of the test sections have none to nominal amounts of transverse cracking, while 32 percent have a moderate or greater amount of transverse cracking.

Rutting

Thirty-five percent of the test sections have a nominal level of rutting, and only 22 percent have a moderate or greater level of rutting that would be expected to initiate some type of overlay or surface repair.

Roughness

Thirty-eight percent of the test sections have a nominal level of roughness, while 24 percent have a moderate or greater level of roughness.

Global Survivability Analysis

A global survivability or probability of failure analysis was completed to determine the age of the flexible pavements to different surface conditions or magnitudes of distress. Table 3 provides a listing of the expected service life to both a low and a moderate level of surface distress. The age to an excessive level of distress was not determined because there were too few sections with this level of distress to perform a valid analysis. As shown by Table 3, the expected service life for any of the distresses to occur at a moderate level is 22 years or more, based on 50 percent probability.

Table 3. Expected Service Life Based on Different Levels and Magnitudes of Distress

Distress Type	Expected Service Life based on a 50% Probability of Occurrence, years	
	Low Distress Level	Moderate Distress Level
Fatigue Cracking	22	**25**
Longitudinal Cracking in Wheel Path	22	**28**
Transverse Cracking	19	**22**
Longitudinal Cracking Outside Wheel Path	18	**22**
Rutting	17	**22**
Roughness or IRI	20	**22**

Analysis of Variance

An analysis of variance was also completed to identify those design features and site factors that have a significant effect on the performance of flexible pavements in the LTPP database. The analysis of variance included the data and information from the SPS-1 experiment, as well as those experiments previously referred to in this technical brief. The analysis of variance, however, was unable to identify specific factors related to the performance characteristics of flexible pavements. One reason for that finding is that too few of the flexible pavements have excessive levels of surface distress. Thus, simple regressions or one-way analysis of variances were unable to identify cause and effect.

Findings

The following lists some of the findings from the survivability analysis and analysis of variance.

There are 109 LTPP flexible test sections, out of 372 sections, that are older than 20 years with no, nominal or low levels of distress. There are 50 test sections that are older than 20 years with no to minor levels of distress. The average service life of flexible pavements is 22 years to a moderate level of distress.

Overall, there are many more conventional and deep strength flexible pavements in the LTPP program as compared to full-depth and semi-rigid pavements. The granular base or subbase layers of conventional and deep strength pavements with excellent performance characteristics have provided a stable platform on which the HMA layers were placed and compacted.

Coarse-grained soils was found to be one of the reasons for the relatively high number of LTPP sections that have performed for 20+ years with no to minor levels of distress.

Most of the conventional and deep strength flexible pavements with excellent performance are located in warm climates, which emphasizes the need for a strong, non-frost susceptible foundation for pavements placed in cold climates.

Rutting in the subgrade or embankment (fill) soils is not believed to be a significant factor in determining the service life of the GPS test sections.

General Summary and Conclusion

The majority of the flexible pavements included in the LTPP database have served for 20 plus years before the load and non-load-related distresses become sufficient to require some type of structural rehabilitation. More importantly, there are a number of test sections where the pavements have less than a low level of distress for more than 20 years of service. In summary, this study confirms the hypothesis that flexible pavements can and do perform satisfactorily in excess of 20 years, if properly designed and constructed.

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