Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume V: SPS-10 Performance Monitoring Guide

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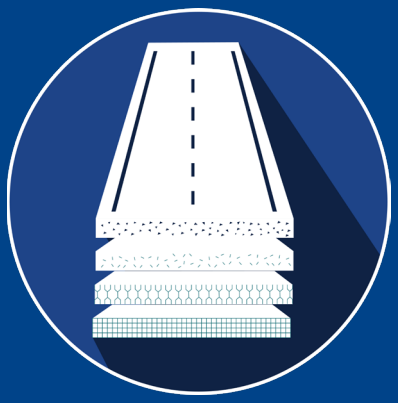

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LTPP™

FOREWORD

Warm-mix asphalt (WMA), an innovative material that is part of the Federal Highway Administration Every Day Counts program, has been implemented by State highway agencies throughout the United States. WMA covers a variety of categories, each designed to allow for the production and compaction of asphalt concrete at temperatures lower than conventional hot-mix asphalt (HMA).

Recognizing that a knowledge gap exists in the comparison of WMA and HMA over the performance life of each type of pavement, the Long-Term Pavement Performance (LTPP) program initiated this research to design a national experiment to study the performance of WMA relative to HMA. New test sections will be recruited into the LTPP program under the designation of the specific pavement studies (SPS)-10 experiment called "Warm Mix Asphalt Overlay of Asphalt Pavement Study."

The purpose of this volume of the report series is to document the guidelines for the development and implementation of the performance monitoring for the SPS-10 experiment for the LTPP program. This experiment is designed to capture information on the short- and long-term performance of WMA relative to HMA. This experiment has been structured to ensure consistency and compatibility with the existing LTPP program objectives and database while addressing information gaps regarding WMA performance. The intent of the SPS-10 experiment is to capture not only field performance but also laboratory test data that will provide both user-agencies and researchers a better understanding of the potential benefits of WMA. Collectively, this information could be used for performance prediction.

Mark Swanlund
Acting Director, Office of Infrastructure
Research and Development

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1,000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

LONG-TERM PAVEMENT PERFORMANCE WARM-MIX ASPHALT STUDY PROJECT REPORT SERIES

This volume is the fifth of six volumes in this research report series. Volume I is the final report, and volume II through volume VI contain detailed information about the design and operations of the experiment. The following list contains the volumes of this series:

Volume	Title	Report Number
I	Long-Term Pavement Performance Warm-Mix Asphalt Study, Volume I: Final Report	FHWA-HRT-22-018
II	Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume II: SPS-10 Experimental Matrix and Research Plan	FHWA-HRT-22-019
III	Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume III: SPS-10 Nomination Guidelines	FHWA-HRT-22-020
IV	Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume IV: SPS-10 Materials Sampling and Testing Requirements	FHWA-HRT-22-021
V	Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume V: SPS-10 Performance Monitoring Guide	FHWA-HRT-22-022
VI	Long-Term Pavement Performance Warm-Mix Asphalt Study Final Report, Volume VI: SPS-10 Construction Documentation Guide	FHWA-HRT-22-023

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AC	asphalt concrete
FHWA	Federal Highway Administration
FWD	falling weight deflectometer
HMA	hot-mix asphalt
LTPP	Long-Term Pavement Performance
RSC	regional support contractor
SPS	Specific Pavement Studies
WMA	warm-mix asphalt

CHAPTER 1. PERFORMANCE MONITORING OF SPS-10 TEST SECTIONS

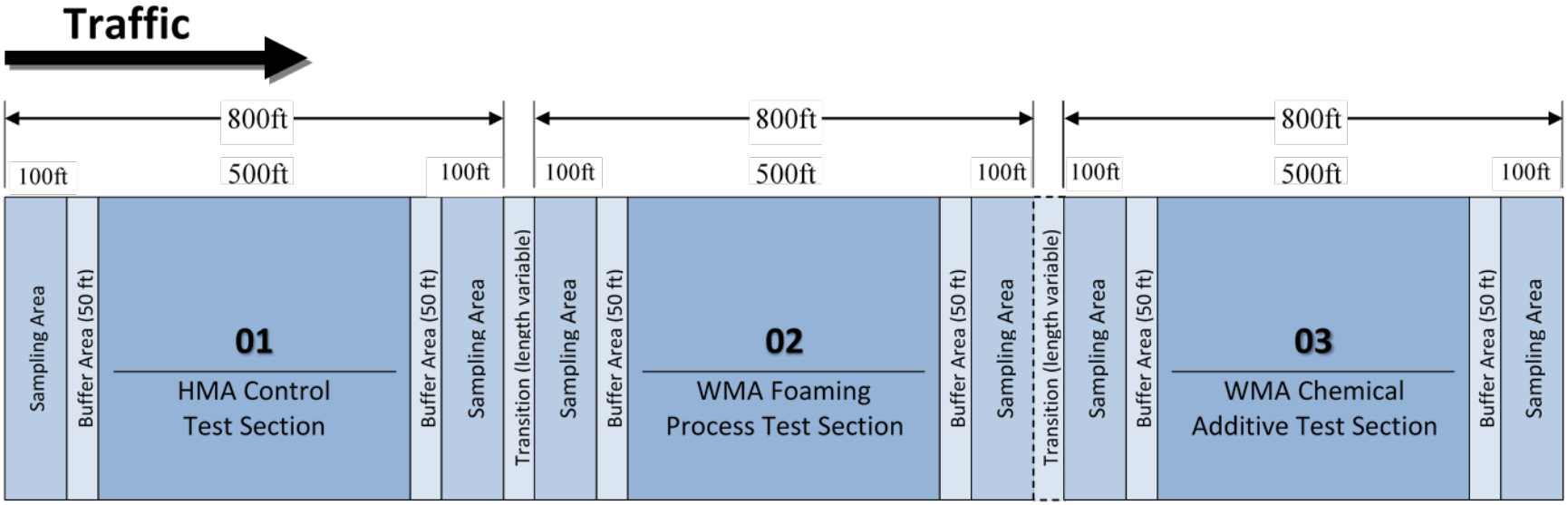
This report provides guidelines for the development and implementation of the performance monitoring program for the Federal Highway Administration's (FHWA's) Long-Term Pavement Performance (LTPP) Specific Pavement Studies (SPS)-10 experiment test sections. FHWA-LTPP regional support contractors (RSCs) must follow these guidelines when developing performance monitoring plans tailored to the conditions encountered on each project.

The SPS-10 experiment is designed to capture information on the performance of warm-mix asphalt (WMA) compared to hot-mix asphalt (HMA), in both the short and long term. The experiment was designed to compare the performance of WMA to HMA. Field performance will be captured over the long term, and data from laboratory testing of WMA materials will be provided to researchers looking to evaluate various features of WMA. Collectively, this information can be used to understand the potential benefits of WMA and generate more accurate performance predictions.

The SPS-10 experiment described in this report is intended for test sections not previously included in the LTPP program. Projects nominated for the SPS-10 experiment will be constructed specifically to satisfy cells within the experimental matrix. They will adhere to the guidelines developed by the project team and approved by FHWA. Because these sections will be nominated for the program before rehabilitation, all construction activities, material properties, and sampling will be documented to ensure a complete dataset. Each SPS experiment in the LTPP program is designed to have limited goals, construction needs, and experimental approaches. The experiments are generally designed to be intensive studies of a few independent variables. This document defines the goals and objectives of the SPS-10 experiment and the independent variables to be studied.

The SPS-10 experiment requires the construction of a minimum of three test sections at each project site. Figure 1 demonstrates a sample test section layout, including stationing, transition areas, and pavement layers. Construction will be limited to overlays of asphalt concrete (AC) pavements only. The minimum three test sections are as follows:

- Highway agencies' standard mix (control section).
- Mix with WMA foaming process category.
- Mix with WMA chemical additive category.



Source: FHWA.

Figure 1. Diagram. Typical SPS-10 site layout.

WMA technologies currently available can be grouped into the following four categories (some technologies are a combination of these):

- Foaming additive.
- Chemical additive.
- Organic additive.
- Foaming process.

The LTPP SPS-10 experiment focuses on the chemical additive and foaming process categories. To compare the materials in the study, the pavement structure and thicknesses of the layers containing the experimental mixtures must be the same on all test sections. Agencies are encouraged to take the opportunity afforded by the construction of these experimental test sections—whose performance will be uniformly monitored over the long term—to construct supplemental sections investigating experimental factors of specific agency interest.

OBJECTIVE

The objectives of the SPS-10 experiment are to:

- Evaluate and improve the practical aspects of implementing a WMA system through a hands-on field trial by interested highway agencies.

- Compare the performance of the selected WMA technologies against mixes designed using current highway agencies' HMA specifications, asphalt-aggregate specifications, and mix design procedures.

- Provide long-term performance data for evaluation and refinement of the WMA technologies, design procedures, and models.

- Test the sensitivity of a WMA technology relative to low-temperature cracking, fatigue, or permanent deformation distress factors.

- Provide highway agencies the opportunity to evaluate the performance of other experimental features by constructing supplemental sections.

A key component to achieving the objectives of the SPS-10 experiment is to develop and execute a performance monitoring plan capable of tracking and collecting the long-term WMA data. The guidelines for the periodic collection of monitoring data are described within this report.

PRE-OVERLAY MONITORING

Because the SPS-10 experiment is based on the overlay of existing AC pavements, it is crucial to capture the condition of the existing pavement before the overlay. As such, the performance monitoring plan will include pre- and post-overlay testing. Current LTPP practice is to capture the condition within 6 mo before and 6 mo after completion of the overlay. This timing may need to be shifted to account for late-season paving, where the 4-mo window would be in the middle of winter in cold-weather locations. For the SPS-10 experiment, pre-overlay testing will consist

of manual distress surveys, falling weight deflectometer (FWD) testing, transverse profile, longitudinal profile, and texture measurements. Manual distress surveys are performed using the *Distress Identification Manual for the Long-Term Pavement Performance Program* (Miller and Bellinger 2014). Likewise, the *LTPP Manual for Collecting and Processing Longitudinal Profile, Macrotexture, and Transverse Profile Data* is used without modification (Perera and Elkins [forthcoming]). The FWD testing plans (i.e., lane designations, drop sequences, stationing) for the SPS-1 in the *LTPP Manual for Falling Weight Deflectometer Measurements*, version 4.1, are used for SPS-10 WMA projects (Schmalzer 2006).

SHORT-TERM PERFORMANCE MONITORING

The SPS-10 experiment will have a modified monitoring frequency to collect early-life performance. This increased frequency will capture early rutting concerns (if the WMA was paved early in the summer) and moisture susceptibility issues (for late-season paving). The increased frequency monitoring includes distress, FWD, texture, transverse profile, and longitudinal profiles. The proposed data collection would occur at an interval of t = 0, 3–6, 12, and 18 mo. This interval will be commensurate with the coring intervals identified in the project's materials sampling and testing plan (Puccinelli et al. 2022). For the time interval t = 0, the data collection will be done within 30 d of the finished construction. The next data collection will fall within 3–6 mo after construction. For the 12- and 18-mo intervals, the data collection will be done either 30 d before or 30 d after the interval. Table 1 summarizes the desired short-term monitoring levels for the SPS-10 experiment. Complete details on time series coring can be found in volume IV of this report series.

Table 1. Summary of short-term LTPP performance monitoring intervals.

Time After Construction (mo)	Longitudinal Profile/Texture	Distress/Transverse Profile	FWD
0	✓	✓	✓
3–6	✓	✓	✓
12	✓	✓	✓
18	✓	✓	✓

LONG-TERM PERFORMANCE MONITORING

Monitoring data are collected periodically throughout the life of each test section to monitor the structural and functional condition of the pavement section over time. These data provide a historical database for developing relationships between performance, traffic counts and axle loads, age, maintenance, and other significant variables.

Directive GO-68 established the current performance monitoring guidelines (Nehme 2019). Table 2 summarizes the desired and minimum monitoring levels by experiment, including the SPS-10 experiment.

Table 2. Summary of LTPP performance monitoring intervals.

Performance Measure	Desired Level	Maximum Allowable Interval Period
Longitudinal profile/texture	Annual	Every 2 yr
Distress/transverse profile	Annual	Every 2 yr
FWD	Every 3 yr	Every 5 yr

After the first 18 mo of short-term monitoring, the monitoring frequency of the WMA experiments is the same as that of the other SPS-10 experiments listed in table 2. The SPS-1 test plan will adequately capture the necessary data for WMA experiments. This monitoring data should be obtained and reported for each test section.

The performance monitoring plan set forth in this document will be used in all SPS-10 experiments for LTPP unless otherwise noted in the most current LTPP directives. In the event of resource constraints, the RSCs will work with FHWA to establish a reduced monitoring plan. It is in the interest of the LTPP that the core sections receive priority for performance monitoring.

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