U.S. Department of Transportation  
Federal Highway Administration  

Pavement Performance Division  
Long-Term Pavement Performance Program  

Specific Pavement Studies  
Experimental Design and Research Plan  
Experiment SPS-10  
Warm Mix Asphalt Study  

Federal Highway Administration  
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November 2013
PREFACE
Guidelines for recruitment, selection, and implementation of test sites included in the Specific Pavement Studies-10 (SPS-10) experiment Warm Mix Asphalt (WMA) Study are presented in this document. This includes a national experimental matrix as well as site requirements. These guidelines should be followed by the FHWA-LTPP Regional Support Contractor (RSC) when working with the State and Provincial Highway Agencies (SHAs) in selecting candidate SPS-10 project locations. The FHWA-LTPP RSC office must coordinate with the participating SHA and FHWA in populating the experimental matrix with SPS-10 projects that meet the criteria set forth in this document.
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1. INTRODUCTION

The purpose of this report is to document the research plan and experimental design for the Specific Pavement Studies-10 (SPS-10) experiment for the Long Term Pavement Performance (LTPP) program. This experiment is designed to capture information on the short- and long-term performance of Warm Mix Asphalt (WMA) relative to Hot Mix Asphalt (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 study will capture not only field performance, but also laboratory test data that will allow both user-agencies and researchers a better understanding of the potential benefits of WMA. Collectively, this information could be used for performance prediction.

For the purposes of this study, WMA is defined as asphalt mixtures produced at least 30°F below normal hot-mix asphalt production temperatures, or asphalt produced at or below 275°F.

The SPS-10 experiment described in this document is intended for test sections not previously in the LTPP database. Projects nominated for the SPS-10 experiment would be constructed specifically to satisfy cells within the experimental matrix and would adhere to the guidelines set forth in this research plan. Because these sections would be nominated prior to construction, all material properties, sampling and construction activities could be documented to ensure a complete data set. SPS experiments in the LTPP program are focused on very specific topics with limited independent variables. This document defines the goals/objectives of the SPS-10, the independent variables to be studied, and the methods used to control other factors that affect pavement performance.

Existing LTPP test sections that are rehabilitated with WMA technology are included in the GPS-6 and GPS-7 experiments. Details regarding the expanded GPS-6 and GPS-7 experiment can be found in the Long-Term Pavement Performance Maintenance and Rehabilitation Data Collection Guide, which has been revised and expanded to account for WMA overlays of existing LTPP test sections.

1.1 BACKGROUND

WMA pavements were first constructed in Europe in 1997. The European experience has been documented in The International Technology Scanning Program Warm Mix Asphalt Scan Summary Report. The results of the tour were promising, but there were still a number of challenges that needed to be addressed, including the long-term performance. Recognizing the potential benefits of WMA (i.e., as a compaction aid, extending the paving season, increasing haul distance, and reducing fuel consumption and emissions) construction of WMA in the U.S. has increased exponentially. The first field trials in the U.S. were constructed in North Carolina and Florida in 2004. By 2008, 32 States had conducted WMA field trials. Interest in WMA has continued to gain momentum and in 2011, 24 States had specifications for WMA construction. In addition, the amount of WMA used between 2009 and 2010 increased by 175% and accounted for 13% of total asphalt production.
There are currently over 35 WMA technologies offered in the U.S. market, each of which is designed to alter the properties of the asphalt binder to allow for improved aggregate coating and compactability at lower production and compaction temperatures as compared to conventional HMA. The 35 technologies currently available can be grouped into the following four categories (some technologies are a combination of these):

- Foaming Additive;
- Chemical Additive;
- Organic Additive; and
- Foaming Process.

The LTPP SPS-10 experiment will focus on the Chemical Additive and Foaming Process categories. Given the growth and popularity of WMA, a number of States have conducted studies on WMA. Additionally, NCHRP has sponsored seven studies on WMA. The majority of studies have investigated mix design practices, engineering properties, and constructability. While NCHRP 9-49A was structured to address long term performance of WMA, the project’s 5-year duration can only capture a fraction of the pavement’s intended design life. As such, there is a need to establish a research plan that successfully captures long term performance and behavior over the typical 20-year design life while also obtaining materials testing results, construction details, pavement structure information, traffic levels, and climatic data. Additionally, the SPS-10 experiment is intended to consider the use of recycled asphalt pavement (RAP). Initial research on the use of RAP with WMA has demonstrated improved mix properties in terms of the blending of old and virgin binders; however, there are many unknowns that need to be quantified in terms of long-term performance including, for example, the effects of different production temperatures on blending and the combined binder properties, selecting optimal binder replacement determination procedures, and effects of asphalt plant type on the final mix.

As mentioned above, the National Cooperative Highway Research Program (NCHRP) has funded several projects on WMA, within the past five years. As of this date, only two of the projects have published final reports. NCHRP staff, however, was generous enough to provide the WMA project team with access to interim reports, and contacts were made with several of the Project Managers of the ongoing projects. Table 1 summarizes the NCHRP work considered.
Table 1. NCHRP Projects Including WMA

<table>
<thead>
<tr>
<th>Project #</th>
<th>Project Name</th>
<th>Start Date</th>
<th>End Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>09-33</td>
<td>A Mix Design Manual for Hot Mix Asphalt</td>
<td>7/1/2005</td>
<td>6/30/2010</td>
</tr>
<tr>
<td>09-47A</td>
<td>Properties and Performance of Warm Mix Asphalt Technologies</td>
<td>7/31/2009</td>
<td>1/12/2013</td>
</tr>
<tr>
<td>09-49</td>
<td>Performance of WMA Technologies: Stage I Moisture Susceptibility</td>
<td>7/26/2010</td>
<td>9/30/2013</td>
</tr>
<tr>
<td>09-53</td>
<td>Properties of Foamed Asphalt for Warm Mix Asphalt Applications</td>
<td>6/1/2012</td>
<td>8/31/2014</td>
</tr>
<tr>
<td>09-52</td>
<td>Short-Term Laboratory Conditioning of Asphalt Mixtures</td>
<td>6/1/2012</td>
<td>11/30/2014</td>
</tr>
<tr>
<td>09-55</td>
<td>Recycled Asphalt Shingles in Asphalt Mixtures with Warm Mix Asphalt Technologies</td>
<td>6/10/2013</td>
<td>9/10/2016</td>
</tr>
</tbody>
</table>

For projects 09-47A and 09-49A, field sections were identified and either monitored from construction, or materials sampling and field evaluations were performed on existing sections. Test sections are also planned for of NCHRP 09-53.

The WMA project team carefully considered how these NCHRP projects may be brought into LTPP as test sections. Other sections, such as those constructed as part of ongoing work under the Asphalt Research Consortium (ARC) were also evaluated. This evaluation was part of the original scope of work, and was also encouraged during the initial WMA Expert Task Group (ETG) meeting.

Integrating existing WMA sections into the LTPP program would provide a jump-start to evaluating the long term performance of in-service sections. That said, LTPP has rigorous guidelines for data collection, review and storage. These guidelines apply to construction, materials sampling and testing, and performance monitoring data.

While the NCHRP (and other) test sections often had personnel on-site during construction, and in some instances utilized LTPP practices for elements of the data collection, on the whole, these sections are not compatible with the existing LTPP Pavement Performance Database (PPDB). The following summarizes the reasons that prevent inclusion of these test sections in the SPS-10 experiment.

- Standard LTPP test sections are 500 feet in length, but most of the NCHRP projects are significantly shorter.
- LTPP prohibits destructive sampling within the test section, while the NCHRP projects performed coring within the test sections.
• LTPP requires distress surveys to be performed by accredited raters using specific forms and definitions. Although these definitions were largely incorporated, the surveys were performed by non-accredited raters.
• Deflection and roughness data were collected on very few of the existing WMA projects, and the equipment used to collect the limited data was not calibrated per LTPP specifications.
• Materials sampling and testing processes were not conducted utilizing LTPP protocols.
• None of the data sets utilized LTPP forms, meaning that even if the information could be found, there would be a substantial effort to get it documented and entered into the LTPP PPDB.

While the test sections themselves are not recommended for inclusion into the LTPP PPDB, the lessons learned in the conduct of the above projects definitely contributed to optimizing decisions made in association with the LTPP WMA projects.

1.2 KEY CONSIDERATIONS

The SPS-10 study has been designed to address information gaps that currently exist with WMA pavements. This section describes some of the key considerations that were used to develop the SPS-10 experimental design.

The data needs for WMA center on how binder and mixture properties affect performance relative to HMA. The first factor in the experimental design will allow a direct comparison of WMA to HMA over a comprehensive spectrum of in situ conditions of climatic conditions and traffic loading. In addition, questions have been raised about the use of WMA technology in mixtures containing RAP. As such, RAP is a feature that was included in the experimental matrix. While various categories of WMA technologies are currently in use, data on the applicability of each category under different in situ conditions have not been quantified.

Because WMA is relatively new, long term field performance data are not available. Concerns with moisture sensitivity, due to lower production temperatures and the presence of aggregate moisture, have been documented but have not yet been thoroughly evaluated on in-service pavements. The SPS-10 is designed to address this concern as well as the effect of WMA on low temperature cracking, fatigue cracking, rutting, and stiffness (including changes over time).

Note that a large number of factors were considered in developing the preliminary experiment design. However, given practical constraints – financial resources and size of the experimental matrix required to adequately represent all factors – the resulting experiment design reflects the prioritization of factors within a statistically sound full factorial, as described in the following section. This study will only consider mixes produced and placed at warm mix temperatures. Mixes produced at normal hot mix temperatures, but placed at warm mix temperatures, where the warm mix technology is only used as a compaction aid, will not be considered as part of the “core experiment”, but could be implemented as Supplemental Sections.
1.3 SPS-10 EXPERIMENTAL DESIGN

SPS experiments typically consist of projects located across North America. Each project is selected and constructed to populate a specific set of site conditions/experimental factors. These factors are combined to develop an experimental matrix. The matrix provides an overview of the projects required to achieve a statistically sound and robust experiment. The representation of WMA technology in the primary tier factorial of the SPS-10 project is shown in Table 2. It identifies the primary experimental factors and their relationships. The site factors are identified across the top of the matrix in Table 2 while pavement mixture factors are listed on the left side. The factors included within the experimental design were selected based on input from the Expert Task Group (ETG) assembled specifically for this study. While many characteristics (or independent variables) were considered, only the major factors discussed below were selected with assistance from the ETG and with approval from FHWA. It would not be practical to attempt to account for all of the independent variables, especially those that have shown little or poor correlation with overall performance.

The primary objective of the study, as stated previously, is to quantify the performance of WMA relative to an HMA. As such, each SPS-10 project location will consist of the following, at a minimum:

- One HMA control section; and
- Two WMA test sections (each using a different category of WMA technology)

Table 2. Experimental Matrix for SPS-10.

<table>
<thead>
<tr>
<th>WMA Technology</th>
<th>Wet</th>
<th>Dry</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Freeze</td>
<td>No Freeze</td>
</tr>
<tr>
<td>Core Test Sections on Project</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>HMA (Control)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>WMA (Foaming Process)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>WMA (Chemical Additive)</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>

Each cell in Table 2 represents the recommended quantity of projects to be nominated and constructed for the SPS-10 experiment. Each project location contains a minimum of three test sections (each 500 feet in length) constructed contiguously along a section of Highway, Interstate, or State Route. The SPS-10 experiment is designed such that all factors (i.e., traffic, climate, subgrade, existing pavement structure, asphalt plant) are constant across all test sections at one project location. The only variation in core test sections is the WMA technology. This allows a direct comparison of the specific WMA technology to HMA under the same in situ conditions and thereby eliminates confounding effects typically introduced when trying to compare pavement features at different locations. Additional details on the site layout can be found in subsequent sections of this report.
Constructing an SPS-10 experiment where both WMA test sections are using technology from the same category will be avoided as part of the core experiment. Should an agency wish to evaluate different WMA technologies within the same category, additional test sections may be built so that the project has more than three test sections. However, each project shall consist of test sections representing at least one WMA test section using a chemical additive, one WMA test section using foam process along with at least one HMA control section. The three sections defined here will be considered the “core” experiment and will be used to populate the national experimental design. Any additional test sections constructed within the project will be considered Supplemental Sections. While data will be collected and stored in the LTPP database for these Supplemental Sections, they will not be used to populate the national experimental matrix. Supplemental Sections are valuable components of the SPS-10 project as they allow Highway Agencies to study specific mixtures of interest.

1.3.1 Replication Considerations
The experimental matrix in Table 2 includes replication of the primary tier factorials. A minimum of two projects shall be recruited for each combination of primary tier factorials of climate and traffic. If more than two projects are nominated and constructed for some cells within the matrix, they will be included in the LTPP database. The intent of the matrix is to achieve a balanced experiment with all factors represented, but does not prevent or limit additional replicates from being included in the program.

Including an adequate number of replication helps to estimate unbiased estimation of experimental errors in designed experiments. Estimation of experimental error is very important in inferential statistics to compare both main and interaction effects and to estimate the standard errors and confidence intervals for treatment means. In addition, to have an adequate number of replications, true replications are required to estimate unbiased experimental error. True replication is only achieved when treatment combinations within a factorial designs are randomly assigned to replicated experimental units. Failure to randomly assign treatments to replications results in pseudo replication. Experimental error computation obtained from pseudo replication is not an independent estimate and underestimates the true error. This increases the probability of Type I errors occurring and increases the chances of detecting false positives treatment differences.

Having “repeat” test sections at one SPS-10 (i.e., multiple test sections using the same WMA technology) is not true replication. In the case of the SPS-10, true replication only occurs when multiple projects are constructed for each primary tier factorial. As such, the experimental design in Table 2, provides for at least two independent projects to be constructed under the same primary factorials.

1.3.2 SPS-10 WMA Definition
For purposes of this LTPP experiment, WMA is defined by the following criteria:

- A mixture produced at or below 275°F or,
- A mixture produced at least 30°F below the production temperature of the HMA control.
This definition of WMA was developed by the ETG with consideration given to accommodate the water-foaming technologies.

1.3.3 Climate
Four climatic zones have been previously defined by LTPP: Wet-Freeze, Dry-Freeze, Wet-No Freeze, and Dry-No Freeze. The criteria established to distinguish wet and dry climates is based on annual precipitation. Climates with an annual precipitation of less than 20 inches/year are considered Dry by LTPP definitions. Conversely, Wet climates are those receiving more than 20 inches of precipitation per year. Freezing Index is used by the LTPP program to define the Freeze and No Freeze climates. A site located where the annual Freezing Index is greater than 150°F-days is considered to be in the Freeze climatic zone by LTPP definitions.

Climate is a site condition that is addressed in the project location experimental matrix. The SPS-10 experiment requires equal representation in all four climatic zones.

The SPS-10 experiment does not require the installation of an automated weather station (AWS) onsite; however, it is preferable that a fully functional weather station (maintained and operated as part of the National Oceanic and Atmospheric Administration or National Weather Service) is in the nearby vicinity.

1.3.4 Traffic Levels
Traffic loading has a direct and significant impact on the long term performance of pavements. Annual traffic loading typically grows with time and the rate of growth is dependent on many factors. This can result in significant differences in annual loading between the beginning and end of the pavement service life. To ensure that the WMA experiment captures a range of loading conditions, two categories are established by evaluating measured loading at the existing LTPP sites. The distribution of average annual Equivalent Single Axle Loads (ESALs) per year is provided in Figure 1, while summary statistics are provided in Table 3. These data were assembled from all LTPP locations where monitored traffic data are available and represent the annual average of all years collected for each location. Note that the ESAL values reported are for one lane in one direction of travel (i.e., design ESALs). As can be seen, the mean for the data set is 338 kESALs per year; however, the distribution is skewed with approximately 60 percent of the sites receiving less than 250 kESALs per year. Based on this distribution and considering the difficulties in obtaining lane closure in high traffic areas, the low traffic category is defined as sites receiving less than 200,000 Equivalent Single Axle Loads (ESALs) per year. A site with traffic greater than or equal to 200,000 ESALs per year will fall into the high traffic category for purposes of this experiment.

Traffic information will be quantified and stored as part of the monitoring data from each site. While test sections with only traffic data from either portable or permanent equipment will be considered for inclusion into the experiment, sections with a continuously operating permanent device is preferred for classification and weight data. This level of data collection is preferred for two reasons: (1) to provide the accurate traffic loading measurements required to develop mechanistic and mechanistic/empirical design models; and (2) to provide the base data necessary to understand the intricacies of the interactions among pavement, traffic load, and environment. Care should be taken during the nomination process to select project locations that have a full
time fully operational WIM on the same route and within close proximity that captures traffic patterns equivalent to those seen at the test section location.

While data collection is preferred on the site continuously for the year, the minimum recommended data collection effort for each site is two weeks of continuous classification data, four times per year (a total of eight weeks of classification data per year). It is the agency’s responsibility to ensure that representative data are collected that account for seasonal variation, weekday/weekend differences, and inconsistent truck loading patterns throughout the year.

Figure 1. Distribution of Annual Traffic Loading at LTPP Sites.

Table 3. Summary Statistics of Annual Traffic Loading at LTPP Sites.

<table>
<thead>
<tr>
<th>Statistic</th>
<th>Average Annual Traffic Loading (kESALs/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>338</td>
</tr>
<tr>
<td>Median</td>
<td>195</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>377</td>
</tr>
<tr>
<td>Minimum</td>
<td>2</td>
</tr>
<tr>
<td>Maximum</td>
<td>2172</td>
</tr>
</tbody>
</table>

1.3.5 WMA types
While there are over 35 different WMA products available, the products can be grouped into four broad categories based on the mechanisms used to modify the binder properties during mixing.
and compaction. The SPS-10 experimental matrix will focus on the Chemical Additive and Foaming Process categories for core test sections. The lists provided under each category are not intended to be a comprehensive set and other products meeting the definitions described below can be used in the SPS-10 experiment.

1.3.5.1 **Chemical Additives** are defined as water-free (non-aqueous) chemistry packages that modify the binder properties to enhance coating, adhesion, and workability at reduced temperatures. These include surfactants, fatty-acid chemical additives, cationic surface-active agents, and rheology modifiers. Examples of products that fall into this category include the following:

- CECABASE;
- Evotherm;
- HyperTherm/QualiTherm; and
- Rediset.

1.3.5.2 **Organic Additives** are plant-based, wax-based, or sulfur-extended materials designed to provide viscosity reduction, aid in asphaltenes dispersion, and act as a lubricant at mixing temperatures below that of conventional HMA. Organic additives are not included in the “core” experiment but are strongly encouraged for use in Supplemental Sections. Examples of organic additives include the following:

- BituTech PER;
- LEADCAP;
- Sasobit;
- SonneWarmix; and
- Thiopave.

1.3.5.3 **Foaming Additives** are defined as water-containing materials added to the mixture to foam the asphalt. The most common foaming additive is synthetic zeolite. Zeolite contains 20-30% water that is released at temperatures above the boiling point of water. The water from the zeolite foams the asphalt binder. Examples of foaming additives include the following:

- Advera; and
- Aspha-min.

1.3.5.4 The **Foaming Process** category includes all WMA types that utilize assemblies/modifications to the plant to foam binder without additives (other than water). This includes foaming nozzles, expansion chambers, vortex mixers, and shearing devices. While the other categories may be added to the mix using some type of nozzle or other addition, the key distinction between the Foaming Process category and others is the absence of additives. WMA technologies that fall into the Foaming Process category only utilize water. Examples of this category include the following:
Accu-Shear;
AQUABlack;
AquaFoam;
Astec Green System;
Eco-Foam;
Gencor Ultrafoam; and
Low Emission Asphalt (LEA).

1.3.6 Recycled Asphalt Pavement (RAP)
Results from the NCHRP 9-43 project indicate that binder from aged RAP will blend with virgin binder at WMA temperatures as long as the production temperatures exceed the high-temperature PG grade of the RAP binder. Field trials have been constructed in the US using WMA technologies in mixes with RAP contents ranging from 20 to 50 percent. There is interest within the community to evaluate the long term performance of WMA with RAP.

The LTPP SPS-5 experiment required all recycled test sections to have a RAP content of 30%. The project description for NCHRP 9-46, “Improved Mix Design, Evaluation, and Materials Management Practices for Hot Mix Asphalt with High Reclaimed Asphalt Pavement Content” defines high RAP content mixtures as those containing more than 25% RAP. Consideration must also be given to the current practice of Highway Agencies. Establishing a threshold incompatible with State practices could result in difficulties nominating and populating the experimental design with test sections. Figure 2 provides a summary of State practice for surface mixtures. As can be seen, over 30 States construct surface mixtures with up to 19% RAP; however, only 2 States report using RAP contents of up to 29%.

![Figure 2. Reclaimed Asphalt Pavement Use by State Highway Agencies.](image)

A multiple factorial approach for RAP was not utilized in the SPS-10 experiment design. However, a requirement for all of the core test sections to have RAP contents between 10% and 25% based on binder replacement (expressed as the amount of binder contribution from RAP as a percentage of total binder in the mixture) has been included. It is anticipated that the RAP binder replacement will follow standard practice by the Highway Agency. The three core test
sections on each project shall have the same RAP percentages and should achieve the same binder replacement levels. If an agency wishes to vary the RAP binder replacement levels or include RAS, Supplemental Sections can be included. However, varying binder replacement levels was not incorporated into the national experimental design of core test sections. Contractors typically introduce additives to RAS stockpiles to ensure workability. In some cases, WMA additives are used for this purpose. If a WMA technology is added to the RAS stockpile, the material can still be used on supplement sections of an SPS-10 project as long as the control section is constructed at HMA temperatures (without additional WMA technology used during the mixing process). The stockpile additive will be documented and recorded in the LTPP database.

1.3.7 Pavement Structure
The SPS-10 experiment will only include new AC overlays over existing flexible (HMA) pavements. New construction, complete reconstruction, overlays of existing PCC or composite pavements will not be allowed in the SPS-10 experiment.

The thickness of the overlay will be determined by the Highway Agency’s standard practice. There will be a strong correlation between the overlay thickness and the annual traffic loading. As such, the overlay thickness will be treated as a covariate in the study and will not be a multi-level category in the experimental design. The thickness determined by the Highway Agency will be documented along with the design process and all inputs used in determining the design. The minimum overlay thickness required for the SPS-10 experiment is 2 inches. This minimum thickness was selected to alleviate complications that arise when performing materials testing, ride quality, and structural testing on thin layers. The maximum overlay thickness required for the SPS-10 experiment is 4 inches.

Pavement structural factors (subgrade, subbase, base, binder and surface course thicknesses) are not controlled as multi-level design factors in the SPS-10 experiments. The subgrade may be either fine or coarse-grained material. The base may be either a granular or stabilized type.

The pavement thickness (and depth of milling, or other surface preparation, if applicable) should remain constant across all test sections at any project location to allow for direct comparison between WMA and HMA. Similarly, the existing pavement structure thicknesses, surface distress types and extents, and subgrade conditions should be consistent throughout the project.

Tack coats shall be required prior to the placement of all WMA and HMA lifts constructed as part of the SPS-10 experiment.

1.3.8 Mixture Design
The SPS-10 experiment focuses on dense-graded asphalt mixtures for the core test sections. The mix design will be developed by the Highway Agency in accordance with standard practice. The mix design for the WMA test sections should be identical to the HMA control. Some Highway Agencies allow minor adjustments to the mix design between the HMA and WMA, while others forbid it. Highway Agency standard practice will be allowed in the SPS-10 experiment. In addition, antistrip agents may be required in the HMA mixture while some of the WMA additives interact with antistrip agents in a way that makes the mixture more susceptible to
moisture damage. This is an example where slight changes to the mixture design between HMA and WMA is warranted and are acceptable in the SPS-10 experiment. The complete mix design and volumetric mixture properties of the HMA and WMA mixtures will be documented and stored in the LTPP Pavement Performance Database (PPDB).

If the Highway Agency wishes to study other mixture types (i.e., Stone Matrix Asphalt or Open Graded Friction Course), test sections may be included in the SPS-10 experiment as Supplemental Sections.

The binder used in the mixture will be selected using the Highway Agency’s normal practice. Modified binders (both polymer and rubber) are allowed in the SPS-10 experiment. Information on the binder modifier type and quantity will be documented and stored in the LTPP database. Binder type and modifier type is not included in the SPS-10 experimental matrix and will be a covariate of the project.

The binder source, binder grade, and binder modification must be consistent across the three core test sections of each project. Should the Highway Agency wish to vary binder properties, Supplemental Sections can be included and will be monitored as part of the LTPP program. Direct comparisons between different binder types or different sources of the same binder type are not a part of the national experimental design for the SPS-10.

In addition, aggregate type, source and gradation must be consistent across the three core test sections of each project. Variations in aggregate properties will be allowed in Supplemental Sections.

2. TEST SECTION CONFIGURATION AND CONSTRUCTION CONSIDERATIONS

The SPS-10 test pavements will be built as part of an overlay of existing asphalt pavement. In all cases, the cross section must be uniform. Lane widening projects are not suitable for this experiment because of the difficulty of discerning the relationship of distresses developed in the existing lanes and those developed in the widened test section.

Figure 3 illustrates the conceptual test site layout for the SPS-10 experiment. The experimental design requires a minimum of 800 feet long, with a core monitoring section of 500 feet which will be used for future non-destructive performance monitoring. A 50-foot buffer on each side of the monitoring area is included to separate the destructive sampling area from the monitoring area. The destructive sampling area consists of 100 feet on each side built at the same time and to the same specifications to allow material sampling without disturbing the 500-foot monitored area and will consist of the outside (i.e., truck) lane only. Sufficient plant production should be provided to ensure acceptable uniformity and consistency in asphalt concrete mixture delivered and placed. Transition zones are required between test sections, and shall be a minimum of 800 feet long. The project requires at least three different mixes (one HMA and two WMA) to be produced at the same plant, and each mix may only be placed on the test section after the plant has reached steady-state operation. The transitions will also be used to ensure the paving train has reached uniform operation and is achieving consistent densities prior to paving within the
test section. This may require longer transitions between the sections, or some other use/disposal of mix produced before the plant achieves steady-state operation. The length of these transitions depends on site conditions, production plant configurations, and construction practices that influence the amount of material required to reach steady-state operations. The minimum project length is 4,000 feet, but may be longer if more than the minimum number of sections are built and/or if the transition zones are longer than the minimum length.

![Figure 3. Typical SPS-10 Site Layout.](image)

Each SPS-10 project shall have a minimum of three test sections. One test section shall consist of HMA as a control. The other two test sections shall be WMA (as defined above); one using the foaming process, and the other using a WMA chemical additive. Additional test sections may be constructed above this minimum. The additional sections will be Highway Agency Supplemental Sections, and will be monitored using LTPP data collection guidelines.

The JMF (job mix formula) for the HMA control and WMA sections shall be identical (with the exception of warm mix technology). Obtaining consistent densities (and air voids) across all test sections is important to the SPS-10 experimental objectives. Care should be taken to ensure that rolling procedures, rolling patterns and required compactive effort are established for each mixture so that uniform densities are achieved both within each 800 foot monitoring/sampling length and within the entire experiment to facilitate appropriate comparisons of performance. In addition, the same compaction equipment shall be used on all three test sections.

3. **BENEFITS TO PARTICIPATING HIGHWAY AGENCIES**

The SPS-10 experiment, while being coordinated through the FHWA LTPP Division, is conducted for and by State and Provincial Highway Agencies. Therefore, the details of the experiment have been selected to address the needs of the highway community. However, the experimental rigor necessary to achieve the desired results from this research requires that participating agencies agree to the same experimental factors and to construct the required test sections in a consistent manner. The statistical aspects of this experiment make the full cooperation of participating highway agencies crucial to its success. While all highway agencies will benefit from the information, knowledge and products that result from this research, participating agencies will accrue additional direct benefits. Since a portion of this research will be conducted in an agency’s jurisdiction on test sections constructed using materials, mix
designs, specifications, and techniques employed by that agency and exposed to local climate and traffic loadings, participating agencies will be able to make direct use of the results. The study will also allow highway agencies the opportunity to quantify the performance differences between their standard HMA and WMA technologies employed in within their jurisdiction.

In addition to these direct benefits, participating agencies will also receive ancillary benefits as a result of direct involvement in the experimental process including valuable insights and exchange of ideas through interaction with the FHWA team, researchers and highway personnel from other agencies.

4. SUPPLEMENTAL SECTIONS

Sponsoring Highway Agencies have the opportunity to expand the experiment to address some of their own interests and concerns as well as incorporate innovative technology through the construction of Supplemental Sections. Additional WMA technologies can be constructed above the required minimum and their performance can be directly compared to that of the core experimental test sections. Supplemental Sections provide participating agencies the opportunity to conduct intensive pavement field research relatively economically by taking advantage of the research infrastructure and monitoring provided by LTPP.

The construction of Supplemental Sections is strongly encouraged. FHWA is prepared to assist interested agencies in the experimental design, data collection, and performance monitoring of such supplemental experiments. Further, if a group of participating agencies desire to join together in such activity (i.e., as a pooled fund study), FHWA is also prepared to work with these agencies to coordinate a multi-State/Provincial supplemental experiment. The following section provides a list of recommended Supplemental Sections for consideration.

4.1 RECOMMENDED SUPPLEMENTAL SECTIONS

Potential Supplemental Sections have been discussed previously those have been assembled and provided in the following list along with additional recommendations based on discussion with the ETG.

- Use of organic WMA additives
- Use of foaming additives
- Varying levels of RAP or including RAP percentages outside the acceptable range for core test sections
- Inclusion of RAS
- Varying the thickness of the overlay layer
- Varying the binder grade
- Varying production temperatures or constructing sections with WMA technology produced at temperatures above the acceptable range for core test sections
- Using multiple WMA technologies in one mixture
- SMA, Gap Graded, or Open Graded mixtures
- Varying aggregate sources
5. PARTICIPATING HIGHWAY AGENCY RESPONSIBILITIES

Participating highway agencies play a key role in the development, construction and conduct of the Specific Pavement Studies, including the following activities:

- Participation in experiment and implementation plans.
- Nomination of test sites.
- Validation of in situ conditions at the site.
- Provide Inventory Data of existing pavements.
- Preparation of plans and specifications.
- Selection of construction contractors.
- Development of mix designs.
- Materials sampling.
- Construction of test sections.
- Construction control, inspection, and management.
- Collection and submission of traffic data.
- Provide traffic control for all test site data collection.
- Collecting and reporting as-built construction data.
- Conducting and reporting of maintenance and rehabilitation activities.

6. FHWA RESPONSIBILITIES

The primary role of FHWA is to provide coordination and technical assistance to participating highway agencies to help insure uniformity and consistency in construction and data collection to achieve the desired study results. Some of the activities the FHWA team will be responsible for include:

6.1 LTPP DIVISION

- Development of experimental design.
- Coordination among participating agencies.
- Final acceptance of nominated test sites.
- Development of uniform data collection guidelines and forms.
- Coordination of materials sampling and testing.
- Monitoring of pavement performance.
- Development and operation of comprehensive database and data entry platform.
- Control of data quality.
- Data analysis and reporting.
References

i Long Term Pavement Performance Maintenance and Rehabilitation Data Collection Guide.


