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STRATEGIC HIGHWAY RESEARCH PROGRAM

SPECIFIC PAVEMENT STUDIES
EXPERIMENTAL DESIGN AND RESEARCH PLAN
FOR EXPERIMENT SPS-5
REHABILITATION OF ASPHALT CONCRETE PAVEMENTS

STRATEGIC HIGHWAY RESEARCH PROGRAM
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Experimental Design and Research Plan
for Experiment SPS-5
Rehabilitation of Asphalt Concrete Pavements

INTRODUCTION

The studies of rehabilitation and overlay techniques were the strongest contenders for inclusion in Specific Pavement Studies (SPS) as determined by previous balloting of highway agencies. Participation in and support of the research plans by the state and provincial highway agencies indicates enthusiasm for early implementation of the plan. Successful completion of the research project SPS-5, "Rehabilitation of Asphalt Concrete Pavements," and the project SPS-6, "Rehabilitation of Jointed Portland Cement Concrete Pavements," will make major contributions to our ability to increase life of the existing primary highway system of the United States and Canada through proper use of rehabilitation and overlay techniques.

The experimental designs and research plans presented here for SPS-5 were adapted from the Specific Pavement Studies on hot recycling of asphalt concrete (AC) pavements originally described in the May 1986 Strategic Highway Research Program Research Plans issued by the Transportation Research Board. Some of the original experimental design factors have been revised based on state and province desires and budget limitations. These plans have been prepared by the SHRP in cooperation with state and provincial highway agency personnel participating in various meetings, including an SPS-5 workshop held in Washington, D.C., February 27-28, 1989. The recommendations of the participants from 23 states and provinces and FHWA are incorporated into the experimental design and research plan described in this report. This research plan will be used by highway agencies and SHRP as a guide for selecting candidate projects to be considered for inclusion in the SPS-5 experiment and for design and construction of the test sections.

PROBLEM STATEMENT

Many United States and Canadian highway agencies are faced with the difficult task of determining the best way to treat existing aging and deteriorating asphalt concrete pavements. Not only must they determine which rehabilitation procedures work best under which circumstances, but they must also determine the most appropriate time to apply such rehabilitation treatments. The problem is further complicated by the need to address an entire network of pavements at various levels of condition and age with limited funding resources.

Asphalt concrete overlays are the most widely used method for rehabilitation of asphalt concrete pavements in the United States. Pavement surface preparation and type and thickness of overlay are the most important details of such rehabilitation methods. Thus, determining the effects of these details on performance under a variety of circumstances is an area of urgently needed research that will help develop improved rehabilitation design procedures.

One of the major LTPP objectives is "To Develop Improved Design Methodologies and Strategies for the Rehabilitation of Existing Pavements." A generally accepted approach for evaluating pavement maintenance and rehabilitation alternatives is the use of pavement management concepts including life-cycle cost analyses of construction and rehabilitation activities. The ability to predict the performance and life expectancy of various rehabilitation strategies, with and without overlays, is essential to pavement management and life-cycle cost analyses. Consequently, the development of improved performance predictions models for various rehabilitation strategies is essential to achieving the LTPP objectives and should be one of the early products of the research.

OBJECTIVE

The objective of this study is to develop improved performance prediction models to be used for determining the additional pavement life that can be expected from application of a variety of asphalt concrete (AC) rehabilitation methods and strategies ranging from minimal to maximum investment in the rehabilitation treatment. The treatments being studied include combinations of surface preparations, overlay thicknesses, and AC overlay type. The study objective includes a determination of the influence of environmental region and initial pavement condition on the effectiveness of rehabilitation methods. Accomplishing this objective will provide substantially improved "tools" for use in pavement management and life-cycle cost analysis activities.

PRODUCTS

One of the primary specific products of this portion of the SHRP-LTPP research will be to evaluate and improve portions of the AASHTO Guide for Design Pavement Structures that pertain to pavement rehabilitation design methods, life-cycle cost analysis, and pavement management. The SPS-5 and SPS-6 experiments will provide uniform and structured field performance data upon which "Part III - Pavement Design Procedures for Rehabilitation of Existing Pavements" and the sections on pavement management and life-cycle cost analysis of the AASHTO Guide can be evaluated and improved. These products are a direct response to the first two objectives of the LTPP program, which are 1) to evaluate existing pavement design procedures, and 2) develop improved pavement rehabilitation design methods and strategies.

The structural overlay method for rehabilitation of existing pavements that is included in the AASHTO Guide is based on a thickness or structural deficiency approach that presumes the existing pavement is structurally inadequate for anticipated future traffic and climatic conditions. This experiment will provide means for the field verification of this design approach. In addition, these AASHTO design procedures are not applicable to non-structural deficiencies and other functional rehabilitation needs. However, these factors will be considered in this experiment.

This study will produce definitive data concerning AC pavement performance and extended life predictions, including the relative cost effectiveness of various rehabilitation methods and strategies involving the use of virgin and recycled asphalt mix, and ranging from minimum surface preparation with thin AC overlay to extensive surface preparation with thick AC overlay.

The key products from the proposed study will include the following:

1. Comparisons and development of empirical prediction models for performance of AC pavements with different intensities of surface preparation, with thin and thick AC overlays, and with virgin and recycled AC overlay mixtures.

2. Evaluation and field verification of the AASHTO Guide design procedures for rehabilitation of existing AC pavements with AC overlays, and other analytical overlay design procedures for AC pavements.

3. Determination of appropriate timing to rehabilitate AC pavements in relation to existing condition and type of rehabilitation procedures.

4. Development of procedures to verify and update the pavement management and life-cycle cost concepts in the AASHTO Guide using the performance prediction models developed for rehabilitated AC pavements.

5. Development of a comprehensive data base on the performance of rehabilitated AC pavements for use by state and provincial engineers and other researchers.

BENEFITS TO PARTICIPATING HIGHWAY AGENCIES

This experiment will provide the states and provinces with actual data on the cost and performance of alternative methods for asphalt pavement rehabilitation. These data are necessary for the accurate use of pavement management systems, including life-cycle cost analysis and predictions. In addition to these direct benefits, participating highway agencies will receive ancillary benefits as a result of direct involvement in the experiment. For example, the interactions between the agency's personnel and the SHRP staff, contract researchers, and highway personnel from other agencies will produce valuable insights and exchange of ideas.

To evaluate innovative rehabilitation designs and local practices, sponsoring states and provinces can construct additional test sections on or near the SPS experimental projects containing factors of special interest. For example, an agency interested in evaluating the performance of a proprietary product such as a recycling admixture, could construct additional test sections along with the national experiment test sections. SHRP will assist with the design, data collection, and performance evaluation of such experiments and will provide coordination for desired regional or partial experiment.

Another primary benefit to participating highway agencies is that a portion of the research will be conducted using the specific pavements and construction practices employed by the participating highway authority, allowing direct use of the results by the agency. Having test sections within a jurisdiction provides the opportunity for the authority to link performance measurements based on the local pavement evaluation techniques directly to the national pavement data base being developed by SHRP. For example, highway agencies using a Dynaflect or Roadrater deflection measurement device can develop correlations with the falling weight deflectometer measurements performed using SHRP equipment.

EXPERIMENTAL DESIGN

The recommended experimental design is shown in Table 1. It identifies the primary experimental factors and their relationships with each other. Table 1 identifies site related factors across the top and rehabilitation treatments down the sides. Each column in this arrangement represents two project locations each of which incorporates several test sections. Each row represents a series of test sections with specific features to be constructed at each project location.

This experimental design is a coordinated research plan intended to produce data and performance information for a variety of overlay procedures constructed to extend the life of existing asphalt concrete pavements. The primary factors being studied are 1) the degree of surface preparation, 2) overlay material (recycled or virgin AC), 3) thickness of AC overlay, and, 4) environmental

Table 1. Experimental design for SPS-5, rehabilitation of asphalt concrete pavements.

REHABILITATION PROCEDURES \ FACTORS FOR MOISTURE, TEMPERATURE, AND PAVEMENT CONDITION			WET				DRY			
			FREEZE		NO FREEZE		FREEZE		NO FREEZE	
			FAIR	POOR	FAIR	POOR	FAIR	POOR	FAIR	POOR
Surface Prep.	Overlay Material	Overlay Thickness								
Routine Maint. (Control)		0	xx	xx	xx	xx	xx	xx	xx	xx
Minimum	Recycled AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
	Virgin AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
Intensive	Recycled AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx
	Virgin AC	2-inch	xx	xx	xx	xx	xx	xx	xx	xx
		5-inch	xx	xx	xx	xx	xx	xx	xx	xx

Each "x" designates a test section

Subgrade Soil: Fine

Traffic: >85 KESAL/Year

(climatic) factors. Other considerations are 1) existing condition of pavement, 2) subgrade soil, and 3) traffic volume and load. In addition, the experiment will include other sections desired by the highway agency to evaluate local practices or innovative features.

SHRP fully recognizes that no agency is able to continue in service any test section, even for research purposes, that becomes unsafe or disruptive to traffic flow. When in the judgment of the highway agency, a test section reaches such a condition, it should be treated as considered appropriate by the state or provincial highway agency. Such sections will be removed from the study and SHRP will endeavor to obtain final condition data prior to their treatment by the highway agency.

Site Related Factors

Site related factors include the four climatic regions (wet-freeze, wet-no freeze, dry-freeze, and dry-no freeze) and two pavement conditions (fair and poor). These levels of climatic regions and pavement conditions will result in eight different study combinations. In addition, each test section will be replicated. Thus, 16 project sites are needed for this experiment. Where ever possible, replications will take place in different jurisdictions to allow a greater range of practices to be studied.

Climatic Factors

The climatic regions are, for the most part, the same as the environmental zones used in the General Pavement Studies (GPS) except they are not modified to correspond with state boundaries. Climatological factors at specific locations will be used for selection of SPS projects. For example, in this experiment, a project in the south east portion of Kansas could fall in the wet-freeze environmental zone, rather than in the dry-freeze zone as indicated on the GPS environmental zone map.

Wet climatic regions are considered to have a high potential for moisture presence in the entire pavement structure throughout most of the year. Dry climatic regions are considered to have a very little and low seasonal fluctuation of moisture in the pavement structure. Freeze regions include locations with severe winters that result in long-term freezing of the subgrade. No-freeze climatic regions are considered to have no long-term freezing of subgrade.

Pavement Condition Factors

The classification of existing pavement condition as fair or poor will be used primarily to screen candidate projects to provide a range of existing distress conditions. Distress condition surveys of all test sections will be made prior to rehabilitation to document pavement condition and distress. However, it is desirable that some type of a composite distress index be used by highway agencies to classify pavement condition when selecting candidate projects for submittal to SHRP. In view of the desire to immediately identify candidate projects for the 1989 construction season, agencies are urged to select projects that they classify as in fair or poor condition and provide details on the procedures used for such classification. This information will be used by the SHRP to further develop a distress index classification procedures for use in selecting the remaining candidate projects for the 1990 construction season.

A structural based classification of present pavement condition will be used because the rehabilitation procedures being studied are intended to overcome structural inadequacy. The types of distress to be included in the classification include cracking, patching, and rutting. The composite distress index will consider the extent and severity of each distress type. Although several types and degrees of distress may occur in a project, all test sections in a project are to be either in fair or poor condition and as the result of the same type of distress.

Other Site Factors

Other factors that contribute to pavement performance which are not included as study factors will be considered in the test site selection process to keep the experiment within a practical, implementable size.

This experimental design is intended for projects built on fine grained subgrade types and for traffic levels above 85 KESAL per year (outside lane) because they represent the situation of greatest concern and provide a sterner test of rehabilitation strategies. If projects sites meeting these criteria are not located, traffic levels as low as 50 KESAL per year and/or with coarse grained subgrade soils will be considered. However, all test sections in a site must have the same type of subgrade soil and traffic.

The proposed experimental design further constrains other factors through the site selection process as follows:

1. Only pavements that are still in their first performance period (i.e., no prior overlay) will be included in the study to allow quantification of the pavement condition prior to overlay (quantification is not possible for previously overlaid pavements).

2. Existing open graded friction courses should be removed by milling if the pavement is to be considered as a candidate project. The addition of an open graded friction course to the new overlay for safety or other reasons is allowed, but should not be considered part of the structural overlay thickness.

3. Only pavement sections that are at least 8 years old will be included in the study to avoid excessively young pavements. This criterion avoids confounding and is consistent with the age range of pavements being considered for rehabilitation.

4. All test sections in a project should have the same design details, construction quality, and should experience uniform traffic movement.

In addition, it is desired that the Structural Number (SN) for candidate pavements be between 0.8 and 1.2 times that computed using the AASHTO Guide procedure to avoid excessively weak or excessively strong pavement. However, a pavement with an SN outside the desired range will be evaluated and allowed if appropriate.

Rehabilitation Treatment Factors

Rehabilitation treatment factors include two levels of surface preparation, two types of overlay material, and two overlay thicknesses. This will result in eight test section combinations at each of the sixteen projects. In addition, each of the sixteen projects will include a control test section which will only receive routine maintenance (i.e., routine pot hole filling and crack repair and sealing). These additional control test sections will not receive rehabilitation treatment until they reached their terminal condition and are removed from the experiment.

Each of the eight test sections will receive one of the eight different rehabilitation approaches defined by the extent of surface preparation, the overlay material used, and the thickness of the asphalt concrete overlay. This brings the total number of test sections (including control sections) for the entire experiment to 144 on 16 project locations.

Surface Preparation

The proposed surface preparation includes a minimum and intensive level. The minimum level consists of limited patching (filling pot holes), crack repair and sealing. The intensive level consists of cold milling of one to two inches of the entire surface layer plus any necessary crack repairs and sealing. The intensive level represents a premium level of surface preparation addressing geometry, rut removal, and removal of aged asphalt concrete along with provision for a high degree of bonding. Milling should be selected such that the milled surface does not coincide with a layer interface. For a given test section, the milled layer should be replaced with the same overlay material being used for the same section prior to placement of the overlay. This thickness should not be considered part of the overlay thickness. Removal of an open graded friction course should not be considered part of the milling for intensive surface preparation.

AC Mix Design

Problems will likely to develop if an agency or a contractor is required to design or build test sections that vary substantially from the normal practice and experience. For this reason, a standard AC overlay mix design is not required. However, to produce reasonably consistent mixes for the AC overlays using local materials and design procedures, the FHWA Technical Advisory T5040.27, "Asphalt Concrete Mix Design and Field Control" (March 10, 1988) shall be used as a guide by the state and provincial highway agencies. This advisory contains detailed recommendations for material selection, mix design, plant operation, and compaction.

Recycled Mix Constraints

The recycled asphalt concrete overlay material type will be further constrained to insure a reasonable level of consistency as follows:

1. The content of reclaimed asphalt pavement (RAP) in the recycled mix will be fixed at 30%. This reflects a widespread practice and construction/contractor capability, avoids potential problems associated with high RAP ratio mixes, and reflects current judgement that a high RAP ratio could be restrictive and not likely to add much information on the comparative effect or benefit of using recycled materials.

2. Only a soft asphalt cement, selected to provide the required consistency of the combined binders, will be used. This reflects the current practice and avoids problems associated with choosing a representative softening agent from numerous proprietary formulations. However, participating highway agencies may wish to consider the use of proprietary softening agents for additional test sections.

3. All RAP for the test sections of a project should be from the same source, but not necessarily from the project on which the test sections are located.

4. The recycled mixture should be designed to meet the same mixture specifications as the virgin asphalt concrete mix.

Overlay Thickness

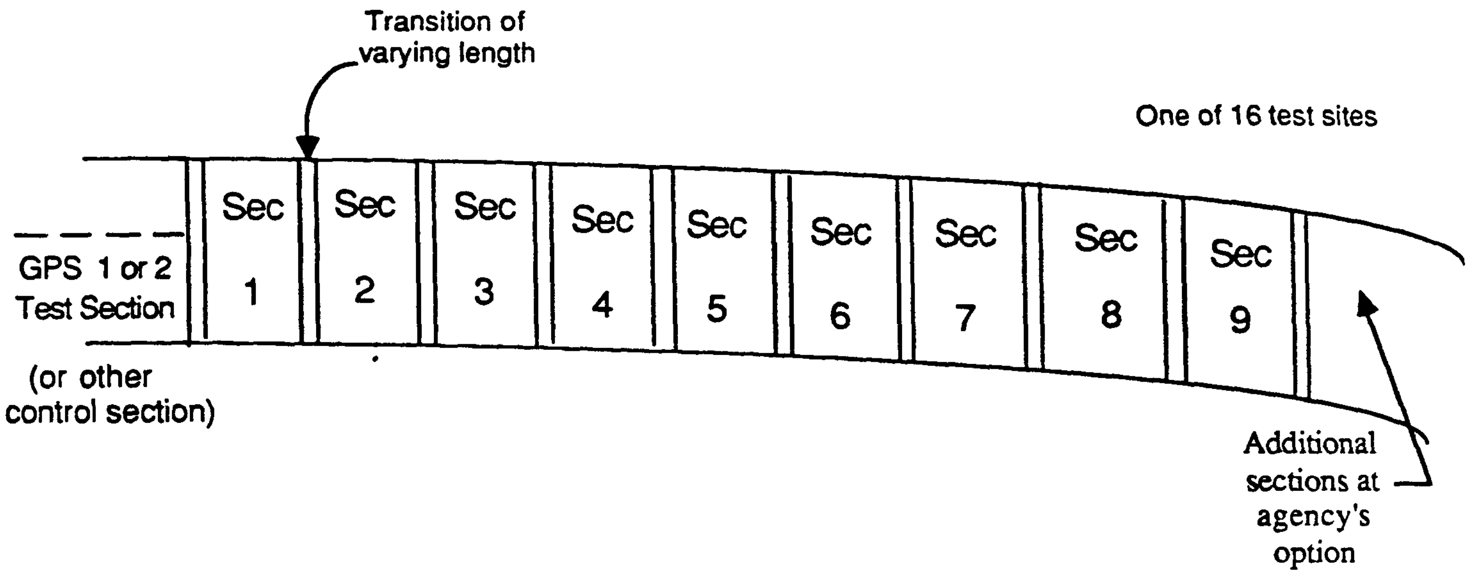
The study design proposes a thin and thick overlay thickness. The thin overlay is defined as 2 inch thick overlay. The thick overlay is defined as 5 inch thick overlay. The surface course of the thick overlay will be of the same mix and thickness as the thin overlay. On milled sections, the same overlay material will be used to replace the milled layer, resulting in an overall overlay thickness equals the milled thickness plus the prescribed overlay thickness.

If desired by the highway agency, additional sections incorporating other features will be evaluated. These sections may include different overlay thickness, overlays with fabrics or fibers, other recycled asphalt mixes, large rock asphalt, or other features.

TEST SECTION SEQUENCE

The sequence shown in Figure 1 is not fixed and may be varied to accommodate local construction conditions. Each test section will be 500 feet in length. The sections will be separated by an appropriate transition length to meet practical construction considerations. Transition section length should be varied based on site conditions. Length should be adequate to accommodate material produced during changes in plant production (virgin vs. recycled). This will assure uniformity of the asphalt mix on the test section.

The sequence of the sections depicted in Figure 1 is not random. The sections are organized based on construction considerations involving surface preparation and overlay material type. This places recycled overlays of



SPS-5 SECTION	SURFACE PREPARATION	OVERLAY MATERIAL	OVERLAY THICKNESS
1	Routine Maintenance		0
2	Minimum	Recycled AC	2-inch
3	Minimum	Recycled AC	5-inch
4	Minimum	Virgin AC	5-inch
5	Minimum	Virgin AC	2-inch
6	Intensive	Virgin AC	2-inch
7	Intensive	Virgin AC	5-inch
8	Intensive	Recycled AC	5-inch
9	Intensive	Recycled AC	2-inch

Figure 1. Illustrative test section layout for SPS-5, rehabilitation of ashpalt concrete pavements.

different thickness adjacent to each other and allows a paver to move from one section to the next without changing materials. Under this approach the overlay thickness can be gradually modified over the transition area.

To help reduce the effort in identifying potential test sites for this experiment, several sources can be used. These include the agency's list of projects scheduled for rehabilitatin, projects identifed as candidates for GPS-6B, "New AC Overlay on AC Pavement", and projects included GPS-1, "Asphalt Concrete Pavements on Granular Base", and GPS-2, "Asphalt Concrete Pavements on Bound Bases". The use of GPS candidate projects will result in reduced data collection effort.

CONSTRUCTION CONSIDERATIONS

Construction problems and variations, as well as environmental conditions during construction could influence the performance of test sections to a great extent. Because construction procedures and control will be the responsibility of the many participating agencies, accurate records of actual construction procedures must be obtained (references to construction specifications will not be adequate). In addition, records must be maintained of weather conditions and events such as equipment breakdowns and material contamination during the test section construction. Testing during construction of the AC overlays will be required to encourage as much uniformity as possible. Guidelines will be developed to cover such items as compaction and air voids content, profile or roughness specifications for the finished overlay, and minimum sampling and testing for quality assurance and control. Field experience gained during the initial projects completed in 1989 will be used to develop these guidelines.

Although the test sections to be monitored are limited to the outside lane in one direction, it is desirable that all rehabilitation preparation activities and overlays be extended the full width of the pavement. Also to ensure uniformity, it is required that all test sections in each site be completed in one construction season.

Arrangements will be made for the collection of AC overlay samples for later testing by SHRP.

PARTICIPATING HIGHWAY AGENCY'S RESPONSIBILITIES

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

- Participation in experimental design and implementation plans
- Nomination of test sites
- Preparation of plans and specifications
- Selection of construction contractor
- Construction of the test pavements
- Construction inspection and management
- Provision of traffic control for all test site data collection
- Routine material sampling
- Collection and reporting of pavement inventory data
- Collecting periodic skid resistance measurements
- Conducting and reporting maintenance activities
- Collection and reporting of traffic and load data

SHRP RESPONSIBILITIES

SHRP responsibilities will include the following:

- Development of the experimental design
- Coordination among participating highway agencies
- Final acceptance of test sites
- Development of standard data collection forms
- Assistance with special sampling requirements
- Coordination of materials sampling and testing
- Monitoring of pavement performance
- Development of a comprehensive database and data entry
- Control of data quality
- Data analysis and reporting

IMPLEMENTATION AND SCHEDULE

This SPS-5 research plan and experimental design is ready for implementation. However, its development was an evolutionary process and change is likely to continue with detailed adjustments as experience is gained from early projects.

Step one of implementation is the identification and submission by highway agencies of candidate projects for possible inclusion in the study. A total of 16 projects, 4 in each climatic region, will be required to complete the experiment as planned. SHRP desires to select and construct test sections on at least 2 or 3 projects during the 1989 construction season. The remaining sections will be selected from the identified candidates to be constructed in 1990. SHRP will assist the highway agencies in identifying candidate projects.

The existing condition of the test sections, in terms of distress, profile, deflections, and material characteristics, must be assessed prior to the rehabilitation and overlay activities. This will require extensive coordination between SHRP staff, regional offices, and the highway agencies. Traffic data must also be collected at each site using WIM equipment. It is required that the WIM equipment be installed within a year of the rehabilitation and perferably when the rehabilitation work is carried out.

The proposed schedule of activities for this experiment is as follows:

Nomination of Candidate Projects:	
- For 1989 Construction Season	April 30, 1989
- For 1990 Construction Season	May 30, 1989
Review and Screening of Candidate Projects	As received
Notification of State/Provinces of Accepted Projects	
- For 1989 Construction Season	June 1, 1989
- For 1990 Construction Season	July 15, 1989
Supplementary Recruitment Activities (with individual agencies)	As needed
Implementation Workshop with Participating Agencies	

- For 1989 Construction Season (with individual agencies)	As required by Participating Agency
- For 1990 Construction Season	Mid-August 1989