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STRATEGIC HIGHWAY RESEARCH PROGRAM

SPECIFIC PAVEMENT STUDIES
EXPERIMENTAL DESIGN AND RESEARCH PLAN
FOR EXPERIMENT SPS-2
STRATEGIC STUDY OF STRUCTURAL FACTORS
FOR RIGID PAVEMENTS

STRATEGIC HIGHWAY RESEARCH PROGRAM
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SPECIFIC PAVEMENT STUDIES

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STRATEGIC STUDY OF STRUCTURAL FACTORS FOR RIGID PAVEMENTS

INTRODUCTION

This report describes the experimental design and implementation considerations for the Specific Pavement Studies experiment SPS-2, Strategic Study of Structural Factors for Rigid Pavements. The proposed experimental design incorporates factors from the experiments on subsurface drainage and high strength concrete proposed in the May 1986 SHRP Research Plans. It has been developed by SHRP in cooperation with state and provincial highway agency personnel participating in various meeting, including an SPS-2 workshop held in Washington, D.C., June 21-22, 1989. The consensus of the participants from Puerto Rico, 14 states, and the Federal Highway Administration and comments furnished by other state and provincial highway agency personnel are incorporated into the experimental design and research plan described in this report. The research plan will be used by the highway agencies and SHRP as a guide for selecting candidate projects to be considered for inclusion in the SPS-2 experiment and for the design and construction of the test sections.

This experiment, while being coordinated through SHRP, is being 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 will require that participating agencies agree to the same experimental factors and to construct the required test sections in a consistent manner.

While highway agencies are primarily concerned with problems and issues of a more local nature, this experiment is designed as a nationwide experiment to fulfill some of the basic needs of the highway pavement community at large. The statistical aspects of this experiment make the full cooperation of participating highway agencies crucial to its success. Hopefully, specific issues of local concern as well as innovative techniques can also be incorporated through the impetus and opportunities provided by this national study.

PROBLEM STATEMENT

Substantial progress has been made over the past century towards providing economical pavements. Pavement design procedures, construction techniques, and material specifications have been developed and refined as tools to aid engineers in design and management of highway pavement systems. While much has been learned in recent years, highway agencies need to know a great deal more to improve existing pavement design methods and the tools needed to effectively manage pavement networks.

At present, highway agencies lack sufficient information on the influence of concrete strength and pavement drainage on the performance of portland cement concrete (PCC) pavements. Although these factors appear in the AASHTO Guide for Design of Pavement Structures, they were incorporated into the equations through rational engineering considerations and not as the direct result of a structured field experiment. Other factors that influence the structural and functional performance of concrete pavements such as joint spacing, joint orientation, and shoulder type are not directly incorporated in the AASHTO Design Guide.

Concrete strength is included in the AASHTO rigid pavement design equation even though it was not a design factor (it was not systematically varied) at the AASHO Road Test. It is included based on the stress ratio concept in which the ratio of tensile stress to tensile strength is rationally related to the fatigue behavior of portland cement concrete. In the AASHTO design equation, concrete strength, as expressed by the modulus of rupture, has a strong effect on the performance life of rigid pavements. This is an important consideration because current trends in developing specifications for rigid pavements are aimed at using PCC strength as a primary indicator of performance. Consequently, a contractor who provides higher PCC strengths might receive a bonus payment based on the present understanding of the relative relationship of PCC strength to pavement performance. This highlights the need for better knowledge of the influence of PCC strength on pavement performance.

Drainage is another factor that is intuitively considered a significant pavement performance factor. Drainage coefficients have been introduced in the AASHTO design equations and other pavement design procedures in a rational combination with other factors. Like strength, the effect of drainage has not been supported by quality experimental field data that directly substantiates its influence on performance.

Effective load transfer contributes significantly to an improved concrete pavement performance and is accounted for in the AASHTO Design Guide. Analytical methods have existed for many years and a number of studies on load transfer have been conducted. However, new approaches exist for providing load transfer such as redistribution of dowels, variation of dowel cross section and skewed joints. The ability of these analytical methods to reliably predict the response and performance of pavements with such load transfer options need to be evaluated. Quantification of the effect of load transfer with respect to the other major structural factors is also required.

Analytical methods show that concrete pavement deflection is reduced by use of tied concrete shoulders or widened lanes. Although specific field studies have been conducted to verify this structural response, additional data is required to evaluate the potential long-term performance improvement. There are other design features, such as joint orientation that are known to influence pavement performance. As more factors are considered, defining the effect of each individual factor analytically becomes more difficult. An experimental design structured to examine such factors is the best way to determine the influence of these factors on pavement performance. Definition of these effects would then provide the means for evaluating and calibrating pavement design models.

Additionally, highway agencies lack information on the interaction of these key factors with other variables such as climate. Therefore, controlled field experiments are necessary to answer the following questions:

> To what extent does the influence of pavement drainage on pavement performance vary from wet to dry climatic zones and what is its relative importance in each zone?

To what extent does concrete strength or type of the base layer influence pavement performance and what is the relative importance of each? How do environmental factors influence the relative importance?

Is there a benefit of using dowels or skewed joints or would undoweled or perpendicular joints provide similar performance? Does the relative performance depend on climatic conditions?

What is the relative performance of jointed plain concrete pavements to jointed reinforced concrete pavements? Does the relative performance depend on climatic conditions?

The General Pavement Studies (GPS) experiments on portland concrete pavements GPS-3, "Jointed Plain Concrete Pavements" and GPS-4, "Jointed Reinforced Concrete Pavements" which are limited to pavements constructed since 1965, address some of the issues addressed by this study. However, the GPS experiments will only provide a limited precision due to the uncertainties in historical data and lack of experimental control over some key variables that influence pavement performance. The most critical unknown in GPS research is the traffic loading applied at each test section since construction. Other historical factors such as special events (rainstorms) or problems during construction of the GPS sections are not uniformly known. Although as many constraints as feasible were applied to selection of GPS test sections, some important factors such as age of the test section, shoulder type, and drainage features are not systematically controlled. Although GPS will provide valuable and timely information, controlled SPS studies of newly constructed pavement sections are necessary to provide an accurate estimate of the relative influence of the key pavement elements that affect pavement performance. The importance of this experiment is highlighted by its ability to evaluate the interaction of drainage, structural parameters, and climatic factors on pavement performance in a controlled manner.

OBJECTIVE

The objective of this study is to more precisely determine the relative influence of the strategic factors that affect performance of rigid pavements. The primary factors addressed in this study include drainage, base type, concrete strength and thickness, and lane width. Other factors addressed in the study include load transfer, joint orientation, and reinforcement. The study objective includes a determination of the influence of environmental region and soil type on these factors. Accomplishing this objective will provide substantially improved "tools" for use in the design and construction of new and reconstructed rigid pavements.

PRODUCTS

Some of the products of this experiment will help accomplish the objectives of the SHRP Long Term Pavement Performance program as stated in the May 1986 Final Report on the Strategic Highway Research Program Research Plans. The key products from the proposed study will include:

1. Evaluation of existing design methods.

2. Development of improved design equations for new and reconstructed pavements.

3. Determination of the effects of specific design features on pavement performance.

4. Development of a comprehensive data base for use by state and provincial engineers and other researchers.

Development of the national pavement data base is the vehicle or tool to expedite the analyses needed to produce the other products. This data base will permit centralized and efficient distribution of massive quantities of data to participating highway authorities, researchers, and other interested parties.

The AASHTO Guide for Design of Pavement Structures is representative of current pavement design methods. It is used in the following discussion to demonstrate the type and nature of products that can be developed from this experiment. However, other design methods or performance equations can be evaluated or improved using similar types of analysis and the extensive data base that will be developed from this study.

The data produced by this experiment will be used to evaluate existing design methods and the performance equations. The AASHTO basic design equation for rigid pavements can be evaluated by comparing observed serviceability index (derived from profile and distress measurements on each test section) against that predicted by the design equation. All of the inputs concerning the pavement structure, traffic, environment, drainage and material properties will be quantified. Additionally, this experiment will permit the variability associated with each of the inputs to be quantified and allow evaluation of the reliability aspects of the model.

The data from this experiment can be used to develop or improve pavement design methods. For example, the findings on the influence of climate may permit a more accurate quantification of the climate influences directly into an empirical design model.

Further development of mechanistic-empirical models, sometimes referred to as "mechanistic" models can be achieved through controlled experimentation. For example, these models can be further developed through improvements in the empirical relationships between mechanistic formulated variables (responses) and measures of pavement distress (such as faulting, cracking, etc.) or through field studies of pavement responses.

An example of an empirical model is the relationship assumed between the computed horizontal tensile strain in the bottom of the concrete layer and the development of fatigue cracks. In these type of models, theoretical based variables, such as computed stresses or strains, are related to measures of distress through regression analysis. Improvement of the empirical portions of these models will greatly enhance their reliability and usefulness for the design of new pavements and the evaluation of existing pavements.

An alternative to improving the empirical portion of mechanistic-empirical models, is the improvement, validation or calibration of the mechanistic portion of the model through field studies of pavement responses. This type of research requires measurement of key pavement responses, such as deflections and strains and the site-specific axle loads and climatic variables. It provides a basis for evaluating theoretical response models, studying the relationship between theoretical material characterizations and materials test results, and establishing the changes in material properties due to environmental effects. Therefore, this research requires the in-pavement instrumentation of selected test sites to obtain the necessary data.

The proposed experimental design consists of a primary (basic) experiment and two secondary (supplementary) experiments. The primary experiment is aimed directly at determining the effects of the following specific pavement design features:

1. In-pavement drainage systems.
2. Base type.
3. Concrete strength.
4. Pavement thickness.
5. Lane width.

The secondary experiments address the following pavement design features:

1. Load transfer.
2. Joint orientation.
3. Reinforcement.

The interaction of these factors will be determined in combination with the effect of environmental region and soil type. The effects of these factors will be studied under realistic performance conditions with significant materials and construction control. This experiment will add significantly to the understanding of long-term performance of new and reconstructed jointed plain and jointed reinforced concrete pavements.

BENEFITS TO PARTICIPATING HIGHWAY AGENCIES

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 and techniques employed by that agency and exposed to local climate and truck loadings, participating agencies will be able to make more direct use of the results. Test sections within an agency's jurisdiction will also allow that agency an opportunity to directly relate their pavement monitoring and performance evaluation methods to those employed by SHRP. For instance, an agency that usually uses a Dynaflect or Roadrater deflection measuring device can develop correlations with the falling weight deflectometer measurements performed using SHRP equipment.

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 SHRP team, researchers and highway personnel from other agencies.

INNOVATION

Sponsoring agencies will also have the opportunity to expand the experiment to meet some of their own interests and concerns as well as incorporate innovative technology. For example, agencies interested in experimenting with high early strength concrete, "fast track" or other innovative ideas could construct additional test sections near the SHRP test sections and directly compare their performance to that of the basic experimental test sections. This approach provides participating agencies the opportunity to conduct intensive pavement field research in an economic manner by taking advantage of the research infrastructure established for the SHRP study.

SHRP encourages the construction of supplemental test sections and is prepared to assist interested agencies in the experimental design, data collection, and performance evaluation of such supplemental experiments. Further if a group of participating agencies desires to join together in such an activity, SHRP is also prepared to work with these states and/or provinces to coordinate a multi-state/provincial supplemental experiment. The section of this report, "Ideas for Extension of Experiment by Participating Highway Agencies", identifies some potential areas for further study in this experiment.

EXPERIMENTAL DESIGN

The experimental design plan for this experiment incorporates input from state and provincial highway agencies and other interested parties. It consists of a primary (basic) experiment and two secondary (supplement) experiments. The basic experiment, designated SPS-2, addresses doweled jointed plain concrete pavements. The supplementary experiments, designated SPS-2A and SPS-2B, address undoweled jointed plain concrete pavements with skewed joints and jointed reinforced concrete pavements, respectively. Table 1 depicts the experimental design for the basic experiment on doweled jointed plain concrete pavements (SPS-2). Table 2 and 3 depict the experimental design for the supplementary experiments on undoweled jointed plain concrete pavements with skewed joints (SPS-2A) and jointed reinforced concrete pavements (SPS-2B), respectively. The study factors are grouped into structural factors that relate the base and concrete surface, and site factors that relate to the climate and subgrade.

STATISTICAL EXPERIMENTAL DESIGN ASPECTS

The full factorial for the basic experiment on doweled jointed plain concrete pavements (SPS-2), as shown in Table 1, contains 192 factor level combinations. In this table, the eight environmentally-related (soil and climate) combinations are shown across the top and the 24 pavement structure combinations are shown along the left side. The construction of 24 test sections at each site would require a greater effort on the part of the participating agencies. Therefore, the basic experiment has been developed so that only 50% of the possible combinations of factors, i.e. 12 test sections, will be built at each site. This approach offers a significant reduction in

Table 1. Basic Experiment on Doweled Jointed Plain Concrete Pavements (SPS-2)

PAVEMENT STRUCTURE					CLIMATE ZONES, SUBGRADE, SITE															
DRAIN	BASE TYPE	PCC		LANE WIDTH	WET								DRY							
					FREEZE				NO FREEZE				FREEZE				NO FREEZE			
		THICK	STRENGTH		FINE		COARSE		FINE		COARSE		FINE		COARSE		FINE		COAPSE	
		in.	psi	ft	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
NO	AGG	8	550	12	J1		L1		N1		P1		R1		T1		V1		X1	
				14		K1		M1		O1		Q1		S1		U1		W1		Y1
			900	12		K2		M2		O2		Q2		S2		U2		W2		Y2
				14	J2		L2		N2		P2		R2		T2		V2		X2	
		11	550	12		K3		M3		O3		Q3		S3		U3		W3		Y3
				14	J3		L3		N3		P3		R3		T3		V3		X3	
			900	12	J4		L4		N4		P4		R4		T4		V4		X4	
				14		K4		M4		O4		Q4		S4		U4		W4		Y4
NO	LCB	8	550	12	J5		L5		N5		P5		R5		T5		V5		X5	
				14		K5		M5		O5		Q5		S5		U5		W5		Y5
			900	12		K6		M6		O6		Q6		S6		U6		W6		Y6
				14	J6		L6		N6		P6		R6		T6		V6		X6	
		11	550	12		K7		M7		O7		Q7		S7		U7		W7		Y7
				14	J7		L7		N7		P7		R7		T7		V7		X7	
			900	12	J8		L8		N8		P8		R8		T8		V8		X8	
				14		K8		M8		O8		Q8		S8		U8		W8		Y8
YES	Perm. ATB	8	550	12	J9		L9		N9		P9		R9		T9		V9		X9	
				14		K9		M9		O9		Q9		S9		U9		W9		Y9
			900	12		K10		M10		O10		Q10		S10		U10		W10		Y10
				14	J10		L10		N10		P10		R10		T10		V10		X10	
		11	550	12		K11		M11		O11		Q11		S11		U11		W11		Y11
				14	J11		L11		N11		P11		R11		T11		V11		X11	
			900	12	J12		L12		N12		P12		R12		T12		V12		X12	
				14		K12		M12		O12		Q12		S12		U12		W12		Y12

AGG = Dense-graded untreated aggregate base
LCB = Lean concrete base
Perm. ATB = Permeable asphalt treated base
All perpendicular doweled joints at 15-feet spacing

Table 2. Supplementary Experiment on Undoweled Plain Concrete Pavements with Skewed Joints (SPS-2A)

DRAINABLE	BASE TYPE	SLAB THICKNESS	LANE WIDTH	SITE a	SITE b
NO	AGG	8	12	a13	
			14		b13
		11	12		b14
			14	a14	
NO	LCB	8	12		b15
			14	a15	
		11	12	a16	
			14		b16
YES	Perm. ATB	8	12	a17	
			14		b17
		11	12		b18
			14	a18	

AGG = Dense-graded untreated aggregate base
LCB = Lean concrete base
Perm. ATB = Permeable asphalt treated base
All skewed joints, variable spacing: 12-15-13-14 feet
Concrete flexural strength: 550 psi @ 14 days
Site a supplements Site J,L,N,P,R,T,V or X in the basic experiment
Site b supplements Site K,M,O,Q,S,U,W or Y in the basic experiment

Table 3. Supplementary Experiment on Jointed Reinforced Concrete Pavements (SPS-2B)

DRAIN	BASE TYPE	PCC THICK in.	PCC STRENGTH psi	LANE WIDTH ft	SITE 1	SITE 2
NO	LCB	8	550	12		d19
				14	c19	
			900	12	c20	
				14		d20
		11	550	12	c21	
				14		d21
			900	12		d22
				14	c22	
YES	Perm. ATB	8	550	12		d23
				14	c23	
			900	12	c24	
				14		d24
		11	550	12	c25	
				14		d25
			900	12		d26
				14	c26	

LCB = Lean concrete base
Perm. ATB = Permeable asphalt treated base

cost to participating agencies and enhances implementation practicality with no significant loss of precision. Thus, 16 test sites are required for this experiment.

Similarly, the full factorial for the supplementary experiment on undoweled jointed plain concrete pavements with skewed joints (SPS-2A), as shown in Table 2, contains 12 pavement structure combinations for each of the eight environmentally-related (soil and climate) sites. However, to enhance implementation practicality, only 50% of these combinations, i.e. 8 test sections, will be built at each the sixteen test sites.

Also, the full factorial for the supplementary experiment on jointed reinforced concrete pavements (SPS-2B), as shown in Table 3, contains 16 pavement structure combination for each of the eight environmentally-related (soil and climate) sites. However, only 50% of these combinations, i.e. 8 test sections, will be built at each of the sixteen test sites.

TEST SITE/TEST SECTION COMBINATIONS

As shown in Table 1, each of the 192 test site/test section combinations included in the basic experiment SPS-2 is indicated by a cell containing a letter-number code. The letter denotes one of 16 test sites (J through Y) where a test section is to be constructed, while the number designates one of twelve test sections that are to be constructed at each site.

As can be seen in Table 1, 48 test sections representing all structural factor and subgrade type combinations in the basic experiment are to be constructed in each of the four climatic regions, with 24 test sections to be constructed on fine-grained subgrade and 24 test sections on coarse-grained soil. Further, for each climate-soil combination, one-half of the 24 test sections are to be constructed at one test site and the other one-half are to be constructed at another site in the interest of implementation practicality. While it would be desirable to have these two sites located in different states and/or provinces, it is not absolutely necessary. However, if the two test sites are located in the same state or province, the two sites would preferably be located on different projects.

Similarly, as shown in Table 2 for the supplementary experiment on undoweled jointed plain concrete pavements with skewed joints (SPS-2A), one-half of the 12 test sections are to be constructed at each site, as indicated by cells each containing a letter-number code. The letter (a or b) refers to one of the 16 test sites (J through Y) where a test site incorporating the basic experiment is to be constructed, while the number designates one of the six test sections that are to be constructed at each site in addition to the twelve sections required for the basic experiment.

Also, for the supplementary experiment on jointed reinforced concrete pavements (SPS-2B), as shown in Table 3, one-half of the 16 test sections are to be constructed at each site, as indicated by cells each containing a letter-number code. The letter (c or d) refers to one of the 16 test sites (J through Y) where a test site incorporating the basic experiment is to be constructed, while the number designates one of the eight test sections that are to be constructed at each site in addition to the twelve sections required for the basic experiment.

The experimental design for this study indicates that each test site will include at least the twelve test sections required for the basic experiment on doweled jointed plain concrete pavements (SPS-2). A test site incorporating the supplementary experiment on undoweled jointed plain concrete pavements with skewed joints (SPS-2A) will include 18 test sections. Similarly, a test site incorporating the supplementary experiment on jointed reinforced concrete pavements (SPS-2B) will include 20 test sections. However, a test site incorporating both supplementary experiments will include 26 test sections.

STATISTICAL IMPLICATIONS

As shown in Table 1 for the basic experiment (SPS-2), the set of 24 sections that are to be constructed in each climatic-soil region is divided into two different subsets, each of which consists of twelve test sections. Subsets with similar test sections are to be constructed in each of the eight climatic-soil regions. Each subset of twelve test sections contains a number of sections at each level of each of the four structural factors. For example, each of six sections will have a thin concrete surface and each of the other six sections will have a thick concrete surface. Also each of four sections will have a dense-graded untreated aggregate base, each of four other sections will have a lean concrete base and each of the remaining four sections will have a permeable asphalt-treated base. Differences among mean values (of distress and performance) for each group of eight similar test sections can therefore be used to evaluate the effects of moisture (Sites J through Q versus Sites R through Y), temperature (Sites J through M and R through U versus sites N through Q and V through Y), soil type (Sites J, K, N, O, R, S, V, W versus Sites L, M, P, Q, T, U, X, Y), and the interactions among these three factors. Mean differences between the two sites in each of the eight columns of Table 1 (e.g. between Sites J and K) can statistically be regarded as chance variations between similar test sites for each of the eight climate-soil combinations and thus provide a basis for the assessment of experimental error.

To achieve the goals of the basic experiment on doweled jointed plain concrete pavements (SPS-2), twelve sections would have to be constructed at each of sixteen sites, preferably located in different states and/or provinces. Similarly, six or eight additional sections would have to be constructed at each of the sixteen sites to achieve the goals of the supplementary experiment SPS-2A on undoweled jointed plain concrete or SPS-2B on jointed reinforced concrete pavements, respectively.

SITE RELATED FACTORS

Site related factors include traffic, four climatic regions (wet-freeze, wet-no freeze, dry-freeze, and dry-no freeze), and two subgrade soil types (fine and coarse).

Traffic

Traffic, while a major factor, is not handled as a multi-level experimental design factor in the experiment. Instead, traffic will be addressed as part of the test site selection process. An eligible test site candidate must have a minimum estimated traffic loading of 200,000 ESAL/year

(Equivalent Single Axle Loads) on the outside lane. Traffic will vary from site to site and will therefore be a co-variable in the study. The actual site specific traffic loading will be monitored through permanently installed weight-in-motion (WIM) equipment with automatic vehicle classification capability.

Climatic Factors

The climate factor levels for this experiment are the same as those for the GPS experiments. The wet climatic regions include locations that have a high potential for moisture in the entire pavement structure throughout most of the year, while dry climatic regions include areas that have very little and low seasonal fluctuation of moisture in the pavement structure. The freeze climatic regions include locations with severe winters that result in long-term freezing of the subgrade, while no freeze climatic regions include areas that do not have long-term freezing of the subgrade.

Site specific climatology data is necessary and may require installation of a local weather station to collect the necessary information. However, if the site is located in close proximity to an existing weather station, then a site specific weather station may not be needed.

Soil factor

The subgrade factor levels for this experiment of fine and coarse are the same as those for the GPS experiments.

STRUCTURAL FACTORS

The proposed experimental design includes two sets of two level structural factors for base/subbase and two sets of three structural factors for surface.

Base Structural Factors

The two sets of factors for base/subbase are base type (dense-graded aggregate and lean concrete) and drainage (yes and no).

Base Type. The base types selected for the study are dense-graded untreated aggregate (unbound), lean concrete, and open-graded asphalt-stabilized materials.

For the undrained pavement sections, a 6 inch thick lean concrete base or a 6 inch dense-graded untreated aggregate base is required. For the drainable pavement sections, a 6-inch thick open-graded (permeable) asphalt stabilized base will be used as part of the drainage system.

Drainage. The drainage factor includes two levels represented by the presence or absence of an in-pavement drainage system. Drainable test sections will incorporate a drainage system that consists of a highly permeable (>20,000 ft/day) asphalt-treated drainage layer extending the full width of the pavement to the outside edge of the concrete pavement, a fabric filter material, and a fabric-wrapped longitudinal edge drain collector system as shown in Figure 1. Neither permeable layer nor longitudinal edge drains will be provided in the non-drained sections.

The permeable drainage layer to be incorporated in the pavement structure will consist of a 6-inch thick asphalt-treated open-graded material meeting the gradation proposed in Table 4. The layer should extend across all pavement lanes and the shoulder. At the edge of the concrete pavement, this treated layer interfaces with an edge drain and trench containing an untreated open graded granular material as shown in Figure 1.

Also as shown in Figure 1, it is recommended that a fabric filter material be used to prevent intrusion of fines into the permeable drainage materials. These filter materials must be designed for each site considering the relative gradations of materials at the interface between the drainage layer and untreated layer. SHRP will provide guidelines for the design of these material and sample specifications for their procurement. The use of this filter fabric should not serve as a proprietary product evaluation test.

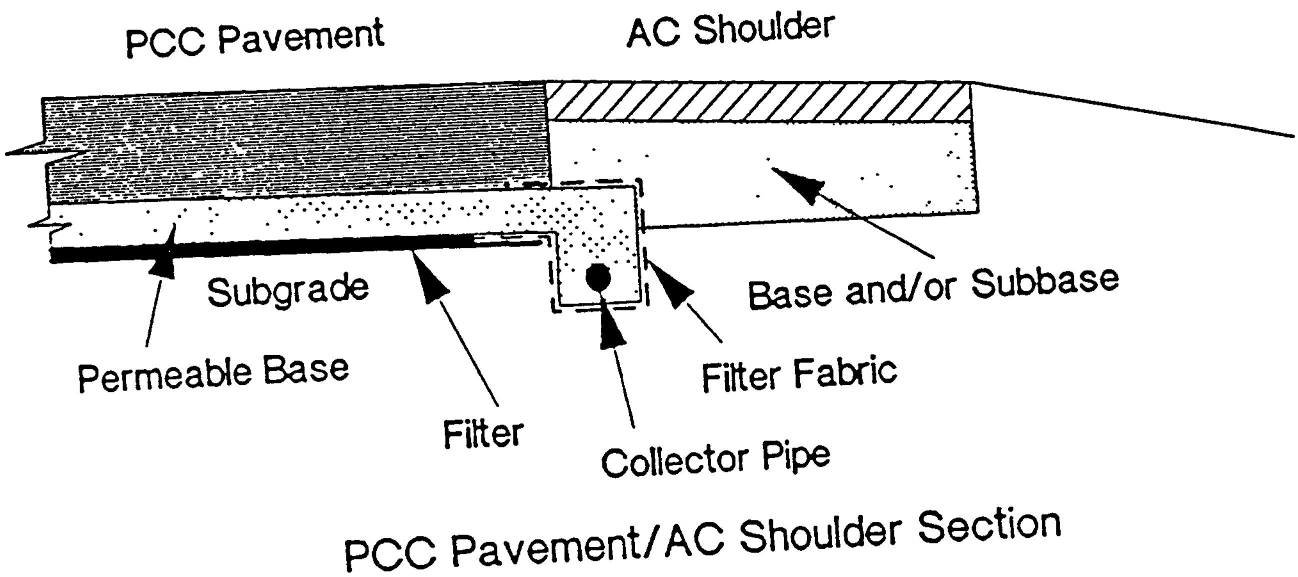

Figure 1. Typical pavement section with permeable base/drainage

Table 4. Gradation for asphalt treated permeable base.

Sieve Size	Percent Passing
1 1/2-inch	100
1-inch	95 - 100
3/4-inch	-
1/2-inch	25 - 60
3/8-inch	-
No. 4	0 - 10
No. 8	0 - 5
No. 10	0 - 2
Coefficient of Permeability (feet/day)	20,000

Each fabric will be designed to site conditions and specified to allow use of materials meeting the specifications. The same filter fabric should be used beneath the treated drainage layer and in the edge drain trench.

In the transition zone from a drained to an undrained section, a transverse collector system may be incorporated into the drainage layer to intercept all water within the drainage layer and move it to the outside edge of the pavement structure. The details of this transverse drainage structure could be similar to that of the edge drain (trench with drain pipe). Details and need for transverse drainage interceptor will depend on site conditions.

Pavement Surface Structural Factors

Surface structural factors addressed in the basic experiment on doweled jointed plain concrete pavements (SPS-2) and the supplementary experiment on jointed reinforced concrete pavements (SPS-2B) include concrete slab thickness, concrete flexural strength, and lane width. Surface structural factors addressed in the supplementary experiment on undoweled jointed plain concrete pavements with skewed joints (SPS-2A) include concrete slab thickness and lane width.

Concrete Thickness. The experimental design includes two levels of concrete slab thickness: 8 inch and 11 inch. These thickness in conjunction with the anticipated traffic, pavement and base type, presence or absence of drainage, and prevailing environmental conditions will provide different performance lives for each test section. The 3 inch difference between the lower and upper levels of concrete thickness is necessary to demonstrate the effect of surface thickness and its interaction with other factors on performance. These thickness levels should remain consistent across all test sites to allow proper evaluation of the effect of pavement thickness on performance.

Concrete Flexural Strength. Two levels of concrete flexural strength are included in the experimental design. These are 550 and 900 psi at 14 days as determined from third point loading tests. These values represent target levels for the mean value of concrete strength.

Lane Width. The experimental design includes two levels of lane width. These are standard 12 feet and 14 feet wide lanes.

Other Pavement Details

. The experimental design requires that different specific pavement structure details be used for each of the basic and supplementary experiments.

Basic Experiment on Doweled Jointed Plain Concrete Pavements (SPS-2). For this experiment, perpendicular transverse joints spaced at a uniform spacing of 15 feet are required. Eighteen inch long epoxy coated dowels spaced at 12 inches on centers, are required at all joints. Dowels with 1-1/4 and 1-1/2 inches diameter are required for the 8 inch and 11 inch thick slabs, respectively.

Supplementary Experiment on Undoweled Jointed Plain Concrete Pavements (SPS-2A). For this experiment undoweled skewed joints with variable 12-15-13-14 feet spacing are required. Only one level of concrete flexural strength, i.e. 550 psi at 14 days will be used in this supplementary experiment.

Supplementary Experiment on Jointed Reinforced Concrete Pavements (SPS-2B). For this experiment, perpendicular joints with a uniform joint spacing of 30 feet are required. Dowel details are similar to those required for the basic experiment. Reinforcement will conform to wire reinforcement institute recommendation for northern climate. Undrained pavement sections with dense-graded untreated aggregate base will not be included in this experiment.

TEST SECTION CONFIGURATION AND CONSTRUCTION CONSIDERATIONS

The test sections may be built as part of a new or reconstructed roadway or as a separate parallel test road. If test pavements are constructed as part of a reconstructed roadway, the reconstruction must include all lanes. In all cases the cross section must be uniform. Pavement widening project are suitable only if all lanes are reconstructed to achieve a uniform pavement cross section at all test sections. Construction of the test sections in a lane which is added to an existing pavement is not suitable for this experiment because of the difficulty of discerning the relationship of distresses developed in the existing lanes to those developed in the widened test sections.

Figure 2 illustrates a conceptual test site layout for the basic experiment. The experimental design requires a minimum test section length of approximately 600 feet (twenty, 30 foot slabs for JRCP and forty, 15 foot slabs for JPCP). This will enable the drilling and sampling operations to be performed outside the 500-ft. monitoring length. Transitions sections are required between test sections. These transition sections should be at least 180 feet long consisting of several 15 feet long JPCP slabs, 30 feet long JRCP slabs, variable spacing JPCP slabs with skewed joints, or combination thereof. The first 60 feet of transition sections on either side of a test section will be identical to the adjacent test section. In instances where slab thickness changes from one test section to another, the change in slab thickness will occur within one transition section slab. Depending on site conditions, transverse drains may be required in transition sections separating drained from undrained test sections.

Ideally all test sections should be placed on low grade fill sections. While test sections may be built on cut or fill, no test section should be built on a cut/fill transition or on side hill fills.

Crowned and non-crowned (constant cross-slope) pavement cross sections can be constructed. On crowned sections, longitudinal edge drains should be constructed on both sides of the pavement.

IDEAS FOR EXTENSION OF EXPERIMENT BY PARTICIPATING HIGHWAY AGENCIES

Most highway agencies probably do not normally build portland cement concrete pavements with the combinations of pavement type and details, base, and drainage system included in this experiment. Agencies participating in this experiment are urged to consider construction of additional experimental sections to evaluate innovative features of local interest in addition to those required. For example, supplemental sections can be constructed as part of the test site to evaluate the following materials or factors:

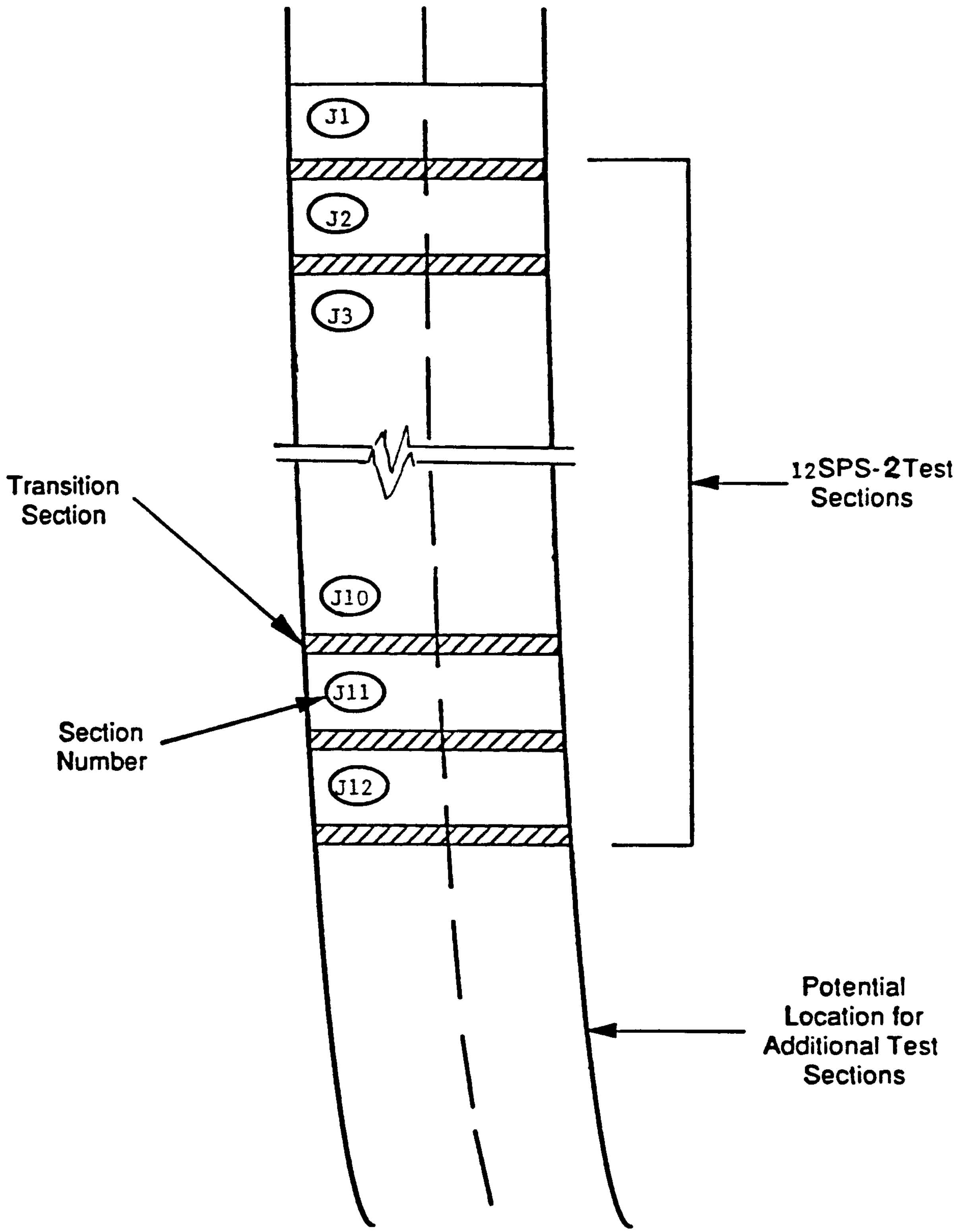

Figure 2. Schematic layout for test sections at Site J

* Other joint spacings.
* Other concrete slab thicknesses.* Alternate drainage methods.
* Very high strength concrete, high early strength concrete.
* Soil cement or non-conforming aggregate bases.
* Tied concrete shoulders

PARTICIPATING HIGHWAY AGENCY RESPONSIBILITIES

Participating highway agencies play the 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.
* Preparation of plans and specifications.
* Selection of construction contractors.
* Development of mixture designs.
* Materials testing to characterize in-place materials.
* Construction of test sections.
* Construction control, inspection and management.
* Installation and operation of Weigh-In-Motion equipment and submission of traffic and load data
* Installation and operation of in-pavement instrumentation and reporting of data on a limited number of test sections.
* Provision of traffic control for all test site data collection.
* Material sampling and testing.
* Collecting and reporting of as-built construction data.
* Conducting and reporting of periodic skid resistance.
* Conducting and reporting maintenance activities.
* Collecting and reporting of weather data.

SHRP RESPONSIBILITIES

The primary role of the SHRP 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 SHRP team will be responsible for include:

* Development of the 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.
* Review of mix design and construction plans.
* Monitoring of pavement performance.
* Development and operation of comprehensive data base and data entry.
* Control of data quality.
* Data Analysis and reporting.

IMPLEMENTATION AND SCHEDULE

This SPS-2 research plan and experimental design is ready for implementation. However, its development was an evolutionary process and refinements may be required as experience is gained from early projects.

The initial step in the implementation of this experiment is the identification and submission by highway agencies of candidate projects for possible inclusion in this study. A total of 16 projects, 4 in each climatic region, will be required to complete the experiment as planned. It is anticipated that only a few SPS-2 projects will be built during the 1990 construction season. The remaining test sites will be selected from the identified candidates scheduled for construction in 1991, or even 1992 if necessary. To assist the highway agencies in identifying candidate projects, guidelines for nominating and evaluating candidate projects for this experiment will be described in detail in a separate report. This report will include nomination forms, identify project selections criteria, and outline highway agency participation requirements.