National Research Council

STRATEGIC HIGHWAY RESEARCH PROGRAM

SPECIFIC PAVEMENT STUDIES EXPERIMENTAL DESIGN AND RESEARCH PLAN FOR EXPERIMENT SPS-8 STUDY OF ENVIRONMENTAL EFFECTS IN THE ABSENCE OF HEAVY LOADS

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Washington, DC 20006

August 1991

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INTRODUCTION

It is well known that environment, that is climate and geology, profoundly affect pavement performance. This is acknowledged by pavement engineers every time they employ "regional factors" or create local adjustments to general pavement design equations. Environmental conditions alone or interacting with the pavement materials may generate major distress in pavements. Frost heave, soil swell and transverse, low temperature cracking are obvious, and common, environmentally related distresses which have little or no traffic related component. There are other distresses that result from the interaction of load and environment. Block cracking in asphalt pavements and faulting and pumping in rigid pavements are common examples of such interactive distress.

The real impact of the natural environment on long-term performance has been extremely difficult to quantify as have the interactions between environmental stresses and load stresses. Because environmental conditions are both omnipresent and constantly varying in time and space, short-term, one-location field tests are inadequate to assess the full impact of environment on long term pavement performance. Many mechanistic models have been developed to explain and predict environmentally induced distress and have been used successfully to indicate when such distresses may overwhelm a particular pavement design and preventive measures are required. What the highway community lacks is a sufficient set of field data that allow the incorporation of such models in general pavement design procedures. Without sufficient field data and this linkage between general design and specific distress models, it is impossible to estimate the servicability losses due to environmental distress or to estimate the risk posed to long-term performance when environmental distresses are not, or can not be, prevented. The AASHTO Guide for Design of Pavement Structures, 1986 (AASHTO Guide) made the first attempt to consider environmental distress in a general "servicability loss" design procedure. This attempt addressed only distress related to frost heave and soil swell and has not been widely applied because of the absence of field data.

Much of the collective experience with environmental distress, particularly in its more subtle forms, comes from low volume roads where the environmentally induced distresses are not masked by load related distresses. Unfortunately, much of this knowledge is not transferable to the heavy traffic situation because the performance mechanisms of the pavement are much different. The Specific Pavement Studies' experiment, Study of Environmental Effects in the Absence of Heavy Loads, designated SPS-8, will utilize lower volume roads as test sites so that a clear picture of environmentally driven distress can be obtained but the pavements under study will be similar in design to primary or interstate highways.

Experiments SPS-1 through SPS-7 study the effects of environment for a broad range of pavement structures that receive years of mixed traffic loadings and develop comparative performance data across climatic and roadbed soil conditions. Experimental data from these studies will make it possible to determine the effect of different environmental conditions on performance for pavements that have similar structures, ages, and accumulated loadings. These studies cannot show the nature and extent of serviceability loss that would have occurred in the absence of traffic since every test section in those experiments will have been subjected to a combination of environmental and traffic loadings.

The proposed SPS-8 experiment will provide data for validation and improvement of the environmental effects models and therefore result in improved design procedures for both rigid and flexible pavement structures in all environmental conditions. The experimental designs and research plans presented here for the Specific Pavement Studies experiment SPS-8, "Study of Environmental Effects in the Absence of Heavy Loads" are a culmination of extensive discussions relative to the extent and type of additional new construction required for the SPS-8 experiment.

PROBLEM STATEMENT

At present, highway agencies lack sufficient information on the influence of environment on serviceability loss in pavements. Current approaches, presented in the AASHTO Guide, are based on a theoretical extension of a limited data set to account for serviceability loss due to active subgrade soils. Active soils are those susceptible to frost heave or swelling and shrinking from moisture content fluctuation. The AASHTO Guide is based on serviceability as the ultimate criterion for failure. The extensive effort currently being expended to evaluate and understand the material and structural requirements for satisfactory pavement performance and load induced loss in serviceability must be further extended to account for the loss in serviceability due to other factors. Therefore, a controlled experiment is necessary to answer the following questions:

> To what extend does the influence of environmental conditions, temperature and moisture, affect pavement serviceability?
>
> What is the influence of climatic region on environmentally-induced serviceability loss?
>
> What is the influence of pavement type and structure on environmental serviceability loss?
>
> What is the effect of very low traffic on the long-term performance of pavement materials?

OBJECTIVE

The objective of this experiment is to measure the deterioration in pavement performance in the absence of heavy loads. The proposed experiment encompasses both flexible and rigid pavement structures built on conventional, non-drained base materials over subgrades of coarse, inactive fine grained and active fine grained soils. The factors to be addressed are pavement type, layer thickness, and subgrade soil type across a factorial of temperature and moisture conditions. The analysis of information developed from this experiment will provide substantially improved data for validation and improvement of the environmental effects models used in the design of rigid and flexible pavements.

PRODUCTS

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 Plans. The key products form the proposed study will include:

1. Evaluation of existing environmental effects (damage) models.

2. Determination of the effects of specific design features, thickness and pavement type, on pavement performance in the absence of heavy loads.

3. Development of a comprehensive data base for use by state and provincial engineers and other researchers for evaluating environmental effects on pavement performance.

BENEFITS TO PARTICIPATING AGENCIES

While all agencies will benefit from the information, knowledge and products that will 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 low traffic loading, participating agencies will be able to make 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.

EXPERIMENTAL DESIGN

The recommended experimental design is shown in Table 1. It identifies the primary experimental factors and their relationships with each other. This design incorporates input from a number of highway agencies and interested parties. Table 1 identifies site-related factors across the top and pavement structure parameters down the side. Each column represents one project location which incorporates two test sections. Each row represents a series of test sections with specific features to be constructed at each project location. Table 1 indicates separate locations for constructing flexible and rigid pavements. However, flexible and rigid test sections may be constructed at the same location.

SITE-RELATED FACTORS

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

Traffic

Traffic is a key factor in this experiment. The objective of isolating environmentally-induced serviceability loss from load associated serviceability loss necessitates a low traffic volume in terms of axle loads. However, the total absence of traffic is equally undesirable. An eligible test site candidate must have an expected traffic volume in the study lane of at least 100 vehicles per day but not more than 10,000 ESAL/year (Equivalent Single Axle Loads). The actual site-specific traffic loading will be determined from weigh-in-motion (WIM) and automatic vehicle classification measurements. Seasonal effects which might cause variations in traffic, such as winter closings caused by heavy snow not being cleared, must be avoided. In this example, the insulating effect of the snow layer coupled with the absence of traffic loading may confound the inferences made relative to the environmental region and soil type.

Table 1. Experimental Design for SPS-8: Study of Environmental Effects in the Absence of Heavy Traffic

PAVEMENT STRUCTURE[1,2)]			FACTORS FOR MOISTURE, TEMPERATURE, AND SUBGRADE TYPE[3)]											
			WET						DRY					
			FREEZE			NO-FREEZE			FREEZE			NO-FREEZE		
Type	Surface Thickness in.	Base Thickness in.	ACTIVE	FINE	COARSE	ACTIVE	FINE	COARSE	ACTIVE	FINE	COARSE	ACTIVE	FINE	COARSE
FLEXIBLE	4	8	x	x	x	x	x	x	x	x	x	x	x	x
	7	12	x	x	x	x	x	x	x	x	x	x	x	x
RIGID	8	6	x	x	x	x	x	x	x	x	x	x	x	x
	11	6	x	x	x	x	x	x	x	x	x	x	x	x

Notes
1) Dense graded HMAC and jointed plain concrete for flexible and rigid pavements, respectively.
2) Dense graded aggregate base.
3) Active soil can be either frost susceptible or swelling type relative to the climatic zone.

o Flexible and rigid pavement sectins may be constructed at the same site.

Climatic Factors

The climatic 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 are 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 would not be needed.

Soil Factor

The subgrade factor levels for this experiment expand on the factor levels of the GPS by categorizing fine grained soils into active and non-active soils. Frost susceptible and swelling soils are accounted for in the active category while non-active soils are included in the fine grained category. Frost susceptibility of subgrade soils is a function of grain size distribution and the resultant void size as well as the availability of free moisture. Soils exhibiting volume changes caused by moisture content fluctuations are generally soils with more than 25 percent passing the No. 40 sieve with that portion having a Liquid Limit greater than 50, Plasticity Index greater than 25 and Soil Suction greater than 1.5 tons per square foot. Coarse grained subgrade soils are considered to be non-swelling, relatively free draining but may be somewhat frost susceptible.

STRUCTURAL FACTORS

The proposed experimental design includes both flexible and rigid test sections. Each test site will contain either two rigid and/or two flexible test sections. The test sections of each pavement type shall be constructed with two different surface course thicknesses on an untreated dense graded aggregate base. The flexible sections shall have two levels of base course thickness while the rigid sections shall have a single base thickness. The two sections of each pavement type will represent two levels of pavement design: thin and thick.

The structural details for the test sections to be included in the SPS-8 experiment include the following:

1. Flexible Test Sections
   a. "Thin"
      4 inch Hot Mix Asphalt Concrete (HMAC) surface
      8 inch dense graded aggregate base

   b. "Thick"
      7 inch HMAC surface
      12 inch dense graded aggregate base

2. Rigid Test Sections
   a. "Thin"
      8 inch jointed plain concrete pavement
      6 inch dense graded aggregate base

   b. "Thick"
      11 inch jointed plain concrete pavement
      6 inch dense graded aggregate base

For rigid pavement test sections, perpendicular doweled joints shall be provided at 15 foot spacing. The target mean value for the concrete flexural strength shall be 550 psi at 14 days as determined from third point loading tests.

The variation in thicknesses of the surface and base layers will result in different pavement design lives within a test site. The influence of structure may then be accounted for in a low traffic condition to isolate the effect of environmental influences on performance. In addition, the test sections will correspond to those required for the SPS-1 (Study of Structural Factors for Flexible Pavements) or SPS-2 (Study of Structural Factors for Rigid Pavements) experiment allowing a direct comparison of performance of selected sections between the experiments at significantly different traffic loadings within the same environmental cell.

CONSTRUCTION CONSIDERATION AND TEST SECTION CONFIGURATION

Construction techniques and materials should be kept uniform to minimize influences of variation on performance. Construction guidelines provided for SPS-1 and SPS-2 experiments shall be followed to achieve the desired level of uniformity with respect to materials, construction quality, and test section length.

The geometric requirements stipulated for the SPS-1 and SPS-2 experiments relative to the width of the outside lane and shoulder are those required for pavement structures for primary highways and expected to carry a minimum of 100,000 ESAL/year. Due to the low traffic level requirement for the SPS-8 experiment, the likelihood of finding eligible candidate sections with that type of pavement geometry is considered low. Therefore, pavements with a lane width of at least 10 feet and an outside shoulder width of at least 4 feet are considered acceptable for this experiment. The shoulder should be constructed with at least a single bituminous surface treatment. Turf or aggregate shoulders are not acceptable.

It is anticipated that projects will be proposed from one of a number of different functional categories. In order of preference these are:

- A parallel lane constructed along an existing new construction project, possibly an SPS-1 or SPS-2 site.
- Port of Entry scales under 24 hour use with full truck diversion.
- Parkways and other roads with very limited truck traffic.

- Park and Forest Service roads.
- Low volume rural roads.
- Frontage roads.

PARTICIPATION REQUIREMENTS

Highway agencies considering participating in the SPS-8 experiment must be willing to perform the following activities:

1. Construct at least the two flexible, the two rigid, or both the flexible and rigid test sections described in the experimental design during the same construction season.

2. Install and operate a traffic data collection station at or near the site to measure the same traffic that passes over the test sections. As a minimum, this station must be operated to obtain continuous automatic vehicle classification and provide four, one week sessions of seasonal weigh in motion measurements each year. However, because of the possible variation in traffic levels it is desirable that the station provides continuous weigh in motion.

3. Perform and/or provide for drilling, coring, and sampling and testing of in-place pavement materials and materials used in the construction of the test sections. SHRP will provide sampling plans tailored to the site plus directives and standard protocols for laboratory tests. Costs for this work must be borne by the participating agency.

4. Provide periodic traffic control for on-site data collection activities such as materials drilling and sampling. deflection measurements, and other monitoring activities.

5. Coordinate maintenance activities on the test sections to prevent application of premature treatments which alter the characteristics of the test sections and limit their use in the study. Collect and report all maintenance on the test sections using the GPS maintenance data collection data forms.

6. Perform snow removal operations, as necessary, to keep the test sections open to traffic during the winter months.

7. Perform and report periodic skid resistance measurements in accordance with practices used for GPS test sections.

8. Provide and maintain signing and marking of test sites.

9. Notify SHRP prior to application of overlays or other such treatments when any of the test sections reach an unsafe condition or become candidates for rehabilitation. As much lead time as possible is needed to allow terminal condition of the test sections to be measured.

SHRP RESPONSIBILITIES

The primary role of SHRP is to provide coordination and technical assistance to the participating highway agencies to help ensure uniformity and consistency in construction and data collection. The role of SHRP will also include the following activities:

- Development of the experiment design.
- Coordination among participating highway agencies.
- Final acceptance of test sites.
- Development of data collection guidelines and forms.
- Monitoring of pavement performance.
- Development and operation of a comprehensive nationwide pavement data base and data entry.
- Control of data quality.

IMPLEMENTATION AND SCHEDULE

The initial step in the implementation of this experiment is the identification and submission by highway agencies of candidate projects for possible inclusion in the study. A total of 24 projects (or 12 projects if both flexible and rigid sections are constructed at the same site) will be required to complete the experiment as planned. 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 selection criteria, and other details.