SPS-2 SEASONAL AND LOAD RESPONSE INSTRUMENTATION
NORTH CAROLINA D.O.T. OPEN HOUSE
Lexington, North Carolina
May 9-11, 1994

OVERVIEW OF THE LTPP PROGRAM

INTRODUCTION

During the early 1980's, the Transportation Research Board (TRB) of the National Research Council, under the sponsorship of the Federal Highway Administration (FHWA) and with the cooperation of the American Association of State Highway and Transportation Officials (AASHTO) undertook a thorough study of the deterioration of the nation's highway and bridge infrastructure system. The study recommended that a Strategic Highway Research Program (SHRP) be initiated to focus research and development activities that would make major contributions to improving highway transportation. The study report published as TRB Special Report 202 during 1984, emphasized six research areas, with the Long Term Pavement Performance (LTPP) program as one of the key research areas. During 1985 and 1986, the detailed research programs were developed for SHRP by independent contractors. The detailed programs were published in May 1986 as a TRB Report entitled, "Strategic Highway Research Program - Research Plans."

The Long Term Pavement Performance was envisioned as a comprehensive program to satisfy "the total range of pavement information needs." It draws on "technical knowledge of pavements presently available and seeks to develop models that will better explain how pavements perform. It also seeks to gain knowledge of the specific effects on pavement performance of various design features, traffic and environment, use of various materials, construction quality, and maintenance practices." As sufficient data becomes available with time, analysis will be conducted by various agencies to provide better performance prediction models for use in design and pavement management, to provide much better understanding of the effects of many variables on pavement performance, and to provide new techniques for pavement design and construction.

This report provides an overview of the LTPP program. The information presented is generally a summary of information presented in the SHRP LTPP Five Year Reports currently under development by various SHRP contractors.

OBJECTIVES AND SCOPE OF THE LTPP PROGRAM

The overall objective of the LTPP program is to assess long-term performance of various pavements and various loading and environmental conditions over a period of 20 years. The specific objectives for the LTPP program are:

1. Evaluate existing design methods.

2. Develop improved design methodologies and strategies for the rehabilitation of existing pavements.

3. Develop improved design equations for new and reconstructed pavements.

4. Determine the effects of (a) loading, (b) environment, (c) material properties and variability, (d) construction quality, and (e) maintenance levels on pavement distress and performance.

5. Determine the effects of specific design features on pavement performance.

6. Establish a national long-term pavement database to support SHRP objectives and future needs.

As developed originally, the LTPP program incorporated three potential types of studies. These include General Pavement Studies (GPS), Specific Pavement Studies (SPS), and Accelerated Pavement Testing (APT). The General Pavement Studies involve a very large experiment consisting of almost 800 in-service pavement test sections throughout the U.S. and Canada embracing an array of site selection factors that will provide a national database needed to meet the objectives of LTPP. The Specific Pavement Studies have their own set of limited goals, construction needs, and experimental approaches that cannot be achieved by the GPS. The SPS are intensive studies of few specific variables involving new construction, maintenance treatment, or rehabilitation activities. The Accelerated Pavement Testing has not been incorporated within LTPP.

The LTPP program involves extensive and comprehensive data collection. The following data are collected for each test section.

1. Inventory
2. Materials Testing
3. Climatic
4. Maintenance
5. Rehabilitation

6. Traffic
7. Monitoring (Falling Weight Deflectometer (FWD), profilometer, surface distress, friction, and transverse profile)

Data are collected for each test section by Regional Contractors (funded initially by SHRP and since 1992, by FHWA). The Regional Contractors also perform deflection and profile testing and conduct manual pavement distress surveys. Photographic distress surveys are performed by another Contractor.

Each of the seven LTPP data modules is composed of numerous tables, with each table representing a collection of related information. The tables contain individual records that store information for a specific pavement test section, layer, etc. LTPP data are stored in the National Information Management System (NIMS) located at TRB in Washington, DC. The database is expected to evolve during the course of the LTPP program to accommodate the data collected and the needs of researchers as they are identified. LTPP data are available to the public only from the NIMS. Before any data are released to the public, a series of quality assurance checks are performed to ensure the integrity of the data.

Experimental Design Philosophy

The development of the experimental design of each specific experiment of the GPS and the SPS was based on identifying factors considered to have significant influence on pavement performance. Three factors were selected as a basis of the sampling factorials and were defined as qualitative (distinct levels) or quantitative (continuous numerical levels). The qualitative factors used in most of the GPS and SPS experiments include the following:

1. Moisture conditions - wet or dry
2. Temperature conditions - freeze or non-freeze
3. Subgrade type - fine or coarse

The generalized moisture and temperature zones defined for the LTPP program are shown in Figure 1. A wet zone is one having annual precipitation greater than 508 mm (20 in.). A freeze zone is one having annual air freezing index greater than 83°C-Days (150°F-Days). A subgrade is defined as being fine if it has more than 50% material passing the #200 sieve.

For the quantitative factors for GPS, mid-points were established for these factors based on expected numerical ranges, so that all values below the mid-point were considered low and all values above the mid-point were considered high. The qualitative factors vary for each GPS experiment and in general include factors such as layer thicknesses and traffic levels. Two distinct levels were defined for all GPS quantitative factors with the exception of three levels (low, medium, and high) for asphalt concrete thickness in GPS-1.

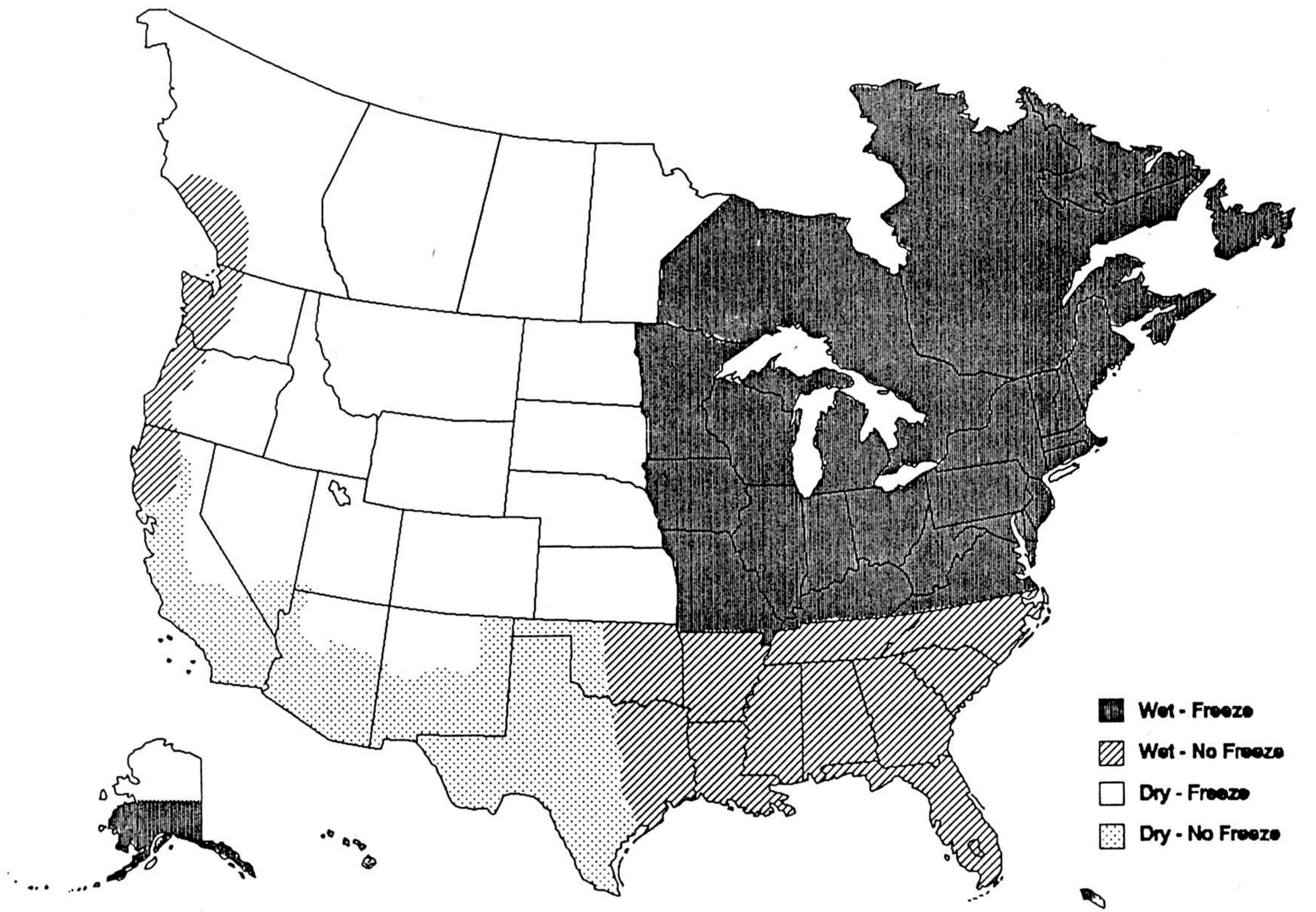

Figure 1 - SHRP-LTPP Environmental Zones

Test Section Layout

Generally, each test section considered under the GPS and the SPS consists of a 152 m (500 ft) monitoring length and a 15.2 m (50 ft) section at each end of the monitoring length used for material sampling. Exceptions are the "crack and seat" test sections in the SPS-6 experiment (discussed later) that have monitoring lengths of 305 m (1,000 ft). In addition, the SPS experiments require multiple tests sections at a given site. These sections are separated by transitions to accommodate changes in the design/construction features. Also, SPS sections designated for pavement instrumentation will incorporate an additional 15.2 m (50 ft) length to allow placement of pavement instrumentation. The overriding philosophy of LTPP is to not permit any destructive testing or sampling within the 152 m (500 ft) or 305 m (1,000 ft) monitoring lengths of the section. The monitoring lengths are used for collecting the specific monitoring data (FWD, profilometer, surface distress, skid (friction), and transverse profile).

Data Collection, Construction, Monitoring, and Testing Protocols and Guidelines

To ensure uniform and consistent data collection and construction, detailed guidelines have been prepared and implemented. These guidelines incorporate collection of inventory data,traffic data, monitoring data, materials testing data, and maintenance and rehabilitation data. In addition, detailed construction guidelines and field sampling have been prepared for the different SPS experiments.

GENERAL PAVEMENT STUDIES

The General Pavement Studies are a series of selected in-service pavements studies structured to develop a comprehensive national pavement performance database. These studies are restricted to pavements that incorporate materials and designs representing good engineering practice and that have strategic future importance. Due to the nationwide thrust of the program, the studies are limited to pavement in common use across the United States.

The GPS program consists of the following studies:

GPS Designation	General Descriptions of Study
GPS-1	Asphalt Concrete (AC) on Granular Base
GPS-2	Asphalt Concrete (AC) on Bound Base
GPS-3	Jointed Plain Concrete Pavement (JPCP)
GPS-4	Jointed Reinforced Concrete Pavement (JRCP)
GPS-5	Continuously Reinforced Concrete Pavement (CRCP)

GPS Designation	General Descriptions of Study
GPS-6A	Existing Asphalt Concrete (AC) Overlay of Asphalt Concrete (AC) Pavement
GPS-6B	Planned Asphalt Concrete (AC) Overlay of Asphalt Concrete (AC) Pavement
GPS-7A	Existing Asphalt Concrete (AC) Overlay of Portland Cement Concrete (PCC)
GPS-7B	Planned Asphalt Concrete (AC) Overlay of Portland Cement Concrete (PCC)
GPS-9	Unbonded Portland Cement Concrete (PCC) Overlay of Portland Cement Concrete (PCC)

It should be noted that the proposed GPS-8 experiment to study bonded jointed concrete pavement overlay was not pursued due to lack of adequate number of acceptable in-service projects.

SPECIFIC PAVEMENT STUDIES

The SPS program involves long term study of specially constructed, maintained, or rehabilitated pavement sections incorporating a controlled set of design and construction features. The objective of SPS is to develop needed information about the cost-effectiveness of targeted design, maintenance, and rehabilitation features and thereby satisfy the overall objective of the LTPP studies to increase pavement life by investigation of various designs of pavement structures and rehabilitated pavement structures, using different materials and under different loads, environment, subgrade soil, and maintenance procedures.

The Research Plan for the Strategic Highway Research Program (SHRP) published during May 1986 provided a detailed preliminary plan for the conduct of the SPS. These preliminary plans were based on comprehensive lists of specific studies compiled by the LTPP Advisory Committee during the SHRP Pre-Implementation Study during 1985 and 1986.

During the first few years of SHRP (beginning in 1987), SHRP's advisory groups and representatives of highway agencies narrowed the SPS program to study of features with potentially high pay-off to a broader group of highway agencies. The current SPS program, developed through that process, incorporates nine experiments grouped into five categories as follows:

1. Study of Structural Factors

SPS-1:	Strategic Study of Structural Factors for Flexible Pavements
SPS-2:	Strategic Study of Structural Factors for Rigid Pavements

2. Study of Pavement Maintenance

SPS-3:	Preventative Maintenance Effectiveness of Flexible Pavements
SPS-4:	Preventative Maintenance Effectiveness of Rigid Pavements

3. Study of Pavement Rehabilitation

SPS-5:	Rehabilitation of Asphalt Concrete Pavements
SPS-6:	Rehabilitation of Jointed Portland Cement Concrete Pavements
SPS-7:	Bonded Portland Cement Concrete Overlays of Concrete Pavements

4. Study of Environmental Effects

SPS-8:	Study of Environmental Effects in the Absence of Heavy Loads

5. Study of Asphalt-Aggregate Mixture Specifications

SPS-9:	Validation and Refinements of SUPERPAVE™ Asphalt Specifications and Mix Design Process

Essentially, the Specific Pavement Studies involve monitoring of newly constructed sections or existing pavement sections subjected to maintenance or rehabilitation treatments.

Each SPS experiment requires construction of multiple test sections at each site. The number of test sections may range from two for SPS-8 to twelve for SPS-1 and SPS-2. In addition, a highway agency may construct supplemental test sections on a SPS site to investigate other factors of direct interest to the agency. The description on the following pages provides the highlights of the SPS-2 Experiment.

SPS-2: Structural Factors for Rigid Pavements

The experiment on Strategic Study of Structural Factors for Rigid Pavements (SPS-2) examines the effects of climatic region, subgrade soil (fine and coarse grained), and traffic rate (as a covariate) on doweled jointed plain concrete pavement sections incorporating different levels of structural factors. These factors include drainage (presence or lack of it as provided by an open-graded permeable asphalt-treated drainage layer and edge drains), concrete thickness (203 and 279 mm (8 and 11 in.)), base type (dense-graded untreated aggregate and lean concrete), concrete flexural strength (3.79 and 6.21 MPa (550 and 900 psi at 14 days)), and lane width (3.9 and 4.6 m (12 and 14 ft)). The experiment requires that all test sections are constructed with perpendicular joints at 4.9 m (15 ft) spacing and stipulate a traffic loading level in the lane in excess of 200,000 ESAL/year.

The combination of the study factors in this experiment result in 24 different pavement structures. As for the experiment on structural factors for flexible pavements, the experiment is designed in a fractional factorial manner to allow the construction of twelve test sections at each site. Table 1 lists the experimental factors and the pavement structures that must be constructed at each site. The experiment includes 192 test sections located at 16 sites. Four of which are located in each of the four climatic regions.

A supplementary experiment, designated SPS-2A, addresses undoweled plain concrete pavements with skewed joints. This experiment requires that all test sections be constructed with a variable 3.9-4.9-4.3-4.6 m (12-15-13-14 ft) joint spacing and includes the same factor levels for drainage, base types, concrete thickness, and lane width covered in the main experiment, but only one level of concrete flexural strength (3.79 MPa (550 psi)). Twelve different pavement structures are required to address these factors. However, six of these sections are constructed at one test site with the complementary six sections to be constructed at another site. Table 2 lists the pavement structures that may be constructed at each test in addition to those sections required for the primary experiment.

Another supplementary experiment, designated SPS-2B, addresses jointed reinforced concrete pavements. This experiment requires that all test sections are constructed with doweled joints at 9.8 m (30 ft) spacing and includes the same factor levels for drainage, concrete thickness, concrete flexural strength, and lane width covered in the main experiment, but only one level of base type (dense-graded untreated aggregate). Sixteen different pavement structures are required to address these factors. However, eight of these sections are constructed at one test site with the complementary eight sections to be constructed at another site. Table 3 lists the pavement structures that may be constructed at each site in addition to those sections required for the primary experiment.

A test site for the study of structural factors for rigid pavements must include at least the twelve test sections required for the primary experiment on doweled jointed plain concrete pavements. However, the test site may also include the six test sections required for the study of jointed plain concrete pavements with skewed joints and/or the eight test sections required for the study of jointed reinforced concrete pavements. Therefore, a test site may include 12, 18, 20, or 26 test sections.

Participation in the SPS-2 experimental program is voluntary and requires the cooperation of the various state agencies to successfully complete the elements of the experimental matrix. To

Table 1 - Experimental Design for SPS-2

PAVEMENT STRUCTURE FACTORS					FACTORS FOR MOISTURE, TEMPERATURE, AND SUBGRADE TYPE															
Drain	Base Type	Portland Cement Concrete		Lane Width, ft	WET								DRY							
					Freeze				No-Freeze				Freeze				No-Freeze			
		Thick In.	Strength psi		Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NO	DGAB	8	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
			900	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
		11	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
			900	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
NO	LCB	8	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
			900	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
		11	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
			900	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
YES	PATB/DGAB	8	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
			900	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
		11	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
			900	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X

Each "x" designates a test section

DGAB = Dense-graded untreated aggregate Base
LCB = Lean concrete base
PATB/DGAB = 4 inch permeable asphalt treated base on 4 inch untreated DGAB base

550 psi = 3.79 MPa, 900 psi = 6.21 MPa
4 in. = 102 mm, 8 in. = 203 mm, 11 in. = 279 mm
12 ft = 3.9 m, 14 ft = 4.6 m

Table 2 - Experimental Design for SPS-2A

PAVEMENT STRUCTURE FACTORS					FACTORS FOR MOISTURE, TEMPERATURE, AND SUBGRADE TYPE															
		Portland Cement Concrete		Lane Width, ft	WET								DRY							
					Freeze				No-Freeze				Freeze				No-Freeze			
Drain	Base Type	Thick In.	Strength psi		Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NO	DGAB	8	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
		11	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
NO	LCB	8	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
		11	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
YES	PATB / DGAB	8	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
		11	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	

Each "x" designates a test section

DGAB = Dense-graded untreated aggregate Base
LCB = Lean concrete base
PATB / DGAB = 4 inch permeable asphalt treated base on 4 inch untreated DGAB base

550 psi = 3.79 MPa, 900 psi = 6.21 MPa
4 in. = 102 mm, 8 in. = 203 mm, 11 in. = 279 mm
12 ft = 3.9 m, 14 ft = 4.6 m

Table 3 - Experimental Design for SPS-2B

PAVEMENT STRUCTURE FACTORS					FACTORS FOR MOISTURE, TEMPERATURE, AND SUBGRADE TYPE															
Drain	Base Type	Portland Cement Concrete		Lane Width, ft	WET								DRY							
					Freeze				No-Freeze				Freeze				No-Freeze			
		Thick In.	Strength psi		Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
NO	LCB	8	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
			900	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
		11	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
			900	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
YES	PATB / DGAB	8	550	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	
			900	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
		11	550	12	X		X		X		X		X		X		X		X	
				14		X		X		X		X		X		X		X		X
			900	12		X		X		X		X		X		X		X		X
				14	X		X		X		X		X		X		X		X	

Each "x" designates a test section

DGAB = Dense-graded untreated aggregate Base
LCB = Lean concrete base
PATB / DGAB = 4 inch permeable asphalt treated base on 4 inch untreated DGAB base

550 psi = 3.79 MPa, 900 psi = 6.21 MPa
4 in. = 102 mm, 8 in. = 203 mm, 11 in. = 279 mm
12 ft = 3.9 m, 14 ft = 4.6 m

provide consistency within the experimental design, some participation requirements were developed. The highway agency must be willing to perform the following activities:

1. Construction of the test sections

   a) Construct at least all 12 test sections that make up one of the experimental sets (J through Y) for the basic experiment.
   b) All test sections must be constructed during the same construction season.
   c) It is desirable that all test sections be opened to traffic at the same time.

2. Purchase, install, operate and monitor traffic data collection at or near the test site that contains a continuous vehicle classification and weigh-in-motion equipment.

3. Purchase, install, operate and monitor a weather station at the test site.

4. Perform and/or provide for drilling, coring, sampling and testing of in-place pavement materials and materials used for construction.

5. Prepare plans, specifications, quantities, and all other documents necessary as a part of the agency's contracting procedures. Also provide for construction control, construction inspection and material conformance testing in accordance with their standard quality control and assurance procedures.

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

7. Coordinate maintenance activities on the test section to prevent premature application of treatments which may alter the characteristics of the test sections and limit their use in the study.

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

9. Notify the LTPP Division of the Federal Highway Works Administration prior to application of overlays or other such treatments, when any of the test sections reaches an unsafe condition or becomes a candidate for rehabilitation.

Similar to the participation requirements above, various site selection criteria was developed. This includes:

1. The project must include new construction of all pavement layers for a new route, realignment, reconstruction or construction of an experimental parallel roadway.

2. The construction project must be of sufficient length to accommodate all of the experimental test sections.

3. All test sections at one site must be constructed on soils classified as either fine-grained or coarse-grained. It is desired the soils characteristics remain relatively consistent throughout the project length.

4. Test sections should be constructed on portions of the grade which are relatively straight and have a uniform vertical grade.

5. Ideally, all test sections should be constructed on shallow fills. The entire length of a test section (approximately 183 m [600 ft]) should be located on either a cut or fill area.

6. Culverts, pipes or other subsurface structures should be avoided in the limits of the test section.

7. Traffic levels should exceed 200,000 ESAL/year and flow should be uniform. Intersections, rest stops, on-off ramps or other ingress/egress routes must be avoided in the limits of the experimental project.

Full details on the SPS-2 Experiment are available through the following documents:

SPS-2 Strategic Study of Structural Factors for Rigid Pavements

Experimental Design and Research Plan
Guidelines for Nomination and Evaluation
Construction Guidelines
Materials Sampling and Testing Requirements
Data Collection Guidelines

The summary presented herein was prepared as a brief overview of the experiment for easy reference during the upcoming discussions on instrumentation of the SPS-2 pavement sections.

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FHWA–LTPP SPS–2 NORTH CAROLINA LOCATION PLAN

STRUCTURAL FACTORS FOR RIGID PAVEMENTS

PAVEMENT MANAGEMENT SYSTEMS LIMITED

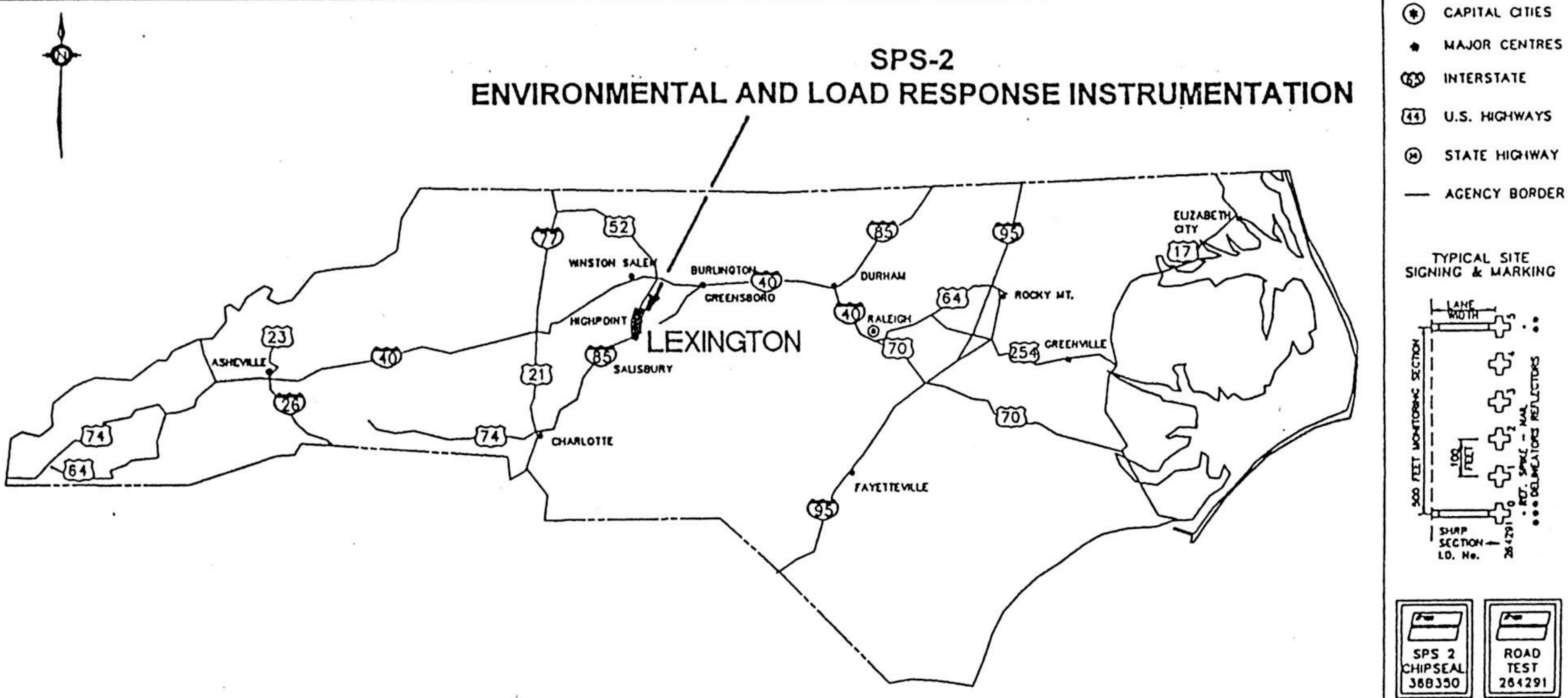

FIGURE 1 - LOCATION PLAN OF NORTH CAROLINA SPS-2 PROJECT ON US 52 SB LEXINGTON BY-PASS, NC.

(from SR 1232 at Lexington to Existing US 52 at Welcome)

NORTH CAROLINA

SPS-2 Project, North Carolina Department of Transportation

Location

US 52 from SR 1232 Lexington (Sta. 130+70) to existing US 52 at Welcome (Sta. 387+00), a distance of 4.85 miles. There is one interchange with US 64 at Sta. 193+00.

Project

US 52 Lexington by-pass. A four lane divided limited access highway with a 68' grass median.

Traffic

23,500-26,100 AADT with 13% trucks. Estimated ESAL - 539 k/yr.

SPS-2

Twelve Experimental SPS-2 500 foot test sections plus two supplementals in the south bound lanes. The six eight inch thick PCC pavement test sections are constructed as a third outside lane between two curves. The inside lane will be blocked to normal traffic, allowing traffic to use lanes two and three.

Contractor

Southern Road Builders Inc. (a division of APAC) are the contractors. Mr. Carl Larkins, Manager, Mr. John Manning, Superintendent was replaced by Mr. Dennis Ramsey. Mr. Roy Mowell was the Forman. Mr. John Range was the Grade Foreman.

J.A. Long Inc. of Gainsville, GA subcontracted for the subgrade stabilization, granular base, and shoulders. Mr. Peter Galloway managed the asphalt paving subcontract for APAC Carolina, Thompson-Arthur Division, Winston-Salem, NC.

The stabilization material was supplied by Lime-Slurry Pazzolank Porta-Batch-Lime Slaking System. Quick Lime was obtained from APG Ripplemead, VA.

Edge-Drain Construction was by AC Construction, Faison, NC.

Joint Sawing and Sealing was by Eaton Construction Co.

Engineering

Construction was under the control of the Division 9 District Engineer, Mr. D. Waters. He was assisted by Mr. Mike Patton, Construction Engineer, Mr. Keith Raulston, Resident Engineer, and Mr. Tom Vickers, Assistant Resident Engineer.

Liaison with the Construction Staff, the Materials Laboratory, FHWA, and the NA Regional Office was maintained by Dr. Shin-Wu, Pavement Management Unit.

The NARO on-site Engineer, Mr. Alex Rutka received valuable assistance with SPS-2 documentation from Mr. Ed Arrowood.

Construction of earthworks to widen for the add-on lane was initiated in May 1993. Subgrade stabilization was started in May and completed in early July. PADL materials were placed in August, September, and November. Granular ABC materials were placed in June, July, and November 1994. Lean Concrete Base, LCB, was placed in mid November. The PCC materials were placed in October and mid-late November 1994.

Sampling and Testing

Bulk samples of the materials were obtained in accordance with the plan prepared by NARO. Field testing with the nuclear density/moisture density testing apparatus, and with plate load bearing testing equipment on loan from Iowa, and with the new NC FWD, were carried out as arranged. Post construction cores and specimens molded from field samples, were tested in the laboratory for fourteen day and twenty eight day flexural and compressive strengths.

Materials

The subgrade is a typical red sandy silt which becomes really soupy when wet. It was stabilized in the top 6-7 inches by addition of about twelve percent of Portland cement or lime-slurry.

The ABC is a dense graded stone from the Martin-Marietta Thomasville Quarry placed 6 inches in thickness as a base or four inches thick as a subbase when used with a four inch PADL base. When used as a subbase, it is heavily primed to form a waterproof layer under the porous PADL. Gradation of the stone is as follows:-

Martin Marietta, Thomasville Quarry, Gradation Type A

Sieve	% Passing
1 1/2"	100
1"	75-97
1/2"	55-79
#4	35-55
#10	25-45
#40	14-30
#200A	4-12

The PADL is essentially a 5/8 inch stone with a ten percent clean sand matrix (A#57 stone from the Martin-Marietta Quarry, Jamestown), with about two percent of an AC 20 asphalt cement.

The PCC 550 and PCC 900 concrete designs were prepared by APAC Georgia, using Martin-Marietta #57M, Thomasville Quarry stone, Martin-Marietta sand, 2MS, Woodlief Quarry, and Flyash, Monex Class F from Bellews Creek, NC. The Portland cement was Tarmac Roanoke, Roanoke, VA. Essentially, the 550 and 900 psi designs required 421 pounds of Type 1 cement with 126 pounds Flyash, and 772 pounds of Type 1 cement with 232 pounds Flyash respectively, per cubic yard, and 35.3 and 35.0 gallons of water.

Some 14 and 28 day test results are shown in attached Table 16.

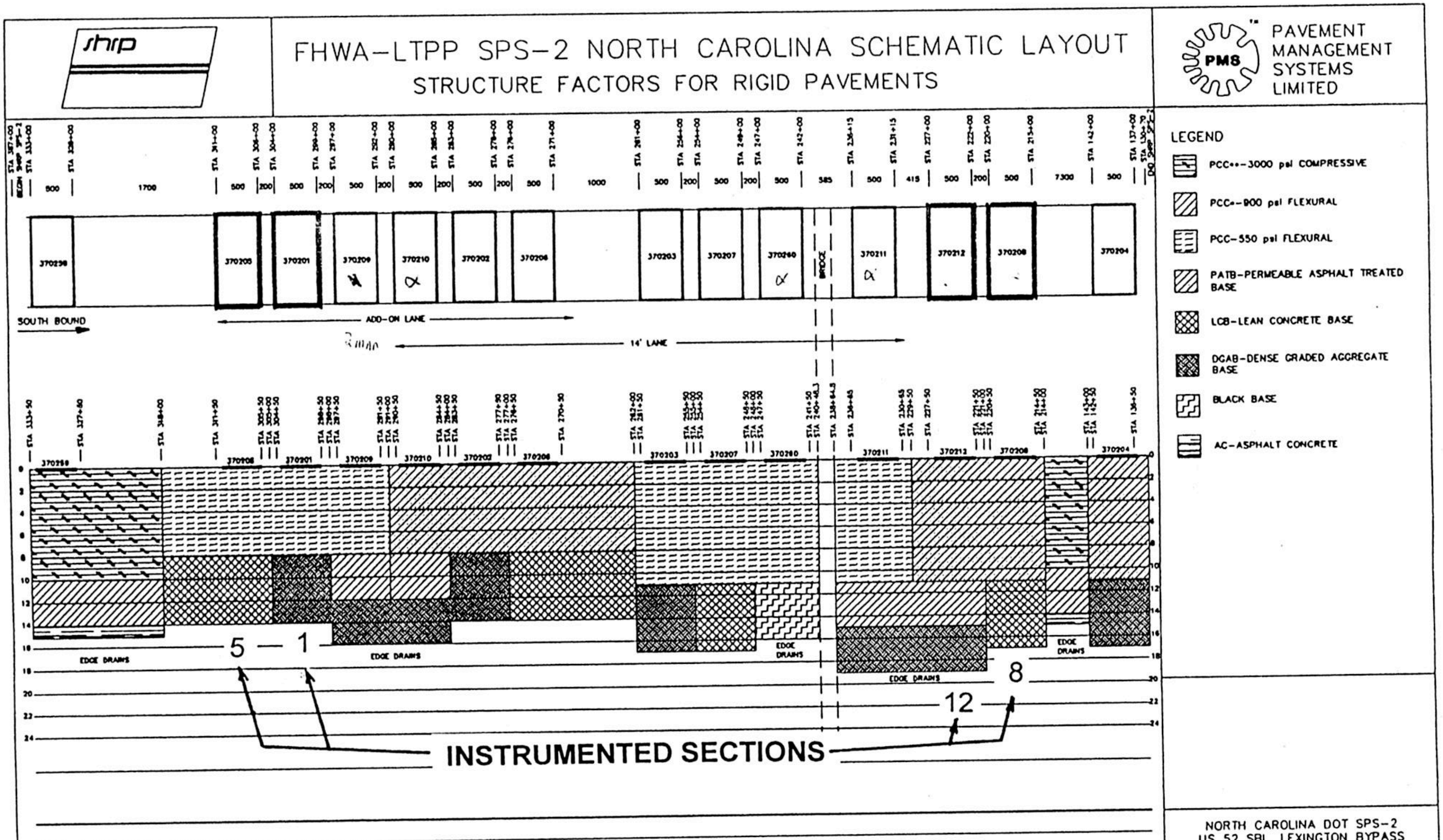

FIGURE 2 - LONGITUDINAL LAYOUT OF TEST SECTIONS

TABLE 1

NC DOT SPS-2: Test Section Layout: US 52 SB, Lexington

Station	Length Ft.	Sec. No.	Concrete Pav't Flexural Strength	Concrete Pav't Thickness Inches	Lane Width Ft.	BASE Type	BASE Thickness Inches	Typical Section	Remarks	Monitor Station	Suggested Construction Station
130+70 143+00	1230'	370204	900	11"	12'	ABC	6"	E t=17"		5 0	137+00 142+00
214+00	7100'			10"	12'	PADL HMAC	4" 1"	t=17" G	edge drain		
221+00	700'	370208	900	11"	12'	LCB	6"	F t=17"		5 0	215+00 220+00
229+50	850'	370212	900	11"	12'	PADL ABC	4" 4"	A t=19"	edge drain	5 0	222+00 227+00
238+64.8	914.8'	370211	550	11"	14'	PADL ABC	4" 4"	A t=19"	edge drain	5 0	231+15 236+15
240+48.3 248+00	751.7'	370260	550	11"	14'	HB	5"	G t=17"	edge drain	5 0	242+00 247+00
255+00	700'	370207	550	11"	14'	LCB	6"	F t=17"		5 0	249+00 254+00
262+00	700'	370203	550	11"	14'	ABC	6"	t=17" E		5 0	256+00 261+00
277+00	1500'	370206	900	8"	14'	LCB	6"	D* t=14"		5 0	271+00 276+00
284+00	700'	370202	900	8"	14'	ABC	6"	C* t=14"		5 0	278+00 283+00
291+00	700'	370210	900	8"	14'	PADL ABC	4" 4"	B* t=17"	edge drain	5 0	285+00 290+00
298+00	700'	370209	550	8"	12'	PADL ABC	4" 4"	B* t=17"	edge drain	5 0	292+00 297+00
305+00	700'	370201	550	8"	12'	ABC	6"	C* t=14"		5 0	299+00 304+00
318+00	1300'	370205	550	8"	12'	LCB	6"	D* t=14"		5 0	306+00 311+00
387+00	6500'	370259		10"	12'	PADL AC	4" 1"	G t=17"	edge drain	5 0	328+00 333+00

* ADD-ON LANE   t= total pavement depth

TABLE 11
SPS-2 US 52 SB LEXINGTON BY-PASS, NC
Asphalt Plant Inspectors Daily Report - I-2 and RHB

SIEVE SIZE	JOB MIX FORMULA	I-2 JOB MIX NO. 92-670-051						RHB - MIX NO. 92-298-051	
		370259			370260			JOB MIX FORMULA	370260
		7/9/93			7/16/93				9/2/93
		SA #9	SA # 10	SA #11	SA #21	SA #22	SA #23		
2								100	100
1 1/2								95	100
1									
3/4	100	100	100	100	100	100	100	69	75
1/2	98	100	100	100	100	100	100		
3/8	95	98	98	98	98	98	97		
No. 4	77	77	79	80	79	77	76	34	38
8	63	61	63	62	63	59	60	28	31
16	51	49	49	48	51	48	48	23	27
40	29	32	31	31	32	30	30	15	18
80	14	16	16	17	14	14	14		
200	6.6	7.2	8.3	8.8*	6.2	6.4	6.7	4.0	3.5
% AC (total)	6.1	6.5	6.7*	6.6	6.2	6.5	6.3	4.0	3.6
% ASH	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.8	0.8
AC Grade									
AC Source									
Non-Strip Pad									

AC 20 COASTAL FUELS, TAPCO 250

Compaction Test

Type	Sample No.	Specific Gravity		% Comp.	Thickness
		Actual	JMF		
I-2	18	2.215	2.320	95.5	1 1/2
	19	2.213	2.320	95.4	1 3/8
	20 pc	2.246	2.320	96.8	1 1/2
	21 pc	2.169	Avg.	93.5*	17/16
	22 pc	2.298	2.320	99.0	1 1/4
	Control Strip		2.320	96.4	
	23	2.202	2.320	94.4*	1 3/8
RHB	1	2.472	2.51	98.5	5 1/8
	2	2.458		97.9	5 1/4
	3	2.396		95.5	5 1/4

TABLE 12
SPS-2 US 52 SB LEXINGTON BY-PASS, NC
Asphalt Plant Inspectors Daily Report - PADL

SIEVE SIZE	PADL MIX - JOB MIX NO. 652-055-051							
	GRADATION		370259	370211	370212		370209	370210
	SHRP REC'D.	JOB MIX TOLERANCE	8/30/93 SA #19	9/2/93 SA # 23	9/3/93 SA # 24	9/3/93 SA # 25	11/22/93 SA #34	11/22/93 SA # 35
1	100	100	100					
1 1/2	100	100	100	100	100	100	100	100
1	95-100	95-100	100	100	100	100	100	100
1/2	25-60	25-60	45	49	52	48	59	60
No. 4	0-10	0-10	10	10	11*	10	11*	7
8	0-5	0-5	5	6*	5	5	6*	3
200	0-2	0-3	1.9	2.4	1.6	1.8	2.1	1.2
% AC	2-2.5	2	2.4	2.4	2.2	1.9	2.1	2
% Ash			0.3	0.3	0.2	0.3	0.6	0.6
Type AC			AC 20	AC 20	AC 20	AC 20	AC 20	AC 20
Source AC			Coastal Fuels	Coastal Fuels	Coastal Fuels	Coastal Fuels	Coastal Fuels	Coastal Fuels
Non-Strip Additive			Tapco 250	Tapco 250	Tapco 250	Tapco 250	Tapco 250	Tapco 250

AGGREGATE - #57 stone from Martin-Marietta Quarry Jamestown

* Out of Specification

TABLE 14.3

NC DEPARTMENT OF TRANSPORTATION AND HIGHWAY SAFETY
STATEMENT OF CONCRETE MIX DESIGN AND SOURCE OF MATERIALS

Project #	S.T600406 STPNH-37-1 (48)	**R.M. Producer:**	APAC-Georgia, Inc.
County:	Davidson	**Plant Location:**	Job Site
Resident Engineer:	Keith Raulston	**Contractor:**	APAC-Georgia, Inc.

Mix Design-One Cubic Yard Based on SSD Condition

Class of Concrete:	Concrete Pavement	**Size of Coarse Aggregate:**	57M
Lab Mix Design Number:	PF-57M-100-102-R REV	**Designed Air Content:**	5.0%

Material		Source	Material Producer/Location
Cement Type I	421 lbs.	Tarmac Roanoke	Roanoke, VA
Flyash	126 lbs.	Monex Class F	Bellews Creek, NC
Fine Agg. +M	1241 lbs.	Martin Marietta, Sand, 2MS	Woodlief Quarry
Fine Agg. +M			
Coarse Agg. +M	1924 lbs.	Martin Marietta, #57M	Thomasville Quarry
Total Water Per C.Y.	30.5 gal.		
Admixture (AE)			
Admixture (Retarder)	5.24 oz.	Hunt Process (Air-In)	Ridgeland, MS
Admixture (Water Red)	27.35 oz.	Hunt Process (HPS-R)	Ridgeland, MS

The quality of mixing water shown is designed to produce a 1.5" slump.

The maximum water permitted by specifications is 35.3 gallons per cu. yd. NOTE: if it is found that more than the maximum water permitted by the specifications is required to produce workability, additional cement will be required to maintain the maximum water cement ratio.

(1) The quantities of fine and course aggregates necessary to conform to specifications in regard to consistency and workability shall be determined by the method described in "Recommended Practice for Selecting Proportions for Concrete" (ACI 211.1-74), and "Pumping Concrete by Pumping Methods" (ACI 304), using the absolute volume basis. The w/c ratio, slump, cement, and air content shall conform to Section 1000 of the Standard Specifications (1990) for the class of concrete desired.

(2) Admixtures used must be from the current approved list of air-entraining agents, water reducers and retarders.

MIX DESIGN DATA

F.A.-FM-	2.56	F.A.-Abs %	0.10	C.A.-Sp.Gr.-	2.77
F.A.-Sp.Gr.-	2.68	C.A.-Abs %	0.70	C.A.-Unit Wt.-	98
Mortar-Cu. Ft. per Cu. Yd.	15.87				

Prepared by APAC Georgia, Inc.

Date: November 03, 1993

TABLE 14.4

NC DEPARTMENT OF TRANSPORTATION AND HIGHWAY SAFETY
STATEMENT OF CONCRETE MIX DESIGN AND SOURCE OF MATERIALS

Project #	S.T600406 STPNH-37-1 (48)	**R.M. Producer:**	APAC-Georgia, Inc.
County:	Davidson	**Plant Location:**	Job Site
Resident Engineer:	Keith Raulston	**Contractor:**	APAC-Georgia, Inc.

Mix Design-One Cubic Yard Based on SSD Condition

Class of Concrete:	Concrete Pavement 900 PSI	**Size of Coarse Aggregate:**	57M
Lab Mix Design Number:	900-2	**Designed Air Content:**	5.0%

Material		Source	Material Producer/Location
Cement Type I	772 lbs.	Tarmac Roanoke	Roanoke, VA
Flyash	232 lbs.	Monex Class F	Bellews Creek, NC
Fine Agg. +M	743 lbs.	Martin Marietta, Sand, 2MS	Woodlief Quarry
Fine Agg. +M			
Coarse Agg. +M	1900 lbs.	Martin Marietta, #57M	Thomasville Quarry
Total Water Per C.Y.	35.0 gal.		
Admixture (AE)			
Admixture (Retarder)	5.0 oz.	Hunt Process (Air-In)	Ridgeland, MS
Admixture (Water Red)	60.2 oz.	Hunt Process (HPS-R)	Ridgeland, MS

The quality of mixing water shown is designed to produce a 1.5" slump.

The maximum water permitted by specifications is 35.0 gallons per cu. yd. NOTE: if it is found that more than the maximum water permitted by the specifications is required to produce workability, additional cement will be required to maintain the maximum water cement ratio.

(1) The quantities of fine and course aggregates necessary to conform to specifications in regard to consistency and workability shall be determined by the method described in "Recommended Practice for Selecting Proportions for Concrete" (ACI 211.1-74), and "Pumping Concrete by Pumping Methods" (ACI 304), using the absolute volume basis. The w/c ratio, slump, cement, and air content shall conform to Section 1000 of the Standard Specifications (1990) for the class of concrete desired.

(2) Admixtures used must be from the current approved list of air-entraining agents, water reducers and retarders.

MIX DESIGN DATA

F.A.-FM-	2.56	F.A.-Abs %	0.10	C.A.-Sp.Gr.-	2.77
F.A.-Sp.Gr.-	2.68	C.A.-Abs %	0.70	C.A.-Unit Wt.-	98
Mortar-Cu. Ft. per Cu. Yd.	15.87				

Prepared by APAC Georgia, Inc.

Date: November 04, 1993

TABLE 16
SPS-2 US 52 LEXINGTON BY-PASS, NC SBL
Concrete Test Results - LCB and PCC

TEST SECTION	STATION & SAMPLE #	DATE SAMPLED	TYPE CONC.	FIELD TESTS				PC09-P69 FLEXURAL, psi SHRP, NC			PC01-P61 COMPRESSION, psi			PC02-P62 TENSILE, psi		
				AIR	SLUMP	CONC. T	AIR T.	14 DAY	28 DAY	365 DAY	14 DAY	28 DAY	365 DAY	14 DAY	28 DAY	365 DAY
LCB																
370206	273+50 BP1	11/13/93	ECON	3.8	1	69	68	-	-	-	3468 (16)	4160				
370208	217+50 BP2	11/9/93	ECON	5.6	1.2	58	44	-	-	-	2975	3785				
PCC																
370259	327+75 FC7	10/24/93	3000 psi 550 psi	4.4	0.7	75	52	578 (15)	616		3950 (15)	4560		338 (15)	502	
370201	301+50 FC1	11/22/93	550 psi	5.6	1	62	44	736 (15)	564 (30)		3900 (15)	4565 (30)		389 (15)	485 (30)	
370202	280+50 FC4	11/21/93	900 psi	5.2	1 1/4	68	54	-	1020 (29)		6560 (15)	7824 (29)		527 (15)	573 (29)	
370206	273+50 FC5	11/21/93	900 psi	5.2	1 1/2	68	58	-	994 (29)		6585 (15)	7297 (29)		550 (15)	550 (29)	
370207	251+50 FC2	11/18/93	550 psi	5.2	1 1/4	68	56	650	736		4495	5331		-	494	
370260	244+50 FC3	11/12/93	550 psi	4.4	1	58	38	663 (17)	642		5750 (17)	6285		526 (17)	546	
370212	224+50 FC6	11/9/93	900 psi	5.5	1.2	63	54	884	-		5908	6470		466	520	

( ) Age, days