FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance Specific Pavement Studies

COLORADO SPS-8

Construction Report on SHRP 080800
Colorado Department of Transportation

DRAFT

Prepared by:

Western Region Contractor
Nichols Consulting Engineers, Chtd.

June 1998

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Co SPS-8

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Long-Term Pavement Performance

August 5, 1998
File: 800.12.8.9.10

Mr. Ahmad Ardani
Colorado DOT
4201 E. Arkansas Ave.
Denver, CO 80222

RE: Colorado SPS-8 - Construction Report on SHRP 080800

Dear Mr. Ardani:

I am submitting the above referenced construction report for your review. Should you have any questions or comments, please do not hesitate to call me at 702/329-4955.

Sincerely,
NICHOLS CONSULTING ENGINEERS, Chtd.

Scott Gibson, P.E.
Agency Coordinator

SG/rkp
Enclosure

cc: ~~Bill~~ Bellinger
John Miller
Shiraz Tayabji

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ABSTRACT

Environmental conditions alone or interacting with pavement materials may generate major distresses in pavements. The impact of the natural environment on long-term performance of pavements has been difficult to quantify as have the interactions between environmental stresses and load stresses. The Colorado SPS-8 project combines two test sections with different portland cement concrete thicknesses in a low traffic environment with a weather station to continuously monitor environmental conditions. Over time, the effect of the environment on the performance of these sections will be monitored. The construction of the sections was monitored closely to insure the sections were constructed according to specifications. Details of construction are presented here, along with minor deviations and problems during construction which may affect the pavement performance.

I. INTRODUCTION

The Strategic Highway Research Program (SHRP) Specific Pavement Studies experiment, SPS-8, was designed as a "Study of Environmental Effects in the Absence of Heavy Loads." Environmental conditions alone or interacting with pavement materials may generate major distresses in pavements. Frost heave, soil swell, D-cracking, popouts, and scaling are common environmentally related distresses which have little or no traffic related component. The objective of the SPS-8 experiment is to measure the deterioration in pavement performance in the absence of heavy loads. This report covers the construction of the SPS-8 project in Colorado in 1993.

II. SPS-8 PROJECT DESCRIPTION

The Colorado SPS-8 project was constructed in Adams County on Chestnut Street in the vicinity of Denver, as shown in Figure 1. Two sections, both 500 feet long, were constructed with different portland cement concrete thicknesses, as shown in Figure 2. The sections are on Chestnut Street, just off 136th Avenue adjacent to I-76 and the SPS-2 site. The cross-sections for the sections are shown in Figures 3 and 4.

The terrain in the area consists of scattered brush and trees and is flat. The site is located on a sandy-clay to clayey-sand material. The site has a longitude of 104°44'48" and latitude of 39°58'18". The elevation is 5095'. Test Section 080811 is located on a -1.7% grade, and Section 080812 is located on a -0.4% grade. Each section is a tangent joined by a 10° curve between the two sections. A 50-foot taper was introduced at the beginning of the sections to allow a change of materials from the State Standard design to the SHRP design. Between sections, a 100-foot taper was used, and at the end, a 50-foot taper back to the State Standard design.

The annual average daily traffic (AADT) in two directions for this section of roadway was 2,500 in 1992, with 5% heavy trucks and combinations. For a design period of 20-years, the total design 18 kip Equivalent Single Axle Loads (ESAL) applications is 259,000.

Based on existing climatic data, the maximum 7-day air temperature for this area is 102°F, which can be translated to a maximum pavement temperature of 147°F. The mean of the annual 7-day maximum air temperatures for this area is 95°F. The minimum air temperature is -36°F. The mean of annual low air temperatures is -17°F. Historical temperature data was from the Fort Lupton 2 SE weather station approximately 8 miles away (latitude 40°4'12", longitude 104°46'0", elevation 5023').

The site is rated as a moderately active site due to frost heave. It falls in the dry freeze SHRP environmental zone, and in the coarse grained subgrade soil category. Following

Denver International Airport Vicinity Map

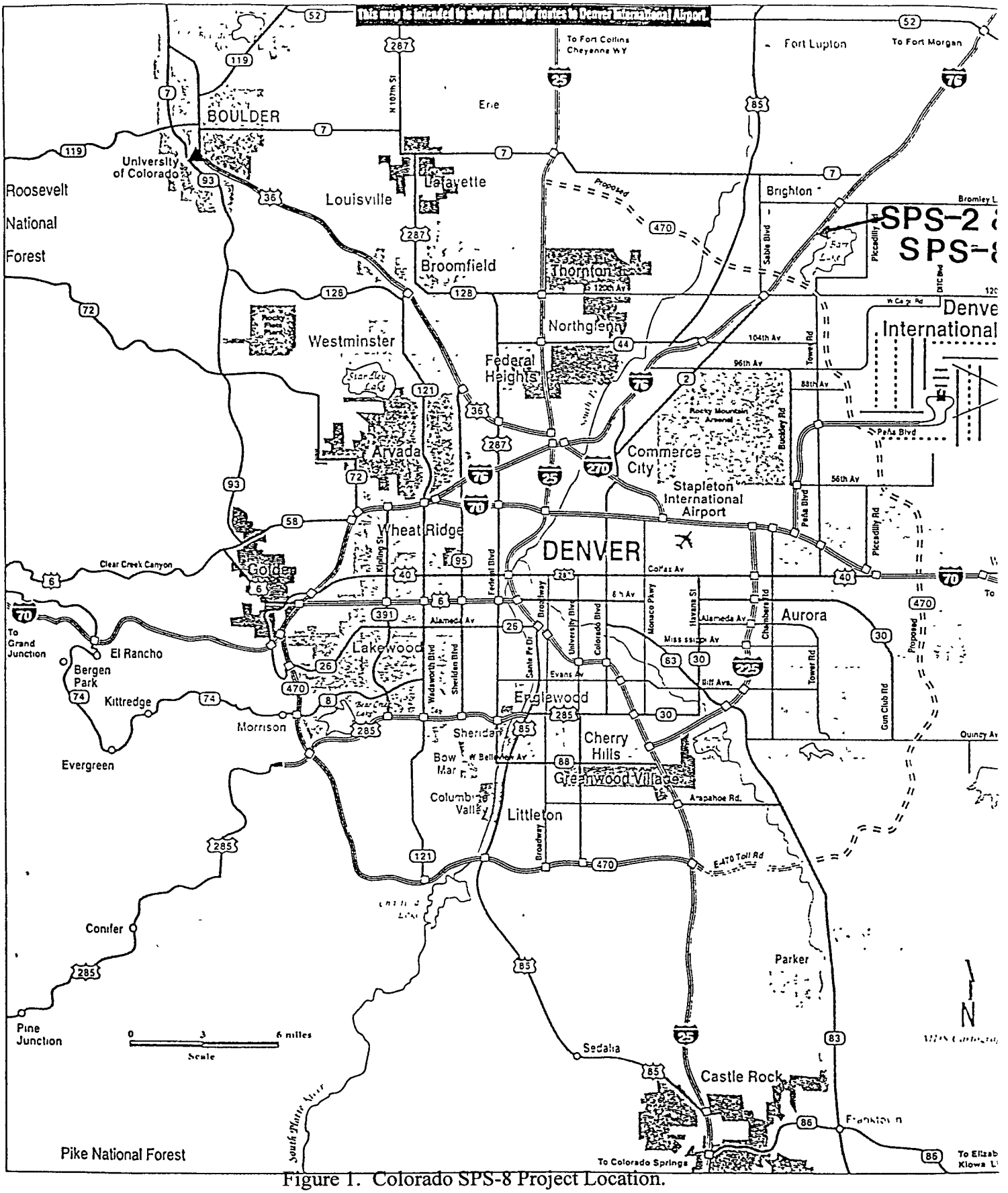


Figure 1. Colorado SPS-8 Project Location.

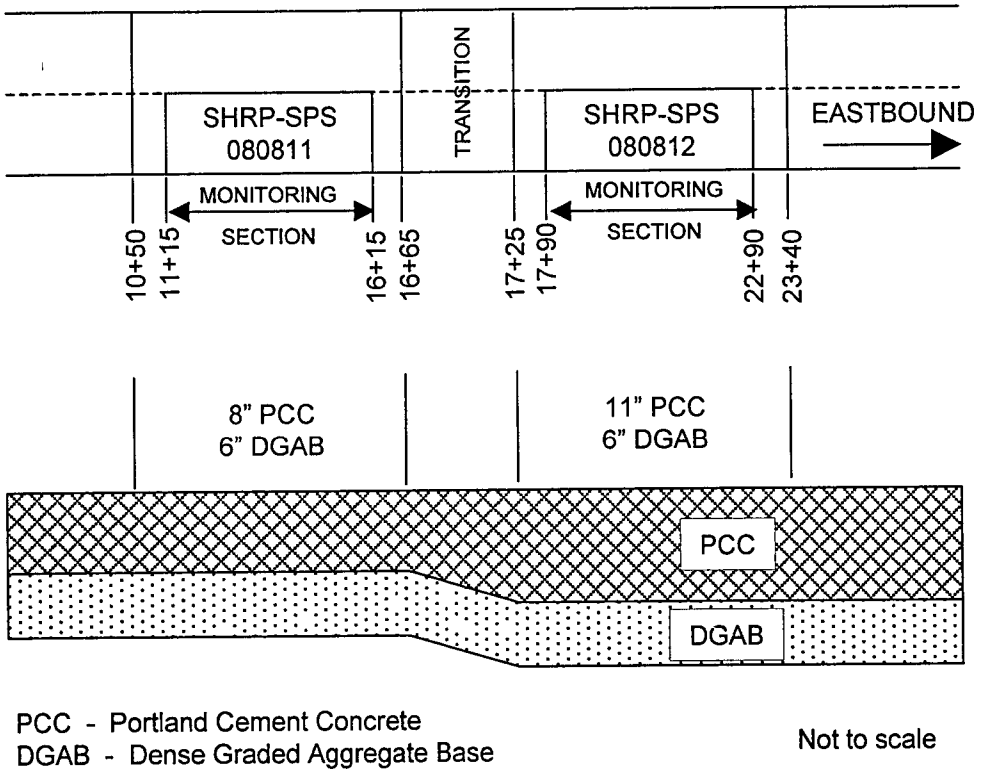


Figure 2. Layout of experimental test sections, Colorado SPS-8 project.

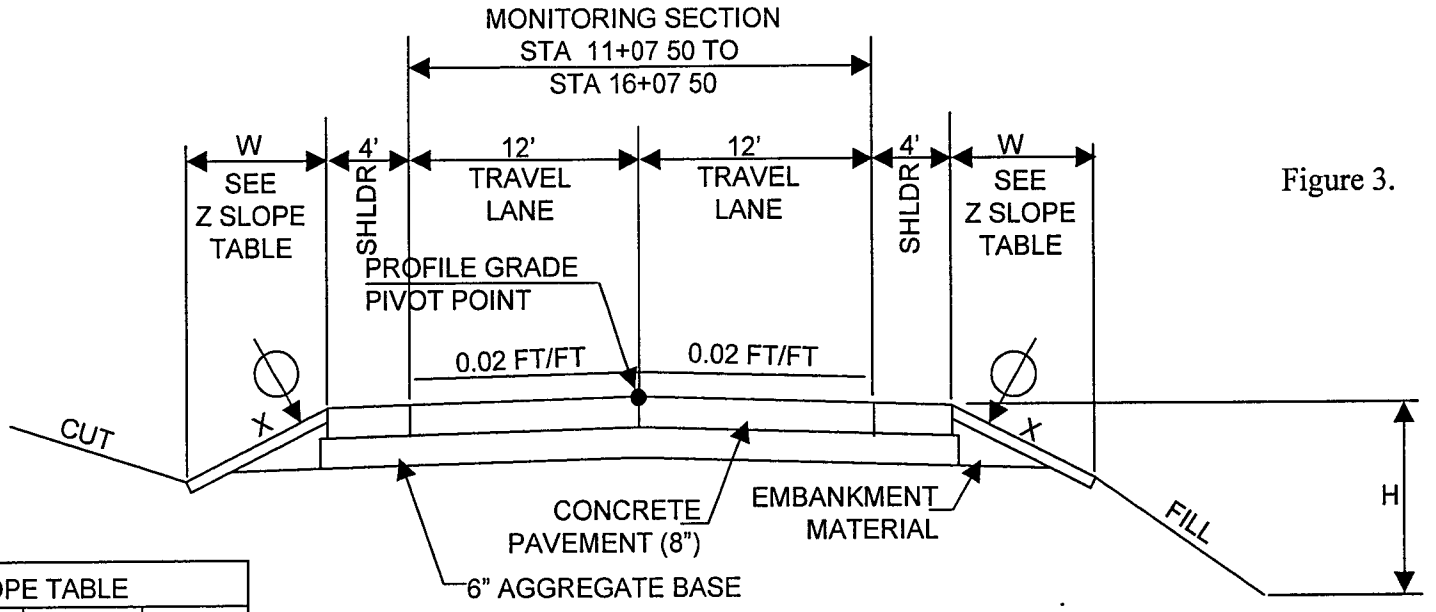


Figure 3.

Z SLOPE TABLE		
STATION	X	Y
10+50 TO 15+50	4 1	2'
15+50 TO 17+00	TRANSITION	
17+00 TO 17+25	5 1	8'

STA 10+50 TO STA 16+65 CHESTNUT STREET

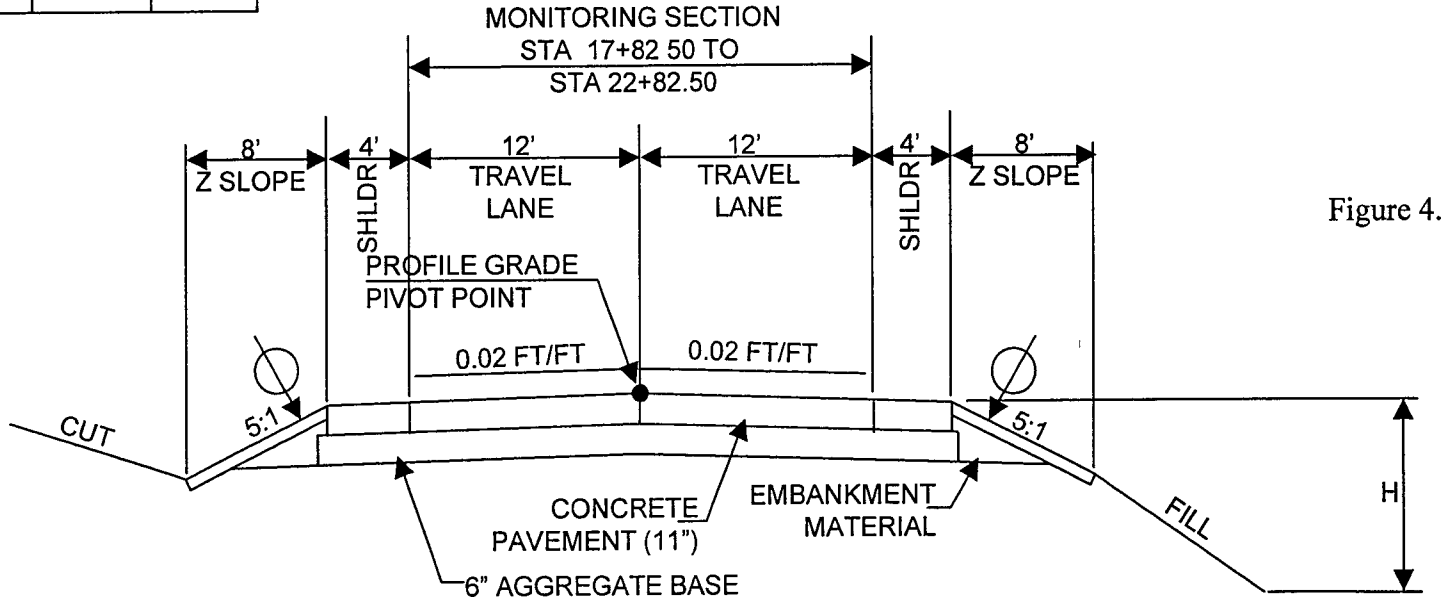


Figure 4.

STA 17+25 TO STA 23+40 CHESTNUT STREET

III. CONSTRUCTION

The project was constructed as a portland cement concrete pavement with 12 foot wide lanes and 4 foot wide shoulders. Two different pavement sections were constructed. The first consisted of 8 inches of portland cement concrete on 6 inches of dense graded aggregate base on subgrade. The second consisted of 11 inches of portland cement concrete on 6 inches of dense graded aggregate base on subgrade. The test sections were each 615 feet long allocated with 500 feet as the monitoring section and the remaining 115 feet set aside for sampling.

SUBGRADE

Subgrade preparation for section 080811 began on October 15, 1993 and was completed on October 26, 1993. Subgrade preparation for section 080812 began on September 29, 1993 and was completed on October 6, 1993. The subgrade was compacted using a 5-ton steel wheel tandem roller. Bulk soil samples were collected from three locations outside the SPS-8 sections. Soil gradation tests were performed on the bulk samples as well as laboratory compaction tests. Table 1 shows the gradations obtained from the referenced soil samples.

Table 1. Field Subgrade Material Gradations
(Material Sampled 10/21/93)

Sieve Size	Percent Passing by Sieve Size		
	Section 080811	Section 080812(1)	Section 080812(2)
2"		95	
1-1/2"		93	
1"		93	100
3/4"	100	93	99
1/2"	99	92	98
3/8"	99	92	98
#4	99	91	97
#10	98	90	94
#40	88	81	71
#80	68	62	46
#200	53.2	45.1	28.7

Nuclear density tests were performed at three locations within the project limits near the areas where the soil samples were taken for the gradation and laboratory compaction tests. Table 2 shows the results of the nuclear density tests as well as the computed relative compaction as compared to the laboratory compaction tests. The locations at which the bulk samples were taken and the nuclear density tests performed can be found in Appendix 1.

Table 2. Colorado SPS-8 Subgrade Compaction Data

Date	C/L Ref.	Station	Density (pcf)	Moisture Content (%)	Compaction (%)	Deviation from Optimum Moisture (%)
Section 080811 (Eastbound Lane)						
10/21	8'	1+00	114.5	16.1	104	+0.2
10/21	8'	2+50	116.4	11.8	105	-4.3
10/21	8'	4+00	117.9	12.4	107	-3.9
Section 080812 (Eastbound Lane)						
10/21	8'	1+90	115.4	11.6	105	-4.7
10/21	8'	2+50	123.6	10.1	104	-2.7
10/21	8'	4+00	127.4	9.3	101	+0.1

DENSE GRADED AGGREGATE BASE (DGAB)

Dense graded aggregate base preparation for both sections was performed on October 26, 1993. The base was placed in a single 6" lift and compacted with a 5-ton steel wheel tandem roller. Aggregate gradation and laboratory compaction tests were performed on bulk samples taken from three different areas within the project limits. Gradations from base samples are shown in Table 3.

Table 3. Field Aggregate Base Gradations
(Material Sampled 10/27/93)

Sieve Size	Percent Passing by Sieve Size		
	Section 080811	Section 080812(1)	Section 080812(2)
1-1/2"	100	100	100
1"	98	95	99
3/4"	92	90	94
1/2"	76	74	78
3/8"	70	66	72
#4	57	63	59
#10	42	40	45
#40	20	19	23
#80	9	10	14
#200	7.8	8.1	9.3

Nuclear density tests were performed at three locations within the project limits near the areas where the soil samples were taken for the gradation and laboratory compaction tests. Table 4 shows the results of the nuclear density tests as well as the computed relative compaction as compared to the laboratory compaction tests. The locations at which the bulk samples were taken and the nuclear density tests performed can be found in Appendix 1.

Table 4. Colorado SPS-8 Dense Graded Aggregate Base Compaction Data

Date	C/L Ref.	Station	Density (pcf)	Moisture Content (%)	Compaction (%)	Deviation from Optimum Moisture (%)
Section 080811 (Eastbound Lane)						
10/27	6'	1+00	130.8	4.1	93	-1.9
10/27	6'	2+50	130.7	3.7	93	-2.1
10/27	6'	4+00	134.2	5.3	96	-0.2
Section 080812 (Eastbound Lane)						
10/27	6'	1+00	128.4	3.9	92	-1.6
10/27	6'	2+50	134.8	4.7	97	-1.1
10/27	6'	4+00	131.0	3.8	95	-2.2

The thickness of the dense graded aggregate base was measured at transverse increments of 36 inches and longitudinal increments of 50 feet. Table 5 shows the maximum, minimum, and average measured dense graded aggregate base thicknesses, and associated standard deviations for the two SPS-8 sections.

Table 5. Dense Graded Aggregate Base Thickness

Section	Minimum Thickness (inch)	Maximum Thickness (inch)	Average Thickness (inch)	Design Thickness (inch)	Standard Deviation (inch)
080811	3.7	8.1	6.0	6	0.98
080812	4.3	11.0	7.5	6	1.39

PORTLAND CEMENT CONCRETE (PCC)

Construction of the portland cement concrete layer began and finished on October 28, 1993 for both of the SPS-8 sections. The paving train consisted of a Gomaco PS60 in front of a Rex slip-form paver. The concrete was supplied by the Castle Rock plant, approximately 4 miles (10 minutes travel time) away. The entire 32 foot width was paved in one pass. The concrete was consolidated using internal vibrators spaced 18 inches apart, extending into the pavement below the finished surface. Finishing of the concrete was performed by screeding, hand-troweling, and machine troweling. The pavement was first textured by a burlap drag, then an astroturf drag, and lastly by a tining machine. After texturing, a membrane curing compound was sprayed onto the pavement.

Transverse joints were constructed every 15 feet along the project. Dowel bars were placed at all transverse joint locations using dowel baskets attached to the dense graded aggregate base. The dowel bars used for Section 080811 were 18 inches long with a diameter of 1.25 inches. The dowel bars used for Section 080812 were also 18 inches long, but with a diameter of 1.50 inches. The dowel bars in both sections were spaced at 12 inch increments. The dowel bars were coated with grease prior to paving. Transverse joints were sawed into the pavement to an average width of 0.3 inch, an average depth of 2.6 inches for the Section 080811,

and an average depth of 3.6 inches for the Section 080812. The joints in both sections were sawed approximately 6 hours after concrete placement and sealed with Dow Corning 888.

A longitudinal joint was constructed in between the two travel lanes. Tie bars 30 inches long, with diameters of 0.63 inch, were mechanically placed at intervals of 30 inches in the concrete along the lane-lane longitudinal joint. Lane to lane longitudinal joints were sawed to an average width of 0.17 inch, an average depth of 2.70 inches for Section 080811, and an average depth of 3.60 inches for Section 080812. A longitudinal joint was also constructed in between the traffic lane and shoulder. This joint was sawed to an average width of 0.21 inch, an average depth of 2.67 inches for Section 080811, and an average depth of 2.50 inches for Section 080812.

The concrete mixture used a maximum aggregate size of 1.5" and a Southwestern Type I/II low alkali cement. The concrete aggregate gradations are shown in Table 6 and the concrete mixture proportions are summarized in Table 7. Concrete test specimens were constructed from bulk samples taken at three locations at the time of construction and from cores drilled after construction. Table 8 shows results from compressive, splitting tensile, flexural, and density tests performed on the specimens.

Table 6. Aggregate gradations for portland cement concrete test sections

Sieve Size	Percent Passing by Sieve Size	
	Coarse Aggregate	Fine Aggregate
1-1/2"	100	
1"	99	
3/4"	87	
1/2"	55	
3/8"	39	
#4	8	
#8		97
#16		78
#30		44
#50		17
#100		3

Table 7. Portland Cement Concrete Mix Design and Aggregate Properties

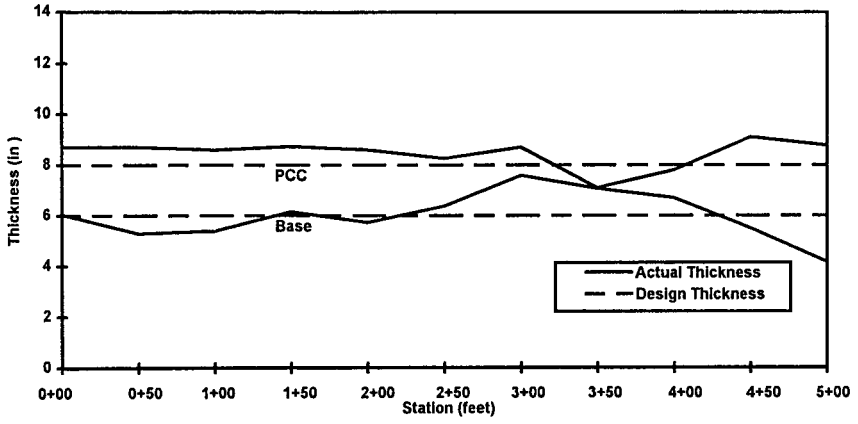
Material	Weight (lbs) per cubic yard of concrete
Coarse Aggregate	1720
Fine Aggregate	1430
Cement	399
Water	236
Admixture	Percent by weight of cement
Fly Ash	25.0
Air-Entraining Admixture	0.1
Property	
Bulk SG of Coarse Aggregate	2.73
Bulk SG of Fine Aggregate	2.60
Composition of Coarse Aggregate	100% Crushed Stone
Composition of Fine Aggregate	100% Natural Sand
Type of Cement	Southwestern Type I/II Low Alkali
Alkali Content of Cement	0.6%
LA Abrasion test of Coarse Aggregate (% Weight Loss)	32.0

Table 8. Portland Cement Test Results

Sample Location*	Compressive Strength (psi)	Splitting Tensile Strength (psi)	Static Modulus of Elasticity (psi)	Density (pcf)	Flexural Strength (psi) (Modulus of Rupture)
B201 (14-day)	3360	390		143.4	510
B201 (28-day)	4020	390			610
B202 (14-day)	2550	350			420
B202 (28-day)	3430	350		143.8	610
B203 (14-day)	2410	240			425
B203 (28-day)	2970	350			500
C201 (14-day)	1930				
C202 (28-day)	2610				
C203 (28-day)			28,000,000		
C205 (14-day)		400			
C206 (28-day)		335			
C210 (14-day)	2490			143.2	
C211 (28-day)	2660			143.3	
C212 (28-day)			25,000,000		
C214 (14-day)		410			
C215 (28-day)		380			
C220 (14-day)	3070			146.7	
C221 (28-day)	2480			146.1	
C223 (14-day)		410			
C224 (28-day)		405			
C226 (28-day)			21,000,000		

*B designation refers to specimens made from bulk samples of concrete; C designation refers to specimens made from drilled cores.

The thickness of the portland cement concrete was measured at transverse increments of 36 inches and longitudinal increments of 50 feet. Table 9 shows the maximum, minimum, and average measured concrete layer thicknesses, and associated standard deviations for the two SPS-8 sections. Figures 5 and 6 shows plots of the as built thicknesses of both the dense graded aggregate base and the portland cement concrete layers.



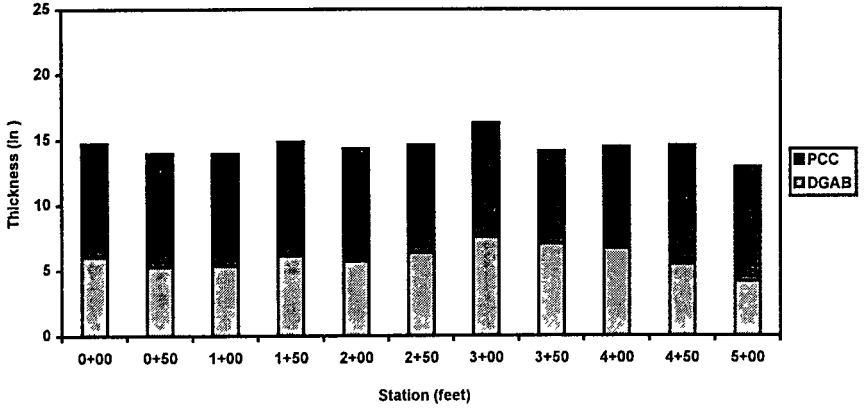
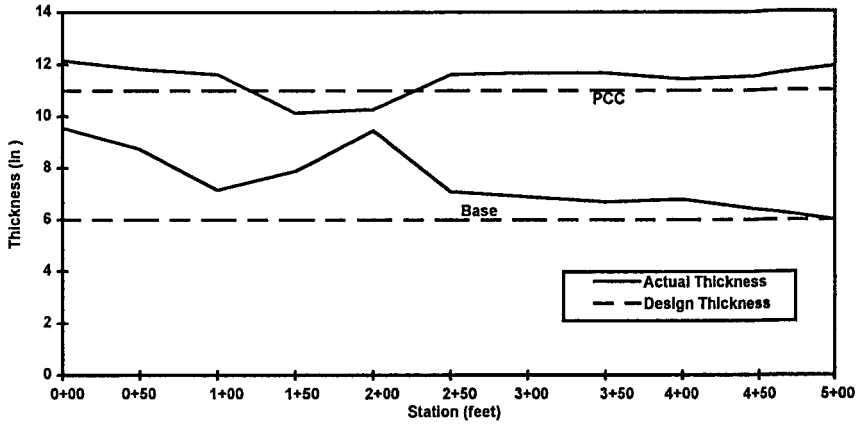


Figure 5. Section 808011 Layer Thicknesses



Section 808012 Thicknesses

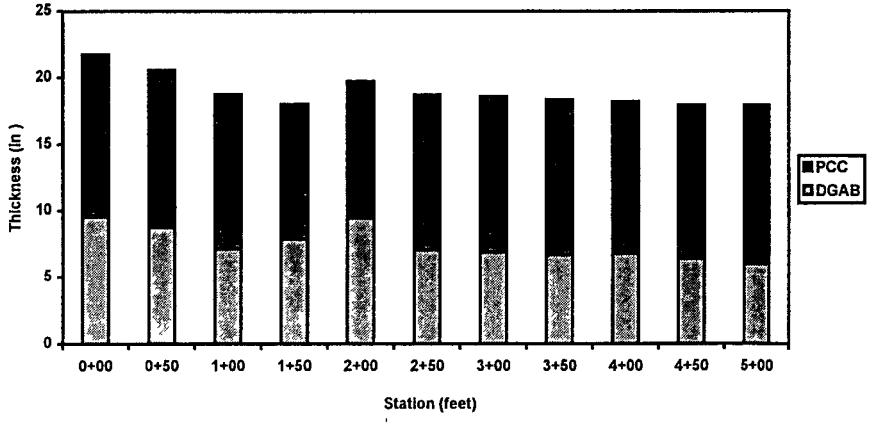


Figure 6. Section 808012 Layer Thicknesses

Table 9. Portland Cement Concrete Thickness

Section	Minimum Thickness (inch)	Maximum Thickness (inch)	Average Thickness (inch)	Design Thickness (inch)	Standard Deviation (inch)
080811	6.5	9.3	8.5	8	0.60
080812	9.4	13.6	11.4	11	0.79

A post construction surface profile was performed using a California profilograph with a 0.20 inch blanking band. The surface profile was corrected by diamond grinding and Section 080811 was found to have a profile index of 35 inches per mile. Section 080812 was found to have a profile index of 38 inches per mile. The thickness of the concrete layer was found after grinding.

IV. SUMMARY

Construction of the Colorado SPS-8 project began in September 1993 with subgrade preparation. In late October, a dense graded aggregate base was constructed with an average thickness of 6.0 inches on Section 080811 and 7.5 inches on Section 080812. Portland cement concrete paving was also performed in late October. Section 080811 was constructed with an average thickness of 8.5 inches and Section 080812 an average of 11.4 inches.

Several deviations from the construction guidelines were noted. Each of these is described below:

1). The construction guidelines state that the concrete must meet a minimum 14-day flexural strength requirement of 550 psi. Of the three bulk PCC samples taken to make beams for flexural strength tests, none met this requirement. The average 14-day flexural strength was 452 psi.

2). The construction guidelines also state that a maximum of 15% fly ash by weight of cement can be used in the concrete mix. The mix placed at these sections contain 25% fly ash.

3). The construction guidelines state that the thickness of the PCC layer should not deviate from the design thickness by more than $^1/_4$" according to rod and level measurements and core measurements. According to rod and level measurements, the average PCC thickness for Section 080811 deviates by 0.5 inches and for Section 080812 by 0.4 inches. The maximum deviation at any one point within Section 080811 was 1.5 inches and within Section 080812 was 2.6 inches. The thicknesses were only confirmed by the two cores taken at one year after construction. The core information taken just after construction contain questionable data and do not corroborate the PCC thicknesses measured by rod and level or the cores taken at one year after construction.

4). The construction guidelines specify a maximum profile index of 10 inch/mile as measured with a California profilograph. The as-built profile index of Section 080811 was 35 inch/mile and of Section 080812 was 38 inch/mile. Both of those profile indices were recorded using a 0.20 inch blanking band. In both cases the as-built profile index highly exceeds the construction guidelines.

5). According to discussions with the LTPP personnel present at the time of construction, very poor weather conditions were present during the paving operations. Snow was falling and a blizzard conditions were impending, which prompted the paving operation to proceed at a pace somewhat faster than normal.

Other than the deviations noted above, this SPS-8 project was constructed in accordance with the LTPP construction guidelines. Despite these deviations, this project should prove to be a valuable test section in achieving the goals of the SPS-8 experimental design.

Appendix

Field Sampling and Testing Locations

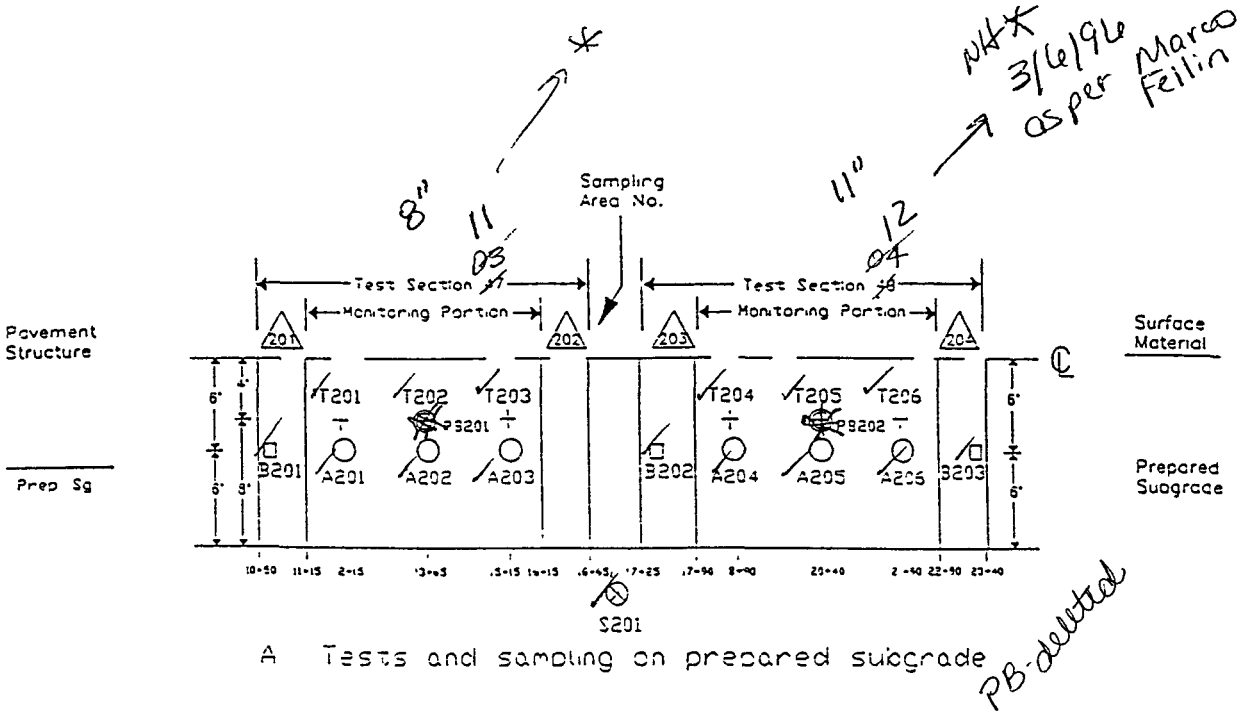


Figure 18. Sampling and test plans for SPS-8 test sections, Chestnut Street, I-76 project, Colorado.

Done 10-25-94
64 ○ = Air content @ 28 days
& Thermal Coefficient
~~Not tested~~
1 day cores

10-28-93
10-25-94
1 year