FEDERAL HIGHWAY ADMINISTRATION

Long Term Pavement Performance
Specific Pavement Studies

SPS-2 CONSTRUCTION REPORT
SHRP 080200

FINAL

Prepared for:
Colordo Department of Transportation
Federal Aid Project No. I 076-1 (138)
I-76 Eastbound, Milepost 18.43
Adams County

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INTRODUCTION

The following construction report provides documentation of the as-built properties for the Colorado SPS-2 project and provides details of any deviations from the experiment construction guidelines. This report is available as an archival reference for future in-depth analysis of the SPS-2 materials and performance. Areas addressed within are construction sequence, layer thicknesses, material properties (as-placed), out of specification materials placed (even if removed and replaced), surface preparation techniques, problems encountered during construction, weather conditions during construction, and the presence of any construction joints within sections. Also included are the permeable asphalt treated base (PATB) mix design, portland cement concrete (PCC) mix design, lean concrete base (LCB) mix design, and summaries of slump and air content results. The sampling areas and tests conducted for each test section are shown in appendix D. A photographic log illustrating construction procedures, equipment and materials; testing procedures and equipment; and problems encountered during construction is located in appendix A. The material properties are found in appendix B and the material thickness measurements (raw data) in appendix C.

BACKGROUND

The SPS-2 experiment was developed to investigate the effect of selected structural factors on the long-term performance of rigid pavements constructed on different soil types in different climatic environments. The structural factors include concrete slab thickness, concrete strength, base material and drainability (permeability), base course thickness, and lane width. The basic experiment 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. However, the option of constructing these sections was not exercised on this project. In table 1, the eight environmentally-related (soil type and climate) combinations are shown across the top and the 24 pavement structure combinations are shown along the left side. To make construction more feasible to the participating agencies, the 24 test sections required were divided into two separate experimental combinations with 12 sections each. The two experimental combinations were constructed at different locations in the western United States, one in Colorado and one in Northern Nevada. Colorado elected to construct the "U Series" of experimental sections.

Table 1. Basic experiment doweled jointed plain concrete pavements (SPS-2).

Pavement Structure					Climate Zone, Subgrade Site															
					Wet								Dry							
					Freeze				No Freeze				Freeze				No Freeze			
Drain	Base Type	PCC Thick in	PCC Strength psi	Lane Width	Fine		Coarse		Fine		Coarse		Fine		Coarse		Fine		Coarse	
					J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y
NO	DGAB	8	550	12	J1		L1		N1		P1		R1		T1		V1		X1	
				14		K13		M13		O13		Q13		S13		U13		W13		Y13
			900	12		K14		M14		O14		Q14		S14		U14		W14		Y14
				14	J2		L2		N2		P2		R2		T2		V2		X2	
		11	550	12		K15		M15		O15		Q15		S15		U15		W15		Y15
				14	J3		L3		N3		P3		R3		T3		V3		X3	
			900	12	J4		L4		N4		P4		R4		T4		V4		X4	
				14		K16		M16		O16		Q16		S16		U16		W16		Y16
NO	LCB	8	550	12	J5		L5		N5		P5		R5		T5		V5		X5	
				14		K17		M17		O17		Q17		S17		U17		W17		Y17
			900	12		K18		M18		O18		Q18		S18		U18		W18		Y18
				14	J6		L6		N6		P6		R6		T6		V6		X6	
		11	550	12		K19		M19		O19		Q19		S19		U19		W19		Y19
				14	J7		L7		N7		P7		R7		T7		V7		X7	
			900	12	J8		L8		N8		P8		R8		T8		V8		X8	
				14		K20		M20		O20		Q20		S20		U20		W20		Y20
YES	PATB DGAB	8	550	12	J9		L9		N9		P9		R9		T9		V9		X9	
				14		K21		M21		O21		Q21		S21		U21		W21		Y21
			900	12		K22		M22		O22		Q22		S22		U22		W22		Y22
				14	J10		L10		N10		P10		R10		T10		V10		X10	
		11	550	12		K23		M23		O23		Q23		S23		U23		W23		Y23
				14	J11		L11		N11		P11		R11		T11		V11		X11	
			900	12	J12		L12		N12		P12		R12		T12		V12		X12	
				14		K24		M24		O24		Q24		S24		U24		W24		Y24

DGAB = Dense-graded untreated aggregate base
LCB = Lean concrete base
PATB = Permeable asphalt-treated base (4-in thickness placed on a DGAB layer)
All perpendicular doweled joints, 15-ft spacing

PROJECT DESCRIPTION

The Colorado SPS-2 site was constructed for the Strategic Highway Research Program (SHRP) as Federal Aid Project No. I 076-1 (138) on I-76 eastbound (M.P. 18.43) in Adams County, near Denver, Colorado (figure 1). The Colorado project is comprised of 13 sections, consisting of 12 primary sections and one state control section (figure 2). This site is located in a dry-freeze zone. The project is located near Barr Lake and wetlands are in close proximity. Also located on the site was a colony of prairie dogs on approximately one acre of the new alignment portion. The prairie dogs were eliminated using gas pellets. The project consists of both a new alignment and removal and reconstruction of a divided 4-lane highway (two lanes in each direction). The annual average daily traffic (two directions) is 8,400 (1988), with 16 percent heavy trucks and combinations. The estimated 18 kip ESAL rate in the study lane is 779,700 per year. The total design 18 kip ESAL applications in the design lane is 15,594,000, with a design period of 20 years. The Colorado SPS-2 was constructed with the primary sections having the criteria shown below in table 2.

Table 2. SPS-2 experiment criteria.

Base Types:	Dense-graded aggregate base (DGAB) Lean concrete base (LCB) Permeable asphalt-treated base (PATB)
Concrete Strengths:	550 psi flexural 900 psi flexural
Pavement Thickness:	8 in 11 in
Lane Widths:	12 ft 14 ft
Drainage Systems:	Non-drainable (figure 3) Drainable (figure 4)

The construction sequencing and layout of the test sections is shown in figure 2 and described in table 3. In addition to the 12 primary SHRP sections, a state supplemental control section, 080259, was also constructed from station 221+10 to 227+90. This section was built using Colorado's standard design criteria: 11 in of PCCP on subgrade, 650 psi flexural strength, and a 12 ft lane width.

Key personnel involved in the project are shown in table 4.

The construction of the SHRP SPS-2 sections was from approximately July 1, 1993 to November 1, 1993. The project was constructed in two phases. Phase 1, the new alignment portion, consisted of seven sections, 080217, 080220, 080221, 080222, 080223, 080224, and 080259, located from station 155+90 to 227+90 (figure 2). Phase 2, the removal and reconstruction portion, consisted of six sections, 080213, 080214, 080215, 080216, 080218, and 080219, located from station 101+40 to 155+60 (figure 2). Phase 1 was opened to traffic on October 7, 1993. Phase 2 was opened to traffic on January 5, 1994.

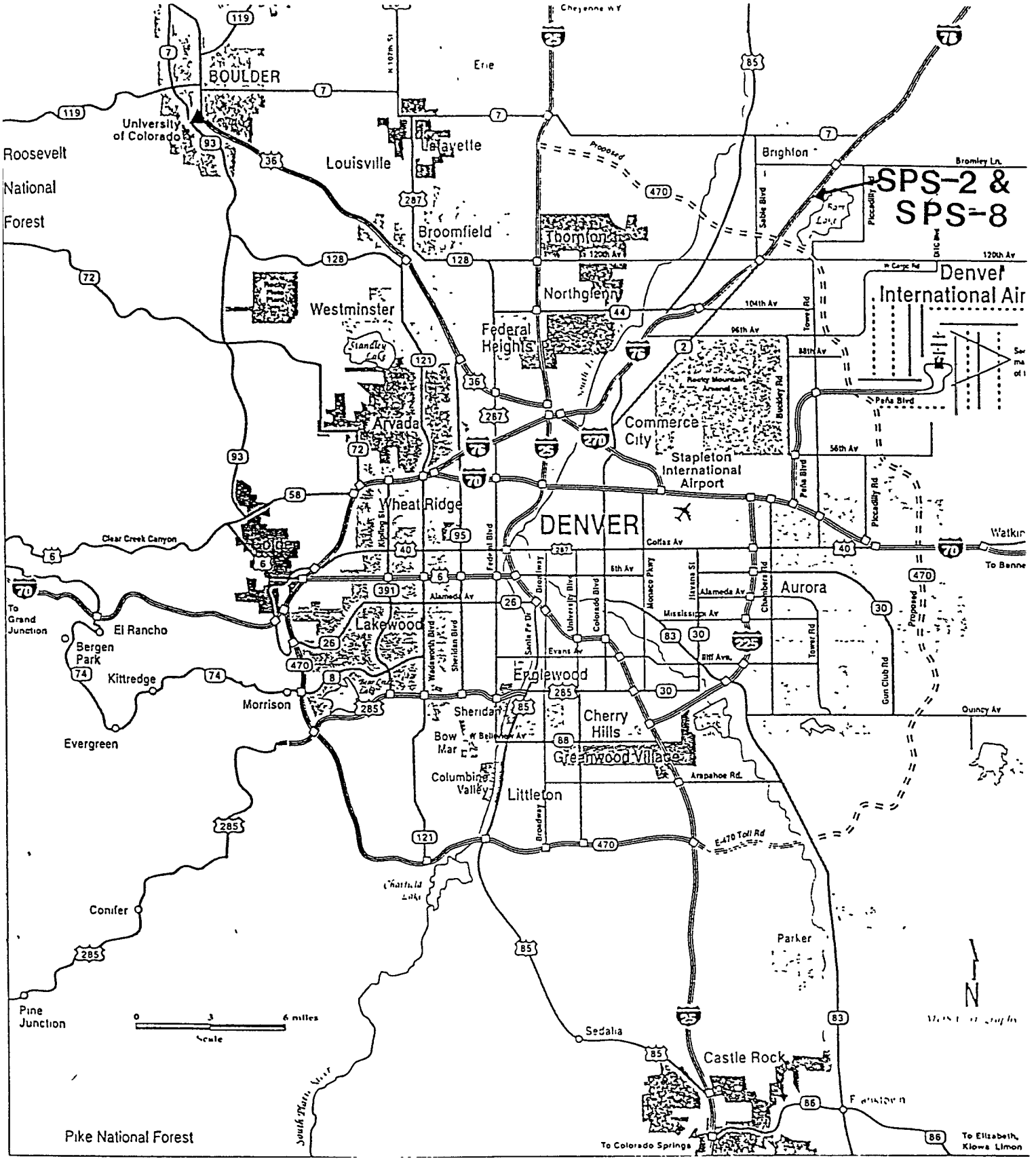


Figure 1. Site location.

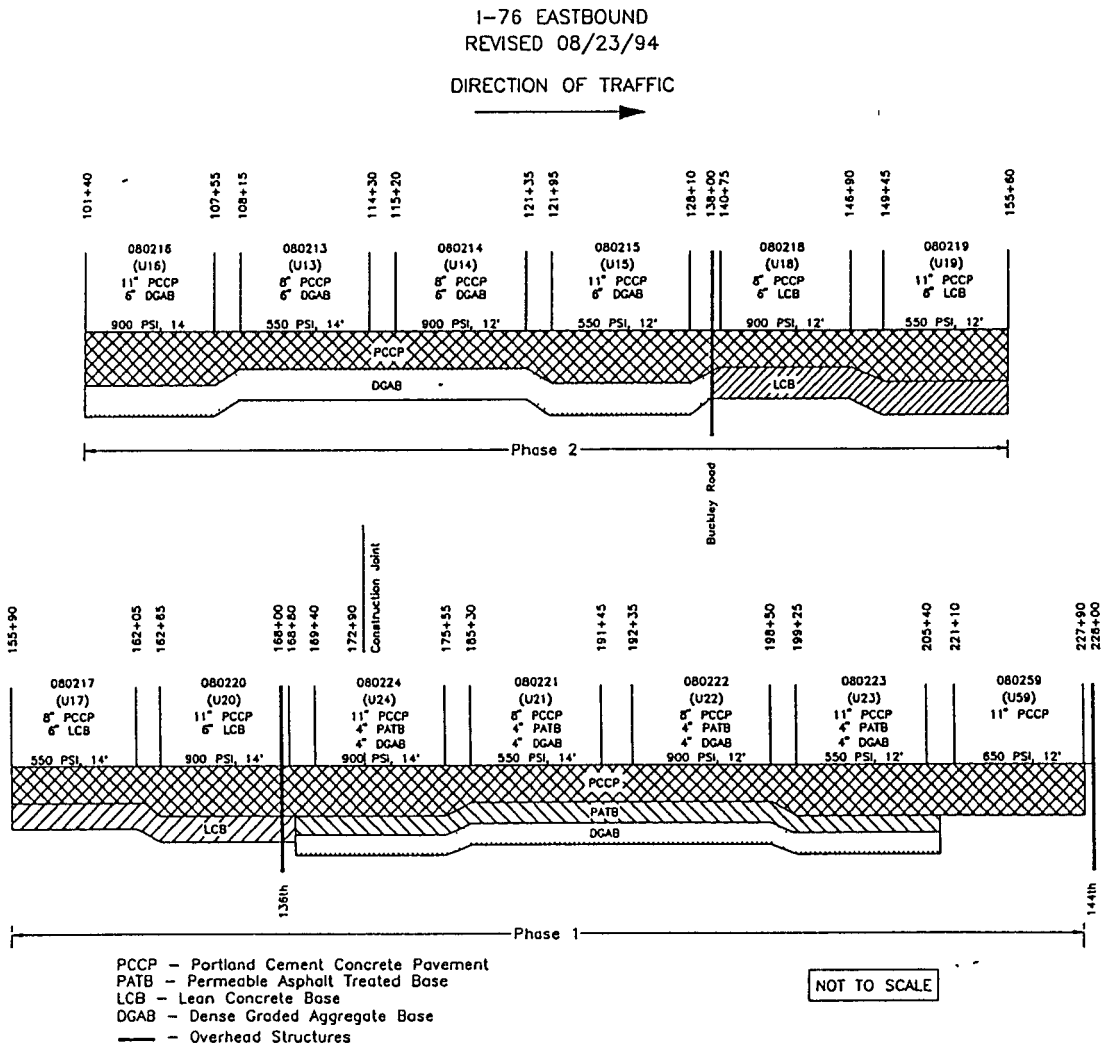


Figure 2. Layout and construction sequence of experimental test sections, Colorado SPS-2 project.

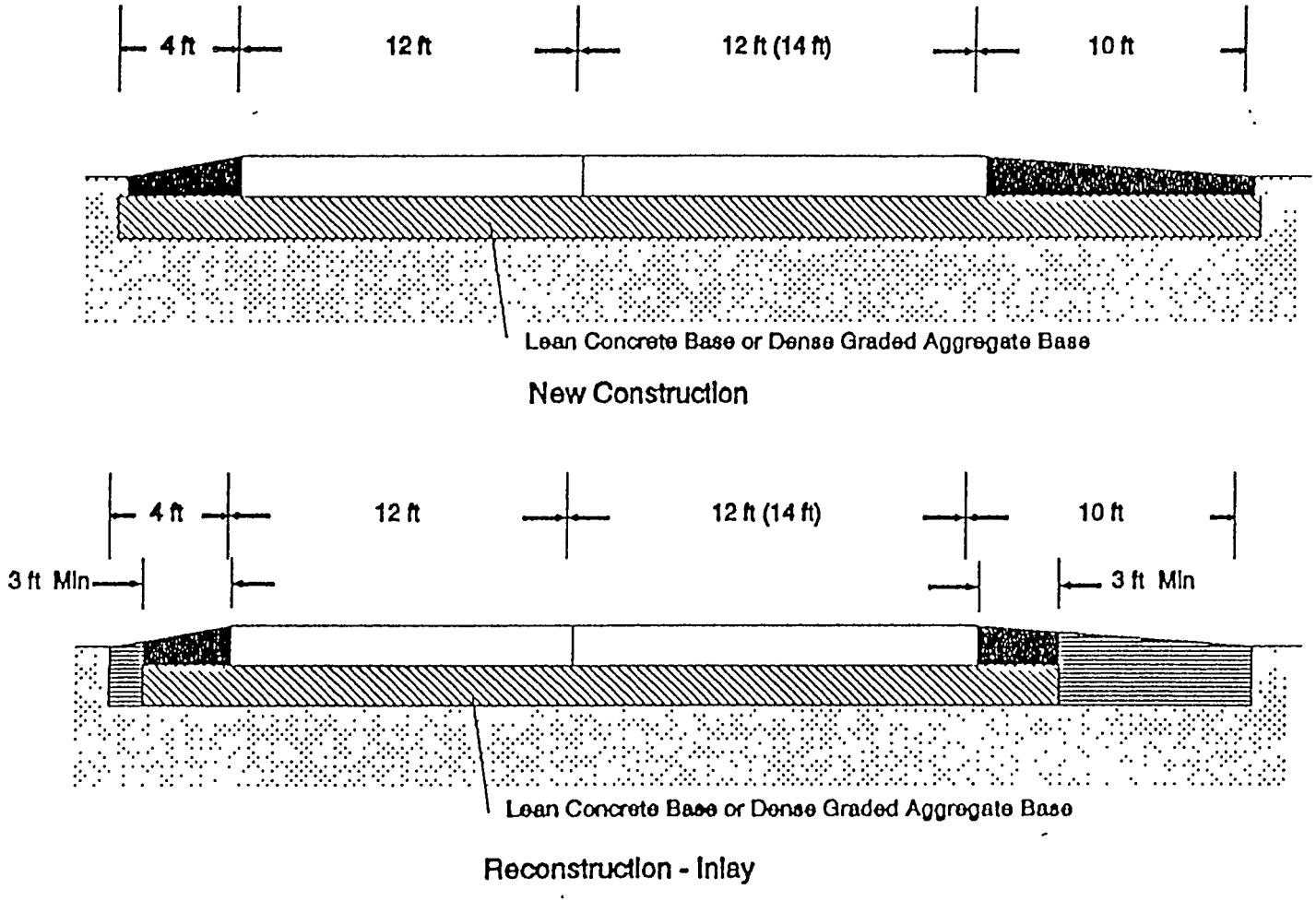


Figure 3. Typical section for test sections with non-drainable base layer.

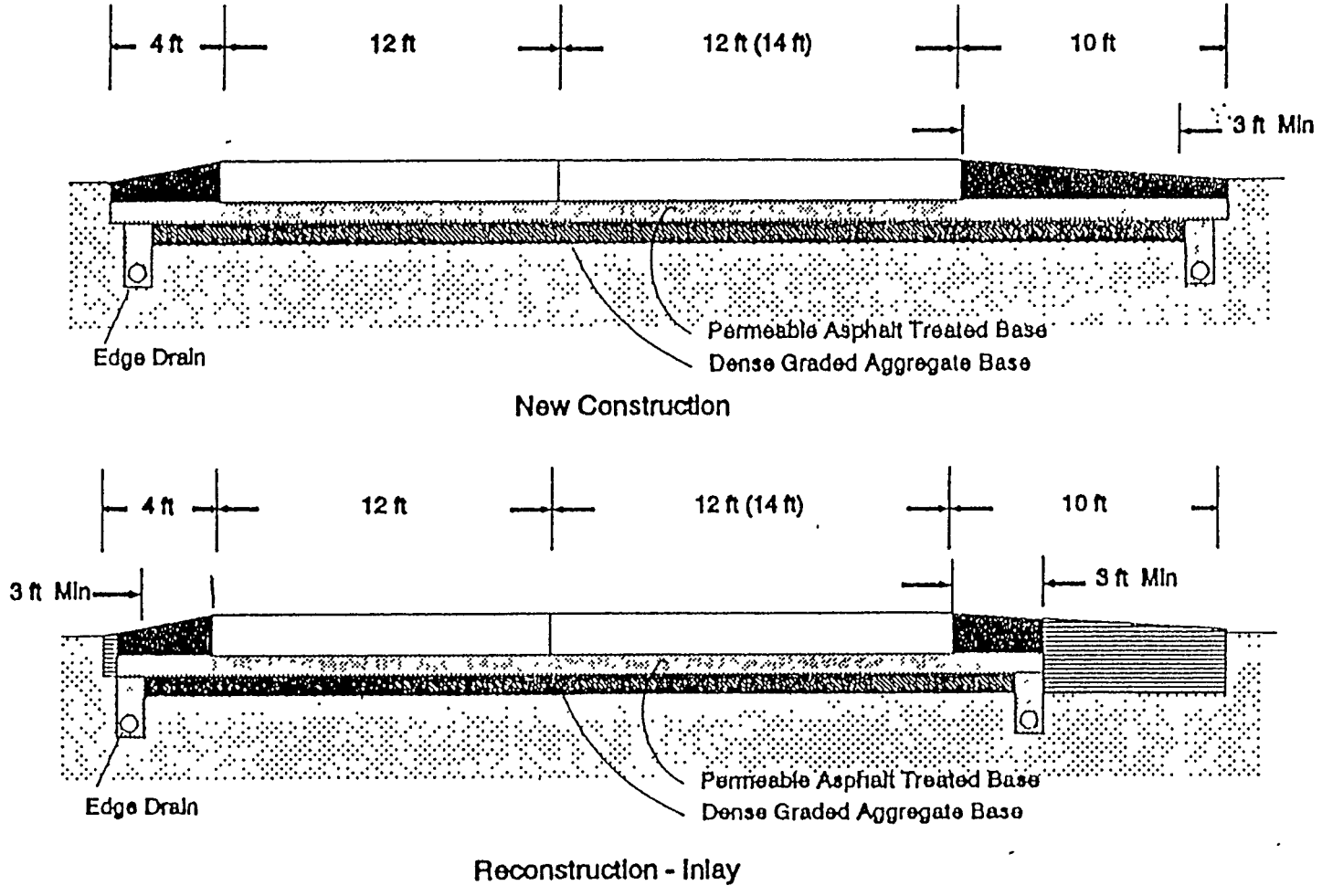


Figure 4. Typical section for test section with drainable base layer.

Table 3. Location of SPS-2 test sections, I-76 Colorado.

Section No.	Start Section	Start Monitor	End Monitor	End Section	Notes
08216	101+40	101+90	106+90	107+55	DG\11"\900#\14'
Trans	107+55			108+15	
080213	108+15	108+65	113+65	114+30	DG\8"\550#\14'
Trans	114+30			115+20	
080214	115+20	115+20	120+20	121+35	DG\8"\900#\12'
Trans	121+35			121+95	
080215	121+95	122+65	127+65	128+10	DG\11"\550#\12'
Trans	128+10			134+00	Large box culverts @ 133
080218	140+75	141+40	146+40	146+90	LC\8"\900#\12'
Trans	146+90			155+90	
080219	149+45	149+95	154+95	155+60	LC\11"\550#\12'
Trans	155+60			155+90	136th Ave. taper & exit ramp
080217	155+90	156+55		159+86 3	LC\8"\550#\14'
080217	159+86.3		161+55	162+05	
Trans	162+05			162+65	
080220	162+65	163+30	168+30	168+80	LC\11"\900#\14'
Trans	168+80			169+40	
080224	169+40	169+90	174+90	175+55	DG\PB\11"\900#\14'
Trans	175+55			185+30	136th Ave entrance ramp
080221	185+30	185+95	190+95	190+45.84	DG\PB\8"\550#\14'
080221	190+45.84			191+45	
Trans	191+45			192+35	
080222	192+35	192+85	197+85	198+50	DG\PB\8"\900#\12'
Trans	198+50			199+25	
080223	199+25	199+90	204+90	205+40	DG\PB\11"\550#\12'

Key to Notes:

DG - Dense Graded Aggregate Base Section
LC - Lean Concrete Base Section
PB - Permeable Asphalt Concrete Base Section
8" or 11" - PCC surface thickness, inches
550# or 900# - design flexural strength for PCC mix, psi
14' or 12' - outside lane width, feet

Table 4. Key project personnel.

Colorado Department of Transportation (CDOT) Ahmad Ardani, LTPP Coordinator Al Eastwood, Resident Engineer Brett Locke, Project Engineer Tom McNeill, Asst. Project Engineer
Castle Rock Construction Ralph Bell, Contractor Jim Lauer, Superintendent
CTL/Thompson, Inc. - Geotechnical Engineers Art Greengard, Jr., Project Engineer, Materials Sampling & Testing Fred Braun, Field Sampling & Testing
Nichols Consulting Engineers, Chtd. Norma Henderson, LTPP Observer

PRE-CONSTRUCTION

CONCRETE TRIAL BATCHING

Appendix B contains all information regarding the trial mix studies conducted on the following PCCP designs:

- CDOT Class P mix
- SHRP 550 psi flexural mix
- SHRP 900 psi flexural mix
- SHRP Lean Concrete Base (500 psi to 750 psi at 7-day strength)

As there was not an LTPP representative present when these mix designs were developed, the only information available is found in the reports from CTL/Thompson, Inc. to the contractor, Castle Rock Construction (appendix B).

CONSTRUCTION

SUBGRADE

Overview

The soil at the site varies from clayey sand to sandy clay, but is predominately sand to clayey sand. The vertical grade is an average of +1.4 percent, in the direction of traffic, with no horizontal curvature. For the experiment, the subgrade is classified as a coarse grained soil.

The equipment used for sections constructed in Phase 1, station 155+90 to 227+90 (sections 080217, 080220, 080221, 080222, 080223, 080224, 080259) were two to five scrapers (CAT 631E) and a dozer (CAT D9). The subgrade was prepared by cutting and filling at the same time on those sections requiring such. The soil was compacted with the weight of the equipment. Compaction was monitored by personnel from CTL/Thompson using a nuclear density gauge. No moisture was added as the water table was approximately 4.5 ft from the surface and the soil exhibited an acceptable level of moisture. A blade (CAT 140G) was used to prepare the subgrade for trimming. The subgrade was trimmed with a GOMACO 9500 using a stringline for grade control. Elevation measurements were taken on every section. Subgrade preparation for Phase 1, station 155+90 to 227+90, began approximately July 1, 1993, and was completed August 19, 1993. Subgrade preparation for Phase 2, station 101+40 to 155+60 (sections 080213, 080214, 080215, 080216, 080218, 080219), commenced the first week of October 1993 and was completed October 14, 1993. The procedures and equipment used were the same as previously listed for Phase 1.

The thickness of the subgrade varied, with six sections on fill (sections 080213, 080214, 080215, 080216, 080221, 080222) and six sections in cut (080217, 080218, 080219, 080220, 080223, 080224). The weather conditions during the subgrade preparation are unknown as the majority of this work was done without the presence of an observer.

Phase 1 - New Alignment

Section 080223

After placing and trimming the DGAB, it was discovered that the subgrade elevation was too high from station 200+40 to 201+25. All of the DGAB and approximately 2.5 in of subgrade were removed from this portion. The subgrade was then recompacted and new elevation measurements were obtained. At station 202+53, a "prairie dog hole" was filled and compacted with soil (fine sand) from the site.

Section 080222

The subgrade appeared to be poorly compacted with approximately 2 in of loose surface material. This section was not recompacted. A plate bearing test and FWD test were conducted at station 195+35.

Section 080221

The subgrade was prepared during different time intervals as this section contained an "access road" for the local residents to cut across the construction site. This road also allowed the construction truck traffic access from the plant to the site. The access road was located from station 187+25 to 190+95 in a north-south direction. The subgrade at this location received a great deal more compaction (from truck traffic) than the rest of the section. Eventually the access road was moved west of the section to approximately station 184+50 so that work could begin on this section. That portion which contained the old access road was brought to grade and tied into the rest of the section. The subgrade for this section was essentially constructed as two separate parts.

Section 080224

The subgrade appeared to be well-compacted with very little loose surface material. This section had a high volume of construction truck traffic as it was located 100 ft east of the 136th Avenue overpass being built.

Section 080220

The subgrade appeared to contain a high moisture content and some pumping was evident in the transition zone between sections 080220 and 080224 at station 169+10. (The site received approximately 1.5 in of rain two days prior to the subgrade preparation for the lean concrete base.) No further action was taken to correct the pumping.

Section 080217

This section is located in a "wetland-like" area which contains a high water table. From station 158+00 to 159+00, a soft spot was removed approximately 6 ft in depth and 6 ft in width in the travel lane. This area was replaced with material (fine sand) from the construction site. From station 159+00 to 160+55, a second soft spot was removed approximately 4 ft in depth and 6 ft in width in the travel lane. This was replaced with material (fine sand) from the construction site. In both instances, two scrapers (CAT 631E) and one loader (CAT D9N) were used to remove, replace, and compact the soil.

As the end-dump trucks backed up to the paver to deliver the lean concrete base, the subgrade exhibited evidence of pumping across the travel lane at the following locations: station 157+05; from station 158+05 to 160+55; and at station 161+55. CDOT's state inspectors requested that the subgrade be compacted with a steel-wheel roller just in front of the trucks.

Paving of the LCB continued although rolling did not appear to remedy the poor subgrade condition and no further action was taken.

Section 080259

The subgrade was in fair condition and contained hairline cracks at station 220+50. A water truck kept the subgrade moist as the section was paved. This section of subgrade was prepared without a representative present to gather any construction notes prior to paving.

Phase 2 - Removal & Reconstruction

Section 080216

The "old highway," which consisted of both asphalt concrete and portland cement concrete, was removed, crushed to approximately 6 in pieces by dropping it and hitting it with a blade, and used as fill to stabilize the subgrade. The fill was approximately 3 ft of old highway material with 2 ft of cover material (fine sand) obtained from the site. The subgrade surface did not appear smooth and no further finishing was done. FWD testing was conducted on the subgrade.

Section *080213*

The fill on this section was approximately 4 ft of old highway material with 2 ft of cover material (fine sand) obtained from the site. The subgrade surface did not appear smooth and contained a divot 1-in in depth and 1/4-in in width which extended across both the travel and passing lanes (no further finishing was done). A plate bearing test and FWD test were conducted on the subgrade at station 111+15.

Section *080214*

The fill on this section was approximately 6 ft of old highway material with 2 ft of cover material (fine sand) obtained from the site. The subgrade surface appeared to be well-compacted. A plate bearing test and FWD test were conducted on the subgrade at station 118+20.

Section *080215*

The fill on this section was approximately 10 ft of old highway material with 2 ft of cover material (fine sand) obtained from the site. The subgrade surface appeared to be well-compacted. A 24-in, Class-3 concrete pipe was previously placed at station 125+15 approximately 10 to 13 ft deep. A plate bearing test and FWD test were conducted on the subgrade at station 125+15. (It was determined that the pipe was too deep to affect the plate bearing results.)

Section *080218*

This section consisted of an approximately 6 ft cut. The subgrade surface appeared to be well-compacted. FWD testing was conducted on the subgrade.

Section *080219*

This section consisted of an approximately 8 ft cut. The subgrade surface appeared to be well-compacted. FWD testing was conducted on the subgrade.

DENSE GRADED AGGREGATE BASE (DGAB)

Overview

During Phase 1 of this experiment, four sections, 080224, 080223, 080222, 080221 (from station 169+40 to 205+40), were constructed using 4 in of Dense Graded Aggregate Base (DGAB). In Phase 2, four sections, 080213, 080214, 080215, 080216 (from station 101+40 to 128+10), were constructed using 6 in of DGAB. The DGAB for Phase 1 was placed on August 4-5, 1993 (080221, 080222, 080223) and August 11, 1993 (080224, 080221). The DGAB for Phase 2 was placed on October 6-8, 1993 (080213, 080214, 080215, 080216).

During both phases, the DGAB was delivered using belly-dump trucks and was spread with a blade (CAT 140G). The trucks drove on the subgrade to deliver the DGAB. The sections were compacted using a steel-wheel roller (CAT CS563) and water was added hourly using a water truck. The grade was maintained using the same stringline control as used for the subgrade. The DGAB was trimmed using a GOMACO 9500. Elevation surveys were obtained on all sections with DGAB.

The weather conditions during DGAB placement in Phase 1 were cool and overcast with light rain on August 4-9 and a heavy rainstorm (1.25 in) on August 10th. It was partly cloudy and warm on August 11th. Weather conditions during Phase 2 consisted of clear and warm conditions on October 6th, cool and overcast with light rain falling on October 7th, and cold and breezy on October 8th.

The DGAB was a Class 5 (table 5) and conformed to the Special Construction Requirements, Section 304 and was pit run material.

The sampling and testing requirements for the DGAB consisted of bulk sampling, moisture and density tests, and elevation measurements on 080223, 080222, 080221, 080224, 080216, 080213, 080216, 080214, and 080215, with plate bearing tests on sections 080222, 080213, 080214, 080215. See appendix D for specific materials sampling and testing plan for each section.

Table 5. SHRP dense graded aggregate base (DGAB)

Physical Properties of Aggregates Sieve Analysis of Fine and Coarse Aggregate	
Sieve Size	Class 5 (LL not greater than 30)
2 in.	
1 ½ in	100
1 in.	95 - 100
3/4 in.	--
No. 4	30 - 70
No. 8	--
No. 200	3 - 15

Phase 1 - New Alignment

Section 080223

On August 19, 1993, the DGAB was replaced from station 200+50 to 201+25 because the subgrade was not to grade. The DGAB for this portion was recompacted with a steel-wheel roller and then trimmed in conjunction with the remaining portion of the section. No FWD testing was conducted.

Section 080222

A plate bearing test and FWD testing were conducted on this section. The DGAB appeared to be well-compacted with no apparent anomalies.

Section 080221

Placement of the DGAB began on August 5, 1993, stopped at station 185+95 and was completed on August 11, 1993. Traffic was still driving across the access road until August 16, 1993. No FWD testing was conducted.

Section 080224

The DGAB was erroneously placed in the 1000 ft transition area between 080221 and 080224. The DGAB was removed from this area with a scraper (CAT 631E) and was spread on 080224 with a blade (CAT 140G). Compaction was attained with the scraper and blade. Water was not added due to a heavy rainstorm (1.25 in) the previous evening. No FWD testing was conducted.

Phase 2 - Removal & Reconstruction

Section 080216

The DGAB was placed on October 7, 1993. The base appeared to be well-compacted. Water was not added due to light rain during the day. FWD testing was conducted. Base was in good condition.

Section 080213

The DGAB was placed on October 7, 1993. A plate bearing test and FWD testing were conducted on October 9th. The base was in good condition.

Section 080214

The DGAB was placed on October 8, 1993. A plate bearing test was conducted on October 9, 1993. FWD testing was conducted on October 11, 1993. The base was in good condition.

Section 080215

The DGAB was placed on October 8, 1993. A plate bearing test and FWD testing were conducted on October 11, 1993. The base was in good condition.

PERMEABLE ASPHALT TREATED BASE (PATB)

Overview

Four drainable sections (080224, 080221, 080222, 080223) were constructed which required placing 4 in of Permeable Asphalt Treated Base (PATB) on 4 in of the Dense Graded Aggregate Base (DGAB). The PATB serves as a drainage layer in the pavement structure. The DGAB is used below the PATB to prevent the contamination of the PATB by the migration of fines from the subgrade. Edge drains (trench with drain pipe) were constructed longitudinally along the outside edge of the travel lane to collect drainage water from the PATB (figure 5).

All PATB drain sections were constructed within the new alignment and are located from station 169+40 to 205+40. After the DGAB placement was completed, an area was trenched for the edge drains. This operation began on August 12, 1993 utilizing a backhoe (CAT E70B). A 1 ft trencher was initially utilized, however, problems were encountered trying to maintain a smooth, clean cut. The trencher was then replaced with the backhoe although this made the trench a few inches larger than the design width of 12 in. The area was trenched to a depth of 14 in and a width of 21 in. The trench was excavated continuously throughout the entire length of each PATB test section. When the trench was completed, a length of geotextile fabric (Typar, 100 percent spunbonded polypropylene, by Exxon Chemical), was placed in the trench with a minimum of 2 ft on either side of the trench. Next, approximately 2 in of the aggregate mixture (table 6) utilized in the PATB (minus the asphalt cement) was put in the bottom of the trench with a truck and shovel, and the collector drain pipe was placed on top with the perforated side down. The collector pipes consisted of 4 in diameter plastic, perforated pipe. Upon placement of the collector pipes, they were covered with a 6 in layer of the same aggregate base mixture. The geotextile fabric was then "folded back" over the aggregate (figure 5). Discharge outlet pipes consisting of 4 in diameter nonperforated rigid pipe were installed at 250 ft intervals. Two transverse interceptor drains (figure 6) were installed perpendicular to the section in the transition zone between drained and undrained base structural sections (at station 185+00 and station 169+00) with the same procedure outlined for the edge drains.

The PATB mix design is found in table 7 and the sieve analysis in table 8. All sections were paved going west against the eastbound direction of traffic. The PATB was placed across both lanes as well as across the trench with the edge drains. The PATB was delivered in end-dump trucks from a continuous mix plant (drum) approximately 10 miles from the site. The grade was controlled using a stringline and all transitions were tapered. Elevation surveys were performed on all PATB sections.

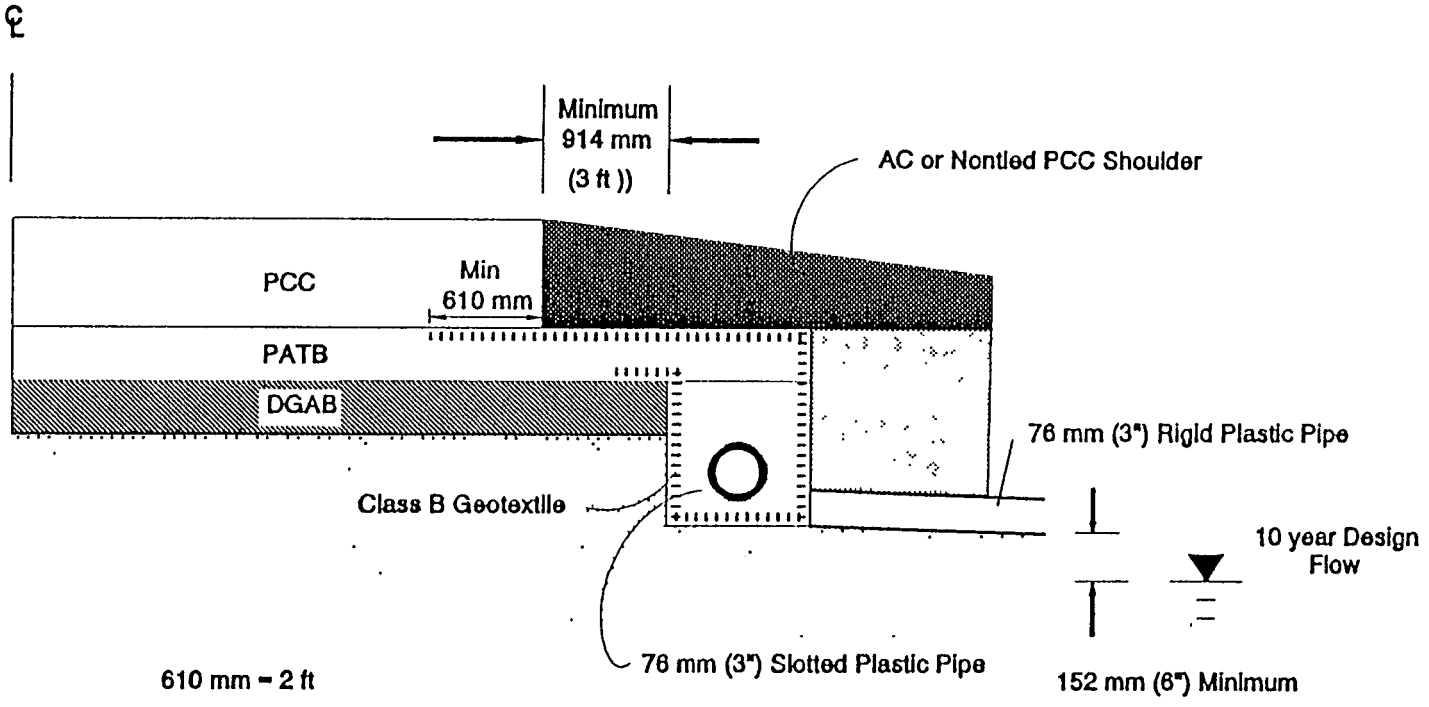


Figure 5. Edge drain detail.

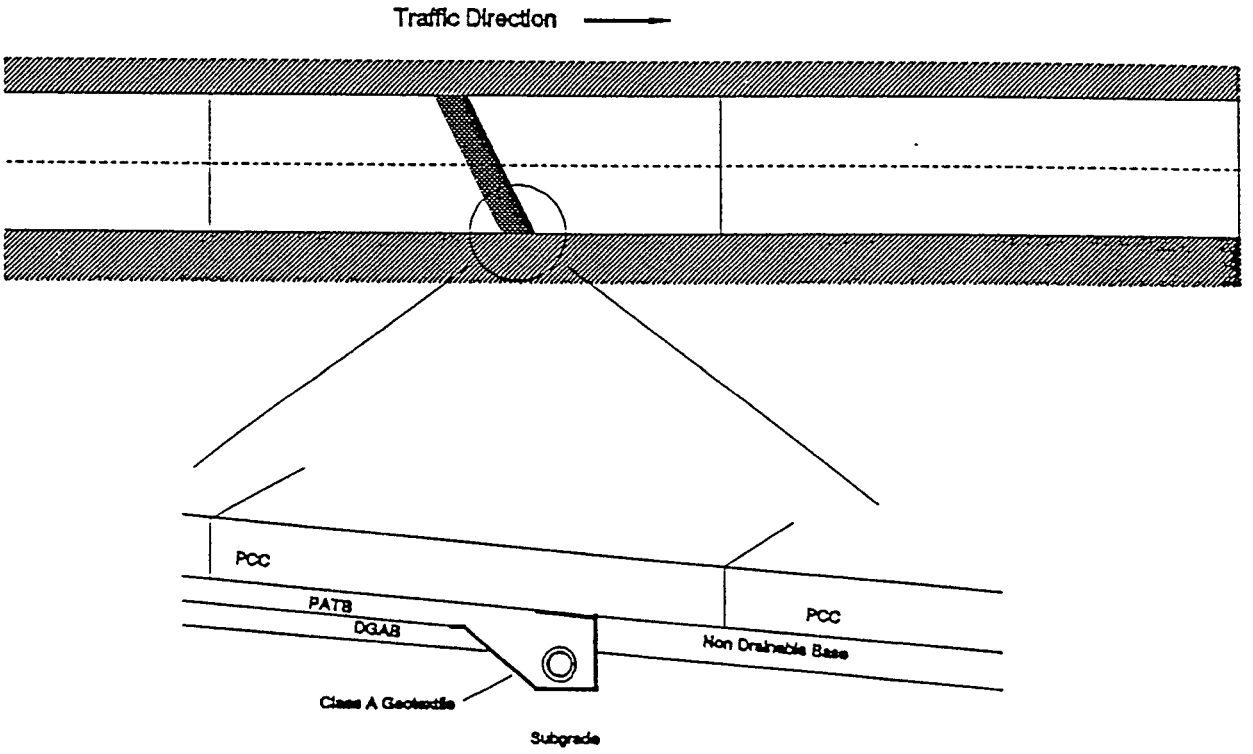


Figure 6. Transverse interceptor drain.

Table 6. SHRP edge drain backfill permeable asphalt treated base (PATB)

Sieve Analysis of Fine and Coarse Aggregates	
Sieve Size	Percent Passing % No. 57
1 ½ in.	100
1 in.	97
¾ in.	58
½ in.	13
⅜ in.	4
No. 4	1
No. 8	1
No. 50	1
No. 200	0.3

Percent Fractured Faces: 76%

Table 7. SHRP CDOT permeable asphalt treated base (PATB) mix design.

Sieve Size	CDOT #57 Specs % Pass
2 in.	
1 ½ in.	100
1 in.	95 - 100
¾ in.	--
½ in.	25 - 60
⅜ in.	--
No. 4	0 - 10
No. 8	0 - 5
No 16	
No. 30	
No. 50	
No. 100	
Material finer than #200 Sieve (%):	0 - 2

Target Asphalt Content: 2.5%
Source & Grade of AC: SIN/SIN AC-10
Additive: 0%

Table 8. SHRP CDOT permeable asphalt treated base (PATB)

Physical Properties of Aggregates Sieve Analysis of Fine and Coarse Aggregate		
Sieve Size	Size #57 Sample % Pass	CDOT Specs. #57 % Pass
2 in.		
1 ½ in.	100	100
1 in	100	95 - 100
¾ in	86	--
⅝ in.	63	
½ in.	40	25 - 60
⅜ in.	20	--
No. 4	8	0 - 10
No 8	6	0 - 5
No. 16	6	
No. 30	5	
No. 50	4	
No. 100	4	
Material finer than #200 sieve (%)	3 1	0 - 2

% Moisture: 0.04
% Asphalt: 2.96

Section 080223

The PATB was placed over a period of hours on August 20, 1993 with a Blaw-Knox 657 track mounted paver in three 13.5 ft wide passes beginning with the eastbound left shoulder. The air temperature at the time of placement varied from 65°F to 90°F. The average temperature of the PATB mix at the time of placement was 190°F. The average thickness was 4.8 in before compaction. The mix was compacted in two passes with an Ingersoll-Rand DA40 steel-wheel roller (10,000 lbs). From station 200+00 to 200+50 the PATB in pass 1 appeared dull which indicated there were perhaps too many fines in the mix. The PATB was not replaced.

Section 080222

The PATB was placed over a period of seven hours on August 23, 1993 with the same paver as above. The section was paved in three 13.5 ft wide passes beginning with the eastbound left shoulder. The air temperature at the time of placement varied from 67°F to 96°F. The average temperature of the PATB mix at the time of placement was 199°F. The average thickness was 5.0 in before compaction. The mix was compacted with the same equipment previously referenced. From station 195+50 to 195+75 of pass 1, the mix appeared slightly dry indicating the presence of fines. Also, from station 193+25 to 193+50, fines were apparent in the mix placed approximately 7 ft from the edge of pavement. The PATB was not replaced, but a load was rejected prior to placing at station 198+75.

Section 080221

The PATB was placed on August 23, 1993 with the same paver previously referenced. The section was paved in four passes due to the widened lane portion of this section. In this section, the fourth pass was only 8 ft wide. The time period for this section was 12.0 hours. The air temperature at the time of placement varied from 60°F to 91°F. The average temperature of the PATB mix at the time of placement was 179°F. The average thickness was 4.8 in before compaction. The mix was compacted in two passes with the same equipment previously referenced. The next day, August 24, 1993, it was discovered that a section of PATB 13 ft wide, in the eastbound right shoulder, from station 189+00 to 187+25, was too low and consequently two more inches of PATB was added. This was the portion of the section that contained the old access road. Also, from station 185+30 to 187+20 the PATB was removed with a small loader and replaced due to excessive fines. The surface had a dull and "cloudy" appearance. When the PATB was removed from this portion, the fabric on the edge drain was torn from station 186+40 to 186+50. The fabric was replaced with a 3 ft overlap of new fabric over the old fabric on either side.

Section 080224

The PATB was placed on August 24, 1993 with the same paver previously referenced. The section was paved in three 13.5 ft wide passes over a period of six hours. The air temperature at the time of placement varied from 80°F to 91°F. The average thickness of the PATB mix was 4.9 in before compaction. The mix was compacted with the same equipment previously

referenced. Some slight down drain was evident in three separate loads and they were rejected.

LEAN CONCRETE BASE (LCB)

Overview

Four non-drainable sections (080217, 080218, 080219, 080220) from station 140+75 to 168+80 were constructed which required placing 6 in of Lean Concrete Base (LCB) on the subgrade. LCB was placed on sections 080217 and 080220 during the construction of Phase 1 (August 30, 1993) and sections 080218 and 080219 during Phase 2 (October 14, 1993). The LCB was placed using a CAT SF550 paver with the end-dump trucks backing up on subgrade. The LCB was finished using a wet burlap drag, hand trowels, and long-handled steel floats. A Burke Wax Emulsion White D.O.T. curing compound was applied to the surface approximately 45 minutes after finishing during Phase 1 and 15 minutes after finishing during Phase 2. A second coat was applied within 24 hours prior to placing the PCCP surface. The LCB was placed in a 38 ft pass in Phase 1. A 32 ft width pass was placed in Phase 2 with an additional 6 ft shoulder placed October 25, 1993. The air temperature at the time of placement for Phase 1 was 70°F with overcast skies, and for Phase 2 was 45°F with overcast skies. Longitudinal joints were cut 1 ft to the right of centerline on all sections. Dowel baskets were anchored on all sections using steel nails driven with an air hammer. The lean concrete mix design is found in table 9 and the sieve analysis in table 10. Air content and slump were monitored in the field by CTL/Thompson, with air content specified between 4-9 percent and a maximum slump of 4 in.

Phase 1 - New Alignment

Section 080217

This section exhibited pumping across both lanes (see Subgrade section) as the LCB was being placed at the following locations: station 157+05; station 158+05 to 160+55; and station 161+55. The LCB mix changed at approximately station 161+55 from a 4 in slump to a 2 in slump. A visual inspection on September 7, 1993 yielded the anomalies listed in table 11. Overall, the finished surface appeared rough approximately 2.5 ft right of centerline, throughout the SHRP lane.

Section 080220

This section exhibited pumping across the travel lane (see Subgrade section) as the LCB was being placed at the following locations: station 166+60, 168+00. A visual inspection on September 7, 1993 yielded the anomalies listed in table 12. Overall, the finished surface appeared rough approximately 2.5 ft right of centerline throughout the SHRP lane.

Table 9. SHRP lean concrete base mix summary.

Average Proportion Properties	
Cement	204 lbs/yd^3
Fly Ash	61 lbs/yd^3
AEA	As Needed
Sand	1550 lbs/yd^3
Coarse Aggregate (No. 57)	1600 lbs/yd^3
Water	255 lbs/yd^3 (30 6 gals)
Slump	3 - 4 inches
Air Content	7 - 9%
WC + P Ratio	0.96 lb/lb
Unit Weight	135 - 138 pcf
Compressive Strength of Test Cylinders:	
3 days	400 - 460 psi
7 days	550 - 750 psi
Portland Cement	Southwestern Type I/II Low Alkali
Fly Ash	Pozzolanic Bridger Class F
AEA	Conchem Pave-Air
Sand	Frei, Pit No. 7 (Platte River)
Rock	Frei, #57, Pit 6 (Clear Creek Quarry)

Table 10. SHRP CDOT lean concrete base mix design.

Physical Properties of Aggregates Sieve Analysis of Fine and Coarse Aggregate				
Sieve Size	Size #57 Sample % Pass	CDOT 703 Specs. % Pass #57	Sand Sample % Pass	CDOT 703 Specs. % Pass
2 in.				
1 ½ in.	100	100		
1 in.	99	95 - 100		
¾ in.	87	--		
½ in.	55	25 - 60		
⅜ in	39	--		100
No. 4	8	0 - 10	100	95 - 100
No. 8	4	0 - 5	97	--
No. 16			78	45 - 80
No. 30			44	--
No. 50			17	10 - 30
No. 100			3	2 - 10
Material finer than #200 sieve (%):	0.5	1.0 max	0.6	3.0 max

Table 11. Section 080217.

Location Stationing	Comment
156+60	transverse crack across the travel lane
157+25 to 157+50	round (2") depressions on the outside edge
157+75	LCB appears to have soft spots
158+20	transverse crack across the travel lane
158+20 to 158+25	segregation in outer wheel path - travel lane
158+75	transverse crack across the travel lane
159+30	2' from outer edge, LCB is gouged
159+50	transverse crack across the travel lane
160+36	transverse crack across the travel lane
160+70 to 160+80	low spot 3' wide, water pooled in bottom
161+30	transverse crack across the travel lane
161+80	transverse crack across the travel lane

Table 12. Section 080220.

Location Stationing	Comment
162+80	transverse crack across the travel lane
163+30	transverse crack across the travel lane
163+55	segregation approx. 6" wide, 2' long in midlane
163+80	transverse crack across the travel lane
164+30	transverse crack across the travel lane
164+60	transverse crack across the travel lane
164+80	small depression, 1" depth - 3' from the edge in travel lane
165+20	transverse crack across the travel lane
165+80	transverse crack across the travel lane
166+15	transverse crack across the travel lane

Phase 2 - Removal & Reconstruction

Section 080218

The LCB was placed on October 14, 1993 from 12:30 p.m. until 4:05 p.m. Light rain began falling off and on about 3:05 p.m. The first ten trucks on the site were rejected due to high air content (≈11.5 percent). This section was paved with a 32 ft width pass. The shoulders were paved 12 days later (October 26, 1993) due to one week of heavy rain in the area. A visual inspection on October 21, 1993 revealed broken edges throughout the entire section. The finished surface was muddy and there were areas containing water stains. The mud was cleaned off at the request of CDOT inspectors.

Section 080219

The LCB was placed on October 14, 1993 from 4:05 p.m. until 7:50 p.m. Sunset occurred at approximately 6:20 p.m. and the final 250 ft of the section was placed in the dark using portable lights. The temperature was approximately 40°F with heavy rain beginning at 7:10 p.m. A visual inspection on October 21, 1993 revealed broken edges throughout the entire section. The finished surface was muddy and there were areas containing water stains. The mud was cleaned off at the request of CDOT inspectors.

PORTLAND CEMENT CONCRETE PAVEMENT (PCCP)

Overview

The experimental design included two levels of concrete slab thickness, 8 in and 11 in, and two levels of flexural strength, 550 psi and 900 psi as determined from third point loading tests at 14 days. The experiment also included two different lane widths, 12 ft and 14 ft. All sections were constructed with perpendicular joints with a uniform joint spacing of 15 ft. Dowels were placed mid-depth using basket assemblies and were aligned parallel to the longitudinal direction of the lane. The dowel baskets were anchored using 5/16 in diameter, 12 in steel pins with a 45° cut at the bottom. A piece of 3/16 in steel bar was welded onto the top of the pin to act as a hook and hold the baskets in place. Dowels were 18 in in length, spaced at 12 in on center and coated with grease. Dowel bars were 1-1/4 and 1-1/2 in diameter for the 8 in and 11 in thick pavements, respectively. The dowel bar alignments were not checked after paving.

All sections were constructed with a slip-form paving operation which incorporated the side-dump procedure. First, the concrete was dumped into a side belt which fed to the track mounted spreader (GOMACO PS60) where the concrete was distributed by augers across the lane. Next, a track mounted slip-form paver (CAT SF550) consolidated the concrete with 26 internal vibrators spaced 18 in apart at a depth of 6 in below the surface. Screeds then struck off the concrete to its design thickness. Following this process, a wet burlap drag and a mechanical oscillating float were used to ready the surface for final finishing. The edges were kept straight and smooth with hand trowels. Two long-handled steel floats, one on either side,

were used to smooth and level the surface. An astro-turf drag was then pulled across the surface for texture. A string line was used to make an indentation across the lane at all joint locations (every 15 ft). This was followed by transverse tining with a tining machine utilizing a 14 ft bar with metal tines. Finally, a white wax-base curing compound was applied to the surface within 45 minutes of placing the concrete.

As the paver proceeded, tie bars were manually placed into a tie bar inserter and then mechanically inserted into the concrete. Tie bars were placed at the inside shoulder (non-SHRP lane) and at the centerline longitudinal joint. The bars were held down for approximately 15 seconds to allow the concrete to envelope the bar and then the device was lifted up for the next tie bar. A measuring wheel with a counting device was mounted to the paver and indicated when to insert the bars. The tie bars were 3 ft long, epoxy coated deformed No.5 bars of grade 40 steel, spaced at 30 in on center.

For both the 550 psi and 900 psi concrete mixes, the target values for slump were 1 to 2-1/2 in and for air content were 5 to 8 percent. Slump and air content values were monitored in the field by CTL/Thompson. These tests were taken from the first three delivery trucks at each section, then every hour until the mix (psi) changed. The 550 psi mix design is found in table 13 and the sieve analysis in table 14. The 900 psi mix design is found in table 15 and the sieve analysis in table 16. The CDOT Class P Standard mix design (section 080259) is found in table 17 and the sieve analysis in table 18.

Table 13. SHRP 550 psi mix summary, average proportion properties.

Cement	399 lbs/yd^3
Fly Ash	100 lbs/yd^3
AEA	6 3 ozs/yd^3
Sand	1430 lbs/yd^3
Rock	1720 lbs/yd^3
Water	236 lbs/yd^3
Slump	1-3/4 inches
Air Content	6 4%
WC+P Ratio	0 47 lb/lb
Density	143 3 pcf
Flexural Strength: 7 days 14 days	 520 psi 572 psi
Portland Cement	Southwestern Type I/II Low Alkali
Fly Ash	Pozzolanic Bridger Class F
AEA	Conchem Pave-Air
Sand	Frei, Pit No 7 (Platte River)
Rock	Frei, #57, Pit 6 (Clear Creek Quarry)

Required average 14-day flexural strength: 525 to 575 psi
Allowable variation of average strength: 165 psi max.
Cumulative variation of average strength: 25 psi actual

Table 14. SHRP - CDOT 550 psi mix design - physical properties of aggregates.

Sieve Analysis of Fine and Coarse Aggregate				
Sieve Size	Size #57 Sample % Pass	CDOT 703 Specs % Pass - #57	Sand Sample % Pass	CDOT 703 Specs. % Pass
2 in.				
1-1/2 in.	100	100		
1 in.	99	95 - 100		
3/4 in.	87	--		
1/2 in.	55	25 - 60		
3/8 in.	39	--		100
No 4	8	0 - 10	100	95 - 100
No 8	4	0 - 5	97	--
No. 16			78	45 - 80
No. 30			44	--
No 50			17	10 - 30
No. 100			3	2 - 10
Material finer than #200 sieve (%)	0 5	1.0 max.	0 6	3 0 max

Table 15. SHRP 900 psi mix summary - average proportion properties.

Cement	749 lbs/yd^3
Fly Ash	150 lbs/yd^3
AEA	3 0 ozs/yd^3
Sand	935 lbs/yd^3
Rock	1865 lbs/yd^3
Water	257 lbs/yd^3
Slump	1-1/2 inches
Air Content	5.7%
WC+P Ratio	0.29 lb/lb
Density	146.4 pcf
Flexural Strength. 7 days 14 days	 845 psi 905 psi
Portland Cement	Southwestern Type I/I Low Alkali
Fly Ash	Pozzolanic Bridger Class F
AEA	Conchem Pave-Air
WRA	Conchem 50 (4 ozs per cwt)
Sand	Frei, Pit No 7 (Platte River)
Rock	Frei, #57, Pit 6 (Clear Creek Quarry)

Required average 14-day flexural strength. 860 to 940 psi
Allowable variation of average strength: 250 psi max.
Cumulative variation of average strength· 45 psi actual

Table 16. SHRP - CDOT 900 PSI mix design - physical properties of aggregates.

Sieve Analysis of Fine and Coarse Aggregate				
Sieve Size	Size #57 Sample % Pass	CDOT 703 Specs. % Pass #57	Sand Sample % Pass	CDOT 703 Specs. % Pass
2 in.				
1-1/2 in	100	100		
1 in.	99	95 - 100		
3/4 in.	87	--		
1/2 in.	55	25 - 60		
3/8 in.	39	--		100
No. 4	8	0 - 10	100	95 - 100
No. 8	4	0 - 5	97	--
No. 16			78	45 - 80
No. 30			44	--
No 50			17	10 - 30
No. 100			3	2 - 10
Material finer than #200 sieve (%)	0 5	1.0 max.	0 6	3 0 max.

Table 17. SHRP - CDOT class P mix design - average proportion properties.

Cement	565 lbs/yd^3
Fly Ash	113 lbs/yd^3
AEA	5 6 ozs/yd^3
WRA (Conchem 50 @ 2.5 ozs/cwt)	17.0 ozs
Sand	1200 lbs/yd^3
Coarse Aggregate (No. 57)	1730 lbs/yd^3
Water	247 lbs/yd^3 (29.7 gals)
Slump	1-1/2 inches
Air Content	6 2%
WC+P Ratio	0 36lb/lb
Unit Weight	142 2 pcf
Temperature	65°F
Compressive Strength of Test Cylinders: 24 hours 3 days 7 days 28 days	 1850 psi 3770 psi 5035 psi 6315 psi
Portland Cement	Southwestern Type I/I Low Alkali
Fly Ash	Pozzolanic Bridger Class F
AEA	Conchem Pave-Air
Sand	Frei, Pit No. 7 (Platte River)
Rock	Frei, #57 Blend (Pit No 2)

Table 18. SHRP - CDOT class P standard mix design - physical properties of aggregates.

Sieve Analysis of Fine and Coarse Aggregate							
Sieve Size	Size #57 Sample % Pass	Size #4 Sample % Pass	55/54 Blend #57/#4 % Pass	CDOT 703 Specs % Pass		Sand Sample % Pass	CDOT 703 Specs % Pass
				#57	#467		
2 in.		100	100		100		
1-1/2 in.	100	96	98	100	95-100		
1 in.	99	57	80	95-100	--		
3/4 in.	87	18	56	--	35-70		
1/2 in.	55	1	31	25-60	--		
3/8 in.	39	1	22	--	10-30		100
No. 4	8	0 5	5	0-10	0-5	100	95-100
No. 8	4	--	3	0-5	--	97	--
No. 16						78	45-80
No 30						44	--
No. 50						17	10-30
No. 100						3	2-10
Material finer than #200 sieve (%)	0.5	0.3	0.4	1.0 max	1.0 max	0 6	3.0 max

The portable batch plant was located on site and contained two bins; one for cement and one for fly ash. The mixing equipment was a central batch (12 yd^3) and was computerized. A badger meter was used for measuring water. The water used for the batch plant was obtained from the City of Brighton's domestic water supply. A concrete plant inspection was conducted on July 13, 1993 and was found to be satisfactory.

All sections in Phase 1 (080259, 080220, 080221, 080222, 080223, 080224, and 080217) were paved going west against the direction of traffic (eastbound lanes). All sections in Phase 2 (080213, 080214, 080215, 080216, 080218, and 080219) were paved in the direction of traffic (eastbound).

Phase 1 - New Alignment

Section *080223*

The 550 psi concrete was placed on September 3, 1993 from 7:50 a.m. until 10:35 a.m. in a 38 ft pass. The air temperature varied from 55°F to 68°F. Twelve air content and slump tests were conducted on this section with two of each required for the bulk samples. The average air content was 6.3 percent and the average slump was 1.7 in. Personnel from CDOT's materials testing laboratory were on site to conduct air content, slump, and unit weight tests in addition to those required by SHRP/LTPP. A comparison of these tests conducted side-by-side (CDOT vs. CTL/Thompson) from the same batch resulted in an unacceptable difference

(greater then 0.5 percent as per CDOT) between the two (CTL/Thompson air = 8.0 percent and CDOT air = 9.3 percent). Paving was halted at station 201+00 for approximately 15 minutes. These tests were repeated twice more and then a different meter was brought out for CTL/Thompson to use. Three more tests were conducted and found to be within the acceptable range. From station 199+25 to 202+00 the dowels were greased on the wrong end and had to be greased again as per a request by CDOT. The transition from 11 in PCCP to 8 in PCCP was started at station 199+25 and completed at 198+50. The transition from the 550 psi mix to the 900 psi mix was completed at station 198+75.

Section 080222

The 900 psi concrete was placed on September 3, 1993 from 11:20 a.m. until 2:30 p.m. in a 38 ft pass. The air temperature varied from 70°F to 78°F. Eight air content and four slump tests were conducted on this section with three of each required for the bulk samples. The average air content was 5.0 percent and the average slump was 2.2 in. Personnel from CDOT's materials laboratory were on site to conduct air content, slump, and unit weight tests. A comparison of the side-by-side tests conducted resulted in acceptable values. Paving stopped at station 196+00 for 10 minutes, at station 195+35 for 15 minutes, and at station 195+15 for 5 minutes, while waiting for tests to be run. At station 194+00 side panels on the screed had to be adjusted resulting in paving being stopped for 10 minutes. The transition from the 900 psi mix to the 550 psi mix was completed at station 191+75.

Section 080221

The 550 psi concrete was placed on September 3, 1993 from 4:00 p.m. until 6:10 p.m. in a 38 ft pass. The air temperature varied from 76°F to 80°F. Nine air content and four slump tests were conducted on this section with one of each required for the bulk samples. The average air content was 8.0 percent and the average slump was 1.9 in. A 4 in pipe had been installed and was discovered "sticking out of the PATB surface" approximately 2 ½ in at station 190+25, about 3 ft from outside edge of the travel lane. After a discussion with CDOT personnel and the contractor, it was not known for what purpose this pipe was intended. The pipe was sawed off flush with the PATB, capped, and paved over. At station 186+00, the dowel basket in the passing lane (non-SHRP) was pulled out during the paving operation and not replaced.

Section 080224

The 900 psi concrete was placed on September 7, 1993 from 8:00 a.m. until 3:05 p.m. when a severe windstorm (low visibility and heavy dust) moved into the area. At approximately 3:10 p.m. it began raining heavily along with the severe winds. At this time, the crew began trying to cover the new pavement but were struggling due to the strong winds and heavy rainfall. At 3:45 p.m. the section from station 185+30 to 172+90 was finally covered with a heavy plastic tarp. At 3:55 p.m., a construction joint was placed at station 172+90 within the monitoring section. The 1000 ft transition between 080221 and 080224 (westbound direction) was paved using the 550 psi mix. The 900 psi mix began at station 176+40. The PATB

fabric located on the edge drains appeared to be in poor condition with tears from station 176+15 to 175+90. Along the entire length of 080224, the edge drains were damaged and contained a "coating" of soil and PCC runoff from the sawcutting process. This was pointed out to CDOT's engineer on the project with the suggestion that the edge drain be checked for damage and any repairs noted. The fabric was torn and dirty, and the trench crushed up to 6 in in some locations due to the paver running over it.

The 900 psi concrete paving began at station 172+90 (the construction joint from previous day's storm - 2 in of rain) on September 8, 1993 at 7:30 a.m. and was completed at 11:05 a.m. The air temperature varied from 45°F to 60°F. The belt on the feeder to the spreader broke at station 169+90 at 10:18 a.m. and five trucks were rejected at 10:50 a.m. because their time limit expired. The paving operation began at 10:53 a.m. and stopped at station 169+25 due to the belt breaking again. A halt was called on paving operations for the day until a new belt could be placed on the spreader.

Three air content and three slump tests were conducted on this section. A bulk sample was not taken on this day due to extreme weather conditions. The average air content was 5.8 percent and the average slump was 1.5 in. On the following day, seven air content and seven slump tests were conducted on the portion from the construction joint westbound to the beginning of the section at station 169+40. One test for each was required along with the bulk sample. The average air content was 6.8 percent and the average slump was 2.1 in.

Section 080220

The 900 psi concrete for this section was placed on September 9, 1993 from 7:15 a.m. until 11:10 a.m. in a 38 ft pass. The air temperature varied from 55°F to 68°F. Five air content and five slump tests were conducted on this section with two required for the bulk samples. The average air content was 6.3 percent and the average slump was 1.9 in. The transition from 11 in PCCP to 8 in PCCP began at station 162+65 and was completed at station 162+05. The transition from the 900 psi mix to the 550 psi mix was also completed at station 162+05.

A third coat of curing compound was applied to the lean concrete base because the second coat required by the experimental design had been applied more than 24 hours prior to paving. (This was done before the rainstorm and the equipment problems mentioned above. The specifications called for an application of the curing compound within 24 hours of paving.) The curing compound was applied from station 167+80 to 162+65. At station 166+80 the spreader was stopped for 9 minutes due to the wet conditions of the soil on the site. The spreader was stuck and had to be pulled out using the paving equipment.

Section 080217

The 550 psi concrete for this section was placed on September 9, 1993 from 12:30 p.m. until 4:15 p.m. The air temperature varied from 72°F to 80°F. Six air content and six slump tests were conducted on this section with three required for the bulk samples. The average air

content was 6.9 percent and the average slump was 1.3 in. The forms on the paver were too large (10 in) for the 8 in lift required. The paver was halted at station 161+00 from 1:10 p.m. until 1:37 p.m. to shorten the forms. From approximately station 159+00 to station 157+00 the spreader was sinking on the outside edge of the SHRP lane due to heavy rain in the area. The spreader had to be supported with wooden planks and chunks of old concrete highway.

Section 080259

This section is a control section for the State of Colorado and was paved with their standard 650 psi concrete mix. Paving began at 7:10 a.m. and concluded at approximately 12:00 p.m. The air temperature varied from 55°F to 80°F. Three air content tests yielded 8,6, and 5.1 percent air. The slump was maintained at 2 in. Overall, no major interruptions were encountered at this section.

Phase 2 - Removal & Reconstruction

Section 080216

The 900 psi concrete was placed on October 11, 1993 from 9:30 a.m. until 2:10 p.m. The air temperature varied from 45°F to 70°F. Paving stopped at station 105+90 for 7 minutes and at station 107+00 for 8 minutes while waiting for delivery trucks. The transition from the 900 psi mix to the 550 psi mix was completed at station 107+50 and from 11 in PCCP to 8 in PCCP at station 107+50. Six air content tests and six slump tests were conducted with one required for bulk sample. The average air content was 7.3 percent and the average slump was 2.2 in.

Section 080213

The 550 psi concrete was placed on October 11, 1993 from 3:40 p.m. until 6:00 p.m. The paving stopped at station 110+15 for 15 minutes due to equipment problems. The air temperature varied from 70°F to 72°F. Five air content tests and five slump tests were conducted with one required for bulk sample. The average air content was 6.1 percent and the average slump was 1.0 in.

Section 080214

The 900 psi concrete was placed on October 13, 1993 from 7:15 a.m. until 10:00 a.m. at station 114+50 with 900 psi mix. The air temperature varied from 50°F to 65°F. The transition from the 900 psi mix to the 550 psi mix was completed at station 121+75. Five air content tests and five slump tests were conducted with one required for bulk sample. The average air content was 7.2 percent and the average slump was 2.3 in.

Section 080215

The 550 psi concrete was placed on October 12, 1993 from 10:20 a.m. until 2:30 p.m. The air temperature varied from 65°F to 72°F. The 550 psi mix was placed to station 128+30. Two air content tests and two slump tests were conducted with one required for bulk sample. The average air content was 6.7 percent and the average slump was 1.0 in.

Section 080218

The 900 psi concrete was placed on October 21, 1993 from 10:00 a.m. until 3:50 p.m. The air temperature varied from 40°F to 55°F. The paving stopped at station 141+25 for 2 hours and 40 minutes due to equipment problems (broken belt on the feeder). The paving stopped again for 20 minutes at station 143+40 because the end-dump trucks were getting stuck in the mud. (Site was extremely wet and muddy due to heavy rainstorms the previous 7-day period.) Dowels were accidentally torn up by the paving equipment at station 141+50 in the SHRP lane. The dowels were not replaced. One air content test and one slump test was conducted. The air content was 6.6 percent and the slump was 2.5 in.

Section 080219

The 550 psi concrete was placed on October 22, 1993 from 8:45 a.m. until 1:10 p.m. The air temperature varied from 38°F to 48°F. Paving on this section progressed smoothly. Four air content tests and four slump tests were conducted with one required for bulk sample. The average air content was 6.3 percent and the average slump was 1.6 in.

SUMMARY

SUBGRADE

High groundwater table, rain and pumping in some sections during subsequent layer placement are the primary conditions of note on the new alignment sections. On the old highway, the embankment consisted of various thicknesses of crushed and pulverized material of the old highway, overlain with fill of fine sand from a cut area.

DENSE GRADED AGGREGATE BASE (DGAB)

The placement of the DGAB on eight of the thirteen sections proceeded without any major problems. The other five sections did not require DGAB.

PERMEABLE ASPHALT TREATED BASE (PATB)

There were some minor problems encountered during the placement of the PATB. These consisted primarily in the trenching of the DGAB and SG. The problem was corrected by using a backhoe instead of a trenching machine. In section 080221, the mix placed was too fine in areas and removed and replacement was performed. (See the section entitled Permeable Asphalt Treated Base.)

LEAN CONCRETE BASE (LCB)

No obvious problems were noted with regard to the placement of the lean concrete base other than those that were weather related. (See section titled Lean Concrete Base.)

PORTLAND CEMENT CONCRETE PAVEMENT (PCCP)

Again, weather and equipment breakdown created some problems with the PCCP paving; otherwise the work met the intentions of the experiment design. The contractor felt the placement of the 550 psi mix was easier to work with due to the high plasticity of the 900 psi mix.

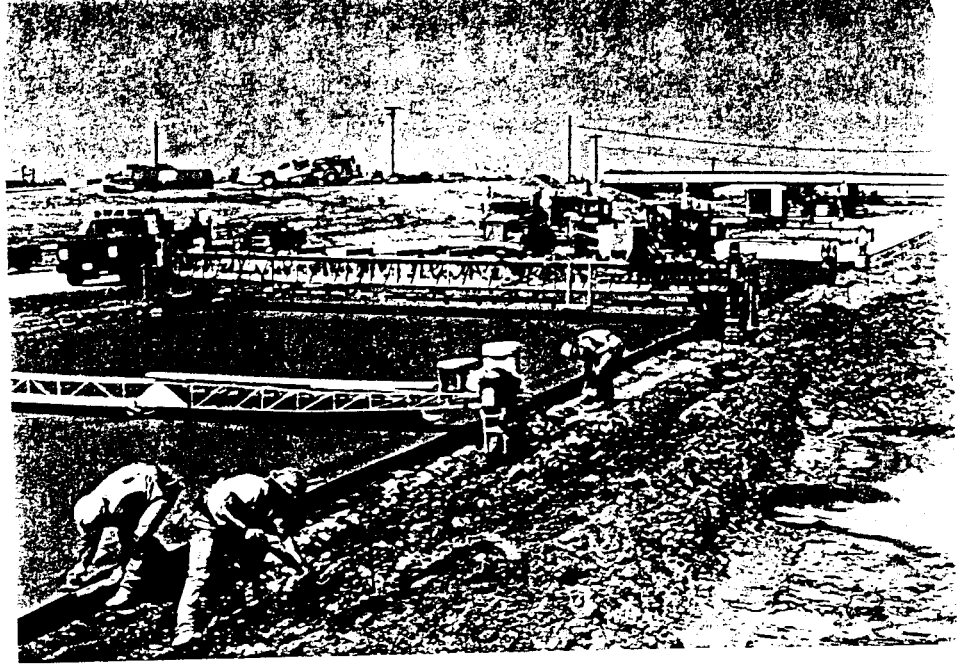
JOINTS

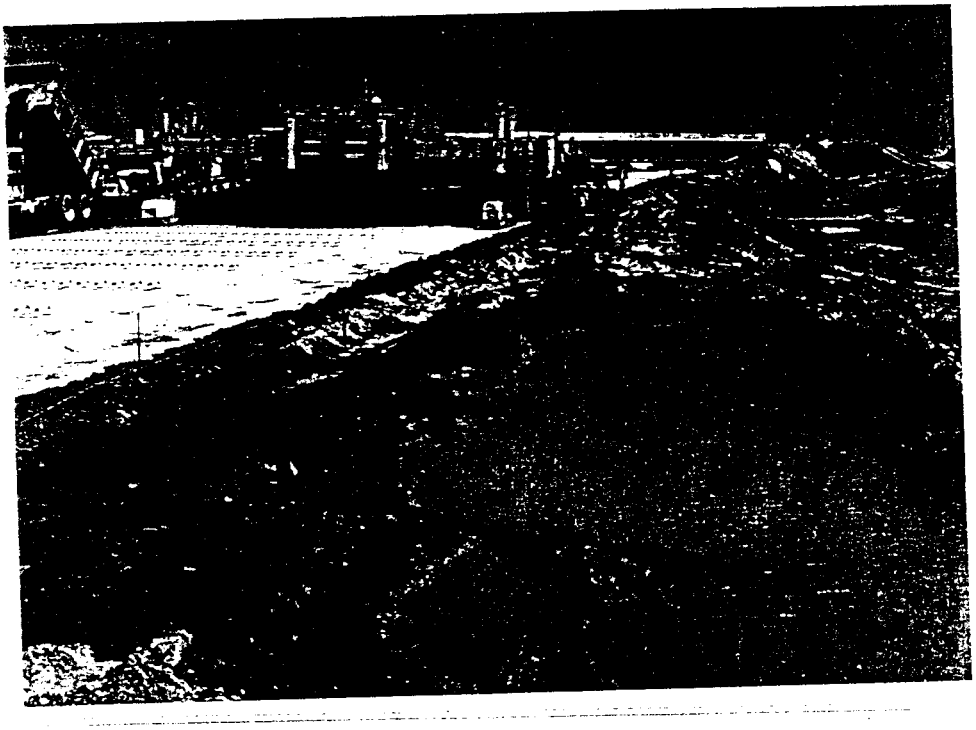
All joints were cut within 8 hours and depended upon the set time of the 550 psi mix and the 900 psi mix. The joints were cut with a diamond wheel sawcutter and were sawed twice to widen. The joint sealant, Dow Corning 888 silicone sealant, was placed after the second cut. The shoulder joint along all sections was sawn full depth.

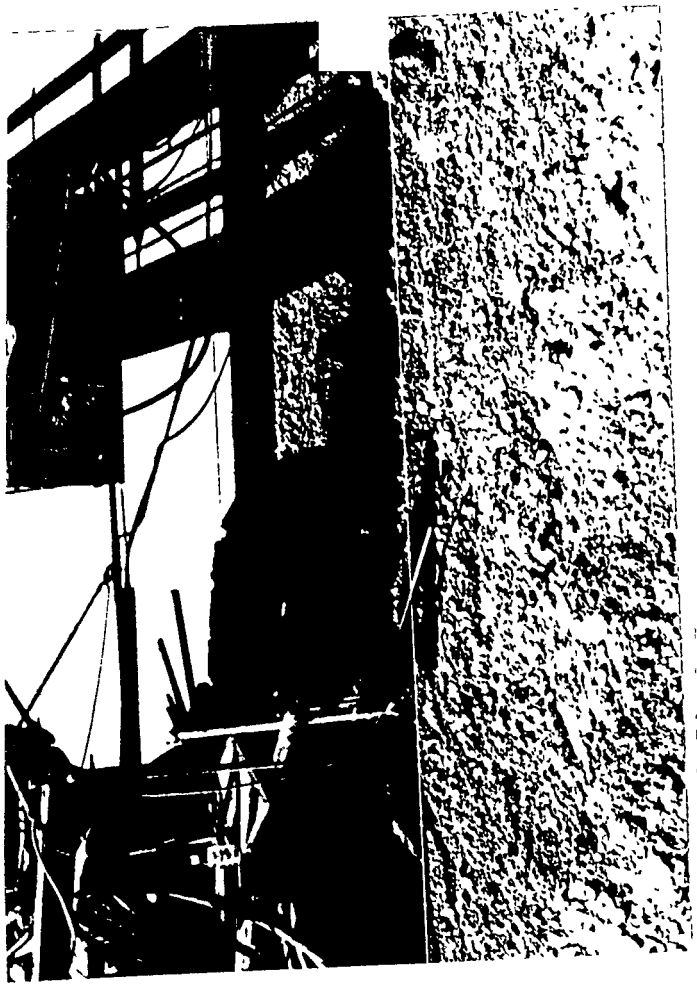
In general then, the SPS-2 construction met the requirements of the experiment and should provide valuable performance data for many years to come.

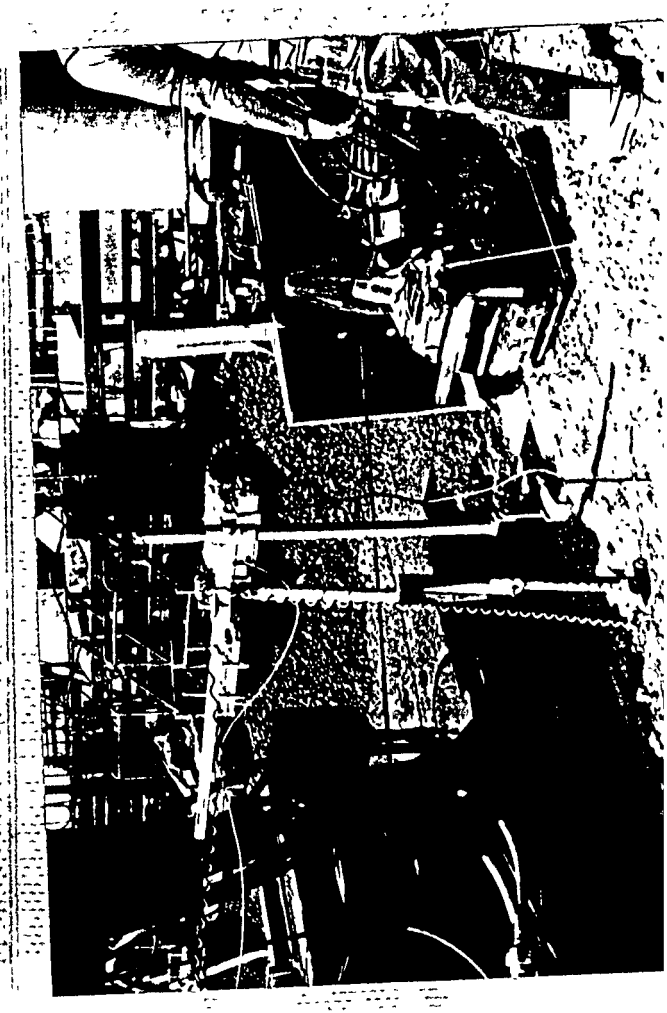
APPENDIX A

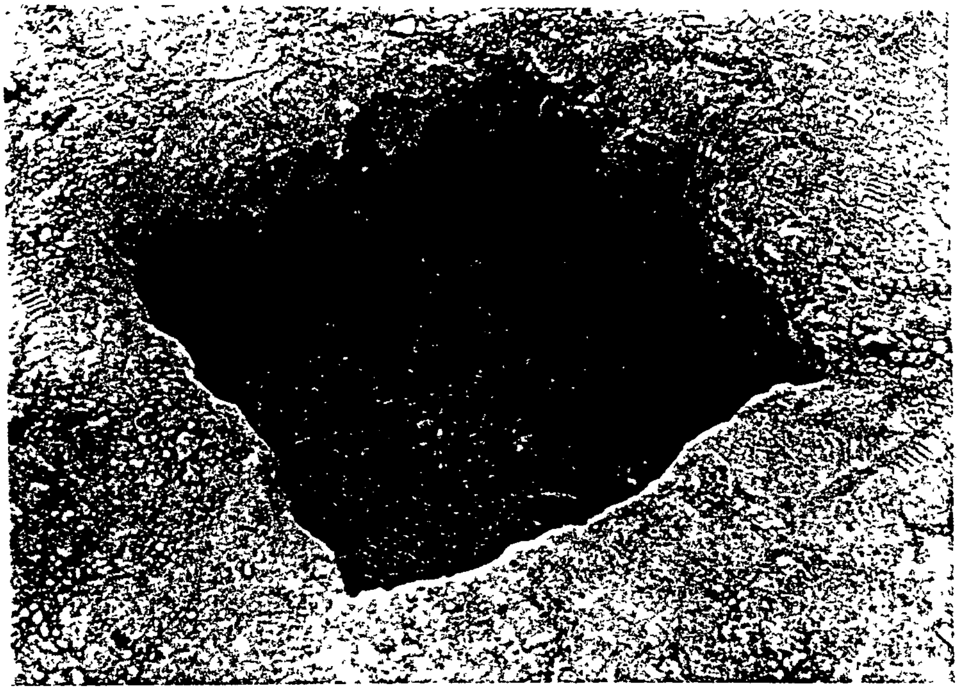
PROJECT PHOTOGRAPHS

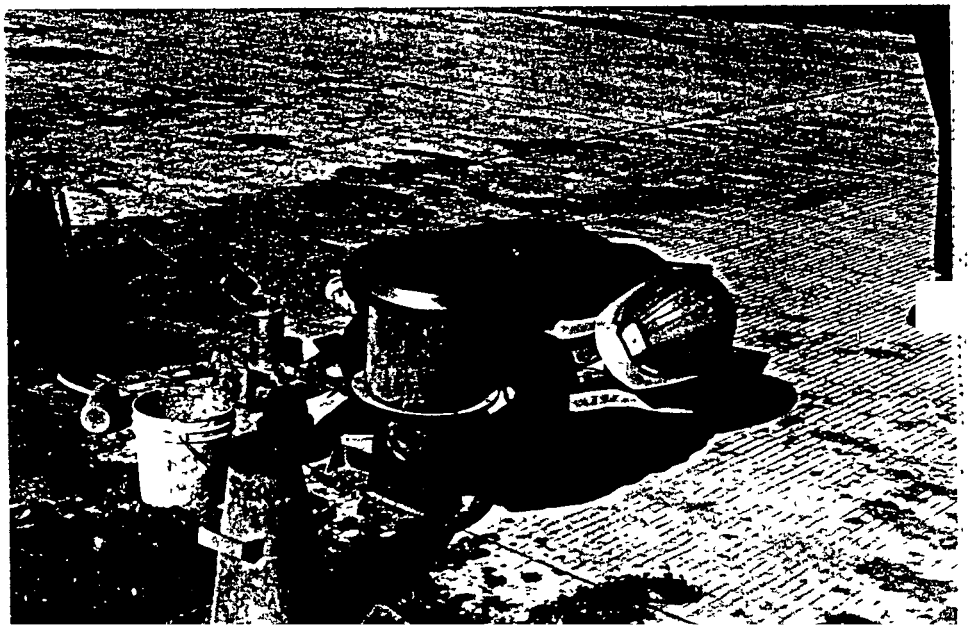


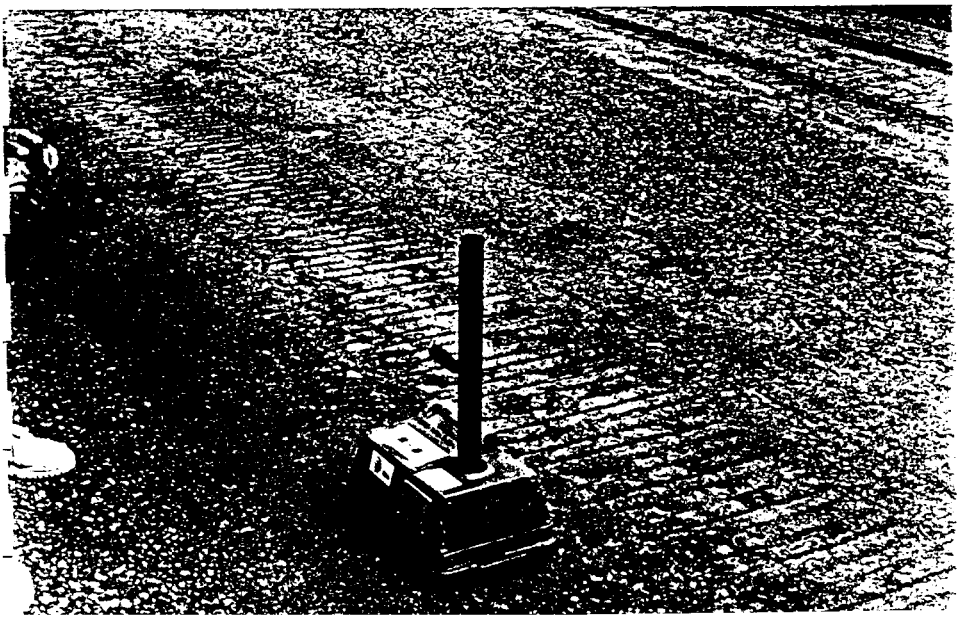


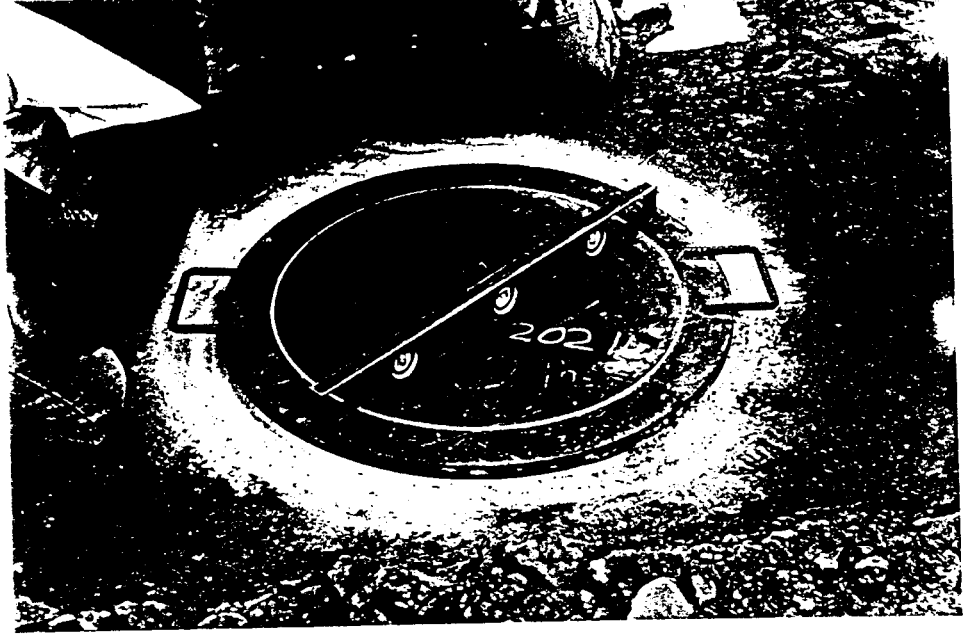


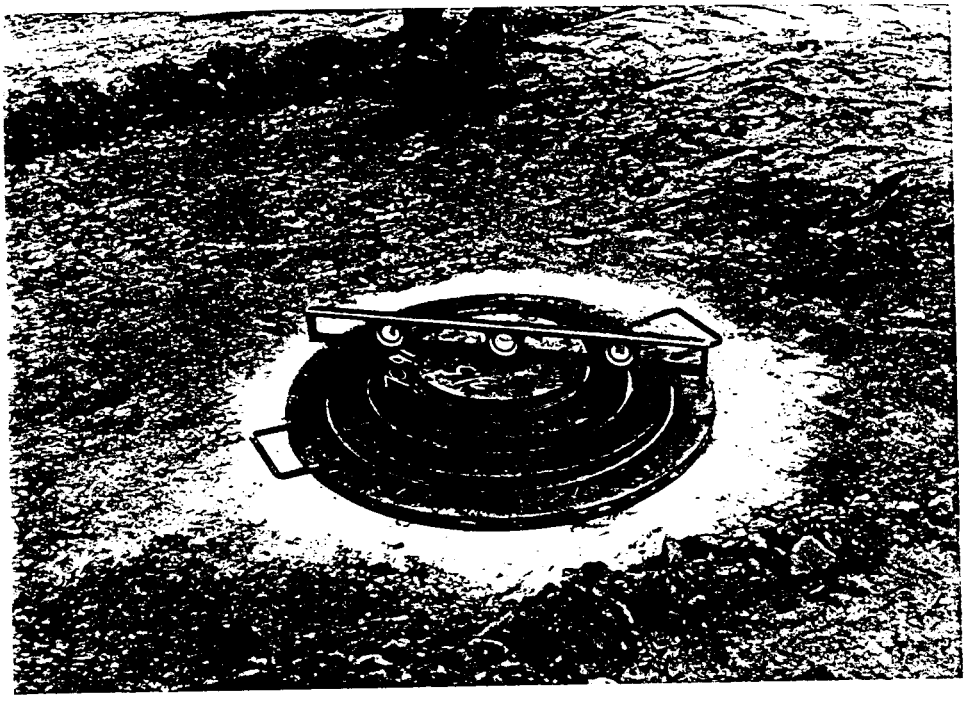


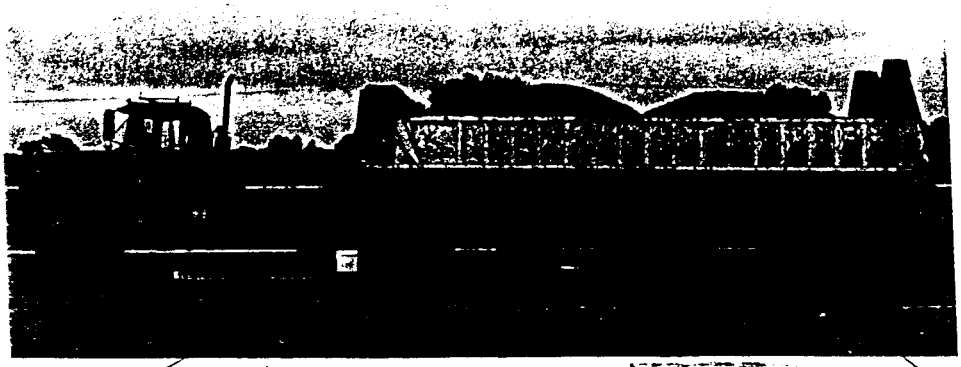


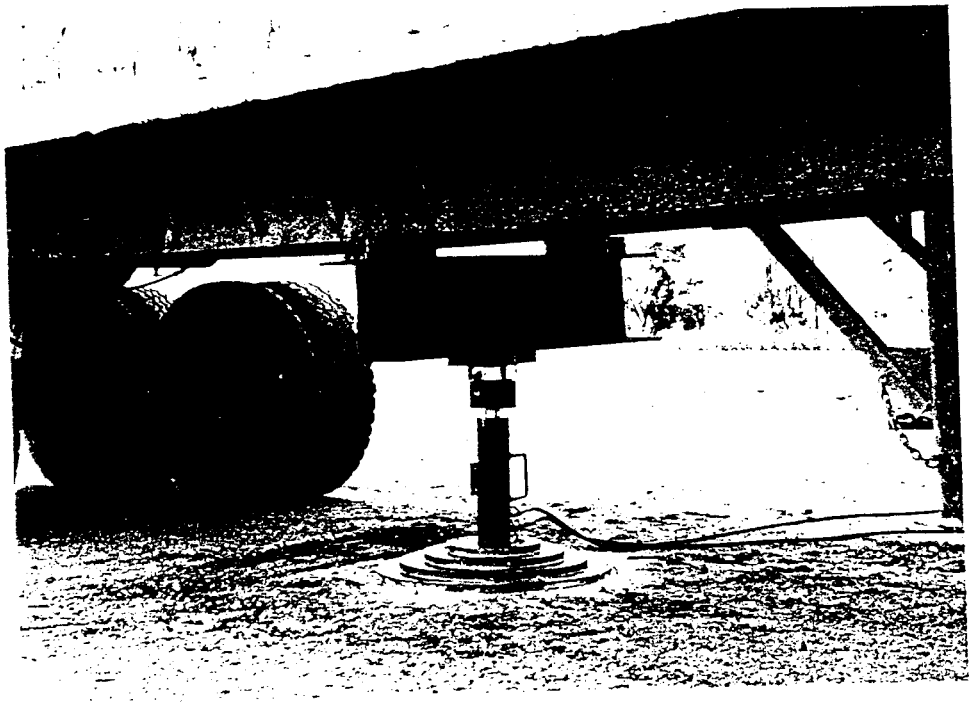


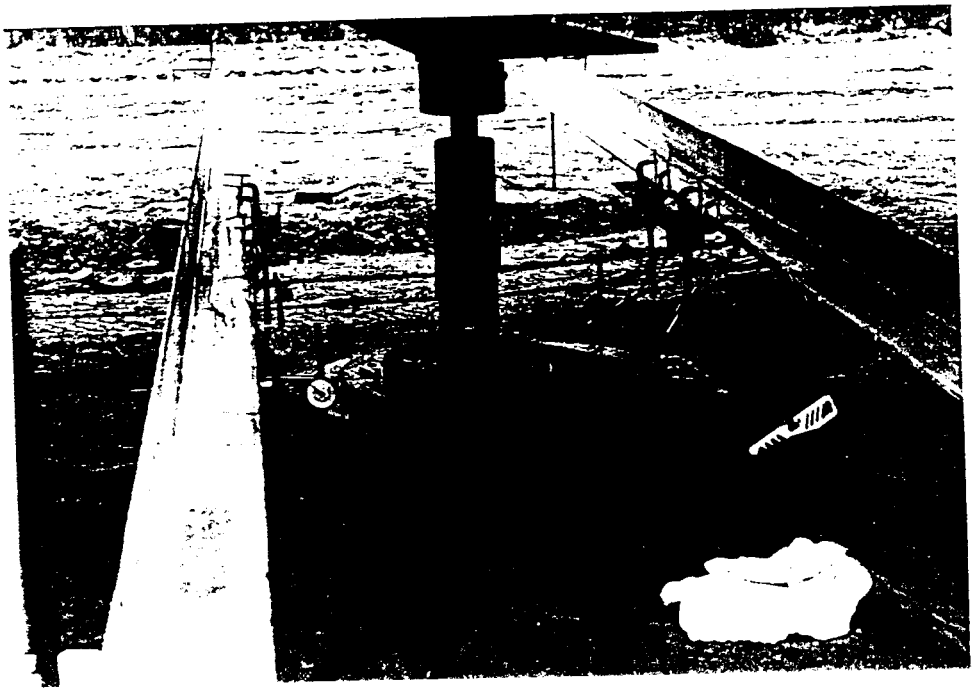










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