CONSTRUCTION REPORT

SHOULDER REHABILITATION EVALUATION
(I-78, - VICINITY OF COKESBURY RD TO WEST OF BUNNS RD.)

BY

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Federal Highway Administration

NOTICE

TECHNICAL REPORT STANDARD TITLE PAGE

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16. Abstract

This report describes the construction phase of a shoulder rehabilitation evaluation on Route I-78 in Hunterdon and Somerset Counties, New Jersey. The installation consisted of the placement of six distinct sections varying in degrees of effort, ranging in price from $3.45 to $44.80 per lineal foot. These sections incorporated the use of plain concrete, stone bases stabilized with lime-fly ash and cement, inlays of lime-fly ash and bituminous concrete, and recycled bituminous surface courses of two and four inch thicknesses.

A description of the designs, methods of construction, problems encountered and the solutions thereof are presented.

The methods for reducing the amount of oversized material in the milling of severely cracked pavement, the prevention of air contamination by lime and fly ashes, compaction of inlaid material in narrow trenches and other ancillary problems should be of interest to other agencies engaged in pavement rehabilitation.

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INTRODUCTION

Many shoulders along portland cement concrete interstate highways exhibit various signs of distress long before overlayment of the mainline pavement becomes necessary

An ideal candidate for a shoulder rehabilitation project was New Jersey's I-78 near Pluckemin where severe alligatoring of some areas of the shoulders and continuous faulting at the juncture with the mainline pavement had progressed beyond the repair capabilities of normal maintenance operations.

Several methods were advanced for correcting the various types of distress. It was expected that field application of these methods on a contract project would provide information on construction costs, maintenance cost factors as well as generating methods of construction for guidelines on future projects. These methods incorporated recycling the bituminous concrete shoulder pavement and stabilizing the underlying quarry processed stone base by the addition of cement and waste mineral fly ash.

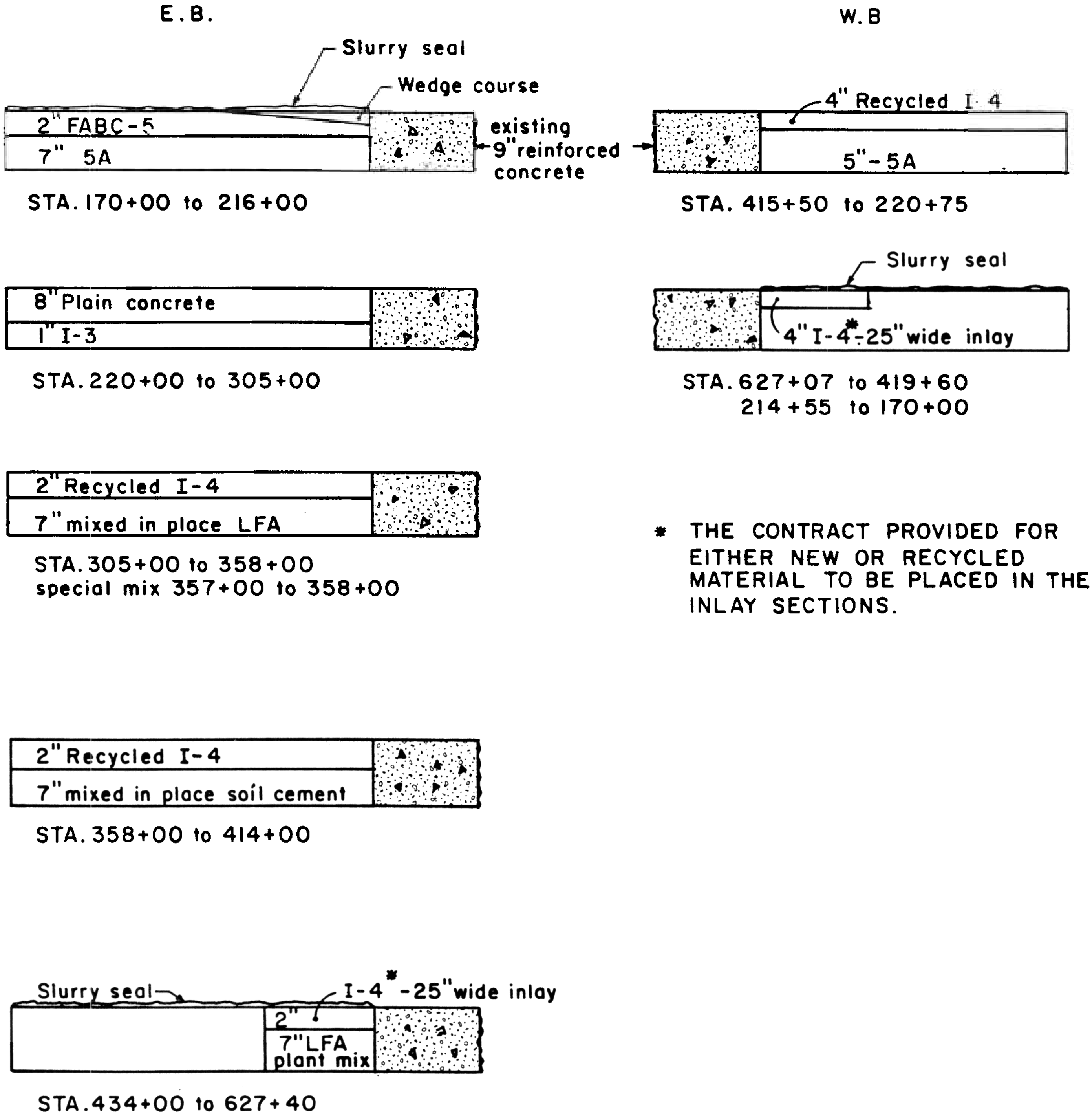
PROJECT DESCRIPTION

Route I-78, Section 3F and 3G was constructed in 1964 as a four lane divided highway. The mainline pavement consists of 9" thick reinforced portland cement concrete lanes, 12' wide with 3/4" expansion joints spaced at 78'2". The 12' wide outside shoulders consisted of 7" of quarry processed stone base topped with a 2" surface course of fine aggregate bituminous concrete (FABC).

In 1977 a condition survey was made by personnel of the Bureau of Geotechnical Engineering and the Bureau of Transportation Structures Research. During the survey it became obvious that portions of both the eastbound and westbound shoulders had become severely deteriorated due to their use as a truck stop rather than for emergency stopping. Until trucks were somehow kept off the shoulder by either increased police enforcement, additional signing or the building of rest areas, the problem would persist unless a stronger pavement section was provided

Research personnel proposed a stronger section by milling and hot mix recycling the bituminous surface course and stabilization of the base course with cement and/or lime-fly ash additions. They also suggested a 4" recycled bituminous mat for use on a non-stabilized base section. Geotechnical Engineering included a shoulder section of eight inch thick plain portland cement concrete tied to the existing outside portland cement concrete travel lane.

Many miles of the shoulders were in good condition except for faulting. In those areas, the shoulder was strengthened by placing a 25" wide inlay adjacent to the mainline pavement. The eastbound inlay consisted of a 7" layer of plant-mix lime-fly ash (LFA) placed to the bottom of the 9" concrete mainline slab and topped with a 2" lift of bituminous concrete. The westbound shoulder received a 25" wide, 4" thick bituminous inlay. The repaired shoulders were then slurry sealed. The aforementioned sections are shown in detail in Figure 1.


E.B.
Slurry seal
Wedge course
2" FABC-5
7" 5A
existing
9" reinforced
concrete
STA. 170+00 to 216+00
8" Plain concrete
1" I-3
STA. 220+00 to 305+00
2" Recycled I-4
7" mixed in place LFA
STA. 305+00 to 358+00
special mix 357+00 to 358+00
2" Recycled I-4
7" mixed in place soil cement
STA. 358+00 to 414+00
Slurry seal
I-4* -25" wide inlay
2"
7" LFA
plant mix
STA. 434+00 to 627+40
W.B
4" Recycled I-4
5"-5A
STA. 415+50 to 220+75
Slurry seal
4" I-4*-25" wide inlay
STA. 627+07 to 419+60
214+55 to 170+00
* THE CONTRACT PROVIDED FOR EITHER NEW OR RECYCLED MATERIAL TO BE PLACED IN THE INLAY SECTIONS.

FIGURE

PRECONSTRUCTION TESTING AND DESIGN

Bituminous Pavement

Six samples were taken of the bituminous shoulder pavement reclaimed asphalt pavement, RAP) throughout the milled area. The recovery results showed the asphalt cement to be quite hard. The penetration at 77°F ranged from 13 to 24 and averaged 18.83 dmm The viscosity at 140°F ranged from 31,441 to 83,857 and averaged 47,379 poises.

Samples of the recovered asphalt having penetrations of 16, 17, and 18 and viscosities at 140°F of 36,913, 55,230, and 45,379 poises were mixed with two new asphalt cements. The first samples mixed with an AC-20 having a penetration (pen) of 81 at ratios of 50/50 and 30/70 recovered to new asphalt. The penetrations were increased to 34 and 49 respectively. The viscosities decreased to 10,448 and 4,849 respectively. The third sample was mixed with a hot-mix recycling agent, HMA 2.5, at a 50/50 ratio which increased the penetration to 56 and reduced the viscosity to 2,805 poises Further laboratory work with an AC-20 with a 98 pen yielded recovered penetrations of 44 and 57 respectively, for ratios of 50/50 and 30/70 reclaimed asphalt to new asphalt.

Job mix formulas were developed for the utilization of 30%, and 50% RAP employing a modified AC-20 having a penetration of 109 @ 77° Fahrenheit (see Appendix A).

Base Stabilization

Soil Cement - The contractor presented the Department with the results of his testing of the 5A base material (see Appendix B) stabilized with 4% and 7% additions of Type II cement. The NJDOT prepared mixes at additive percentages of 4, 5, 6, and 7% of Type I cement yielding strengths of 890 to 1,260 psi (see Appendix B). The decision was made to use a 5% cement addition which would give a seven day strength of approximately 910 psi. The lesser strength was selected on the theory that more but smaller shrinkage cracks may form, lessening the ikelihood of their reflecting through the bituminous overlay. Cylinders made of the eventual field mixed material were humidity cured at 100^{o}F for 7, 28, and 45 days. The unconfined compressive strengths of these samples were 486, 700, and 744 psi respectively. The lower strengths obtained in the field are indicative of the variability inherent in stabilization under field conditions as opposed to plant mixing.

Lime-Fly Ash - The lime-fly ash admixture composition conformed to NJDOT's standard specification (see Appendix D). The old Type 5 Class A base material, however, differed slightly in gradation with 100% passing the 2" screen (see Appendix B) rather than the 1 1/2" screen as in the present specification. The percentages of ime-fly ash, aggregate and water which produced the greatest density were chosen as the mix design properties. Test cylinders from the eventual field mixed and plant mixed materials were prepared. The field mixed compression test cylinders were humidity cured for 7, 14, 28, 105, and 120 days and the plant mixed materia for 7, 28, and 45 days. Unconfined compressive strength values were 375, 700, 923, 1370, and 1435 psi for the field mix specimens, and 763, 1850, 1743 psi respectively for the plant mixed material (see Appendix C). These latter values again indicate the relative lack of control occurring with a field-mixed operation

METHODS OF CONSTRUCTION

The project started with the milling of the eastbound bituminous surface on May 13, 1981 and finished with the slurry seal application of the westbound shoulder on October 29, 1981. A key sheet showing the exact location is shown in Appendix E.

Milling

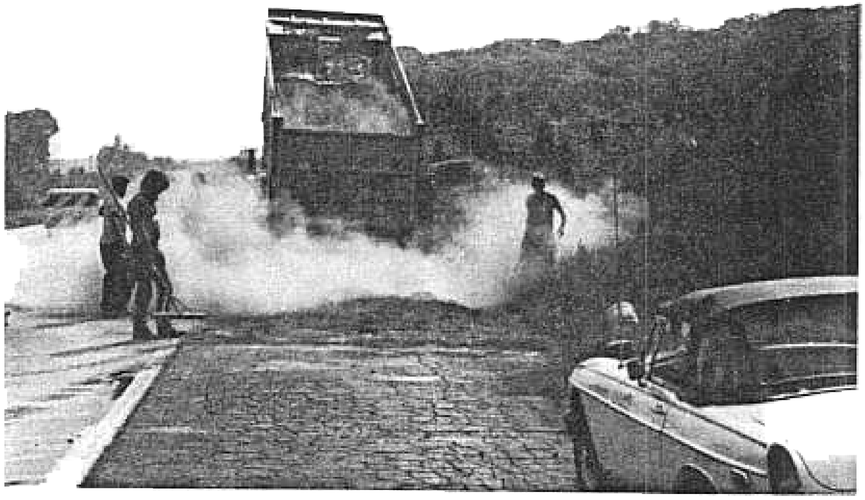
The 2" bituminous surface course was milled from both the eastbound and westbound shoulder for recycling feedstock (RAP) in those areas where stabilization and the 4" surface course replacements were to be placed. On start up, the machine was making a single pass at approximately fifty feet per minute. The bituminous pavement was coming up in chunks than desired and also contained a small amount of the base material. Approximately 50% of the material passed the 2" screen. The forward speed slowed to 30 feet per minute and the amount of oversized was reduced to approximately 25%. Alligatored pavement tends to come up in the same size as the pattern in situ. It was decided to change the depth of cut 1/2" in an effort to reduce the oversize as well as eliminate the pick up of the stone base. This system worked very we at forward speeds of 35 to 40 feet per minute with little or no pick up of the stone base and approximately 90% of the material passing the 2" screen. The second pass with the milling machine removed the residual bituminous pavement and was not used for recycling.

Lime-Fly Ash Stabilization

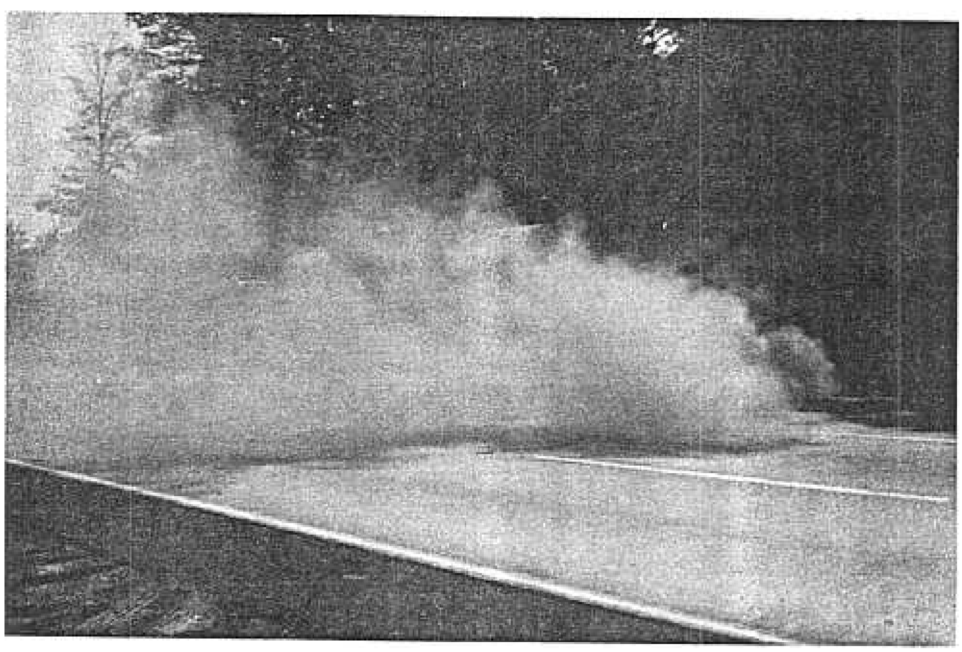
Previous laboratory trials showed that a 3.5% lime and 12% fly ash addition to the stone base would require removal of 1 1/2" of the 5A stone base leaving a 5 1/2" thickness to be stabilized. This blend of lime-fly ash, when applied to the stone at a rate of 100 #/sq. yd.*, wetted, mixed with a Bomag machine (rotor tiller) and rolled, gave the desired 7" thickness of stabilized base. The moistened ime-fly ash blended material was first placed by tailgate dumping from tandem trailers. The material was then fine spread by grader to the desired coverage of 100#/sq. yd., on the stone base. Unfortunately, the addition of the water at the plant during loading was not uniformly distributed through the load of LFA mixture to prevent dusting. Six truckloads were placed using this method.

During the following week, 12 tanker loads of the dry blended lime-fly ash were placed by pneumatic unloading as the truck traversed a measured distance. This and the previous method produced clouds of dust (see photos 1 and 2) that were considered hazardous to drivers and workers. A third method was to remove approximately 200# per square yard

*This quantity of lime-fly ash amounted to a 2 3/4" thickness of deposited material.



No. 1 - Tail Gate Unloading of Lime-Fly Ash

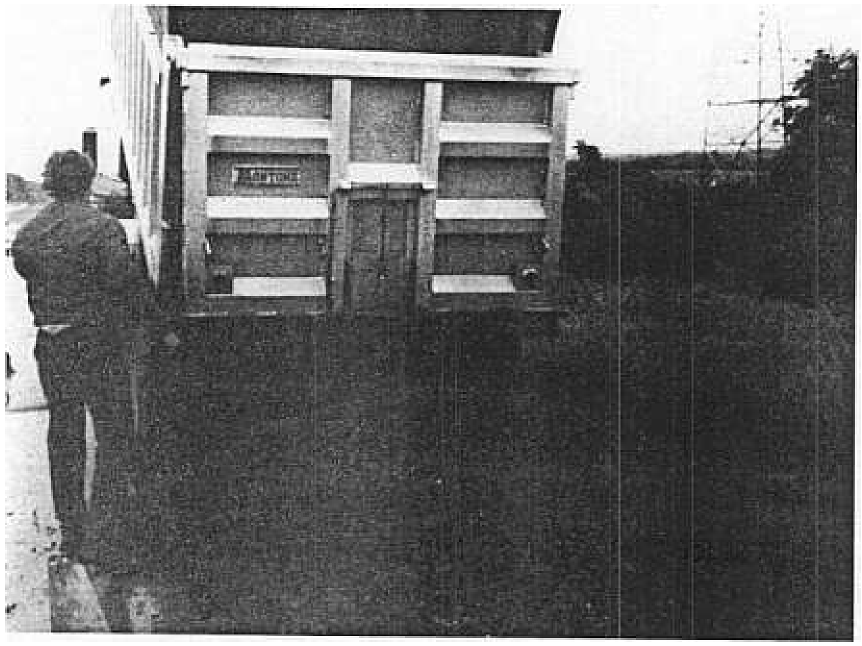


No. 2 - Pneumatic Placement of Lime-Fly Ash of the stone base, return it to the plant and add the entire 100#/sq. yd of blended lime-fly ash and water to produce an extremely enriched plant mix. This material was then transported and placed by tailgating the material, graded out and mixed with the stone base as previously described. There was absolutely no dusting (see photos 3 and 4) This method is the only one that would be recommended for any future mixed-in place project along a trafficked highway or adjacent to a residential area.

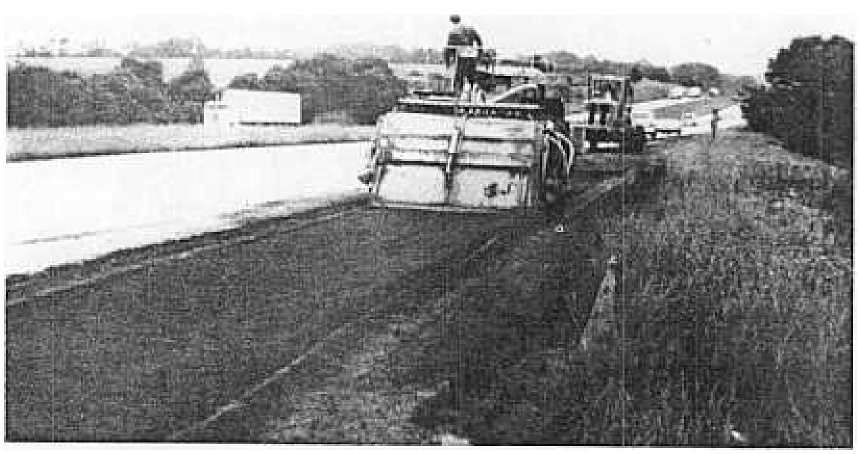
Another problem addressed was mixing with the Bomag machine. The bearing housing on this piece of equipment protrudes about six inches out from the drum and prevents the machine from mixing close to the concrete slab. This necessitates casting the unmixed aggregate and lime-fly ash by grader atop the adjacent mixed material and mixing by two passes of the Bomag machine. The material was then bladed into the excavated area by the grader. Moisture content was checked after the second pass if necessary, water was added through the Bomag machine as additional passes were made. Water is supplied to the Bomag machine by a tanker. A pump on the Bomag is adjusted to deliver the quantity of water needed as determined from a chart which takes into account the forward speed, the depth to be tilled and the moisture needed. The stabilized base was then rolled, fine graded and rerolled

Soil Cement Stabilization

The cement stabilization was performed in the same manner as the lime-fly ash. It differed only in the amount to be excavated (less than 1/2") due to the smaller quantity and volume of the cement, 31 lbs



lacement Enriched Plant Mix ly Ash



ing Enriched Plant Mix ime ly Ash

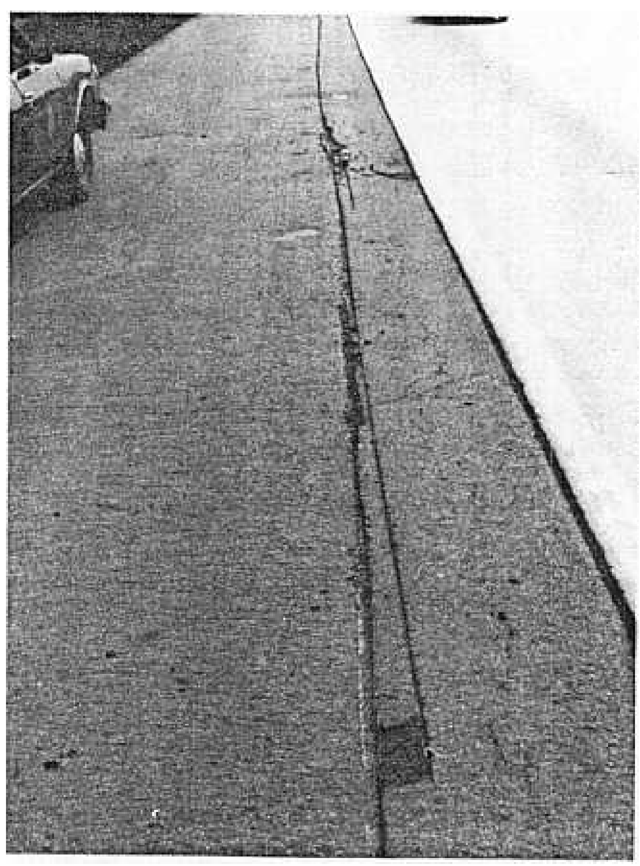
square yard. The pneumatic placement of the cement caused dusting almost as severe as the lime-fly ash and both would present problems with EPA and OSHA (see photo 5). Since cement is a hydraulic setting material, there is no way of premoistening or using the enriched plant mix method if the project is any distance from the plant. To alleviate these problems it would be best to bring a portable plant to the job site and mix the fu thickness of the base material with the cement and place it as a plant mix material.

Shoulder Inlays

Excavation and Stabilization - Faulting of the shoulder adjacent to the mainline pavement was to be corrected through the placement of an inlay of new materials to bring the shoulder to the height of the pavement. The eastbound inlay was a 25" wide, 7" deep section of plant mix lime-fly ash topped with 2" of I-4. The westbound inlay was a 25" wide medium aggregate bituminous concrete (I-4 mix) inlay 4" deep (see Appendix D).

The contract called for longitudinal saw cutting of the bituminous shoulder pavement. After 2700 feet of saw cutting had been completed, the resident engineer permitted cutting with a hardened wheel mounted on a grader. This method leaves alot to be desired. First of all, the cut is not as straight as that achieved by saw cutting. In the vicinity of milepost 25 the width of the FABC cut for excavation varied from 25-3/4" to 22-1/2" to 27-1/4" in a 25' length. Furthermore, the damage is compounded when the operator tries to correct his errors (see photo 6). Secondly, this latter procedure damages the remaining

No. 5 - Pneumatic Placement of Cement

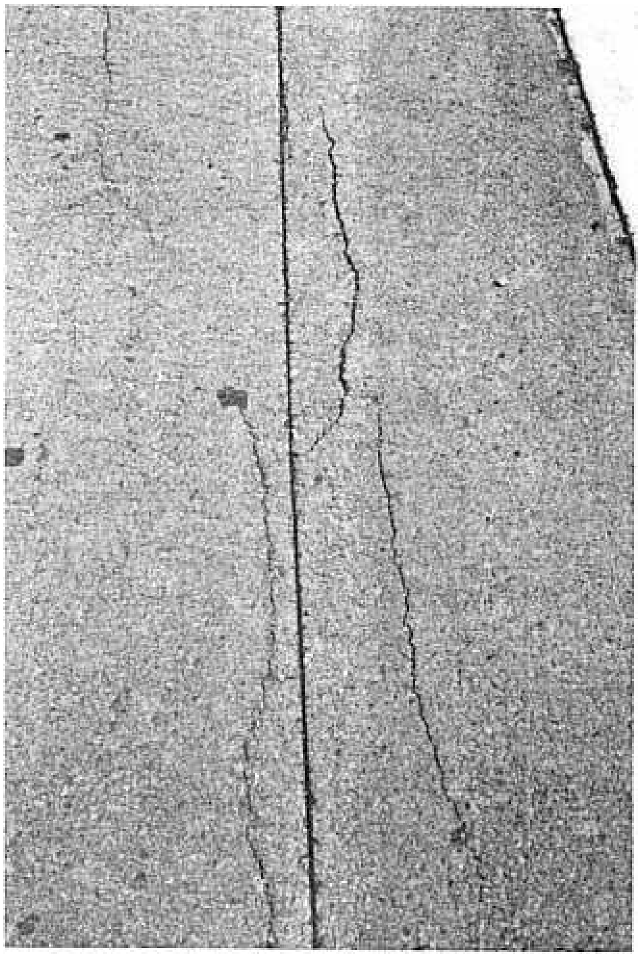


No. 6 - Cutting by Wheel on Grader

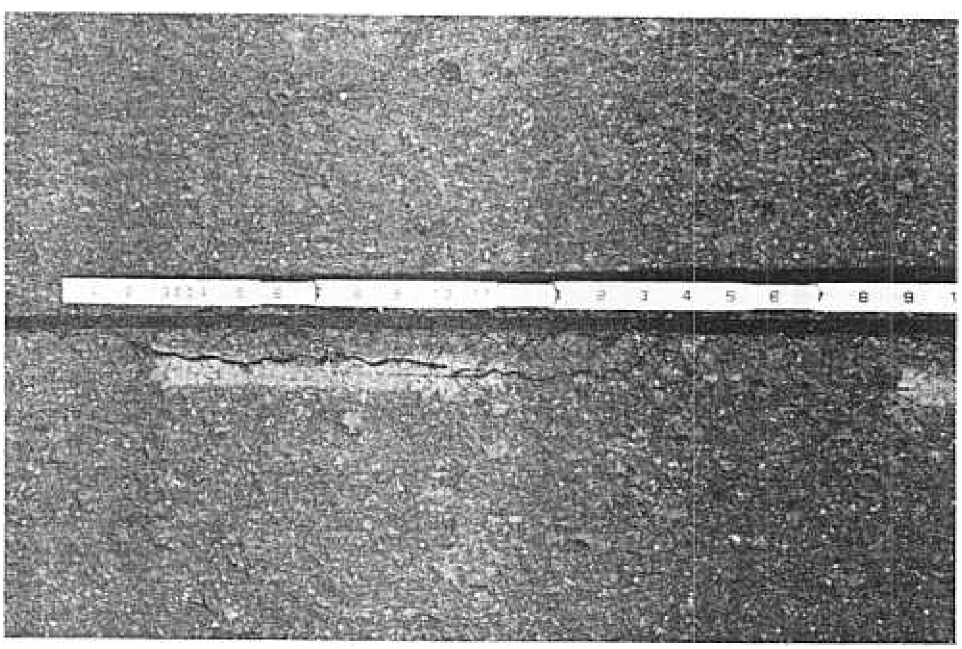
pavement. The pressure exerted on the wheel caused some new longitudinal cracking as wel as opening up some of the hairline cracks to 3/8 of an (see photos 7 and 8). Thirdly, the depth of cut varied due to the long wheelbase of the grader which cannot follow the undulation of the pavement surface. Since the cut wasn't entirely through the pavement there was a tendency to lift the residual mat off the stone base during the excavation operation. A good operator on the grader coupled with prudent inspection could alleviate some of the aforementioned problems, however, sawing appears to be the preferable method.

The excavation of the sawn bituminous and base materials was accomplished by a nove method devised by the contractor. A fixture welded inside the bucket of a front-end loader and a plate with an inclined plane was inserted and locked in place (see photo 9 simple arrangement permitted the excavation and loading of the truck in a single operation

The trench was filled with plant mix lime-fly ash by paver with a strike-off extension adjusted to the width of the trench Compaction was with the right wheel of a three-wheeled roller, the left rear wheel and front drum remaining on the mainline pavement. This caused differential compaction due to the cant of the roller The roller was then moved onto the shoulder and the left rear wheel for compaction. The cross slope compensated for the 2" depth of the base material keeping the roller on an even plane and giving excellent compaction. The material compacted when the roller was on the

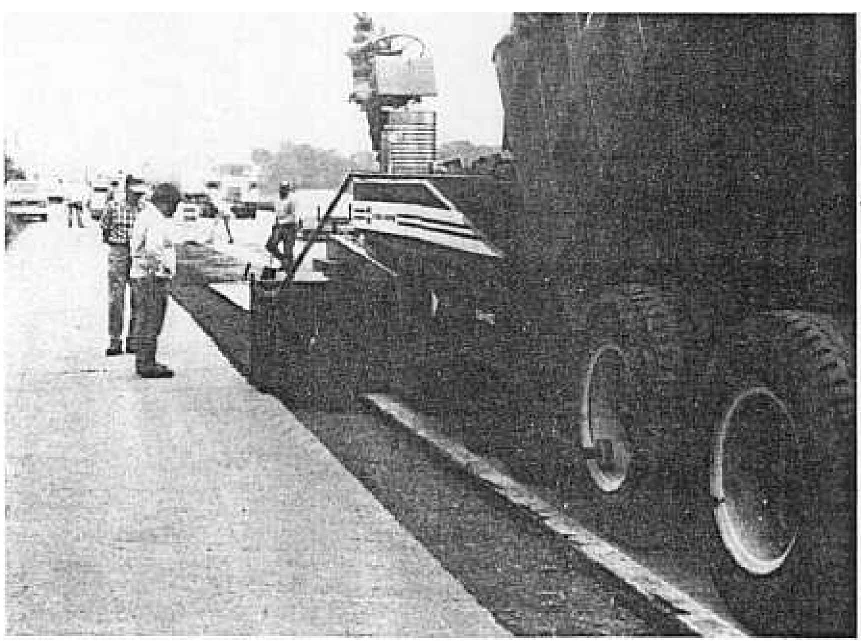


7 - Enlarging Cracks



8 - Pressure Cracking

No. 9 - Excavation For Inlay of Lime-Fly Ash



No. 10 - 4" MABC Inlay

pavement, subsided an additiona 1"-1¼" against the mainline pavement when rerolled with the roller placed on the shoulder. This method of compaction, however, had to be discontinued because the inside edge of the right whee started to cut into the shoulder pavement due to the heat of the noonday sun. The balance of the project was tamped with a plate compactor. The best method for future work would be to specify a trench roller.

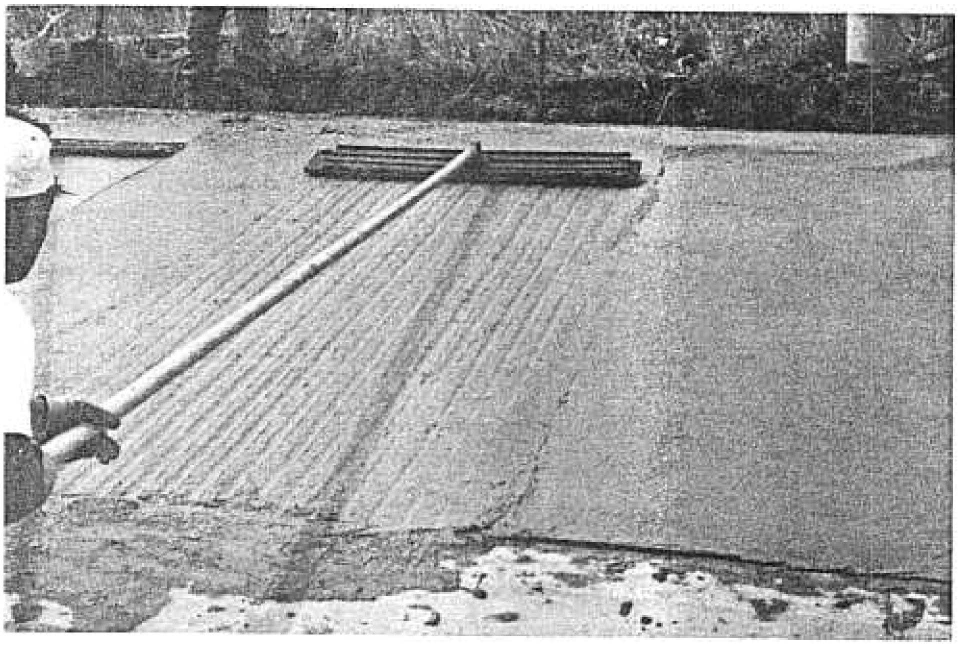
Bituminous Sections - All of the bituminous mix used in the inlay work, both the 2" eastbound and 4" westbound was constructed with virgin MABC top course material (Mix I-4) placed with a paving machine with a strike-off extension (see photo 10). Virgin material was used since the daily tonnage was too small to justify a recycled mix

New Shoulder Pavement

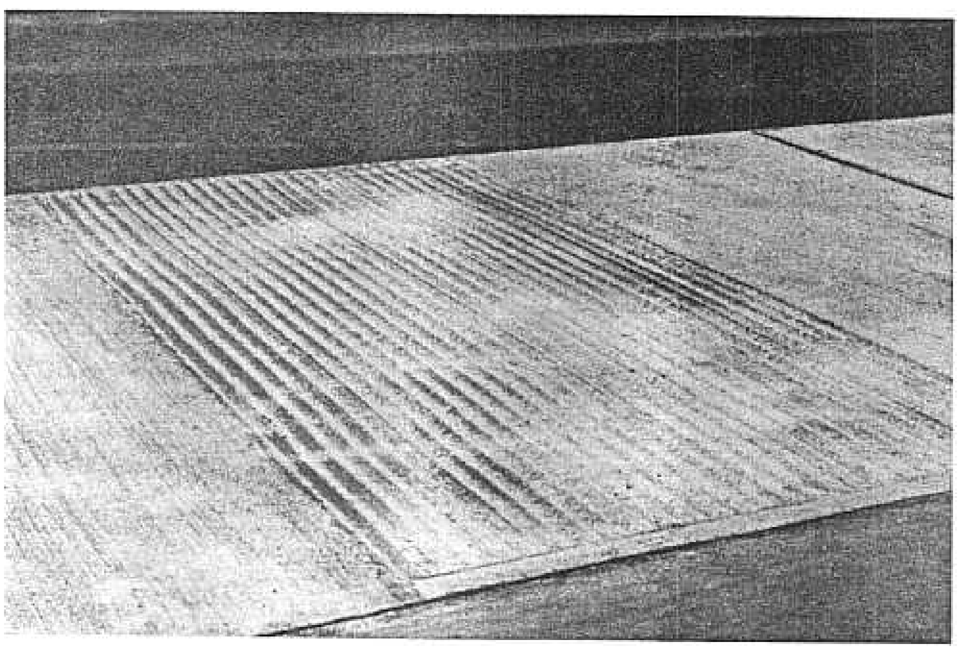
Portland Cement Concrete - In the area to receive a portland cement concrete shoulder, the existing bituminous concrete pavement and stone base was excavated. One inch of I-3 soil aggregate (see Appendix D) was placed on the subbase as a leveling and filler course for the 8" plain concrete shoulder. Deformed 5/8" bars were used to tie the shoulder to the mainline pavement. The bars were 15" long, 4" of which was grouted in 1-1/4" diameter holes drilled horizontally the mainline slabs at mid-depth. Spacing was 30". Some of the slabs had the tie bars inserted within 6" of the expansion joints. Because of interference with the mainline pavement dowels, this was changed to keep the bar at a minimum of 12" from the joint. Type A undoweled transverse joints were formed to match the joints in the mainline pavement.

The Type A joint consisted of three bearing plates (1/4" x 4" x 18" welded at right angles to a 12 gauge steel center plate supporting a 3/4" bituminous impregnated fiber joint filler 7" high. A 1" finishing strip attached to the top of the filler after finishing was removed prior to sealing with a hot poured rubberized asphalt sealer conforming to Federal Specification SS-r-405. Four contraction joints were equally spaced at 15.63' within the 78'-2" slabs. A 6' corrugated rumble strip was formed 5' from each Type A joint. The corrugations 4-1/2" center-to-center of the crests, starting 2" in from the mainline pavement and running out to the shoulder pavement edge to avoid water entrapment. In forming the rumble strip, severa shovelfuls of concrete were removed from the area; a corrugated template was tapped ightly in place and the pattern chased several times with a long handled forming tool until the desired configuration was achieved (see photos 11 and 12

Bituminous Concrete - Approximately 7100 tons of recycled -4 Appendix A) mixture was placed on the full width of the 12' shoulder on the east and westbound lanes. The thickness on the lime-fly ash and soil cement was designed for a 2" overlay, whereas the westbound lane was designed for a single 4" lift over the in-place stone base An MC-70 was used as a prime coat on the stone base and soil cement sections. The recycled mixture was processed through a drum mixer which



No. 11 Chasing the Rumble Strip

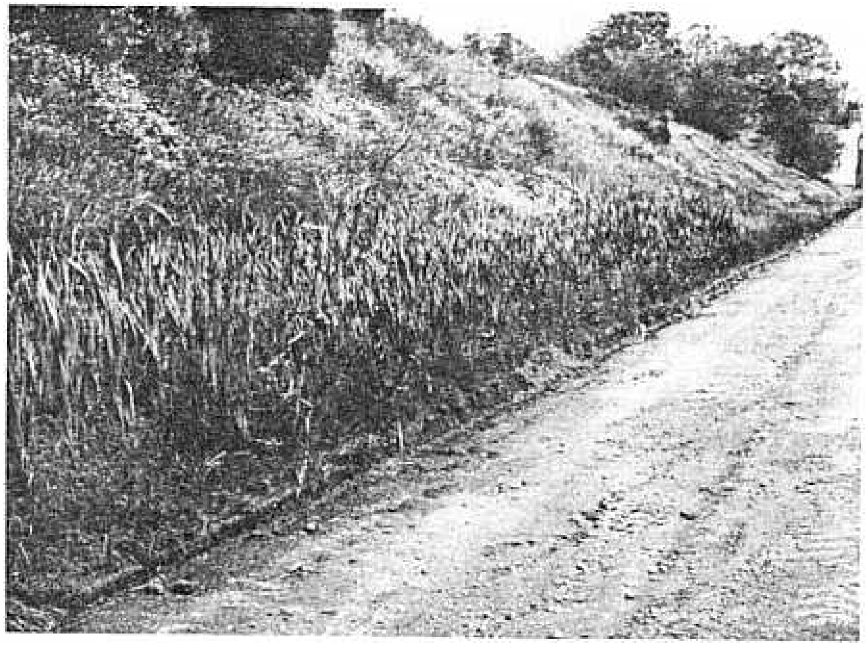


No. Finished Rumble Strip

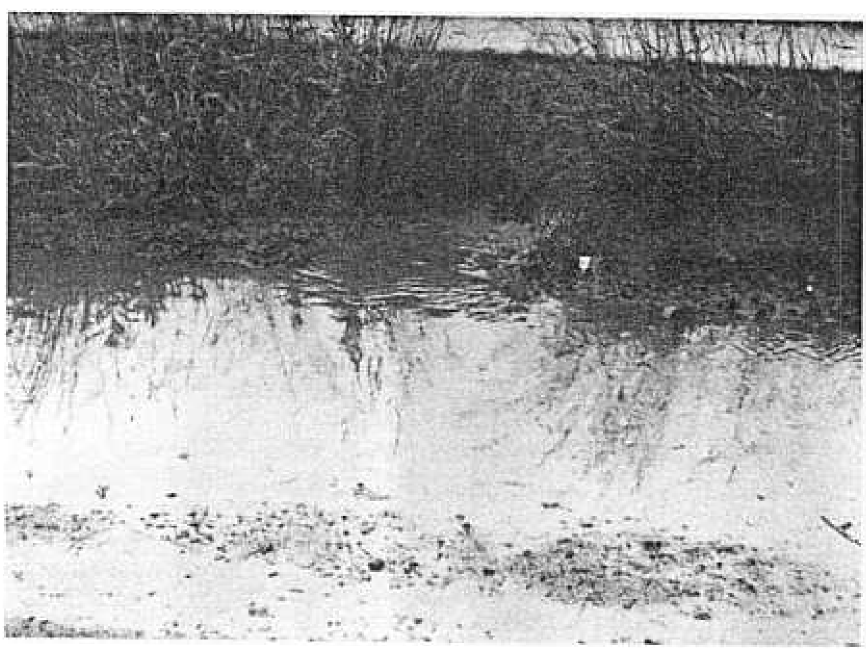
had been retrofit for recycling. Although the origina specifications called for a 50/50 salvaged to new materia ratio, the plant was permitted to start up at a 30/70 ratio to ascertain the effect on the plant baghouse and on the air quality at the plant site. After producing 1823 tons, the ratio was changed to 40/60 for the remaining 5250 tons. No problem was encountered in the hot mix recycling efforts.

It should be pointed out that the plant was paid on the basis of a 50/50 mixture and that any additional cost for virgin materials was borne by the producer. During and after placement of the mix several noteworthy observations were made. 1 Drainage ditches should be installed (especially in cuts) to prevent water from permeating the base or flowing along the newly placed pavement (see photos 13 and 14) 2) The berm should be graded back at least one foot from the pavement edge. This would prevent grass and soil from being imbedded in the mix by the paver (see photos 15 and 16). 3) The riding quality on the westbound shoulder is not as good as the eastbound. It would be preferable to place two 2" lifts rather than a single 4" lift. 4) The bituminous mat can and should be placed over the lime-fly ash stabilized base as soon as convenient. This would eliminate the necessity of a contractor having to water cure over a weekend, prevent damage due to inclement weather and surface contamination due to traffic. Furthermore, it can be a safety factor against dropping off the pavement as wel as reducing the possibility of collision with the safety protective equipment.

A bituminous core survey of the 4" westbound shoulder showed an average thickness of 4.72". The air voids ranged from 2.1 to 5.6%, the

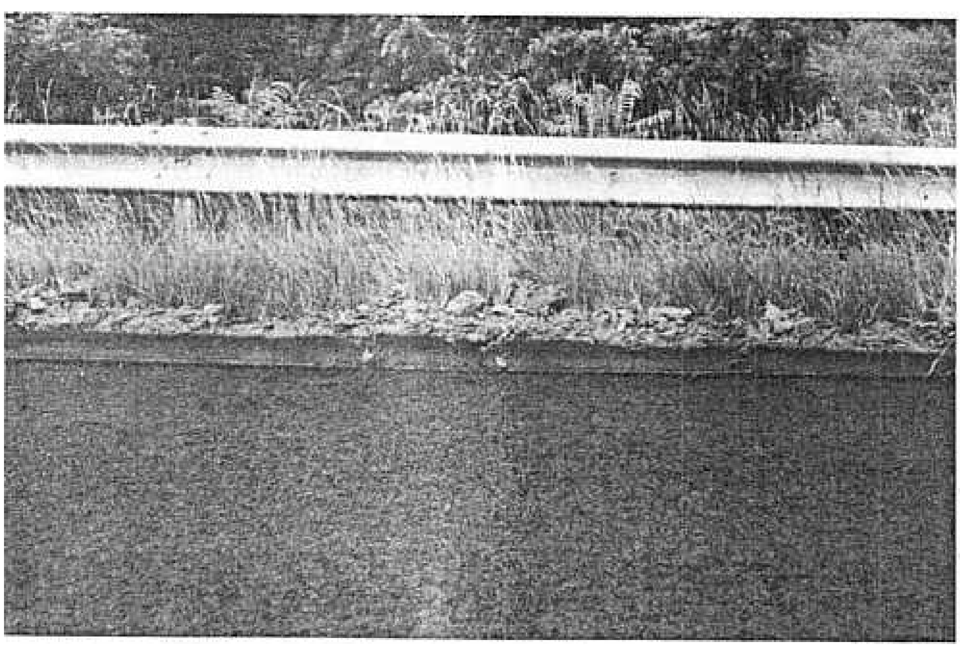


No. 13 - Install Drainage Ditches



No. 14 - Prevent Water Damage

Intrusive Grass



Paver Pushing Back Berm

average being 3.45%. The air voids in the 2" eastbound shoulder ranged from 3.1 to 7.9%, the average being 5.96%. The average thickness over the lime-fly ash was 2.46"; the average thickness over the soil cement was 3.38". This difference was due to the removal of 1-1/2" of the stone base rather than the 1/2" to accommodate the lesser weight of 31 lbs./sq. yds. of cement versus 100 lbs./sq. yd. of ime-fly ash

Wedge Course

A section of the shoulder from Station 170+0 to 215+90 was scheduled to be replaced with concrete. The shoulder was in good condition except for minor faulting. It was decided to correct the faulting via a wedge course and a slurry seal applied over the entire shoulder. The wedge was variable in width running from 18" to 36". An I-6 mix (see Appendix D) was selected for its ability to be feathered out. The tack material was an RC-70. Because of undulation of the shoulder pavement, the tack coat and bituminous mix were hand placed to meet the desired grade and cross slope. A slurry seal was then applied. This construction change saved approximately $190,000.

SLURRY SEAL

A Type II slurry seal was placed in a single pass. Prior to application, the pavement was broomed and cracks cleaned of intrusive grass and other debris. A light spray of water was applied to the pavement surface directly preceding the spreader. The average rate or percentage of material deposited was 15.5% CCS-1H cationic emulsified asphalt, 12 lbs. of washed traprock per square yard, and 1% portland cement as the minera filler.

COSTS

The following table gives the cost of the various test sections based on the unit bid prices in-place, including any ancillary costs such as excavation, saw cutting, asphalt prime coat, tack coat, surface course, and slurry seal.

	Dollars	
	Per Sq. Yard	Per Linear Foot
Concrete	33.60	44.80
Lime-Fly Ash and 2" Recycled I-4	15.53	20.71
Soil Cement and 2" Recycled -4	12.53	
I-4, 4" Thick	10.34	13.79
Inlay-7" LFA 2" I-4 and Slurry Seal	19.64	
Inlay-4" I-4 and Slurry Seal	15.53	
Wedge Course* and Slurry Seal	.883	

*Not to be considered in the study since would only be used in specific applications.

CONCLUSIONS AND RECOMMENDATIONS

1. The pneumatic placement of cement and lime-fly ash for shoulder stabilization should not be considered on future projects

2. Lime-fly ash aggregate base mixed in a central plant can be effectively placed through a conventiona paver.

3. The enriched mixed method for the placement of lime-fly ash should be used for in-place base stabilization (see page 7).

4. A trench roller should be used for compaction on narrow inlays too small for a conventional roller

5. In the placement of bituminous materia on a shoulder, the berm should be cleared for at least one foot beyond the edge of the shoulder.

6. Drainage ditches should be installed, cleared, or reshaped prior to shoulder rehabilitation to prevent water from infiltrating the stone or flowing along the newly stabilized base

7. A bituminous surface course should be placed on a lime-fly ash stabilized base as soon as possible to prevent damage from traffic reduce the danger of pavement dropoff and collision with safety protective equipment.

8. If riding quality is a factor in shoulder resurfacing, two 2" lifts are preferable to a single 4" lift

9. The experimental shoulder sections established on Route -78 should be monitored for four years to establish cost/performance factors for each of the trial rehabilitation strategies

APPENDICES

APPENDIX A

Form LB-83 5/80

NEW JERSEY DEPARTMENT OF TRANSPORTATION

BITUMINOUS CONCRETE MIX DESIGN

DATE May 28, 1981

PROJECT Route 78 Section 3K & 4T I-Ir-78-0(3)22 JOB CODE 1816 302 / 1816 303

PRODUCER Uniset Asphalt PLANT LOCATION Watchung, NJ

CONTRACTOR Whitmeyer Brothers ADDRESS P.O.Box 617-Hammonton, NJ 08037

JOB MIX FORMULA
(Total percent passing each sieve)

SIEVE	Mix No. I4 30% ReCyc.		Mix No. I4-40% ReCyc.		Mix No. I4 50% Recyc.		Mix No.	
SIZE	Formula	Average of 5	Formula	Average of 5	Formula	Average of 5	Formula	Average of 5
2"								RANGE
1½"								
1"	100	100	100	100	100	100		
¾"	98	95-100	98	95-100	98	95-100		
½"	85	75-95	85	75-95	85	75-95		
3/8"	75	65-85	75	65-85	76	65-85		
	52	35-65	52	35-65	52	35-65		
# 8	40.0	36.0-44.0	39.5	35.5-43.5	39.5	35.5-43.5		13
# 16								
# 30								
# 50	16.5	13.5-19.5	17.0	14.0-20.0	19.0	16.0-22.0		
# 100								
# 200	5.3	3.9-6.7	5.4	4.0-6.8	6.3	4.9-7.7		4.8
* ASPH. CONT.	5.00	4.55-5.45	5.00	4.55-5.45	5.00	4.55-5.45		1.5

* PERCENT ASPHALT CEMENT BASED ON THE TOTAL WEIGHT OF MIXTURE

CRITERIA - ORIGINAL MIX DESIGN				
	Mix No. RECYCLE	Mix No.	Mix No.	Mix No.
Stability-Lbs.	2000			
Flow Value-0.01"	14			
Air Voids-percent	4.2			
Wt./Sq. Yd./Inch Thick	116.4			

Mix temperature at plant must exceed lay-down temperature by at least 10 if ambient temperature is or above. If ambient temperature is or lower, mix temperature must exceed lay-down temperature by at least 15°. Mix temperature must not exceed 325°.

MIX DESIGNED BY: J. Smith NJDOT DATE APPROVED: 5-26-81 Verification Plug-Lab SERIAL NO.: N/A

AMENDED BY JOB MIX FORMULA CHANGE DATED ______ ON FILE WITH THE N.J.D.O.T.

DISTRIBUTION

- Bureau of Inspection
- Bureau of Quality Control ✓
- Regional Construction Engineer
- Bituminous Laboratory
- Core Drill Group
- Residnet Engineer
- Contractor
- Supplier
- Regional Materials Office (2)

J. Smith-Lab

RECYCLED ASPHALT MATERIALS
DRYER DRUM PLANT

This design for 2" thickness

Signed [signature]
Project Engineer, Materials

BIN PULLS

MIX NO. 30%	PER CENT	APPARENT Specific Gravity	COMPONENTS - - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	29.0	N/A	Recycle Material
Bin No. 3 #67	24.2	"	Fanwood Crushed Stone-Watchung
Bin No. 2 #89	23.2		" "
Bin No. 1 Sand	19.[illegible]		and-Lakewood *
Filler	1.[illegible]		Baghouse Fines
Asph. Content	3.3		West Bank Oil 109 pen.

Maximum Theoretical Specific Gravity: 2.595

Approximate Cold Feed Proportions:

MIX NO. 40%	PER CENT	APPARENT Specific Gravity	COMPONENTS PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	38.9	N/A	Recycle Material
Bin No. 3 #67	24.3		Fanwood Crushed Stone-Watchung
Bin No. 2 #89	19.4		" "
Bin No. 1 Sand	14.6		Clayton Sand-Lakewood, NJ *
Filler			
Asph. Content	2.8		West Bank Oil 109 pen.

Maximum Theoretical Specific Gravity: 2.595

Approximate Cold Feed Proportions

MIX NO. 50%	PER CENT	APPARENT Specific Gravity	COMPONENTS - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	48.9	N/A	Recycle Material
Bin No. 3 #67	24.5		Fanwood Crushed Stone-Watchung
Bin No. 2 #89	15.6		" "
Bin No. 1 Sand	8.3		Clayton Sand-Lakewood, NJ *
Filler			
Asph. Content	2.2		

Maximum Theoretical Specific Gravity 2.595

Approximate Cold Feed Proportions :

MIX NO.	PER CENT	APPARENT Specific Gravity	COMPONENTS - - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4			
Bin No. 3			
Bin No. 2			
Bin No. 1			
Filler			
Asph. Content			

Maximum Theoretical Specific Gravity

Approximate Cold Feed Proportions:

REMARKS: - XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX

* Supplier has the option to use screenings with sand to maintain control of mixture should they desire. (as per J. Smith NJDOT)

RECEIVED
BUR OF QUALITY CONTROL
JUN 3 1981
N.J. DEPT. OF TRANSPORTATION

RECYCLE ASPHALT - 2" XXXXX Thickness

DRYER DRUM PLANT

Form LB-83 5/80

NEW JERSEY DEPARTMENT OF TRANSPORTATION

BITUMINOUS CONCRETE MIX DESIGN

DATE May 28, 1981

PROJECT Route 78 Section 3K & 4T I-Ir 78-0(3)-22 JOB CODE 1816 302 / 1816 303

PRODUCER Uniset Asphalt PLANT LOCATION Watchung, NJ

CONTRACTOR Whitmeyer Brothers ADDRESS P.O. Box 617-Hammonton, NJ 08037

JOB MIX FORMULA

(Total percent passing each sieve)

SIEVE	Mix No. T4 30% ReCyc.		Mix No. T4 40% ReCyc.		Mix No. T4 50% ReCyc.		Mix No.	
SIZE	Formula	Average of 5	Formula	Average of 5	Formula	Average of 5	Formula	Average of 5
2"								
	99	100*	98	100	98	100		
	96	95-100	95	95-100	95	95-100		
	84	75-95	84	75-95	85	75-95		
	75	65-85	75	65-85	77	65-85		
# 4	51	35-65	52	35-65	54	35-65		
# 8	40.0	36.0-44.0	40.5	36.5-44.5	40.0	36.0-44.0		13
# 16								
# 30								
# 50	15.5	12.5-18.5	16.0	13.0-19.0	17.0	14.0-20.0		
# 100								
# 200				3.5-6.3	5.2			4.8
* ASPH. CONT.	5.00	4.55-5.45	5.00	4.55-5.45	5.00	4.55-5.45		1.5

* PERCENT ASPHALT CEMENT BASED ON THE TOTAL WEIGHT OF MIXTURE.

CRITERIA - ORIGINAL MIX DESIGN				
	Mix No. RECYCLE	Mix No.	Mix No.	Mix No.
Stability-Lbs.	2000			
Flow Value-0.01"	14			
Air Voids-percent	4.2			
Wt./Sq. Yd./Inch Thick	116.4			

Mix temperature at plant must exceed lay-down temperature by at least 10 if ambient temperature is or above. If ambient temperature is or lower, mix temperature must exceed lay-down temperature by at least 15°. Mix temperature must not exceed 325°.

MIX DESIGNED BY: J. Smith NJDOT DATE APPROVED: 5-26-81 Verification Plug-Lab SERIAL NO N.A

AMENDED BY JOB MIX FORMULA CHANGE DATED ______ ON FILE WITH THE N.J.D.O.T.

DISTRIBUTION

- Bureau of Inspection
- Bureau of Quality Control ✓
- Regional Construction Engineer
- Bituminous Laboratory
- Core Drill Group
- Residnet Engineer
- Contractor
- Supplier
- Regional Materials Office (2)

J. Smith-Lab

RECYCLED ASPHALT MATERIALS
This design for 4" thickness.

*Milling Contains Type 5 Class A coarse aggregate which is in excess of 1" size.

DRYER DRUM PLANT

Signed [signature]

MIX NO. 30%	PER CENT	APPARENT Specific Gravity	COMPONENTS - - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	28.9	N/A	Recycle Material
Bin No. 3 #67	21.1		Fanwood Crushed Stone-Watchung, NJ
Bin No. 2 #89	24.0		" "
Bin No. 1 Sand	20.7		Clayton Sand-Lakewood, NJ *
Filler	1.5		Reclaimed Fines
Asph. Content	3.8		West Bank Oil 109 pen.

Maximum Theoretical Specific Gravity: 2.595

Approximate Cold Feed Proportions:

MIX NO. 40%	PER CENT	APPARENT Specific Gravity	COMPONENTS - - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	38.7	N/A	Recycle Material
Bin No. 3 #67	18.4		Fanwood Crushed Stone-Watchung, NJ
Bin No. 2 #89	22.2		" "
Bin No. 1 Sand	16.9		Clayton Sand-Lakewood, NJ *
Filler	0.5		Reclaimed Fines
Asph. Content	3.3		West Bank Oil 109 pen.

Maximum Theoretical Specific Gravity: 2.595

Approximate Cold Feed Proportions

MIX NO. 50%	PER CENT	APPARENT Specific Gravity	COMPONENTS - PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4 Recycle	48.6	N/A	RECYCLE Material
Bin No. 3 #67	16.5		Fanwood Crushed Stone - Watchung, NJ
Bin No. 2 #89	19.9		" " "
Bin No. 1 Sand	12.1		Clayton Sand-Lakewood, NJ *
Filler			
Asph. Content	2.9		West Bank Oil 109 pen.

Maximum Theoretical Specific Gravity: 2.595

Approximate Cold Feed Proportions :

MIX NO.	PER CENT	APPARENT Specific Gravity	COMPONENTS PRODUCER AND LOCATION
Bin No. 5			
Bin No. 4			
Bin No. 3			
Bin No. 2			
Bin No. 1			
Filler			
Asph. Content			

REMARKS: -

* Supplier has the option to use screenings with sand to maintain control of mixture should they desire (as per J. Smith-NJDOT).

RECYCLE ASPHALT - 4" Thickness

DRYER DRUM PLANT

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BUR. OF QUALITY CONTROL
3 1981
N.J. DEPT. OF TRANSPORTATION

Form AD-40 5/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO Don Sessa

FROM Joe Smith

SUBJECT Rt. 78, Sec. 3K & 4T
Soil Cement Recommendations

DATE 06-08-81 TELEPHONE NO. 2-3471

Cement Content = 5% Type

Avg Max Density = 137 #/Ft^3

Avg Optimum Mosture = 7.5%

Density Control:

Method = AASHTO T-99 Method C

95% of Avg Max Density = 130.2 #/Ft^3

The maximum density, compressive strength and the optimum moisture content all vary depending upon the gradation of the 5A subbase material. Unfortunately, the 5A subbase material is also variable.

To assist you in your field control work, I have provided the following information:

1. 5A Gradations.
2. Graph of Compressive Strengths.
3. Density Curve - No Cement.
4. Density Curve - With Cement.
5. Rate of Application.

Joseph R Smith

cc O. Abbott
F. Stia
K. Afferton

SOIL CEMENT SUMMARY OF RESULTS

Form LB-9 2 75

NEW JERSEY DEPARTMENT OF TRANSPORTATION
Trenton, New Jersey

REPORT OF ANALYSIS OF AGGREGATE

-30-

SERIAL NO. 282462 282463 Contractor's Sam.

(1)

CHARGED TO: Rte 78 Sec 3K + 4T

PROPOSED USE

KIND OF MATERIAL Existing 5A SIZE Shoulder TYPE Material CLASS

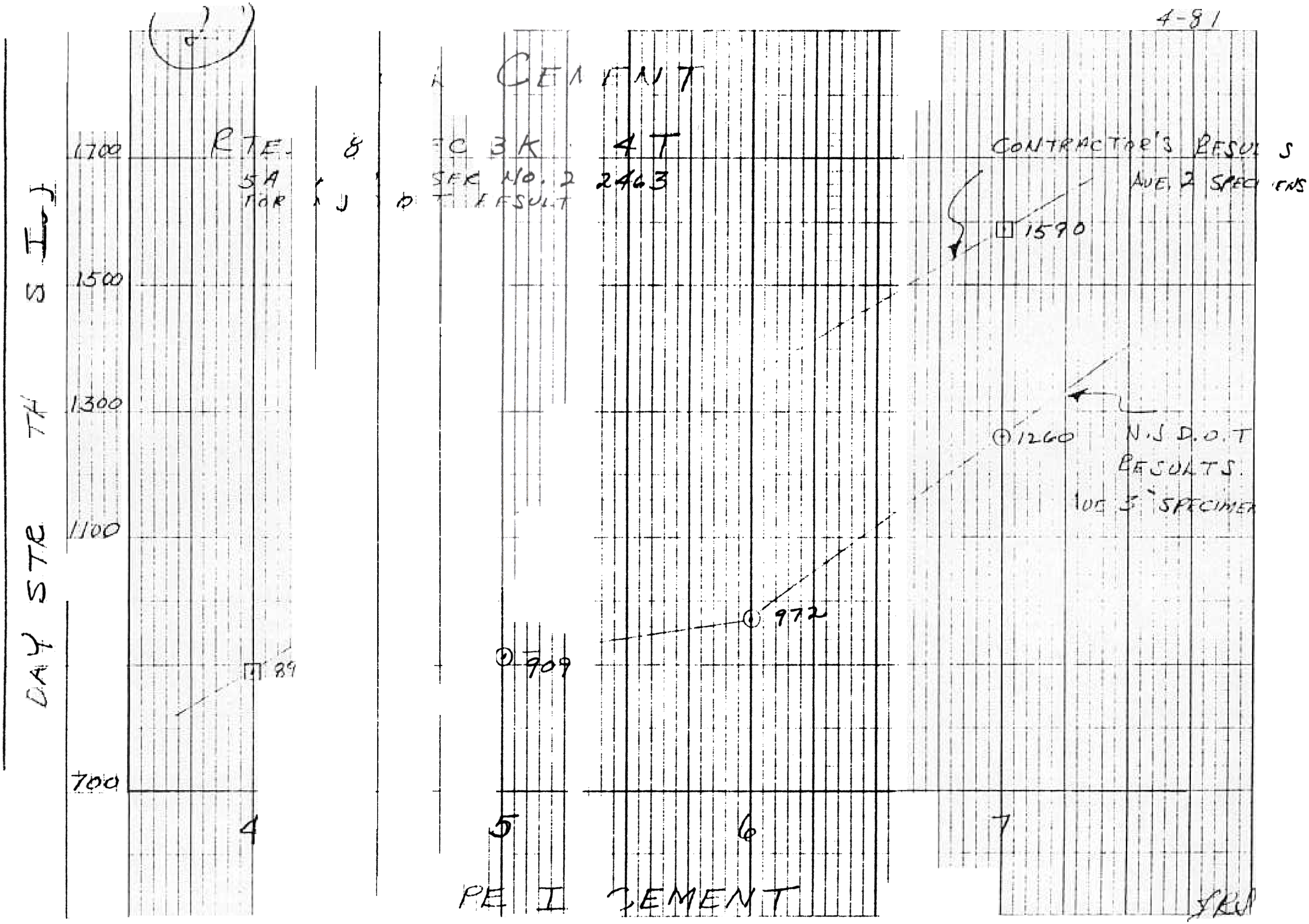
PRODUCER LOCATION

PLANT LOCATION

SAMPLE TAKEN FROM					REPORTED TO
QUANTITY REPRESENTED					
MARKS ON SAMPLE					
SAMPLED BY	Hallrigel	Sessa	Contractor		
DATE TAKEN					
DATE REC'D. AT LAB.					
SEAL NO.					
	282462	282463	Contractor Sample		

	TOTAL PERCENT PASSING			REQUIRED Min. (Original for Specs.)		Present I-5 (5A) Specs.	
4"							
3½							
		100					
	90 96	99	100	100		100	
¾"	66	65	70	55	90	70	100
	53	33	44	25	60	30	80
	25.2	17	19	15	30		
	25.7	12	7			10	35
	14.1	4.6	3.8	5	12	5	12
REFLECTANCE							
LIQUID LIMIT							
		N.P.					

REMARKS:


CEM NT
RTE. 8 C 3A 4T
5A SEC NO. 2 2463
FOR T RESULT
CONTRACTOR'S RESUL S
AVE. 2 SPECI ENS
1590
N.J. D.O.T
RESULTS.
AVE 3 SPECIMEN
1260
972
909
89
1700
1500
1300
1100
700
4
5
6
7
DAY STE TH S I J
PE I CEMENT

SOIL CEMENT SUMMARY OF RESULTS

(3)

New Jersey Department of Transportation

LABORATORY SOIL ANALYSIS

Form LB-200 (ol 6 72

MOISTURE – DENSITY RELATIONSHIP

Serial No. ______ Date Tested 1981 Producer ______

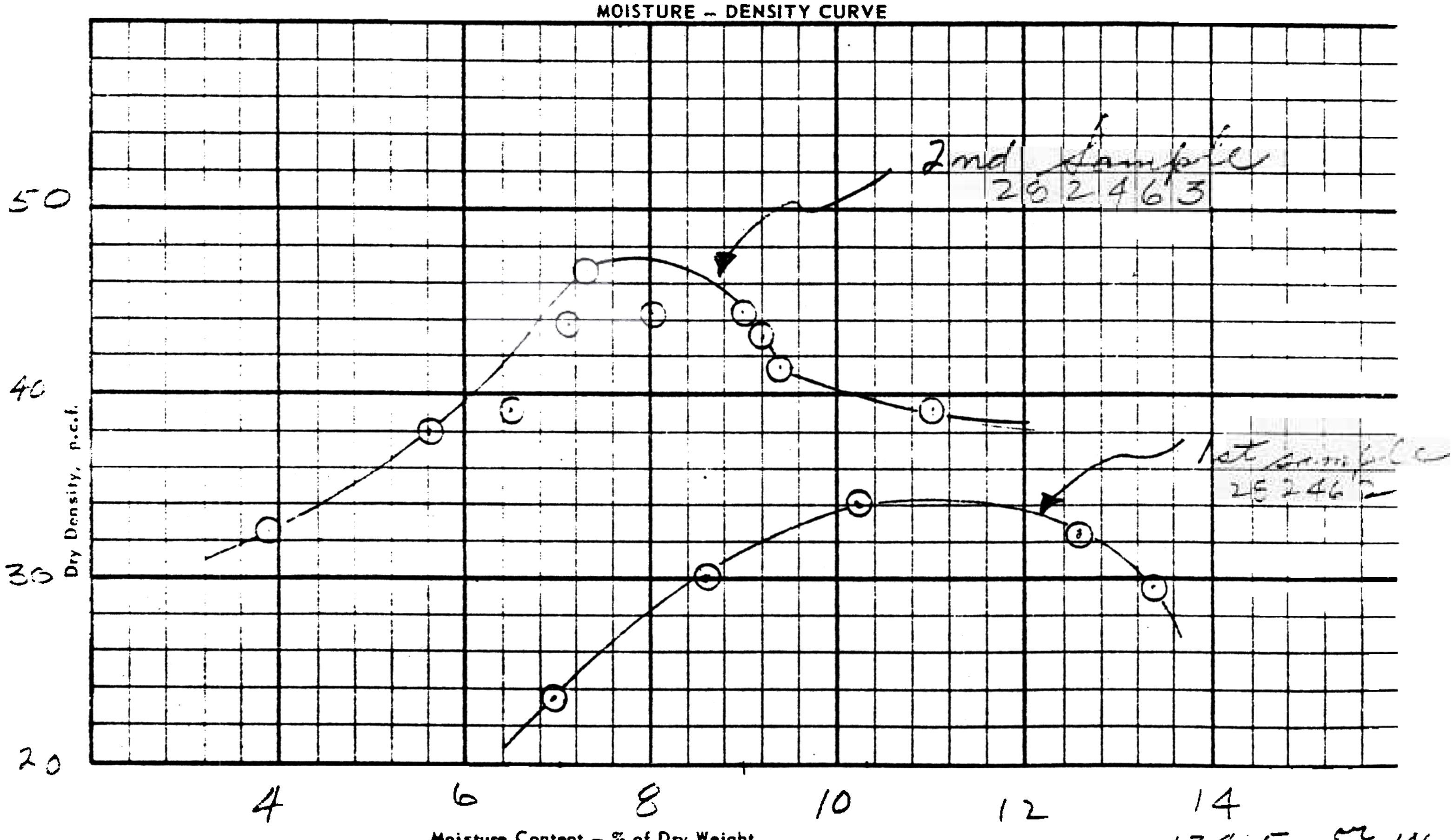
Route 78 Sec 3K+4T I-78-01-2(3)32 – 3"+#4= ______

Section Existing 5A Station Shoulder Material – #4= ______

AASHO or ASTM Designation T-99 Method C

REST RESULTS										
Trial No.		1	2	3	4	5	6	7	8	9
Water Added	%									
Weight of Cyl. & Soil	gms.									
Weight of cyl.	gms.									
Dry Density Curves – NO CEMENT ADDED										
Can Number										
Weight Wet Soil & Can	gms.									
Weight Dry Soil & Can	gms.									
Weight Loss	gms.									
Weight of Can	gms.									
Dry Density	p.c.f.									

MOISTURE – DENSITY CURVE



Max. Dry Density 134.5 p.c.f. or 146.5

Optimum Moisture 11.0 % or 7.5

SOIL CEMENT SUMMARY OF RESULTS

New Jersey Department of Transportation

(4)

LABORATORY SOIL ANALYSIS

Form LB-200 (5) 6 72

MOISTURE – DENSITY RELATIONSHIP

Serial No. ______ Date Tested 1981 Producer ______

Route 78 Sec 3K + 4T I-78-C1-0(3)32 – ¾" + #4= ______

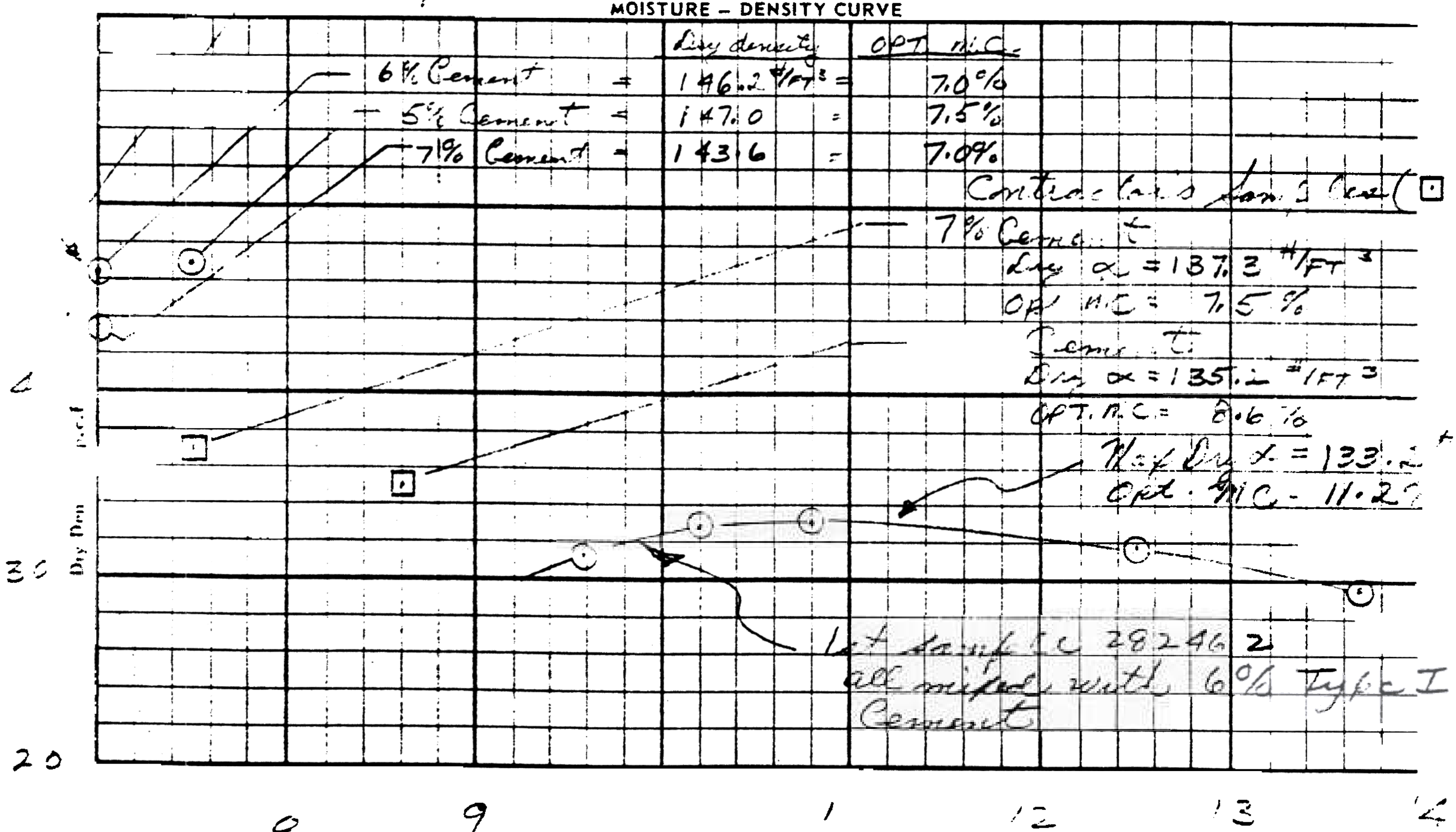
Section Existing 5A Shoulder Material – #4= ______

AASHO or ASTM Designation T-99 Method C

Trial No.		1	2	3	4	5	6	7	8	9
Water Added	%									
Weight of Cyl. & Soil	gms.									
Weight of cyl.	gms.									
Weight of Soil										
Wet Density	p.c.f.									
Dry Density Information – VARIOUS AMOUNTS OF TYPE I CEMENT										
Can Number										
Weight Wet Soil & Can	gms.									
Weight Dry Soil & Can	gms.									
Weight Loss	gms.									
Weight of Can	gms.									
Weight of Dry Soil	gms.									

2nd sample 282663

MOISTURE – DENSITY CURVE



Moisture Content – % of Dry Weight

Max. Dry Density ____

Optimum Moisture ____

Soil Cement (5A + 5% Type I Cement)

5. Rt. 79 / 3K + 4T

Application Rate

1 SY @ 6" Thick = $4.5\ FT^3$

(5A)
$137\ \#/FT^3 \times 4.5\ FT^3 = 616\ \#/SY$ (5A)

5% Cement

$616\ \#/SY \times .05$ 31# Cement/SY

Cement

94 #/ft [illegible]

$\frac{31\#}{94\#} = 0.33\ FT^3$

$SY = 3' \times 3 \times T$ [illegible] $= .33\ FT^3$

Thickness Cement $= \frac{.33\ FT^3}{9\ FT^2}$

$0.037\ FT$

Thickness Cement $= 0.037\ FT \times \frac{12}{FT}$

Thickness Cement = **0.44 inches**

Form AD-40 5/77

NEW JERSEY DEPARTMENT OF TRANSPORTATION

MEMORANDUM

TO MEMORANDUM OF RECORD

FROM Nicholas P. Vitillo

Senior Engineer,
Transportation Research

SUBJECT Lime-Fly Ash and Soil-Cement Stabilization

DATE 8-21-81

TELEPHONE NO.

Part A - Preliminary Laboratory Investigation

The preliminary laboratory investigation was concerned with determining the mix design for both types of stabilization. The proportions were based on the moisture-density relationship and the unconfined compressive strengths of the mixtures

The Fernwood laboratory developed the mix design using AASHTO T99, Method C with replacement for compaction of the moisture-density tests (ASTM D698). The percentages of ime-fly ash aggregate and water which produced the greatest density were chosen as the mix design proportions. The same procedure was used for the soil-cement mix design.

The unconfined compressive strengths of these specified mix designs were verified by compacting these materials into cylinder form, curing them at specific temperature and for various times, and then soaking the cylinders and braking them according to ASTM D1633, Part 4, and ASTM C593, Section 8.

Part B - Field and Subsequent Investigation

The field and subsequent investigation included preparing unconfined compression test cylinders from field mixed material recording field densities and moisture content and sampling field mixed or plant mixed material for cement or ime content determination respectively.

The lime-fly ash compression test cylinders were made using the ASTM D698 procedure, cured at a humid 100^{o}F for 7, 14 and 28 days and broken. The plant mixed material was cured 7, 28 and 45 days. The average strengths developed are listed below and llustrated in Figure In addition, vacuum saturation tests were run (ASTM C593, Part 9) at the same cure period.

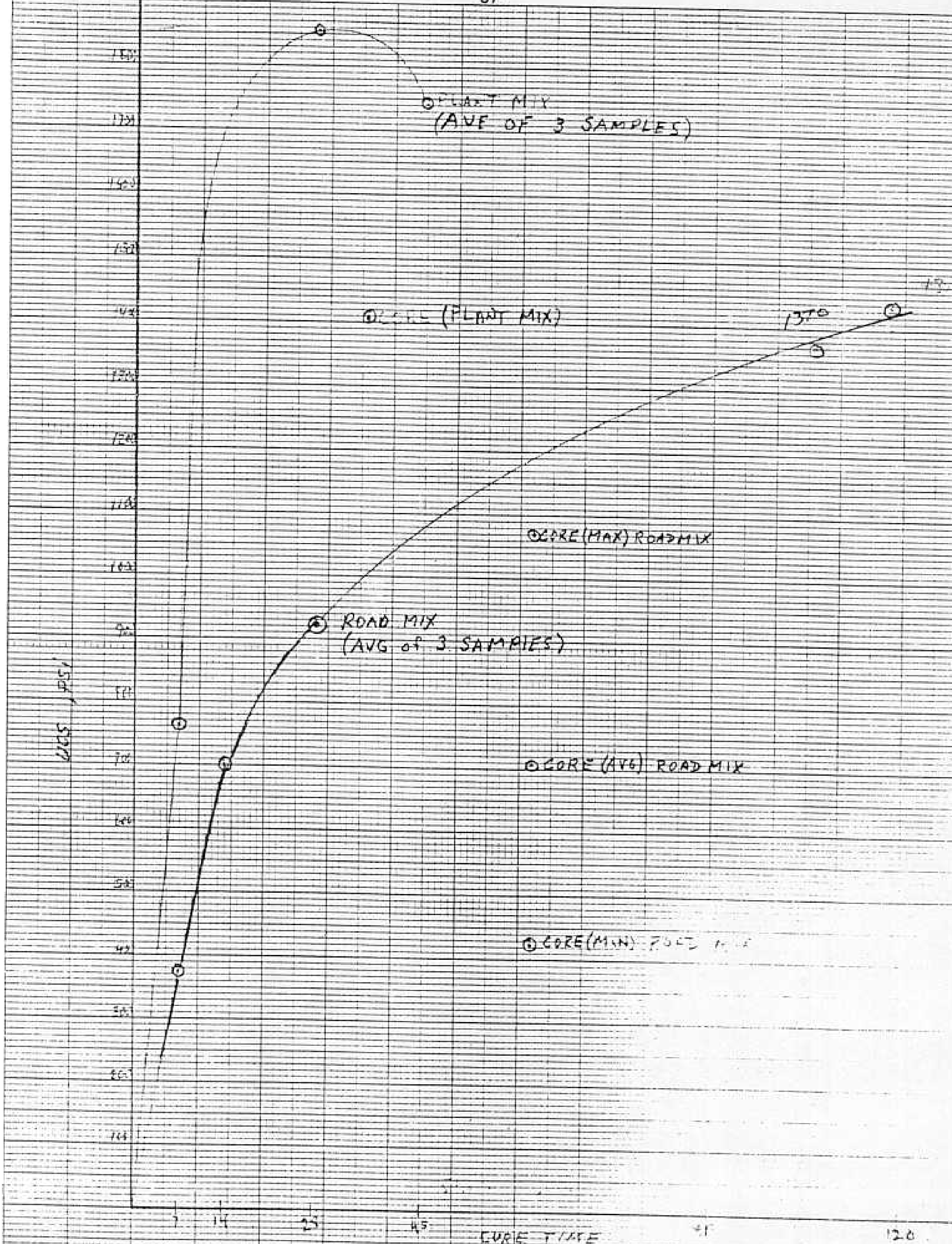
Unconfined Compressive Strength, psi

	Road Mix	Vacuum Saturation	Plant Mix
7 day	375	395	763
14 day	700	746	
28 day	923	842	1850
45 day			1743
105 day	1370		
120 day	1435		

The soil-cement compression test cylinders were made using the ASTM D698 procedure, cured for 7, 28 and 45 days, and broken. The average strengths developed are listed below and illustrated in Figure 2.

Unconfined Compressive Strength, psi

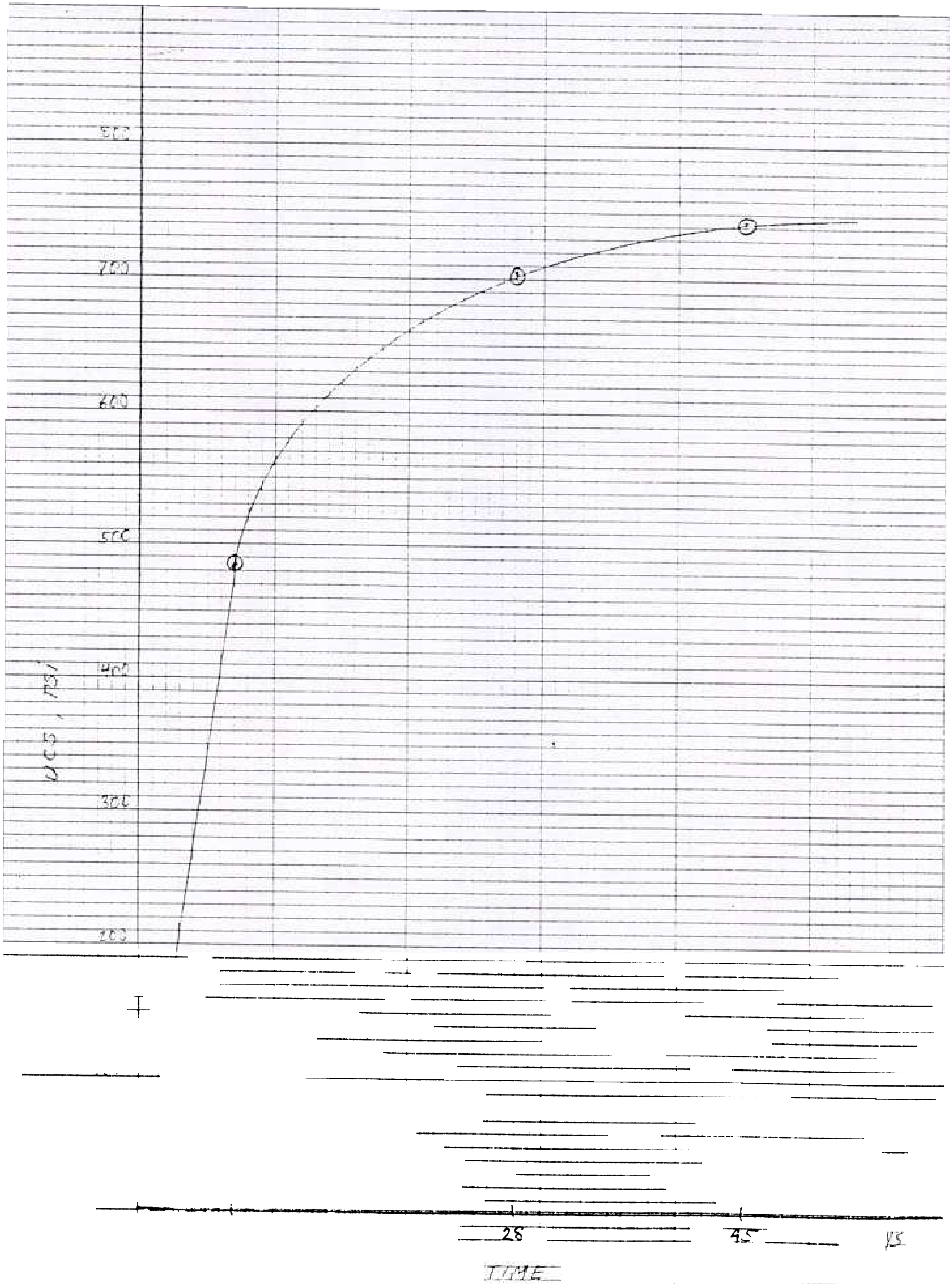
	Road Mix
7 day	485.7
28 day	700.3
45 day	744



LIME-FLY ASH

46

K&E X 10 TO 1/2 INCH 7/6 10 KEUFFEL & ESSER CO. MADE IN U.S.



SOIL-CEMENT

In addition, Freeze-Thaw test (ASTM D560) and Wet-Dry test (ASTM D559) were run on soil-cement cylinders. The average weight loss for the Freeze-Thaw test and Wet-Dry test was 7.17% and 5.5% respectively were 10% if allowable

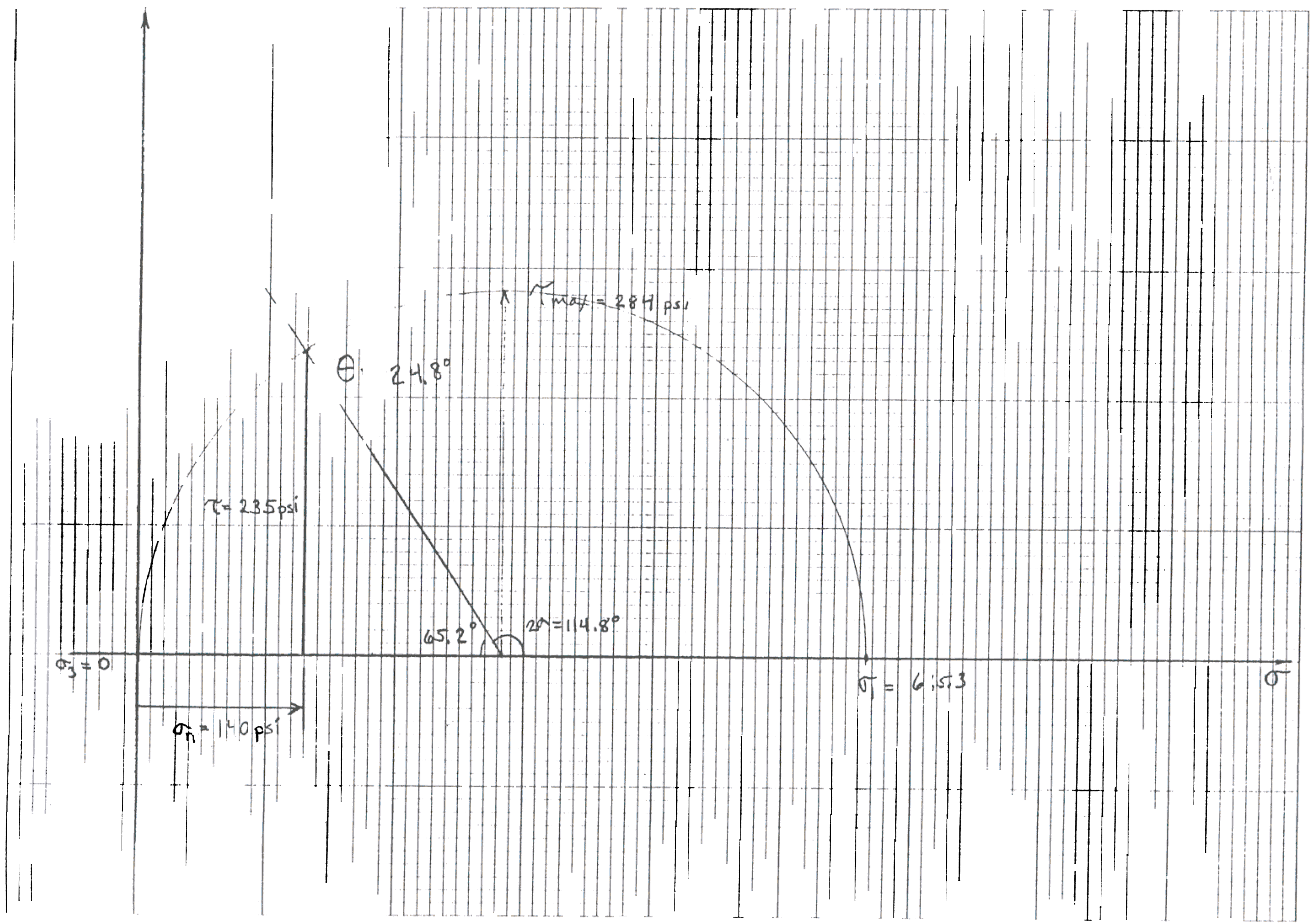
The field densities of the mixtures were estimated by using a surface nuclear gauge in the 2" direct transmission mode. The lime-fly ash had an average dry density of 123.35 pcf at a moisture content of 12%. The soil-cement had a density of 120 pcf at 16. (% moisture).

Samples of the mixed materia was brought to the Fernwood lab for titration analysis (ASTM D806 Soil-Cement and ASTM 3155 Lime-Fly Ash) to determine the cement content of the soil-cement mixture and to determine the lime content of the lime-fly ash mixtures (road and plant mixed).

Confusion in communication at the lab caused neither of these tests to be performed. The cement or lime content of the mixture therefore was not determined. The lab did run a chemical analysis of the component parts of the mixture, as well as, a chemical analysis of the mixture but the results are too varied to be conclusive.

Cores were taken by removing an 8" core from the bituminous layer and taking a 4" core from the lime-fly ash layer. The core taken from the plant mixed material had a strength of 1406.9 psi after 36 days of curing in the field. The cores taken from the road-mix materia had an average of 709 psi after 62 days of curing in the field

The longest core had a length to diameter ratio of almost 2. The rupture angle was recorded along with the unconfined compressive strength and the Mohr circle in Figure 3 was developed.



$\tau_{max} = 284$ psi
θ: 24.8°
$\tau = 235$ psi
65.2°
$2\theta = 114.8°$
$\sigma_3 = 0$
$\sigma_1 = 6{,}153$
σ
$\sigma_n = 140$ psi

APPENDIX D

Aggregate Gradations

	Top Course		Slurry Seal	Soil Aggregate
	I-4	I-6	Type II	I-3
1"	100			(4") 100
3/4	95-100			60-100
1/2	75-95			
3/8	65-85	100	100	
No. 4	35-65	80-100	85-100	30-70
No. 8	25-50	65-100	65-90	
No. 16	18-40	40-80	45-75	
No. 30	12-30	20-65	30-55	
No. 50	10-23	7-40	18-35	5-35
No. 100		5-20	10-21	
No. 200	4-10	4-16	5-15	0-5
AC	4.5-9.5			

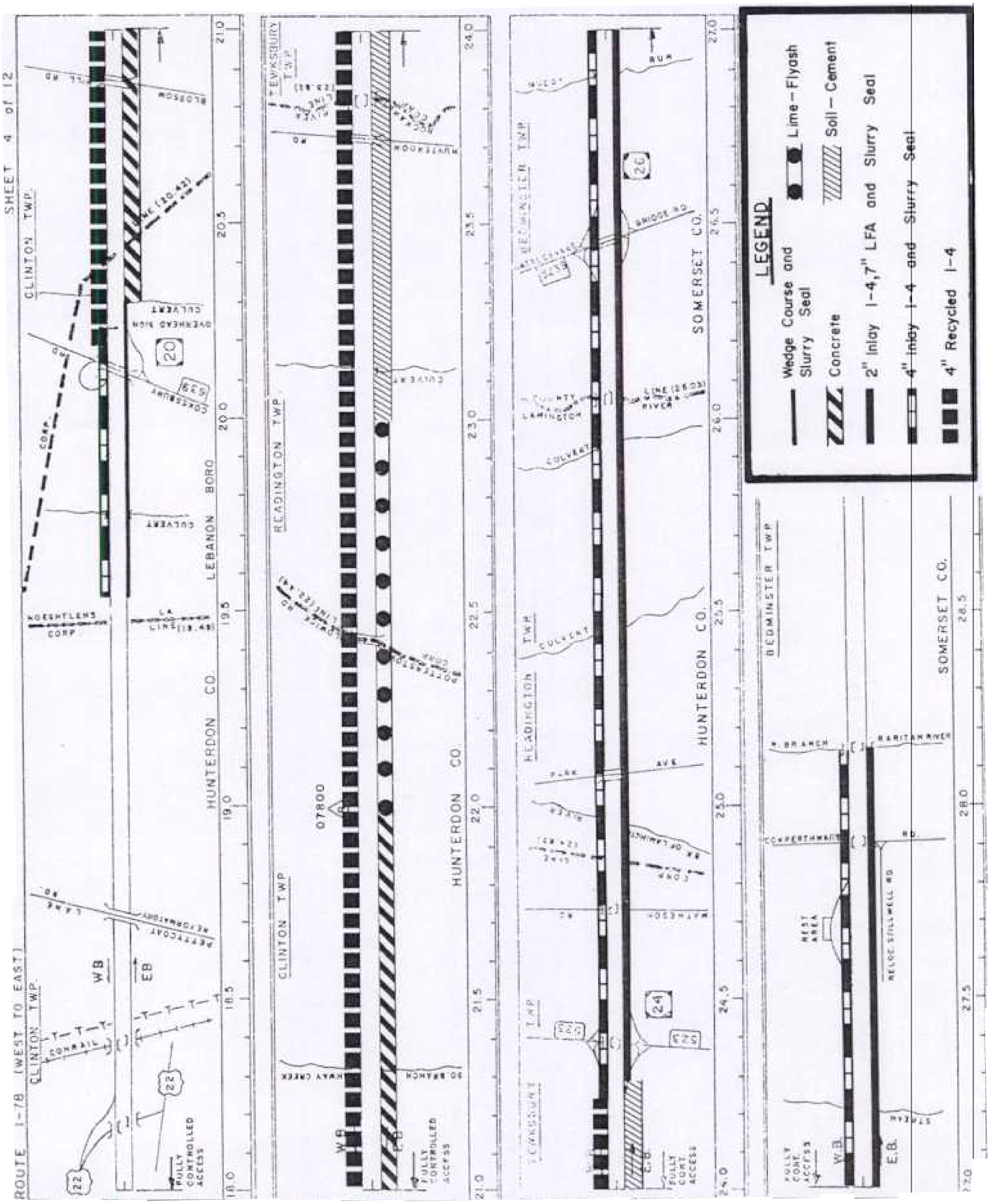
Slurry Specifications

Emulsion	Cationic CCS-1H	12% to 21%
Aggregate	Washed Traprock	Min. 10 lbs./yd.
Mineral Filler	Portland Cement	1%
Water		As per design formula

Lime-Fly Ash Specification

1. Soil Aggregate 87.0% ± 3%
2. Hydrated Lime 3.5% ± 1%
3. Fly Ash 12.0% ± 2%
4. The amount of water used in the mix shall be within 2% at the time of final mixing. During excessive hot weather or long travelling distances, an excess may be requested by the engineer.

APPENDIX E


ROUTE I-78 (WEST TO EAST)
SHEET 4 of 12
LEGEND
Wedge Course and Slurry Seal
Concrete
2" Inlay I-4,7" LFA and Slurry Seal
4" Inlay I-4 and Slurry Seal
4" Recycled I-4
Lime-Flyash
Soil-Cement
HUNTERDON CO.
SOMERSET CO.
CLINTON TWP.
LEBANON BORO
READINGTON TWP.
TEWKSBURY TWP.
BEDMINSTER TWP.
WB
EB
FULLY CONTROLLED ACCESS