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Whitetopping an Existing Asphalt Pavement with Polyolefin Fiber Enriched PCC

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Curt Dunn, John Wolf,

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UGPTI ☐
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*see supplementary notes

North Dakota DOT
Materials and Research Division
300 Airport Road
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North Dakota DOT
Materials and Research Division
300 Airport Road
Bismarck ND 58504-6005

14. Supplementary Notes

15. Abstract

Purpose and Need

Rehabilitation techniques and methods are being considered by highway agencies as our roadway system ages. One technique is whitetopping. This technique involves the application of a thin lift of portland cement concrete (PCC) over an existing asphalt roadway.

The use of PCC as an overlay material may have some advantages such as control of reflective cracking and rutting. PCC, however, is brittle in nature and has a tendency to crack in tension. Plastic shrinkage cracks can form before the concrete hardens as well as the formation of stress cracks after hardening.

The whitetopping concept is based on the belief that when the PCC is bonded to the underlying asphalt the two layers behave as one composite layer. The bonding of the two pavement layers into one composite layer should force the neutral axis in the PCC slab downward. This will tend to cause the PCC to act more in compression and reduce the tensile stresses placed on the PCC.

To improve PCC properties the addition of reinforcing fibers are sometimes added to attempt to create a more ductile failure mechanism, to increase toughness, and to prevent the formation of large cracks.

Objective

The objective of this study is to determine if a thin lift of PCC, reinforced with polyolefin fibers, can serve as an alternative to a conventional bituminous overlay of existing asphalt pavement.

Scope

Items that will be monitored and evaluated on the whitetopping experimental section will include: What are the distresses in the pavement, what is the overall pavement condition, have the fibers affected the ride of the PCC section, do the fibers show an ability to control reflective cracking, comparison of performance of the fiber reinforced PCC section to adjacent bituminous overlay sections. The evaluation period for this study will be approximately five years with evaluations annually.

The project is located on the crossroad at the Steele interchange on Interstate 94 which is near reference point 193.

Summary

The cracks in the polyolefin fiber concrete mix have increased drastically in severity since the last review. It appears some maintenance may be required in the three 25' sections to prevent any further breakups and improve the overall ride. It was apparent to the review team that in general, as the joint spacing increases, the performance of the concrete decreases. Joint spaces of less than 15' were performing at a satisfactory level. However, panels with joint spacing of greater than 15' showed several signs of cracking, faulting, and spalling.

There was also a noticeable difference in performance between the NB and SB lane. This is thought to be a result of different lane thickness. The NB lane with a 4.5" section of PCC seems to be performing much better in all panels less than 25' in length. Other than the three 25' panels, the NB lane has experienced almost no distresses while the SB lane has experienced cracking, faulting, and moderate spalling.

The subgrade modulus also seemed to have an impact on how the roadway was performing. It seemed that most of the distresses found before construction were concentrated in the same location as the 25' panels. Upon collecting FWD data it was discovered that this area had some of the lowest soil moduli in the entire test section. The field team believes that subgrade problems should be repaired prior to constructing a whitetopping project

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NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION

Experimental Study ND 97-01

Whitetopping an Existing Asphalt Pavement with Polyolefin Fiber Enriched PCC

Second Evaluation Report

Project IM-1-094(040)193

August 2001

Prepared by

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION
BISMARCK, NORTH DAKOTA
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U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT	EXPERIMENTAL PROJECT NO. STATE: ND; YEAR: 97; NUMBER: 01; SURF: 1	CONSTRUCTION PROJ NO IM-1-094(040)193 8	LOCATION Steele 2 Counties
	EVALUATION FUNDING 1 X HP&R; 2 CONSTRUCTION; 3 DEMONSTRATION; 4 IMPLEMENTATION 48	NEEP NO. 49	PROPRIETARY FEATURE? X Yes; No 51
SHORT TITLE	TITLE 52: Whitetopping an Existing Asphalt Pavement with Polyolefin Fiber Enriched PCC		
THIS FORM	DATE 140: MO. 0 8 - YR. 2 0 0 1	REPORTING 1: 1 INITIAL; 2 X ANNUAL; 3 FINAL	

KEY WORDS		
	KEY WORD 1	KEY WORD 2
	KEY WORD 3	KEY WORD 4
	UNIQUE WORD	PROPRIETARY FEATURE NAME

CHRONOLOGY	Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
	01-97	05-97	05-02		
	277	281	285	289	293

QUANTITY AND COST	QUANTITY OF UNITS	UNITS	UNIT COST (*Dollars, Cents*)
	4000 297	1 LIN. FT 2 **X** SY 3 SY-IN 4 CY 5 TON 6 LBS 7 EACH 8 LUMP SUM 305	38,720.00 306

AVAILABLE EVALUATION REPORTS			
	X CONSTRUCTION 315	X PERFORMANCE	FINAL

EVALUATION	CONSTRUCTION PROBLEMS	PERFORMANCE
	1 NONE 2 SLIGHT 3 X MODERATE 4 SIGNIFICANT	1 EXCELLENT 2 GOOD 3 SATISFACTORY 4 x MARGINAL

APPLICATION			
	1 ADOPTED AS PRIMARY STD. 2 PERMITTED ALTERNATIVE	4 x PENDING 5 REJECTED	*(Explain in remarks if 3, 4, 5, or 6 is checked)*

REMARKS

321

The polyolefin fiber concrete is experiencing cracking, faulting at the joints and spalling at the joints. Block cracking has occurred in a larger panel section where the transverse and longitudinal joints intersect. The general consensus of the research team was the whitetopping test section is performing marginally. 700

Experimental Study ND 97-01

Whitetopping an Existing Asphalt Pavement with Polyolefin Fiber Enriched PCC

SECOND EVALUATION REPORT

Project IM-1-094(040)193

August 2001

Written by

Curt Dunn/John Wolf

Disclaimer

TABLE OF CONTENTS

Whitetopping an Existing Asphalt Pavement with Polyolefin Fiber Enriched PCC

ND 97-01

Objective

Rehabilitation techniques and methods are being considered by highway agencies as our roadway system ages. One technique is whitetopping. This technique involves the application of a thin lift of portland cement concrete (PCC) over an existing asphalt roadway.

The use of PCC as an overlay material may have some advantages such as control of reflective cracking and rutting. PCC, however, is brittle in nature and has a tendency to crack in tension. Plastic shrinkage cracks can form before the concrete hardens as well as the formation of stress cracks after hardening.

The whitetopping concept is based on the belief that when the PCC is bonded to the underlying asphalt the two layers behave as one composite layer. The bonding of the two pavement layers into one composite layer should force the neutral axis in the PCC slab downward. This will tend to cause the PCC to act more in compression and reduce the tensile stresses placed on the PCC.

To improve PCC properties the addition of reinforcing fibers are sometimes added to attempt to create a more ductile failure mechanism, to increase toughness, and to prevent the formation of large cracks.

The 3M corporation has created a new fiber material which it calls the Polyolefin Fiber System. The Polyolefin Fiber System is comprised of 2" polyolefin macrofiber bundles as shown in photo 1 on the following page. 3M believes polyolefin fibers are unique in that, even with high volumes added, they are easily dispersed into the PCC mix and also offer non-corrosive properties.

Photo 1. View of the Polyolefin Fiber System

The objective of this study is to determine if a thin lift of PCC, reinforced with polyolefin fibers, can serve as an alternative to a conventional bituminous overlay of existing asphalt pavement.

Scope

The North Dakota Department of Transportation (NDDOT) has constructed an experimental whitetopping project. The project consists of milling existing asphalt material from the roadway and replacing it with a thin lift of polyolefin fiber enriched PCC. The whitetopping section has various joint spacings throughout and is equipped with longitudinal as well as transverse joints.

Items that will be monitored and evaluated on the whitetopping experimental section will include:

- What are the distresses in the pavement.
- What is the overall pavement condition.
- Have the fibers affected the ride of the PCC section.
- Do the fibers show an ability to control reflective cracking.
- Comparison of performance of the fiber reinforced PCC section to adjacent bituminous overlay sections.

The evaluation period for this study will be approximately five years.

LOCATION

The experimental coating system has been incorporated into North Dakota project IM-1-094(017)156. The bridge selected for this system is bridge number 94-160.649L which is the westbound Haycreek separation structure on Interstate 94 located between reference markers 160 and 161 within the city limits of Bismarck, North Dakota as shown in Appendix A. The control structure is bridge number 160.649R which is the eastbound Haycreek separation structure on Interstate 94. Photo 1 is an overview of the bridge location.

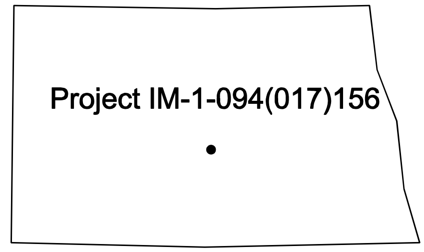


Photo 1: View of the site looking west.

Traffic

Table 2 depicts the two way traffic estimates on the Steele Interchange. No updated traffic information was available for this latest evaluation.

Year	Pass	Trucks	Total	30th MAX HR	ESALs	
					Flex	Rigid
1996	1,410	190	1,600	160	150	250
1998	1,510	190	1,700	170	150	250
2001 (SB)	774	204	978	100	155	245
2001 (NB)	832	173	1,005	105	130	210

Table 2

Design

Experimental test section design

The design of the whitetopping section involved determining the:

1. Proper thickness.
2. Amount of polyolefin fibers to include in the mix.
3. Number of joints to include and the spacings of the joints.
4. Locations for the placement of longitudinal joints if used.
5. Thicknesses at the end of the test section to complement the asphalt roadway adjacent to it.
6. Optimum location that experiences moderate to heavy traffic coupled with turning traffic as well as a range of traffic speeds.

The section of roadway selected for the whitetopping test section was experiencing a combination of transverse and longitudinal cracking with only minor rutting. Core data showed approximately 6-3/4" to 7" of asphalt material was present on the roadway over 5" of aggregate base.

With the known depth of the asphalt material it was possible to mill off 3", add the thickness of the whitetopping, and still retain 3" to 4" of asphalt material for use as a base. This was a significant factor in the design since it is very advantageous to complement the whitetopping with a sound asphalt base whenever possible.

It was determined that a thickness of 3-1/2" of fiber enriched concrete would replace approximately 3" of milled asphalt material for the whitetopping test section. It was also determined that, based on the manufacture's recommendations, the two-inch 3M Polyolefin fibers would be blended with the PCC at a rate of 25 lbs per cubic yard (approximately 2.0% by volume).

Early in the design stage the spacing of the joints ranged from 15' to 30'. A range of 6' to 25' was later agreed upon. Materials and Research hopes to gather, from the various joint spacings, some insight as to what length joints can be successfully placed on a thin lift whitetopping project.

It was decided that the transverse and longitudinal joints be sawed to a depth of 1/4 the thickness of the fiber reinforced concrete slab + 1/4" and not be sealed. Therefore, the sawed joints will be approximately 1-1/8" deep, 1/8" wide.

The proposed length of the whitetopping test section will be 255' which includes an additional 15' wedged shaped section at the north end of the test section. This thickened edge section is designed to carry additional stresses transferred between the interface of the PCC and bituminous pavement lying adjacent and to the north of the test section. Experimental sections done in other states have experienced distresses in the first slab adjacent to the asphalt pavement. This transition section, as shown in Figure 1, will increase to a thickness of approximately 5-1/2" at the interface.

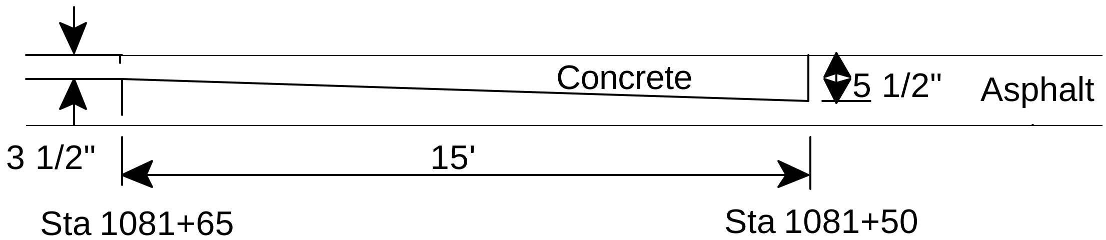


Figure 1

Laboratory Testing

In addition to the design of the experimental section mentioned above, Materials and Research conducted several tests in the laboratory to determine if the addition of Polyolefin Fibers would alter the properties and work ability of PCC. It was decided that cylinders and beams would be tested for compression and flexural strength respectively. Other tests such as slump and air tests would also be performed on both mixes.

Materials and Research also conducted moisture and specific gravity tests of the course and fine aggregate. The results are shown in Appendix B. All of the laboratory tests were conducted in the central laboratory located at the Materials and Research Division of The North Dakota Department of Transportation (NDDOT).

After the various tests on the aggregate were conducted, the results were entered into a mix design computer program. The initial lab mix design called for approximately 5.5 gallons of water per sack of cement, however, during the initial trials the slump was too high and the air content was too low. After several trials it was determined that approximately 4.5 gallons of water per sack of cement would be used to achieve the proper mix design. Air entrainment was also added to the mix.

The proportions for one cubic yard of concrete is shown in table 3. The actual lab mix design used for all of the tests is shown in Appendix C.

PROPORTIONS FOR CUBIC YARD OF CONCRETE		
Material	Unit Of Measurement	Quantity Of Unit
Cement	Lbs	677
Sand	Lbs	1,191
Rock	Lbs	1,751
Water	Liter	111.8
Air Entrainment	Liter	0.27

Table 3

The Polyolefin fibers were blended with the PCC at a rate of 25 lbs per cubic yard. It was also determined beforehand that the fibers would be introduced into the PCC after it was allowed to mix for three minutes and sit for an additional two minutes. The fibers would then be allowed to revolve with the PCC until they appear to be dispersed through the mix.

Laboratory Results

The results of the beam and cylinders breaks for both the control mix and the fiber reinforced mix is shown below in the tables 4 and 5 respectively. The results are shown in pounds per square inch (psi). Since two cylinders were tested on each occasion only an average of the two will be shown here. The PCC cylinder records for both the cylinders and beams are included in Appendix D.

RESULTS OF THE FLEXURAL STRENGTHS OVER VARIOUS AGES				
Type of Beam	1 Day	3 Day	7 Day	28 Day
Plain PCC (psi)	285	483	561	723
Fiber-reinforced PCC (psi)	405	526	578	699

Table 4.

RESULTS OF THE COMPRESSION STRENGTHS OVER VARIOUS AGES				
Type of Cylinder	1 Day	3 Day	7 Day	28 Day
Plain PCC (psi)	2534	3965	4853	6491
Fiber-reinforced PCC (psi)	2550	3689	4702	5988

Table 5

During the course of batching and casting beams and cylinders, it became evident that the addition of fibers into plain PCC had altered its workability. The fiber-reinforced PCC tended to become stiffer, sometimes awkward, and required more energy to handle. The fibers made it a little more difficult to finish the PCC. The slump was perhaps the most significant change in the behavior of the PCC. With the addition of fibers into the PCC the slump registered consistently lower than the slump of the plain PCC mix. The slump averaged about 2.8 inches less during the course of the batching phase.

Adding fibers required at least two more minutes of mixing in order for the fibers to become dispersed within the PCC mix.

When it became time to break the cylinders and beams, the strengths (compression or flexural) were within close proximity to each other.

Materials and Research also conducted air tests on both types of PCC. The percentage of air in the control mix was 3.5% as opposed to 4.1% in the fiber enriched mix. This was consistent with previous research which indicated that the difference in air percentage between plain PCC and PCC enriched with polyolefin fibers is not significant.

The 25 pounds of polyolefin fibers added to one cubic yard of concrete did not affect the strength of the PCC, however, the fibers appeared to hold the cracks together. This became especially true as the PCC aged.

Construction

In the following pages a condensed version of the construction stage of the project will be presented. On May 15, 1997, Materials and Research visited the project site where the whitetopping test section was to be placed.

Photo 2 depicts an overview of the existing roadway before construction began. A survey was conducted during this visit to determine how many distresses were present, including any longitudinal and transverse cracking. The stationing of each distress was also recorded. This information may be useful in determining if the PCC overlay will control reflective cracking.

Photo 2. An overview of the existing roadway, prior to milling, where the whitetopping section is now located (looking south).

Ernie's Concrete Construction was the sub-contractor for the installation of the whitetopping test section. The project engineer was Doug Fercho. Acting engineer for the first half of the project in Doug's absence was Bernard Southam. The engineer submitted a copy of the mix design. A copy is located in Appendix E.

On June 3, 1997, Materials and Research arrived on the site about 8:30 a.m. The contractor had completed the milling process in the North Bound (NB) lane and was in the process of placing the first load of fiber PCC. It was determined that the fibers would be introduced into the batch after all of the components required to produce PCC were added. The fibers were then allowed to disperse into the batch while the PCC was in the revolution stage. It was also determined that at least one point, during the revolution stage, the mixer would reverse motion to allow any fiber bundles stuck on the fins to dislodge and become dispersed. The contractor used a movable screed similar to one normally used for bridge decks to finish the fiber rich PCC.

Photo 3 shows the consistency of the fiber PCC as it is discharged from the mixing truck.

Photo 3. A view of the polyolefin fiber PCC as it is discharged from the mixing truck.

Photo 4. Shows the use of pitchforks to spread the fiber reinforced concrete.

Photo 4 the shows the contractor's use of pitchforks to move and place the fiber rich PCC because of the decreased workability of the material. Photo 5 depicts a view of the joints being cut by the Soft-Cut procedure. This procedure is a slightly different procedure than that of the traditional saw cutting.

Photo 5. A view of the joints being sawed by the soft-cut procedure

One advantage of the soft cut is the ability to start cutting several hours sooner. Time is a critical factor in this type of sawing operation.

All of the joints, longitudinal and transverse, were sawed approximately 1-1/8" deep and 1/8" wide and were not sealed. After construction was finished in the NB lane, traffic was opened within three days. During the next few days the contractor prepared the South Bound (SB) lane for construction and began pouring fiber PCC on June 18, 1997. During the sawing of joints on the SB lane, the joints appeared to have less spalling. The contractor began sawing the SB lane side approximately six hours after the initial PCC was placed.

Overall the actual construction of the Whitetopping section went moderately well. Early in the construction of the NB lane, the contractor suffered a break down with one of the caster wheels on the mechanical screeder.

During the June 18, 1997 visit, Materials and Research was able to evaluate the NB lane. The fiber PCC in the NB lane had been done approximately two weeks prior to the pouring of the SB lane. Most of the joints had relieved except for some of the shorter ones. There were no visible cracks emerging in the slab except for one corner crack.

During the course of construction there were some deviations from the original design of the Whitetopping section. One of the alterations was the joint spacings. Table 6 shows the arrangement of the joint spacings after construction. The numbers are rounded off to the nearest foot for the sake of simplicity. The section was measured to be approximately 230' in length. The total length includes the two 15' thickened edge sections on each end.

³ North

25'	25'	25'	15'	15'	15'	20'	10'	20'	10'	10'	15'	6'	7'	6'	6'

Table 6

Another deviation was the placing of two previously mentioned thickened edge sections rather than one which the plans called for. The extra thickened edge section was constructed adjacent to the crossroad structure on the south side of the project. This condition may influence cracking in addition to the joints present.

Still another deviation from the original design was the slab thicknesses. As was previously mentioned during the milling operation the contractor ran out of asphalt on the outer edge of part of the NB lane. As a result previously milled material was put back in place. However, not enough was replaced prior to the placing of the fiber PCC. A decision was made in the field to pour the fiber PCC at a lessened slope of 0.011'/1', instead of a slope of 0.021'/1' as originally called for in the plans. This was done to achieve a thicker slab of PCC to make up for the lost asphalt near the edge.

The original plan called for an overall slab thickness of 3-1/2". Not knowing exactly what the depth of the PCC slab was in both lanes, Materials and Research conducted coring operations in several areas of the whitetopping section. Cores were taken in areas that would not be influenced by the two thickened edge sections located on both ends.

In the SB lane the average recorded depth of fiber PCC is approximately 3.5" with approximately 4.0" of remaining asphalt underneath. In the NB lane the average recorded depth of fiber concrete is approximately 4.5" with approximately 2.5" of remaining asphalt underneath.

Unfortunately, with more than one depth of fiber PCC recorded it will make it more difficult to evaluate because of the added variability. To make sound judgements on whether 3.5" of fiber PCC is acceptable or not as a whitetopping option requires that the test section placed be in close proximately to the actual design. Since the SB lane was constructed more to the original design and intent of the study it will obviously be the lane more closely watched. The NB lane may be evaluated on the merits that it possesses 4.5" of fiber PCC, however, the asphalt base is approximately 1.5" thinner than the SB lane and may have an effect on its performance.

A copy of the NDDOT Plans and Specifications are provided in Appendix F.

Evaluation

On August 8, 2001 a three member NDDOT research team traveled to the whitetopping site at the Steele interchange to conduct the third evaluation of the fiber reinforce PCC overlay. The team consisted of Mike Marquart, Bryon Fuchs, and John Wolf all from Materials and Research. The following pages will describe the findings of this evaluation.

During earlier evaluations of this project several distresses were detected. It was determined that most of these distresses occurred in the 25' panels, particularly along the first two joints from the North end. Distresses consisted of multiple cracks emanating outward with the highest concentration of secondary cracks near the intersection of the longitudinal and transverse joints.

Photo 6. View of North side of project

Cracks similar to map cracking have broken the PCC into several 1 to 2 square foot blocks. Photo 7 shows an example of this type of cracking. These breakups were experiencing severe spalling and some PCC had become dislodged despite the efforts of the polyolefin fibers to hold it in place. It appeared that several weathering cycles and heavy traffic had broken the bonds between the fibers and PCC at this joint.

Photo 7. Map cracking occurring at the first joint on the north side of the project.

Since the last evaluation in 1998 the distresses have moved progressively outward and increased in severity. Photo 8 shows a picture of the first joint in the 25' panels in 1998.

Photo 8. Shows the 1st joint on the north side of the project in 1998.

Photo 9 shows that same joint in 2001. This joint located between the first two 25' panels seemed to be performing very poorly.

The second joint from the North side of the project also was experiencing some transverse and secondary cracking along the joint. Like the first joint, our most recent field review showed that most of the cracks have increased in their level of severity. The number of cracks had also increased, and spalling along cracks and joints has occurred.

Photo 9. Shows the same joint as in photo 8, but in 2001.

Photos 10 and 11 show this joint in 1998 and 2001 respectively.

It appeared that in general, the South side of the test section was performing much better than the North side. This may be a result of the smaller joint spaces and a generally stronger subgrade found on the south side of the project. FWD data gathered in 2000 and 2001 also shows that the subgrade strength below the 25' panels was slightly lower than the rest of the test section.

Photo 10. Shows the 2nd joint on the north side of the project in 1998.

Photo 11. A view of the second joint in 2001.

The FWD also appeared to show a decrease of nearly 1400 psi in the soil modulus beneath the entire test section from 2000 to 2001. The average modulus changed from 7000 psi in 2000 to 5600 psi in 2001. This weakening subgrade seems to be having some effect on the performance of the PCC overlay. The SB lane had a particularly low soil modulus in the first 40 feet of the test section. This was were some of the more severe cracks were occurring. The FWD data from 2000 and 2001 can be found in Appendix G.

Previous evaluations also discovered longitudinal settlement at midpanel of the South Bound lane. This led the field team to believe that the previously mentioned distresses were caused, in part, as a result of a weak subgrade.

Several other joints in the SB lane have also experienced faulting ranging from 1/8" to 1/2". The joints in the NB lane did not show any signs of faulting. Photo number 12 shows faulting that has occurred at one of the SB lane joints.

Photo 12. Faulting that has occurred in the SB lane

Knowing that the NB and SB lanes were each constructed to different specifications, the field team attempted to draw a conclusion about the performance of each design. The SB lane was constructed using an overlay of 3.5" PCC on 4" of existing asphalt. The NB lane however was constructed using a 4.5" PCC overlay and only 2.5" of asphalt. Excluding the first two 25' panels, the NB lane is performing very well when compared to the SB lane. The NB lane experienced only a fraction of the transverse and longitudinal cracks that were found in the SB lane, and all cracks in the NB lane were still tightly bonded due to the reinforced fibers.

The polyolefin fibers did seem to be helping to control cracks from widening. Most of the cracks found in the shorter panels were still tight and seemed to be bonded by the fibers. The fibers also helped secure some of the PCC that had broken off of the wider panels, but several pieces had already become dislodged.

The field team also inspected the fibers effect on the widening of the joints. It appears that most of the fibers were broken and no longer tied to the adjoining panels. Some joint spaces, like the one shown in photo 13 have widened to over 3/4".

Photo 13. Fibers have broken after joint widening has occurred

The PCC test section seemed to show very few signs of reflective cracking. The distresses at the first joint on the north side of the project and two low severity longitudinal cracks seemed to be the only signs of reflective cracking coinciding with distress cracks found in the asphalt prior to construction.

The field review team also performed a brief inspection of the asphalt control section adjacent to the PCC test site. The asphalt appeared to be performing much better than the fiber reinforced PCC section. Other than two transverse cracks that had formed, the section seemed to be performing very well.

During the evaluation, the team also evaluated the ride of both the fiber reinforced PCC and the asphalt control section. The cracking and faulting in the SB lane of the PCC test section did have a noticeable affect on the ride. The NB lane did ride somewhat smoother, but neither lane performed as well as the asphalt control section.

Summary

The cracks in the polyolefin fiber concrete mix have increased drastically in severity since the last review. It appears some maintenance may be required in the three 25' sections to prevent any further breakups and improve the overall ride. It was apparent to the review team that in general, as the joint spacing increases, the performance of the concrete decreases. Joint spaces of less than 15' were performing at a satisfactory level. However, panels with joint spacing of greater than 15' showed several signs of cracking, faulting, and spalling.

There was also a noticeable difference in performance between the NB and SB lane. This is thought to be a result of different lane thicknesses. The NB lane with a 4.5" section of PCC seems to be performing much better in all panels less than 25' in length. Other than the three 25' panels, the NB lane has experienced almost no distresses while the SB lane has experienced cracking, faulting, and moderate spalling.

The subgrade modulus also seemed to have an impact on how the roadway was performing. It seemed that most of the distresses found before construction were concentrated in the same location as the 25' panels. Upon collecting FWD data it was discovered that this area had some of the lowest soil moduli in the entire test section. The field team believes that subgrade problems should be repaired prior to constructing a whitetopping project.

Appendix A

ASH GROVE CEMENT COMPANY

WESTERN REGION
100 MT. HWY. 518
CLANCY, MT 59634-9701
PHONE (406) 442-8855
FAX: (406) 442-9262

CERTIFIED MILL ANALYSIS NO. 11-96-15

Silo: 11
Type: I-II, low alkali

ASTM C-150-95
AASHTO M-85 93

Chemical Composition (%)

SiO2	21.8
Al2O3	4.4
Fe2O3	2.6
CaO	63.7
MgO	3.2
SO3	2.6
Loss on Ignition	1.3
Insoluble Residue	0.36
Total Alkalies (as Na2O)	0.35

Potential Compound Composition (%)

C3S	53
C2S	23
C3A	6.9
C4AF	9

Physical Test Results

Blaine Fineness, m2/kg	392
Normal Consistency, %	24.8
Setting Times, minutes	
Vicat Initial	163
Final	294
False Set, %	76
Autoclave Expansion, %	0.036
Air Entrainment, %	8.0
Compressive Strengths, MPa (psi)	
1-Day	10.8 (1570)
3-Day	20.3 (2940)
7-Day	29.3 (4250)

The cement represented here is certified to comply with the above noted specifications.

Date: January 16, 1997

Chief Chemist

Dakota Ready Mix

Mechanical Analysis C136 Fine Concrete Aggregate

Sample Description Source Fisher St 6

Sample ID 040397-01 Operator GLD

Material Retained on:	A Wt Retained gms	B % of Total Sample A/(sample wt)	C Acumulative % Retained B + C	D Accumulative % Passing 100-C	Specifications ASTM	Specifications NDDOT
3/8"			~~100~~ 0	100	100	100
#4	1.9	.3	.3	99.7	95-100	95-100
#8	76.1	12.5	12.8	87.2	80-100	
#16	[illegible]	[illegible]		64.0	50-85	45-80
#30	275.5	45.2	58.0	42	25-60	
#50	161.0	26.4	84.4	15.6	10-30	10-30
#100	85.8	14.1	98.5	1.5	2-10	0-10
#200	7.9	1.3	99.8	.2	0-3	0-3

A-2

Dry Sample Weight 610.1

*Make sure sample is dry. Record dry weight.
Wash, then decant water over #200 Sieve.
Dry, let cool, and shake material over nested sieves.
Record individual weights retained.

514.1 .7 .1 .07% Shale

.2
80
93.7
7.9
85.8

Dakota Ready Mix

Mechanical Analysis: (C136) Course Concrete Aggregate

Sample Description/Source Riverdale - Fisher

Sample ID Z2497-1 **Operator** ______

Material Retained on:	A Wt Retained lbs/gms	B % of Total Sample A/(sample wt)	C Acumulative % Retained B + C	D Accumulative % Passing 100-C	Specifications
2"					
11/2"					100
1"	0		0	100	95-100
3/4"	658.4	15.1	15.1	85	
1/2"	2212.4	50.9	66.0	34	25-65
3/8"	949.2	21.8	87.8	12	15-55
#4	445.1	10.2	98.0	2	0-10
#8				1.5	0-5

Dry Sample Weight 4346.2

Dry Sample Weight ***After wash*** 4310.1

Wt Loss ______

%-200 .8
(Loss/Dry Sample Wt.)

Make sure sample is dry. Record dry weight.
Wash, then decant water over #200 Sieve.
Dry, let cool, and shake material over nested sieves.
Record individual weights retained.

1525.9 11.2 .7

A-3

CONCRETE, SAND, AND GRAVEL WORKSHEET

Department of Transportation, Materials & Research
SFN 2455 (Rev. 4-96)

White topping

Project	County
IM-1-094 040	Kidder
Submitted By	**Date Received**
	6-3-97

GRAVEL

Pit Location	
Owner: Fisher Sand & Gravel	
Sampled From: Stockpile	
Date Sampled: 6-3-97	Field Sample No.: 2
Lab. No.	Size No.: 3

(mm)	Ret.	Wt. Ret. Non-Cum.	Wt. Ret. Cum.	% Ret.	% Pass	ND Spec.
100	4"					
90	3 1/2"					
75	3"					
63	2 1/2"					
50	2"					
37.5	1 1/2"		0	0	100	100
25.0	1"		0	0	100	9500
19.0	3/4"		482	11.8	88.2	[illegible]
16.0	5/8"	1044	~~[illegible]~~			
12.5	1/2"	1852	~~[illegible]~~	45.3	54.7	25-65
9.5	3/8"	2676	~~[illegible]~~	65.5	34.5	25-55
4.75	No. 4	3925	~~[illegible]~~	96.1	3.9	0-10
2.36	No. 8	3937	~~[illegible]~~	96.3	3.7	0-5
Minus No. 8		[illegible]	4087.9			
Wt. Check						
Original Wt.		4086.2				
Fineness Modulus						

AASHTO T-27 Tested By: ______

	Tested By
Soundness % Loss – AASHTO T-104	
Specific Gravity – AASHTO T-85	
% Absorption – AASHTO T-85	
L.A. Abrasion (Grad.) % Loss – AASHTO T-96	
Wt. Rodded Lb./c.f. (Kg/m^3) – AASHTO T-19	
% Moisture AASHTO T-255	

SAND

Pit Location	
Owner: Same	
Sampled From: S.P.	
Date Sampled: 6-3-97	Field Sample No.: 2
Lab. No.	

(mm)	Ret.	Wt. Ret. Non-Cum	Wt. Ret. Cum.	% Ret.	% Pass	ND Spec.
9.5	3/8"		0	0	100	100
4.75	No. 4		0	0	100	95-100
2.36	No. 8		36.1			
2.00	No. 10					
1.18	No. 16		95.7	28.6	71.4	45-80
600um	No. 30		182.0			
425um	No. 40					
300um	No. 50		282.2	84.4	15.6	10-30
150um	No. 100		328.5	98.2	1.8	0-10
75um	No. 200		332.2	99.3	0.[illegible]	0-3
Minus No. 200 (75um)			332.8			
Original Wt.		3345				
Wt. After Wash		332.7				
Wash Loss						
Wt. Check						
Fineness Modulus						

	Tested By
Soundness % Loss – AASHTO T-104	
Specific Gravity – AASHTO T-84	
% Absorption – AASHTO T-84	
Color – AASHTO T-21	
Wt. Loose Lb./c.f.(Kg/m^3) – AASHTO T-19	
% Moisture AASHTO T-255	

*Attention Advised

AASHTO T–11 Tested By: ______
AASHTO T–27 Tested By: ______

☐ District
☐ Central Lab.

6-3-97
Date

Testing Lab Supervisor

Appendix B

6967
202.3

WORKSHEET FOR SPECIFIC GRAVITY OF FINE AGGREGATE

Department of Transportation, Materials & Research
SFN 2199 (Rev. 3-96)

PIT LOCATION: SE1/4 4-145-84	LABORATORY NO.: Research
OWNER: Underwood	PROJECT: Lab Use
SAMPLED FROM:	COUNTY:
SUBMITTED BY: Dean Sharp	RECEIVED: 11-5-96

Weight of oven dry sample.	494.4	grams (A)
Weight of saturated surface dry sample in air.	500.0	grams
Weight of (3) flask and water to calibration mark.	1268.1	grams (B)
Weight of flask, sample, and water to calibration mark.	1578.3	grams (C)

CONCRETE AGGREGATE

Bulk Specific Gravity (saturated surface dry). 2.634

$$\frac{500}{B + 500 - C} = \frac{500}{1268.1 + 500 - 1578.3} = \frac{500.0}{189.8} = 2.6344$$

Bulk Specific Gravity 2.605

$$\frac{A}{B + 500 - C} = \frac{494.4}{1268.1 + 500 - 1578.3} = \frac{494.4}{189.8} =$$

Apparent Specific Gravity 2.654

$$\frac{A}{B + A - C} = \frac{494.4}{1268.1 + 494.4 - 1578.3} = \frac{494.4}{184.2} =$$

Absorption 1.133 %

$$\frac{500 - A}{A} \times 100 = \frac{500 - 494.4}{494.4} \times 100 = \frac{5.6}{494.4} \times 100 =$$

Test T–84 Tested By: ____

4469.3
1106.0

WORKSHEET FOR SPECIFIC GRAVITY OF COARSE AGGREGATE

Department of Transportation, Materials & Research
SFN 10081 (Rev. 3-96)

PIT LOCATION	LABORATORY NO. Clayton
OWNER	PROJECT
SAMPLED FROM	COUNTY
SUBMITTED BY	RECEIVED

Weight of oven dry sample in air.	3363.3	grams (A)
Weight of saturated surface dry sample in air.	3403.2	grams (B)
Weight of saturated sample in water	2113.2	grams (C)

CONCRETE AGGREGATE

Bulk Specific Gravity (saturated surface dry). 2.638

$$\frac{B}{B-C} = \frac{3403.2}{3403.2 - 2113.2} = \frac{3403.2}{1290.0} = 2.6381$$

Bulk Specific Gravity 2.607

$$\frac{A}{B-C} = \frac{3363.3}{3403.2 - 2113.2} = \frac{3363.3}{1290.0} = 2.6072$$

Apparent Specific Gravity 2.690

$$\frac{A}{A-C} = \frac{3363.3}{3363.3 - 2113.2} = \frac{3363.3}{1250.1} = 2.6904$$

Absorption 1.19 %

$$\frac{B-A}{A} \times 100 = \frac{3403.2 - 3363.3}{3363.3} \times 100 = \frac{39.9}{3363.3} \times 100 = 1.1863$$

Test T–85 Tested By: ______

Appendix C

NC 4

CONCRETE MIX DESIGN INPUT SCREEN

SPG-CEMENT 3.15 SPG-SAND 2.63 SPG-ROCK 2.64

SPG-FLYASH 0.00 % SAND 40 % ROCK 60

% CEMENT 100 % FLYASH 0 CEMENT, SACKS 7.2

ABSORPTION, SAND(%) 1.1330 ABSORPTION, ROCK(%) 1.1863

MOISTURE, SAND (%) 3.1566 MOISTURE, ROCK (%) 0.9082

PERCENT AIR 5.5 WATER-GAL/SACK 4.50

BATCH SIZE 1/ 60 CU. YD. SINGLE, DBL, OR TRIPLE BATCH 2

PROPORTIONS FOR SINGLE BATCH
4.50 GAL/SACK

CEMENT, LBS = 11.28

SAND, LBS = 19.85 ROCK, LBS = 29.19

WATER, LBS= 4.11 WATER, ML = 1864

AE 4.5 ml

PROPORTIONS FOR DOUBLE BATCH

CEMENT, LBS = 22.56

SAND, LBS = 39.70 ROCK, LBS = 58.38

WATER, LBS= 8.22 WATER, ML = 3728

Appendix D

Beams

~~CONCRETE CYLINDER~~ RECORD

Department of Transportation, Materials & Research
SFN 10083 (Rev. 12-93)

Fibers

PROJECT NO.	DISTRICT	GRAVEL SOURCE
COUNTY	**CLASS**	**SAND SOURCE**
SUBMITTED BY	**CONTRACTOR**	**YEAR**

FIELD NO.	LAB NO.	kPa	MIX USED	WATER LITER/ SACK	SACKS PER CU M	DATE CAST	DATE TESTED	AGE OF ~~CYL.~~ Beam	PART OF STRUCTURE
	C-B-1	483	4.5 gal 7.2 Sack			4/26	5/1	3	
	FB-1	526.4				4/26	5/1	3	
	CB-2	560.5				4/28	5/5	7	
	FB-2	578.1				4/28	5/5	7	
	CB-3	285				4/29	4/30	1	
	FB-3	404.6				4/29	4/30	1	
	CB-4					4/29	5/27	28	
	FB-4					4/29	5/27	28	

CONCRETE CYLINDER RECORD

Department of Transportation, Materials & Research
SFN 10083 (Rev. 12-93)

Fibers

PROJECT NO.	DISTRICT	GRAVEL SOURCE
COUNTY	CLASS	SAND SOURCE
SUBMITTED BY	CONTRACTOR	YEAR

FIELD NO.	LAB NO.	kPa	MIX USED	WATER LITER/ SACK	SACKS PER CU M	DATE CAST	DATE TESTED	AGE OF CYL.	PART OF STRUCTURE
	CC-1 ✓	112110 3965	4.5 gal 7.2 Sacks			4/28	5/1	3	
	FC-1 ✓	104140 3680				4/28	5/1	3	
	FC-2 ✓	104500 3696				4/28	5/1	3	
	CC-2	136790 4838				4/28	5/5	7	
	CC-3	137640 4865				4/28	5/5	7	
	FC-3	136910 4842				4/28	5/5	7	
	FC-4	128980 4562				4/28	5/5	7	
	CC-4 ✓	75570 2673				4/29	4/30	1	
	CC-5 ✓	67720 2395				4/29	4/30	1	
	FC-5 ✓	71850 2541				4/29	4/30	1	
	FC-6 ✓	72380 2560				4/29	4/30	1	
	CC-6					4/29	5/27	28	
	CC-7					4/29	5/27	28	
	FC-7					4/29	5/27	28	
	FC-8					4/29	5/27	28	

Appendix E

North Dakota Department of Transportation

CONCRETE PROPORTION DESIGN

PROJECT: IM-1-094(040)193 CONTRACTOR: ERNIE'S CONCRETE
TYPE OF WORK: ULTRA THIN WHITETOPPING

DESIGN NO.: 1 DATE: 05/13/97 CLASS OF CONCRETE: HI-ER

TYPE & BRAND OF CEMENT: TYPE I/II

SOURCES: Cement ASHGROVE WEST ; Sand RIVERDALE ; Rock RIVERDALE

SPECIFIC GRAVITIES:
Gc= 3.14 (Cement); Gfa= 0.00 (Flyash); Gs= 2.63 (Sand); Gr= 2.65 (Rock)*
*(Combine if two rock sizes)

PERCENT OF TOTAL AGGREGATE (by weight):
S= 45% Sand; Ra= 55 % Size 3 Rock; Rb= 0 % Size Rock

CALCULATIONS: (for 27 C.F. Batch Size)

	PROPORTIONS		LBS/BATCH		C.F.
CEMENT:	(94lbs/Sack) x (7.1 Sacks/C.Y.) x (27 /27) Adjusted to 0.0 Sacks/C.Y. for Flyash	=	667.40	C=	3.41
FLYASH:	0 % Flyash used		0	FA=	0
WATER:	(4.6 Gal/Sack) x (8.33) x 7.1 Sacks Cement/C.Y. (includes free moisture in aggregates)	=	272.06	W=	4.36
AIR:	6 % (assumed entrained air in mix)		XXXXXX	A=	1.62
Dry Wt., T= 2902.74	Absolute Volume, V, of Total Aggregate			V=	17.61
	Combined Specific Gravity of Total Aggregate			Gsr=	2.64
SAND, Dry Wt.		=	1306.23	S=	7.96
ROCK, Size 3, Dry Wt.		=	1596.51	R=	9.65
ROCK, Size , Dry Wt.		=	0		
	TOTAL WEIGHT PER BATCH	=	3842.20	BATCH SIZE=	27.00

CALCULATED UNIT WEIGHT = 142.30 ____________________

94-154-225

Appendix F

2-23-98

DESIGN DATA				
Traffic	Average Daily			Est. Max. Hr.
Current 1996	Pass: 4720	Trucks 930	Total 5650	610
Forecast 2016	Pass: 8490	Trucks 1680	Total 10170	1095
Minimum Sight Dist. for:		Design Speed 70 MPH		
Stopping 600'		Bridges		
Full Control of Access				
No Point of Access Other Than at Interchange Ramps				

JOB# 17

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	IM-1-094(040)193	1

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

IN KIDDER COUNTY

Federal Aid Project - IM-1-094(040)193

Hot Bituminous Overlay & Incidentals
(Both Roadways)

GOVERNING SPECIFICATIONS:

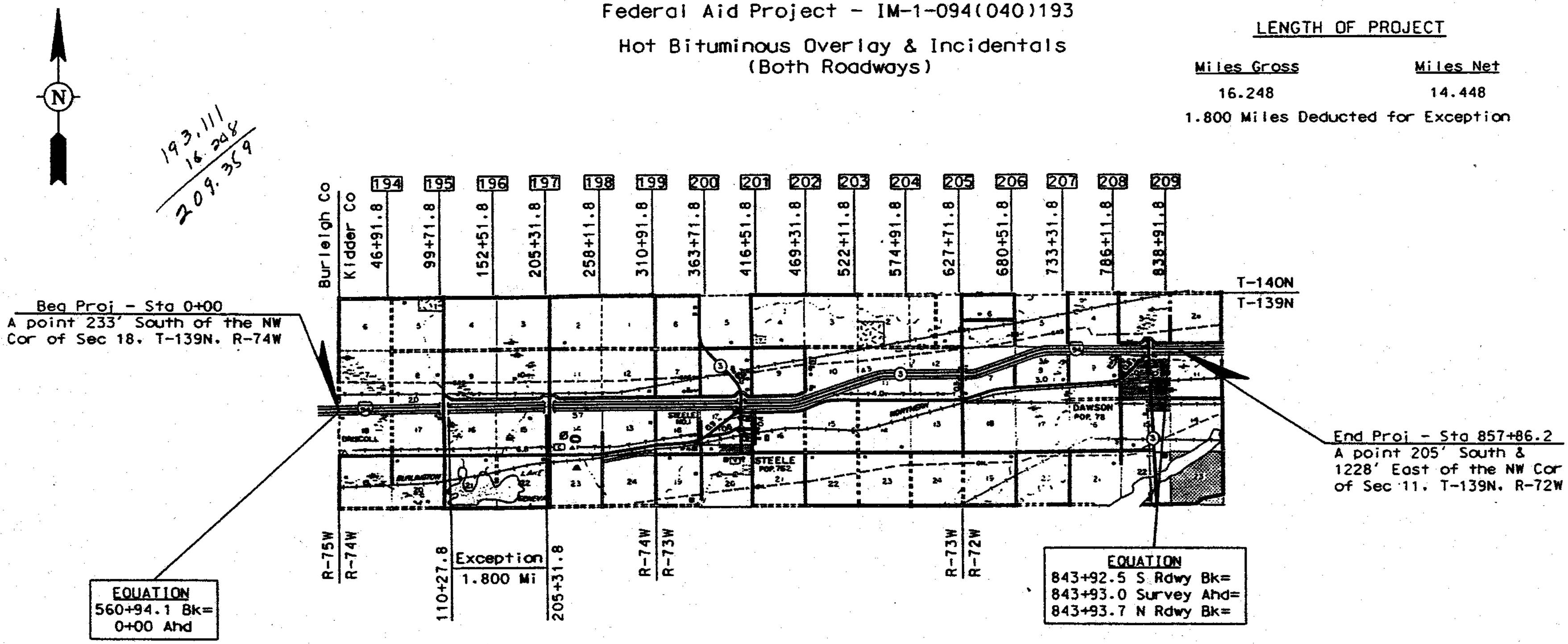
Standard Specifications adopted by the North Dakota Department of Transportation September 1992: Standard Drawings currently in effect: and other Contract Provisions submitted herein.

LENGTH OF PROJECT

Miles Gross	Miles Net
16.248	14.448

1.800 Miles Deducted for Exception

193,111
16.248
209.359



PAVING SECTION *Brian Rosin*
URBAN SECTION
TRAFFIC SECTION *[signature]*
RURAL SECTION
RECOMMEND APPROVAL 1-3, 1997
DESIGN ENGINEER *Kenneth E. [signature]*

titlesht

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ADMINISTRATOR DATE

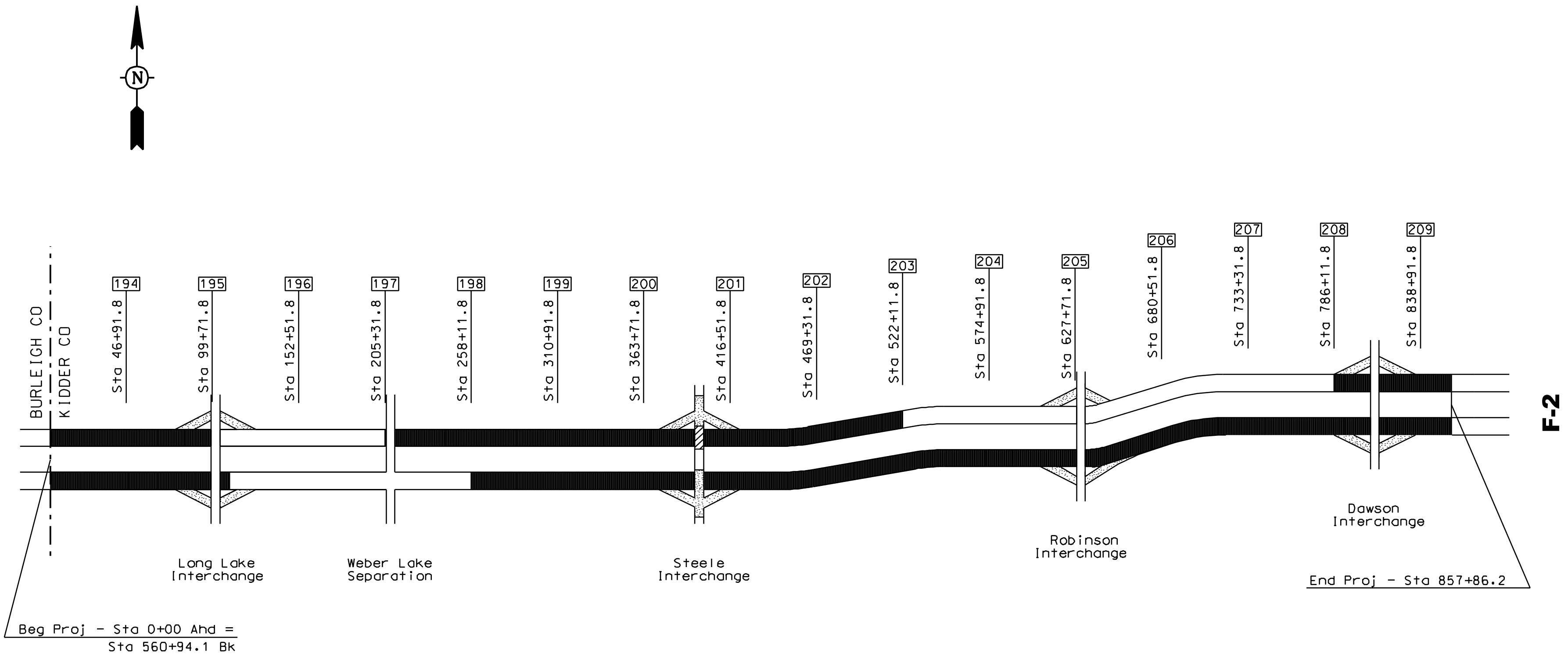
APPROVED DATE 1-3-97

Ray Zink

DIRECTOR OF HIGHWAYS AND ENGINEERING
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

RAY ZINK REGISTERED PROFESSIONAL ENGINEER P.E. 972 NORTH DAKOTA

STATE	PROJECT NO.	SHEET NO.
ND	IM-1-094(040)193	3



LEGEND

- Mainline Hot Bit Pvmt Overlay
- PCC Whitetopping
- Crossroad & Ramp Hot Bit Pvmt

SCOPE OF WORK

COUNTY LINE TO DAWSON

HOT BIT PVMT OVERLAY

SCOPWRK

FHWA REGION	STATE	FED. AID PROJ. NO.	SHEET NO.
8	N.D.	IM-1-094(040)193	7

ESTIMATE OF QUANTITIES

REVISED 02/11/1997

SPEC	CODE	ITEM DESCRIPTION	UNIT	MAINLINE	RAMPS	TOTAL
103	0100	CONTRACT BOND	L SUM	1		1
202	0130	REMOVAL OF CURB & GUTTER	LF	160		160
202	0230	REMOVAL OF INLETS	EA	4		4
203	0198	EMBANKMENT-TYPE B	L SUM	1		1
203	0208	GUARDRAIL EMBANKMENT-TYPE C	EA	22		22
216	0100	WATER	M GAL	572	116	688
401	0100	MC70 OR 250 LIQUID ASPHALT	GAL	67		67
401	0152	SS1H OR CSS1H EMULSIFIED ASPHALT	GAL	53,966	7,747	61,713
408	0170	HOT BITUMINOUS PAVEMENT CL 25	TON	18,674	6,282	24,956
408	0320	120-150 ASPHALT CEMENT	TON	1,102	371	1,473
409	0233	HOT BITUMINOUS PAVEMENT QC/QA CL 33	TON	75,406	3,085	78,491
409	0320	120-150 ASPHALT CEMENT	TON	4,298	176	4,474
409	0900	TESTING	TON	75,406	3,085	78,491
409	0910	CORED SAMPLE	EA	586	16	602
410	0105	MILLING BITUMINOUS PAVEMENT	SY	6,960	14,033	20,993
410	0110	MILLING PCC PAVEMENT	SY	1,067		1,067
550	0500	FIBER REINF CONCRETE PAVEMENT	SY	968		968
550	0648	FULL DEPTH REPAIR-END PREPARATION	EA	14		14
550	0652	CONCRETE PAVEMENT REPAIR-FULL DEPTH-CONTINUOUS	SY	149		149
602	1200	JERSEY BARRIER FORMED OR SLIP FORMED	LF	68		68
702	0100	MOBILIZATION	L SUM	1		1
704	0100	FLAGGING	MHR	350	50	400
704	0104	OBLITERATION OF PAVEMENT MARKING	SF	134		134
704	1000	TRAFFIC CONTROL SIGNS	UNIT	4,082		4,082
704	1010	ONE LANE TRAFFIC CONTROL	L SUM	1		1
704	1050	TYPE I BARRICADE	EA	7		7
704	1052	TYPE III BARRICADE	EA	30		30
704	1060	DELINEATOR DRUMS	EA	30		30
704	1067	TUBULAR MARKERS	EA	654		654
704	1081	VERTICAL PANELS-BACK TO BACK	EA	14		14
704	1087	SEQUENCING ARROW PANEL-TYPE C	EA	2		2
706	0300	FIELD LABORATORY-TYPE C	EA	2		2
754	0117	FLAT SHEET FOR SIGNS-TYPE 3A REFL SHEETING	SF	139		139
754	0210	STEEL GALV POSTS-STANDARD PIPE	LBS	1,412		1,412

ESTIMATE NUMBER: 799 RUN DATE: 02/11/1997 TIME: 13:05:23

C:\design\quanst.dgn Jan. 08, 1997 15:25:26

F-3

202 P01 REMOVAL OF INLETS AND CURB AND GUTTER: The Steele Interchange overhead has 40 lineal feet of curb and gutter and an inlet at each bridge corner.

The contractor shall remove the curb and gutter and the inlets. Each pair of inlets consists of a 4 foot long 30 inch diameter reinforced concrete pipe and a 5 foot long 30 inch diameter reinforced concrete pipe, resting on 6 inch thick concrete bases with inlet castings and grates. Each pair of inlets is connected with a 15 inch corrugated steel pipe and drained by a 15 inch corrugated steel outlet pipe with end section and 75 lineal feet of galvanized metal flume.

The contractor shall remove the 30 inch RCP risers, inlet castings and grates, and the outlet pipe end sections and flumes. The remaining 15 inch corrugated steel pipes shall have their ends capped with concrete and the inlet holes shall be backfilled and compacted. The metal flumes shall be removed and the areas disturbed by removal of end sections and flumes shall be backfilled and seeded. Concrete caps shall have a minimum thickness of 9 inches.

The removed curb and gutter, drain frames and grates, inlet risers, pipe end sections and flumes shall be retained by the contractor and disposed of outside the highway right of way.

The removal of the curb and gutter shall be measured by the lineal foot and paid for at the contract unit price bid for the item "Removal of Curb and Gutter,"

The item "Removal of Inlets" will be measured by the number of inlets removed. The quantity measured will be paid for at the contract unit price and shall be full compensation for all materials, labor and equipment required to remove the inlets as described above.

409 P01 HOT BITUMINOUS PAVEMENT: The Hot Bituminous Pavement Class 33 shall be paver laid in two approximately equal lifts.

410 P01 MILLED MATERIAL: The material milled from the roadway shall be stockpiled at the NDDOT Steele Maintenance Yard at a location determined by the engineer.

550 P01 FULL-WIDTH REPAIRS: Full-depth 24' wide repair areas will be removed and placed in two halves, split at the centerline. The passing lane shall be repaired first.

550 P02 FIBER REINFORCED CONCRETE PAVEMENT: Fibers used in the concrete are 2" 3M Polyolefin Fibers. There will be no substitution for these fibers. The contact person for the polyolefin fibers is:

Cliff McDonald
3M Center, Building 251-3B-13
St Paul, MN 55144-1000
(612) 736-7390
(612) 736-7496 Facsimile

A Manufacturer's representative shall be on site for placement of the Fiber Reinforced Concrete Pavement. The Manufacturer Representative and Materials and Research Division, NDDOT are to be notified one week prior to placement of concrete with fibers. The contact at the Materials and Research Division is Clayton Schumaker. Phone number is(701) 328-6906.

The 3M Polyolefin fibers shall be blended at 25 pounds per cubic yard of concrete. High-Early-Strength Concrete shall be used.

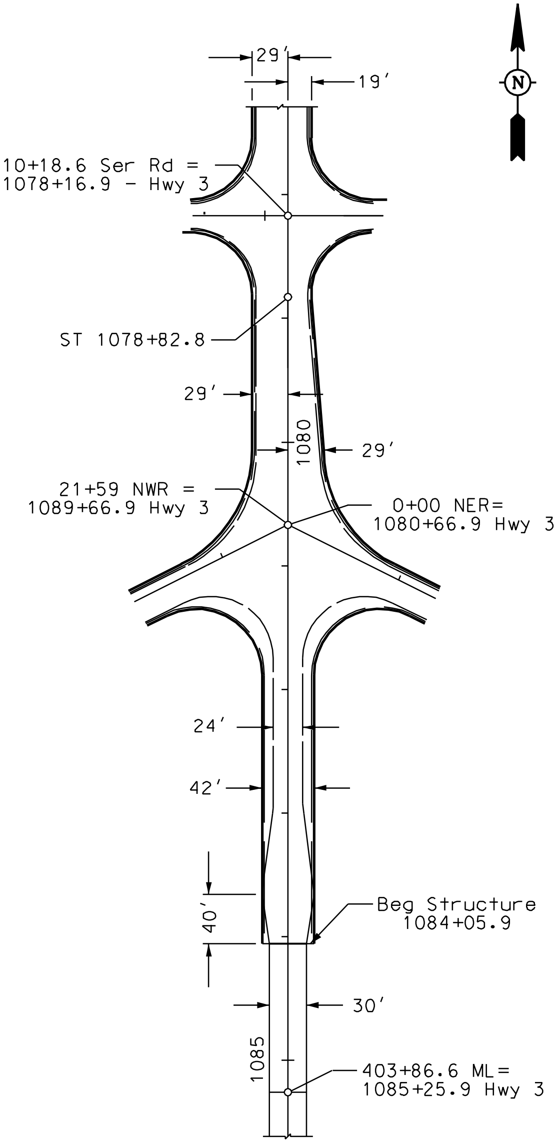
A 12' x 20' (3½" depth) section of fiber reinforced concrete pavement shall be placed at the NDDOT Steele Maintenance Yard at a location determined by the engineer. This section shall be placed a minimum of 24 hours prior to beginning placement on the roadway. No joints will be required in this section. The purpose of placing this section is to familiarize the contractor with placing this material prior to using it on the roadway.

F-4

550 P03 PLACING PORTLAND CEMENT CONCRETE: Placing of concrete in full-depth repairs shall be performed the same day the concrete is removed. If this is not possible, the repair shall be made safely traversable by an errant vehicle.

Placing, consolidating, finishing, and curing of the concrete shall be as provided in Section 550 except as follows: The faces of the old concrete around the section to be replaced shall be wetted with water before the new concrete is placed. The concrete shall be dumped or conveyed into the repair area in such a way that there will be no segregation of the aggregates and cement, and then spread into place, vibrated with a mechanical vibrator, and smoothed. Excessive vibrating shall be avoided. Concrete shall be finished flush with the adjacent pavement surface and shall be straightedged to ensure a smooth riding surface.

STATE	PROJECT NO.	SHEET NO.
ND	IM-1-094(040)193	15



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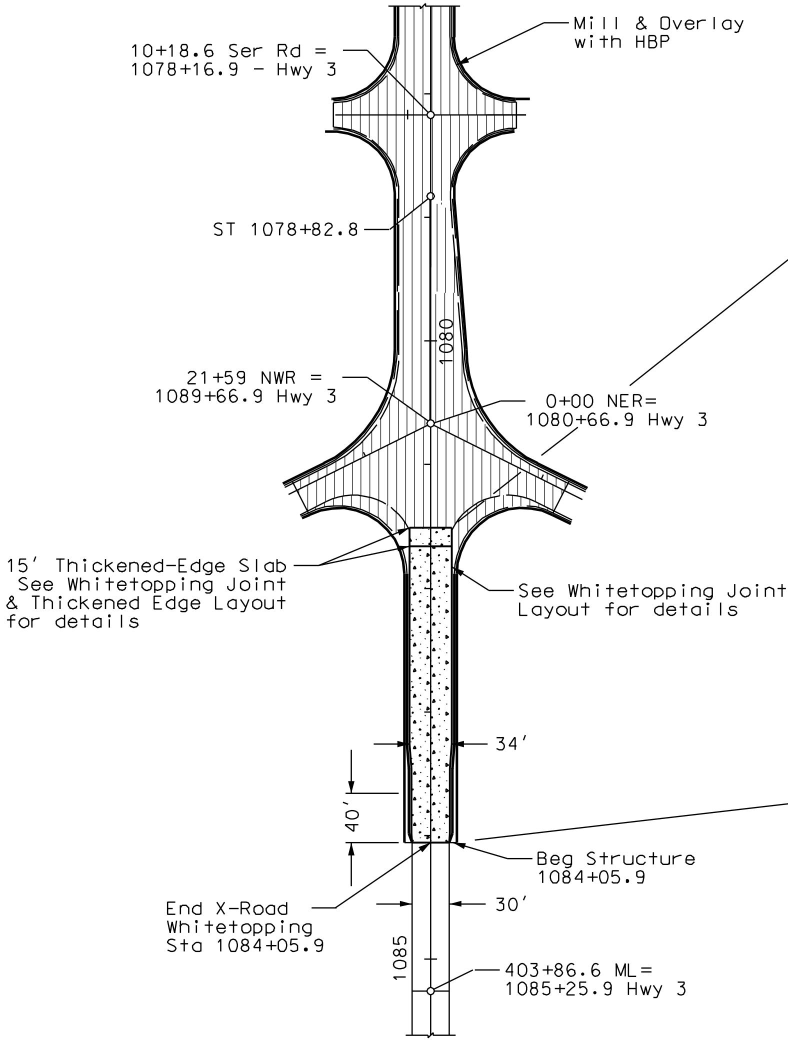

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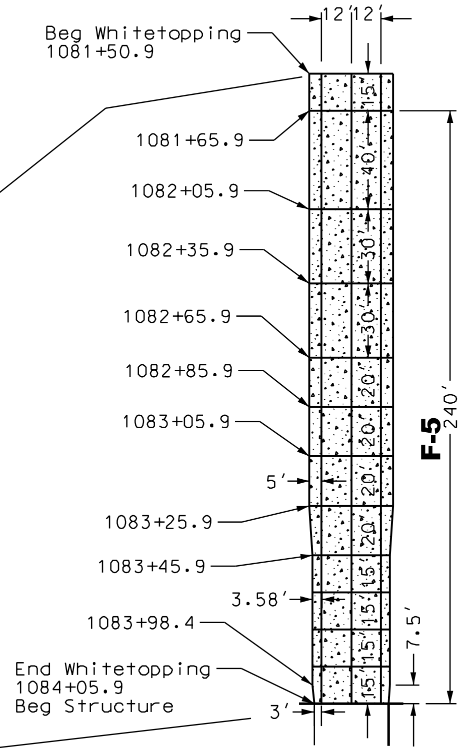


WHITETOPPING JOINT LAYOUT

F-5

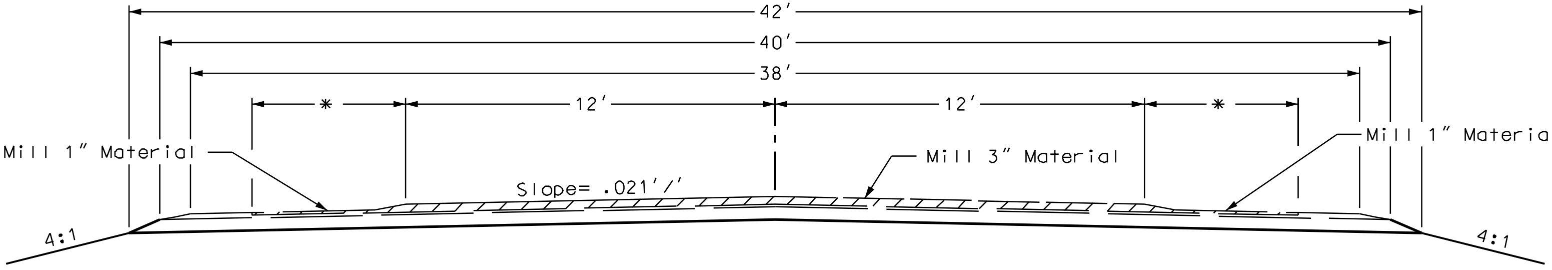
NORTH STEELE CROSSROAD
MILLING AND OVERLAY DETAIL

COUNTY LINE TO EAST OF DAWSON

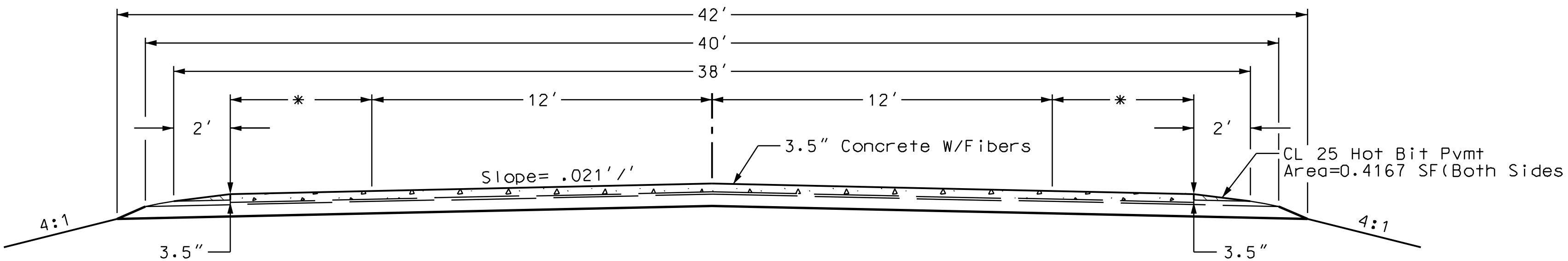
BITUMINOUS PAVEMENT OVERLAY

STLEINTR

STATE	PROJECT NO.	SHEET NO.
ND	IM-1-094(040)193	14



Milling Section



Whitetop Section
Sta 1081+65 to Sta 1084+05.9

F-6

*Width Varies from 3' to 5'.
See Steele Interchange Crossroad
Milling and Surfacing Typical Sheet

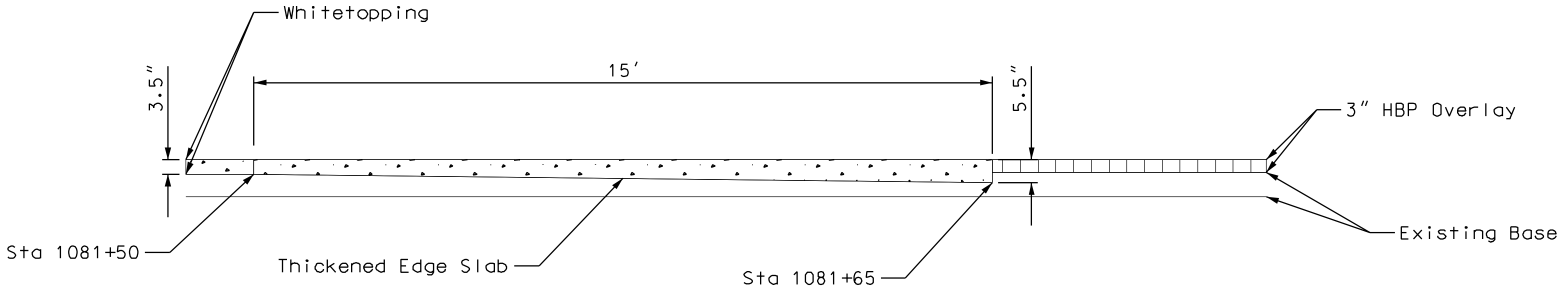
MILLING & WHITETOPPING TYPICAL
STEELE INTERCHANGE CROSSROAD

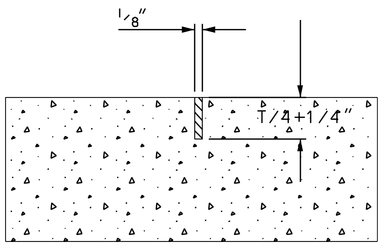
COUNTY LINE TO EAST OF DAWSON

HOT BITUMINOUS OVERLAY

STLEXRDN

STATE	PROJECT NO.	SHEET NO.
ND	IM-1-094(040)193	14A





TRANSVERSE AND LONGITUDINAL JOINT SAWING DETAIL
(NOT TO BE SEALED)

F-7

WHITETOPPING JOINT AND
THICKENED EDGE LAYOUTS

COUNTY LINE TO EAST OF DAWSON

HOT BITUMINOUS OVERLAY

WTTOPDT

Appendix G

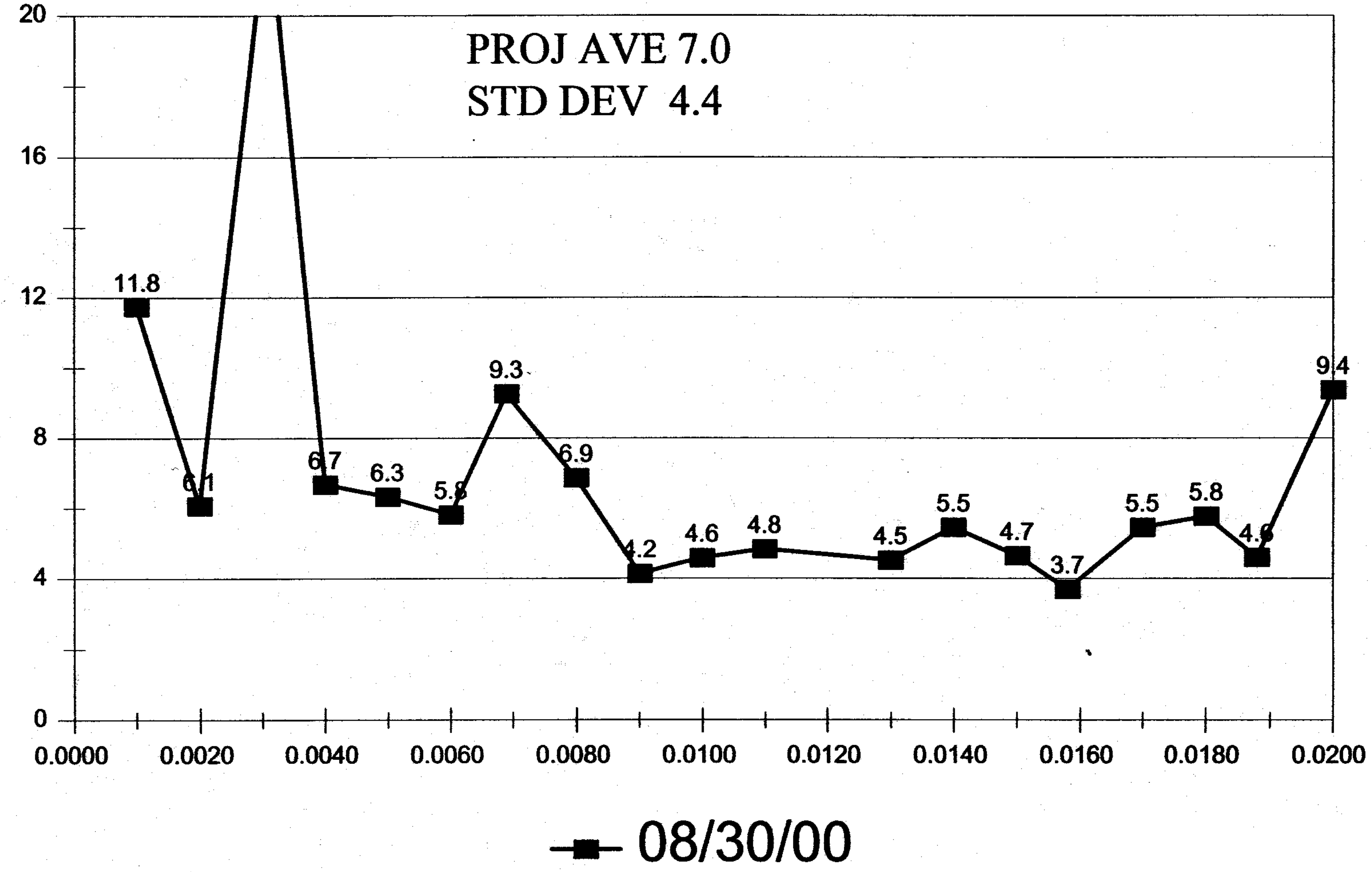
ELMOD RUNS

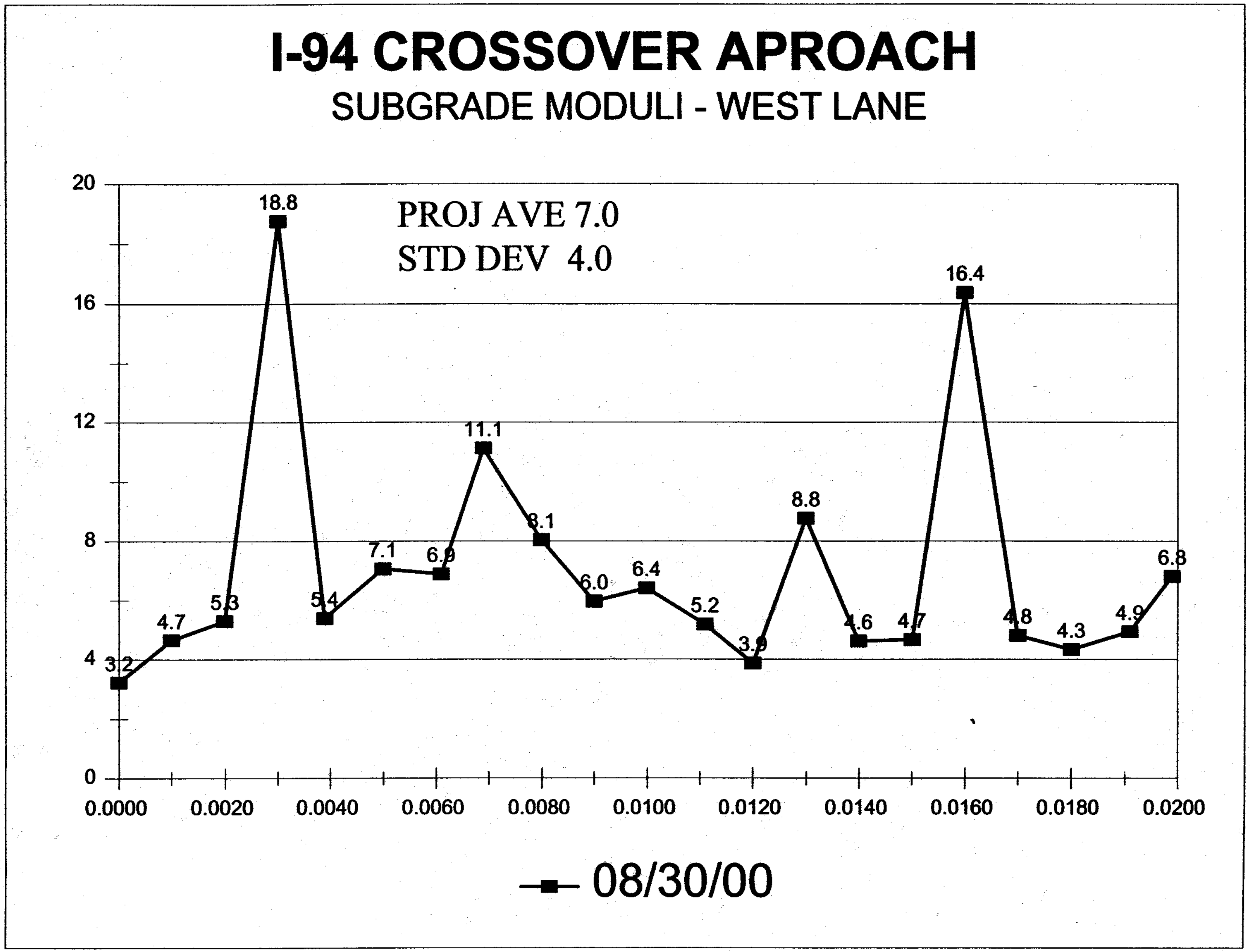
PROJECT NUMBER: IM-1-094(040)193 DESCRIPTION: I94 STEELE CROSSOVER YEAR: 00

FILENAME	MILE+FEET (begin - end)	RUN DATE	SECTION: PAVEMENT (inches) PCC	SECTION: BASE (inches) HMA+BASE	PREVIOUS 24 HOUR AVE TEMP (°F)	PROCESSED (✓): ELMOD	PROCESSED (✓): PLOT
A094193.f20	00+00 to 02+00	8-30-00	3.5	9	65.		
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS: M-7.0 D-47.5						
B094193.f20	00+00 to 02+00	8-30-00	4.5	7.5	65		
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS: M-7.0 D-38.5						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						

I-94 CROSSOVER APROACH

SUBGRADE MODULI - EAST LANE





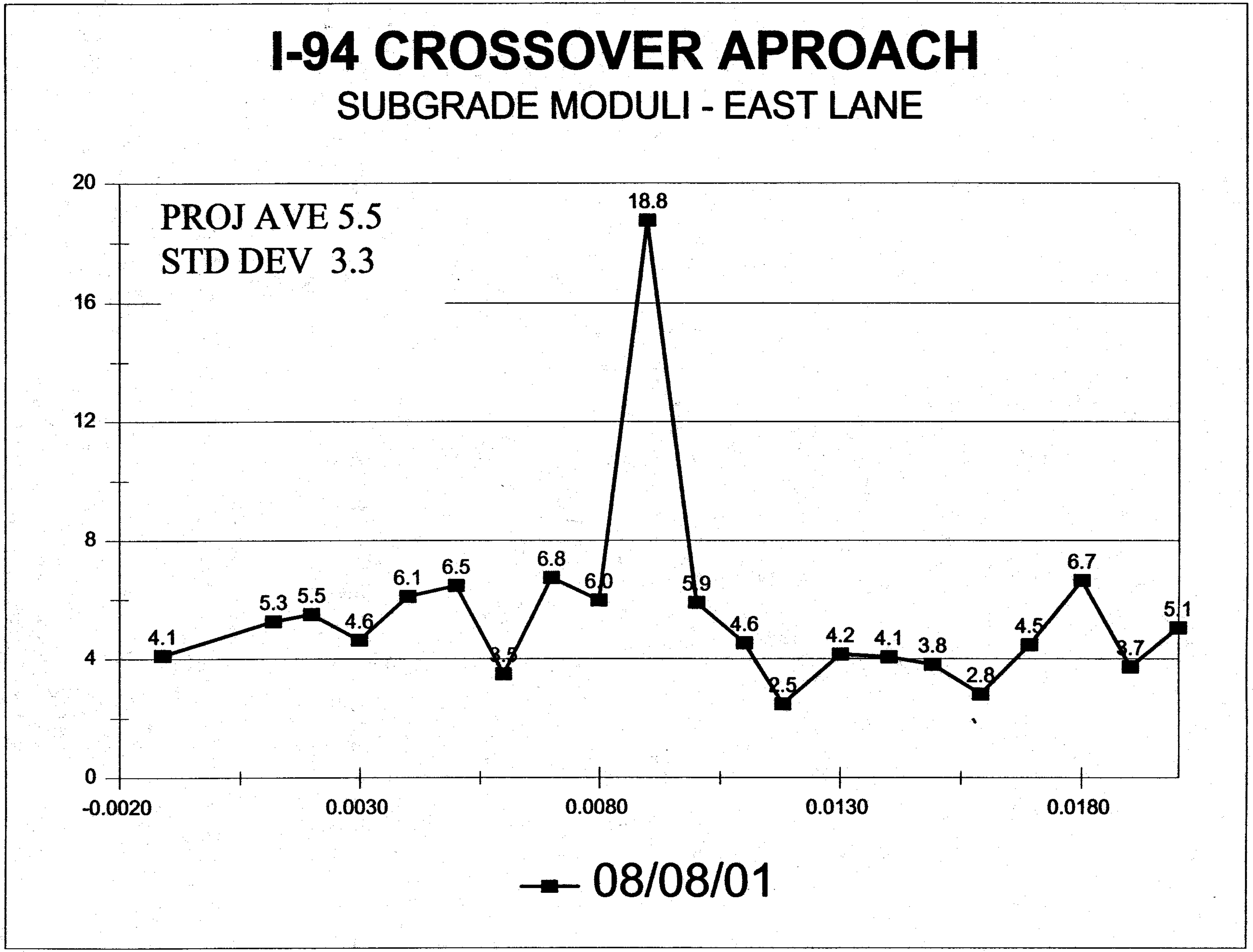
I-94 CROSSOVER APROACH
SUBGRADE MODULI - WEST LANE
PROJ AVE 7.0
STD DEV 4.0
20
16
12
8
4
0
18.8
16.4
11.1
8.8
8.1
7.1
6.9
6.0
6.4
5.2
3.9
4.6
4.7
4.8
4.3
4.9
6.8
5.3
4.7
3.2
5.4
0.0000
0.0020
0.0040
0.0060
0.0080
0.0100
0.0120
0.0140
0.0160
0.0180
0.0200
08/30/00

G-3

ELMOD RUNS

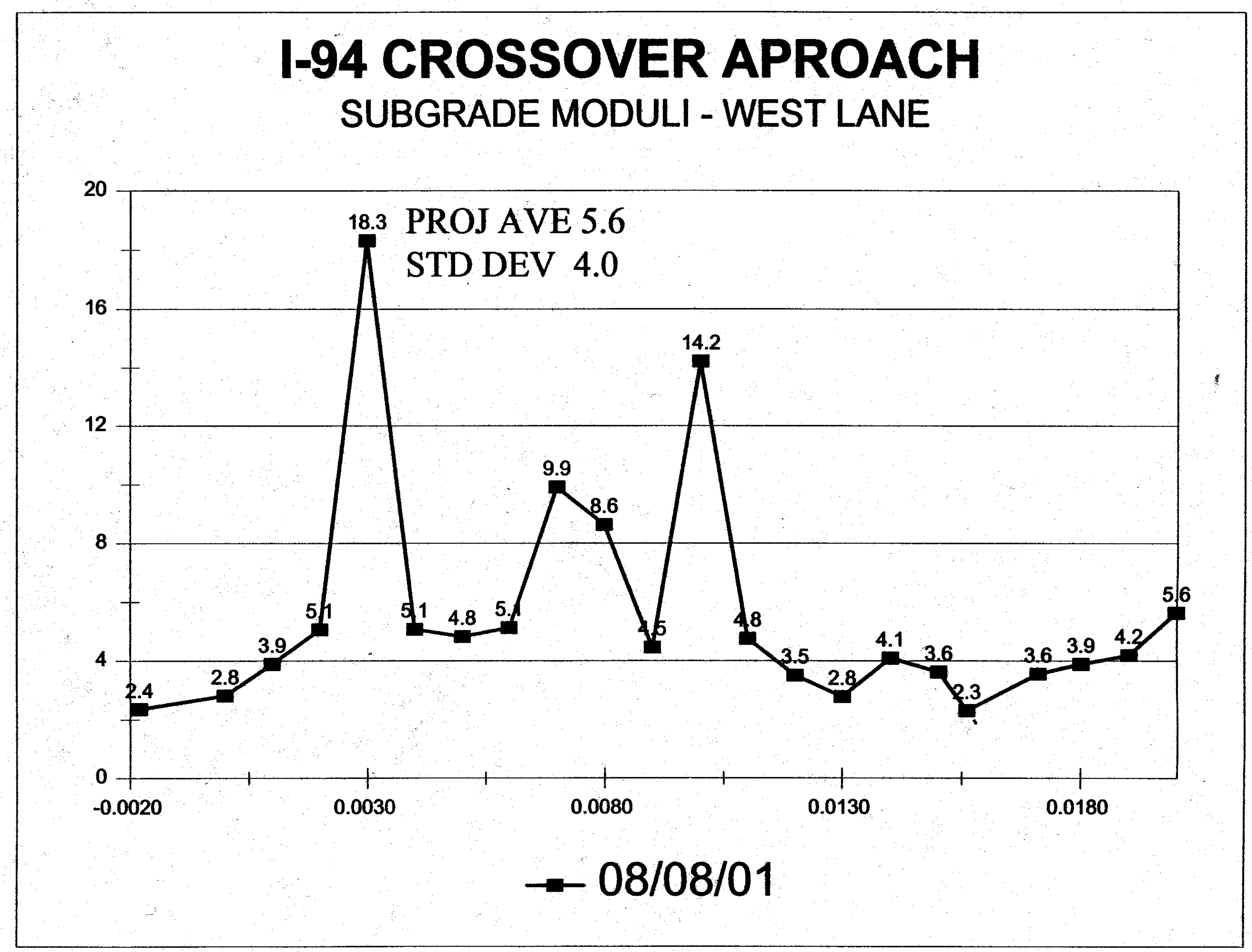
PROJECT NUMBER IM-1-094(040)193 DESCRIPTION: Steele cross road aproach YEAR: 01

FILENAME	MILE+FEET (begin - end)	RUN DATE	SECTION PAVEMENT (inches) PCC	SECTION BASE (inches) HBP + BASE	PREVIOUS 24 HOUR AVE TEMP (°F)	PROCESSED (✓) ELMOD	PROCESSED (✓) PLOT
094193.f20	-00+18 to 02+00	8-8-01	3.5	9	81		
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS: South Bound		M-5.6	D-51.4			
094193n.f20	-00+11 to 02+00	8-8-01	4.5	7.5	81		
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS: North Bound		M-5.6	D-45.7			
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						
PLOTS: SUB___ BASE___ PAVE___ DEFL___	COMMENTS:						



I-94 CROSSOVER APROACH
SUBGRADE MODULI - EAST LANE
PROJ AVE 5.5
STD DEV 3.3
20
16
12
8
4
0
-0.0020
0.0030
0.0080
0.0130
0.0180
4.1
5.3
5.5
4.6
6.1
6.5
6.8
18.8
5.9
4.6
2.5
4.2
4.1
3.8
2.8
4.5
6.7
5.1
08/08/01

G-5



I-94 CROSSOVER APROACH
SUBGRADE MODULI - WEST LANE
PROJ AVE 5.6
STD DEV 4.0
20
16
12
8
4
0
18.3
14.2
9.9
8.6
5.1
5.1
4.8
5.1
4.5
4.8
2.4
2.8
3.9
3.5
2.8
4.1
3.6
2.3
3.6
3.9
4.2
5.6
-0.0020
0.0030
0.0080
0.0130
0.0180
08/08/01

G-6