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NDDOT OTHER*	☐		
NDSU	☐		
UND	☐		
UGPTI	☐		
OTHER*	☐		

*see supplementary notes

14. Supplementary Notes

15. Abstract

Purpose and Need

Whitetopping is the process of placing concrete on an existing asphalt roadway. An advantage of whitetopping is the ability to resist rutting and shoving that can cause collection of water on the roadway. Whitetopping impedes structural related distresses such as loss of support, pumping, faulting and corner breaks when constructed on a strong base. Another advantage of this process is to bridge isolated problems that would be reflected through a flexible pavement.

Objective

The objective of this experimental feature is to determine if whitetopping is a feasible option for rehabilitation of an asphalt roadway in North Dakota.

Scope

In order to determine the effectiveness of whitetopping as possible rehabilitation technique, the North Dakota Department of Transportation (NDDOT) elected to set up a test section to collect and evaluate performance data on this type of project. The NDDOT has constructed three test sections of 5", 6" and 7" of PCC to be placed over an existing asphalt section. Each whitetopping test section was approximately 500' in length. The project is located on US Highway 52 between Pingree and Buchanan, ND. The project will be evaluated on visual distresses and ride for a period of ten-years with reports every two-years.

Summary

Test sections 1 and 3 are showing the most distresses. The primary distress is longitudinal cracking. Test section 1 had a 40' longitudinal crack that appeared immediately after construction. The location of this crack is in the same area as the distresses shown in photo 1 prior to whitetopping the asphalt. These distresses appeared to have reflected through the whitetopping section. Test section 2 is performing well with only minor distresses. The ride was fair to poor in all test sections. The control section is performing well with minor rutting and four transverse cracks. The ride is better on the control section when compared to the test sections. The maintenance costs of the whitetopping sections were considerably less than that of the control section.

Recommendation

Based on the condition of the roadway, whitetopping appears to be a feasible option for rehabilitation of an asphalt roadway. A concrete overlay of 6" appears to be the best performing thickness. The initial cost of the whitetopping was more than the mine and blend, but the maintenance costs where significantly less. At the end of the 10-year evaluation, the whitetopping would benefit from CPR, grinding, or other maintenance work to improve the ride. These maintenance operations could add additional life to the pavement.

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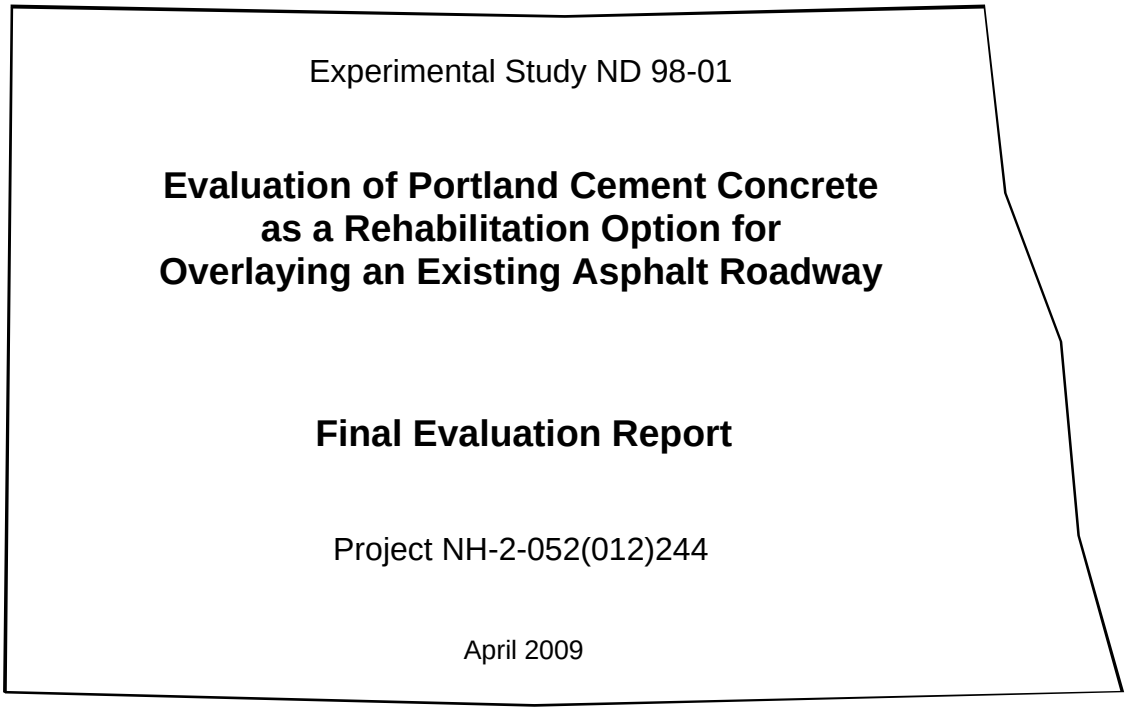
NORTH DAKOTA
DEPARTMENT OF TRANSPORTATION

MATERIALS AND RESEARCH DIVISION



Experimental Study ND 98-01

Evaluation of Portland Cement Concrete as a Rehabilitation Option for Overlaying an Existing Asphalt Roadway

Final Evaluation Report

Project NH-2-052(012)244

April 2009

Prepared by

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FEDERAL HIGHWAY ADMINISTRATION

EXPERIMENTAL PROJECT REPORT

EXPERIMENTAL PROJECT

EXPERIMENTAL PROJECT NO. (1)

STATE	Y EAR		NUMBER	SURF
ND	1998	-	01	

CONSTRUCTION PROJ NO (8): NH-2-052(012)244

LOCATION: Stutsman; 28 Counties

EVALUATION FUNDING (48)

1 HP&R
2 X CONSTRUCTION
3 DEMONSTRATION
4 IMPLEMENTATION

NEEP NO. (49):

PROPRIETARY FEATURE? (51): Yes / X No

SHORT TITLE

TITLE (52): Evaluation of Portland Cement Concrete as an Option for Overlaying an Existing Asphalt Roadway

THIS FORM

DATE (140): MO. 04 -- YR. 2009

REPORTING: 1 INITIAL; 2 ANNUAL; 3 X FINAL

KEY WORDS

KEY WORD 1 (145): Pavement Concrete

KEY WORD 2 (167): Overlays

KEY WORD 3 (189):

KEY WORD 4 (211):

UNIQUE WORD (233): Whitetopping

PROPRIETARY FEATURE NAME (255):

CHRONOLOGY

Date Work Plan Approved	Date Feature Constructed:	Evaluation Scheduled Until:	Evaluation Extended Until:	Date Evaluation Terminated:
06-98	06-98	06-08		04-09
277	281	285	289	293

QUANTITY AND COST

QUANTITY OF UNITS (ROUNDED TO WHOLE NUMBERS) (297):

UNITS (305):

1 LIN. FT
2 SY
3 SY-IN
4 CY
5 TON
6 LBS
7 EACH
8 LUMP SUM

UNIT COST (*Dollars, Cents*) (306):

AVAILABLE EVALUATION REPORTS

X CONSTRUCTION (315) | X PERFORMANCE | X FINAL

EVALUATION

CONSTRUCTION PROBLEMS (318)

1 X NONE
2 SLIGHT
3 MODERATE
4 SIGNIFICANT
5 SEVERE

PERFORMANCE (319)

1 EXCELLENT
2 GOOD
3 X SATISFACTORY
4 MARGINAL
5 UNSATISFACTORY

APPLICATION

(320)

1 ADOPTED AS PRIMARY STD.
2 X PERMITTED ALTERNATIVE
3 ADOPTED CONDITIONALLY
4 PENDING
5 REJECTED
6 NOT CONSTRUCTED

(Explain in remarks if 3, 4, 5, or 6 is checked)

REMARKS

(321)

The test sections are performing satisfactory. Longitudinal cracking has occurred in two of the test sections that are adjacent to HBP. There is also low severity transverse and longitudinal joint spalling which is typical of PCC pavements.

700

Form FHWA 1461

Experimental Study ND 98-01

Evaluation of Portland Cement Concrete as a Rehabilitation Option for Overlaying an Existing Asphalt Roadway

FINAL EVALUATION REPORT

Project NH-2-052(012)244

April 2009

Written by
Curt Dunn, Bryon Fuchs,
John Wolf and Matt Luger

Disclaimer

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Evaluation of Portland Cement Concrete as a Rehabilitation Option for Overlaying an Existing Asphalt Roadway ND 98-01

Objective

The objective of this experimental feature is to determine if whitetopping is a feasible option for rehabilitation of an asphalt roadway. Whitetopping is the process of placing concrete on an existing asphalt roadway. An advantage of whitetopping is the ability to resist rutting and shoving that can cause collection of water on the roadway. Whitetopping impedes structural related distresses such as loss of support, pumping, faulting and corner breaks when constructed on a strong base. Another advantage of this process is to bridge isolated problems that would be reflected through a flexible pavement.

The concept behind whitetopping is that when PCC is bonded to an underlying layer of asphalt, the two form a composite layer forcing the neutral axis in the slab downward. This would cause more of the concrete to be acting in compression rather than tension.

Whitetopping has not been a rehabilitation method used by the North Dakota Department of Transportation in the past.

Scope

In order to determine the effectiveness of whitetopping as possible rehabilitation technique, the North Dakota Department of Transportation (NDDOT) elected to set up a test section to collect and evaluate performance data on this type of project. The NDDOT has constructed three test sections of 5", 6", and 7" of PCC to be placed over an existing asphalt section.

The whitetopping sections were part of a larger project NH-2-052(012)244 which consisted of a mine and blend, and applying a new layer of hot bituminous pavement (HBP). This particular roadway was chosen because it had good existing soil conditions and considerable truck traffic.

Each whitetopping test section was approximately 500' in length separated by transition sections of 50'.

Location

The location for this experimental project is north of Jamestown on Highway 52 between Pingree and Buchanan. Refer to Figure 1 for project location. The total project length is approximately 7.743 miles long. The whitetopping test sections and the corresponding control section are between Reference Points 249 and 250.

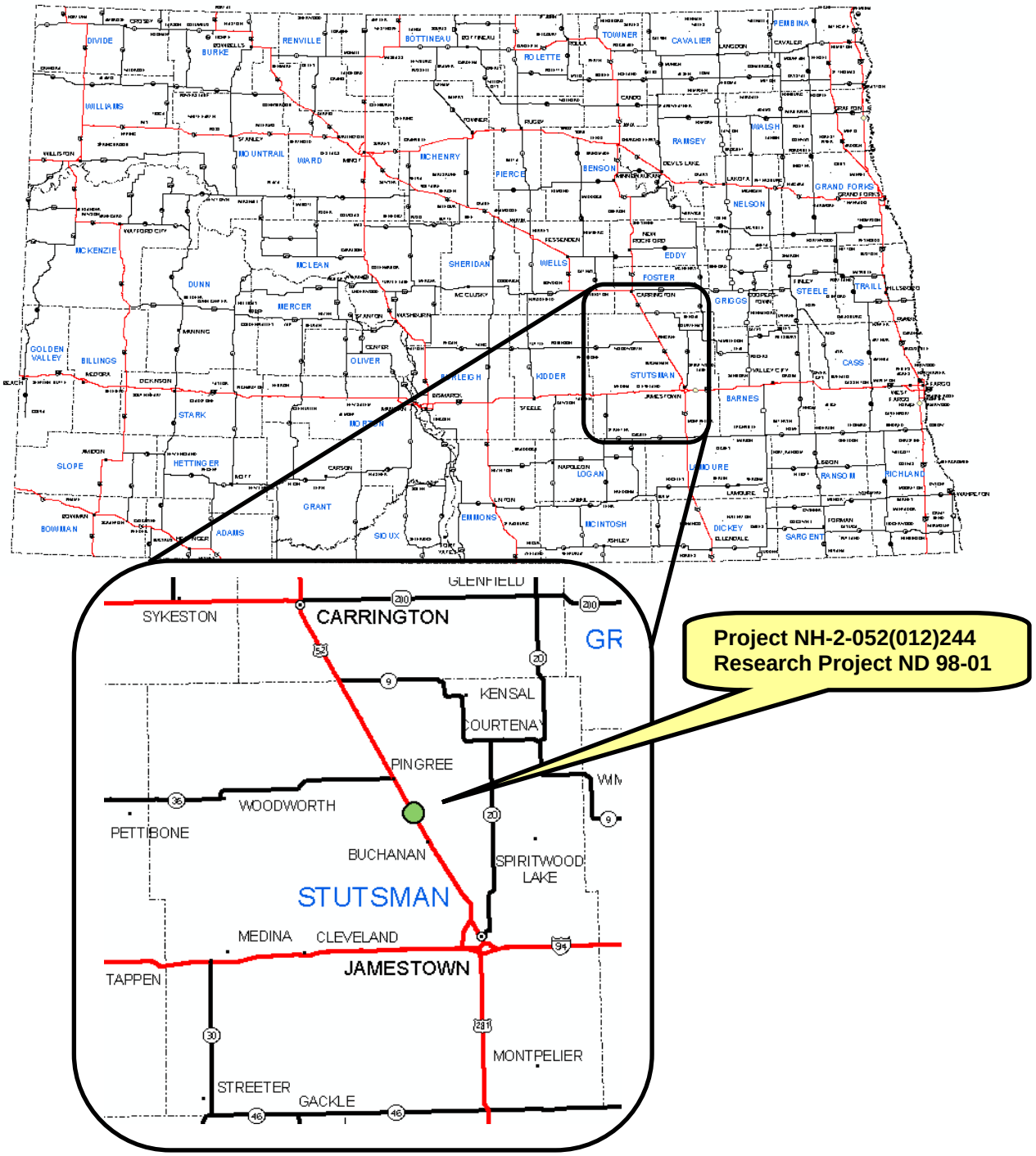


Figure 1 - Project location.

Project Historical Information

Construction

Project history for the roadway section is shown in Table 1.

Junction ND 36 South to 4-lane at Buchanan				
Year	**Construction**	**Depth**	**Width**	**Asphalt Oil**
1948	Grade	-	36'	-
1950	Aggregate Base	4.0"	32'	-
1950	Hot Bituminous Pavement	4.0"	22'	-
1966	Shoulder Widening	-	48'	-
1966	Bituminous Base Shoulders	-	16'	SM-K
1966	Hot Bituminous Leveling Course	1.5" - 5.3"	24'	SM-K
1966	Hot Bituminous Pavement	1.5"	24'	120-150
1973	Hot Bituminous Pavement	0, 1.1", 1.5"	0, 12', 24'	200-300
1978	Dugouts	1.0' - 1.5'	-	120-150
1978	Aggregate Base Shoulders	4.0"	18'	-
1978	Hot Bit Pavement	2.5"	24'	120-150
1990	Maintenance Chip Seal	-	24'	MC-3000
1995	Hot Bituminous Pavement Patch	1.5"	-	120-150

Table 1

Traffic

Past and current two-way daily traffic is shown in Table 2.

Year	Pass	Trucks	Total	ESAL Annual Growth Rate	Two-way ESALs	
					Flexible	Rigid
1998	1,750	550	2,300	2.0%	480	800
2000	1,920	480	2,400	1.8%	425	700
2004	1,155	500	1,655	1.8%	445	725

Table 2

Design

NDDOT considered several roadways as candidates for a whitetopping test section. US 52 was considered because of its good existing soil conditions, a thick section of existing asphalt (approximately 17"), and considerable truck traffic.

The roadway in question was experiencing distresses such as longitudinal and transverse cracking, rutting (1/8" to 3/8") and shoving pavement, and depressed transverse cracks. This segment of roadway was listed as poor for the ride and the international roughness index. Photo 1 depicts a segment of US 52 with a severely depressed longitudinal crack. One of the rehabilitation options for this roadway was to mill the existing asphalt and overlay with new HBP. However, this option was not considered since the existing cracks would eventually reflect through the new pavement.

Photo 1 - Overview of distressed areas on a segment of US 52.

The option of mining and blending the existing asphalt and base together and overlaying with HBP was chosen. First, 9” of asphalt was milled and removed, then, aggregate was placed on the remaining roadway structure and blended together to achieve a 14" base. A 5" layer of HBP was placed on the blended base section.

It was also decided that whitetopping test sections would be constructed by milling the existing asphalt and overlaying with PCC. This option was chosen in part to determine if PCC has the ability to control reflective cracking.

The experimental feature was designed to consist of milling 5" to 7" of existing asphalt and then placing PCC of various thicknesses as follows in Table 3.

Test Section	Depth (Inches)
1	5
2	6
3	7

Table 3

The total length of the whitetopping was designed to be approximately 1600 feet. A transitional distance of 50 feet was to be placed in between each section. Figure 2 shows the sections of the experimental feature.

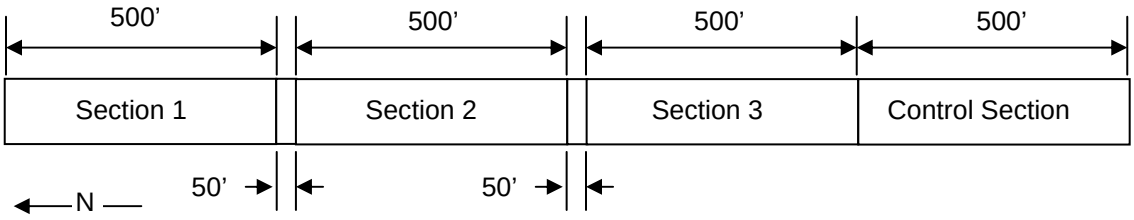


Figure 2 - Experimental Sections.

The width of the lanes within the experimental feature were originally designed to be 13.5' with 4.5' asphalt shoulders, however, they were later changed to 12' wide lanes with 6' concrete shoulders. The longitudinal joint tie bar sizes and spacings are listed in Table 4.

Pavement Depth	Location	Bar Size	Bar Spacing
5"	Centerline	#4 x 2' -0"	2' -6"
6"	Centerline	#4 x 2' -0"	2' -10.5"
7"	Centerline	#4 x 2' -0"	3' -3"
5"	12' left and right	#2 x 1' -6"	2' -6"
6"	12' left and right	#2 x 1' -6"	2' -10.5"
7"	12' left and right	#3 x 1' -6"	3' -3"

Table 4

The transverse joint spacing within the experimental sections were originally designed to be 12' for the 5" thick section, 13' for the 6" section, and 14' for the 7" section. However, they were later changed as shown in Table 5. This design approach was more in line with the American Concrete Paving Association (ACPA) practices.

PCC Pavement Depth	Joint Spacing
5"	10.0'
6"	11.5’
7"	13.0’

Table 5

Transverse joint saw cut depths were designed for T/4 + 1/4" with the saw cuts to be 1/8" wide.

Surface preparation for the whitetopping sections was to mill the existing asphalt. The milling established the grade-line and crown for the concrete section. After the milling was completed, it was very important that the remaining surface be thoroughly cleaned and free of loose particles and dust in order to establish favorable conditions for a proper bond between the existing asphalt and the PCC.

Construction

Whitetopping Section

Construction of the whitetopping test sections began on June 16, 1998. The contractor was Upper Plains Contracting. The contractor began paving at approximately 6:30 a.m. NDDOT project engineer was James O'Brien of the Valley City District. A research team from the NDDOT visited the site.

Photo 2 depicts the surface after the milling was concluded. Upon further examination there appeared to be some loose particles and dust still present on the surface. On the left side of Photo 2 tie bars are visible which are located between the impending shoulder and mainline.

Photo 2 - HBP surface after milling was concluded.

All of the PCC was batched in Jamestown, North Dakota and transported to the site in ready mix trucks.

Photo 3 depicts an overview of the finished slab in the northbound lane of section 1 (5" PCC). The contractor commented that during the construction of the 5" PCC slab he had to lower the tie bars. This was necessary since the paver was hitting the top ends of the bars leaving them sticking out of the slab after the paver passed over them.

Photo 3 - Overview of finished slab in the northbound lane of section 1 (5" PCC).

Photo 4 depicts excess curing compound that was sprayed where the southbound lane would be constructed.

Photo 4 - View of excess curing compound sprayed where the southbound lane would be constructed.

The NDDOT personnel were concerned the over-sprayed curing compound would hamper the bonding effect between the PCC and the existing asphalt. The contractor agreed to remove the compound from the surface prior to placing the slab. The contractor finished all three test sections in the northbound lane by mid to late afternoon. Although precise times were not kept, the placing of the 6" slab required a little more time than the 5" slab because of the increase in the volume of PCC. The contractor commented that the job would have progressed at a faster rate if the ready mix trucks could have kept up to the paver.

On June 25, 1998 the contractor began paving the southbound lane. A research team from the NDDOT again visited the site to monitor and evaluate the construction of the other half of the whitetopping test sections. Photo 5 is an overall view of the paving operation in the southbound lane.

Photo 5 - Paving operation in southbound lane.

Photo 6 shows a close-up view of small particles and dust that remained on the milled surface that were not blown off prior to paving.

Photo 6 - Small particles found on the HBP prior to paving.

Photo 7 depicts an overall view of test section 1. A representative of the Materials and Research Division visited the site a few weeks after construction. The test sections were free of distresses except for a longitudinal crack located in the northbound lane near the beginning of test section 1. Photo 8 depicts a view of this distress which spans approximately 40'.

Photo 7 - Overall view of test section 1.

Photo 8 - Longitudinal crack in test section 1 after construction.

Control Section

As previously mentioned the Control Section is composed of a blended base overlaid with HBP. The existing section was first milled to a depth of 9". After the milling operation was completed, 6" of course aggregate was placed on the remaining roadway structure and blended together to achieve a blended 14" base. A 5" layer of HBP consisting of 3" of recycled large stone mix topped with 2" of Class 31 was then placed on the blended base section. The project engineer commented that the construction phase went well.

The performance of this section will be compared to the white topping test section.

Cost

Table 6 tabulates the following bid items associated with the whitetopping test sections.

Description	Units	Unit Bid
5" Non-Reinforced Concrete Pavement Class AE	SY	$20.40
6" Non-Reinforced Concrete Pavement Class AE	SY	$23.25
7" Non-Reinforced Concrete Pavement Class AE	SY	$25.70
Milling Bituminous Pavement	Ton	$3.60

Table 6

Table 7 tabulates the following bid items associated with the asphalt control section.

Description	Units	Unit Bid
Milling Bituminous Pavement	Ton	$3.60
Aggregate Base Course Class 5	Ton	$4.85
Blended Base Course	SY	$1.17
Water	M Gal	$12.00
MC70 or 250 Liquid Asphalt	Gal	$0.87
Blotter Material Class 44	Ton	$9.55
SS1H or CSS1H Emulsified Asphalt	Gal	$0.87
Virgin Aggregate Large Stone Mix	Ton	$5.50
Recycled Hot Bituminous Pavement-Large Stone Mix	Ton	$6.70
120-150 Asphalt Cement	Ton	$137.00
Hot Bituminous Pavement QC/QA Class 31	Ton	$13.20
Trimming Base Course	SY	$0.24

Table 7

Table 8 tabulates the price per square yard of each pavement section. The unit prices listed above were used to tabulate the square yard price. The prices do not reflect items such as contract bonds, flagging, testing, mobilization, etc.

	Blend Base/HBP	5" Whitetopping	6" Whitetopping	7" Whitetopping
Price/SY	$10.11	$21.40	$24.45	$27.10

Table 8

Evaluation

On October 23, 2008 a NDDOT research team traveled to the PCC overlay test section to conduct the final evaluation of this project. This test section is located on Highway 52 between RP 249 and 250. The team consisted of Matt Luger, Kyle Evert, Tom Bold, and Andy Mastel of the Materials and Research Division. The following pages describe the findings of this evaluation.

Test Section 1

Test Section 1, composed of 5" PCC with 10' joint spacing on 12" of HBP, showed the most signs of distress of all three test sections.

During a post construction evaluation of the white topping test section, it was discovered that some cracks had begun to form. In the summer of 1999 the Valley City district performed some preventive maintenance on the longitudinal cracks. This process consisted of using a router to saw ½" of PCC adjacent to the cracks, and filling the void with the polymer sealant CRAFCO 231. The Valley City District has since resealed the longitudinal cracks with an asphalt binder.

The review team located approximately 220 feet of low to medium severity longitudinal cracking in this section. Ten corner breaks were noted, one with low severity spalling. There were also 4 transverse cracks noted. Some of the transverse cracks were located on the same panels that had longitudinal cracks. This gave the concrete a 'block cracking' appearance indicating a failure of the underlying asphalt and/or subgrade. This distressed area is shown in Photo 9. Most of the transverse joints had light spalling. The joint sealant was losing contact with portions of the PCC panels due to spalling. The longitudinal joints also had low and medium severity spalling. The areas of medium spalling have been repaired with an asphalt material. Photo 10 shows the condition of a typical longitudinal and transverse joints as well as areas of spalling and spalling repair.

Photo 9 - Longitudinal and Transverse cracks in test section 1

Photo 10 – Typical longitudinal and transverse joints.

Longitudinal and transverse joints along the shoulder are performing well. The shoulders in this section showed no signs of distress other than one transverse crack that has extended from the SB lane. The distresses noted in each evaluation are provided in the following table:

Section 1			
Evaluation	**Longitudinal Cracking**	**Transverse Cracking**	**Other distresses**
2001	130 feet in NB lane	0 feet observed	Low severity spalling at joints
2003	130 feet in NB lane 10 feet in SB lane	12 feet in SB lane	Low severity spalling at joints 1 corner break Block cracking in one location
2005	150 feet in NB lane 40 feet in SB lane	12 feet in NB lane 12 feet in SB lane	Low severity spalling at joints 4 corner break Block cracking in one location
2008	180 feet in NB lane 40 feet in SB lane	24 feet in NB lane 24 feet in SB lane	Low severity spalling of transverse joints. Medium severity spalling of longitudinal joints. 10 corner breaks. Block cracking in one location.

Table 9

Test Section 2

Test Section 2 is composed of 6" PCC with 11.5' joint spacing on 11" of HBP. The overall pavement condition is performing well. Photo 12 below shows an overview of test section 2.

Photo 12 – Overview of Section 2, 6" PCC overlay

At the time of evaluation section 2 had some low severity spalling occurring at transverse joints and also the centerline longitudinal joints. There was also approximately 15 feet of longitudinal cracking. Longitudinal and transverse joints along the shoulder are performing very well. The shoulders in this section show no signs of distress. The distresses noted in each evaluation are provided in the following table:

Section 2			
Evaluation	**Longitudinal Cracking**	**Transverse Cracking**	**Other distresses**
2001	0 feet observed	0 feet observed	Low severity spalling at joints
2003	0 feet in NB lane 11.5 feet in SB lane	0 feet observed	Low severity spalling at joints
2005	0 feet in NB lane 11.5 feet in SB lane	0 feet observed	Low severity spalling at joints
2008	0 feet in NB lane 15 feet in SB lane	0 feet observed	Low severity spalling at joints

Table 10

Test Section 3

Test Section 3 is composed of 7" PCC overlay with 13’ joint spacing on 10" of HBP. The overall pavement performance is satisfactory.

The review team located approximately 140 feet of low severity longitudinal cracking that occurred in Section 3. This section had some low severity spalling occurring at transverse joints and also the centerline longitudinal joint. There were also four corner breaks in this section which still appeared to be very tight. There was an area of ‘block cracking’ located at the transition of test section 3 and the control section. Photos 14, and 15 show a progression of the distresses at this transition from 2003 to 2008.

Photo 14 - Longitudinal crack in test section 3 looking north on 9/18/03.

Photo 15 – Block crack in test section 3 looking North on 10/23/08

The shoulders in this section show no signs of distress. The distresses noted in each evaluation are provided in the following table:

Section 3			
Evaluation	**Longitudinal Cracking**	**Transverse Cracking**	**Other distresses**
2001	40 feet in NB lane	0 feet observed	Low severity spalling at joints 1 corner break
2003	91 feet in NB lane 13 feet in SB lane	12 feet in NB lane	Low severity spalling at joints 4 corner break
2005	130 feet in NB lane 13 feet in SB lane	12 feet in NB lane	Low severity spalling at joints 4 corner break
2008	130 feet in NB lane 13 feet in SB lane	12 feet NB lane	Low severity spalling at joints 4 corner break

Table 11

Control Section

The review team also inspected the asphalt control section located directly south of the whitetopping test site. The section appeared to be in good condition. Photo 16 shows the general condition of the control section. Some bleeding had occurred in the north bound lane.

Photo 16 - Overview of Control Section looking North

There were also a few isolated patches where the chip seal had been scraped off the HBP near an existing approach. It is believed that this may have been caused by farm machinery or some other form of heavy equipment.

Four transverse cracks where identified within the control section. Minor rutting has occurred, ranging from 1/16” to 1/8”. Also, a 40 foot longitudinal crack had formed along centerline near the field approach.

Photo 17 - Transverse Crack in Asphalt Control Section

The distresses noted in each evaluation are provided in the following table:

Control Section			
Evaluation	**Longitudinal Cracking**	**Transverse Cracking**	**Other distresses**
2001	0 feet observed	72 feet	None noted
2003	0 feet observed	72 feet	1/16” to 1/8” rutting
2005	40 feet in SB lane	144 feet	1/16” to 1/8” rutting
2008	40 feet in SB lane	144 feet	1/16” to 1/8” rutting

Table 12

Ride

During the inspection, the review team drove over both the test and control sections. All three experimental sections had fair to poor ride quality. A possible explanation for this distress was the temperature of the roadway combined with the effects of a flexible asphalt base. The ride quality was significantly better on the control section.

Falling Weight Deflectometer (FWD)

FWD data is summarized in the table below for 2000 through 2008. Refer to Appendix B for graphs.

FWD Data									
Section	**Station**	**2000 Soil Modulus (ksi)**	**2001 Soil Modulus (ksi)**	**2002 Soil Modulus (ksi)**	**2003 Soil Modulus (ksi)**	**2004 Soil Modulus (ksi)**	**2005 Soil Modulus (ksi)**	**2006 Soil Modulus (ksi)**	**2008 Soil Modulus (ksi)**
	249.3226	13.2	11.0	11.6	10.5	16.5	16.0	13.7	14.1
	249.3276	12.7	11.2	9.6	13.9	17.6	16.0	10.9	11.4
	249.3326	12.1	9.6	9.7	9.6	19.6	14.6	10.5	12.1
	249.3376	13.4	7.6	9.3	9.9	17.2	20.1	8.5	27.3
1	249.3426	11.3	8.0	8.9	10.0	14.2	15.9	8.3	10.1
	249.3476	12.7	13.0	9.9	11.7	15.8	19.8	9.9	9.0
	249.3526	13.2	12.9	8.5	10.9	19.0	18.4	7.9	15.1
	249.3576	13.1	12.8	9.4	11.7	10.8	14.6	8.6	9.5
	249.3626	17.5	12.4	10.4	11.3	18.6	14.9	10.6	9.6
	249.3801	15.3	17.7	15.0	21.4	18.5	11.6	19.6	17.7
	249.3850	16.8	15.6	18.5	12.9	19.5	20.2	11.5	19.0
	249.3901	20.9	19.9	12.6	11.3	25.3	10.7	11.6	12.0
	249.3950	14.0	11.7	12.8	18.7	15.8	15.9	13.3	20.5
2	249.4000	13.8	17.9	17.4	15.6	18.0	17.3	13.1	20.9
	249.4050	19.6	11.4	11.4	12.3	16.6	20.8	17.9	15.0
	249.4100	15.2	15.2	10.4	13.1	13.6	16.0	11.0	11.9
	249.4151	26.5	16.1	15.6	13.2	18.7	20.2	11.2	27.4
	249.4200	15.0	25.6	14.3	9.5	17.8	17.0	29.1	13.8
	249.4350	20.9	14.7	12.1	19.3	19.2	9.6	13.6	18.5
	249.4400	17.0	25.0	13.1	18.9	17.0	16.6	23.2	13.9
	249.4450	16.4	15.3	15.7	15.5	21.2	17.4	19.5	15.6
3	249.4500	24.6	21.5	19.2	24.4	17.5	19.7	12.0	24.3
	249.4550	25.1	19.3	9.4	13.6	11.8	11.1	10.8	12.8
	249.4600	17.4	20.3	15.2	15.7	18.3	9.5	14.9	13.2
	249.4650	18.5	22.5	19.6	21.5	18.9	24.5	17.4	21.8
	249.4901	10.1	8.7	N/A	11.5	13.2	12.7	10.4	12.1
	249.4950	11.1	9.9	N/A	12.1	15.9	10.2	12.5	11.6
	249.5001	13.7	9.1	N/A	14.5	21.0	12.8	12.9	13.1
	249.5051	15.6	10.7	N/A	15.0	16.7	10.2	12.2	12.4
Control	249.5101	10.8	12.5	N/A	11.0	14.1	13.2	16.0	16.1
	249.5150	17.0	15.3	N/A	20.7	27.4	13.8	26.9	16.2
	249.5200	18.8	10.4	N/A	24.5	24.2	12.0	17.0	21.4
	249.5253	15.6	15.2	N/A	20.7	20.3	19.8	19.3	17.9

Table 13

Maintenance Costs

During their service life, each test section received a crack repair operation that included routing of the cracks and sealing with CRAFCO 231. A few years later the cracks were sealed again with an asphalt binder. Exact costs of these operations are unknown. However, after a discussion with the Valley City District, a reasonable estimation of the cost of these operations was determined to be $94.70 per 500 ft for each operation.

The control section received 1 contract chip seal and 1 additional crack sealing operation during its ten year service life. Again, exact costs of these operations are unknown. However, based on the engineers estimate, it can be assumed that the chip seal operation was approximately $100,000 for the 7.7 mile segment from Jct ND 36 to Buchanan (this segment includes the control section). Again, after a discussion with the Valley City District, a reasonable approximation for the crack sealing operation was $1,000 per mile.

Table 14 below shows the approximate 10-year maintenance costs for each section per square foot and the total 10-year maintenance costs.

	Control Section	5" Whitetopping	6" Whitetopping	7" Whitetopping
10-year Maintenance Costs per SY	$0.66	$0.09	$0.09	$0.09
Total 10-year Maintenance Costs	$1,324.52	$189.39	$189.39	$189.39

Table 13

Summary

Test sections 1 and 3 are showing the most distresses. The primary distress is longitudinal cracking. Test section 1 had a 40' longitudinal crack that appeared immediately after construction. The location of this crack is in the same area as the distresses shown in photo 1 prior to whitetopping the asphalt. These distresses appeared to have reflected through the whitetopping section. Test section 2 is performing well with only minor distresses. The ride was fair to poor in all test sections. The control section is performing well with minor rutting and four transverse cracks. The ride is better on the control section when compared to the test sections. The maintenance costs of the whitetopping sections were considerably less than that of the control section.

Recommendation

Based on the condition of the roadway, whitetopping appears to be a feasible option for rehabilitation of an asphalt roadway. A concrete overlay of 6" appears to be the best performing thickness. The initial cost of the whitetopping was more than the mine and blend, but the maintenance costs where significantly less. At the end of the 10-year evaluation, the whitetopping would benefit from CPR, grinding, or other maintenance work to improve the ride. These maintenance operations could add additional life to the pavement.

Appendix A

DESIGN DATA				
Traffic	Average Daily			Est. Max. Hr.
Current 1997	Pass: 2017	Trucks 480	Total 2300	230
Forecast 2017	Pass: 2180	Trucks 580	Total 2760	280
Minimum Sight Dist. for:		Design Speed 60 MPH		
Stopping 600'		Bridges		
Safe Passing 2300'				
Passing for Marking 1000'				

JOB# 2

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	1

NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

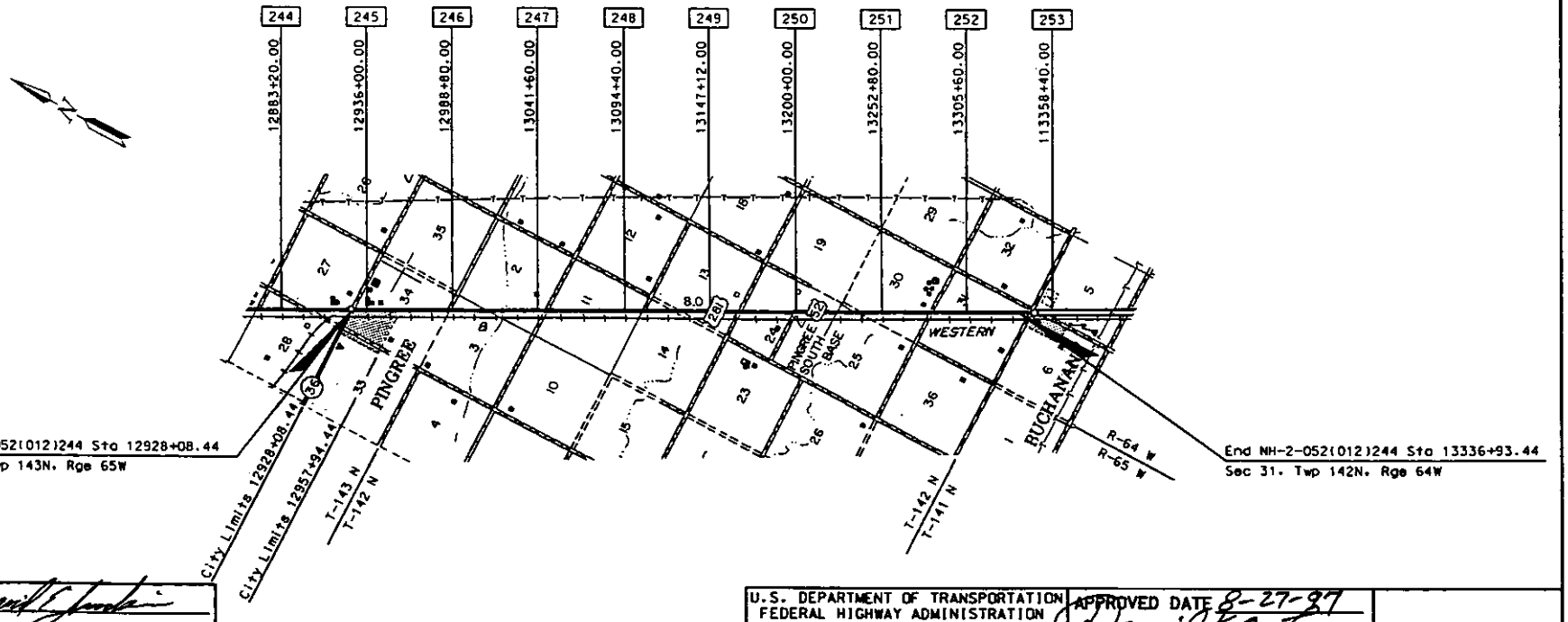
IN STUTSMAN COUNTY
FEDERAL AID PROJECT NO NH-2-052(012)244
BLENDED BASE COURSE, RECYCLED HOT BITUMINOUS PAVEMENT LARGE STONE MIX,
&
HOT BITUMINOUS PAVEMENT

GOVERNING SPECIFICATIONS:

Standard Specifications adopted by the North Dakota Department of Transportation October 1997: Standard Drawings currently in effect: and other Contract Provisions submitted herein.

LENGTH OF PROJECT

7.743 Miles



Beg NH-2-052(012)244 Sta 12928+08.44
Sec 27, Twp 143N, Rge 65W

End NH-2-052(012)244 Sta 13336+93.44
Sec 31, Twp 142N, Rge 64W

A-1

DESIGNER David E. Jundt
DESIGNER
DESIGNER
RECOMMEND APPROVAL 8-27, 1997
DESIGN ENGINEER: Kenneth E. Bird

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL HIGHWAY ADMINISTRATION

APPROVED

DIVISION ADMINISTRATOR DATE

APPROVED DATE 8-27-97
David K.O. Leer
P.E. 1199
DIRECTOR OF HIGHWAYS AND ENGINEERING
NORTH DAKOTA DEPARTMENT OF TRANSPORTATION

r:\project\20052244.012\d_paving\ Jul. 10, 1997 08:43:37

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	8

BASIS OF ESTIMATE

DESCRIPTION	UNITS	SECTION 6 QUANTITY PER MILE	SECTION 6 WIDTH	SECTION 9 QUANTITY PER MILE	SECTION 9 WIDTH	SECTION 10 QUANTITY PER MILE	SECTION 10 WIDTH	SECTION 11 QUANTITY PER MILE	SECTION 11 WIDTH
Water for Dust Palliative @ 25 MGal/Mile, for Blended Base @ 15 Gal/SY, & for Borrow @ 10 Gal/CY	MGal	423		25		25		25	
Salvaged Aggregate Base (shoulders)	Ton	1811							
Aggr Base Course Class 5 @ 1.875 Ton/CY	Ton	5767	38′						
Blended Base Course (existing base, existing Aggregate Base shldrs, and class 5)	SY	25227	43′						
MC-70 or 250 Liq Asph for Prime Coat @ 0.18 Gal/SY (top of Blended Base Course)	Gal	4224	40′						
MC-70 or 250 Liq Asph for Prime Coat @ 0.25 Gal/SY (top of reshaped aggr shldrs)	Gal			2053	7′-7′	2053	7′-7′	2053	7′-7′
SS-1h or CSS-1h Emuls Asph for Tack Coat @ 0.05 Gal/SY (top of prime)	Gal	1115	38′	381	6.5′-6.5′	381	6.5′-6.5′	381	6.5′-6.5′
SS-1h or CSS-1h Emuls Asph for Tack Coat @ 0.05 Gal/SY (between shldr lifts & top of large stone mix)	Gal	1056	36′	352	6.5′-6.5′	352	6.5′-6.5′	352	6.5′-6.5′
Blotter Material Cl 44 @ 8 Lbs/SY for Prime Coat Maintenance	Ton	89	38′	33	7′-7′	33	7′-7′	33	7′-7′
Recycled Hot Bit Pvmt - Large Stone Mix @ 2.0 Ton/Cy (70% virgin aggregate, 30% milled bit material)	Ton	3119	36′						
120-150 Asph Cement for Rec Hot Bit Pvmt - Large Stone Mix @ 3.6% of Rec Hot Bit Pvmt	Ton	112.18							
Virgin Aggregate for Recycled Hot Bit Pvmt - Large Stone Mix	Ton	2105							
Hot Bit Pvmt Class 31 @ 2.0 Ton/CY	Ton	2471	36′	1791	4.5′-4.5′	1936	4.5′-4.5′	2082	4.5′-4.5′
120-150 Asph Cement for Cl 31 Hot Bit Pvmt @ 5.8% of Cl 31 Hot Bit Pvmt	Ton	143.3		103.9		112.3		120.8	
Milling Bituminous Pavement	Ton	7123		4105		4105		4105	

A-2

BASIS OF ESTIMATE

BASEST01

100 020 WORK SCHEDULE: In order to minimize interference with traffic operations, a detailed schedule shall be agreed to prior to beginning work, between the engineer, utility companies, and the contractor and subcontractors, if any.

105 P01 The contractor shall notify the local utility companies prior to the beginning of construction, so they may determine the location of all utilities in the project area.

110 P01 This project is subject to the conditions of Section 404 Nation-wide Permit No. 26. The following special conditions, if applicable, must be met:

1. Heavy equipment working in wetlands must be placed on mats or other measures must be taken to minimize soil disturbance.

2. No discharge of dredge or fill material may consist of unsuitable material (e.g., trash, debris, car bodies, etc.) and material discharged must be free from toxic pollutants in toxic amounts.

3. Any structure or fill authorized will be properly maintained, including maintenance to ensure public safety.

4. Appropriate erosion and siltation controls must be used and maintained in effective operating condition during construction, and all exposed soil and other fills must be permanently stabilized at the earliest practicable date.

5. Discharge of dredge or fill material or equipment movement in wetland areas shall be avoided to the maximum extent practicable.

6. Discharge of dredge or fill material into breeding areas for migratory waterfowl must be avoided to the maximum extent practicable.

7. To the maximum extent practicable, discharges must not permanently restrict or impede the passage of normal or expected high flows or cause the relocation of the water (unless the primary purpose of the fill is to impound water).

8. If the discharge creates an impoundment of water, adverse impacts on the aquatic system caused by the accelerated passage of water and/or the restriction of its flow shall be minimized the maximum extent practicable.

9. All temporary fills must be removed in their entirety and the affected area returned to its pre-existing elevation.

202 P01 REMOVE APPROACH: This work shall consist of removing the existing approach as directed by the engineer. See Basis of Estimate (Slope flattening and pipe extensions) sheet for location.

All costs to remove and salvage topsoil, remove and dispose of approach material, replace the topsoil and seed with class II seed mixture in accordance with section 708.02 of the Standard Specifications shall be included in the unit price bid for "Remove Approach."

200 P02 PIPE REMOVAL: All pipe removed on this project will be disposed of by the contractor. The disposal site will not be visible from the highway. All costs to remove and dispose of pipe will be incidental to other items.

203 P01 REMOVE & SALVAGE TOPSOIL (Mainline slope flattening): This work shall consist of salvaging the exsting topsoil and placing it back on the inslope when the borrow placement is complete.

All costs to complete this work shall be included in the unit price bid for "Remove & Salvage Topsoil."

203 P02 BORROW: The contractor shall locate and provide the borrow material needed for flattening mainline inslope. Ordinary compaction shall be used to flatten the inslope.

Borrow for flattening mainline inslope shall be cross sectioned at the borrow site and measured by the cubic yard. Payment for "Borrow" shall be accordance with section 203.02 E3 of the Standard Specifications.

NOTES

NSHEET3

A-3

203 P01 APPROACH INSLOPE RECONSTRUCTION: The cost of labor, equipment, and materials to perform the following work will be included in the price bid for "Approach Inslope Reconstruction."

1) Strip and stockpile three inches of topsoil from the embankment and excavation areas.
2) Flatten the approach inslopes steeper than 4:1 to 8:1. The material used to flatten the slope will be compacted in accordance with Section 203.02 I of the Standard Specifications. When available the embankment material may be obtained within the R/W in locations approved by the engineer. Embankment not available within the R/W will need to be obtained from borrow. The contractor shall furnish the borrow. The cost to obtain the site and the borrow shall be included in the price bid for "Approach Inslope Reconstruction."
3) Replace the topsoil on both the excavation and embankment areas and seed with Class II seed mixture in accordance with Section 708.02 of the Standard Specifications.

Payment will be made for each approach inslope that is flattened. For example, if both inslopes of an approach are flattened, two units will be measured and paid for.

203 P02 FLATTEN DITCH BLOCK SLOPES: The slopes of the ditch blocks shall be flattened to 10:1. The embankment material required to flatten the slopes will be compacted in accordance with Section 203.02 I of the Standard Specifications. The topsoil shall be stripped from both the embankment and excavation areas, stockpiled, and replaced when the work is complete. Both areas shall be seeded with Class II mix. The excavation may be obtained within the right of way areas approved by the engineer. Only one unit will be measured and paid for per ditch block regardless if one or both slopes were flattened. The cost of excavation, compaction of embankment, stripping, replacing topsoil, and seeding will be incidental to the price bid for "Flatten Ditch Block Slopes" each.

704 P01 TRAFFIC CONTROL: Construction traffic control devices shall be in accordance with Standard D-704-24, Type U and Type T for flattening approach sideslope. If it becomes necessary to close a lane on mainline, a Type F sign layout as shown on Standard D-704-19 shall be used. All signs shall be removed during non-working hours and the flagging is the responsibility of the contractor. All costs for flagging and traffic control device placement and removal shall be included in the price bid for traffic control.

714 P01 CMP EXTENSIONS: The corrugated metal connecting bands for relay end sections and extensions of corrugated metal pipe shall be furnished by the contractor. The cost of the bands shall be included in the unit price bid for Corrugated Steel Pipe Culverts.

714 P02 SILTED PIPES: If the contractor encounters silted-in pipes, he will extend the pipes along the existing flow lines. The silted-in material will be removed 50 feet, unless otherwise directed by the engineer, from the ends of the extended pipe and used to flatten the approach inslopes. Removal of the silt will be incidental to "Approach Inslope Reconstruction."

714 P03 CENTERLINE PIPE EXTENSION: The embankment required to extend the centerline pipe at sta.13277+42.44 shall be included in the unit price bid for the pipe. The quantity of embankment required for this purpose has been estimated to be 40 CY.

The embankment for other centerline pipe to be extended is included in the price bid for "Borrow".

714 P04 PIPE CULVERTS: If an existing pipe end requires repair before the extension can be made, the contractor shall remove or straighten the damaged length of pipe to a point where the extension can be made. Regardless of the method used to prepare the existing pipe ends, the pay length will be measured from the point on the existing pipe where the repaired damage or removal begins to the end of the new extension. The pipe lengths as shown on the quantity sheet have been calculated assuming the contractor has removed the damaged ends. The cost of straightening existing pipe ends or removing them shall be included in the price bid for pipe culverts.

754 P01 EXISTING SIGNS: Existing signs will be reset as directed by the engineer. Cost to reset signs shall be included in the price bid for other items.

APPROACH SLOPE FLATTENING AND PIPE EXTENSIONS NOTE SHEET

302 P01 BLENDED BASE COURSE: The Blended Base Course shall consist of a uniform blend of Class 5 Aggregate, the salvaged aggregate base (shldr) and the existing base material. The estimated depth of the blended base is 14". The contractor shall place the Class 5 material on the roadway ahead of the blending operation. The blended base shall be laid in not more than 3" lifts and compacted in accordance with Section 302.04 E of the Standard Specs. Surface tolerance shall be in accordance with Section 302.04 G Type B of the Standard Specs. The unit price bid for "Trimming Base Course" by the SY shall include all costs to obtain the surface tolerance specified.

The Class 5 material will be measured and paid for by the ton of Class 5 material placed on the roadway. All costs for producing, hauling, placing, and compacting the Class 5 material shall be included in the unit price bid for "Aggregate Base Course-Class 5."

The unit price bid for "Blended Base Course" shall include all costs for sizing, blending, stockpiling on inslopes, placing the blended material on the roadway, and compacting the blended base. "

407 P01 RECYCLED HOT BITUMINOUS PAVEMENT - LARGE STONE MIX: The mixture shall be compacted to at least 92 percent of theoretical maximum density as determined by AASHTO T-209.

407 P02 The virgin gradation for the hot bituminous pavement-large stone mix shall meet the following gradation and physical requirements:

Sieve Size	Percent Passing
1"	100
¾"	86-100
½"	70-90
No. 4	33-55
No. 8	18-39
NO 30	6-27
No. 200	0-6.0

A minimum of 90% of the plus No. 4 material shall have one fractured face and 70% of the minus No. 4 material shall be produced by a mechanical crushing process. The maximum LA abrasion will be 40%. The maximum allowable shale content will be 5%.

408 P01 HOT BITUMINOUS MIX SUPPLIED: A quantity of 6000 ton of hot bituminous pavement - class 31 shall be loaded in state maintenance trucks at the plant site. The engineer and the contractor will coordinate so there is the least amount of disruption to the project activities. State maintenance forces will be responsible for all traffic control at their work site. All costs for providing the mix, including the asphalt cement, shall be included in the unit price bid for "hot bituminous mix supplied."

410 P01 MILLED MATERIAL: Any milled material remaining at the completion of the project shall be stockpiled at the NDDOT stockpile site at reference point 251.04 as directed by the engineer.

704 010 MAINTAINING ACCESS: The contractor will be responsible for providing access to all residential dwelling and business establishments adjacent to this project. Final details on location of access points and construction procedures shall be worked out with the engineer in the field prior to the start of the project.

704 P01 TRAFFIC CONTROL: The Traffic Control Devices List has been developed using the following layouts on the Standard Drawings for Traffic Control:

D-704-22, Layout Types K & L for construction trucks hauling material.
D-704-26, Layout Type Y for construction trucks hauling material.
D-704-30, Layout for windrow marking

704 P02 COORDINATION OF DETOURS: The detour required for this project utilizes ND 9 and ND 20. This detour is also required for project NHU-2-052(014)265 being constructed in Jamestown. Therefore to coordinate all phases of the detour the following conditions apply:

a) Signs and traffic control devices required for the detour have been included in both contracts.

b) The contractor for the project that initially requires the detour shall install the detour signs and devices.

c) That contractor is then responsible for maintaining the detour for the duration of need for all contracts. No extra compensation will be allowed. Any costs associated with an extended maintenance period shall be considered incidental.

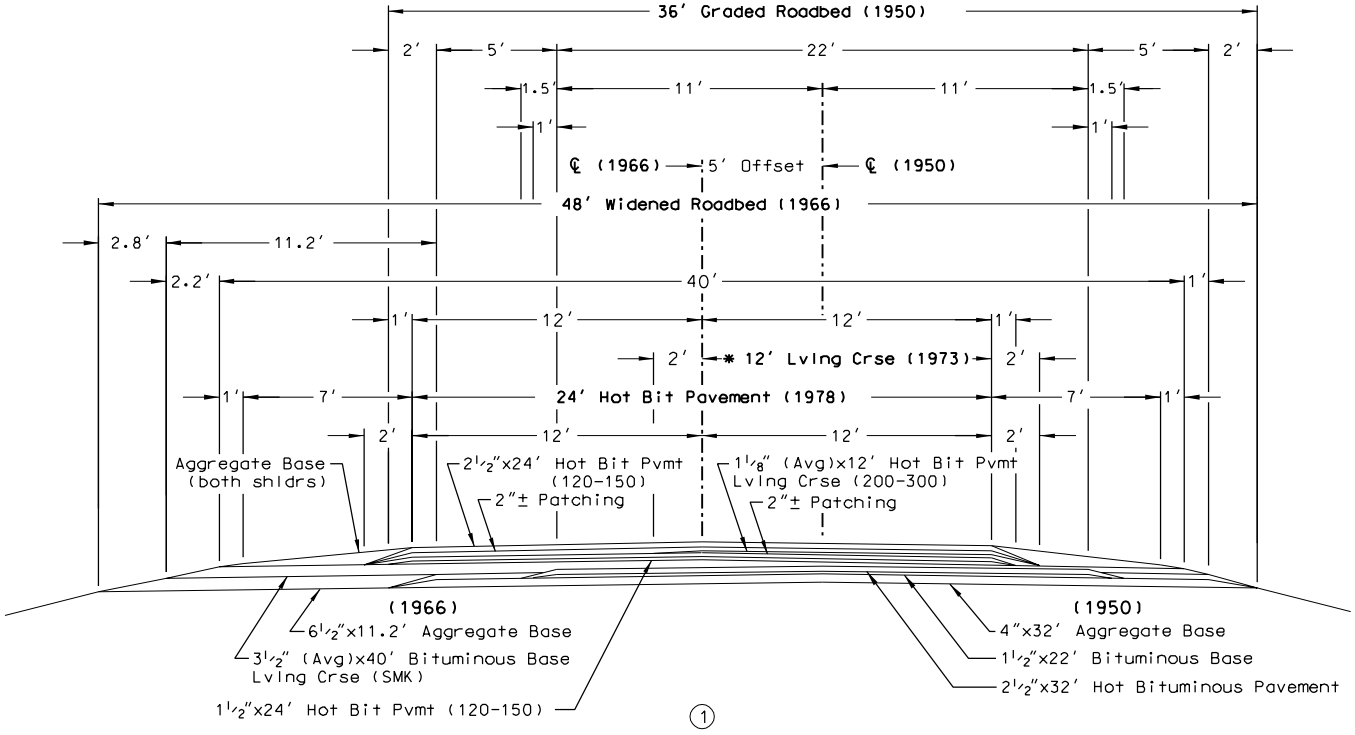
d) This contractor will then be responsible for removing the detour traffic control devices and signs and restoring traffic when the detour is no longer needed.

e) All traffic control signs and devices required for the detour will then be deleted from the contract for the remaining project. No payment will be made for any costs associated with the elimination of the items.

f) Contractor should make allowances in their bids for the above conditions.

NOTES

NSHEET4



①

* LEVELING COURSE (1973)

12928+08.44 to 12963+93.44
12987+93.44 to 13031+93.44
13034+93.44 to 13047+93.44
13050+43.44 to 13107+43.44
13126+93.44 to 13163+93.44
13166+93.44 to 13195+93.44
13197+93.44 to 13204+93.44
13212+93.44 to 13226+93.44
13246+93.44 to 13256+93.44
13288+93.44 to 13336+93.44

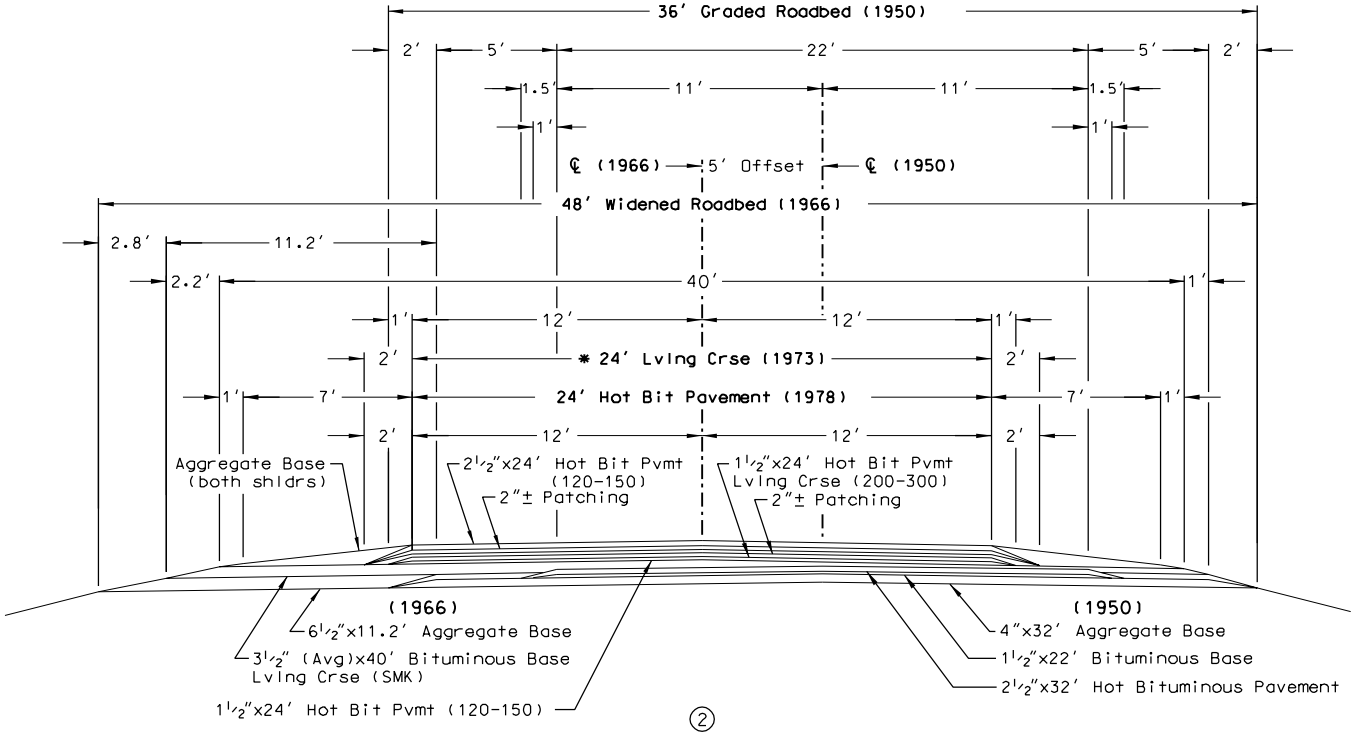
EXISTING SECTION

* 12' Leveling Course
(Southbound Lane)

TYPICO1R

A-6

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	12



②

* LEVELING COURSE (1973)

12963+93.44 to 12987+93.44
13031+93.44 to 13034+93.44
13047+93.44 to 13050+43.44
13163+93.44 to 13166+93.44
13195+93.44 to 13197+93.44
13204+93.44 to 13212+93.44

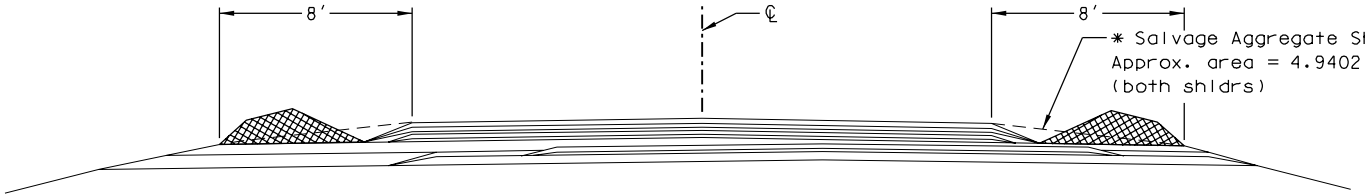
EXISTING SECTION

* 24' Leveling Course

TYPICO2R

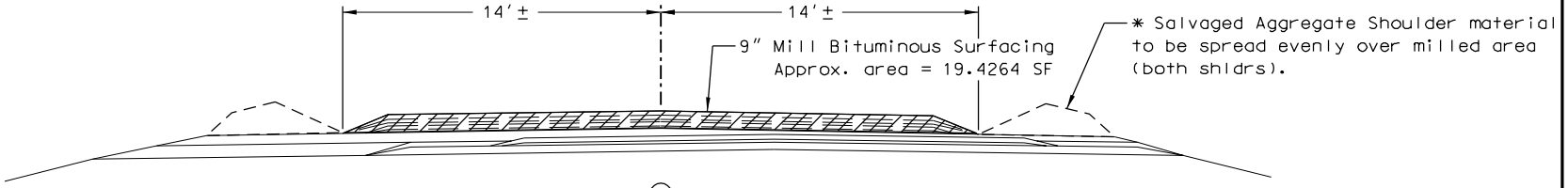
A-7

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	13



③

* All costs for moving the existing shoulder material off the bituminous slough and spreading the material over the milled area is included in the price bid for "Blended Base Course".



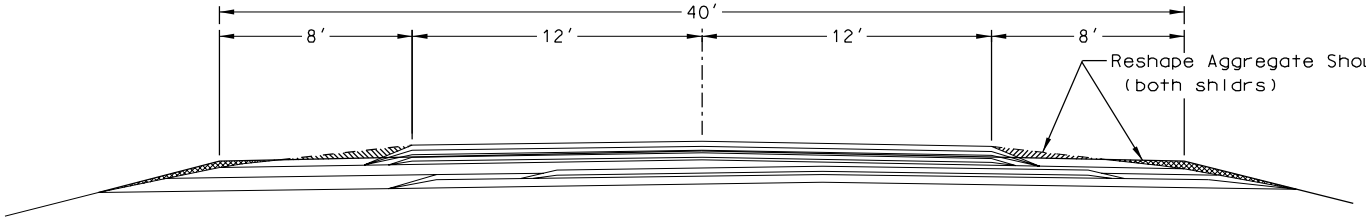
④

MILLED SECTION
12928+08.44 to 13178+88.00
13194+88.00 to 13336+93.44

TYPICO3R

A-8

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	15



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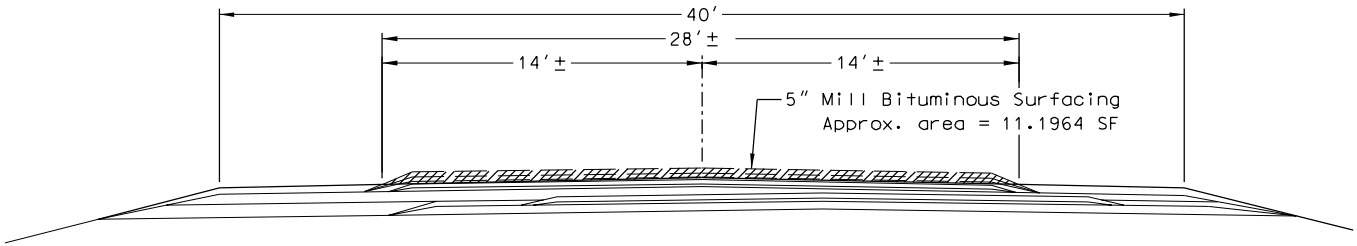


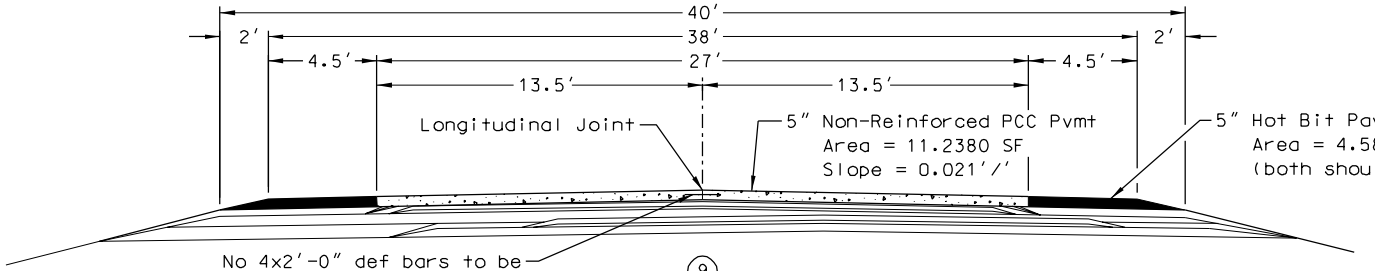
⑧

5" MILLED (TEST SECTION)

13178+88.00 TO 13194+88.00

TYPICO5R

A-9

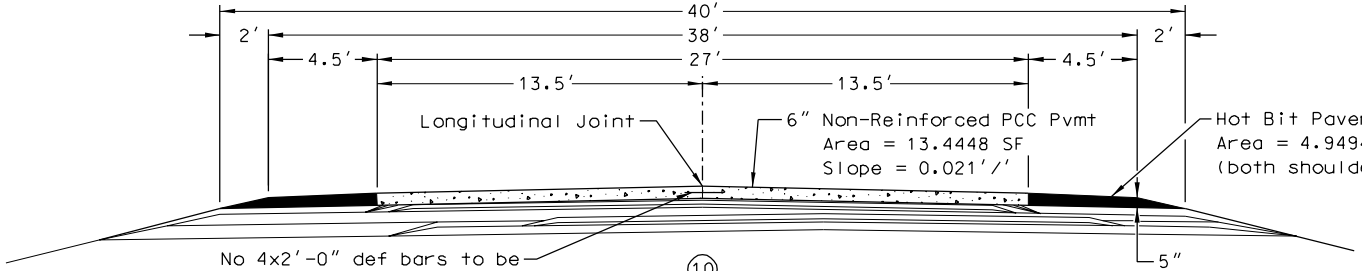


(9)

13178+88.00 TO 13183+88.00

PCC Thickness Transition 13183+88.00 TO 13184+38.00

Hot Bit Pavement (PCC Thickness Transition)
Area = 4.7647 SF
(both shoulders)

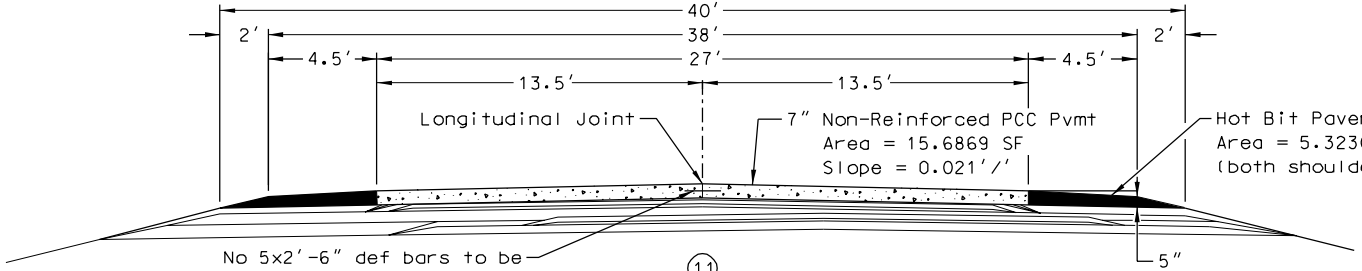


(10)

13184+38.00 TO 13189+38.00

PCC Thickness Transition 13189+38.00 TO 13189+88.00

Hot Bit Pavement (PCC Thickness Transition)
Area = 5.1362 SF
(both shoulders)



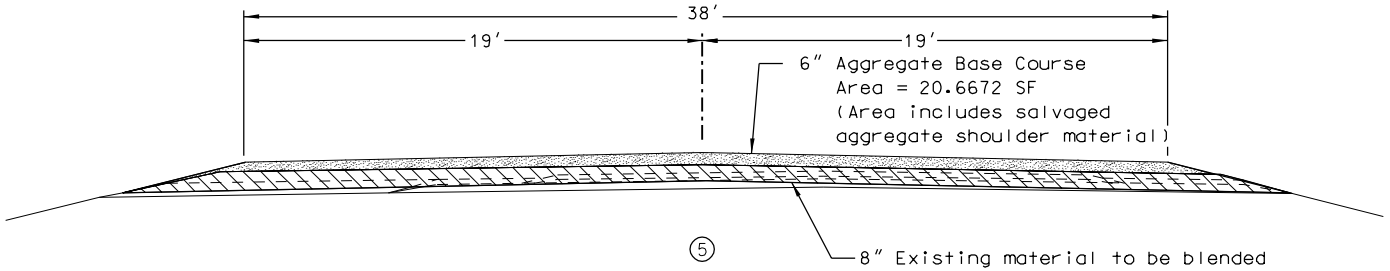
(11)

13189+88.00 TO 13194+88.00

PCC PAVEMENT (TEST SECTION)

TYPICO6

FHWA REGION	STATE	PROJECT NO.	SHEET NO.
8	ND	NH-2-052(012)244	14



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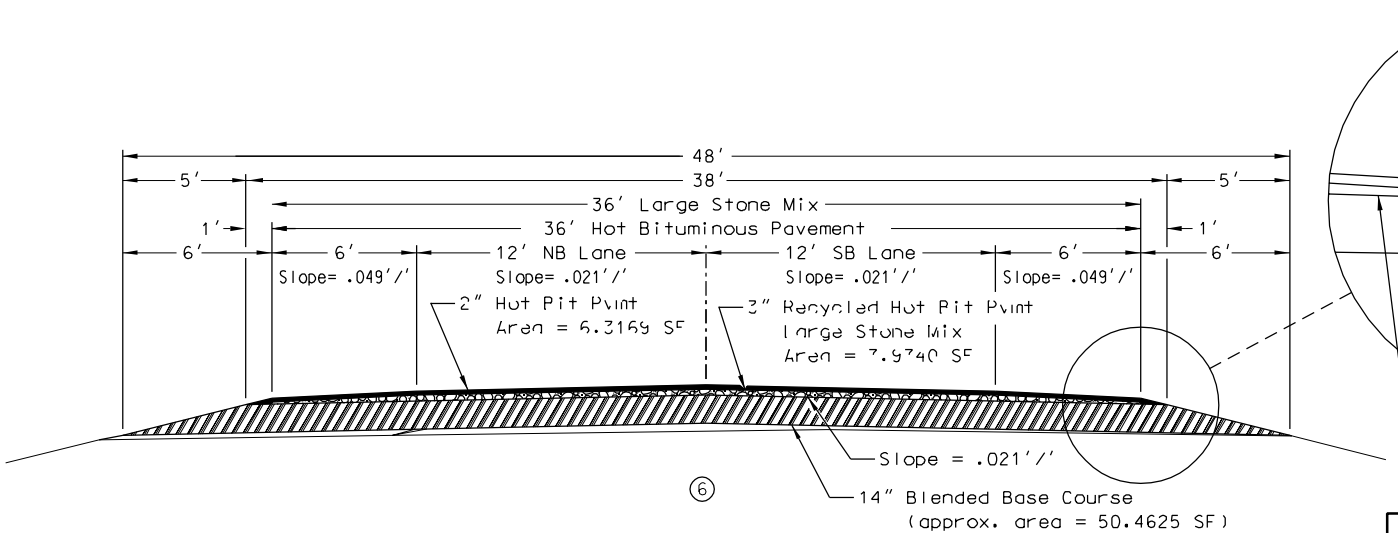
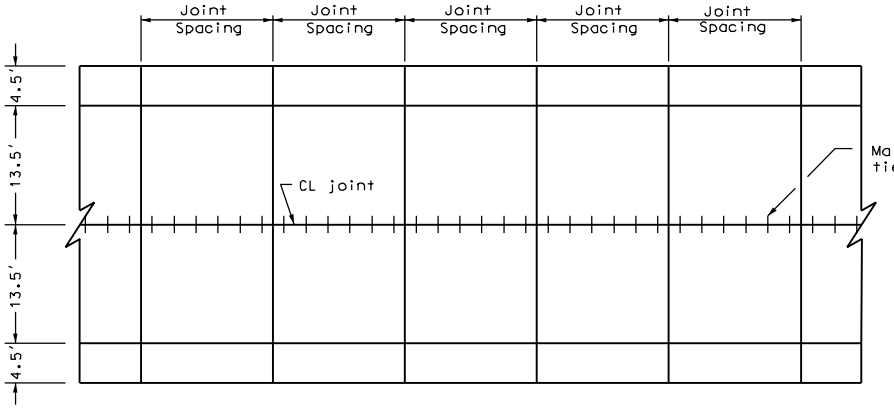


⑥

SURFACING SECTION
12928+08.44 to 13178+88.00
13194+88.00 to 13336+93.44

TYPICO4R

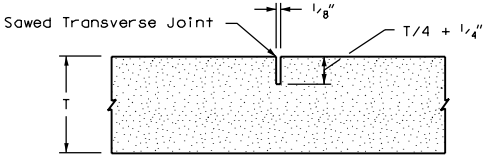
A-11



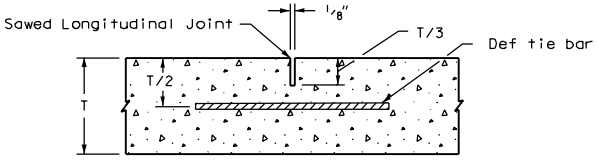
PLAN VIEW

Longitudinal Joint Tie Bars				
	Pavement Depth	Joint Spacing	Bar size	Bar spacing
Main Line CL	5"	12'	#4 x 2'-0"	3'-0"
	6"	13'	#4 x 2'-0"	3'-3"
	7"	14'	#5 x 2'-6"	3'-6"

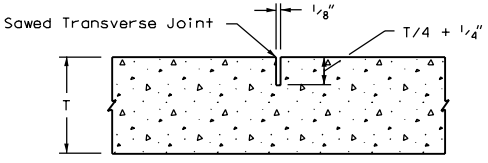
T = Pavement Depth



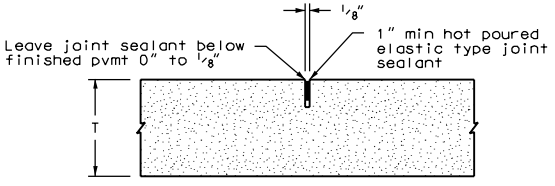
TRANSVERSE JOINT
(HBP Shldr)



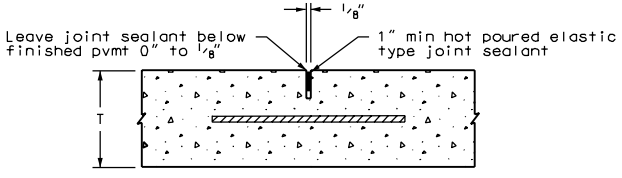
LONGITUDINAL JOINT
(PCC Pvmt)



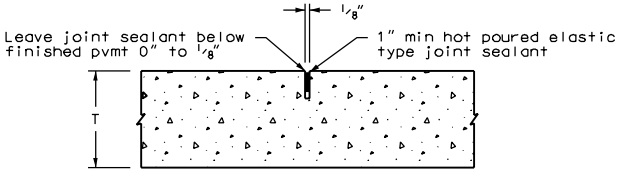
TRANSVERSE JOINT
(PCC Pvmt)



JOINT SEALING DETAIL
(Transverse Joint)



JOINT SEALING DETAIL
(Longitudinal Joint)



JOINT SEALING DETAIL
(Transverse Joint)

JOINT DETAILS

DJT.dgn

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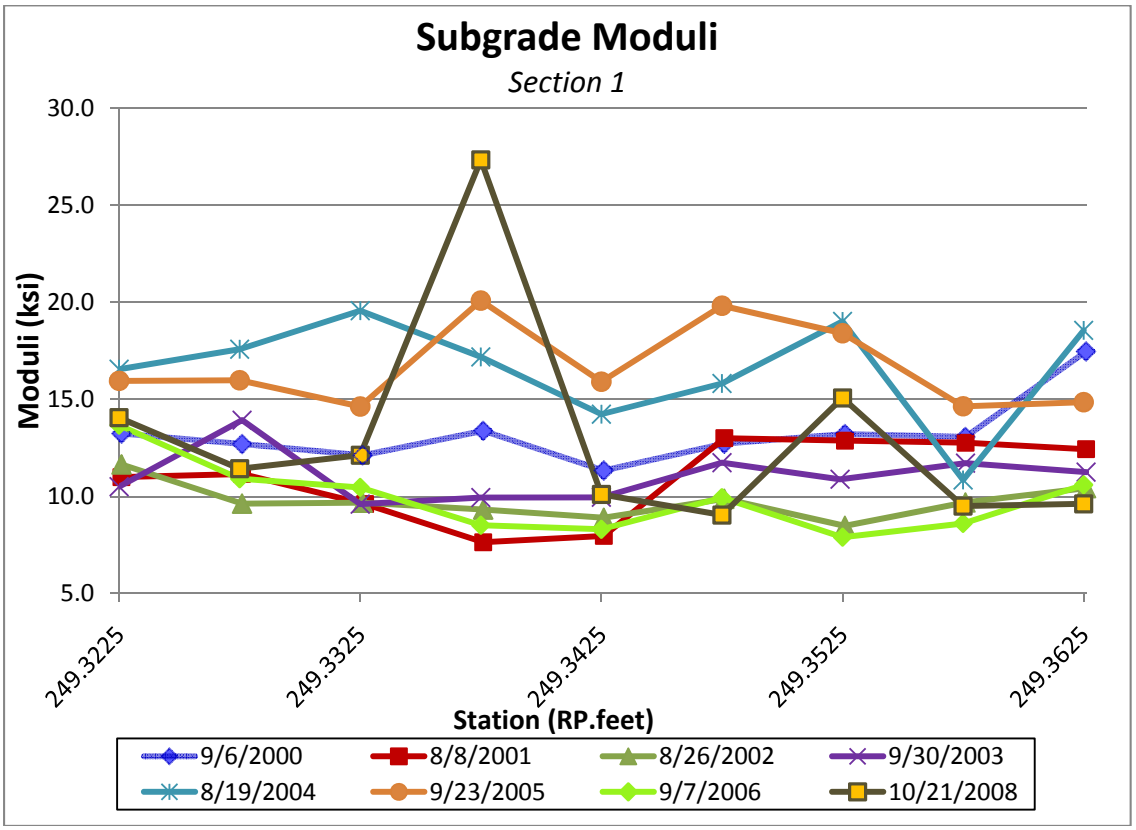
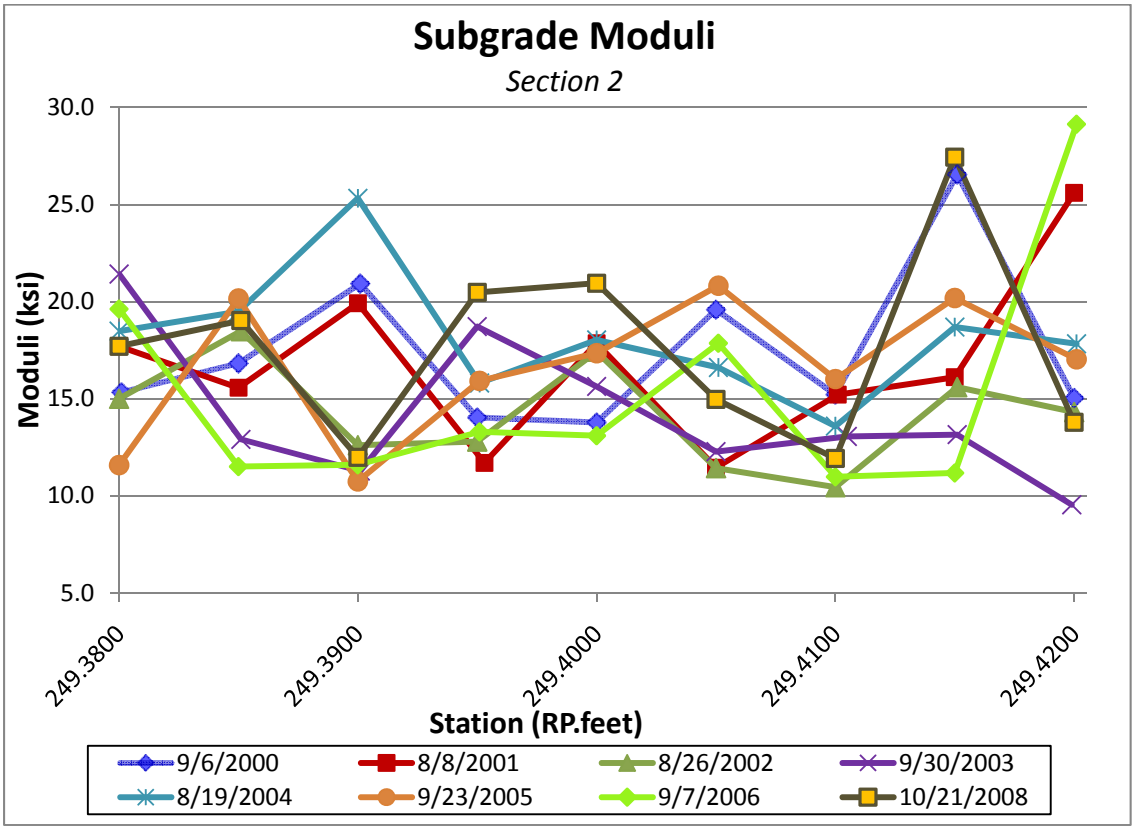
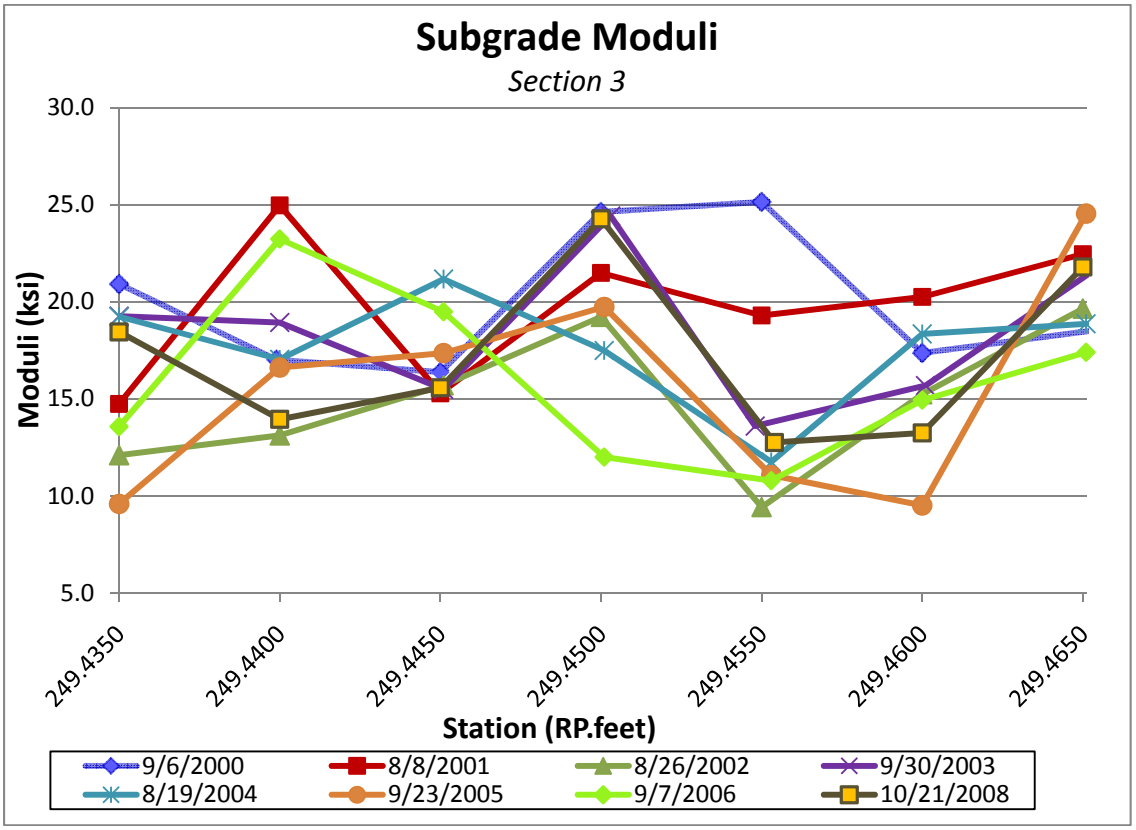
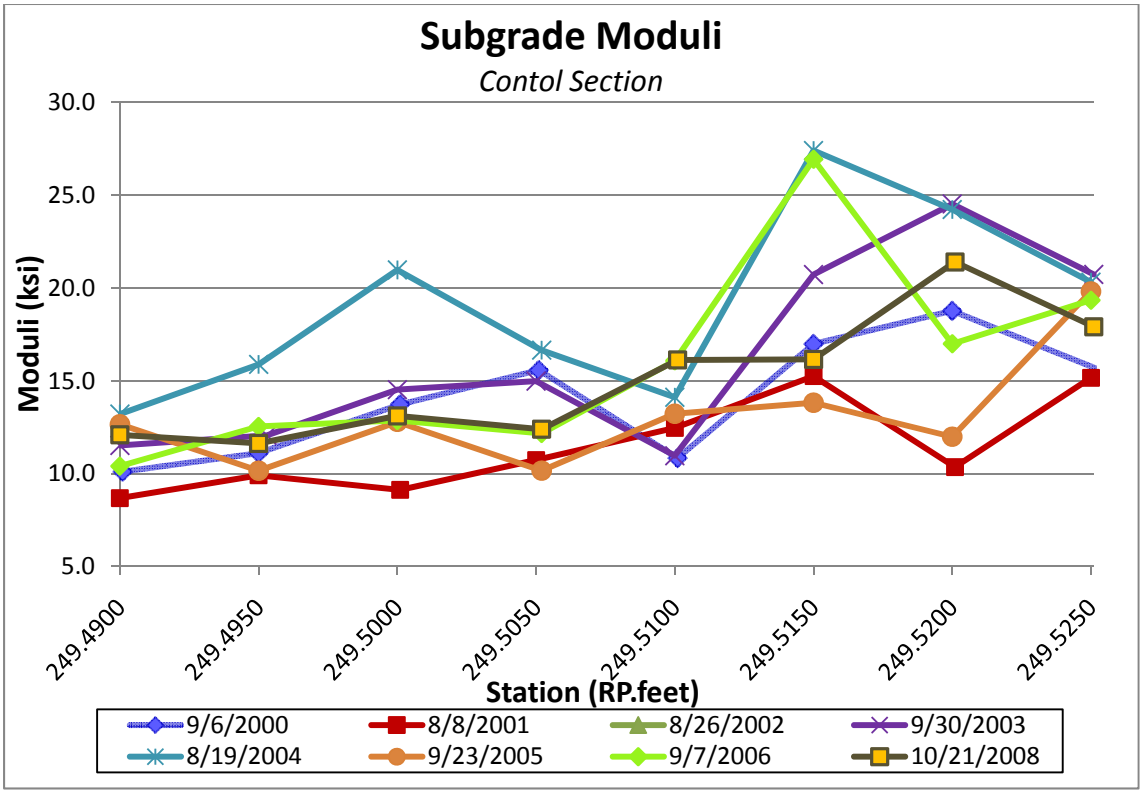
Appendix B

FWD Data


Subgrade Moduli
Section 1
Moduli (ksi)
30.0
25.0
20.0
15.0
10.0
5.0
249.3225
249.3325
249.3425
249.3525
249.3625
Station (RP.feet)
9/6/2000
8/8/2001
8/26/2002
9/30/2003
8/19/2004
9/23/2005
9/7/2006
10/21/2008


Subgrade Moduli
Section 2
Moduli (ksi)
30.0
25.0
20.0
15.0
10.0
5.0
249.3800
249.3900
249.4000
249.4100
249.4200
Station (RP.feet)
9/6/2000
8/8/2001
8/26/2002
9/30/2003
8/19/2004
9/23/2005
9/7/2006
10/21/2008


Subgrade Moduli
Section 3
30.0
25.0
20.0
15.0
10.0
5.0
Moduli (ksi)
249.4350
249.4400
249.4450
249.4500
249.4550
249.4600
249.4650
Station (RP.feet)
9/6/2000
8/8/2001
8/26/2002
9/30/2003
8/19/2004
9/23/2005
9/7/2006
10/21/2008


Subgrade Moduli
Contol Section
30.0
25.0
20.0
15.0
10.0
5.0
Moduli (ksi)
249.4900
249.4950
249.5000
249.5050
249.5100
249.5150
249.5200
249.5250
Station (RP.feet)
9/6/2000
8/8/2001
8/26/2002
9/30/2003
8/19/2004
9/23/2005
9/7/2006
10/21/2008