NOVACHIP- ULTRATHIN BONDED WEARING COURSE

Construction Report
October 2005

Wilson B. Brewer, Jr.
Project Manager
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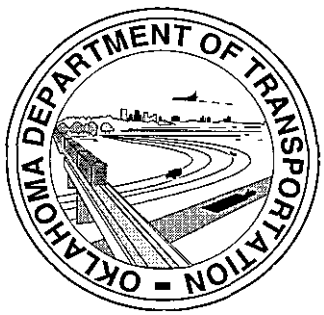
Engineering Manager



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16. ABSTRACT

Open Graded Friction Course (OGFC) pavement sheds water and provides good skid resistance. A problem with OGFC surfaces is short life before raveling begins. The Oklahoma Department of Transportation (ODOT) is testing several alternative surfaces. Surfaces being tested and compared include Novachip placed over new and old asphalt mixes, an OGFC and a Permeable Friction Course (PFC), each over new mixes. The report looks at construction techniques and compares each of the alternative surfaces.

Other state DOT's report that Novachip has a proven track record in the maintenance field. Uses include repairing of oxidized surfaces, extending life of the surface and restoring skid resistance. ODOT needs to know if the cost and performance of NovaChip is equal to/or better than OGFC, ODOT's standard surface treatment.

Based on ease of construction, NovaChip and OGFC were approximately equal, yet the requirement of the special NovaChip laydown machine makes the that product unique. The PFC also needed a special machine (at the plant) to introduce the fiber into the mix.

17. KEY WORDS	18. DISTRIBUTION STATEMENT
NovaChip, Permeable Friction Course, asphalt transfer machine, ultrathin bonded wearing course, membrane.	No restrictions. This publication is available from the office of Planning & Research Division, Oklahoma DOT.

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Unclassified	Unclassified	38	NA

SI (METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units

Symbol	When you know	Multiply by	Ti Find	Symbol
	LENGTH			
in	inches	25.40	millimeters	mm
ft	feet	0.3048	meters	m
yd	yards	0.9144	meters	m
mi	miles	1.609	kilometers	km
	AREA			
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.0929	square meters	m^2
yd	square yards	0.8361	square meters	m^2
ac	acres	0.4047	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
	VOLUME			
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.0283	cubic meters	m^3
yd^3	cubic feet	0.7645	cubic meters	m^3
	MASS			
oz	Ounces	28.35	grams	g
lb	pounds	0.4536	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
	TEMPERATURE (exact)			
°F	degrees Fahrenheit	(°F-32)/1.8	degrees Celsius	°C
	FORCE and PRESSURE or STRESS			
lbf	poundforce	4.448	Newtons	N
lbf/in^2	poundforce per square inch	6.895	kilopascals	kPa

Approximate Conversions from SI Units

Symbol	When you know	Multiply by	Ti Find	Symbol
	LENGTH			
mm	millimeters	0.0394	inches	in
m	meters	3.281	feet	ft
m	meters	1.094	yards	yd
km	kilometers	0.6124	miles	mi
	AREA			
mm^2	square millimeters	0.00155	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectares	2.471	acres	ac
km^2	square kilometers	0.3861	square miles	mi^2
	VOLUME			
mL	millileters	0.0338	fluid ounces	fl oz
L	liters	0.2642	gallons	gal
m^3	cubic meters	35.315	cubic feet	ft^3
m^3	cubic meters	1.308	cubic feet	yd^3
	MASS			
g	grams	0.0353	Ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams	1.1023	short tons (2000 lb)	T
	TEMPERATURE (exact)			
°C	degrees Celsius	9/5+32	degrees Fahrenheit	°F
	FORCE and PRESSURE or STRESS			
N	Newtons	0.2248	poundforce	lbf
kPa	kilopascals	0.1450	poundforce per square inch	lbf/in^2

NOVACHIP- ULTRATHIN BONED WEARING COURSE

CONSTRUCTION REPORT

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October 2005

TABLE OF CONTENTS

LIST OF FIGURES

INTRODUCTION

Open Graded Friction Course (OGFC) surfaces are placed on roadways for reasons associated with increased friction (traction) for motorist safety. In the past years, raveling problems typically occur in a short period of time (6 to 8 years) after the OGFC is placed on many of the roadways(1). The Oklahoma Department of Transportation (ODOT) is experimenting with several products and procedures to achieve longer life of the surface and provide the same level of safety as OGFC. NovaChip, trademark name, is a proprietary surface treatment which can be utilized to enhance skid properties, resist rutting, seal raveling in existing roads which have permeability issues, and reduce the water spray during rainy weather. NovaChip is being used on interstate roads in other states (2). NovaChip is an ultrathin bonded wearing surface with coarse aggregates in a hot mix placed over a special liquid asphalt membrane using a special machine to place the membrane without tire contact. In this project, an OGFC and an experimental Permeable Friction Course (PFC), placed on interstate roads, will have a performance comparison to the NovaChip surface.

BACKGROUND

Data regarding pavement conditions were recorded by ODOT's Pavement Management Branch of the Planning & Research Division. The data for stretches of roadway where the NovaChip was placed was recorded in 2001, before rehabilitation construction. Pavement condition ratings referred to in this report have a scale indices from 0 to 100, with 100 being the best. The indices are as follows. Ride is the measure of pavement smoothness in International Ride Index (IRI). Rutting is a measure of permanent wheel path deformation in asphalt concrete (AC) pavements. The functional index is a measure of non-load related distresses. The structural index is a measure of load-related distresses.

ODOT's Pavement Management branch had pavement condition summary sheets for the areas where the NovaChip project was located, based on data collected in the fall of 2001, the last data filed prior to rehabilitation construction. See Figures 1 & 2 for examples of distresses.

Figure 1 A small pop out and cracking.

Figure 2. Centerline raveling and cracking.

The NovaChip project in Custer county had a ride index of 99, a rut index of 100, a functional index of 97, and a structural index of 99. The surface material was constructed with a porous mix, which gave it a functional index of 97. A second NovaChip project in Washita county had a pavement condition summary sheet that was based on data collected in 2001. A high level of deformation was evident, as shown by the rut index of 62. Other indices were ride at 89, the functional index at 76 and the structural index at 87. See Appendix A for pavement management project reports.

The PFC project area in Custer county was rated in September of 2001. The ride index was the lowest of all the ratings with an index of 83. The other ratings were a rut index of 97, a functional index of 93 and a structural index of 99. Beckham county is where the OGFC is located. It had a rutting problem that was measured and recorded on the pavement condition summary sheets in September 2001. The rut index was 51, the ride index was 80, the functional index was 91 and the structural index was 98. See Appendix A for a complete detail report of ODOT's pavement management project reports.

OBJECTIVES

The objectives of this project are as follow:

- Document existing pavement conditions.
- Monitor construction, document specifications and construction procedures.
- Evaluate and assess NovaChip properties under field conditions.
- Compare performance of NovaChip to a PFC and an OGFC.
- Write reports 1) after construction and 2) after several years of monitoring.

INFORMATION ON PROJECTS

The Novachip surface was placed on two projects. The first Novachip project was number IM-40-3(066)069, located on Interstate 40 in Custer County. It begins at mile marker 69.19 and extends east to mile marker 76.75. This was a resurface job done for the purpose of enhancing skid properties and sealing the existing Type BH asphaltic concrete pavement surface. The second project was

number IMY-0040-2(127)045, on Interstate 40 in Washita County. It begins at mile marker 45.17 and extends east to mile marker 52.97. The project was a deep (1½ inch) coldmilling operation and included several full depth removal locations (underneath overpasses and through a lake area). The remaining part of the contract included placing three inches of Type S-3 PG 76-28 asphalt concrete, four inches of Type S-4 PG 76-28 asphalt and a $^3/_4$ inch layer of NovaChip as a wearing surface. See Appendix B for typical sections drawings.

The PFC project was located on Interstate 40 in Custer County, project number IMY-40-3(063)076. It begins at 83.63 and extends west to mile marker 86.27. Three inches of existing pavement was removed by coldmilling. It was then overlaid with six inches of Type S-3 PG 76-28 asphalt, two inches of Type S-5 PG 76-28 asphalt and $^3/_4$ inch layer of PFC as a wearing surface.

The standard OGFC project was located on Interstate 40 in Beckham County. The project number was IMY-40-2(115)033, it begins at mile marker 33.02 and extends east to mile marker 40. The project is a deep mill (2 inches)and overlay project with five inches of Type S-3 PG 76-28 asphalt, two inches of Type S-4 PG 76-28 asphalt and a $^3/_4$ inch layer OGFC as a wearing surface. See Appendix B for typical sections drawings.

SPECIFICATIONS

Specifications for each of the surfacing operations have similar characteristics. Mixing temperature for the NovaChip was between 320°F and 350°F. Compaction temperature was between 195°F and 330°F. Asphalt content was 5.0% of mix weight. See Appendix C, NovaChip Mix Design Sheet.

The PFC mixing temperature was 340° F to 345°F. This mix included polypropene fibers that were introduced and mixed into the PFC with a machine built by High Tech (a trademark name). The compaction temperature was 300°F. Its asphalt content was 6.0% +/- 0.4% of mix weight. See Appendix C, Special Provision, Bases and Surfaces.

The OGFC mixing temperature was between 275° F and 350° F, and the asphalt content was 5.7% +/- 0.3% of mix weight. See Appendix C for an ODOT Materials Division Mix Design Sheet. Immediately following placement of the OGFC material, the surface was rolled for 2 or 3 passes with the static steel wheel, self-propelled roller, according to ODOT specification number 405.04(I), (7).

NOVACHIP CONSTRUCTION

NovaChip's plant operation consisted of preparing a two bin mix, that included a $^{3}/_{4}$ inch gap graded aggregate processed by a dryer drum mixer. The aggregates were blended with a PG 76-28 OK liquid asphalt. The mix was then transported to the job site, after loading into dump trucks.

At the site, the asphalt transfer machine would receive the material, remix it and convey it into the front hopper of the Novachip machine. See Figure 3.

Figure 3. An asphalt transfer machine mixing NovaChip and placing it into the hopper.

The Novachip laydown machine moves the asphaltic concrete material to the back hopper, from where it is placed on the roadway. See Figure 4.

Figure 4. A NovaChip laydown machine.

This machine carried a special membrane tack with it that was sprayed on. After spraying, the spray sets up to form a waterproof membrane. The spraying operation takes place between the back wheels and the screed. This system allowed for the tack to meet the surface without the back wheels of the laydown machine tracking through it. See Figure 5.

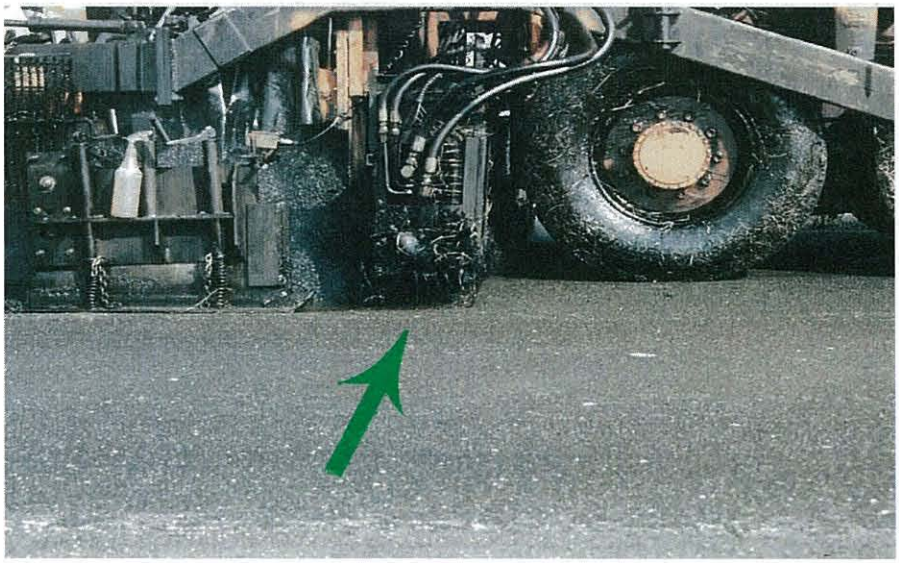

Figure 5. A special membrane tack sprayed in front of the screed.

The asphalt material was laid $^{7}/_{8}$ inch thick with a $^{1}/_{8}$ inch roll down, making it $^{3}/_{4}$ inch mat and resulting in an average weight of 72 lbs per sq ft. See Figure 6.

Figure 6. Placing a NovaChip mat.

Mat temperature was 285°F, measured behind the laydown machine. A steel wheel roller moved as close as 10ft behind. A second steel wheel roller followed the first. A rolling pattern was established although no density specification was used. On each project, the outside lanes were placed, then the inside lanes See Figure 7.

Figure 7. Connell Construction Company rolls Novachip.

INVESTIGATION

The Custer County NovaChip project was evaulated after the Field Division personnel's final inspection. Several isolated areas were noticed to have small amounts of segregation. These were located at the start of the project and made up less than 1% of the total surface area. The Custer County project was generally easy to construct. Work on the Washita County project resulted in no problems in placement. No segregation was found. The following observations were made on both projects during the investigation. Both projects had a minimum amount of traffic delay, a quiet ride, shed water and very little tire spray in wet weather.

The Custer County PFC project had some constructability issues. The fibers needed to be hand placed into the machine that introduced them into the drum plant. The yard where the plant was located had a noticeable amount of fiber on the ground. The asphalt concrete's drain down of liquid asphalt was low and its performance was excellent. The mix was stiffer than an OGFC in placement. The completed PFC surface has a quiet ride, sheds water and very little water spray in wet weather.

The OGFC is not a difficult mix to construct. It is laid at 69 lbs per sq ft. The Beckham County project had about 1% of segregation of the total surface area when completed. It also has a quiet ride, shed water and very little water spray in wet weather. The construction cost was less the other mixes.

CONCLUSION

All three treatments were similar in their constructability performance evaluation. Water spray during and after a rain storm was reduced and each of the surfaces provided good visibility. This results in an improved safety factor for the motoring public.

The NovaChip project in Custer County was constructed directly on the surface of an oxidized, well traveled, porous surface. The other surface courses were over new mixes. This makes the NovaChip project difficult to evaluate against any of the other projects in this study. Novachip laydown represents an added cost for the average contractor because it requires special equipment. Novachip has a good track record with other state Department of Transportation agencies as a maintenance surface repair treatment (8). All of the surfaces will be observed for at least three years and their performance will be compared. If an accurate life cycle cost analysis is to be done, it should take place after failure of the surfaces.

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3. Donald E. Watson, Kathryn Ann Moore, Kevin Williams, and L. Allen Cooley, Jr., "Refinement of New-Generation Open-Graded Friction Course Mix Design," Transportation Research Record, No. 1832, p. 78, October 2003.

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7. "Standard Specifications for Highway Construction," Oklahoma Department of Transportation, Sections 406 and 708, Oklahoma, August 1999.

8. Ted Keiter, "Novachip," Final Report, Commonwealth of Pennsylvania Department of Transportation , October 2002.

APPENDIX A

PAVEMENT MANAGEMENT PROJECT REPORTS

Pavement Management Project Report

Oklahoma Department of Transportation

September 2003

J/P Number: 20258(04)
Project Number: IMY-040-3(066)069
Proposed Let Date: 4/2004
Highway/County: I-40 in Custer County
Location: From MM 69 to 77
Control: 20-04, 0.00-7.59
Milemarkers: 69.16-76.75
Length: 7.59 mi

Original Construction: 1962 - I-40-3(12)069 - 4.5" Asphalt Concrete on 8" FABB & 6" Select

Treatments: 1979 - I-IR-40-3(40)069 - OGFC
1997 - 2" AC Type B, 3" AC Type A, 2" coldmilling & fabric

Pavement Condition Summary (Data Collected Fall 2001)

Condition Indices (0-100 scale with 100 being best):

Ride Index	99	A measure of pavement smoothness (IRI converted to 0-100 scale)
Rut Index	100	A measure of rutting in AC pavements
Functional Index	97	A measure of non-load related distresses
Structural Index	99	A measure of load-related distresses

Distresses:

Average IRI (in/mi)	64	<60=v. good;61-90=good;91-120=fair;120-170=poor;>170=v.poor
Average Rut Depth (in)	0.09	<0.15=good; 0.15-0.35=fair; >0.35=poor
Maximum Rut Depth (in)	0.15	<0.4=good; 0.4-1.0=fair; >1.0=poor
# of Low Sev. Transv. Cracks/0.01mi	0.2	<2.0=good; 2.0-4.0=fair; >4.0=poor
# of M/H Sev. Transv. Cracks/0.01 mi	0.0	<0.5=good; 0.5-1.0=fair; >1.0=poor
% Length w/ Low Sev. Allig. Crack	1%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ M/H Sev. Allig. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Low Sev. Misc. Crack	3%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ M/H Sev. Misc. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Raveling	0%	<5%=good; 5%-15%=fair; >15%=poor
% Area w/ AC Patching	0.2%	<0.6%=good; 0.6%-1.3%=fair; >1.3%=poor

Discussion:

There is little observable distress on this pavement. Ride is good and rutting is low.

Pavement Management Project Report
Oklahoma Department of Transportation

Jan. 24, 2003

J/P Number: 19574(04)
Project Number: IMY-40-2(127)045
Proposed Let Date: 02/2004
Highway/County: I-40 Washita County
Location: W of Clinton, MP 45 to 53
Control: 75-02, 3.18-11.01
Milemarkers: 45.17-53.00
Length: 7.83 mi
Type: Rural Interstate

Original Construction: 1960 - I-40-2(17)047 - 4.5" AC, 8" Soil Cement, 6" Select Borrow

Treatments: 1967 - IMC-75(12) - 1.5" Overlay
1977 - I-40-2(85)047 -AC Leveling Course and OGFC
1988 - IR-40-2(105)045 - 2" AC Type B w/ 1.25" Coldmill, Fabric & OGFC

Pavement Condition Summary (Data Collected 9/2001)

Condition Indices (0-100 scale with 100 being best):

Ride Index	89	A measure of pavement smoothness (IRI converted to 0-100 scale)
Rut Index	62	A measure of rutting in AC pavements
Functional Index	76	A measure of non-load related distresses
Structural Index	87	A measure of load-related distresses

Distresses:

Average IRI (in/mi)	86	<60=v. good;61-90=good;91-120=fair;120-170=poor;>170=v.poor
Average Rut Depth (in)	0.31	<0.15=good; 0.15-0.35=fair; >0.35=poor
Maximum Rut Depth (in)	0.51	<0.4=good; 0.4-1.0=fair; >1.0=poor
# of Low Sev. Transv. Cracks/0.01mi	0.4	<2.0=good; 2.0-4.0=fair; >4.0=poor
# of M/H Sev. Transv. Cracks/0.01 mi	0.6	<0.5=good; 0.5-1.0=fair; >1.0=poor
% Length w/ Low Sev. Allig. Crack	10%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ M/H Sev. Allig. Crack	0%	<5%=good; 5%-15%=falr; >15%=poor
% Length w/ Low Sev. Misc. Crack	35%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ M/H Sev. Misc. Crack	1%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Raveling	0%	<5%=good; 5%-15%=fair; >15%=poor
% Area w/ AC Patching	1.7%	<0.6%=good; 0.6%-1.3%=fair; >1.3%=poor

Discussion:

The predominant pavement distresses seen on this project are significant rutting, extensive miscellaneous (non-wheelpath) cracking and depressed thermal cracks that are beginning to reflect through the last overlay. There is also a significant amount of blade patching. Ride is good.

Pavement Management Project Report

Oklahoma Department of Transportation
June 22, 2005

J/P Number:
Project Number:
Proposed Let Date:
Highway/County: I-40 in Custer County
Location: From Milepost 83.63 to 86.27
Control & Distance: 20-04 from 14.76 to 17.11
Project Length: 2.35 miles

Original Construction: EB—1959—I-40-3(6)082- 4.5" AC on 8" Soil Cement Base
WB—1967—I-40-3(22)082—4.5" AC on 8" FABB

Treatments:

EB—1971—I-40-3(34)082 - 2" AC Overlay
EB & WB—1980—I-FI-40-3(49)077—3" AC Overlay w/ 2" Coldmilling
EB & WB (outside lanes only) - year unknown - Mill & Overlay (not recorded but seen in video)

Pavement Condition Summary (Data Collected Sept 2001)

Condition Indices (0-100 scale with 100 being best):

Ride Index	83	A measure of pavement smoothness (IRI converted to 0-100 scale)
Rut Index	97	A measure of rutting in AC pavements
Functional Index	93	A measure of non-load related distresses
Structural Index	99	A measure of load-related distresses

Distresses:

Average IRI (in/mi)	103	<60=v.good;61-94=good;95-119=fair;120-170=poor;>170=v.poor
Average Rut Depth (in)	0.11	<0.25=good; 0.25-0.50=fair; >0.50=poor
# of Low Sev. Transv. Cracks/0.01 mi	0.9	<2.0=good; 2.0-4.0=fair; >4.0=poor
# of Med/Hi Sev. Transv. Cracks/0.01 mi	0.0	<0.5=good; 0.5-1.0=fair; >1.0=poor
% Length w/ Low Sev. Allig. Crack	1%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ Med/Hi Sev. Allig. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Low Sev. Misc. Crack	1%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ Med/Hi Sev. Misc. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Raveling	0%	<5%=good; 5%-15%=fair; >15%=poor
% Area w/ AC Patching	0.0%	<0.6%=good; 0.6%-1.3%=fair; >1.3%=poor
Skid Number (3/2002)	37	<35=poor

Discussion:

This pavement has had a mill and overlay in the outside lane since 1980 that was not recorded. The primary distress seen in this pavement was poor skid.

Pavement Management Project Report

Oklahoma Department of Transportation
June 22, 2005

J/P Number:
Project Number:
Proposed Let Date:
Highway/County: I-40 in BeckhamCounty
Location: From Milepost 33.02 to 40
Control & Distance: 05-04 from 7.81 to 14.99
Project Length: 7.18 miles

Original Construction: 1971—I-40-2(19)032--4.5" AC on 8" FABB w/ 6" Lime Treat Subgrade

Treatments: 1985—IR-40-2(101)032 - 2" AC Overlay w/ fabric
Year Unknown—Mill and Overlay outside lanes only (seen in video)

Pavement Condition Summary (Data Collected Sept 2001)

Condition Indices (0-100 scale with 100 being best):

Ride Index	80	A measure of pavement smoothness (IRI converted to 0-100 scale)
Rut Index	51	A measure of rutting in AC pavements
Functional Index	91	A measure of non-load related distresses
Structural Index	98	A measure of load-related distresses

Distresses:

Average IRI (in/mi)	110	<60=v.good;61-94=good;95-119=fair;120-170=poor;>170=v.poor
Average Rut Depth (in)	0.38	<0.25=good; 0.25-0.50=fair; >0.50=poor
# of Low Sev. Transv. Cracks/0.01 mi	0.0	<2.0=good; 2.0-4.0=fair; >4.0=poor
# of Med/Hi Sev. Transv. Cracks/0.01 mi	0.5	<0.5=good; 0.5-1.0=fair; >1.0=poor
% Length w/ Low Sev. Allig. Crack	1%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ Med/Hi Sev. Allig. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Low Sev. Misc. Crack	1%	<10%=good; 10%-35%=fair; >35%=poor
% Length w/ Med/Hi Sev. Misc. Crack	0%	<5%=good; 5%-15%=fair; >15%=poor
% Length w/ Raveling	0%	<5%=good; 5%-15%=fair; >15%=poor
% Area w/ AC Patching	0.8%	<0.6%=good; 0.6%-1.3%=fair; >1.3%=poor
Skid Number (3/2002)	37	<35=poor

Discussion:

This pavement has had a mill and overlay in the outside lane since 1985 that was not recorded. The primary distresses seen in this pavement were moderate rutting, patching, depressed thermal cracks that were starting to reflect through the overlay in the outside lanes, and poor skid.

APPENDIX B

TYPICAL SECTION DRAWINGS

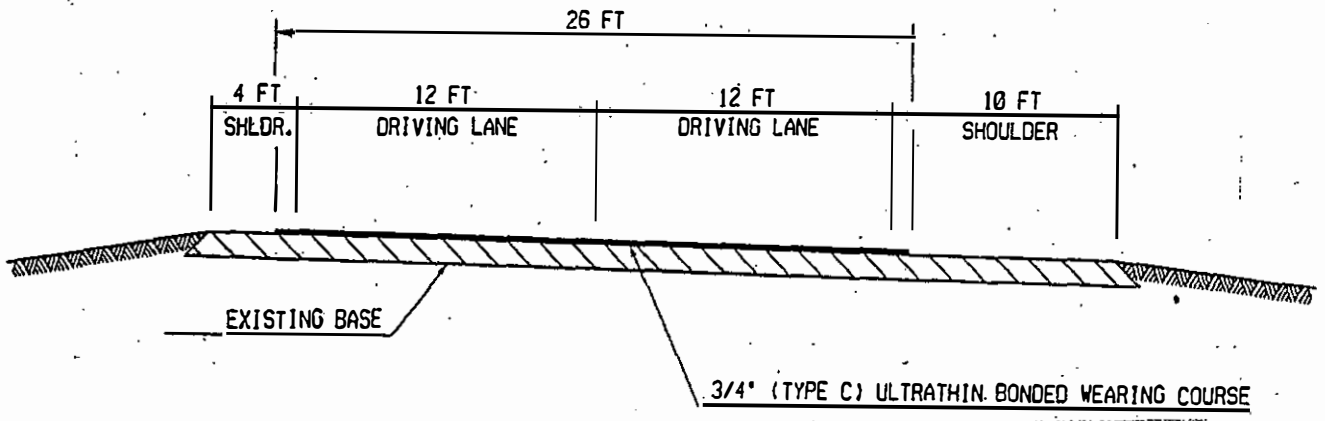
STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION

PLAN OF PROPOSED

ULTRATHIN BONDED WEARING COARSE

I-40

PROJECT NO. IMY-0040-3(066)069 JP#:20258(04)



TYPICAL SECTION NUMBER

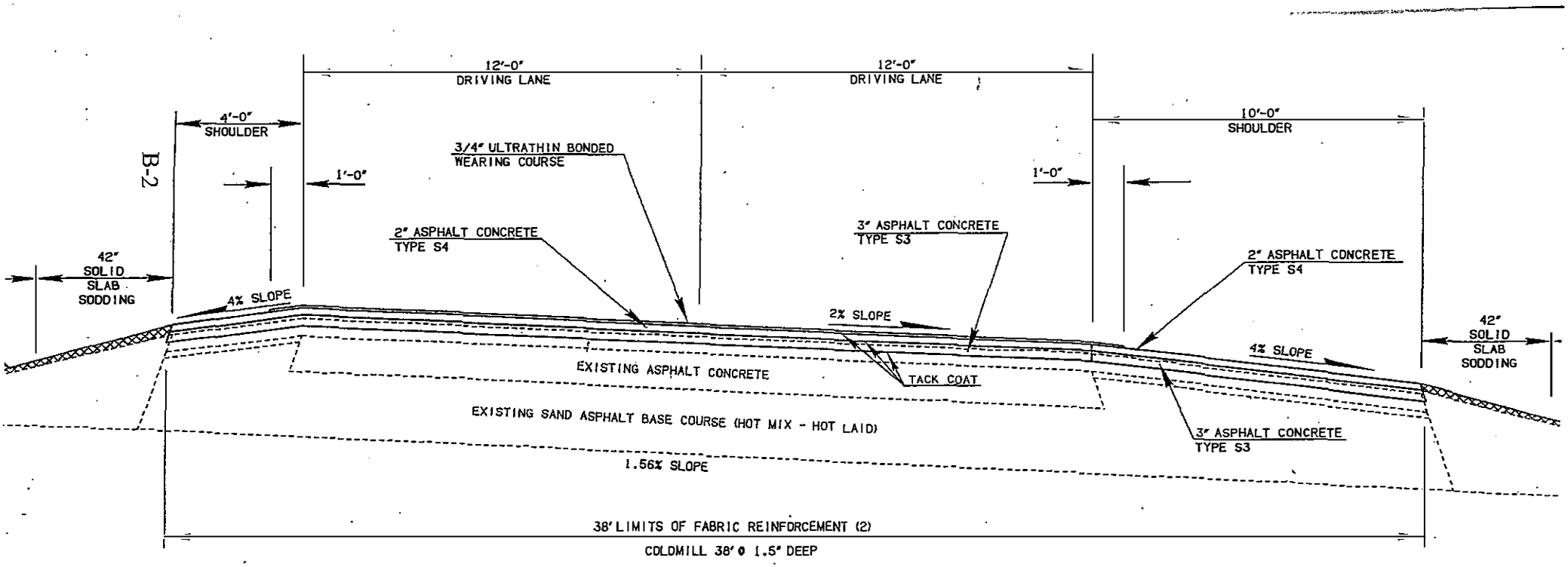
CUSTER COUNTY

STATE HIGHWAY

FEDERAL AID PROJECT NO. IMY-0040-2(127)045
INTERSTATE RESURFACING PLANS
INTERSTATE HIGHWAY NO. 40

WASHITA COUNTY

CONTROL SECTION NO. 40-75-02
STATE JOB NO. 19574(04)
NBIS NO. 16937 & 16936 , 14359 & 14358



HALF TYPICAL SECTION NO. 1

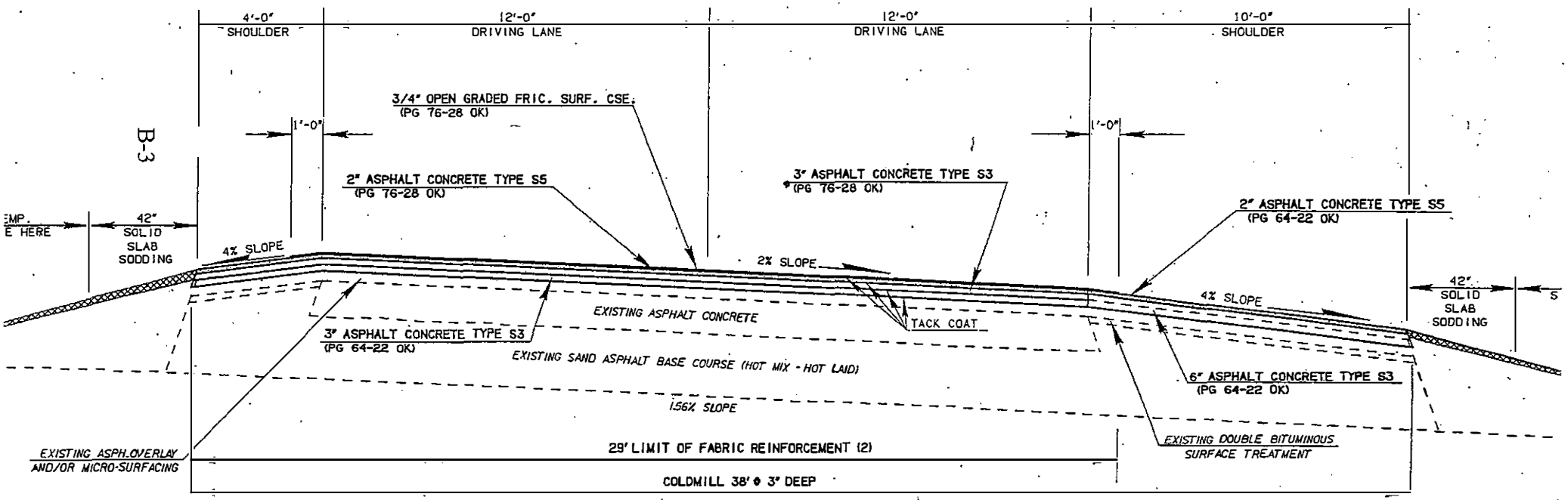
STA. 2428+00.00 TO STA. 2474+60.82 EASTBOUND
STA. 2475+92.38 TO STA. 2678+34.34 EASTBOUND
STA. 2689+65.67 TO STA. 2708+36.00 EASTBOUND
STA. 2691+65.67 TO STA. 2708+36.00 WESTBOUND
STA. 2718+66.00 TO STA. 2840+00.00 EAST & WEST BOUND

STATE HIGHWAY

FEDERAL AID PROJECT NO. IMY-40-3 (063) 076 IR
INTERSTATE RESURFACING PLANS
INTERSTASTE HIGHWAY NO. 40

CUSTER COUNTY

CONTROL SECTION NO. 40-20-04
STATE JOB NO. 12687(05)



B-3

HALF TYPICAL SECTION NO. 1

STA. 4477+30.00 TO STA. 4528+00.00 EASTBOUND
STA. 4477+30.00 TO STA. 4538+00.00 WESTBOUND
STA. 4562+00.00 TO STA. 4601+29.42 EASTBOUND
STA. 4562+00.00 TO STA. 4601+29.42 WESTBOUND

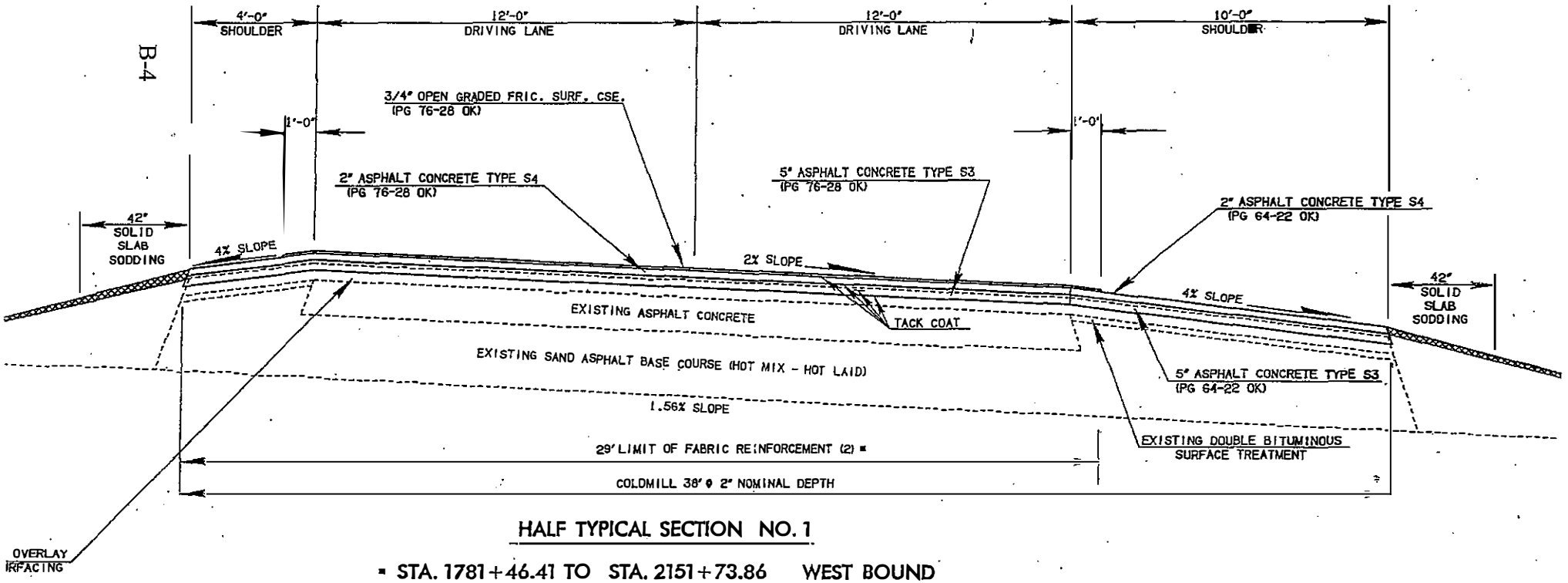
STATE HIGHWAY

FEDERAL AID PROJECT NO. IMY-40-2(115)033
OVERLAY, SURFACING, EROSION CONTROL & TRAFFIC PLANS
INTERSTATE HIGHWAY NO. 40

BECKHAM COUNTY

CONTROL SECTION NO. 40-05-01
STATE JOB NO. 10814(04)

B-4



HALF TYPICAL SECTION NO. 1

- STA. 1781+46.41 TO STA. 2151+73.86 WEST BOUND
- STA. 1779+94.75 TO STA. 2151+69.43 EAST BOUND

APPENDIX C

SPECIFICATIONS

NOVACHIP® MIX DESIGN SHEET

KOCH Pavement Solutions ...Longer Lasting Roads

KOCH MATERIALS LABORATORY 415 NORTH 10th STREET TERRE HAUTE, INDIANA 47807

PROJECT - I-40, Custer Co., Weatherford, OK
CONTRACTOR - Ritchie Paving
BINDER - PG 76-28 OK G_b = 1.025
SUPPLIER - KMC - Muskogee
SALESMAN - Joe Ridley

W.O. US.OK.NC.2004.0378
DATE COMPLETED: 19-Aug-04
ENGINEER: Stephen Fain
TECHNICAL CONTACT: Robert Lee
PHONE: (817) 504-7540

Mixing Temperature 320-350 °F
Compaction Temperature 290-310 °F
Asphalt Content Percentage 5.0 %
Add 0.5% Kling Beta 2912

AGGREGATE GRADATIONS - INDIVIDUAL AND BLEND

KMC Lab No.		2003.0696 C-Run MMM@S	2003.0701 5/8" MMM@S	2003.0702 Scrns. MMM@S		
% in Blend		27.0	65.0	8.0	100.0 Blend	Type C Specs
SIEVE						
1/2"	12.50 mm	98	95	100	96	75 - 100
3/8"	9.50 mm	94	65	100	75	50 - 80
#4	4.75 mm	76	7	94	33	25 - 38
#8	2.36 mm	57	3	66	22	19 - 27
#16	1.18 mm	42	2	46	16	15 - 23
#30	0.600 mm	30	2	31	12	10 - 18
#50	0.300 mm	22	2	21	9	8 - 13
#100	0.150 mm	16	1	14	6	6 - 10
#200	0.075 mm	11.4	1.1	9.4	4.5	4.0 - 6.0
Aggregate Gsb		2.596	2.600	2.586	2.598	
FAA (T 304-96, Method A)					47	40 min
Sand Equivalency (T176-86)		60		72	57	45 min
Meth. Blue (TP57-99)		9		5	8	10 max
F & E, 3:1 (D4791-95)		39	10		19	25 max
Micro-Deval (TP58-99)		7	12		10	18 max
LA. Abrasion (T96-99)		26	25		25	35 max
Crushed Face (ASTM D 5821)						
% Crushed, single face		100	100		100	95 min
% Crushed, two faces		100	100		100	85 min
Water Absorption (T255-92)		0.8	0.6	0.9	0.8	*Producers Historical Data

Draindown (T305-97) 0.01 %
Film Thickness = 11 microns

Tensile Strenth Ratio (T283) 105 %
Recommended min. emulsion shot rate = 0.21 gal/yd^2

The rates given for the application of polymer modified emulsion do not take existing surface conditions into account.
The rates need to be field adjusted to account for the field NovaChip mix properties and the existing pavement surface condition.

STATE OF OKLAHOMA
DEPARTMENT OF TRANSPORTATION
MATERIALS DIVISION

A.D. No. 007-008-004 PFC **Design No.** 3077-OAEST-04075
Project No. IMY-40-3(63)76IR 12687(05) **Hwy.** I-40 **ESAL** 30M+
Contractor Western Plains Construction Co. **Producer** Western Plains Const. Co.

MATERIAL	SOURCE	%USED
3/4" Chips	Dolese @ Richard Spur, OK(1601)	15
5/8" Chips	Dolese @ Cyril, OK(0801)	85
Cellulose Fibers	Hi-Tech Asphalt Solutions @ Mechanicsville, VA	
Anti-Strip Add.(AD-here HP+)	ARR-Maz @ Winter Haven, FL	
Asphalt Cement (PG76-28OK)	Koch @ Muskogee, OK	

Laboratory No.

Aggregate Percent Passing	3/4" Chips	5/8" Chips	Combined Aggregate	Job Formula	JMF Tolerance
3/4"	100	100	100	100	± 0
½"	37	90	82	82	± 7
3/8"	15	55	49	49	± 7
No. 4	5	7	7	7	± 7
No. 8	3	3	3	3	± 5
No. 16	2	2	2	2	± 4
No. 30	2	2	2	2	± 4
No. 50	1	2	2	2	± 4
No. 100	1	2	2	2	± 3
No. 200	1.1	1.3	1.3	1.3	± 2
%AC (PG76-28OK)				6.0	± 0.4
%Cellulose Fibers By Weight of Aggregate				0.3	
%Anti-Strip Add. By Weight of Asphalt Cement				0.5	
Mix Temperature @ discharge from Mixer, °F				325	± 20
Optimum Roadway Compaction Temperature, °F				305	

Tests on Asphalt Cement:

	Found	Required
Spec. Grav. @ 77 °F	1.0241	

Tests on Compressed Mixtures (at Design AC Content):

	SGC	Dens. % o Gmm	Dens. % of Gmm Req'd
Nini			
Ndes	50	80.7	78-82
Nmax			

Tests on Aggregates:

	Found	Required
F.A.A. %U	N/A	N/A
Sand Equivalent	N/A	N/A
L.A. Abrasion	25.3	40 Max.
Durability (DC)	79.4	40 Min.
IOC	0.76	
Insoluble Residue	51.6	40 Min.
Fractured Faces	100/100	75/75 Min.
Gse	2.689	
Gsb	2.656	
Specimen Wt.	3850	

Tests on Compressed Mixtures:

Percent Asphalt	Gmb	Gmm	Dens. % of Gmm	Dens. % of Req'd of Gmm	V.M.A. (%)	V.M.A. (Min.%)	%VFA	%VFA Req'd	%DP	%DP Req'd
5.5	1.970	2.469	79.8		29.9		32.5		0.25	
6.0	1.978	2.450	80.7	78-82	30.0		35.8		0.23	
6.5	2.008	2.432	82.6		29.3		40.5		0.21	

Mix Layer Depth: < 4"
Compacted Wt. 91.7 lbs./sq.yd./1" thickness
QA/QC Project: Tolerances shall be governed by PWL SP 411-9QA(a-y)99 Rev. 10/10/03.
Drain Down 0.02 (Required: 0.2 Max.)

MEETS SPECIFICATION REQUIREMENTS for 708-3(a-g)99 Rev. 2/4/02
708-10(a-c)99 Rev. 9/26/02

OKLAHOMA DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISIONS FOR
PLANT MIX BITUMINOUS BASES AND SURFACES

These Special Provisions revise, amend and where in conflict, supersede applicable sections of the 1999 Standard Specifications for Highway Construction, English and Metric, as applicable. Units of measurement are provided in the subsections in both English and Metric equivalents. The units applicable for this project will be those specified in the project plans.

708.02. MINERAL AGGREGATE. *(Add PFC column in Table 1 as follows:)*

TABLE 1
PHYSICAL PROPERTIES OF AGGREGATES

Test	PFC
L.A Abrasion(a) , % wear, maximum	30
Sand Equivalent(b), % minimum	
less than 3 Million ESALs	40
3 Million ESALs to 30 Million ESALs	45
greater than 30 Million ESALs	50
Mechanically Fractured Faces(b,c,j), % minimum	100/95
Aggregate Durability Index(a), minimum	40
Insoluble Residue(d,e), % minimum	40
Micro-Deval (a), % wear, maximum	25
Flat or Elongated Pieces(b,c,f), % maximum	10
Natural Sand and Gravel(b), % maximum	0
Clay Balls and Friable Particles(g), % maximum	0
Soft Particles(a), % maximum	5
Sticks or Roots(a), % maximum	0

(a) Applies to each source except as noted.
(b) Applies to the combined aggregate except as noted.

(c) Applies to the aggregate retained on the No.4 (4.75mm) sieve
(d) Applies to the combined coarse aggregate.
(e) Applies to the coarse aggregate used in the surface course. Does not apply to shoulders and temporary detours.
(f) A flat piece is one in which the maximum width is greater than 5 times the maximum thickness. An elongated piece is one in which the maximum length is greater than 5 times the maximum width.
(g) Applies to the combined aggregate. Provided the maximum for the combined aggregate is not exceeded, a maximum 1.5 percent will be allowed for any one source.
(j) In the requirement format "xx/yy", "xx" denotes the percentage of coarse aggregate requiring one fractured face and "yy" denotes the percentage of coarse aggregate requiring 2 fractured faces.
(l) Regardless of the actual design life of the roadway, the design ESALs are based on 20 years.

(a) Coarse Aggregate. (Add the following:) The coarse aggregate for PFC shall be that part of the aggregate retained on the No.8 (2.36mm) sieve and shall consist of clean, tough, durable particles.

(b) Fine Aggregate. (Add the following:) No fine aggregate shall be used in the permeable friction course. Fine aggregate is defined as aggregate passing the No.8 (2.36mm) sieve and consisting of hard, durable grains of natural sand, crushed stone, stone dust, crushed gravel, mine chat or jig-sand or any combination of these materials.

708.04. COMPOSITION OF MIXTURES. *(Change as follows:)*

(a) Asphalt Mix Design and Initial Job-Mix Formula. The PFC mix design and initial job-mix formula are the responsibility of the Contractor and shall be submitted to the Materials Division for review. The review of the proposed mix design will be to determine that the mix meets the design criteria.

The Contractor shall furnish one mix design for each specific PFC mixture listed on the plans or in the Contract. The mix design shall be prepared in an approved laboratory of the Contractor's choice. A request for laboratory approval may be made either by a Contractor or a Laboratory. Approval will be according to the Materials Division Policy for Asphalt Mix Design Laboratories. Mix designs will not be approved for use until the Contractor submits an acceptance letter stating acceptance status, project number and mix design designation, or signs and returns the mix design to the Materials Engineer.

The initial job-mix formula shall meet the requirements of tables 5E and 6E. The contractor shall prepare a trial mixture.

If the trial mixture, prepared at the initial job-mix formula proportions, fails to meet the requirements of Tables 5E and 6E, the Contractor may propose changes to the job-mix formula. If the changes result in a mixture meeting these Specifications, the job-mix formula will be adjusted accordingly.

The job-mix formula shall establish a single percentage of aggregate passing each required sieve, a single percentage of asphalt to be contained in the mixture, and a single temperature of the mixture at point of discharge from the plant.

The job-mix formula with the allowable tolerances shown in Table 7 shall establish the Specification limits for each mixture. The aggregate gradation shall not exceed the broad range given in table 5E.

(c) Recycled Bituminous Pavements. (Delete and replace as follows:)
No reclaimed asphalt pavement shall be used in the permeable friction course.

TABLE 5E
PFC MIXTURE GRADATION AND BINDER CRITERIA

(Percent Passing)

3/4" (19.0mm)	100
1/2" (12.5mm)	80 - 100
3/8" (9.5mm)	35 - 60
No. 4 (4.75mm)	1 - 20
No. 8 (2.36mm)	1 - 10
No. 200 (0.075mm)	1 - 4
Binder Content, % of mix weight	6.0 - 7.0
Cellulose Fiber Content, % of mix weight	0.2 - 0.5
Anti-Stripping Additive, % of binder weight	0.5

TABLE 6E
PROPERTIES OF LABORATORY MOLDED SPECIMENS

Mixture Property	PFC Design Requirements	PFC Field Requirements
Drain-down	< 0.20 %	-
Lab-Molded Density (a)	80	78 - 82

(a) PFC specimens shall be molded on a Superpave gyratory compactor at N = 50 gyrations. Due to the inherently high air void content of PFC mixtures, the CoreLok™ apparatus according to OHD L-45 must be used to determine G_{mb} instead of the OHD L-14 method.

708.05. TOLERANCES. *(Add PFC column to Table 7:)*

TABLE 7
RANGE OF TOLERANCES FOR PFC MIXTURES

Sieve Size	Percent Passing
No.4 (4.75mm) & larger	± 7
No.8 (2.36mm)	± 5
No.200 (0.075mm)	± 2
Asphalt Cement	± 0.4(a)
Temp. of mix as discharged from mixer, °F (°C)	± 20 (± 10)

(a) The tolerance shown for asphalt content is for individual samples. The average asphalt content by OHD L-26 shall be within ± 0.2 percent of the job-mix formula.

708.07. SAMPLING AND TESTING FOR PFC.

(a) Methods. Sampling and testing shall be done in accordance with AASHTO methods, except as noted below:

1. ***Sampling and Testing Aggregates:***

Sampling	T 2
Sieve Analysis	T 27
Material Passing No.200 (0.075 mm) Sieve	T 11
Los Angeles Abrasion	T 96
Mud, Clay Balls, Sand Clusters, Sticks and Roots, Retained on No. 4 (4.75 mm) Sieve	OHD L-9
Fractured Faces	OHD L-18
Flat or Elongated Particles in Coarse Aggregate	ASTM D4791
Sand Equivalent (Clay Content)	T 176
Aggregate Durability Index	T 210
Insoluble Residue	OHD L-25
Soft Particles	OHD L-38

2. ***Sampling and Testing Bituminous Mixtures:***

Mechanical Analysis of Extracted Aggregate	T 30
Sampling(a)	T 168
Bitumen Content	OHD L-26

Maximum Specific Gravity of Bituminous Paving Mixtures	T 209
Preparation and Density of Hot Mix Asphalt Specimens by SHRP Gyratory Compactor(b)(c)	T 312
Determination of Draindown Characteristics In Uncompacted Asphalt Mixtures	T 305
Determining the Specific Gravity and Unit Weight of Compacted Bituminous Mixtures Using the CoreLok™ Apparatus	OHD L-45

(a) The sample size of compacted bituminous pavement shall be in accordance with T 168.
(b) Lab molded specimens shall be compacted to N = 50 gyrations to determine the density, % of G_{mm}. All reported values shall be the average of 2 specimens.
(c) Design mixtures shall be mixed at 325°F (163°C), aged at 300°F (149°C) for a minimum of 2 hours and a maximum of 4 hours, and compacted at 300°F (149°C). Field samples shall be compacted at 300°F(149°C). No aging period is required for field samples, but they should be heated for a minimum of 2 hours to completely dry the sample and to ensure that the sample has stabilized at 300°F(149°C).

3. ***Testing Asphalt Materials***

Performance Graded Asphalt Binder	MP 1
Accelerated Aging of Asphalt Binder Using a Pressure Aging Vessel	PP 1
Creep Stiffness by Bending Beam Rheometer	TP 1
Rheological Properties by Dynamic Shear Rheometer	TP 5
Grading or Verifying Asphalt Binder	PP 6
Solubility in Trichloroethylene	T 44
Flash and Fire Points by Cleveland Open Cup	T 48
Water	T 55
Rolling Thin Film Oven Test	T 240
Specific Gravity by Pycnometer	T 228

stormy; and when the wind or other conditions prevent proper leveling and consolidation.

Aggregate stockpiles must be reasonably dry so that drum mixing will drive out all remaining moisture.

(g) **Spreading and Finishing.** Prior to placing PFC, clean all foreign matter from the surface of the existing roadbed. The temperature of the mixture for placement on the road shall be 300 ± 25°F.

The PFC shall not be windrowed prior to spreading and finishing. A Materials Transfer Device or Materials Transfer Vehicle (MTD/MTV) shall be used for placement of the PFC. At the Engineer's discretion, isolated portions of a project may be exempted from use of the MTD/MTV.

The material shall be continuously remixed or reblended either internally in the transfer device, in a paver hopper insert, or in the paver's hopper. Remixing/reblending shall be accomplished by using remixing augers or paddles capable of continuously blending the PFC.

The MTD/MTV, haul units, and the paver shall work together to provide a continuous, uniform, segregation-free flow of material. The number of haul units, speed of the paver, plant production rate, and speed of the MTD/MTV shall be coordinated to avoid stop and go operations. The wings of the paver/receiving hopper shall not be raised (dumped) at any time during the paving operation.

If a MTD/MTV unit malfunctions during laydown operations, the Contractor may continue until any PFC in transit or stored in a silo has been laid and until such time as there is sufficient PFC placed to maintain traffic in a safe manner. Laydown operations shall cease afterward, until the equipment is operational.

Any MTD/MTV unit which exceeds 20,000 pounds per axle will be allowed to cross bridges in good condition, provided the unit's hopper is substantially empty, the vehicle travels at crawl speed, and the wheels on the vehicle travel as close as possible to the underlying beam lines. For bridges in poor condition or posted for load limits, the Engineer will consult Bridge Division to determine if any additional limitations are necessary, such as transporting the unit on a vehicle with more axles to distribute the load.

The mat shall be free from segregation, non-uniform texture, bleeding or fat spats, and cracking.

(h) **Joints.** The location of the longitudinal joint shall be on the lane lines, and offset from the underlying joint a minimum of 3 inches. All construction joints shall be tight, smooth, butt-type joints.

(i) **Compaction.** Immediately following placement of the PFC material, roll the surface with 2-3 passes of a static (non-vibratory) steel-wheeled, self-propelled roller of such weight as approved by the Engineer.

Finish the surface so that it is smooth and true to the dimensions shown on the Plans. Immediately correct any low or defective areas by removing them, replacing them with new material, and compacting them to conform to the remainder of the pavement. Such corrective work shall be done at the expense of the Contractor.

Trucks and all other traffic shall not be permitted on the finished PFC pavement until the surface temperature is within 10°F of ambient temperature or two hours time has elapsed from final rolling.

406.05. METHOD OF MEASUREMENT.

Permeable Friction Course, including aggregate, liquid asphalt, cellulose fiber, and other ingredients as specified in the job-mix formula - will be measured by the ton of combined mixture.

Tack Coat will be measured and paid for in accordance with Section 407.

406.06. BASIS OF PAYMENT.

Accepted quantities of Permeable Friction Course measured, as provided above, will be paid for at the contract unit price as follows:.

PERMEABLE FRICTION COURSE.....TON

Such payment shall be full compensation for furnishing all materials, equipment, labor and incidentals to complete the work as specified.

A.D. No. 007-015-003 | Open Graded Friction Course | **Design No.** 3016-OAEST-03057

Project No. IMY-40-2(115)033 10814(04) **Hwy.** I-40 **Avg. Daily Traffic** 30M+

Contractor: Cornell Construction Co. Inc. **Producer** Cornell Construction Co. Inc.

MATERIAL	SOURCE	% USED
"D" Rock	Martin-Marietta Matl's @ Snyder, OK (3802)	40
Shot	The Dolese Co. @ Cooperton, OK (3801)	25
3/8" Chips	The Dolese Co. @ Cooperton, OK (3801)	35
Anti-Strip Add.(Kling Beta 2912)	Akzo-Nobel @ Waco, TX	
Asphalt Cement PG76-28OK	Koch @ Muskogee, Okla.	

Laboratory No.

Aggregate Percent Passing	"D" Rock	Shot	3/8" Chips	Combined Aggregate	Job Formula	JMF Tolerance
1/2"	100		100	100	100	±0
3/8"	87	100	97	94	94	±7
No. 4	29	85	15	38	38	±7
No. 10	3	8	3	4	4	±4
No. 200	1.0	1.7	1.5	1.3	1.3	±2
% Asphalt Cement PG76-28OK					5.7	±0.3
Anti-Strip additive by weight of Asphalt Cement, %					0.5	
Mix Temperature @ discharge from Mixer, °F					290	±20
Optimum Roadway Compaction Temperature, °F						

Tests on Asphalt Cement:

	Found	Required
Abs. Visc. @ 140°F		
Kin. Visc. @ 275°F		
Spec. Grav. @ 77°F	1.0199	

Tests on Aggregates:

	Found	Required
Sand Equivalent	91	45 Min.
L.A. Abrasion % Wear	28.7	30 Max.
Durability (DC)	80	40 Min.
IOC	0.31	
Insoluble Residue (Cal)	0.0	30 Min.
Fractured Faces	100	75 w/2
ESG	2.710	
Hveem Wt.	1040	

Tests on Compressed Mixtures:

Percent Asphalt	Spec. Grav. Specimen	Max. Theo. Spec.Grav.	Dens. % of Max. Theo.	Dens. % Req'd. of Max. Theo.	V.M.A. (%)	V.M.A. (Min.%)	Hveem Stab.	Hveem Stab.(Min.)

Retained Strength 95.6% *75% Mininum Required*
Compacted Wt. 92.7 *lbs./sq.yd./1" thickness*

Tolerances for this project shall be governed by Special Provision 411-3QA(a-h)99.

MEETS SPECIFICATION REQUIREMENTS

MIXTURE TYPE:	OPEN GRADED FRICTION SURFACE[a]
Sieve Size	
$1^1/_2$ inch(37.5 mm)	
1 inch(25.0 mm)	
$^3/_4$ inch(19.0 mm)	
$^1/_2$ inch(12.5 mm)	100
$^3/_8$ inch(9.5 mm)	90-100
No. 4(4.75 mm)	25-45
No. 10(2.0 mm)	0-10
No. 40(425 µm)	
No. 80(180 µm)	
No. 200(75 µm)	0-5
Asphalt Cement[d], % of mix mass	-[f]
Viscosity Grade Asphalt Cement	-[g]