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July 8, 2008

Virginia Department of Transportation
Richmond District
2430 Pine Forest Drive
Colonial Heights, VA 23834

Attn: Mr. Mike Wells

Subject: Report for I-64 Pavement Evaluation in Henrico County
From Parham Road (MP 5.8) to I-95 (MP 11.8)
VDOT Reference: Contract No. 26913
MACTEC Reference 6420084001

Dear Mr. Wells:

MACTEC Engineering and Consulting, Inc. (MACTEC) is pleased to provide this transmittal report for pavement testing on I-64 in Henrico County, VA.

Objective

The objective of this project was to perform pavement testing on I-64 in Henrico County between Parham Road and I-95.

Pavement Testing

The project on I-64 in Henrico County is approximately 6 miles long and has three lanes with the predominant pavement surface being continuously reinforced concrete pavement. The scope of the pavement testing included non-destructive Falling Weight Deflectometer (FWD) testing, pavement coring and boring, Dynamic Cone Penetrometer (DCP) testing and laboratory soil testing.

FWD Testing

MACTEC performed non-destructive deflection testing during the nights of June 19 and 20, 2008 using a MACTEC owned and operated Dynatest Model 8002 Falling Weight Deflectometer (FWD). As specified by VDOT in the scope of work the FWD basin testing was conducted at 300-foot intervals in the center of the travel lane for each direction. The drop sequence and recorded deflections were performed in accordance with the Virginia Department of Transportation (VDOT) Manual of Instruction (MOI) Chapter 6. The data were reviewed for quality control using MODTAG ver 4.1.4.

The raw FWD data files in F25 format were submitted in our June 25, 2008 e-mail transmittal.

MACTEC Engineering and Consulting, Inc.
12104 Indian Creek Court, Suite A • Beltsville, MD 20705 • Phone: 301-210-5105 • Fax 301-210-5032
www.mactec.com

Pavement Boring and Coring

Boring and core locations were provided by VDOT in the scope of work. They were marked in the field on the outside shoulder by VDOT. MACTEC obtained utility clearances from MISS Utility prior to the boring/coring operations.

During the setup of the traffic control for the boring operations on the night of June 24, 2008 MACTEC found lane closures for another work zone for a bridge project within the project limits. These lane closures caused disruptions to the coring and boring operations. Due to the conflicting traffic control required for the boring operations and the bridge work, the borings in the eastbound travel lanes could not be completed after the first two nights. After discussions with VDOT, attempts were made by MACTEC to coordinate with the contractor for the bridge project to extend their lane closures to allow at least two borings to be taken. However, the contractor was unable to extend the lane closures. None of the borings for the eastbound travel lane could be performed. Due to the lack of time available during the boring at MP 8.76 (B10) on the westbound travel lane, only a core to the bottom of the concrete pavement could be taken.

Borings extended to a depth of 5 feet while the shoulder cores were taken to the bottom of the asphalt surface. For the boring at MP 9.4 on the westbound travel lane (B11), refusal was met at 24 inches below the top of the pavement surface.

The boring/core locations and the pavement thickness at each location are presented in Table 1.

Table 1: Boring Locations and Pavement Thickness

Location	Boring/Core	Pavement Thickness
Eastbound Outside Shoulder – MP 6.08	B5	3.75 inches of asphalt concrete on a 17 inch aggregate base
Eastbound Outside Shoulder – MP 7.0	C1	3.5 inches of asphalt concrete
Eastbound Outside Shoulder – MP 9.0	C2	4 inches of asphalt concrete
Eastbound Outside Shoulder – MP 10.87	C3	3.25 inches of asphalt concrete
Eastbound Inside Shoulder – MP 6.08	C10	4.5 inches of asphalt concrete
Eastbound Inside Shoulder – MP 7.0	C4	3.5 inches of asphalt concrete
Westbound Travel Lane – MP 6.2	B7	8 inches of concrete on a 8 inch aggregate base
Westbound Travel Lane – MP 6.4	B8	8.5 inches of concrete on a 10 inch aggregate base
Westbound Travel Lane – MP 7.4	B9	8 inches of concrete on a 8 inch aggregate base
Westbound Travel Lane – MP 8.76	B10	8 inches of concrete
Westbound Travel Lane – MP 9.4	B11	8.5 inches of concrete on a 8 inch aggregate base
Westbound Outside Shoulder – MP 6.4	C6	3.5 inches of asphalt concrete
Westbound Outside Shoulder – MP 8.6	C7	3.5 inches of asphalt concrete
Westbound Outside Shoulder – MP 9.4	C8	3.5 inches of asphalt concrete
Westbound Outside Shoulder – MP 10.9	C9	3 inches of asphalt concrete
Westbound Inside Shoulder – MP 6.4	C5	3.5 inches of asphalt concrete

Prepared/Date: KSP 7/8/2008
Reviewed/Date: TH 7/8/2008

Photographs of the pavement cores are presented in Appendix A. The boring logs are provided in Appendix B.

Dynamic Cone Penetrometer (DCP) Testing

Dynamic Cone Penetrometer (DCP) Testing was conducted in concurrence with the boring operations. DCP testing was performed at the eastbound outside shoulder at MP 6.08 (B5) and the westbound travel lane at MP 6.2, 6.4, and 7.4 (B7, B8, and B9 respectively). DCP testing could not be performed at MP 9.4 on the westbound travel lane (B11) due to refusal of the boring.

The DCP index was obtained and the CBR was calculated from the equation $CBR = 292/DCP^{1.12}$ specified in *ASTM D6951-03, Standard Method for Use of Dynamic Cone Penetrometer in Shallow Pavement Applications*. Using this correlation, the estimated CBR for location B7 was less than 10. The ASTM specifies a different equation for calculating CBR for CL soils with a CBR less than 10: $CBR = 1/(0.017019*DCP)^2$. This equation was used to calculate the CBR for boring B7. The results of the DCP testing, estimated CBR, and graphs of the penetration depth vs DCP index are presented in Appendix C.

Soil Testing

Subgrade soils were retained from the boring operations for performing laboratory testing. The tests included Water Content as per ASTM Standard D2216 for all five borings and Atterberg Limits and Sieve Analysis for three borings. The results of these tests are presented in Appendix D.

Closing

Pavement testing was done for I-64 in Henrico County within the project limits. The four borings in the travel lane in the eastbound direction could not be obtained due to a conflict with the ongoing bridge project within these limits.

Please do not hesitate to contact us if you have any questions or concerns. We appreciate having this opportunity to work with you.

Sincerely,

MACTEC Engineering and Consulting, Inc.

Kiran Pokkuluri, P.E. (VA)
Pavement Task Leader

for John S. Miller, P.E. (VA) with permission
Senior Principal Engineer

Attachments: Appendix A: Photographs of Pavement Cores
Appendix B: Boring Logs
Appendix C: Results of DCP Testing
Appendix D: Results of Laboratory Testing

APPENDIX A

PHOTOGRAPHS OF PAVEMENT CORES

Figure 1: Pavement Core from B5

Figure 2: Pavement Core from C1

Figure 3: Pavement Core from C2

Figure 4: Pavement Core from C3

Figure 5: Pavement Core from C10

Figure 6: Pavement Core from C4

Figure 7: Pavement Core from B7

Figure 8: Pavement Core from B8

Figure 9: Pavement Core from B9

Figure 10: Pavement Core from B10

Figure 11: Pavement Core from B11

Figure 12: Pavement Core from C6

Figure 13: Pavement Core from C7

Figure 14: Pavement Core from C8

Figure 15: Pavement Core from C9

Figure 16: Pavement Core from C5

APPENDIX B

BORING LOGS

Virginia Department of Transportation

PROJECT #: 6420-08-4001
LOCATION: I-64 EB Outside Shoulder in Henrico County, VA
STRUCTURE:

B-5

STATION: MP 6.08 OFFSET:
LATITUDE: LONGITUDE:
SURFACE ELEVATION: n/a ft COORD. DATUM:

Date(s) Drilled: 6/26/2008 - 6/26/2008
Drilling Method(s): 4" Core Bit
SPT Method:
Other Test(s): DCP
Driller: Pablo Rios - MACTEC
Logger: Jack Roughton - MACTEC

GROUND WATER

FIELD DATA											LAB DATA		
		SOIL				ROCK							
								DIP					
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
											LL	PI	
2					2.5						33	6	11.3
4													
6													

DESCRIPTION OF STRATA

0.0 /
3.75" Asphalt CONCRETE (1.5" Surface Course, 2.25" Base Course)

0.3 /
17" Aggregate Base

1.8 /
Brown yellow silty SAND, moist (SM)

Boring terminated at 6.75' on 6/26/2008

REMARKS: RIG TYPE: Coring Machine and Hand Auger.
Core samples obtained from eastbound shoulder lane.

SPT_LOG:I-64 PAVEMENT TESTING 6420-08-4001.GPJ:8.1.017:050307:07/08/08

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PROJECT #: 6420-08-4001
LOCATION: I-64 WB Travel Lane in Henrico County, VA
STRUCTURE:

B-7
PAGE 1 OF 1

STATION: MP 6.2 OFFSET:
LATITUDE: LONGITUDE:
SURFACE ELEVATION: n/a ft COORD. DATUM:

Date(s) Drilled: 6/25/2008 - 6/25/2008
Drilling Method(s): 4" Core Bit, Hand Auger
SPT Method:
Other Test(s): DCP
Driller: Pablo Rios, Jack Roughton - MACTEC
Logger: Malcolm D. Young - MACTEC

GROUND WATER

FIELD DATA											LAB DATA		
		SOIL				ROCK							
								DIP					
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
											LL	PI	

DESCRIPTION OF STRATA

Depth	Description	LL	PI	Moisture Content (%)
	0.0 / 8" CONCRETE			
2	1.3 / 8" AGGREGATE BASE			
4	2.2 / Red yellow sandy lean CLAY, moist (CL)	41	16	23.7
	Boring terminated at 5.0' on 6/25/2008			20.0

Sample interval: 3.5, 5

REMARKS: RIG TYPE: Coring Machine and Hand Auger.
Core samples obtained from westbound travel lane. Soil samples obtained at about 3.5 feet and 5.0 feet.

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SPT_LOG:I-64 PAVEMENT TESTING 6420-08-4001.GPJ:8.1.017:050307:07/08/08

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PROJECT #: 6420-08-4001
LOCATION: I-64 WB Travel Lane in Henrico County, VA
STRUCTURE:

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PAGE 1 OF 1

STATION: MP6.4 OFFSET:
LATITUDE: LONGITUDE:
SURFACE ELEVATION: n/a ft COORD. DATUM:

Date(s) Drilled: 6/25/2008 - 6/25/2008
Drilling Method(s): 4" Core Bit, Hand Auger
SPT Method:
Other Test(s): DCP
Driller: Pablo Rios, Jack Roughton - MACTEC
Logger: Malcolm D. Young - MACTEC

GROUND WATER

FIELD DATA												LAB DATA		
		SOIL				ROCK								
								DIP						
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)
											0.0 / 8.5" CONCRETE			
2					2.67						1.5 / 10" AGGREGATE BASE			12.8
4					5						2.7 / Brown sandy lean CLAY, moist (CL)	40	17	16.9
											Boring terminated at 5.0' on 6/25/2008			

REMARKS: RIG TYPE: Coring Machine and Hand Auger.
Core samples obtained from westbound travel lane. Soil samples obtained at about 2.67 feet and 5.0 feet.

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SPT_LOG:I-64 PAVEMENT TESTING 6420-08-4001.GPJ:8.1.017:050307:07/08/08

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Virginia Department of Transportation

PROJECT #: 6420-08-4001
LOCATION: I-64 WB Travel Lane in Henrico County, VA
STRUCTURE:

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PAGE 1 OF 1

STATION: MP7.4 OFFSET:
LATITUDE: LONGITUDE:
SURFACE ELEVATION: n/a ft COORD. DATUM:

FIELD DATA

Date(s) Drilled: 6/25/2008 - 6/25/2008
Drilling Method(s): 4" Core Bit, Hand Auger
SPT Method:
Other Test(s): DCP
Driller: Pablo Rios, Jack Roughton - MACTEC
Logger: Malcolm D. Young - MACTEC

GROUND WATER

LAB DATA

DEPTH (ft)	ELEVATION (ft)	SOIL: STANDARD PENETRATION TEST HAMMER BLOWS	SOIL: SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	ROCK: CORE RECOVERY (%)	ROCK: ROCK QUALITY DESIGNATION	ROCK: DIP: STRATA	ROCK: DIP: JOINTS	STRATA LEGEND	DESCRIPTION OF STRATA	LIQUID LIMIT (LL)	PLASTICITY INDEX (PI)	MOISTURE CONTENT (%)
											0.0 / 8" CONCRETE			
2					2.67						1.3 / 8" AGGREGATE BASE			13.6
4					5						2.7 / Brown lean CLAY with rock fragments, moist (CL)			14.2
											Boring terminated at 5.0' on 6/25/2008			

REMARKS: RIG TYPE: Coring Machine and Hand Auger.
Core samples obtained from westbound travel lane. Soil samples obtained at about 2.67 feet and 5.0 feet.

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SPT_LOG:I-64 PAVEMENT TESTING 6420-08-4001.GPJ:8.1.017:050307:07/08/08

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Virginia Department of Transportation

PROJECT #: 6420-08-4001
LOCATION: I-64 WB Travel Lane in Henrico County, VA
STRUCTURE:

B-11
PAGE 1 OF 1

STATION: MP 9.4 OFFSET:
LATITUDE: LONGITUDE:
SURFACE ELEVATION: n/a ft COORD. DATUM:

Date(s) Drilled: 6/24/2008 - 6/24/2008
Drilling Method(s): 4" Core Bit, Hand Auger
SPT Method:
Other Test(s):
Driller: Pablo Rios, Jack Roughton - MACTEC
Logger: Malcolm D. Young - MACTEC

GROUND WATER

FIELD DATA											LAB DATA		
		SOIL				ROCK							
								DIP					
DEPTH (ft)	ELEVATION (ft)	STANDARD PENETRATION TEST HAMMER BLOWS	SOIL RECOVERY (%)	SAMPLE LEGEND	SAMPLE INTERVAL	CORE RECOVERY (%)	ROCK QUALITY DESIGNATION	STRATA	JOINTS	STRATA LEGEND	LIQUID LIMIT	PLASTICITY INDEX	MOISTURE CONTENT (%)
											LL	PI	
2					5								5.7

DESCRIPTION OF STRATA

0.0 /
8.5" CONCRETE

0.7 /
8" AGGREGATE BASE

1.4 /
Brown Sandy lean CLAY, moist (CL)

Hand Auger Refusal at 2.0' on 6/24/2008

REMARKS: RIG TYPE: Coring Machine and Hand Auger.
Core samples obtained from westbound travel lane.

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SPT_LOG:I-64 PAVEMENT TESTING 6420-08-4001.GPJ:8.1.017:050307:07/08/08

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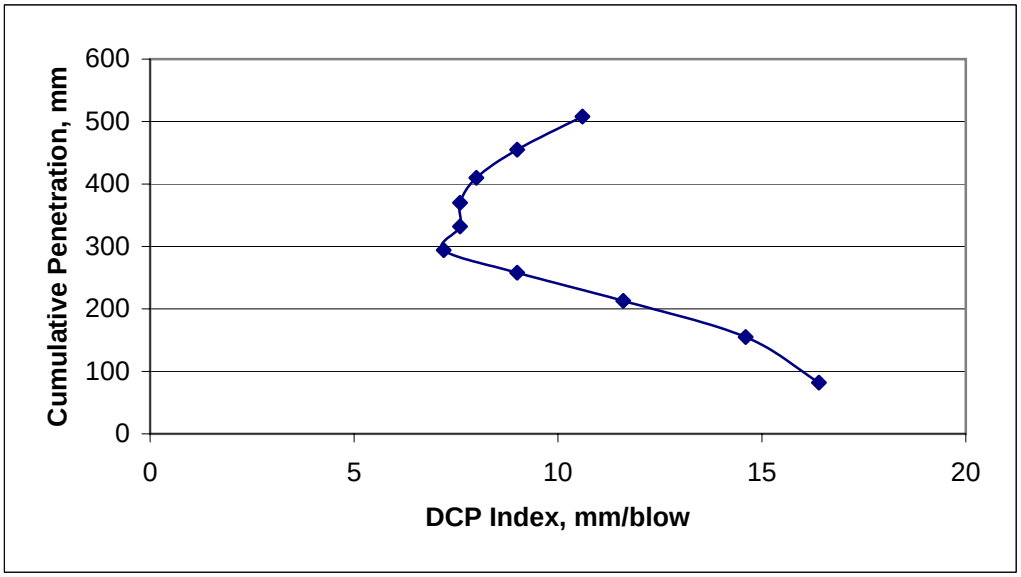
APPENDIX C

RESULTS OF DCP TESTING

Project: I-64 Pavement Testing **Date:** 6/26/2008
Location: Eastbound Outside Shoulder - MP 6.08 **Personnel:** Pablo Rios
Depth of Zero point Below Surface: 21 inches **Hammer Weight:** 8 kg
Material Classification: Silty Sand

Number of Blows	Cumulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Factor	DCP Index mm/blow	CBR %
0	0	0				
5	82	82	16	1	16	13
5	155	73	15	1	15	14
5	213	58	12	1	12	19
5	258	45	9	1	9	25
5	294	36	7	1	7	32
5	332	38	8	1	8	30
5	370	38	8	1	8	30
5	410	40	8	1	8	28
5	455	45	9	1	9	25
5	508	53	11	1	11	21

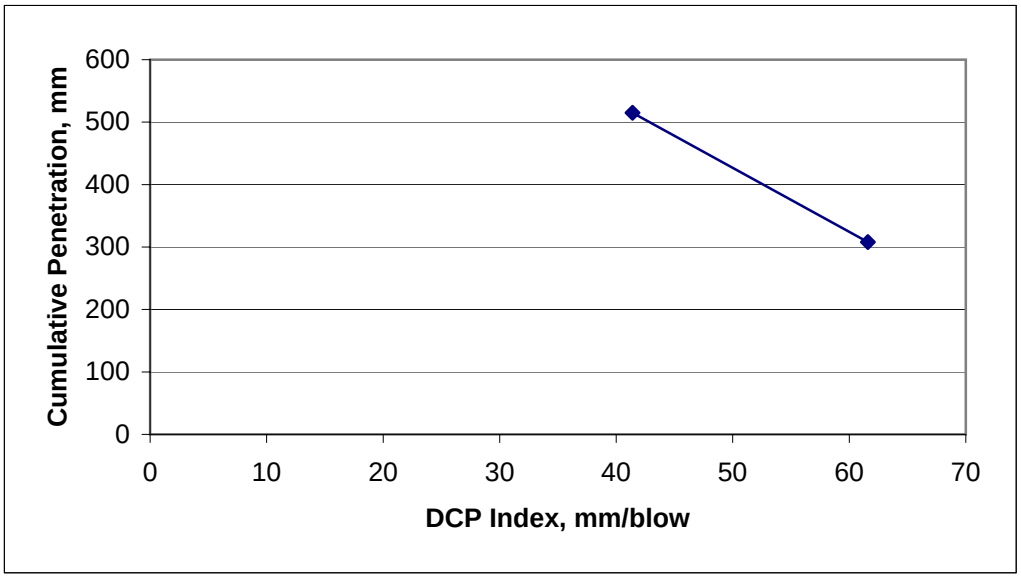
Note: CBR calculated using formula CBR = 292/DCP^1.12



Project: I-64 Pavement Testing
Date: 6/25/2008
Location: Westbound Travel Lane - MP 6.2
Personnel: Pablo Rios
Depth of Zero point Below Surface: 16 inches
Hammer Weight: 8 kg
Material Classification: Sandy Clay

Number of Blows	Cumulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Factor	DCP Index mm/blow	CBR %
0	0	0				
5	308	308	62	1	62	1
5	515	207	41	1	41	2

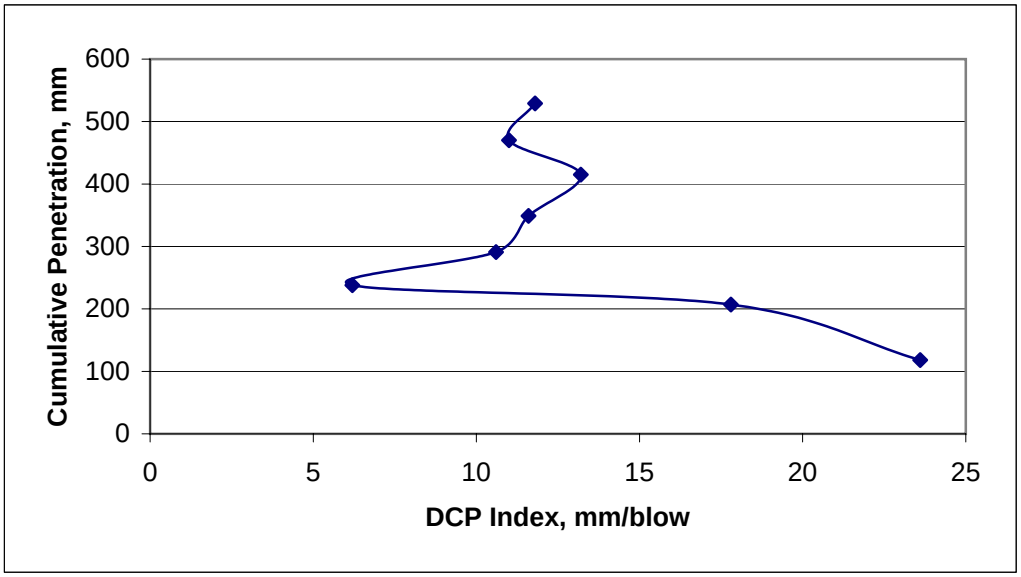
Note: CBR calculated using formula CBR = 1/(0.017019*DCP)^2



Project: I-64 Pavement Testing **Date:** 6/26/2008
Location: Westbound Travel Lane - MP 6.4 **Personnel:** Pablo Rios
Depth of Zero point Below Surface: 18.5 inches **Hammer Weight:** 8 kg
Material Classification: Sandy Clay

Number of Blows	Cumulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Factor	DCP Index mm/blow	CBR %
0	0	0				
5	118	118	24	1	24	8
5	207	89	18	1	18	12
5	238	31	6	1	6	38
5	291	53	11	1	11	21
5	349	58	12	1	12	19
5	415	66	13	1	13	16
5	470	55	11	1	11	20
5	529	59	12	1	12	18

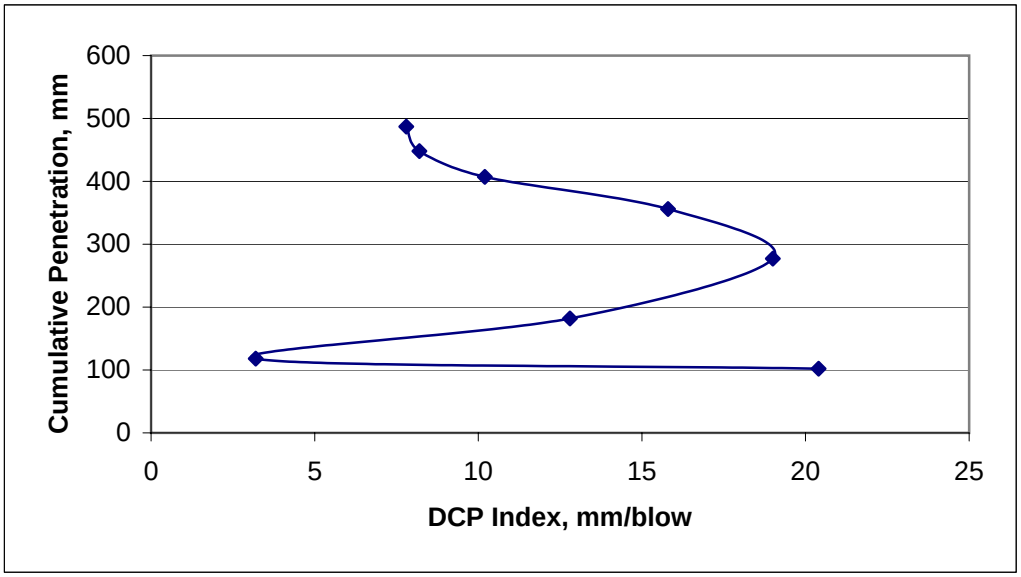
Note: CBR calculated using formula CBR = 292/DCP^1.12



Project: I-64 Pavement Testing **Date:** 6/25/2008
Location: Westbound Travel Lane - MP 7.4 **Personnel:** Pablo Rios
Depth of Zero point Below Surface: 16 inches **Hammer Weight:** 8 kg
Material Classification: Clay

Number of Blows	Cumulative Penetration (mm)	Penetration Between Readings (mm)	Penetration Per Blow (mm)	Hammer Factor	DCP Index mm/blow	CBR %
0	0	0				
5	102	102	20	1	20	10
5	118	16	3	1	3	79
5	182	64	13	1	13	17
5	277	95	19	1	19	11
5	356	79	16	1	16	13
5	407	51	10	1	10	22
5	448	41	8	1	8	28
5	487	39	8	1	8	29

Note: CBR calculated using formula CBR = 292/DCP^1.12



APPENDIX D

RESULTS OF LABORATORY TESTING

MACTEC
22455 Davis Drive, Suite 100
Sterling, Virginia 20164
(703) 404-7000

Summary of Soil Classification Test Data

PROJECT NAME: I-64 Pavement testing
PROJECT NUMBER: 6420-08-4001
DATE: 07/03/08

SAMPLE								ATTERBERG LIMITS			
ID	DEPTH (ft.)	TYPE	SOIL DESCRIPTION	SOIL CLASS.	% RETAINED NO. 4 SIEVE	% FINER NO. 200 SIEVE	NAT. MOIST. (%)	L.L.	P.L.	P.I.	COMMENT
B-7	3.5	Bag	Red yellow sandy lean CLAY	CL	4.0	56.2	23.7	41	25	16	
B-7	5.0	Bag					20.0				
B-8	2.67	Bag					12.8				
B-8	5.0	Bag	Brown sandy lean CLAY	CL	6.0	56.0	16.9	40	23	17	
B-9	2.67	Bag					13.6				
B-9	5.0	Bag					14.2				
B-5	2.5 - 5.0	Bag	Brown yellow silty SAND	SM	1.5	21.7	11.3	33	27	6	
B-11	5.0	Bag					5.7				

NOTES:
1. Soil classification and testing in accordance with USCS, ASTM D2487, D421, D422 & D4318
2. L.L.= Liquid Limit N.P.= Non-Plastic
   P.L.= Plastic Limit N.L.L.=No Liquid Limit
   P.I. = Plasticity Index
3. Soil color determined from Munsell Soil Chart

Prepared by: PMT

Reviewed
Muthu Arigovindan
Manager, Lab

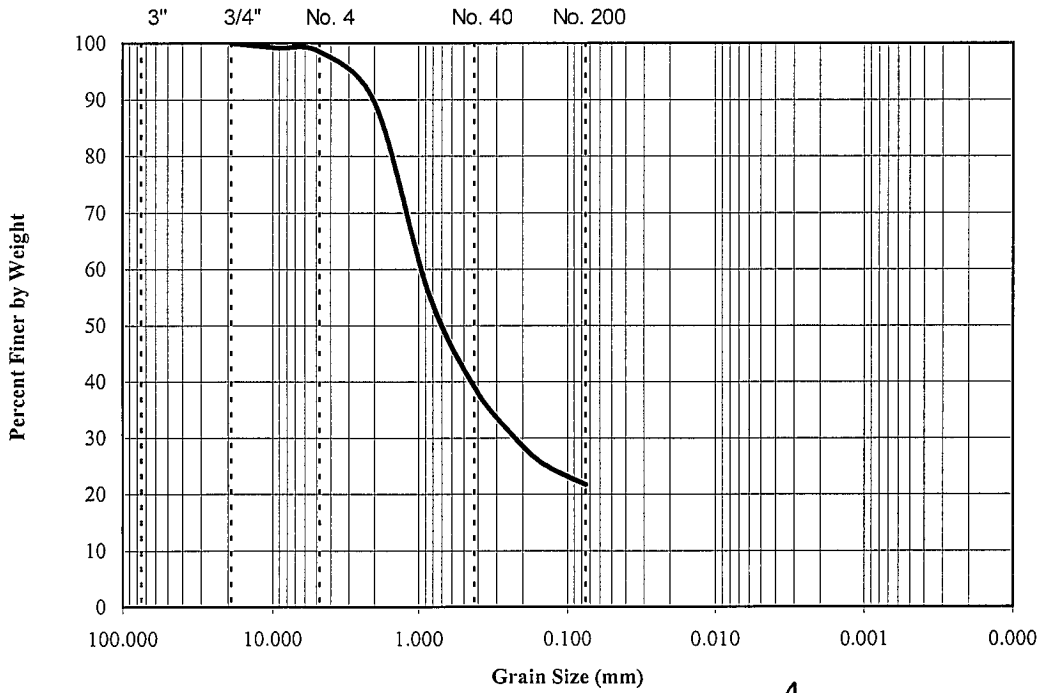
MACTEC ENGINEERING AND CONSULTING, INC
22455 Davis Drive, Suite 100
Sterling, Virginia 20164
(703) 404 7000

Project Name: I-64 Pavement Testing
Project Number: 6420-08-4001
Report Date: 7/8/2008

Washed Particle Size/Gradation Test Report
ASTM D422
Sample Number: B-5, @5.0 feet, MP 6.08, EB Outside Shoulder

Sieve Size	Cumulative (g)	Wt. Retained Each Sieve (g)	Cumulative % Passing
3/4 in.	0.00	0.0	100.0
3/8 in.	2.08	2.1	99.2
# 4	4.05	2.0	98.5
# 10	28.14	24.1	89.5
# 20	118.81	90.7	55.6
# 40	162.77	44.0	39.1
# 60	183.54	20.8	31.3
# 100	198.86	15.3	25.6
# 200	209.33	10.5	21.7
Wt. of Soil, g	267.32		

Particle Size Analysis
U.S. Standard Sieve Sizes



Prepared by: PMJ

Reviewed by:

Sieve, B-5,@ 5.0'.xls

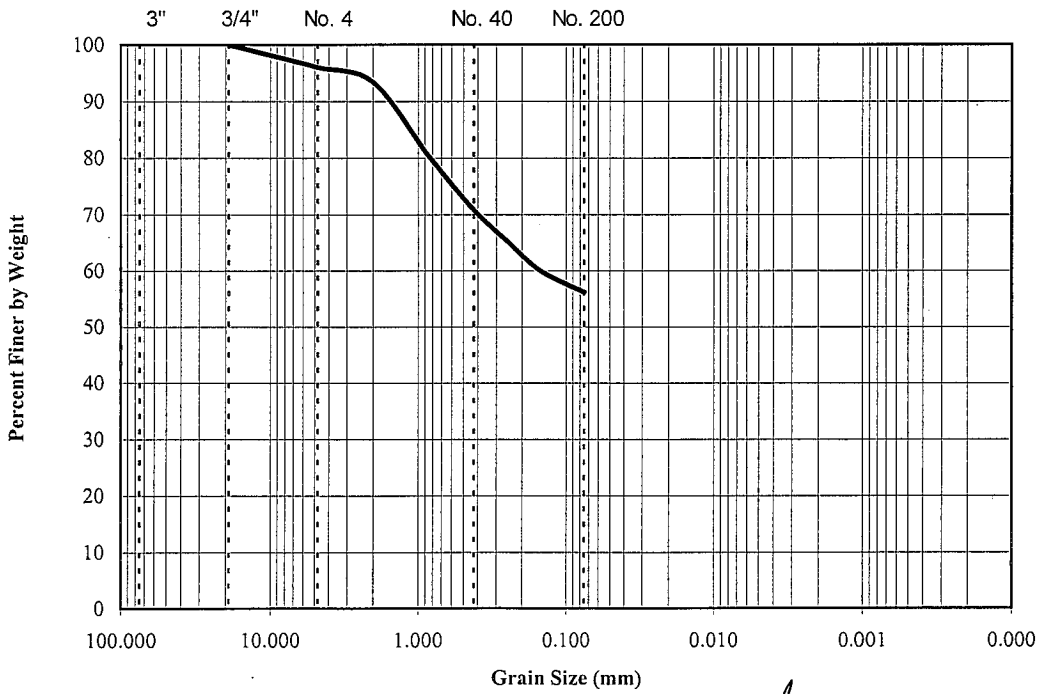
MACTEC ENGINEERING AND CONSULTING, INC
22455 Davis Drive, Suite 100
Sterling, Virginia 20164
(703) 404 7000

Project Name: I-64 Pavement Testing
Project Number: 6420-08-4001
Report Date: 7/3/2008

Washed Particle Size/Gradation Test Report
ASTM D422
Sample Number: B-7, @ 3.5 feet, MP 6.2, WB Travel Lane

Sieve Size	Cumulative (g)	Wt. Retained Each Sieve (g)	Cumulative % Passing
3/4 in.	0.00	0.0	100.0
3/8 in.	6.67	6.7	98.0
# 4	13.24	6.6	96.0
# 10	21.98	8.7	93.4
# 20	65.27	43.3	80.4
# 40	97.14	31.9	70.8
# 60	116.30	19.2	65.1
# 100	133.32	17.0	60.0
# 200	145.70	12.4	56.2
Wt. of Soil, g	333.02		

Particle Size Analysis
U.S. Standard Sieve Sizes



Prepared by: pMT

Reviewed by:

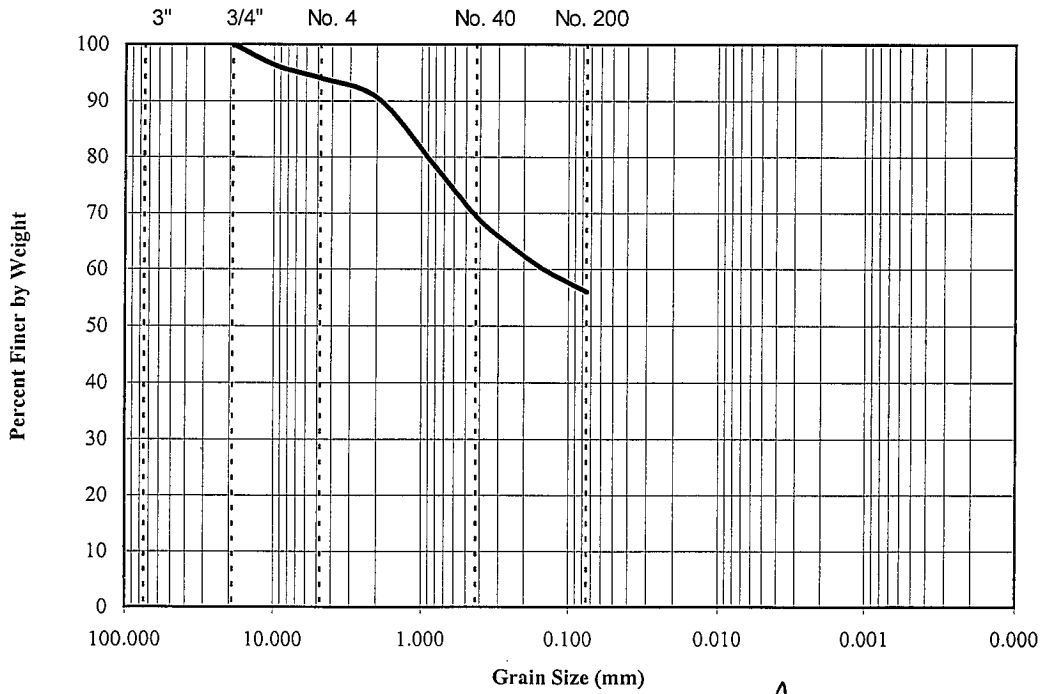
MACTEC ENGINEERING AND CONSULTING, INC
22455 Davis Drive, Suite 100
Sterling, Virginia 20164
(703) 404 7000

Project Name:	I-64 Pavement Testing
Project Number:	6420-08-4001
Report Date:	7/3/2008

Washed Particle Size/Gradation Test Report
ASTM D422
Sample Number: B-8, @5.0 feet, MP 6.4, WB Travel Lane

Sieve Size	Cumulative (g)	Wt. Retained Each Sieve (g)	Cumulative % Passing
3/4 in.	0.00	0.0	100.0
3/8 in.	10.74	10.7	96.2
# 4	16.82	6.1	94.0
# 10	26.34	9.5	90.6
# 20	58.68	32.3	79.1
# 40	86.16	27.5	69.4
# 60	100.57	14.4	64.2
# 100	112.28	11.7	60.1
# 200	123.59	11.3	56.0
Wt. of Soil, g	281.11		

Particle Size Analysis
U.S. Standard Sieve Sizes



Prepared by: PMT

Reviewed by: