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Technical Memo

Project 0-6132: Task 6 – Test Sections in the Districts

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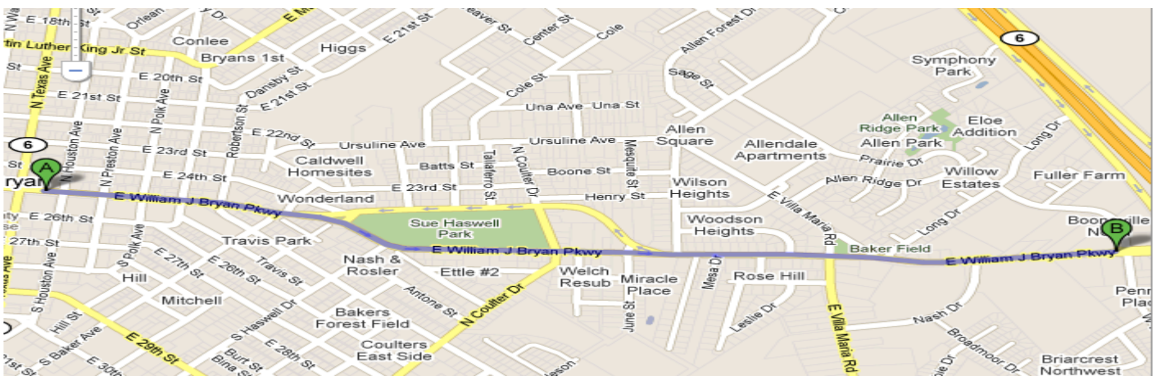
CC:	Tom Scullion (t-scullion@tamu.edu)
From:	Lubinda F. Walubita
Date:	February 10th , 2011
Subject:	Lab Test, Distress (Crack) Survey, and Construction Reports for the TTI Sections on FM 158 (Brazos County, Bryan District, TX)



Summary

This Tech Memo provides a summary of the Lab Test, Distress Survey, and Construction Reports for the CAM Test Sections constructed on FM 158 (E William J. Bryan Pkwy) in the Bryan District. TTI was requested by both the Contractor (Knife River Corporation) and the Bryan District to assist with the mix design. The contactor was initially having problems getting his proposed mix design to pass the Hamburg (HWTT) and Overlay tester (OT) requirements for a CAM design. This was a concern as they had successfully designed and constructed an earlier project with an identical mix design. The Bryan District Lab Engineer asked for an evaluation of the proposed mix to assess if a lower asphalt-binder content would meet the CAM requirements and potentially save the District money.

Based on extensive lab testing by TTI, recording of the construction process, and field tests conducted just after construction, the following conclusions and recommendations were made:

a) The cause of the contractors' problem was that the initial asphalt-binder proposed (Martin PG 76-22) actually graded out as a PG 82-22. While having good performance in the HWTT, the mix made with this asphalt-binder could not pass the OT requirements (< 200 cycles).

b) Two alternative PG 76-22 asphalt-binders were evaluated, Valero and Jebro, both of which had no problems passing the HWTT and OT requirements.
c) The contractor elected to use the Jebro PG 76-22 asphalt-binder and the Bryan District's Special Specification Item 3131 with the volumetric design requirement (98% density after 50 gyrations); the optimum asphalt-binder content was found to be 7.1%. At this asphalt-binder content, the HWTT rut depth was 5.4 mm after 20,000 passes and 1000 OT cycles.
d) TTI performed performance tests at a lower target density of 96.5% on both asphalt-binders (Valero and Jebro) and found that all criteria were met while using approximately 0.5% less asphalt-binder; i.e., Hamburg < 5.0 mm rutting after 20 000 passes and OT > 750 cycles for 6.5% PG 76-22 Jebro and 6.6% PG 76-22 Valero, respectively.
e) The District elected to place the mix with a target asphalt-binder content of 6.7% (Jebro), which is allowable under the CAM spec, where the asphalt-binder is paid for as a separate bid item. The 6.7% PG 76-22 Jebro asphalt-binder corresponded to 97% lab density; with Hamburg = 4.3 mm rutting after 20 000 load passes and OT = 1 000 cycles.
f) The modified CAM mix-design (6.7% PG 76-22 Jebro) was accordingly placed on the entire project length of about 1.6 miles long as a 1 inch thick overlay (over an about 12 inch thick existing HMA) by Knife River Corporation late 2010 from Dec 10th to 31st.
g) Lab test were conducted on plant mixed materials delivered to the project. The measured asphalt-binder content was close to the design value (6.55% versus 6.7%) and the measured HWTT and OT also did not differ significantly from the design values.
h) Some construction problems were encountered in the field with equipment malfunctioning, specifically the Roadtec MTD, which had to be changed including switching from using belly-dump to tipper trucks.
i) The ride values on the completed project were a cause for concern. However, it should be noted that this is an urban section with construction occurring under high traffic. The section also has many drainage structures and multiple stop and go intersections.

Prior to construction, TTI researchers had conducted a crack survey and marked out 6 test sections; 3 in the EB direction and 3 in the WB direction. Plans are to periodically monitor the test sections at least twice per year during the cold (crack evaluation) and hot (rutting evaluation) weather seasons, respectively including : (1) visual crack surveys, (2) rut measurements (straightedge), (3) surface profiles (ride quality), (4) GPR, (5) skid measurements (with TxDOT aid), (6) FWD (with TxDOT aid), and (7) coring (where applicable).

Lessons Learned

1) Not all PG 76-22 asphalt-binders are manufactured equal; it is apparent that material source has an influence. TxDOT currently does not test the upper end, therefore an asphalt-binder can be a PG 82 but still be accepted as a PG 76.
2) In addition to the 98% target density, performance tests on future CAM designs should also be run at asphalt-binder contents found at lower densities such as 96.5 or 97%.
3) The Bryan District policy of recommending a PG 76-22 with 1% lime for CAM designs to be placed as surface layers in high traffic locations appears to be working well; considerations should be made to incorporating these requirements into the Statewide specification Item 365.

Acknowledgements

Special thanks go to Stephen Kasberg (TxDOT), Darlene Goehl (TxDOT), and Knife River Corporation for permitting and assisting TTI Researchers conduct the survey, record/document the construction process, run field tests, and collect materials including asphalt-binders, aggregates, plant-mixes, and cores for lab testing.

APPENDIX I: HMA MIX-DESIGN DETAILS AND LAB TEST REPORT

CAM MIX-DESIGN, SPEC ITEM 3131

Aggregate type: Capitol limestone
Aggregate-blend: 21% Gr5 (Delta pit) + 18% D-rock (Marble Falls pit) + 60% screenings (Marble Falls pit)

RAP: None
Anti-strip: 1.0% hydrated lime (Austin White Lime)

Asphalt-binder: ***Jebro PG 76-22***, Valero PG 76-22, and Martin PG 76-22

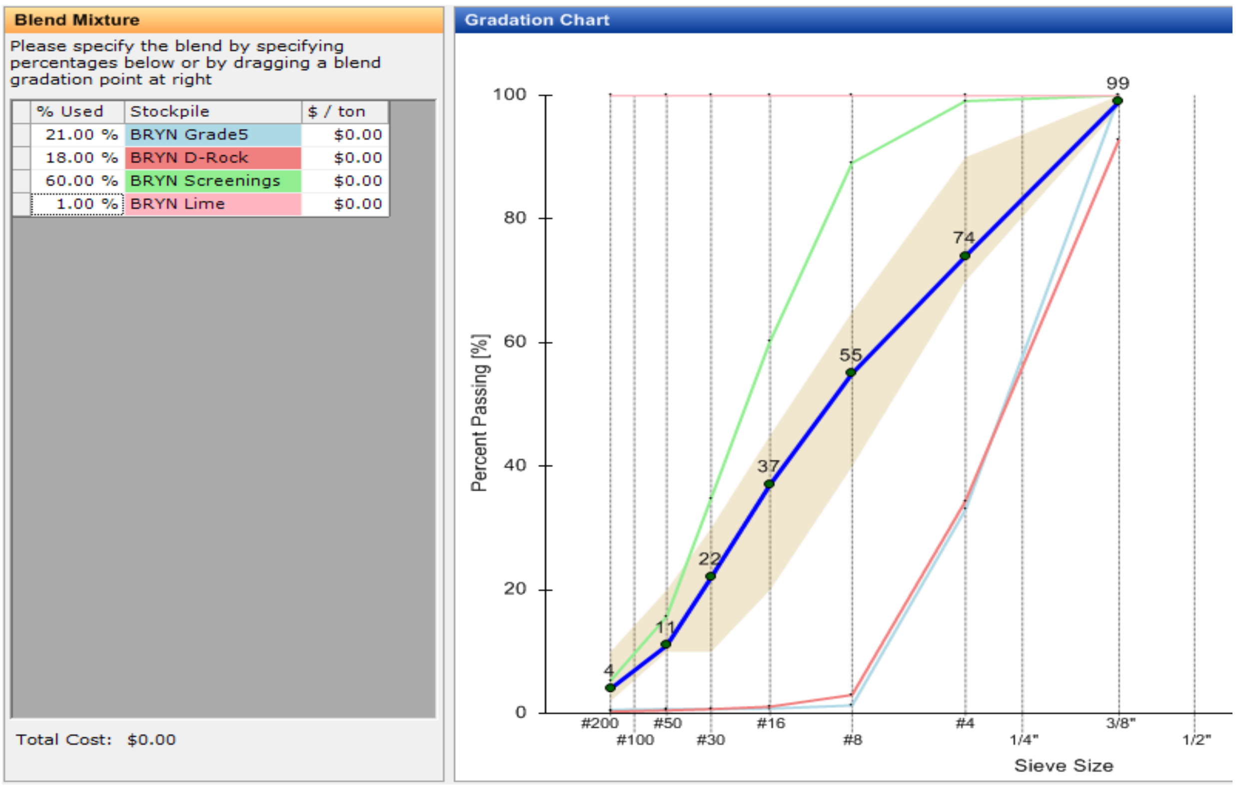


Fig I-1. Aggregate Gradation.

Table I-1. Asphalt-Binder DSR and BBR Results.

#	Source	Actual Tested PG Grade	DSR (High Temp)		BBR (Lower Temp)	
			G* (kPa)	G*/Sin δ (kPa) (> 1.00)	S (MPa) (< 300)	m-value (> 0.300)
1	***Jebro PG 76-22***	***PG 76-22***	***1.41***	***1.54***	***174***	***0.325***
2	Valero PG 76-22	PG 76-22	1.55	1.61	132	0.316
3	Martin PG 76-22	PG 82-22	1.03	1.05	77	0.317

Table I-2. Hamburg and Overlay Results – Jebro PG 76-22.

#	Asphalt-Binder Content	Corresponding Lab Density	VMA (>17)	Hamburg @ 20 k (< 12.5)	Overlay Cycles (Avg.) (> 750)	Average OT Peak Loads (lb)
1	6.5%	96.5%	18.7	3.2 mm	861	600
2	***6.7%***	***97.0%***	***18.7***	***4.3 mm***	***1 000***	***774***
3	6.9%	97.5%	18.7	5.0 mm	938	640
4	7.1%	98.0%	18.7	5.4 mm	1 000	612

Table I-3. Hamburg and Overlay Results – Valero PG 76-22.

#	Asphalt-Binder Content	Corresponding Lab Density	VMA (>17)	Hamburg @ 20 k (< 12.5)	Overlay Cycles (Avg.) (> 750)	Average OT Peak Loads (lb)
1	6.5%	96.5%	19.0	4.5 mm	736	580
2	6.7%	97.5%	18.1	4.9 mm	951	630
3	6.9%	98.0%	18.1	5.7 mm	956	553
4	7.1%	98.4%	18.4	7.4 mm	1 000	563

Table I-4. Hamburg and Overlay Results – Martin PG 76-22.

#	Asphalt-Binder Content	Corresponding Lab Density	VMA (>17)	Hamburg @ 20 k (< 12.5)	Overlay Cycles (Avg.) (> 750)	Average OT Peak Loads (lb)
1	6.5%	96.7%	18.4	2.9 mm	132	815
2	6.7%	98.5%	17.2	3.6 mm	169	770
3	6.9%	98.9%	17.4	4.1 mm	173	696
4	7.1%	99.0%	17.6	4.4 mm	173	835

NB: All Hamburg and OT samples were molded and tested at 7±1% AV.

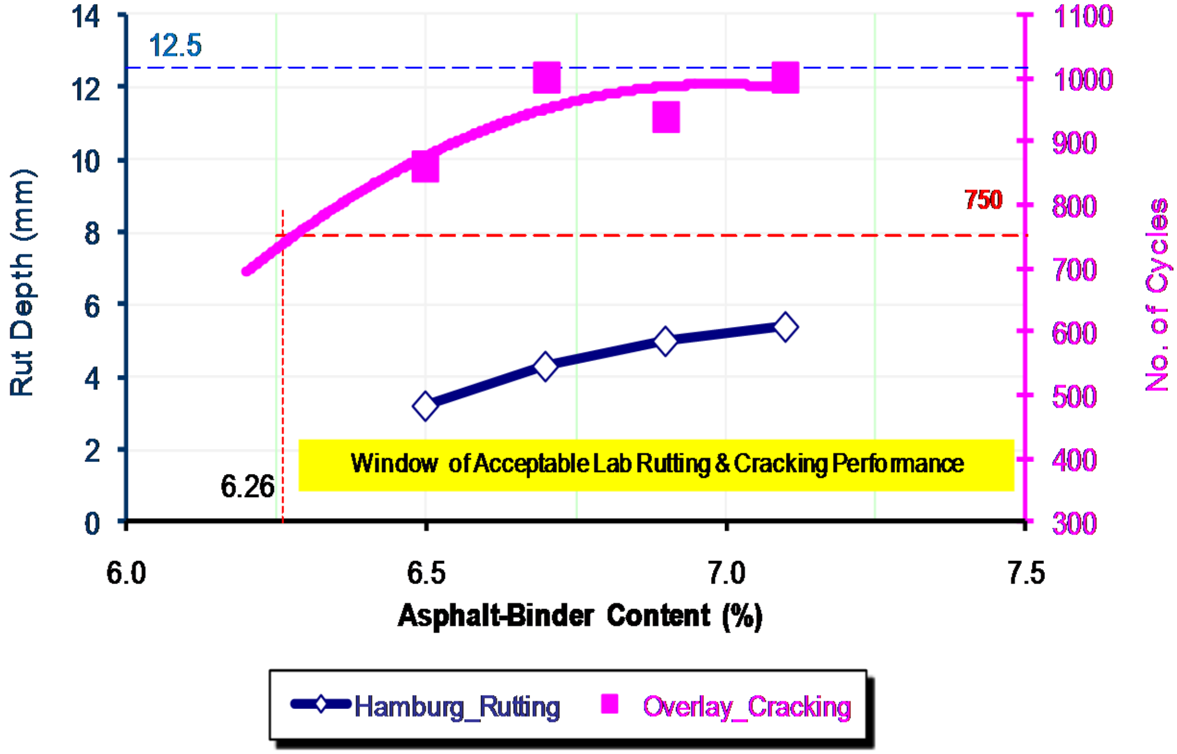


Fig I-2. Hamburg and OT Results for Jebro PG 76-22.

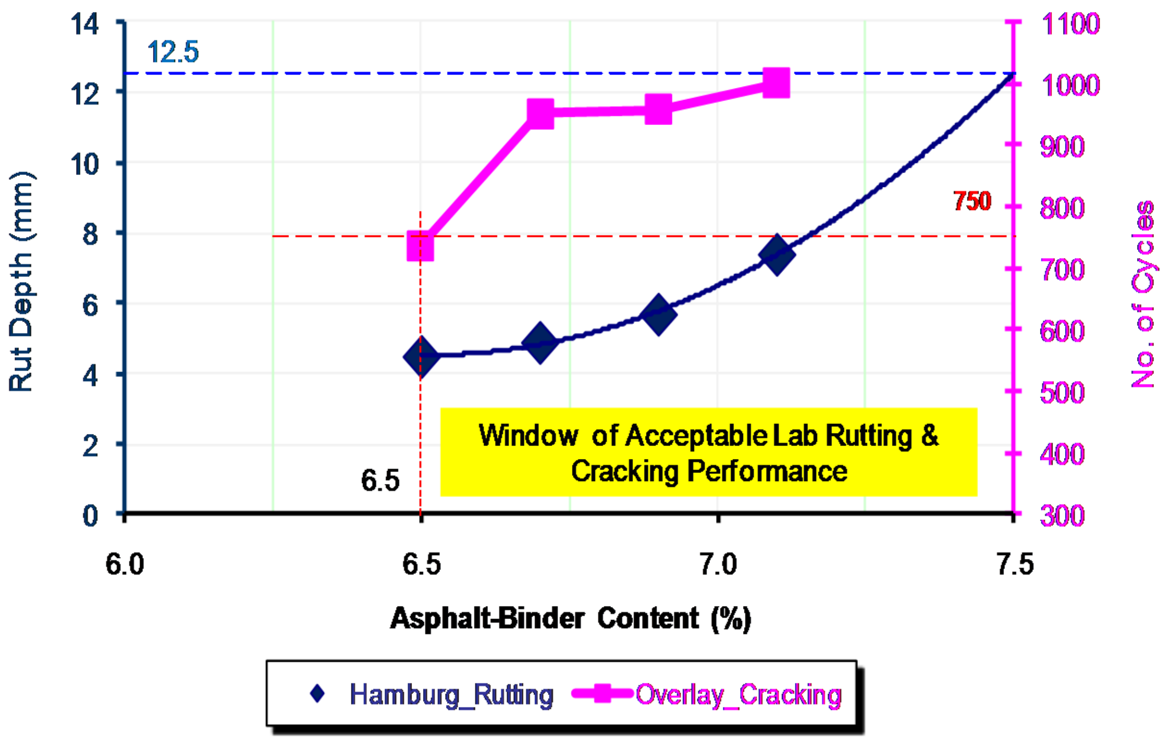


Fig I-3. Hamburg and OT Results for Valero PG 76-22.

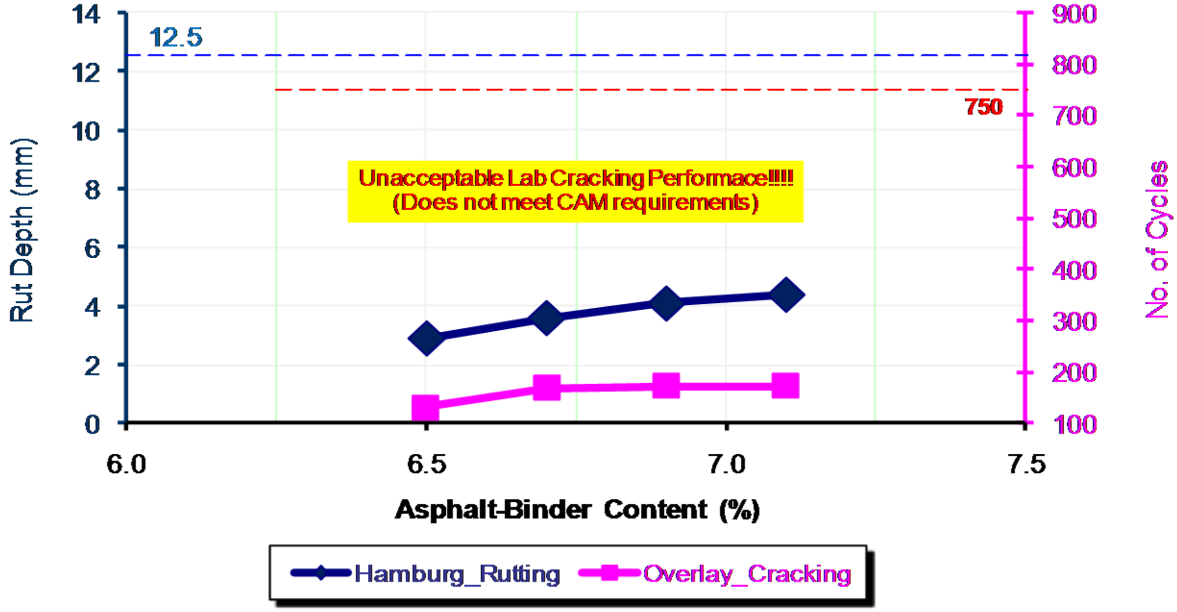
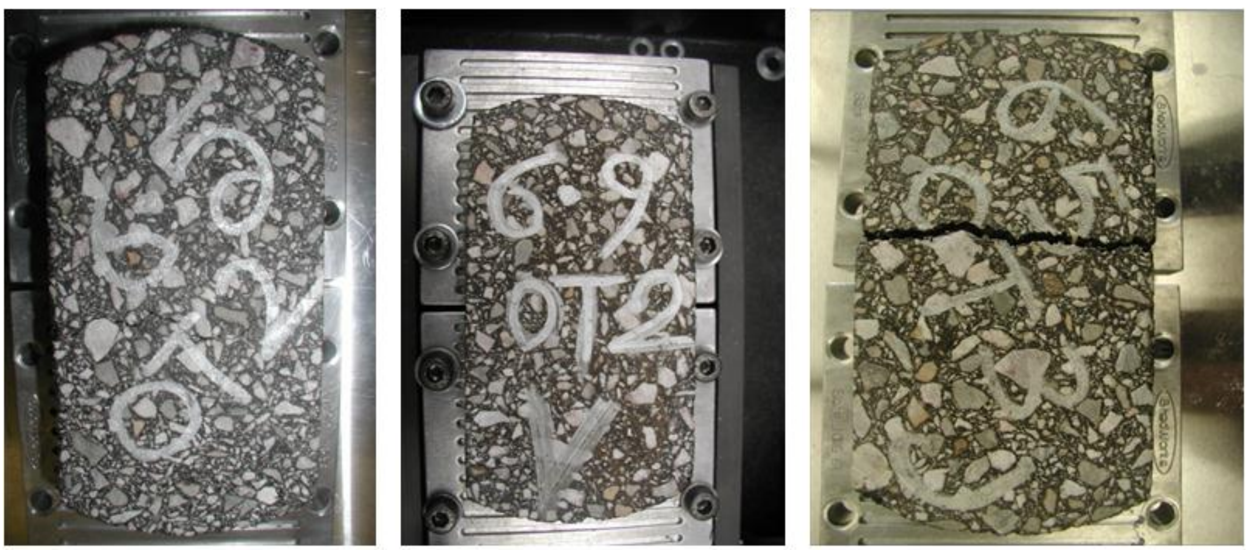


Fig I-4. Hamburg and OT Results for Martin PG 76-22.



Jebro PG 76-22 Valero PG 76-22 Martin PG 76-22

Fig I-5. OT Pictures.

<u>NB</u>: All Hamburg and OT samples were molded and tested at 7±1% AV.

Table I-5. Mix-design Sheet – Combined Gradation

SAMPLED BY:	TTI	SPEC ITEM:	3131
SAMPLE LOCATION:	TTI	SPECIAL PROVISION:	
MATERIAL CODE:	TTI	MIX TYPE:	CAM
MATERIAL NAME:	CRACK ATTENUATING MIXTURE		
PRODUCER:	KNIFE RIVER - BRYAN PLANT(TTI)		
AREA ENGINEER:		PROJECT MANAGER:	

COURSE\LIFT:		STATION:		DIST. FROM CL:		CONTRACTOR DESIGN # :	KRC 205

	BIN FRACTIONS						
	Bin No.1	Bin No.2	Bin No.3	Bin No.4	Bin No.5	Bin No.6	Bin No.7
Aggregate Source:	CAPITOL	CAPITOL	CAPITOL	AUSTIN			
Aggregate Pit:	DELTA	MARBLE FALLS	MARBLE FALLS	WHITE LIME			
Aggregate Number:							
Sample ID:	GRADE 5	D ROCK	SCREENINGS	LIME			
Rap?:							

	Bin No.1		Bin No.2		Bin No.3		Bin No.4		Bin No.5		Bin No.6		Bin No.7		Total Bin	Combined Gradation: Lower & Upper Specification Limits			Restricted Zone		
Individual Bin (%):	21.0	Percent	18.0	Percent	60.0	Percent	1.0	Percent		Percent		Percent		Percent	100.0%						
Sieve Size:	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum.% Passing	*Wtd Cum. %*	Cum. % Passing	Lower	Upper	Within Spec's	*Lower*	*Upper*	*Within Spec's*
3/8"	99.9	21.0	92.9	16.7	100.0	60.0	100.0	1.0							98.7	98.0	100.0	Yes			
No. 4	33.0	6.9	34.4	6.2	99.1	59.5	100.0	1.0							73.6	70.0	90.0	Yes			
No. 8	1.3	0.3	3.0	0.5	89.1	53.5	100.0	1.0							55.3	40.0	65.0	Yes			
No. 16	0.8	0.2	1.1	0.2	60.2	36.1	100.0	1.0							37.5	20.0	45.0	Yes			
No. 30	0.7	0.1	0.7	0.1	34.8	20.9	100.0	1.0							22.2	10.0	30.0	Yes			
No. 50	0.7	0.1	0.5	0.1	15.7	9.4	100.0	1.0							10.7	10.0	20.0	Yes			
No. 200	0.6	0.1	0.3	0.1	5.3	3.2	100.0	1.0							4.4	2.0	10.0	Yes			

Table I-6. Mix-design Sheet – Summary (Jebro PG 76-22)

Target Density, %:	**98.0**
Number of Gyrations:	**50**

CRM* Content

	TEST SPECIMENS							Mixture Evaluation @ Optimum Asphalt Content			
								Indirect Tensile Strength (psi)	Hamburg Wheel Tracking Test		Overlay Tester Min. Number of Cycles
	Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)		Number of cycles	Rut depth (mm)	
1	6.5	2.412	2.492	2.763	2.500	96.5	18.7		See Table 2 & Fig. 2	See Table 2 & Fig. 2	See Table 2 & Fig. 2
2	**6.7**	**2.418**	**2.488**	**2.768**	**2.492**	**97.0**	**18.7**				
3	7.5	2.442	2.475	2.791	2.462	99.2	18.6				
4	8.5	2.462	2.425	2.772	2.426	101.5	18.8				
5											

Effective Specific Gravity:	2.774

Estimated Percent of Stripping, %:	

Optimum Asphalt Content :	**7.1**
VMA @ Optimum AC:	**18.6**

Interpolated Values	
Specific Gravity (Ga):	2.429
Max. Specific Gravity (Gr):	2.482
Theo. Max. Specific Gravity (Gt):	2.479

Remarks:

Table I-6. Mix-design Sheet – Summary (Valero PG 76-22)

Target Density, %:	**98.0**
Number of Gyrations:	**50**

CRM* Content

TEST SPECIMENS							Mixture Evaluation @ Optimum Asphalt Content			
							Indirect Tensile Strength (psi)	Hamburg Wheel Tracking Test		Overlay Tester Min. Number of Cycles
Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)		Number of cycles	Rut depth (mm)	
6.5	2.380	2.480	2.748	2.479	96.0	19.0		See Table 3 & Fig. 3	See Table 3 & Fig. 3	See Table 3 & Fig. 3
6.7	2.409	2.472	2.747	2.471	97.5	18.1				
6.9	2.416	2.465	2.747	2.464	98.1	18.1				
7.1	2.418	2.454	2.742	2.457	98.4	18.2				

Effective Specific Gravity:	2.746

Estimated Percent of Stripping, %:	

Optimum Asphalt Content :	**6.9**
VMA @ Optimum AC:	**18.1**

Interpolated Values	
Specific Gravity (Ga):	2.415
Max. Specific Gravity (Gr):	2.466
Theo. Max. Specific Gravity (Gt):	2.465

Remarks:

Table I-6. Mix-design Sheet – Summary (Martin PG 76-22)

Target Density, %:	**98.0**
Number of Gyrations:	**50**

CRM* Content	

TEST SPECIMENS							Mixture Evaluation @ Optimum Asphalt Content			
								Hamburg Wheel Tracking Test		
Asphalt Content (%)	Specific Gravity Of Specimen (Ga)	Maximum Specific Gravity (Gr)	Effective Gravity (Ge)	Theo. Max. Specific Gravity (Gt)	Density from Gt (Percent)	VMA (Percent)	Indirect Tensile Strength (psi)	Number of cycles	Rut depth (mm)	Overlay Tester Min. Number of Cycles
6.5	2.397	2.484	2.753	2.481	96.6	18.5		See Fig. Table 4 & Fig. 4	See Table 4 & Fig. 4	See Table 4 & Fig. 4
6.7	2.444	2.477	2.753	2.473	98.8	17.0				
6.9	2.439	2.463	2.745	2.466	98.9	17.4				
7.1	2.435	2.455	2.744	2.459	99.0	17.7				

Effective Specific Gravity:	2.749

Estimated Percent of Stripping, %:	

Optimum Asphalt Content :	**6.6**
VMA @ Optimum AC:	**17.6**

Interpolated Values	
Specific Gravity (Ga):	2.427
Max. Specific Gravity (Gr):	2.480
Theo. Max. Specific Gravity (Gt):	2.476

Remarks:

APPENDIX II: DISTRESS SURVEY REPORT

PROJECT DETAILS

Table II-1. Project and Location Details.

Item	Details	GPS Coordinates
Hwy name	FM 158 (W. J. Bryan Pkwy)	-
Total project length	≅ 1.6 miles	-
Project limits	Praire Rd (just west of SH 6 bypass) to Business SH 6 (Texas Avenue)	-
Project start location	SH 6 bypass (Bryan USPS)	N 30° 40. 307'; W 096° 20. 603'
Project end location	Texas Avenue (Brazos County Health Dept.)	N 30° 40. 446'; W 096° 22. 134'

CRACK (TRANSVERSE) MAPPING

Test Section 01a (FM 158, EB Outside Lane)

Length: 1 042 ft

Start point: N 30° 40. 446'; W 096° 22. 134"
(Landmark: Brazos County Health Dept.; intersection of WJ Bryan Pkwy. & N. Houston Ave.)

End point: N 30° 40. 422'; W 096° 21. 950'
(Landmark: St. Joseph elementary school; intersection of WJ Bryan Pkwy & Pierce Ave.)

Table II-2. Transverse Crack Mapping on Test Section 01a (FM 158, EB Outside Lane).

Crack#	Distance from Crack#1 (ft)	GPS Location	Severity
1	0	N 30° 40. 446'; W 096° 22. 134'	High
2	147	-	Medium
3	166	-	High
4	188	-	Medium
5	260	-	Medium
6	331	-	Medium
7	407	-	Low
8	558	-	Low
9	743	-	Low
10	830	-	Low
11	900	-	Low
12	1042	N 30° 40. 422'; W 096° 21. 950"	High

Test Section 01b (FM 158, WB Inside Lane)

Length: 1 075 ft

Start point: N 30° 40. 324; W 096° 20. 566' (Landmark: Church of Nazarene; 2122 WJ Bryan Pkwy)
End point: N 30° 40. 298'; W 096° 20. 763' (Landmark: 2100 WJ Bryan Pkwy/Vacant Building)

Table II-3. Transverse Crack Mapping on Test Section 01b (FM 158, WB Inside Lane).

Crack#	Distance from Crack#1 (ft)	GPS Location	Severity
1	0	N 30° 40. 307'; W 096° 20. 603'	Low
2	23	-	Medium
3	104	-	High
4	200	-	High
5	241	-	Medium
6	304	-	Medium
7	368	-	Medium
8	404	-	High
9	486	-	High
10	549	-	Low
11	605	-	Low
12	635	-	Low
13	690	-	Medium
14	770	-	Medium
15	789	-	High/Right on the pedestrian crossing on Nash St.
16	828	-	High
17	858		Medium
18	881	-	Medium
19	922	-	High
20	970	-	High
21	1015	-	Medium
22	1031	-	Medium
23	1057	-	High
24	1064	-	High
25	1075	N 30° 40. 298'; W 096° 20. 736'	High

Test Section 02a (FM 158, EB Inside & Outside Lane)

Length: 1 021 ft

Start point: N 30° 40. 334; W 096° 21. 580' (Landmark: Sue Haswell Park parking lot)
End point: N 30° 40. 328'; W 096° 21. 387'
(Landmark: Haswell pool parking lot; Crossing of WJ Bryan Pkwy & Coulter Dr.)

Table II-4. Transverse Crack Mapping on Test Section 02a (FM 158, EB Lane).

Inside Lane			Outside Lane		
Crack #	**Distance from Crack #1 (ft)**	**Severity**	**Crack #**	**Distance from Crack #1 (ft)**	**Severity**
1	0	High	1	0	High
2	292	High	2	13	Medium
3	243	Medium	3	37	High
4	295	High	4	117	High
5	548	High	5	201	Medium
6	657	Low	6	292	High
7	715	Medium	7	295	High
8	74	Low	8	438	Low
9	455	High	9	548	High
10	821	Low	10	685	High
11	1021	High	11	715	High
			12	741	High
			13	755	High
			14	878	High

Test Section 02b (FM 158, WB Inside & Outside Lane)

Length: 1 058 ft

Start point: N 30° 40.413; W 096° 21.469' (Landmark: Crossing of WJ Bryan Pkwy & Taliaferro St.)
End point: N 30° 40.410'; W 096° 21.664' (Landmark: Entrance to Sue Haswell Park; Road bifurcation)

Table II-5. Transverse Crack Mapping on Test Section 02b (FM 158, WB Lane).

Inside Lane			Outside Lane		
Crack #	**Distance from Crack #1 (ft)**	**Severity**	**Crack #**	**Distance from Crack #1 (ft)**	**Severity**
1	0	Low	1	0	High
2	239	Medium	2	447	Medium
3	294	High	3	663	Medium
4	583	Medium	4	704	Low
5	704	High	5	711	Low
6	860	Low	6	717	Low
7	917	Low	7	726	Medium
8	950	Low	8	745	High
9	975	Medium	9	764	Medium
10	992	Medium	10	776	Medium
11	995	Low	11	992	Medium
12	1058	Medium	12	1052	Medium

Test Section 03a (FM 158, EB Inside Lane)

Length: 1 159 ft

Start point: N 30° 40. 295'; W 096° 20. 836' (Electric substation; Crossing of WJ Bryan Pkwy. & Long Dr.)
End point: N 30° 40. 307'; W 096° 20. 603' (Landmark: Bryan USPS)

Table II-6. Transverse Crack Mapping on Test Section 03a (FM 158, EB Inside Lane).

Crack#	Distance from Crack#1 (ft)	GPS Location	Severity
1	0	N 30° 40. 295'; W 096° 20. 836'	Medium
2	30		Low
3	43		Medium
4	110		High
5	150		High
6	252		High
7	293		High
8	353		High
9	381		Medium
10	397		Low
11	430		Low
12	469		Low
13	489		High
14	503		Low
15	550		Medium
16	558		Medium
17	584		High
18	651		High
19	665		Low
20	705		High
21	734		High

Table II-6 (Continued).
Transverse Crack Mapping on Test Section 03a (FM 158, EB Inside Lane).

Crack#	Distance from Crack#1 (ft)	GPS Location	Severity
22	830		High
23	850		Low
24	951		Medium
25	1011		Medium
26	1033		Medium
27	1077		Low
28	1086		High
29	1121		Low
30	1159	N 30° 40. 307'; W 096° 20. 603'	High

Test Section 03b (FM 158, WB Outside Lane)

Length: 1 185 ft
Start point: N 30° 40. 422'; W 096° 21. 950'
(Landmark: St. Joseph elementary school; intersection of WJ Bryan Pkwy & Pierce Ave.)
End point: N 30° 40. 466'; W 096° 22. 163' (Landmark: Brazos County Health Dept.)

Table II-7. Transverse Crack Mapping on Test Section 03b (FM 158, WB Outside Lane).

Crack#	Distance from Crack#1 (ft)	GPS Location	Severity
1	0	N 30° 40. 422'; W 096° 21. 950'	Medium
2	104	-	High
3	301	-	High
4	322	-	High
5	346	-	Low
6	379	-	High
7	770	-	Low
8	872	-	Medium
9	1131	-	Low
10	1185	N 30° 40. 466'; W 096° 22. 163'	High

Figure II-1. Example of Cracking on Section 1 - FM 158 WB @ Intersection of Nash Dr. and William J. Bryan Pkwy.

Figure II-2. Example of Cracking on Section 3 - FM 158 WB Adjacent to Brazos County Health Center.

Figure II-3. Example of Cracking on Section 1 - FM 158 EB Intersection of William J. Bryan Pkway and Pierce St.

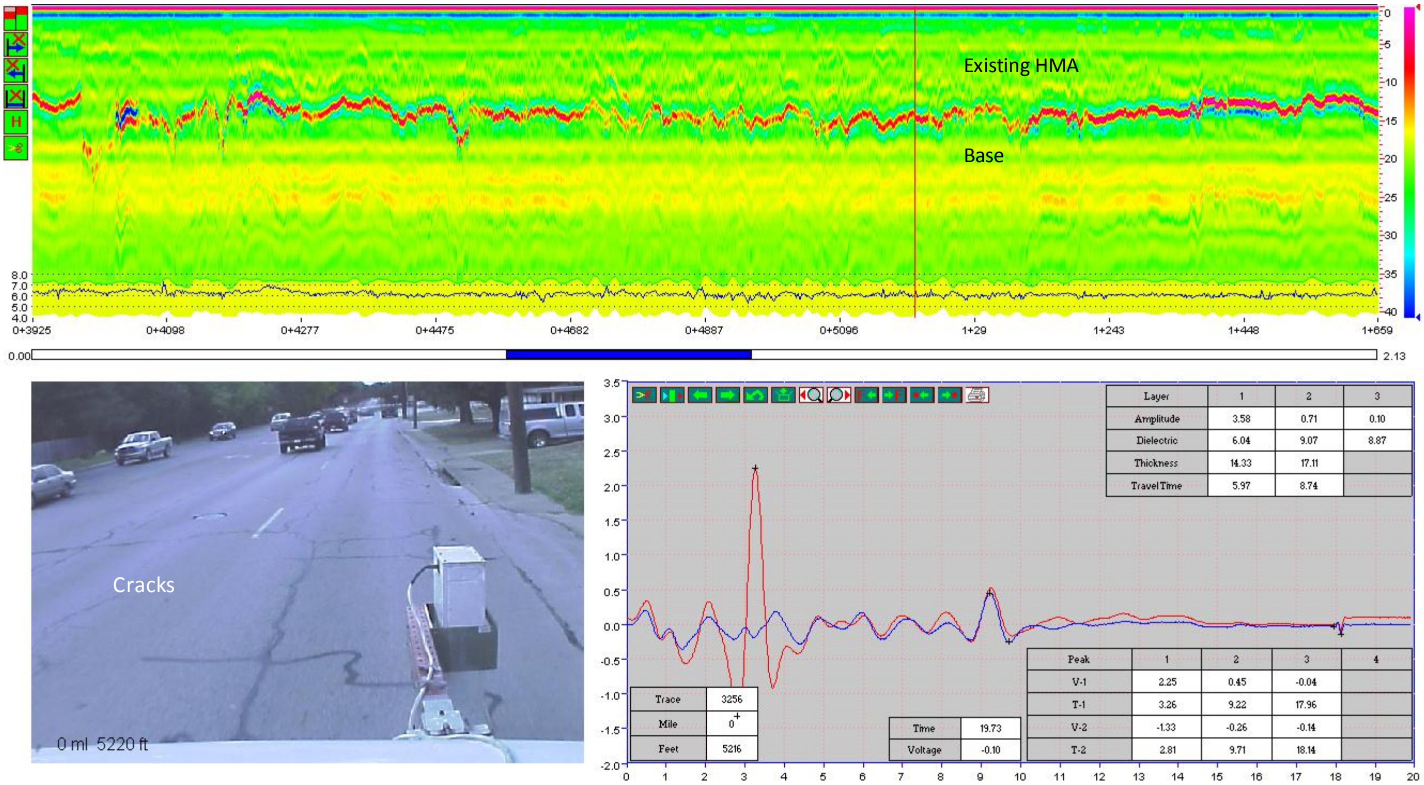


Figure II-4. GPR Test Run on WB Outside Lane Prior to Overlay Placement.

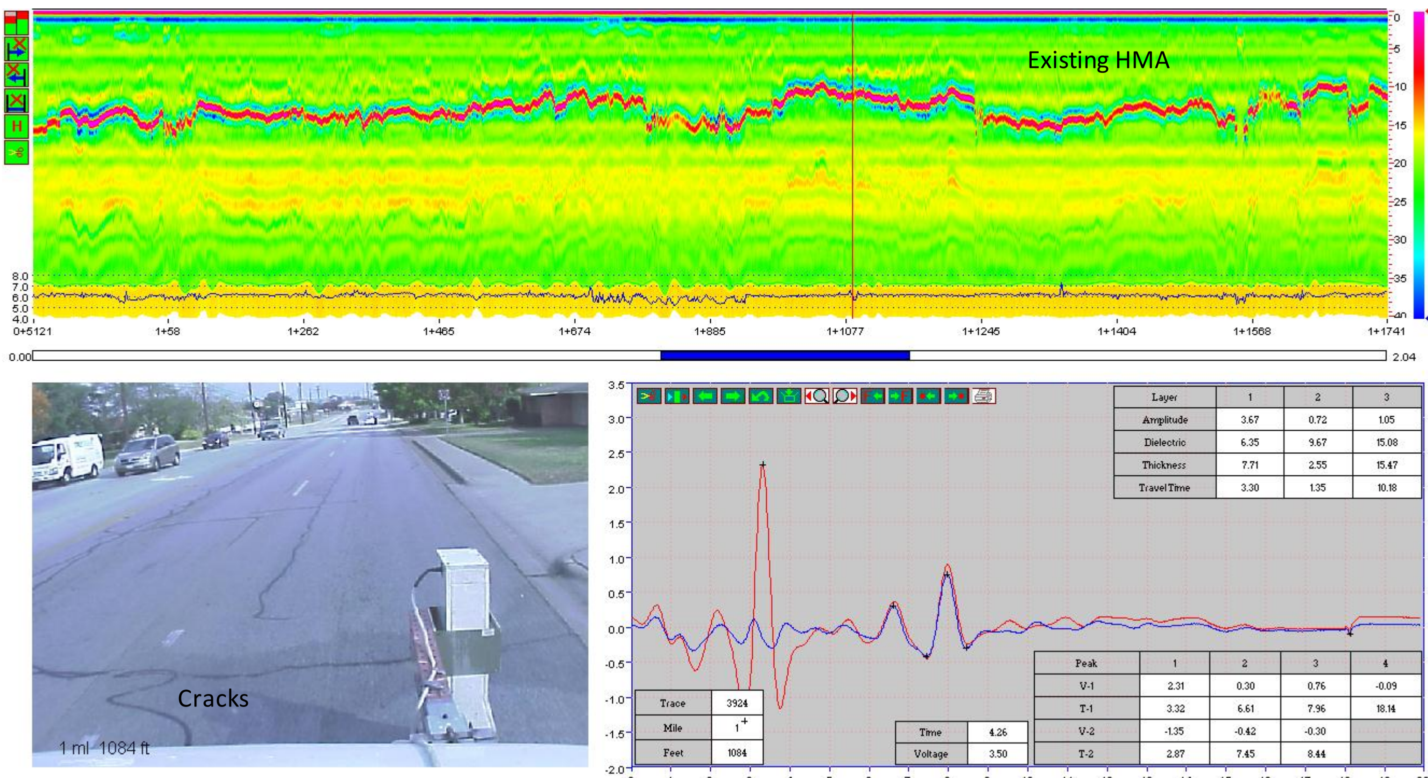


Figure II-4. GPR Test Run on EB Outside Lane Prior to Overlay Placement.

APPENDIX III: CONSTRUCTION REPORT

Highway:	FM 158 (W. J. Bryan Pkwy)
Construction Date:	Winter 2010 (Dec 10th through 31st, 2010)
Contractor:	Knife River Corporation
Construction:	1-inch thick HMA overlay with intermittent Mill & Inlay on some sections
HMA mix:	CAM (Item 3131)
Bid price:	$80/ton for the PG 76-22 asphalt and $93/ton for the aggregate

Table III-1. QC/QA Test Results on Plant-Mix, Cores, & In-situ HMA Mat.

#	Item	Truck# 09	Truck# 18
1	Design AC (PG 76-22 Jebro)= Avg. Ignition Oven AC (uncorrected) = (Tolerance ±0.3%)	6.7% 6.5%	6.7% 6.64%
2	Hamburg on plant-mix after 20 00 passes = OT on plant-mix =	2.9 mm 738 cycles	5.8 mm 854 cycles
3	Lab design density = 97% Avg. HMA mat density during construction (PQI) = 92% Avg. core density (TTI) = 94.1% Avg. core density on section where Paver had stopped due to change of MTD = 91.3%		
4	Avg. PVMNT surface temperature during construction = 67 °F Avg. HMA mat temperature during construction = 290 °F Production temperature ≅320 °F		
5	Compaction pattern = 6 vibratory passes (14 ton steel wheel roller) Final compacted HMA mat = 1 inch		

Table III-2. Aggregate Gradation Extractions on Plant-Mixes.

Sieve Size	Sieve Size (mm)	Design - Passing (%)	Spec - Passing (%)		Plant-Mix (Passing)	
			Lower	Upper	Truck# 9	Truck# 18
3/8"	9.5	98.7	98	100	96.8%	98.4%
#4	4.75	73.6	70	90	65.5%	69.7%
#8	2.36	55.3	40	65	45.7%	48.5%
#16	1.18	37.5	20	45	34.5%	36.3%
#30	0.06	22.2	10	30	28.7%	30.4%
#50	0.03	10.7	10	20	23.8%	25.3%
#200	0.0075	4.4	2	10	5.9%	6.8%

Table III-3. Average High-Speed Profiles (IRI) Measured Just after Construction.

Lane	Avg. Left WP (in/mi)	Avg. Right WP (in/mi)	Average (in/mi)
EB Inside	93.2	86.7	89.9
EB Outside	84.9	109.4	97.2
WB Inside	83.9	83.9	83.9
EB Outside	102.0	124.5	113.2
Overall avg.			96.1

Figure III-1. Example of Milling Operation and Milled-Off section.

Figure III-2. MTD and Truck Types.

Figure III-3. Paver, IR Bar, and Compactor.

Figure III-4. Final Compacted HMA Overlay Mat (1-Inch thick).

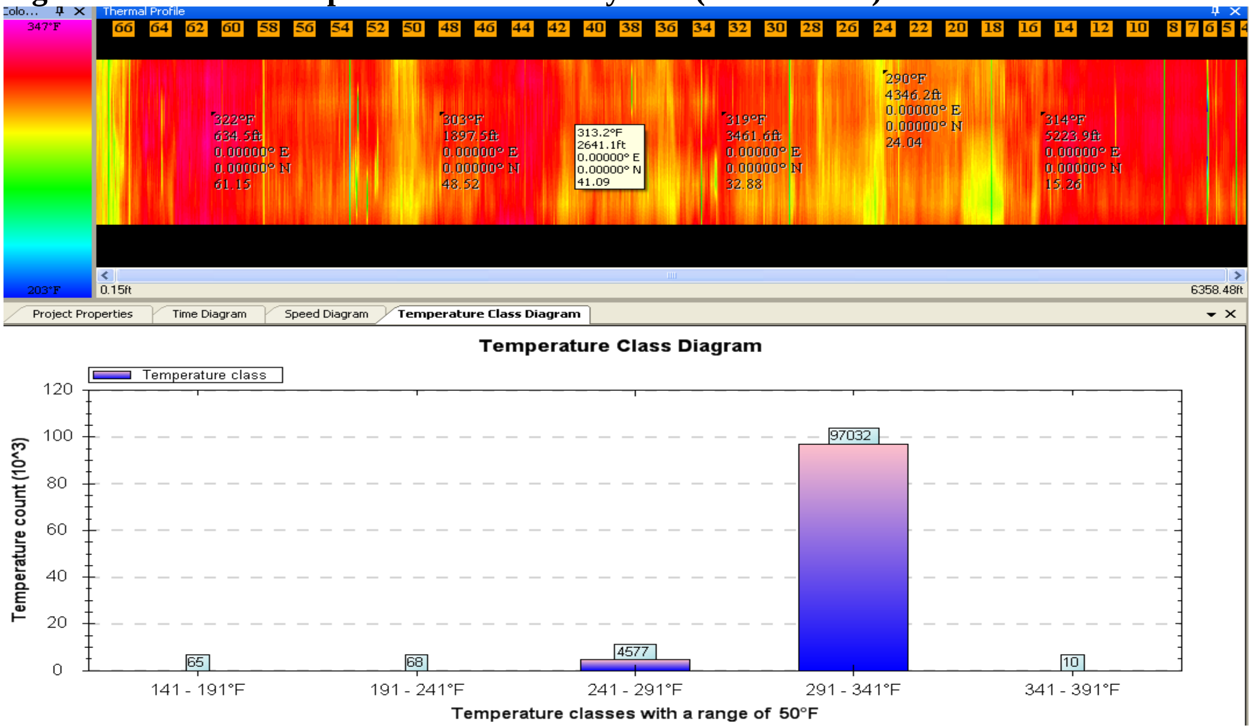


Figure III-5. Example of Infra-Red Thermal Profiles.

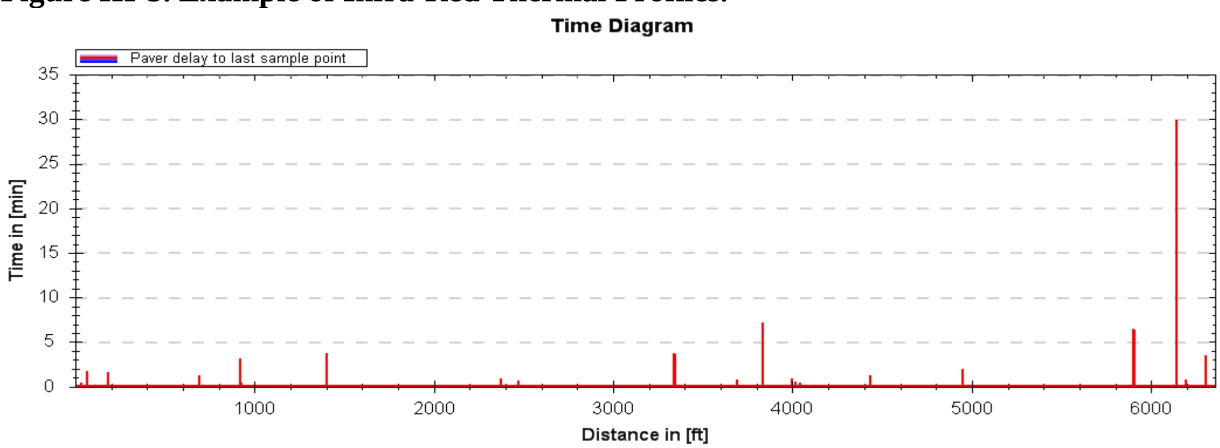


Figure III-6. Example of a Temperature Time Diagram.

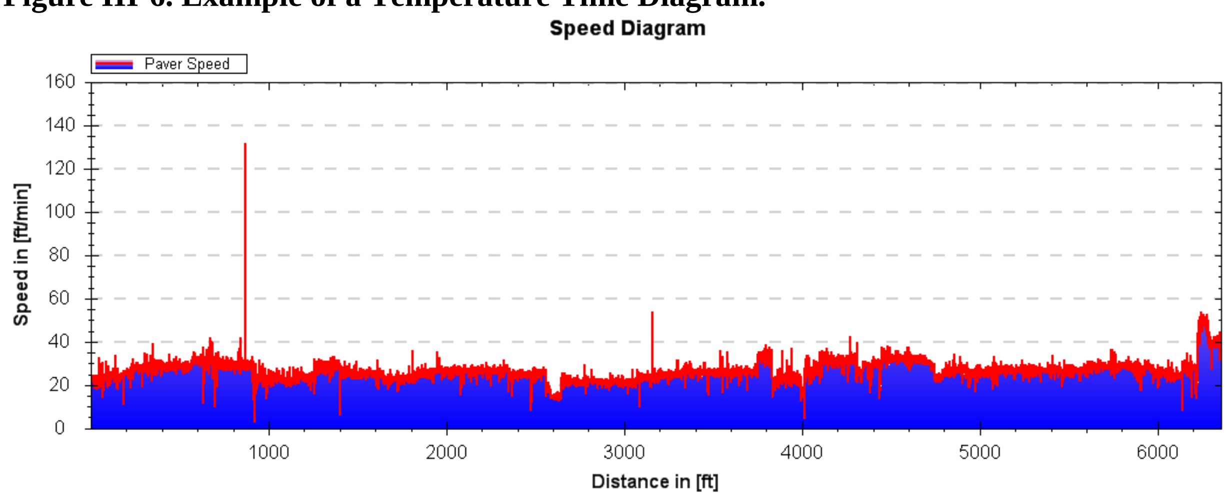


Figure III-7. Example of a Paver Speed Diagram.

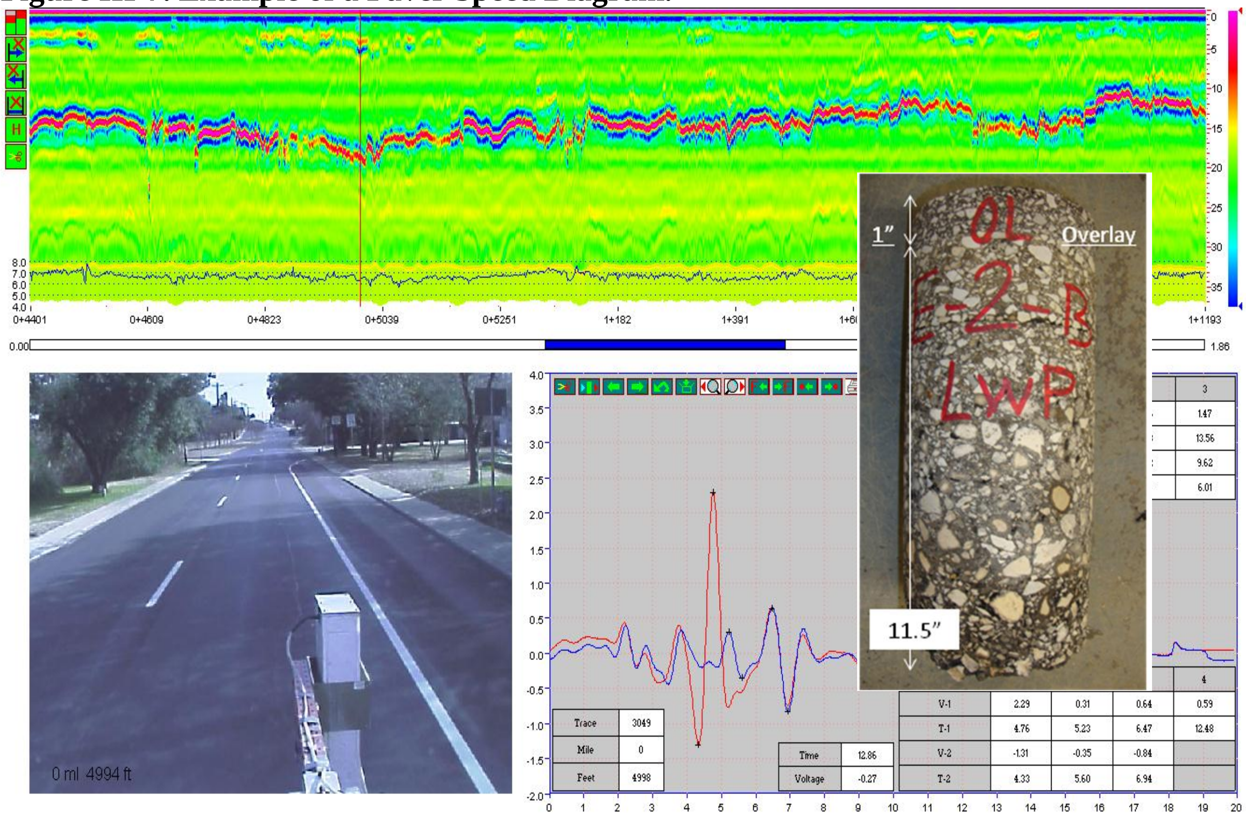


Figure III-8. GPR on EB Outside Lane Just after Construction.

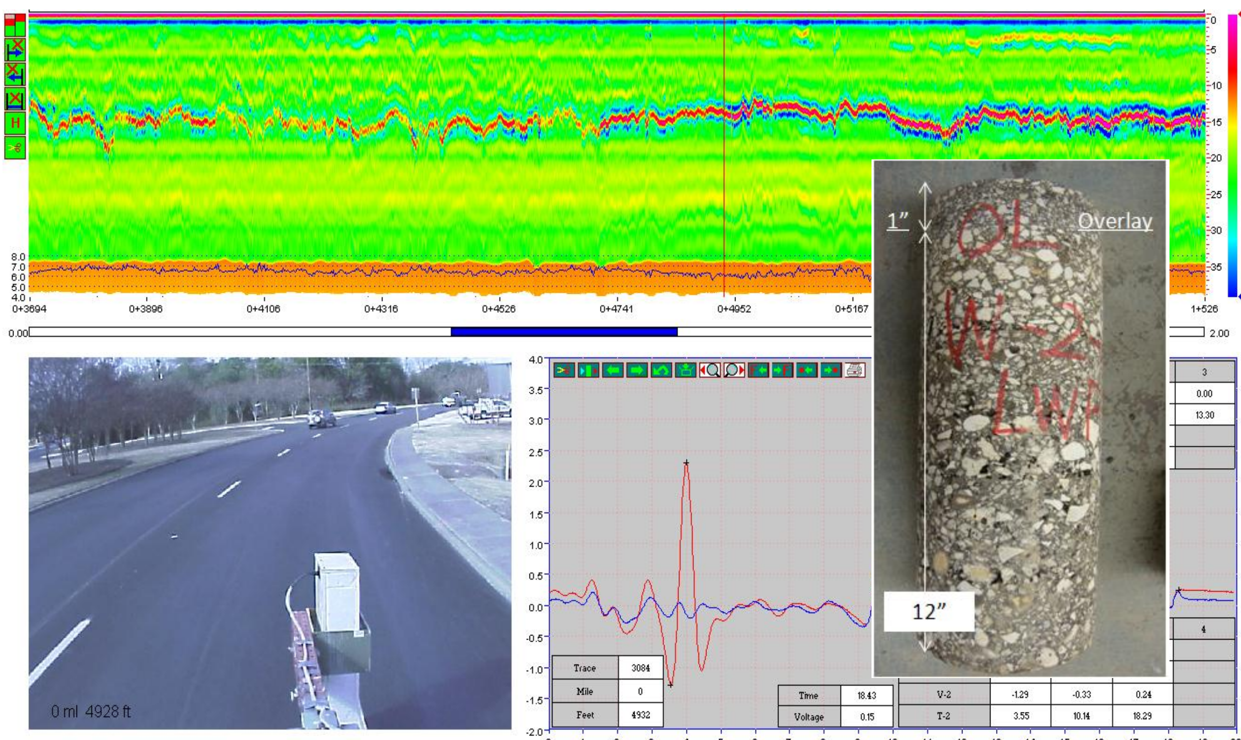


Figure III-9. GPR on WB Outside Lane Just after Construction.

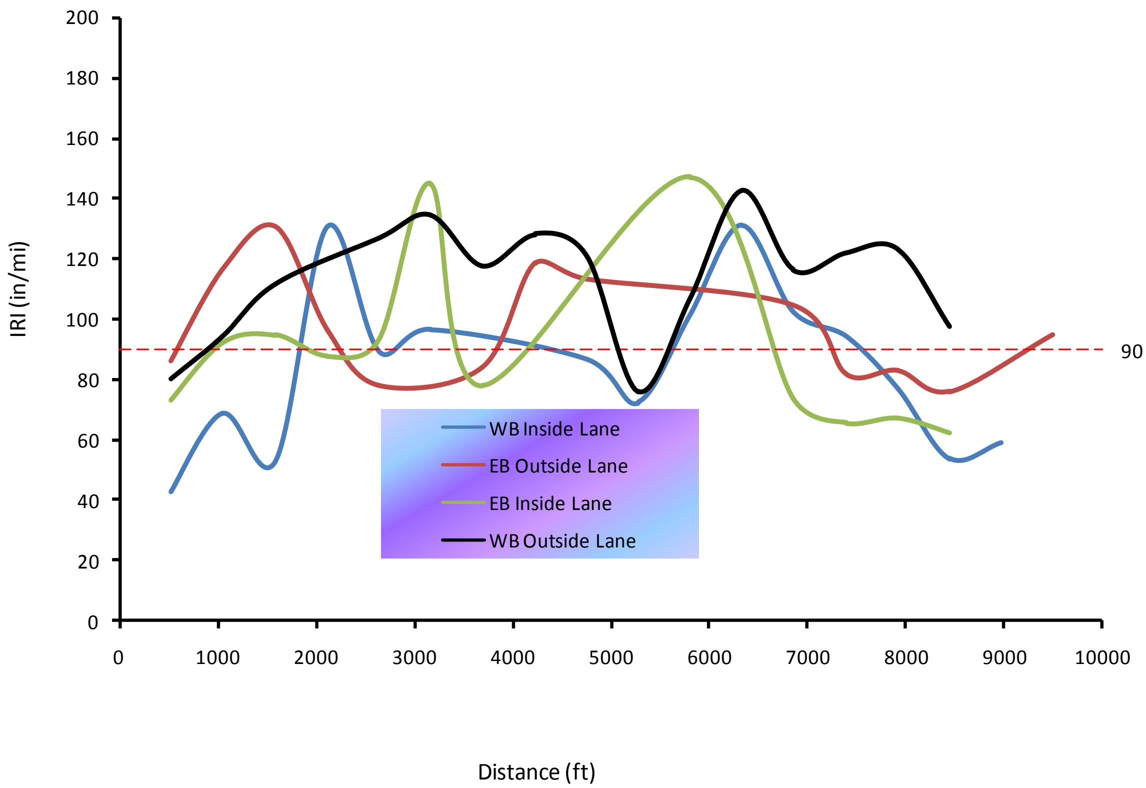


Figure III-10. IRI Plots (Just after Construction, Jan 2011).

Note: Looks like it is not easy get good ride in urban sections with all of the drainage and tight curves. Nonetheless, it is a low speed road (35-40 mph).

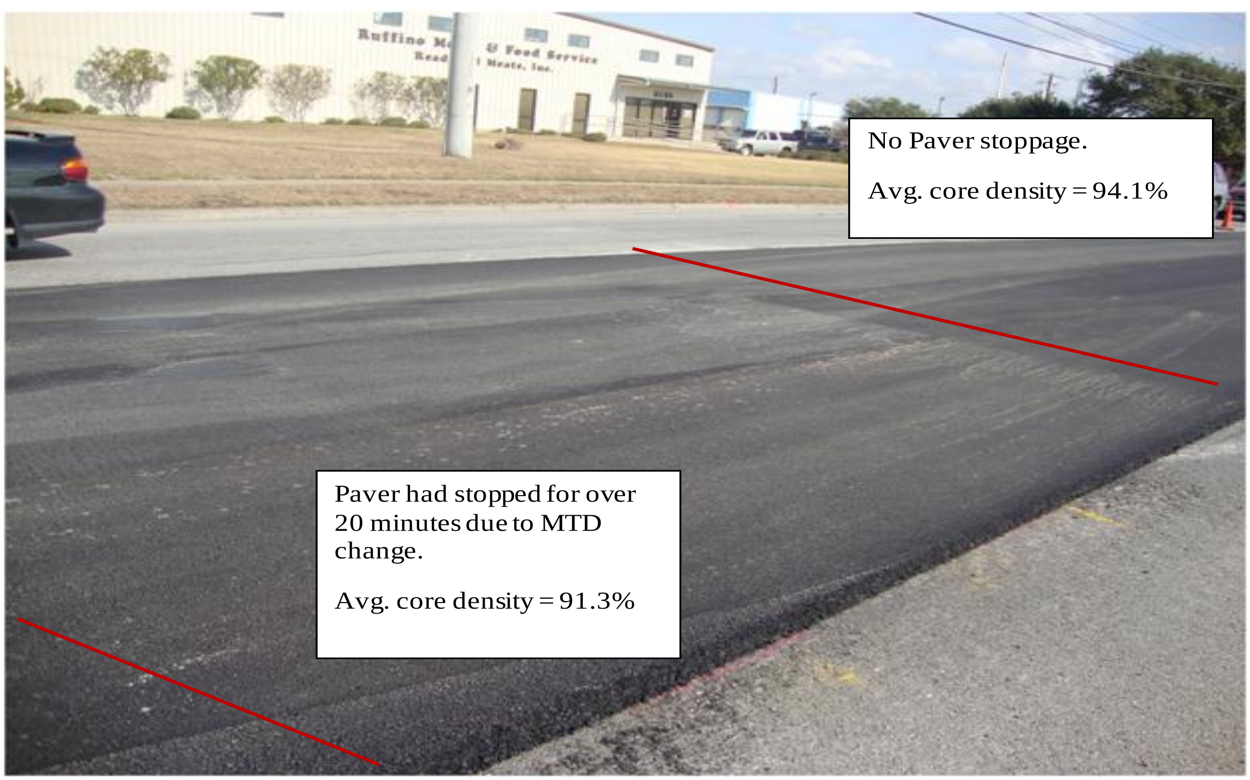


Figure III-11. Comparisons of Core Densities.