APT-ALF TESTING AT LTRC IN LOUISIANA
- **SUMMARY REPORT** -

by

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Section A: SUMMARY (KEY FINDINGS AND RECOMMENDATIONS)

As outlined in the Project 0-6132 work plan, the objective of this task was to develop and undertake the APT- ALT test program. This task was completed with the assistance of Louisiana Transportation Research Center (LTRC) in Louisiana. This report summarizes the work completed and key findings. Detailed APT test results can be found in the following Technical Reports: Report 0-6132-1, 0-6132-2, and 0-6132-3.

Objectives: As an integral part of Study 0-6132, the primary objectives of this task included the following:

1) To validate the new generation mix-design procedure (balanced) under APT testing using the ALF machine.
2) To compare the HMA mix performance designed using the traditional Texas Gyratory (TG) versus the balanced mix design (BMD) method based on Hamburg and Overlay testing:
   - TG (Control) = 4.3% PG 76-22 + limestone
   - Balanced (Modified) = 5.2% PG 76-22 + limestone
3) To correlate the lab test predictions to field APT performance.

HMA Mix: A ¾-inch nominal maximum aggregate size (NMAS) dense-graded Type C mix was comparatively evaluated, designed based on two mix-design methods, namely:

1) The traditional Texas Gyratory (TG) method, at 4.3% OAC; denoted as the Control.
2) The new balanced mix-design (BMD, based on Hamburg and Overlay testing) method, at 5.2% OAC; denoted as the Modified.

A comparative step-by-step illustration of the mix-design methods is shown in Section B. The HMA mix-design details including the selected design OAC are shown in Section C.

Test Sections: Eight test sections were constructed; four representing the Control mix and the remaining four, with the Modified mix, for the following tests:

1) Rutting evaluation
2) Cracking evaluation – fatigue and reflective cracking.

Details of these test sections are shown in Section C. As shown in Section C, the rutting and fatigue crack sections consisted of 3 inch thick HMA over granular base over cement treated subbase and subgrade. The reflective cracking sections on the other hand consisted of 2 inch thick HMA over jointed concrete pavement (JCP) over cemented subbase and subgrade. As seen in Section C, some of the reflective cracking sections were purposely jointed and voided with low LTE so as to better evaluate the performance of the two mix-designs in terms of reflective cracking.

ALF Trafficking: In total, 1,081,000 ALF load passes were applied between 2009 and 2011. The individual number of ALF passes and loading parameters applied on each test section are shown in Section E.

Rutting and Reflective Cracking Tests: In general, the APT performance of these test sections was consistent with lab predictions and as theoretically expected. The Control (low AC) performed better in terms of rutting resistance but poorer in terms of cracking resistance as expected; see Section F. This to some extent provided a validation platform for the proposed balanced mix-design method.

Fatigue Cracking Test Sections: These sections performed unexpectedly; the Modified (high AC) cracked whilst there was none on the Control; see Section F. Also, both sections had accumulated substantially high rutting. As illustrated in Sections F and G, forensic evaluations suggested the following:

- The Control section (4 inches) was thicker than the Modified (3 inches) in terms of the surfacing HMA layer; construction issues.
- The distresses were found to be related to the base and construction problems
- Coring indicated micro-damage and micro-caking on Section 7.
- ALF trafficking on these sections was done towards summer with high temperatures, and hence, the high rutting, particularly on Section 8.

Key Findings and Recommendations

1) The rutting sections performed as expected; the Control performed relatively better than the Modified and correlated with lab test predictions.
2) The reflective cracking sections performed as expected and correlated with lab test results; the Control sections cracked earlier than the Modified, the 50% LTE Section 4 cracked earlier than Good LTE Section 3.
3) Besides rutting, the fatigue crack sections performed unexpectedly; the Modified sections cracked but none on the Control predominantly related to the base problems, construction issues, and time of ALF trafficking.

Overall, these APT results provide a basis for consideration to standardize the balanced mix-design method and incorporate both the Hamburg and OT tests in future HMA mix designs. Without doubt, incorporating both the Hamburg rutting and OT cracking tests in Texas' new generation mix-design procedures will aid to cost-effectively save TxDOT millions of dollars in terms of:

- Optimizing HMA constructability (workability and compactability), thus achieving high construction quality pavements.
- Optimizing rutting and cracking performance, thus minimizing maintenance and rehabilitation activities.

Section B: OVERVIEW OF THE MIX-DESIGN METHODS

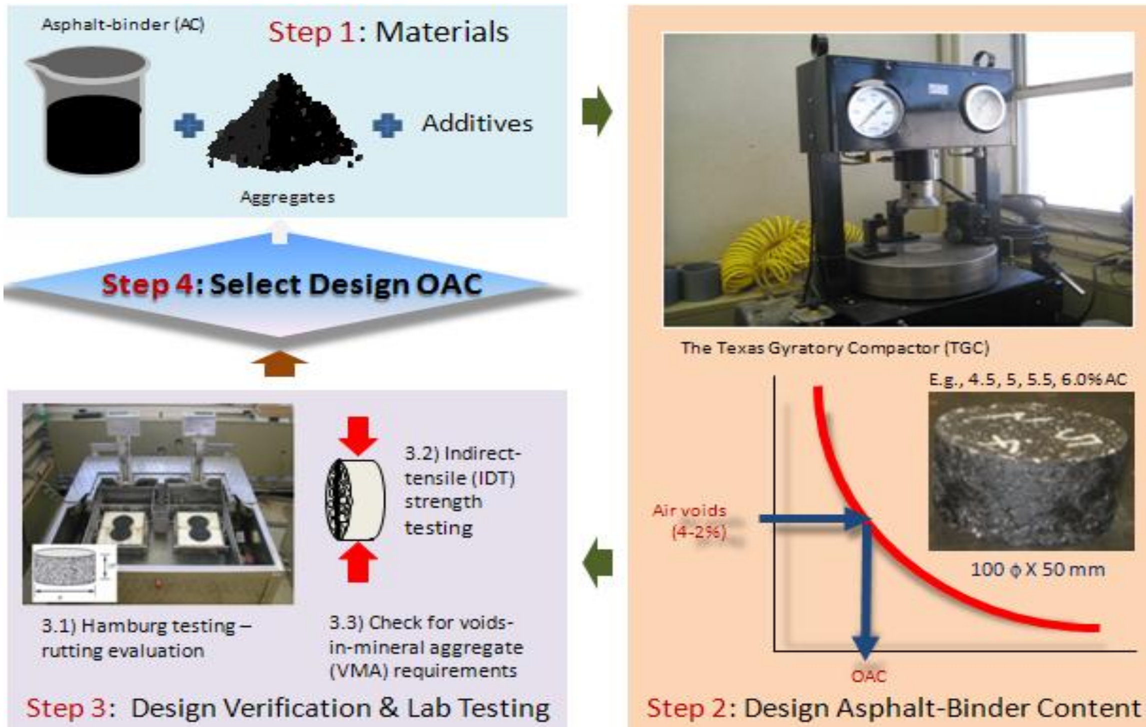

Figure B-1. The Traditional TGC HMA Mix-Design Process.

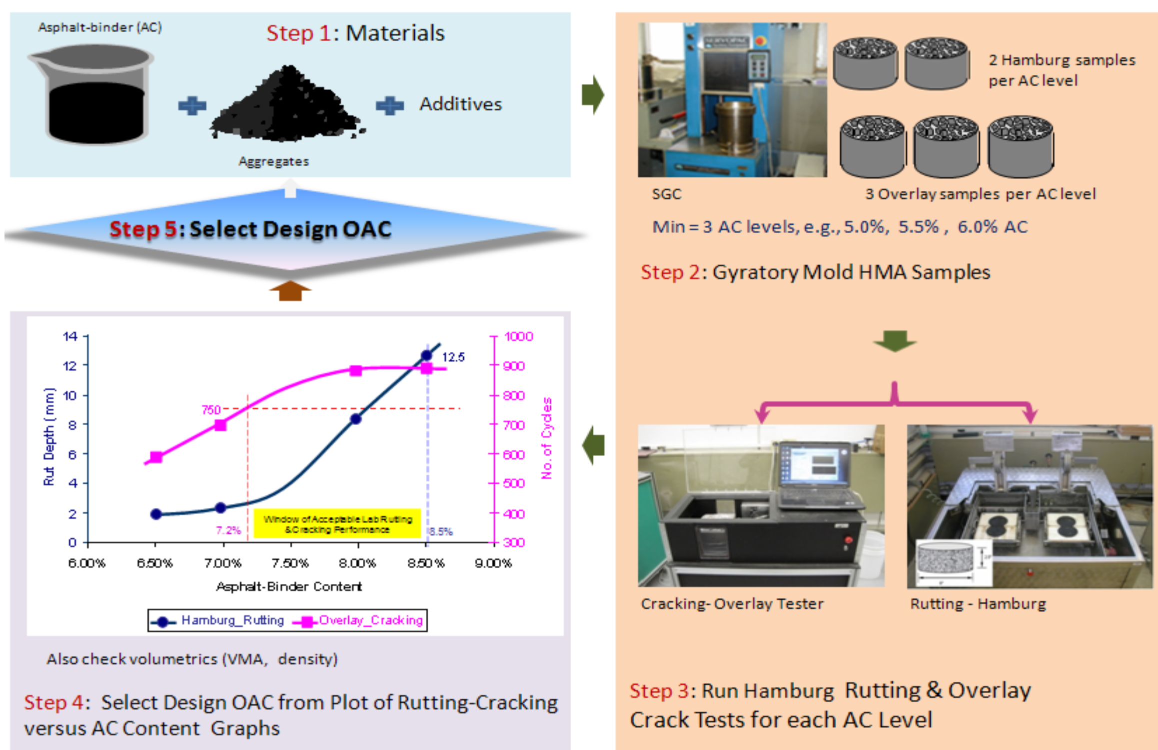

Figure B-2. The Balanced HMA Mix Design (BMD) Process.

Section C: HMA MIX-DESIGN DETAILS

Table C-1. HMA Mixes Used for ALF-APT Testing.

Item	TG Method	Balanced (BMD) Method
Mix designation	Control	Modified
Mix Type	Type C	Type C
Materials	PG 76-22 (Valero) + Limestone (Brownwood, TX)	PG 76-22 (Valero) + Limestone (Brownwood, TX)
Design OAC	4.3%	5.2%
Corresponding TGC lab density (96% ≤ TGC < 98%	96.0%	97.5%
VMA (≥ 14%)	14.0	14.2%
Hamburg rutting (≤ 12.5 mm)	4.7	7.0
Overlay crack cycles (≥ 300)	90	600
ITD (85 ≤ IDT ≤ 200 psi)	165 psi	130 psi
APT placement	Control sections	Modified sections

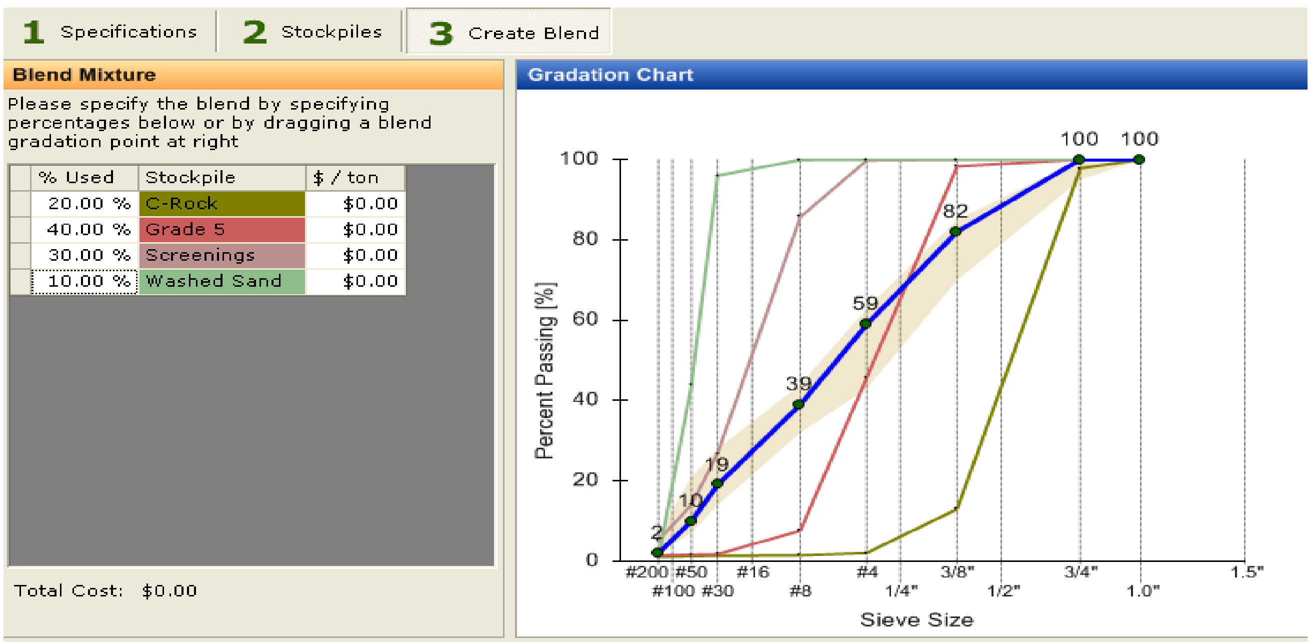

Figure C-1. Aggregate Gradations for the Type C Mix.

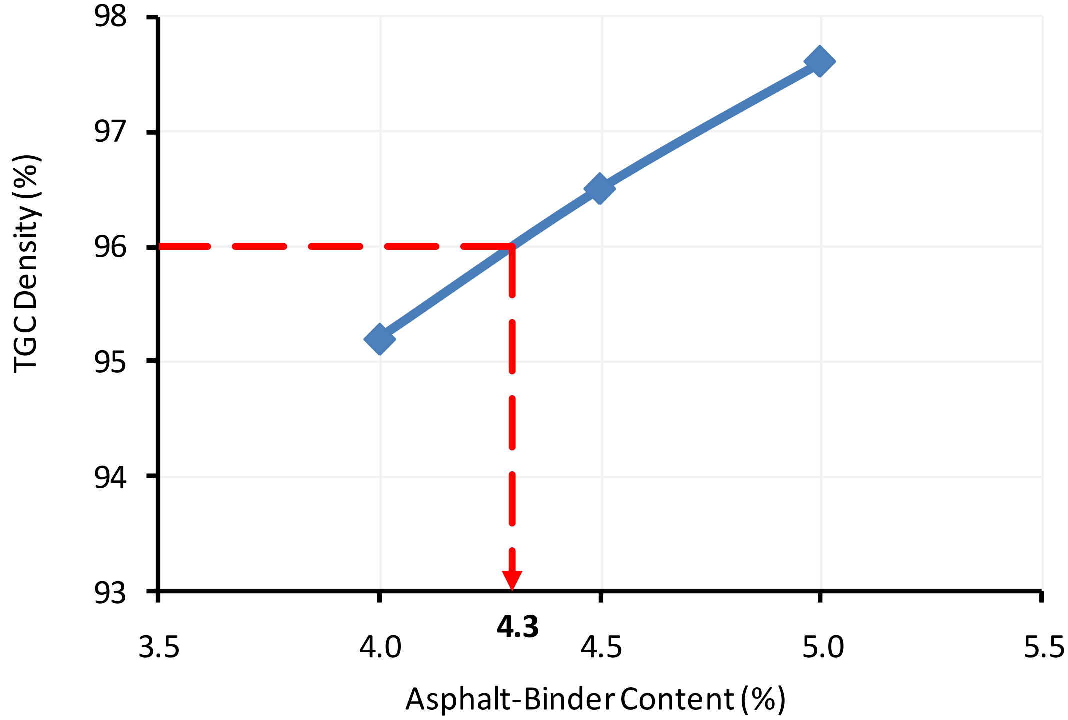

Figure C-2. Design OAC Selection Based on the TGC Method.

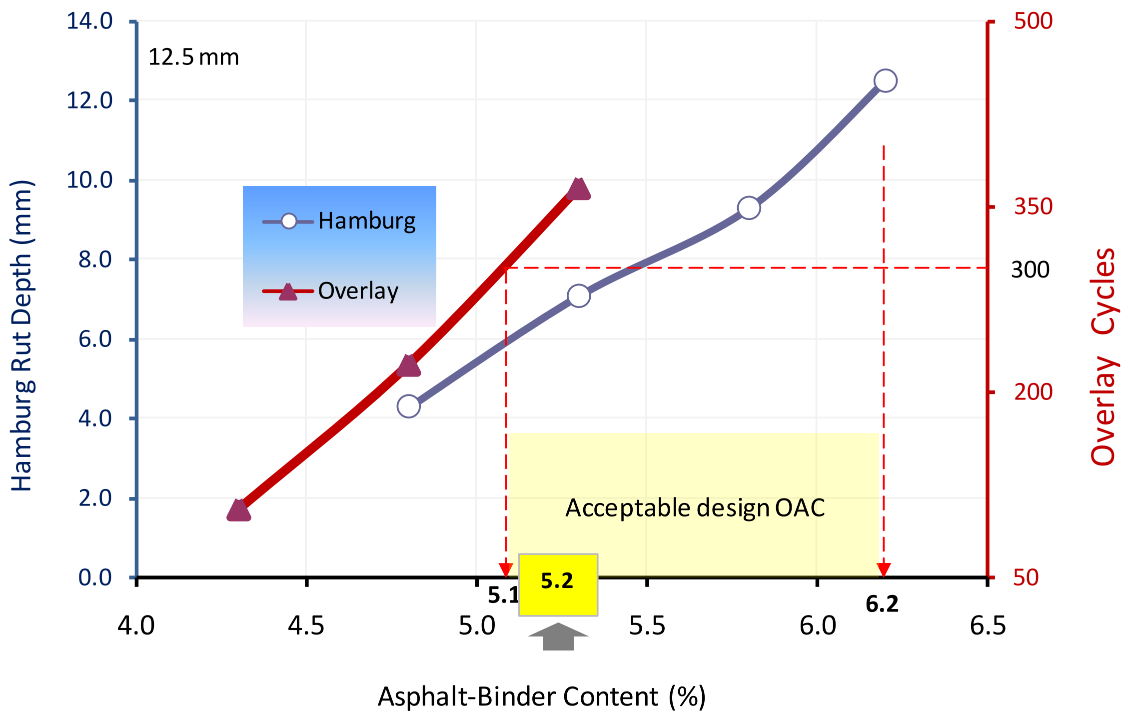

Figure C-3. Design OAC Selection Based on the Balanced (BMD) Method.

Section D: APT TEST SECTIONS

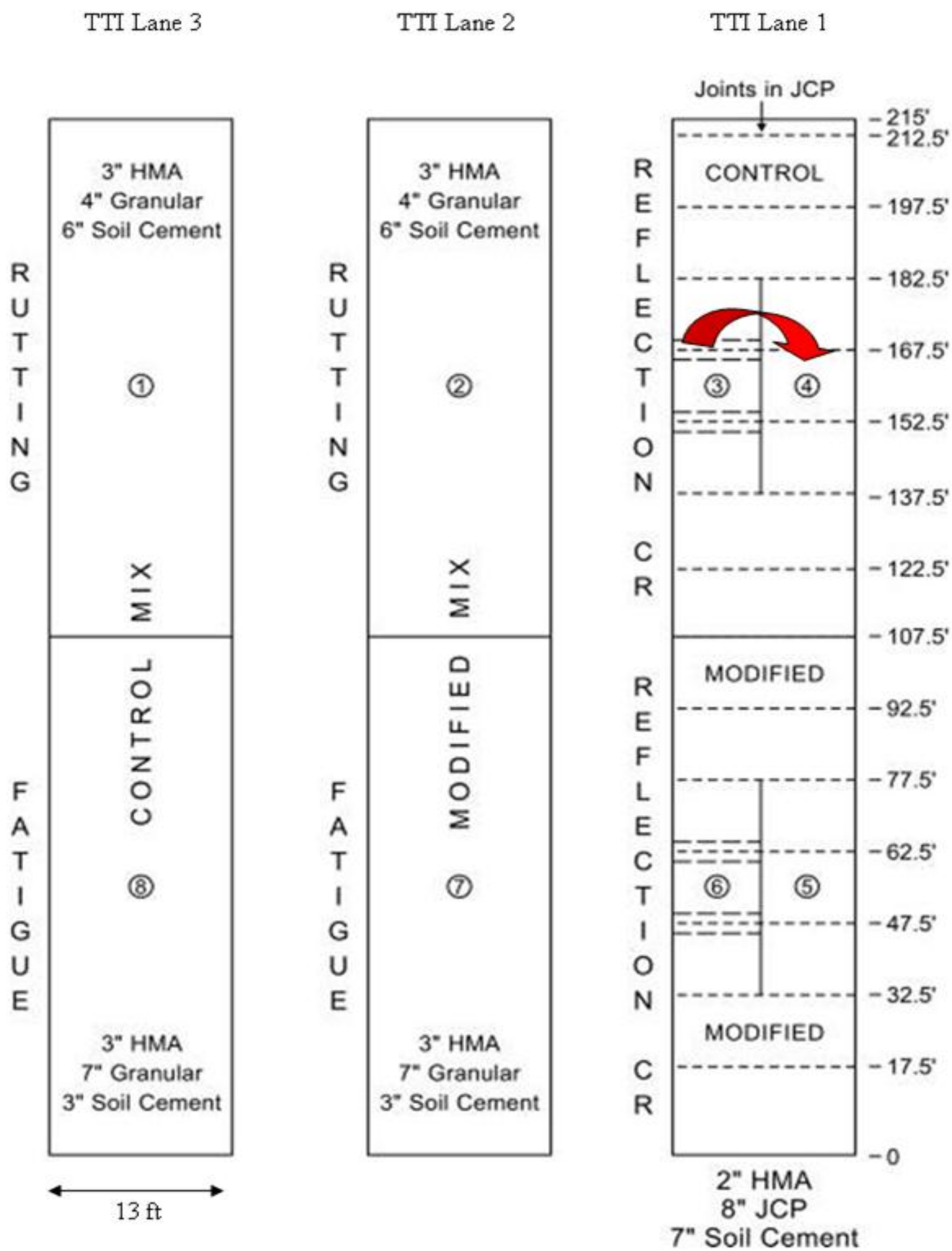

Figure D-1. Layout of the Test Sections.

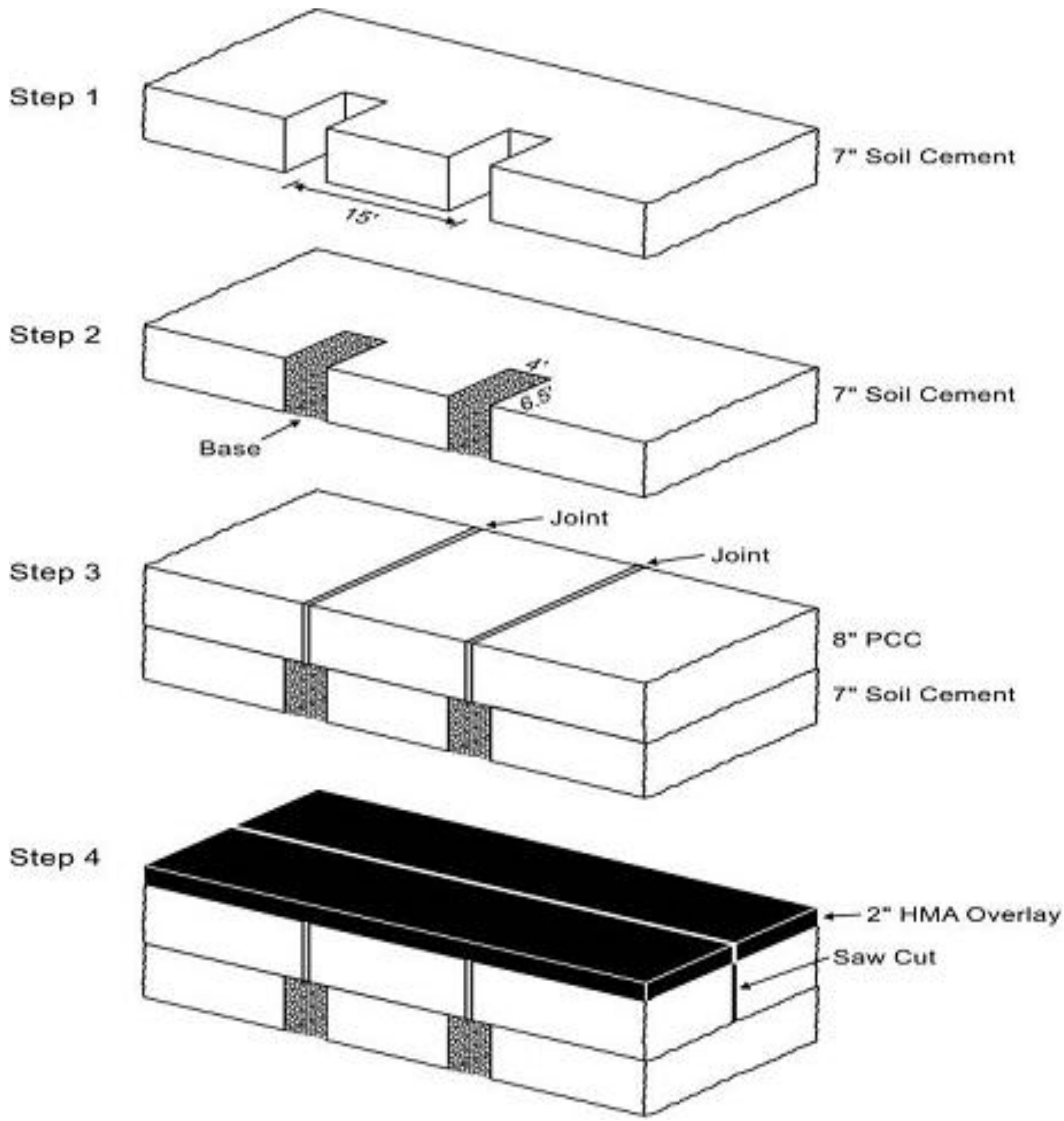

Figure D-2. Construction of the Low LTE Joints (TTI Lane 1).

Figure D-3. HMA Placement of the APT Test Sections.

Figure D-4. Finished HMA Mat on the APT Test Sections.

Section E: ALF LOADING PARAMETERS AND NUMBER OF PASSES

Table E-1. ALF Loading Test Parameters during Trafficking.

Sec#	Test Period	ALF Load Passes (K= 1 000)	Total ALF Load Passes	Tire Load (lbs)	Lateral Wander	AvgAir Temp. During Trafficking (°F)	HMA Mix	Purpose	Distress Observed
1	Sept – Nov 2009	100K	100,000	9 750	None	74.5	Control	Rut evaluation	8 mm rutting
2	Sept – Nov 2009	100K	100,000	9 750	None	74.5	Modified	Rut evaluation	15 mm rutting
3	Dec 09 – Feb 2010	0-75K 75-175K	75,000 100,000	9 750 14 600	None	48.0	Control	Reflection crack evaluation	Cracking was only visible after 175 k load passes
4	Dec 09 – Feb 2010	0-75k 75-131 k	75,000 56,000	9 750 14 600	None	48.0	Control	Reflection crack evaluation (50% LTE)	Cracking started after 75 k ALF load passes
5	Dec 10 - Feb 2011	0-75 K 75-175 K	75,000 100,000	9 750 14600	None None	- -	Modified	Reflection crack evaluation	Cracking started after 143 k ALF load passes @ joint location Station +47.5
6	Dec 10 - Jan 2011	0-75 k 75-100 k	75,000 25,000	9 750 14600	None None	- -	Modified	Reflection crack evaluation (50% LTE)	None
7	Mar – Jun 2010	0-125K 125-150K	125,000 25,000	9 750 14 350	None YES	73.0 73.0	Modified	Fatigue crack evaluation	Cracked @ 150 k; 11 mm rutting after 100k
8	Mar – Jun 2010	0-125K 125-150K	125,000 25,000	9 750 14 350	None YES	73.0 73.0	Control	Fatigue crack evaluation	No cracking; 8 mm rutting after 100 k

Total	**1,081,000**
Balance	119,000

Note: ALF tire pressure = 105 psi (on all test sections); Wheel speed = 10.5 mph (on all test sections); Tire print width = 9 inches (on all test sections)

Section F: ALF-APT RUTIING AND REFLECTIVE CRAKING RESULTS

Table F-1. Summary of Lab and Field APT Test Results.

Item	Rutting		Reflective Cracking	
	Control 1	Modified 1	Control 2	Modified 2
Lab-molded (lab design) - lab	4.7 mm	7.0 mm	105 (< 300)	330 (> 300)
Plant-mix from test site - lab	2.3 mm	4.1 mm	041 (< 300)	446 (> 300)
Raw materials from plant - lab	3.0 mm	7.7 mm	032 (< 300)	306 (> 300)
Field APT performance after 75 000 ALF load passes	7.7 mm	11.8 mm	Cracked	No cracking

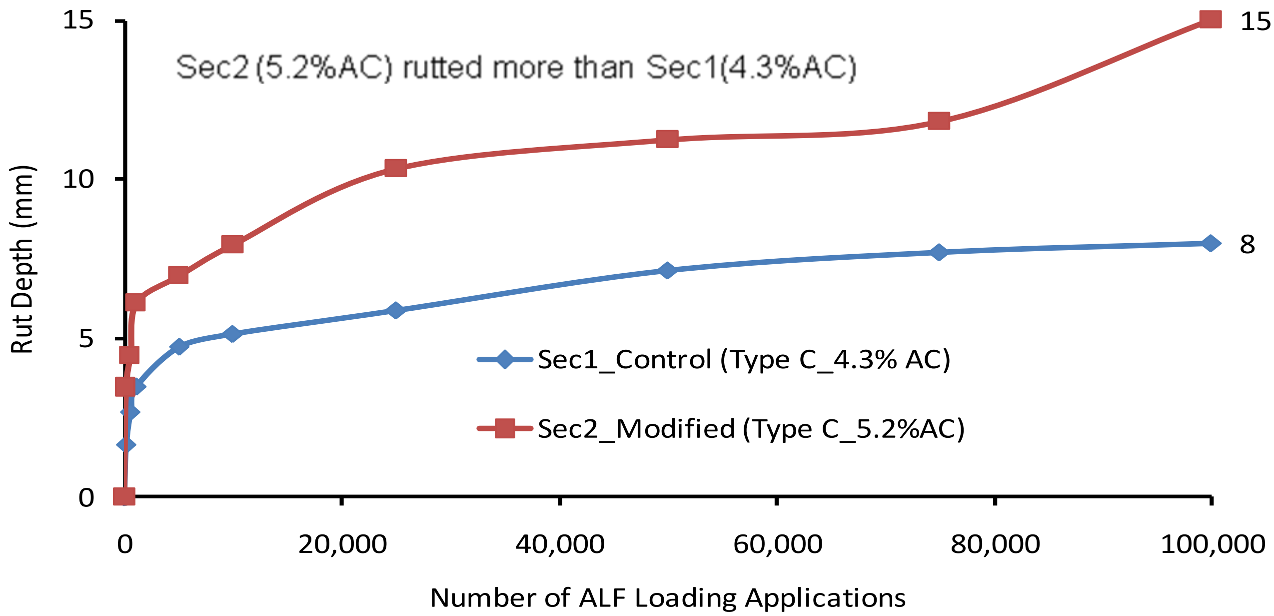

Figure F-1. ALF-APT Rutting Results.

Figure F-2. Trenching and Pictorial Comparison of Rutting.

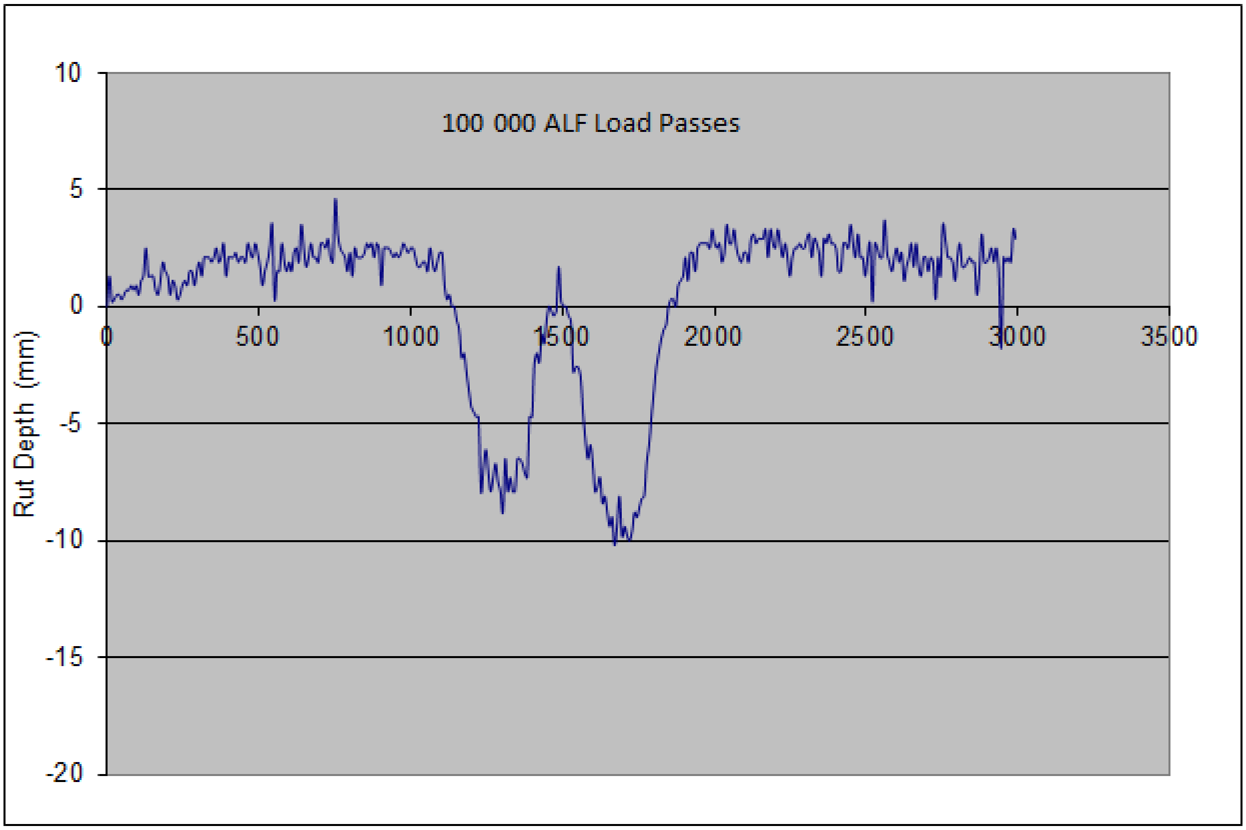

Figure F-3. Transverse Rut Measurements on Control Section 1.

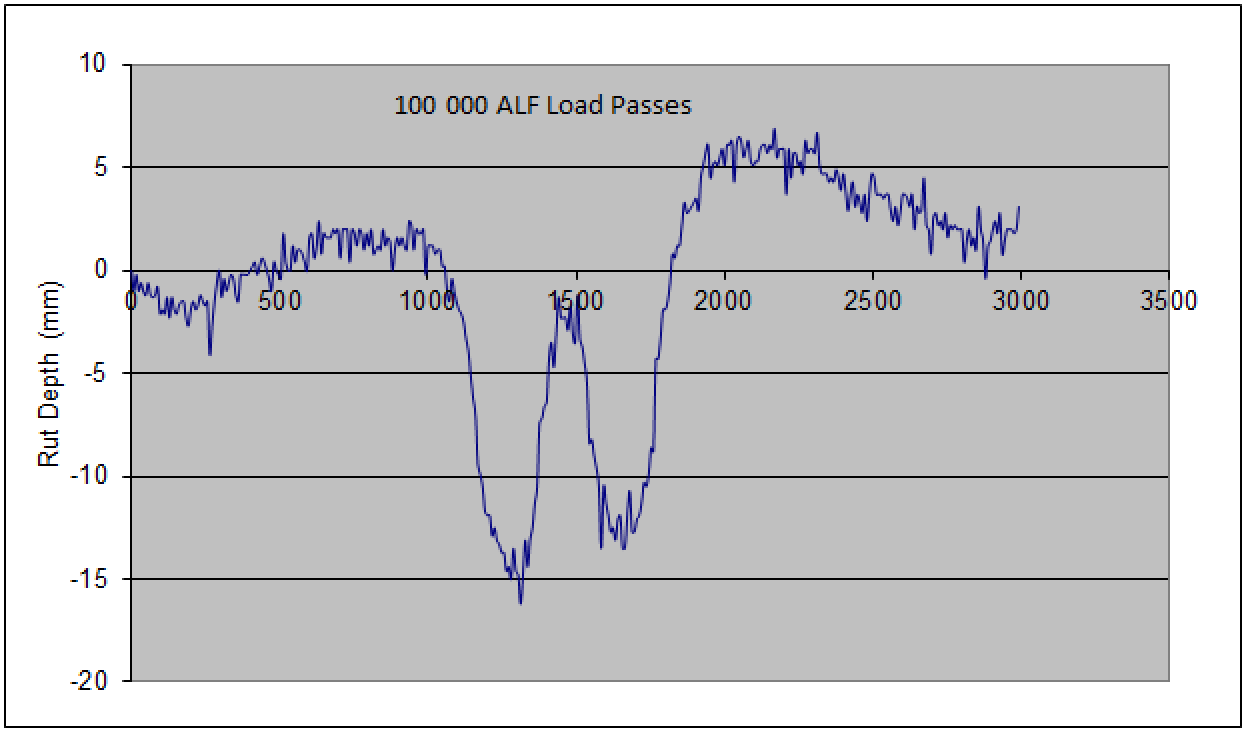

Figure F-4. Transverse Rut Measurements on Modified Section 2.

Figure F-5. Reflective Cracking on Control Section 4 (Type C; 4.3% OAC = 50% LTE.

(For Section 3_Control (Type C; 4.3% OAC) = Good LTE; cracks appeared only after 175 k ALF load passes)

Figure F-6. Section 5 _Modified (Type C; 5.2% OAC) = Good LTE; Cracking at Joint Location Station# 47.5 after 143 k ALF Load Passes

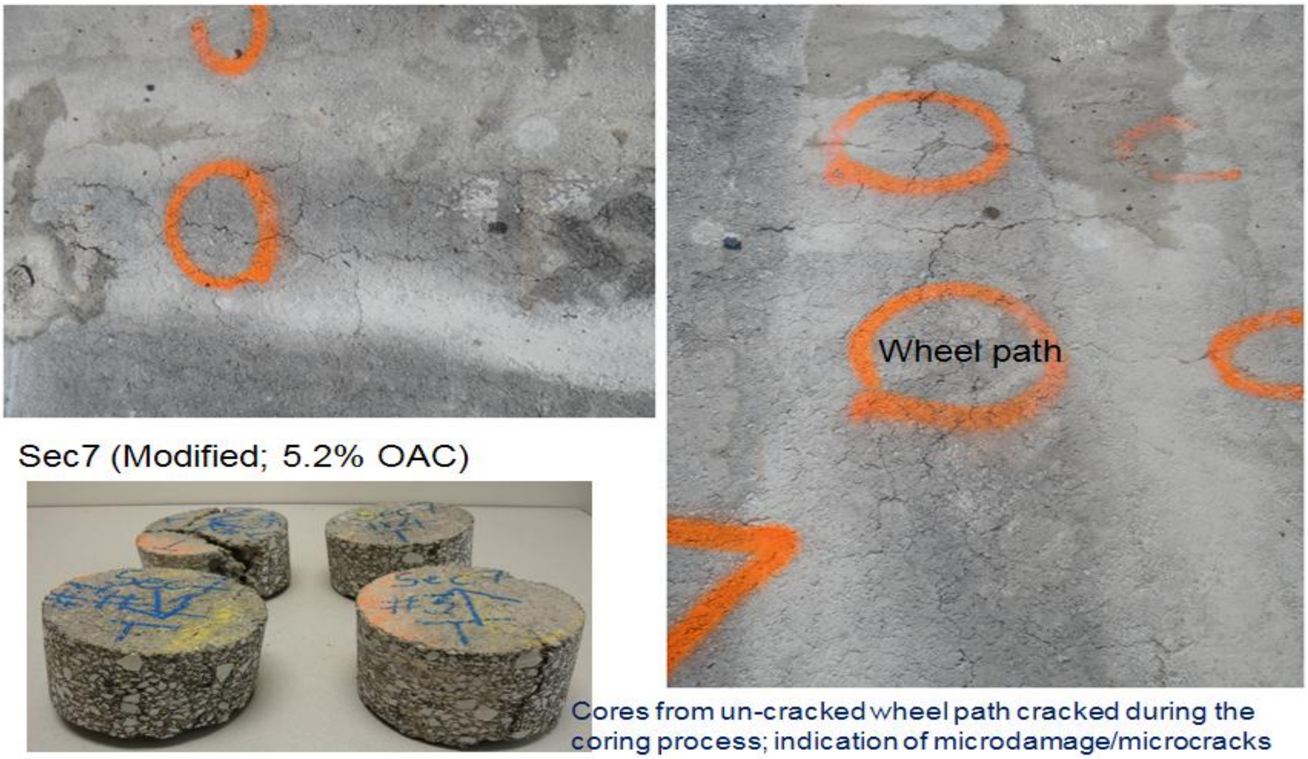

Figure F-7. Fatigue Cracking on Section 7.

Figure F-8. Base Related Rut Failure of Fatigue Crack Sections.

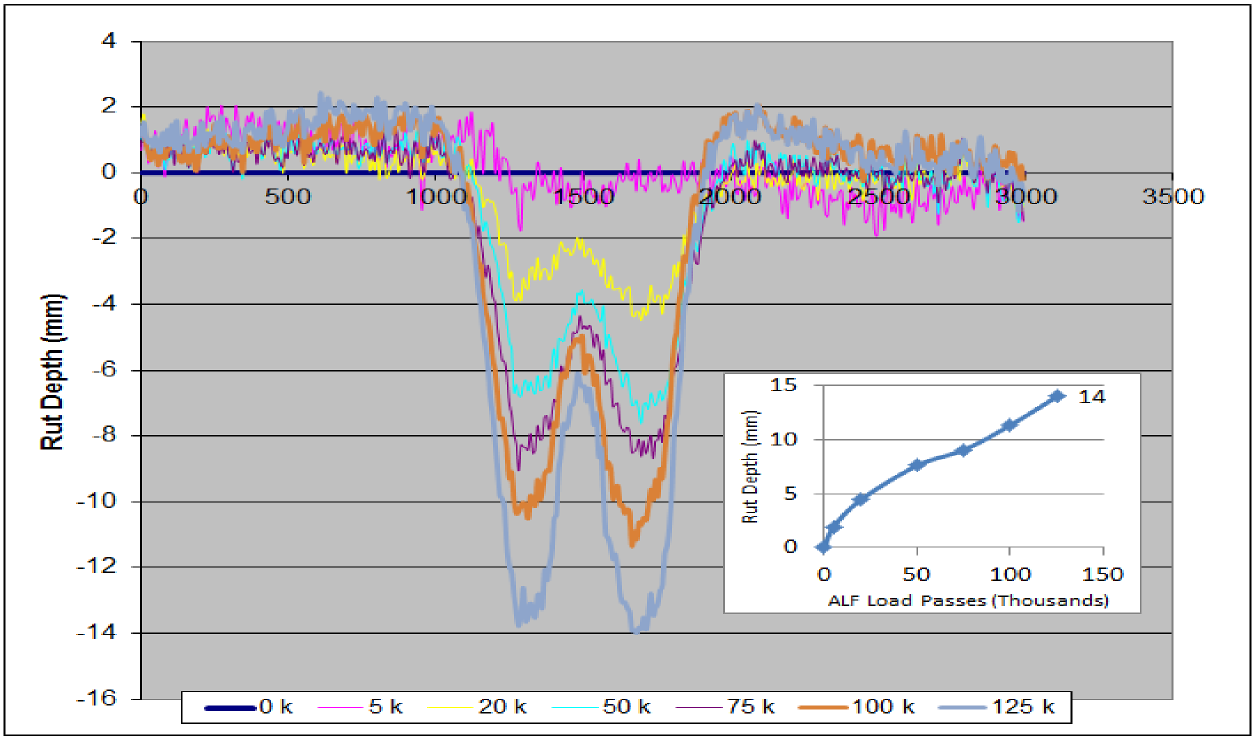

Figure F-9. Transverse Rut Measurements on Control Section 7.

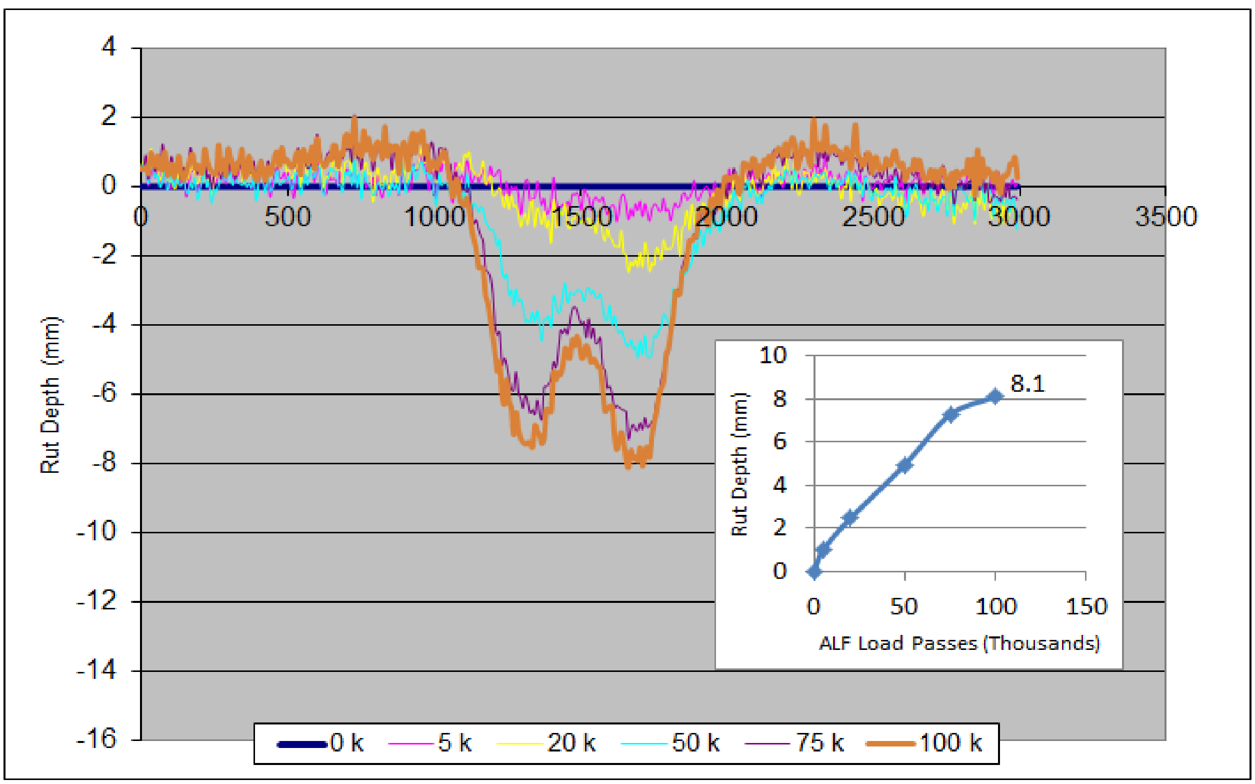

Figure F-10. Transverse Rut Measurements on Modified Section 8.

Section G: CORING AND FORENSIC EVALUATION

Figure G-1. Cracked and Un-Cracked Cores on Section 7 (5.2% OAC).