TEXAS DEPARTMENT OF TRANSPORTATION

USE GROUND PENETRATING RADAR TECHNOLOGY TO EVALUATE RUTTING IN AN ASPHALT OVERLAY

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September 16~19, 2013, RPUG Meeting, San Antonio, TX

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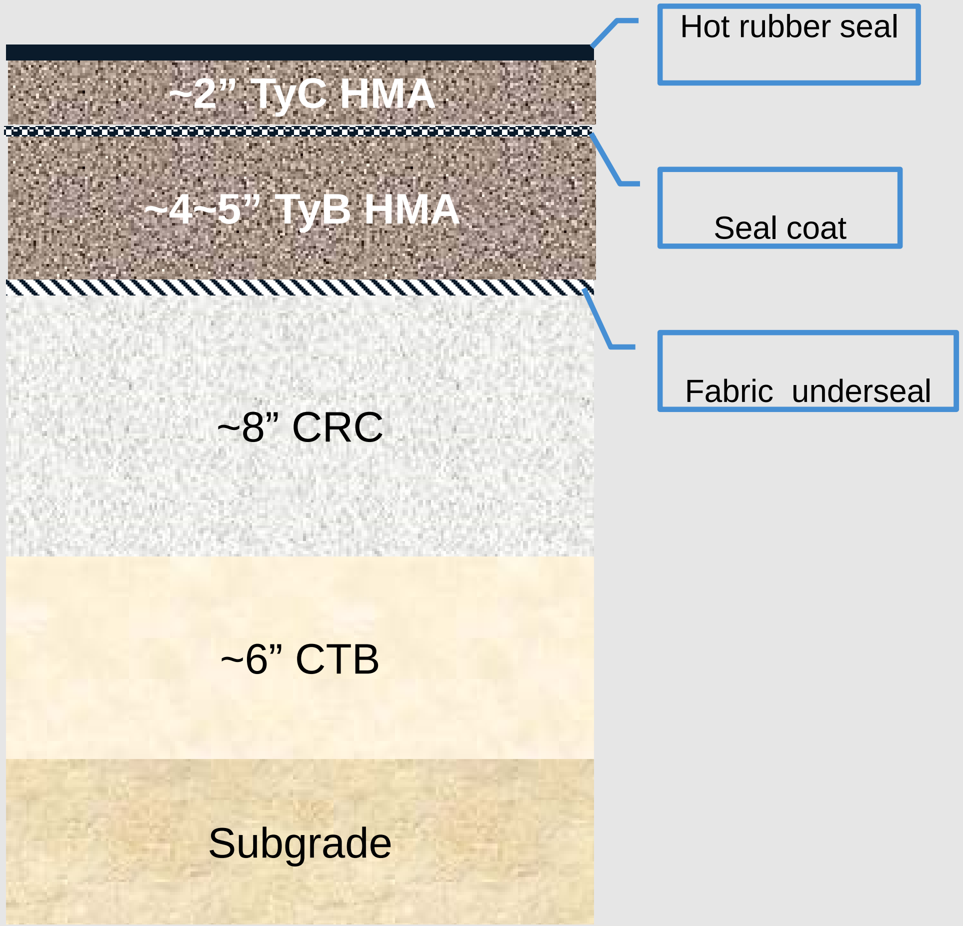
Introduction

- What is rut
- Causes of rut
- Layer-based rut study
- Methods to evaluate layer-based rut
- Focus of this study

Background (1)

Pavement structure



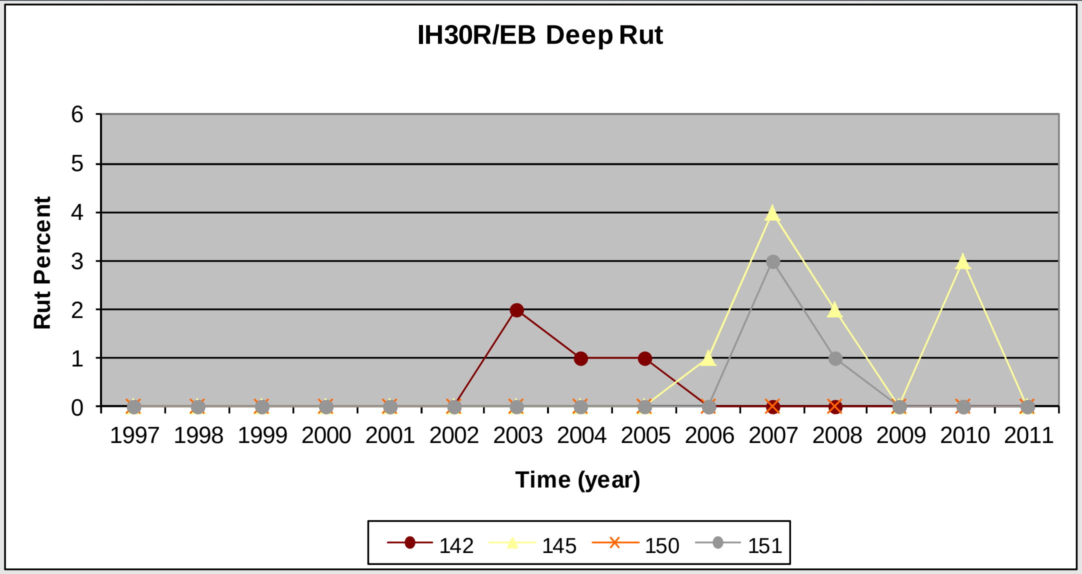
Project history

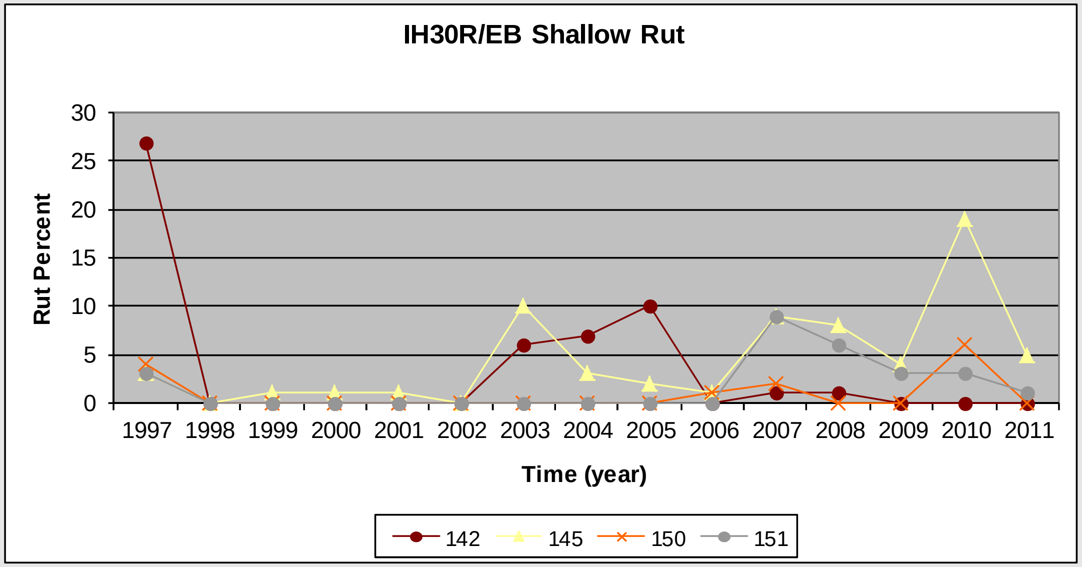
- Hot rubber seal: 2006
- Hot mix asphalt overlay: 1998

Traffic

- 2010 AADT: 24610
- Truck percentage: 26%
- 20 years ESALs: 33 million

Background (2)





Background (3)

Experimental Design

Non destructive testing

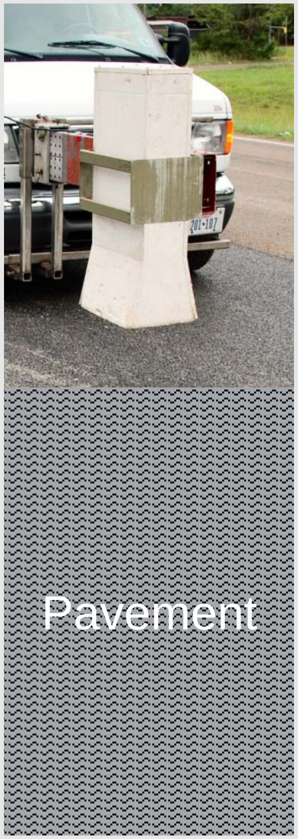
- Ground Penetrating Radar used to estimate pavement layer thickness
  - Right wheel path
  - Middle of lane

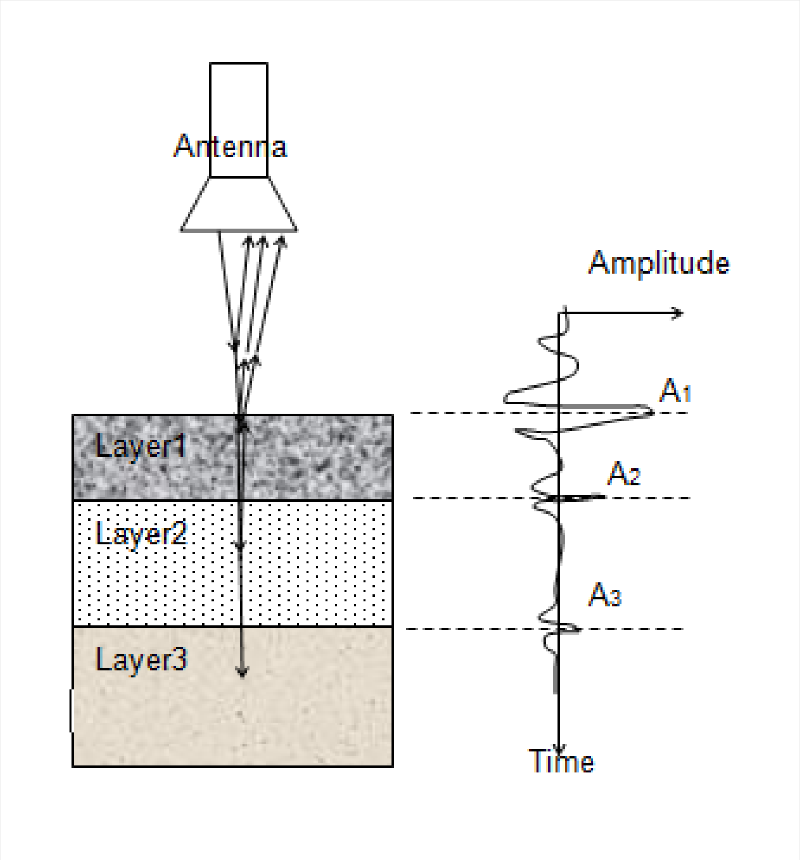
Destructive testing

- Coring used to calibrate GPR thickness estimates
- Trenching used to verify permanent deformation estimated by GPR

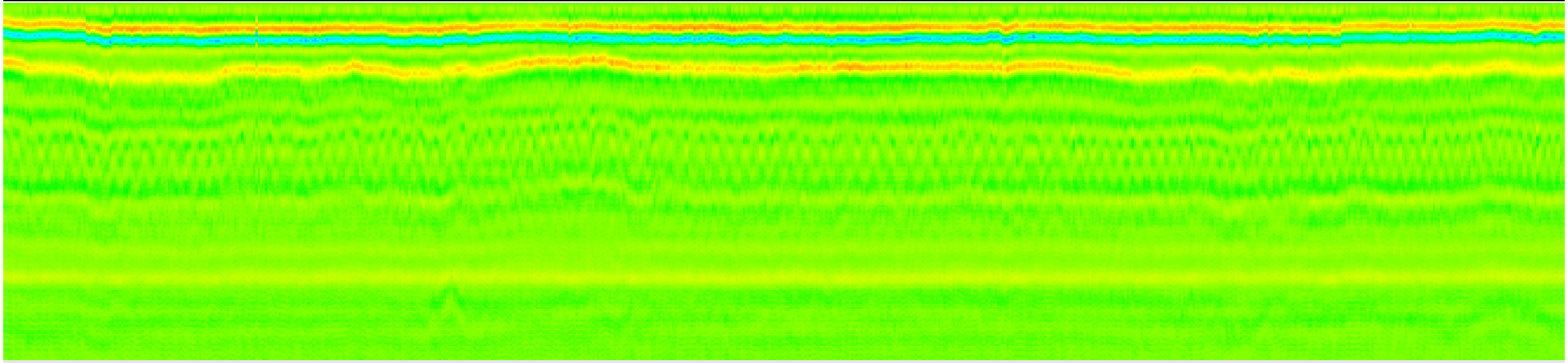
NDT and DT complement each other to accommodate evaluation of permanent deformation across the entire length of the segment under study.

GPR Principle





GPR Colorful Map View



Thickness Estimation Based on GPR Signal

Dielectric

$$\varepsilon = \left[\frac{1 + A_1 / A_m}{1 - A_1 / A_m} \right]^2$$

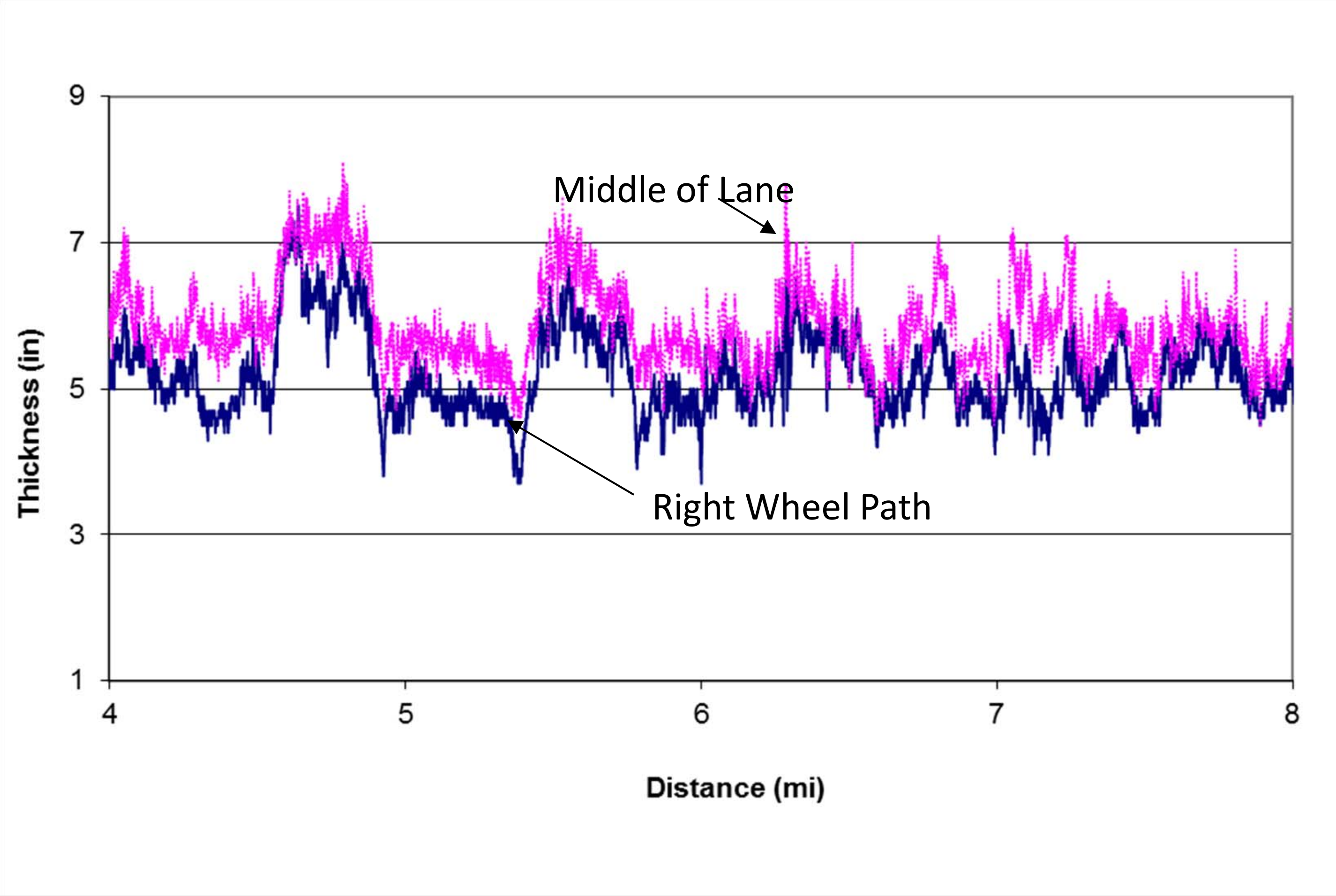
A_1: Amplitude of reflection from pavement surface, in volt;
A_m: Amplitude of reflection from a metal plate (placed on a pavement surface), in volt.

Thickness

$$h = \frac{ct}{\sqrt{\varepsilon}}$$

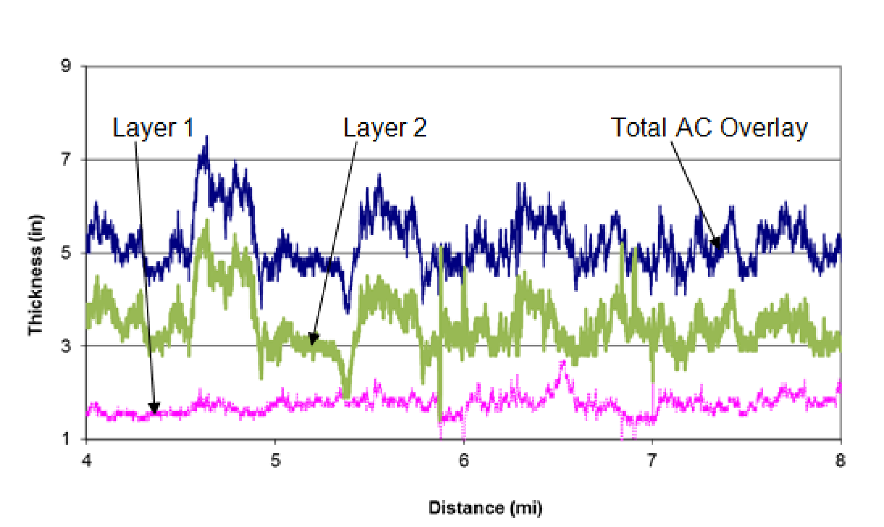
c: A constant representing the speed of the EM wave traveling in the air, i.e. approximately 3x108 m/s or 11.8 inch/ns; and
t: One way travel time of an EM wave in a given layer.

Total AC Overlay Thickness

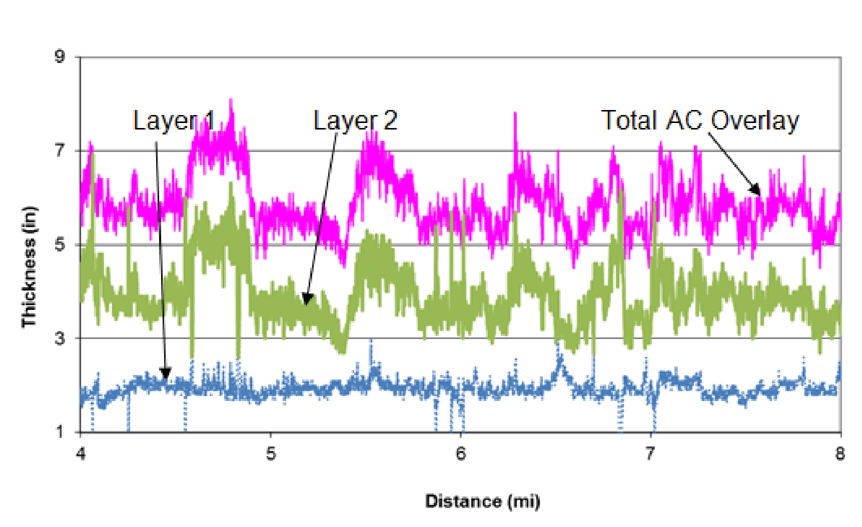


AC Layer Thickness Along Different Scan Lines

Right Wheel Path



Middle of Lane



Thickness Calibration

$$\varepsilon^* = K_0 + K_1\varepsilon + K_2\varepsilon^2$$

Where,

ε^*: Calibrated dielectric;

ε: GPR estimated dielectric; and

$K_0 \sim K_0$: Calibration factors.

$$h^* = \frac{ct}{\sqrt{K_0 + K_1\varepsilon + K_2\varepsilon^2}}$$

$$\text{Minimize } \sum_i \left(\frac{h_i}{h_i^*} - 1 \right)^2$$

Where,

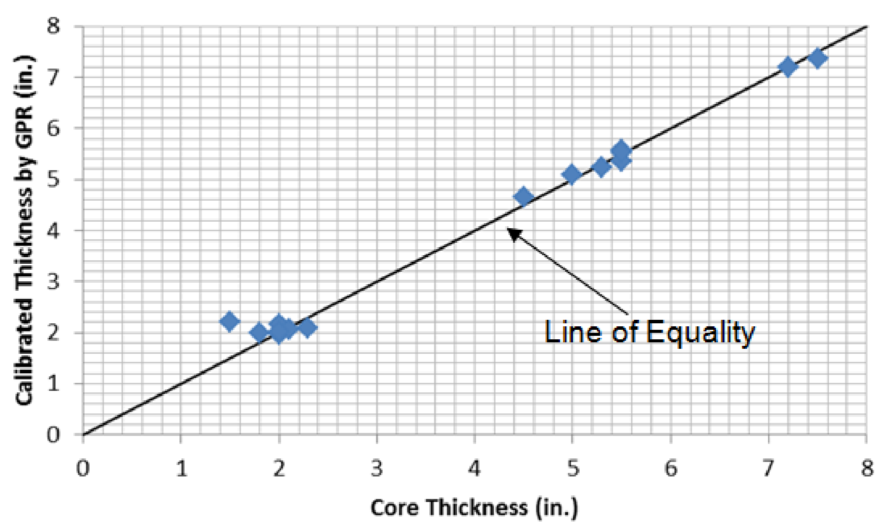
h_i: GPR estimated thickness at the ith core location; and

h_i^*: Thickness of the ith core.

Calibration Results

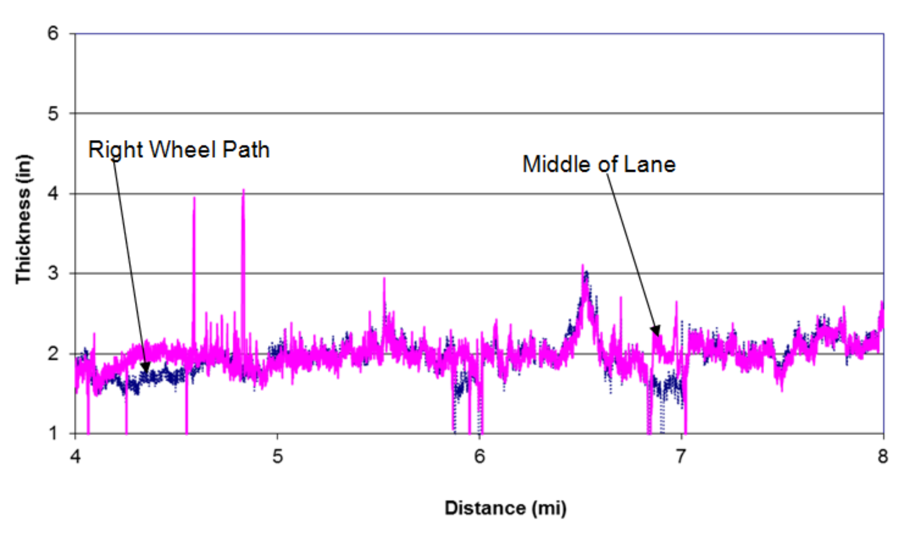
	Right Wheel Path					Middle of Lane				
	GPR(in)			Difference		GPR(in)			Difference	
Core#	Before*	After*	Core(in)	Before	After	Before	After	Core(in)	Before	After
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
1	5.3	5.4	5.5	-3.6%	-1.8%	5.8	5.6	5.5	5.5%	1.8%
2	7.2	7.4	7.5	-4.0%	-1.3%	6.9	7.2	7.2	-4.2%	0.0%
3	4.8	5.1	5.0	-4.0%	2%	5.7	5.5	5.5	3.6%	0.0%
4	4.7	4.7	4.5	4.4%	4.4%	5.5	5.2	5.3	3.8%	-1.9%

*"Before" means before calibration by cores; "After" means after the calibration.

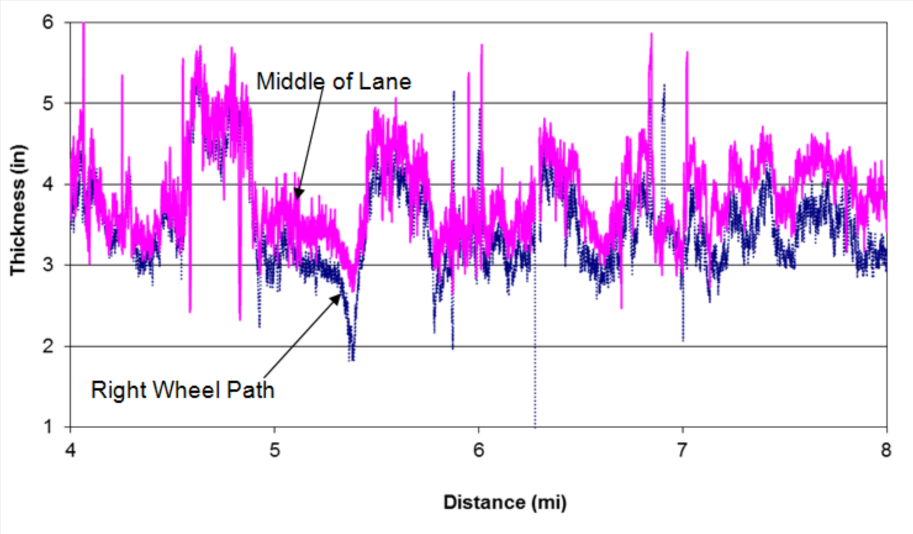


Layer Based Thickness Comparison

AC Layer 1



AC Layer 2

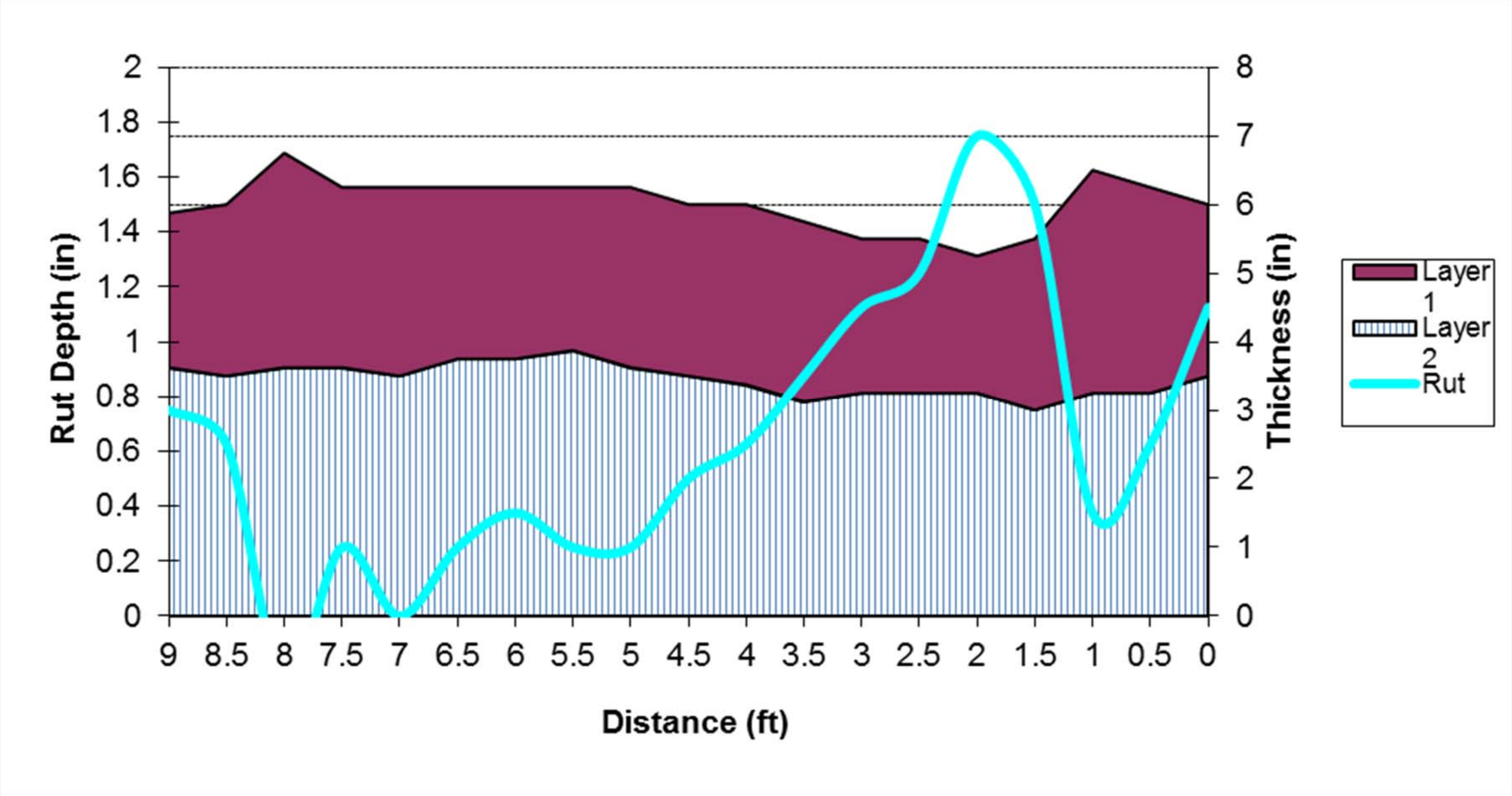


Layer Based Permanent Deformation Statistics

Percent	Percentile Thickness Difference (in)	
	Layer1	Layer2
90%	0.31	1.07
80%	0.17	0.87
70%	0.1	0.74
60%	0.06	0.64
50%	0.02	0.54
40%	-	0.45
30%	-	0.37
20%	-	0.28
10%	-	0.15

Trenching in Field

Permanent Deformation from Trench



PD (in.)	GPR	Trench
Layer 1	0.63	0.63
Layer 2	0.27	0.38

Conclusion Remarks

- GPR can serve as an effective tool to
  - Evaluate permanent deformation in AC overlay
  - Identify layer-based permanent deformation
  - Provide full length survey coverage
  - Provide fast and nondestructive survey results

Thank You
&
Be Safe