Warm Mix Asphalt in Texas

Cindy Estakhri, P.E.
Texas Transportation Institute

Dale Rand, P.E.
Texas Department of Transportation

Texas Transportation Institute

TxDOT's Warm Mix Asphalt-Definition

- Warm Mix Asphalt (WMA) is defined as additives or processes that allow a reduction in the temperature at which asphalt mixtures are produced and placed.
- When WMA allowed, temperatures should be from 215°F to 350°F.
- When WMA required, temperatures should be from 215°F to 275°F.

Warm Mix Benefits

- More Durable Pavement
  - Less oxidized + less absorption = better fatigue life
- Better in-place densities
  - Improved fatigue life
  - better bonus for contractor
- Wider Paving Window
  - Winter Paving
  - Night Paving
- Reduced Emissions, Smoke & Odor
- Direct Energy Savings ~ $1/ton
- Less problems with crack seals swelling

Current Status

- WMA is allowed for use at Contractor's option on most HMA projects
- A few districts require WMA by plan note
  - Environmental reasons – non attainment areas
  - Overlays on pavements with rubber crack seal
- Most Contractor's have or are in the process of installing a WMA additive system

TxDOT Warm Mix Jobs

- October 2007: ~ 2000 tons
- October 2008: ~120,000 tons
- October 2009: 1,000,000 tons ++
- October 2010: Widespread Implementation

Many WMA Proprietary Technologies Available (19+)

- ***Foaming Processes*** introduce small amounts of water which turns into steam, expanding the binder phase and reducing mix viscosity.
  - **Astec Double Barrel Green**
  - **Terex WMA System**
  - **Maxam Aqua Black**
  - **Advera**

- ***Chemical Modifiers*** rely on a variety of different mechanisms, such as surfactants to help coat the aggregate at lower temperatures or waxes which decrease the viscosity above their melting point.
  - **Evotherm**
  - **Rediset**
  - **Sasobit**

TTI Research
What we did……

- Effects of Warm Mix Additive on Mixture Design
  - 3 Mixing and Compaction Temperatures
- Effects of Warm Mix Additive on Performance Tests
  - Hamburg
  - Overlay Test
  - Resilient Modulus
  - Fatigue Analysis
- Field and Laboratory Evaluation/Demonstration Projects
- Field Performance Evaluations

Field Evaluation

- Cores
  - Hamburg
  - Overlay Test
  - Indirect Tension
  - Density
  - X-ray computed tomography
- Ground Penetrating Radar (uniformity of construction)
- Falling Weight Deflectometer

Field Projects Evaluated

District	*Service Age*	*Quantity of WMA*	*WMA Process*
San Antonio	5 years	2000 tons	Evotherm
Lufkin	4 years	800 tons 800 tons 800 tons 800 tons	Evotherm Advera Rediset Sasobit
Fort Worth	*4 Years*	*36000 tons*	*Evotherm*
Austin	*4 Years*	*8000 tons*	*Evotherm*
Wichita Falls	*4 Years*	*68000 tons*	*Double Barrel Green*
Beaumont	4 years	1000 tons	Rediset

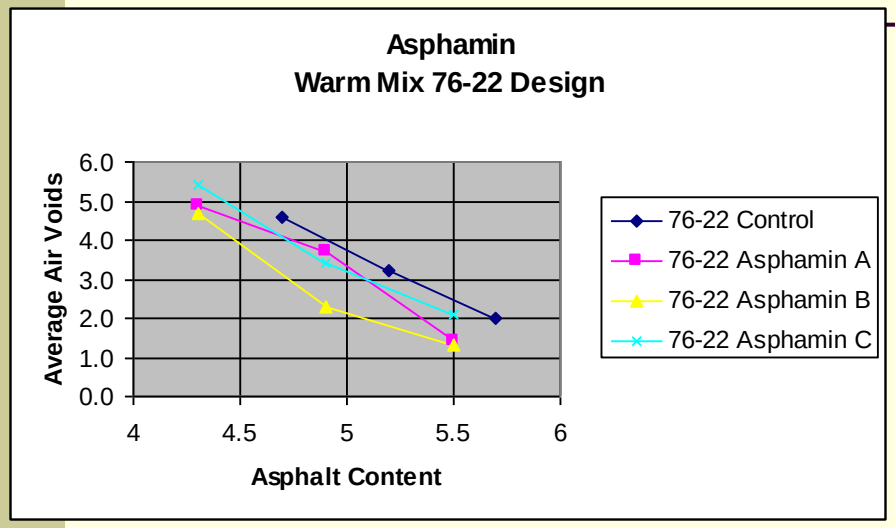
What we found……..

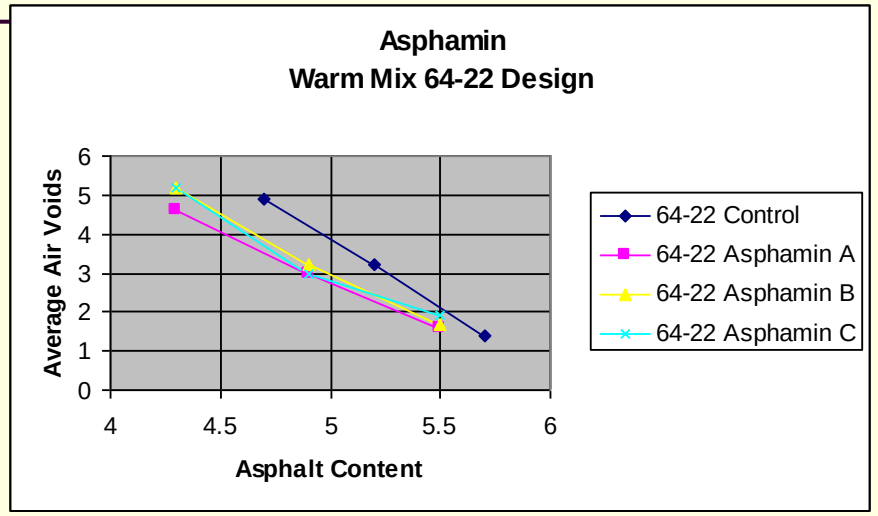
in terms of

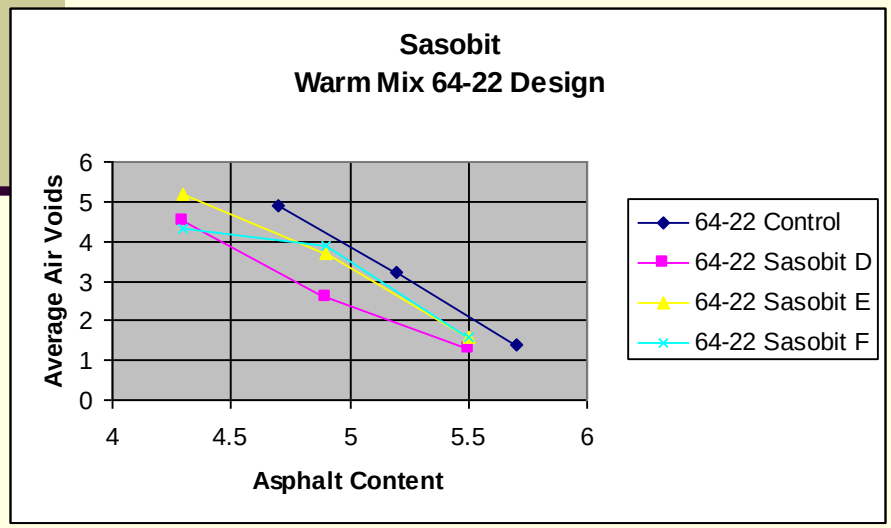
- Effect of WMA on Selection of AC Content (Mix Design)
- Effect of WMA on Performance Tests
- Effect of WMA on QC Requirements
- Effect of WMA on Field Performance

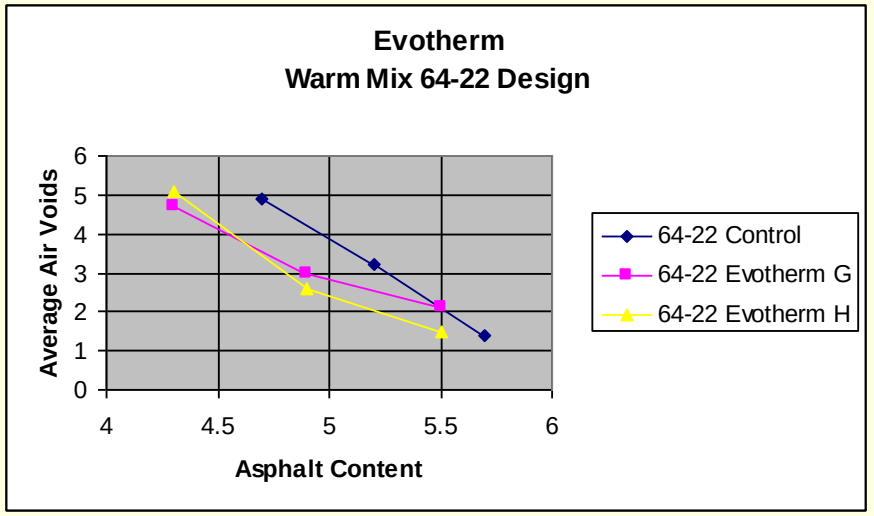
Item 340/341 Mix Design

Texas Gyratory Mix Designs

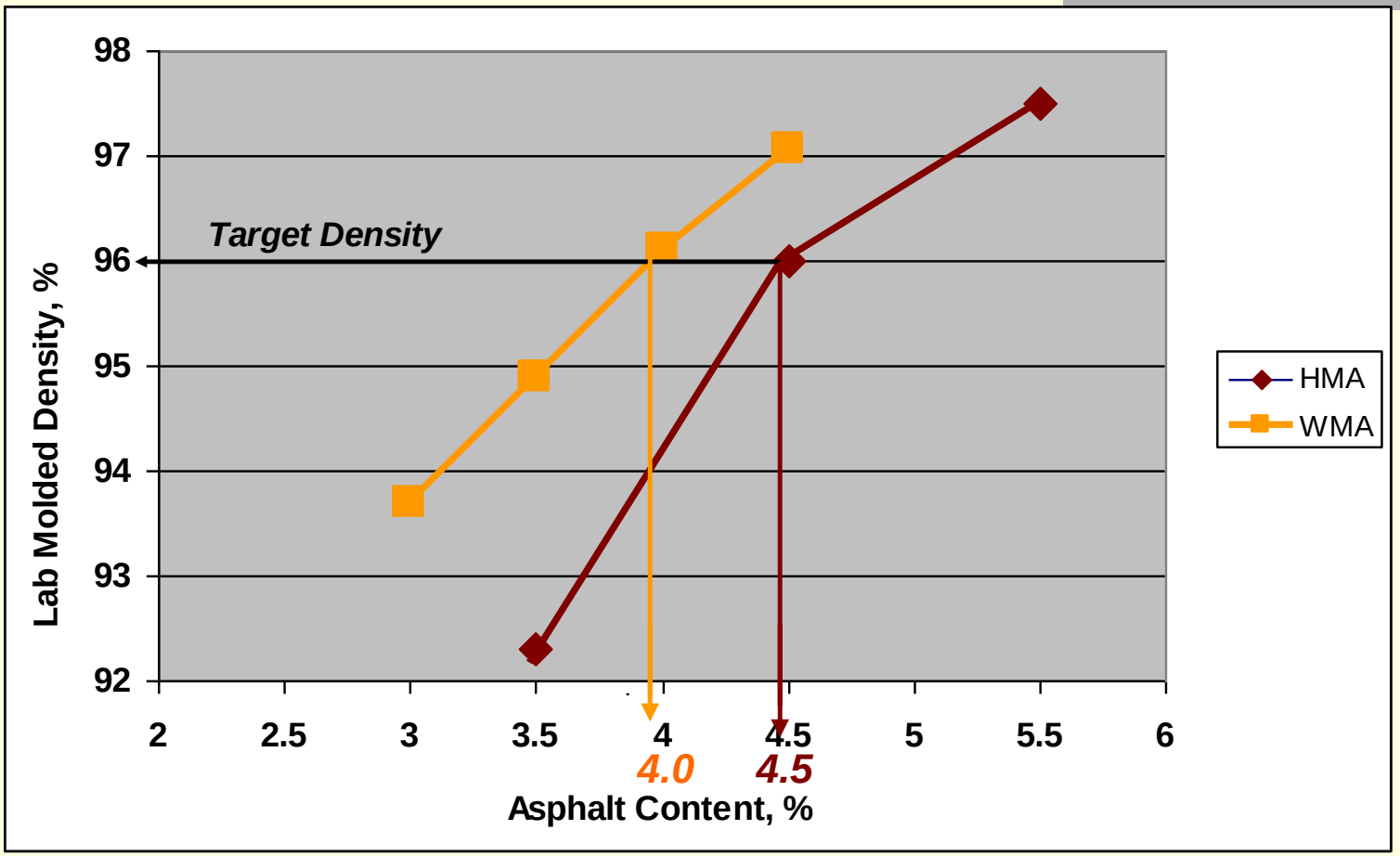








Effect of Warm Mix Additive on Mix Design – Asphalt Content

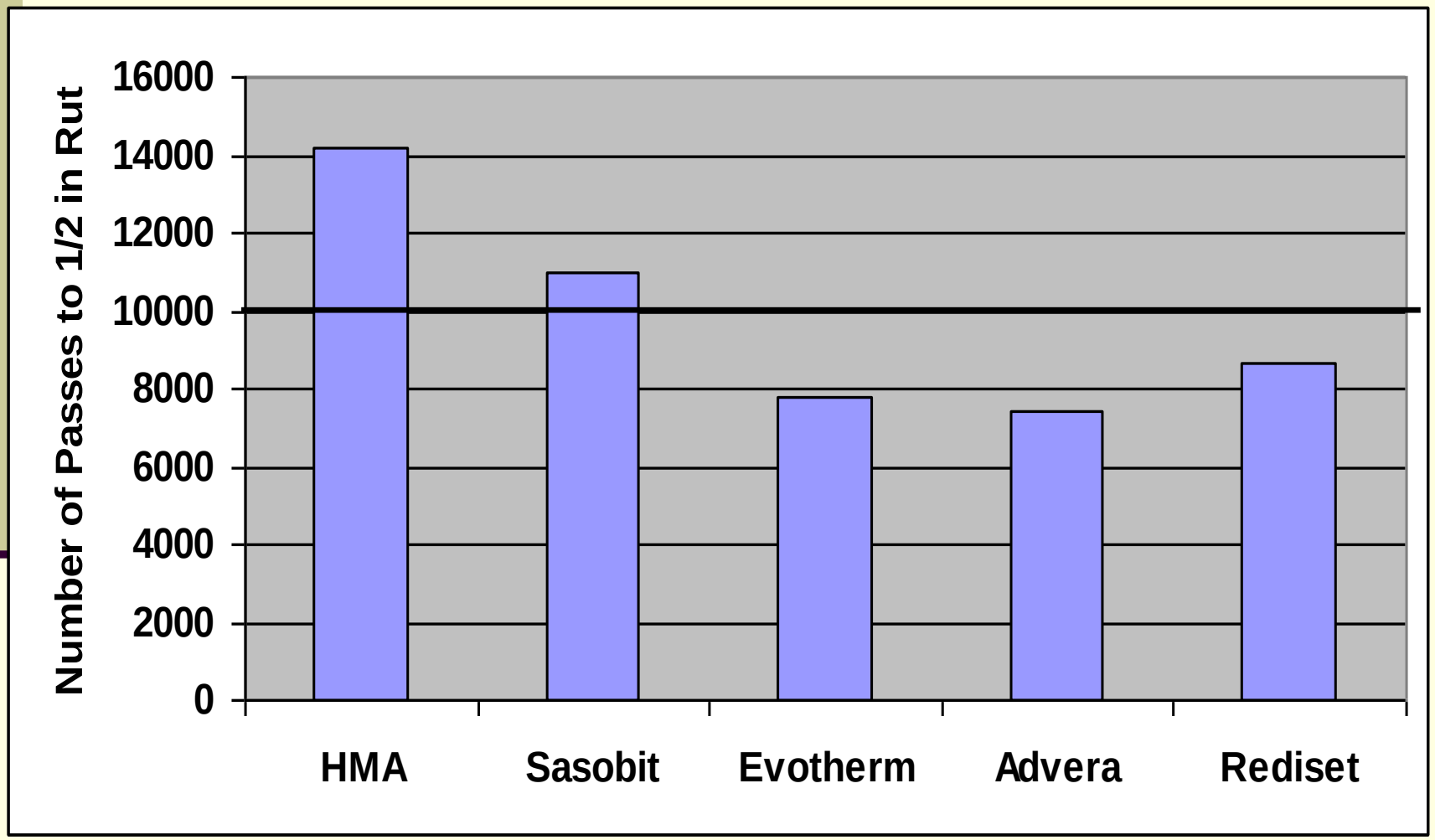


WMA should be designed without the additive to avoid low AC content mixes

Effect of WMA on Performance Tests

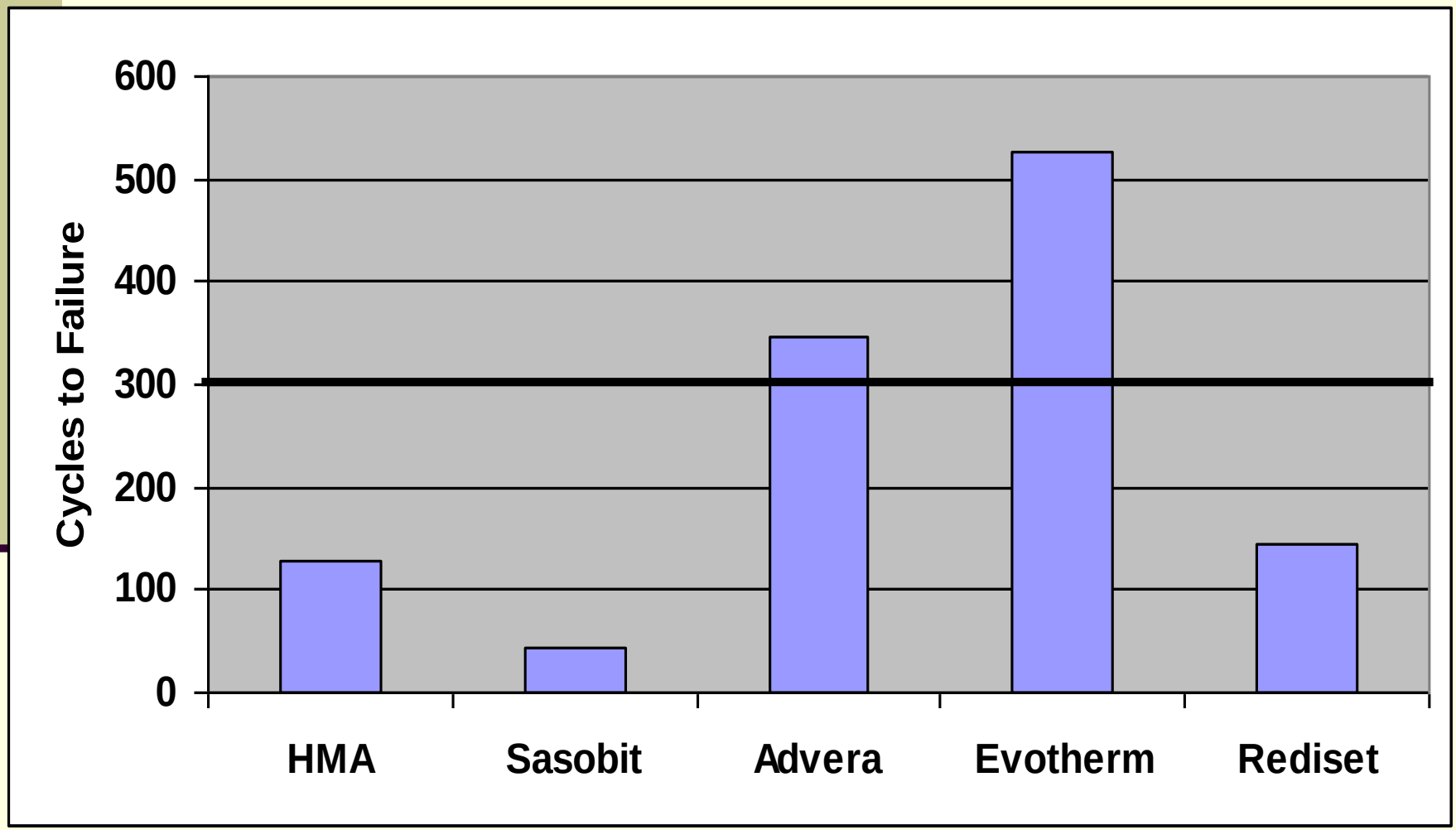
- Hamburg Wheel Tracking
  - Decrease in rutting resistance
- Overlay Test
  - Increase in cracking resistance
- Indirect Tensile Strength
  - Decrease in tensile strength
- Dynamic Mechanical Analysis
  - Improvement in fatigue life
- Surface Energy Measurements
  - Decrease in moisture resistance

Hamburg Results
Lab-Molded Plant Mix

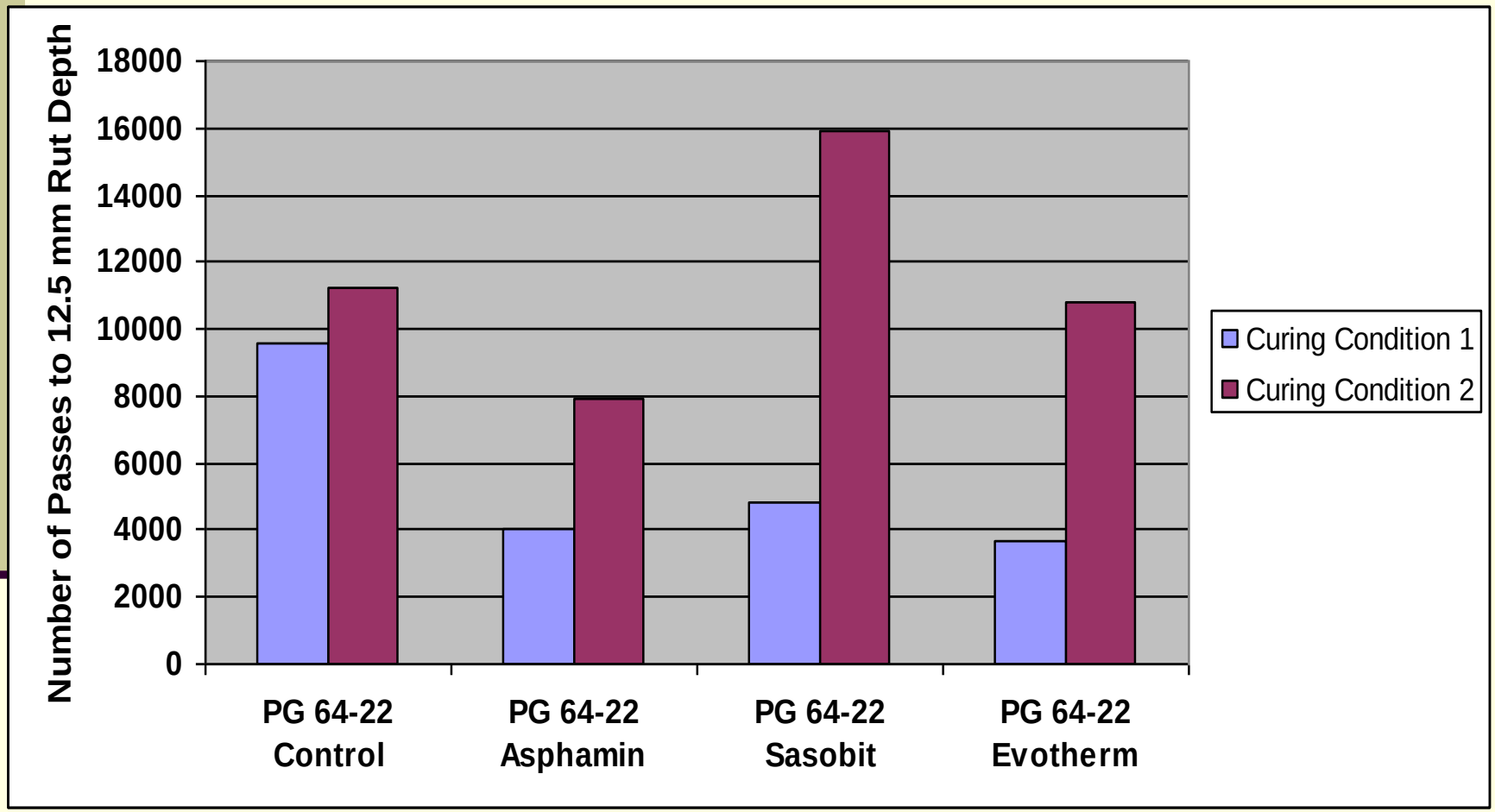


TTI Overlay Test

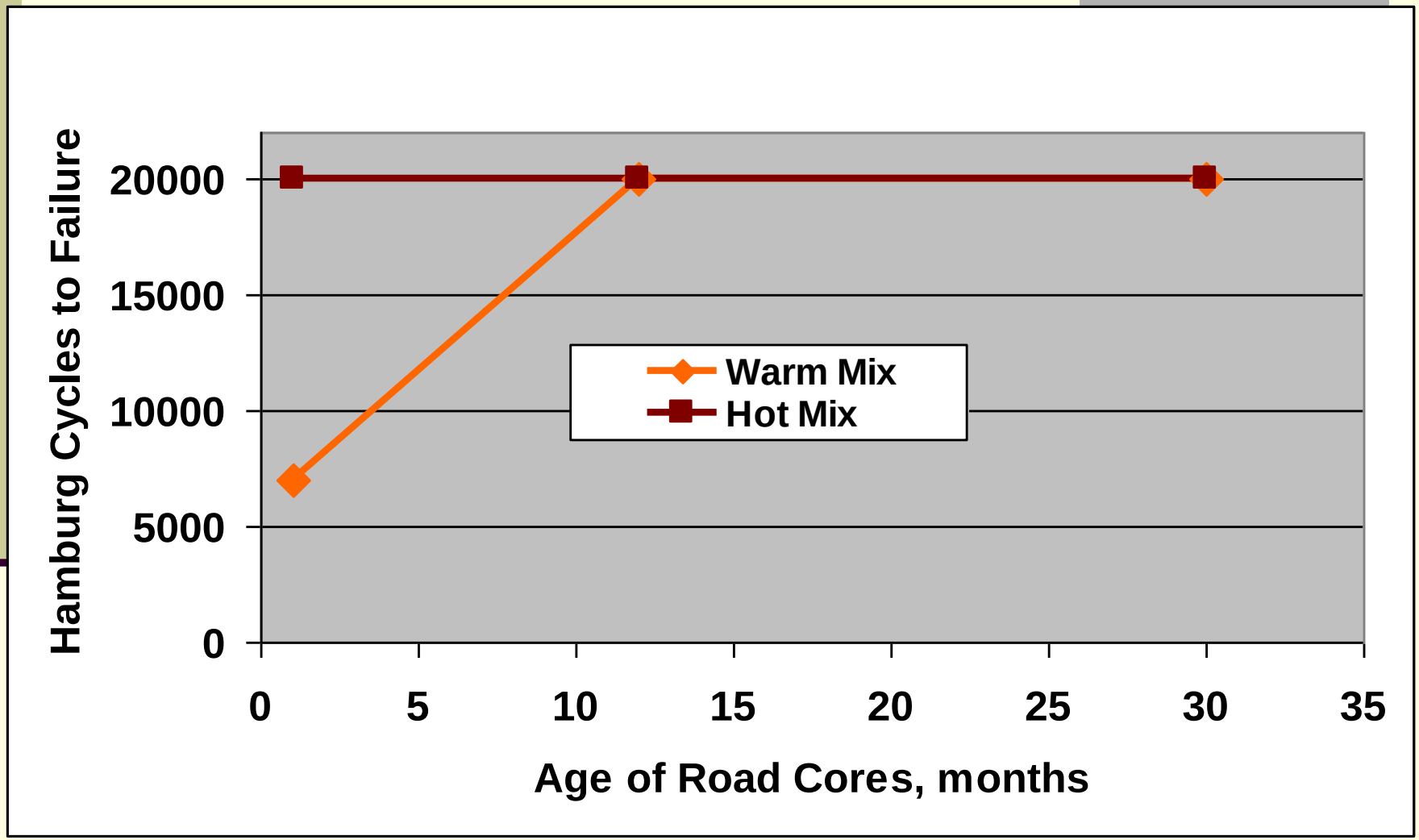
Overlay Test Results
Lab-Molded Plant Mix



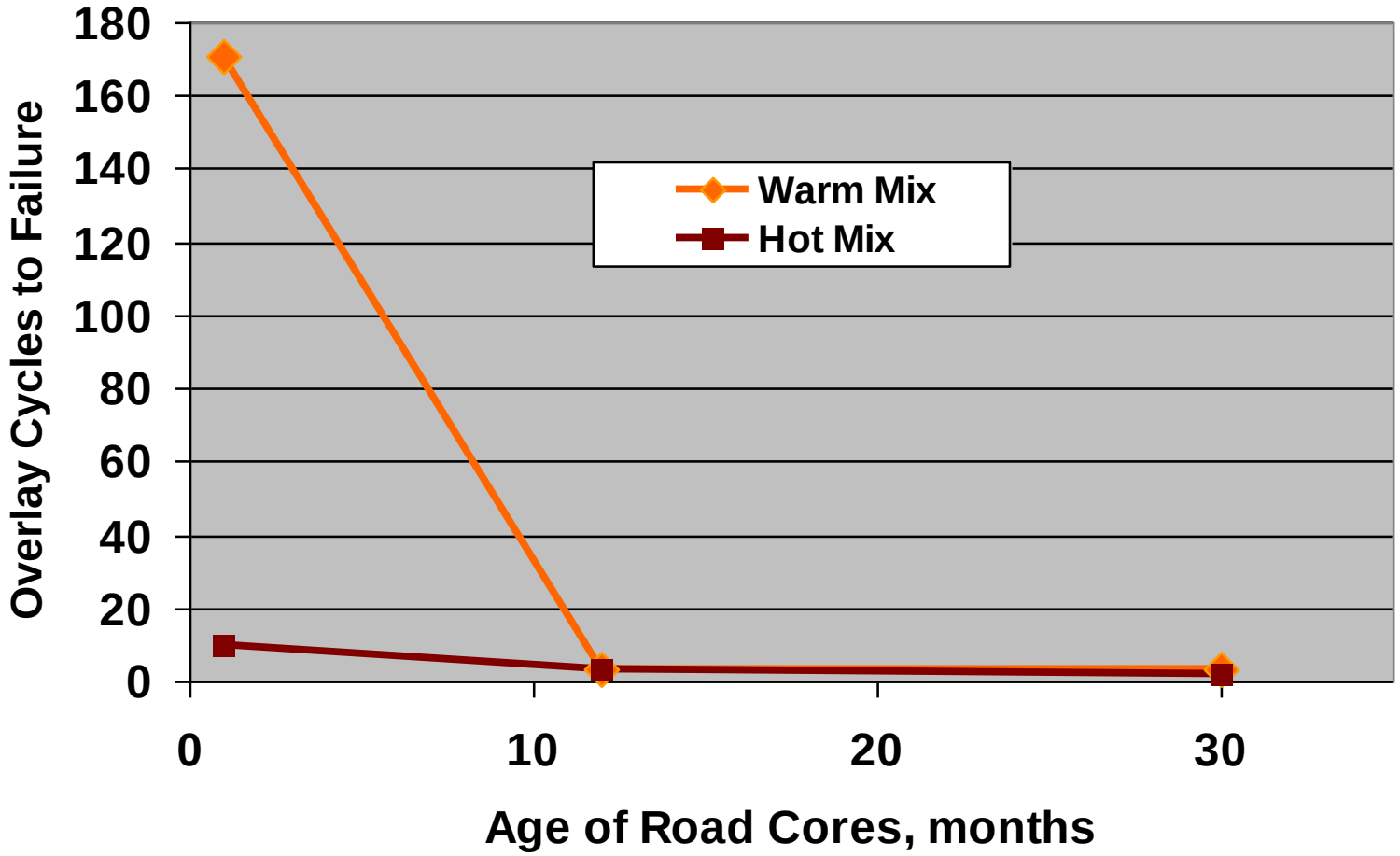
Hamburg At Different Curing Conditions



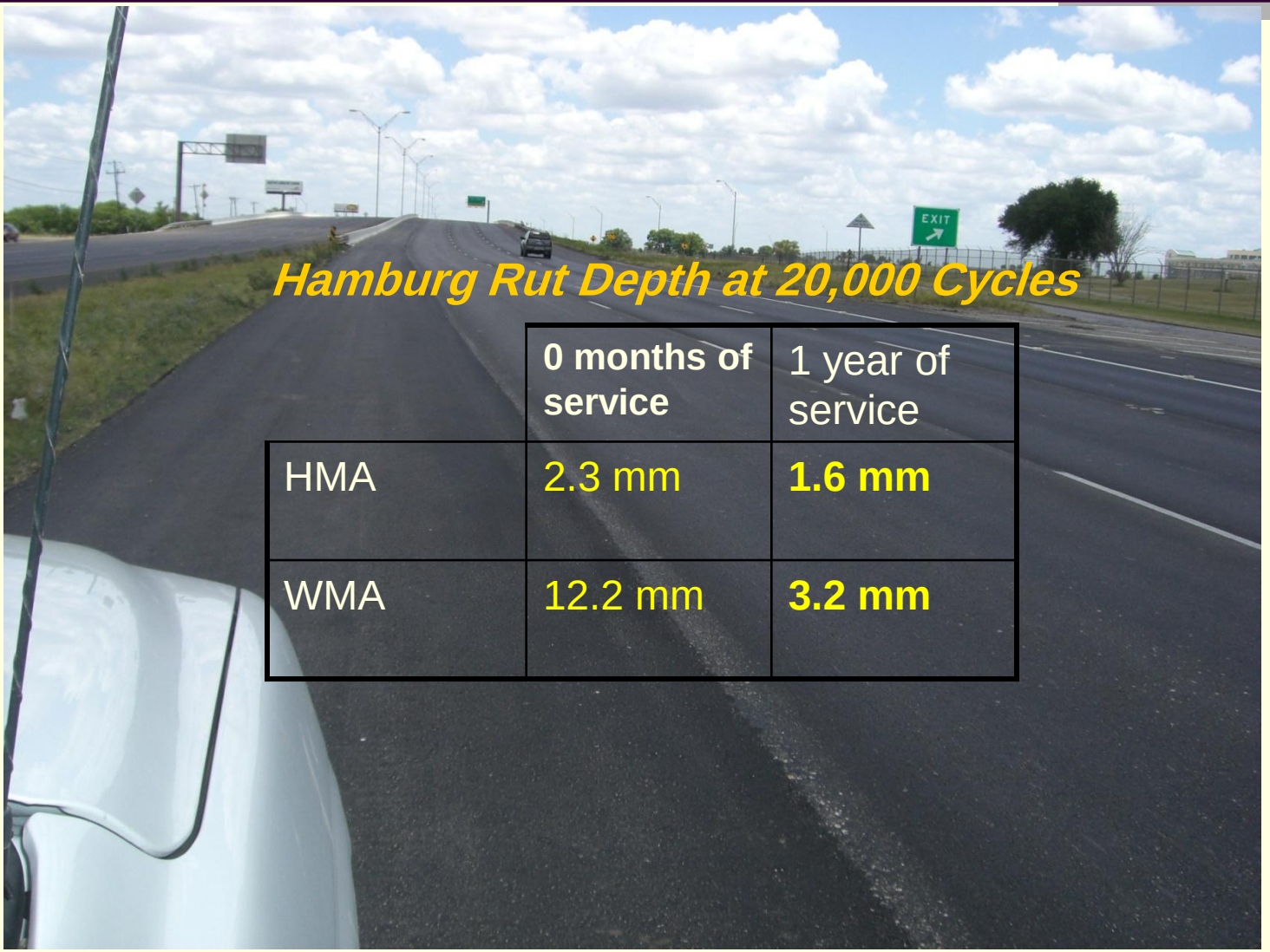
Hamburg Wheel Tracking Data San Antonio (Loop 368)



Overlay Test Data
San Antonio (Loop 368)



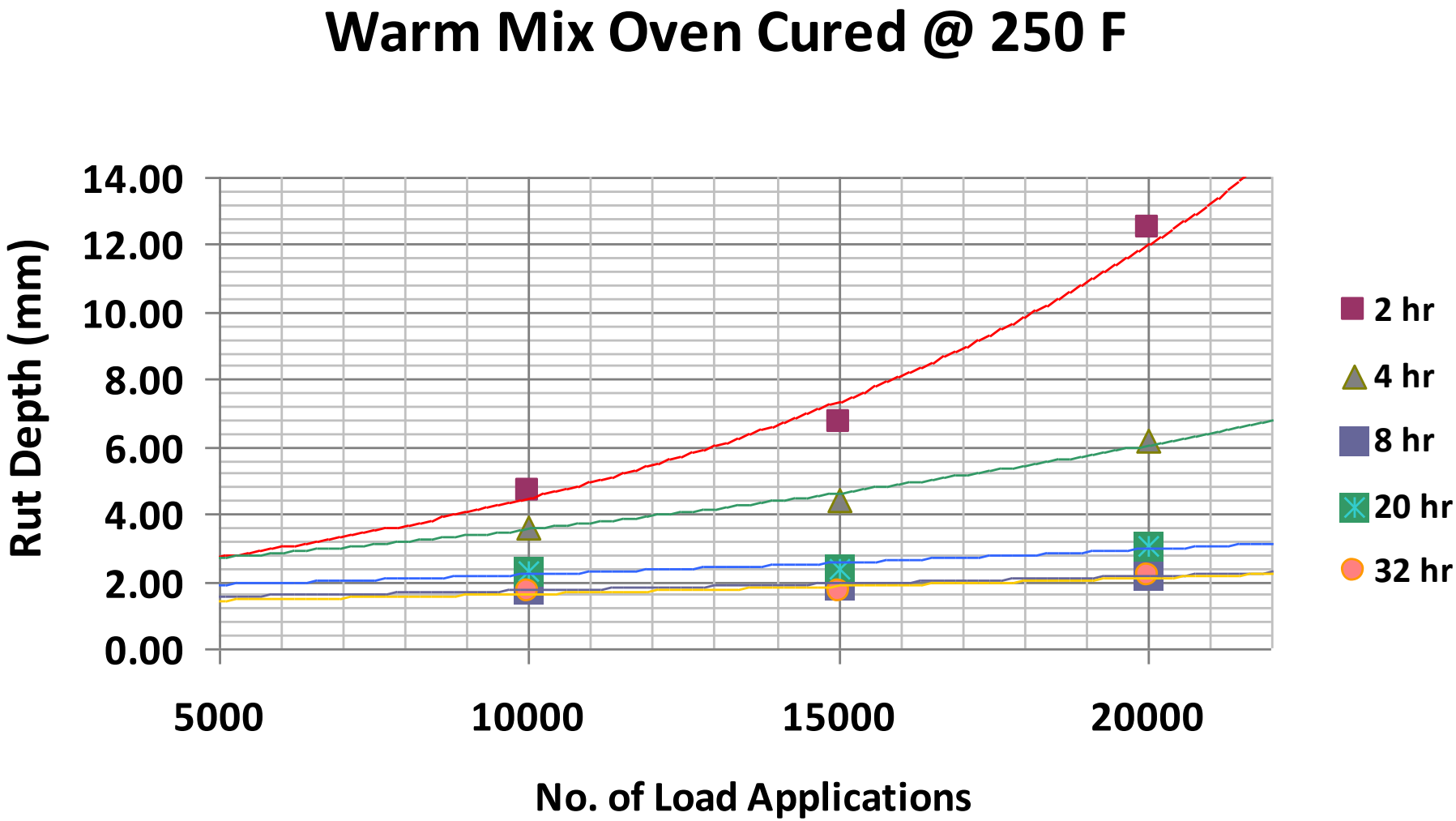
US 71 Austin District



Hamburg Rut Depth at 20,000 Cycles

	0 months of service	1 year of service
HMA	2.3 mm	**1.6 mm**
WMA	12.2 mm	**3.2 mm**

Hamburg Wheel Tracking Test



Significance of Aging/Stiffening Effect

- The oven curing time and temperature is a critical factor in performance tests and laboratory molded density (QC).
  - Curing at compaction temperature may yield poor Hamburg results for WMA which may not reflect field performance.
  - Curing at temperatures above compaction temperature can yield very high lab molded densities (in the pay penalty range).

FM 324 - Lufkin

HMA

WMA

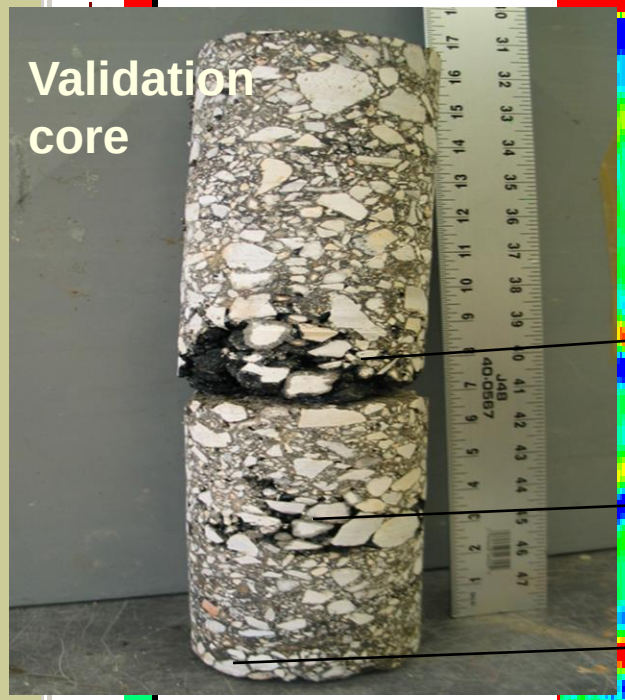
Lufkin Project after 4 years

Field Performance

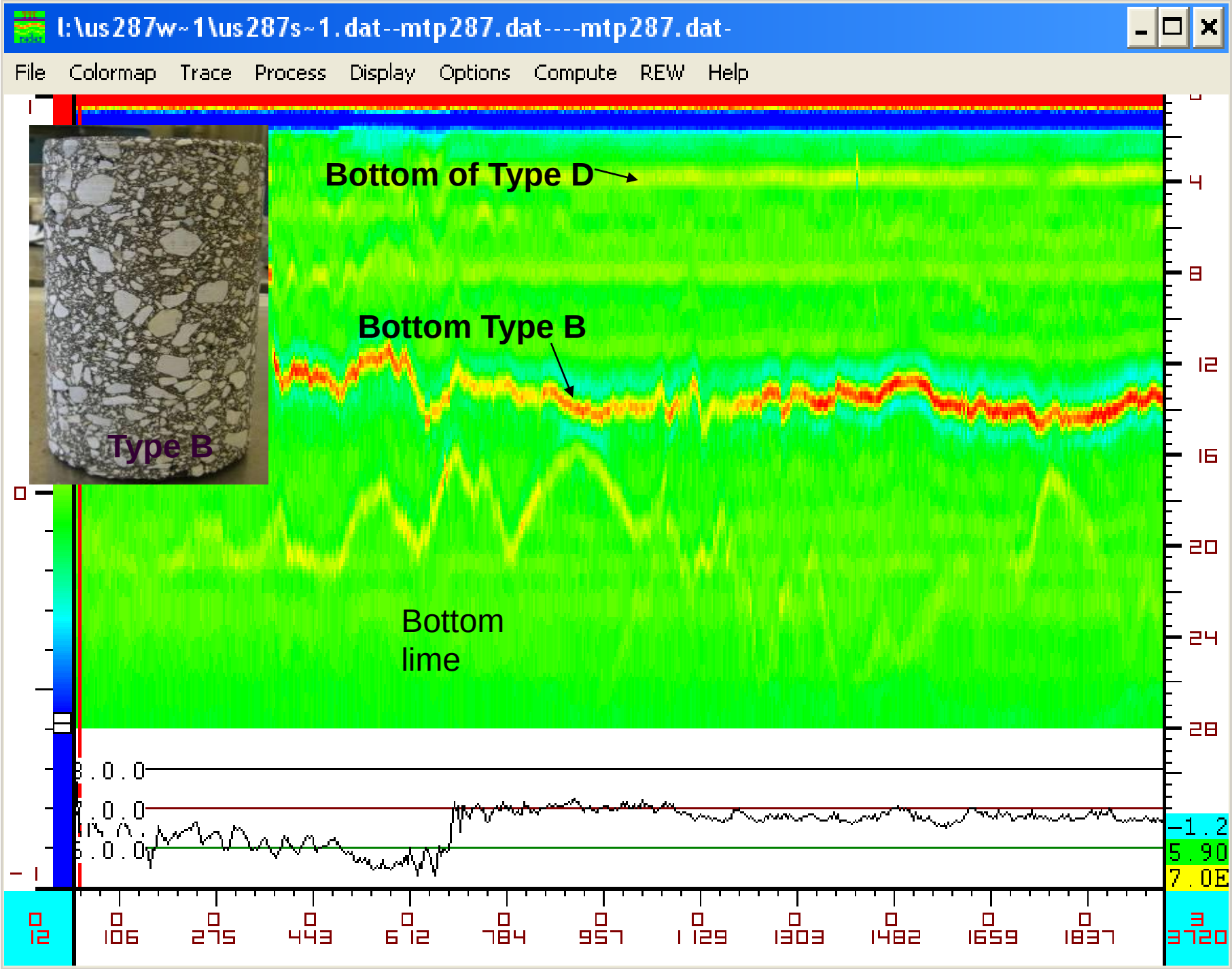
- Equivalent to HMA
- Uniformity of construction
- Uniformity of density
- Structurally equivalent to HMA

BU 287 Fort Worth District

File Colormap Trace Process Display Options Compute REW Help



Using GPR to detect compaction problems in full depth hot mix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File
Colormap
Trace
Process
Display
Options
Compute
REW
Help
Bottom of Type D
Bottom Type B
Type B
Bottom
lime
0
4
8
12
16
20
24
28
106
275
443
612
784
957
1129
1303
1482
1659
1837
3720

Structural Strength Testing with FWD

Perpetual Pavement SH 114

Type B Chico Limestone

4.5% PG 64-22

E @ 106 F 580 ksi

E @ 77 F 1392ksi

Warm Mix Shoulder on BU 287

Type B Chico Limestone

4.3% PG 64-22 WMA (Evotherm)

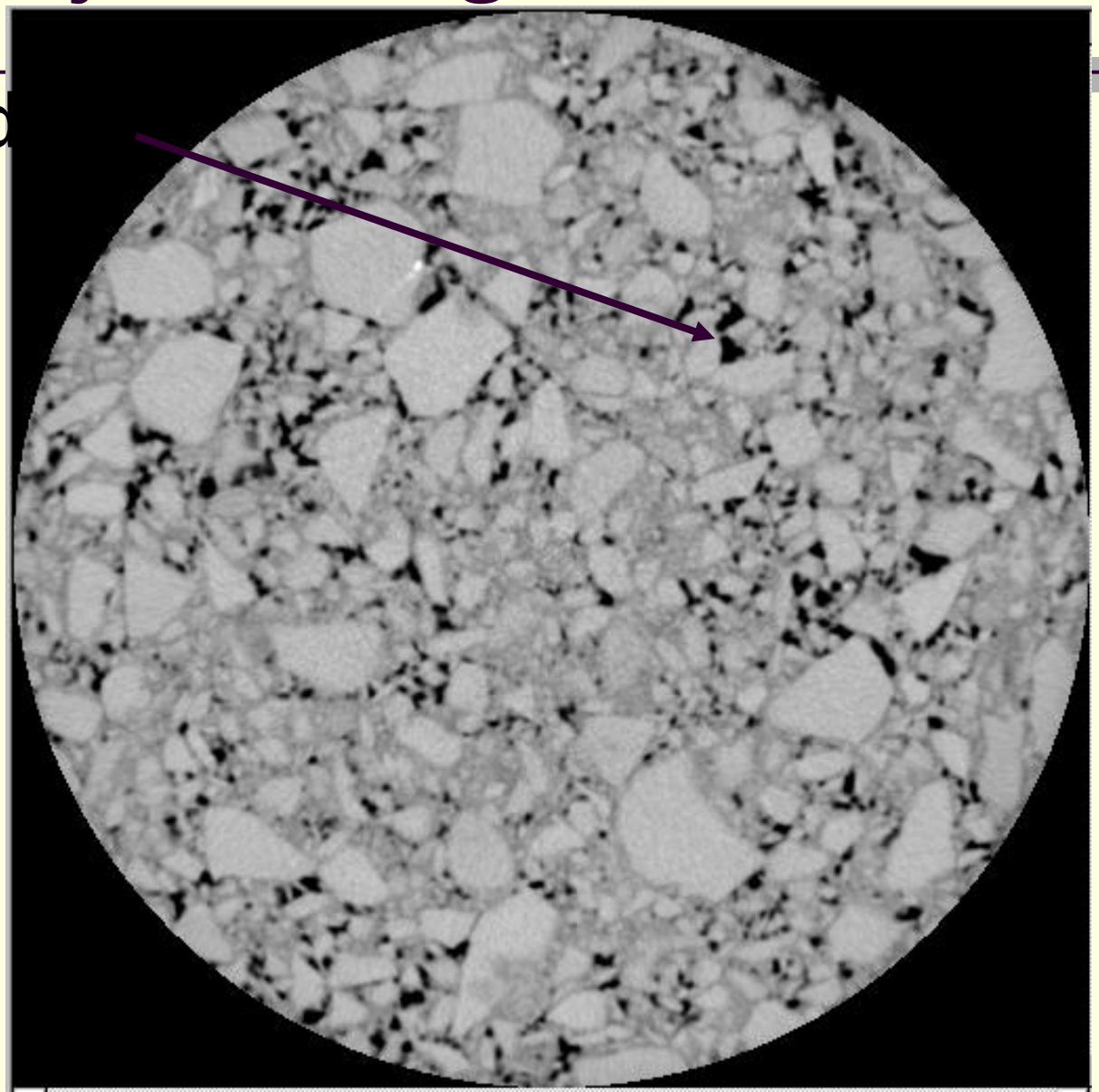
E @ 93 F 739 ksi

E@ 77 F 1256 ksi

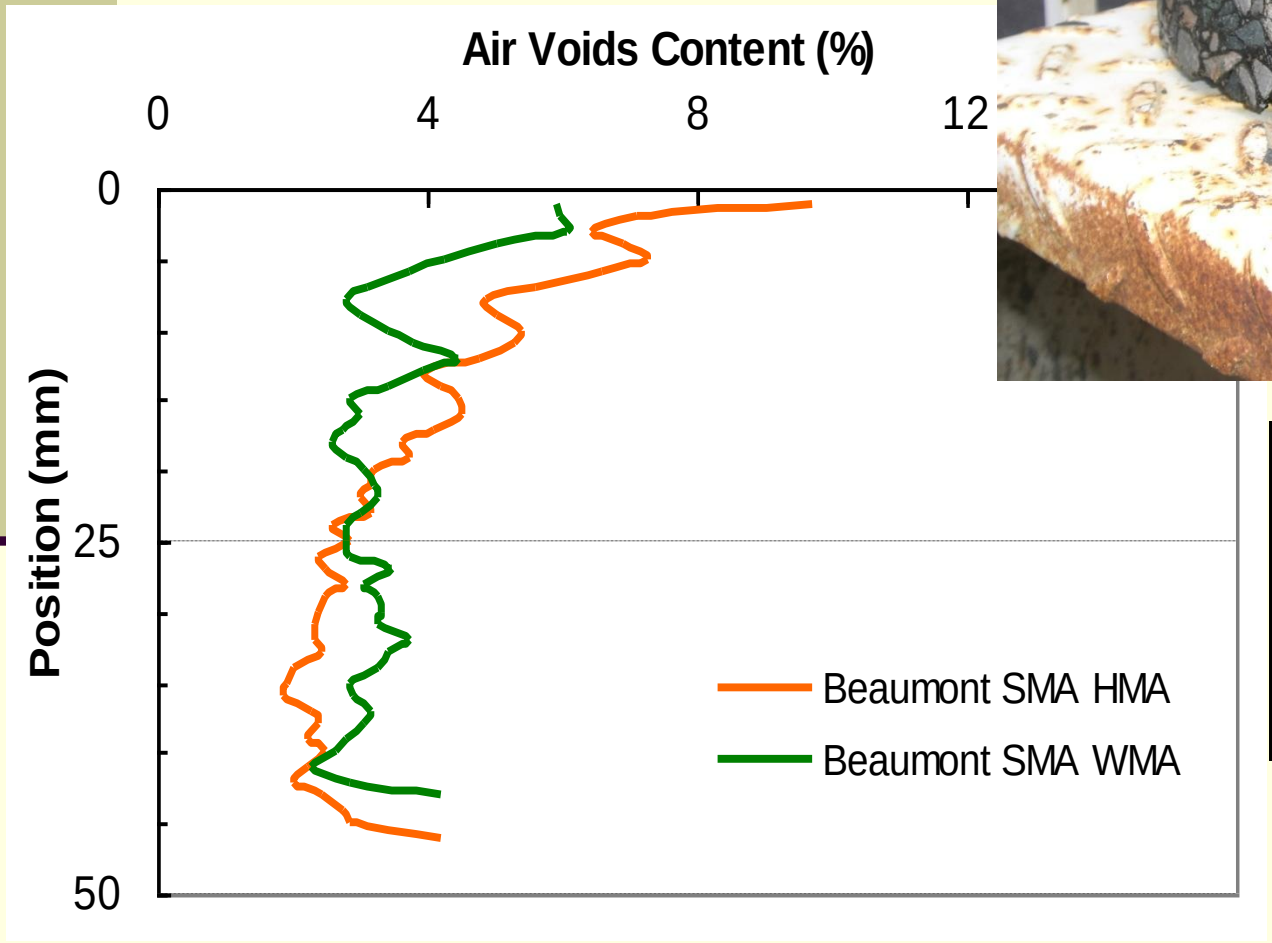
No significant difference

X-Ray CT Image

Air Void



X-Ray CT of Cores



HMA
Mean 3.76% SD 1.25

WMA
Mean 3.44% SD 0.62

Pending WMA Issues/Concerns

- Long Term Performance?
- Constructability Issues – Tenderness.
- Use of RAP and RAS with WMA.
- Mandated Use of WMA may be on the Horizon.
- Use in Mixes other than dense-graded.

4 month old new surfacing

IH 20 SMA F Summer 2010

- Designed with PG 76-22
- Changed to PG 70-22 after passing Hamburg
- Warm Mix (foam) selected as contractor option
- Temperatures not reduced because of thin mat
- Severe bleeding experienced all lanes all directions
- Problems observed during record high temps in summer 2010

Findings

- Warm mix additives improve compactability which can lead to a reduction in asphalt content if incorporated in the mixture design process.
- WMA is initially less stiff than HMA but stiffens considerably within the first year of service and with increases in laboratory oven curing time/temperature.
- Field performance of WMA is comparable to HMA. Uniformity of WMA construction may be better than HMA.

Recommendations

- Design WMA mixtures without the additive for selection of asphalt content.
- Do performance tests on WMA with the additive.
- For quality control of WMA, oven cure mix at the warm mix compaction temperature.
- For performance testing, increase oven curing time/temperature to better represent data from field core testing and to standardize a process for curing all warm mixes similarly.

San Antonio Loop 368
Performance Good After 5 Years