

Effects of Temperature Segregation on Density, Fracture Resistance, and Rutting Performance of Asphalt Mixtures

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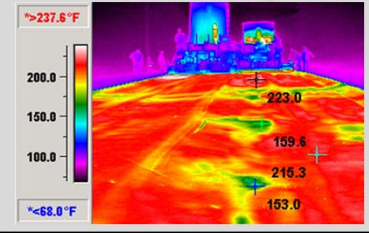


Annual Meeting of the Southeastern Asphalt User Producer Group
November 15 – 17, 2016
Corpus Christi, Texas



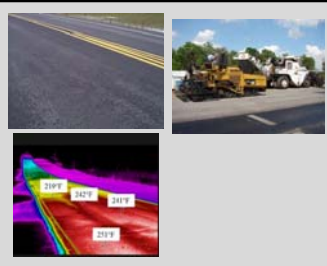
My Story

- Background
- Objective
- Scope
- Methodology
 - Field Experiment
 - Lab Experiment
- Results
 - Type of temp Segregation
 - Effect on Performance
- Summary



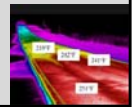
Background

- Types of segregation
 - Gradation
 - Temperature
 - Aggregate-asphalt



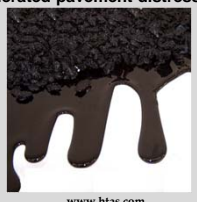
Background

- Types of segregation
 - gradation
 - most common type
 - coarse aggregate-rich or fine aggregate-rich spots
 - occurs as result of aggregate stockpiling and handling, production, storage, truck loading practices, construction practices, and equipment adjustments
 - common solution
 - multiple drop truck loading from storage bin at plant
 - Use of Material Transfer Vehicle from truck bed to paver
 - temperature
 - a.k.a. thermal differential
 - occurs as result of differential cooling rate of portions of mix
 - in exposed part of mix in haul truck,
 - along sides of truck box, and
 - in wings of the paver.



Background

- Types of segregation (cont'd)
 - aggregate-asphalt
 - a.k.a. drain-down
 - common in SMA
 - lack of homogeneity in asphalt mixture constituents of in-place mat
 - Leads to accelerated pavement distresses.



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Background

- Concerns
- Segregated areas would develop localized premature distresses
 - fatigue cracking,
 - rutting,
 - raveling,
 - pothole, etc.



Pictures courtesy of MOBA Corporation

Background

- State agencies do expect **uniformity** of asphalt mixtures
 - appropriate to required quality
 - LDOTD standard specifications for roads and bridges requires operational details
 - truck loading practice and use of MTV to prevent **gradation** segregation
- Link between **temperature segregation** and **asphalt pavement performance**
 - mechanical properties
 - Provide solution(s) to fix the problem

Background

- Thermal Imaging Devices
- Continuous Thermal Scanning Equipment – **Pave IR**



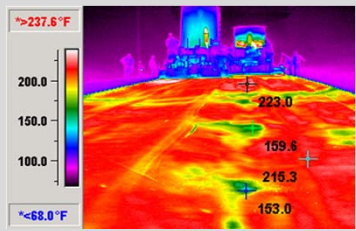
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Background

- Thermal Imaging Devices



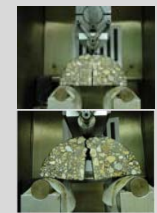
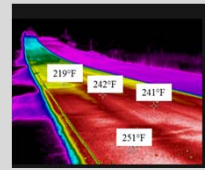
Courtesy of FLIR Systems



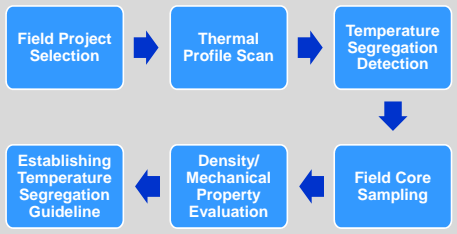
Courtesy of MOBA Corporation

Objectives

- Identify **temperature segregation** range during paving operation
- Evaluate effect of temperature segregation
 - Density
 - Cracking at intermediate temperature
 - Rutting
 - Stiffness

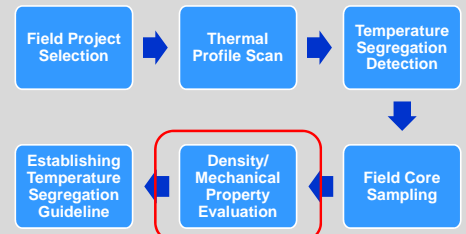


Methodology




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Methodology



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Field Projects



- **Seven projects**
 - LA 30
 - LA 1058
 - US 165
 - LA 1053
 - LA 411
 - LA 940
 - LA 1
- **Ten mixtures**
 - 6 wearing course
 - 3 binder course
 - 1 shoulder
- **Weather Conditions**
 - Winter, spring, and summer
 - 54 F ~ 89 F

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Field Projects

Construction Factors						
Route	LA 30	LA 1058	US 165	LA 1053		LA411
Course	Wearing	Wearing	Wearing	Binder	Wearing	Wearing
Season	Winter	Spring	Spring	Summer	Summer	Winter-Spring
Paving Time	Night	Day	Day	Day		Day
Length	5.2 miles	8.0 miles	5.9 miles	2.3 miles	2.5 miles	5.43 miles
MTV Model	Roadtec SB2500D	Roadtec SB2500E	Roadtec SB2500D	Weiler E2850	Roadtec SB2500D	
Paver Model	CAT AP655D	CAT AP1055E	CAT AP1055E	CAT AP1055D	CAT AP1055E	
Target Laydown Temp.	300°F	275°F (WMA)	300°F	300°F		290°F (WMA)
Haul Time	10 minutes	30 minutes	50 minutes	40 minutes		40 minutes
Weather Condition						
Air Temp. °F	Max.	64.6	82.9	82.0	88.0	93.0
	Min.	41.9	60.1	64.9	72.0	79.0
	Avg	54.0	73.2	74.8	84.3	89.0

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Field Projects

	Route	Parish	Contractor	Month	Length, mi
Phase I	LA 30	Ascension	A	Dec. 2014	5.2
	LA 1058	Tangipahoa	B	Mar. 2015	3.9
	US 165	Rapides	C	Apr. 2015	5.9
	LA 1053	Tangipahoa	D	Jun. 2015	2.2
Phase II	LA 1053	Tangipahoa	D	Jul. 2015	2.6
	LA 411	Pointe Coupee	E	Mar. 2016	5.4
	LA 940	Ascension	E	Apr. 2016	3.0
	LA 1	Ascension	E	Jun. 2016	3.3


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Continuous Thermal Scanning Equipment – Pave IR Mixture Temperature at Paving



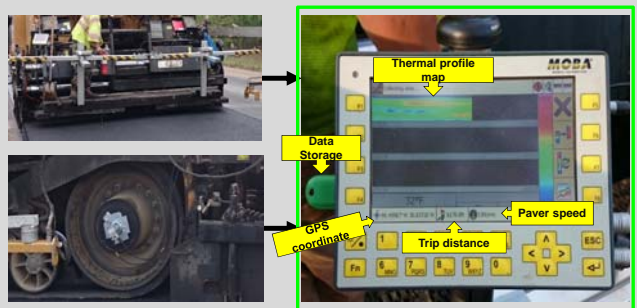
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Continuous Thermal Scanning Equipment – Pave IR Mixture Temperature at Paving

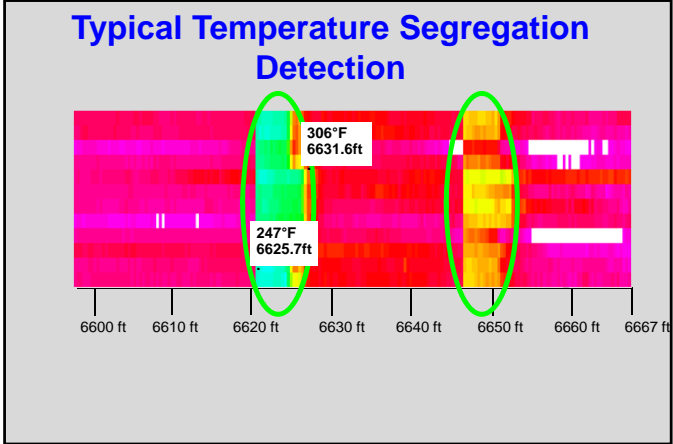
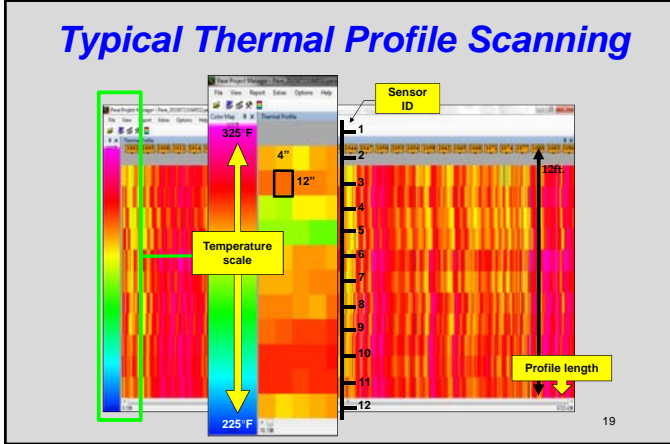


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Typical Thermal Profile Scanning



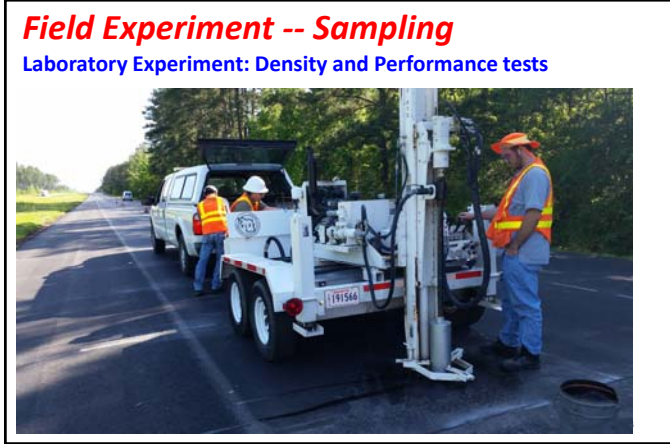
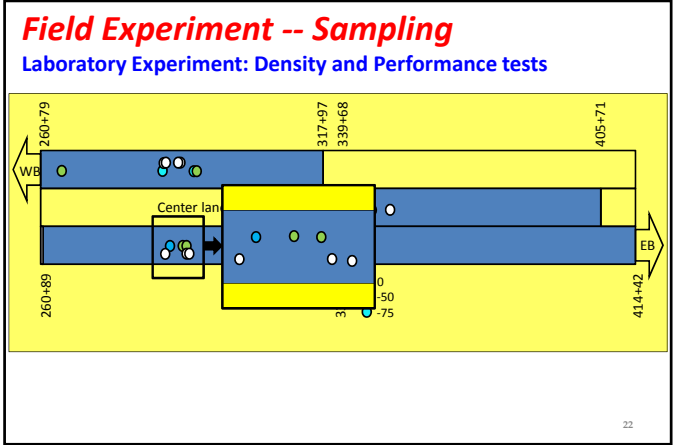
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Categories of Temperature Segregation

$\Delta T = \text{PaveIR measured temperature} - \text{Target Laydown Temperature}$
 $\Delta T = 325^{\circ}\text{F} - 300^{\circ}\text{F} = 25^{\circ}\text{F}$

Temperature Differential (ΔT) Groups	Temperature Range	Severity Level
0	Target	None
-25	Target-25°F	Low
-50	Target-50°F	Medium
-75	Target-75°F	High
-100	Target-100°F	Very High



Types of Temperature Patterns

- Cyclic
- Irregular

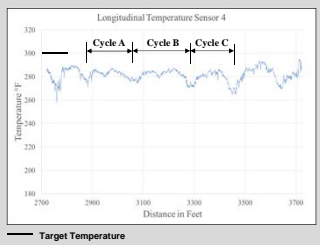


Types of Temperature Patterns

- Cyclic
- Irregular



Cyclic Temperature Patterns



- Observations**
- Repeating Pattern of temperature fluctuation
 - Magnitude of each cycle (top to bottom) is < 30°F
 - Frequency of occurrence ~ 100-200'
 - Amount of load in each truck
 - 2" mat
 - Temperature cycles may be caused by truck load
 - Cycle length varies with amount of mix in each truck
 - Truck waiting time can affect magnitude

Large Truck – More mix



Small Truck – less mix

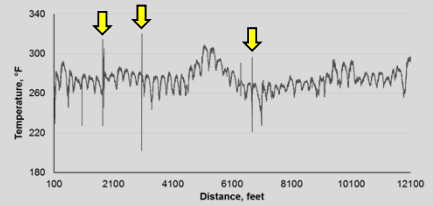


Types of Temperature Patterns

- Cyclic
- Irregular



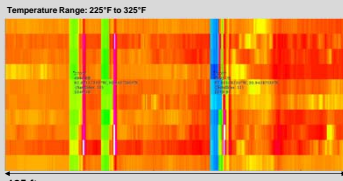
Irregular Temperature Patterns



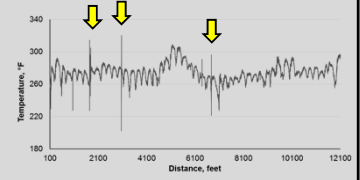
- Occurs at paver stop locations
- Compactors stop operation 50-200-ft. behind paver
- Un-compacted asphalt mix starts to cool



Irregular Temperature Patterns

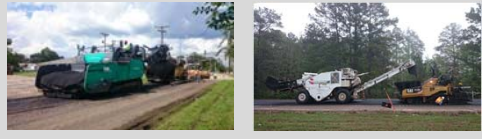


- Causes of Paver Stops**
- Delayed Haul unit
 - Equipment Troubleshoot
 - Asphalt mix spillage in path



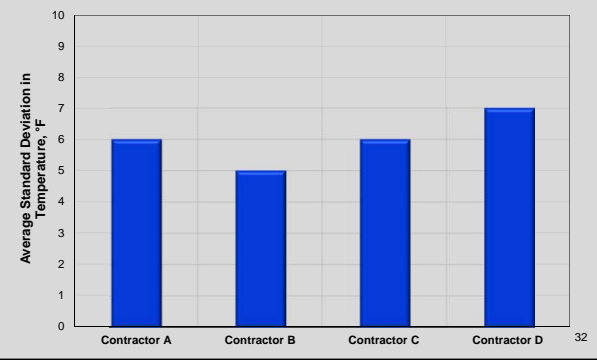
Field Experiment: Construction Factors

- Factors affecting Temperature Uniformity
 - Contractors
 - Material Transfer Vehicles (MTV)



Construction Factors – Contractors

- Comparing average standard deviation for four contractors

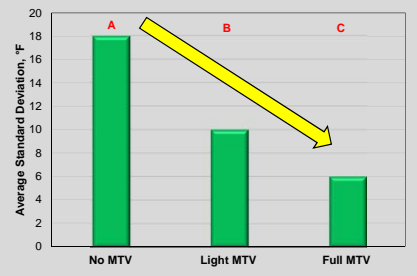


Construction Factors – Material Transfer Vehicle

- No MTV
- Light MTV → no storage
- Full MTV → storage 30 ton



Construction Factors – Material Transfer Vehicle



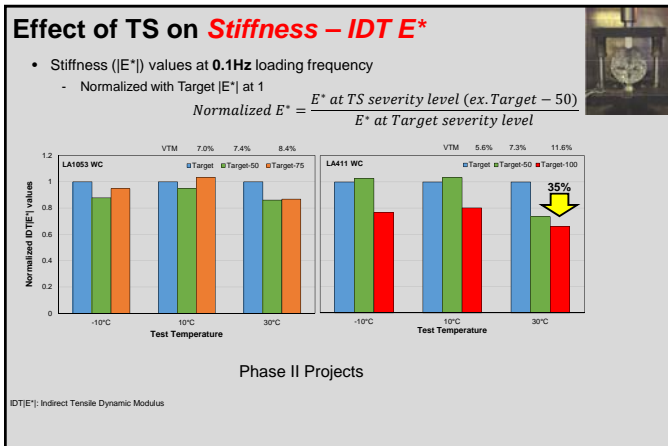
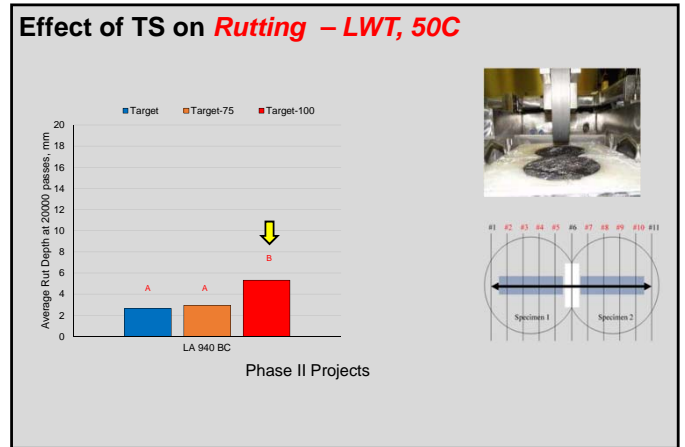
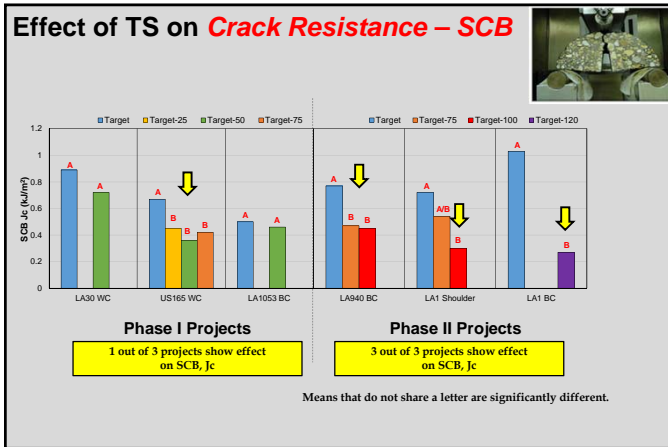
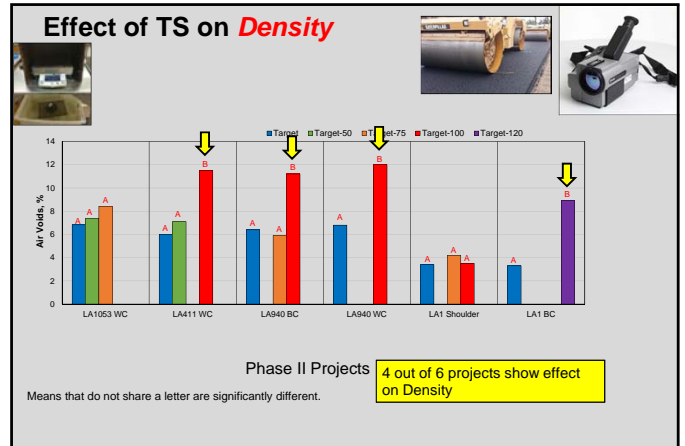
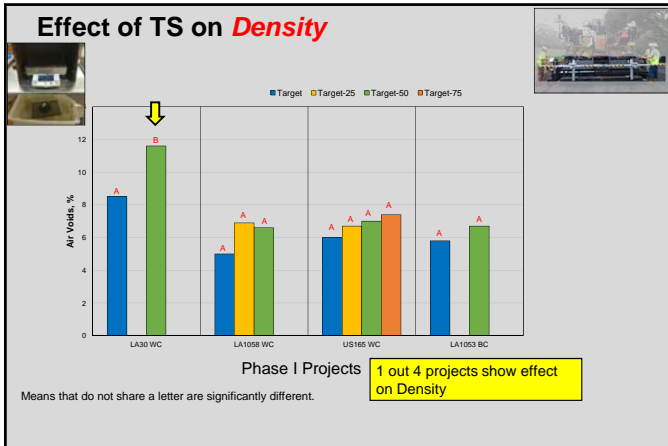
Laboratory Experiment

Laboratory Test	Property Evaluated	Test Temperature	Protocol
Bulk Specific Gravity – Density Testing	Density	25±0.5°C	AASHTO T166
Loaded Wheel Tracking Test	Permanent Deformation	50±0.5°C	AASHTO T324
Semi-Circular Bending Test	Fracture Resistance	25±0.5°C	ASTM D8044
Indirect Dynamic Modulus (IDT E ¹)	Stiffness	-10°C, 10°C, 30°C	Proposed AASHTO



Results

Density and Mechanical Property Evaluation



- ### Summary
- ✓ TS of asphalt mixtures during pavement construction
 - ✓ In general, **quality** is affected when cold area temperatures drop
 - ✓ Types of temperature segregation
 - Cyclic,
 - Irregular
 - ✓ Cyclic segregation
 - Cooling of asphalt mixture on each truck load
 - Truck load delivery
 - magnitude of temperature drop affected by climatic condition
 - In general, < 30 °F
 - ✓ Irregular segregations
 - Interruption in paving operation
 - magnitude of temperature drop is a function of duration of stops
 - temperature drop of 75 to 100 °F after 15 to 20 minutes of paver stops was observed
 - ✓ Contactors
 - Similar TS standard deviations
 - ✓ Use of MTV
 - Effective in reducing TS as compared to Light MTV and no MTV

- Summary**
- ✓ **Pavement Air Voids**
 - lower paving temperatures → increase in air voids
 - ✓ **Crack Resistance: SCB test results at 25°C**
 - Decrease in critical strain rate energy was observed with lower paving temperatures
 - Cause early cracking
 - ✓ **Rutting: LWT, 50C**
 - Increase in rut depth with an increase in TS
 - ✓ **Stiffness**
 - Decreased with an increase in TS and air voids
 - ▶ Significant at higher temperature
 - Lead to early distresses
 - Affect Smoothness
 - ✓ **Monitor pavement performance**
 - Distress survey
 - ✓ **Specification guidelines for implementation**
 - Measurement of temperature segregation
 - Best practice Guideline
 - minimize temperature segregation



THANK YOU