

A photograph of a construction site where a large white asphalt paver machine is paving a road. Several workers in high-visibility vests and hard hats are standing around the machine, some using tools to guide the paving process. The scene is set outdoors on a clear day with trees and buildings in the background.

Engineered Warm Mix Asphalt

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NWPMA Annual Conference

October 23, 2012



Workshop Overview

- WMA—State of the Art
- Understanding the Benefits of WMA
- Avoiding the Pitfalls of WMA
- Planning for your next WMA project
- WMA Case Studies



WMA—State of the Art

- WMA Snapshot circa 2012
- What is Warm Mix Asphalt?
- Why Warm Mix Asphalt is the Future of our Industry

WMA Snapshot circa 2012

- 23 WMA Technologies @ www.warmmix.org
- NCHRP 9-43 “Mix Design Practices for WMA”
- FHWA Reported WMA Tonnage for 2010
 - 47.6M tons of WMA produced in the US
 - 13.2% of total asphalt production
- FHWA Performance Metrics for WMA
 - 40 DOTs have WMA Specification by 2011
 - 30 DOTs achieve WMA production targets by 2012
- IARC assesses asphalt cement and its emissions as
 - Group 2B “Possibly carcinogenic to humans...”

WMA Defined

Warm Mix Asphalt Technologies generally allow a reduction in the temperature at which asphalt mixes are produced and placed thus helping the environment and workers' health and safety. WMA technologies can also be used as a compaction aid extending the paving season in colder climates when produced at normal temperatures at which hot mix asphalt is produced.

- WMA—when ambient temperatures are consistently **above 50°F**, the asphalt mix temperatures are typically reduced by 25°F to 80°F, depending on the technology used, plant mix configuration, % RAP used, and construction conditions.
- Cold Weather WMA Application—when ambient temperatures are consistently **below 50°F**, the asphalt mixes are typically produced at near normal or slightly reduced temperatures of hot mix asphalt (depending on the technology used, % RAP used, and construction conditions) and is intended to facilitate placement and compaction at colder temperatures.

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WMA Benefits—General

- Stack Emissions
 - Environmental
 - Worker Safety
 - Emissions at the Paver
 - Reduced Energy Consumption
 - Increased Capability to Use RAP
- WMA Technology has Many Potential Benefits!

WMA Benefits—Construction

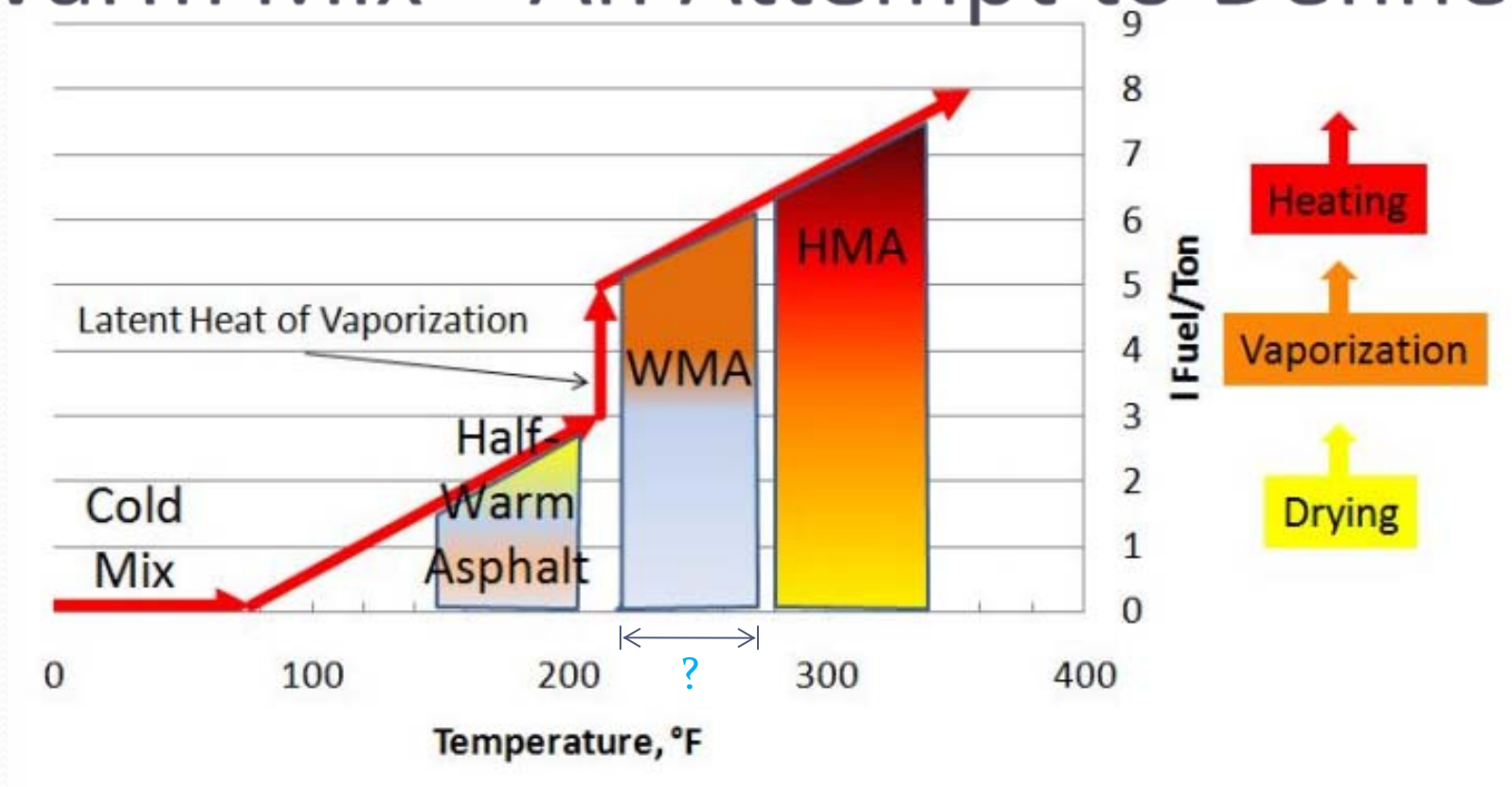
- Cold Weather Paving (Extended Season)
 - Longer hauls
 - Improved Workability
 - Larger Compaction Window
 - Reduced Thermal Segregation
 - Improved Opportunity to Achieve Density Incentive Pay
-
- Do We Need a Compaction Aid?

WMA Benefits—Performance

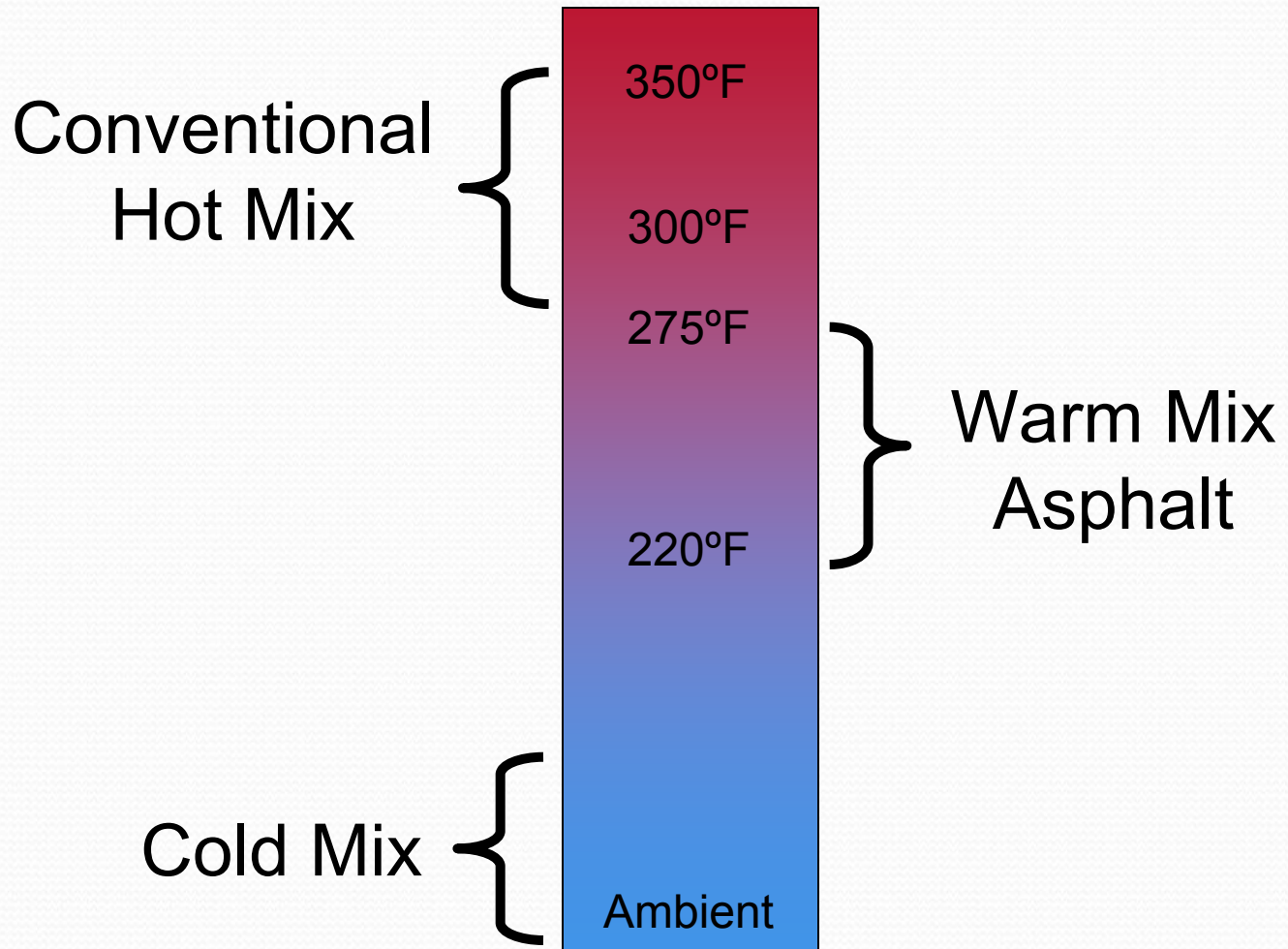
- Rut Resistance
 - Durability
 - Crack Resistance
 - Ride Quality
 - Moisture Sensitivity
-
- Will WMA perform as well and last as long as HMA?

What is Warm Mix Asphalt?

Warm Mix—An Attempt to Define



What is Warm Mix?



What is Warm Mix?

2005: There were three WMA technologies:

- Aspha-min – foam zeolite
- Sasobit – wax
- Evotherm – surfactant

2009: ~ 10 WMA technologies

2012: ~ 23 WMA technologies with many differences including:

- WMA mechanism—additive or process
- Effective temperature range for **production and compaction**

2015: ???

WMA Additives / Foaming Systems

- Advera
- Aspha-Min
- Evotherm
- LEA-CO
- Low Emission Asphalt
- Rediset WMX
- Sasobit
- WAM Foam
- Cecabase RT
- Qualitherm
- ECOBIT
- Thiopave
- Astec Double Barrel Green
- Gencor Green Machine
- Maxam Aquablack
- Stansteel Accu-Shear
- Tri-Mix WMA Injection
- Terex WMA System
- Eco-Foam II
- Meeker Warm Mix
- HGrant Warm Mix
- SonneWarmix

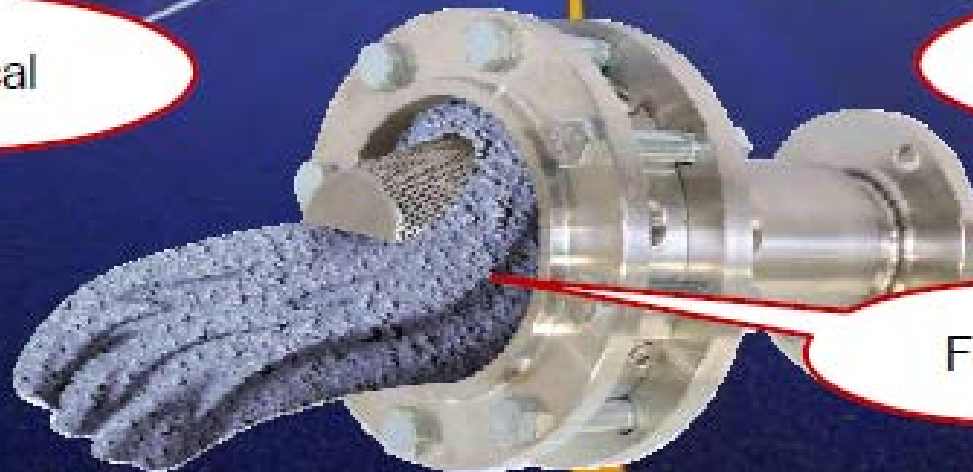
There are three categories (types) of WMA Technologies:



Chemical



Organic



Foaming

Foam

Organic (Wax)

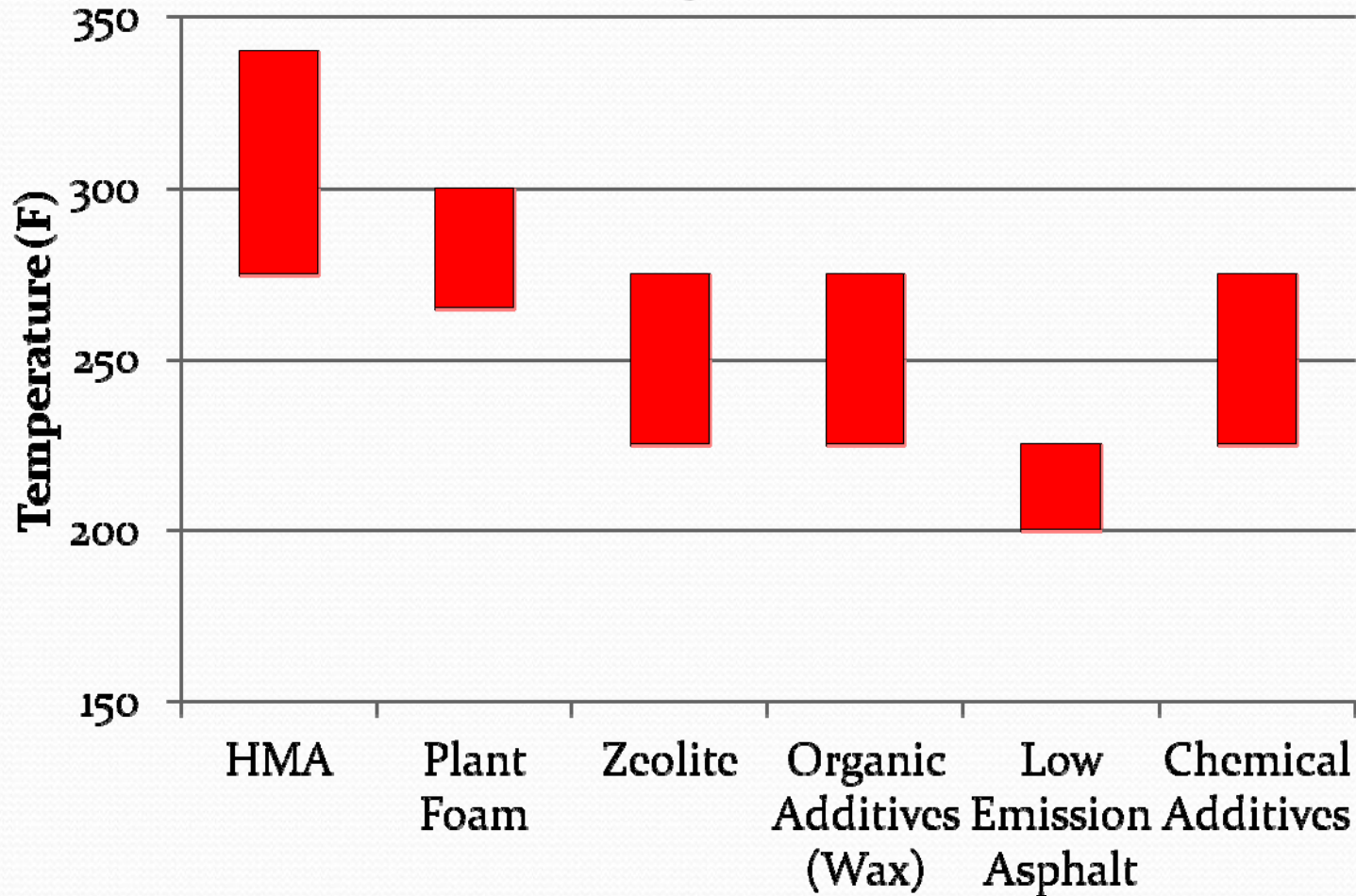
Surfactant

Hybrid

WMA Additives / Foaming Systems

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WMA Plant Temperatures



Questions?

Benefits of WMA—General



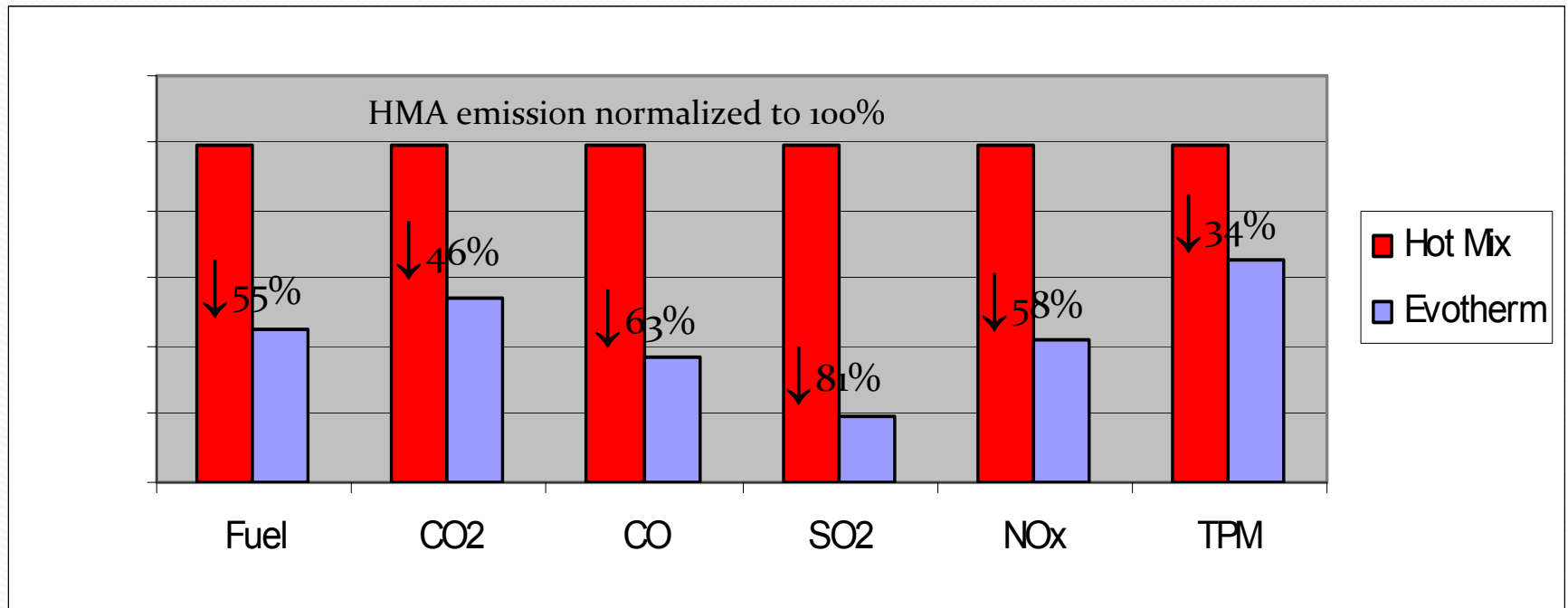
Why Warm Mix?

- Stack Emissions
 - Environment—Good Neighbor
 - Worker Safety—IARC
- Emissions at the Paver
 - Worker Safety
- Reduced Energy Consumption
 - Lower Plant Temps → Less Fuel to Heat Mix
- Increased Capability to Use RAP

Easiest to
Attain

Depends...on
WMA
Technology

Reduced Emissions / Plant



200 °F Evotherm, 310°F HMA control

Reduced Emissions / Plant



Hot Mix



Warm Mix

Reduced Emissions / Plant



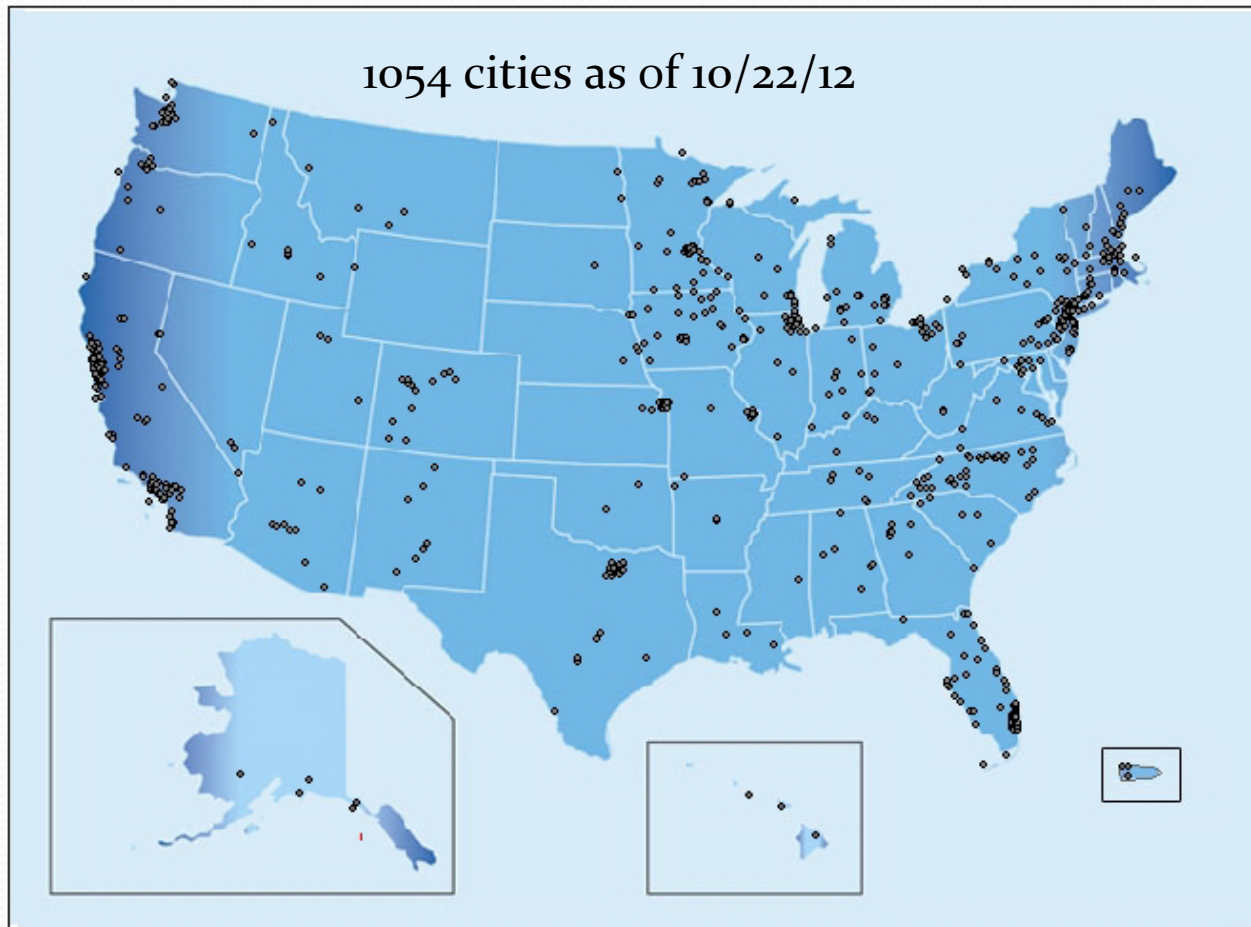
222 F



276 F

Mayors Climate Protection Agreement

Auburn
Bainbridge
Island
Battle Ground
Bellevue
Bellingham
Bremerton
Burien
Camas
Carnation
Clyde Hill
Coupeville
Edmonds
Everett
Ferndale
Issaquah
Kirkland
Lacey



Lake Forest Park
Lynnwood
Olympia
Pacific
Redmond
Renton
Sammamish
Seattle
Shoreline
Snoqualmie
Spokane
Tacoma
Tukwila
Tumwater
Vancouver
Washougal
Yarrow Point

Reduced Emissions / Construction



Warm Mix Asphalt



Warm Mix Asphalt

Reduced Emissions / Construction



Hot Mix Asphalt



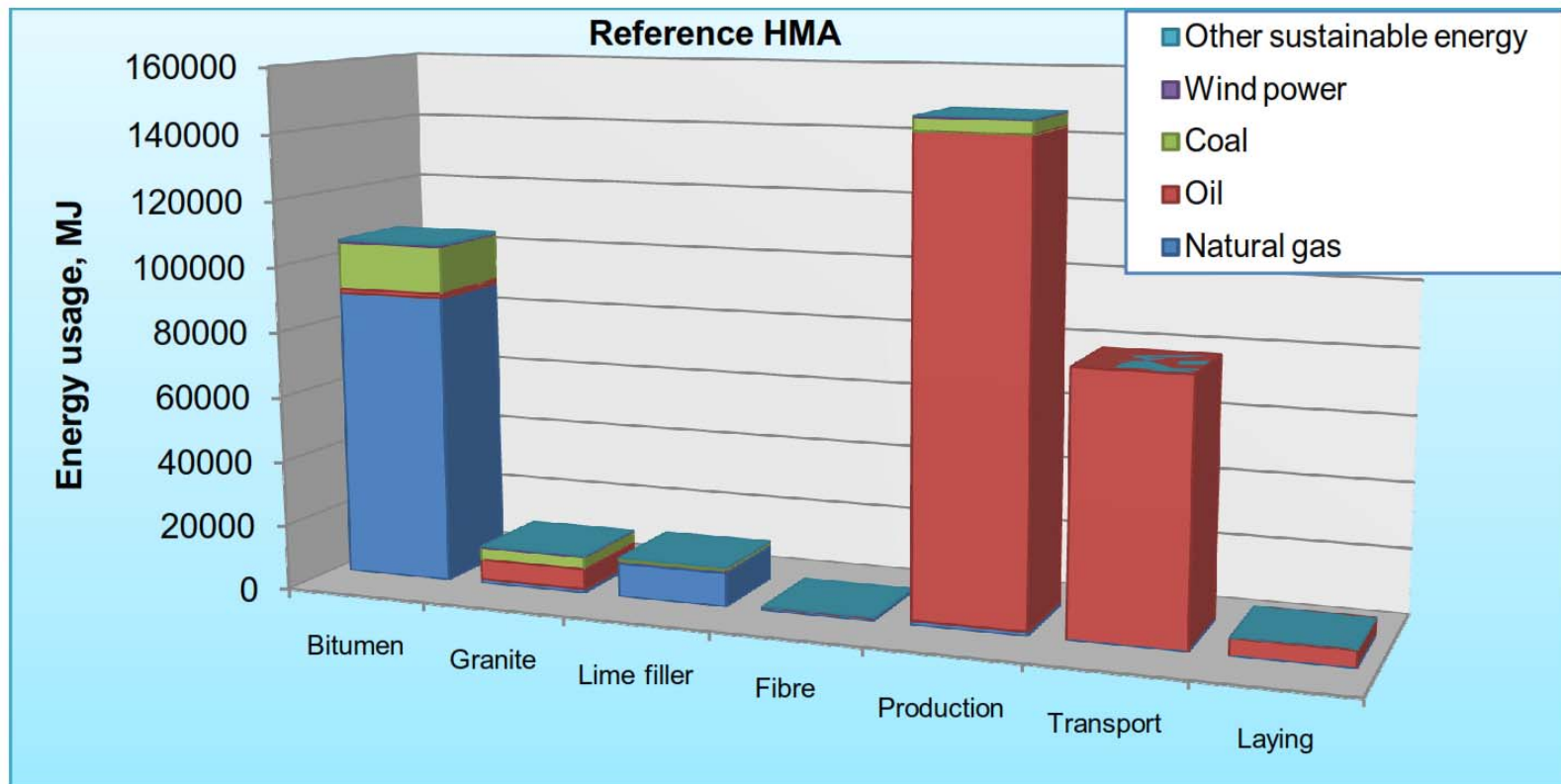
Warm Mix Asphalt

Reduced Emissions / Paver

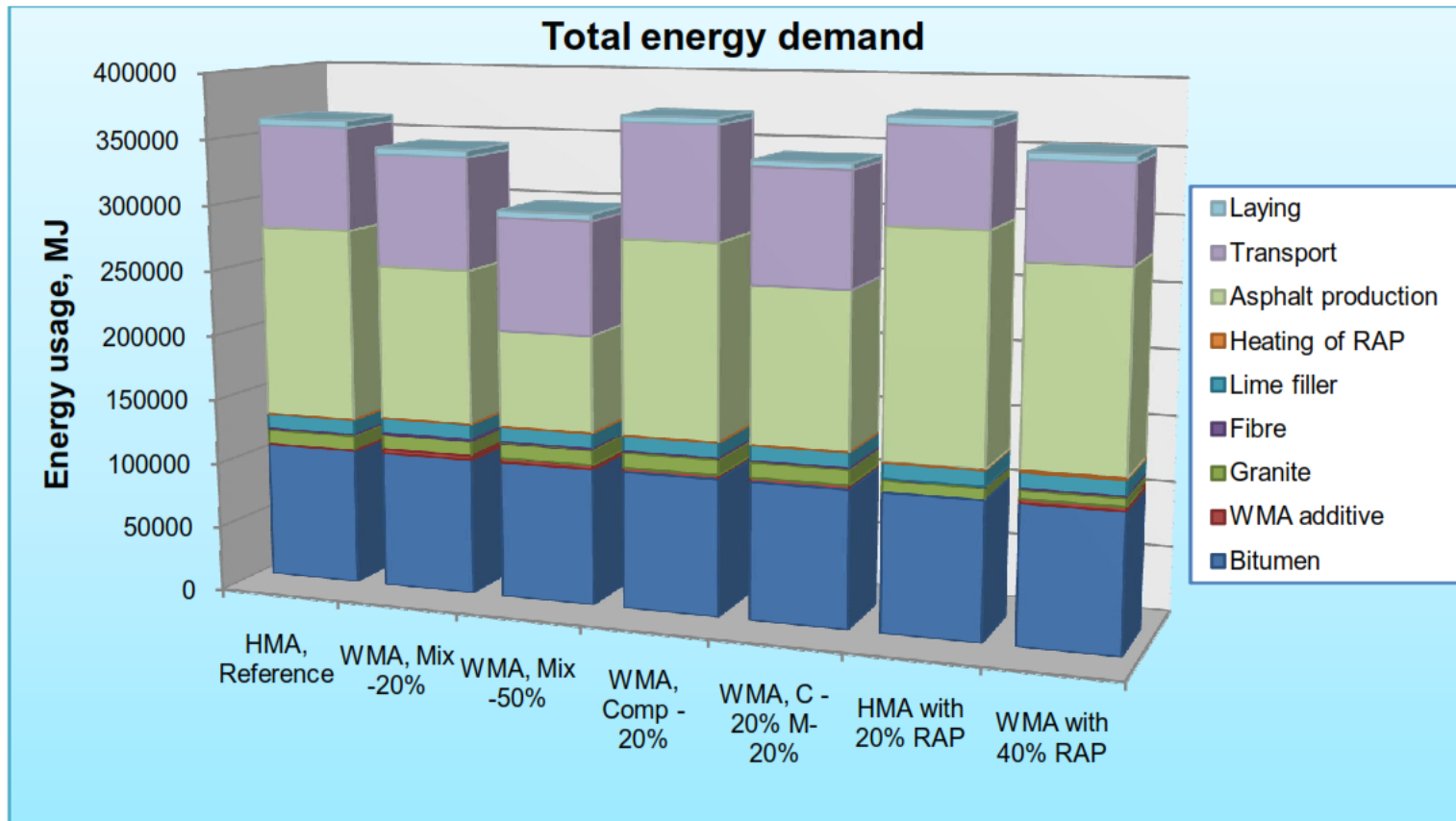
- Limestone
- PG76-22
- T mix: 240°F
- ΔT : 95°F



Life Cycle Energy Consumption



Total Energy Consumption



Total Energy Consumption

	HMA, Reference	WMA, Mixing - 20%	WMA, Mixing -50%	WMA, Comp - 20%	WMA, Comp - 20% Mix- 20%	HMA with 20% RAP	WMA with 40% RAP
Total energy demand, MJ	362606	342781	298327	371921	342285	375913	353834
Percentage	100%	95%	82%	103%	94%	104%	98%

Increased Capability to Use RAP

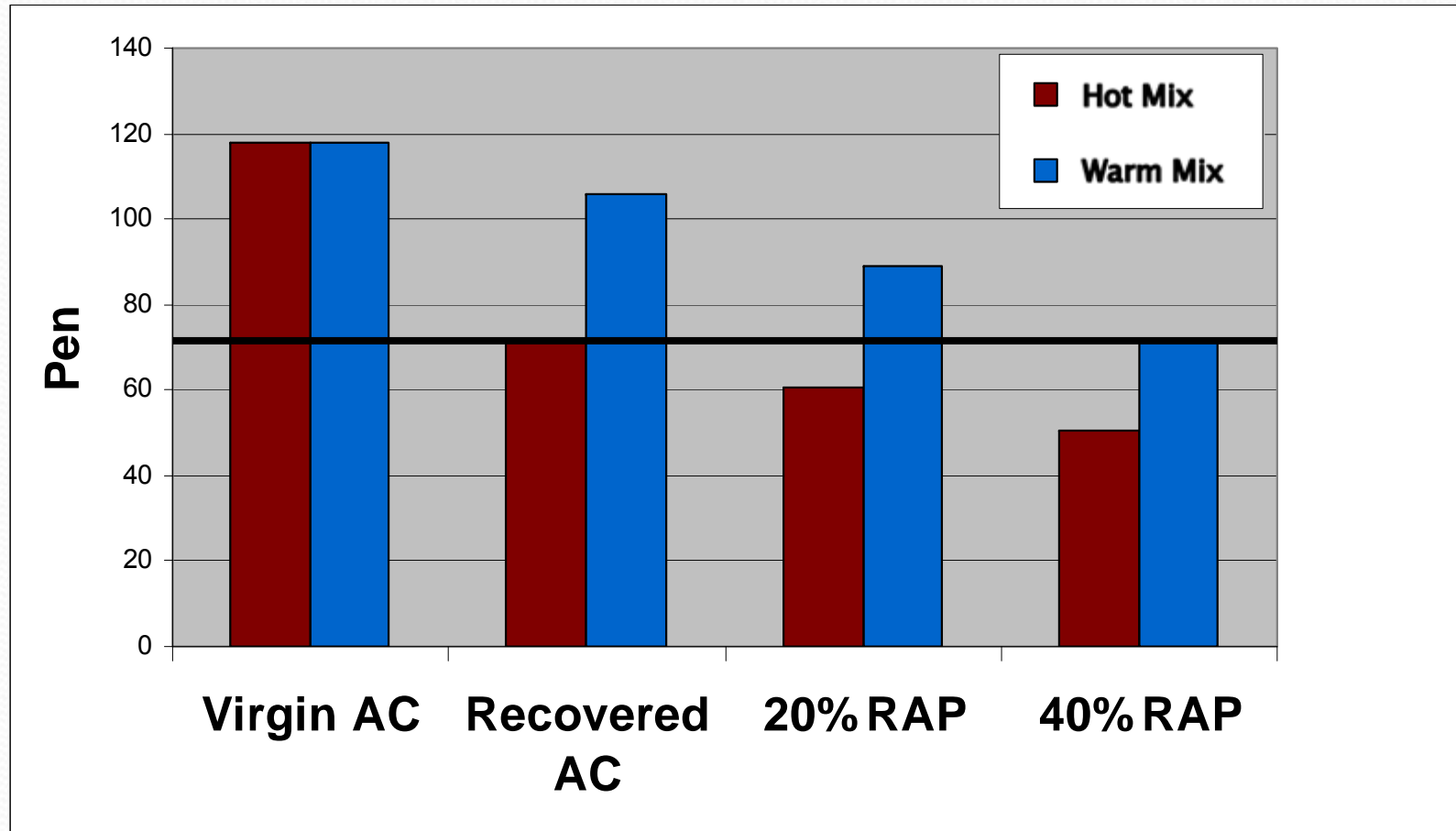
High RAP Warm Mix Asphalt

	Control	20% RAP	28% RAP	35% RAP
Pen	29	39	32	28
Viscosity	25,920	16,087	16,738	23,470
Ductility	38	79	54	42
DSR 64	7.35	4.39	5.74	7.56
MSCR	26	42	37	32
DSR 70	3.48	2.11	2.91	3.59
BBR -12	0.394	0.437	0.406	0.393

Increased Capability to Use RAP

Property	40% RAP HMA Control	40% RAP WMA	Superpave Specification
Mix Production Temperature, °F	330	248	not applicable
Viscosity (Pa-s)	1.357	1.017	3 Pa-s max.
G*/sinδ at 64°C, kPa	9.60	5.31	not applicable to field binder samples
G*/sinδ at 70°C, kPa	4.54	2.59	
G*/sinδ at 76°C, kPa	2.18	1.27	
G*/sinδ at 82°C, kPa	1.08	0.642	
G*/sinδ at 88°C, kPa	0.56	-	
Penetration (dmm)	15	23	not applicable
BBR Stiffness (MPa)	222	158	300 MPa max
m-value	0.296	0.328	0.300 min
Pressure Aging Vessel G* x sinδ, kPa	5663	3218	5000 kPa max

Increased Capability to Use RAP



Questions

WMA Benefits—Performance



WMA Benefits—Performance

- Durability ?
 - Rut Resistance ?
 - Crack Resistance
 - Ride Quality
 - Moisture Sensitivity ?
-
- Will WMA Perform As Well or Better than HMA?

Increased Durability

Warm Mix Asphalt

Hot Mix Control



(TxDOT Cores After 1 Year)

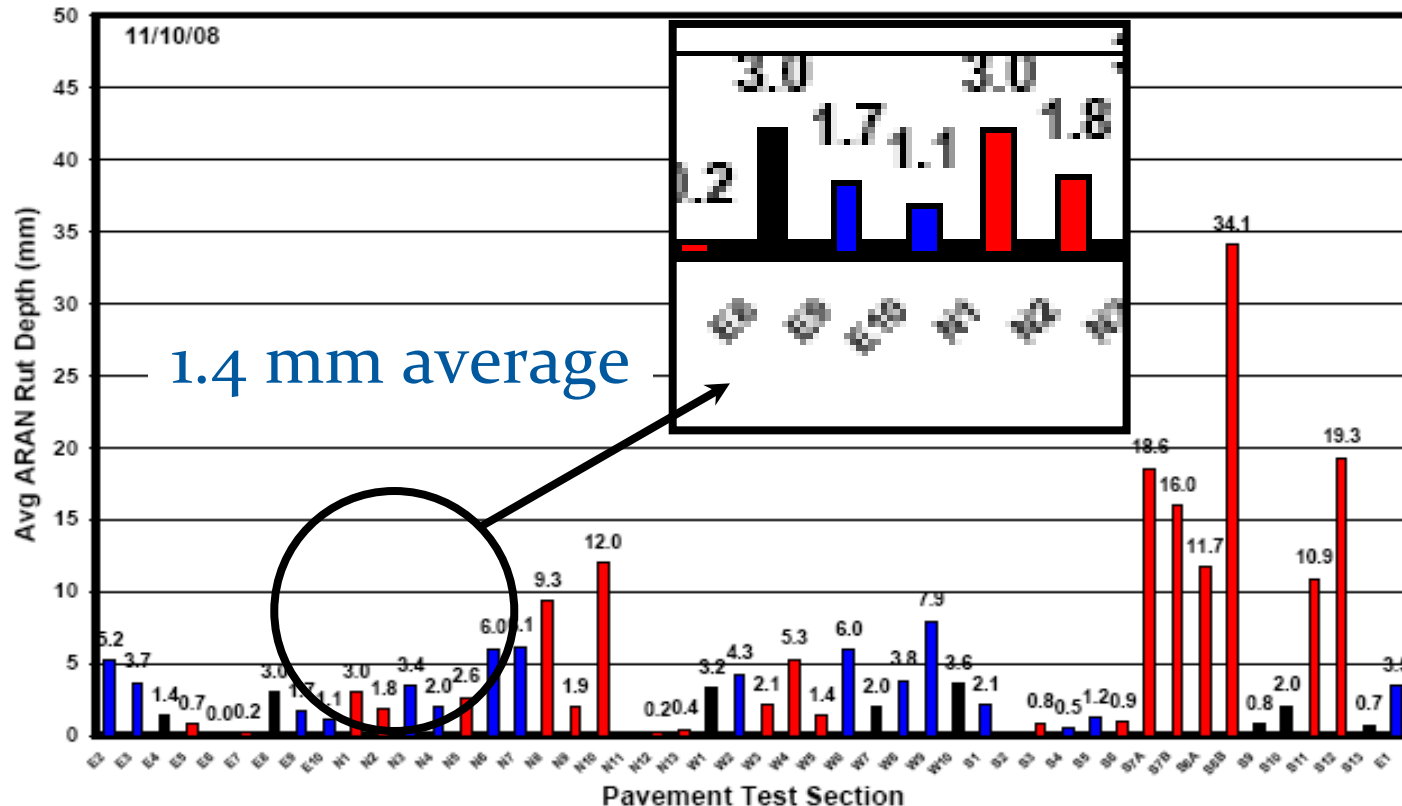
Rut Resistance



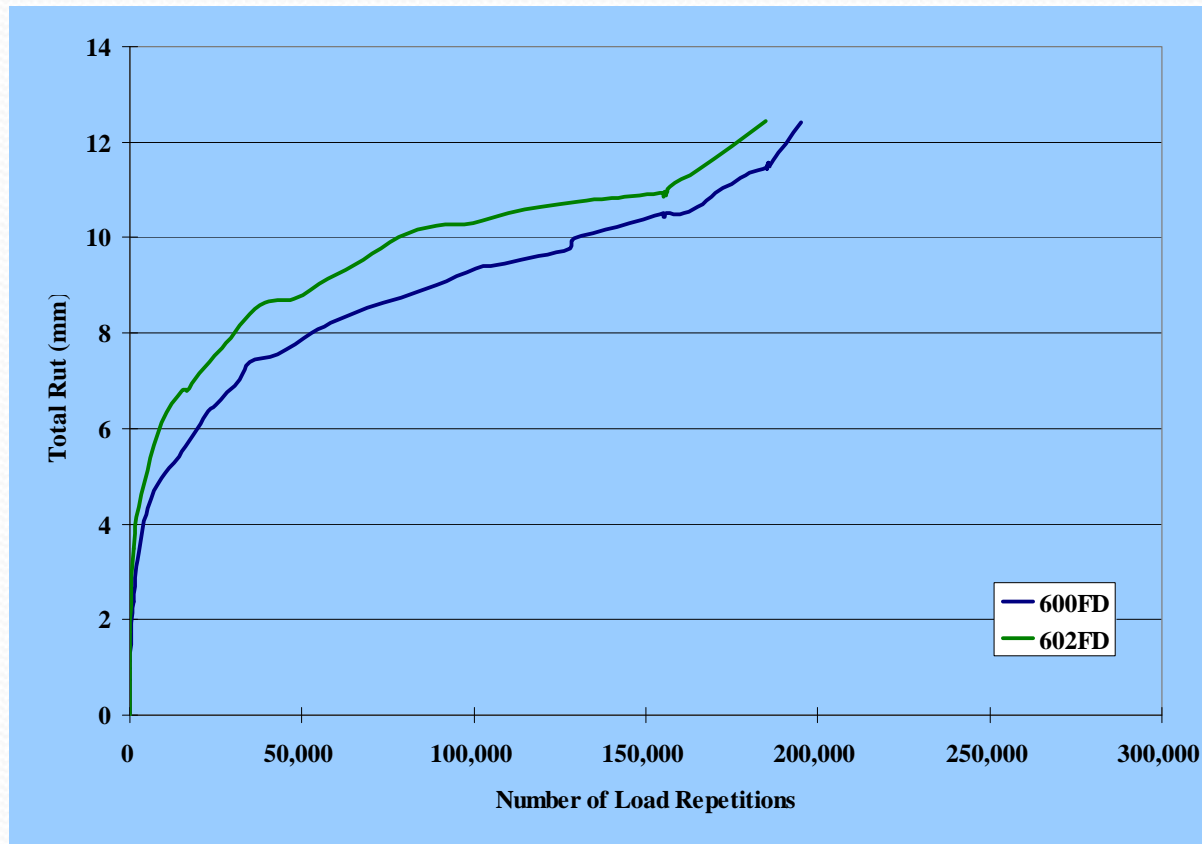
Rut Resistance—NCAT

Rutting Performance

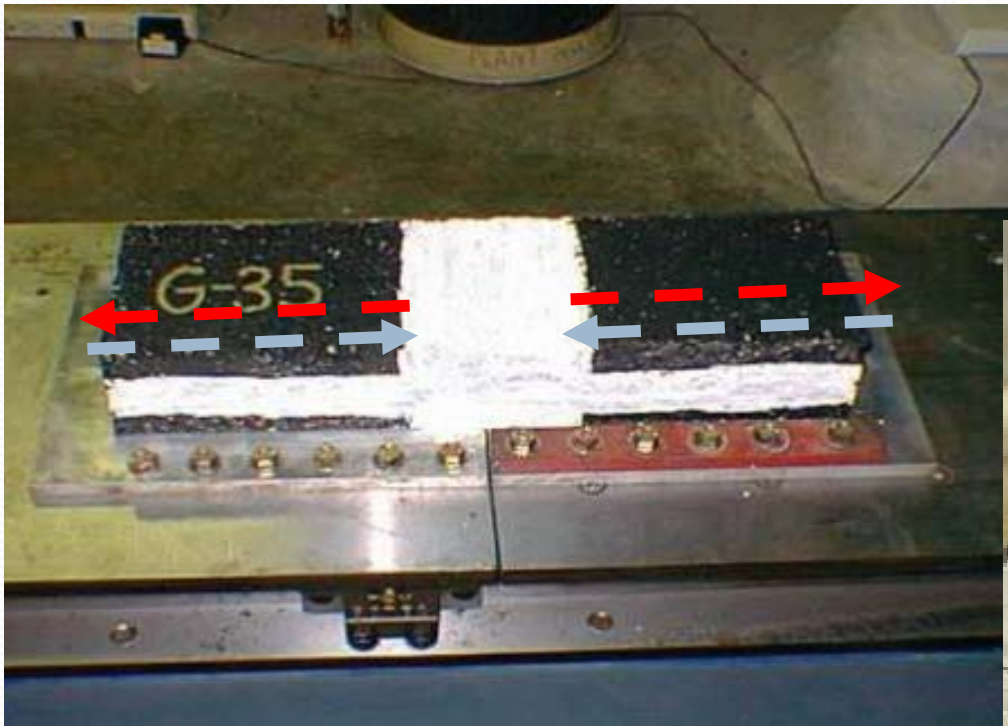
Cycle of Construction Shown by Color (Black=2000, Blue=2003, Red=2006), N1-N10 & S11 Structural (M-E)



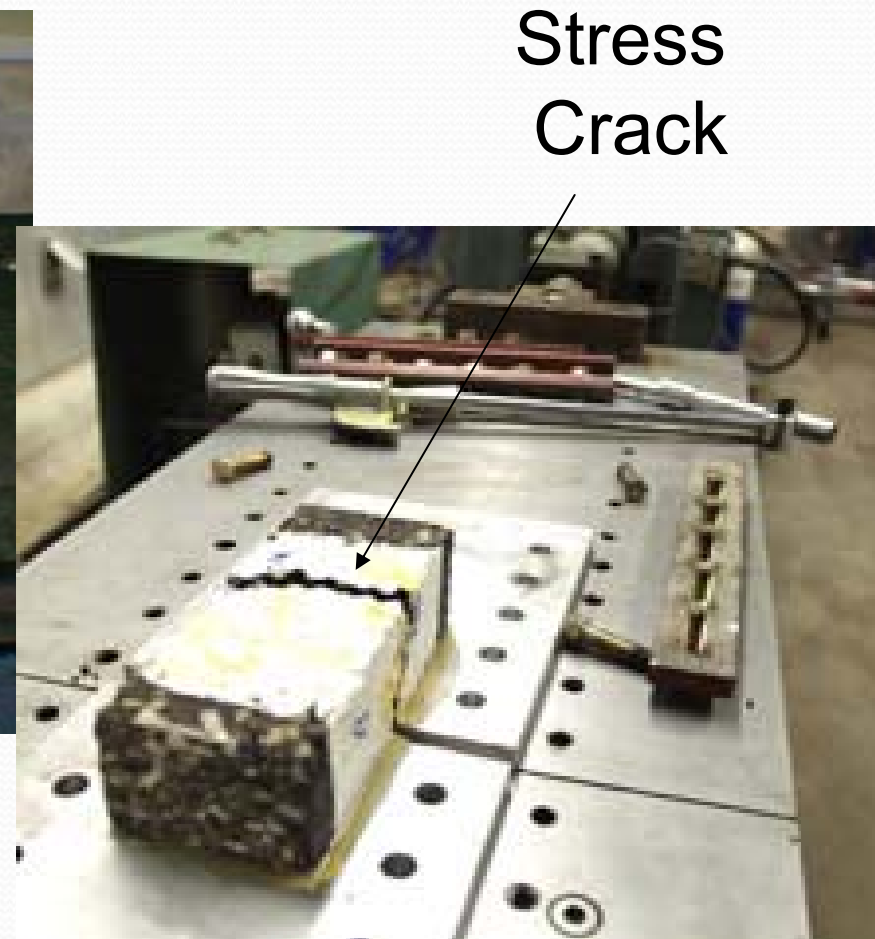
Rut Resistance-Caltrans HVS



Increased Crack Resistance

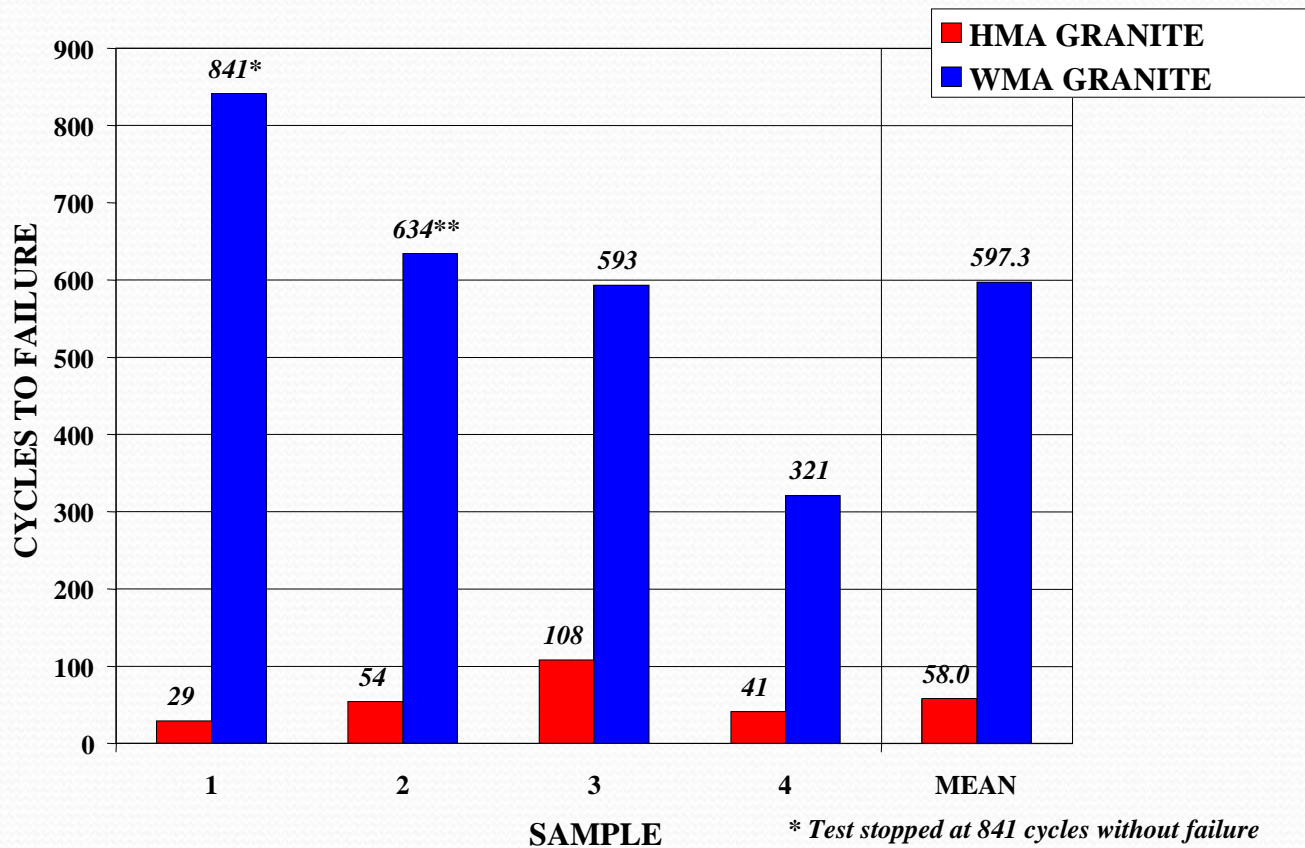


TxDOT Overlay Tester



Stress
Crack

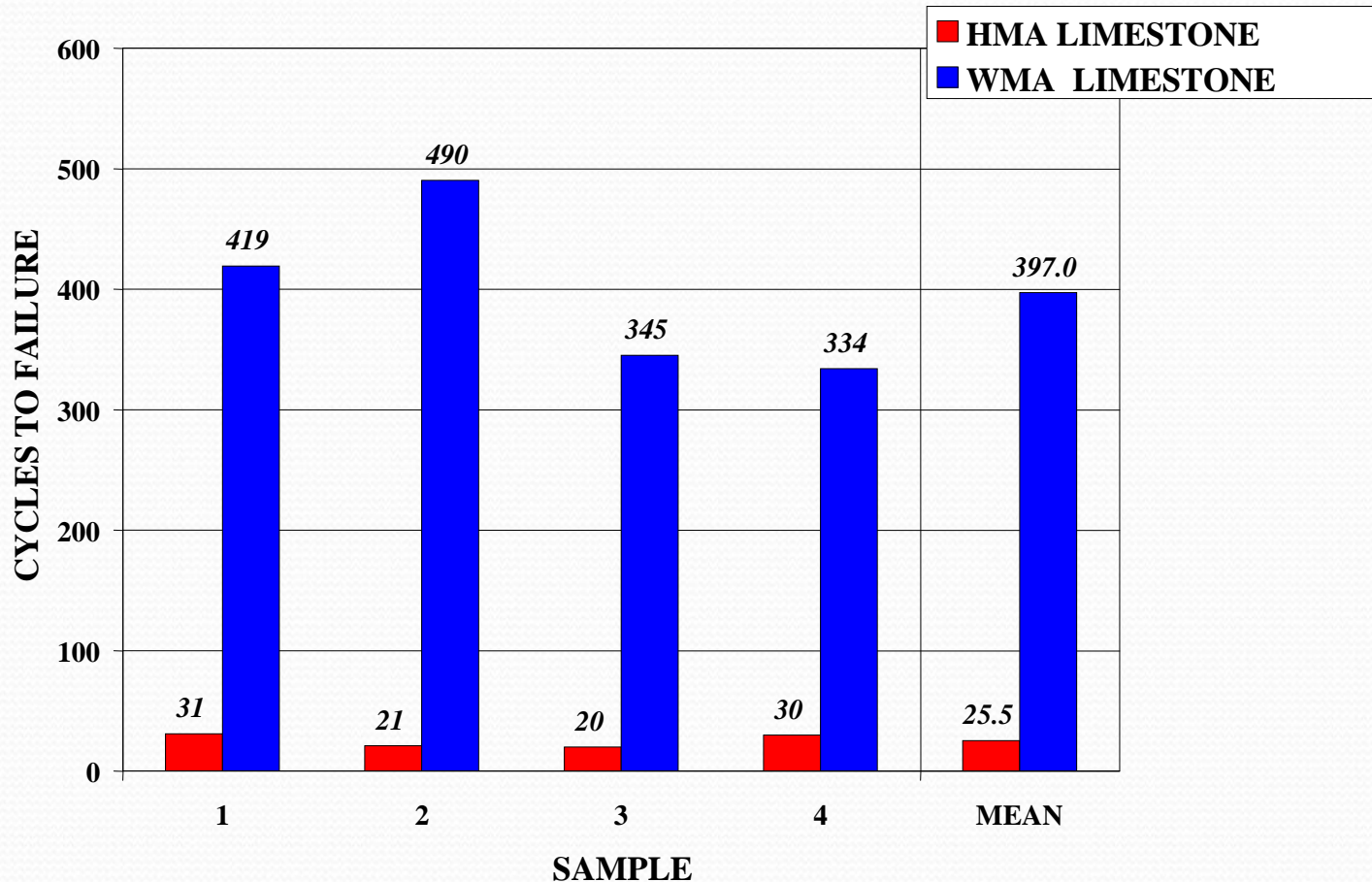
Increased Crack Resistance



* Test stopped at 841 cycles without failure

** Test stopped at 634 cycles without failure

Increased Crack Resistance



Other Benefits (Concerns?)

- Improved Ride Quality
- Moisture Sensitivity

Questions?

WMA Benefits—Construction

WMA Benefits—Construction

- Cold Weather Paving (Extended Season)
- Longer hauls
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Extended Season Paving

Mix contained 40% RAP PG 64-22
WMA mix temperature
behind the screed



Ground temperature
at 7 a.m. was $< 15^{\circ}\text{F}$



Extended Season Paving

Mix contained 40% RAP PG 64-22



Paving



Compaction

Extended Season Paving

Mix contained 40% RAP PG 64-22

Excellent joint compaction

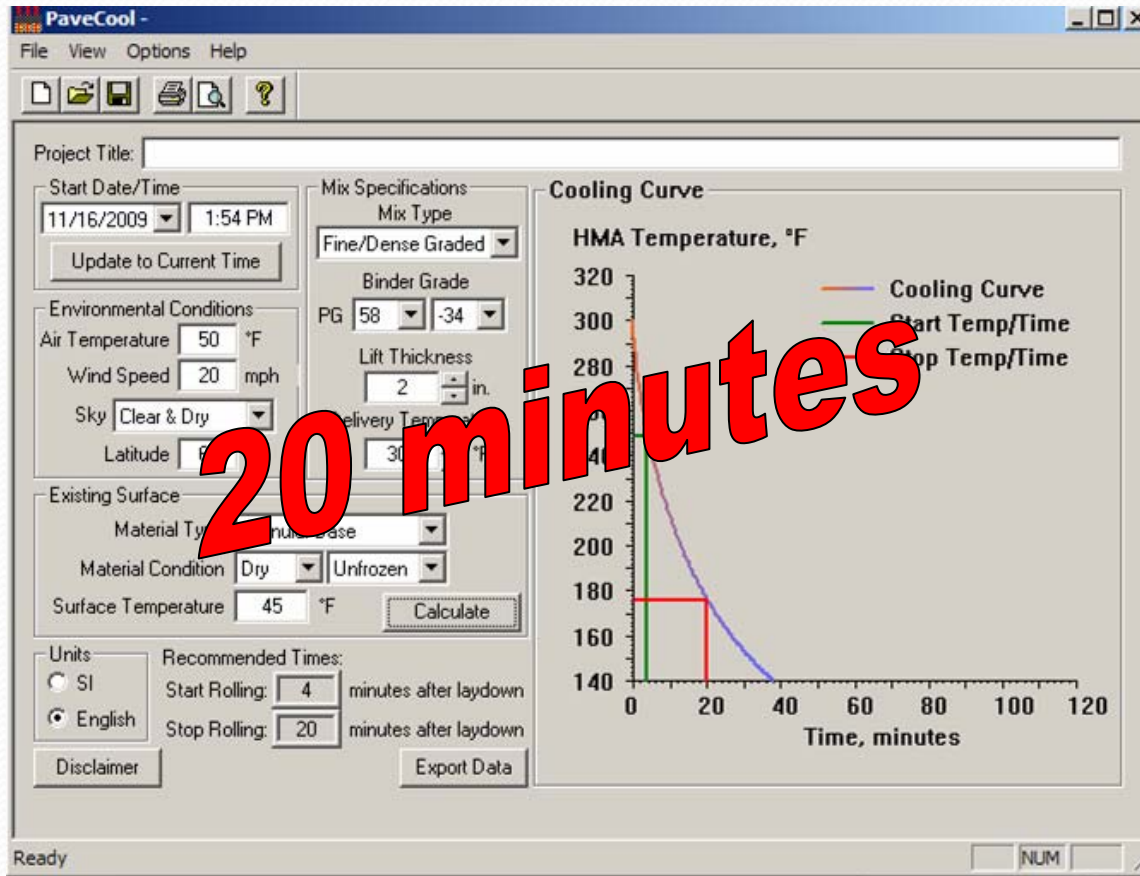


Air voids of cores
all > 92% of Gmm

A close-up photograph of an asphalt joint. The top half shows a dark, dense asphalt surface, while the bottom half shows a lighter, more porous surface. A white coin is placed on the joint to provide a scale reference.



Time Available for Compaction



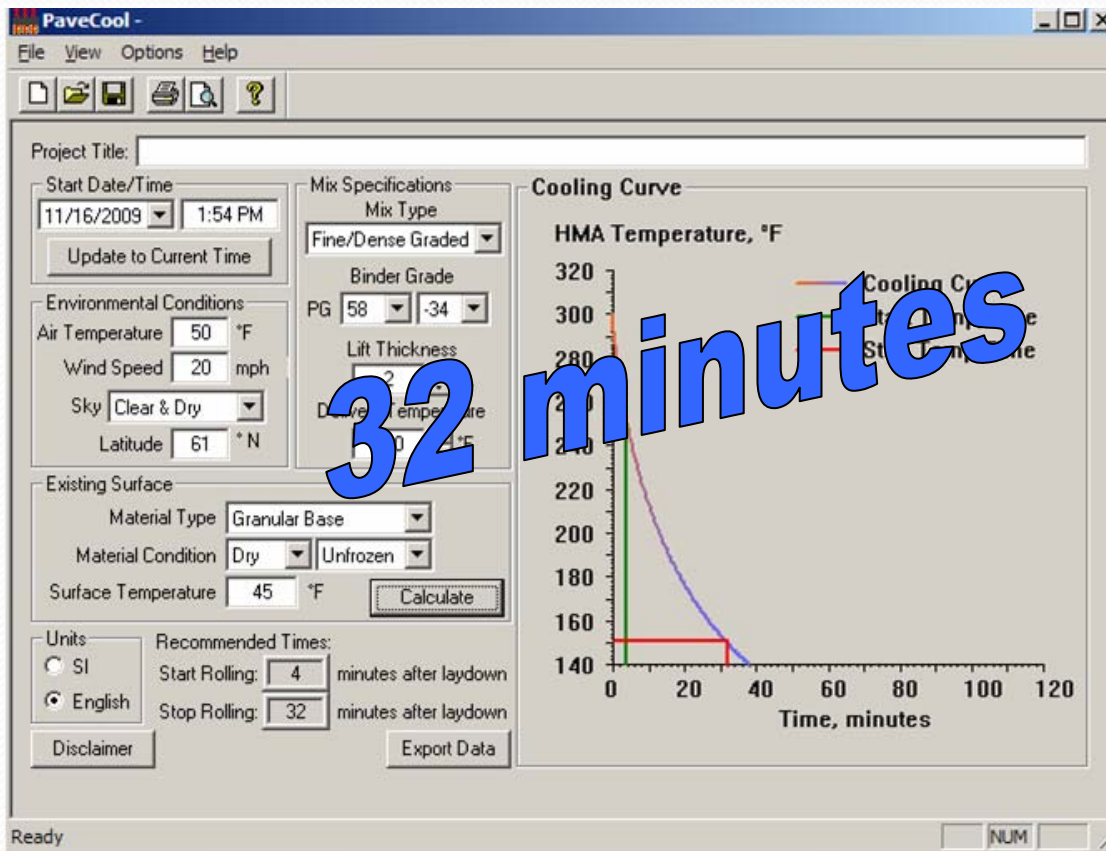
Delivery Temp
300F

Surface Temp
45F

Cessation Temp
175F

HMA at 50°F Air Temp

Time Available for Compaction



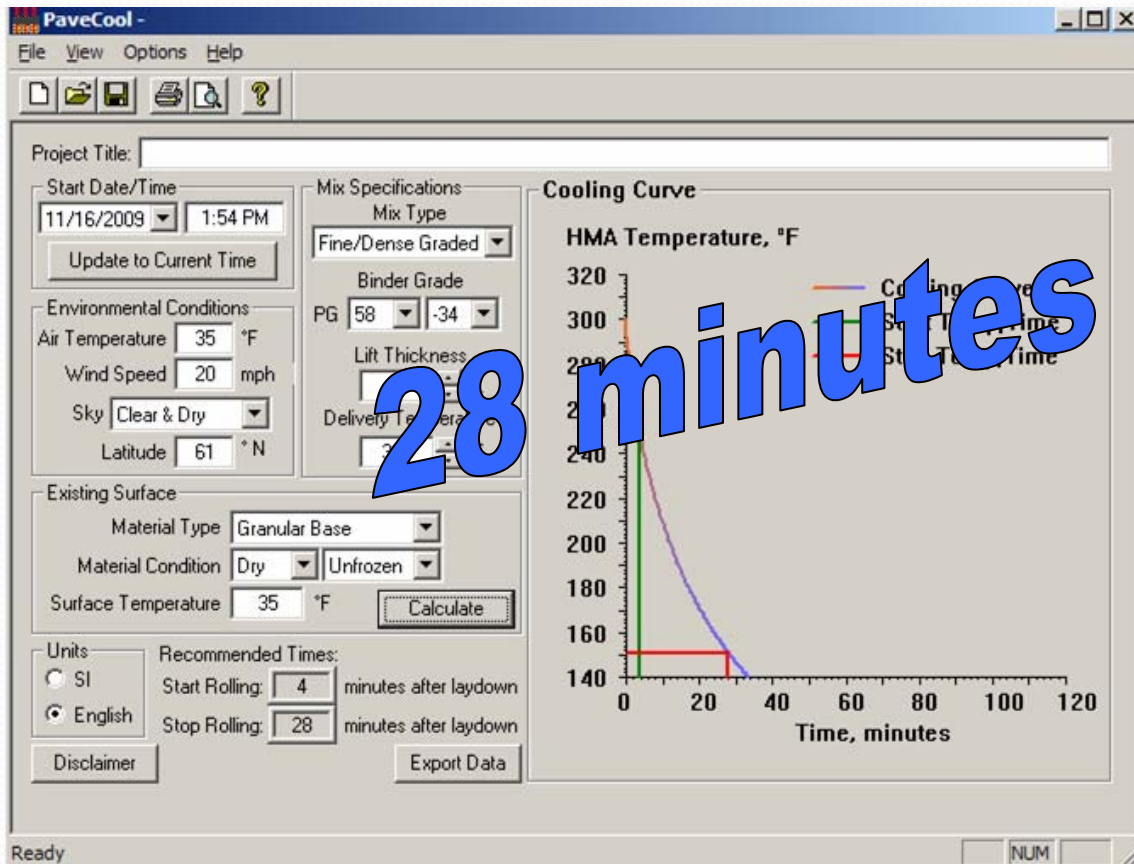
Delivery Temp
300F

Surface Temp
45F

Cessation Temp
150F

WMA at 50°F Air Temp

Time Available for Compaction



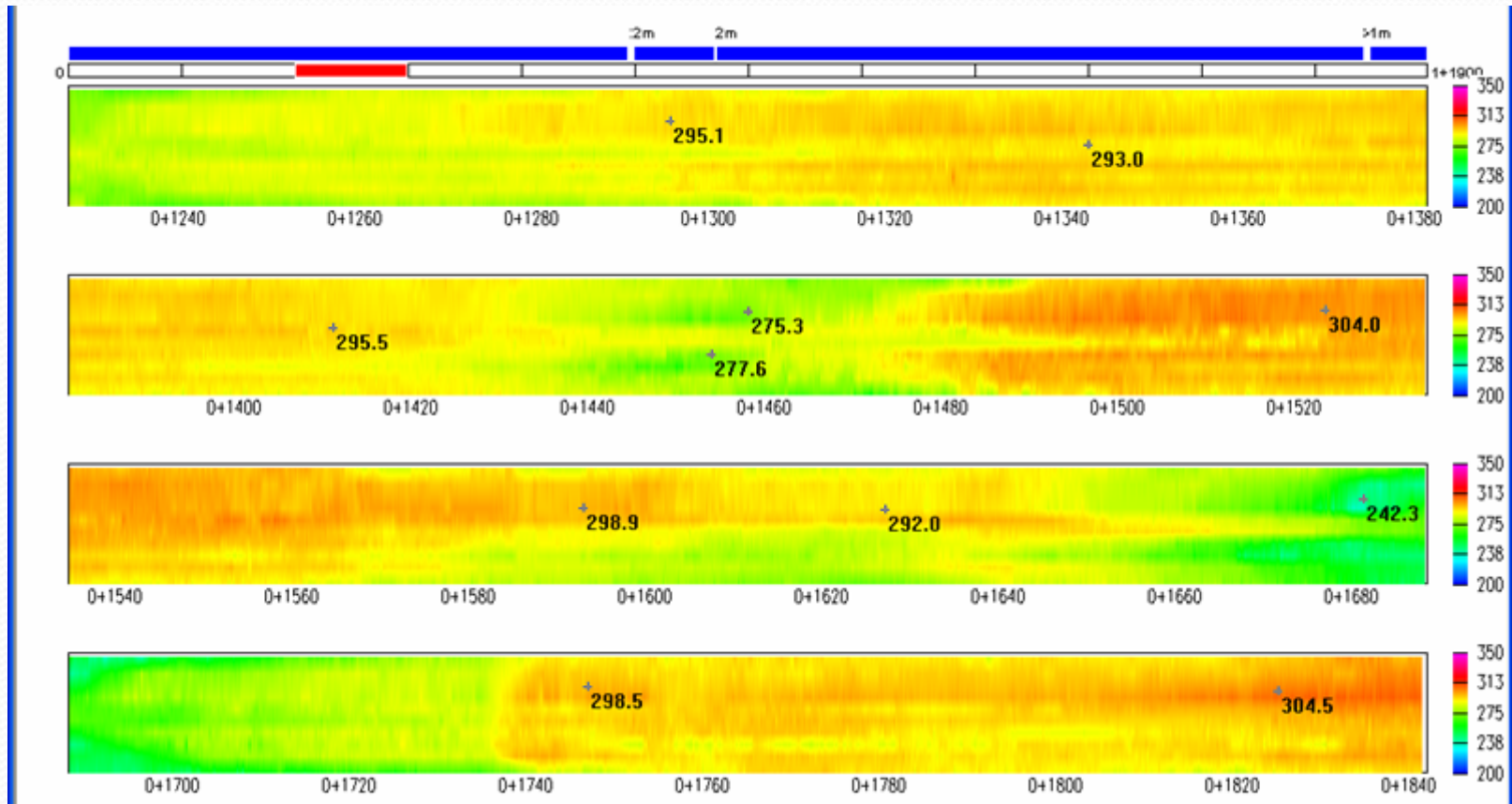
Delivery Temp
300F

Surface Temp
35F

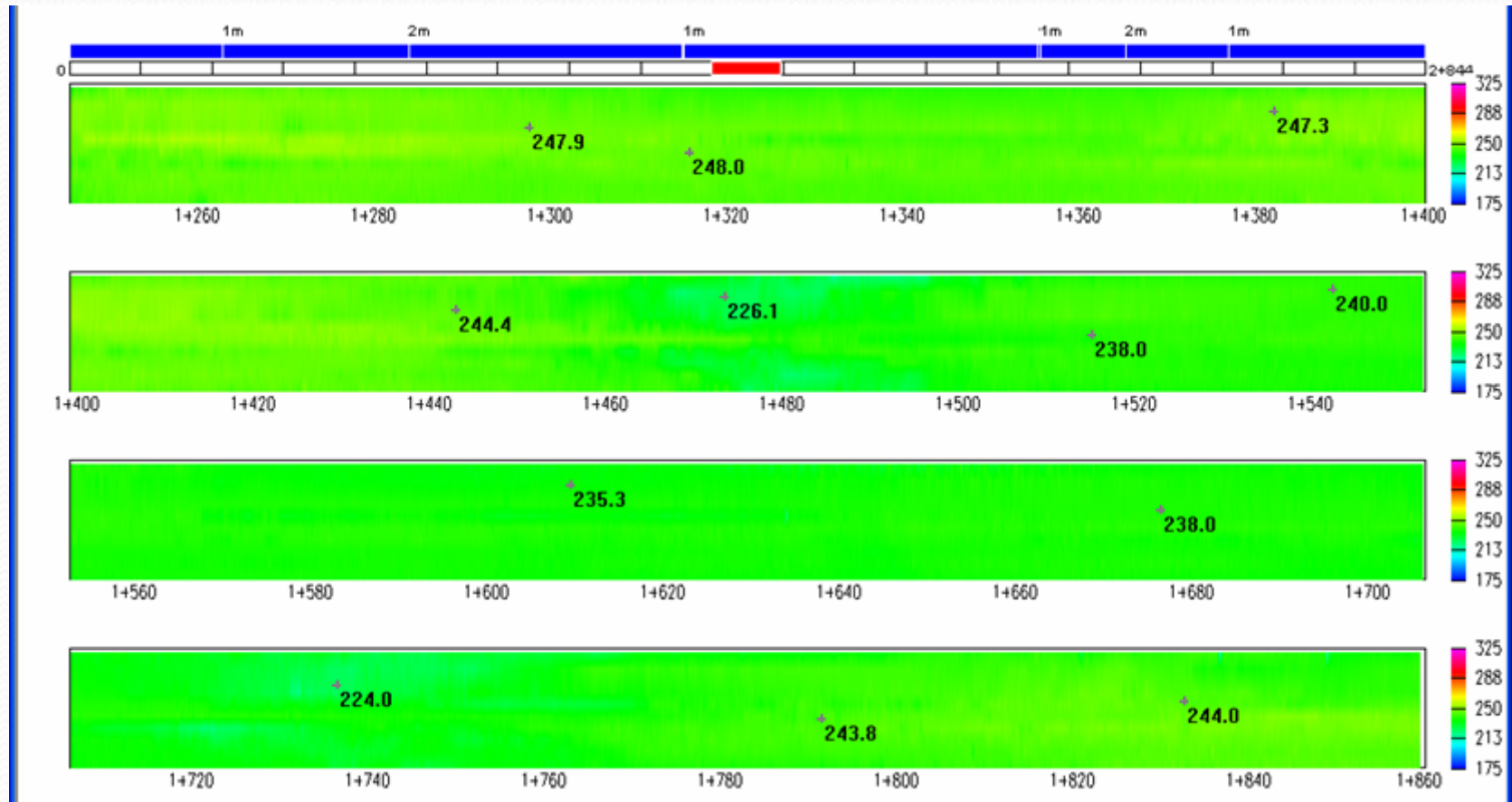
Cessation Temp
150F

WMA at 35°F Air Temp

Reduced Thermal Segregation



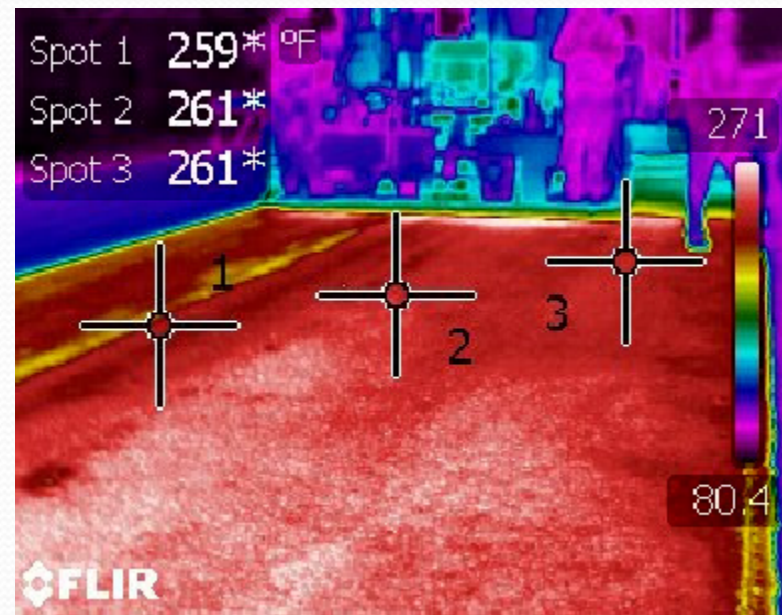
Reduced Thermal Segregation



Reduced Thermal Segregation



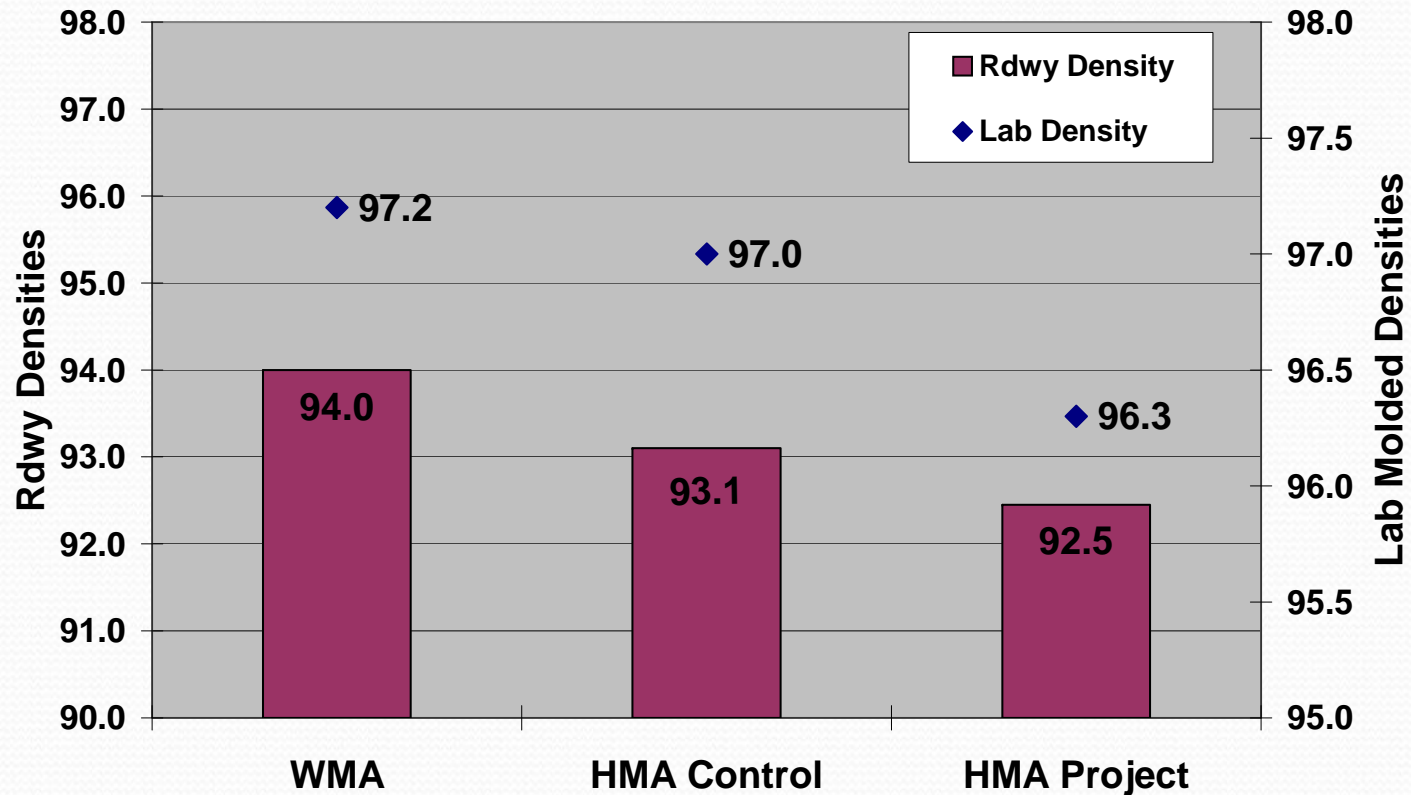
Hot Mix Asphalt



Warm Mix Asphalt

Improved Compaction

Roadway & Lab Densities @ 4.6% PG76-22



Potential for Incentive Pay

Roadway Densities
TxDOT Specification % Bonus



Questions?

Case Studies

Case Studies—Asphalt Rubber



- I-5 Near Orland, CA
- Heavy Traffic
 - 26,000 AADT
 - 28% Trucks
- ½" RHMA-O WMA
 - Open Graded Friction Course
- Asphalt Rubber
 - PG64-16 Base
- 16,000 Tons WMA

Case Studies—Asphalt Rubber

Load Out Temp 290°F

Windrow Temp 280°F



Case Studies—Asphalt Rubber

Breakdown Rollers



250-260°F Breakdown



Success Stories—Increased RAP

City of Portland



Mix

½" NMAS 100 Gyration

30 % RAP

PG 70-22ER

HMA Production

Temp

335 F

Case Studies—Increased RAP

City of Portland



WMA Production
255F

WMA Density
>= 94% Gmm

Crew Reports
Very workable and
less exhausting to
work with WMA
compared to HMA

Case Studies—Airport Pavement

Anchorage Intl Airport—RON Aprons



Base Layer—PG 58-34, $\frac{3}{4}$ " NMAS Superpave

Case Studies—Airport Pavement

Anchorage Intl Airport—RON Aprons



Pavement Stiffness for WMA Equal to HMA

WMA—It is the
future of our
industry!

Thank You!

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