

# Warm Mix Asphalt in Minnesota

A photograph of an asphalt plant. In the foreground, a white truck is positioned under a large black metal structure, likely a conveyor or loader. A large plume of white steam or smoke rises from the structure. In the background, several large, cylindrical storage silos are visible, some with red and black horizontal stripes. The sky is clear and blue.

**Tim Clyne**  
**Mn/DOT**

*North Dakota Asphalt Conference*

# What is Warm Mix Asphalt (WMA)?

Technology that allows the reduction of mixing temperature by 20 to 100 F

★ 50 F typical

Acts as a lubricator, not viscosity reducer

★ Reduces surface tension of asphalt binder

★ Allows binder to flow and coat aggregates

# Environmental Benefits of WMA

## Green Technology

- ★ **Lower greenhouse gas emissions (~30-90%)**
  - ★ **CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>2</sub>, VOC, etc.**
- ★ **Lower fuel consumption (~30%)**
- ★ **Reduced exposure of workers to fumes**
- ★ **Eliminates the need for fume evacuation equipment on plant and paver**

# Operational Benefits of WMA

## Construction Practices

- ★ Lower plant wear
- ★ Longer haul distances
- ★ Late season paving
- ★ Better compaction
- ★ Early site opening
- ★ More comfortable working conditions for plant and paving crews

# Performance Benefits of WMA

## Better Pavement Performance

- ★ Can use RAP and/or shingles with WMA
- ★ Reduced binder aging
- ★ Less susceptible to low temperature and fatigue cracking
- ★ Eliminates bump at joint when overlaying concrete
- ★ Rutting and stripping performance still being investigated

As good as or better than traditional HMA

# WMA Technologies

## Foaming Technologies

- ★ **Water**

- ★ **Additive**

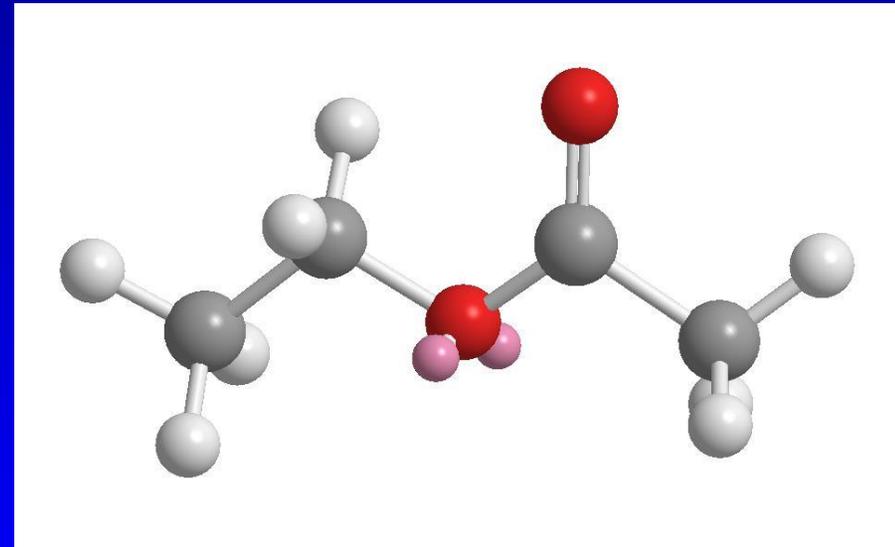
## Organic Additives

- ★ **Wax**

## Chemical Additives

- ★ **Surfactants**

- ★ **Anti-strip agents**



# Technology Overview\*\*

- WAM-Foam  
- Rediset WMX 
- Low Emission Asphalt  
- Aspha-Min 
- AquaFoam 
- Advera 
- Ultrafoam GX 
- Sasobit 
- Terex 
- REVIX 
- Accu-Shear 
- Evotherm 
- Aquablack 
- Cecabase RT 
- Double Barrel Green 
- Thiopave  

\*\*FHWA does not endorse any particular proprietary product or technology.

Courtesy: Matt Corrigan, Dave Newcomb

OT  
terials

# OVERVIEW OF WMA TECHNOLOGIES

# Foam (water)



Astec Double Barrel Green



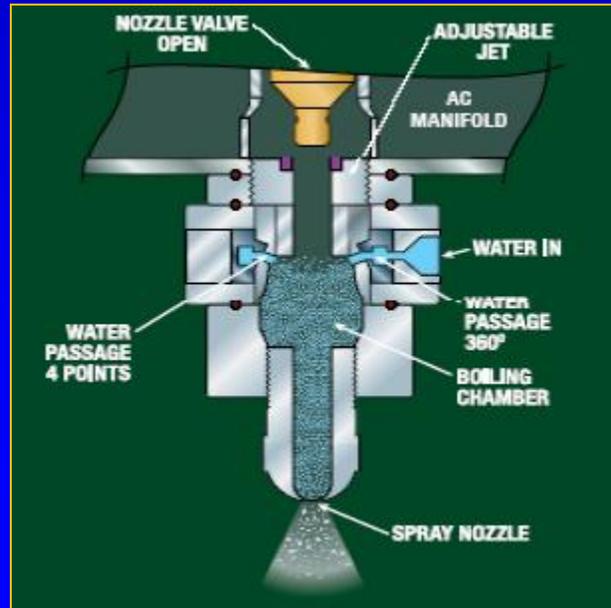
Gencor Ultrafoam GX



Maxam AQUABlack



Stansteel Accu-Shear



TEREX Warm Mix

# Foam (additive)



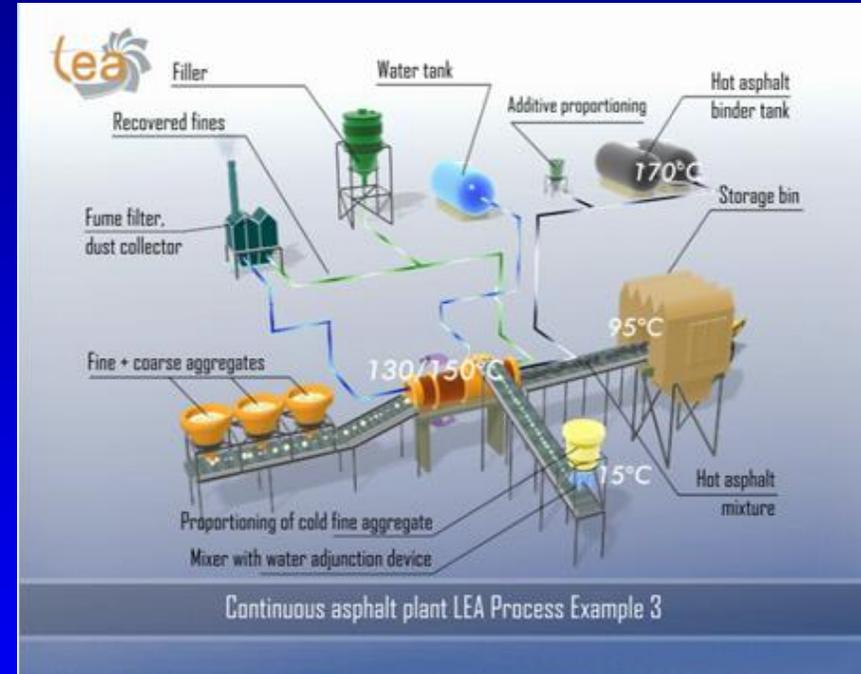
**Aspha-Min**



**Readiset WMX**



**Advera**



**Low Emission Asphalt**

# Organic



**Sasobit**



**2000 lb "Supersack"**



**Shell Thiopave**

# Chemical



Evotherm



REVIX

# WMA Technology Applications

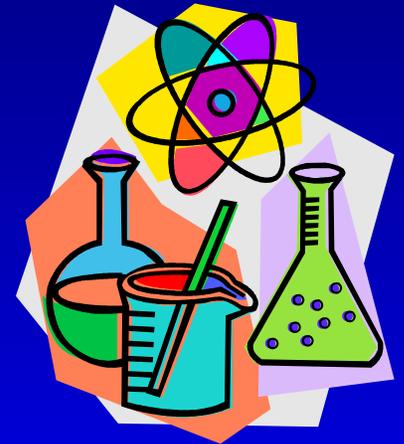
Asphalt terminal blend

Added to binder line at plant

Added to aggregate stream at  
plant

Mineral filler feed line

Range from zero to moderate  
plant modifications



# WMA EXPERIENCE IN MINNESOTA

# Oil Gravel

Cell 32 (1998) – Cold Mix Paving Practice

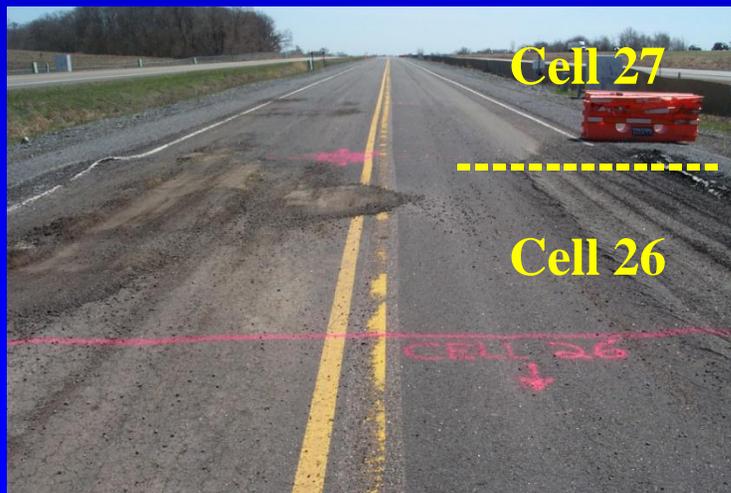
Cell 27 (1999) – Chip Seal / Large Stone Base

Cell 28 (1999) – Oil Gravel (luke warm mix) / Large Stone Base

Cell 26 (2000) – Oil Gravel (warm mix) / Reclaimed Base

Cell 27 (2000) – Oil Gravel (warm mix) / Large Stone Base

Several County Roads throughout Minnesota



- ★ Oil Gravel requires solid base
- ★ No Transverse Cracking or Rutting
- ★ Some Fatigue and Rough Ride

# Olmsted & Goodhue Counties

First known true WMA jobs in MN (2007)

- ★ Revix (Evotherm 3G) technology

- ★ Olmsted CR 104

  - ★ 5 mile stretch

- ★ Goodhue CSAH11

  - ★ 537 tons placed in 4,200 feet of the EB lane



# Crow Wing County

## County Road 108 (2008)

- ★ **2913 tons WMA, 272 tons HMA**
- ★ **58-34 HMA vs. 58-28 WMA**
  - ★ **WMA is \$3-\$4 lower than HMA**
- ★ **Estimated 5 years of extended service life**
  - ★ **Life cycle cost analyses are favorable for WMA**
- ★ ***ASCE Cold Regions paper 2009***

**County now allows alternate bids on several projects**

- ★ **20,000 tons WMA in 2009 (CR 2)**

# 2008 MnROAD Construction

Warm Mix Asphalt						Control
15	16	17	18	19	23	24
3" WM	5" WM 58-34	5" WM 58-34	5" WM 58-34	5" WM 58-34	5" WM 58-34	3" 58-34
11.1" 64-22 1993 HMA	12" 100% recycle PCC	12" 50% RePCC 50% Class 5	12" 100% RAP	12" CI-5	12" Mesabi Ballast	4" Cl6sp
Clay	12" Cl3sp	12" Cl3sp	12" Cl3sp	12" Cl3sp	12" Cl3sp	Sand
58-34 Surface Binder	7" Select Gran	7" Select Gran	7" Select Gran	7" Select Gran	7" Select Gran	100' Fog Seal 2008
	Clay	Clay	Clay	Clay	Clay	100' Chip Seals 2009 2010 2011 2012

# Mix Design Requirements

**Wear and Non-Wear**

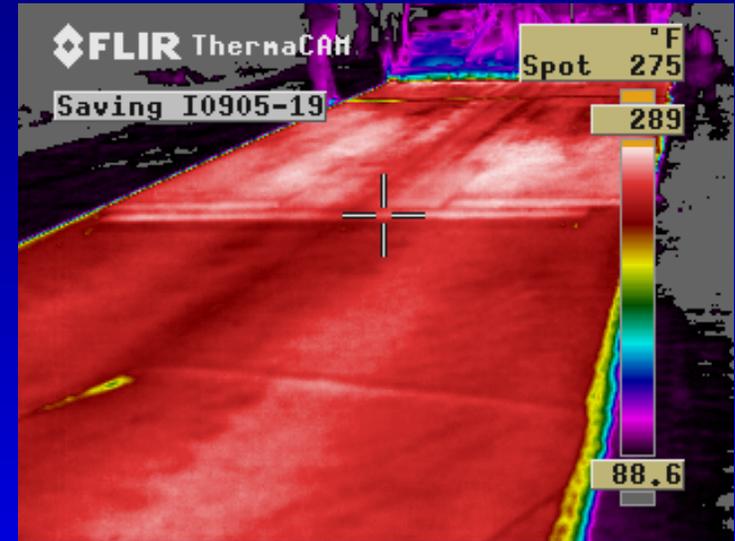
**12.5 mm NMAS**

**Traffic Level 4**

**PG 58-34**

**20% RAP from MnROAD**

**No requirements for WMA technology**



Next several slides courtesy of Chris Miller, Hardrives

# REVIX™ Technology

Developed by Mathy Technology and Engineering  
and Paragon Technical Services, Inc.

- ★ **Chemical additive added at terminal or HMA plant**
- ★ **Requires no plant modification**
- ★ **Binder shipped from Mathy with WMA chemical package already added**

**This technology is now marketed as Evotherm 3G**



# Mix Design

## Existing SPWEB440 Mix Design

- ★  $\frac{3}{4}$ " 100% Crushed Stone
- ★  $\frac{1}{2}$ " Granite Chips
- ★ Washed Granite Sand
- ★ Crushed Millings from MnROAD

## Replaced Standard Binder with WMA Binder

- ★ Lab compaction temperature 235° - 245° F

Ran points to find optimum AC content for  
SPWEB440

Non-Wear MDR written from trial point data



# WMA Production

Day 1 – 990 tons of SPNWB430C

- ★ No change in GMM from design
- ★ Drastic increase in Gmb (about 0.040)
- ★ Lower than expected Air Voids and VMA
- ★ Lower gyrating temperature gave equal results



# WMA Production

Day 2 – 1996 tons of SPWEB440C

- ★ Aggregate proportion change as well as add AC% reduction
- ★ Air Voids on target
- ★ VMA drop of about 1.0



# WMA Laydown

Business as usual – only cooler  
Positive comments from the crew  
Rolling Pattern Challenges



# Laydown Temp (224 F)



# Density Results

## Non-Wear

- ★ All cores > 93.0%
- ★ Low air voids

## Wear

- ★ Cores averaged 92%



# WMA vs HMA



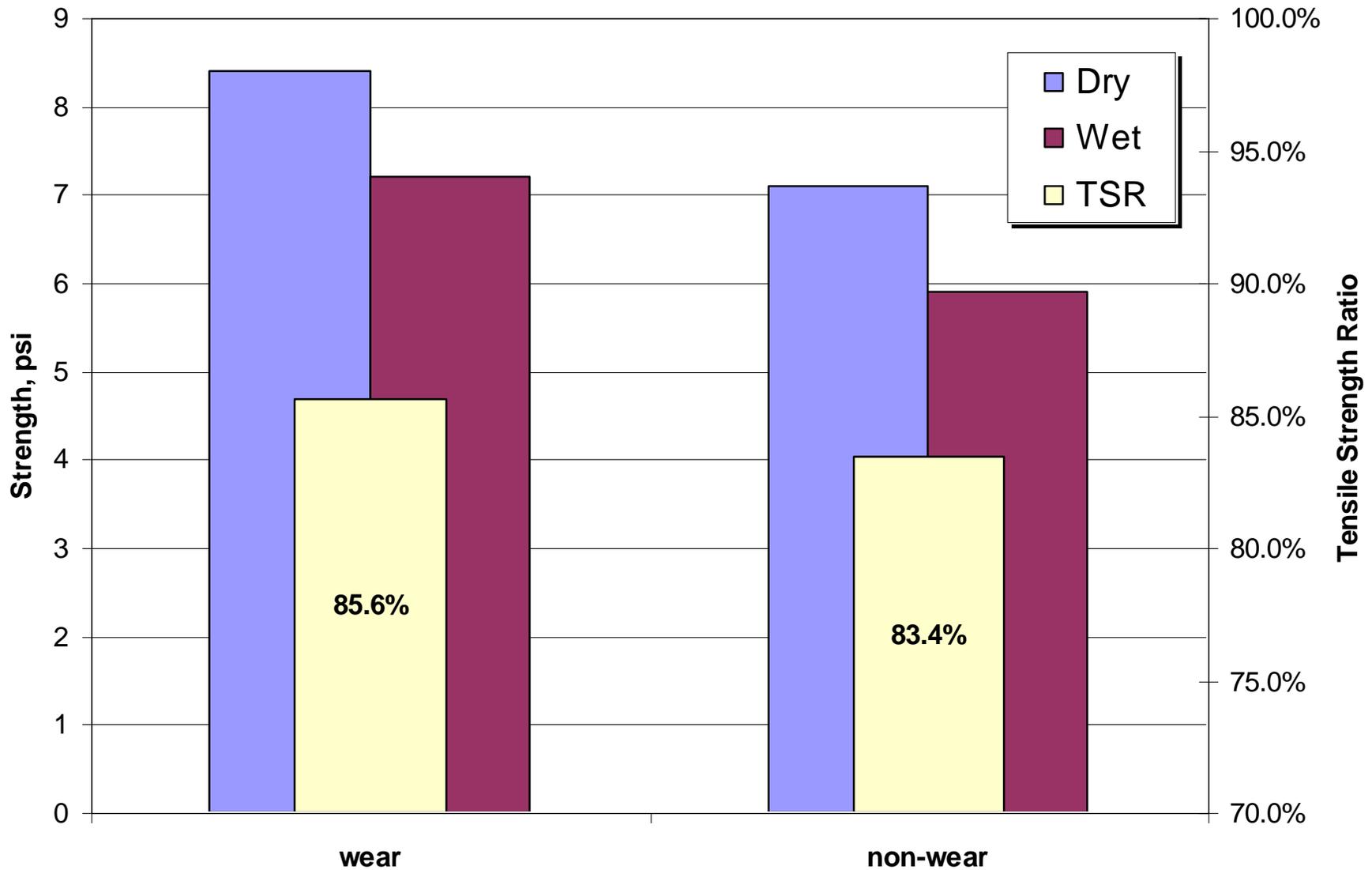
# WMA vs. HMA



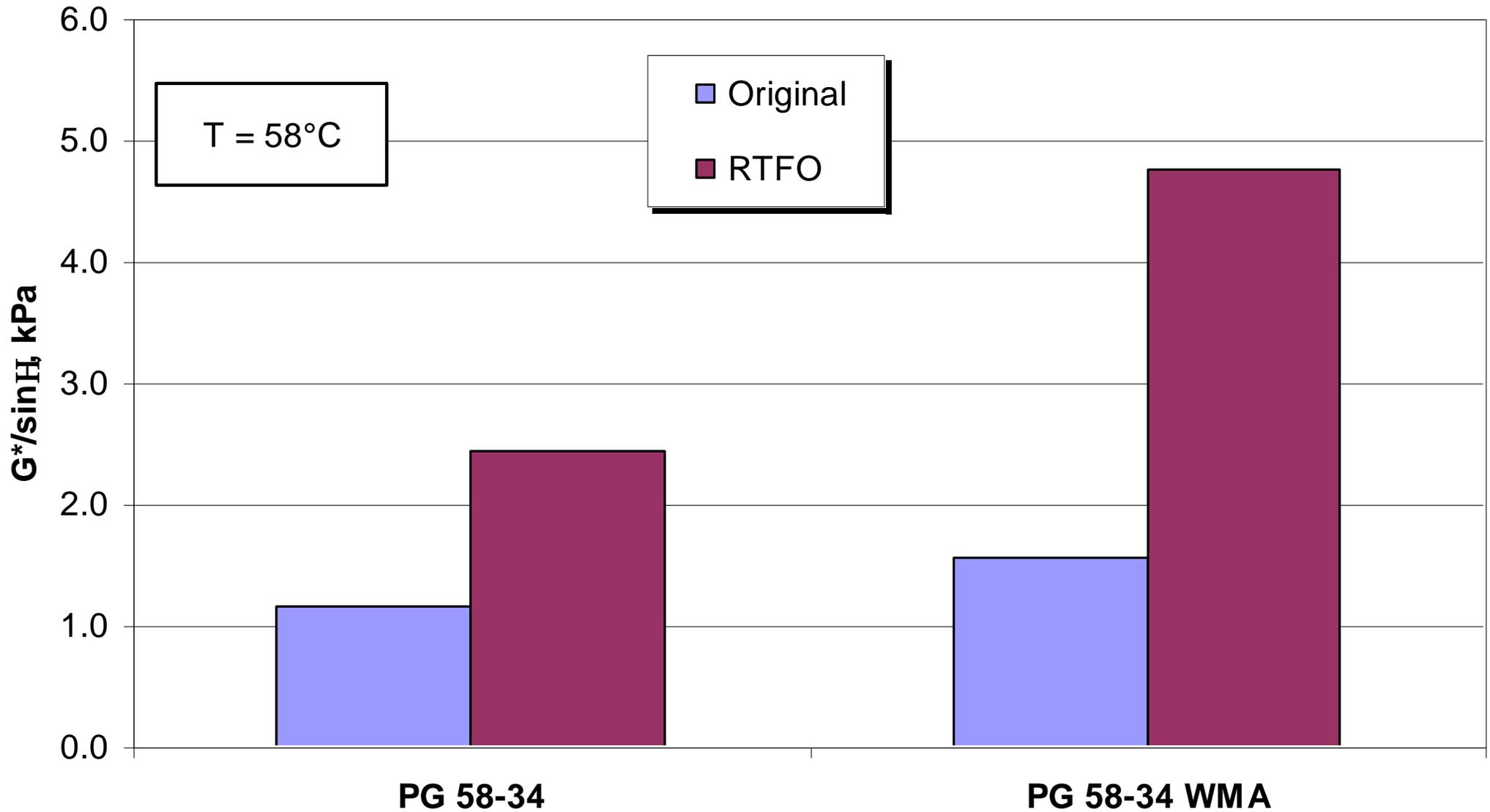
# WMA vs. HMA



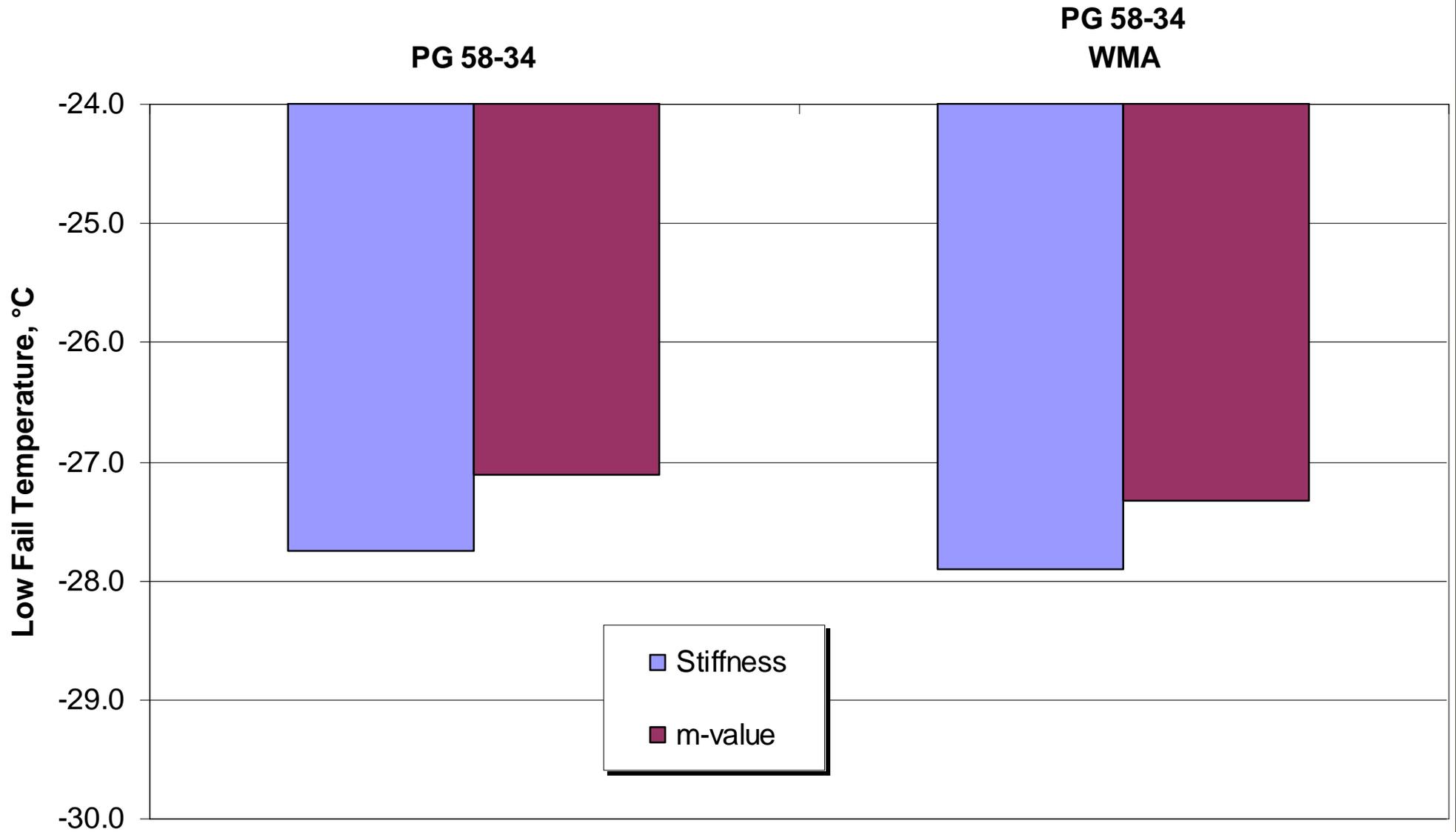
# Stripping Potential



# Binder DSR Testing



# Binder BBR Testing



# Lessons Learned

More lab work needed at mix design to determine compaction temperature range

Definite energy savings

Appears as though fumes/emissions were less

Equal density appears to be achievable with equal or less effort



# Mn/DOT Trunk Highway 95

## Late season paving (2009)

- ★ Contractor was delayed, needed to finish paving before winter
- ★ Supplemental Agreement – Mn/DOT paid extra \$0.60 per ton for WMA
- ★ Business as usual – good density, etc.



# Bituminous Roadways



## Maxam AquaBlack

- ★ Installed on 2 local plants
- ★ 15% of production was WMA



# Mn/DOT District 7 and 3 Projects in 2010

## First Mn/DOT projects requiring WMA

### S-1 (2360) PLANT MIXED ASPHALT PAVEMENT – USE OF WARM MIX ASPHALT TECHNOLOGIES

The provisions of the attached 2360 Plant Mixed Asphalt Pavement (Gyratory Design) Specification is hereby modified as follows in order to use Warm Mix Asphalt (WMA)

All provisions for the production and placement of WMA will be the same as the conventional HMA mixtures as stipulated in 2360 Plant Mixed Asphalt Pavement (Gyratory Design) Specification except as noted below.

#### S-2.1 MIXTURE DESIGN

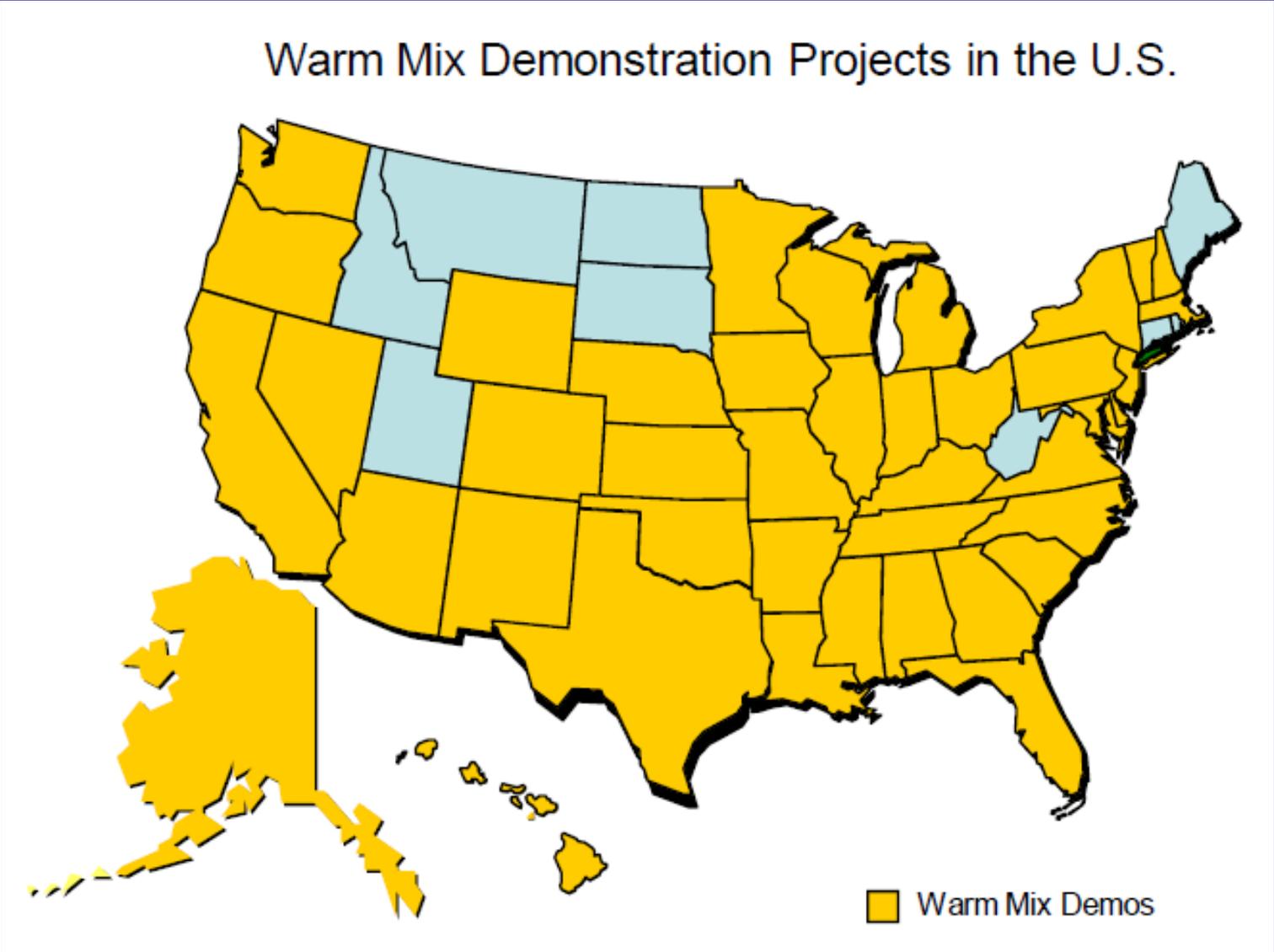
The contractor is responsible to use the same design used to produce the Hot Mix Asphalt, then modifying it to accommodate products or processes to meet the Warm mix criteria. This modification process will be limited to the same as described by the WMA Technical Working Group and found at <http://www.warmmixasphalt.com/WmaTechnologies.aspx>

Recycled Asphalt Shingles will not be allowed in any mixes on this project.

#### S-3.1 MIXTURE QUALITY MANAGEMENT

The Warm Mix Asphalt produced will not be allowed to exceed temperatures greater than 275 °F. Any WMA over that temperature will not be allowed to be used.

# WMA Projects in the U.S. (Dec 2009)



Courtesy: Dave Newcomb

# Outstanding Issues

## Early Rutting

- ★ No known problems have occurred
- ★ Binder grade bump may be needed

## Moisture Damage

## Long Term Performance



# Research In Progress

**NCHRP 09-43, Mix Design Practices for Warm Mix Asphalt**

**NCHRP 09-47A, Properties and Performance of Warm Mix Asphalt Technologies**

**NCHRP 09-49, Performance of WMA Technologies: Stage I - Moisture Susceptibility**

# Mn/DOT 2010 Bituminous Specification

Previously WMA was handled on a case-by-case basis

★ 2009 Position Memo

★ [www.dot.state.mn.us/materials/bituminous.html](http://www.dot.state.mn.us/materials/bituminous.html)

Table 2360.6-C5  
Mixture Temperature Control<sup>(C)</sup>

Air Temperature °F [°C]	Compacted Mat Thickness, inches <sup>(A)</sup>			
	1 inch [25 mm]	1-1/2 inch [40 mm]	2 inch [50 mm]	≥3 inch [75 mm]
+32-40 [0-5]	--	265 <sup>(B)</sup> [129]	255 [124]	250 [121]
+ 41-50 [6-10]	270 <sup>(B)</sup> [130]	260 [127]	250 [121]	245 [118]
+ 51-60 [11-15]	260 <sup>(B)</sup> [127]	255 [124]	245 [118]	240 [115]
+ 61-70 [16-21]	250 <sup>(B)</sup> [121]	245 [118]	240 [115]	235 [113]
+ 71-80 [22-27]	245 [118]	240 [115]	235 [113]	235 [113]
+ 81-90 [28-32]	235 [113]	230 [110]	230 [110]	230 [110]
91+ [+ 33]	230 [110]	230 [110]	230 [110]	225 [107]

(A) Based on approved or specified compacted lift thickness.

(B) A minimum of one pneumatic-tire roller shall be used for intermediate rolling unless otherwise directed by the Engineer. The Engineer may specify or modify in writing (with concurrence from the Department Bituminous Engineer) a minimum laydown temperature.

(C) Not applicable if a WMA additive or process is used.

# SUMMARY

# Production and Paving Best Practices

**Work to minimize aggregate moisture**

**Make sure the burner is tuned for the temperature**

**Keep baghouse temperature above condensation point**

**Consider superheating aggregate ahead of RAP**

**Follow normal placement practices**

# WMA Investigation and Implementation

FHWA working in partnership with AASHTO and Industry to establish clear targets for implementation

WMA Technical Working Group (TWG)

FHWA Expert Task Groups

First projects requiring WMA

- ★ **Binder, Mixture, and Models**

Regional User-Producer Groups

- ★ **Share data and information**

Move out of demonstration phase

**Training and Education**

# Online Resources

[www.warmmixasphalt.com](http://www.warmmixasphalt.com)

[www.fhwa.dot.gov/pavement/asphalt/wma.cfm](http://www.fhwa.dot.gov/pavement/asphalt/wma.cfm)

[www.hotmix.org](http://www.hotmix.org)

[www.asphaltisbest.com](http://www.asphaltisbest.com)



# Publications

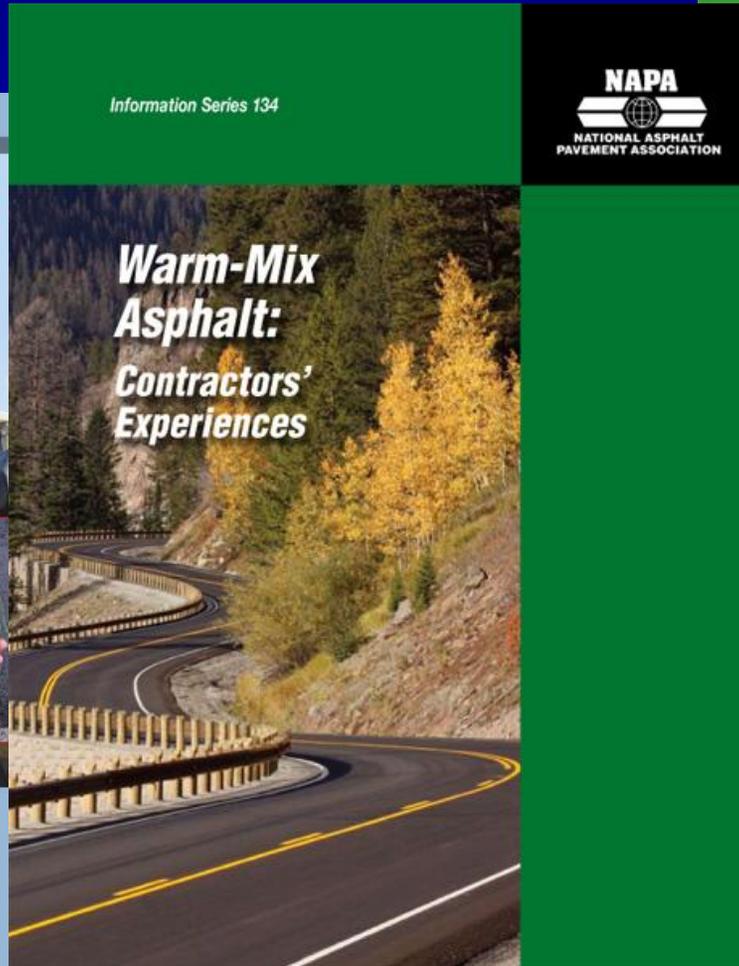


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Research Program

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# Conclusions

**WMA should meet all Superpave requirements**

**Warm mix is the future of asphalt mixtures**

**Technology providers coming forward**

**Industry and agencies must work together to make it happen**

**Advantages far outweigh concerns**



# Thank You!

**Tim Clyne**

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