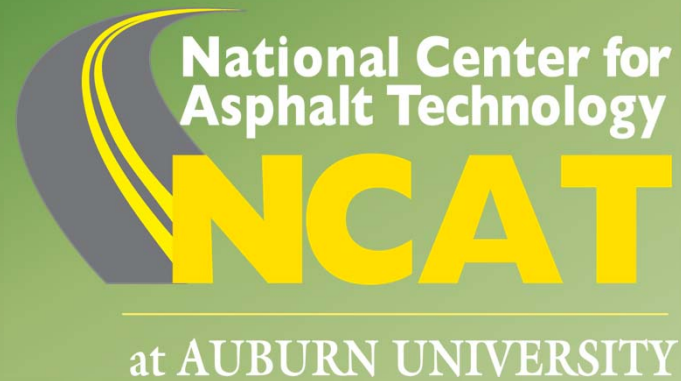
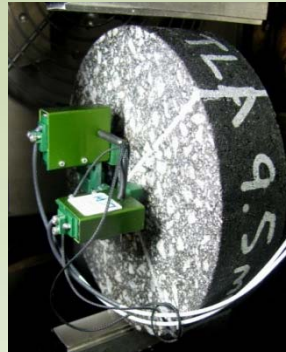




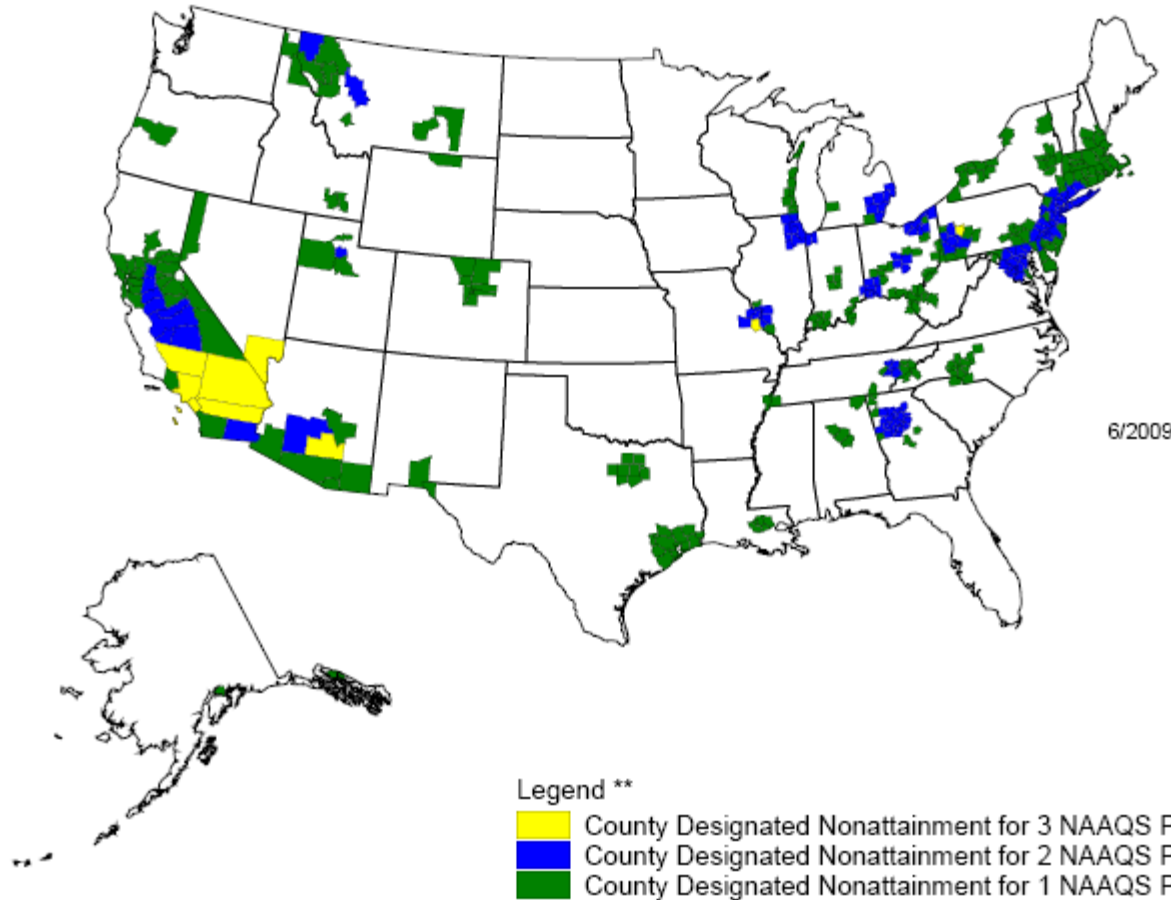
Warm Mix Asphalt Introduction and Processes



**Original driver of WMA was
the need to reduce emissions
especially in non attainment
areas**

Counties Designated "Nonattainment"

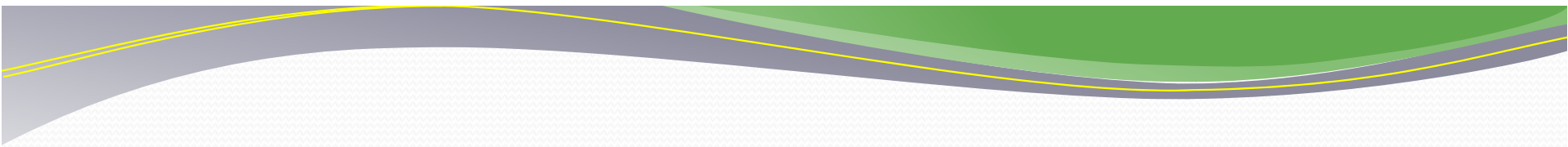
for Clean Air Act's National Ambient Air Quality Standards (NAAQS) *



* The National Ambient Air Quality Standards are health standards for lead, carbon monoxide, sulfur dioxide, ground level 8-hr ozone, and particulate matter (PM-10 and PM2.5). There are no nitrogen dioxide nonattainment areas.

European Tour for WMA 2002

First Test Section in US in 2004



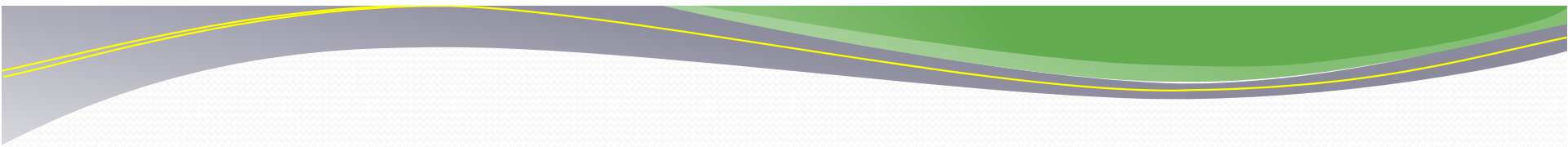
Warm Mix Asphalt

- WMA is produced with special additives or technologies at temperatures 30 to 70°F lower than typical HMA
- Some people define WMA as having a maximum temperature approximately 275 degrees F

Use of Warm Mix Asphalt

- Reduces emissions
- Reduces fuel use
- Reduces oxidation during production
- Improves compactibility
- Often used as compaction aid for late season paving
- Similar performance to HMA





Some Early Concerns

- Cost
- Equipment Adjustments
- Performance
 - Moisture Susceptibility
 - Rutting

Mixes underneath silos
HMA on left, foamed asphalt on right



Lower fumes and emissions (~30-90%)



**There are now over 30
WMA processes**

sasol
reaching new frontiers



2003



**KOLO
VEIDEKKE**



Shell
Thiopave



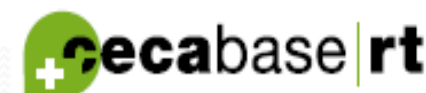
MWV
EVO THERM
WARM MIX ASPHALT TECHNOLOGY



**KOLO
VEIDEKKE**



2011



WMA Categories

1. Organic Additives
2. Chemical Additives
3. Asphalt Foaming Technologies
 - a. Foaming additives
 - b. Water Injection Systems
4. Combinations of above

WMA Categories

1. Organic Additives

- Sasobit (Sasol)
- SonneWarmix (Sonneborn)
- Rediset (Akzo Nobel) – *also contains chemical additives*
- Bitutech PER (Engineered Additives)
- LEADCAP (KICT-KUMHO)
- Thiopave (Shell)

WMA Categories

2. Chemical Additives (Surfactants)

- Evotherm (MeadWestvaco)
- Cecabase RT (Arkema Group)
- HyperTherm/QualiTherm (QPR)

Typical dosage rates of 0.2 to 0.5% of the binder

Many of the WMA Chemical Additives provide anti-stripping additive compounds

WMA Categories

3. Asphalt Foaming Technologies

a. Foaming Additives (Zeolites)

- Advera (PQ Corp.)
- Aspha-min (Eurovia)

Foaming Additive rates are typically 0.25 to 0.30% by weight of mix

WMA Categories

3. Asphalt Foaming Technologies

b. Water Injection Systems

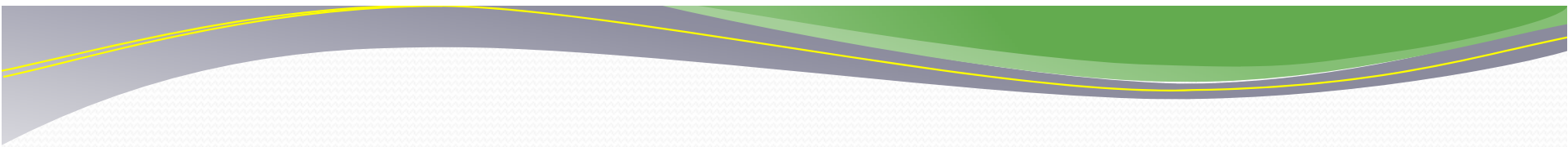
- Accu-Shear (Stansteel)
- AquaBlack (Maxam)
- AquaFoam
- Double Barrel Green (Astec)
- Eco-Foam II (AESCO/MADSEN)
- Meeker Warm Mix
- Terex WMA System
- Ultrafoam GX2 (Gencor)

Most water injection foaming systems add 1 to 2% water by weight of binder

WMA Categories

4. Combinations

- Low Emission Asphalt (McConnaughay)
 - Combined foaming and chemical additives
 - Mix production temperatures are typically lower than other WMA processes



Three most common WMAs

- Foam
- Evotherm
- Sasobit

Energy Savings with WMA

- Fuel savings for WMA in Europe have been reported to be from 20 to over 50% for some WMA technologies.
- US studies have reported burner fuel savings of 0 - 30%, with 15 to 25% being typical.



Reduced Emissions with WMA



- Especially noticeable at load-out

Observed Reductions in Emissions

Emission	Norway	Italy	Netherlands	France	Canada
CO ₂	31.5	30-40	15-30	23	45.8
SO ₂	NA	35	NA	18	41.2
VOC	NA	50	NA	19	NA
CO	28.5	10-30	NA	NA	63.1
NO _x	61.5	60-70	NA	18*	58.0
Dust	54	25-55	NA	NA	NA

(*) Reported as NO₂
All values reported are in percentages.

From FHWA

DR1

Reviewer's Comments:

1. Cite the Scan report 2007 FHWA Intl Scan - http://www.warmmixasphalt.com/submissions/68_20080223_FHWA-PL-08-007.pdf
Deepak Raghunathan, 7/3/2012

Better Work Environment



Improved Compactability

- Improves workability and ease of compaction
- Compaction is important to long term performance of mixture
- Allows placement and compaction during cooler weather



Overlaying a Crack Sealed Pavement

- Overlaying pavements with joint/crack sealant typically results in bump
- Bumps do not roll out, results in poor ride and lack of adequate density
- WMA has been used to solve this problem



Better Workability?

- Most contractors report WMA improves workability
- Some also report finish to be better, especially at joints.



Long Haul Distances

- Haul times with WMA from 1 to 3 hours reported
 - Generally successful in achieving target density
 - Crusting / lumps of mix less than with HMA
- Some contractors use normal mix temperatures with WMA technology so in this case, the WMA technology is just a compaction aid



Cold Weather Paving

- Several example projects using WMA to pave in near freezing temperatures have been reported
- Also often used for long haul distances



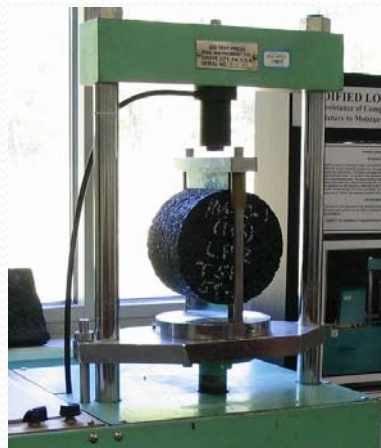
Plant Concerns with WMA



- Lower production temperatures could lead to:
 - Less efficient burner operation
 - Incomplete drying of the virgin aggregates
 - Condensation in the baghouse
 - Increase amperage on motors

Lab Tests on WMA

- Nearly all WMA mixes produced to date have used HMA mix designs
- Lower mix temperatures cause less asphalt absorption for some aggregates that can change volumetric properties
- Lab tests for rutting and moisture damage potential for WMA commonly yield less favorable results compared to HMA



WMA Testing

- No difference in performance seen in the field to date
- Test method or criteria often adjusted to be more comparable to HMA
- We had similar issues with SMA when adopted

Combining WMA and RAP

- WMA technologies can improve the ability to properly coat aggregates and RAP during production
- Lower production temperatures will reduce plant aging of binders which may allow for increased use of RAP without grade bumping
- Many agencies allow higher RAP with WMA



Placement of Foamed Asphalt with 30% RAP

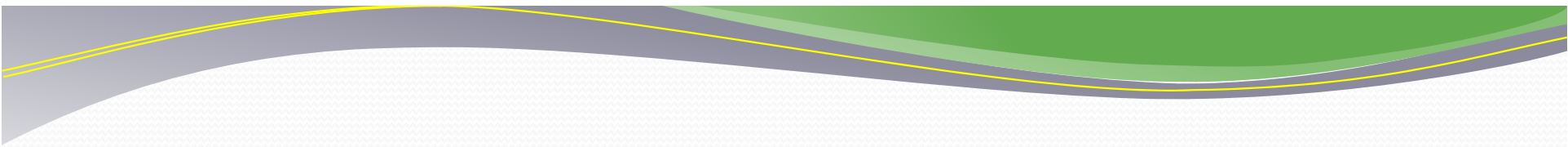
- Material was workable and easy to place and compact
- Reduced smoke



Cost of WMA Technologies

- Added costs for WMA vary by technology and economy-of-scale. Costs generally range between about 50¢ to \$4 per ton of asphalt mix.
- Some costs may be offset by energy savings and other benefits.





WMA status at end of 2011, FHWA

- 40 state DOTs had specifications for WMA
- More than 30 WMA technologies
- At least 30 state DOTs had met the WMA target values

Agency Specifications

- WMA technology product acceptance list
- Sometimes lots of effort to get on product acceptance list
- Very similar to HMA Spec
- Sometimes test methods or criteria are adjusted

**Many state DOTs have
permissive specification**

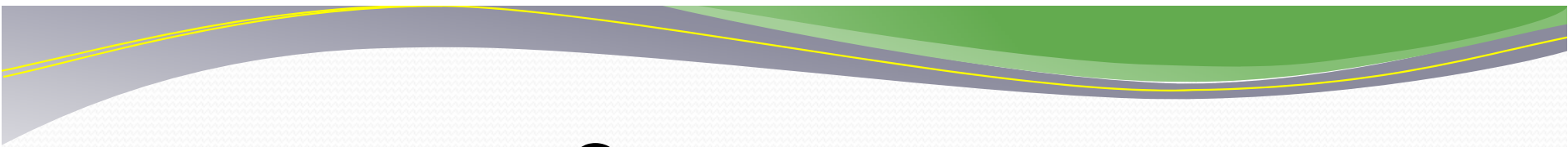
**Performance of WMA has
been good even though lab
test results often lower for
WMA than for HMA**

NCHRP Projects Completed, Underway, and Projected

- NCHRP 9-43 Mix Design Properties for WMA
- NCHRP 9-47 Engineering Properties, Emissions, and Field Performance of WMA Technologies
- NCHRP 9-47A Properties and Performance of WMA Technologies
- NCHRP 9-49 Performance of WMA Technologies: Stage I--Moisture Susceptibility
- NCHRP 9-49A Performance of WMA Technologies: Stage II--Long-Term Field Performance
- NCHRP 9-52 Short-Term Laboratory Conditioning of Asphalt Mixtures
- NCHRP 9-53 Properties of Foamed Asphalt for WMA Applications
- NCHRP 9-55 Recycled Asphalt Shingles in WMA Mixtures

Other Resources

- www.warmmixasphalt.com
- NAPA (www.asphaltpavements.org)
 - Warm Mix Asphalt: Best Practices, 3rd Ed. (*QIP-125*)
- FHWA-NHI Courses
- NCAT short courses, webinars, and website



Summary

- WMA has been used successfully since first test section placed in 2004
- 19.2 million tons of WMA in 2009
- 47.6 million tons of WMA in 2010
- Approximately 500 million tons of asphalt mixture per year
- More and more states are beginning to use permissive specs
- Use of WMA has already reached approximately 15-20% in US

Summary (Cont'd)

- Some contractors use WMA technology on most all work---they simply increase the temperature of the mix for HMA
- FHWA five year goal beginning about 2 years ago is for WMA to be 50% of all mixes
- Much research being done to evaluate performance
- In some areas it is becoming more difficult to obtain HMA

Any Questions???