Evaluation of Warm Asphalt Technologies

Brian D. Prowell, P.E.
Graham C. Hurley
We Can Reduce Temperatures Today with No Additives

- Pre-Superpave – typical compaction temperature 275 °F
- Place Thicker Lifts – NCHRP 9-27
  - 3 x NMAS for fine graded
  - 4 x NMAS for coarse graded
- Tarp Trucks
- Drier Aggregate – pave under stockpiles
Based on MultiCool
Why Warm Asphalt?

Research by Stroup-Gardiner and Lange at AU indicates increased emissions with increased temp.
Why Warm Asphalt?

- Reduce production and laydown temperatures
- Reduce emissions
- Reduce energy costs
- Reduce aging of binder
- Other Possible Benefits:
  - Cool weather paving (extend season)
  - Compaction aid for stiff mixes
Comparison of Visible Emissions

Hot Mix (155 °C) 311 °F
WAM (110 °C) 230 °F

Courtesy of Shell/Kolo Veidekke
What are Warm Asphalt Mixes?

Several processes have been developed to improve mixture workability allowing lower production and laydown temperatures:

- WAM Foam – Shell/Kolo Veidekke
- Zeolite – Eurovia/Hubbard Construction
- Sasobit – Sasol Int./Moore and Munger
- Evotherm - MeadWetvaco
WAM-Foam

- Two Phase addition of asphalt
  - Aggregate coated with “soft” asphalt
  - Hard asphalt foamed to mix with pre-coated aggregate
  - Soft asphalt controls minimum placement temperature
  - Material placed as low as 80 °C (176 °F), 50 – 60 °C (90 – 108 °F) reduction
  - Requires plant modification for foaming, estimated at $50,000 - $70,000. No additional costs thereafter
  - Special asphalt feeds may be required
Two phase bitumen mixing method

bitumen
hard

milk

mineral aggregates

Courtesy IFTA GmbH
WAM Foam Installation in Hot Mix Asphalt Plant

2000

Courtesy of Shell/Kolo Veidekke
Zeolite

- Zeolites are crystalline hydrated aluminum silicates.
- Aspha-min®, is a special Zeolite added to the hot mix asphalt in the temperature range of 100 to 200 °C (212 to 392 °F).
- When the Zeolite is heated, it gives up its internal moisture, approximately 21% by weight, microscopically foaming the asphalt.
Addition of aspha-min®

- Aspha-min is typically added at an addition rate of 0.3% by weight of mix
- Expected to increase mix cost by approximately $1.50 per ton
- Can be added to the mineral filler or fed separately
- Can be added directly into the pugmill of a batch plant, or
- Can be blown into a drum plant using a specially built feeder
Granulated aspha-min®
Sasobit/Sasoflex

- Fischer-Tropsch synthetic waxes – Sasobit
  - Produced from gasification of coal or natural gas feed stocks
  - Added to binder
  - Can incorporate an SBS modifier using special cross-linking agent (Sasoflex)
  - Does not require high-shear blending
  - May negatively impact low temperature properties
Sasobit

31 degree F reduction in compaction temperature

Temperature, C

Viscosity, cP

Control PG 64-22
Sasobit PG 64-22

Mixing Range
Compaction Range

52 58 64 70 76 82 88 100 120 135 150 165 180 200
Sasobit
Evotherm

- Emulsion – approximately 70% binder residue
- Includes adhesion promoters (e.g. anti-stripping agents)
- Storage at 80 °C (176 °F)
- Some steam liberated upon mixing
Project Partners (To Date)

- NCAT
- NAPA Env. Survival Fund
- FHWA
- Mead-Westvaco
- Sasol International
- Eurovia/Hubbard
Study Objectives

• Evaluate Warm Asphalt Technologies for U.S. Paving Practices
  – High production
  – Rapid Turn-over to traffic

• Potential Concerns
  – “Curing” Time
  – Increased Potential for Moisture Damage
  – Binder effects
How Do You Measure Compaction in Lab?

• Superpave gyratory compactor is not sensitive to reduced temperature – control mix produces the same voids.
• Field Compaction, Marshall and Vibratory (PTI) Compaction sensitive to temperature/workability changes.
Limestone - SGC

Compaction Temperature, F

Air Voids, %

PG 58-28 Aspha-min
PG 58-28 Control
PG 64-22 Aspha-min
PG 64-22 Control
Vibratory Compaction – Granite

Air Voids, %

- Control
- Zeolite
- Sasobit
- Evotherm

300F
265F
230F
190F
Vibratory Compaction - Granite

Air Voids, %

300F  265F  230F  190F

PG 64-22  2.5% Sasobit  PG 70-22 4% Sasoflex  PG 76-22  PG 76-22 4% Sasoflex
Summary of Laboratory Compaction

• Aspha-min Evotherm and Sasobit improved compaction with both the SGC and vibratory compactor. For PG 64-22:
  – Evotherm reduced air voids 1.5%
  – Sasobit reduced air voids 0.9%
  – Aspha-min reduced air voids 0.8%

• Warm asphalt additive may reduce design asphalt content
German Autobahn Paving
Cure Time – Early Concern

- In Germany, traffic may not be immediately returned to traffic
- When does Warm asphalt’s workability end?
- Will pavements rut if traffic allowed on an hour or so after placement?
European Cure Time Experience

- Sasobit being used for repaving Frankfurt Airport.
  - Placing 24 inches of HMA in 7.5 hour window (approx. 1,500 tons)
  - Opening to jet aircraft at 85 °C (185 °F)

- WAM Foam Paving SMA on ring road around Oslo Norway
  - Night work opened for rush hour traffic
Strength Gain Experiment

Zeolite Strength Gain

Tensile Strength, psi

- 2 Hours
- 4 Hours
- 2 Hours + 1 Day
- 2 Hours + 3 Days
- 2 Hours + 5 Days

Warm
Control
Resilient Modulus

Would the use of Warm Asphalt effect pavement thickness design?
Interaction Plot for Resilient Modulus

- Agg: Granite, LMS
- Binder: 58-28, 64-22
- C or W: C, W
- Temp: 190, 220, 265, 300

- Graph showing the interaction plot for resilient modulus with different aggregates (Agg), binders (Binder), and types of materials (C or W) at various temperatures.
APA Rut Testing
Summary of Stiffness and Permanent Deformation

- No evidence of required “cure time” based on indirect tensile strength after various aging periods
- Statistical Analysis indicated that the inclusion of warm asphalt additives did not effect modulus or APA rut depth
  - Decreased temperature did decrease modulus and increase rut depth. This may be related to decreased aging of the binder
  - Higher density generally resulted in higher modulus
Moisture Susceptibility
Simulating a Drum Plant
Failure Modes

Adhesive

Cohesive
Moisture Susceptibility

- All technologies evaluated to date and control have in some cases indicted moisture susceptibility.
- Tests at “normal” temperatures have not indicted a problem.
- TSR and Hamburg do not always agree, Hamburg sometimes indicates better performance.
- Problems can be mitigated with anti-stripping agents.
Field Sections
Laydown of Polymer Modified Warm Asphalt with Zeolite at 250 F

94% Gmm
55 F Air Temp.

4 passes of Rubber Tire, followed by 4 vibratory passes, followed by static finish roller
U.S. Drum Plant Addition of Aspha-min
Seeing is Believing!

Hot Mix 314 F

138.1 pcf

Aspha-min Mix 254 F

138.5 pcf
Evotherm Field Trial
Near Indianapolis, IN
July 2005
MD SMA Sasobit Trial
Capital Beltway
Summary

- Three warm asphalt processes used in Europe for up to 6 years
- Allow compaction at lower temperatures
- SGC not sensitive to compaction temperature
- Data indicates warm asphalt additive could reduce optimum asphalt content
- Minimum temperature to which compaction is improved is dependent upon technology – ranges from 265 to less than 190 °F
Summary

• Rutting susceptibility of warm asphalt mixtures similar to hot mix produced at the same temperature
  – Some technologies improve rutting susceptibility
  – Rutting tends to increase with reduced production temperatures due to decreased aging of the binder
  – May need to use a stiffer binder below mixing temperatures of 275 °F

• Lower production temperatures may increase potential for moisture damage due to incomplete drying of the aggregate
  – Certain technologies may increase moisture susceptibility
  – Moisture susceptibility can be mitigated with appropriate additives
Recommendations

- At this time, determine optimum asphalt content without warm asphalt additive
- If mixing temperature is below 275 °F, consider using stiffer binder grade
- Conduct Tensile Strength Ratio Tests at anticipated production temperatures
- Consider use of Hamburg wheel tracking test in lieu of TSR
A Word About Cost

- Most additives, warm asphalt or other, are expected to increase the price of the HMA.
- Some processes or additives may require plant/production modifications.
- It is not anticipated that the fuel savings will totally offset these costs.
- This project is a look ahead to make sure that we can continue paving, even in non-attainment areas.
Thanks!