Stripping and Moisture Susceptibility Failures
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The Adhesive Interface

Factors Affecting Adhesion:
- Surface Energy
- Surface Chemistry
- Mechanical Interlock

Chemistries at the Interface:
- Polar Species
- Surface Active Agents
- Mineralogy
- Concentration
- Charge
In asphalt mixes, a balance must be maintained between adhesion and cohesion.

In colder temperatures, cohesive forces in the bitumen may cause the film to contract.

Water can also migrate into the interface, causing negative charges to develop.

Sufficient adhesive force must be present to counterbalance the cohesive force.
• The higher the silica content, the less likely the asphalt and aggregate will adhere well
• Higher silica content aggregates respond well to LAS/WMA
Liquid Anti-Strips (LAS) dosed at 0.25 to 0.75% w/w asphalt

- Alters aggregate surface charge
- **Product performance tailored for the materials**
- Reduced aged hardening of asphalt, likely due to oxygen scavenging capabilities and reducing mixing and compaction temperatures when used as Warm Mix Asphalt
- Many Warm Mix Asphalt (WMA) have LAS properties for better workability and compaction

Hydrated Lime dosed at 1-2% w/w aggregate

- Hydrated lime is quicklime rehydrated with $\text{H}_2\text{O}$ and pulverized; acts similar to Portland cement; acts like mineral filler and stiffens the asphalt binder & mix
- Can improves fracture toughness at low temps
- Alters oxidation kinetics to reduce their effects
- Alters plastic properties of clay fines to improve moisture stability and durability
- Process more effective if the aggregate is coated with hydrated lime prior to mixing with asphalt
Lime Vs LAS/WMA Performance Testing
Example Project Data – South Central US

- Measure performance of 1.5% Lime and 0.5% LAS/WMA
- Hamburg Wheel Tracker
- Materials
  - Crushed Gravel, Type C Surface Mix
  - 16% RAP Blend
  - PG 64-28

- HMA Curing
  - HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, TEX 241-F based on Binder PG before molding
Testing Objectives

• Contractor’s existing blend adjusted to account for removal of lime P200

• Remove lime from blend, adjust to account for lost of fine material & add 0.5% LAS/WMA

• Confirm Volumetric Properties

• Run HWT
Hamburg Wheel Tracking Data

- LAS/WMA successfully substituted into adjusted aggregate blend
- Volumetric properties for both blends were similar
- Performance Tests indicate mix can be produced with LAS/WMA in lieu of Lime
Example Project Data – South Central US

- Measure performance of
  - 1% Lime
  - 0.5% LAS/WMA
  - 1% Lime + 0.5% WMA
- Hamburg Wheel Tracker
- Materials
  - Crushed Gravel
  - 10% RAP Blend
  - Specified PG 64-28
- Confirm Volumetric Properties

- HMA Curing
  - HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, TEX 241-F based on Binder PG before molding
- WMA Curing
  - Cure warm-mix asphalt (WMA) mixtures at 275°F for 4 hr. ±5 min. before molding.
  - WMA is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using WMA additives or processes
• HMA mixtures cured for 2 hr. ±5 min. at temperature listed in Table 2, PG 64-28 = 275°F

• Evaluated several products
  • 1% Lime
  • 0.5% WMA 1
  • 0.5% WMA 2
  • 0.5% WMA 3
  • 1% Lime + 0.5% WMA 3
Hamburg Results
WMA Curing

- WMA Mixtures cured at 275°F for 4 hr. ±5 min. before molding
- Evaluated products
  - 1% Lime
  - 0.5% WMA 1
  - 0.5% WMA 2
  - 0.5% WMA 3
  - 1% Lime + 0.5% WMA 3
Example Project Data

South Eastern US

Measure performance of LAS and lime utilizing:
• Tensile Strength Ratio
• 24 hour conditioning
• 1 freeze-thaw cycle
• 3 freeze-thaw cycles
• Hamburg Wheel Tracker

Materials Used
• Nova Scotia Granite
• PG 64-22 Venezuelan base asphalt
Test Results – Wet Strength

![Graph showing wet strength results for different treatments and control.]

- Control
- 0.5% A
- 0.5% B
- 0.5% C
- 0.5% D
- 1.0% Lime
Hamburg Wheel Track

- Different LAS have varying performance in the HWT
- LAS performance can be equal to that of Lime based on performance testing
- Demonstrates the importance of testing materials in the mix
Lime Supply

• Source
• Logistics
• Material Handling
Lime Source
Logistics & Material Handling

• There are various ways of adding hydrated lime to HMA at the plant
  • a lime solution is sprayed on the aggregate
  • Some plants “marinate” aggregate stockpiles in a lime slurry
  • The hydrated lime can be added to the aggregate on the cold feed belt

• Cost Benefit Analysis of Anti-Strip Additives in Hot Mix Asphalt with Various Aggregates, Christensen, et.al, PENNDOT, May 2015

• The Benefits of Hydrated Lime in HMA, Little, et.al, National Lime Association, 2001
LAS/WMA Supply

- Source
  - Renewable
  - Sustainable
  - Green
- Logistics
- Material Handling
What comes from the Pine Tree?

- Chemicals for
  - Adhesives for tape
  - Roads/Highways
  - Books
  - Chewing gum
  - Detergents
  - Concrete Sidewalks
  - Water Purification Filters – Activated Carbon
  - Filters for Fuel Recovery
LAS Supply

**Crude Tall Oil**
- by product from paper making process
- Looks like dark, molten caramel - is made up of rosin, fatty acids and other natural materials
- Sap of pine trees

**Refining Process**
- Tall Oil Fatty Acids
- Tall Oil Rosins
- Distilled Tall Oil
- Tall Oil Pitch
LAS Pump Tank
Telemetry Units
Totes/Pumps

Logistics
Material Handling

• 6,000 or 10,000 gallon Pump Tanks
  • Remote Telemetry
  • Supplier maintains tank and monitors supply
  • Used as needed
• 275 gallon tote
  • 40” x 48” x 46”
  • Durable steel frame
  • Stackable 2 high when full and stationary
  • Free pick-up service for disposal of empty totes
Cost Analysis

• Lime: $200/ton
  • 1% w/w Aggregate
  • $2.00/mix ton
  • Not including storage & handling costs
  • Approx. $2-5/mix ton

• LAS/WMA: $1.20 - $2.80/lbs.
  • 0.5% w/w Asphalt
  • $0.70 – $1.60/mix ton
Environmental Costs - Green Effects

• Hydrated Lime: 1100 - 1200 lbs. of CO2 emissions per ton of hydrated lime manufactured
• LAS/WMA: 100 lbs. of CO2 emissions per ton of LAS manufactured
• The carbon emissions from Hydrated Lime are likely an order of magnitude higher than those for the LAS/WMA
Lime and LAS/WMA Use by State

- Survey of Ingevity Sales personnel
- October 2018
Summary

- Stripping
  - Adhesion/Cohesion Theories
- Performance Test Data Comparison
  - HWT
  - TSR
- Supply
  - Source
  - Logistics
  - Materials Handling
- Costs
  - $  
  - Environmental
- Where Materials Are Used
Conclusions

• Performance-based specifications: Advances in materials testing opens doors to more material choices
• Agencies should use the performance related test(s) that are most predictive
• LAS/WMA can have advantages in performance, cost, handling and supply when compared to Lime
• Some materials may react better to Lime; Some materials may react better to LAS/WMA
• Let the performance test results drive the decision
Questions?

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