Utah Experience

With

Elastomeric and PPA Binder Modification
Utah has a unique climate and geography requiring unique solutions
Where is Utah?
Climate

- Temperature Range
  - Low Desert: High 115°F Low 26°F
  - Colorado Plateau: High 110°F Low -10°F
  - Basin & Range: High 110°F Low -15°F
  - Mountain: High 100°F Low -20°F

- Common Daily Temperature Swing
  - Summer 40°F
  - Spring/Fall 50°F
  - Winter 30°F
Traffic

- Local Industrial and Mining
- Cross Country Trucking
  - East/West I-80, I-84, I-70
  - North/South I-15, (666, 191, 6)
Challenges to Pavement

- Typical distress mechanisms
  - Rutting (hot)
  - Stripping (wet)
  - Fatigue Cracking (intermediate)
  - Thermal Cracking (cold)
  - Raveling (cold)

- Construction Flaws
  - Segregation (raveling)
  - Density (fatigue or raveling)
Observations

- Utah pavement performance history leads to the conclusion that mixes produced with refinery run binders will eitherrut or suffer brittle failure.
- Something must be added to the HMA mix to stabilize it in our climate extremes.
- Mixes built with the same binder but different aggregates perform differently.
Postulate

- Although binder is an important part of the stability of the mix, it is not the only important factor.
- Desirable mix properties can be extended by adding toughness to the binder.
- Desirable antistripping properties can be obtained through priming aggregate surfaces.
Specification Philosophy

- UDOT would rather support innovation through performance specification as opposed to recipe specification.
- Contractors and suppliers have great knowledge and must be included in development of specifications.
- Contractors and suppliers should control their own processes through quality control programs.
- Use Standard AASHTO tests with local interpretation.
Solutions

- Supporting cold temperature properties through toughness
- Supporting intermediate temperature properties through elasticity
- Supporting high temperature properties through high elastic stiffness
- Mix stability testing
Binder Toughness (Cold)

- Direct Tension at low grade temp. +10 deg. C, aged binder.
Elastic Recovery

- Test run at intermediate temperature, 77 deg F.
- Pull – Relax for 5 seconds – Cut
- Recovery must be 70% for Rule of 98
- Assures elastomeric properties in the standard fatigue temperature range.
Binder Elasticity (Hot)

DSR at High Grade Temp. Unaged Binder
Mix Stability

- Hamburg Wheel Tracker
  - Drives High Temperature Stiffness
  - Drives Stripping Resistance
  - Drives post binder testing additives which may change the cold temperature toughness properties.

- Needed – Cold Temperature Mix Toughness Test.
Alternative Theory

- High Modulus for the MEPDG
- I-84 Morgan 2005
  - Mill 8”, Till 8” and Cement Treat Base - 500 psi
  - 7” 64-34ut, TLA 4%, RAP 30%
Linear Kneading Compactor and Hamburg Wheel Tracker
Test Specifications

- 158 lb Steel Wheel load (203 mm Dia. by 47 mm wide)
- 20,000 passes per test
- Water Temperature @ 50°C (122°F), level and temp. maintained
- Speed @ 52 passes per minute
- Rut data recorded every 20 passes at 11 points using LVDT’s
Slab Preparation

- Compact to 7% air voids plus or minus 1%
- Slab size: 320 mm (12.6 inch) long by 260 mm (10.2 inch) wide and 40 mm deep (1.6 inch).
Test Matrix

- Two Aggregates, Quartzite and Limestone
- Four Binders, two without acid and two with acid, all four are PG 64-34
- Each with and without Lime
Asphalt Binders: PG 64-34

These are off the shelf “branded” PMA binders

- Binder 1
- Binder 2
- Binder 3 – 0.85% Acid Modified
- Binder 4 – 0.56% Acid Modified

Gas Chromatography is the method used to measure the acid content. It looks for the approximate phosphorus amount.
Unknown Information

- Base Binder
- Binder formulation
- Polymer and Acid data
Aggregates

- Crushed Quartzite
- Crushed Limestone
Quartzite and Limestone Aggregate Physical Properties

Table 1. Quartzite and Limestone Aggregate Physical Properties

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Quartzite</th>
<th>Limestone</th>
<th>UDOT Spec.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soundness AASHTO T-104 (Sodium Sulfate)</td>
<td>2.09</td>
<td>10.07</td>
<td>16% Max</td>
</tr>
<tr>
<td>Natural Sand</td>
<td>0</td>
<td>0</td>
<td>0% Max</td>
</tr>
<tr>
<td>Fracture Face Count - One Face</td>
<td>100</td>
<td>100</td>
<td>95% Min</td>
</tr>
<tr>
<td>Fracture Face Count - Two Face's</td>
<td>97</td>
<td>95</td>
<td>90% Min</td>
</tr>
<tr>
<td>Los Angeles Wear, AASHTO T-96</td>
<td>16.9</td>
<td>24</td>
<td>35% Max</td>
</tr>
<tr>
<td>Sand Equivalent, AASHTO T-176</td>
<td>71</td>
<td>69</td>
<td>60% Min</td>
</tr>
<tr>
<td>Uncompacted Voids, AASHTO T-304</td>
<td>46.5</td>
<td>46.4</td>
<td>45% Min</td>
</tr>
<tr>
<td>Flat and Elongated (1:3) ASTM D-4791</td>
<td>7.2</td>
<td>10.5</td>
<td>20% Max</td>
</tr>
<tr>
<td>Dust Ratio, SP 2</td>
<td>F</td>
<td>NP</td>
<td>0.6 : 1.4</td>
</tr>
<tr>
<td>Plastic Index, ASTM D-4318</td>
<td>NP</td>
<td>NP</td>
<td>0% Max</td>
</tr>
</tbody>
</table>
Hamburg Test in Operation
Example Hamburg Slabs
Example Test Graph
Passing Test

Center Point Rutting

-20 -15 -10 -5 0 5 10 20

Rut Depth

Wheel Track Passes

Test 10, HMA, Binder 1, No Acid, Quartzite, Aggregate, No Lime

R Slab

L Slab
Example Test Graph
Failing Test

Center Point Rutting
Creep or Rutting Slope
Stripping Slope
Stripping Inflection Point

Test 63, SMA, Binder 3, With 0.85% Acid, Quartzite Aggregate, With Lime

Wheel Track Passes

Rut Depth (mm)
R Slab
L Slab
HMA Maximum Rut Depth (mm)

- Binder 1: 69.69-34
- Binder 2: 70.92-34
- Binder 3: 71.42-34
- Binder 4: 70.54-34

Acid Information:
- Binder 1: 0.85% acid
- Binder 2: 0.56% acid
HMA Rut Slope (percentage)

Binder 1 69.69-34
Binder 2 70.92-34
Binder 3 71.42-34
Binder 4 70.54-34
0.85% acid

Quartzite N/L
Quartzite Lime
Limestone N/L
Limestone Lime

0.56% acid
HMA Average Inflection Point (Passes)

Binder 1: 69.69-34
Binder 2: 70.92-34
Binder 3: 71.42-34
Binder 4: 70.54-34

Quartzite N/L
Quartzite Lime
Limestone N/L
Limestone Lime

0.85% acid
0.56% acid
Conclusions

- Acid modification may or may not help the mix. How much depends on compatibility issues.
- These results point out the need for mix testing.
- Hydrated Lime reduces the rutting slope by about half.
- Presence of inflection point is not desirable.
Recommendations

- Always check the mix for performance with the Hamburg – We need Mix Tests!
- Follow exact procedures in preparing Hamburg samples and running the test.
- To test for acid and other formulation parts, we need more than the AASHTO M-320 specification. This leads to local plus specifications.