Sulfur in Asphalt: The Missouri Experience (Mix Design Perspective)

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Missouri Mix Bid Item
SP095C w/PG 70-22

• Contractor-Ideker, Inc.
• Project: Missouri Highway US 71
• 9.5mm Superpave Surface
• 100 gyration compactive effort
• PG 70-22 Polymer Modified Binder
• Design Per MoDOT specs. Section 403
  – AASHTO R35
INITIAL CONSIDERATIONS

• AGGREGATE AVAILABLE:
  – Limestone ½” clean chip
  – Limestone 3/8” chip
  – Limestone mfg. sand
  – Drag sand (chert tailings from mine operation)
INITIAL CONSIDERATIONS

- AGGREGATE SPECIFIC GRAVITIES:
  - ½” clean chip, Gsb=2.546, Absorption=2.9 %
  - 3/8” chip, Gsb=2.658, Absorption=0.6 %
  - Mfg. sand, Gsb=2.495, Absorption=2.9 %
  - Drag Sand, Gsb=2.560, Absorption=1.2 %
DESIGN AGGREGATE STRUCTURE

• COLD FEED %’s:
  – ½” clean chip @ 21 % (Gsb=2.546, Abs.=2.9%)
  – 3/8 chip @ 38 % (Gsb=2.658, Abs.=0.6%)
  – Mfg. Sand @ 18 % (Gsb=2.495, Abs.=2.9 %)
  – Drag Sand @ 23 % (Gsb=2.560, Abs.=1.2%)

COMBINED Gsb=2.581
Weighted Absorption=1.6 %
0.45 Power Chart
Conventional Mix Design Values

- Bitumen Content: 6.0 % PG 70-22
- Air Voids: 4.0 %
- VMA: 15.5 %
- VFA: 73.8 %
- Tensile Strength Ratio: 97.7 %
- Mix Temp.: 325 F
- Compaction Temp.: 295 F
- Max. Specific Grav.: 2.419
Shell Thiopave

• Thiopave is a material developed as a bitumen substitute in the production of asphalt mixtures
• Thiopave is used to replace 20-25 % of the mass (weight) of the bitumen required by the mixture design with at least the same volume of Thiopave
• Used to enhance stiffness and rut resistance while maintaining ductility and resistance to cracking
Shell Thiopave

- Shell supplied the:
  - Thiopave pellets
  - Sarawax SX 100 compaction agent
  - Technical information (MSDS, mix design)
  - Technical staff to provide oversight and make recommendations on our first sulfur mix design
MIX TEMP: 275 +/- 10 F

Good Ventilation Needed
SARAWAX SX100 (Organic Compaction Agent)
SARAWAX SX100 blended with asphalt binder (PG 64-22)
THIOPAVE PELLETS

- Thiopave pellets are preheated at 140 F
- Aggregate was preheated at 290 F
- Asphalt/Sarawax blend then weighed into preheated aggregate
- Mixing begins then pre-weighed quantity of Thiopave pellets are added
- Thiopave pellets melt at 245 F
NEW TOTAL BINDER CONTENT

• Thiopave + Bitumen Wt. %=

\[ A \, \frac{(100) \times R}{100R - Ps \times (R-Gbitumen)} \]

A = Weight % bitumen in Conventional Mix = 6.3
R = Thiopave to bitumen substitution ratio
    = GThiopave/Gbitumen = 1.92/1.03 = 1.86408
Ps = Weight % Thiopave in Binder = 38.5%

\[ A = 7.6 \% \text{ (NEW TOTAL BINDER CONTENT)} \]
Bitumen to Thiopave Ratio

- Bitumen Weight % of TOTAL: 61.5 %
- Thiopave Weight % of TOTAL: 38.5 %
- SARAWAX @ 1.5 %
TOTAL BINDER CONTENT

• NEW TOTAL BINDER CONTENT = 7.6 %
  – Bitumen Ratio % = 61.5 %
  – % Bitumen of New TOTAL BINDER =
    • 7.6 % * (61.5/100) ~ 4.67 %

  – % Thiopave of New TOTAL BINDER =
    • 7.6 % * (38.5/100) ~ 2.93 %
Thiopave Mix Design Values

TOTAL NEW BINDER %: 7.6 %  
-4.67 % PG 64-22 (22 % reduction)  
-2.93 % Thiopave

Air Voids: 4.0 %
VMA: 16.0 %
VFA: 74.8 %
TSR: 90.4 %
Max. Specific Grav.: 2.445