SMA and OGFC
Louisiana’s Experience

Presented by: Bill King

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LABORATORY EVALUATION OF SMA
- 1999 AAPT by Mohammad, et. al.

Louisiana’s Typical Usage and Special SMA Project

Open-Graded Friction Course
BACKGROUND
SMA - Stone Mastic Asphalt

- Gap-Graded, dense HMA
- Large portion coarse aggregates
  - All crushed
  - Forms high stability structural matrix
  - Good internal Friction
  - Agg. interlock to resist load-induced shear
- Mastic binds the structural matrix together
  - Asphalt cement
  - Fine aggregate
  - Stabilization additives to prevent AC runoff
OBJECTIVES

- Evaluate
  - The Performance of SMA Mixes Using Locally Available Materials Compared to Conventional Type 8 WC Mix
  - The Influence of Aggregate type on the Performance of SMAs
<table>
<thead>
<tr>
<th>Mix</th>
<th>Gradation</th>
<th>Asphalt</th>
<th>Aggregate</th>
<th>Abbrev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Dense</td>
<td>PAC-40</td>
<td>LS</td>
<td>D_PL</td>
</tr>
<tr>
<td>II</td>
<td>SMA</td>
<td>PAC-40</td>
<td>LS</td>
<td>S_PL</td>
</tr>
<tr>
<td>III</td>
<td>SMA</td>
<td>PAC-40</td>
<td>Nova</td>
<td>S_PN</td>
</tr>
<tr>
<td>IV</td>
<td>SMA</td>
<td>PAC-40</td>
<td>SS</td>
<td>S_PS</td>
</tr>
<tr>
<td>V</td>
<td>SMA</td>
<td>MG 20-40</td>
<td>LS</td>
<td>S_ML</td>
</tr>
<tr>
<td>VI</td>
<td>SMA</td>
<td>AC - 30</td>
<td>LS/Fiber</td>
<td>S_AL</td>
</tr>
</tbody>
</table>
Average $V_a$

- Dense – 3.7%
- SMA – 3.6%
Mixtures Volumetrics – VMA

Voids in Mineral Aggregate

Average VMA
- Dense – 14
- SMA – 18
Mixtures Volumetrics – VFA (Voids Filled with Asphalt)

Average VFA
- Dense – 74
- SMA – 80
AC Content

Average % AC

- Dense – 4.4
- SMA – 6.5
Lab Performance

- Fundamental Engineering Tests
- Other Performance Related Testing
Fundamental Engineering Tests

- **GTM Gyratory Shear Index (GSI)**
  - Ratio of maximum gyratory angle to the minimum gyratory angle
    - GSI >1 indicates mix susceptible of rutting

- **Indirect Tensile Resilient Modulus Test**
  - Measures elastic properties of HMA, stiffness

- **Indirect Tensile Creep Test**
  - Measure of permanent deformation characteristics

- **Axial Creep Test**
  - Measure of permanent deformation characteristics
Fundamental Engineering Tests

- SST Tests
  - Frequency Sweep at Constant Height (FSCH)
    » Measures Viscoelastic properties, $G^*$ & $\delta$
  - Repetitive Shear at Constant Height (RSCH)
    » Measures permanent strain characteristics
      • Rut Susceptibility
  - Repetitive Shear at Constant Stress Ratio (RSCSR)
    » Measures permanent strain characteristics
      • Rut Susceptibility
Other Performance Related Testing

- **Loaded Wheel Test (Hamburg Wheel Tracking)**
  - Measures rutting and moisture susceptibility

- **Resistance to Aging**
  - Captured by using ratio of $M_r$ aged/$M_r$ unaged

- **Draindown Test**
  - Measures amount of asphalt draindown
**IT Resilient Modulus Test - Elastic Properties**

Average $M_r$ @ 25 °C

- Dense – 3761
- SMA – 2759
Gyratory Shear Susceptibility

![Bar chart showing GSI values for different categories: D_PL, S_PL, S_PN, S_PS, S_ML, S_AL. The categories are represented by different letters: A, BC, C, BC, BC, B.]
Axial Creep Test (40°C)
Axial Creep Test (40°C)
Axial Creep Test (40°C) Binder Influence
Axial Creep Test (40°C) Aggregate Influence
Long Term Aging

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>D_PL</td>
<td>1.2</td>
</tr>
<tr>
<td>S.PL</td>
<td>1.16</td>
</tr>
<tr>
<td>S.PN</td>
<td>1.25</td>
</tr>
<tr>
<td>S.PL</td>
<td>1.17</td>
</tr>
<tr>
<td>S.ML</td>
<td>1.25</td>
</tr>
<tr>
<td>S.AL</td>
<td>1.17</td>
</tr>
</tbody>
</table>
Draindown Test Results

<table>
<thead>
<tr>
<th></th>
<th>S_PL</th>
<th>S_PN</th>
<th>S_PS</th>
<th>S_ML</th>
<th>S_AL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>0.25</td>
<td>0.26</td>
<td>0.22</td>
<td>0.01</td>
<td>0.01</td>
</tr>
</tbody>
</table>

LTRC
$G^*$ of FSCH Test 50C?
Phase Angle of FSCH Test

Phase Angle Averages

Frequency (Hz)
Phase Angle (degrees)
D-PL
S-PL
Effect of AC Type on $G^*$

G* Averages: Asphalt Types

- S-PL
- S-ML
- S-AL

Frequency (Hz)

$G^*$ (psi)
Effect of Aggregate Type on $G^*$ at 10 Hz
Loaded Wheel Tracking Test
Hamburg Wheel Tracking @ 50°C
20,000 Passes

Average Rut Depth

- Dense – 3.7 mm
- SMA – 3.9 mm
Louisiana’s Typical SMA Usage
Special SMA Project
Louisiana’s Typical SMA Usage

• > 35000 ADT
  • Interstates
  • High volume rural and urban primary routes
  • Special Projects
• Usually used as a wearing course.
  • Exception US 61 in Baton Rouge, 2” mill, 2” SMA as binder course, OGFC wearing course utilizing a trackless tack coat.
Hale Boggs – “Luling” Bridge
I-310 Mississippi River Crossing
New Orleans, Louisiana
Background

- Cable Stayed Bridge w/ Orthotropic Bridge deck (one of four in the world at time of design)
- Epoxy HMA system selected for initial wearing course
  - Failed due to separation caused by moisture and material separation
Epoxy Modified Asphalt Deck (Typical Failure)
1996 Deck Designed with SBS modified SMA

- PG 88 -22 SBS modified SMA mixture w/ 20% Granite Fines
History of Performance

• Achieving density proved to be difficult on the deck, and an average of 92% TMD was recorded.

• The mix failed in 1998 due to lack of bond between the mix and the steel deck attributed to moisture allowed thru mix and insufficient tack rate (0.1 gallon per square yard)
“Good Section” of SMA Deck at year 4
US 61 SMA, Gonzales LA

Hamburg Test, 50C
4mm @ 20,000 passes
Louisiana’s Experience With OGFC Mixtures
Background

- What is OGFC?
  - Acronym for Open Graded Friction Course
    » PFC - Permeable Friction Course
    » PMS – Plant Mix Seal
    » ACFC - Asphalt Concrete Friction Course
    » Popcorn Mix
  - It is a porous, gap-graded, predominantly single size aggregate bituminous mixture which promotes effective drainage of rain water.

- Used in United States since 1950

- Louisiana Developed OGFC in late 1960’s.
  - To provide a skid resistance surface while reducing water spray.
Louisiana developed OGFC prior to the Federal Highway Safety Program Management Guide and Instructional Memorandum of 1973
- Required establishment of a Skid Accident Reduction Program
Advantages of OGFC

- Lower pavement noise levels
- Reduced risk of hydroplaning
- Reduced Splash/Spray effect
  - Improves wet weather visibility
  - Improves visibility of traffic markings
- Increase in mix durability
  - More asphalt binder used due to fibers/polymers
  - Higher film thickness
- Resistant to Rutting
Advantages of OGFC

- Maintain Speed in wet weather
  - Porous pavements reduces tendency of drivers to slow down in wet weather
  » Contributes to increasing capacity during wet weather, thus reducing traffic congestion
Disadvantages of OGFC

- Higher cost
- Excessive Speed
  - Which could possibly increase rate of accidents
- Clogging of air voids
  - Reduces permeability and noise absorption
  - Function of traffic and environment
- Possible lower initial skid resistance
  - Increased initial film thickness reduces aggregate micro texture
    » Polishing of aggregate due to traffic reduces the initial film thickness increasing the micro texture, thus increasing the skid resistance
Disadvantages of OGFC

- In cold weather climatic regions
  - Greater quantities of salt required in winter use when compared to a dense-graded mix
After receiving the Federal Instructional Memorandum
- Plant Mix Seal (PMS) on all roads with an ADT > 4000
- In 1980, all roads with an ADT > 3000 required PMS
In 1980’s problems encountered

- End-of-life (original 5-yr life expectancy)
  » Raveling
- Failures during or shortly after construction

Moratorium Issued
Louisiana’s Past Experience

- Forensic Analysis
  - In 1979, design asphalt content significantly reduced to offset asphalt cement drain down
    » Resulted in increasing oxidation
  - Mix temperatures were reduced to offset drain down
    » Resulted in moisture retained in high absorptive aggregate
  - Failures related to moisture and temperature
Specifications revised
- Maximum moisture content for aggregates
- Instituted construction season between May to September
- Increased minimum ambient air temperatures

Moratorium then lifted

After Moratorium lifted, 12 OGFCs placed without incidence

1982 – 1983 failures began to occur again
- Extreme severe winter
- End-of-life service (8 – 11 years) of previously placed OGFCs
Louisiana’s Past Experience

- In 1984
  - Second Moratorium Issued
    » Still in effect today
  - Final experimental polymer modified OGFC placed
    » 10 – mile section of LA 48, Poydras – Reggio
      - OGFC Control Section - AC-30 using % AC consistent with 1979, Design 6.2%
      - OGFC Polymer Modified Sections - % AC consistent with 1960’s, Design 6.7%
Louisiana’s Past Experience

- AC-30 control sections raveled in 2 years
- Polymer modified sections performed without raveling until rehabilitation circa 1999-2001
  - 15 – 17 year life span
Louisiana’s Recent Experience

- 1993 Research Study
  - Evaluation of Field Projects Using Crumb Rubber Modified Asphaltic Concrete
    - 5 State Routes
      - 8 CRM pavement sections utilizing 8 different CRM processes or applications
      - 3 of the 5 State routes utilized either SMA and/or OGFC
Louisiana's Recent Experience

- **June 2003**
  - US 71, Grant Parish
  - Project length
    - 830 feet
  - Site selected because of high accident rate.
  - 94 tons placed
  - Estimated Film Thickness
    - 31 microns
## 2005 Visual Data Analysis

<table>
<thead>
<tr>
<th>State Route</th>
<th>Description</th>
<th>AVG RNDM (L. F.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>US 61 (10+ Yrs)</td>
<td>1&quot; OGFC w/SAMI</td>
<td>257.1</td>
</tr>
<tr>
<td></td>
<td>17.5% CRM (Arizona Wet) Gap-Graded (SMA)</td>
<td>68.2</td>
</tr>
<tr>
<td></td>
<td>Polymer Gap-Graded (SMA)</td>
<td>152.2</td>
</tr>
<tr>
<td></td>
<td>Conventional - PM</td>
<td>237.9</td>
</tr>
</tbody>
</table>
## 2005 Visual Data Analysis

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<thead>
<tr>
<th>State Route</th>
<th>Description</th>
<th>AVG RNDM (L. F.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>LA 15 (10+ yrs)</td>
<td>Rouse (CRM) Dense-Graded</td>
<td>284</td>
</tr>
<tr>
<td></td>
<td>17.5% CRM (Arizona Wet) Gap-Graded (SMA)</td>
<td>48</td>
</tr>
<tr>
<td></td>
<td>Conventional</td>
<td>231</td>
</tr>
</tbody>
</table>
Latest Completed Construction Project - May 2005

- Route I-20, Monroe, LA.
  - Britton Road – Vancil Road
  - Contractor – D & J Construction CO., L.L.C.
  - Project Length 5.8 Miles
    » or 23.2 Lane Miles
  - ~9000 tons of OGFC
  - Traffic Data
    » 2004 ADT = 29,600
    » 2012 ADT = 32,000
    • T = 18%
I-20
Type 8F Wearing

I-20
OGFC

LTRC
Currently Under Construction

- US 61, Baton Rouge Louisiana
  - Existing Composite Pavement
  - Typical Section
    » 2 inch mill
    » 2 inch SMA binder course
    » ¾ inch OGFC
  - Utilizes a Trackless Tack Coat and conventional paver
- 5.5 Miles
- 32200 ADT
- SMA – 26,598 Tons @ $ 85/ton
- OGFC – 9,061 Tons @ $ 100/ton
For Those of You Who Have Sons, and for Those Who Wish They Didn’t
Thank You!