Friction Courses in the Southeast

2006 Southeast Pavement Management and Design Conference

May 9, 2006
Overview of New-Generation Open-Graded Friction Courses

- Background
- Benefits
- Materials
- Mix design
- Construction
- Noise Reduction
History of OGFC

- First Use in 1944
- FHWA Design Procedure in 1974
- Stripping of Underlying Layer
- Quick Failure Mode (Raveling)
- Moratorium in 1980s
- Needed Improvements
Use of OGFC

- 38% Still Use
- 38% Discontinued Use
- 8% Do Not Use
- 16% Did Not Respond

Based on 1998 Survey
Benefits of OGFC

- Friction
- Driver Visibility
- Striping Visibility
- Noise Reduction

% of Agency Response

NCHRP Synthesis 284
Friction
Driver Visibility

OGFC

Conventional
Regular Surface
OGFC Surface
**Benefit – Reduces Hydroplaning**

**New Generation Open Graded Mix**
- 22 % Air Voids

- Rain falls onto mix and drains away through first layer

**Conventional Mix**
- 4 % Air Voids

- Water stands on surface – Causes backspray, increases risk of hydroplaning
Advantages

• Provides Water Drainage
  – Reduce Hydroplaning
  – Improve Friction
• Improves Visibility
  – Reduce Splash/Spray
  – Improve Visibility of Traffic Stripes
  – Reduce Headlight Glare
• Improves Smoothness
• Reduces Noise
Selection of Materials
Aggregate for OGFC

- High quality coarse aggregate
  - Hard
  - Angular (Nearly cubical)
  - Rough textured
## Gradation Range

<table>
<thead>
<tr>
<th>Sieve, mm</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0</td>
<td>100</td>
</tr>
<tr>
<td>12.5</td>
<td>80 – 100</td>
</tr>
<tr>
<td>9.5</td>
<td>35 – 75</td>
</tr>
<tr>
<td>4.75</td>
<td>10 – 25</td>
</tr>
<tr>
<td>2.36</td>
<td>5 – 10</td>
</tr>
<tr>
<td>0.075</td>
<td>0 – 4</td>
</tr>
</tbody>
</table>
Typical Gradations

Percent Passing

Sieve Size, mm

0.075 2.36 4.75 9.5 12.5 19.0
• Most U.S. projects use a polymer modified asphalt PG 76-22
  (Bump high temperature by two grades)
Primary Function of Stabilizer

- Prevent Draindown
- Stabilizers hold AC in place during mixing, hauling and placement
- Most stabilizers do not add significant “strength”
Types of Stabilizers

- Cellulose Fiber
  - Loose
  - Pellets
- Mineral Fiber
- Polymer
- Crumb Rubber
Fibers for Draindown

Cellulose

Mineral

400 : 1

400 : 1
Mix Design Method

- FHWA Procedure – 1974
  - Surface Capacity Test
  - Pyrex Bowl Method
- Modified Marshall Design
- Superpave Gyratory
Mixing Temperature
Optimum AC Content

- No drain down
  - Increase mixing temperature

- Desired drain down
  - Optimum mixing temperature

- Excessive drain down
  - Decrease mixing temperature
N_{design} - Compaction

Relationship Between Gyratory and 50 Blow Marshall Density (Corelok G_{mb})

- Granite
- Gravel
- Traprock

Number of Gyrations

G_{mb (SGC)} / G_{mb (Marshall)}
CoreLok Density

Double Bags were Necessary
Dimensional vs CoreLok

\[ y = 0.6859x + 4.0546 \]

\[ R^2 = 0.8441 \]
Conclusions from Compaction Study

- $N_{\text{design}}$ for OGFC - Use 50 gyrations
- More aggregate breakdown with Marshall hammer
- CoreLok is more accurate for determining air voids than dimensional method
- Minimum air voids should be:
  - 16% for CoreLok
  - 18% for Dimensional
Test Methods

- Stone-on-Stone
- Draindown
- Permeability
- Abrasion
  - Cantabro Test
- Moisture Susceptibility
- Rutting
  - Asphalt Pavement Analyzer
  - 64°C
A sample of mix is placed in a basket made of ¼" mesh.
Place basket in an oven at estimated production temperatures for 1 hour.
Draindown = Mass of binder that has drained off the aggregate.
Typical Drain-down – AC Only
Drain-down with Polymer & Fiber
Increased Film Thickness

- Dense: 8µm
- Old OGFC: 25µm
- New OGFC: 33µm
- There are concerns that $\frac{1}{4}''$ mesh may be too large for finer mixes
- A smaller mesh size was investigated
Draindown (percent)

\[ y = 1.0107x + 0.0463 \]

\[ R^2 = 0.9188 \]

AASHTO (4.75 mm basket)

AASHTO (2.36 mm basket)
Effect of Fiber and PG on Draindown

![Graph showing the effect of fiber and PG on draindown. The graph compares the draindown with and without fiber, using two different grades of PG (67-22 and 76-22). The x-axis represents the without fiber condition, while the y-axis represents the with fiber condition. The graph shows a downward trend for both conditions, indicating decreased draindown with the addition of fiber.](image-url)
Conclusions - Draindown

• The repeatability of the draindown test was improved by using the 2.36 mm (No. 8) wire mesh rather than the standard 4.75 mm (No. 4) mesh

• The addition of fiber stabilizers was the most significant factor in reducing binder draindown
Traprock – 3 Samples
Pg 67-22 @ 6.0%

Before

After
Traprock @ 6.0%    PG 76-22
Conclusions - Cantabro

• The Cantabro test appears to be a good method for evaluating the cohesiveness and durability of OGFC mixes

• No significant difference in Marshall (100 mm) and SGC (150 mm) Cantabro results

• Polymer-modified asphalt and rubberized asphalt significantly improves the performance of OGFC mixtures as determined by the Cantabro test
Tensile Strength after 1, 3, 5 Freeze-Thaw Cycles

- Granite $R^2 = 0.0439$
- Gravel $R^2 = 0.2781$
- Traprock $R^2 = 0.2056$

![Graph showing tensile strength over freeze-thaw cycles for granite, gravel, and traprock.](image-url)
Permeability
### Permeability Results - Granite

<table>
<thead>
<tr>
<th>Gradation</th>
<th>Binder</th>
<th>AC(%)</th>
<th>Perm. (m/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>fine</td>
<td>67-22</td>
<td>6</td>
<td>66.8</td>
</tr>
<tr>
<td>fine</td>
<td>76-22</td>
<td>6</td>
<td>70.8</td>
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<tr>
<td>fine</td>
<td>76-34</td>
<td>6</td>
<td>45.2</td>
</tr>
<tr>
<td>medium</td>
<td>67-22</td>
<td>6</td>
<td>68.3</td>
</tr>
<tr>
<td>medium</td>
<td>76-22</td>
<td>6</td>
<td>135.2</td>
</tr>
<tr>
<td>medium</td>
<td>76-34</td>
<td>6</td>
<td>49.9</td>
</tr>
<tr>
<td>coarse</td>
<td>67-22</td>
<td>6</td>
<td>141.6</td>
</tr>
<tr>
<td>coarse</td>
<td>76-22</td>
<td>6</td>
<td>136.6</td>
</tr>
<tr>
<td>coarse</td>
<td>76-34</td>
<td>6</td>
<td>108</td>
</tr>
</tbody>
</table>
Permeability Results

- Dependent on Gradation
- Dependent on Aggregate Type (Gsb)
- Within Lab Std. Dev. – 22.76 m/day
Mix Design Requirements

- VCAmix < VCA DRC
- Minimum Air Voids
  - 16 % CoreLok
  - 18 % Dimensional
- Maximum 20 % Cantabro Loss
- Maximum 0.3 % Draindown
- AASHTO T283
  - 1 Freeze/Thaw cycle
  - 80% TSR \textit{minimum}
- Minimum Permeability – 100 m/day (Coarse OGFC Only)
Tack Coat

• Rate – 0.06-0.1 gal/sy
Typical Rolling Pattern

Breakdown: 2 Coverages - Static
Final: 2 Coverages - Static
Noise Reduction
How Would You Design A Quiet Pavement?
### Summary of Data

<table>
<thead>
<tr>
<th>Surface</th>
<th>Average</th>
<th>Low</th>
<th>High</th>
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</thead>
<tbody>
<tr>
<td>PCC</td>
<td>101</td>
<td>97</td>
<td>106</td>
</tr>
<tr>
<td>AC</td>
<td>98</td>
<td>93</td>
<td>101</td>
</tr>
<tr>
<td>SMA</td>
<td>97</td>
<td>93</td>
<td>100</td>
</tr>
<tr>
<td>Nova Chip</td>
<td>98</td>
<td>95</td>
<td>99</td>
</tr>
<tr>
<td>OFGC – C</td>
<td>97</td>
<td>95</td>
<td>98</td>
</tr>
<tr>
<td>OGFC - F</td>
<td>95</td>
<td>92</td>
<td>98</td>
</tr>
</tbody>
</table>
Noise Reduction - OGFC
Effect of -3dB(A)

Equivalent to 1/2 the Intensity
### Test Section Layout

#### North Tangent

<table>
<thead>
<tr>
<th></th>
<th>N 5</th>
<th>N 6</th>
<th>N 7</th>
<th>N 8</th>
<th>N 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1 (1 ¼ inches)</td>
<td>AZ OGFC</td>
<td>AZ OGFC</td>
<td>AZ OGFC</td>
<td>PEM</td>
<td>PEM</td>
</tr>
<tr>
<td>Layer 2 (1 ¼ inches)</td>
<td>Track</td>
<td>AZ OGFC</td>
<td>PEM</td>
<td>PEM</td>
<td>Track</td>
</tr>
</tbody>
</table>

#### South Tangent

<table>
<thead>
<tr>
<th></th>
<th>S 4</th>
<th>S 5</th>
<th>S 6</th>
<th>S 7</th>
<th>S 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Layer 1 (1¼ inches)</td>
<td>&lt; 4.75 SMA</td>
<td>4.75 SMA</td>
<td>9.5 SMA</td>
<td>4.75 DGA</td>
<td>9.5 DGA</td>
</tr>
<tr>
<td>Layer 2</td>
<td>Track</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Comparison of Surface Texture

PEM

ARIZ
Comparison of Surfaces

Noise Level (dB(A) - 45 mph)

OGFC/PEM  Thick OGFC  Thin OGFC  PEM  TRZ  Thick PEM  ARZ  BRZ  Thin PEM  SMA
QUESTIONS ????