STATUS OF ULTRA-FINE & THIN DENSE-GRADED MIXTURES

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VIRGINIA PAVEMENT RESEARCH AND INNOVATION SYMPOSIUM
JUNE 26-27, 2018
Outline

• Introduction
• SM 4.75 and SM 9.0 projects
• Lab performance testing
• Field performance
• Conclusions
INTRODUCTION

- VDOT maintains the third largest public road network
- 49,167 miles of Secondary roads (~100,000 lane miles)
- Developing durable mixes will provide significant savings

Pavement Condition - Secondary

Ref: State of the Pavement, VDOT Maintenance Division, 2016
INTRODUCTION
Thin Dense-Graded Mixtures: SM 4.75 and SM 9.0

- Allows to overlay more lane miles with less tonnage.
- Improve ride quality, extend pavement life, increase durability

Can place in 0.75”-1” thick

Smooth, fine surface texture
Construction

Sawn cores/plugs are not be required to determine maximum density
# SM 4.75 Placement

<table>
<thead>
<tr>
<th>Mix ID/ District</th>
<th>RAP content (%)</th>
<th>Design AC (%)</th>
<th>AC content (Mix) (VTRC results)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-1059/ Fredericksburg</td>
<td>20</td>
<td>6.2</td>
<td>6.39</td>
</tr>
<tr>
<td>14-1063 Culpeper</td>
<td>25</td>
<td>7.1</td>
<td>7.13</td>
</tr>
<tr>
<td>15-1025 NOVA</td>
<td>20</td>
<td>6.3</td>
<td>6.63</td>
</tr>
<tr>
<td>15-1076, Hampton Roads</td>
<td>30</td>
<td>6.3</td>
<td>6.38</td>
</tr>
<tr>
<td>15-1077, NOVA</td>
<td>30</td>
<td>6.0</td>
<td>6.42</td>
</tr>
<tr>
<td>15-1086, NOVA</td>
<td>30</td>
<td>5.7</td>
<td>5.75</td>
</tr>
<tr>
<td>15-1090, NOVA</td>
<td>30</td>
<td>6.0</td>
<td>6.24</td>
</tr>
</tbody>
</table>
### SM 9.0 Placement: Richmond District

<table>
<thead>
<tr>
<th>Mix ID</th>
<th>RAP content (%)</th>
<th>Design AC (%)</th>
<th>AC content (Mix) (VTRC results) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>65 Gyration Mix</td>
<td>30</td>
<td>6.0</td>
<td>5.97</td>
</tr>
<tr>
<td>50 Gyration Mix</td>
<td>30</td>
<td>6.0</td>
<td>5.94</td>
</tr>
<tr>
<td>50 Gyration+ Natural sand Mix</td>
<td>30</td>
<td>6.0</td>
<td>5.79</td>
</tr>
<tr>
<td>50 Gyration+ Fibers Mix</td>
<td>30</td>
<td>6.0</td>
<td>5.64</td>
</tr>
<tr>
<td>50 Gyration + Natural Sand Trial 2</td>
<td>30</td>
<td>6.0</td>
<td>5.75</td>
</tr>
<tr>
<td>65 Gyration Mix (producer 2)</td>
<td>30</td>
<td>5.9</td>
<td>6.32</td>
</tr>
</tbody>
</table>
Semi-circular Bend (I-FIT) Results

Cracking test
Measures a “Flexibility Index”
Higher index = less crack susceptible

![Graph showing results of Cracking test for SM 4.75 and SM 9.0]
Overlay Test Results

Cracking test: Cycles to failure
More cycles = less crack susceptible
Cracking test
Provides a “Cracking Test index” (CTindex)
Higher index = less crack susceptible
## Why Brittle?
### Binder Test Results (SM 4.75)

<table>
<thead>
<tr>
<th>MIX ID</th>
<th>% RAP</th>
<th>%AC</th>
<th>PG Grade (Extracted Binder)</th>
<th>True High temperature Grade (Extracted Binder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14-1059</td>
<td>20</td>
<td>6.39</td>
<td>70-16</td>
<td>74</td>
</tr>
<tr>
<td>14-1063</td>
<td>25</td>
<td>7.13</td>
<td>64-22</td>
<td>67</td>
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<tr>
<td>15-1025</td>
<td>20</td>
<td>6.63</td>
<td>76-16</td>
<td>78</td>
</tr>
<tr>
<td>15-1076</td>
<td>30</td>
<td>6.38</td>
<td>76-22</td>
<td>76</td>
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<tr>
<td>15-1077</td>
<td>30</td>
<td>6.42</td>
<td>76-22</td>
<td>77</td>
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<tr>
<td>15-1086</td>
<td>30</td>
<td>5.75</td>
<td>82-22</td>
<td>82</td>
</tr>
<tr>
<td>15-1090</td>
<td>30</td>
<td>6.24</td>
<td>70-22</td>
<td>72</td>
</tr>
</tbody>
</table>
Permeability results for SM 4.75 mix

![Graph showing permeability results for SM 4.75 mix. The x-axis represents VTM, %, and the y-axis represents Perm x 10^-5 cm/sec. Different symbols and colors represent data from different locations and contractors: Culpeper, Hampton Roads, Frederickburg, NOVA Contractor A, NOVA Contractor B, NOVA Contractor C plant 1, and NOVA Contractor C Plant 2. The graph includes a line indicating the max allowable value.]
Field Density and Permeability results for SM 4.75 mix
Field Density and Permeability results for SM 9.0 mix

50 Gyration Mix (Average air voids: 8%)

Natural Sand Mix (Average air voids: 6.9%)

Fiber Mix (Average air voids: 10.7%)
Good Field Placement (SM 4.75)

20% RAP; 6.3% AC; WMA (foamed)

Smooth, fine surface texture

AC content ranged from 6.07% to 6.50%; average 6.34%
(JMF was 6.3%)
Good Field Placement (SM 4.75)
15% RAP; 6.0% AC; WMA (foamed)

General appearance is good; nice texture
AC content ranged from 5.96% to 6.37%; average 6.1%
(JMF was 6.0%)
Field Issues (SM 4.75): Placement Temperature

30% RAP; 5.7% AC

Mix raveled within 24 hours of placement

Thin lifts tend to cool more quickly

Close-up of raveling
Field Issues (SM 4.75): Placement Temperature
30% RAP; 6.0% AC; foamed

Segregation, raveling
Field Issues (SM 4.75): Different Thickness
Field Performance: SM 4.75

Before Condition  

After 4 Years
Field Performance: SM 4.75

Before Condition

Typical existing transverse and longitudinal cracks

After 4 Years
Field Performance: SM 9.0

After 9 months
Mix with Natural Sand

After 9 months
Mix with Fibers
Before Paving Condition Vs Good Practices

Crack Sealed before paving

Milled 4” placed 3” of BM-25.0D HMHB with 1” of SM-4.75D.
CONCLUSIONS

SM-4.75 and SM 9.0 should be placed during warm weather

Measures to reduce brittleness:
- Require more virgin AC
- Use of high-polymer or softer binder grade (PG 58-28) where existing surfaces are cracked?

Density requirement?
ACKNOWLEDGEMENT

David Shiells
Bryan Smith
Todd Rorrer
Tommy Schinkel
Kevin McGhee, VTRC
VDOT Central Office Materials
VDOT Districts
FHWA
VAA / Industry