The Development and Use of High Performance Thin Overlay Systems

NEAUPG 2009 Annual Meeting
Portland, Maine
October 8, 2009

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HMA Thin Surface Mixes

• Not New – in use since the early 1900’s
• Originally all fine aggregate – plus AC
  – Could work well in low stress application
  – But tended to rut and crack under higher traffic /stress
HMA Thin Surface Mixes

- City of Rockville, Maryland – 1960’s
  - Fine graded Marshall mix with AC-10
  - Named it “Smoothseal”
HMA Thin Surface Mixes

- Ohio DOT
  - Borrowed Rockville idea and product name
  - First use in 1973
  - Added polymers in 1990’s
  - Type A – 5/8” thick
    - Sand mix with 8.5% AC
  - Type B – ¾” thick
    - 4.75 mm mix with 6.4% AC
HMA Thin Surface Mixes

- Ohio DOT
  - Oldest “Smoothseal™” pavement has lasted 28 years
  - Average life of “Smoothseal™” overlay
    - Over Asphalt – 16 years
    - Composite pavement – 7-11 years (depending on traffic)
HMA Thin Surface Mixes

- Superpave research successful in reducing rutting on major highways – typically coarser and drier mixes
- Superpave mixes perhaps not suited for low volume secondary and subdivision roads – including 4.75 mm mix
  - Harder to place – handwork issues
  - Harder to compact
  - Shorter life span
    - Durability
    - Fatigue life
HMA Thin Surface Mixes

- SP 4.75 mm mix
- Re-designed mix to produce High Performance Thin Overlay
- HPTO – designed to overcome problems with older Thin Surface Mixes
HPTO Design

- Requirements
  - Improve Durability
    - Higher AC/ film thickness mix (VMA)
    - Dense / non-segregating mix (in-place density)
  - Rut & Crack Resistant
    - PMA Binder
    - High quality aggregates
    - Mix performance test
HPTO – Developed to meet Two Applications

Local & Secondary Roads
- Suburban development
  - Higher traffic and stress on pavement
  - Intolerance of traffic interruption (get-in & get-out and don’t come back)
  - Usual maintenance treatments no longer acceptable

Primary & Interstate Hwy
- Budget shortfalls require delays in some normal rehabilitations
- Need to provide a “maintenance” application until next major rehab
- HPTO can provide a solution
HPTO Applications

Local Use

DOT Use
Development of the FlexGard System

- Research Objectives
  - Longer life material
    - Adhesion to underlying pavement
    - Rutting
    - Fatigue cracking
    - Durability
  - Use local aggregates
  - Friendly to local contractors
  - Good Constructability
  - Cost effective product
    - Can be placed 3/4” – 1 1/4” thick
    - Little milling required
Development of the FlexGard System

• Achieving Research Objectives
  – Rutting Performance
    • Quality aggregates
    • Good aggregate gradation
    • Specially Engineered Polymer-Modified Asphalt (PMA)
    • Mix performance test (APA, Hamburg, AMPT)
Development of the FlexGard System

- Achieving Research Objectives
  - Fatigue cracking
    - Increased asphalt content
      - Slightly gap-graded mix
      - Mix design at 3% air void target (SGC = 50 gyrations)
      - Minimum 7% asphalt content
    - Specifically designed to increase fatigue life
      - Thicker asphalt film coatings – min. VMA = 18%
      - Greater resistance to aging
HPTO & 9.5 mm Mix Gradation Plot
Development of the FlexGard System

• Achieving Research Objectives
  – Balanced Performance
    • NCAT test track
    • Higher binder content possible with no rutting when PMA used
    • National study - PMA
      – National study – increased pavement life of 5-7 years
      – Significant fatigue life improvement
Initial Installation of the HPTO for Local Roads

- NuStar Asphalt Refinery in Paulsboro, NJ
  - Main entrance road
  - 20 year old existing HMA pavement
  - Approximately 5 loaded tanker trucks per day
  - Substantial fatigue cracking
  - Rutting not an issue
  - Minimal pavement deflection under loads
Initial Installation of the FlexGard System

• NuStar Asphalt Refinery in Paulsboro, NJ
  – Full depth HMA patching section in one lane
  – Compare performance
Initial Installation of the FlexGard

- Construction objectives
  - Adhesion to underlying pavement
    - Require clean and dry pavement
    - Use PG 64-22 as tack coat material
    - Require complete and even coverage
Initial Installation of the FlexGard System

- NuStar Asphalt Refinery in Paulsboro, NJ
  - Constructability
    - Specification density achieved easily
      - 7% AC content and 3% design air voids makes compaction easier
Initial Installation of the FlexGard System

- NuStar Asphalt Refinery in Paulsboro, NJ
  - Constructability
    - Required laydown temperature is only 300° - 310°F
Initial Installation of the FlexGard System

• NuStar Asphalt Refinery in Paulsboro, NJ
  – Constructability
    • Handwork not a problem
Initial Installation of the FlexGard System

• NuStar Asphalt Refinery in Paulsboro, NJ
  – Constructability
    • Transverse and longitudinal joints are excellent
    • Project appearance is very good
Paulsboro FlexGard – Pavement Evaluation

- Evaluation each year
  - Rut & crack survey
  - Pavement coring
Paulsboro HPTO - Cores
Paulsboro HPTO — after 3 years
Paulsboro HPTO – 3 years old

Original  
After 3 years
Harford County FlexGard Project
Harford County FlexGard Project
Harford County FlexGard Project
Performance Testing of the FlexGard Mix

- Laboratory Testing
  - Rutting
    - Asphalt Pavement Analyzer (APA)
  - Fatigue Cracking
    - Flexural Beam Fatigue Device
  - Reflective Cracking
    - Texas Overlay Tester
  - Permeability
    - Flexible Wall Permeability Tester
  - Skid Friction
    - Skid Trailer
Asphalt Pavement Analyzer Results – Test Project

Rutting Comparison

Less than 1/3 rutting of Standard Mix

- **Standard 9.5 mm Mix**
- **FlexGard™**

Rutting

mm
Performance Testing of the FlexGard Mix

- Flexural Beam Fatigue Testing
  - Measure number of cycles to failure
Flexural Beam Fatigue Results – Harford County Project

Fatigue Life Comparison

12 X Fatigue Life of Control Mix

- Standard 9.5 mm Mix
- FlexGard™

Cycles

Fatigue Life

0

10,000

20,000

30,000

40,000

50,000
Climatic Loading – Horizontal Movement

Hot Mix Asphalt Overlaid on PCC

Horizontal Tensile Stress due to Expansion/Contraction of PCC from Temperature

Horizontal Stress/Strain is modeled using Overlay Tester
Overlay Tester Results – Harford County Project

Texas DOT requires minimum of 300 cycles to pass the test

77F

Test Temperature

Number of Cycles to Failure

7 times more cycles than Standard Mix

Standard 9.5mm Mix

FlexGard™

Texas DOT requires minimum of 300 cycles to pass the test
Flexible Wall Permeability Testing

- For Pavement Preservation, important to “seal” pavement to limit moisture
- Permeability on order of a silt/clay, required testing in “Flexible Wall” Permeability Set-up

Samples cored from 6-inch diameter gyratory sample
Typical Permeability Values

100 times less permeable
## Surface (Skid) Friction, SN$_{40}$

<table>
<thead>
<tr>
<th>Material Type</th>
<th>Skid Number</th>
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<tbody>
<tr>
<td>FlexGard™</td>
<td>53</td>
</tr>
<tr>
<td>9.5 mm Mix (New)</td>
<td>51.6</td>
</tr>
<tr>
<td>9.5 mm Mix (4 Yrs)</td>
<td>54.3</td>
</tr>
<tr>
<td>19mm Mix (4 Yrs)</td>
<td>55.7</td>
</tr>
<tr>
<td>19mm Mix (5 Yrs)</td>
<td>47.7</td>
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DOT Application for Interstate & Primary Roads

• Material needed for ‘intermediate’ maintenance application (one that extend pavement life but without impact on existing clearances)
• Prefer to use a ‘non-proprietary’ product
• HPTO can be a solution
NJ DOT HPTO Materials

- New Jersey requirements
  - Thin-lift \( \leq 25\text{mm} \) thick (Ideally)
    - eliminate change to existing infrastructure (bridge clearances, drainage, etc.)
  - Minimal Impact to Users (Coverage vs. Unit Time)
  - Re-new and upgrade road surface (Ride Quality - serviceability)
  - No “Cure-time” dependent materials
  - Must withstand high stresses
# NJDOT HPTO - Specification

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
<th>FlexGard</th>
<th>NJ HPTO</th>
<th>NJ 9.5 mm (I-5)</th>
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<tbody>
<tr>
<td>12.5 mm</td>
<td>100</td>
<td></td>
<td>100</td>
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<tr>
<td>9.5 mm</td>
<td>100</td>
<td></td>
<td>100</td>
<td>95</td>
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<tr>
<td>4.75 mm</td>
<td>65-95</td>
<td></td>
<td>65-85</td>
<td>60</td>
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<tr>
<td>2.36 mm</td>
<td>35-55</td>
<td></td>
<td>33-55</td>
<td>42</td>
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<tr>
<td>1.18 mm</td>
<td>20-35</td>
<td></td>
<td>20-35</td>
<td>32</td>
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<tr>
<td>0.60 mm</td>
<td>15-30</td>
<td></td>
<td>15-30</td>
<td>24</td>
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<tr>
<td>0.30 mm</td>
<td>10-20</td>
<td></td>
<td>10-20</td>
<td>15</td>
</tr>
<tr>
<td>0.075 mm</td>
<td>4-10</td>
<td></td>
<td>5-8</td>
<td>6.3</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Binder Type</th>
<th>FlexGard XP</th>
<th>PG 76-22 (PMA)</th>
<th>PG 64-22</th>
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<tbody>
<tr>
<td>Minimum AC%</td>
<td>7.0%</td>
<td>7.0%</td>
<td>5.1</td>
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<tr>
<td>% Air Voids</td>
<td>3.0%</td>
<td>3.5%</td>
<td>4.0</td>
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<tr>
<td>VMA</td>
<td>&gt; 18%</td>
<td>&gt; 18%</td>
<td>16.3</td>
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<tr>
<td>SGC N&lt;sub&gt;des&lt;/sub&gt;</td>
<td>50</td>
<td>50</td>
<td>75</td>
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<tr>
<td>APA Rutting</td>
<td>Max. 5 mm</td>
<td>Max. 4 mm</td>
<td></td>
</tr>
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NJ I-295 HPTO Project
NJ I-295 HPTO Project
FlexGard / HPTO System

Summary

• Can be designed for county / municipal roads as well as Interstate highways
• Based on lab tests & project performance to date – should provide longer life than conventional mix (9.5mm)
• User friendly - local materials and contractors
• Cost effective alternative to “mill & fill”
• Good performance to date for state agencies with PMA
  – Ohio DOT
  – NJ DOT – HPTO
  – NYSDOT – 6.3 mm mix
Questions?