Implementation of Performance-Based HMA Mixtures in NJ

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Acknowledgements

- Eileen Sheehy, Materials Bureau of NJDOT
- Robert Blight and Susan Gresavage, NJDOT Pavement Design and Management
- Robert Sauber, Advanced Infrastructure and Design, AID (formerly NJDOT)
- Frank Fee, NuStar Energy
- Mike Jopko, Trap Rock Industries
Problem

- Current asphalt mixture design procedures based on volumetrics – no performance check
  - Aggregate gradation, VMA, VFA
- Asphalt binder specs provide an idea of performance but not reliable for today’s asphalt mixtures
  - High RAP & RAS mixtures
  - Warm mix asphalt
  - Differences in asphalt plant production and storage
- Production issues and binder contamination (storage tank and lines) – more later
So, Why Performance-Based Specs?

- Tests the “End Result”
- Combines the interaction of the aggregate, asphalt binder, and other additives (RAP, WMA, fibers, etc) with the plant production and storage (temperature and time)
  - Current methods looks at the components separately
- Shouldn’t material actually on roadway be tested for performance?
Performance-Based Specs – NJDOT’s Specialty Mixes

- These mixtures are designed to help with a specific condition/distress on a pavement in NJ
  - Granted, some mixes may not be appropriate for other states/regions
  - Performance testing associated with mixture design phase and plant production phase
Are these mixes designed differently?

- No – still using Superpave methods and procedures
- However,
  - Included mixture performance testing to ensure mixes are performing at required level(s)
  - Some difference in material selection (i.e. – no natural sands, different asphalt binders, change in volumetric targets)
  - MAKE SURE TO READ THE SPECIFICATIONS AHEAD OF TIME!
  - MAKE SURE TO CONTACT MATERIAL/BINDER SUPPLIERS AHEAD OF TIME!
NJDOT Design & Acceptance

1. Perform volumetric design and NJDOT verification
2. Supply Rutgers University lab prepared loose mix (or virgin materials) for performance testing
3. Produce mix through plant and pave test strip off site
4. Sample during production and supply Rutgers University loose mix for performance testing
5. Sample and test every other Lot
General Performance Tests Used

- Rutting Check – Asphalt Pavement Analyzer (AASHTO T340)
- Flexural Cracking Check – Flexural Beam Fatigue (AASHTO T321)
- Pavement Cracking Check – Overlay Tester (NJDOT B-10 & ASTM Spec coming)
Asphalt Pavement Analyzer

- AASHTO T340
- 100 lb. wheel load; 100 psi hose pressure
- Tested at 64°C (148°F) for 8,000 cycles
- Samples at specified air voids
- APA Rutting < “X” mm to pass
Flexural Beam Fatigue

- Flexural Beam Device, AASHTO T321
- Test mixes ability to withstand repeated bending
- Run at strain levels higher than expected field strains to accelerate testing
Overlay Tester

- Sample size: 6” long by 3” wide by 1.5” high
- Loading: Continuously triangular displacement 5 sec loading and 5 sec unloading
- Definition of failure
  - Discontinuity in Load vs Displacement curve
NJ’s Performance-Based Mixes

- High Performance Thin Overlays (HPTO)
- Bridge Deck Water-proofing Surface Course (BDWSC)
- Bottom Rich Base Course (BRBC)
- Bottom Rich Intermediate Course (BRIC)
High Performance Thin Overlay (HPTO)

- Main Purpose – used as a rut-resistant and durable thin lift mix for maintenance/pavement preservation (DOT and Local Aid), as well as a superior leveling course (DOT)
HPTO

- 4.75mm Superpave
- 7% min PG 76-22 binder
- 3.5% AV @ N_{design} = 50 Gyrations
- Field Compaction: 2 - 7% mat voids
- 1” +/- Lift Thickness
  - Steel roller in static mode
- Performance Test: APA
  - APA Rutting < 4mm at 8,000 cycles
HPTO Applications

- Thin Lift Overlay for Preventive Maintenance
- Leveling Course
- Bridge Deck Overlay
  - Small quantity

Beginning to use in conjunction with WMA to reduce potential for swelling due to PCC joint sealants and patching materials
Bridge Deck Waterproofing Surface Course (BDWSC)

- Main Purpose – to provide a rut and fatigue resistant and impermeable bridge deck overlay mix that can be placed using static rollers (i.e. – preserving critical bridge infrastructure)
Bridge Deck Waterproofing Surface Course (BDWSC)

- Highly Modified Mix for Bridge Decks
- Mixture Performance Testing
  - Rutting = APA
  - Cracking = Flexural Beam Fatigue
- 50 Gyrations @ 1% AV, 7% min AC
- 3% Max Air Voids in the Field
BDWSC

- Recommended Binders: PG 76-28 to a PG 82-34 Polymer Modified Binder, or
- Concentrated Thermoplastic Polymeric Asphalt Modifier (dry mix)
- APA: < 3 mm @ 8,000 loading cycles
- Flexural Fatigue: >100,000 cycles @ 1500 microstrains (originally used 2000µε)
- Mix Performance Tests used for final acceptance, regardless of binder grade or additive
BDWSC
Rt.80 ACROW Bridge
BDWSC
Rt. 80 ACROW Bridge

- Life of the HMA overlay
  - Nov. 2009 – Paved 2.5” to 3.5” of HMA 12.5H76 Surface Course
  - March 26, 2010 – Opened to WB traffic
  - April 8, 2010 – Started patching HMA due to excessive and rapid deterioration – cracking and shoving
  - May 5 – 6, 2010 - Removed FAILED HMA
  - “HMA overlay practically failed immediately but was patched until more resilient mix placed”
BDWSC
Rt.80 ACROW Bridge
BDWSC
Rt.80 ACROW Bridge

Sealing cracks on 4/22/10 morning with cold patch.
BDWSC
Rt.80 ACROW Bridge
BDWSC
Rt. 80 ACROW Bridge

- Life of the BDWSC
  - Paved BDWSC on May 5-6, 2010
  - Opened to WB traffic immediately
  - WB Traffic on BDWSC until Dec. 17, 2010
  - 7 ½ months with ZERO distress!
  - Opened to EB traffic January 2011
  - 6 months with ZERO distress!
  - ACROW temporary bridge taken down at end of 2011.
- 1.5 years of service with no distress
BDWSC
Rt. 80 ACROW Bridge
BDWSC
Rt.80 ACROW Bridge
Bottom Rich Base Course (BRBC)

- Main Purpose – base course mixture designed specifically to meet the flexural needs of a perpetual pavement (site specific)
Bottom Rich Base Course (BRBC)

• Used summer 2010 on I-295 rubblization project to decrease the required pavement thickness.
• 19 mm Base Course mix with 5% min. of PG 76-28 binder
  • Binder grade chosen based on initial mix testing
• Fatigue Resistance - 100 μ-strain @ 100,000,000 cycles
  • Based on Endurance Limit procedure from NCHRP Project 9-38
• APA (rutting) 5mm at 8,000 cycles
Endurance Limit from NCHRP Project 9-38

- Used methodology in NCHRP Report 646
- Conduct flexural beam fatigue at 400 and 800µε
  - 3 samples each
- Use 95% confidence interval with a selected # of repetitions
BRBC – Perpetual Pavement Design

- 40-75 mm SMA, OGFC or Superpave
- 100 mm to 150 mm Zone of High Compression
- High Modulus Rut Resistant Material (Varies As Needed)
- Max Tensile Strain
- Flexible Fatigue Resistant Material 75 - 100 mm
- Pavement Foundation
I-295 Design Methodology

- Evaluated maximum tensile strain with 8” HMA over rubblized PCC
  - Used JULEA software to estimate tensile strain
  - Resulted in 82 micro-strains (rounded up to 100 microstrains to be conservative)

- Final design pavement cross-section
  - 2” SMA Surface
  - 3” 19M76 Intermediate Course
  - 3” of NJDOT Bottom Rich Base Course
    - Designed specifically for this project
    - Utilized Endurance Limit concept
50 Gyrations @ 3.5% AV
2%-8% Mat Air Voids

Full flexural fatigue suite required during mixture design and test strip production
3 beams at 400 με and 3 beams at 800 με
Only 3 beams at 800 με during plant production (1st and every 5th Lot)
BRBC in Field
BRBC Core Samples
BRBC

Calculated Endurance Limit for 100,000,000 Cycles

BRBC = 126 Micro-strains
19M76 = 68 Micro-strains

- Winslow Lot #1 BRBC
- American Lot #8A 19M76

Fatigue Life (cycles)

Micro-strain

100,000,000
10,000,000
1,000,000
100,000
10,000
1,000
100
100
1,000
10,000
10,000

Rt.295 BRBC Fatigue Results @ 800 micro-strains
## Rt.295 BRBC Fatigue Results @ 800 micro-strains

<table>
<thead>
<tr>
<th>Lot</th>
<th>Flexural Beam Fatigue (cycle)</th>
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<tbody>
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<td>19M76</td>
<td>1,698</td>
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<tr>
<td>Lot#1</td>
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<td>39,188</td>
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<tr>
<td>Lot#17</td>
<td>57,112</td>
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</table>

The chart shows the flexural beam fatigue results for various lots, with each lot's results ranging from 1,698 to 76,081 cycles at 800 micro-strains.
Rt.295 BRBC APA Rut Results

APA Rutting (mm)

< 5mm APA Rutting Criteria

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<th>APA Rutting (mm)</th>
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<tr>
<td>#22</td>
<td>2.5</td>
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Bottom Rich Intermediate Course (BRIC)

- Main Purpose – to be placed over PCC/bottom of HMA overlay on composite pavement to withstand cracking due to horizontal joint movement (environmental) and vertical joint movement (traffic).
  - Important to note – mixture placed over BRIC still needs to be flexible enough to resist residual vertical bending.
Reflective Cracking on MA 1495
Bottom Rich Intermediate Course (BRIC)

- Superpave 4.75 mm Intermediate Course with PG 70-28 binder
  - Very similar to TxDOT’s CAM mixture
- Mix performance testing required.
  - TTI Overlay Tester (reflective cracking)
  - APA (rutting)
- A number of projects proposed this year
  - 1” BRIC
  - 1.5” to 2” SMA Surface Course
SOME THINGS TO WATCH OUT FOR
Binder Storage Tank

- Manufacturers recommend to not drain tanks below heating coils
- Therefore, always have residual binder at bottom of tank
Residue as % of Load

Percentage of Total Load vs Inches of Residue

- Percentage of Total Load:
  - 0.00%
  - 2.00%
  - 4.00%
  - 6.00%
  - 8.00%
  - 10.00%

- Inches of Residue:
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
Asphalt Lines from Storage Tanks

- Leads from storage tank to mixing vessel (drum or pug mill)
- Typical length ~ 70 ft
- Typical ID ~ 4 inches
- Equates to around 0.2 tons of residual liquid binder in the asphalt lines alone
In Summary: Why NJ Using Performance-Based Mixes?

- Today’s roadways, with high traffic and extreme climate conditions, require more than Mill 2”, Pave 2” on typical HMA
- Based on performance data (lab and field), along with costs for mixes, these mixes are a “Smart Economic Investment”
- Need tools in the toolbox for all situations
- Have to make sure we use the “Right Mix, On the Right Road, At the Right Time, for the Right Price”
Thank you for your time!

Questions?

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