Performance Related Specifications (PRS) in the Northeast – Hot Mix Asphalt Perspective

SHRP2 Performance Specifications for Rapid Renewal (R07)

Thomas Bennert, Ph.D., Rutgers University

September 21, 2016
Presentation Overview

• Introduction
• Guideline to Developing Performance Related Specifications (PRS) for HMA
  – Identifying needs
  – Baseline/target development
  – Sampling/Testing Protocols
• Current “Northeast” Practices
• Summary/Conclusions
Why the Need for PRS for HMA?

- Currently a concern among state agencies that current volumetric mixture design does not ensure good field performance
- Depending on climate, traffic, pavement conditions, different state agencies require different levels of performance
  - Not all HMA is created equal
    - New Jersey – rutting, fatigue cracking, reflective cracking
      - Different criteria required for different mix type, location in pavement, and pavement type
Original Intent of HMA Design

(Hveem, 1940)
• **Performance-Based:** Quality Assurance specifications that describe the desired levels of fundamental engineering properties that are predictors of performance and appear in primary prediction relationships
  – Resilient modulus, creep properties, fatigue properties
  – Models that can be used to predict pavement stress, distress, or performance

• **Performance-Related:** Quality Assurance specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance
  – Air voids for HMA; Compressive strength for PCC
  – HMA performance testing(?)

Terms (TRB Circular E-C173)
Guideline for Developing Performance Related Specifications (PRS)
Guidelines for Developing PRS

- Know your pavement performance
- Develop a baseline for performance
- Select an appropriate test procedure
- Develop testing & specification structure
- Go back and re-evaluate
Know Your Pavement

- Important to recognize pavement issues
- Testing methods should try to model distress types found in the field
  - Rutting, fatigue cracking, reflective cracking, thermal cracking
    - Mode of failure should be used in the lab
    - Test temperatures should model climate conditions
- Example:
  - New Jersey: Fatigue Cracking
    - Bridge Deck Mix – uses Flexural Beam fatigue
    - Bituminous Rich Intermediate Course – use Overlay Tester
Develop a Performance Baseline

• How would you like your materials to perform?
  – Historical field data (PMS)
  – Database of material properties
  – Performance criteria should be developed using the performance of local materials
    • Try to avoid “adopting” other state’s specifications when you do not have history of local material performance

• New Jersey Example: High RAP Specification
  – Performance criteria based on virgin (0% RAP) mix

• NYCDOT: HMA Specification
  – Developing performance criteria based on 30% RAP mix (30% RAP is minimum NYC must use)
Select Appropriate Test Procedure

- Priorities of test procedure
  - Correlates to field performance
  - Sensitivity to mixture properties
  - Repeatability
  - Ease of use (procedure, test specimen, time and analysis)
  - Availability/Cost

- NCHRP 9-57 Study – Mixture Cracking Tests

<table>
<thead>
<tr>
<th>Thermal cracking tests</th>
<th>Reflection cracking tests</th>
<th>Fatigue cracking tests</th>
<th>Top-down cracking tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. DCT</td>
<td>1. OT</td>
<td>1. Beam fatigue</td>
<td>1. IDT-Florida</td>
</tr>
<tr>
<td>2. SCB-IL</td>
<td>2. SCB-LTRC</td>
<td>2. SCB-LTRC</td>
<td>2. SCB-LTRC</td>
</tr>
<tr>
<td>3. SCB (AASHTO TP105)</td>
<td>3. BBF</td>
<td>3. OT*</td>
<td></td>
</tr>
</tbody>
</table>

*OT for fatigue cracking was added later by request of the panel.
Select Appropriate Test Procedure

- **Example: New Jersey**
  - Rutting: Asphalt Pavement Analyzer (AASHTO T340)
  - Fatigue Cracking:
    - Bridge Decks – Flexural Beam Fatigue (AASHTO T321)
    - BRIC, HRAP – Overlay Tester (NJDOT B-10; TxDOT Tx-248F)
  - Rt 80 in New Jersey
    - 2015 construction
    - NJDOT HPTO mixture
    - Testing indicated 1st 4 nights’ production failed rutting criteria
### Select Appropriate Test Procedure

- **Example:** New Jersey HPTO

<table>
<thead>
<tr>
<th>Date</th>
<th>Original</th>
<th>RTFO</th>
<th>PG Grade</th>
<th>Jnr (1/kPa)</th>
<th>% Rec</th>
<th>MSCR Grade</th>
<th>δ @ 76C (Orig)</th>
<th>δ @ 76C (RTFO)</th>
<th>APA (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5/27/2015</td>
<td>77</td>
<td>76.6</td>
<td>PG76</td>
<td>0.36</td>
<td>59</td>
<td>PG64E</td>
<td>73.6</td>
<td>68.3</td>
<td>6.56</td>
</tr>
<tr>
<td>5/28/2015</td>
<td>78.8</td>
<td>78.8</td>
<td>PG76</td>
<td>0.18</td>
<td>72.9</td>
<td>PG64E</td>
<td>69.5</td>
<td>64.5</td>
<td>6.23</td>
</tr>
<tr>
<td>5/29/2015</td>
<td>79.6</td>
<td>79.6</td>
<td>PG76</td>
<td>0.17</td>
<td>74.4</td>
<td>PG64E</td>
<td>69.9</td>
<td>64.5</td>
<td>6.5</td>
</tr>
<tr>
<td>6/3/2015</td>
<td>78.3</td>
<td>78.7</td>
<td>PG76</td>
<td>0.16</td>
<td>75.5</td>
<td>PG64E</td>
<td>69.6</td>
<td>63.5</td>
<td>6.84</td>
</tr>
<tr>
<td>6/4/2015</td>
<td>86.5</td>
<td>79</td>
<td>PG76</td>
<td>0.17</td>
<td>92.4</td>
<td>PG64E</td>
<td>58.9</td>
<td>58.4</td>
<td>3.66</td>
</tr>
<tr>
<td>6/5/2015</td>
<td>84.2</td>
<td>78.6</td>
<td>PG76</td>
<td>0.14</td>
<td>77.6</td>
<td>PG64E</td>
<td>65.4</td>
<td>64.8</td>
<td>3.87</td>
</tr>
<tr>
<td>6/9/2015</td>
<td>87</td>
<td>81.1</td>
<td>PG76</td>
<td>0.061</td>
<td>89.2</td>
<td>PG64E</td>
<td>60.7</td>
<td>60.1</td>
<td>3.92</td>
</tr>
<tr>
<td>6/10/2015</td>
<td>83.7</td>
<td>81.7</td>
<td>PG76</td>
<td>0.1</td>
<td>80.2</td>
<td>PG64E</td>
<td>66</td>
<td>61.8</td>
<td>4.32</td>
</tr>
<tr>
<td>6/11/2015</td>
<td>86.3</td>
<td>80.9</td>
<td>PG76</td>
<td>0.051</td>
<td>91.3</td>
<td>PG64E</td>
<td>60.8</td>
<td>58.4</td>
<td>3.98</td>
</tr>
<tr>
<td>6/12/2015</td>
<td>82.4</td>
<td>81.2</td>
<td>PG76</td>
<td>0.048</td>
<td>91.3</td>
<td>PG64E</td>
<td>66.8</td>
<td>60.4</td>
<td>3.73</td>
</tr>
<tr>
<td>6/17/2015</td>
<td>87.5</td>
<td>81.8</td>
<td>PG76</td>
<td>0.046</td>
<td>92.2</td>
<td>PG64E</td>
<td>60.6</td>
<td>57.9</td>
<td>3.83</td>
</tr>
<tr>
<td>6/18/2015</td>
<td>87.6</td>
<td>82.6</td>
<td>PG82</td>
<td>0.041</td>
<td>92.4</td>
<td>PG64E</td>
<td>61.2</td>
<td>59.2 @ 82C</td>
<td>2.94</td>
</tr>
<tr>
<td>6/19/2015</td>
<td>86.5</td>
<td>82.3</td>
<td>PG82</td>
<td>0.041</td>
<td>92.4</td>
<td>PG64E</td>
<td>59.2</td>
<td>59.2 @ 82C</td>
<td>2.73</td>
</tr>
<tr>
<td>6/24/2015</td>
<td>83.8</td>
<td>79.5</td>
<td>PG76</td>
<td>0.074</td>
<td>89.1</td>
<td>PG64E</td>
<td>62</td>
<td>59.7</td>
<td>3.99</td>
</tr>
</tbody>
</table>
Select Appropriate Test Procedure

- Example: New Jersey HPTO
  - PMS Test Data – Collected July 2016
Select Appropriate Test Procedure

• Be careful of adopting test methods and criteria developed by other agencies
  – Should you consider a rutting and fatigue cracking to “balance” performance?

• Be careful of selecting test procedures where results may be dependent on multiple failure mechanisms
  – Example: Hamburg Wheel Tracking (TxDOT) for rutting
    • Running test under couples stripping and rutting – which mode of distress dominates?
Select Appropriate Test Procedure

Rutting rates for wet HWT before and after stripping onset are different. Rutting rate for dry HWT is uniform.
Select Appropriate Test Procedure

Graph showing RUT depth in mm against Hamburg Wheel Passes for different asphalt types:
- PG 58-28 @ 50°C Wet
- PG 58-28 @ 50°C Dry
- PG 58-28 @ 58.5°C Dry

The graph indicates the performance of asphalt under varying conditions, helping in the selection of an appropriate test procedure.
Develop Specification Structure

• Stage of testing
  – Should it be included during mix design? Test strip? QC/QA?

• Frequency of testing
  – Lot, night’s production?
  – Keep in mind time requirements of the test method

• Responsible testing laboratory
  – State lab, consultant, university partner, asphalt plant under state inspection

• Handling failing results
  – Remove/replace, pay adjustment, stop production to adjust mix
Develop Specification Structure

• Example: New Jersey
  – Testing conducted;
    • During mix design, required test strip, 1st and every other Lot
      – Small production quantities are tested once per night production
  – Testing laboratory;
    • Up until 1/2016 – University Partner (Rutgers University – AMRL Accredited)
    • 1/2016 – Present – NJDOT Central Laboratory
      – Rutgers helped to install equipment and provide training on sample
        fabrication, testing, and analysis
  – Handling failing results
    • Mix design – must conduct redesign until passes
    • Test strip – must conduct another test strip until passes
    • Mainline – pay adjustment (negative only at this time)
### Table 902.11.04-2 Performance Testing Pay Adjustments for HMA HIGH RAP

<table>
<thead>
<tr>
<th>Surface Course</th>
<th>Intermediate Course</th>
<th>PPA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>APA @ 8,000 loading cycles, mm (AASHTO T 340)</strong></td>
<td><strong>PG 64-22</strong></td>
<td><strong>PG 76-22</strong></td>
</tr>
<tr>
<td>t ( \leq 7 )</td>
<td>t ( \leq 4 )</td>
<td>t ( \leq 7 )</td>
</tr>
<tr>
<td>7 &gt; t &gt; 10</td>
<td>4 &gt; t &gt; 7</td>
<td>7 &gt; t &gt; 10</td>
</tr>
<tr>
<td>t ( \geq 10 )</td>
<td>t ( \geq 7 )</td>
<td>t ( \geq 10 )</td>
</tr>
<tr>
<td><strong>Overlay Tester, cycles (NJDOT B-10)</strong></td>
<td><strong>PG 64-22</strong></td>
<td><strong>PG 76-22</strong></td>
</tr>
<tr>
<td>t ( \geq 150 )</td>
<td>t ( \geq 175 )</td>
<td>t ( \geq 100 )</td>
</tr>
<tr>
<td>150 &gt; t &gt; 100</td>
<td>175 &gt; t &gt; 125</td>
<td>100 &gt; t &gt; 75</td>
</tr>
<tr>
<td>t ( \leq 100 )</td>
<td>t ( \leq 125 )</td>
<td>t ( \leq 75 )</td>
</tr>
</tbody>
</table>
Task or Idea Identification/Modification

Modification of Procedures/Specifications

Focused Research & Evaluation

Application/Pilot Project Studies

Results Analysis/Spec Development

Go Back and Re-evaluate
2015 HPTO – retained binder samples
- Need to re-evaluate asphalt binder specification for HPTO?
Current “Northeast” State Performance Related Specifications
Northeast Survey

• Brief email survey sent out to “Northeast” states regarding current/potential use of PRS
  1. Is your state using PRS, and if so, at what level?
  2. Who conducts the testing?
  3. What pavement distresses are you concerned with?
  4. What performance tests are you using?
  5. What types of asphalt mixtures are you using PRS?

• States responding
  – 8 Northeast (CT, DE, NH, NJ, NY, PA, RI, VT) + Missouri
• At what level is your state using PRS?
  – 2 states using/developing PRS solely for mixture design acceptance
  – 1 state using/developing PRS for mixture design and Quality Acceptance
  – 2 states using/developing PRS for quality acceptance
  – 2 states still working on PRS
  – 2 states not interested at the moment
Northeast Survey

• Who is/would be responsible for testing within your PRS?
  – 3 states using solely their agency laboratory
  – 1 state combining agency and consultant services
  – 2 states combining agency and university partner
  – 1 state requiring contractor to hire accredited laboratory
Northeast Survey

• What pavement distresses are you most concerned with?
  – Fatigue cracking (7 states)
  – Thermal cracking (6 states)
  – Rutting (5 states)
Northeast Survey

• What performance tests are you using/considering using?
  – Rutting
    • Hamburg Wheel Tracking: 3 states
    • Asphalt Pavement Analyzer: 2 states
    • AMPT Flow Number: 1 state
  – Fatigue cracking
    • Semi-circular Bend (SCB): 3 states
    • Overlay Tester: 2 states
    • Flexural Beam Fatigue: 2 states
  – Thermal cracking
    • Disc Compact Tension (DCT): 1 state
Northeast Survey

- What performance tests are you using/considering using?

<table>
<thead>
<tr>
<th>Mix Design</th>
<th>Quality Control</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Rutting</strong></td>
<td><strong>Rutting</strong></td>
</tr>
<tr>
<td>Flow Number</td>
<td>Hamburg</td>
</tr>
<tr>
<td>APA</td>
<td>APA</td>
</tr>
<tr>
<td>Hamburg</td>
<td></td>
</tr>
<tr>
<td><strong>Fatigue Cracking</strong></td>
<td><strong>Fatigue Cracking</strong></td>
</tr>
<tr>
<td>Flexural Beam</td>
<td>Flexural Beam</td>
</tr>
<tr>
<td>Overlay Tester</td>
<td>Overlay Tester</td>
</tr>
<tr>
<td>SCB</td>
<td>SCB</td>
</tr>
<tr>
<td><strong>Thermal Cracking</strong></td>
<td><strong>Thermal Cracking</strong></td>
</tr>
<tr>
<td>N.A.</td>
<td>DCT</td>
</tr>
</tbody>
</table>
Northeast Survey

• What types of asphalt mixtures are you concentrating PRS on?
  – Specialty mixes (High RAP, Bridge Deck, etc): 3 states
  – High traffic volume: 1 state
  – When job requires > 6000 tons: 1 state
  – All HMA: 1 state
Summary/Conclusions

• HMA volumetrics do not tell the whole story
  – Used as a surrogate for actual performance testing
  – Increased use of polymers, WMA, recycled binders can change performance without changing volumetrics

• PRS/PBS can provide confidence to state agencies that HMA designed and produced will perform to a required level

• Many layers within PRS/PBS that agencies must consider
  – Not a one size fits all. Agencies need to develop specifications that best works for their traffic, pavement, and climate conditions
Thank you for your time!

Thomas Bennert, Ph.D.,
Rutgers University
Center for Advanced Infrastructure & Transportation
bennert@rci.rutgers.edu
609-213-3312