NCHRP 20-07/Task 406 Final Report

1. The need for a new generation of asphalt mix design
2. Survey of state DOTs and asphalt contractors
3. Literature review on the development and state-of-the-practice of asphalt mixture performance testing
4. Draft AASHTO standard practice and specification
5. Identifying knowledge gaps and developing research needs
6. Development of research problem statements
Draft AASHTO Standards

Scope

- A framework for balanced design of asphalt mixtures
- Guidance on development of a job mix formula
  - Mixture volumetric properties
  - Performance-based/related test results
- Guidance on preliminary selection of mix parameters for performance prediction analyses
Summary of the Practice

- Four optimal BMD approaches
  - A. Volumetric Design with Performance Verification
  - B. Volumetric Design with Performance Optimization
  - C. Performance-Modified Volumetric Mix Design
  - D. Performance Design

- Major differences among the four approaches
  - Degree of strictness on meeting volumetric criteria
  - Innovation potential in meeting performance criteria

Approach A. Volumetric Design with Performance Verification

- Conduct volumetric mix design to select optimum $P_b$
- Conduct rutting and cracking tests at optimum $P_b$
  - PASS
  - FAIL
    - Redesign mix
- Conduct moisture damage test at optimum $P_b$
  - FAIL
    - Decrease moisture susceptibility
  - PASS
- Establish JMF / Production
Approach B. Volumetric Design with Performance Optimization

1. Conduct volumetric mix design to select preliminary optimum $P_b$
2. Conduct rutting and cracking tests at preliminary optimum and two (or more) additional $P_b$
   - PASS
   - FAIL
     - Redesign mix
3. Select optimum $P_b$
4. Conduct moisture damage test
   - PASS
   - FAIL
     - Decrease moisture susceptibility
5. Establish JMF / Production

Approach C. Performance-Modified Volumetric Mix Design

1. Select initial aggregate structure and $P_b$
2. Conduct rutting and cracking tests at initial $P_b$
   - FAIL
   - PASS
     - Adjust initial $P_b$ or use different mix components or proportions
     - Decrease moisture susceptibility
3. Conduct moisture damage test at initial $P_b$
   - PASS
4. Check volumetric properties
5. Establish JMF / Production
Approach D. Performance Design

Select binder grade and initial aggregate structure

Conduct rutting and cracking tests at three (or more) $P_b$ values

FAIL

Select optimum $P_b$

Conduct moisture damage test at optimum $P_b$

FAIL

Decrease moisture susceptibility

PASS

Check volumetric properties

PASS

Establish JMF / Production

Mix Variables for BMD Optimization

Gradation  Asphalt Content  Modifiers  Additives

RAP Content  RAS Content  Rejuvenator
Rutting Tests

- Asphalt Pavement Analyzer (AASHTO T 340)
- Flow Number Test (AASHTO T 378)
- Hamburg Wheel-Tracking Test (AASHTO T 324)
- Hveem Stability Test (AASHTO T 246)
- Superpave Shear Tester (AASHTO T 320)

Cracking Tests

- BBR Mixture Bending Test (AASHTO TP 125)
- Direct Tension Cyclic Fatigue Test (AASHTO TP 107)
- Disc-Shaped Compact Tension Test (ASTM D7313)
- Flexural Bending Beam Fatigue Test (AASHTO T 321)
- Illinois Flexibility Index Test (AASHTO TP 124)
- Indirect Tensile Asphalt Cracking Test (ASTM D8225-19)
- Indirect Tensile Creep Compliance and Strength Test (AASHTO T 322)
Cracking Tests (continued)

- Indirect Tensile Energy Ratio Test
- Indirect Tensile Fracture Energy Test (AASHTO Draft Procedure, NCHRP Research Report 843)
- Overlay Test (Tex-248-F and NJDOT B-10)
- Semi-Circular Bend Test at Intermediate Temperature (ASTM D8044)
- Semi-Circular Bend Test at Low Temperature (AASHTO TP 105)
- Uniaxial Thermal Stress and Strain Test (ASTM WK60626)

Moisture Damage Tests

- Hamburg Wheel-Tracking Test (AASHTO T 324)
- Indirect Tensile Strength Test (AASHTO T 283)
- Moisture Induced Stress Tester (ASTM D7870)
Information Covered for Each Test

- Specimen conditioning and aging
- Test temperature
- Test criteria

Example – Flow Number Test

5.3. Flow Number Test (AASHTO T 378)

5.3.1. Specimen Conditioning and Aging—condition loose mix test samples for 4 hours at 135°C for hot mix asphalt (HMA) and 2 hours at field compaction temperature for warm mix asphalt (WMA) prior to compaction.

5.3.2. Test Temperature—select a test temperature as the high-adjusted PG temperature determined using the LTTP Band software.

5.3.3. Test Criteria—compare the test results with the criteria given in Table 2, or criteria specified by the state highway agency.

Table 2. Flow Number Test Criteria

<table>
<thead>
<tr>
<th>Traffic Level, million ESALs</th>
<th>HMA Minimum Average Flow Number*</th>
<th>WMA Minimum Average Flow Number*</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to &lt; 10</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>190</td>
<td>105</td>
</tr>
<tr>
<td>&gt;30</td>
<td>740</td>
<td>415</td>
</tr>
</tbody>
</table>

*recommended criteria from NCHRP report 678, page 142 (AAT, 2011);
*recommended criteria from NCHRP report 691, page 80 (Bonaparte, 2011).
### Example – IDEAL-CT Cracking

6.7. **Indirect Tensile Asphalt Cracking Test (ASTM D6225-19)**

6.7.1. **Specimen Conditioning and Aging**—condition loose mix test samples in accordance to R 30, Section 7.2 Short Term Conditioning for Mechanical Property Testing.

6.7.2. **Test Temperature**—the typical target test temperature is 25°C, but other target intermediate test temperatures can be used. One choice for the target intermediate test temperature is PG IT defined in M 370, or M 332 and provided in Equation 1.

\[
PG\ IT = \frac{PG\ HT + PG\ LT}{2}
\]

where:

- **PG IT** = intermediate performance grade temperature (°C).
- **PG HT** = climatic high-performance grade temperature (°C), and
- **PG LT** = climatic low-performance grade temperature (°C).

6.7.3. **Test Criteria**—compare the test results with the criteria given in Table 11, or criteria specified by the state highway agency (Note 11).

<table>
<thead>
<tr>
<th>Traffic Level, Millions ESALs</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 to &lt; 10</td>
<td>TBD</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>TBD</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>TBD</td>
</tr>
</tbody>
</table>

**Note 11**—the Virginia Department of Transportation currently uses a preliminary minimum cracking tolerance index (CTI prob) of 0.70 for acceptance of high RA mix asphalt surface mixtures designed using performance criteria (Virginia Department of Transportation, 2019).

### Test Selection and Criteria

#### Rutting Test

<table>
<thead>
<tr>
<th>Traffic (MESALs)</th>
<th>Flow Number</th>
<th>Min. FN</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>N/A</td>
<td>53</td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>190</td>
<td>740</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>30</td>
<td></td>
</tr>
</tbody>
</table>

#### Cracking Test

<table>
<thead>
<tr>
<th>Traffic (MESALs)</th>
<th>Disc-shaped Compact Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>N/A</td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>400</td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>460</td>
</tr>
<tr>
<td>&gt; 30</td>
<td>690</td>
</tr>
</tbody>
</table>

#### Moisture Damage Test

<table>
<thead>
<tr>
<th>Traffic (MESALs)</th>
<th>Min. Fracture Energy (kN·m)</th>
<th>Tensile Strength Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>N/A</td>
<td>0.80</td>
</tr>
<tr>
<td>3 to &lt; 10</td>
<td>400</td>
<td></td>
</tr>
<tr>
<td>10 to &lt; 30</td>
<td>460</td>
<td></td>
</tr>
<tr>
<td>&gt; 30</td>
<td>690</td>
<td></td>
</tr>
</tbody>
</table>

Agency FN Criteria | Agency DCT Criteria | Agency TSR Criteria |
Timeline

- August 2018: first draft submitted to AASHTO
- February 2019: balloted by AASHTO committee
  - Affirmative: 25 out of 37 for R xx-xx practice
  - Affirmative: 26 out of 37 for M xx-xx specification
- July 2019: comments addressed and revised draft submitted to AASHTO
- Near future?

Thanks!

Questions?