MTO Perspectives on Performance Testing
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Materials Standards and Specifications Office

2020 OAPC Asphalt Technical Symposium Webinar
June 16, 2020
Outline

- Development of MTO Specifications
- Equipment Procurement
- Performance Testing of Asphalt Mixtures
- Performance Testing Findings
- Performance Testing Implementation
Adoption of SHRP Performance Graded Asphalt Cement (PG) system

Premature cracking identified on provincial highways

Poor asphalt cement quality identified as one primary cause of premature cracking

New asphalt cement tests validated to predict premature cracking

Asphalt Cement Specification limits the use of Recycled Engine Oil Bottoms (REOB) through Ash Content Testing

Asphalt Cement Initiatives (33 Contracts selected to include the newly developed tests)

Series of field trials conducted to investigate and develop new asphalt cement tests

Development of MTO Specifications

1997

2000

2004-2006

2007-2009

2010

2011
Performance Evaluation of 33 contracts

AG Report on Road Infrastructure Construction Contract Awarding and Oversight contained seven recommendations

MTO Action Plan for Highway Construction Contracts and Oversight included actions for 2017 construction season and long term actions for 2018 and beyond

MODIFIED ERS with higher benchmarks; suspended incentives. RAS not allowed. The use of RAP was suspended in surface mixes. ExBBR test fully implemented along with MSCR, DENT, Ash

Recovered Asphalt Cement acceptance as interim measure. Phasing-in mix performance testing for acceptance.

MSCR and DENT tests implemented

Ministry’s Path Forward presented to industry. ExBBR test piloted on select contracts

2012-2014

2016

2015-2016

2017

2018-20+

PGAC specification includes Cross-Over Temperature (Tδ45) and Low Temperature Critical Spread (ΔTc) on 20 hr PAV and 40hr PAV for information
• Participant in FHWA Transportation Pooled Fund Program TPF-5 “Implementation of the AMPT for Superpave Validation” since late 2000’s
• NHI AMPT training course at NCAT (May 2-5, 2011)
• National Workshop (Sept11-12, 2012)
• In 2012, MTO acquired an Asphalt Mixture Performance Tester (AMPT)
• Tests conducted on AMPT:
  • Dynamic Modulus
  • Flow Number
  • Stress Sweep Rutting (SSR) Test
  • Cyclic Fatigue (large and small specimens)
Equipment Procurement

- 30 kN Dynamic Testing System (DTS-30) Purchased in 2017
- Servo-hydraulic testing machine applying loads in tension or compression dynamic loading modes
- Environmental controlled chamber -40°C to 80°C
- Complete with various testing jigs, strain gauges, and linear variable differential transducers (LVDTs)
Tests that can be conducted on DTS-30:

- Disk-Shaped Compact Tension (DCT)
- Semi-circular Bend (SCB)
- Cyclic Fatigue
- Dynamic Modulus
- Flow Number
- Texas Overlay
- Indirect Tensile Creep Compliance
- Resilient Modulus
- Four Point Bending
- TSRST (Thermal Stress Restrained Specimen Test)
Equipment Procurement

Hamburg Wheel Tracking (HWT) procured in 2016 with the following features:

- Accommodates both dry and wet testing conditions
- Used to evaluate rutting potential and moisture susceptibility
- Applies a wheel load of $705 \pm 4.5$ N on each wheel
- Adjustable speed of 40 to 60 wheel passes per minute across the specimen
- Controls the temperature over a range of $25.0^\circ C$ to $70.0^\circ C$ to an accuracy of $\pm 0.5^\circ C$
• Initiated in mid 2017 to develop acceptance criteria for post-production mixes
• Asphalt mix designs are becoming more complex due to the increased use of various materials and technologies (i.e. recycled materials, binder additives/modifiers, warm mix asphalt technologies, etc.). All of these could impact mixture performance
• Mix volumetrics are insufficient for predicting behaviour of post-production asphalt mixtures
• There is an urgent need to establish reliable performance tests that can help produce durable asphalt pavements, while creating a balance between resistance to cracking and rutting
In addition to well established tests used to predict rutting, MTO reviewed various cracking tests listed in NCHRP 9-57 report.

Also interested in properties of in-situ asphalt cement.

The most promising tests selected for evaluation were:

- Semi Circular Bend – SCB IFIT (fatigue cracking)
- Disk Shaped Compact Tension - DCT (low temperature cracking)
- Dynamic Modulus and Cyclic Fatigue Test (fatigue cracking)
- Hamburg Wheel Tracking (rutting and moisture damage)
- PG grading of asphalt cement recovered from production mix (impact of RAP, etc.)
A work plan was developed to explore the use of performance tests to predict pavement rutting and cracking resistance, and to develop acceptance criteria based on the selected tests.

Approach:

- Evaluate a number of performance tests that address various modes of cracking by testing either loose production asphalt mix or pavement cores.
- Select appropriate performance tests for use as acceptance (QA) tests to assess resistance of placed asphalt mixtures to cracking, rutting, and moisture damage.
- Conduct testing on the recovered AC from the same production asphalt mixtures and evaluate for acceptance.
- Develop acceptance criteria for mix performance tests and recovered AC.
- Establish new specifications based on findings.
Performance Testing of Asphalt Mixtures

- Loose asphalt mix samples were collected from regional contracts and sent to QA labs for sample preparation.
- Loose mix samples were sent to QA labs for extraction and recovery of asphalt cement.
- Field core samples were collected and sent to MTO Bituminous laboratory.
- Two contracts were chosen for each of the below mix/PGAC combinations for sampling:
  - SMA (70-28)
  - SP12.5 FC2 (70-28)
  - SP12.5 FC2 (64-34)
  - SP12.5 FC1 (58-28)
  - SP12.5 FC1 (64-28)
  - SP12.5 (58-34)
  - SP12.5 (52-34)
  - SP19 (64-28)
  - SP19 (58-28)
Performance Testing on Aged Pavement Cores

• In a recent study, a number of good performing and poor performing asphalt pavements were selected
• The pavements were constructed between 2005 and 2013
• Pavement cores were taken and tested by SCB and DCT tests
• Pavement condition expressed in terms of DMI loss per year
• RAP was present in two good performing contracts, indicating that RAP could be used responsibly in the asphalt mix
• Fair to good correlation between pavement distress and both FI and DCT fracture energy
• Good performing pavements had FI > 3 and DCT fracture energy > 550 J/m²
These fracture energy-based tests are able to produce reasonable results even when conducted on the aged pavement cores.
Mix Performance Testing

Based on evaluation of various performance tests, MTO is currently focusing on the following tests to predict cracking and rutting resistance for acceptance:

- **Flexibility Index (FI) test using Semi-Circular Bend (SCB) Geometry**
  - (intermediate temperature crack resistance)

- **Disk-Shaped Compact Tension (DC(T)) test**
  - (low-temperature crack resistance)

- **Hamburg Wheel Tracking (HWT) test**
  - (rutting resistance and moisture damage)
Types of Cracking and Fracture Based Cracking Tests

DTS-30kN

FIT test using SCB geometry

DC(T) Test
Flexibility Index Test: Semi-Circular Bend (SCB) Geometry

According to AASHTO TP124

- Test Temperature: 25°C
- Specimen Thickness: 50 mm
- Notch Depth: 15 mm
- Monotonic loading: 50 mm/min

Outcome:
- Fracture Energy (J/m²)
- Flexibility Index (FI)

Load-Displacement curve of SCB

Slope at post-peak inflection point (m)

SCB Test Setup
SCB Specimen Preparation

1. Cutting into discs
2. Cutting discs in half
3. Cutting the notch
Mix Performance Testing: FL Test

[Diagram showing load vs. displacement for Mix A, Mix B, Mix C, and Mix D.]

[Image of a testing equipment and samples.]
Mix Performance Testing: FIT Test Results

<table>
<thead>
<tr>
<th>Mix</th>
<th>Asphalt Mix</th>
<th>Lab Specimens</th>
<th>Field Specimens</th>
<th>SMA Threshold</th>
<th>Other Mixes Threshold</th>
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</thead>
<tbody>
<tr>
<td>Mix1</td>
<td>SMA 12.5PG70-28</td>
<td>30</td>
<td>28</td>
<td>30</td>
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<td>Mix12</td>
<td>SP 12.5FC1PG58-28</td>
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<td>Mix14</td>
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<td>Mix15</td>
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<td>SP 12.5PG52-40</td>
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</table>
Disk-Shaped Compact Tension (DC(T)) Test

According to ASTM D7313

Test Temperature: 10° C higher than low PG grade

Crack Mouth Opening Displacement (CMOD) Rate: 1mm/min

Outcome:

Fracture Energy (J/m²)

Load (kN)

Fracture energy

\[ G_f = \frac{W_f}{(\text{thickness} \times \text{ligament})} \]

Work of fracture (W_f)

CMOD Displacement (mm)
Saw Cutting Equipment

Automatic Pave Saw

Tile Saw for precise cutting
DC(T) Specimen Preparation

1. Cutting into discs
2. Cutting the edge of discs
3. Marking the holding holes
4. Coring the holding holes
5. Cutting the notch
6. Gluing the knife edges
Mix Performance Testing: DC(T) Test Results

Asphalt Mix
- Plant Produced Laboratory Compacted Specimens
- Pavement Field Cores

Mix 1
- SMA 12.5
- PG70-28

Mix 2
- SMA 12.5
- PG70-28

Mix 3
- SMA 12.5
- PG70-28

Mix 4
- SMA 12.5
- PG70-28

Mix 5
- SMA 12.5
- PG70-28

Mix 6
- SMA 12.5
- PG70-28

Mix 7
- SMA 12.5
- PG70-28

Mix 8
- SMA 12.5
- PG70-28

Mix 9
- SMA 12.5
- PG70-28

Mix 10
- SMA 12.5
- PG70-28

Mix 11
- SMA 12.5
- PG70-28

Mix 12
- SMA 12.5
- PG70-28

Mix 13
- SMA 12.5
- PG70-28

Mix 14
- SMA 12.5
- PG70-28

Mix 15
- SMA 12.5
- PG70-28

Mix 16
- SMA 12.5
- PG70-28

Preliminary Minimum Threshold value for SMA and SP12.5FC2

Preliminary Minimum Threshold value for all other mixes
Hamburg Wheel Tracking Test

According to AASHTO T324

Samples submerged in water

Test Temperature: 50°C, 44°C

Max. number of wheel passes: 20,000

Outcome

Rut depth vs. # of load passes
Mix Performance Testing: HWT Test Results

Mixes compared:
- Mix1 SMA12.5 PG70-28
- Mix2 SMA12.5 PG70-28
- Mix3 SP12.5 FC2 PG70-28
- Mix4 SP12.5 FC2 PG70-28 20%RAP
- Mix5 SP12.5 FC2 PG70-28 20%RAP
- Mix6 SP12.5 FC2 PG64-28 20%RAP
- Mix7 SP12.5 FC2 PG64-34 20%RAP
- Mix8 SP12.5 FC2 PG64-34
- Mix9 SP12.5 FC2 PG58-28
- Mix10 SP12.5 FC2 PG58-28
- Mix11 SP12.5 FC1 PG58-34
- Mix12 SP12.5 FC1 PG58-34 @ 44°C
- Mix13 SP12.5 PG58-34
- Mix14 SP12.5 PG52-40
- Mix15 SP12.5 PG52-40
- Mix16 SP12.5 PG52-40 @ 44°C
- Mix17 SP12.5 PG52-40
- Mix18 SP12.5 PG52-40

Graphical representation:
- Preliminary Maximum Threshold value for SMA and SP12.5FC2
- Preliminary Maximum Threshold value for all other mixes

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# HWT Thresholds under Consideration

<table>
<thead>
<tr>
<th>PGAC Grade</th>
<th>Test Temperature (°C)</th>
<th>Thresholds</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-XX</td>
<td>50</td>
<td>Max. 6.0 mm Rut Depth @20000 Passes</td>
</tr>
<tr>
<td>64-XX</td>
<td>50</td>
<td>Max. 12.5 mm Rut Depth @20000 Passes</td>
</tr>
<tr>
<td>58-XX and 52-XX</td>
<td>44</td>
<td>Max. 12.5 mm Rut Depth @20000 Passes</td>
</tr>
</tbody>
</table>
Phased-In approach starting 2020:
Collecting post-production samples from select contracts
Testing for information purposes by QA Labs

SCB Flexibility Index Testing
Hamburg Wheel-Track Testing
DCT testing

Contractors are encouraged to use balanced mix design

SCB correlation ongoing

2 CTAA papers underway
Long-Term Plan:

Testing carried out by equipped and capable laboratories (QC/QA/Referee)

Phase in performance testing on post-production mix

Conduct long-term aging on mixes, analyze effects, and establish mix performance acceptance criteria in relation to in-service pavement performance

Implement mix performance specifications to improve quality of asphalt mixes used on Ontario’s highways
Questions?

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