INDUSTRY PERSPECTIVE ON ONTARIO PAVEMENT CRACKING RESEARCH

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Asphalt Institute - Canadian Field Engineer
Outline

- Hwy 655 Phase I project
- 2011 MTO Asphalt Cement Initiatives
- Hwy 655 Phase II project
Disclaimers

- This is an Ontario industry perspective
- Industry did not collect any of the data
Hwy 655 Phase I

- Located about 25 km N of Timmins
- 7 test sections (500 m) paved in 2003
  - All specified PG 64-34 to ensure modification
  - Pavement temperatures below -37°C @ pavement surface (calculated from pavement thermistors at 20 mm) were observed in the first 2 years ($T_{\text{air}} < -40^\circ\text{C}$)
  - Winter of 2013-14, had multiple $T_{\text{air}} < -40^\circ\text{C}$
  - OHMPA and MTO shared the cost to retain an independent consultant to report on the test sections in 2008 (Gerry Huber)

<table>
<thead>
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<tr>
<td>Lat = 48.62°N</td>
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<tr>
<td>$\text{Low}_{\text{StdDev}}$ = 2.5°C</td>
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<td>$T_{\text{pav 98%}}$ = -36.1°C</td>
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</table>
Modified Figure 1 - Cracking Type and Distribution

Gr = Recovered M320 Grade
ExBBR = Extended BBR (tank)
Loss = Extended BBR (tank)
CTOD = DENT (tank at 25°C)
Ash = Ash Content
SN = Back Calculated Effective Structural Number
ΔTc = 20 hr Calculated from Hesp paper [CTAA 2015]

5 Year Cracking Length (m)

<table>
<thead>
<tr>
<th>Material</th>
<th>5 Year Cracking Length (m)</th>
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<tbody>
<tr>
<td>Elvaloy</td>
<td>100</td>
</tr>
<tr>
<td>Kraton</td>
<td>200</td>
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<tr>
<td>Premium</td>
<td>300</td>
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<tr>
<td>Multiphalte</td>
<td>400</td>
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<tr>
<td>Hyperphalte</td>
<td>500</td>
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<tr>
<td>Unmodified</td>
<td>600</td>
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<td>Stylink</td>
<td>700</td>
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</table>

Gr
ExBBR
Loss
CTOD
Ash
SN
ΔTc
$\Delta T_{c(20)}$ on Hwy 655 - Phase I

Data extracted from *Physical Hardening in Asphalt*, Hesp, CTAA 2015

![Graph with data points and regression lines](image)
Study on 20 Pavements in Eastern and Northeastern Ontario*

- Study done in 2007 on pavements that were 7 to 14 years old at that time
- AC – 6 pen graded contracts, 13 PGAC and 1 unknown
- Distress survey carried out at three locations and averaged – only transverse cracks were measured
- 4 cores taken for recovered testing of the AC
  - Extended BBR (LS 308) and DENT (LS 299)

<table>
<thead>
<tr>
<th>Site</th>
<th>Hwy</th>
<th>Location</th>
<th>AADT</th>
<th>Trucks (%)</th>
<th>Daily Truck Number</th>
<th>Total Asphalt (mm)</th>
<th>Age</th>
<th>LTPP Binder v2.1 (°C)</th>
<th>Binder Course Grade (%RAP)</th>
<th>Surface Course Grade (%RAP)</th>
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<td>O</td>
<td>Wilno</td>
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<td>–</td>
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<td>58-34 M</td>
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<td>64-34</td>
<td>64-34</td>
</tr>
</tbody>
</table>
Thickness ≤ 90 mm
Grade Unknown
PMA
RAP
2011 MTO Asphalt Cement Initiatives

- MTO and Industry collaborated between 2005 and 2011 on 2 new test procedures – ExBBR and DENT
- A mutually acceptable test protocol and acceptance limits were developed by the MTO-OHMPA Binder Task Group
- Total of 38 trial projects paved between 2012 and 2015
- 16 have reached the end of the warranty period with no contract disputes and so the projects are considered closed
- Data from these 16 projects was shared with Industry and analysed for this presentation
All testing on new asphalt cement from QA samples and was tested by MTO QA laboratories.

Testing included: Standard (M320) 1 hr BBR test; LTLG and Loss from the Extended (72 hr) BBR test; CTOD from the DENT test (Ontario procedure); MSCR % Recovery; and Ash test.

Crack monitoring was carried out by MTO at 3 years using their new ARAN.

These results are preliminary in nature.

This is industry’s analysis of the results.
Asphalt Cement
...2011 Trials

2011 Construction (18 Contracts) - 2014 lvision- Total Cracking

- 2011-2018: Mill + Pave 1
- 2011-5104: Mill + Pave 3

Cracking m/km

- LYY (Slight)
- LYY (Mod)
- LS 308 + LS 299 (Slight)
- LS 308 + LS 299 (Mod)
- MSCR (Slight)
- MSCR (Mod)

April 2015

MTO presentation at the 2015 OHMPA Annual General Meeting
MTO, Ontario’s Strategy to Enhance Asphalt Cement Quality – CTAA 2015

Note: LTLG is Low Temperature Limiting Grade and MSCR is Multiple Stress Creep Recovery test.
Correlation between Construction Type and Cracking
Results of MTO ARAN Cracking Measurement at 3 years

Construction type influences cracking
Best performers
- Pulverize + Pave 3
- FDR + Pave 2
- CIREAM + Pave 2

Total Cracking (m/km)

Overlay
- Pulverize
- Mill
- FDR
- CIREAM

Filled symbols indicate LTPP grade is 6C lower than specified grade

Overlay 1 Lift
- Pulverize 1 Lift
- Pulverize 3 Lifts
- Mill 1 Lift
- Mill 2 Lifts
- Mill 3 Lifts
- FDR 2 Lifts
- CIREAM 2 Lifts
Moderate Correlation (trending correctly)

Results of MTO ARAN Cracking Measurement at 3 years

\[
y = 38.378x + 350.69 \\
R^2 = 0.4888
\]

Filled symbols indicate LTPP grade is 6°C lower than specified grade

Overlay
Pulverize
Mill
FDR
CIREAM

1, 2, 3 - HMA lifts

Specified M320 (1 hr BBR) Difference (°C)
measured by MTO QA testing
Poor Correlation (trending correctly)
Results of MTO ARAN Cracking Measurement at 3 years

Filled symbols indicate LTPP grade is 6°C lower than specified grade.

Total Cracking (m/km)

72 hr ExBBR Specified Low Temperature Limiting Grade Difference (°C)
measured by MTO QA testing

y = 19.5x + 197.01
R² = 0.2232
No Correlation (trending incorrectly)

Results of MTO ARAN Cracking Measurement at 3 years

Filled symbols indicate LTPP grade is 6C lower than specified grade

$y = 304.37e^{0.0964x}$

$R^2 = 0.0425$

April 2016
No Correlation (trending incorrectly)
Results of MTO ARAN Cracking Measurement at 3 years

Filled symbols indicate LTPP grade is 6C lower than specified grade

\[ y = 204.96e^{0.0502x} \]
\[ R^2 = 0.1683 \]

1, 2, 3 - HMA lifts

Total Cracking (m/km)

DENT CTOD Difference from Specification (mm)

measured by MTO QA Testing
Poor Correlation (trending correctly)
Results of MTO ARAN Cracking Measurement at 3 years

Overlay
Pulverize
Mill
FDR
CIREAM

1, 2, 3 - HMA lifts

Filled symbols indicate LTPP grade is 6C lower than specified grade

Total Cracking (m/km)

MSCR Recovery Difference from Curve (%) measured by MTO QA testing

\[
y = 285.22e^{-0.013x} \\
R^2 = 0.1332
\]
No Correlation (trending incorrectly)
Results of MTO ARAN Cracking Measurement at 3 years

Filled symbols indicate LTPP grade is 6C lower than specified grade

\[ y = 324.91e^{-2.135x} \]
\[ R^2 = 0.2337 \]
Summary of the cracking at 3 years based on MTO monitoring and testing

- Industry’s analysis of preliminary data
- On Mill and Pave with 2 lifts
  - The standard 1 hr BBR test shows better correlation than 72 hr Extended BBR test
  - Loss doesn’t correlate – engineering control
    - Asking for DENT or MSCR seemed to control Loss
  - Ash (REOB/VTAE) doesn’t correlate – engineering control
  - MSCR has poor correlation (trends correctly)
  - DENT doesn’t correlate (trends incorrectly)
- These charts will change – it has only been three years
Hwy 655 Phase II

- Located about 25 km N of Timmins
- 8 test sections paved in 2008 as a follow-up to the Phase I study
  - All specified PG xx-34 with a formula for elastomeric modification
  - All but control used a 300/400 Pen Cold Lake asphalt
  - 5 sections with elastomer (formula), one control and two with fibre (mix)
- Results presented in the MTO paper given at the CTAA conference in 2015

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LS-308 Low Temp Grade at 1Hr & T+10 (°C), Original AC in 7 Years

- 2014 Total Cracking (m/km)
- LS-308 Low Temp Grade on Original AC, °C

R² = 0.3306

Acceptable

MTO, Ontario’s Strategy to Enhance Asphalt Cement Quality – CTAA 2015
Comparison of M320 LTG and ExBBR LTLG on Hwy 655 - Phase II

(cracking at 7 yrs)

Note that the open symbols at the same cracking level represents the LS 308 LTLG for the same sample of binder. The LTLG for the 7% D1101 is not shown because it goes off the chart to the right at -19.7°C.

- **M320 300/400 Tank**
- **M320 Elastomer Tank**
- **LTLG 300/400 Tank**
- **LTLG Elastomer Tank**
- **M320 52-34 Tank**
- **LTLG 52-34 Tank**

**Equations**

- **M320 Elastomer Tank**
  \[ y = 58.86x + 2,687.22 \]
  \[ R^2 = 0.85 \]

- **LTLG Elastomer Tank**
  \[ y = 13.83x + 928.73 \]
  \[ R^2 = 0.50 \]
ExBBR LTLG Loss on Hwy 655 - Phase II
(cracking at 7 yrs)

Total Cracking (m/km)

Loss (°C)

- 2.5% 4170
- 7% D1118
- 52-34
- 7% D1101
- 3.5% D1101
- 2% D1101 + 1% PPA
- Fibres

y = 15.39x + 407.92
R² = 0.34

300/400 Tank
Elastomer Tank
52-34 Tank
Linear (Elastomer Tank)
CTOD on Hwy 655 - Phase II
(cracking at 7 yrs)

- 2% D1101 + 1% PPA
- 2.5% 4170
- 7% D1118
- 3.5% D1101
- 7% D1101

Linear (Elastomer Tank):
\[ y = 3.99x + 393.50 \]
\[ R^2 = 0.45 \]

- Fibres
- 52-34 Tank
- 300/400 Tank
- Elastomer Tank
ΔTc(20) on Hwy 655 - Phase II
(cracking at 7 yrs)

\[ y = -27.79x + 472.11 \]
\[ R^2 = 0.41 \]

- **7% D1101**
- **7% D1118**
- **2% D1101 + 1% PPA**
- **3.5% D1101**

Legend:
- **300/400 Tank**
- **Elastomer Tank**
- **52-34 Tank**
- **Linear (Elastomer Tank)**
Thank you