Outline

• Introduction
• University of Alberta Questionnaire Survey
• Laboratory Investigation on Patching Material
• Acknowledgments
Outline

• Introduction

• University of Alberta Survey results

• Laboratory Investigation on Patching Material

• Acknowledgments
Potholes

• Pothole: a bowl-shaped depression that penetrates through the top layer down to the base course

• Common deterioration in cold regions where adverse weather conditions accelerate pavement distress.

• Potholes generate from water penetrating into the top layer of asphalt through the cracks, which is accelerated by freeze-thaw cycles.
Potholes

ASTM D6433:

- Low severe: less than 25 mm deep is in the low severe;
- Moderately severe: 25–50 mm deep;
- Highly severe: More than 50 mm deep

https://localsealcoating.com/asphalt-pothole-repair/
Potholes and Economy

City of Edmonton:

- number of potholes filled:
  - 2014: 438,000*
  - 2016: 406,152**
  - 2017: 664,739**

- Annual pavement operating budget allocated to pothole repair: 37%*

* Ref.: University of Alberta survey results, 2014
** Ref.: http://yegcitybudget.ca/operating-budget/expenses/roads-infrastructure/
Outline

• Introduction
• University of Alberta Survey Results
• Laboratory Investigation on Patching Material
• Acknowledgments
Questionnaire Survey

- In 2014, a questionnaire was developed in the University of Alberta and distributed to municipalities and transportation agencies in Canada.

- Objectives:
  - Investigating the severity of the pothole problem throughout Canada;
  - Determining the factors responsible for pothole development;
  - Identifying current pothole patching practices;
  - Determining the performance of patching techniques.
Alberta Transportation,
Manitoba Infrastructure and Transportation,
Ontario Ministry of Transportation,
Quebec Ministry of Transportation,
Saskatchewan Ministry of Highways and Infrastructure,
New Brunswick Department of Transportation and Infrastructure
  • City of Edmonton
  • City of Calgary
  • City of Red Deer

Distribution of (a) population; (b) land area in Canada
Probable Cause of Pothole

(scale: 1–5, where 5 is most important cause)
## Pothole Repair Season

<table>
<thead>
<tr>
<th>Province</th>
<th>Winter repairs (%)</th>
<th>Summer repairs (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>MB</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>ON</td>
<td>40</td>
<td>60</td>
</tr>
<tr>
<td>QB</td>
<td>43</td>
<td>57</td>
</tr>
<tr>
<td>SK</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>NB</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>City of Edmonton</td>
<td>24</td>
<td>76</td>
</tr>
<tr>
<td>City of Calgary</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>City of Red Deer</td>
<td>10-20</td>
<td>80-90</td>
</tr>
</tbody>
</table>
# Survival Period of Repaired Patch

<table>
<thead>
<tr>
<th>Repair Period</th>
<th>Province</th>
<th>&lt; 3 months</th>
<th>3-6 months</th>
<th>6-9 months</th>
<th>9 months – 1 year</th>
<th>1-1.5 year</th>
<th>1.5-2 year</th>
<th>&gt; 2 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Winter</td>
<td>AB</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MB</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>QB</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SK</td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NB</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Summer</td>
<td>AB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ON</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>QB</td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>SK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NB</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Probable Causes of Failure

- Raveling
- Edge disintegration
- Cracking
- Missing patch
- Shoving
- Bleeding
- Dishing

Average rating
# Repair Methods and Materials

<table>
<thead>
<tr>
<th>Province</th>
<th>Throw-and-go (%)</th>
<th>Semipermanent (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AB</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>MB</td>
<td>100</td>
<td>0</td>
</tr>
<tr>
<td>ON</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>QB</td>
<td>80</td>
<td>20</td>
</tr>
<tr>
<td>SK</td>
<td>70</td>
<td>30</td>
</tr>
<tr>
<td>NB</td>
<td>95</td>
<td>5</td>
</tr>
<tr>
<td>Average</td>
<td>84</td>
<td>16</td>
</tr>
<tr>
<td>City of Edmonton</td>
<td>48</td>
<td>47</td>
</tr>
<tr>
<td>City of Calgary</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>City of Red Deer</td>
<td>0</td>
<td>100</td>
</tr>
</tbody>
</table>

- **Patching material other than hot mix asphalt (HMA)**
  - Quality Pavement Repair (QPR): AB, MB, SK, NB
  - EZ street: AB
  - Instant Asphalt Repair (IAR): MB
  - Conventional Cold Mix (CCM): AB, ON, QB, SK
Outline

• Introduction

• University of Alberta Survey results

• Laboratory Investigation on Patching Material

• Acknowledgments
Cold Asphalt Mixes

Binder type: Polymer modified cutback for all except for Oil Mix and PAP which were bitumen emulsion.
Laboratory Tests

- Ignition oven test (AASHTO T308)
- Marshall Stability test (ASTM D6927)
- Indirect tensile strength (ITS) test (AASHTO T283)
- Adhesiveness test (Virginia DOT, 1998)
- Cohesiveness test (AASHTO TP-44-94)
- Wheel track test (WTT) (AASHTO T324-11)
Ignition Oven Test
(AASHTO T308)
Aggregate Particle Size
(Dense graded)

1: bitumen content
2: dust content
3: course aggregate content
Aggregate Particle Size
(Open graded)

1: bitumen content
2: dust content
3: course aggregate content
Samples Preparation

- No curing:
  - Failed over the night

- Curing Procedure:
  - Overnight @ 65°C
  - Overnight @ 135°C

65°C cured samples

Failed during weight measuring

135°C Sample
Marshall Stability Test Results

Dense graded CMA

Open graded CMA

Marshall Stability of HMA

Flow number (mm)

Stability

MQ

Flow
Indirect Tensile Strength (ITS) (AASHTO T283)

- Tensile strength and moisture sensitivity

Sample Saturation  
Sample Freezing  
Sample Thawing  
Sample Testing

Failure Type

Some of the tested samples (broken)
ITS Test Results

\[ S_t = \frac{2000P}{\pi Dt} \]

- \( S_t \) = tensile strength in kPa,
- \( P \) = maximum load in N,
- \( t \) = specimen thickness in mm, and
- \( D \) = specimen diameter in mm.

\[ \text{TSR} = \frac{S_2}{S_1} \]

- \( S_1 \) = tensile strength of dry sample in kPa, and
- \( S_2 \) = tensile strength of saturated or freeze-thaw sample
Adhesiveness Test
(Virginia DOT, 1998)

- Adhesiveness test measures the bonding between applied cold patch and the original pavement.

Compact by Marshall Hammer (10 blows)  Cold mix on HMA  Measure the time 5-30 s desirable  Weight the Remnants
Adhesiveness Test Results

**Graph:**

- **Y-axis:** Time (sec)
- **X-axis:** Samples (1 to 12)
- **Legend:**
  - Dense graded CMA
  - Open graded CMA
- **Note:** The acceptable range is indicated by the horizontal line.

**Observations:**

- Sample 2 has the highest time, suggesting a low adhesiveness level.
- Other samples within the acceptable range, indicating moderate adhesiveness.
- Sample 10 stands out near the acceptable range, possibly indicating a test outlier.
Cohesiveness Test
(AASHTO TP-44-94)

- Internal bonding strength of cold patching materials
  - Materials were tested at temperatures of 4°C and 25°C

**Weight the sample**
Compact (25 blows)

**Sample extrusion**

**Rolling the sieve**
20 rolls in 20 sec
(Sieve: 25.4 mm opening size)

**Weight the Remnants**
Min. 60% acceptable
Cohesiveness Test Results

![Bar chart showing cohesiveness test results for Dense graded CMA and Open graded CMA. The chart compares Remnants (%) at 4C and 25C. The graph includes a horizontal line indicating the minimum acceptable level for cohesiveness.]
## Summary of the Test Results

<table>
<thead>
<tr>
<th>Laboratory Test</th>
<th>Tested Parameters</th>
<th>CMA</th>
<th>HMA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Marshall Stability</td>
<td>Stability (N)</td>
<td>6800</td>
<td>18950</td>
</tr>
<tr>
<td></td>
<td>Flow (mm)</td>
<td>1.75</td>
<td><strong>1.50</strong></td>
</tr>
<tr>
<td></td>
<td>MQ (N/mm)</td>
<td>3886</td>
<td><strong>12,633</strong></td>
</tr>
<tr>
<td>Indirect Tensile Strength</td>
<td>ITS (kPa) Dry</td>
<td>790</td>
<td>1568</td>
</tr>
<tr>
<td></td>
<td>TSR (Saturation)</td>
<td>1.05</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>TSR (F-Thaw)</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Cohesiveness</td>
<td>Remnants (°C) 4C</td>
<td>94</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>Remnants (°C) 25C</td>
<td>98</td>
<td>99</td>
</tr>
<tr>
<td>Adhesiveness</td>
<td>Time (sec)</td>
<td>5.46</td>
<td>49.9</td>
</tr>
</tbody>
</table>

**Red:** not acceptable
Hamburg Wheel Tracker
(AASHTO T324-11)
HWT Test Procedure

- Test on cured and uncured samples

Dry test

Wet test (25°C)

Wet test (50°C)
WTT Results

Number of passes

Rut-depth (mm)

(a)

(b)

CMA-2

CMA-8

OCD*

CMA-1 CMA-2 CMA-3 CMA-4 CMA-5 CMA-6 CMA-7 CMA-8 CMA-9

* Oven-cured sample tested under dry condition.
WTW Results

*Oven-cured sample tested under wet condition.*
Moisture Resistance

- Moisture susceptibility index (MSI): the ratio of the wet rut depth to the dry one
Epoxy Grout

Epoxy resin (Component A)
Curing agent (Component B)

Aggregates: recycled glass beads with a nominal size of 0.63 mm.
Setting time: adjustable between 3 – 90 minutes.
Application temperature: 4 to 43° C.
Epoxy Grout Test Results

- Marshall stability: 1850 N
- Indirect tensile strength: 2940 N (3 times of HMA)
- No sensitivity to freeze/thaw cycles
- No permanent deformation after 20000 cycles
Epoxy grout was quite sensitive to temperature changes, but not sensitive to the loading time.
Mastic Asphalt

Polymer modified bitumen + aggregates.
Mixing temperature: 200° C
Minimum pavement temperature: 4° C
Mastic Asphalt

![Rutting depth vs No. of passes graph]

Rutting depth (mm) vs No. of passes
Acknowledgements

A special thanks to:

- Mr. Al Cepas,
- Alberta Transportation,
- Manitoba Infrastructure and Transportation,
- Ontario Ministry of Transportation,
- Quebec Ministry of Transportation,
- Saskatchewan Ministry of Highways and Infrastructure,
- New Brunswick Department of Transportation and Infrastructure
- City of Edmonton
- City of Calgary
- City of Red Deer
Thank you!