A Forensic Investigation:
Potential Issues with
Recycled Concrete Materials (RCM)

November 18, 2015
Introduction

• This presentation is in no way meant to convey any negative connotation to the Contractor or Supplier of the RCM.

• Both have excellent reputations with York Region and within the industry.
Introductory Questions

• Have you used Recycled Concrete Materials (RCM) on any of your projects?
• Have you had good experience with RCM?
• Have you had issues with RCM?

Image Source: renewcanada.net (Graham Pellets)
Highway 427 Project Limits

South of Highway 7 to Zenway Boulevard
Problems Encountered

New lane raised approx. 70 mm

JAN/05/2010
Problems Encountered

Crack reappears between lanes

Unevenness between lanes is a safety concern
Problems Encountered

- Swale created adjacent to lane
- Guiderail height outside of desirable range
Problems Encountered
Possible Causes

• Typical frost heave problem due to winter freeze/thaw?

• Material problem? If so, which material?
Possible Causes

• Subgrade (Native/Earth Material)?

• Recycled Concrete Material (RCM)?

• Asphalt?

• Drainage?
Possible Causes: Asphalt

- Falling Weight Deflectometer (FWD) test confirmed asphalt is generally structurally adequate
- No issue with material identified

Conclusion: Asphalt not the cause of the problem
Possible Causes: Subgrade

- Standard Penetration Test (SPT) confirmed subgrade had good strength
- Grain size/hydrometer test confirmed subgrade material had low to moderate susceptibility to frost heave

Conclusion: Subgrade not the cause of the problem
Possible Causes: Drainage

- Frost heave?
  - Relatively shallow drainage between the Highway 7 off-ramp to just north of Highway 7
  - Does not explain why there is a problem in high fill areas
  - Pavement remains expanded after two winter periods and repair

Not typical for frost heave situations
Conclusion for Drainage as a Possible Cause

- Poor drainage may be a contributing factor to the problem, however it is not the main cause
Possible Causes: RCM

- Moisture Contents
  - New highway constructed adjacent to existing highway that has been in operation for approximately 20 years
  - Expect similar moisture contents
Possible Causes: RCM

Moisture Contents

Typical 8 to 11%
Possible Causes: RCM

- In-situ wet/dry density (after issue identified)
  - Wet Density
    - Typically ~2150 kg/m³
    - 1680 - 1990 kg/m³
  - Dry Density
    - Typically ~1950 kg/m³
    - 1450 - 1750 kg/m³

Represents 15% to 20% expansion
Possible Causes: RCM

• Petrographic Analysis
  • Coarse aggregate
    • Up to 10% deleterious material found (by mass)
    • Gypsum, wallboard, drywall and plaster
  • Fine aggregate
    • Up to 2.9% of contamination
    • Up to 12.1% of soft RCM
Possible Causes: RCM

• Chemical Test
  • Highly expansive sulphate minerals (thaumasite and ettringite) found up to 18% (by mass)
  • Gypsum found up to 5% (by mass)
  • Sulphate Concentration (risk of expansion)
    • Low Risk: \( \leq 3000 \, \mu g/g \)
    • Moderate Risk: between 3000 and \( \leq 8000 \, \mu g/g \)
    • High Risk: \( > 8000 \, \mu g/g \)
### Possible Causes: RCM

<table>
<thead>
<tr>
<th>Sample Location</th>
<th>sulphate Concentration (µg/g)</th>
<th>Risk of Heave</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade</td>
<td>&lt;100</td>
<td>Nil/Low</td>
</tr>
<tr>
<td>Shoulder Sample 1</td>
<td><strong>19,900</strong></td>
<td>High</td>
</tr>
<tr>
<td>Shoulder Sample 2</td>
<td><strong>19,700</strong></td>
<td>High</td>
</tr>
<tr>
<td>Shoulder Sample 3</td>
<td><strong>20,100</strong></td>
<td>High</td>
</tr>
<tr>
<td>Shoulder Sample 4</td>
<td><strong>20,000</strong></td>
<td>High</td>
</tr>
<tr>
<td>Shoulder Sample 5</td>
<td>7,600</td>
<td>Moderate</td>
</tr>
<tr>
<td>Road Sample 1</td>
<td>740</td>
<td>Low</td>
</tr>
<tr>
<td>Road Sample 2</td>
<td>680</td>
<td>Low</td>
</tr>
</tbody>
</table>

Low Risk: ≤ 3000 µg/g    Moderate Risk: between 3000 and ≤ 8000 µg/g    High Risk: > 8000 µg/g
### Possible Causes: RCM

Sampling from 2 other sources

<table>
<thead>
<tr>
<th>Sample Source</th>
<th>Sulphate Concentration (µg/g)</th>
<th>Risk of Heave</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCM in 427 shoulder</td>
<td>7,600 to 20,100</td>
<td>Moderate to High</td>
</tr>
<tr>
<td>RCM under 427 pavement</td>
<td>680 to 740</td>
<td>Low</td>
</tr>
<tr>
<td>RCM (Contract A)</td>
<td>5,770</td>
<td>Moderate</td>
</tr>
<tr>
<td>RCM (Contract B)</td>
<td>1,970</td>
<td>Low</td>
</tr>
</tbody>
</table>
Possible Causes: RCM

Simulation using RCM from

Samples from 427 (already expanded)

Samples from Contractors A & B
Conclusion

We theorize that the key factor causing pavement and shoulder problems is the deleterious material in the RCM
What do we think may have happened?

- RCM contained high volumes of deleterious materials
  - Gypsum, wallboard, drywall and plaster

- When crushed, deleterious materials become fine aggregate falling below 4.75mm sieve
  - OPSS 1010 (Nov. 2003) only had test for coarse aggregate (above 4.75mm sieve) and by mass
What do we think may have happened?

- When deleterious materials sit in water and in contact with cement
  - Material can expand up to 2.5x of its original size
How do we prevent this in the future?

• OPSS MUNI 1010 (Nov. 2013)
  • Does not address the potential expansive deleterious materials

• York Region created specifications when using RCM:
  • Supplier to certify no building construction and demolition waste materials
    • Drywall or gypsum
  • Petrographic Analysis
  • *Chemical Analysis*
What is the industry doing about this?

• Aggregate Recycling Ontario (ARO)
  • Developing new Best Practices Guide and Quality Plan requirements
  • Considering the development of aggregate facility certification program

• Contact
  • Brian Messerschmidt
  • (705) 927-3247
  • brian.messerschmidt@sympatico.ca
  • http://aggregaterecyclingontario.ca
Final Thoughts

• York Region continues to strongly promote the use of recycled materials and uses RCM on its projects

• To help avoid a similar situation in the future:
  • Testing done before material is delivered on site
  • Review material when delivered on site
  • QA/QC sampling
Questions?

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York Region