



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

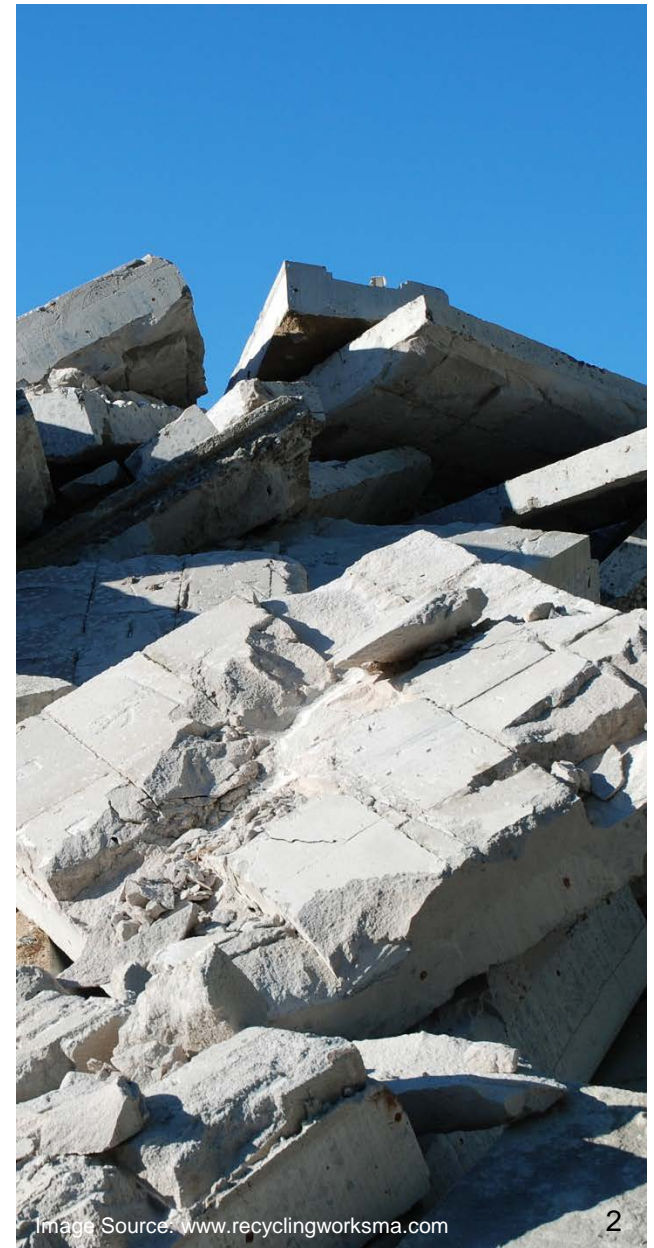
November 18, 2015





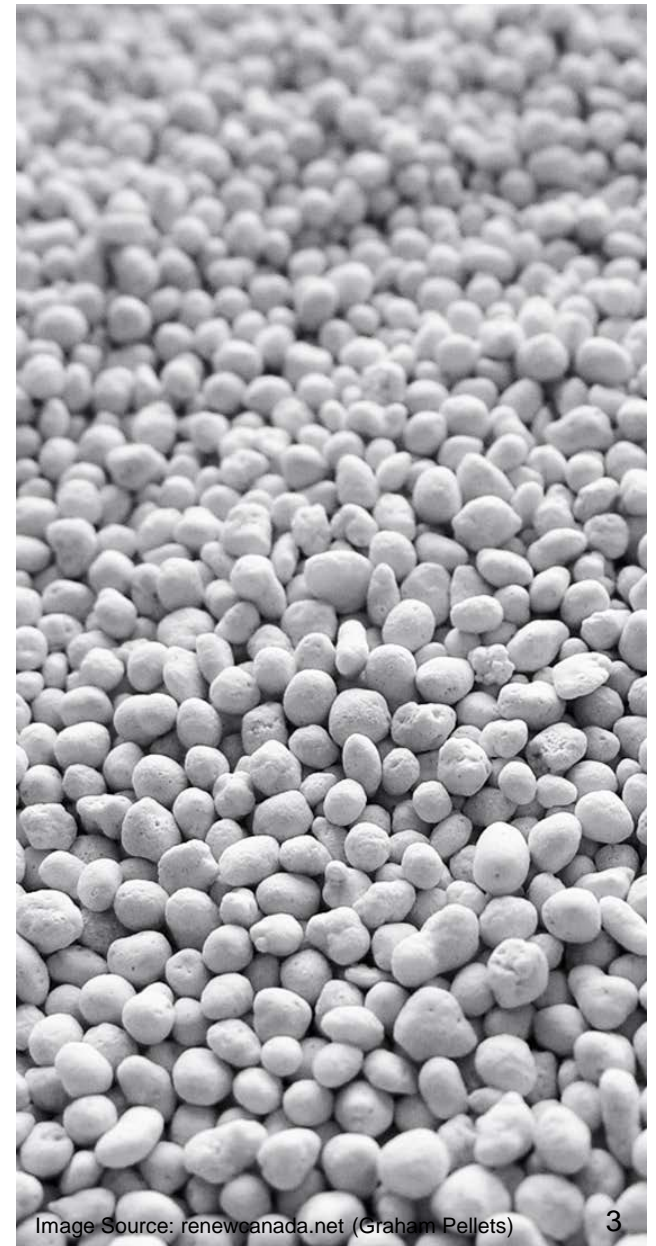
# Introduction

- 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?



# Highway 427 Project Limits





# Problems Encountered



# Problems Encountered





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# Problems Encountered





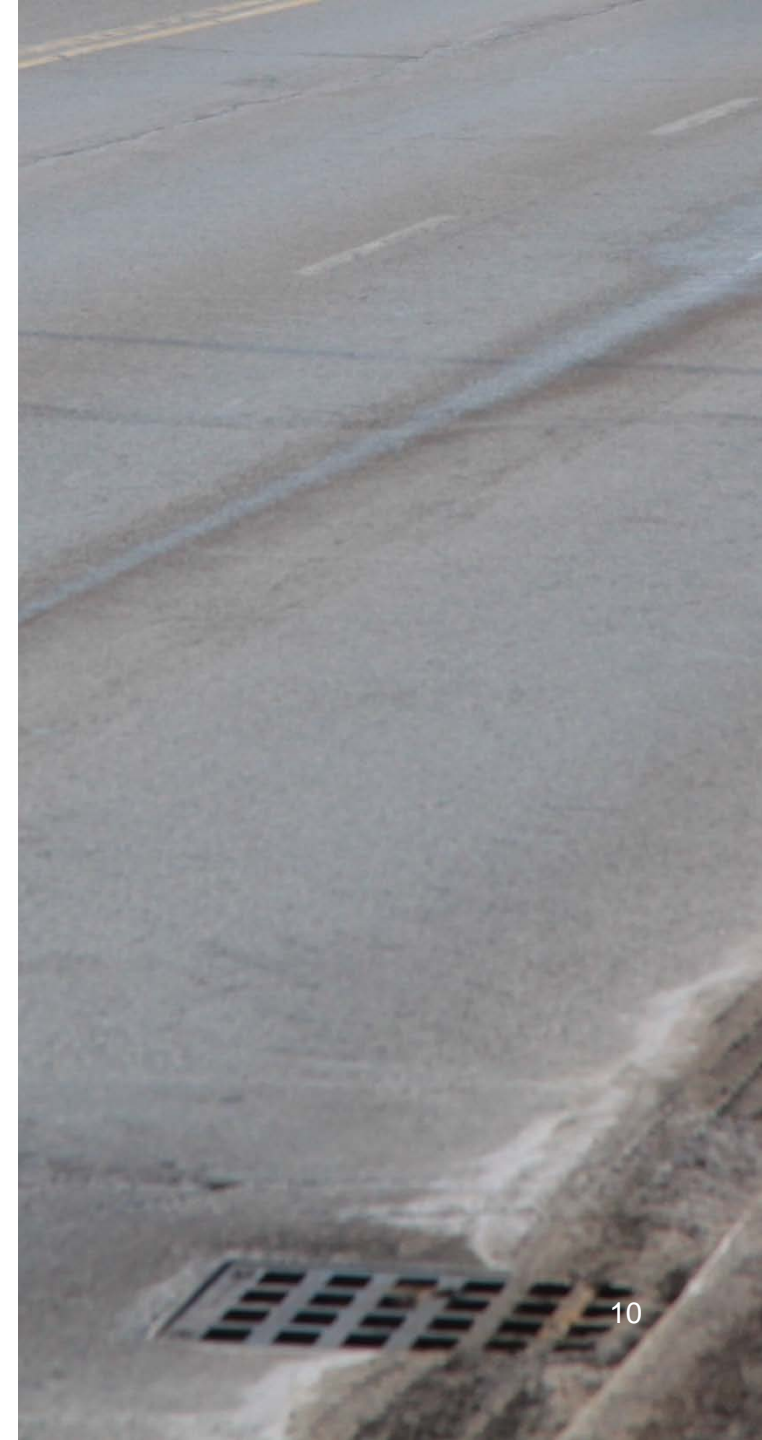
# Possible Causes

- 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

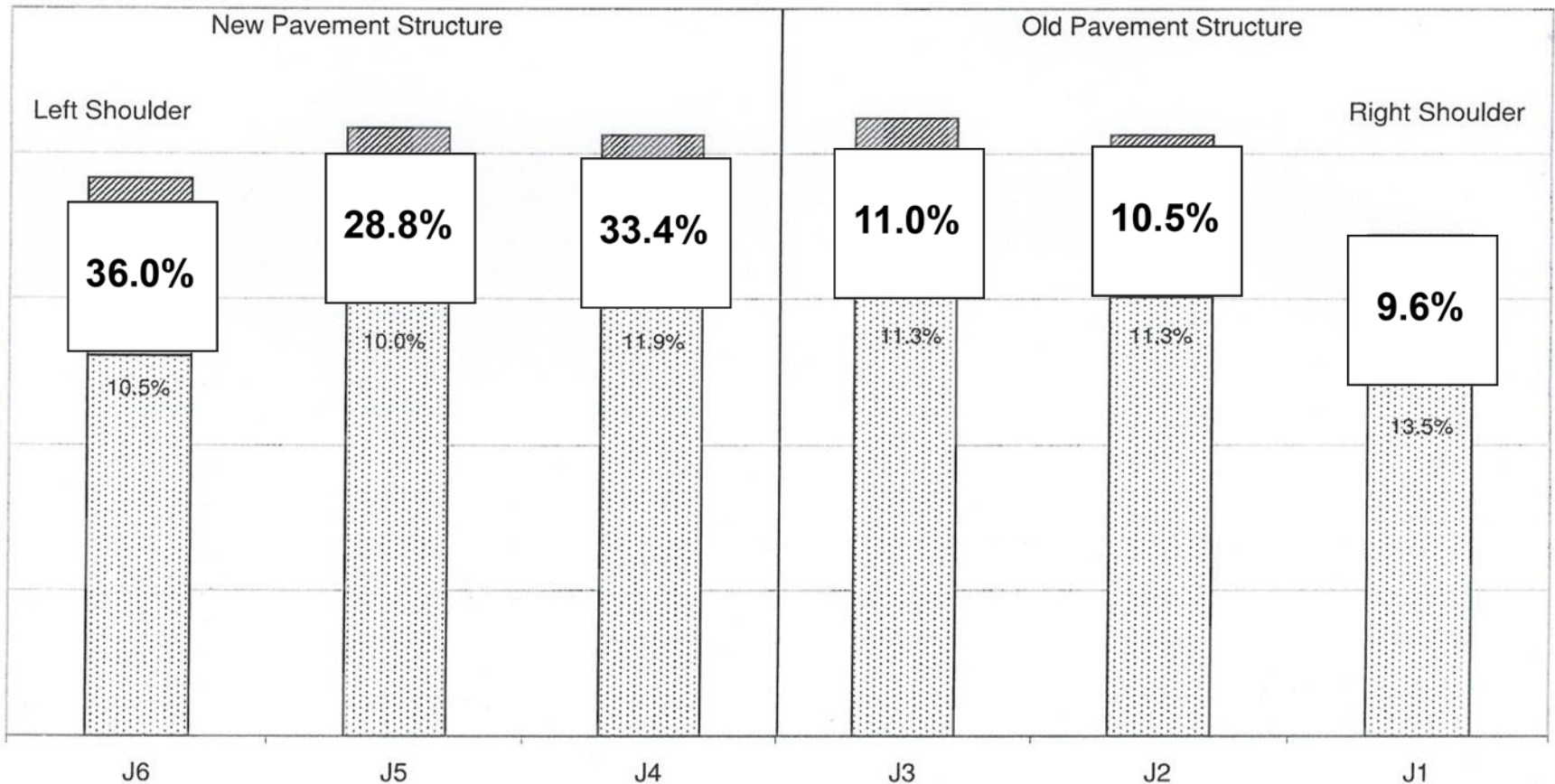
- Moisture Contents
  - New highway constructed adjacent to existing highway that has been in operation for approximately 20 years
  - Expect similar moisture contents



# 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/m<sup>3</sup>
    - 1680 - 1990 kg/m<sup>3</sup>
  - Dry Density
    - Typically ~1950 kg/m<sup>3</sup>
    - 1450 - 1750 kg/m<sup>3</sup>

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:  $\leq 3000 \mu\text{g/g}$
    - Moderate Risk: between 3000 and  $\leq 8000 \mu\text{g/g}$
    - High Risk:  $> 8000 \mu\text{g/g}$

# Possible Causes: RCM

Sample Location	Sulphate Concentration (µg/g)	Risk of Heave
Subgrade	<100	Nil/Low
Shoulder Sample 1	<b>19,900</b>	<b>High</b>
Shoulder Sample 2	<b>19,700</b>	<b>High</b>
Shoulder Sample 3	<b>20,100</b>	<b>High</b>
Shoulder Sample 4	<b>20,000</b>	<b>High</b>
Shoulder Sample 5	7,600	Moderate
Road Sample 1	740	Low
Road Sample 2	680	Low

Low Risk:  $\leq 3000$  µg/g

Moderate Risk: between 3000 and  $\leq 8000$  µg/g

High Risk:  $> 8000$  µg/g



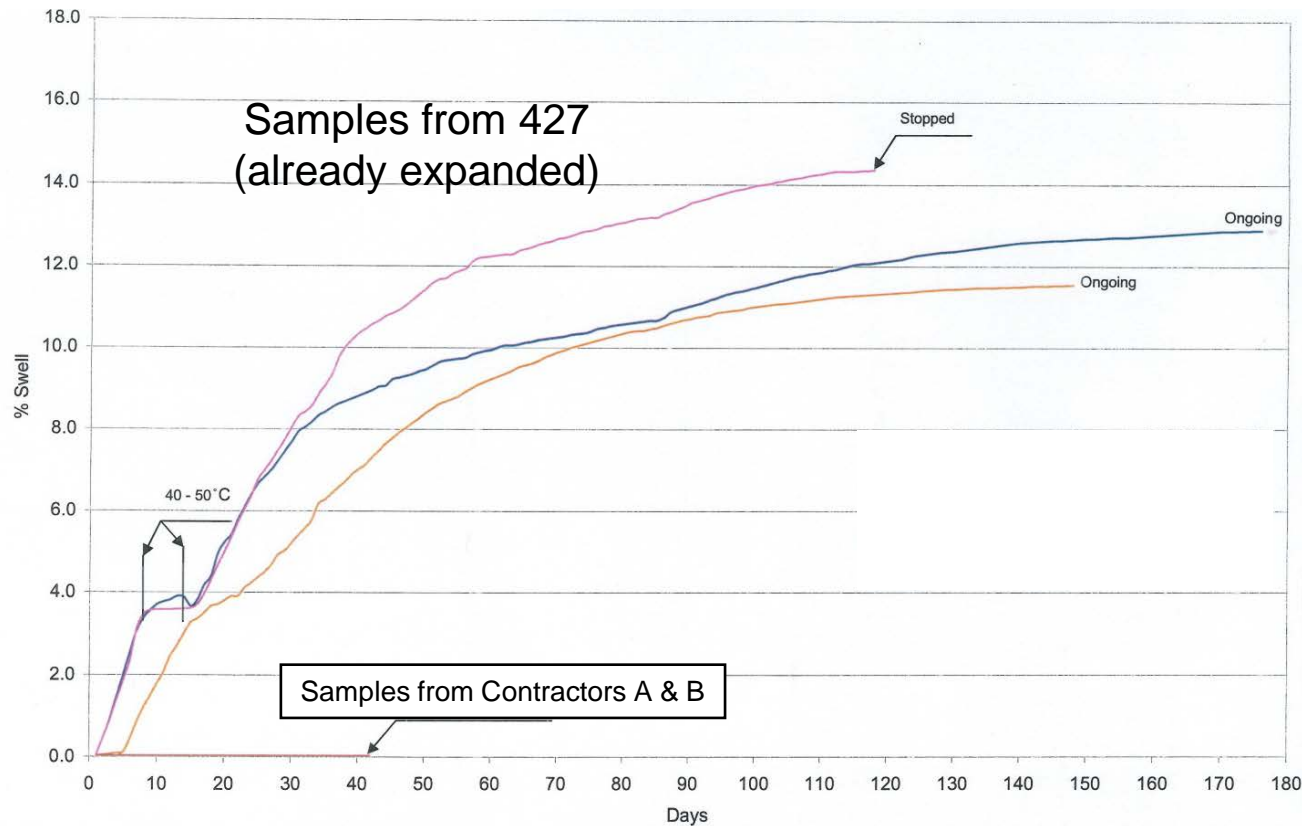
# Possible Causes: RCM

## Sampling from 2 other sources

Sample Source	Sulphate Concentration (µg/g)	Risk of Heave
RCM in 427 shoulder	<b><i>7,600 to 20,100</i></b>	<b><i>Moderate to High</i></b>
RCM under 427 pavement	680 to 740	Low
RCM (Contract A)	5,770	Moderate
RCM (Contract B)	1,970	Low

# Possible Causes: RCM

## Simulation using RCM from



# 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](mailto: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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