Road Salting on Parking Lots: Permeable Pavement vs. Conventional Asphalt

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Executive Summary

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Road Salting in Canada

- Excessive Road Salting in Ontario, Canada
  - Every year over 5 million tons of road salt were used in Canada (Environment Canada, 2012);
  - Excessive road salting on parking lots and pedestrian walkways.

Source: http://saveourstream.blogspot.ca/2011_03_01_archive.html
Winter Road Salting: Cause for Concern

- Damage to downstream groundwater ecosystems and human health;
- Road salt accumulates in urban areas: Cl\(^-\) in urban rivers exceed 100 mg/L;
- Road salts cannot be effectively removed by stormwater management controls, such as SWMM ponds.
Permeable Pavement & Road Salt

- Permeable Pavement (PP) is promoted as an alternative to mitigate negative effects of road salts during winter seasons.
  - Frost resistance;
  - Buffering effects to slow down road salt release;
  - Potential to reduce road salt application rate (Roseen, 2014).
Objective

- The purpose of the research is to evaluate the winter performance on permeable and impermeable pavements on Lake Street Parking Lot, St. Catharines over 2 years.

- This presentation will present the following data collected throughout 2015/2016 winter:
  - Safety impacts: skid resistances and slipping risks;
  - Environmental impacts to downstream water system
    ➢ Conductivity levels
    ➢ Chloride loading and concentration
Site Description
Methodology

- **Skid Resistance Measurement**
  - ASFT T2GO™ Portable Friction Tester (PFT)

\[
\text{Coefficient of Friction (COF)} = \frac{F_D}{F_N}
\]
Methodology

- **Continuous Cl⁻ /Conductivity & Outflow Discharge Monitoring**
The winter of 2015-16 could end up as one of the warmest winters on record for Canada as a whole as a very strong El Niño persists into the upcoming season.


Results
– Skid Resistance Measurements
Results
– Skid Resistance Measurements

• Skid resistance on PA and PC are significantly lower than ASH surface 20 min, 40 min, and 60 min after salting (p-value < 0.05);
• Required COF value for leveled surfaces designed for pedestrians is 0.5 (Accessibility standard);
• Skid resistance level on ASH and PC were restored to required levels within 60 min.
Results
– Skid Resistance Measurements

- Why Skid Resistance Level on ASH is so high?
  - When snow depth is small, the influence from snow is marginal;
  - Large amount of salt granules were observed on the ASH, while salt granules are embedded in PA and PC surfaces and provide less roughness;

- COF values measured by PFT may not be a good representation of pedestrian safety on winter surfaces:
  - Additional force imposed by operator to maintain constant speed will be falsely interpreted as increased COF;
  - PFT is poorly performance on winter road surfaces with grits and ice, great fluctuation in COF measurement is observed (Bergstrom, 2003).
Results
– Conductivity and Chloride Level Monitoring

- Different EC-Cl\textsuperscript{-} linear fit relationships are developed for high or low conductivity in PA and PC pavement outflows.

**PA**

- $y = 341.72x - 248.33$
- $R^2 = 0.98$
- $y = 130.44x - 59.89$
- $R^2 = 0.92$

**PC**

- $y = 411.39x - 877.75$
- $R^2 = 0.97$
- $y = 24.54x + 230.33$
- $R^2 = 0.033$
Results
– Seasonal Chloride Trend

Chloride Concentration (Winter: Jan 18 to Mar 31)

Date: 18-Jan to 28-Mar

- PC
- PA
- ASH
Results
– Seasonal Chloride Trend

During winter season (January to March):
• Cl⁻ level in PC and PA are only 14% and 21%, respectively, of ASH;
• Cl⁻ level in ASH is very high (> 19000 mg/L);
• Cl⁻ level in PA and PC is around 2000 – 4000 mg/L.
Results
– Seasonal Chloride Trend

Chloride Concentration (Spring-Summer: Apr 1 to Jun 22)
Results
– Seasonal Chloride Trend

Monthly Average Chloride Concentration

After Winter Season (April to June):
• Lower Cl⁻ level are observed in ASH (monthly average Cl⁻ concentration less than 100mg/L in June);
• PA and PC maintain a moderate level of chloride release (average 227 and 292 mg/L).
Results
– Event-based Chloride Trend

![Graph showing event-based chloride trend over time with dates and precipitation depth. The graph includes lines for ASH, PC, and PA, with chloride level (mg/L) on the y-axis and date on the x-axis.]
Results
– Event-based Chloride Trend

March 2\textsuperscript{nd} Salting Event:
• Rapid respond in ASH system: Cl\textsuperscript{-} spiked from 2000 mg/L to over 10000 mg/L
• Delayed release in PC and PA

- Rapid respond in ASH system: Cl\textsuperscript{-} spiked from 2000 mg/L to over 10000 mg/L
- Delayed release in PC and PA
Conclusions

- **Safety Benefits:**
  - ASH Skid resistance was higher than PA and PC immediately after salting.
  - PC and ASH show compatible skid resistance level 60 min after salting.

- **Environmental Benefits:**
  - PA and PC attenuate the Cl⁻ release during winter season, and postpone release until spring and summer.
  - On event-based, buffering effect in PA and PC to slow down the release of dissolved chloride.
Future Plans

- Continuous monitoring going on 2016/17 winter;
- Improve current skid resistance measurement method;
- Chloride mass loading and mass balance calculation will be presented.
References

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Questions?

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Results
– conductivity and Chloride Level Monitoring

Conductivity Level (Jan 18 to Jun 22)

- Precipitation
- PC
- PA
- ASH
Results
– conductivity and Chloride Level Monitoring

\[ y = 296.73x - 49.68 \]
\[ R^2 = 0.83 \]