High albedo surfaces for thermal stabilisation of road embankment built on permafrost

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Introduction

Heat absorbed by dark pavement can increase thaw penetration within a road embankment and can induce instability caused by thaw settlement of the underlying permafrost.
High albedo road surfaces (HAS) can reduce the heat absorbed by the pavement thus increasing stability of the embankment.
Past experiments with HAS have shown that they can efficiently reduce thaw penetration but that they present some technical flaws regarding skid resistance and durability.

Objectives

The main objective of this project is to provide a way to evaluate the relevance of using HAS and especially to:

- **Quantify the effect of a pavement's albedo on its surface temperature**
- **Provide methods to evaluate technical properties of HAS**

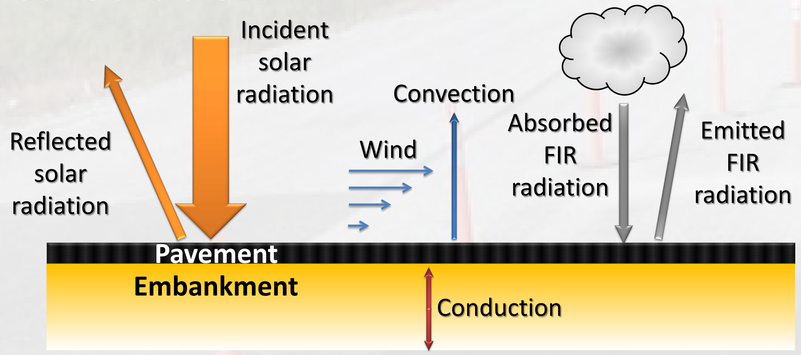
Methodology

Test section in Beaver Creek, Yukon along the Alaska Highway

- Four surfaces with different albedos
  - Bituminous surface treatment using light coloured aggregates
  - Asphalt cold mix
  - Lafrentz (white coating)
  - Nippo (grey coating with high infrared reflection)
- Surface temperatures recorded from august 2012
- Albedo (a) measured using pyranometer (ASTM E1918)

Albedo	Cold mix	L-BST	Nippo	Lafrentz
August 2012	0,04	0,23	0,40	0,60
Mai 2013	0,14	0,23	0,29	0,55

Model for surface temperature calculation



Energy balance at the surface of the pavement

$$0 = q_r + q_c + q_e + q_g$$

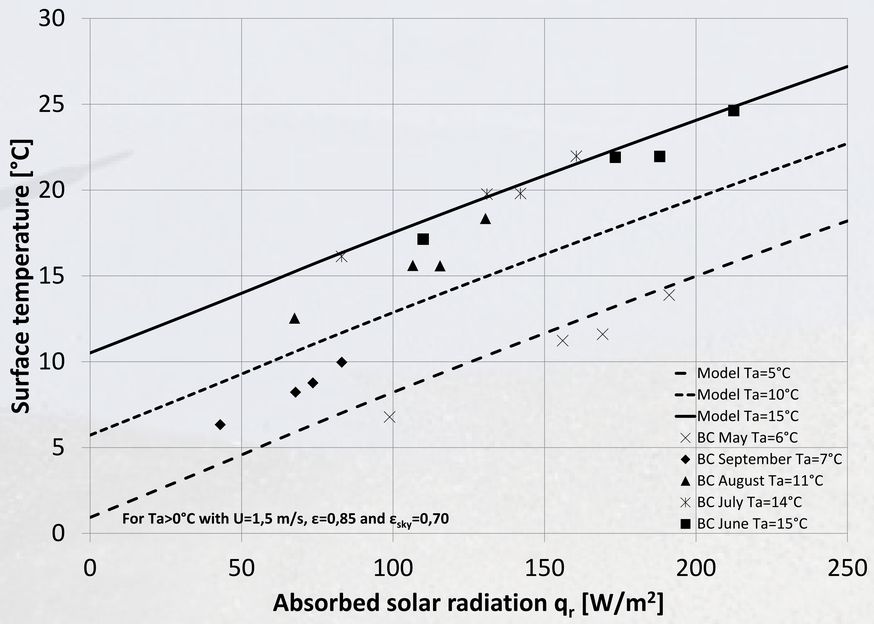
Solar radiation $q_r = (1 - a)q_i$

Convection $q_c = h_c(T_s - T_a)$

FIR radiation $q_e = \sigma\left(\varepsilon_s T_s^4 - \varepsilon_{sky} T_a^4\right)$

Conduction $q_g = -0{,}085 q_{i\_max} sin\left(\frac{(n-2)\pi}{6}\right)$

Monthly average surface temperature



Technical properties of HAS

The following properties and test methods are proposed to evaluate the skid resistance and the durability of HAS.

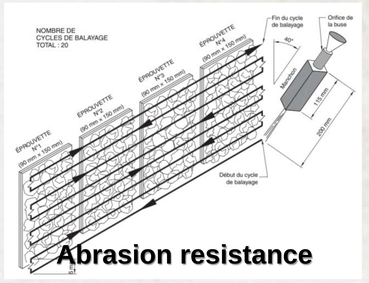
Skid resistance

- **Micro texture**
  - British pendulum
  - ASTM E303
  - Low speed skid resistance
- **Macro texture**
  - Sand patch test
  - ASTM E965
  - High speed skid resistance and water management
  - Provides durability and thermal benefits


Skid resistance evaluation

Durability

- **Samples**
  - High albedo coating applied on asphalt plate
- **Abrasion resistance**
  - Sand blast method
  - Measured mass loss of coating after each cycle
- **Adhesion to substrate**
  - Direct tension test
  - Indicate adhesion force of coating to substrate
- **Resistance to freeze/thaw cycles**
  - ASTM C666
  - Thawing in water at 4°C
  - Freezing in air at -18°C
  - Visual evaluation of degradation




Direct tension test

Conclusion

A model has been developed to predict surface temperature of pavements in function of their albedo based on energy balance at the surface of the pavement. The model has been validated using data from a test section in Beaver Creek, Yukon.
A method to evaluate the technical properties of HAS regarding durability and skid resistance has been proposed.