Assessment of Runway Surface Condition by British Pendulum Testing under the Global Reporting Format Winter Conditions

Jean-Denis Brassard
Anti-Icing Materials International Laboratory, Université du Québec à Chicoutimi, Canada

UQAC AMIL

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Outline

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3. Research project
4. Introduction
5. Methodology
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7. Acknowledgment
8. Conclusions

Self-presentation

- Research professor at AMIL since 2018
- Chair of the G12 Runway de-icing product Performance working group
- Co-Chair of the G12 Runway de-icing product

What is AMIL? Anti-icing Materials International Laboratory

EXPERTS IN ICING AND COLD REGIONS ENGINEERING

MISSION
Support industries in solving problematic related to cold climates and icing while training highly qualified personnel through world-class research and development projects.

The following is a non-exhaustive list of activities offered by the laboratory:

- Realisation of small-to-large R&D projects involving or not graduate students of all levels
- Development and testing of de-icing and anti-icing systems
- Development of experimental setups and procedures representative of cold climates and icing conditions
- Simulation of snow and ice accumulations
- Characterisation of the physical properties of ice, ice adhesion and icephobic materials.
- Application and development of testing standards (ASTM, SAE, ISO, etc.)
- Applications for collaborative project grants (NSERC, CRIAQ, PRIMA, MITACS, etc.)

Research Team

Gelareh Momen, P.eng. Ph.D.
Scientific Director
Cold region engineering, icephobic coatings and innovative materials

Jean-Denis Brassard, P.eng. Ph.D.
Atmospheric icing, airport runways, cold climate operations, ground icing, de-icing and anti-icing of structures, material characterisation.

Derek Harvey, P.eng. Ph.D.
Material characterisation and system testing, design of ice protection systems, numerical simulation and optimization, advanced composite materials.

Eric Villeneuve, P.eng. Ph.D.
In-flight and ground icing, aircraft de-icing and anti-icing, aerodynamics, vibration, heat transfer and numerical simulation.

Caroline Blackburn, P.eng.
Icing of structures, ice adhesion, characterization of icephobicity, project and quality management.

Marc Mario Tremblay, chemist
Characterisation of anti-icing and de-icing materials for aircraft and runways.

RESEARCH INFRASTRUCTURE AND CAPABILITIES

Five cold chambers

- 3 m to 9 m high
- Temperature control range of +10ºC and -40ºC
- Controlled simulation of precipitations:
  - Freezing rain
  - Snow
  - Freezing fog
  - Freezing drizzle
  - Sea spray

Two refrigerated, closed loop, wind tunnels

- Qualification of aircraft ground de/anti-icing fluids
- Simulation of in-flight icing conditions at temperatures as low as -40ºC and wind speeds up to 110 m/s

Laboratory testing

- Evaluation of specialized products for aircraft and airport runways
- Characterization of icephobic materials
- Measurement of ice adhesion strength
- Evaluation of the mechanical properties of ice
- Rain erosion testing

Exterior winter testing

- Product testing in natural snowing conditions
- Validation of de-icing and anti-icing in natural conditions
- Observation and documentation of winter precipitations

A research project for Airports winter maintenance operation optimization

PROBLEMATIC

- Yearly, tons of products are use to de-ice and anti-ice
- Products have effects on both environment and corrosion.

PROJECT OBJECTIVES

- To optimize the winter operations of airport
  - Evaluating the performances
  - Determining the spreading rates
  - Deepen the understanding the runway de-icing products

8 students involved : 4 B.eng, 2 master and 2 doctoral

Year 2 out of 3 of the project

Introduction

- Snowstorms and ice storms impair northern airports
- It results in poor braking performance on runway
- Between 2010 and 2019 : 15.5% of all the accidents

Introduction (continued)

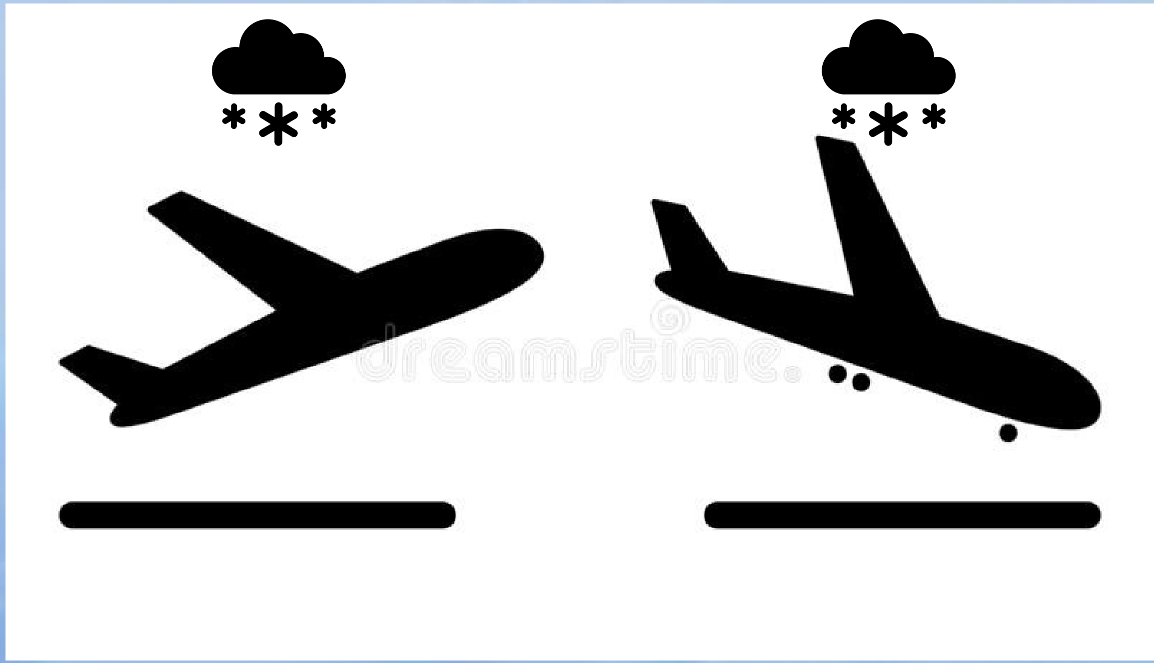
- A slight deposit of snow or a small coating of ice render the runway slippery and unsafe.
- Just in 2019 it costs more then 4B$ to the industry

Winter Runway Maintenance Operations

Mechanical

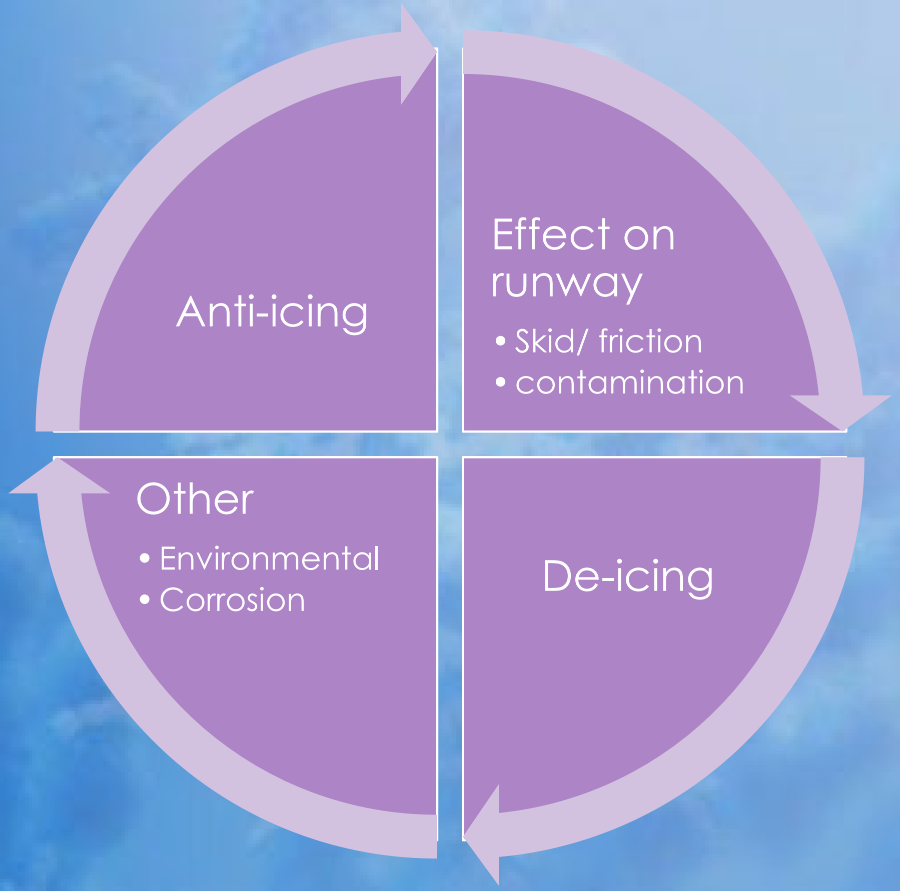
Chemical : Solid and liquid RDP

Sanding



Runway De-icing Product Performance

BASED ON OUR EXPERIENCE



SKID/friction

- Classification of the ASTM
  - (i) fixed tests
  - (ii) braking tests
  - (iii) contact tests and
  - (iv) Non-contact tests

Thomas J. Yager et al. 2013

Contamination

- Transport Canada
  - Advisory Circular (AC) No. 300-019
- Global Report Format
- Runway Condition Assessment Matrix
- Runway condition code

Assessment Criteria		Downgrade Assessment Criteria (Control/Braking Assessment Criteria)		
Runway Surface Description	**RWYCC**	**CRFI Range**	**Vehicle Deceleration or Directional Control Observation**	**Pilot Braking Action**
• DRY	6		-	-
• FROST • WET (The runway surface is covered by any visible dampness or water up to and including 1/8 inch (3 mm) depth) **Up to and including 1/8 inch (3 mm) depth:** • SLUSH • DRY SNOW • WET SNOW	5	0.40 or higher	Braking deceleration is normal for the wheel braking applied AND directional control is normal	GOOD
-15°C and Colder outside air temperature: • COMPACTED SNOW	4	0.39 to 0.35	Braking deceleration OR directional control is between Good and Medium	GOOD TO MEDIUM
• SLIPPERY (WHEN) WET (wet runway) • DRY SNOW or WET SNOW (Any depth) ON TOP OF COMPACTED SNOW **Greater than 1/8 inch (3 mm) depth:** • DRY SNOW • WET SNOW **Warmer than -15°C outside air temperature:** • COMPACTED SNOW	3	0.34 to 0.30	Braking deceleration is noticeably reduced for the wheel braking effort applied OR directional control is noticeably reduced	MEDIUM
Greater than 1/8 inch (3 mm) depth: • STANDING WATER • SLUSH	2	0.29 to 0.20	Braking deceleration OR directional control is between Medium and Poor	MEDIUM TO POOR
• ICE	1	0.19 or lower	Braking deceleration is significantly reduced for the wheel braking effort applied OR directional control is significantly reduced	POOR
• WET ICE • SLUSH ON TOP OF ICE • WATER ON TOP OF COMPACTED SNOW • DRY SNOW or WET SNOW ON TOP OF ICE	0		Braking deceleration is minimal to non-existent for the wheel braking effort applied OR directional control is uncertain	LESS THAN POOR / NIL

The aim of this research…

- The main descriptions of winter conditions are directly obtained from this matrix, allowing them to be reproduced under controlled laboratory conditions.
- There is no standardized methodology for evaluation
- The goals of this work are:
  - (i) to reproduce in the laboratory the above-mentioned winter conditions and
  - (ii) to assess their impact on the runway surface conditions using the British Pendulum Tester.
  - (iii) to test it with RDP

Methodology

- Substrate
- Contaminations
- Measurements

Substrates

› Runway vs commercial concrete block

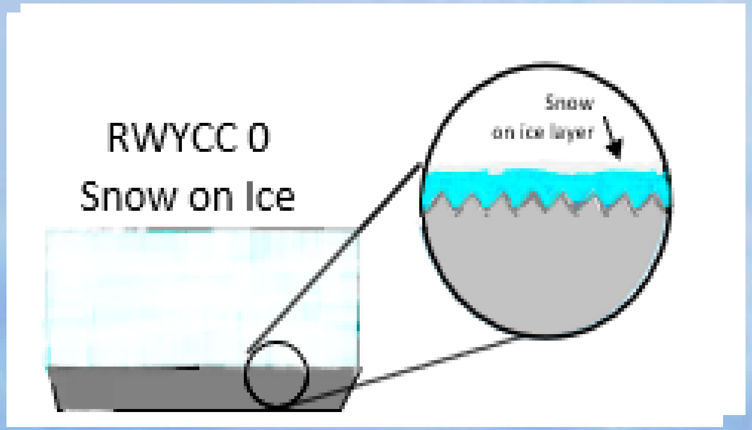
During previous studies, several substrates were evaluated in the same conditions and we determined that this commercial concrete pavement :

Provides the more repetitive result

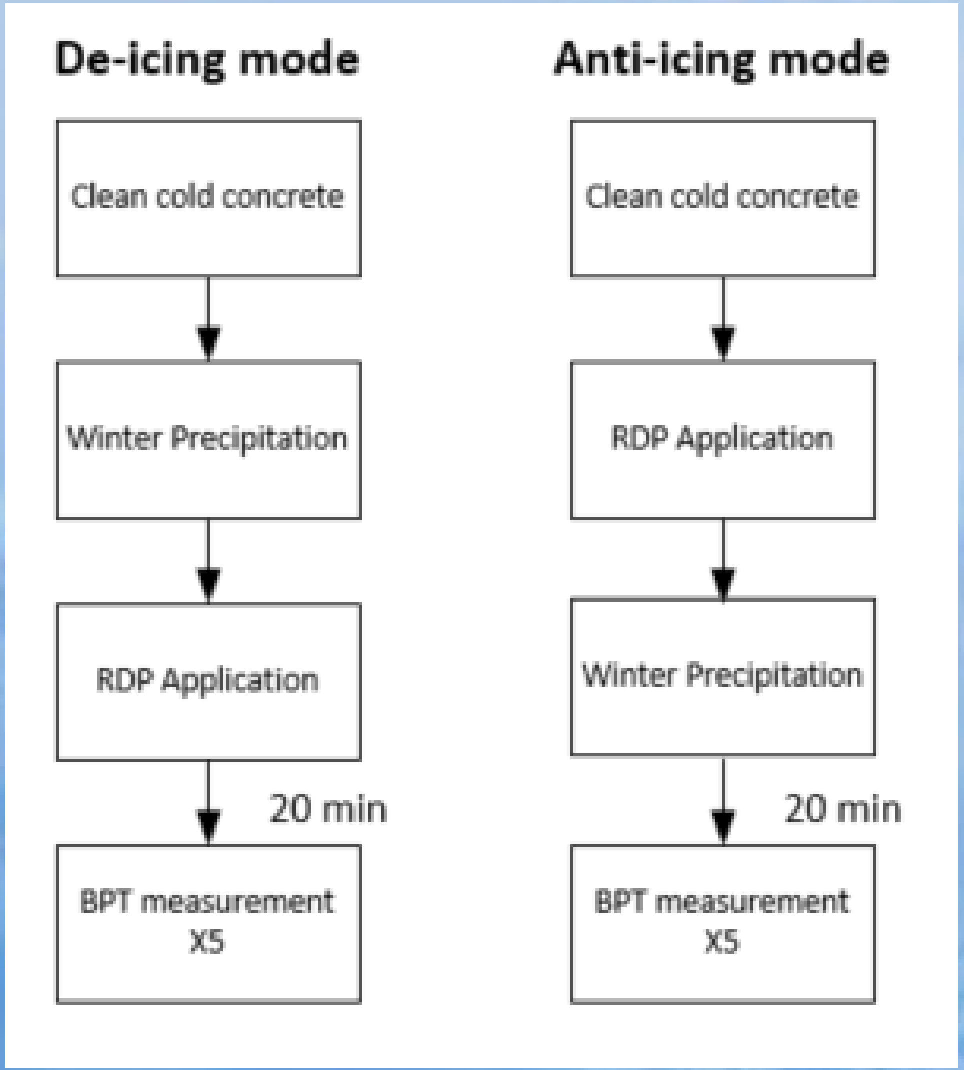
Gives similar results to the actual runway concrete :

- Porosity
- Skid resistance
- Icing

Substrates contamination preparation



De-icing and anti-icing protocols



SKID MEASUREMENT

Following ASTM E303

British Pendulum Tester

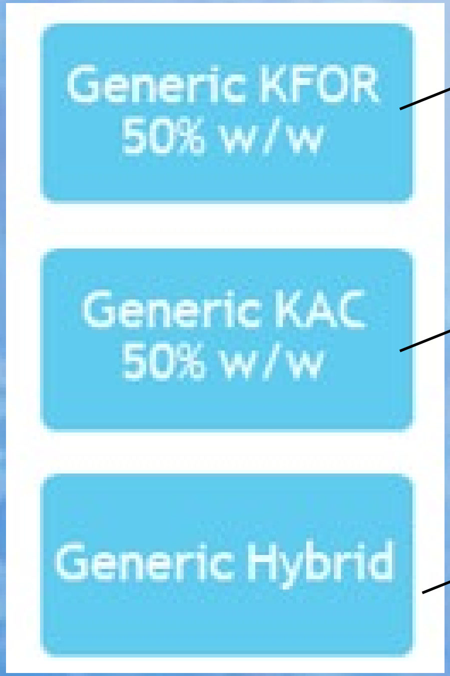
Result is BPN: British Pendulum number

The higher is the number, the best is the surface

5 measurements per condition,

RDP used during the experiment

In the pure form : no corrosion inhibitor or additives

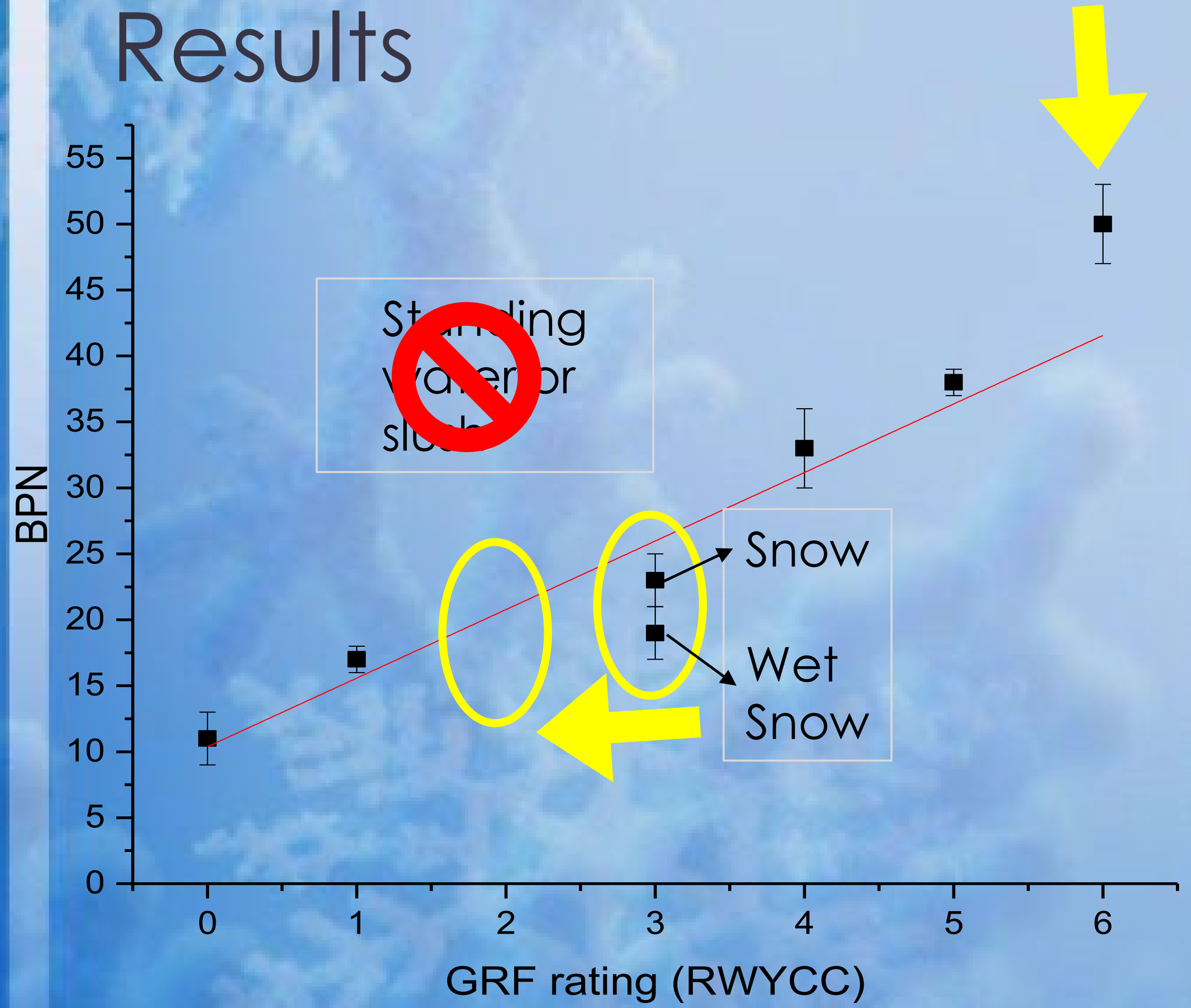


Potassium Formate

Potassium Acetate

Potassium Acetate + Ethylene Glycol

Results



- BPN correlated well with GRF and RWYCC
- Linear relationship with an intercept forced at 11 give a R^2 of 0.93

GRF vs BPN vs CRFI

$$\mu = \frac{3BPN}{(330 - BPN)}$$

Assessment Criteria		Downgrade Assessment Criteria (Control/Braking Assessment Criteria)		
Runway Surface Description	RWYCC	CRFI Range	Vehicle Deceleration or Directional Control Observation	Pilot Braking Action
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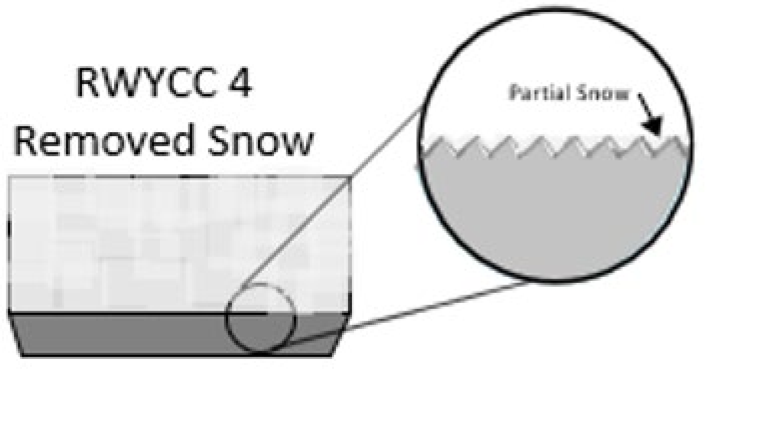
Condition	RWYCC	BPN	Corresponding coefficient of friction	CRFI Range	In the range (<10%)
Dry	6	50	0.54	>0.4	yes
Wet with water	5	38	0.39	>0.4	yes (3%)
Removed snow	4	33	0.33	0.35 - 0.39	yes (6%)
Snow	3	23	0.22	0.30 - 0.34	no (27%)
Wet snow	3	19	0.18	0.30 - 0.34	no (40%)
Ice	1	17	0.16	< 0.19	yes
Snow on ice	0	11	0.10	< 0.19	yes

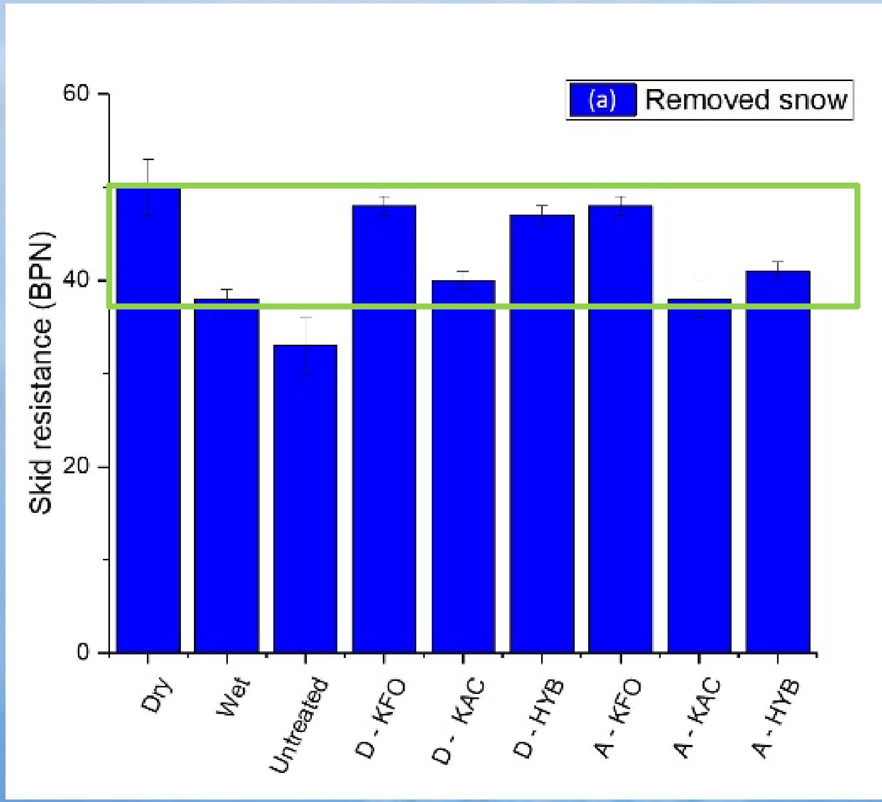
Sabey et al. 1964

Assessing the impact of RDP under those conditions…

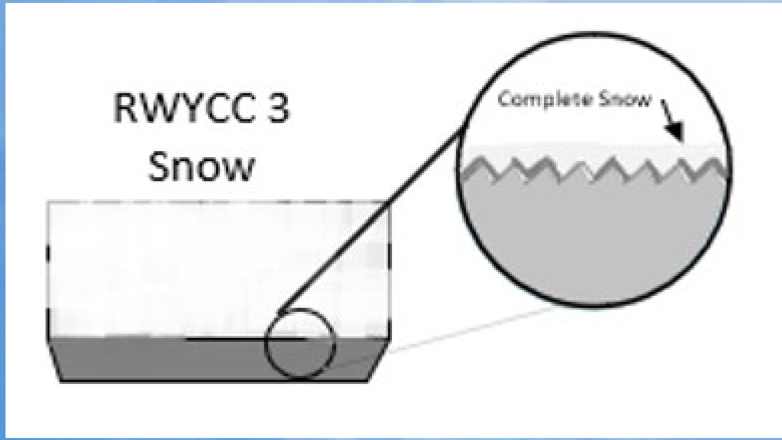
Anti-icing VS De-icing

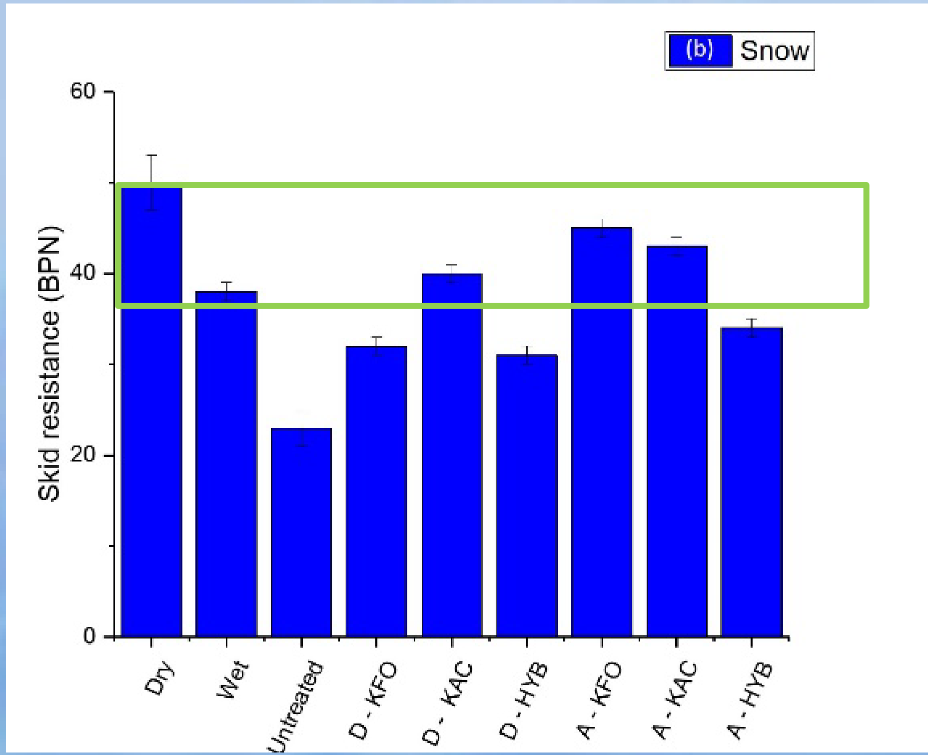


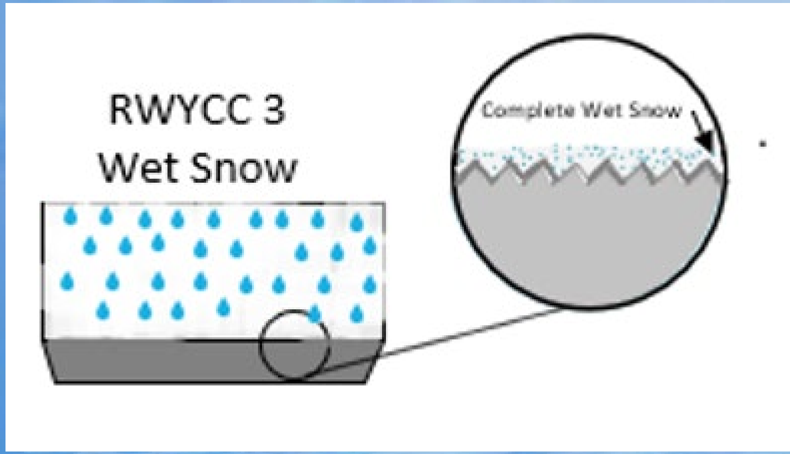
RWYCC 4
Removed Snow
Partial Snow

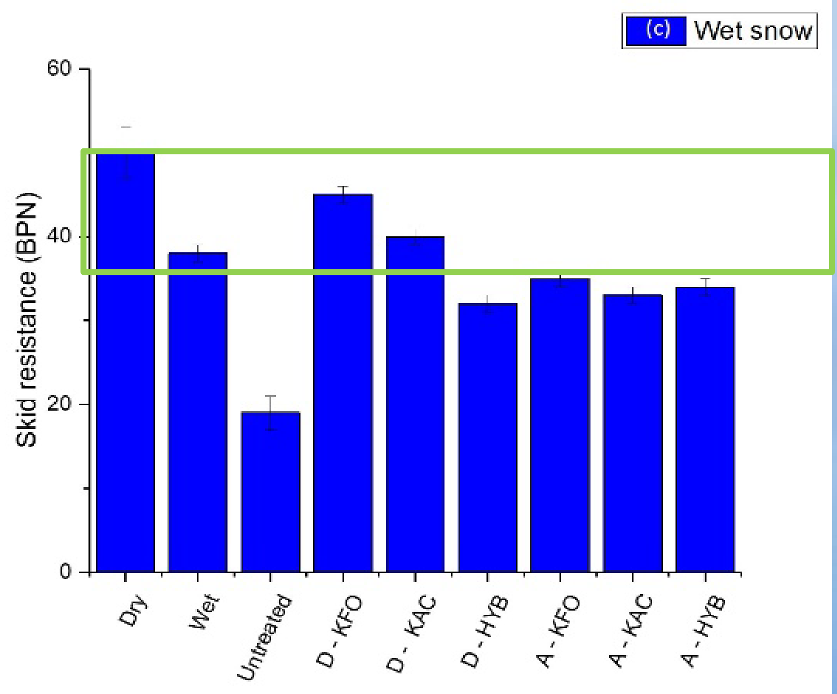


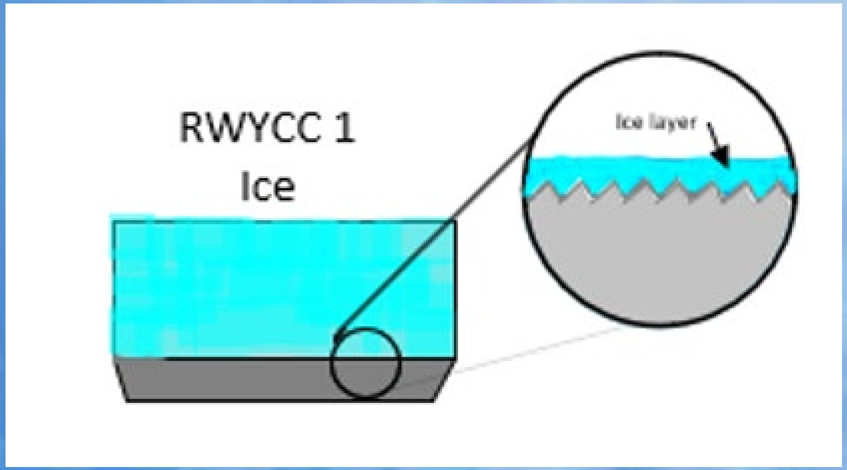
(a) Removed snow
Skid resistance (BPN)
0
20
40
60
Dry
Wet
Untreated
D - KFO
D - KAC
D - HYB
A - KFO
A - KAC
A - HYB

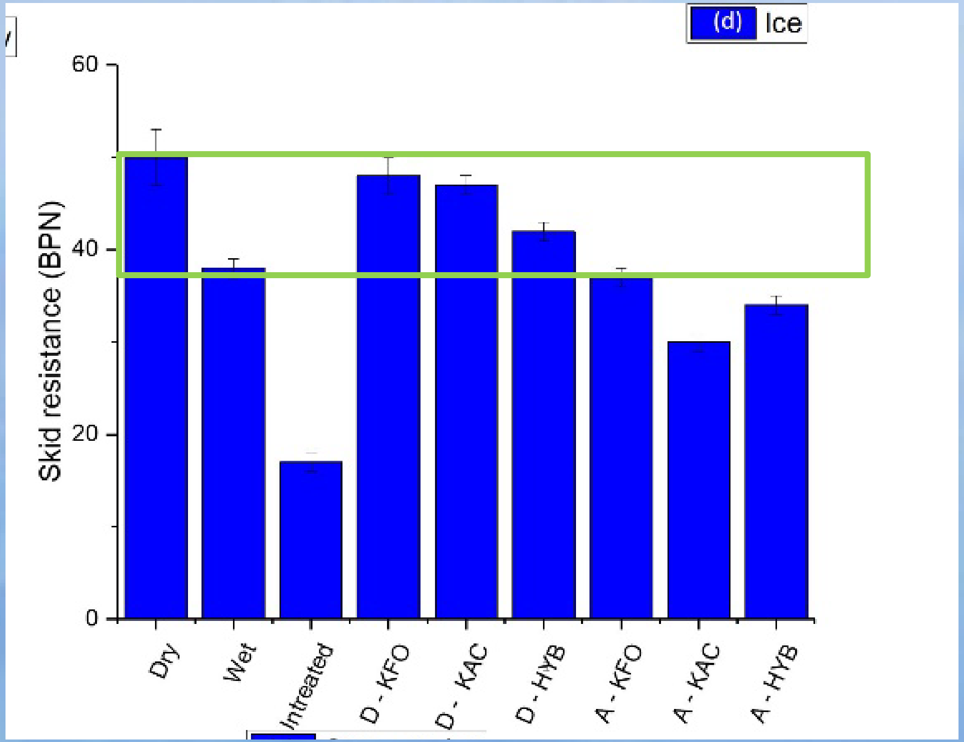

RWYCC 3
Snow
Complete Snow

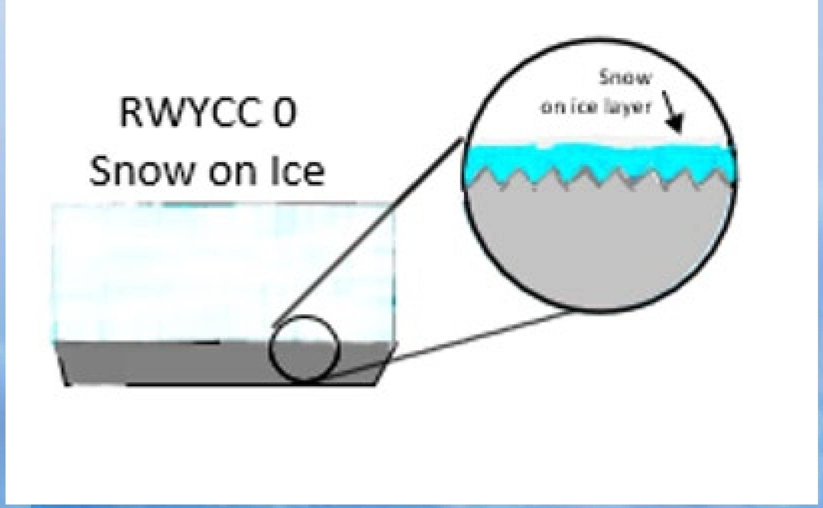

(b) Snow
Skid resistance (BPN)
0
20
40
60
Dry
Wet
Untreated
D - KFO
D - KAC
D - HYB
A - KFO
A - KAC
A - HYB

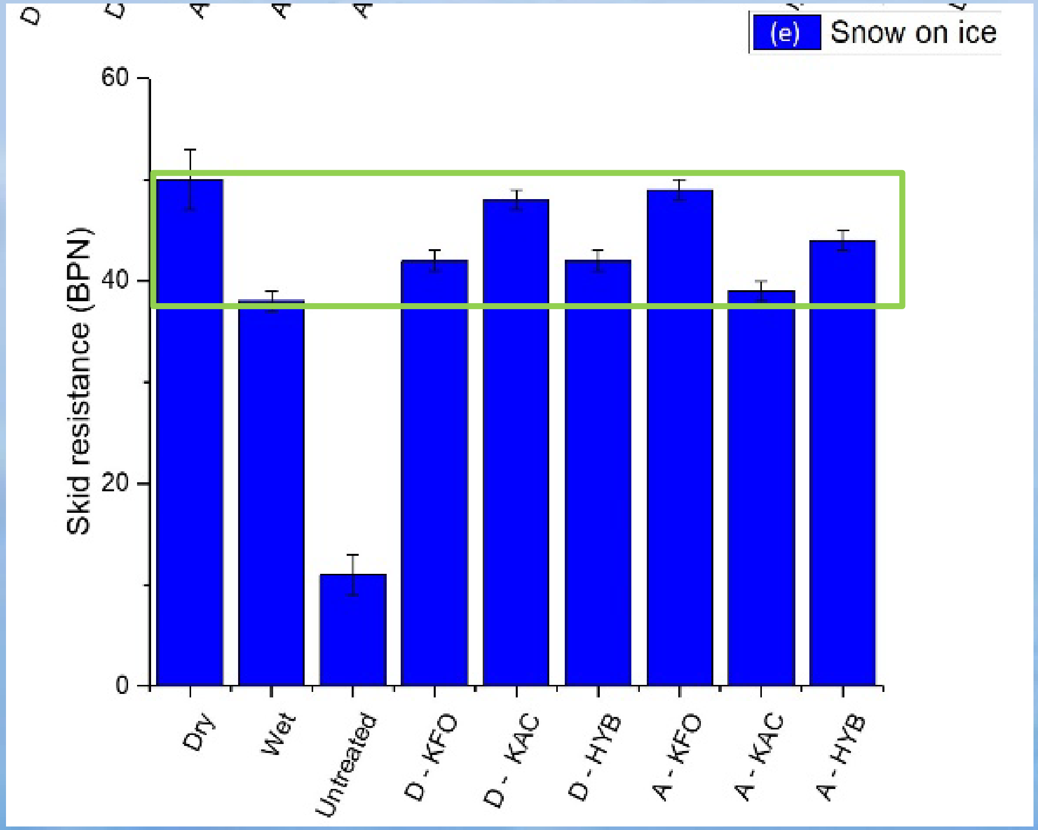

RWYCC 3
Wet Snow
Complete Wet Snow


(c) Wet snow
Skid resistance (BPN)
0
20
40
60
Dry
Wet
Untreated
D - KFO
D - KAC
D - HYB
A - KFO
A - KAC
A - HYB


RWYCC 1
Ice
Ice layer


(d) Ice
Skid resistance (BPN)
60
40
20
0
Dry
Wet
Untreated
D - KFO
D - KAC
D - HYB
A - KFO
A - KAC
A - HYB


RWYCC 0
Snow on Ice
Snow
on ice layer


(e) Snow on ice
Skid resistance (BPN)
60
40
20
0
Dry
Wet
Untreated
D - KFO
D - KAC
D - HYB
A - KFO
A - KAC
A - HYB

Conclusions

- The reproduction of the GRF winter conditions were possible in the laboratory.
- The results obtained using the British Pendulum Tester correlated well with RWYCC ratings.
- The proposed testing conditions can be used to evaluate the impact of the different winter chemical treated used during the winter operation, especially in airports.
- It will also help to establish minimal requirements following the needs of the airport’s operators.

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Questions

Jean-denis1_brassard@uqac.ca