Performance of an Alternative Deicer with Invasive Starfish Extract Additive

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ARTEL

Carleton University

Carleton University

Established: 1942
Located in: Ottawa, Canada
Students: 31,000
Faculties and staff: 4700
Ranking: Among Top 5 in comprehensive universities in Canada as per MacLean's 2021 ranking

Project support: Starstech, South Korea
Student: Mitch Lawlor, MASc Student, 2021-2023

Evaluating Performance of Alternative Deicers for Winter Road Maintenance: Deicing and Corrosivity

by

Mitchell Lawlor

A thesis submitted to the Faculty of Graduate and Postdoctoral Affairs in partial fulfillment of the requirements for the degree of

Master of Applied Science

in

Civil Engineering

Carleton University
Ottawa, Ontario

Outline

- Introduction
- Objectives
- Test Overview
  - Ice Melting Test Overview
  - Ice Penetration Test Overview
  - Corrosion Test Overview
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- Conclusions and Recommendations

Introduction

- On average 60 million tons of salt used worldwide annually
- Most common deicers are chloride based
  - Sodium Chloride (Most used)
  - Calcium Chloride
  - Magnesium Chloride
- Benefits
  - Increase transportation efficiency
  - Salted roads reduce accidents by 88.3%
  - Reduce Crashes by 10%
- Drawbacks
  - Environmental Impacts
  - Corrosivity

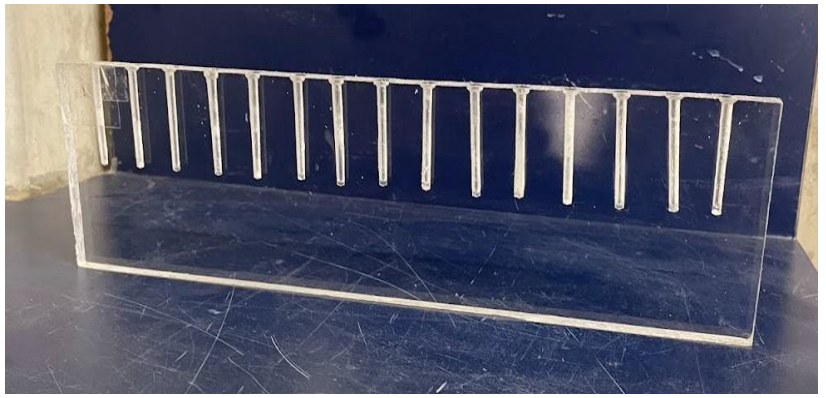
Objectives

- Assess the ice melting capabilities of alternative deicers and compare the results to rock salt
- Assess the ice penetration capabilities of alternative deicers and compare the results to rock salt
- Assess the levels of corrosion that alternative deicers produce in comparison to rock salt
- Determine rock salt's ability to melt snow and ice in a field setting during extreme cold winter conditions

Testing Program

Ice-Melting Capacity Test

Ice Penetration Test



Corrosivity Test

Field Test

Deicing Materials Tested

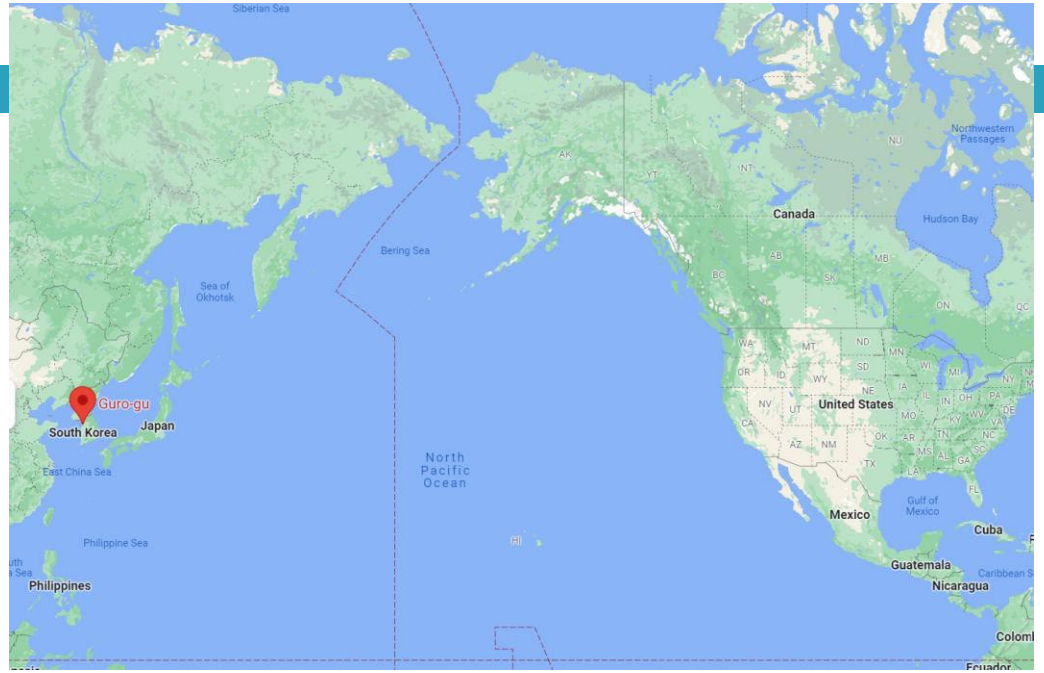
Rock Salt

Organic Melt (FUSHION)

ECO ST

ECO-ST Composition

- Alternative Deicer originated from South Korea
- Utilizes an invasive species of starfish
- Uses a porous structure of calcium carbonate
- Adsorbs chlorine ions
- Minimizes environmental effects and corrosion



Deicer	ECO ST	ECO ST 0.5% Starfish Extract	ECO ST 1% Starfish Extract	ECOST 1.5% Starfish Extract	ECOST 2% Starfish Extract	ECOST 2.5% Starfish Extract	Organic Melt	NaCl
Label	A	B	C	D	E	F	G	H

Starfish Additive

Raw Material

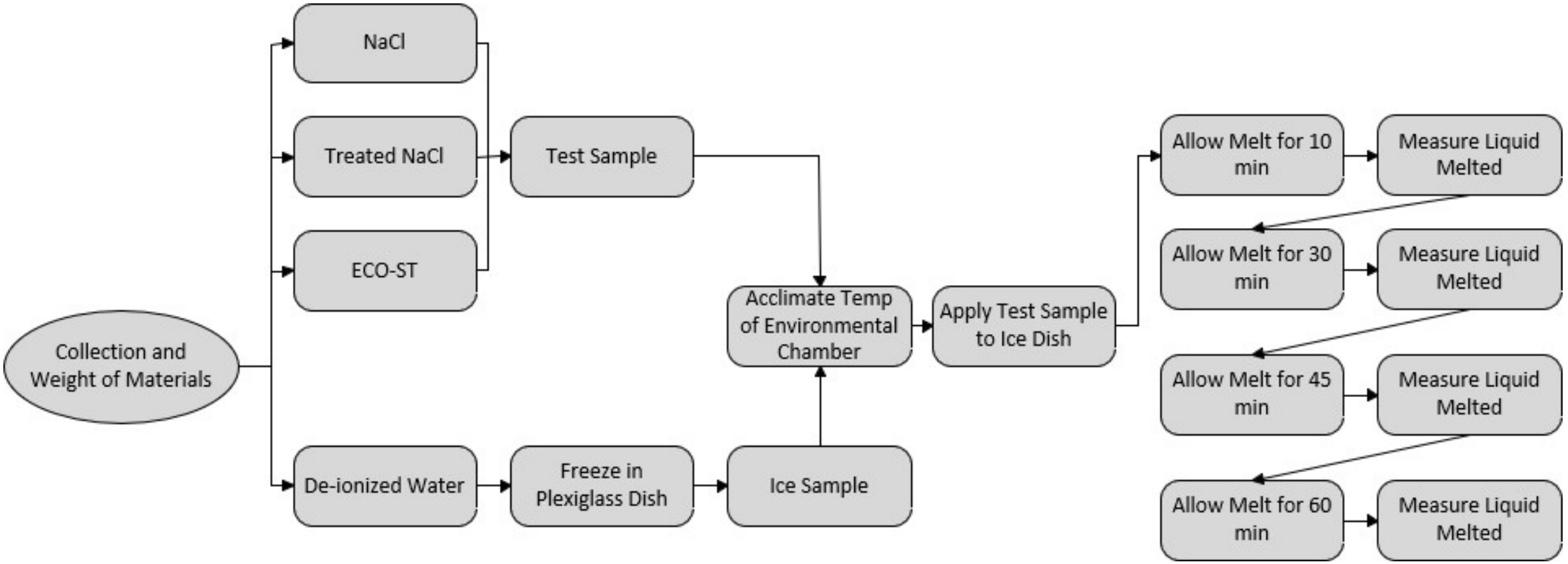
Extract

Final Product

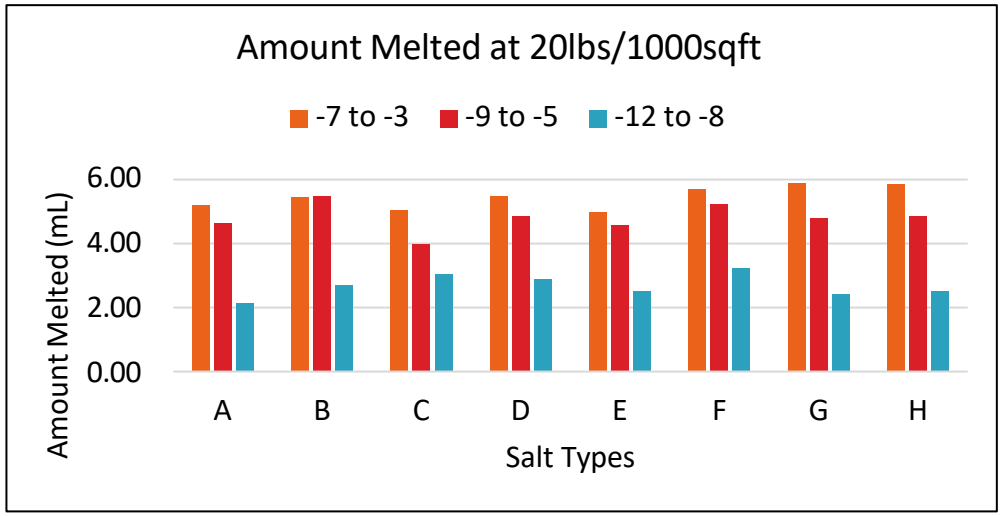
Overview of Ice Melting Tests

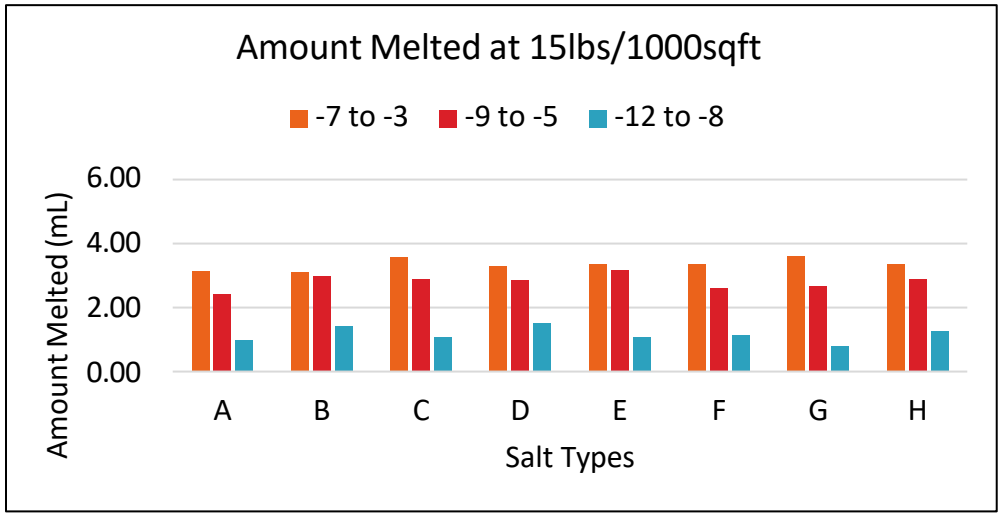
- 8 Type of Deicing Salts
- 168 Samples Tested
- 672 Data Points

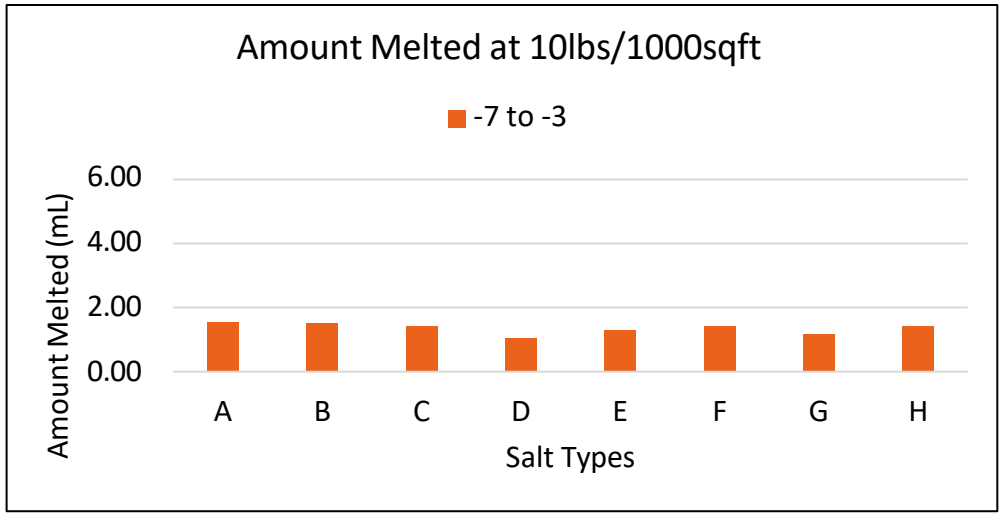
Methodology



Ice Melting Test Results

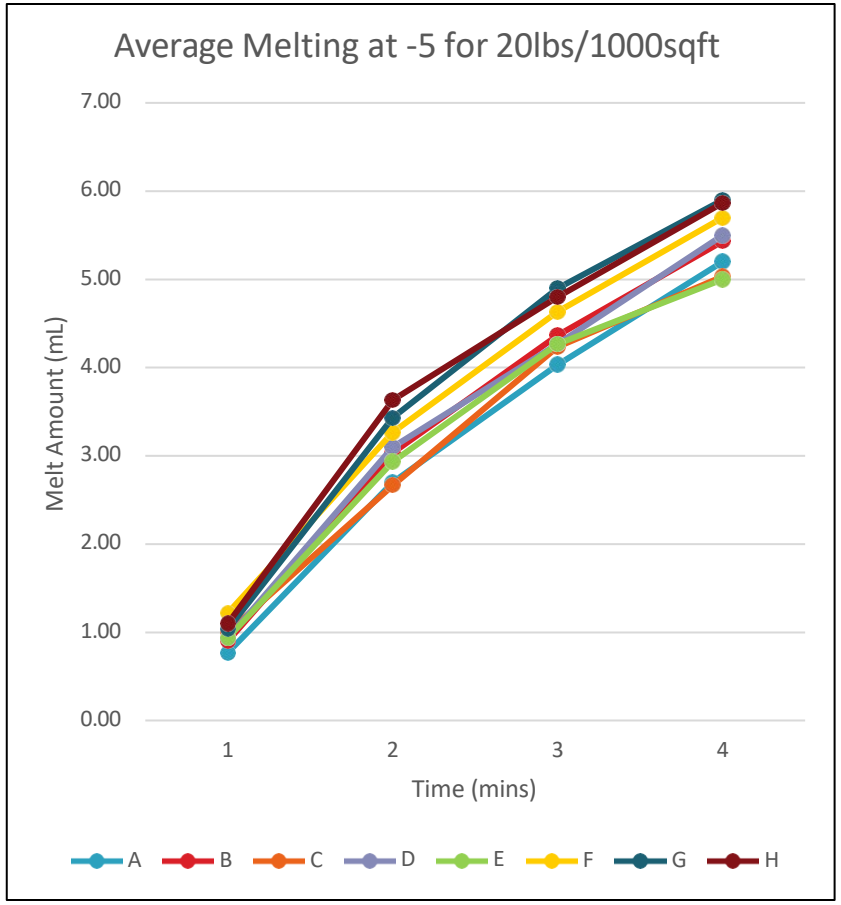


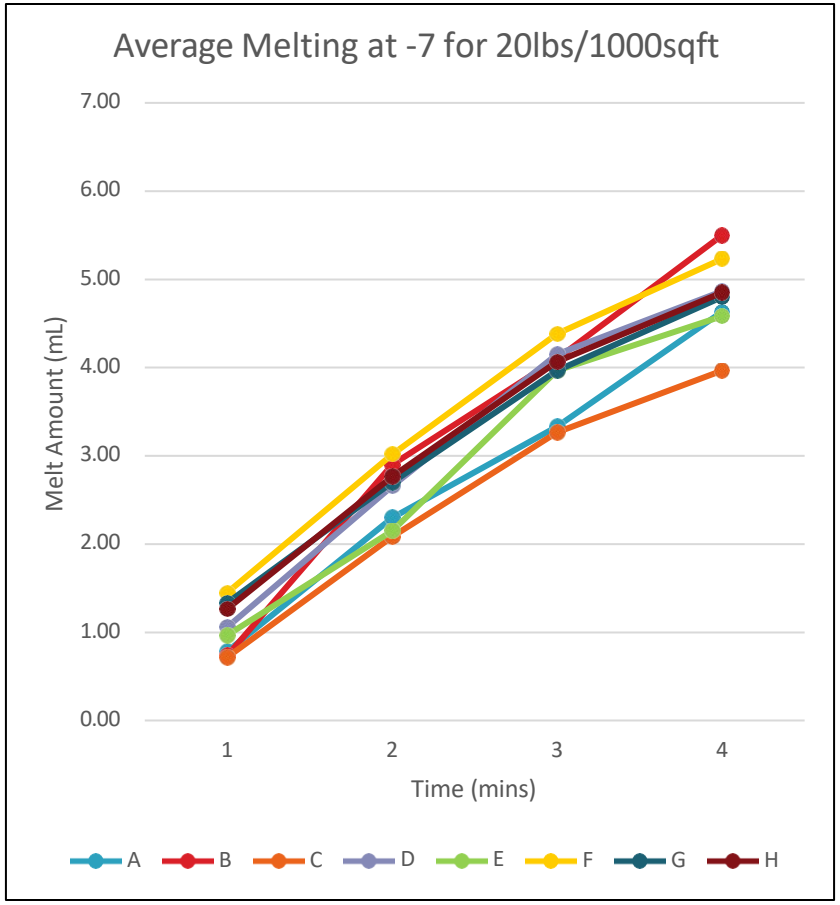


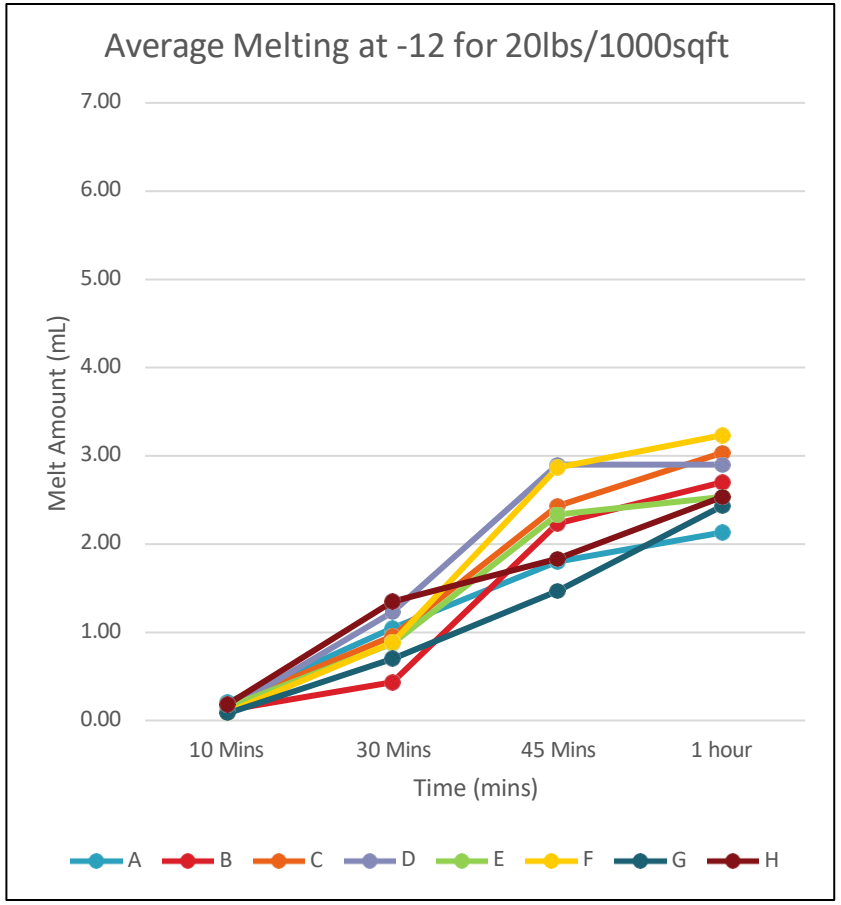


A-F: ECO ST Variants, G: Eco Solutions Organic Melt, H: NaCl

Ice Melting Tests Results Continued







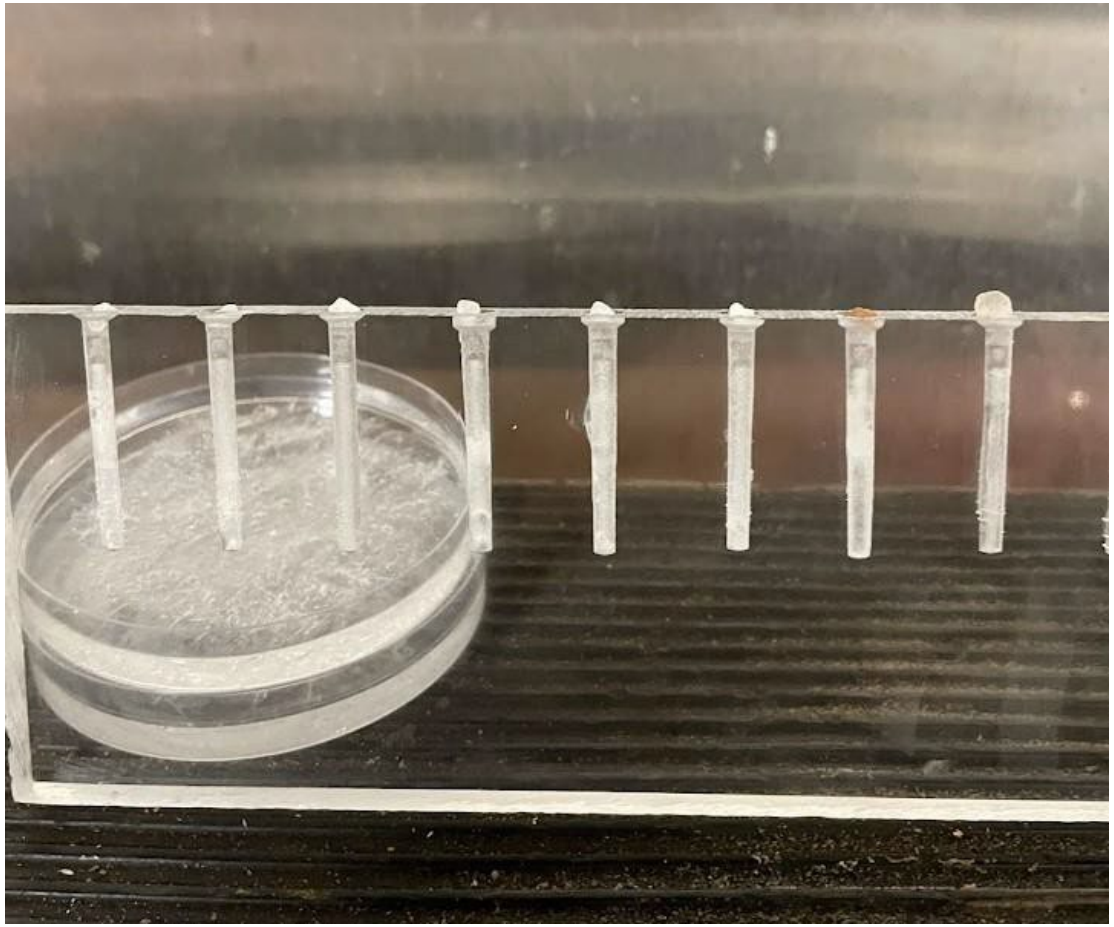
A-F: ECO ST Variants, G: Eco Solutions Organic Melt, H: NaCl

Overview of Ice Penetration Tests

48 Samples Tested Total

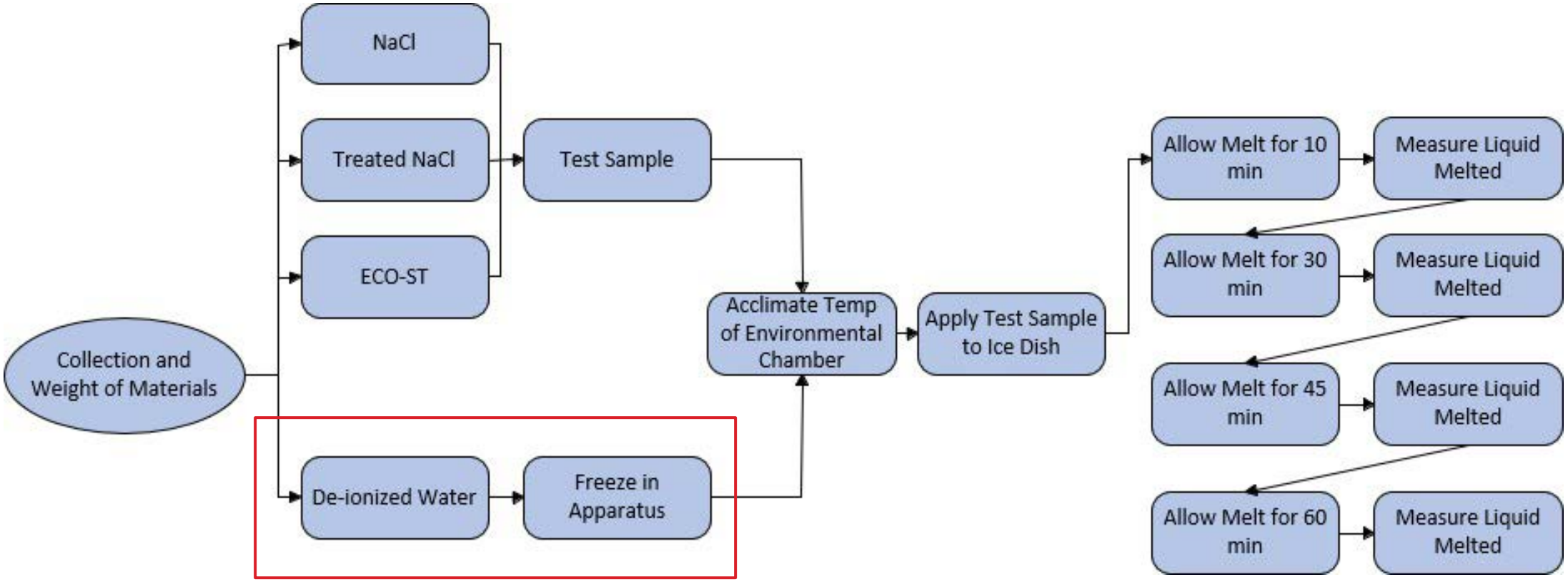
192 Data Points Collected

8 Types of Deicer

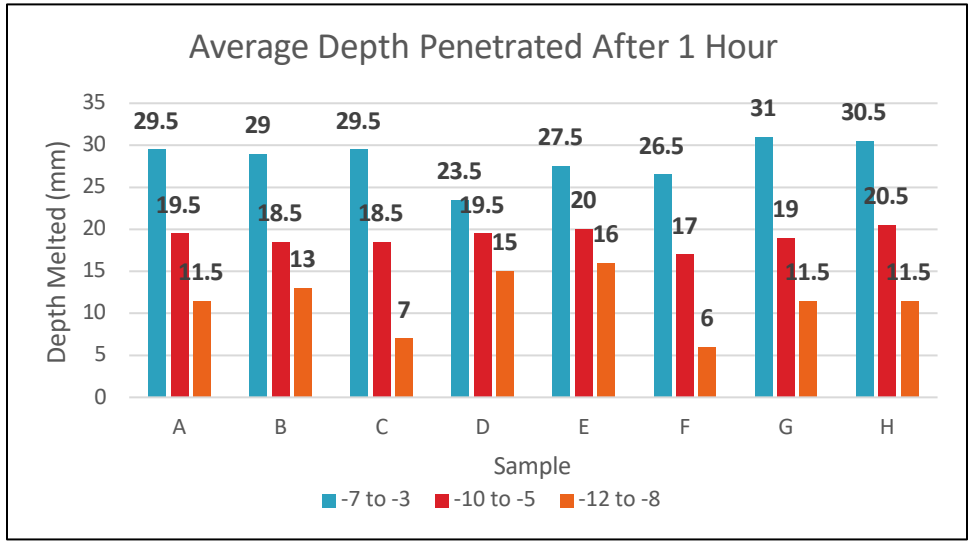


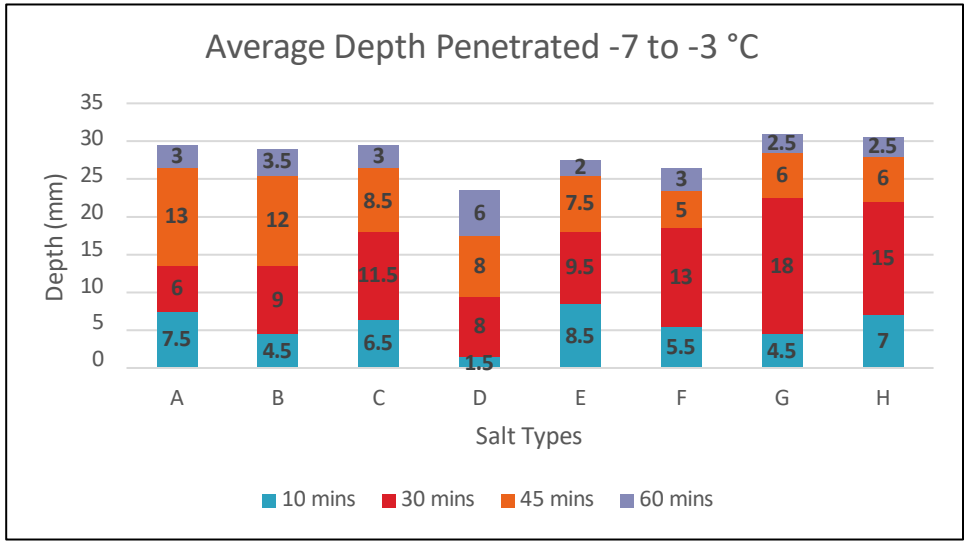
*Salt Types A-H (from left to right)

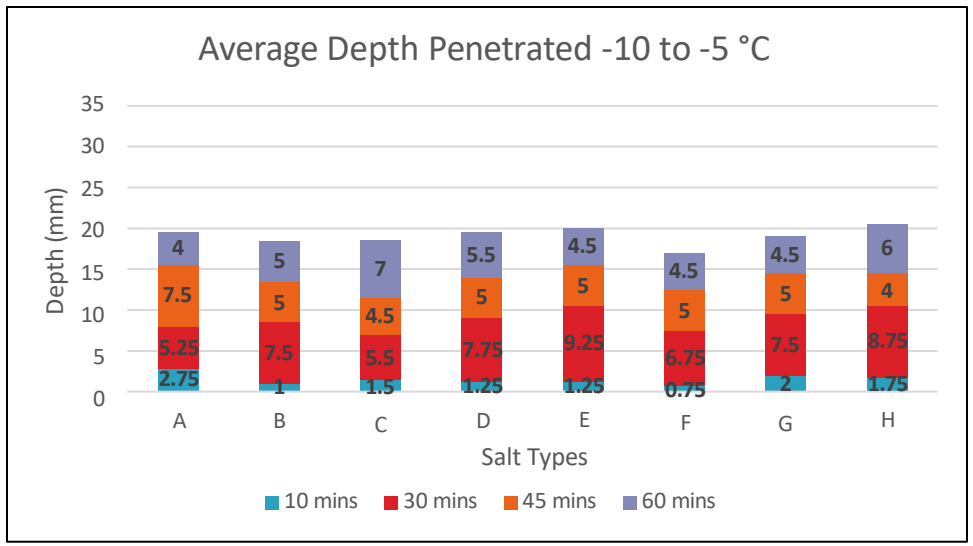
Methodology

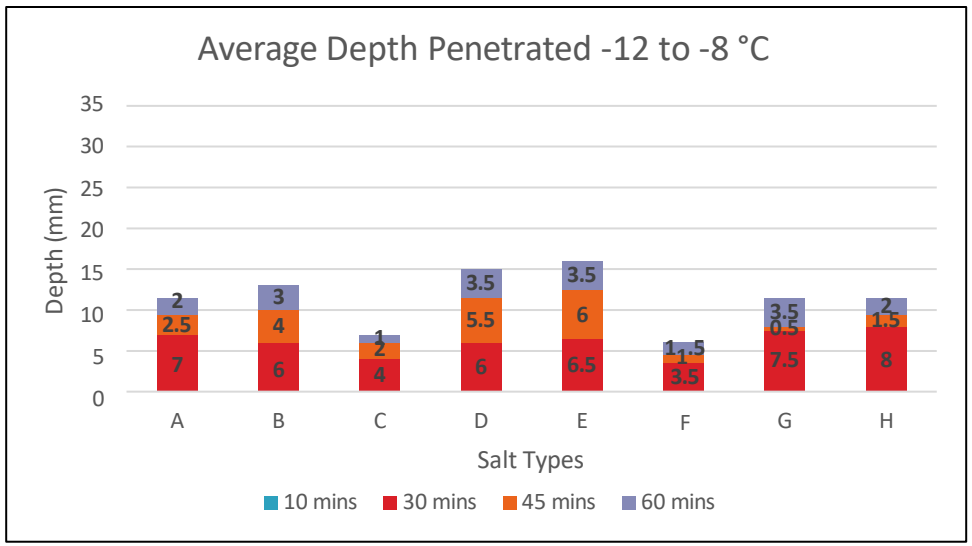


Ice Penetration Test Results









Overview of Corrosion Tests

24 Samples Tested Total

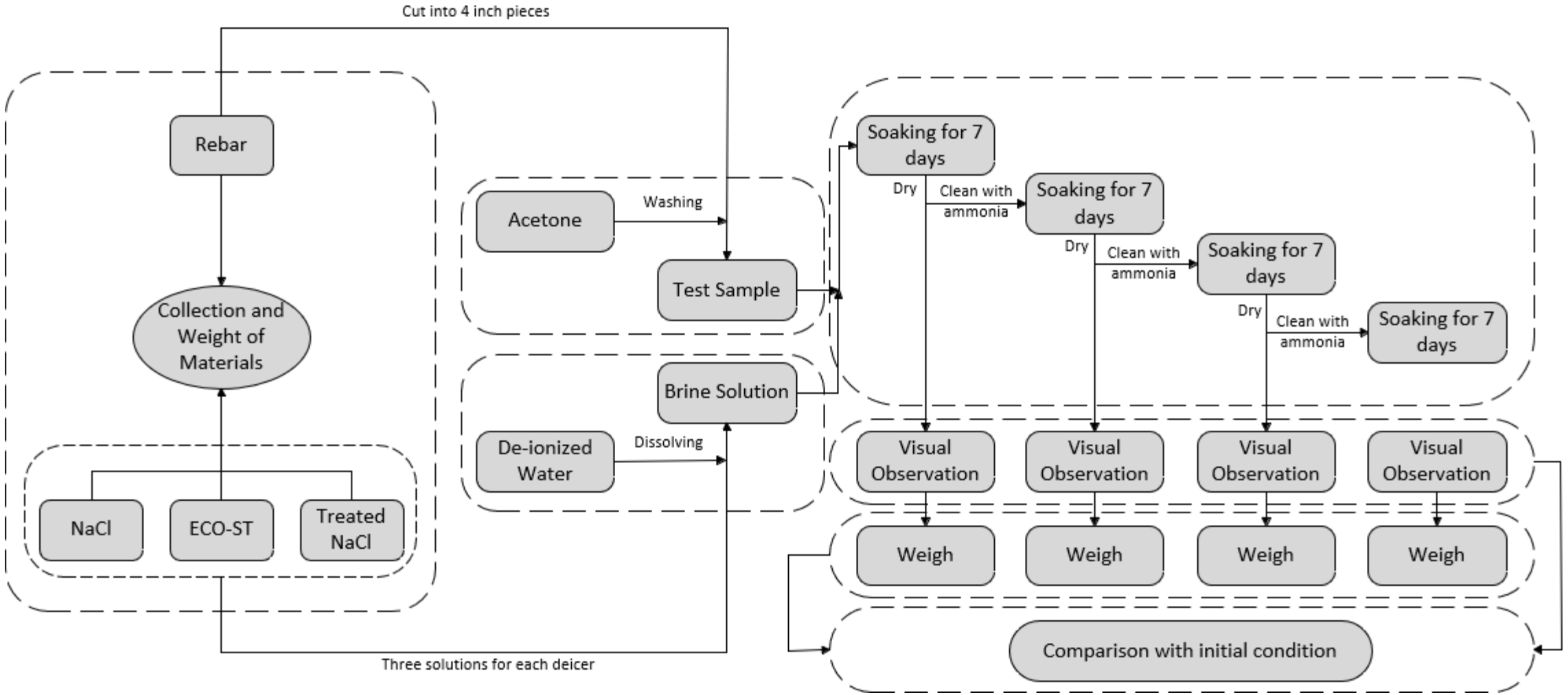
10M Carbon Steel Rebar

3 Types of Materials Tested:

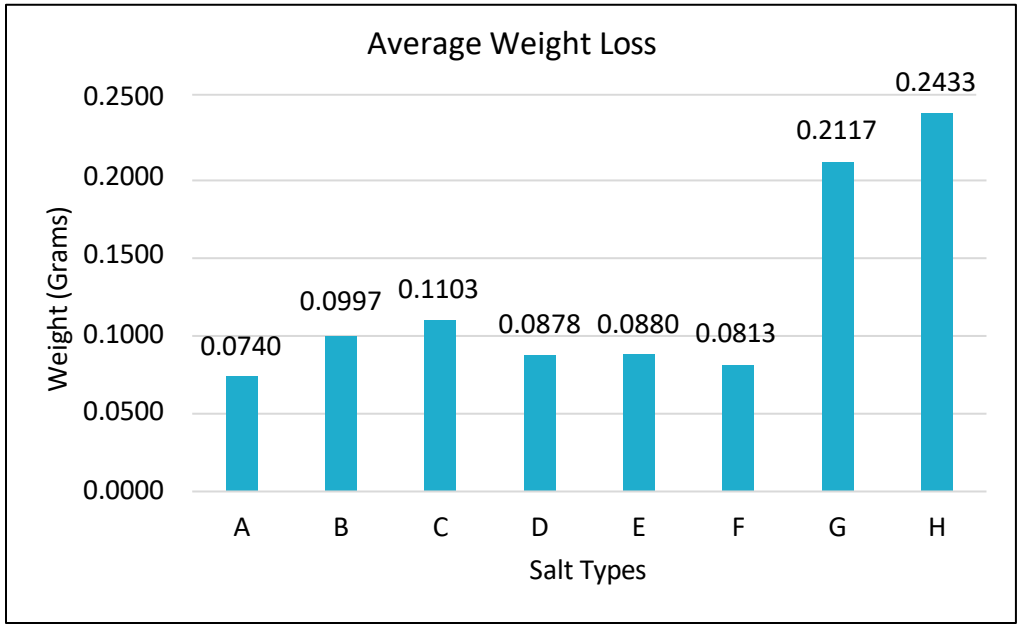
- 6 Variants of ECO ST (A-F)
- Organic Melt from Eco Solutions (G)
- NaCl (H)

Letters represent the salt types used

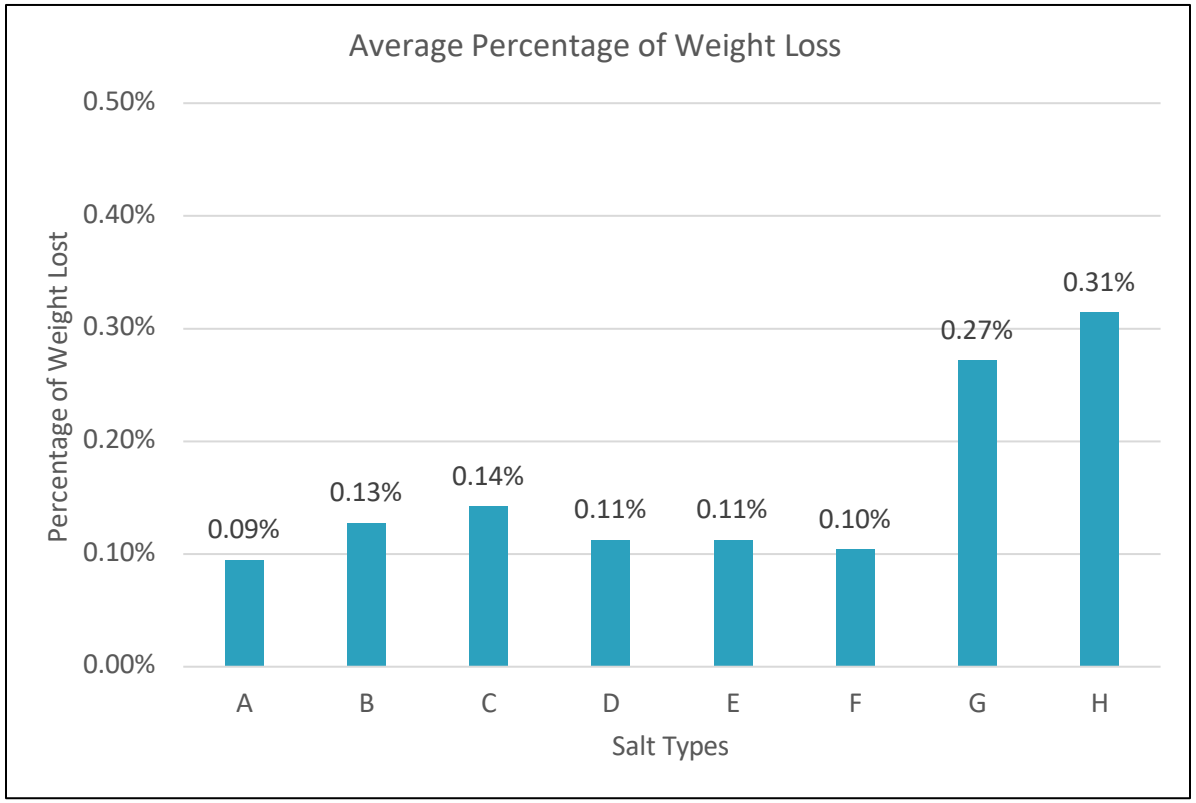
Methodology



Corrosion Test Results



Corrosion Test Results Continued



A-F: ECO ST Variants, G: Eco Solutions Organic Melt, H: NaCl

Overview of Field Tests

Evaluating Rock Salts efficiency at extreme cold conditions

Winter 2022

No Alternatives Deicers

3 Loading Rates

5 Events Recorded

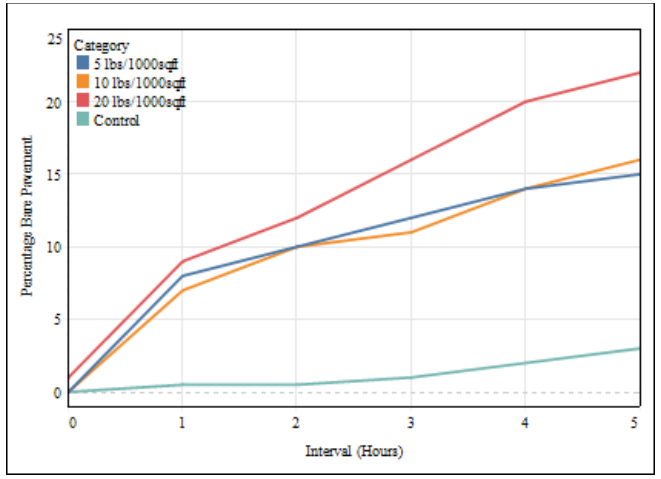
96 Data Points Recorded

Methodology

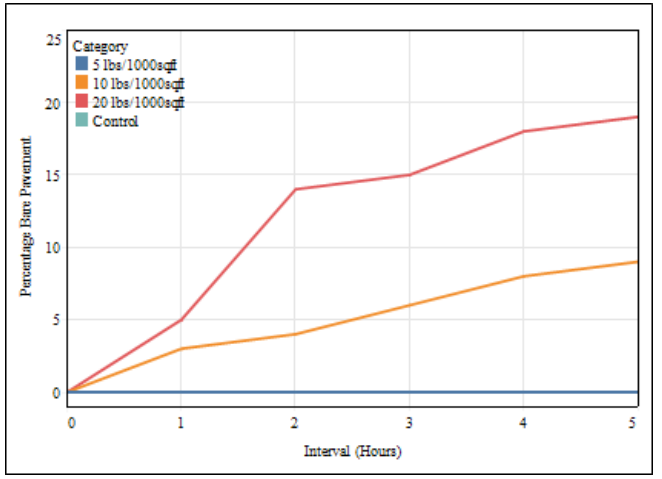
Observe forecast → Wait for snow to stop → Prepare site → Measure and apply salt → Observe and collect data

Field Test Results

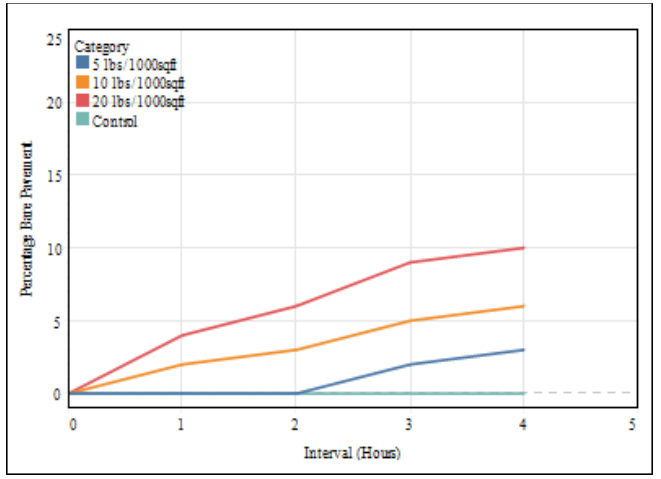
Feb 8th, 2022 T: -2.82 PT:-9.2



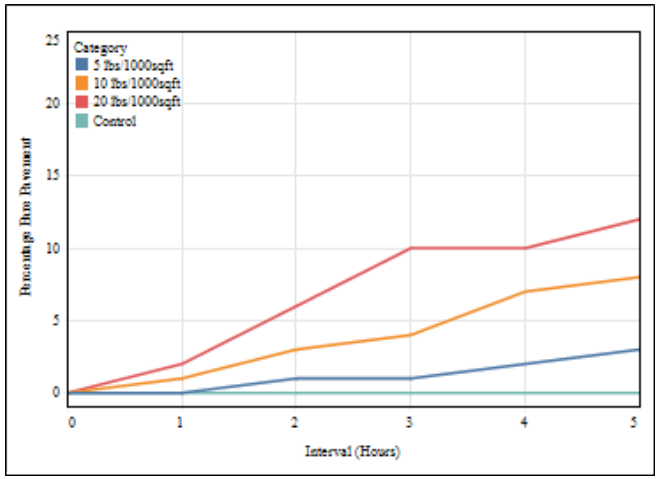
Feb 20th, 2022 T:-9.23 PT: -23.2



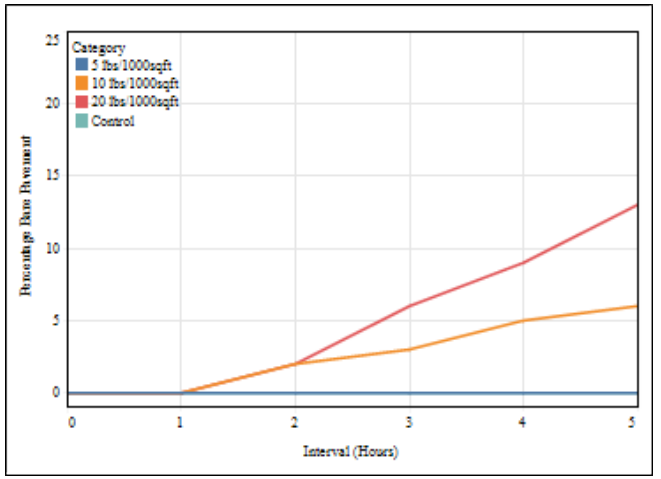
Feb 21th, 2022 T: -2.66 PT: -10.2



Feb 27th, 2022 T:-15 PT: -19.6



Feb 28th, 2022 T:-3.18 PT: -12.3



T – Air Temperature
PT- Pavement Temperature

All in degrees Celsius

Conclusion & Recommendations

Ice Melting/Penetration Test

- Alternatives show comparable results with rock salt
- Eco ST has potential to be more efficient at lower temperatures depending on starfish extract
- Loading rates are very crucial to melting capacity

Corrosion Test

- Visual observation displayed road salt having the highest amount of corrosion
- Eco ST exhibited the most promising results with a formation of coating on the steel surface
- Eco ST experienced the best quantitative results
- A slight benefit using Eco Solutions Organic Melt over road salt

Conclusion & Recommendations

Field Tests

- Unfavorable results were determined
- The highest application rate of 20lbs/1000sqft had best performance at all temperatures
- In low temperatures the lowest loading rate performed very poorly

Recommendations

- Continue field research in extreme cold conditions and include alternative deicers
- Test ecological effects of alternative deicers (chloride adsorbtion, BODs, etc.)
- Add liquid deicer alternatives to compare to solid

Limitations

I. Allocation of space for the field testing due to Carleton's liability issues

II. Obtaining the materials for the field tests as they came from South Korea

III. Weather restrictions

IV. Equipment restrictions for corrosivity tests

Publications

- Lawlor, M. Hossain, K. Rana, M. (2023) A Field Investigation on Ice-Melting Capacities of road Salt in Extreme Cold Weather Conditions in Ottawa, Canada.
- Lawlor, M. Hossain, K. Rana, M. (2023) An Investigation on Corrosivity of Road Salt and Alternatives on Steel. Transportation Association of Canada.
- Lawlor, M. Hossain, K. (2023) An Investigation on the Deicing Potential of Road Salt and Alternative Deicers. Being Prepared for Canadian Journal of Civil Engineering.

Acknowledgements

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- Asst. Prof. Masud Rana

Thank you

Research Group website: https://carleton.ca/artel/

Carleton University

ARTEL Advanced Road & Transportation Engineering Lab