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Laboratory Investigation of the Effect of De-Icing Chemicals on Airfield Asphalt Concrete Pavement Materials

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Presentation Outline

- **Background**
- **Objectives**
- **Experimental investigation**
- **Observations and test results**
- **Conclusions**

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Background

- The level of friction provided by runway surfaces is a major factor affecting the braking performance of aircraft on snow and ice contaminated runways .

- Pavement de-icers are frequently used during the winter season and concerns related to the damaging effects of urea on the environment paved the way for new alternative de-icers.

- In the early 1990s, Transport Canada initiated a series of investigations to evaluate the effects of new de-icers on airport pavements.

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Objectives

The study consisted of 3 Phases and the objectives are:

- **Phase 1 - To evaluate the effect of runway de-icers on the durability of pavement construction aggregates.**
- **Phase 2 - To evaluate the effect of runway de-icers on aged asphalt pavement samples when subjected to freeze-thaw cycles.**
- **Phase 3 - To study the effect of runway de-icers on the durability of new asphalt samples when subjected to freeze-thaw followed by wet-dry cycles.**

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Experimental Investigation
Phase 1

This Phase consisted of two parts:

- **Part A: Determine the most damaging chemical concentration**
- **Part B : Determine the effect of the other test parameters**

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Experimental Investigation
Phase 1

Preparation of Test Samples

- The two commonly used aggregates were selected.
- Three different aggregate sizes selected, visually inspected and subjected to Petrographic examination.

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Experimental Investigation Phase 1

Preparation of Deicing Solutions

- The100% concentration of each deicer was determined and the amount of chemical recorded
- The information was then used to calculate and prepare solutions of 0, 1, 2, 5, 10 and 50% concentrations.

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Experimental Investigation Phase 1 - Part A:

- **The medium size aggregate only was used and the samples subjected to total of 30 freeze-thaw cycles.**
- **Samples were conditioned in distilled water for 24 hours then removed, dried for 24 hours and weighed.**
- **After every 5 freeze-thaw cycles, the samples were removed, washed through the medium sieve size, dried for 24 hours, then weighed.**

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Experimental Investigation
Phase 1- Part B

- **The large and small size aggregates were used and the samples subjected to 50 freeze-thaw cycles.**

- **After every 5 cycles, the samples were removed, washed through the large and small sieve size, dried for 24 hours, then weighed.**

Experimental Investigation
Phase 2

HMAC Samples Preparation & Conditioning

- **33 cores, 100 mm in diameter and 60mm thick were obtained from Ottawa International Airport.**
- **Samples were grouped into sets of three and one set was kept dry for reference.**
- **From the findings in Phase 1, the critical solutions of urea, potassium acetate, sodium formate and sodium acetate were used.**

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Experimental Investigation Phase 2

HMAC Samples Preparation & Conditioning

- **Two sets of three cores were immersed in each solution, including distilled water, at room temperature for 24 hours for saturation and then removed, surface dried and weighed.**
- **The cores were subsequently immersed in the various solutions and subjected to freeze-thaw cycles.**
- **One freeze-thaw cycle consisted of 24 hours freezing at –35° C followed by 24 hours thawing at +30° C.**

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Experimental Investigation
Phase 3

HMAC Samples Preparation & Conditioning

- **A total of 51 asphalt cores were obtained from a project at Dorval International Airport.**
- **The dimensions, weight and density of each sample were determined.**
- **The data was used to group the samples into sets with approximately the same mean density and dimensions.**

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Experimental Investigation
Phase 3

HMAC Samples Preparation & Conditioning

- Six cores kept dry
- 45 cores immersed for 24 hours in various solutions including distilled water.
- Cores removed, surface dried and weighed, then immersed for additional sequences of 12 hours, then removed, surface dried and weighed until saturation.
- This was achieved when the difference in weight was less than 1%.

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Experimental Investigation
Phase 2

Test Procedures

- Weight of saturated surface-dry samples was taken after the first day of immersion and at the end of every five freeze-thaw cycles.
- At the end of each test period, the weight of each core was determined after a drying period of 1, 2, 4, 6 and 11 days .
- The samples were visually examined and their indirect tensile shear strength (ITS) determined.

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Experimental Investigation
Phase 2

Test Procedures

- Following the ITS test, the asphalt cement was extracted and the remaining penetration determined.
- The aggregate gradation was also obtained.

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Experimental Investigation
Phase 3

Test Procedures

- **Part A: Samples subjected to 15 freeze-thaw cycles.**
- **Part B: Samples subjected to 15 freeze-thaw cycles followed by 40 wet-dry cycles.**

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Experimental Investigation
Phase 3

Test Procedures

- 9 samples per solution were subjected to 15 freeze-thaw cycles.
- Following, three samples per solution were removed, surface dried and weighed after 0, 4 and 7 days of drying at room temperature.
- The mechanical and physical properties of the hot mix were determined.

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Experimental Investigation
Phase 3

Test Procedures

- The remaining 6 samples per solution, were subjected to 40 wet-dry cycles at 40° C.
- A wet-dry cycle consisted of 48 hours immersion and 24 hours drying.
- Following the wet-dry sequence, the physical and mechanical properties of the hot mix were determined.

Indirect Tensile Strength Test

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Phase 1 – Observation and Test Results

- The aggregates subjected to freeze-thaw cycles suffered disintegration.
- The limestone broke along finite planes while the quartzite broke in pieces.
- The damage was quantified by determining the accumulated percentage of weight loss (APWL)

  $APWL= (W_{o} - W_{n}/ W_{o}) \times 100$

  Where: Wo = initial weight, W_n = weight of undamaged particles after n freeze-thaw cycles.

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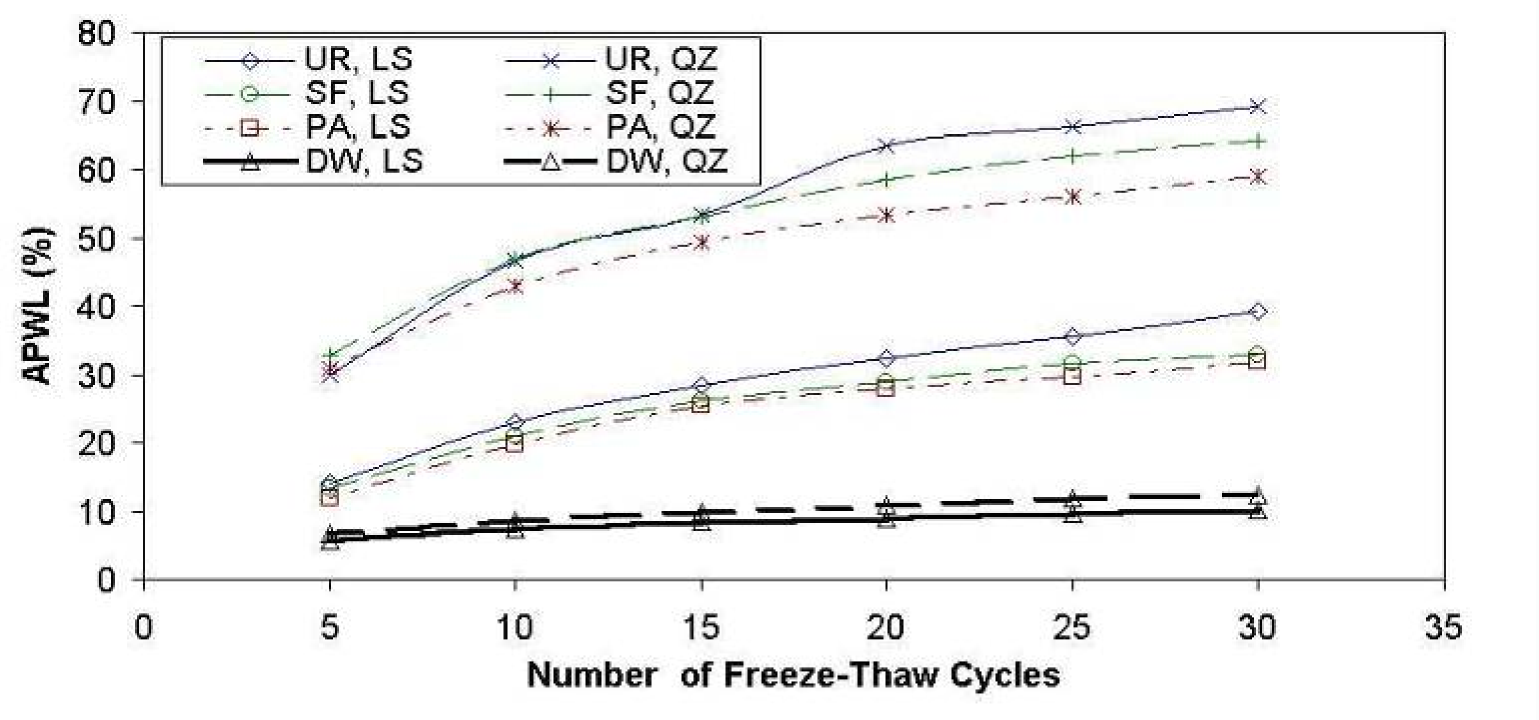
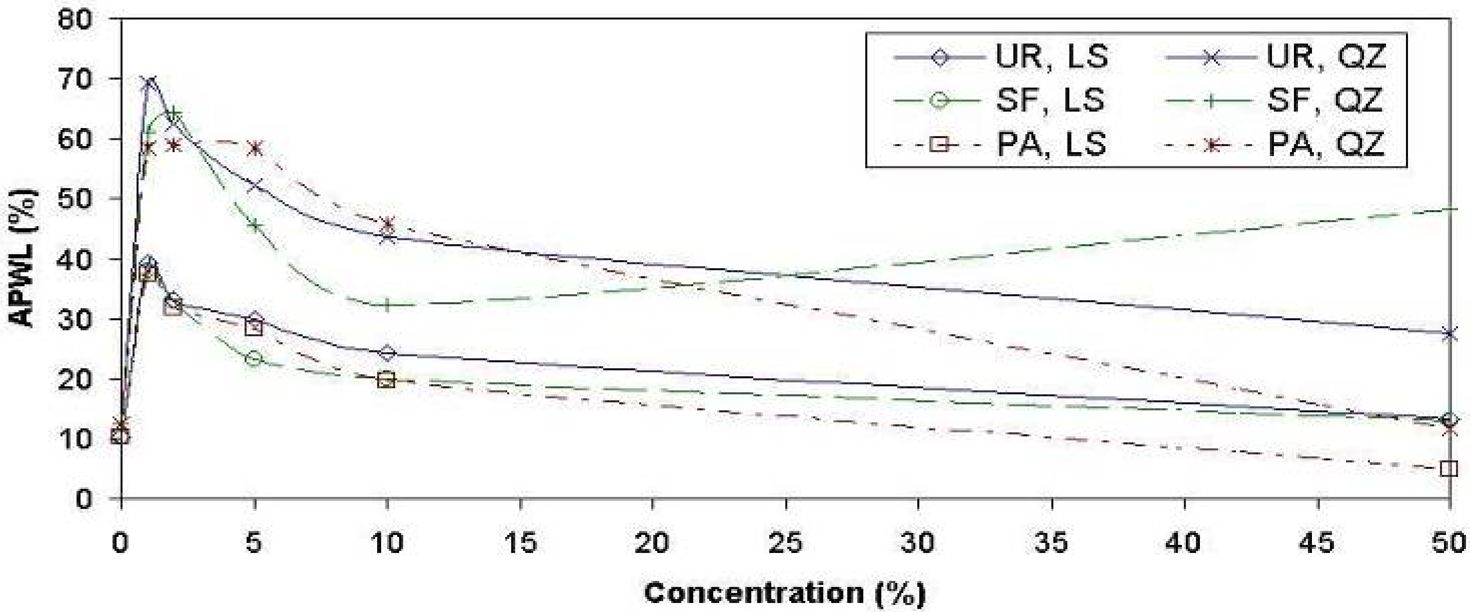
Phase 1 – Observation and Test Results



Effect of freeze-thaw on medium-size aggregates

Phase 1 – Observations and Test Results



Effect of solution concentration on medium size aggregates

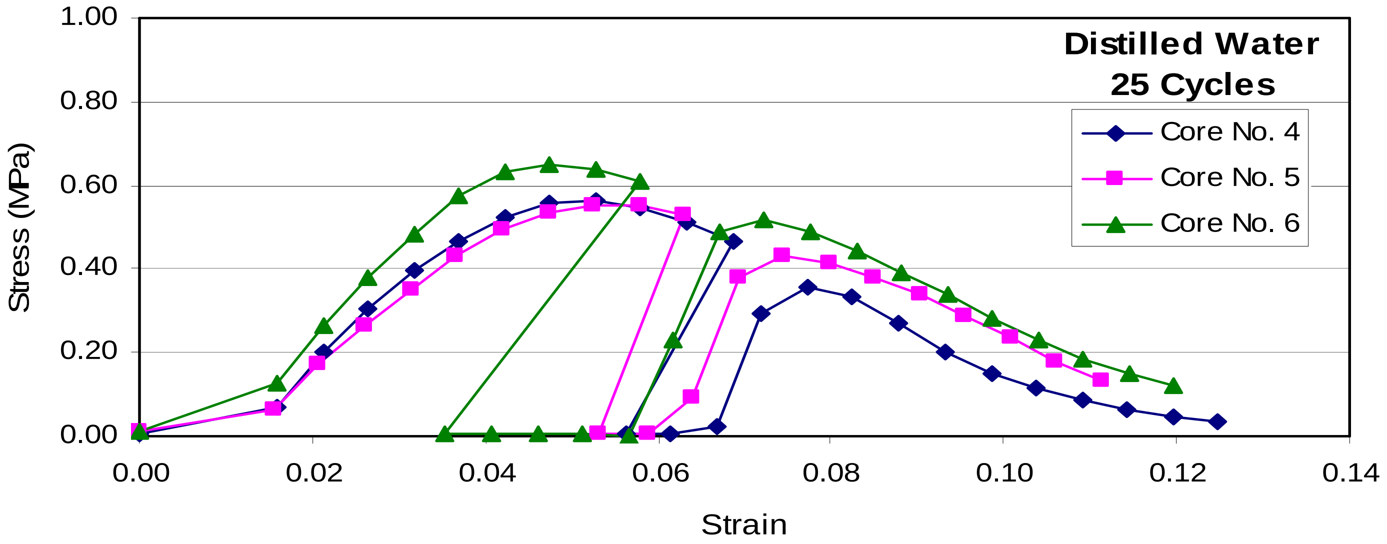
Phase 2 – Observations and Test Results

- **Damage was observed after 15 cycles.**
- **Specimens subjected to urea deteriorated the most.**
- **All conditioned specimens had lower indirect tensile strength than the dry control samples.**
- **After 25 cycles for all samples, the average ITS was considerably lower than that of the dry samples.**
- **ITS was almost constant for the samples immersed in the four de-icers and slightly higher for those immersed in distilled water.**

Phase 2 – Observations and Test Results

- At the end of the 50 freeze-thaw cycles, no further deterioration of strength occurred beyond that observed at the end the of 25 cycles.
- After 25 cycles, the elastic modulus was lower than that of the dry samples.
- After 50 cycles, the elastic modulus of the samples conditioned in urea was about 35% lower than that observed after 25 cycles.

Phase 2 – Observations and Test Results



Samples Conditioned in Distilled water – After 25 Cycles

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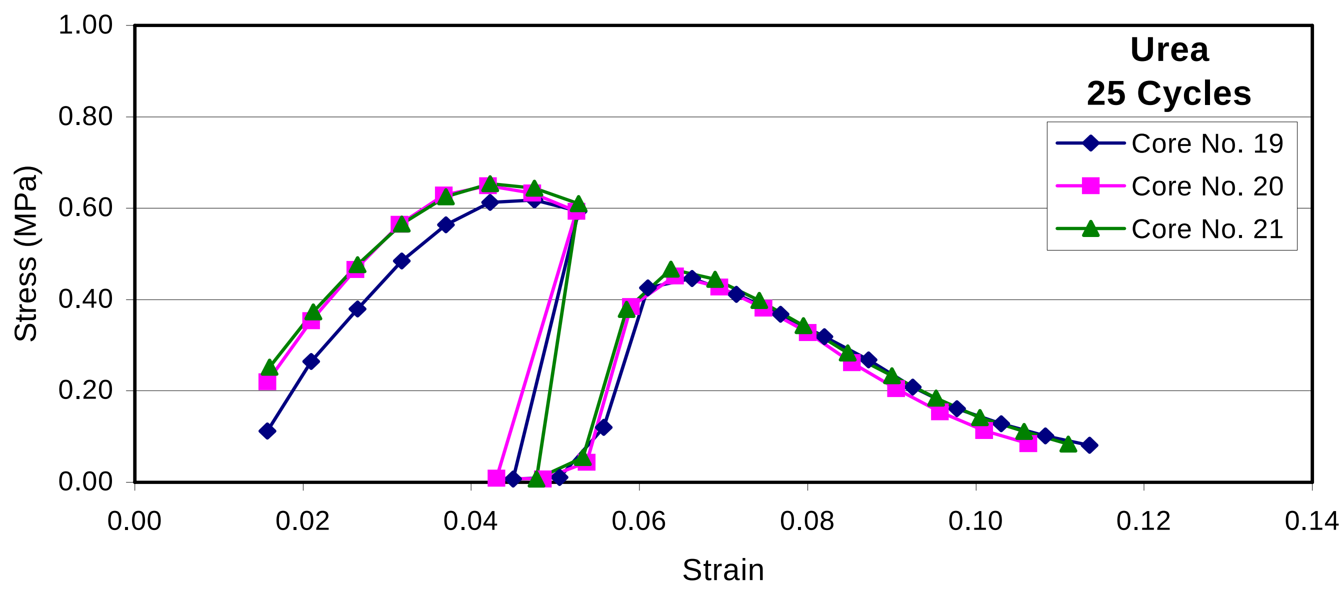
Phase 2 – Observations and Test Results



Samples conditioned in urea – After 25 Cycles

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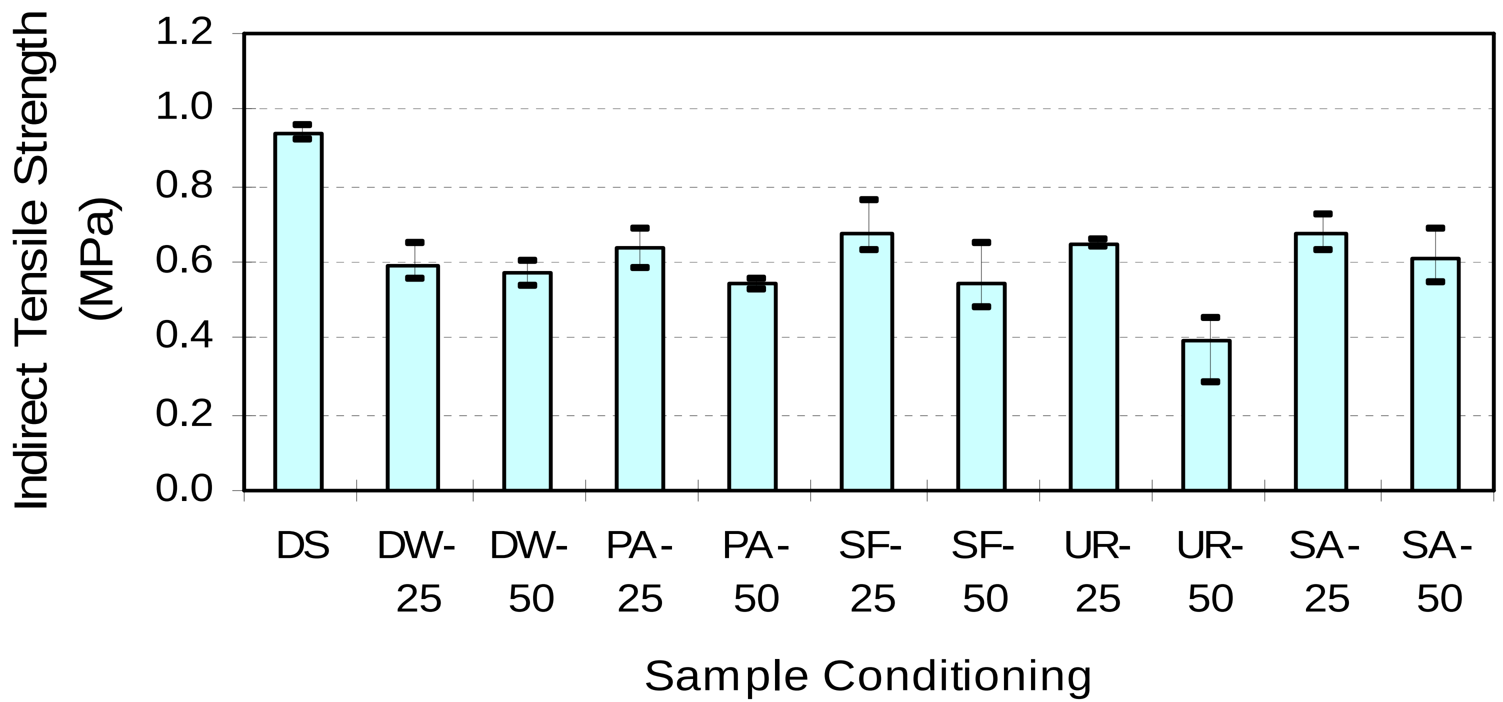
Phase 2 – Observations and Test Results



Indirect tensile strength (Minimum and Maximum)

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Phase 3 - Observations and Test Results

- **After 15 freeze-thaw cycles, no damage or particle break up was observed.**
- **All specimens gained weight during the freeze-thaw cycles.**
- **The rate of weight gain decreased as the number of freeze-thaw cycles increased.**
- **The same trend was also observed during the wet-dry cycles.**

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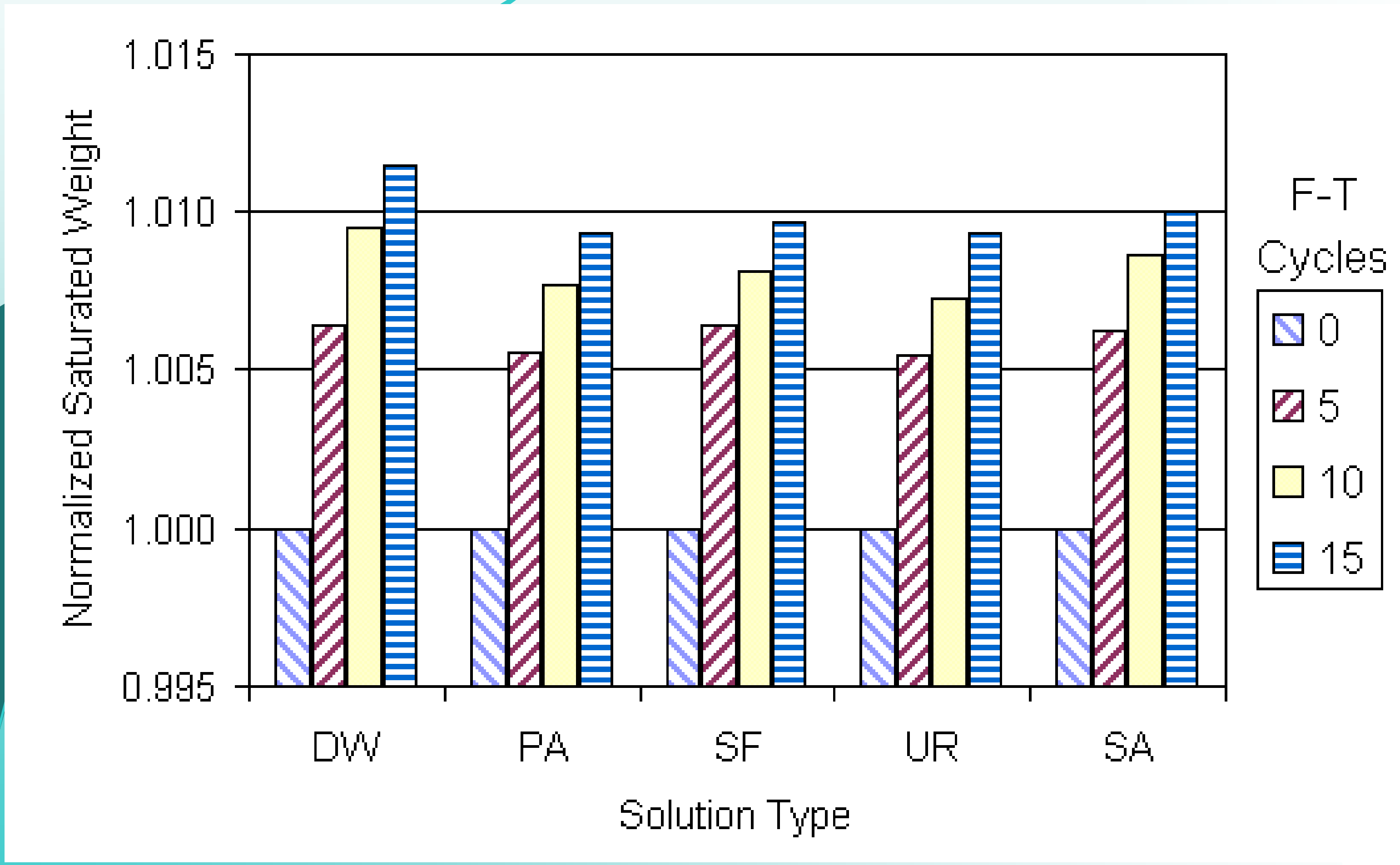
Change of Normalized Saturated Weight during Freeze-Thaw Cycles



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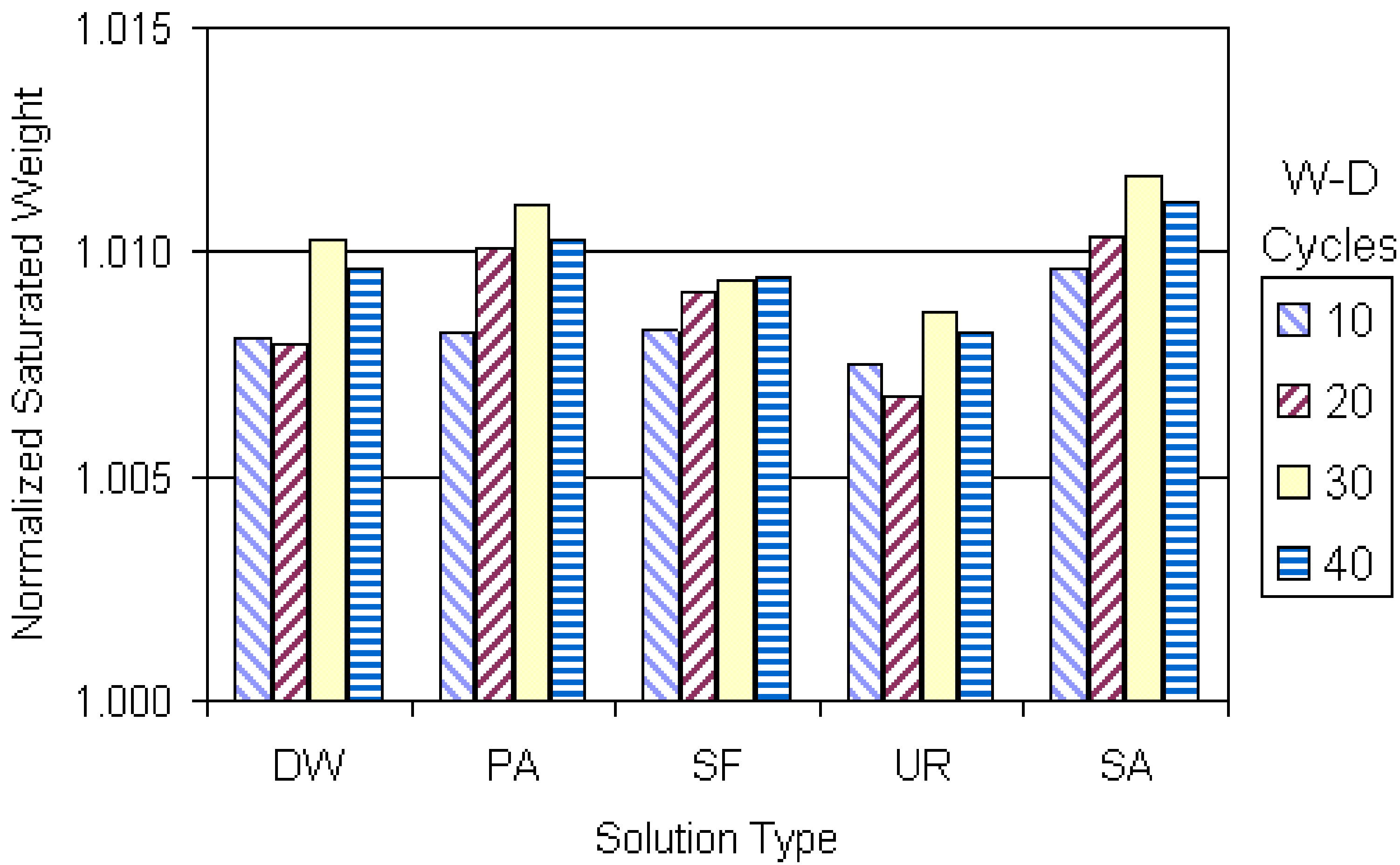
Change of Normalized Saturated Weight during Wet-Dry Cycles



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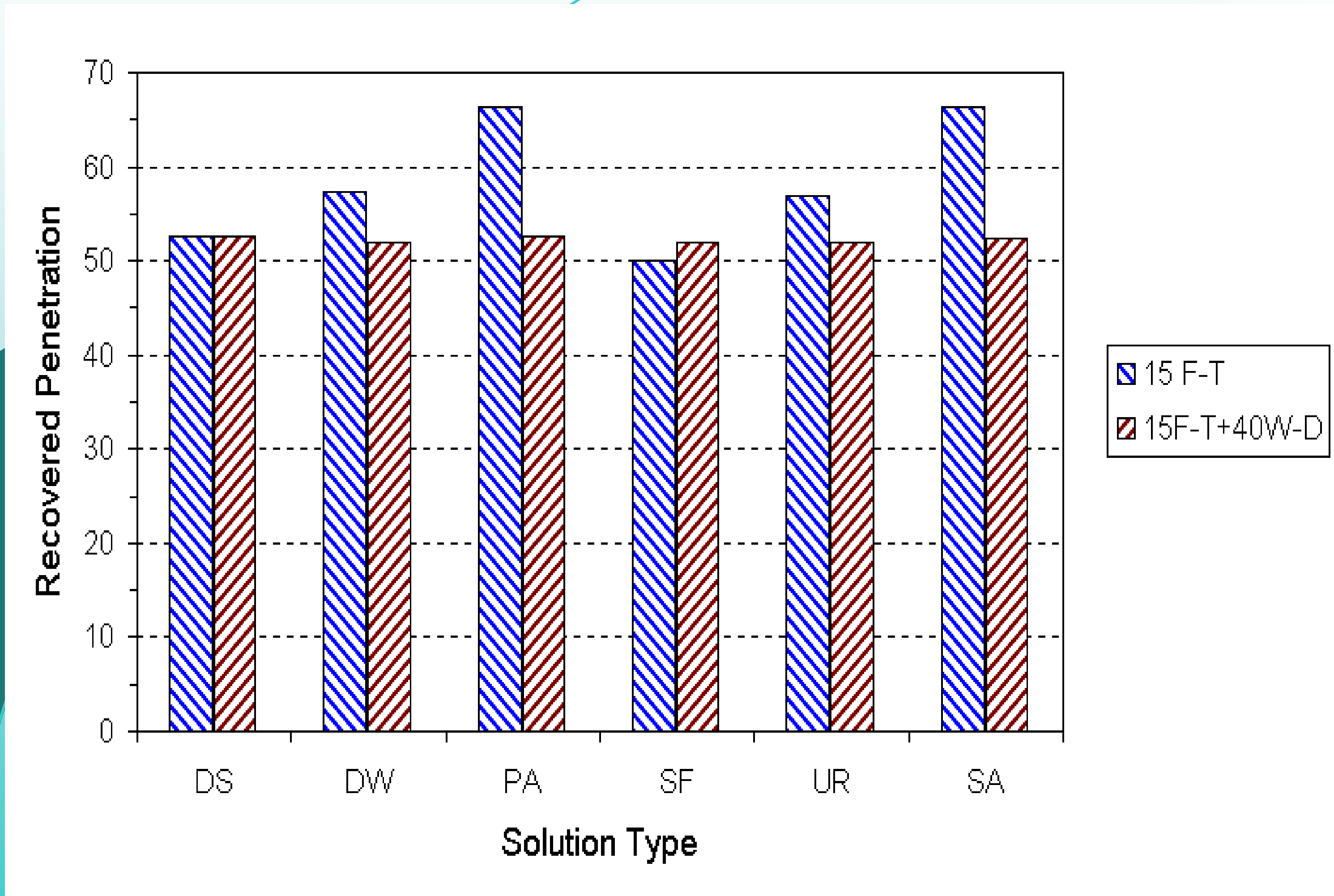
Penetration Test Results of Recovered Bitumen



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Conclusions

- **In the laboratory, all de-icers have some damaging effect on both aggregates and HMAC mixes. The maximum damage depends on the de-icer and its degree of concentration in the solution.**
- **Limestone aggregates have a higher resistance to de-icers than quartzite.**
- **HMAC exposed to freeze-thaw while immersed in deicing solutions may experience loss of tensile strength and elasticity.**

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Conclusions

- **After being exposed to deicing solutions and freeze-thaw cycles, a HMAC pavement will not suffer an additional loss of strength and elasticity due to wet-dry cycles during the warm season.**
- **Sodium acetate is the only deicer in this study to cause further loss of strength and elasticity as a result of exposure to warm wet-dry cycles.**
- **Finally, it should be noted that this study was initiated based on a proactive approach and not because deicers-induced damage was a problem in Canada.**

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THANK YOU

QUESTIONS??

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