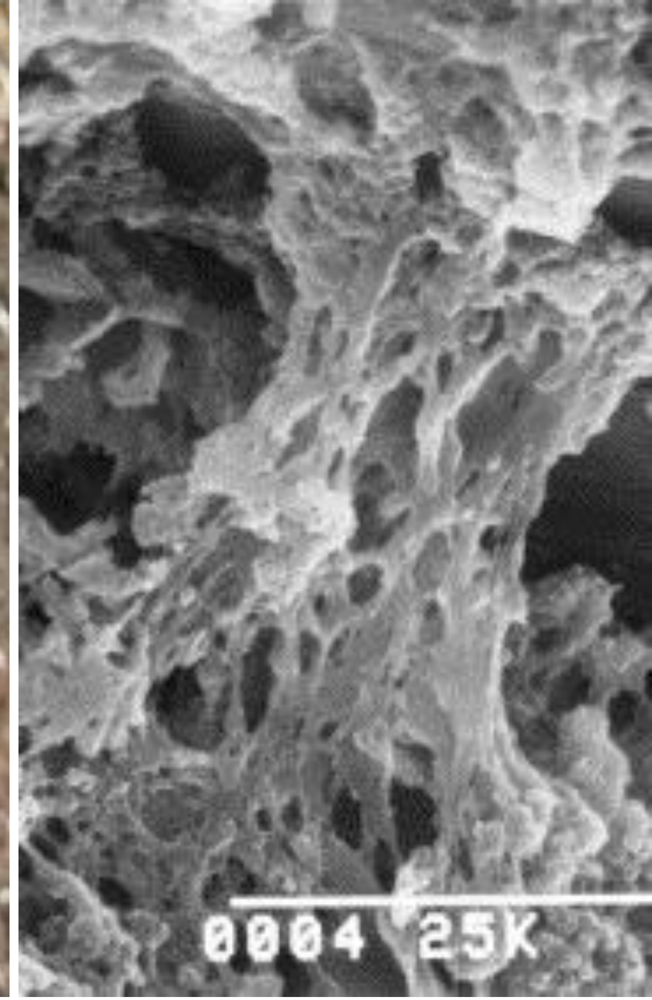
Edison Coatings, Inc.

IMPROVEMENTS TO FREEZE-THAW RESISTANCE OF HISTORIC MORTARS



AIR ENTRAINMENT

•ASTM C226 ADDITION

WATER REPELLENT

•SILANE/SILOXANE EMULSION (10% Solids)

•SILANE CREAM (80% Solids)

POLYMER MODIFICATION

•PROPRIETARY ACRYLIC LATEX W/WET ADHESION MONOMER

FREEZE-THAW IMPROVEMENT

COMMON APPROACHES

St. Patrick's Basilica
Montreal
Repointed 1998

20 Years of In Situ Comparative Testing

Latex-Modified vs. Unmodified Mortars

"POTENTIAL USES FOR POLYMER-MODIFIED REPOINTING MORTARS"

FERNANDO PELLICER, DFS ARCHITECTURE, MONTREAL
2002

Photo 01: Mixer's paddles not reaching the sides of the bucket, creating a crust of dry ingredients on the sides of the bucket.

Photo 02: New paddles were installed, which are now reaching the sides of the bucket.

Photo 03: Polymer used for mortar: restoration latex RL1 by Edison Coating Inc

Photo 04: Liquid composed of 50% restoration latex RL1 by Edison Coating Inc. and 50% potable water is to be measured carefully separately before.

Photo 05: Liquid composed of 50% restoration latex RL1 by Edison Coating Inc. and 50% potable water is to be carefully mixed separately before being added to the dry mortar mix.

Photo 06: Liquid (mixed previously) being added to mortar mix.

Photo 07: Mortar is too dry and doesn't stick to the fingers.

Photo 08: Mortar is of the good consistency and sticks to the fingers.

Photo 09: Vicat cone penetration test performed on fresh mortar sample.

Photo 10: Air content test performed on site on fresh mortar sample.

Photo 11: Cubes of fresh mortar taken for compressive tests.

Photo 12: Contractor to make sure mortar doesn't stick to the mixer's paddles when mixing.

DFS POLYMER MODIFICATION STUDY

EAST BLOCK – PARLIAMENT HILL

EDISON POLYMER MODIFICATION STUDY

1:2.5:8 TYPE O MORTAR

COMPRESSIVE STRENGTH
ASTM C109

Mortar Mix	Sample	Cure Method	Compressive Strength (psi)	Average (psi)
1:2.5:8 Non-Modified	1	10-Day Damp	725	658
	2	10-Day Damp	600	
	3	10-Day Damp	650	
	4	18-Day Damp	800	758
	5	18-Day Damp	700	
	6	18-Day Damp	775	
1:2.5:8 Modified	2	7 Air + 3 Damp	750	775
	3	7 Air + 3 Damp	800	
	4	7 Air + 11 Damp	850	850
	5	7 Air + 11 Damp	850	
	6	7 Air + 11 Damp	850	

~12% STRENGTH INCREASE

EDISON POLYMER MODIFICATION STUDY

1:2.5:8 TYPE O MORTAR

WATER VAPOR TRANSMISION
ASTM E96

Mortar Mix	Sample	Vapor Transmission (g/in^2/hr)
1:2.5:8 Non-Modified	1	0.0939
	2	0.1080
	3	0.0920
	Average	0.0979
1:2.5:8 Modified	1	0.0745
	2	0.0731
	3	0.0716
	Average	0.0730

~75% PERMEABILITY RETAINED

EDISON POLYMER MODIFICATION STUDY

1:2.5:8 TYPE O MORTAR

WATER ABSORPTION

Mortar Mix	Time(min)	Cure Method	Water Absorption (g/100 cm^2)	Water Absorption (%)
1:2.5:8 Non-Modified	initial	18-Day Damp	-	-
	15	18-Day Damp	31.56	3.37
	60	18-Day Damp	61.2	6.53
	120	18-Day Damp	81.44	8.69
	240	18-Day Damp	111.84	11.93
	360	18-Day Damp	132.48	14.13
	1440	18-Day Damp	138.2	14.74
1:2.5:8 Modified	initial	7 Air + 11 Damp	-	-
	15	7 Air + 11 Damp	3.32	0.38
	60	7 Air + 11 Damp	6.24	0.72
	120	7 Air + 11 Damp	8.2	0.94
	240	7 Air + 11 Damp	11.08	1.27
	360	7 Air + 11 Damp	13.84	1.59
	1440	7 Air + 11 Damp	15.96	2.87

~80% REDUCTION IN ABSORPTION

Freeze- Thaw Durability Of Pavement Mortars

ASTM C666 (Modified): Resistance of Concrete to Rapid Freeze-thaw

- American Natural Cement and Sand
- 1:1, 1:1.5, and 1:2
- 28 day cure (95% RH)
- 16 hrs at -18˚C (0 °F) and 8 hrs at 22˚C (72 °F)


0 Cycles
1:1
1:1.5
1:2


50 Cycles
1:1
1:1.5
1:2

ASTM C672 (Modified):
Scaling Resistance Of Concrete Surfaces Exposed To Deicing Chemicals

- 6.35 mm (0.25 in) of 4% Calcium Chloride Solution
- 18 hrs at -18˚C (0 °F) and 6 hrs at 22˚C (72 °F)

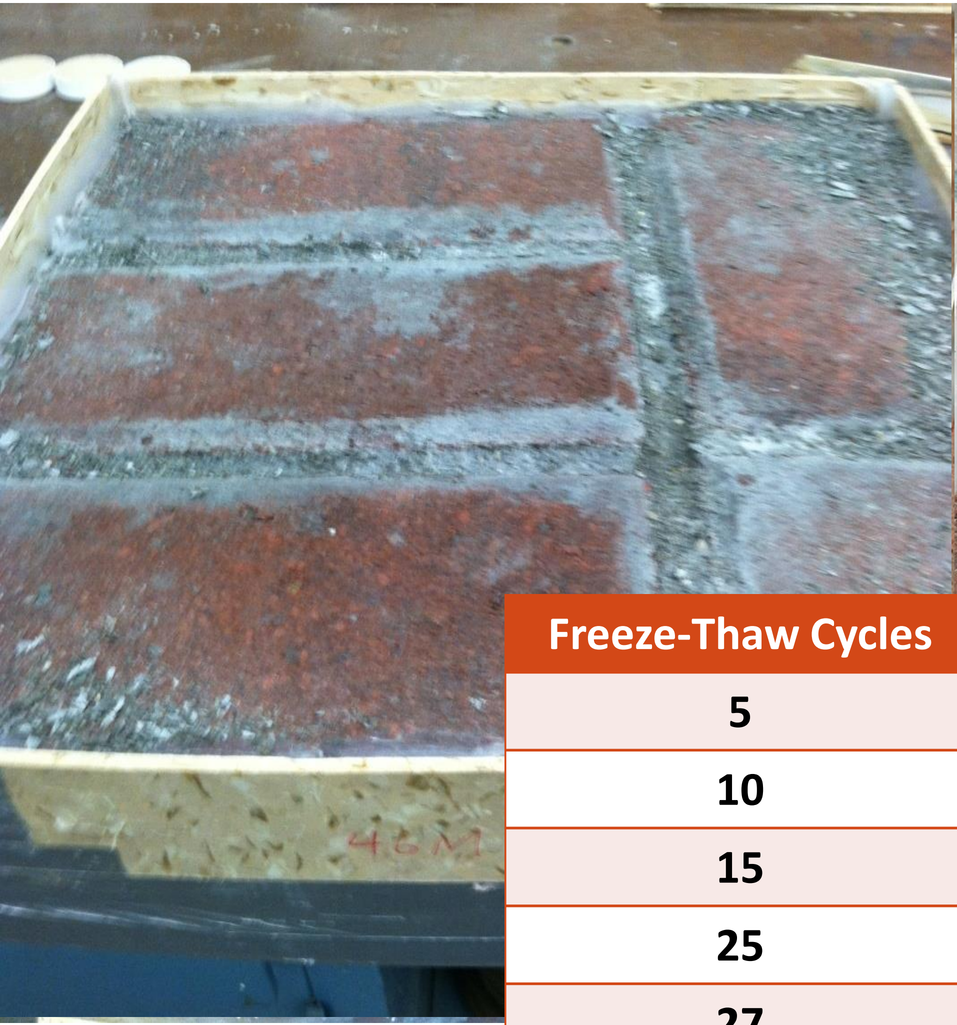
Mortars Tested

Binder	Proportions	Modification	Cure Time
Portland/Lime	1:0.25:3.75 (M)	None	7
Portland/Lime	1:0.25:3.75 (M)	100% Liquid Polymer	7
Portland/Lime	1:1:6 (N)	None	7
Portland/Lime	1:1:6 (N)	88C Silane Cream	7
Portland/Lime	1:1:6 (N)	75% Liquid Polymer	7
Portland/Lime	1:2:9 (O)	50% Liquid Polymer	7
Portland/Lime	1:2:9 (O)	75% Liquid Polymer	7
Portland/Lime	1:2:9 (O)	100% Liquid Polymer	7
American Natural Cement	1:1	None	56
American Natural Cement	1:1	89W Siloxane	56
American Natural Cement	1:1	12% Air	28
American Natural Cement	1:1	100% Liquid Polymer	28
American Natural Cement	1:2	100% Dry Polymer	28
American Natural Cement	1:2	50% Liquid Polymer	28
American Natural Cement	1:2	100% Liquid Polymer	28
European Natural Cement	1:1	100% Liquid Polymer	28
NHL 3.5	1:2.5	None	28
NHL 3.5	1:2.5	88C Silane Cream	28
NHL 3.5	1:2.5	100% Liquid Polymer	28

ASTM C672: Scaling Ratings

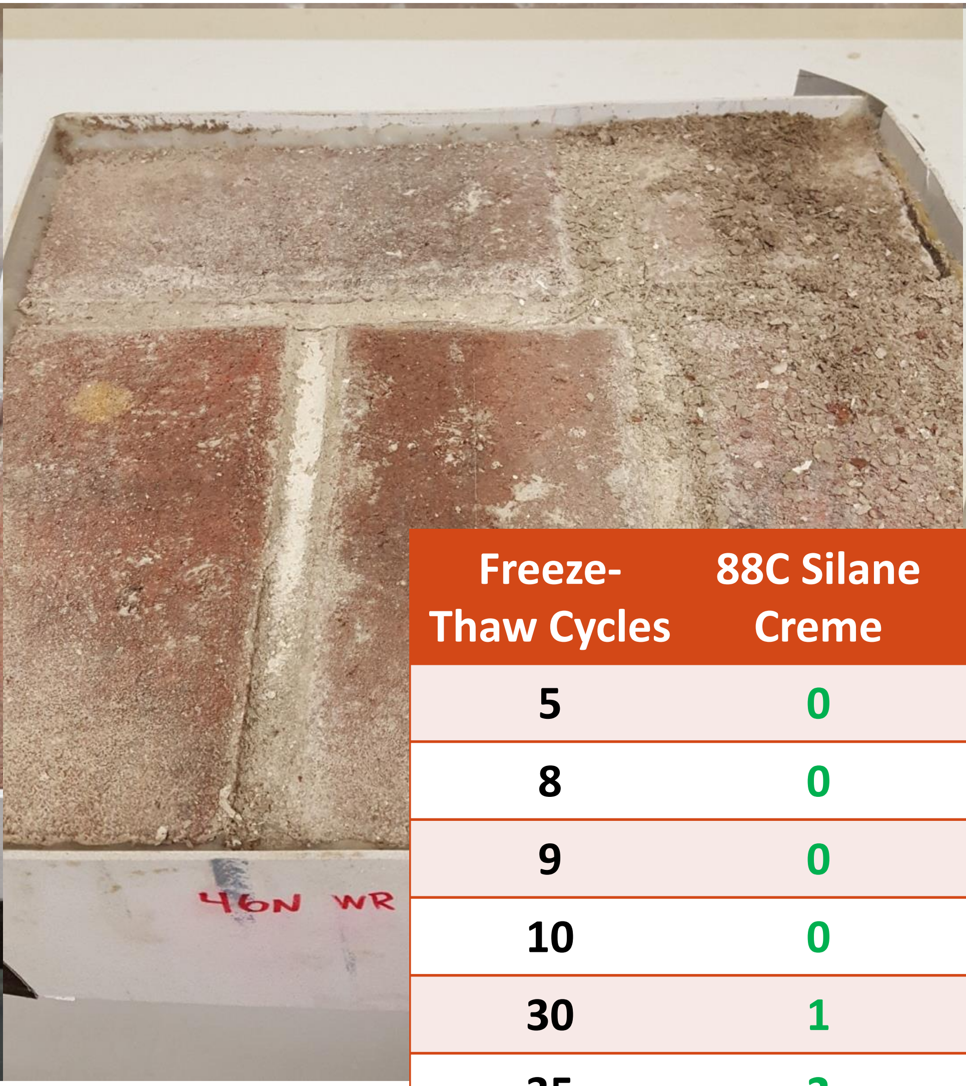
Rating	Observations
0	No Scaling
1	Very Slight Scaling
2	Slight to Moderate Scaling
3	Moderate Scaling
4	Moderate to Severe Scaling
5	Severe Scaling

Type M – No Modification vs. 100% Liquid Polymer



Freeze-Thaw Cycles	No Mod	100% LP
5	0	0
10	2	0
15	3	0
25	4	0
27	5	0
50	5	0

Type N – No Modification vs. 88C Silane vs. 75% Liquid Polymer

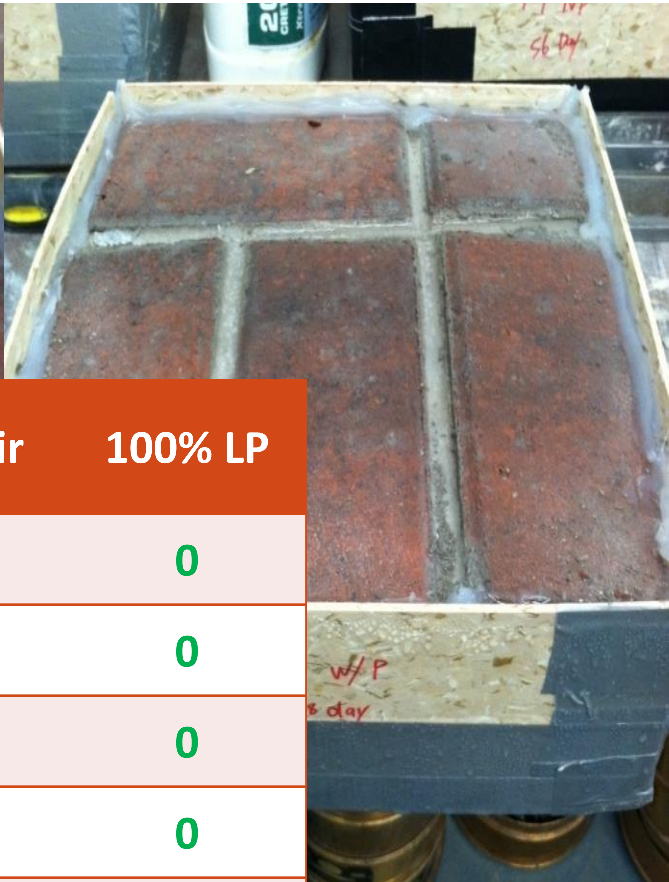


Freeze-Thaw Cycles	88C Silane Creme	Untreated	75% LP
5	0	1	0
8	0	3	0
9	0	4	0
10	0	5	0
30	1	5	0
35	2	5	1
50	3	5	1

Type O – 50% vs. 75% vs. 100% Liquid Polymer

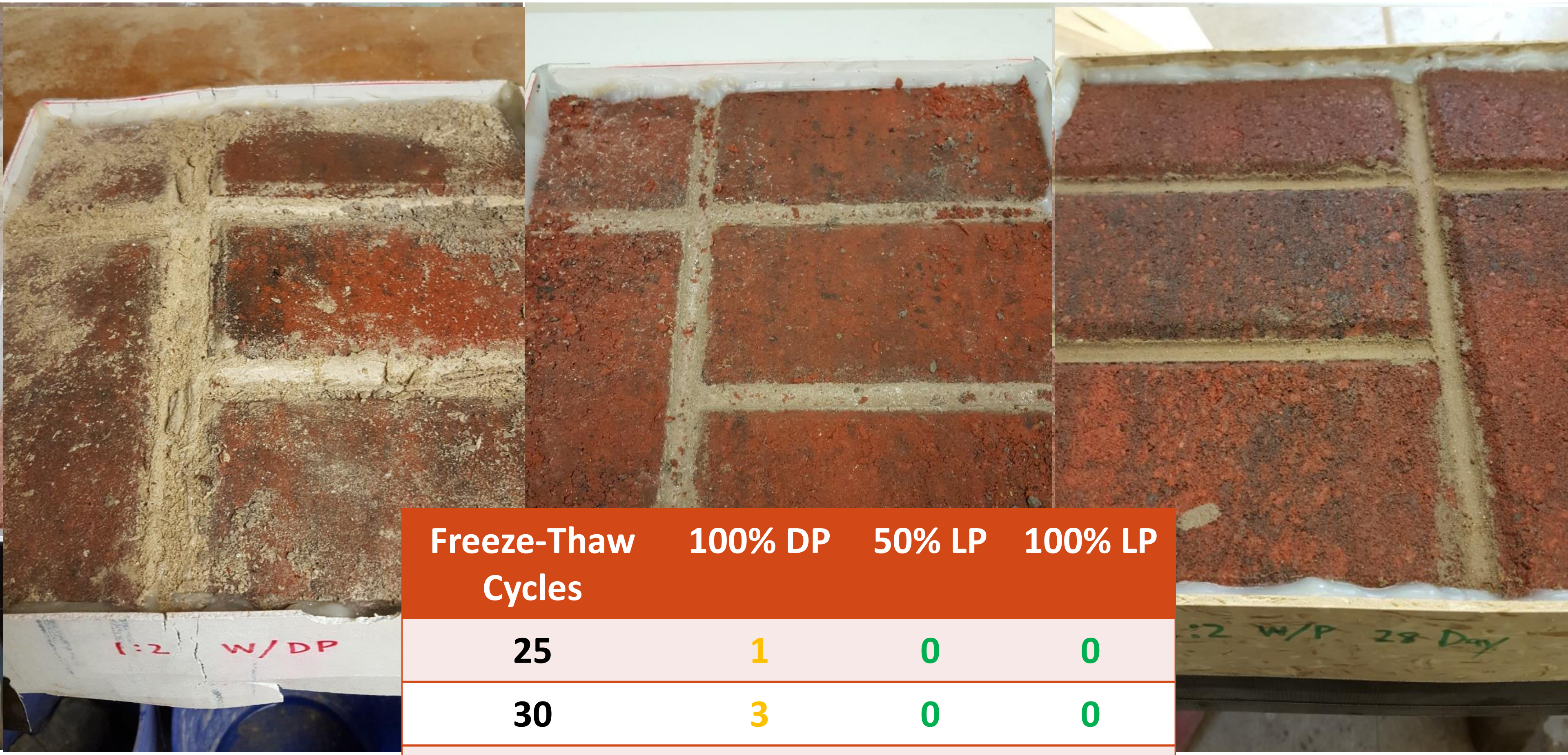
Freeze-Thaw Cycles	50% LP	75% LP	100% LP
25	1	0	1
30	2	1	1
35	3	1	2
40	4	2	2
45	5	2	2
50	5	2	2

ANC 1:1 – No Modification vs. 89W Siloxane vs. 12% Air vs. 100% Liquid Polymer



Freeze-Thaw Cycles	Untreated	89W Siloxane	12% Air	100% LP
1	2	2	0	0
3	5	5	1	0
5	5	5	3	0
10	5	5	5	0
15	5	5	5	1
25	5	5	5	1
50	5	5	5	1

ANC 1:2 – 100% Dry Polymer vs. 50% Liquid Polymer vs. 100% Liquid Polymer

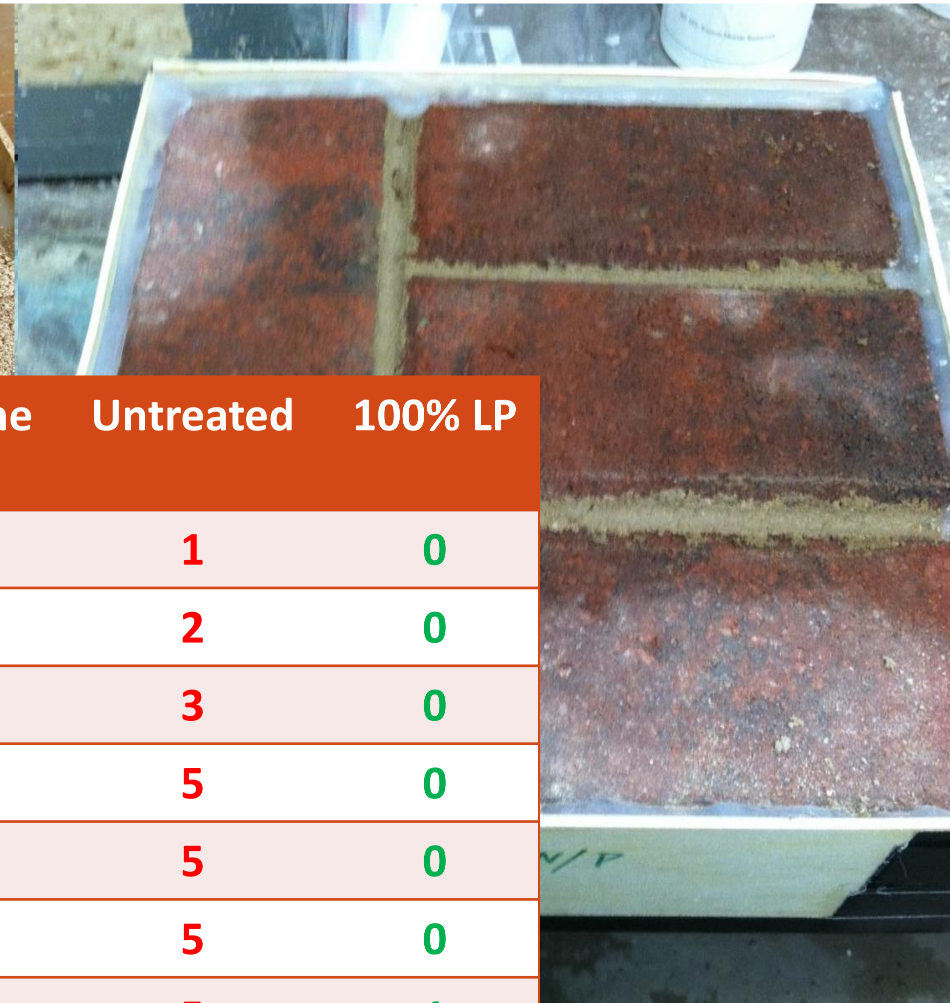


Freeze-Thaw Cycles	100% DP	50% LP	100% LP
25	1	0	0
30	3	0	0
35	4	1	0
40	5	1	0
50	5	2	1

ENC 1:1 – 100% Liquid Polymer

Freeze-Thaw Cycles	Rating
20	1
25	2
30	2
40	2

NHL 3.5 1:2.5 – No Modification vs. 88C Silane vs. 100% Liquid Polymer



Freeze-Thaw Cycles	88C Silane Cream	Untreated	100% LP
3	0	1	0
5	0	2	0
10	0	3	0
13	0	5	0
20	1	5	0
30	2	5	0
40	3	5	1
50	4	5	1

ASTM C67: Part 8 Absorption

- Cold Water Submersion
  24 hrs at 22˚C (72 °F)
- Boiling Water Submersion
  1 hr at 100˚C (212 °F)
- Calculate Saturation Coefficient

Saturation Coefficient

Mortar	Modification	SC	Cycles	Rating
Type M	None	0.95	27	5
	100% LP	0.45	50	0
Type N	None	0.90	10	5
	75% LP	0.27	50	1
Type O	50% LP	0.28	45	5
	75% LP	0.18	50	2
	100% LP	0.09	50	2
ANC 1:1	None	0.96	3	5
	12% A	0.85	10	5
	100% LP	0.16	50	1
ENC 1:1	100% LP	0.27	40	2
ANC 1:2	100% DP	0.74	40	5
	50% LP	0.57	50	2
	100% LP	0.49	50	1
NHL 3.5	None	0.78	13	5
	100% LP	0.33	50	1

Conclusions

Freeze-Thaw Resistance Improves With:

- GOOD: Longer Curing Times Before First Freeze
- BETTER: Air Entrainment
- BEST: Polymer Modification
  Silane Cream Water Repellent

Polymer Optimization:

- 75% Liquid Polymer

Research
Ongoing

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CENTRAL POST OFFICE
OTTAWA
4 YEARS AFTER REPOINTING
POLYMER-MODIFIED MORTAR