IMPROVEMENTS TO FREEZE-THAW, SALT-SCALING & WATER RESISTANCES OF MASONRY MORTARS

CHAD LAUSBERG

DIRECTOR OF TECHNICAL SERVICES

EDISON COATINGS, INC.

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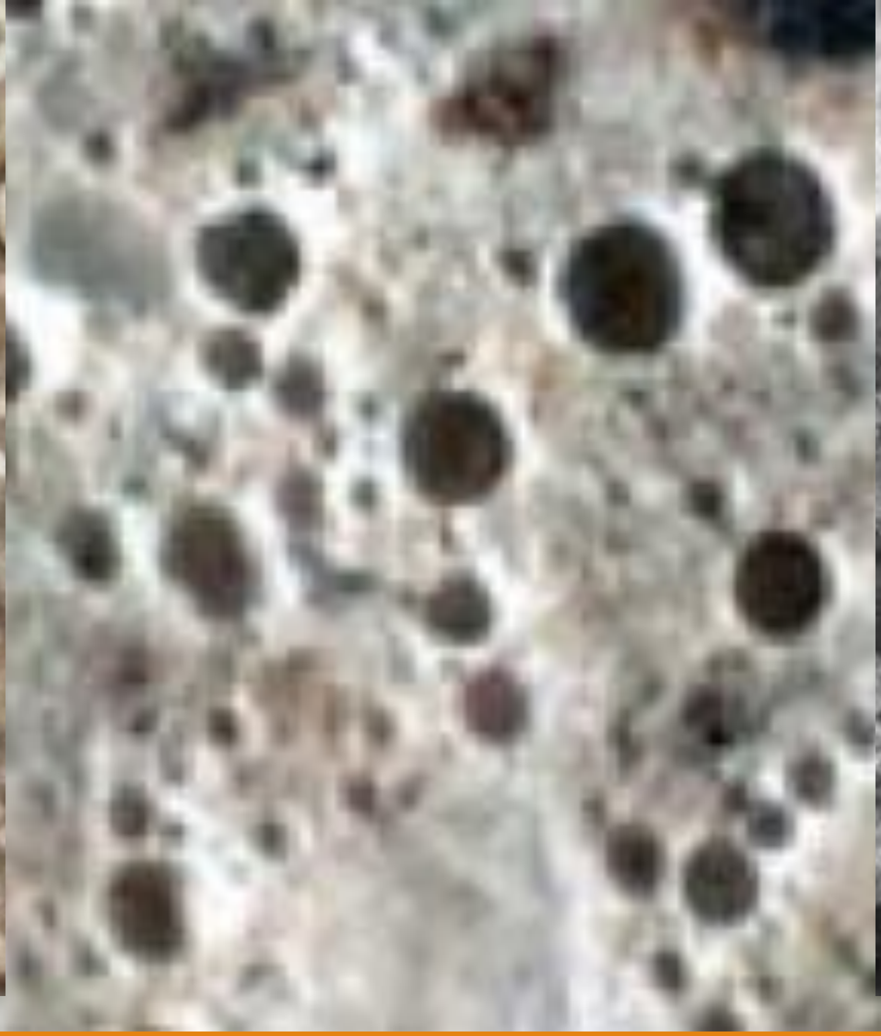
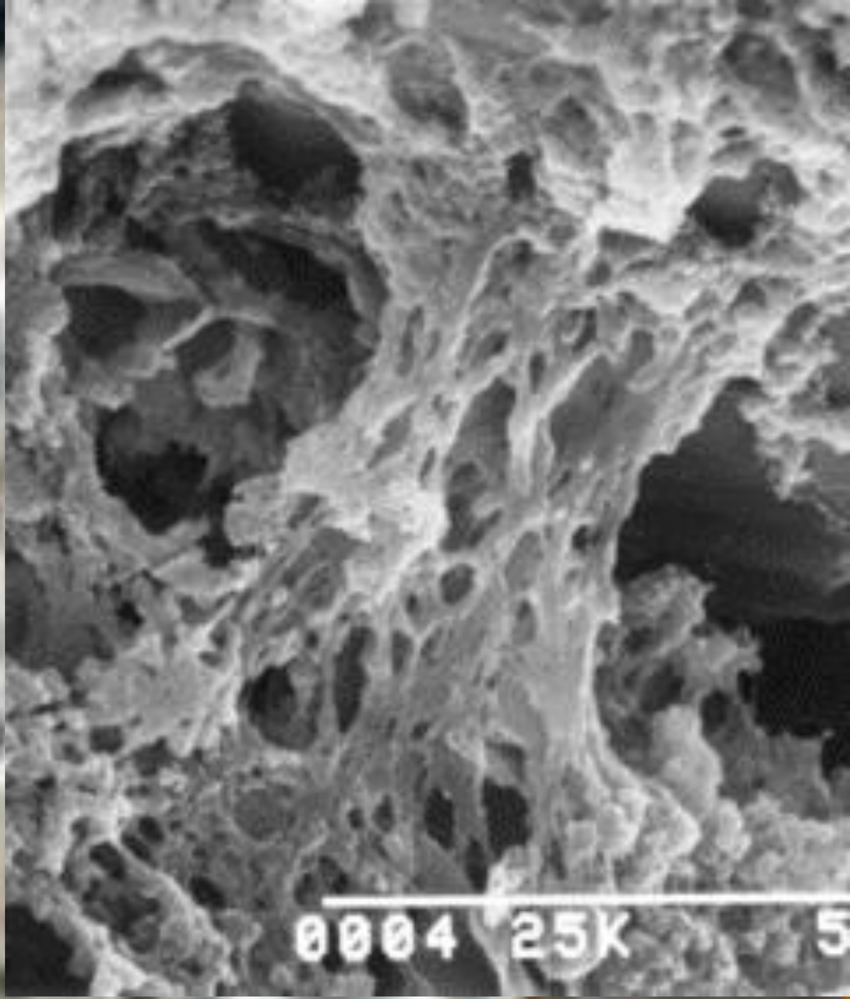




COMMON APPROACHES

FREEZE-THAW IMPROVEMENT

WATER REPELLENT

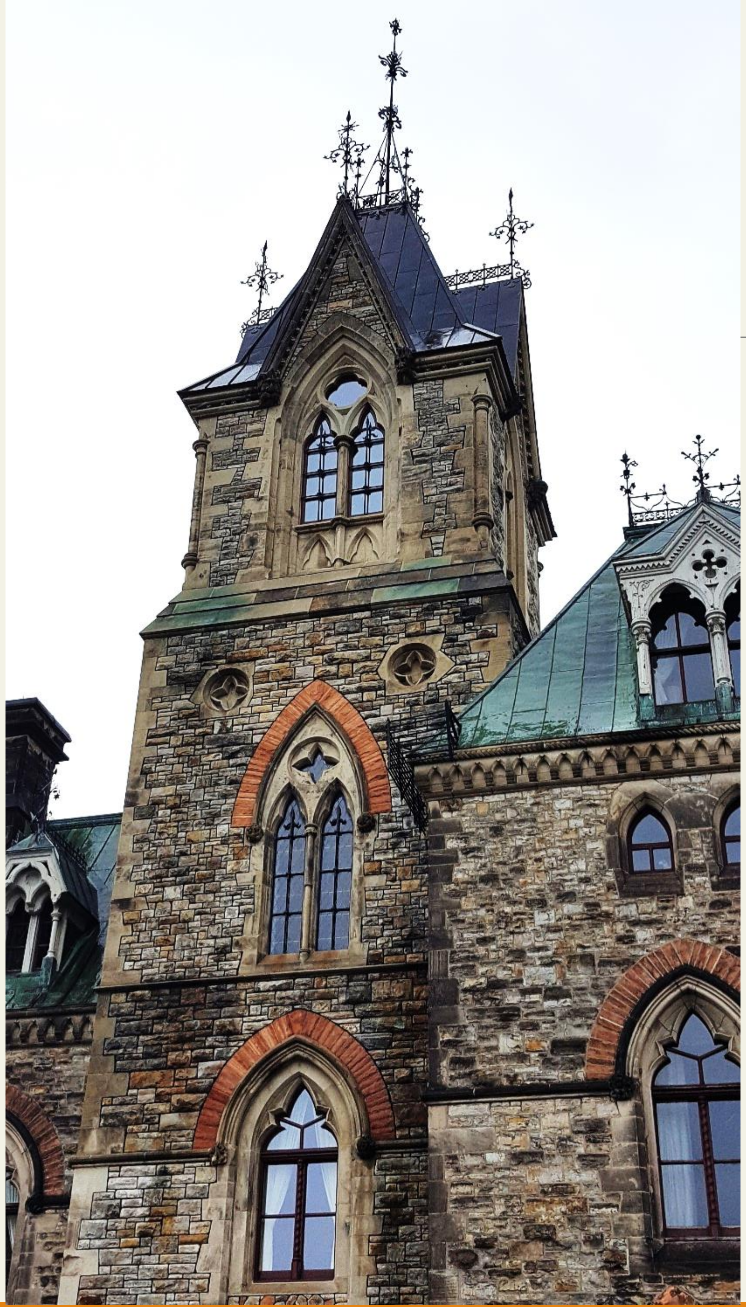
- SILANE/SILOXANE EMULSION (10% Solids)
- SILANE CREAM (80% Solids)

AIR ENTRAINMENT

- ASTM C226 ADDITION

POLYMER MODIFICATION

- PROPRIETARY ACRYLIC LATEX W/WET ADHESION MONOMER
- ALTERNATIVE POLYMERS



2012-13:

FREEZE-THAW FAILURE IN 1ST WINTER

TYPE O MORTAR

1	Portland Cement
2.5	Type SA Lime
8	Sand

Northwest Tower
East Block
Parliament Hill
Ottawa

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

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

50 Cycles

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)**

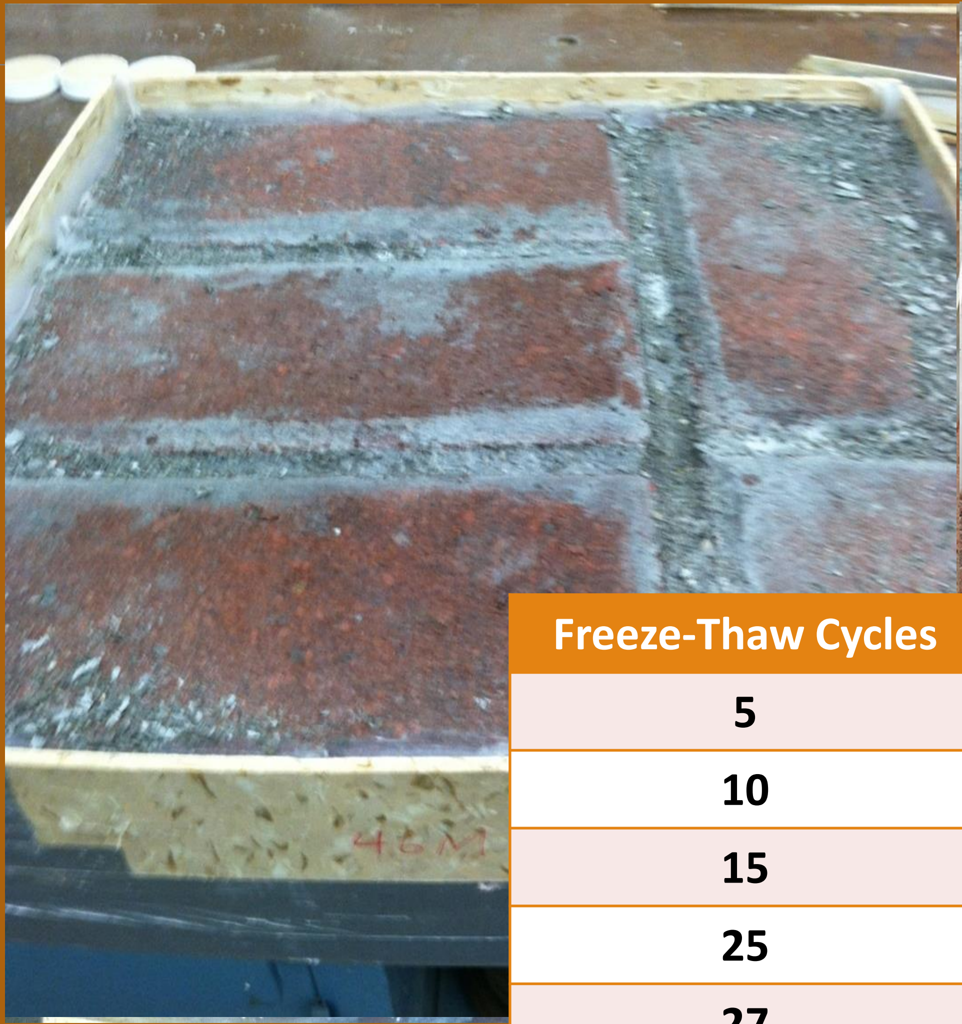
Mortars

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

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

- **A number between 0 and 1**
- **Reflects How Readily Water Is Absorbed by Comparing Cold Water Immersion vs. Boiling Water Immersion**
- **High Saturation Coefficient (Near 1) Indicates Rapid Cold Water Absorption and Vulnerability to Freeze-Thaw Damage**
  - **Exterior Brick Should Have Saturation Coefficient <0.8**

$$\text{Saturation Coefficient}=\frac{(\text{cold weight-dry weight})}{(\text{boiling weight-dry weight})}$$

ABSORPTION % (WEIGHT): COLD VS. BOIL

Mortar	Modification	Cold	Boil
Type M	None	5%	5%
	100% LP	8%	17%
Type N	None	9%	10%
	75% LP	8%	32%
Type O	50% LP	10%	35%
	75% LP	6.5%	35%
	100% LP	1%	13%
ANC 1:1	None	10%	10%
	100% LP	3%	19%
ENC 1:1	100% LP	6.5%	23%
ANC 1:2	100% DP	15%	22%
NHL 3.5	100% LP	6.5%	19%

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

THE UNEXPECTED:

SATURATION COEFFICIENT VS. % AIR VS. SCALING

Mortar	Modification	SC	%Air	Cycles	Scaling Rating ASTM C672
Type N	None	0.9	10.1	10	5
	75% LP	0.27	43	50	1
Type O	75% LP	0.18	42.1	50	2
ANC 1:1	None	0.96	2.9	3	5
	12% Air	0.85	12	10	5
	75% LP (reduced air)	0.78	22.4	25	5
	100% LP	0.16	46	50	1
NHL 3.5	None	0.78	5.6	13	5
	100% LP	0.33	30	50	1

WET CURING?

Latex Modified Mortars Are DRY Curing

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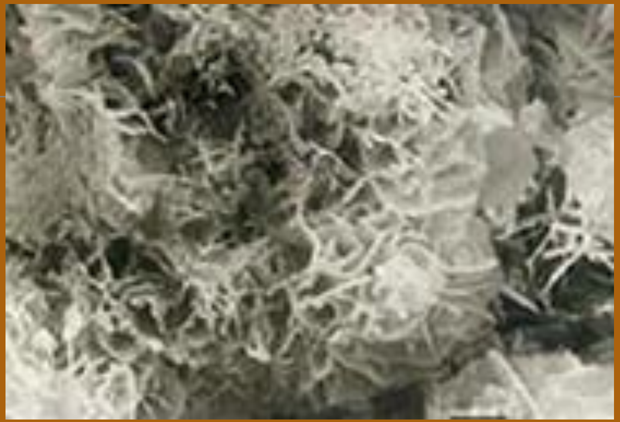
Jefferson Building
Washington, DC

Russell Senate Office Building
Washington, DC

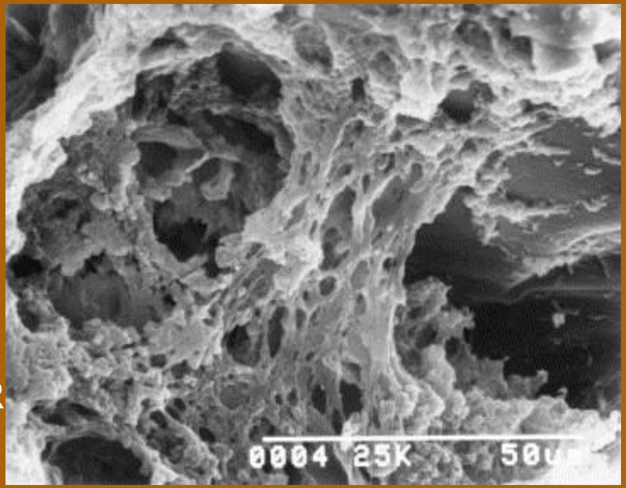
LATEX-MODIFIED CEMENT TECHNOLOGY

Why Do We Use It?

- **Increases Adhesion**
  - Typically 2x – 4x Higher
- **Improves Flexibility**
  - Typically 2x – 3x Flexural Strength
- **Lowers Shrinkage**
  - Up to 70% Reduction
  - Eliminates Shrinkage Cracking
- **Reduces Curing Requirements**
  - 0 – 24 hrs (max.) Wet Curing
- Does Not Impair Breathability



MICROPHOTOGRAPH: PORTLAND CEMENT IN EARLY STAGE OF HYDRATION



MICROPHOTOGRAPH: LATEX MODIFIED MORTAR AFTER ACID DIGESTION

IMPLICATIONS

- **Latex-Modification Does Not ONLY Improve Freeze-Thaw Resistance**
  - **Water Resistance**
  - **Salt Scaling Resistance**
  - **Bond Strength/Tensile Strength**
  - **“Flexibility”**
  - **Shrinkage**
  - **Volume Yield**
- **Latex-Modification Can Improve Mortar Performance in Difficult Exposure Areas**
  - **Copings**
  - **Water Tables**
  - **Stairways**
  - **Pavements**
  - **Marine**
- **May Allow Use of Mortar In Place of Sealants**
- **Can Overcome Deleterious Process Shortcuts Like Omital of Wet Curing**
- **Latex-Modified Natural Cement Mortars Can Be Applied Continuously, Rather Than In “Lifts”**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QUESTIONS?

STAIRWAY AT U. S. CAPITOL BUILDING
LATEX-MODIFIED MORTAR TEST AREA

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