Expanding the Pour Season for Bridge Deck Overlays with Latex Modified Concrete

2024 Spring ACI Concrete Convention

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Agenda

- Backstory of low temperature cure research conducted by Trinseo
- Specified LMC overlay temperature restrictions
  - Contractor challenges
- Low temperature cure project
  - Project design and execution
  - LMC performance under low temperature cure conditions
  - What this means for state DOTs and LMC overlay installers

Backstory of Low Temperature Cure Research Conducted by Trinseo

Modifier A™/NA Latex

Trinseo manufactures Mod-A latex in the same location, Midland, MI, using the same recipe for over 50 years & offers/supports:

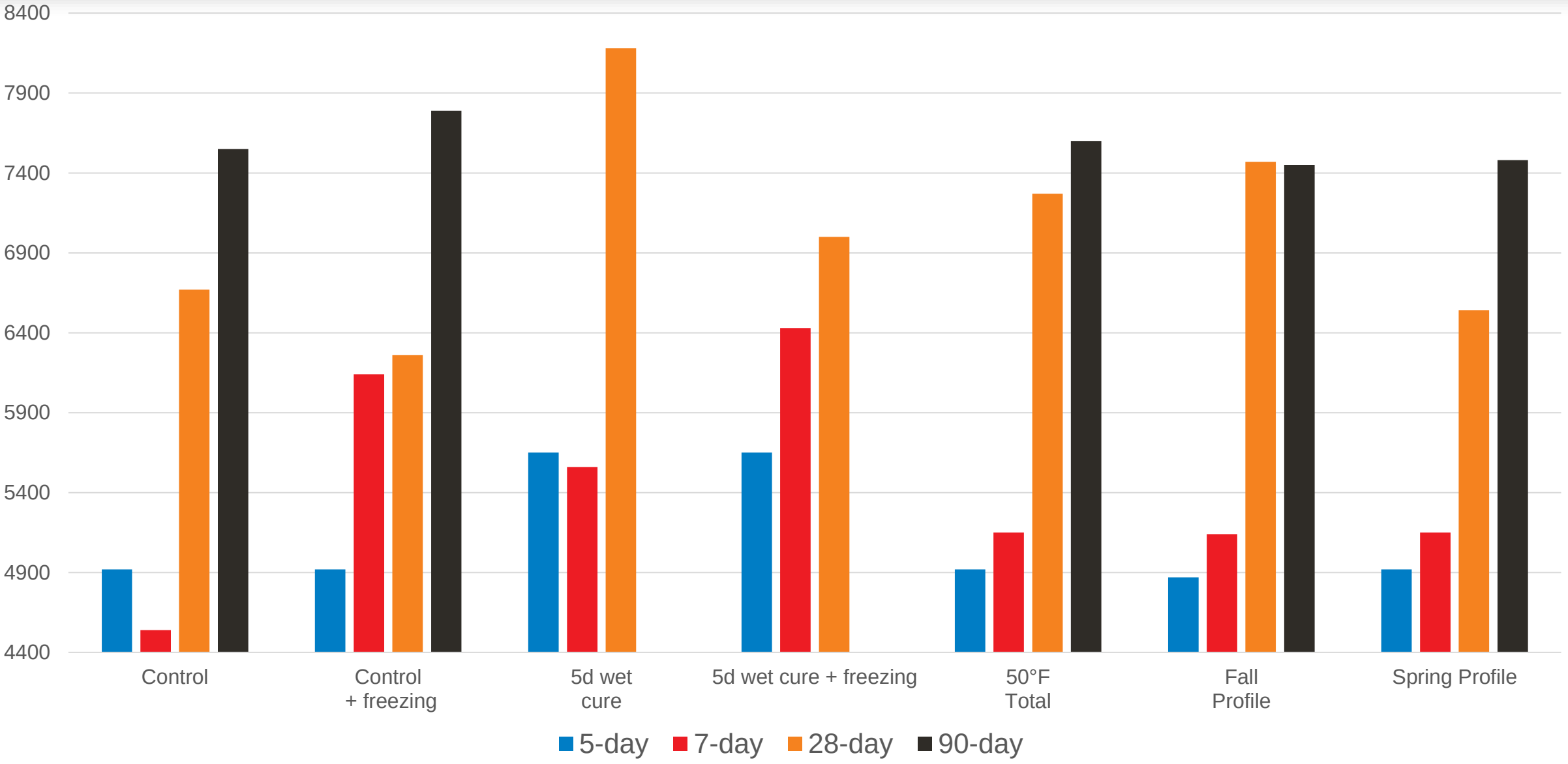
- DOT Certification/Support
- Historical Data/Expertise
- Laboratory Testing
- Customer/Contractor Support
- Meets FHWA RD-78-35 Standard

Introduction and Background

Typical LMC Curing/Drying Conditions

- Two days wet cure
  - Cement hydration
  - Compressive strength development
- Two to three days air dry
  - Coalescence of latex
- Minimum temperature 50˚ F

ASTM C39 Compressive Strength, psi



AASHTO T-277 Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration

Age Tested Avg of 2 cylinders	Control	Control + Freezing	5d Wet Cure	5d Wet Cure + Freezing	50° F Total	Fall Profile	Spring Profile
	Adjusted Readings, Coulombs						
28 days	2507	2639	1921	2437	3677	2803	2700
90 days	1229	1124	1002	1247	1401	1433	1137
6 months	821	831	692	793	801	795	788

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4,000	High
2,000–4,000	Moderate
1,000–2,000	Low
100–1,000	Very Low
<100	Negligible

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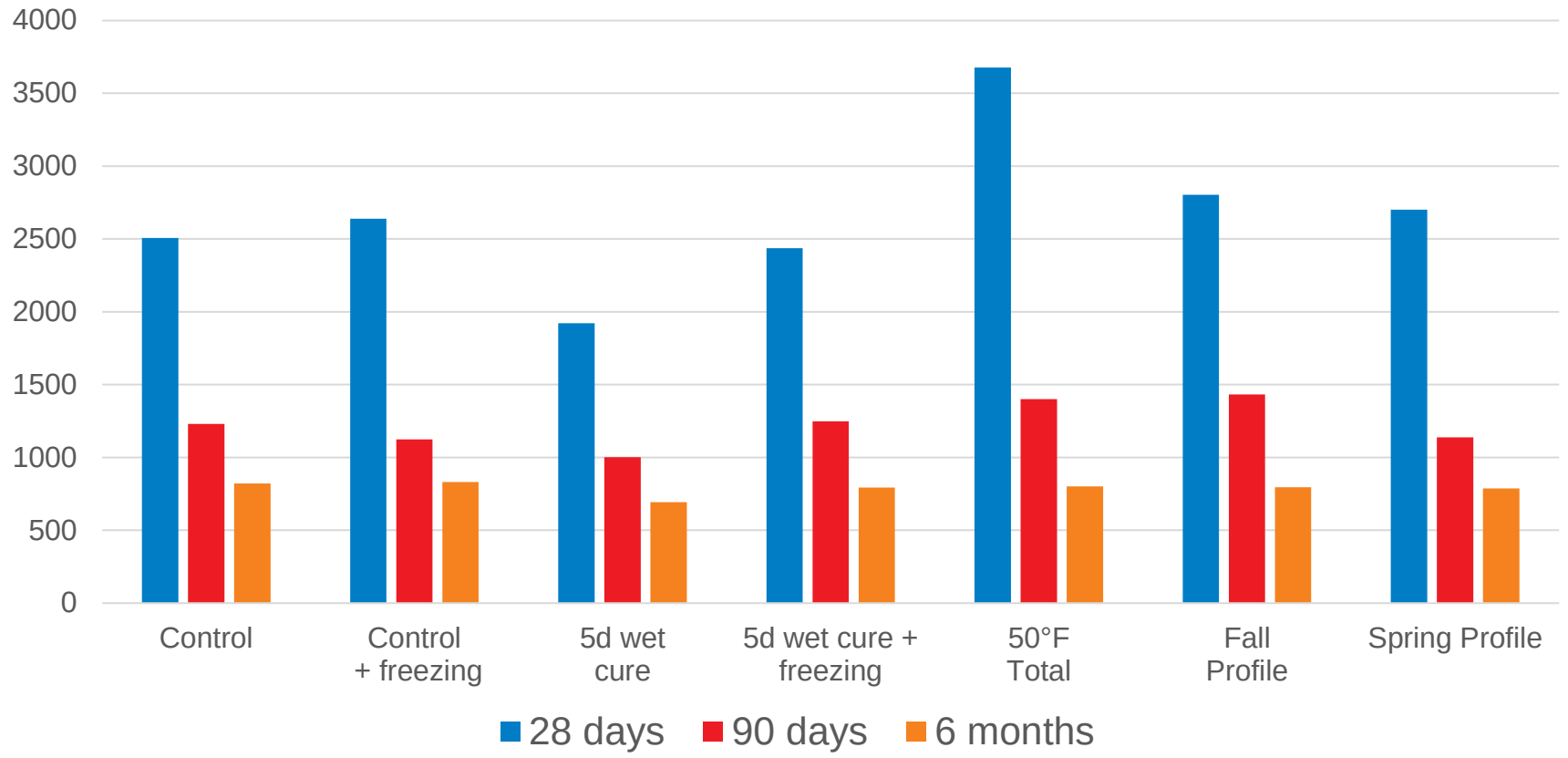

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Specified LMC Overlay Temperature Restrictions

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- Specifications are typical of temperature restrictions for batched materials and during placement / cure operations
  - Ambient temp. at placement inconsistent
  - Varying minimum batched material temp.
  - Cure temp. of LMC above 45 F

505.20.10.2 No latex modified concrete shall be placed at ambient or deck surface temperatures below 45 F. Latex modified concrete shall be protected to maintain a minimum specified curing temperature of 45 F. Any concrete damaged by freezing or that is exposed to a temperature of less than 45 during the first 8 hours after placement shall be removed and replaced at the contractor's expense.

505.20.10.3 The temperature of the latex modified concrete at time of placement shall be between 45 F and 90 F. If either the aggregate or water is heated, the maximum temperature for each shall be 100 F at the time of addition to the mix. Any method of heating during the mixing of concrete may be used provided the heating apparatus will heat the mass uniformly and avoid hot spots that will burn the material. Cement or aggregate containing lumps or crusts of hardened material or frost shall not be used.

Construction Requirements. (a) Weather Limitations. Construction of the overlay should be performed when the ambient, mixture, and prepared surface temperatures are between 55° F and 75° F. In all instances, the LMC overlay shall be placed and kept at a temperature above 45° F for at least 96 hours after placement. The mixture shall not be placed when the ambient, mixture, or prepared surface temperature is above 85° F. The Contractor shall take approved steps to maintain all temperatures within these limits or cease overlay placement until such temperature limits can be maintained. The LMC overlay shall be protected from rain, excessive evaporation, or other atmospheric conditions that cause difficulty in the satisfactory finishing and curing of the overlay. This may require scheduling placement to avoid such conditions or the use of approved coverings or other equipment to mitigate the effects of such conditions. Material damaged by such conditions shall be removed at the direction of the Engineer and at no cost to the Department. If changing conditions necessitate a delay during placement operations, the Contractor shall implement delay measures as described in section (f) below.

606.03.02 Weather Limitations. Construct the overlay during the night time hours when the ambient temperature will remain below 85 °F, the wind velocity is low, and hot conditions or rain are not expected. During hot weather, place the concrete when the ambient temperature falls to 85 °F or below. Complete placement of concrete before the ambient air temperature reaches 85 °F. Do not place concrete when the ambient temperature away from artificial heat is less that 45 °F and falling, except when using Type III cement. Keep all concrete at a temperature above 45 °F for at least 96 hours after placing. Make provisions for the uniform distribution of heat, and do not allow any area of the concrete surface to be heated to a temperature above 85 °F. To accomplish uniform distribution of heat during cold weather, provide housing, heating, or insulation methods that the Engineer approves. Do not place concrete during rain or drizzle. If it begins to rain or drizzle during placement, cease placement and finish and protect the material already in place.

References

- MoDOT Standards and Specifications 2019; Section 505.20.10.2 and 505.20.10.3
- ARDOT Job Special Provision Job 012377 Latex Modified Concrete Overlay
- Kentucky Transportation Cabinet Standards and Specifications 2019; Section 606.03.02

Contractor Challenges

- Projects have specific time constraints for when work can be completed on bridges
  - Expansive scope of work for bridge rehabilitations
  - Staged construction
- Risk lies with the Contractor even when batching, placing and curing LMC within project specifications.
- Low temperature curing testing previously tested to 50 F

Contractor Challenges

- Means and methods for batching LMC within temp. limits
- Maintaining Latex temp.
- Maintaining concrete temp. during cure period
- Have a complete work plan


Carrier
3000R
CONCRETE
STRATHROY
MAXIMUM 24000 litre
CAPACITY 6340 US gal
TR212

Low Temperature Cure Project

Project Review

- Project design
- Sample preparation
- Test methods and sample conditioning
- Test results
- Summary and conclusions

Project Design

- Cure temperatures selected

  Control temperatures: 50, 72˚ F

  Low temperatures: 35, 40, 45˚ F

- Performance tests selected

Test	Test Designation
Compressive Strength of Cylindrical Concrete Specimens	ASTM C39-18
Bond Strength of Epoxy-Resin Systems Used with Concrete by Slant Shear	ASTM C882-20
Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration	AASHTO T 277-15 (2019)

Project Design

- Specimen count and testing frequency
- 165 total specimens required; plus 45 concrete bases needed for ASTM C882
- LMC was produced by Concrete Strategies during actual LMC installations in Disney, OK
- Sample specimens were prepared at the project site by GTS, Inc.

Number of Specimens Per Temperature				
Day	ASTM C39	ASTM C882	AASHTO T 277	
2	3			
5	3			
28	3	3	3	
90	3	3	3	
180	3	3	3	
Total	**15**	**9**	**9**	**33**

Mix Design

Material Type	Material	Quantity	Unit/yd^3	Specific Gravity (SSD)	Volume
Type I-II Cement	Buzzi Cement - Pryor Plant	658.00	Lbs	3.150	3.35
Admixtures	Trinseo Mod A Latex	206.54	Lbs	1.010	3.28
Water	Water	146.00	Lbs	1.000	2.34
Stone	Pryor Stone - 3/8" Chips	1284.00	Lbs	2.607	7.89
Sand	Muskogee Sand - Concrete Sand	1477.00	Lbs	2.612	9.06
Air	Entrained (estimated)	4.0%	--	--	1.08
	Total	**3771.58**	**--**	**--**	**27.00**
	Target	**Batch Day 1**	**Batch Day 2**		
Unit Weight (lb/ft^3)	139.69	136.8	134.7		
Actual % Fine Aggregate	53.50%				
Air, %	3.0 - 6.0	4.8	5.0		
Actual water:cement ratio	0.39	0.39	0.39		
Slump	4 - 6 inches	9.25	9.75		
Concrete Temperature, °F	50 - 85	65	70		
Ambient Temperature, °F		49	50		

Sample Preparation / Pre-Batching

- Three weeks prior to the first batch day, 45 Portland cement mortar bases were cast for slant shear testing
  - 3-inch by 6-inch cylinders
  - High strength Portland cement mortar mix
  - Cast against plastic dummy molds to create a 30˚ angle

LMC Production and Sample Preparation

- **Batch day 1:**

  Samples for the 35, 40, and 45˚ F systems were cast on April 21, 2021

  Ambient temperature was 49˚ F

- **Batch day 2:**

  Samples for the 50 and 72˚ F systems were cast on April 29, 2021

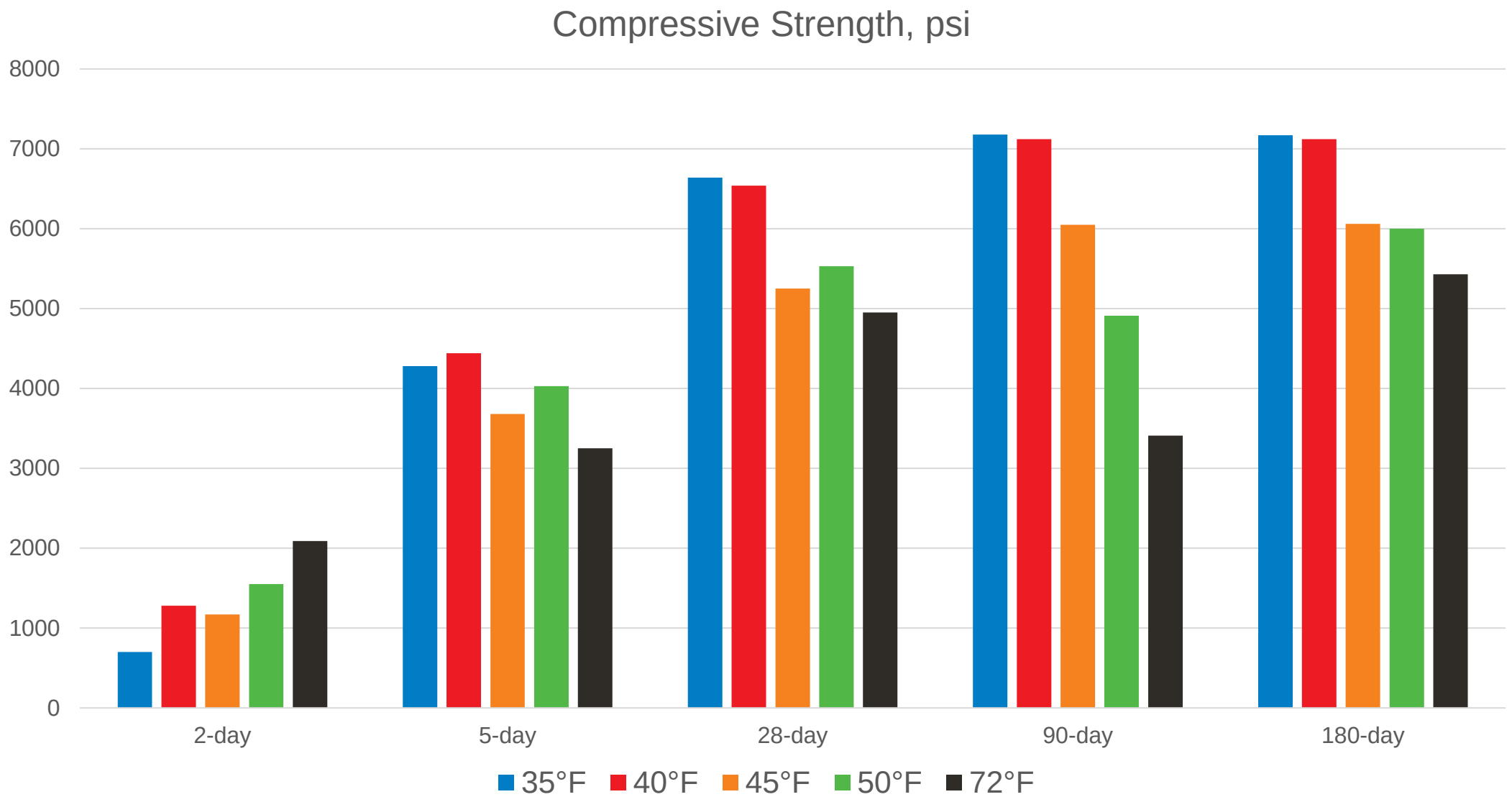
  Ambient temperature was 50˚ F

April 21 Batch Day 1

Compressive Strength – ASTM C39

- Samples were cast on-site during the two batch days into 4-inch x 8-inch cylinder molds
- All samples were de-molded, placed in limewater, and controlled to the targeted temperature until the time of testing
- Samples were removed from the refrigerators immediately prior to testing

Compressive Strength – ASTM C39



Slant Shear – ASTM C882

- LMC was placed directly onto the 30-degree Portland cement mortar bases inside 3-inch x 6-inch cylinder molds
- Samples were cured on-site overnight
- Cylinders were transferred to the laboratory after the initial curing period and placed in water baths at the targeted temperature
- Samples were removed from their water baths and brought to room temperature in preparation for sulfur capping

Slant Shear – ASTM C882

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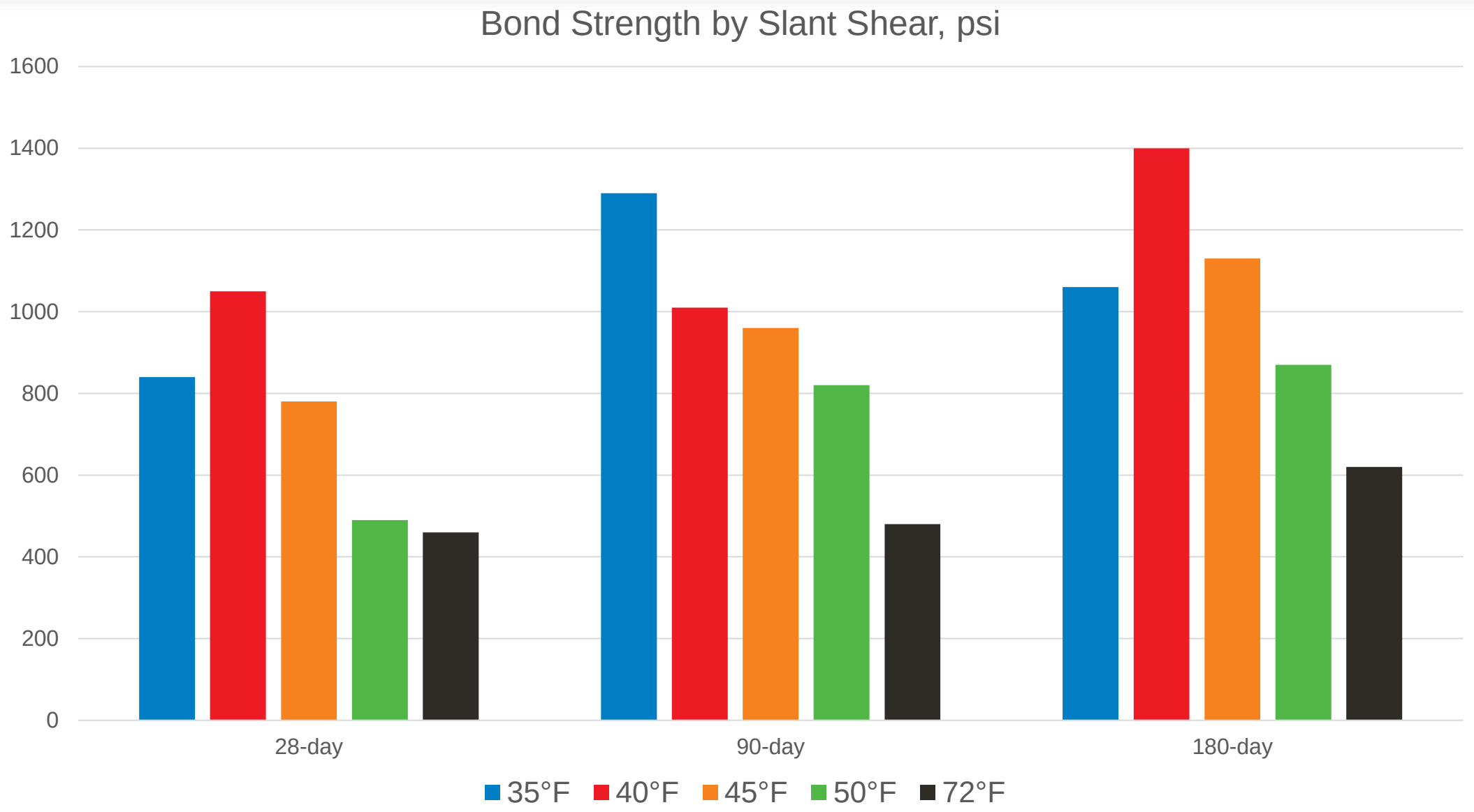

Chloride Ion Penetration Resistance – AASHTO T 277

- One day prior to testing, samples were removed from their temperature-controlled environments
- Samples were cut and sealed with a clear, waterproof silicone, followed by conditioning in a vacuum chamber overnight

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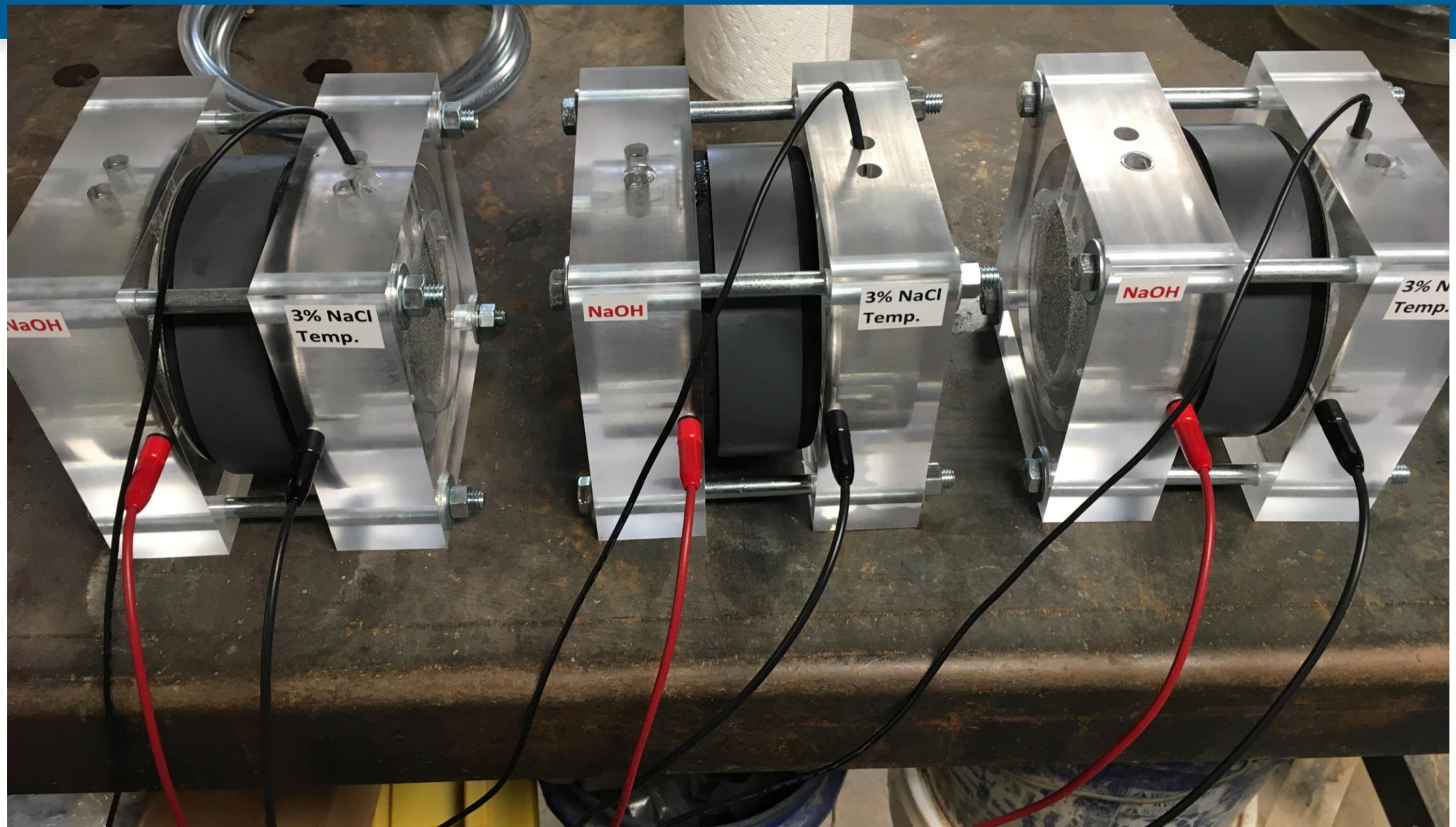

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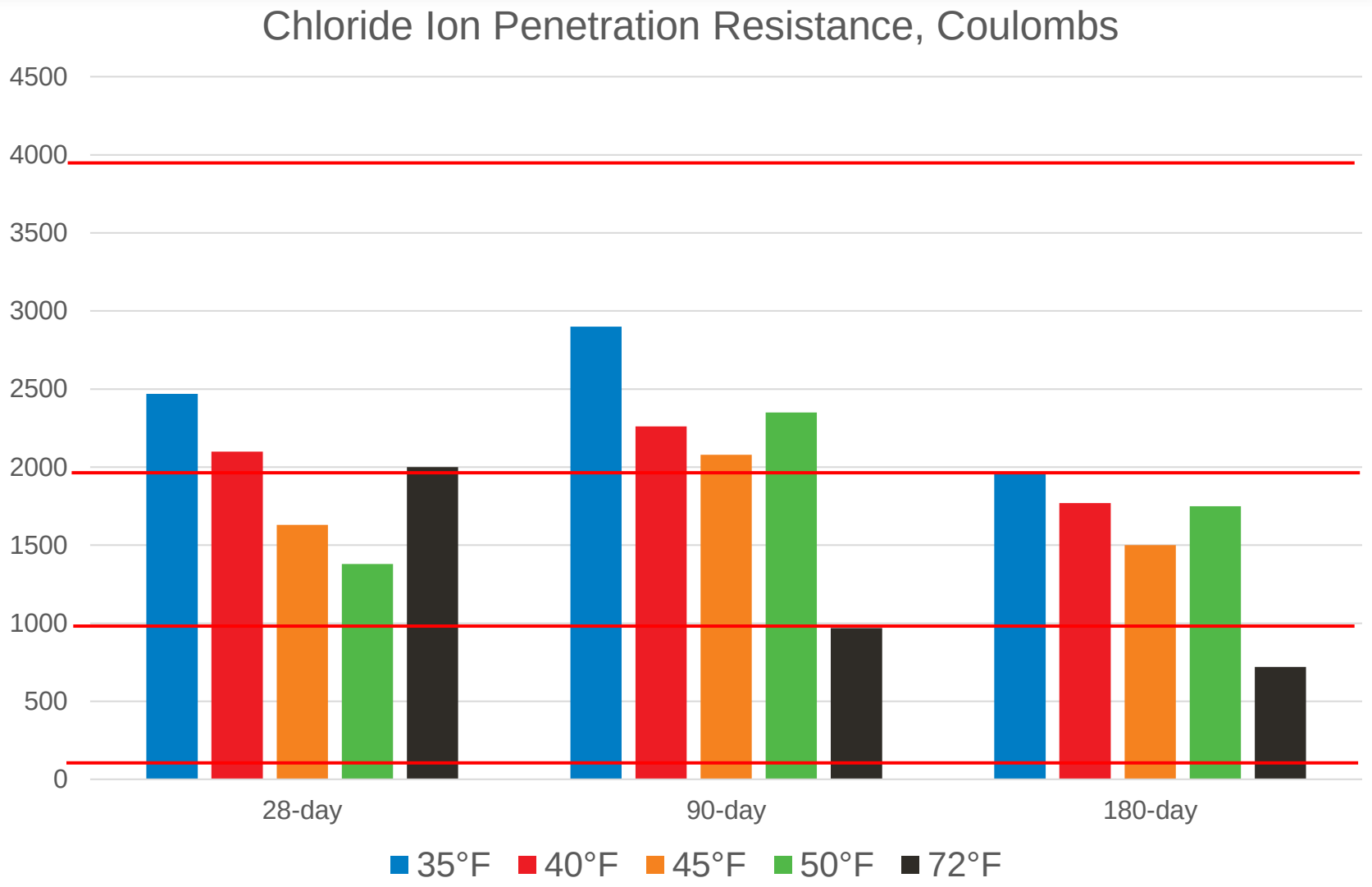

Summary and Conclusions

- Compressive Strength Development
  - excellent for LMC when cured under low temperature conditions
- Bond Strength by Slant Shear
  - excellent for LMC when cured under low temperature conditions
- Chloride Ion Penetration Resistance
  - improves over time from moderate to low penetration, as expected with LMC systems

- LMC can be poured at lower temperatures without compromising performance
- DOTs and installers should re-examine temperature specifications
- Pouring of LMC can be expanded into the late fall and early spring seasons

Questions?

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Thank you

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