Enhancing Concrete Performance with Multi-Crystalline Enhancer (MCE) September 10, 2025

Tyson D. Rupnow, Ph.D., P.E.
Associate Director, Research

LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT

LOUISIANA TRANSPORTATION RESEARCH CENTER

Outline

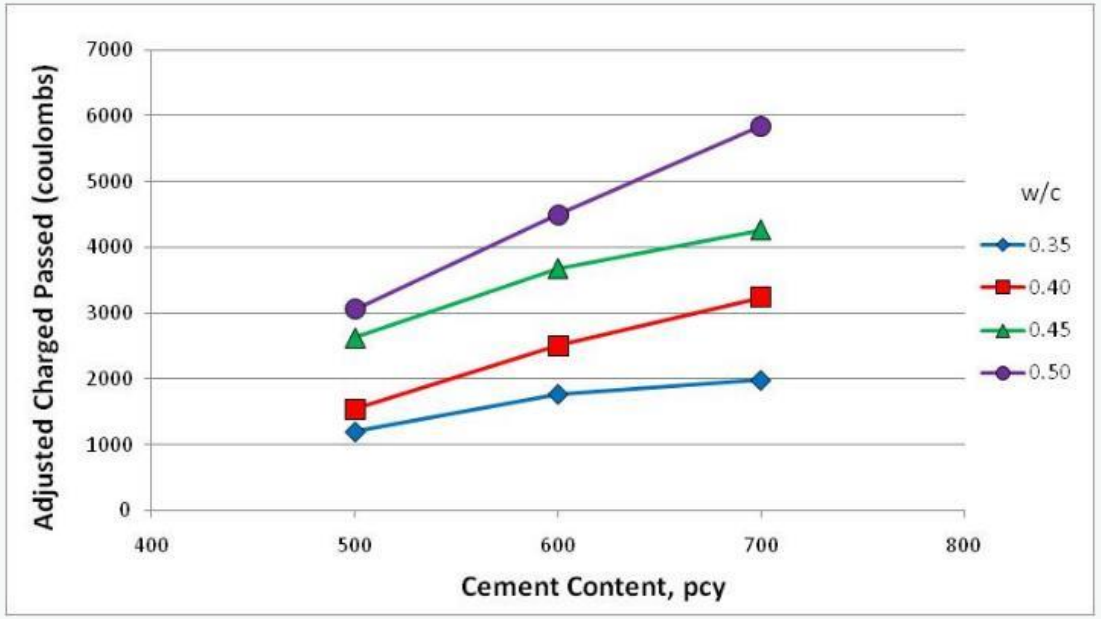
- Background
- Laboratory Results
- Field Applications
- Questions

Background

- Critical Factors in Concrete Longevity
  - Design
    - Traffic, support, steel selection
  - Construction
    - Methods suited to project specifics
    - QC/QA program is a must have
  - Materials
    - Concrete durability is most important

Background

		Workability	Transport	Strength	Cold weather	Shrinkage	Aggregate stability
Aggregate System	Type, gradation	✓✓	-	-	-	-	✓✓
Paste quality	Air, w/cm, SCM type and dose	✓	✓✓	✓✓	✓✓	✓	✓
Paste quantity	Vp/Vv	✓	-	-	-	✓✓	-

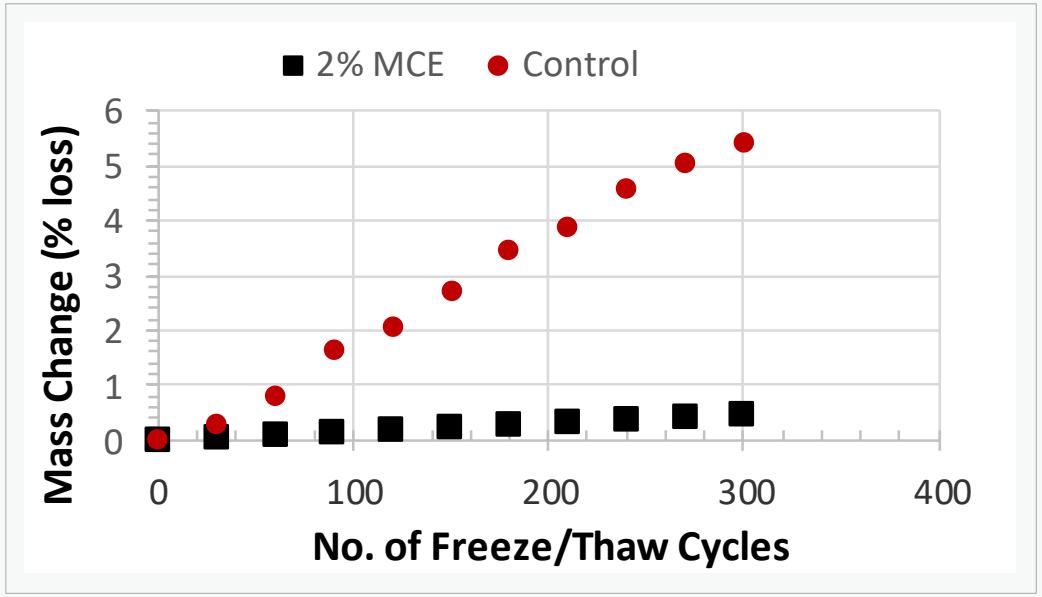


Multi-Crystalline Enhancer (MCE)

- Crystalline water proofer
  - Enhances compressive strengths
  - Improves FT performance
  - Reduces permeability
  - Reduces ice adhesion
  - Does not change construction, curing, batching practices
- Added to fresh concrete at batching
- 2% by weight – been standard

Laboratory Results - FT

- IDOT C4 Mixture



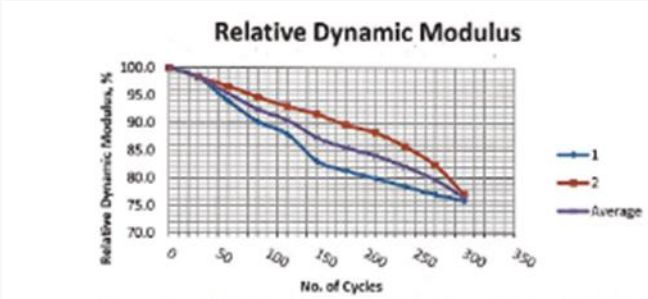


Figure 4.a: Relative Dynamic Modulus – Untreated Mix

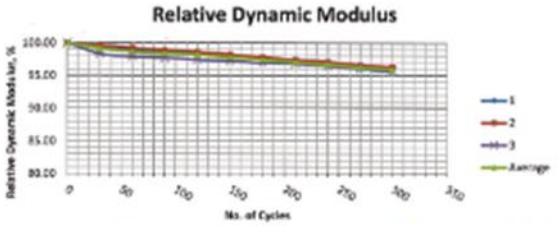


Figure 4.b: Relative Dynamic Modulus – Treated Mix 2%

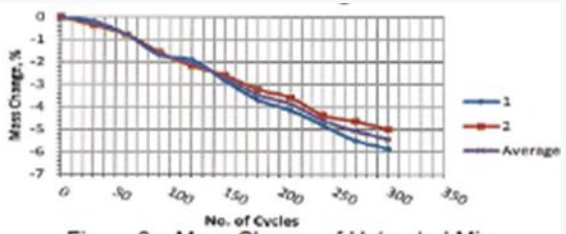


Figure 3.a Mass Change of Untreated Mix

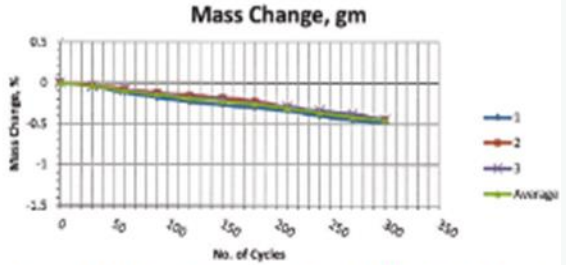
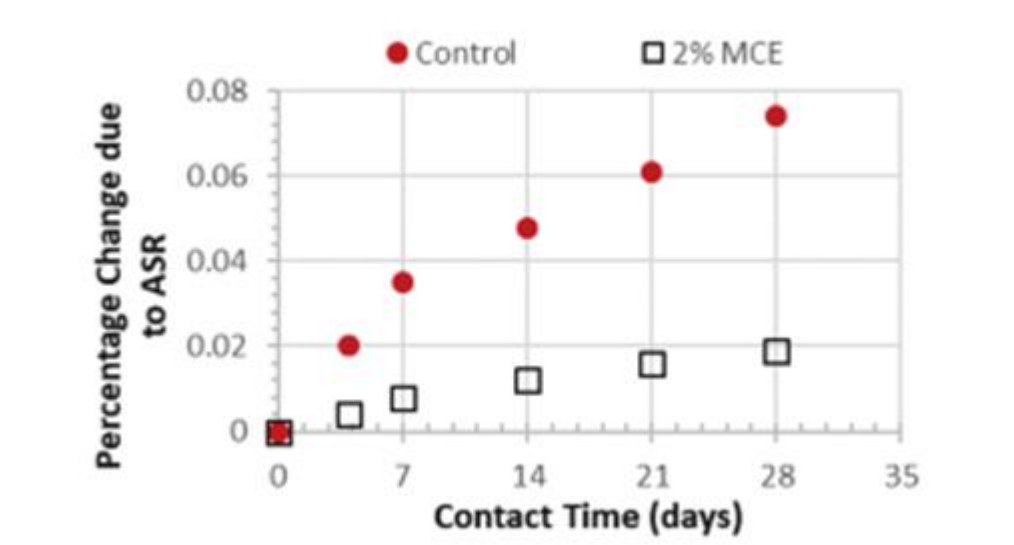


Figure 3.b Mass Change – Treated Mix 2% Internal

Laboratory Results - ASR

- 1567 Testing
  - IDOT C4 mixture with Platt River Aggregates



Water Permeability – CRD-C48-92

- TxDOT mixture proportions
- 300+ day old concrete
- 200 psi pressure differential

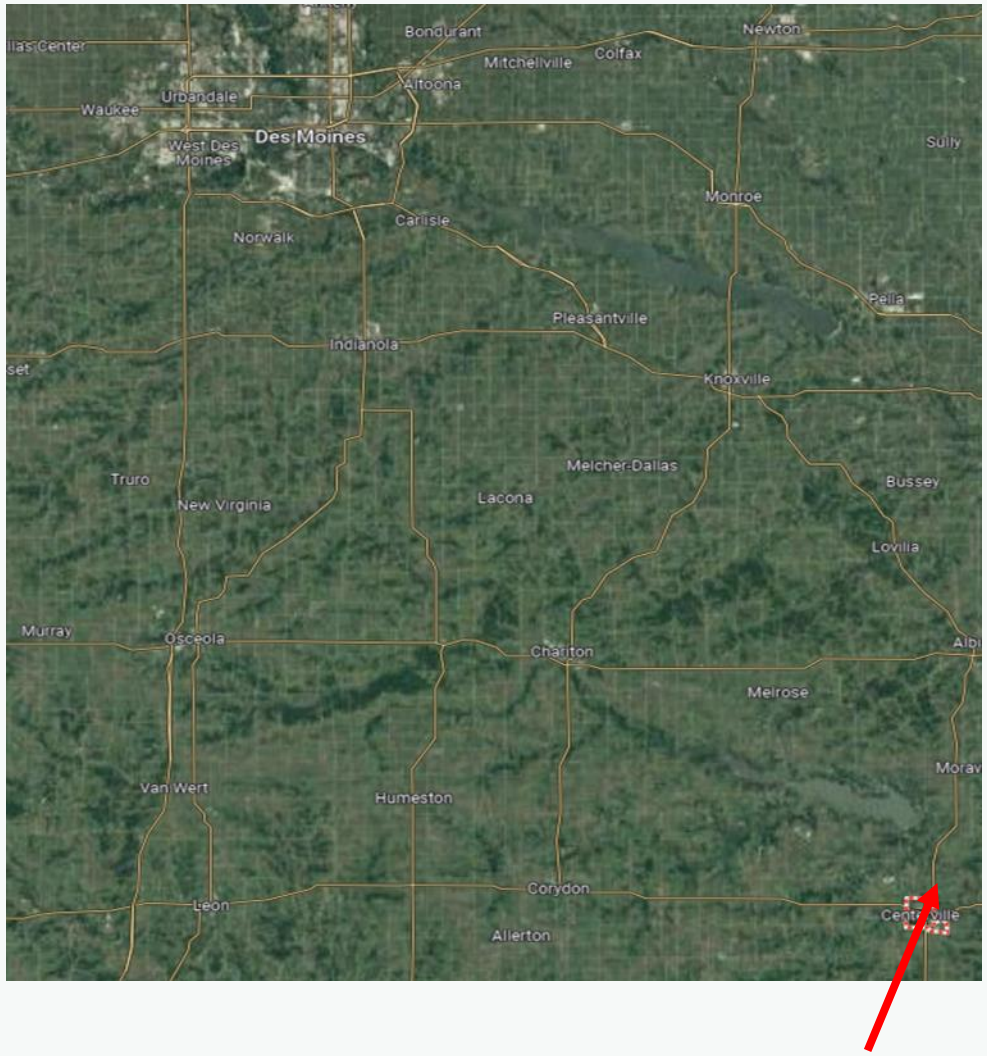
Cylinder ID	Coefficient of Permeability, cm/sec
4 of 12 (2% MCE)	4.985×10^{-10}
7 of 12 (2% MCE)	5.121×10^{-10}
12 of 12 (2% MCE)	4.925×10^{-10}
3 of 11 (2% MCE)	5.621×10^{-10}
7 of 11 (2% MCE)	5.195×10^{-10}
9 of 11 (Control)	2.223×10^{-6}

Ice Adhesion

- UT Arlington
  - Shear testing has shown a reduction of 70% in the bond strength of ice to MCE treated concrete samples

Field Application – IDOT Slide Bridge

- Iowa Hwy 5
  - Centerville, IA
  - Lateral Slide Bridge
  - Deck placed August 4, 2023
  - Ideal Ready Mix Co.
  - IDOT C-4WR-C CL3



Mixture Proportions

- Type IL Cement
- Fly ash
- w/cm
- Coarse aggregate
- Sand
- WR
- MCE dosage rate

- 470 pcy
- 117 pcy
- 0.42
- 1424 pcy
- 1516 pcy
- Adjusted for site conditions
- 147 fl oz per cuyd
- “target 2% cementitious weight”

Water Permeability / Chloride Penetration

- CRD-C48-92 @ 200 psi differential

Permeability Comparison		
Sample Designation	Age at Time of Testing	Coefficient of Permeability (cm/sec)
Control	28	6.65×10^{-7}
MCE (Lab sample)	28	3.58×10^{-12}
MCE (Field Trial 1)	28	3.01×10^{-11}
MCE (Field Trial 2)	28	2.28×10^{-11}
MCE (Field Trial 3)	28	2.61×10^{-11}

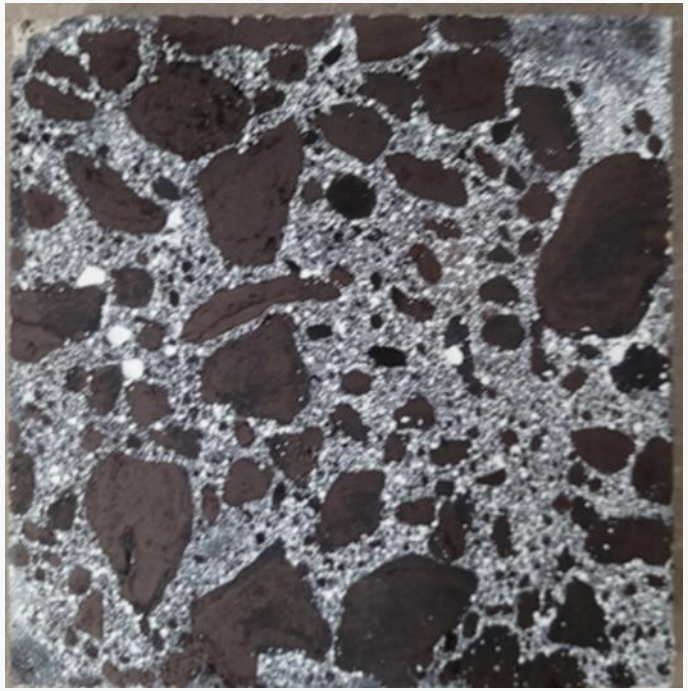
- Nortest 492
  - Chloride migration coefficient from non-steady state migration

Sample Name	*Dnssm, m^2/s*
MCE1	*17.314×10^{-12}*
MCE2	*17.921×10^{-12}*
MCE-Pavix1	*14.899×10^{-12}*
MCE-Pavix2	*14.202×10^{-12}*
Control1	*24.061×10^{-12}*
Control2	*24.923×10^{-12}*

Hardened Air and Length Change

- Hardened Air Content
  - 8.74% and 8.33%
  - Spacing Factor
    - 0.082mm
  - Specific Surface
    - 36-39 mm^{-1}

- Drying Shrinkage
  - 28-day – 0.013%

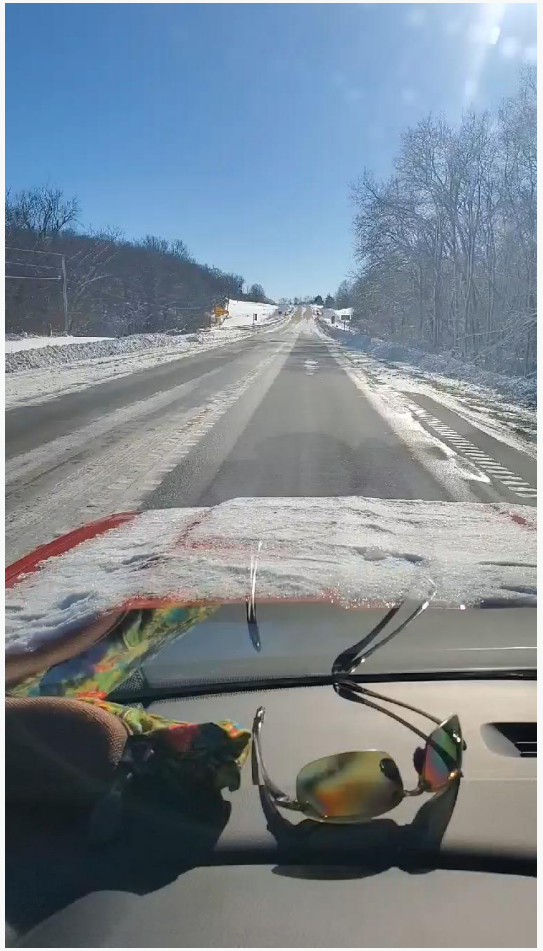


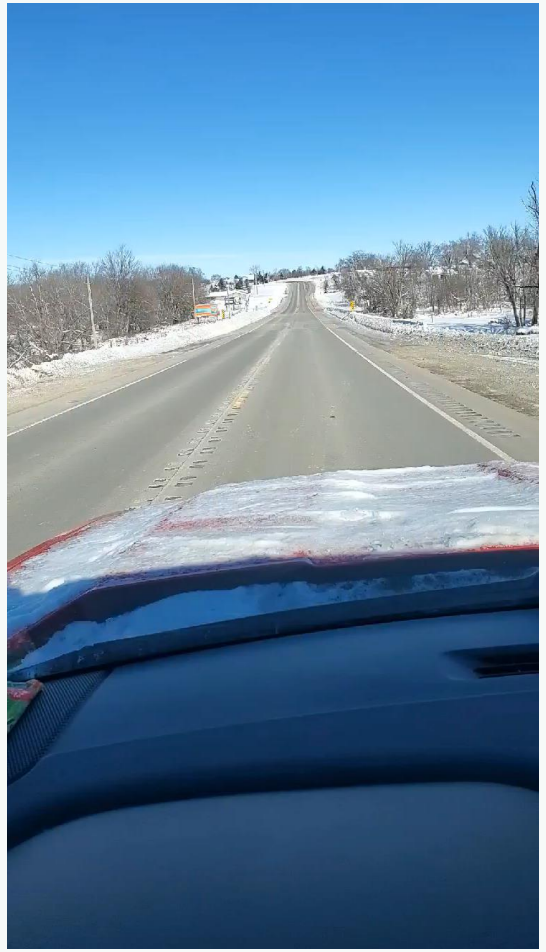
Construction

Construction Summary

- 6” slump allowed via waiver
- 270 cuyd
- Pump operator noted significantly lower pump pressures
- 7-day wet curing
- No initial surface cracking or initial distress after wet curing operations
- No surface distresses after the slide

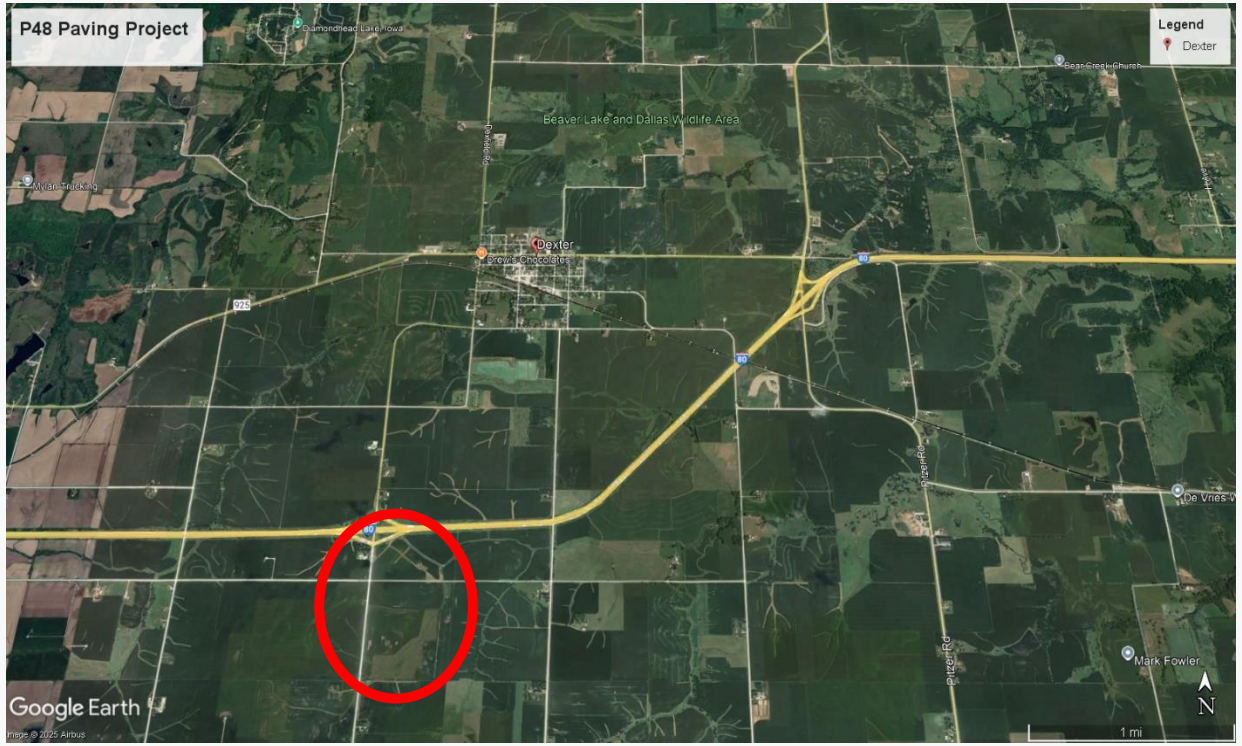
Post Construction – Ice Adhesion



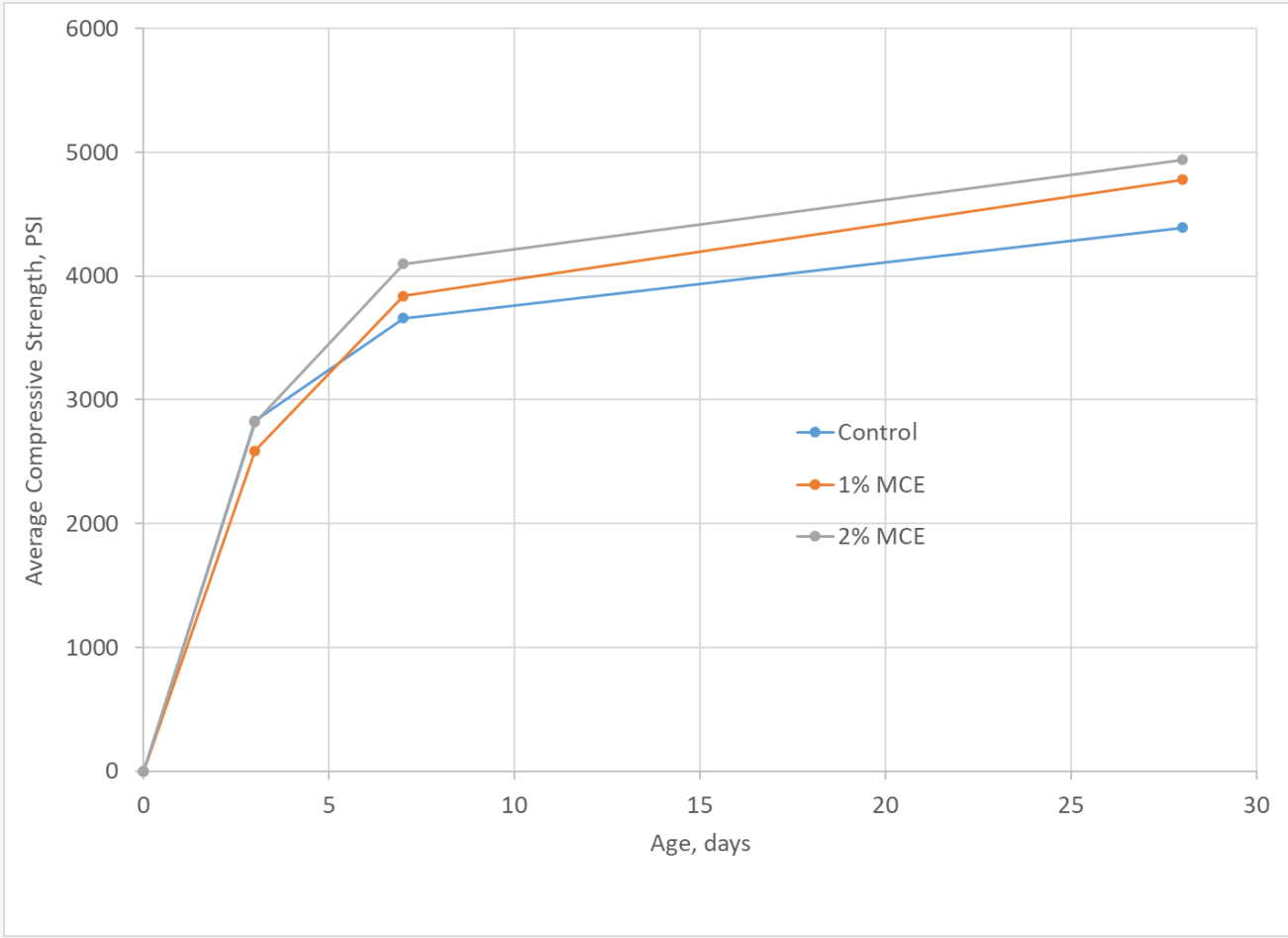


Paving Project – P48

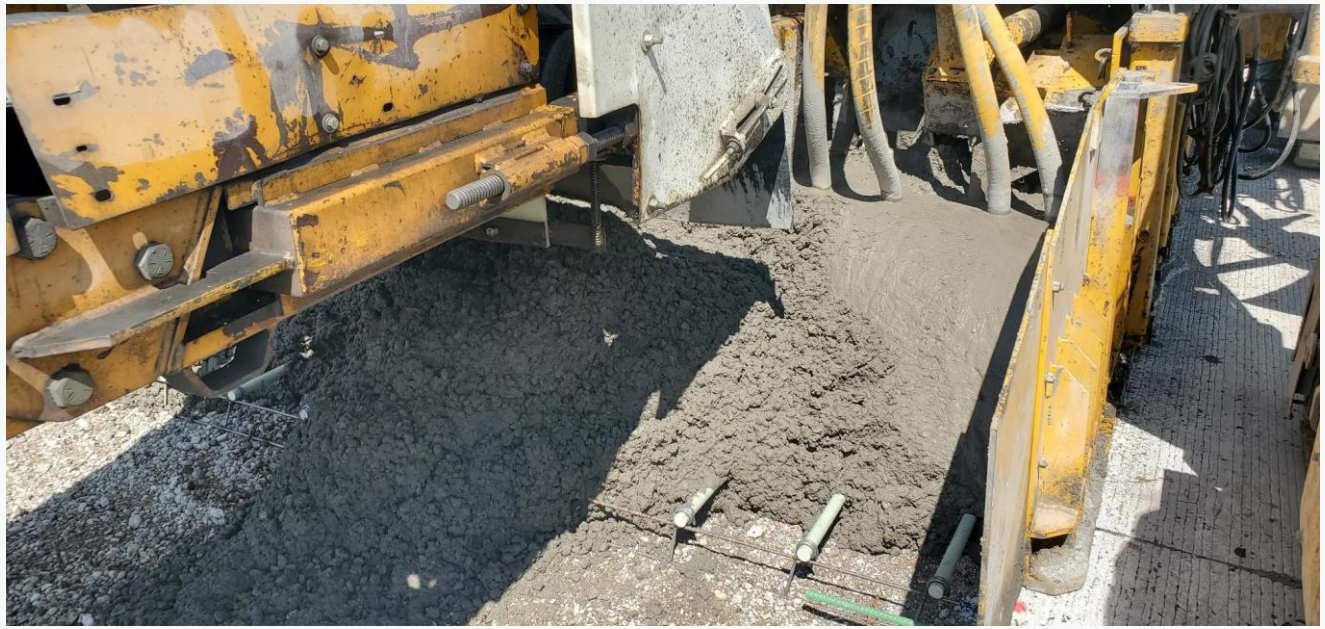
- Manatts
- MCE dosage rate – 1% (0.60 gallon)
- ¾ - 1” slump
- 4568 yd^3
- 2 miles of pavement
- 60 sec mixing time
- 5-mile travel



Paving Project



Paving Project



Contractor Comments

- Manatts was impressed noting improved surface cream
- No issues with edges or cold joints
  - Even with a delay in truck arrival
- Project is finishing up now

Questions