

# Workability & Finishing for Municipal Pavements

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Technology Center



# Acknowledgments

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- Lee Shepard, Iowa Concrete Paving Association
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- Matt Sheehan, Concrete & Construction Consultants

# Outline

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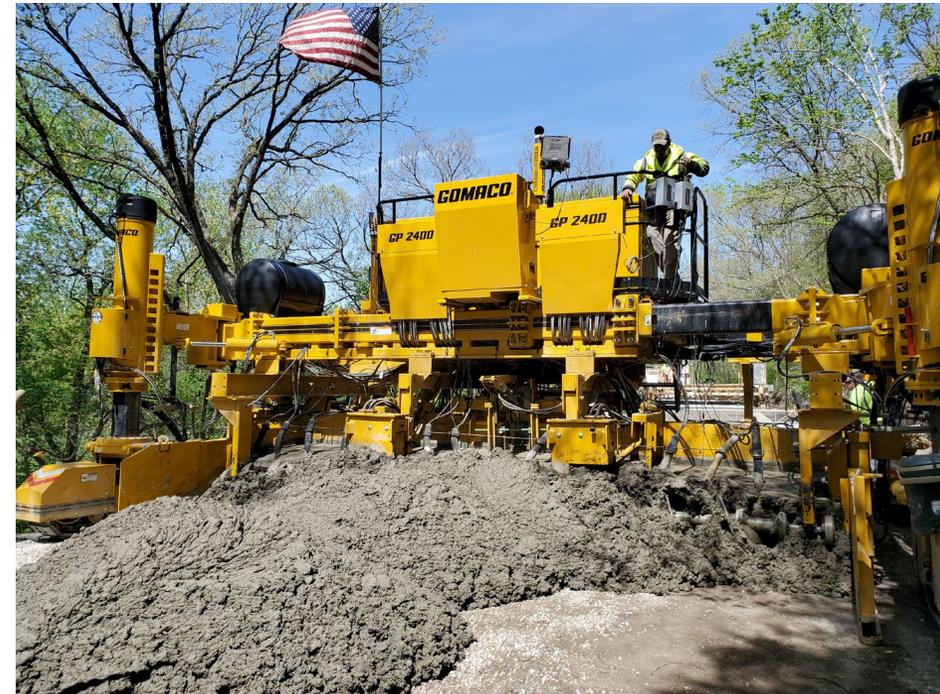
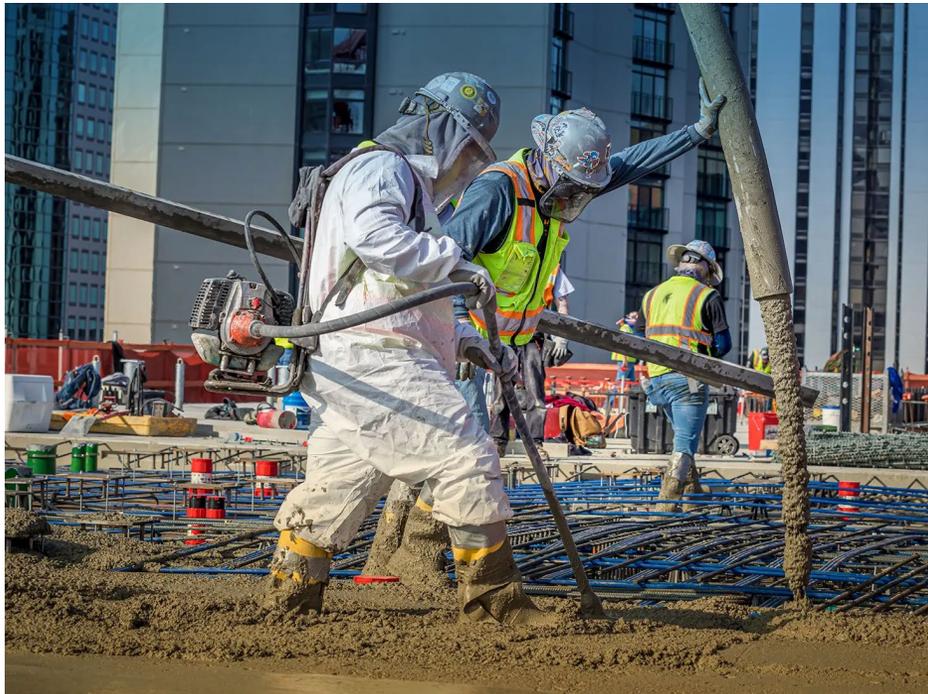
- Introduction & Background
- Review of Best Practices & Things to Avoid
- Adjustments & Adaptations

# Introduction & Background

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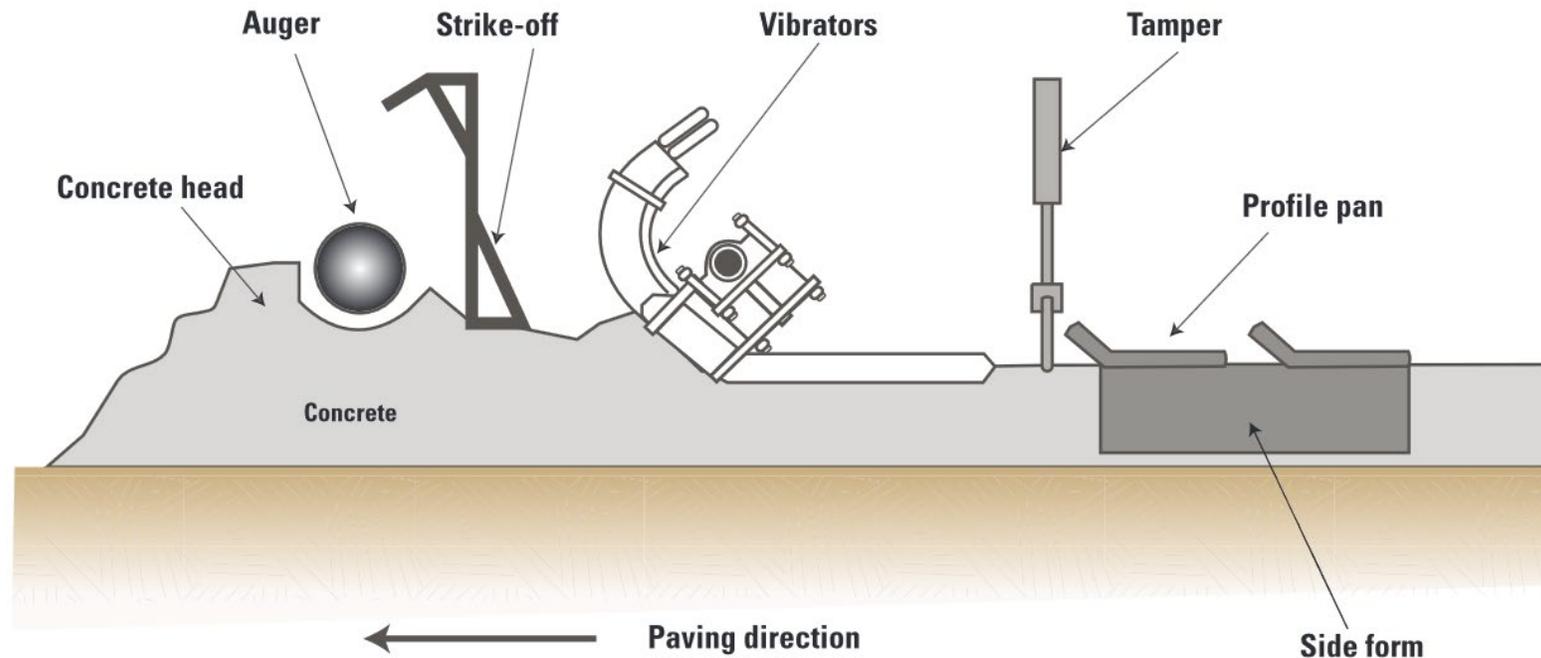
# Workability

- Ease of mixing, placing, consolidating, and finishing concrete
- Required workability depends on the method of placement



# Slipform Paving

- The standard method of placement for concrete pavements
- The slipform paving machine screeds, consolidates, and extrudes the concrete pavement slab:



# Slipform Paving

- While slump is not the best way to measure workability...  
...concrete for slipform paving is typically delivered with a slump of 0.5 to 1.5 inches



# Fixed Form Paving

- SUDAS 7010: short runs up to 250 ft may be placed using fixed forms with an air, vibratory, or laser guided screed
- Strike-off and placement by hand allowed for patches and other placements with dimensions less than 8.5 ft (Iowa DOT 2301)



# Fixed Form Paving

- Concrete for fixed form paving is typically delivered with a slump of 3 to 4 inches



# Current Issues

- In the last few years, owners and contractors have reported an increase in scaling and other types of surface defects in floor slabs, exterior flatwork, and pavement hand placements
  - No increase found in slipform paving concrete (rare in general)



# Current Issues

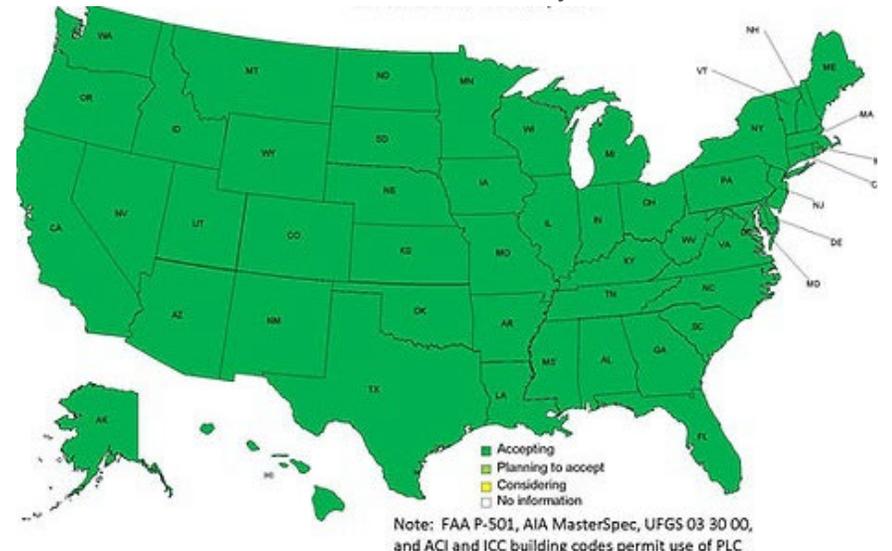
- While surface defects are not a new problem, has anything changed in the last few years?
  - New materials (portland limestone/Type IL cement)
  - New mix specifications (C-SUD)
  - Workforce turnover



# Portland Limestone Cement (Type IL)

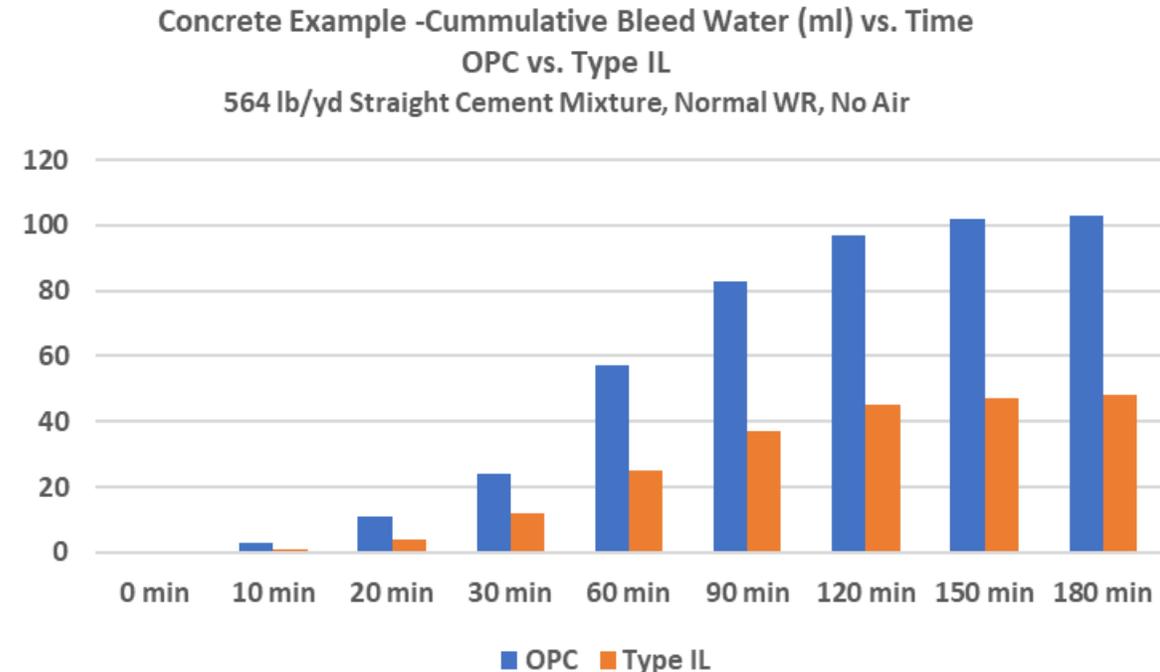
- PLCs have replaced Type I/II cement as our everyday, general purpose cement
- They contain less clinker and more finely ground limestone than conventional Type I/II cement
  - Up to 15% limestone allowed
  - 8-12% typical today
  - Type I/II contained 5% limestone

**State DOT Acceptance of Portland-Limestone Cement**  
Tentative Date, February 2024



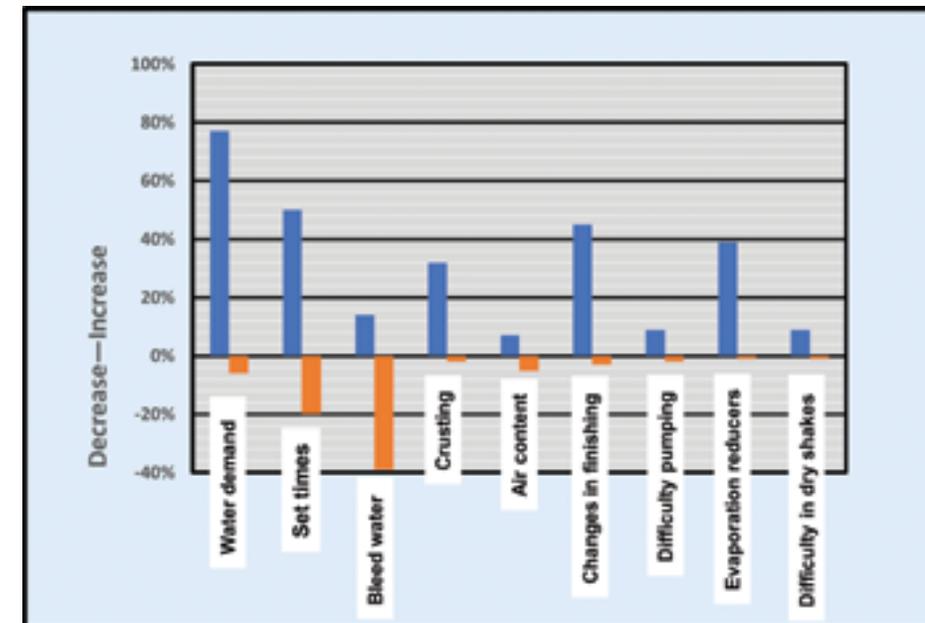
# Portland Limestone Cement (Type IL)

- Differences from Type I/II cement:
  - Ground to a greater fineness
  - Rate of initial strength gain (24-72 hours) can be more sensitive to temperature
  - Increased water demand
  - Reduced bleed water



# Portland Limestone Cement (Type IL)

- Reported issues from users:
  - Increased water demand and reduced bleeding
  - Changes to finishing, curing, and sawing
  - Inconsistent or unpredictable behavior
  - Changing behavior with admixtures



# C-SUD Mixtures

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- Pavement mix developed to enhance durability for city streets
- Differences from a typical Class C mix (C-3 or C-4):
  - Optimized aggregate proportions, often with an intermediate aggregate (limestone chip or pea gravel)
  - Lower paste content (550-560 lbs./yd<sup>3</sup> cementitious)
  - Lower maximum water w/cm (0.42)
    - Compare to 0.45 or 0.488
  - A higher SCM substitution rate is allowed

# C-SUD Mixtures

- The C-SUD specification was developed based on Iowa DOT's QM-C specification, which is optimized for slipform paving
- Generally not as workable or as easy to finish as concrete used for fixed form and hand placements
  - Leaner and less “creamy” thanks to reduced paste content and low w/cm
  - “Stickier” with higher SCM contents
  - Increased difficulty with PLCs?



# Adding Everything Up...

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- Surface defects are not a new problem
- However, many users feel that recent changes have led to differences in concrete workability and finishability
- Experienced finishers may be struggling with these changes, and new workers may face a steeper learning curve
  
- These factors are likely combining to increase the amount of finishing errors
- They are also probably making concrete less forgiving of mistakes and shortcuts that have been common for a long time

# How Can We Adapt?

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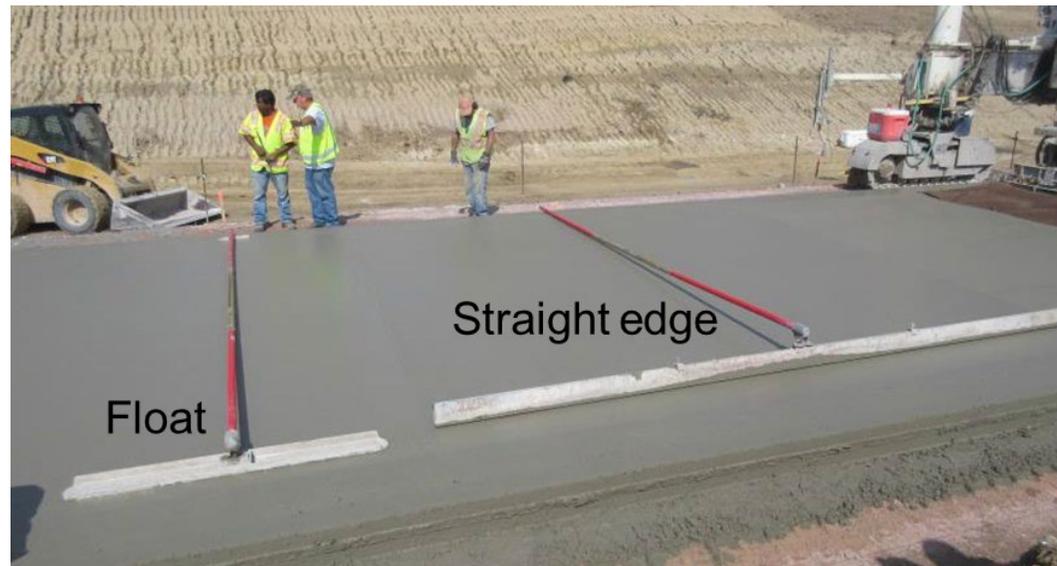
1. Renew focus on quality and best practices for preparing, placing, and finishing workable concrete pavement mixtures
2. Identify adjustments we can make to our mix specifications and finishing practices to consistently produce better pavements

# Review of Best Practices & Things to Avoid

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# Placement & Finishing

- Ideally, finishing is mostly achieved by the paving machine
- Finishing activities remove small imperfections and seal the surface of the slab – the less effort it takes, the better!
  - Straight edge corrects bumps and dips
  - Float fills surface voids



# Placement & Finishing

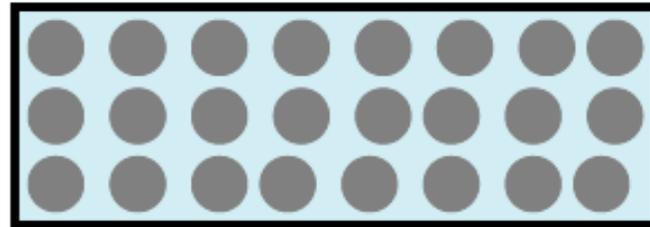
- Finishing when paving is going well:



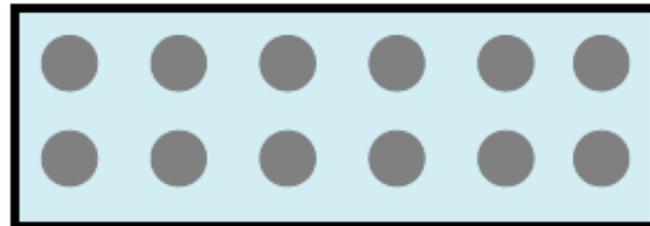
# Placement & Finishing

- During placement, controlling water content in the mixture and at the surface is key to producing durable concrete
- Too much water in the mix compromises strength and durability

$w/c = \text{Low}$



$w/c = \text{High}$



# Placement & Finishing

- Excessive water content (or a poorly-proportioned mixture) can also lead to edge slump



# Placement & Finishing

- The surface can become more difficult to finish when conditions are hot, dry, windy, or when delivery has been slow
- Finishers sometimes add water to the surface, but this practice increases susceptibility to delamination and surface defects



# Placement & Finishing

- Unfortunately, adding water to the surface can be a difficult tendency for crews to overcome even in good conditions...



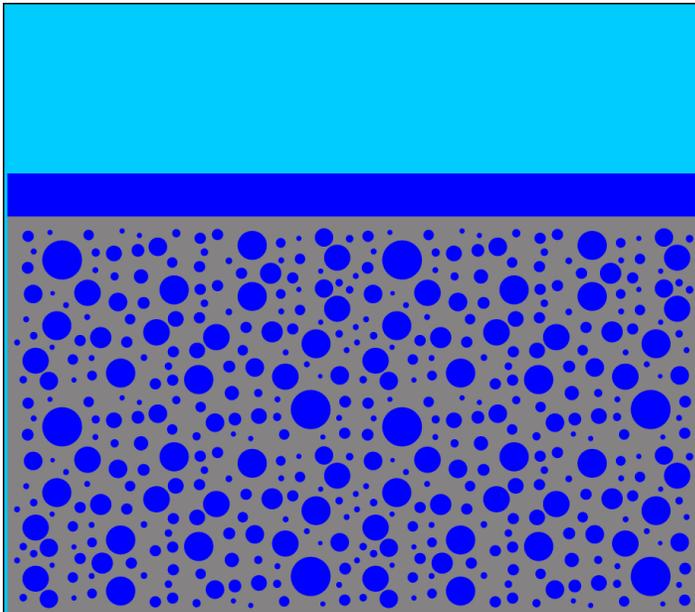
# Placement & Finishing

- This occurred on a calm, 65°F afternoon in September...



# Placement & Finishing

- Make sure not to finish bleed water into the surface – allow it to evaporate before proceeding with floating or troweling
- Pavements with a low w/cm don't usually exhibit a lot of bleeding, but it could be more likely with hand placements



# Placement & Finishing

- Over-finishing and over-consolidation (too much vibration) can lead to a loss of air content, which can also cause scaling and other freeze-thaw durability issues



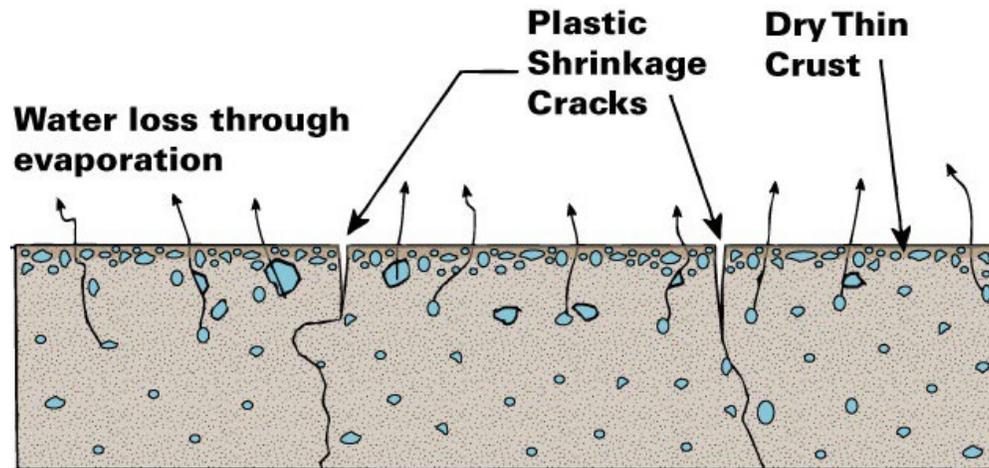
# Curing

- After finishing and texturing, white pigmented curing compound is applied to the surface
- Prevents evaporation of water from the mix, allowing for uniform hydration that produces a strong, durable surface



# Curing

- If the surface dries out too quickly, plastic shrinkage cracking can occur when the surface dries out too quickly
- Inadequate hydration leads to a less dense, less durable surface susceptible to scaling, abrasion, and de-icing chemicals



# Curing

- Iowa DOT and SUDAS specified application rate is 15 yd<sup>2</sup>/gal
- The final surface should look like a white sheet of paper



vs.



# Curing

- Make sure the correct curing compound is being used
  - Curing compounds that meet ASTM C309 do not necessarily meet Iowa DOT and SUDAS requirements!
- ASTM C156 Moisture Retention:

Test time	IDOT Wax Based Cure (4105)	PAMS	ASTM C309
24 Hours	0.20 kg/m <sup>2</sup>	0.15 kg/m <sup>2</sup>	-
72 Hours	0.40 kg/m <sup>2</sup>	0.40 kg/m <sup>2</sup>	0.55 kg/m <sup>2</sup>

# Anticipating Challenges

- Anticipating how site conditions affect the mixture can help in making adjustments to placement, finishing, and curing practices
  - Haul time
  - Wait time
  - Temperature
  - Humidity
  - Wind



# Adjustments & Adaptations

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# Placement & Finishing

- We talked a lot about controlling water content...
- ...so what should we do instead of this?



# Placement & Finishing

- It is acceptable to wet the burlap drag on the back of the paving machine to aid in closing the surface
  - If a slurry appears at the surface and runs down towards the edge, reduce the amount of water applied to the burlap



# Placement & Finishing

- Possible adjustments to assist with finishing:
  - Add water to the mix in the truck, but make sure not to exceed the maximum w/cm
  - Use or adjust dosage rates of **water reducing admixtures** and/or hydration stabilizers
  - Consider use of **finishing aids**
- Finishers can bring fresh concrete or mortar from in front of the paving machine back to help close up voids behind the paver



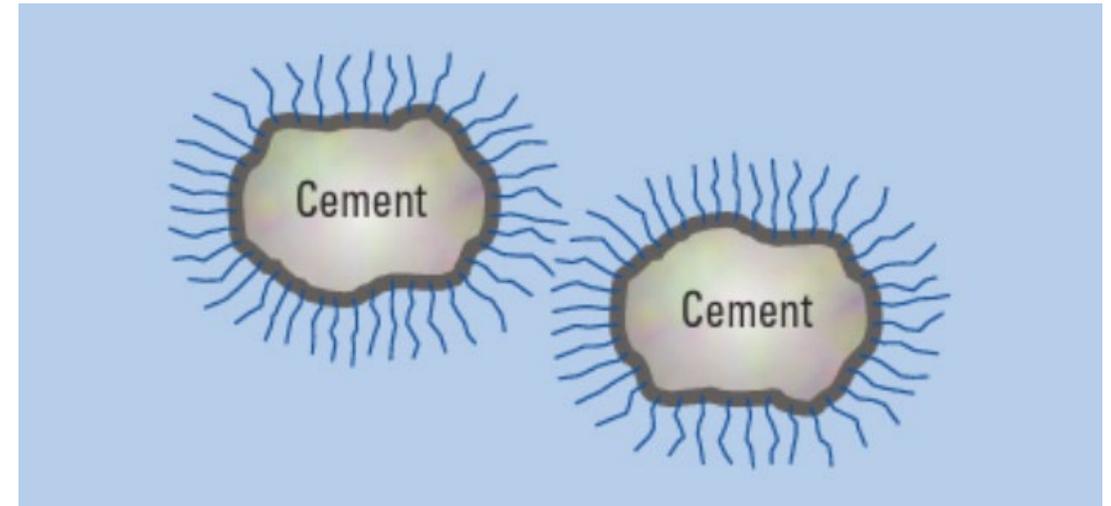
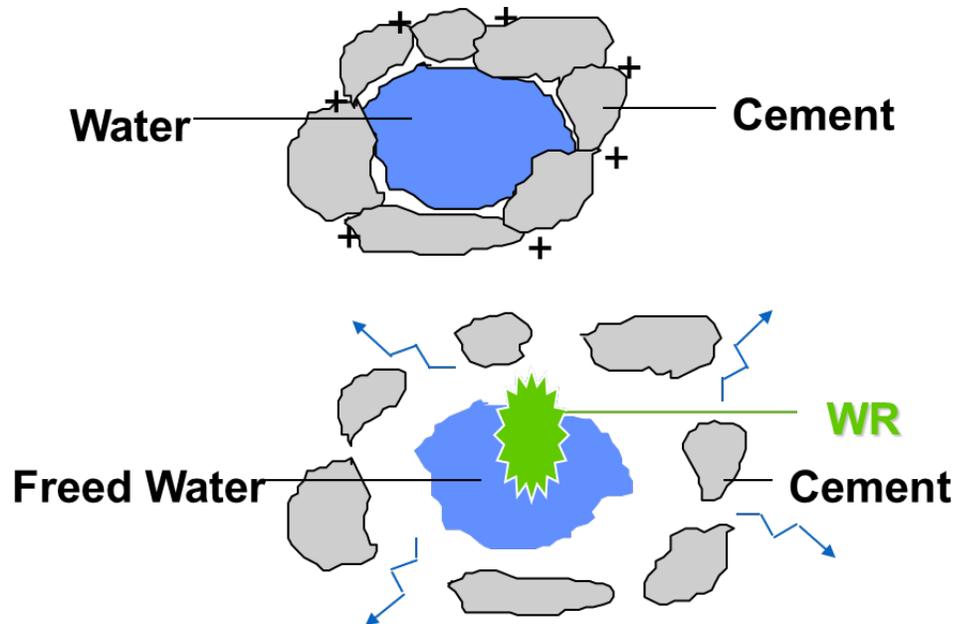
# Placement & Finishing

- Can concrete be finished too quickly to allow for bleeding?
  - This placement was completely finished within 20 minutes of being delivered to the grade



# Water Reducing Admixtures

- Water reducing admixtures are very helpful to enhance the workability of concrete without increasing water content



# Water Reducing Admixtures

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- Efforts are underway to update design guidance and specifications to encourage and ease use of water reducers
- With changes to cements (Type IL & blended cements), concrete producers and contractors have found that they need to make adjustments to WRA types and dosage rates
  - Trial batching and testing are critically important!

# C-SUDHW Mixtures

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- Even as we identify improvements and adjustments to placement and finishing practices, it is clear that improvements are also needed to the C-SUD mix specification to make it more suitable for hand placements
- ICPA, Iowa DOT & CP Tech Center collaborated with several cities to test out a new **C-SUDHW** mix specification in 2025
  - Altoona
  - Ames
  - Ankeny
  - Cedar Rapids
  - Iowa City
  - West Des Moines

# C-SUDHW Mixtures

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- Key mix design parameters:
  - Hold to a lower maximum w/cm (0.435), since water content is critically important to durability
  - Increase paste content to 593 lbs./yd<sup>3</sup> to provide more cream to assist with finishing
  - Use 20 to 25% fly ash
  - Require use of water reducing admixture

# C-SUDHW Mixtures

- Feedback from contractors so far:
  - “Works fine”
  - “Finished like C-4”
  - “Sealed up nice, no curb issues at 3 inch slump. Definitely more cream”
  - “Closed up nicely. Very little working. Water reducer did its job”



# Finishing Aids

- Newer types of finishing aids consist of colloidal silica
  - Dense, amorphous  $\text{SiO}_2$  nanoparticles
  - Pozzolanic and highly reactive
- Applied to the surface to aid finishing and ultimately produce a more dense, durable, abrasion-resistant surface



# Evaporation Retardants

- Evaporation retardants are water-based organic compounds that form a film on the surface to prevent rapid moisture loss
- Although they are applied to the surface, they are not finishing aids and should not be worked or finished into the surface!
- Must allow them to evaporate before finishing



# New Admixtures

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- A number of companies are beginning to introduce a variety of new Type S (Specific Performance) admixtures
  - Colloidal silica, or nanosilica
  - Crystalline C-S-H + other materials
  - Viscosity and thixotropy-modifying
- These materials are being marketed for a variety of purposes:
  - Strength enhancing
  - Hydration enhancing
  - Improved workability
  - Improved durability
  - Reduce cement content

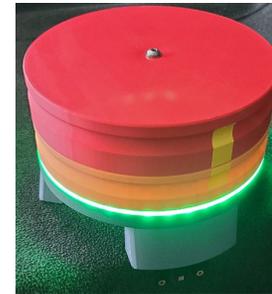
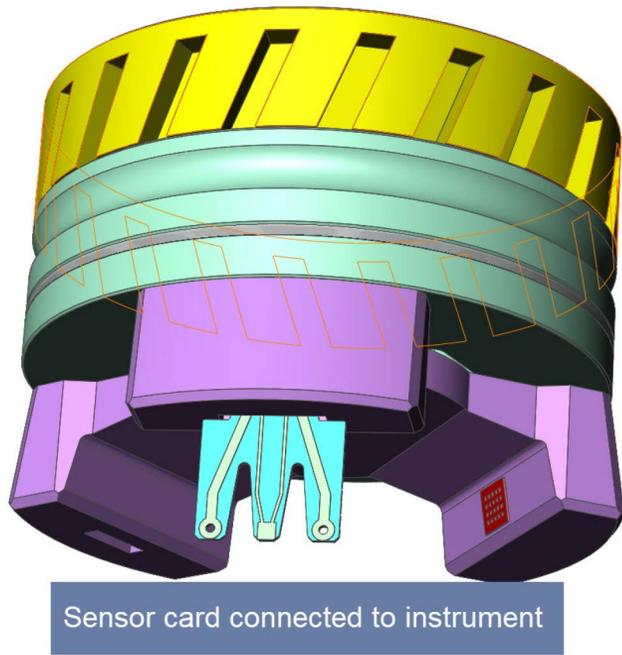
# New Admixtures

- Work is ongoing to better understand the effects of these admixtures on fresh and hardened concrete properties, and how to evaluate and specify different products
- Be careful of claims that external curing is no longer needed when using these types of products – testing is needed



# New Technologies

- New sensors and test methods may also be able to help us improve finishing, curing, and sawing practices



# Additional Guidance

- New article published in August 2025 in Concrete International magazine:

## Field Guide to Placing and Finishing Type IL Cement Concrete

by Chad White, Bryan M. Birdwell, Jerry A. Holland, and Michael G. Hernandez

**W**ith the dramatic increase in manufacturing since 2021, ASTM C595/C595M Type IL cement, also known as portland-limestone cement (PLC), has become the most common type of cement used in the United States. While many contractors have successfully placed millions of square feet of slabs and paving comprised of Type IL cement, contractors in some regions have reported plastic and hardened concrete issues, including slower strength gain and slab surface defects such as early surface crusting, cracking, excessive crazing, and delamination. Developing an understanding of how PLC differs from ordinary portland cement (OPC) can help contractors modify and adapt finishing means and methods to meet these challenges. This article is an attempt to explain the differences between the two binder types, based on direct observation and reports from finishers placing concrete with Type IL cement. Readers should note, however, that these observations cannot represent all situations, as local materials, weather, and finishing processes can heavily influence performance.

The key difference between traditional ASTM C150/C150M Type I/II/V cement and ASTM C595/C595M Type IL cement is the maximum limestone content by mass of the blended cement (5% and 15%, respectively). While early promotional materials touted PLC as a one-for-one replacement for OPC, field observations and subsequent work have indicated that the changeover is not that simple. For example, the additional limestone in PLC can impact admixture effectiveness. Furthermore, PLC performance appears to be more sensitive to variances in physical properties and chemical composition. Changes in performance have been correlated with variations in product from the same cement mill and, more significantly, with differences in product from different cement mills.

### Using Type IL Cement

When using PLC (Type IL cement), considerations include:

- Be aware of the blended limestone content. Type IL(8) cement, with 8% limestone content, will perform differently than Type IL(14), with 14% limestone content;

- When using supplementary cementitious materials (SCMs) or slag cement in combination with PLC, the strength gain behaviors appear to be less predictable than historically seen with OPC (Type I/II cement). The ready mixed concrete producer's history with each PLC concrete mixture provides important information;
- PLC concrete may not have the same strength gain at a given age as compared to OPC concrete. Most Type IL cement produced in the United States is produced by intergrinding of the limestone and clinker. As a result, the clinker constituent in PLC may be finer than in Type I/II cement. Also, many cement manufacturers have increased the alite-to-belite ratio in their clinker—increasing the percentage of the faster reacting alite can provide comparable early strengths to Type I/II cement. The behavior of the cement will vary with the fineness of the grind as well as the alite-belite ratio;
- Intergrinding of limestone and clinker can also increase the fineness of PLC, so PLC concrete mixtures tend to have a higher water demand (an additional 1.0 to 3.0 gal/yd<sup>3</sup> [5 to 15 L/m<sup>3</sup>]). Be mindful of the total amount of water being held back on batch tickets and ask the concrete producer to maximize the use of water up to the allowable water-cement ratio (w/c) to obtain slump before using water-reducing admixtures. Once the mixture is dialed in, the held-back water should typically be no more than 1.0 to 1.5 gal/yd<sup>3</sup> (5 to 7 L/m<sup>3</sup>);

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