# Troubleshooting Concrete Pavement Issues During & After Construction

## Fall 2026 Iowa Concrete Lunch & Learn

Dan King, PhD, PE

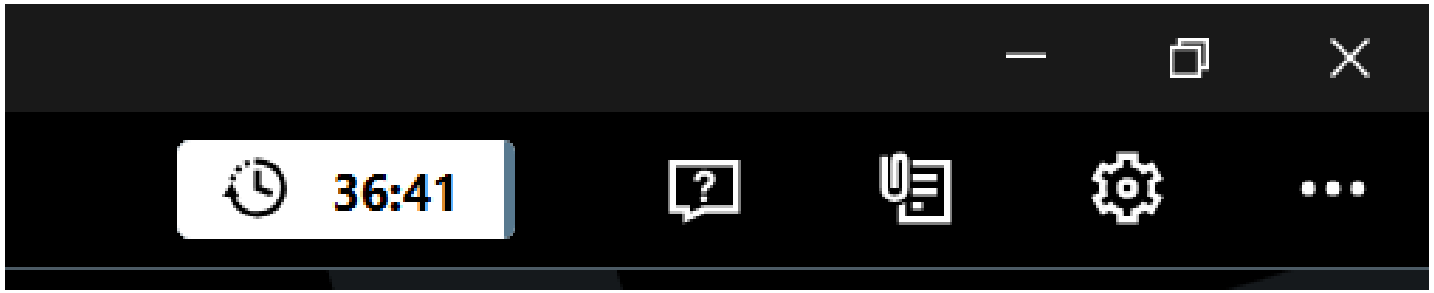
Leif Wathne, PE

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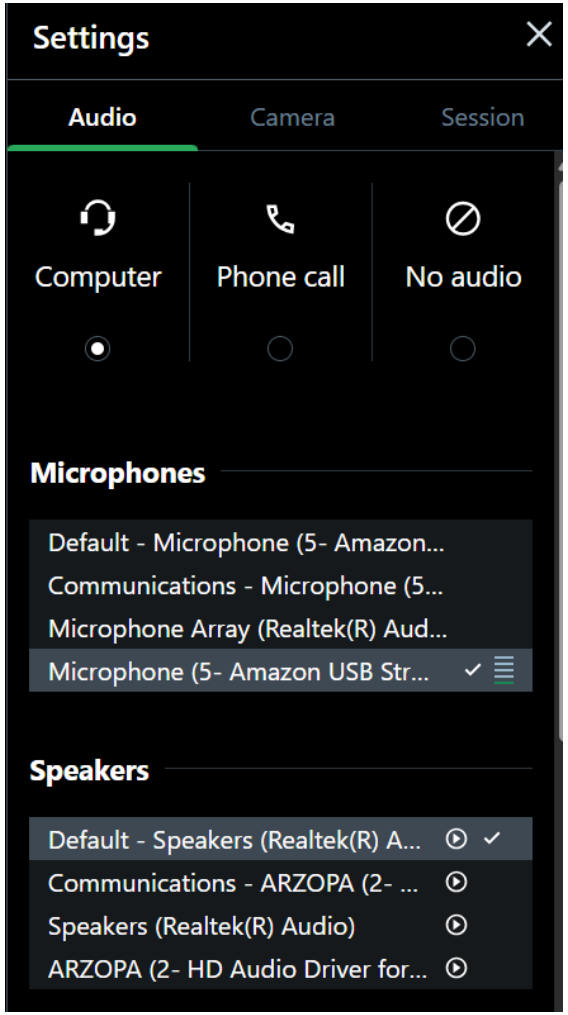
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- Please note the new location of the GoTo Webinar options menu bar at the top right of your screen



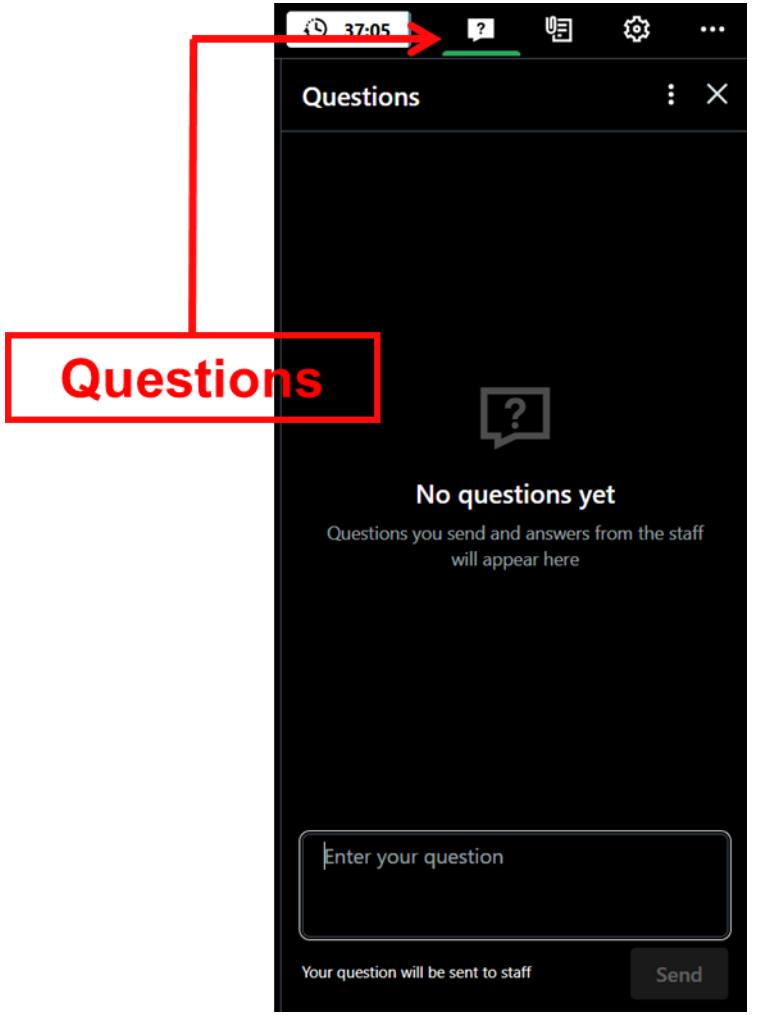
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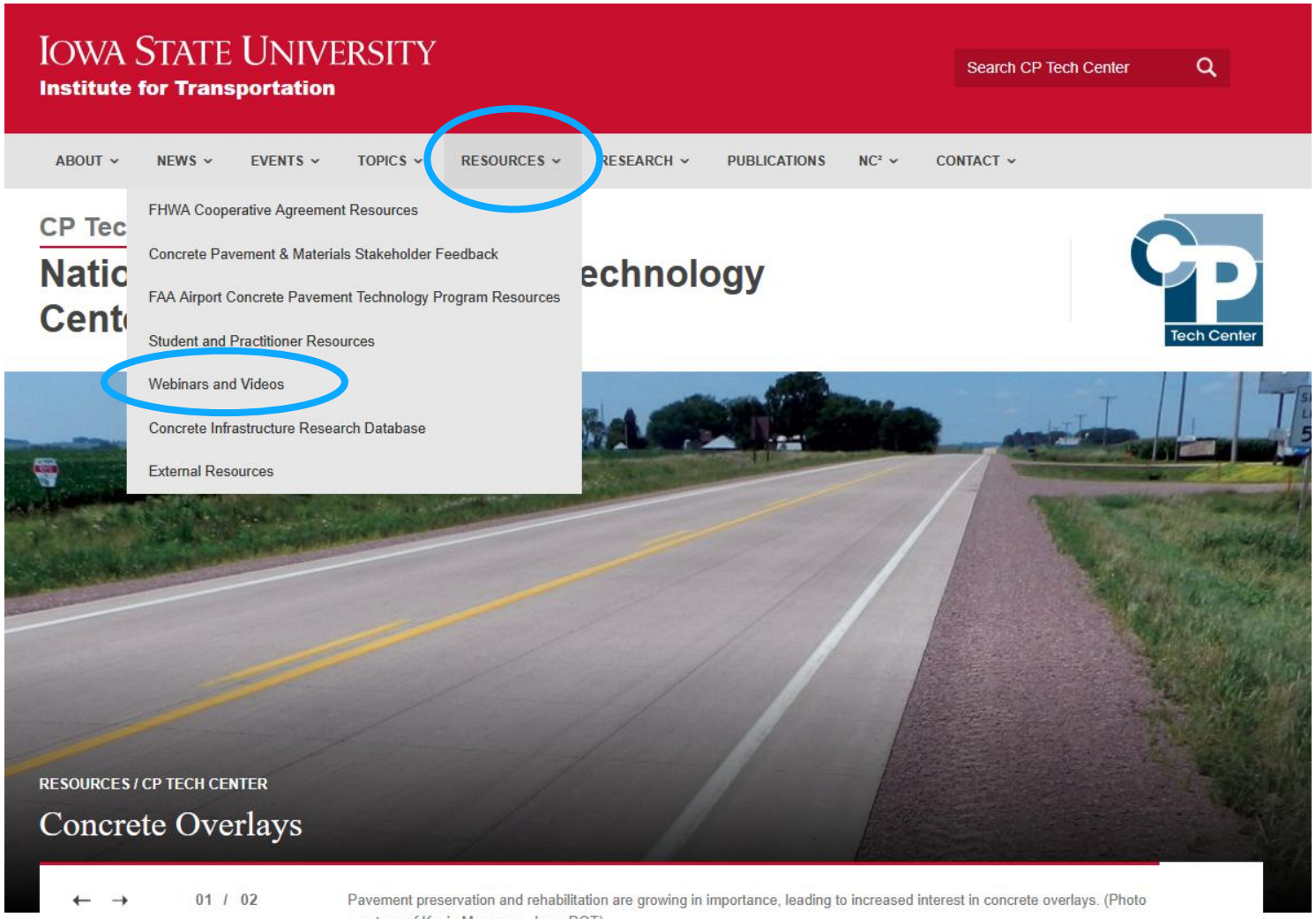


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- To post a question, please use the Questions feature of your options menu
- Type questions anytime during the webinar
- We will compile all of the questions after the webinar is finished and post a full Q&A online on the “Webinars and Videos” page on the CP Tech Center website

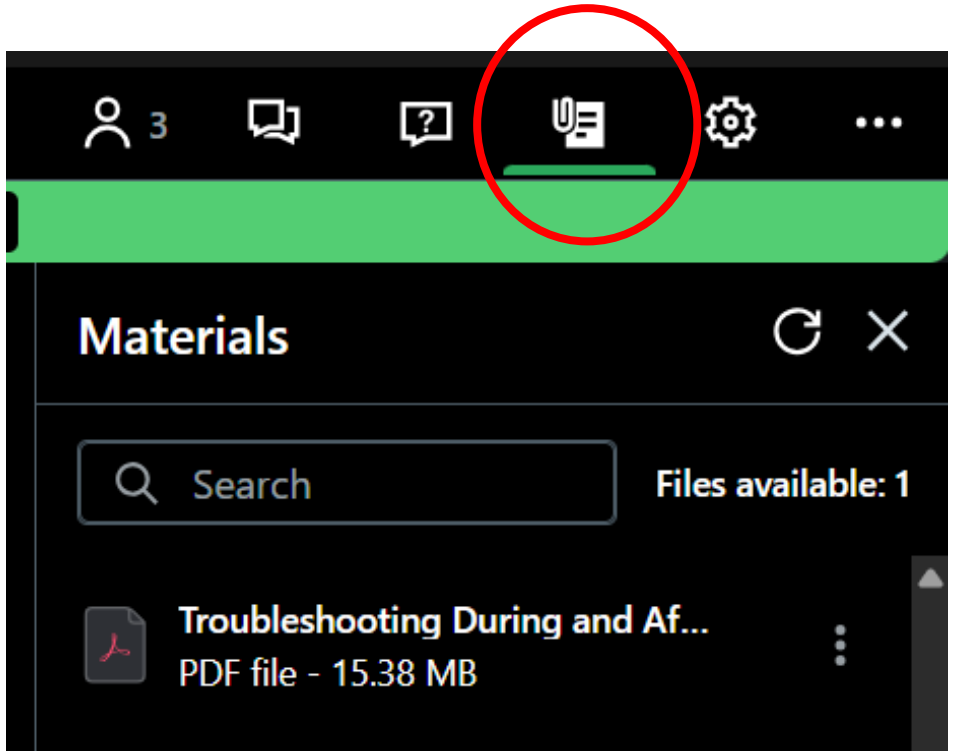


# Housekeeping



# Housekeeping

- A link to download a pdf of the slides is included under the “Handouts” tab
- PDH forms and an evaluation survey will be sent out after the webinar



# Troubleshooting Concrete Pavement Issues During & After Construction

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# Acknowledgments


- Thanks to Iowa DOT & ICPA for supporting this program
- Special thanks to:
  - Jerod Gross, Snyder & Associates
  - American Concrete Pavement Association
  - Todd Hanson, Iowa DOT
  - Elijah Gansen, Iowa DOT

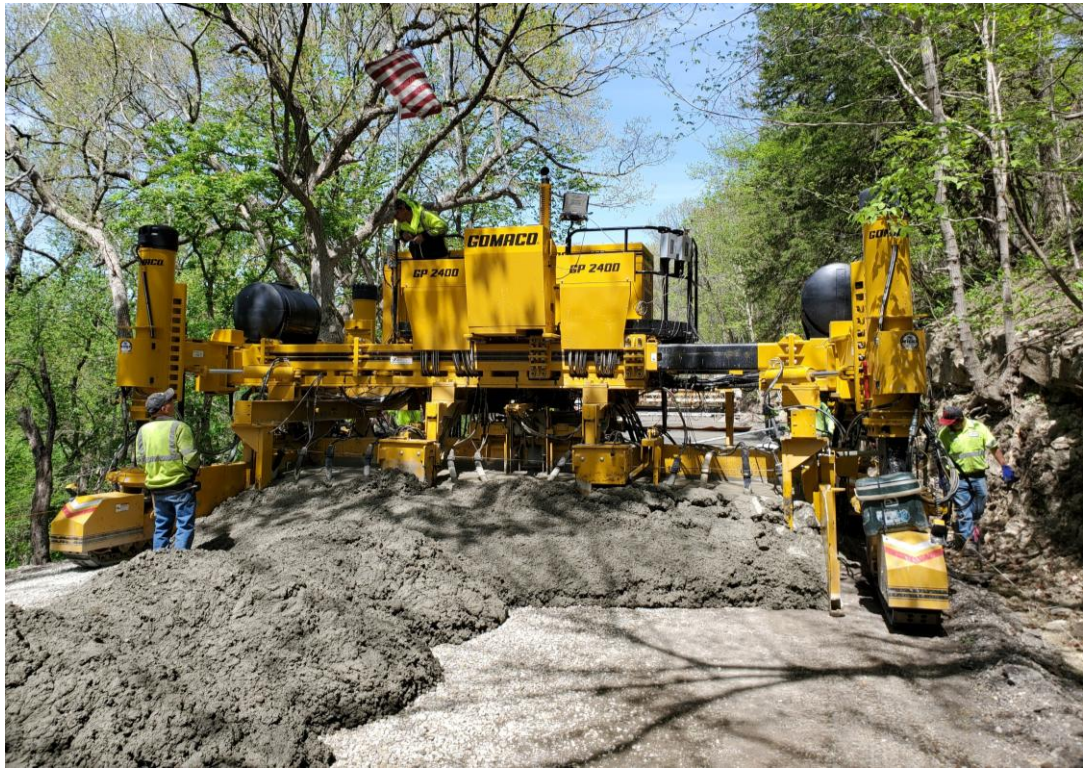
# What Does a Good Paving Day Look Like?

# What Does a Good Paving Day Look Like?

- Clear weather
- No breakdowns with equipment or trucks
- Concrete delivered to the site is consistent and uniform
- Test results consistently meet spec
- Mix is easy to place, consolidate and finish
- Finishers aren’t having to work too hard or falling behind
- Curing is done in a timely fashion and with proper coverage
- Sawing is finished in a timely fashion

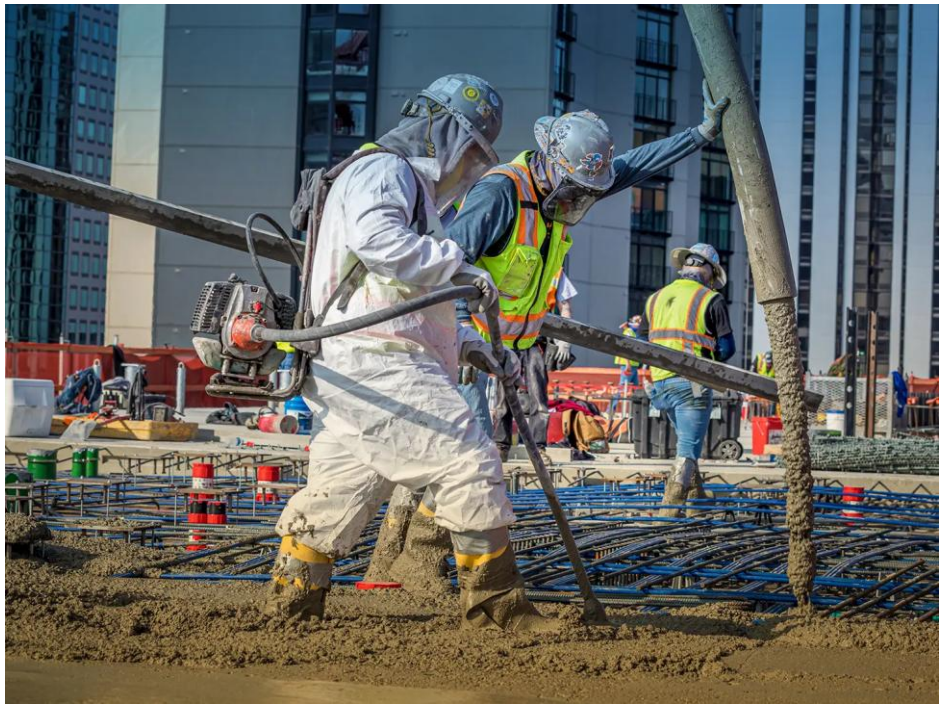
# Uniformity

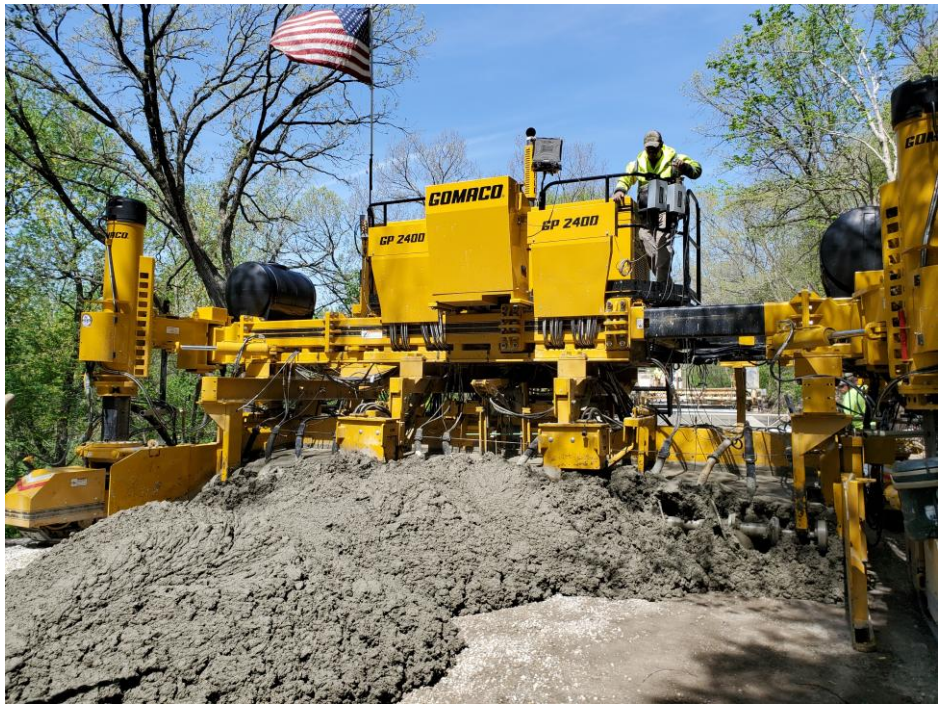
- The concrete mix ideally will be uniform from batch-to-batch
- When the mix is consistent, minimal adjustments (like water addition) should be needed on-site during construction



# Workability

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



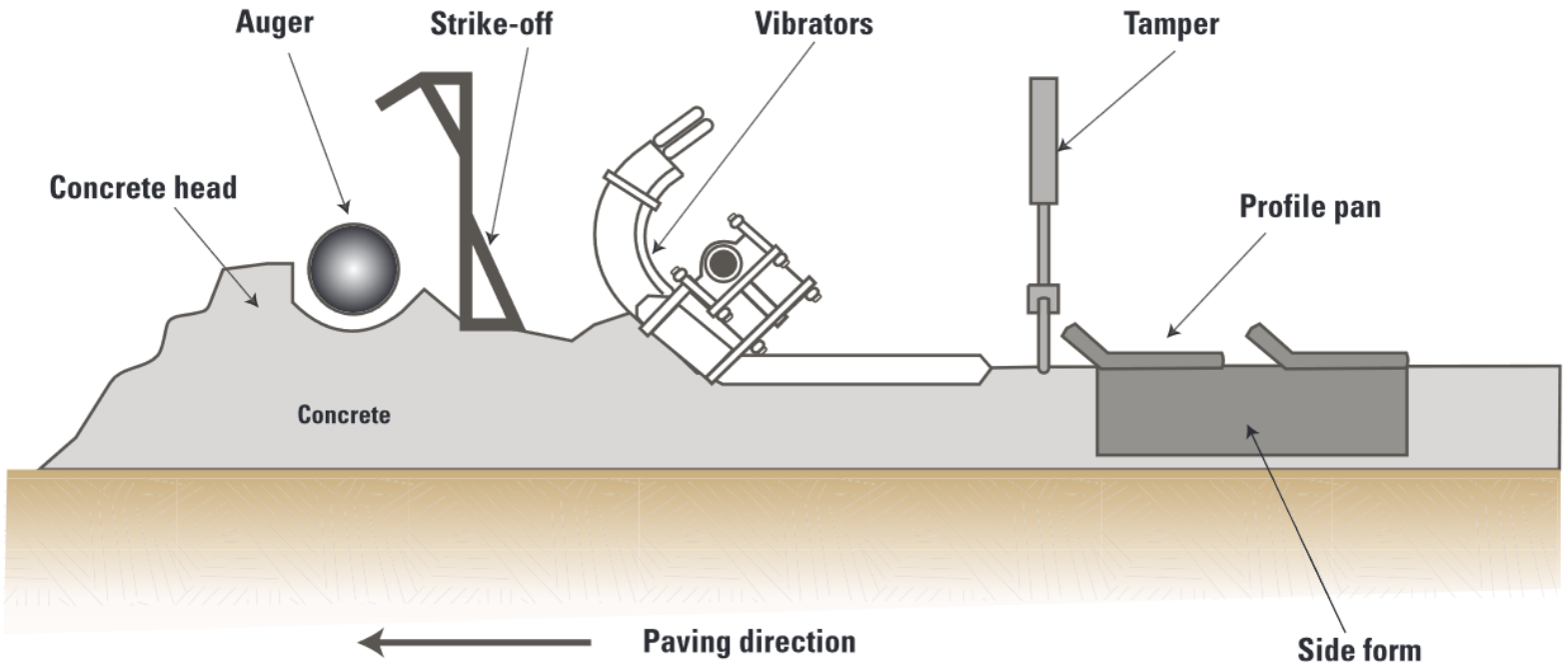





L Image: Baker Concrete

# Slipform Paving

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



# Slipform Paving

- Slump is not a comprehensive measure of concrete workability, but concrete with a slump of 0.5 to 1.5 inches generally works well for slipform paving



# Slipform Paving

- Keeping a consistent head (height) of concrete in front of the paver is important to producing a uniform, smooth pavement
  - Allows the paver to maintain a consistent speed
  - Consistent height of material in the grout box
  - Maintains a consistent vibration energy to consolidate the mix






Image: GOMCAO

# Fixed Form Paving & Hand Placements

- 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)







L Image: Allen Engineering

# Fixed Form Paving & Hand Placements

- Concrete for fixed form paving and hand placements is typically delivered with a slump of 3 to 5 inches



# 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

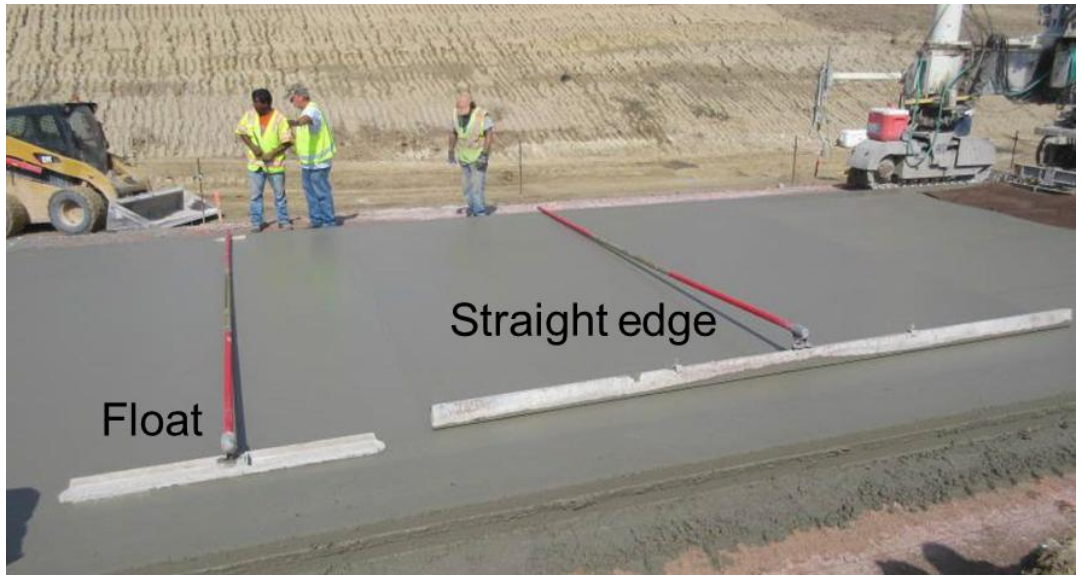





Image: Matt Fonte

# Finishing

- When things are going well:



# Finishing

- Fixed-form and hand placements will obviously require more manual finishing effort
- Mixes will generally have a somewhat higher cementitious materials content and w/cm ratio to aid with finishing





Image: Henry Prenger, Amrize

# Control of Water Content

- Controlling the water content of the mixture is one of the most important construction activities that factors into long-term durability
  - All else being equal, when water is added to the mixture, it is easier to place and finish
  - However, if too much water is added to the mix or to the concrete surface, it can compromise strength and durability
  - Ideally, we proportion the mix to achieve the needed workability without having to add water

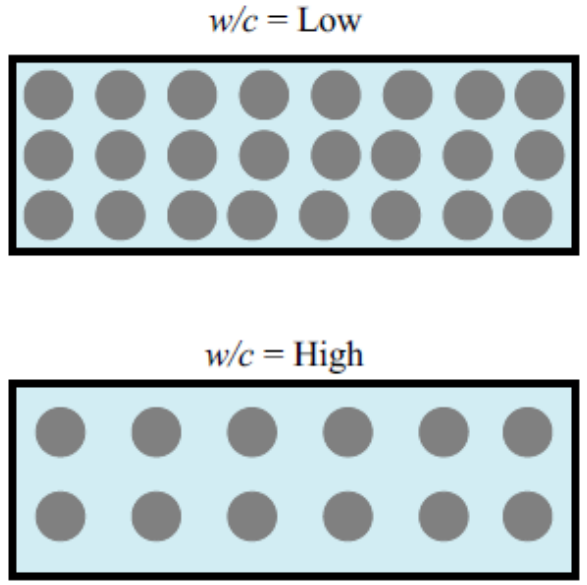





Image: ACA

# Curing

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





Image: Iowa DOT

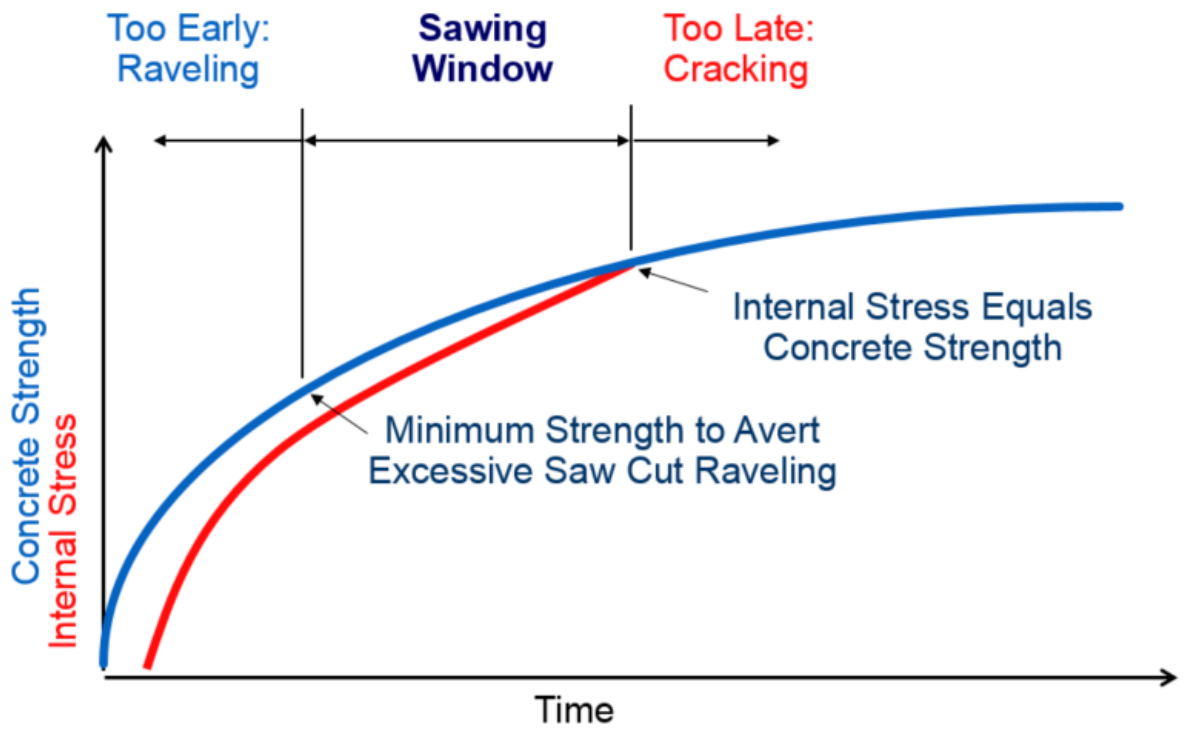
# Curing

- Curing compound should be uniformly applied such that the final surface looks like a white sheet of paper (MnDOT):



# Joint Sawing

- Joint sawing must be completed within the sawing window
  - Period where concrete is strong enough to saw without raveling or spalling, and before tensile stresses exceed strength




- Conventional saws
  - Window starts about 4 to 12 hours after placement
- Early-entry saws
  - Window starts from 1 to 4 hours after placement



Image: ACPA

# Troubleshooting: During Construction

# Non-Uniformity & Inconsistency

- If the concrete mixture is not uniform from batch-to-batch, it can cause issues with placement, consolidation, and finishing





# Sources of Non-Uniformity

- Proper aggregate stockpile management at the batch plant plays a key role in producing consistent, high quality concrete
- Changes in aggregate gradations and moisture contents can have significant effects on consistency and workability







Images: FHWA

# Sources of Non-Uniformity

- Variation in water content and aggregate gradations can make the concrete more difficult to place, consolidate and finish, or prone to issues such as edge slump:







R Image: ACPA

# Sources of Non-Uniformity

- Disruption of delivery time can lead to non-uniformity in the mix
- If the paving machine is forced to stop and start due to inconsistent delivery, it can also affect surface texture and smoothness

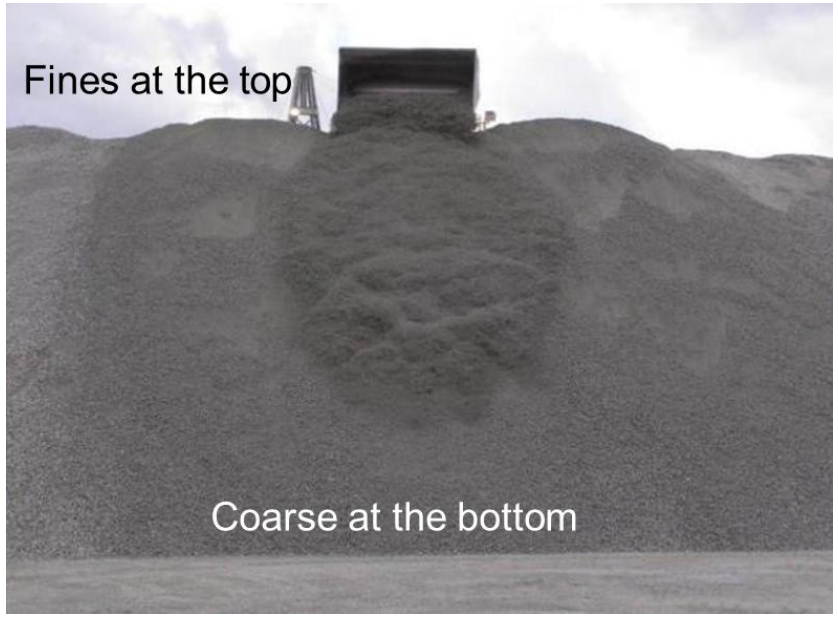





Image: CemenTech

# Troubleshooting at the Batch Plant

- Build stockpiles long and wide, not high, in order to minimize the potential for segregation
- Monitor moisture content and keep as uniform as possible
- Minimize potential for contamination between stockpiles






# Troubleshooting at the Batch Plant

- Ensure adequate mixing time to achieve uniformity of the mixture
- Monitor addition time of aggregates, cementitious materials, and admixtures
- Aim for a steady rate of delivery while accounting for factors such as weather, traffic, and availability of drivers and trucks



# Workability Challenges

- A number of factors can lead to the concrete not being as workable as desired (i.e. more difficult to place and finish):
  - Non-uniform/inconsistent mix
  - Delays in delivering concrete to the site
  - Poorly-proportioned mix
  - Mix not suitable for placement method
  - Hot, dry, and/or windy conditions



# Workability Challenges

- When the mix isn't as workable as we'd like it to be, one of the first adjustments is often to add water
- It's ok to add water to the mix, but it is critical that it is done properly and that we monitor how much has been added
- Key factors:
  - Do not exceed the maximum water content, or w/cm
  - Do not add uncontrolled water to the surface
  - Do not retemper concrete that has begun to set



# Control of Water Content

- SUDAS 7010 & Iowa DOT 2301:
  - “When necessary to add additional mixing water at the site of placement, mix the batch at least an additional 30 revolutions of the drum at mixing speed”
  - “Do not use concrete which has dried, partially hardened, or requires retempering”
    - Retempering: adding water and re-mixing after concrete the concrete has begun to set
    - This is only explicitly mentioned in the spec for integral curb, but is important for all concrete placements!

# Control of Water Content

- It is also important to avoid adding water to the surface to aid the finishing process, even though we realize it is a common practice!
- Iowa DOT 2301 & SUDAS 7010:
  - “The practice of lubricating the pavement surface by sprinkling water by spray, brush, or other methods to afford greater ease in finishing operation is not allowed.”



# Control of Water Content

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



# Control of Water Content

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



# Control of Water Content

- There is no way to monitor or control water content when adding it and finishing it into the surface
- This additional water can compromise the strength and durability of the concrete at the surface of the slab, and potentially lead to surface defects:





# Troubleshooting Workability Challenges

- So if we can’t add water to the surface, what can we do when the concrete is difficult to finish?
- When slipform paving, it is acceptable to wet the burlap drag on the back of the paving machine to aid in closing the surface:



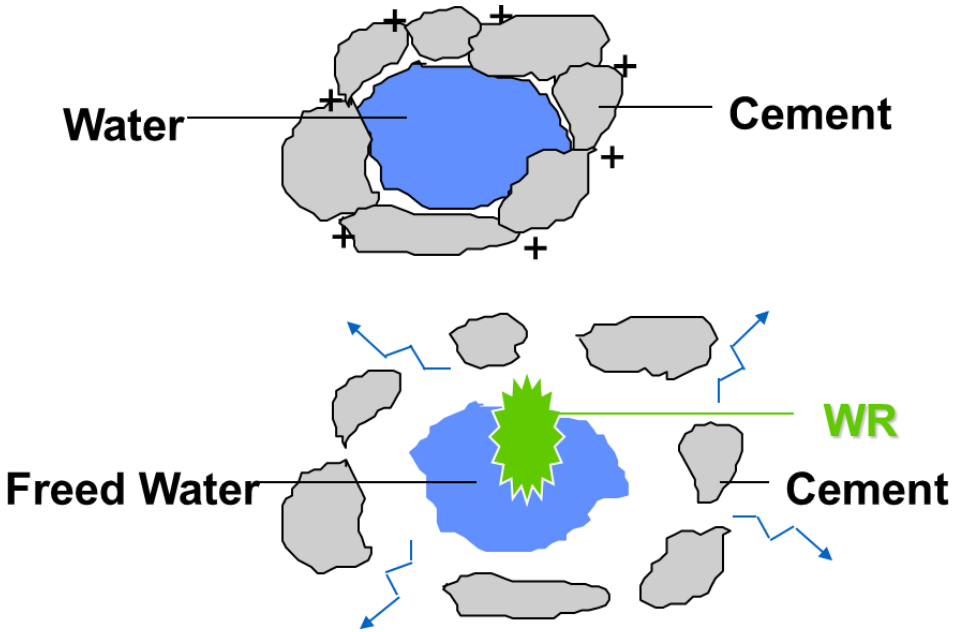
# Troubleshooting Workability Challenges

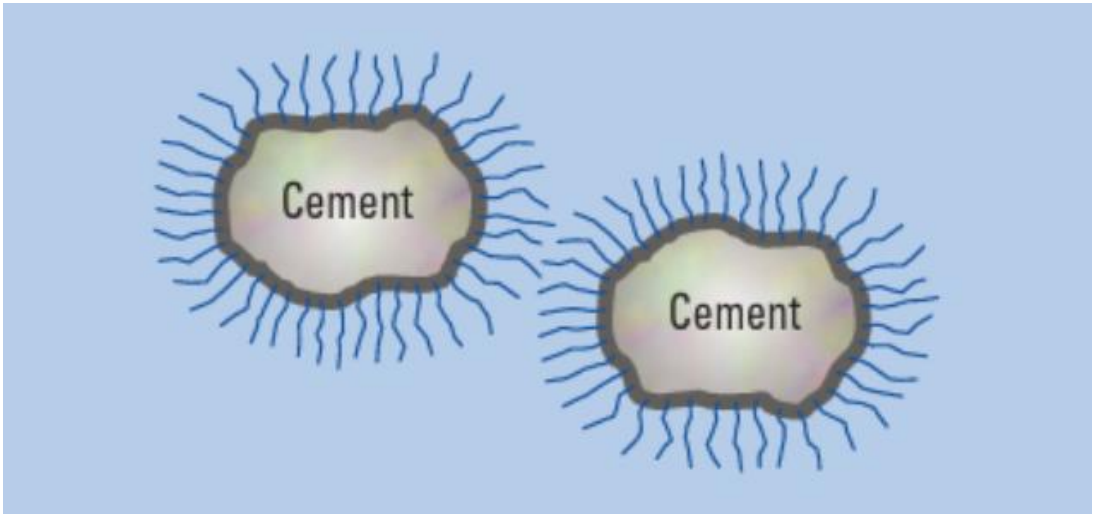
- Other suggestions to assist with finishing:
  - Bring fresh concrete or mortar from the point of discharge back to the slab to help close up the voids in the finished surface
  - Add water to the mix in the truck, consistent with SUDAS and Iowa DOT requirements
  - Use or adjust dosage rates of water reducing admixtures and/or hydration stabilizers
  - Consider use of finishing aids



# Water Reducing Admixtures

- Water reducing admixtures are very helpful to enhance the workability of concrete without increasing water content or exceeding the maximum w/cm



# Water Reducing Admixtures

- Water reducers can be useful tools, and are very commonly used in concrete paving today
- Adjusting the water reducer dosage rate may be an even better first lever to pull than adding water to improve workability
- Allow the contractor and/or concrete producer to adjust the water reducer dosage rate
  - Iowa DOT IM 403: “dosage rates may be adjusted, within manufacturers range limits, to improve workability for the conditions on the project”

# Finishing Aids

- Newer types of finishing aids consist of colloidal silica
  - Dense, amorphous $SiO_2$ nanoparticles
  - Pozzolanic and highly reactive
- Applied to the surface to aid finishing and ultimately produce a more dense, durable, abrasion-resistant surface



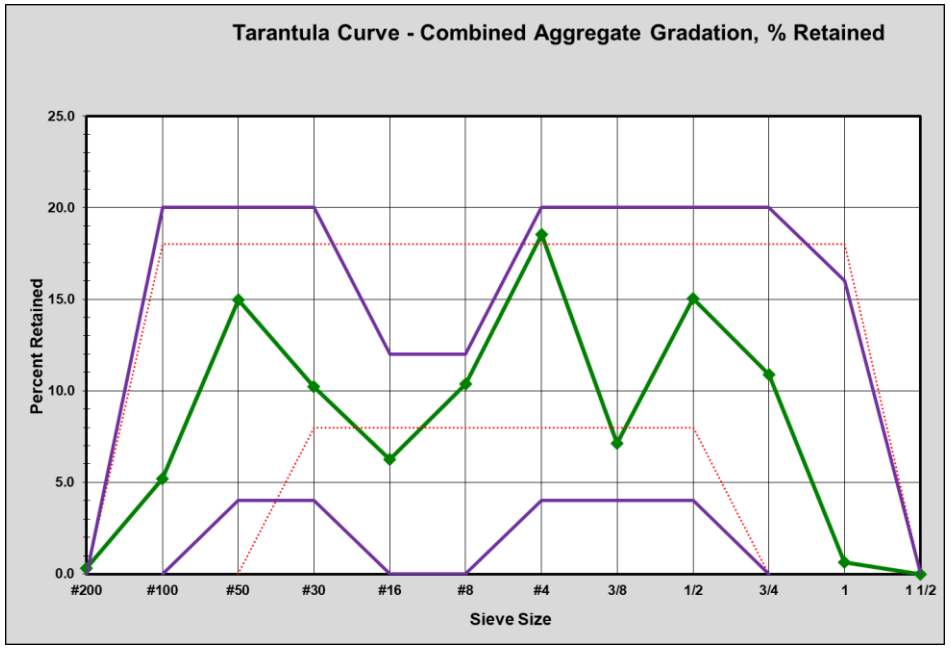




Images: Lythic Solutions

# Troubleshooting Workability Challenges

- Other mixture adjustments:
  - Perform trial batches to identify any unseen issues with cements or SCMs
  - Analyze the combined aggregate gradation using the tarantula curve
  - When using a high-durability mix (C-SUD) for fixed-form paving or handwork, consider the new C-SUDHW mix



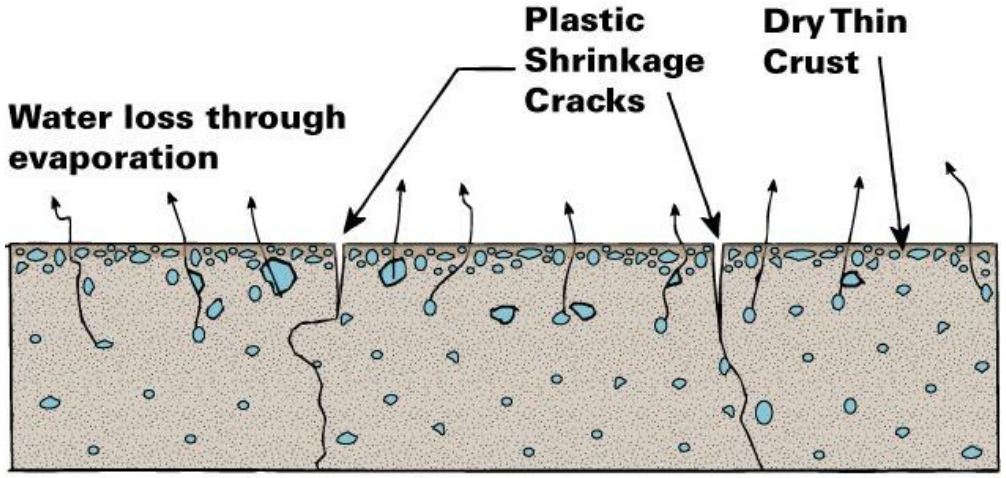
# Inadequate Curing

- SUDAS 7010 & Iowa DOT 2301:
  - Curing compound must be applied within 30 minutes of finishing at an application rate of 15 $yd^2$/gal
- While we don't (yet) have a way to measure curing, it is absolutely critical to achieve the "white sheet of paper" look



# Inadequate Curing

- When the surface dries out too quickly, plastic shrinkage cracking can occur:

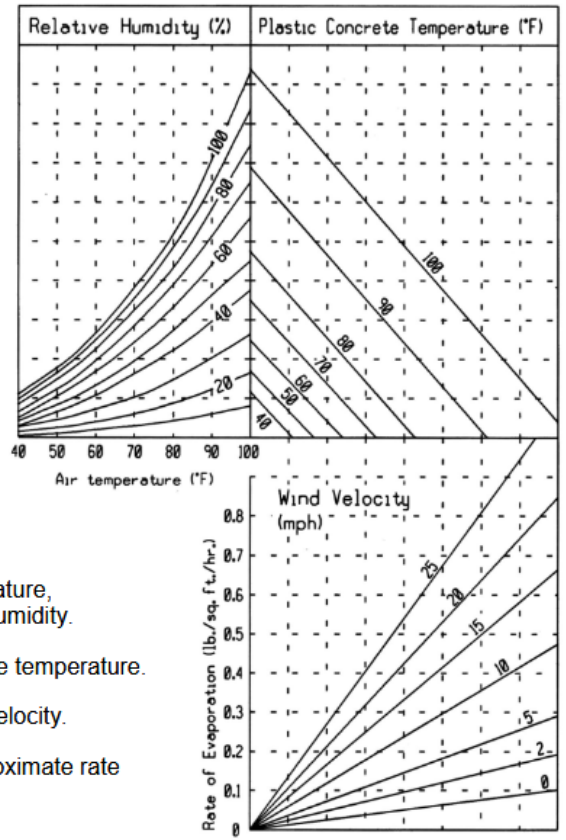





# Inadequate Curing

- The potential for plastic shrinkage cracking can be exacerbated in highly evaporative conditions
  - Hot temperatures
  - Low humidity
  - High winds
  - Intense sunlight
- When evaporation rates exceed 0.1 lb/ft$^2$/hr, special attention may be needed

**Theoretical Rate of Evaporation Chart**




To Use this Chart:

1. Enter with air temperature, move up to relative humidity.
2. Move right to concrete temperature.
3. Move down to wind velocity.
4. Move left , read approximate rate of evaporation

# Inadequate Curing

- A lack of hydration near the surface due to inadequate curing can also lead to a less dense, less durable surface susceptible to scaling, abrasion, and damage from de-icing chemicals





Image: Gerard Moulzolf, AET

# Troubleshooting Curing Challenges

- Anticipate how site conditions affect the curing process:
  - Paving equipment (e.g. cure cart vs. handheld sprayer)
  - Effect of wind on spraying/application
  - Effect of evaporation rate on cracking potential
- Apply additional applications of curing compound as needed to ensure uniform coverage
- In especially challenging conditions, consider using an evaporation retardant
- Make sure you use the proper curing compound!

# Troubleshooting Curing Challenges

- When using handheld sprayers, make sure you there is enough curing compound and enough time is spent to achieve sufficient application



# Troubleshooting Curing Challenges

- On days where it looks like evaporation could be a challenge, tools such as the PourDay app can be helpful to assess the evaporation rate



# Troubleshooting Curing Challenges

- SUDAS 7010.3.04.2 (“Hot Weather”) contains on best practices when evaporation rates exceed 0.1 lb/ft$^2$/hr:
  - Apply an evaporation retardant or 1.5x the standard specified rate of curing compound
  - Protect and moisten forms and subgrade
  - Eliminate delays between placing and curing
  - Use a fog spray to increase RH of the ambient air if there is a delay in applying curing compound
  - Discontinue placement if evaporation rate exceeds 0.3 lb/ft$^2$/hr

# 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





Image: Deco-Crete

# Troubleshooting Curing Challenges

- 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 Loss Test:

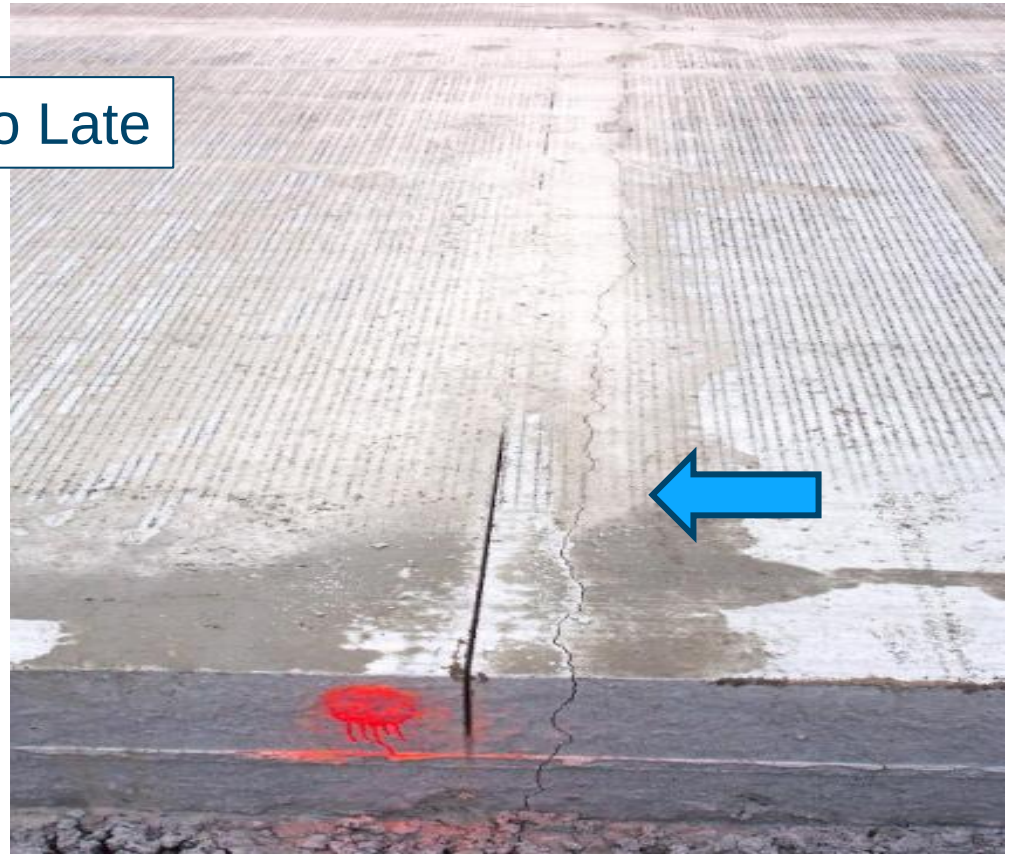
| Test time | IDOT Wax Based Cure (4105) | PAMS | ASTM C309 |
|---|---|---|---|
| **24 Hours** | 0.20 kg/m$^2$ | 0.15 kg/m$^2$ | - |
| **72 Hours** | 0.40 kg/m$^2$ | 0.40 kg/m$^2$ | 0.55 kg/m$^2$ |

# Troubleshooting: After Construction

# Early-Age Cracking

- Cracking due to joint sawing issues

Too Late



Too Shallow

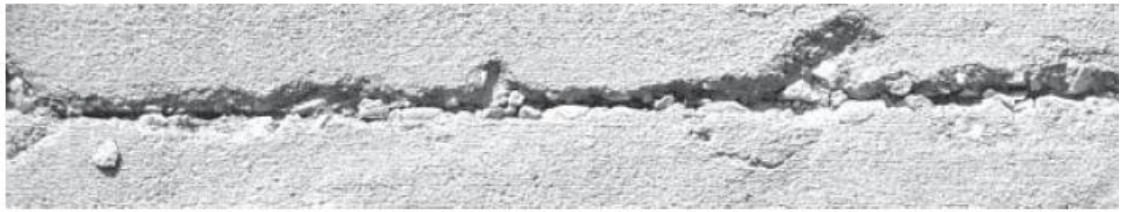




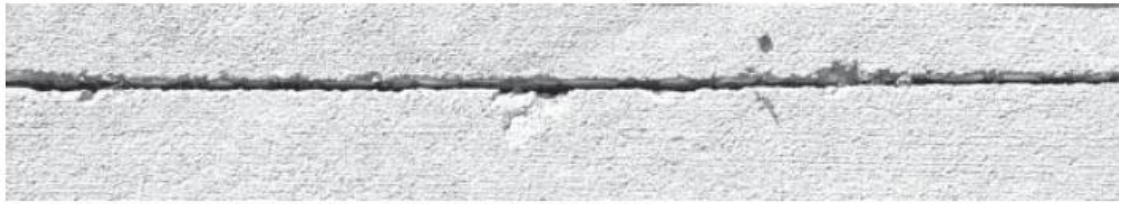
R Image: Jerod Gross

# Timing of Joint Sawing

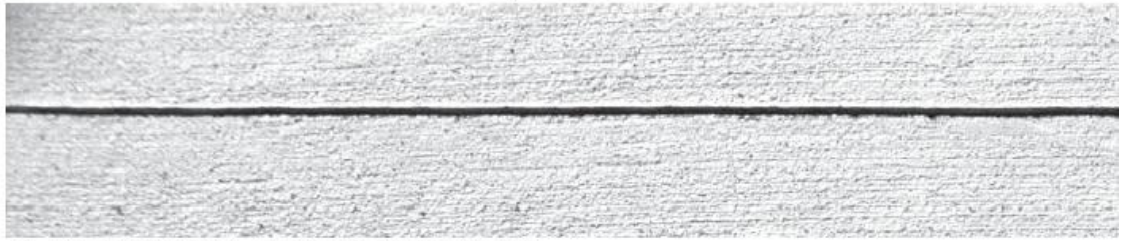
- Joint sawing must be completed within the sawing window
  - Period where concrete is strong enough to saw without raveling or spalling, and before tensile stresses exceed strength



*A. UNACCEPTABLE RAVELING - Sawed too early*



*B. MODERATE RAVELING - Sawed early in window*



*C. NO RAVELING - Sawed later in window*

# Troubleshooting Timing Issues

- The sawing window is sensitive to many factors:
  - Temperature changes can speed up or delay set time, shifting the window
  - Sharp decreases in temperature late in the day or overnight can increase shrinkage, narrowing the window
  - Windy, sunny, or dry conditions can lead to more evaporation, increasing shrinkage and narrowing the window
  - Mixtures with greater cement and/or water contents experience more shrinkage, narrowing the window

# Troubleshooting Timing Issues

- Be prepared for changing weather conditions, both day-to-day and throughout the project

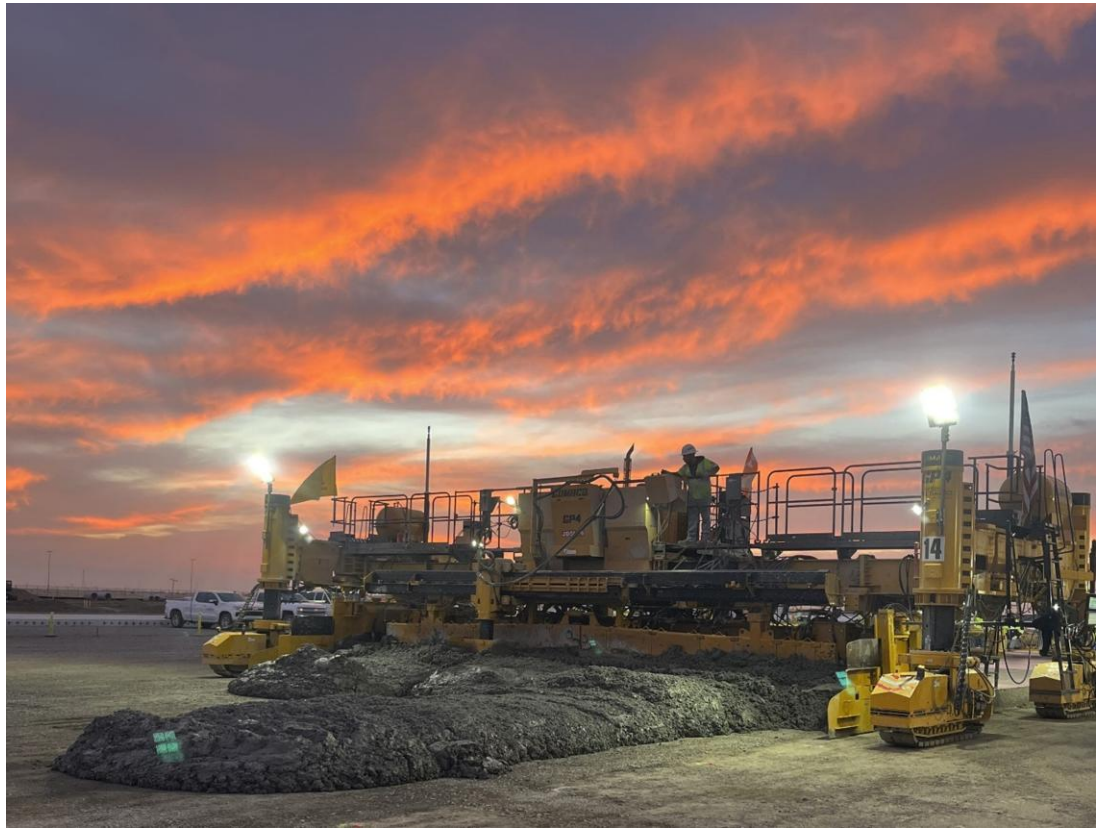




Image: SWCPA

# Depth of Joint Sawing

- Joints must be sawed deep enough to weaken the plane and ensure the cracks form at the saw cut locations
- Note differences in specifications for:
  - Transverse vs. longitudinal joints
  - Doweled vs. un-doweled transverse joints
  - Early-entry vs. conventional saws



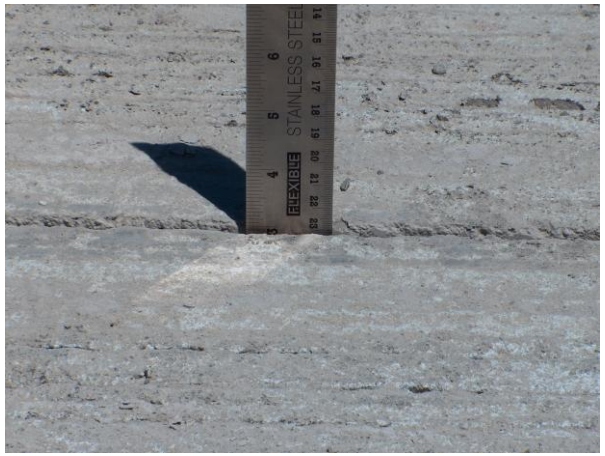


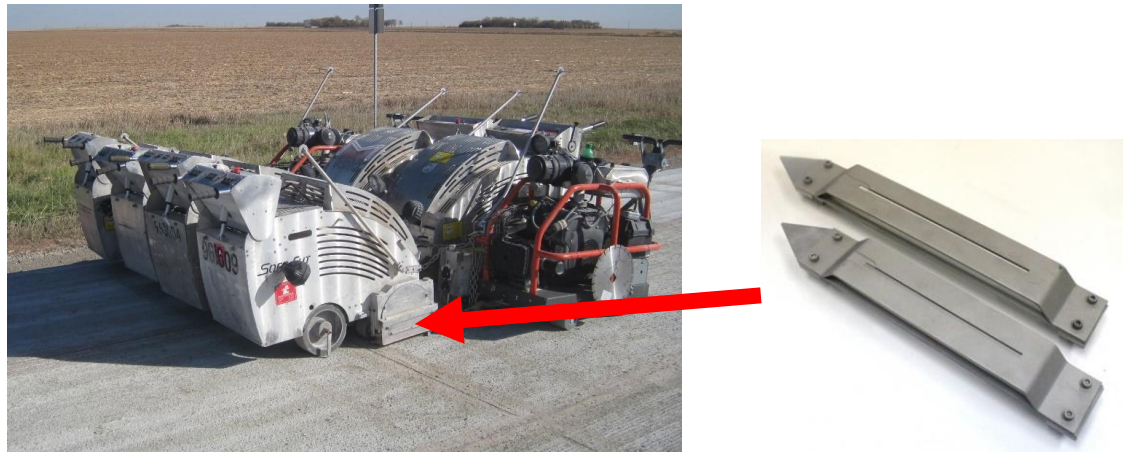


Images: Iowa DOT

# Troubleshooting Depth Issues

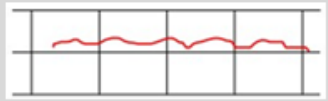
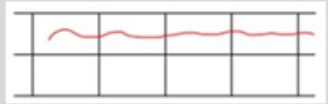
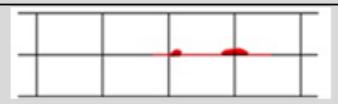
- Verify saw cut depth in the field!
  - If longitudinal joints are shallow, you may have time to re-saw
- Maintain blades and equipment
  - Select proper blade for aggregate type
  - Regularly check for wear and replace blades
  - Check the skid plate on early-entry saws



# Recommended Repairs

- Appendix 9-6 of the Iowa DOT construction manual:

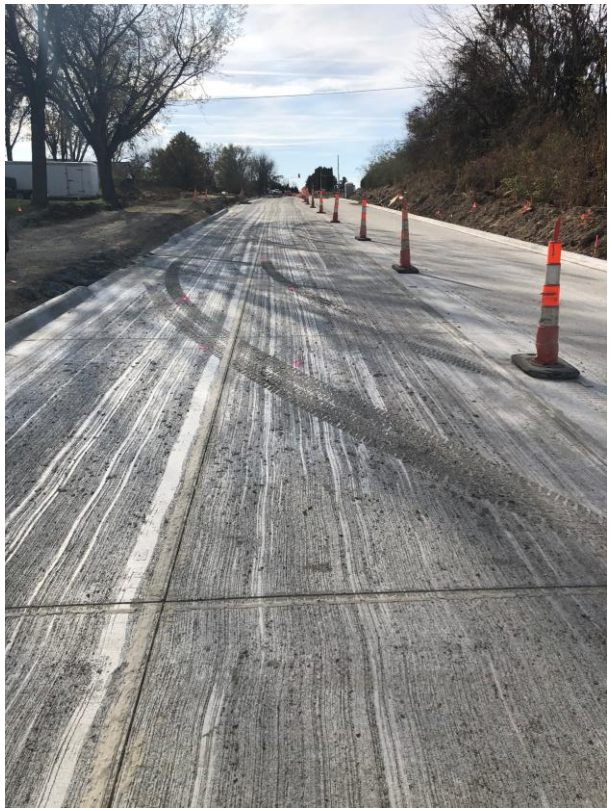
| Defect | Orientation | Location | Description | Transverse JT, D or UnD | Recommended Repair | Example |
|---|---|---|---|---|---|---|
| Uncontrolled Crack | Longitudinal | Relatively parallel to & within 1 ft. of JT. May cross or end at long.JT | Full-Depth | Either | Saw/route & seal the crack or cross-stitch the crack<br>Epoxy sawed joint if uncracked |  |
| Uncontrolled Crack | Longitudinal | Relatively parallel to & within wheel path, 1-5 ft. from JT | Full-Depth, hairline, or spalled | Either | Remove and replace panel or cross-stitch crack |  |
| Uncontrolled Crack | Longitudinal | Relatively parallel to & >5 ft. from a longitudinal JT or edge | Full-Depth | Either | Cross-stitch crack |  |
| Spalled sawcut or uncontrolled crack | Longitudinal | Anywhere | Spalled | Either | Partial-Depth Repair |  |
| Uncontrolled Crack | Diagonal | Anywhere | Full-Depth | Either | Full-Depth Repair |  |
| Uncontrolled Crack | Multiple per panel | Anywhere | Two or more full depth cracks dividing panel into 3 or more pieces | Either | Remove and replace panel |  |

Full-Depth repair per Specification 2529
Partial-Depth repair per Specification 2530
Cross-stitch repair per Construction Manual 9.27
Repairs should be made without use of Calcium Chloride unless early opening to traffic is necessary.

a LTR = load-transfer restoration (if faulted less than 1/2"); 3 dowel bars per wheel path grouted into slots sawed across the crack. Slots must be parallel to each other and the longitudinal joint. Backfill with non-shrink, cement-based grout. Diamond grind if faulting is severe.

# Surface Defects

- Sometimes the traveling public gets a little too excited to use the new road…







Images: Steve Mallicoat

# Troubleshooting Tire Tracks

- The good news is that tire tracks rarely pose issues with structural integrity
  - MnROAD study, 2017
    - Deliberate early loading of concrete pavement test sections 2 to 10 hours after placement
    - No indication of structural problems after 5+ years of service
      - Just the functional issue of rough ride at a section loaded after 2 hours



# Recommended Repairs

- Shallow depressions can be corrected with diamond grinding
- Deeper ruts will need to be patched, full- or partial-depth



- 24th Street, Ames, IA
  - Paved in 1982
  - Tire tracks held up well for 42 years
  - No adverse impacts with later diamond grinding

# Recommended Repairs

- Damage to the edge of the slab requires full depth repair





Image: Steve Mallicoat

# Surface Defects

- Scaling is flaking or peeling of the top 1/8” to 1/2” of the surface
- As discussed, scaling is frequently a consequence of finishing water into the surface or inadequate curing

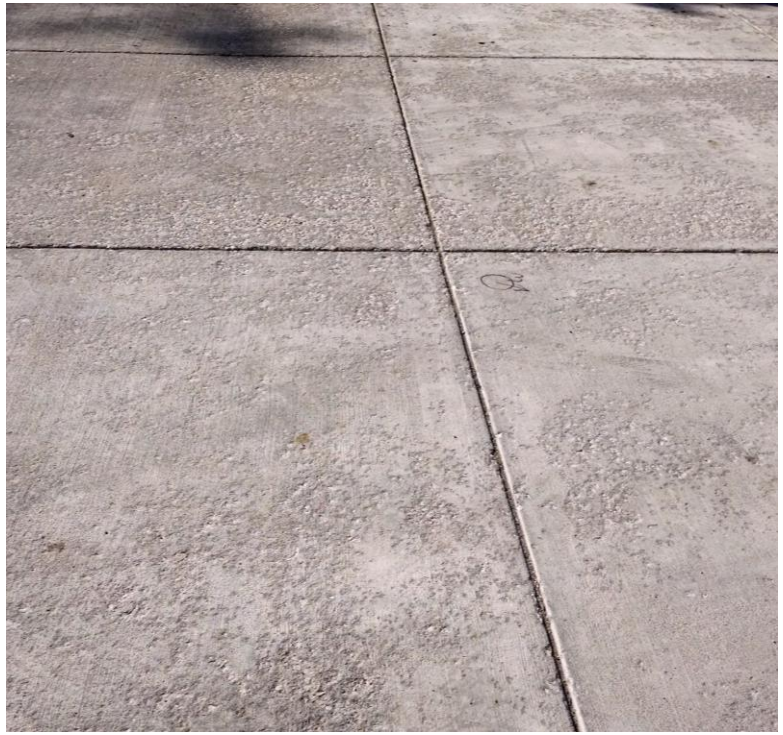




Image: Gerard Moulzolf, AET

# Surface Defects

- Crazing is the formation of very shallow cracks at surface due to poor curing or from finishing bleed water into the surface
- Popouts result from the loss of aggregate particles at the surface due to physical or chemical reactions within the aggregates
- Surface tearing may result from excessive friction when operating the paving machine or vibratory screed too fast



Crazing



Popouts



Tearing



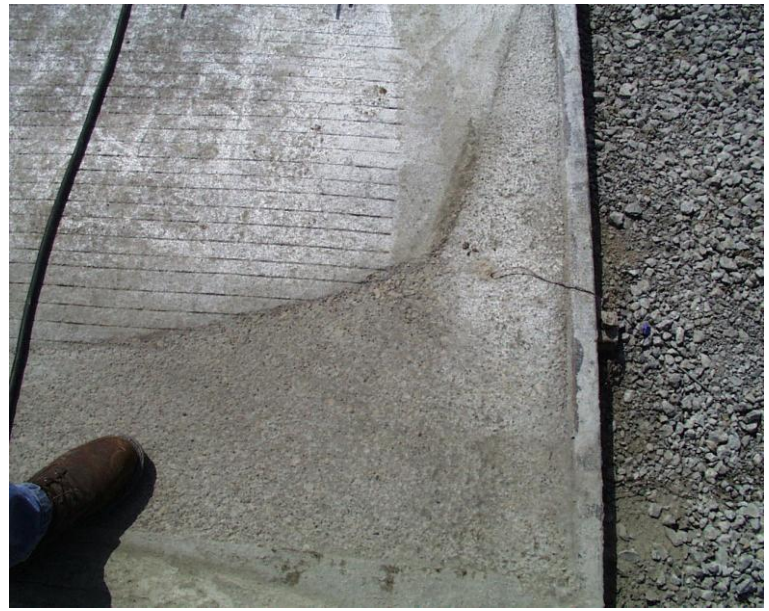
Images: Concrete Construction

# Surface Defects

- Rain damage can result in a loss of surface texture
  - If the concrete is still plastic, cover it and leave it alone
  - Do not finish rain water into the surface







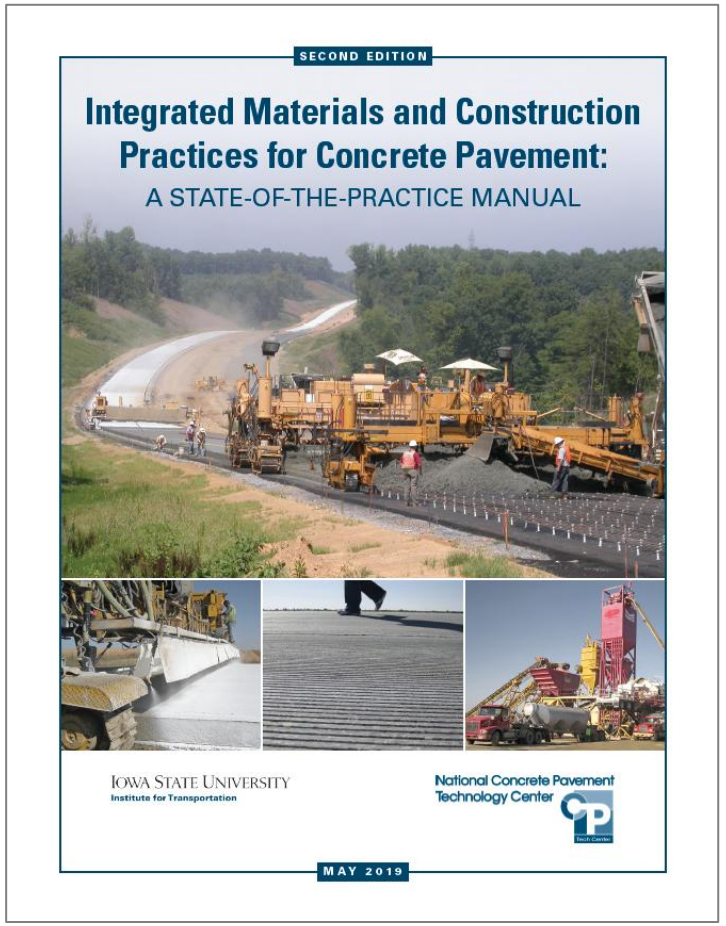


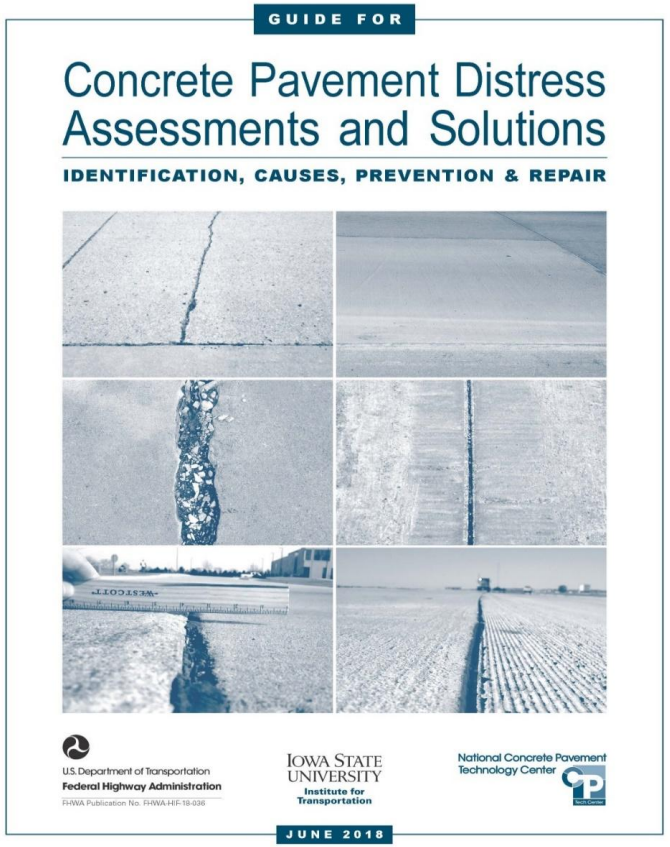
Images: Iowa DOT

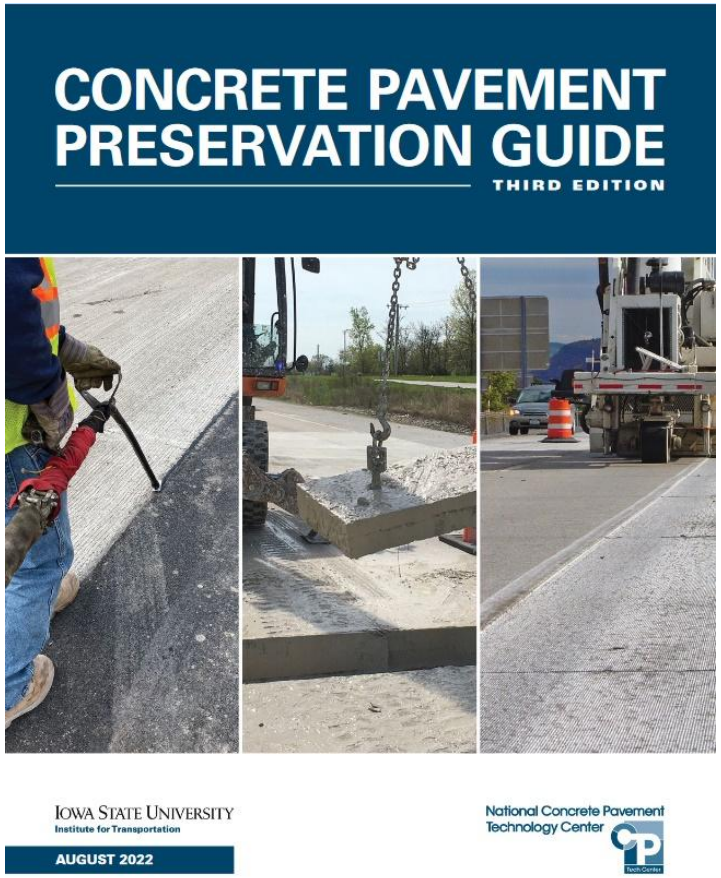
# Recommended Repairs

- Repair strategies for these types of minor surface defects:
  - Penetrating surface sealers to protect surfaces
  - Low viscosity repair materials to fill tight cracks
  - Epoxy and cementitious materials to fill voids
  - Diamond grinding to restore or improve surface texture

# Additional Resources from the CP Tech Center




**https://cptechcenter.org**


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