Internal Curing Concrete

Dr Peter Taylor
Payam Vosoughi

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John Ries, ESCSI
Dale Bentz, NIST
Jason Weiss, Oregon State
Internal Curing

• Why?
• How?
• So What?
Internal Curing - Why

• Curing is promoting hydration by
  ➢ Providing water
  ➢ Keeping it warm
Internal Curing - Why

- Without curing we will increase risk of
  - Cracking
  - Scaling
  - A soft surface
  - Warping
- What about strength?
Internal Curing - Why

![Graph showing property change over time with continuous cure and curing stops.]

- **Continuous cure**
- **Curing stops**
Internal Curing - Why

External water
Internal Curing - Why

Internal water
Internal Curing - How

- Material should
  - Hold sufficient water
  - Hold the water until needed and not effect w/c
  - Give up water at high RH (desorption)
  - Not adversely effect the concrete quality
Internal Curing - How

- Lightweight fine aggregate
- Super Absorbent Polymers
Simple IC Mixture Design

- Need 7 lbs of IC water per 100 lbs of cementitious
- 600 lbs cementitious = 42 lbs of IC water
- Assume 18% LWA absorption in the field
- Assume LWA at 55 lbs/cf
- $55 \times 0.18 = 9.9$ lb/cf water
- 90% desorption = 8.9 lb/cf water
- Need 42 lbs IC water / 8.9 = 4.7 cf of LWA
- 4.7 cf x 55 lb/cf = 259 lbs of LWA aggregate
Guide Specification

• In preparation
• QC is critical
• Minimum 15% absorption
• Monitor moisture state of LWFA and adjust mixture
• Monitor strength and formation factor
The LWFA should be wet

- Place under sprinkler for minimum of 48 hours
- Allow stockpiles to drain for 12 to 15 hours immediately prior to use
- Measure absorption before batching
Internal Curing - How

• Can we do without this?
• Nope
  ➢ Still have to keep the surface hydrating
  ➢ That’s where the abuse happens
Internal Curing - So What

• Benefits
  ➢ Better hydration & SCM reaction
    ➢ Improved durability
    ➢ Less cement
  ➢ Less shrinkage, warping, cracking
  ➢ Extended service life
    ➢ Improved economics
  ➢ Increased sustainability
Internal Curing - So What

- More Hydration

Espinoza-Hajazin (2010) 90 days, cured @ 50% RH
Internal Curing

- Relative permittivity (RP) of fresh concrete
  - RP of water is 20 times higher than other components
  - Therefore higher RP means higher moisture content
Internal Curing

- Reduced capillary pressure
- Reduced risk of plastic cracking
Internal Curing – So What

• Less Shrinkage (Sealed)

Henkensiefken (2009)
Internal Curing – So What

• Less Shrinkage = Less Cracking

Schlitter (2010)
Internal Curing – So What

- Reduced Warping
Internal Curing – So What

- Reduced Permeability
Internal Curing - How

• Looks too easy…
  • Need an extra stockpile
  • It has to be wet
  • Transport?
Internal Curing – So What

- Service Life Prediction (MEPDG)
Internal Curing – So What

Cusson (2010)
Buchanan County

- Three span bridge at Pine Creek
  - One half conventional (both lanes)
  - Other half using Internal Curing Concrete

- About 20% (by mass) of fine aggregate replaced with light weight aggregate
- Other mix proportions unchanged
Looking West – IC placed first
Construction
## Hardened Properties

<table>
<thead>
<tr>
<th>Age (days)</th>
<th>Laboratory</th>
<th>Field</th>
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<tbody>
<tr>
<td></td>
<td>Field samples</td>
<td>Lab samples</td>
</tr>
<tr>
<td></td>
<td>Control 20% IC</td>
<td>Control 20% IC 30% IC</td>
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<tr>
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<td>7 6.6</td>
<td>6.4 7.3 8.7</td>
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<td>9.8 9.2</td>
<td>9.2 10.6 12.6</td>
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<td>41.1 45.6</td>
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Sidewalk Demonstration
Mechanical Properties

- No significant change in tensile strength
- Slight increase in compressive strength
- Significant decrease in stiffness

<table>
<thead>
<tr>
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<th>Tensile strength (psi)</th>
<th>Compression strength (psi)</th>
<th>MoE (ksi)</th>
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<td>91-day</td>
<td>28-day</td>
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<tr>
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<tr>
<td>IC concrete</td>
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</table>
The Big Story

• Reduced Warping
• Theoretically sound
• Some construction challenges
• Little change in structural performance
• Helps durability and cracking risk
• Recommended for
  ➢ Bridge decks
  ➢ Thin overlays

“Go do good things”