Optimum Moisture Content of Substrate Prior to Applying Cementitious-Based Repair Materials (FAQ 28/364.XXT)

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Happy Retirement, Fred!

“Keep up the good work! And you will learn a lot!”
OUTLINE

• Importance of Moisture Condition of Concrete Substrate – Why?
• Evaluation of Surface Moisture Condition – How?
• Current Industry Practices for Moisture Condition – What?
• Optimal Moisture Condition – ???
AGENDA

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  • Evaluation of Surface Moisture Condition – How?
  • Current Industry Practices for Moisture Condition – What?
  • Optimal Moisture Condition – ???
WHY –
Longevity of Concrete Repair
WHY – Longevity of Concrete Repair

- Substrate Concrete
- New Repair Material
- BOND
WHY – Longevity of Concrete Repair

- Substrate Concrete
- New Repair Material
- BOND

- Surface soundness and roughness – Bruised substrate
- Surface cleanliness – Residue and contamination
- Improper bonding materials
- Improper placement of bonding materials
- Clogged concrete substrate pores with water (saturated)
- Dry substrate when insufficient moisture is present in repair material
WHY –
Bonding between New Repair Material and a Prepared Substrate

When the repair materials are absorbed into the substrate by the action of capillary suction and gravity locking around the pore structure and mechanical interlock with surface roughness.

*The condition of the pores found at the bonding surface is of utmost importance to achieve bond.*
WHY –

**Moisture Condition of Concrete Substrate**

- Dry Substrate
- Saturated Surface Dry (SSD)

*Wet substrate will reduce or eliminate any bond strength between the new repair material and substrate*
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How –

**Dry Surface – Definition**

- Allowed to dry and during the drying time, it has not been subjected to hosing down, rain, or other sources of moisture
- Drying may take hours or days depending on environmental conditions
How –

Dry Surface – Evaluation Method

• No standard test method
• Practical field approaches
  – Place a few drops of water on the concrete surface – if the water is absorbed immediately, then the concrete substrate can be considered dry
  – Observe the concrete color – the concrete surface appears lighter when dry, darker when wet or saturated
How –
**Saturated Surface Dry (SSD) – Definition**

• ACI Concrete Terminology & ICRI Concrete Repair Terminology
  “Condition of an aggregate particle or other porous solid when the permeable voids are filled with water and no water is on the exposed surfaces”

• What does it mean?
  – For **aggregates**, it means that the particles are fully saturated, with no film of water over their surface
  – For **concrete**, it means that the porosity immediately under the surface is saturated, with no film of water at the surface
How –
Saturated Surface Dry (SSD) – Definition
How – 
*Saturated Surface Dry (SSD) – Evaluation Method*

• Generally little or no guidance
• Investigated devices / techniques (R&D works)
  – Embedded Relative Humidity Probe
  – Moisture Meters (Impedance, Resistance)
  – Capillary Suction Test
  – Initial Surface Absorption Test (ISAT)
  – Water Absorption
  – …
How –
Saturated Surface Dry (SSD) – Evaluation Method

• Proposed Field Methods
  – Visual Inspection
    • By looking at the surface, if any water glistens at the observed surface then the surface is saturated and not saturated surface dry
  – Compressed air jetting of surface
    • Jet a stream of compressed air on concrete surface
    • Observe the flow of high velocity air – deflecting air leaving the surface contains visible moisture indicates that the surface is saturated
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What –

Current Industry Practices for Moisture Condition

• ICRI No. 030130 Guide Specifications for Structural Concrete Repairs
  – Para. 3.4 H Bonding
    “Saturated Surface-Dry Substrate: Predampen concrete substrate surfaces to saturated
    surface-dry condition immediately prior to placement.”
  – Commentary (Para. 3.4 H)
    “The repair area must be properly dampened with water prior to the application of the
    mortar scrub coat or other bonding agents, except in cases where proprietary bonding
    agents call for a dry substrate…”
What –
Current Industry Practices for Moisture Condition

• ICRI No. 030130 Guide Specifications for Structural Concrete Repairs
  – Commentary (Para. 3.4 H)

“It may be necessary to wet the repair substrate more than once or for periods 2 hours or longer in order to achieve proper dampening. The goal is to achieve a specified minimum bond strength. The Design Professional should work with the Contractor to determine the procedure based on confirmation through testing that the specified bond strength is achieved. When developing the procedures, consideration should be given to varying the procedures with variations in weather conditions. Standing water must be removed prior to the bonding agent application to provide a saturated surface dry (SSD) substrate.”
What –
Current Industry Practices for Moisture Condition

• General Instructions from Proprietary Material
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• Optimal Moisture Condition - ???
Optimal Moisture Condition – Is it SSD?

• Limited research available
  – Schrader (1992)
  – Saucier and Pigeon (1992)
  – Vaysburd et al. (2016)
  – …

• Achievement of optimal bond promoted by a somewhat drier substrate
Optimal Moisture Condition – Current Research

- Saucier and Pigeon (1992)
- Dry surface vs. surface wetted for 1 hr before casting new concrete
- No significant differences observed.
Optimal Moisture Condition – Current Research

Effect of prewetting on bond

<table>
<thead>
<tr>
<th>Material</th>
<th>Surface condition</th>
<th>Strength, psi</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>shear</td>
<td>Tension</td>
<td></td>
</tr>
<tr>
<td>Old concrete*</td>
<td>Dry</td>
<td>405</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>Wet 18 hours</td>
<td>340</td>
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<tr>
<td>Dry-mix shotcrete+</td>
<td>Air dry</td>
<td>470</td>
<td>140</td>
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<tr>
<td></td>
<td>Wetted (SSD)</td>
<td>580</td>
<td></td>
<td>410</td>
</tr>
<tr>
<td>Latex-modified shotcrete+</td>
<td>Air dry</td>
<td>—</td>
<td>470</td>
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<tr>
<td></td>
<td>Wetted (SSD)</td>
<td>—</td>
<td>140</td>
<td></td>
</tr>
</tbody>
</table>

*Data from Corps of Engineers WES Report No. 6-518.
+Data from D. Gill, Corps of Engineers, Bonneville.

- Schrader (1992)
- “Thoroughly wetting a surface prior to placing an overlay or patch is not always a good idea.”
- “Overwetting can be harmful”
Optimal Moisture Condition – Current Research

- Vaysburd et al. (2016)
- "[For normal strength concrete and repairs], pre-wetting of the substrate is not necessary for optimum bond strength."
SUMMARY

• Moisture condition of a prepared substrate has a direct effect on the bond strength and durability of the repair
• Evaluation of moisture condition, especially SSD condition, does not have a clear guideline
• Current industry practice recommends SSD as referred moisture condition to receive new repair material
• Limited research results suggest that a drier substrate may achieve an improved bond
CONCLUSIONS

• Need in the industry for improved guidance regarding moisture condition of the substrate prior to repair
  – Achievement
  – Evaluation

• *SSD* as a rule to be reconsidered in view of reported data
  – Definition
  – Guidance

• Development of a Technote
Thank You!

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