

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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WHY – *Longevity of Concrete Repair*



THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



WHY – *Longevity of Concrete Repair*

- Substrate Concrete
- New Repair Material
- BOND



WHY – *Longevity of Concrete Repair*

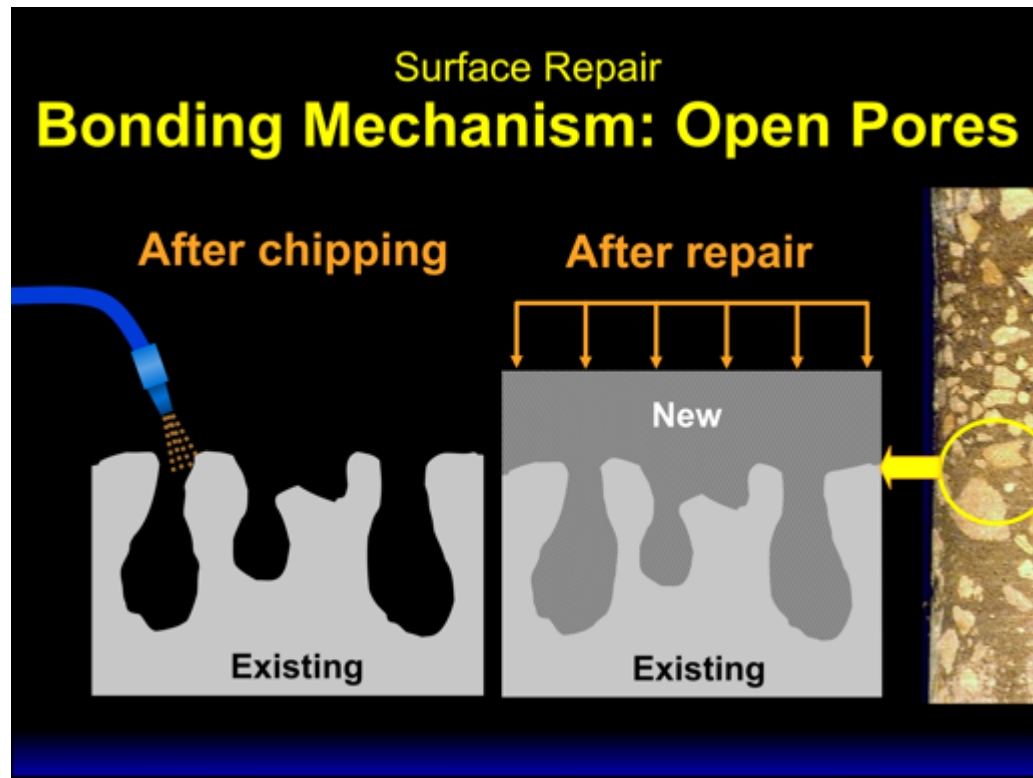
- Substrate Concrete
- New Repair Material
- BOND



- 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

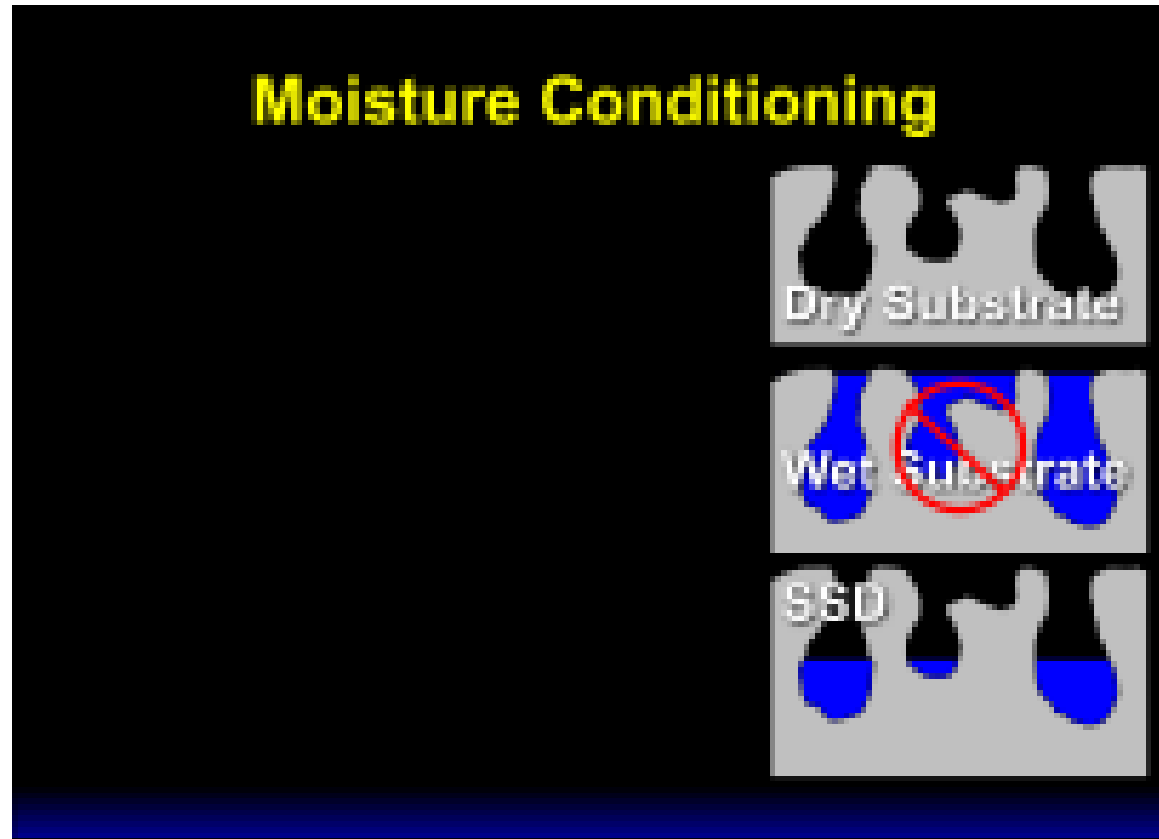


When the repair materials are absorbed into the substrate by the action of capillary suction and gravity locking around the pore structure and mechanical interlock with surface roughness.

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)

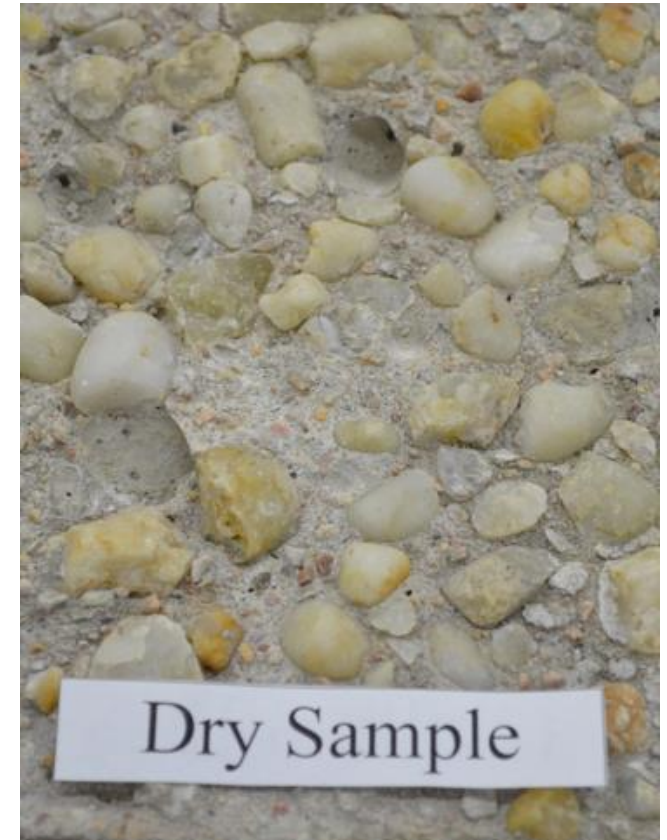
Wet substrate will reduce or eliminate any bond strength between the new repair material and substrate

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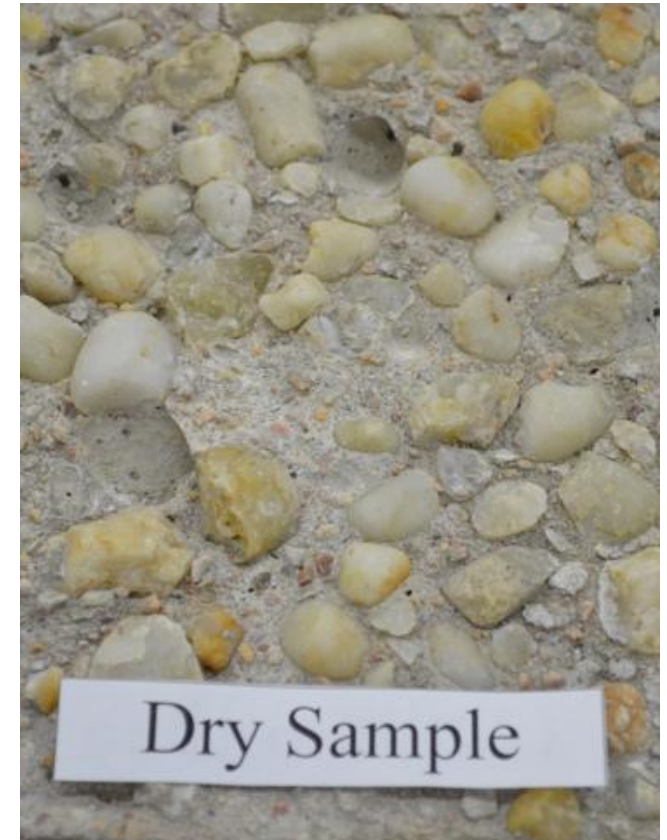
How – *Dry Surface – Definition*

- 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

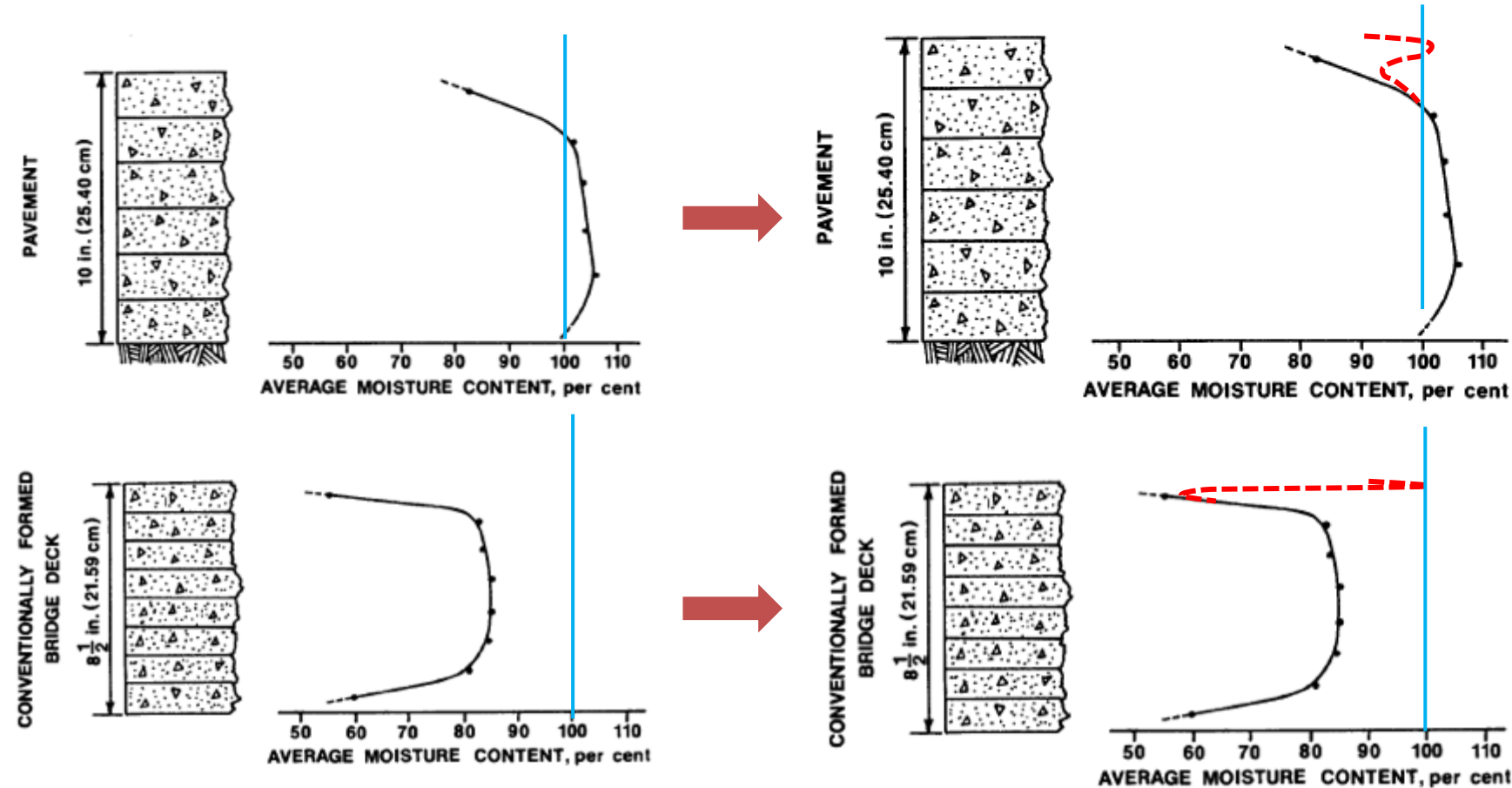


How –

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

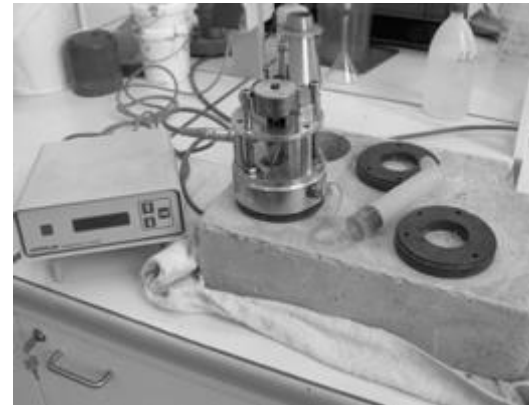


THE WORLD'S GATHERING PLACE FOR ADVANCING CONCRETE



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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- **Current Industry Practices for Moisture Condition – What?**
- Optimal Moisture Condition – ???

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

APPLICATION INSTRUCTIONS

SURFACE PREPARATION

- Concrete surface must be clean and sound.
- Remove all deteriorated concrete, dirt, oil, grease, and other bond-inhibiting materials from the area to be repaired.
- Be sure repair area is not less than 1/4" (6 mm) deep.
- Preparation work should be done by high pressure water blast, scabblor or other appropriate mechanical means to obtain an exposed aggregate surface profile of $\pm 1/8"$ (3 mm) [minimum CSP-6].
- To ensure optimum repair results, the effectiveness of decontamination and preparation should be assessed by a Tensile Adhesion Strength (pull-off) test.
- Saw cutting perimeter edges of concrete repair area at a dovetail is preferred.
- Substrate should be Saturated Surface Dry (SSD) with clean water prior to application. No standing water should remain during application.
- Rust, scale, mortar, concrete, dust and other loose and deleterious material which reduces bond or contributes to corrosion shall be removed from steel reinforcement.
- Surfaces shall be prepared using abrasive blast cleaning techniques or high pressure water blasting to achieve a bright metal finish.

APPLICATION

1. Build forms in accordance with ACI 347R. Keep the unrestrained surface area of the repair to a minimum.
2. Saturate the prepared concrete substrate by filling the prepared formwork with clean water 24 hours before placement.
3. Immediately before the placement of [redacted], completely drain this water and seal the drainage outlets, leaving the substrate saturated surface-dry (SSD) with no ponded water remaining.
4. In jobsite circumstances where the formwork cannot be filled with water to achieve an SSD surface, the prepared concrete substrates must be thoroughly hosed down with clean water to achieve an equal level of saturation. Apply the repair material with sufficient pressure to ensure intimate contact with the substrate.

PRODUCT APPLICATION

Read all installation instructions thoroughly before installation.

1. Before application, ensure that prepared concrete is saturated surface-dry (SSD).
2. Apply a scrubcoat of [redacted].
3. Apply [redacted] directly to the scrubcoat before it dries out.
4. Apply [redacted] by float, working from the center of the repair to the outer edge. Finish the application similar to the surrounding concrete.
5. Apply at a thickness between featheredge and 4" (10 cm).



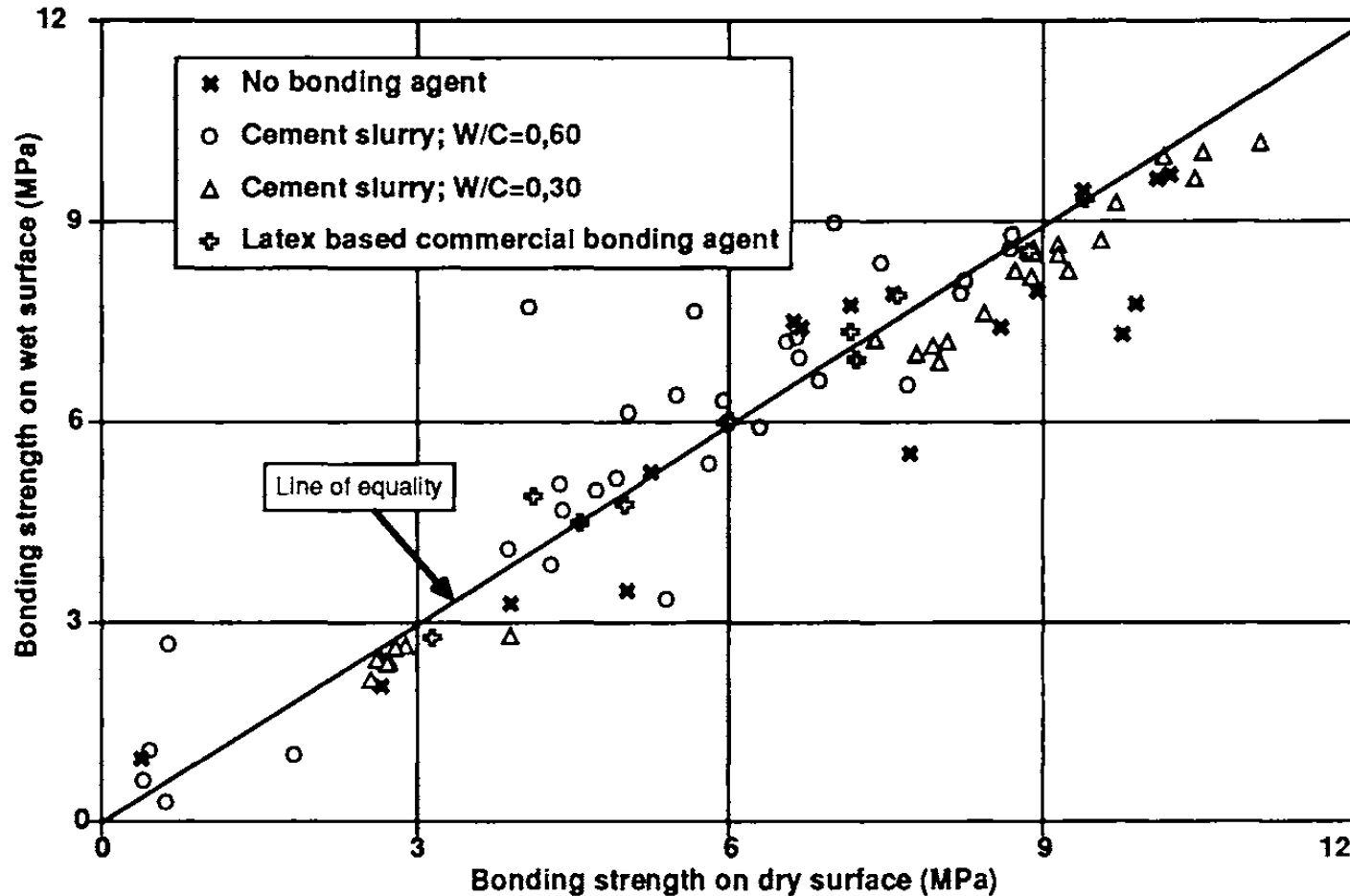
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Optimal Moisture Condition – Is it SSD?

- 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

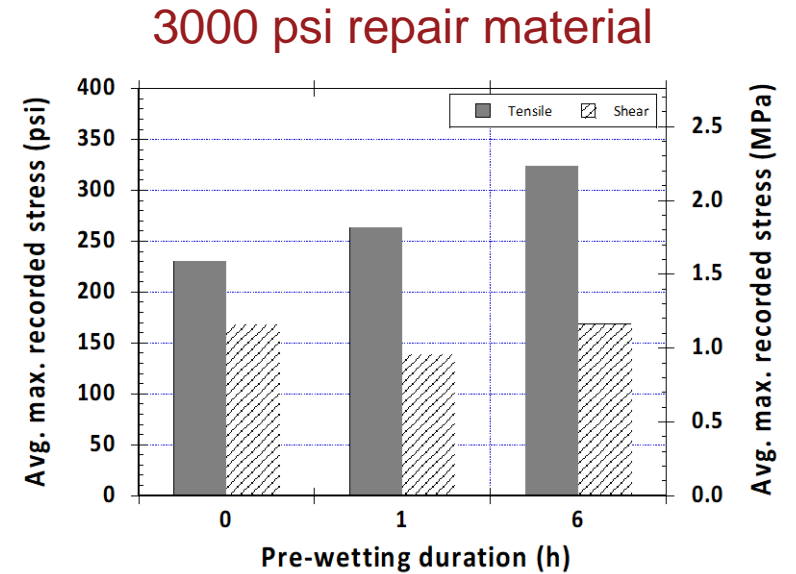
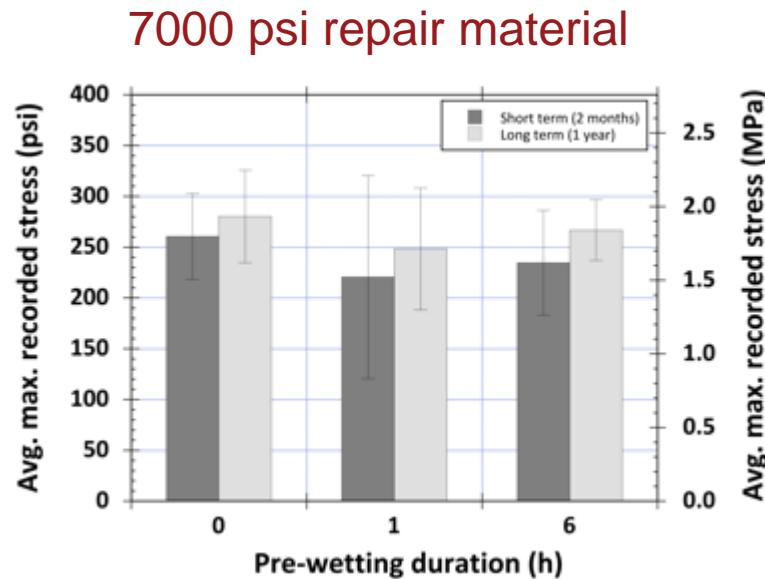
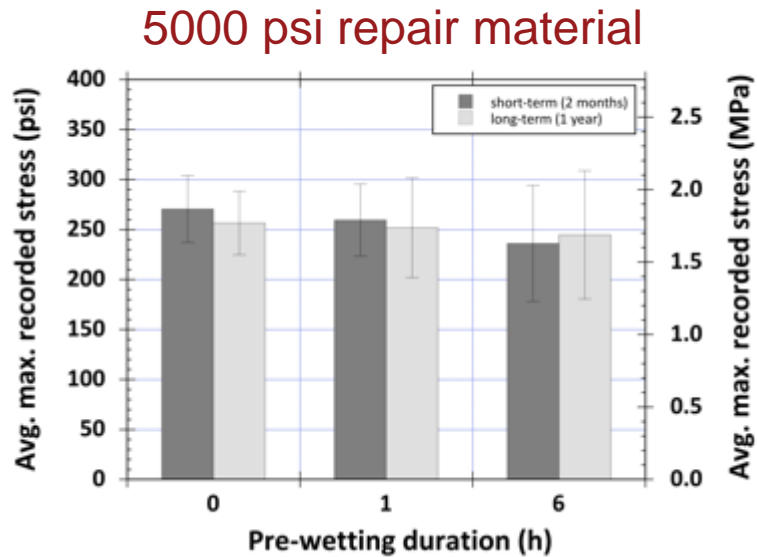
| Material | Surface condition | Strength, psi | |
|---------------------------------------|-------------------|---------------|---------|
| | | shear | Tension |
| Old concrete* | Dry | 405 | — |
| | Wet 18 hours | 340 | — |
| Dry-mix shotcrete ⁺ | Air dry | — | 470 |
| | Wetted (SSD) | — | 140 |
| Latex-modified shotcrete ⁺ | Air dry | — | 580 |
| | Wetted (SSD) | — | 410 |

*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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