Moisture Evaluation and Remediation for Concrete Substrates

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Learning Outcomes

• At the end of this webinar you will be able to:
  – Define the current methods used to measure moisture in concrete
  – Identify the current standards
  – Define the remediation methods
Introduction

• Excess moisture in concrete can:
  – Cause discoloration
  – Interrupt polymerization of products
  – Lead to delamination of bonded coating systems

• This webinar will review how to test for moisture in concrete and how to remediate the problem when an unacceptable level is found.

FIRST STEPS

From ICRI 310.2 (formerly 03732)
Preliminary Investigation

- Type of concrete
  - Lightweight/Normal weight
  - W/C & mix design
  - Concrete thickness
  - Concrete age
  - Surface condition
- Presence of radiant heat, vapor barrier
- Location, location, location
  - Roof/walls/drainage/climate control/ventilation
  - Where to test and # of tests
### TABLE 1

Typical Surface Properties of Finished Concrete[^1]

|-----------------|---------|--------------|--------------|----------|

[^1]: Reference for Table 1.

**Appearance**

- **DUST**
- **Texture**

[^2]: Porosity measurements.
[^3]: Strength values.

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[^1]: Reference for Table 1.
Water Beading

Water Wetting

pH of Surface

Phenolphthalein in ~70% Alcohol

pH of Wash Water
Two Types of WATER

- Natural WATER Sources
  - Weather
  - Water Table
  - Hydrostatic Pressure
  - Osmosis
  - Subslab Vapor
  - Indoor RH
  - Dew Point

- Artificial WATER Sources
  - Mix Water
  - Curing Water
  - Leakage/Spills
  - Cleaning
  - Surface Preparation

Construction Methods to Minimize NATURAL Water Ingress

Kanare, H. Concrete Floors & Moisture, Eng. Bulletin #119
PCA/NRMCA, 2005
Drying of 4” Slabs to MVTR = 3 Lb/1000 sq. ft.

Drying from one side
Bottom side moist

Stage 1 Bleed water on surface evaporates
Stage 2 Water evaporates from pores refilled from within concrete = settlement
Stage 3 Water evaporates from within as vapor = drying
Stage 4 Apply non-breathable coating

Artificial WATER Sources
- Mix Water
- Curing Water
- Leakage/Spills
- Cleaning
- Surface Preparation

Drying of Concrete Two Sides

Stage 1: Bleed water on surface evaporates

Stage 2: Water evaporates from pores refilled from within concrete

Stage 3: Water evaporates from within as vapor = drying

Stage 4: Apply non-breathable coating

Other Drying Factors
4" Thick 0.5 W/CM 64°F RH 60%
2 weeks rain, 2 weeks moist
Dry to 90% RH
Two Side Drying

Thickness
4” = 1
6” = Twice as Long
7” = 2 ½ Times as Long
8” = 2.8 Times Longer than 4”
10” = 3 ½ Times Longer

Kanare, H. Concrete Floors & Moisture, Eng. Bulletin #119
PCA/NRMCA, 2005

Swedish Concrete Association, 1997
Other Drying Factors
4" Thick 0.5 W/CM 64°F RH 60%
2 weeks rain, 2 weeks moist
Dry to 90% RH
Two Side Drying

Temperature
RH 60%, 64°F
50°F = 30% More Time
77°F = 20% Less Time
86°F = 30% Less Time

Swedish Concrete Association, 1997
Surface Preparation Methods

From ICRI 310.2

Surface Preparation Methods

From ICRI 310.2 (formerly 03732)
Surface Preparation Methods

- Detergent Scrubbing
- Low Pressure H₂O
- Acid Etching
- Grinding
- Sand/Abrasive Blasting
- Shot Blasting
- Scarifying
- Needle Scaling
- Hydrodemolition/High/Ultrahigh H₂O Pressure
- Scabbling
- Liquid Surface Etchant
- Flame Blasting
- RotoMilling

Bruising Induced Bond Failure

ADDs WATER
CAN CAUSE BRUISING
Bond/Tensile Adhesion/ Bruising Test

ICRI 210.3 (formerly 03739)
ASTM 1583
Bond Test

Testing for Moisture
Testing for Moisture

• Moisture should be tested after surface preparation, prior to coating

• Concrete substrates should be tested under expected service conditions after the coating is applied

General Guidance
ASTM E 1907, F 710
ACI 302.2 R-06
ICRI Certification Program

• ASTM D 4263, Standard Test Method for Indicating Moisture in Concrete by the Plastic Sheet Method
Plastic Sheet Test

- ASTM D 4263
- A 18 inch X 18 inch clear plastic sheet with a thickness of 4 mils is taped to an area of concrete
- After a minimum of 16 hrs the sheet is examined for moisture condensation

Plastic Sheet Test

- Qualitative method that indicates the capillary moisture in the concrete substrate
Testing for Moisture

- ASTM F 1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride

Calcium Chloride Test

- ASTM F 1869
- A quantitative method for determining the rate of moisture vapor emitted from a concrete substrate
- The quantity of measure is expressed as the rate of moisture vapor emission, measured in pounds of moisture over a 1000 ft² area during a 24 hr period
Calcium Chloride Test

- A “snapshot” in time
- The moisture vapor emission rate only reflects the condition of the concrete floor at the time of the test and is effected by ambient conditions

*Effect of temperature on calcium chloride emission tests for different concretes (Kanare 2005)*

Calcium Chloride Test

- Select an area for testing
- Measure the initial weight of the calcium chloride drying agent
- Place the weighed dish in the designated testing area
- Place a plastic cover of known area over the dish and tape the plastic cover to the concrete substrate
- After 60-72 hours the plastic cover is removed and the dish of calcium chloride is reweighed to determine the amount of moisture absorbed
**Calcium Chloride Test**

- 3 tests for the first 1000 ft²
- 1 test per additional 1000 ft²
- Maximum amount allowed:
  - 3 lbs per 1000 ft² in 24 hrs

**Testing for Moisture**

- ASTM F 2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In Situ Probes
In-Situ Probe Method

- ASTM F 2170
- A quantitative determination of percent relative humidity in concrete slabs for field or laboratory tests

Relative humidity is defined as the ratio of the amount of water vapor actually in the air compared to the amount of water vapor required for saturation at that particular temperature and pressure, expressed as a percentage.
In-Situ Probe Method

Two procedures are defined:
- Procedure A for hardened concrete
- Procedure B for fresh concrete

Procedure A
- Conditioning
  - Concrete substrates shall be at service temperature for at least 48 hours
In-Situ Probe Method

• Procedure A
  – Drill cylinder hole in cured concrete
  – Insert hole liner
  – Place rubber stopper in hole liner
  – Allow 72 hours to achieve moisture equilibrium within the hole before making relative humidity measurements
  – Measure relative humidity using probe in hole and digital meter

• Procedure B:
  – Before placing concrete, secure liner tube to formwork or steel reinforcement
  – Secure a solid rod in the liner
    • Rod will exclude fresh concrete from entering the liner
  – Place, consolidate and finish the concrete, ensuring the liner remains at required depth
  – Remove the rod after the concrete hardens and place a rubber stopper into the liner
  – Holes formed by casting liners in fresh concrete can be used to measure relative humidity as soon as the concrete hardens
  – Measure relative humidity using probe in hole and digital meter
In-Situ Probe Method

• Perform three tests for the first 1000 ft\(^2\) and at least one additional test for each additional 1000 ft\(^2\)

• If the relative humidity is 75%, the concrete has the acceptable moisture level of 5%
Testing for Moisture

- ASTM F 2420, Standard Test Method for Determining Relative Humidity on the Surface of Concrete Floor Slabs Using Relative Humidity Probe Measurement and Insulated Hood

Relative Humidity Test

- ASTM F 2420
- A quantitative determination of percent relative humidity above the surface of concrete
Relative Humidity Test

• Concrete substrate shall be at service temperature and relative humidity expected under normal use for at least 48 hours prior to performing test.

Relative Humidity Test

• Clean surface
• Seal an insulated hood firmly to the concrete substrate
• Place stopper in probe hole
• Allow a period of 72 hours to elapse before taking readings with probe
• Remove stopper
• Insert humidity probe and allow probe to equilibrate (probe has reach equilibrium when relative humidity readings do not drift more than 1% over a period of 20 minutes)
• Take readings using humidity probe
Relative Humidity Test

• Perform three tests for the first 1000 ft² and at least one additional test for each additional 1000 ft²

Relative Humidity Test

• If the relative humidity is 75%, the concrete has the acceptable moisture level of 5%
Moisture Remediation

- Remove the affected areas and eliminate the source of moisture
- Barrier systems, applied as topical treatments to exposed concrete, have been used successfully to reduce moisture vapor emission rates
  - Liquid Membranes (Acrylics and Epoxies)
  - Reactive Penetrants (Alkali silicates)
  - Modified cementitious underlayments
  - Controlled permeability underlayments
  - Dispersive Membranes (Fibrous mat underlayment systems)
  - Assembly Systems (Permeable flooring systems)
Summary

• Moisture in concrete, if not detected, can cause premature coating failures. If moisture is detected within a concrete substrate at an unacceptable level, remediation needs to take place prior to coating application.