Understanding its Effects on Coatings

MOISTURE IN CONCRETE

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Moisture, pH and Alkalies

- Freshly placed Portland Cement pH 12.5
  - Provides passivation of embedded steel
Carbon Dioxide and ambient air react

- Over time concrete pH will reach 8.5
- Carbonizing starts from the surface and moves down at a rate of 0.04” per year
- Carbonization proceeds most quickly at 50% RH and ceases if concrete is submerged
Effects of Alkalis and Moisture

- Alkalis can be a problem for coatings if
  - Surface pH is too high
  - Moisture traveling up through concrete bring alkalies to the surface
Sources of Moisture

- **Weather**
  - Precipitation before, during and after concrete placement
    - Destabilize prepared sub-base
    - Saturated blotter layer can increase concrete drying time
    - Erosion of top surface of newly placed concrete
    - Creates high moisture content in concrete
- **Capillary Rise**
  - High water tables and small enough soil granule size can result in capillary rise of water
Hydrostatic Pressure

- High outside water table
Osmosis

- Soluble salts at the concrete surface and the presence of moisture create osmotic blistering in coatings
• **Subslab Vapor**
  - Subgrade soil RH at 100%
  - State of equilibrium is achieved between low and high RH
- Ambient RH
  - Moisture in the air and the top surface of the concrete reach equilibrium
Dew Point

- Concrete surface temperature is lower than the dew point of the ambient air
Cement and Concrete

- **Components of Concrete**
  - **Cement**
    - Reacts chemically with water, even underwater
  - **Aggregates**
    - 60% – 75% of volume
  - **Admixtures**
    - Water reducing, set controlling and shrinkage reducing
  - **Supplementary Materials**
    - Pozzolans (fly ash, ground slag, silica fume)
    - Improve concrete properties (workability and finishability)
Cement and Concrete

- **Hydration**
  - Consumption of water through chemical reaction
  - Forms gel as it grows out of cement particles
  - Gel solidifies into rock like state
  - 50% of hydration in 7 days
  - 90% of hydration in 28 days
  - Water cement ratio critical
    - Theoretically sufficient water for hydration process at .38 water to cement ratio
Hydrated Concrete
Concrete Curing

- Concrete must be kept moist during curing to build properties.
- Hydration of cement will stop if RH of the concrete drops below 80%.
Porosity

- **Capillary pores**
  - Capillary pores are remnants of water filled spaces
  - Higher water to cement ratios will increase capillary pores

- **Gel pores**
  - Left over from hydration process
  - Much smaller in size

- **Entrained air**
  - Vary in size (.0004 to .4 in)
  - Do not generally contain water, but can accumulate in some cases
Permeability

- New concrete has continuous capillary pore system
  - Permeability is high
- Capillary pore system becomes discontinuous through hydration
  - Except with water to cement ratios that exceed .70

<table>
<thead>
<tr>
<th>Water-cement ratio</th>
<th>Time required</th>
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<tbody>
<tr>
<td>0.40</td>
<td>3 days</td>
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<tr>
<td>0.45</td>
<td>7 days</td>
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<tr>
<td>0.50</td>
<td>14 days</td>
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<tr>
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<td>6 months</td>
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<tr>
<td>0.70</td>
<td>1 year</td>
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<td>&gt;0.70</td>
<td>impossible</td>
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* Powers 1959.
Permeability of concrete depends on water to cement ratio
Drying of Concrete

- Concrete must be sufficiently dry to develop adequate bond of coating materials.
- A typical yard of concrete with a 0.5 water-cement ratio contains 275 lb of water. About half will be used during hydration. The other half is free water.

<table>
<thead>
<tr>
<th>Concrete type</th>
<th>Water-cement ratio</th>
<th>Time to 90% RH, weeks</th>
<th>Time to 85% RH, weeks</th>
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<tr>
<td>Typical residential concrete</td>
<td>&gt;0.5</td>
<td>&gt;12</td>
<td>&gt;19</td>
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<tr>
<td>Concrete with some self-desiccation</td>
<td>0.38 – 0.50</td>
<td>9 – 12</td>
<td>15 – 19</td>
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<tr>
<td>Rapid-drying concrete</td>
<td>0.38 – 0.32</td>
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<td>Self-drying concrete</td>
<td>&lt;0.32</td>
<td>3 – 5</td>
<td>6 – 10</td>
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</table>

* Swedish Concrete Association.
Concrete Drying Stages

- **Drying Stage 1**
  - Pores in freshly placed concrete are saturated with liquid water and drying begins by evaporation from exposed surface.
Concrete Drying Stages

- **Drying Stage 2**
  - When moisture has retreated below the surface, movement depends on fluid flow along the surface pores and evaporation into the pores
Concrete Drying Stages

- **Drying Stage 3**
  - When moisture is no longer continuously wetting the surface of pores, moisture must evaporate within the body of the paste and diffuse toward the surface.
Concrete Drying Stages

- **Drying Stages**
  - Stage 1 has a constant rate and depends on air movement and RH. Stage 2 and 3 depend on the properties of the cement paste.
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<tr>
<th>Days</th>
<th>w/c = 0.4</th>
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<th>w/c = 0.6</th>
<th>w/c = 0.7</th>
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* Brewer 1965.
Drying of Lightweight Concrete

- Lightweight concrete takes twice as much time to dry than regular concrete.
Measuring Moisture in Concrete

- **Qualitative Moisture Tests**
  - Involves taping an 18 inch square plastic sheet to the surface of the concrete for 24 hours.
  - This test only shows that moisture is present-not the amount of moisture.
Measuring Moisture in Concrete

- Electrical Impedance device
  - Transmits a radio-frequency alternating-current and can accurately detect moisture down to a depth of 2 inches.
Measuring Moisture in Concrete

Contour map showing concrete surface measured with electrical impedance device
Measuring Moisture in Concrete

- Qualitative Moisture Tests
  - Moisture vapor emission test
Measuring Moisture in Concrete

- Relative Humidity Measurement
  - Measuring RH within the concrete slab when placed at 40% of the slabs depth.
  - Measurements must be taken after 72 hours.
Measuring Moisture in Concrete

- The moisture gradient formed as concrete dries will redistribute itself after a floor coating is applied over the top surface of the slab.
Recommendations Before Coating Concrete

- Concrete on grade with a propensity for high moisture content should be treated with AquaLok II
- Maximum moisture content at 4.5% when using an electrical impedance device
- Maximum 3 lb per 1,000 square feet in a 24 hour period when using a calcium chloride test kit
- Maximum 80% relative humidity when measuring with a relative humidity device
Contact Us!

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