Understanding its Effects on Coatings

MOISTURE IN CONCRETE

RAPID Curing Sealants & Coatings

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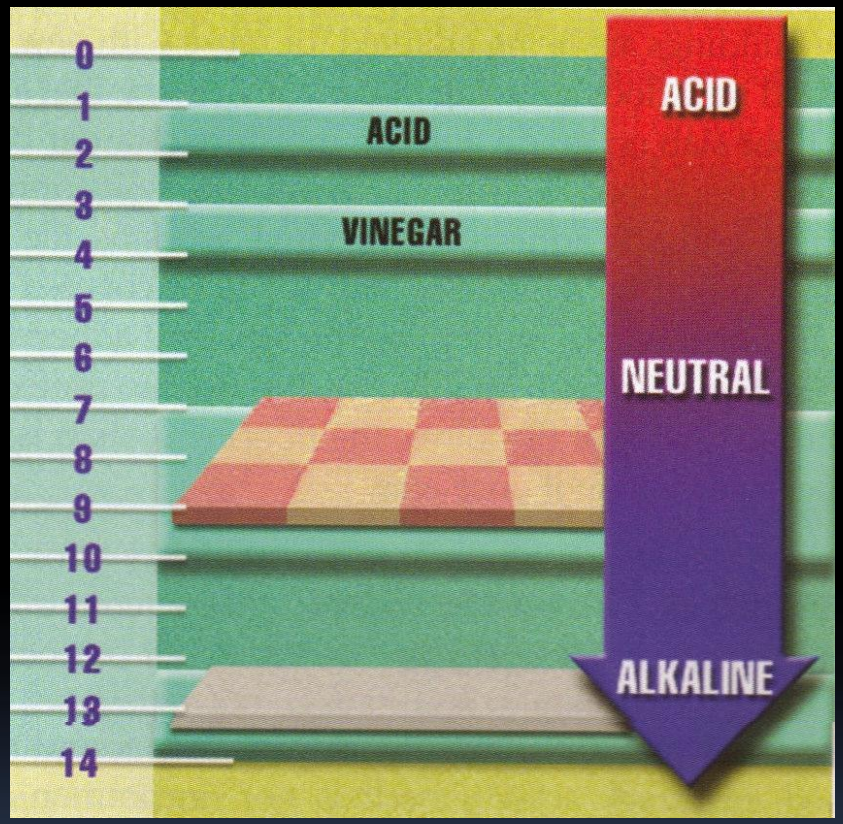
Moisture, pH and Alkalies



- Freshly placed Portland Cement pH 12.5
  - Provides passivation of embedded steel

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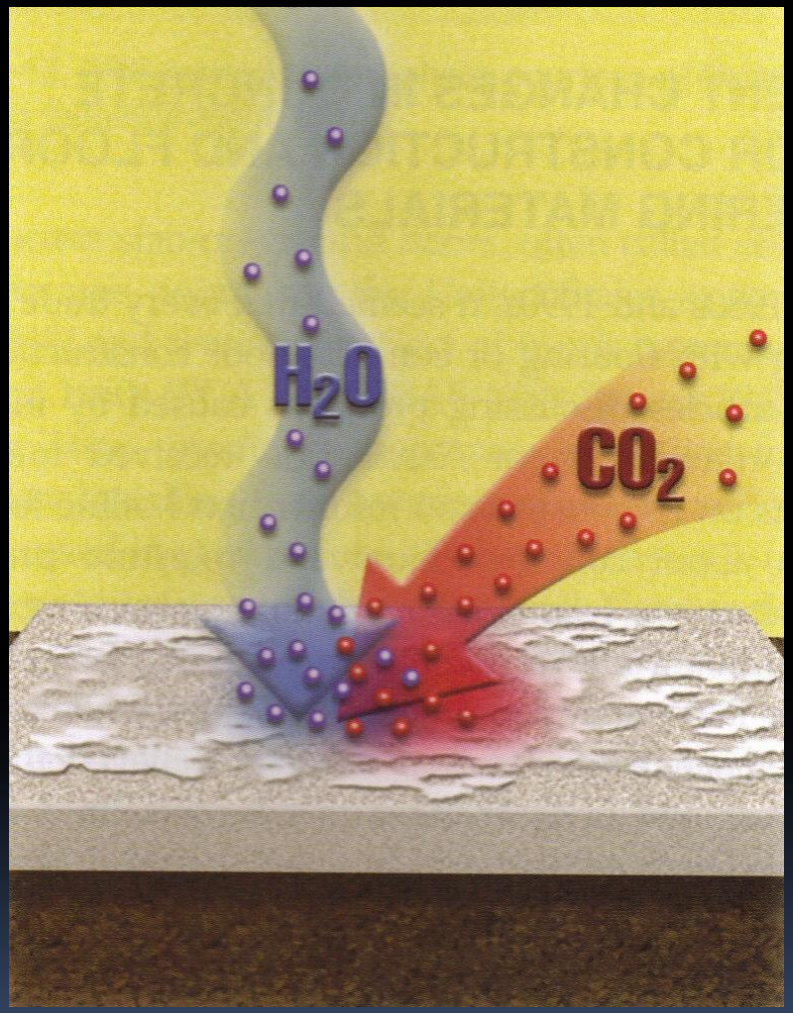

- Carbon Dioxide and ambient air react
  - Over time concrete pH will reach 8.5
  - Carbonizing starts from the surface and moves down at a rate of 0.04" per year
  - Carbonization proceeds most quickly at 50% RH and ceases if concrete is submerged

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Effects of Alkalies and Moisture

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

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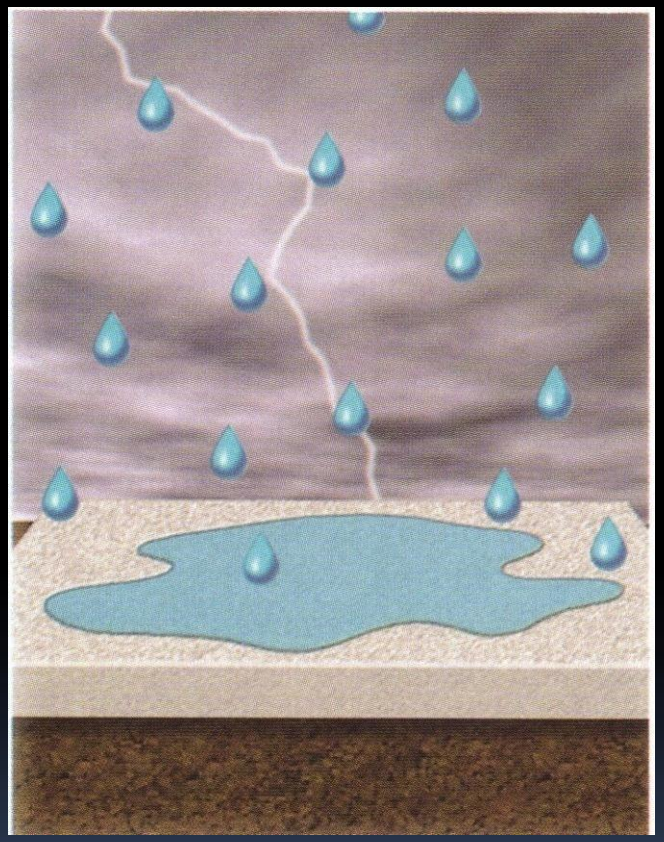
Sources of Moisture



- **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

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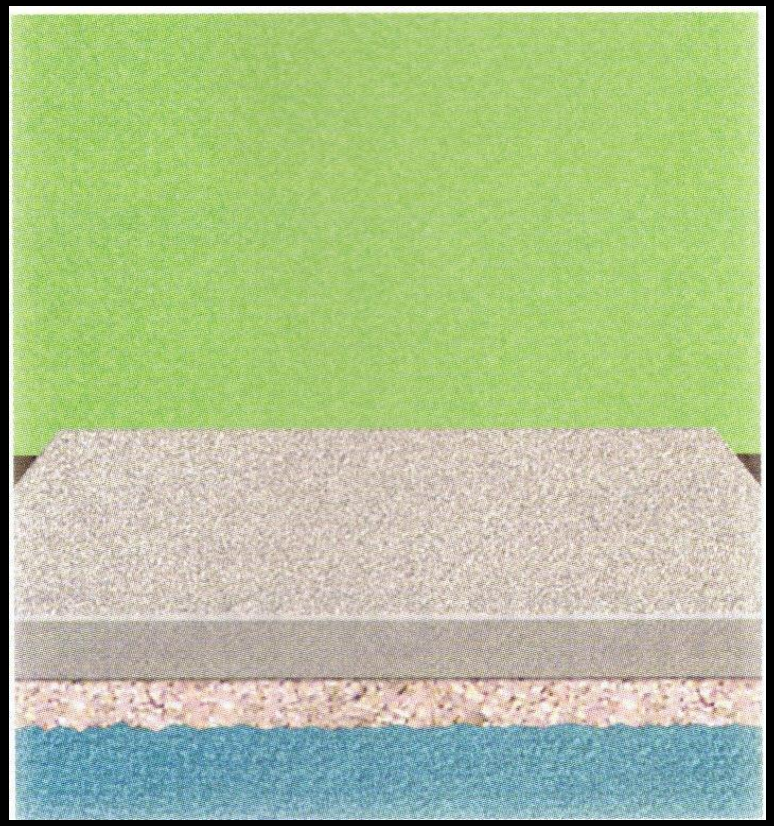

- **Capillary Rise**
  - High water tables and small enough soil granule size can result in capillary rise of water

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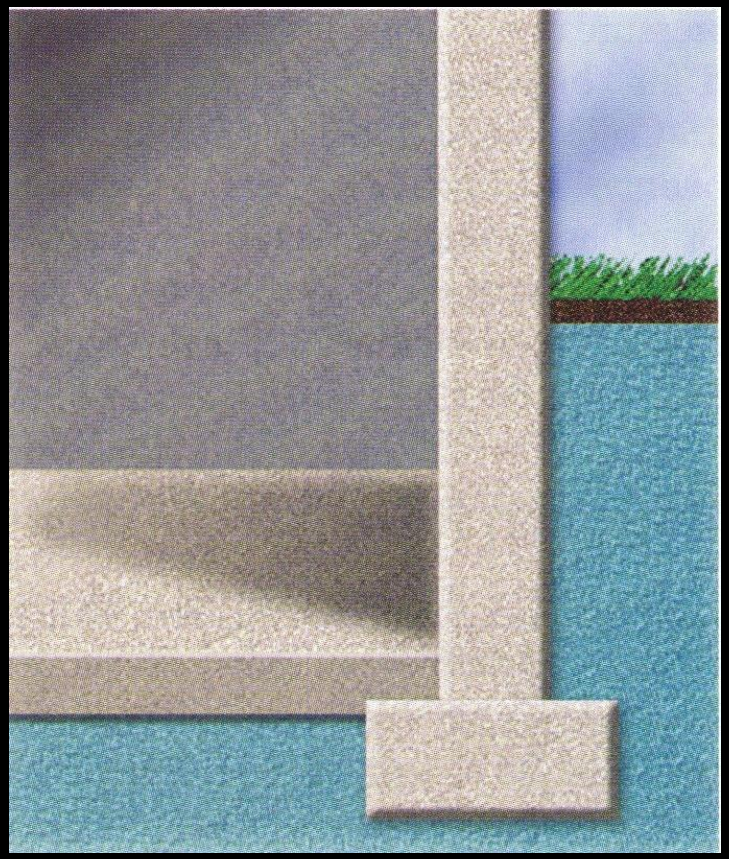

- **Hydrostatic Pressure**
  - High outside water table

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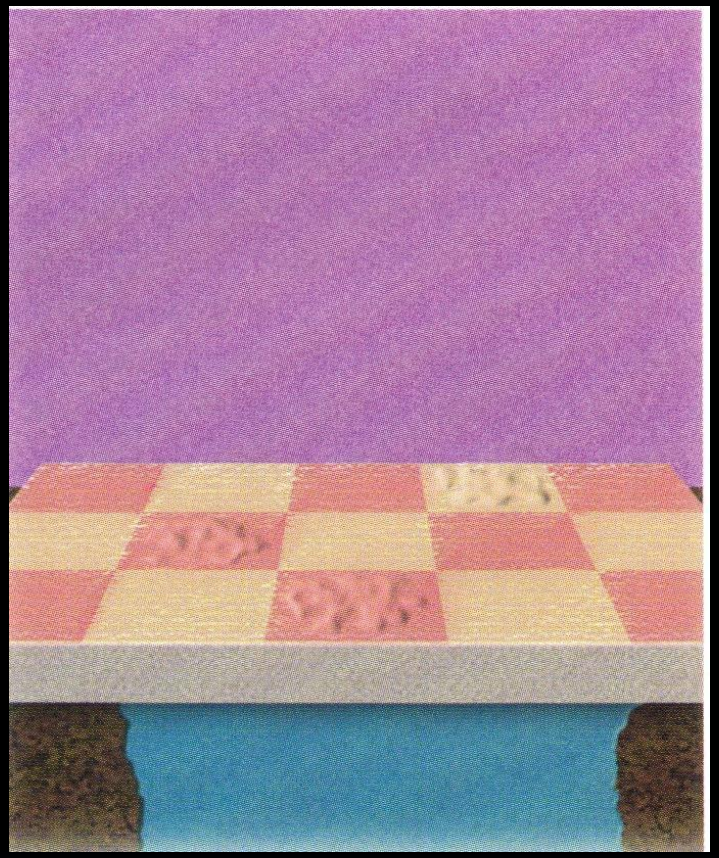

- **Osmosis**
  - Soluble salts at the concrete surface and the presence of moisture create osmotic blistering in coatings

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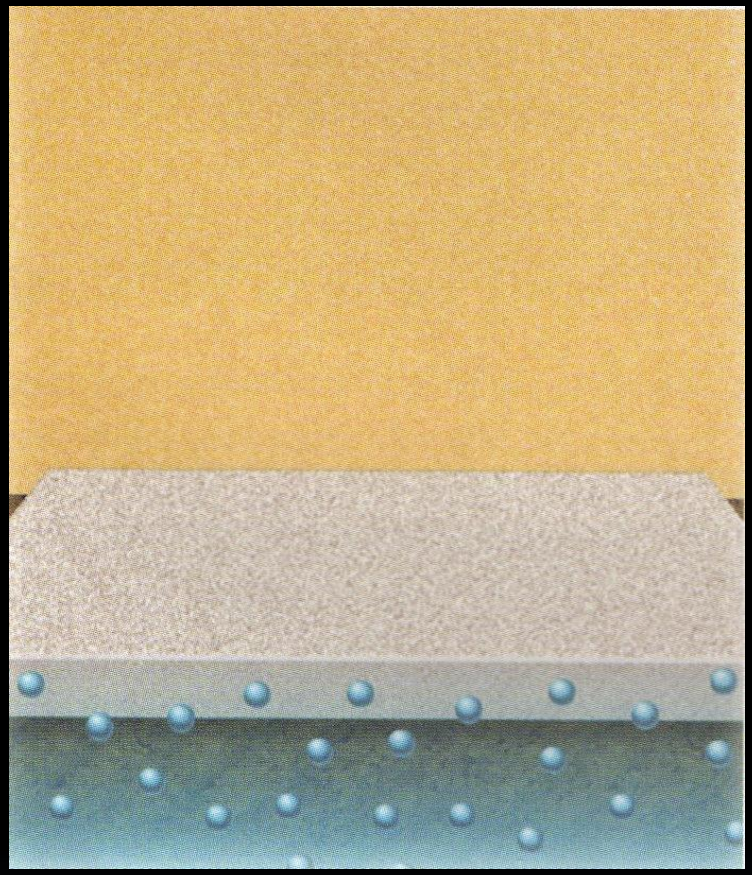

- **Subslab Vapor**
  - Subgrade soil RH at 100%
  - State of equilibrium is achieved between low and high RH

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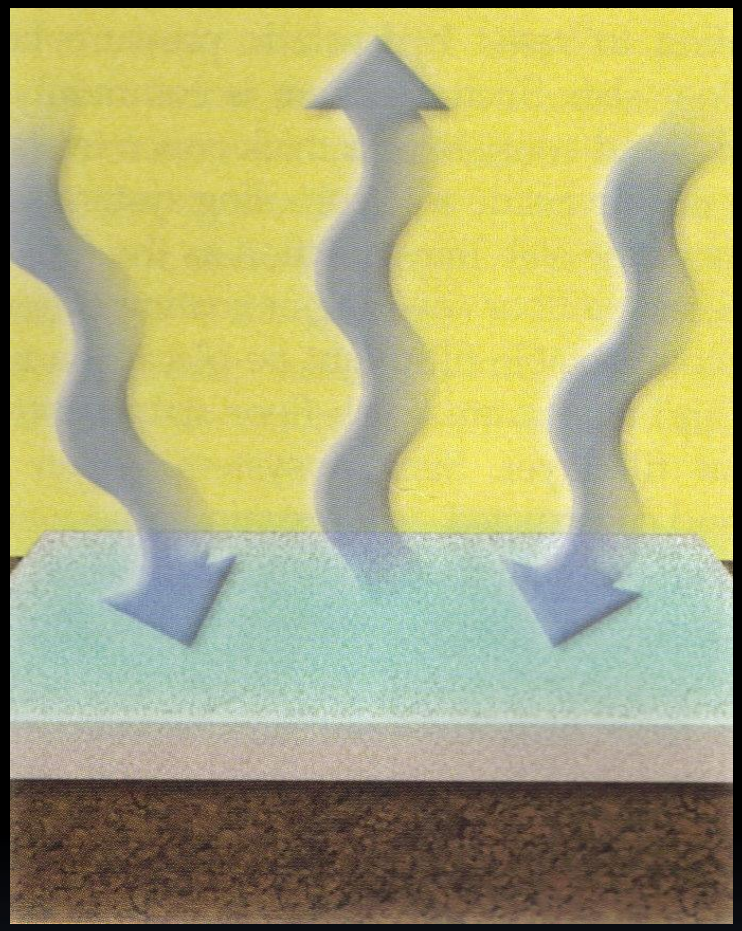

- **Ambient RH**
  - Moisture in the air and the top surface of the concrete reach equilibrium

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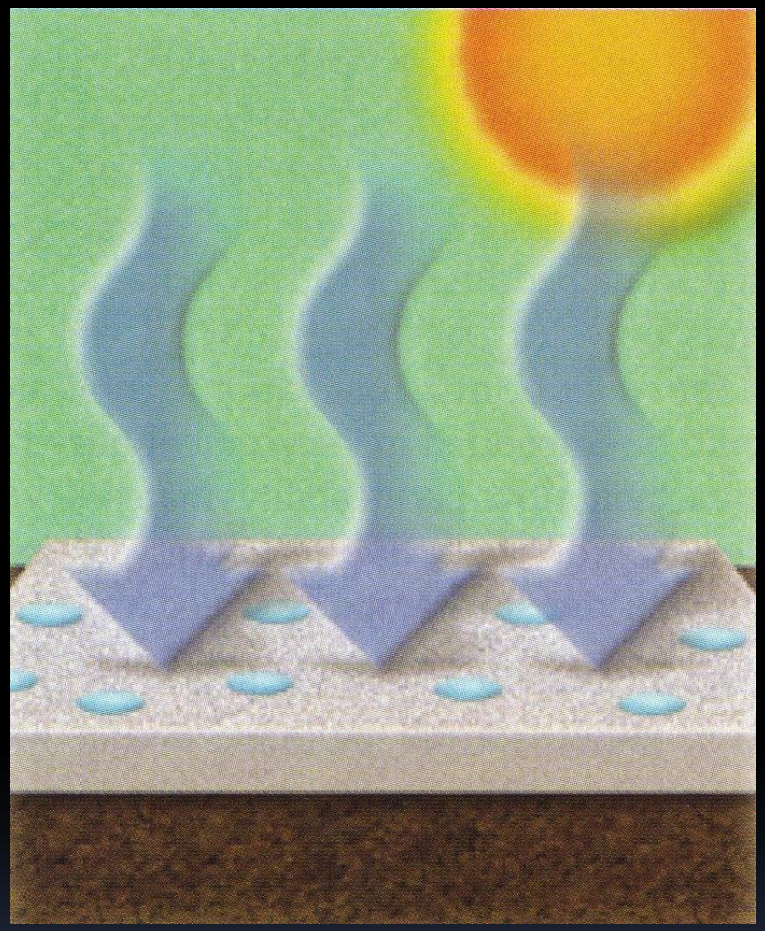

- **Dew Point**
  - Concrete surface temperature is lower than the dew point of the ambient air

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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)

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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

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Hydrated Concrete

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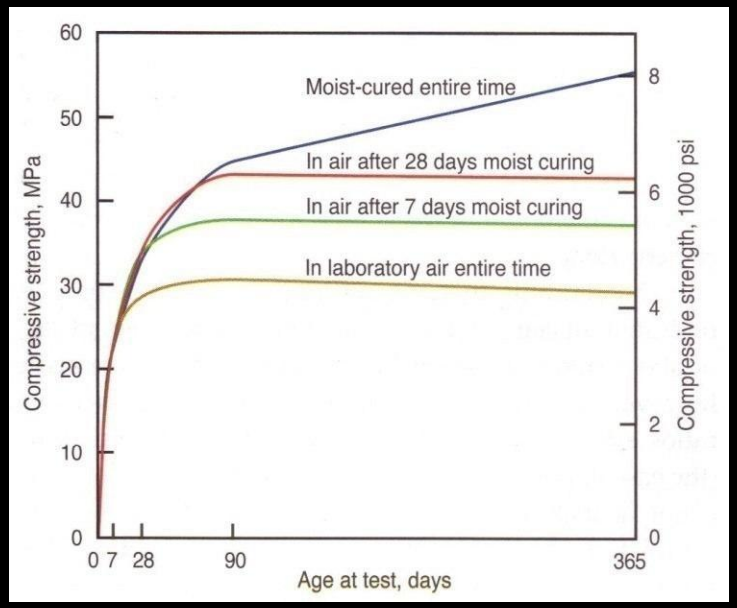
Concrete Curing



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

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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

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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

Water-cement ratio	Time required
0.40	3 days
0.45	7 days
0.50	14 days
0.60	6 months
0.70	1 year
>0.70	impossible

* Powers 1959.

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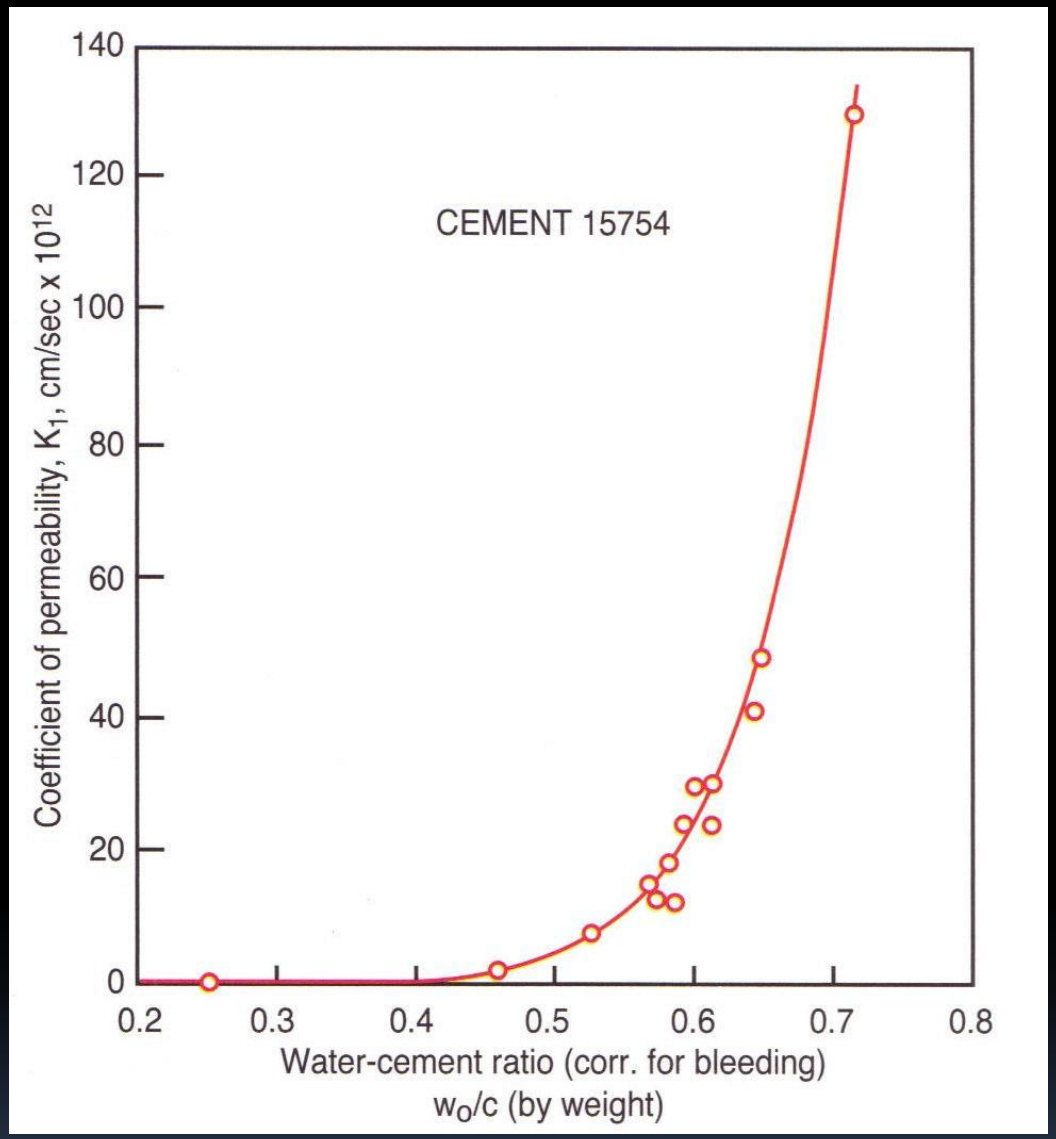

- **Permeability of concrete depends on water to cement ratio**

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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

Concrete type	Water-cement ratio	Time to 90% RH, weeks	Time to 85% RH, weeks
Typical residential concrete	>0.5	>12	>19
Concrete with some self-dessication	0.38 – 0.50	9 – 12	15 – 19
Rapid-drying concrete	0.38 – 0.32	15 – 19	10 – 15
Self-drying concrete	<0.32	3 – 5	6 – 10

* Swedish Concrete Association.

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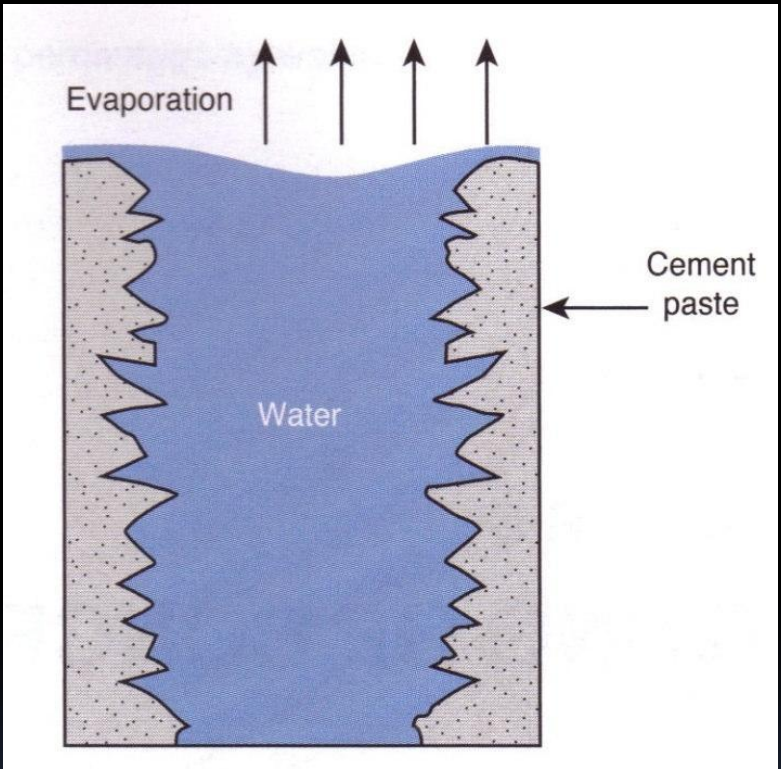
Concrete Drying Stages



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

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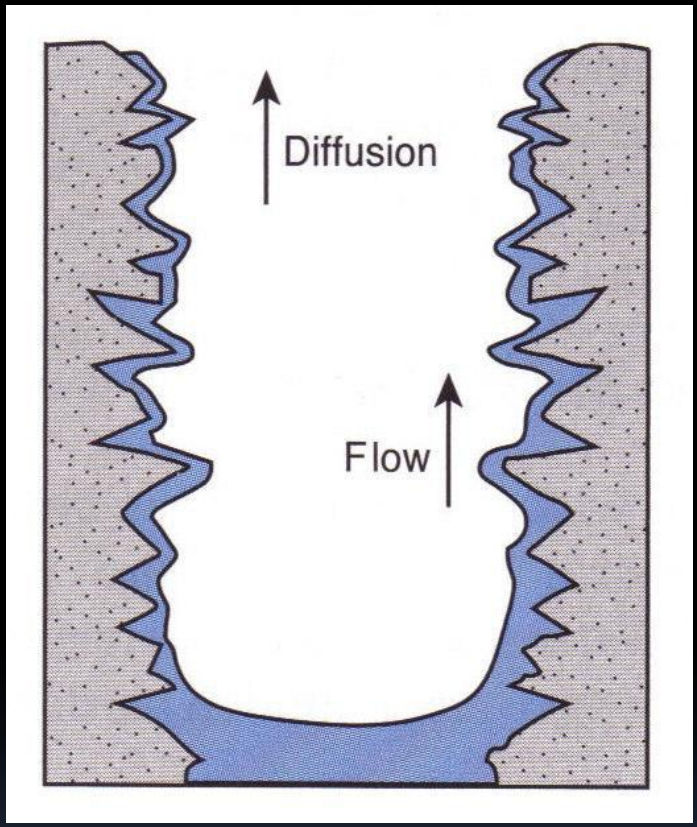
Concrete Drying Stages



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

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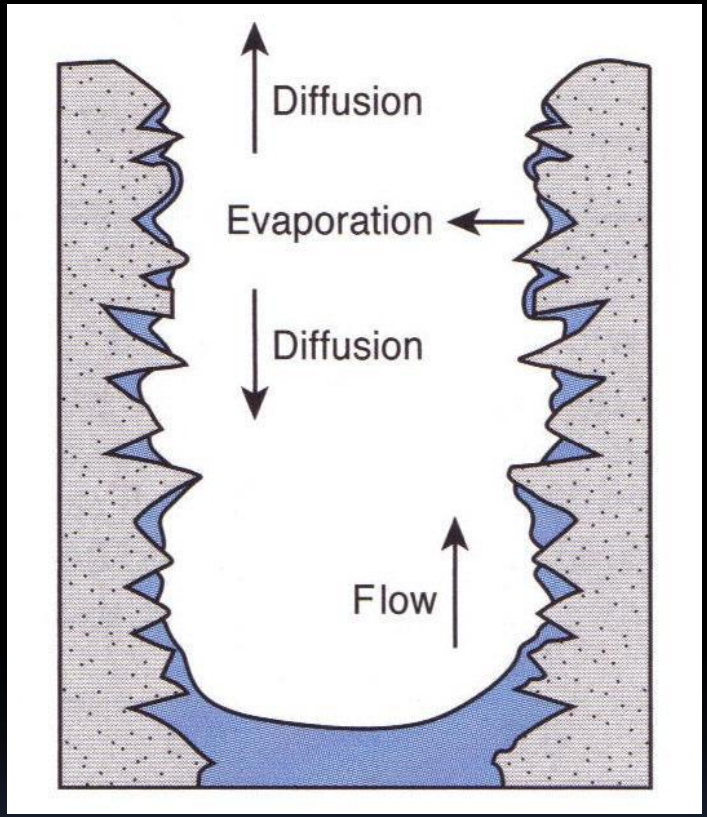
Concrete Drying Stages



- 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

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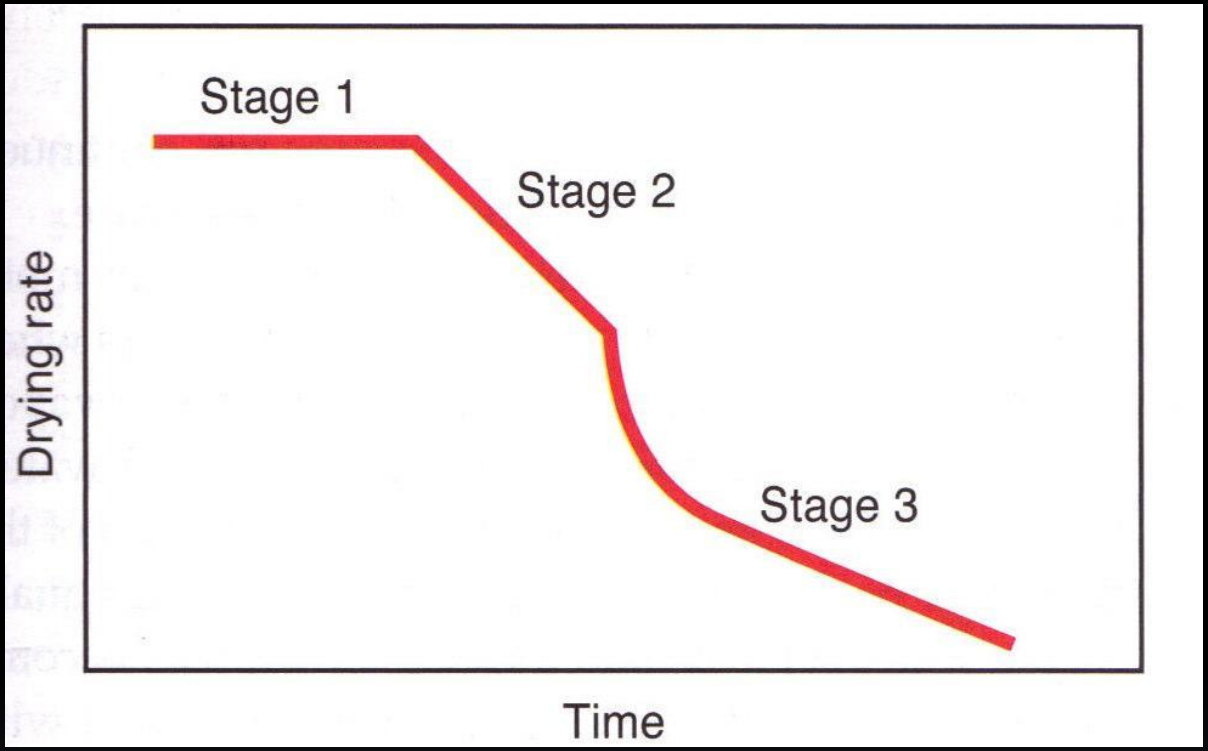
Concrete Drying Stages



- 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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Table 5-2. Moisture Outflow in lb/1000 sq ft/24h from 100-mm (4-in.) Concrete Slabs*

Liquid water in contact with underside of concrete slab							
Days	w/c = 0.4	w/c = 0.5	w/c = 0.6	w/c = 0.7	w/c = 0.8	w/c = 0.9	w/c = 1.0
3	16.5	26.7	39.8	69.9	92.6	113.1	150.2
7	9.3	16.1	26.4	40.5	56.2	73.7	92.6
14	6.2	10.3	17.1	27.8	38.1	49.4	62.4
28	4.1	6.5	11.3	18.2	25.7	33.9	40.5
60	2.7	4.5	7.5	11.7	16.1	20.9	25.4
90	2.4	3.8	6.5	9.9	13.0	17.1	20.6
180	1.7	3.1	5.1	7.5	10.3	13.4	16.5
365	1.4	2.4	4.5	6.5	8.6	11.3	14.1
Water vapor in contact with underside of concrete slab							
Days	w/c = 0.4	w/c = 0.5	w/c = 0.6	w/c = 0.7	w/c = 0.8	w/c = 0.9	w/c = 1.0
3	17.1	27.4	39.4	58.3	72.0	83.7	93.3
7	10.3	16.5	23.0	28.8	33.6	37.7	42.5
14	6.2	9.9	13.4	16.5	19.2	21.6	23.3
28	3.8	6.2	9.9	10.3	11.7	12.3	13.0
60	2.7	4.1	5.5	6.9	7.5	8.2	8.6
90	2.4	3.4	4.8	5.8	6.2	6.5	7.2
180	1.7	2.7	3.8	4.5	4.8	4.8	5.1
365	1.4	2.1	3.1	3.4	3.8	3.8	3.8
Dry air in contact with underside of concrete slab							
Days	w/c = 0.4	w/c = 0.5	w/c = 0.6	w/c = 0.7	w/c = 0.8	w/c = 0.9	w/c = 1.0
3	17.8	27.4	39.1	55.9	65.8	72.7	78.2
7	10.6	15.8	20.9	26.1	30.9	35.0	39.4
14	6.5	9.6	12.7	15.8	17.1	18.9	20.6
28	3.8	5.8	7.9	8.9	9.6	10.3	11.0
60	2.4	3.8	4.5	5.1	5.5	5.8	6.2
90	1.7	2.7	3.4	3.8	4.1	4.5	4.8
180	1.0	1.7	2.1	2.1	2.4	2.7	3.1
365	0.7	1.0	1.4	1.4	1.7	1.7	1.7

* Brewer 1965.

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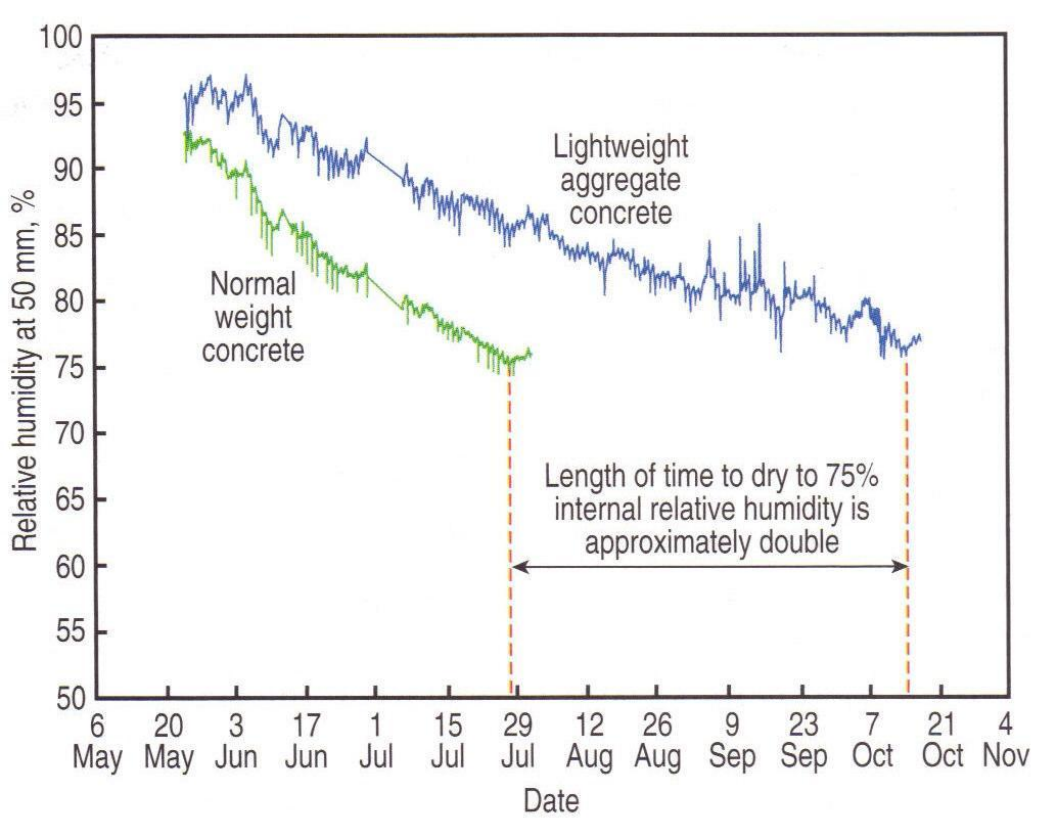
Drying of Lightweight Concrete



- Lightweight concrete takes twice as much time to dry than regular concrete.

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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.

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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.

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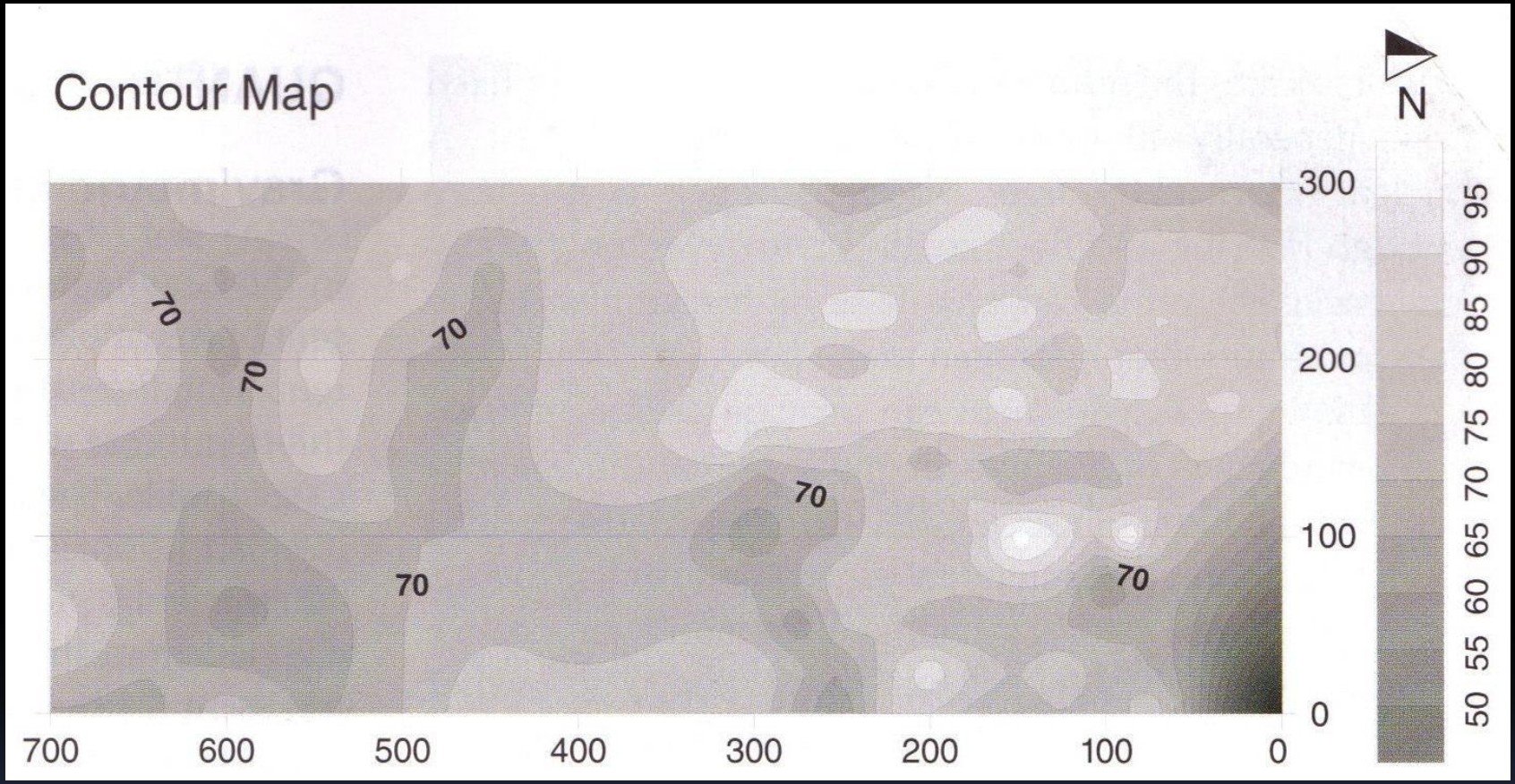
Measuring Moisture in Concrete



- Contour map showing concrete surface measured with electrical impedance device

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Measuring Moisture in Concrete

- Qualitative Moisture Tests
  - Moisture vapor emission test

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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

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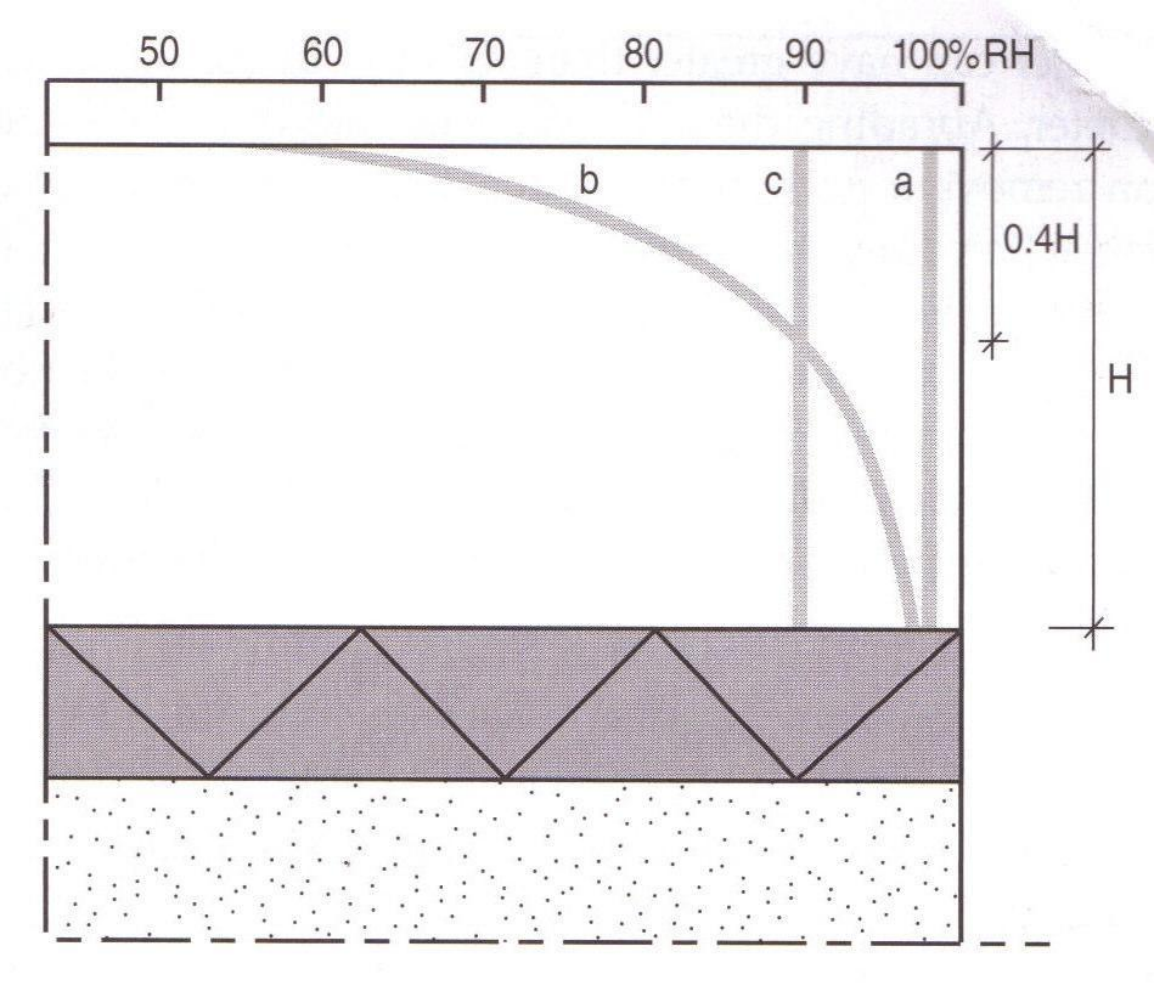
Measuring Moisture in Concrete



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

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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

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