ICRI 2012 FALL CONVENTION
Life-Cycle Repair SUSTAINABILITY

INTERNATIONAL CONCRETE REPAIR INSTITUTE

Moisture Mitigation:
The Ultimate in Sustainability

NOVEMBER 7-9 RANCHO MIRAGE, CA RANCHO LAS PALMAS RESORT

PRESENTED BY: Brian N. Cordak

KÖSTER Waterproofing Systems USA

LET'S EXPLORE

- **Moisture Mitigation & Sustainability**
- **Moisture Activity In Concrete**
- **Avoidable Flooring Failures**
- **Why Vapor Moisture Emission Cause Failures**
- **What Is DRY Concrete**
- **MVER (Calcium Chloride) vs RH Testing**
- **Qualifying A Viable MMS**
- **A Word About High Performance Adhesives**
- **Proactive vs Reactive Solutions**
- **Steps To Success**

MOISTURE MITIGATION & SUSTAINABILITY

Life-cycle of floor coverings reduced from 20 Years to 7or 8

Catastrophic failures generally occur in the first year of the life-cycle

FLOORING FAILURES ESTIMATED AT 1 BILLION DOLLARS ANNUALLY

Average cost to replace is 2.15 to 6 times of original

HEALTH & ECOLOGICAL IMPACT

Nosocomial (hospital acquired) infections in patients that may arise as a result of exposure to organisms released into the environment during construction & renovation activities contribute to;

OVER TWO MILLION PATIENTS INFECTED IN U.S. HOSPITALS EACH YEAR

MORE THAN 90,000 DEATHS!

SOURCE: AARP Report January 2007

10’s of Thousands of Tons Debris In Landfills Annually

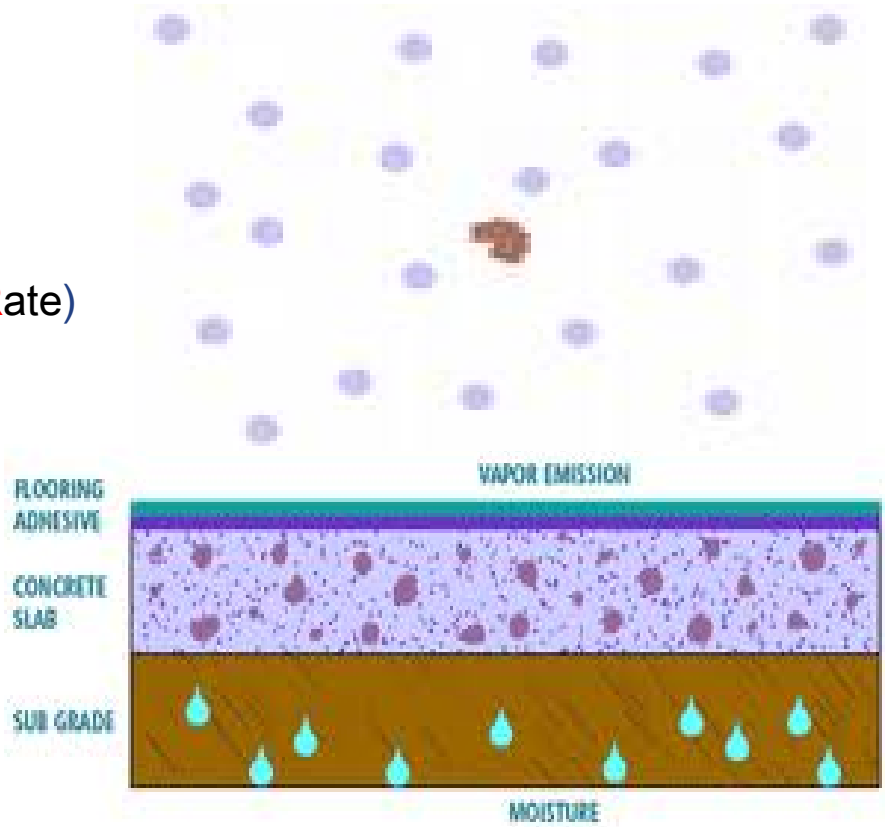
Moisture Activity In Concrete Occurs In Two Forms

In A Liquid State
Capillary Action
Hydrostatic Pressure
Moderate to High *psi*.

NOT TO BE CONFUSED WITH…

A Gaseous State

- Simply Humid Air
- Diffusive Action
- Vapor Static Pressure
- MVER (Moisture Vapor Emmission Rate)
- Measured in *lb/1000 ft²/24 hr…or*
- Percent of RH



Commonly Known As Moisture Vapor Emission

A DAILY CHALLENGE IN OUR INDUSTRY
RESULTING IN FLOORING FAILURES

MOISTURE IN:
GAS FORM / LIQUID FORM

Vapor Emission **(GAS)** Pressures:

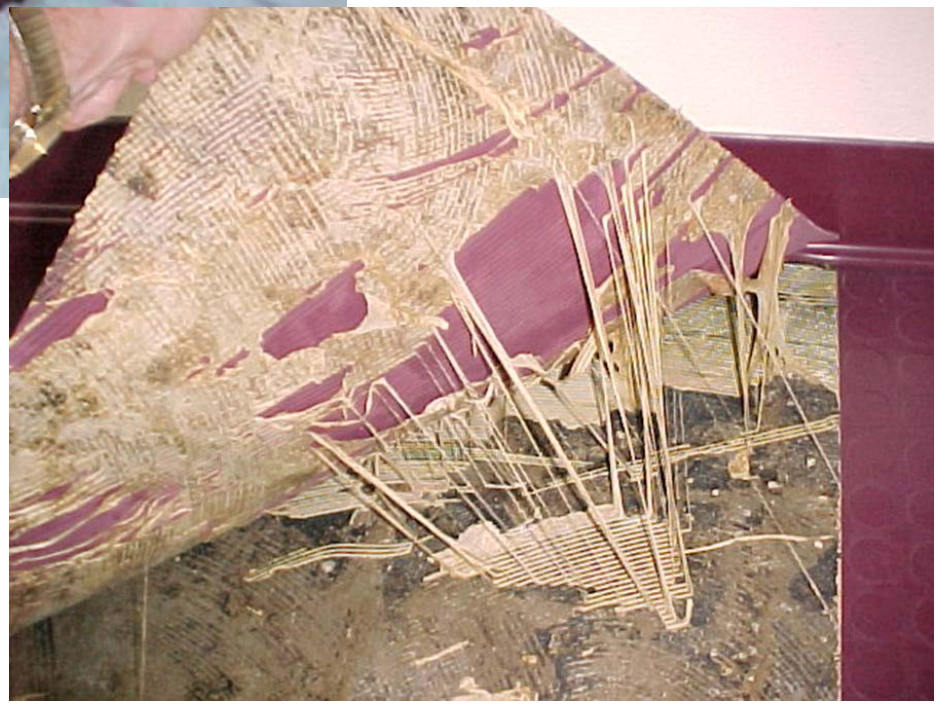
- **Humid gas passing through the capillaries of the concrete with minimal pressure, negligible water, and will dry out when surface is not covered.**

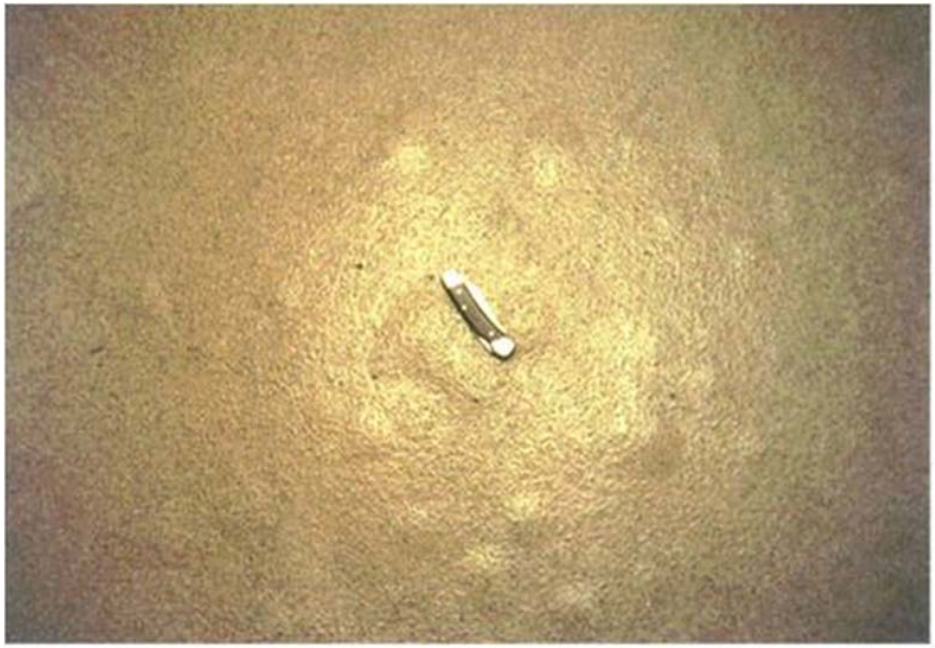
Hydrostatic **(WATER)** Pressures:

- **Generally moderate to high pressure PSI, saturates the concrete, moves laterally, and remains constantly wet.**

AVOIDABLE FLOORING FAILURES

- Adhesive Breakdown
- De-bonding
- Osmotic Blisters
- Microbials
- Floor Expansion
- Staining
- Condensation
- Curling/Cracking





The Common Denominator??

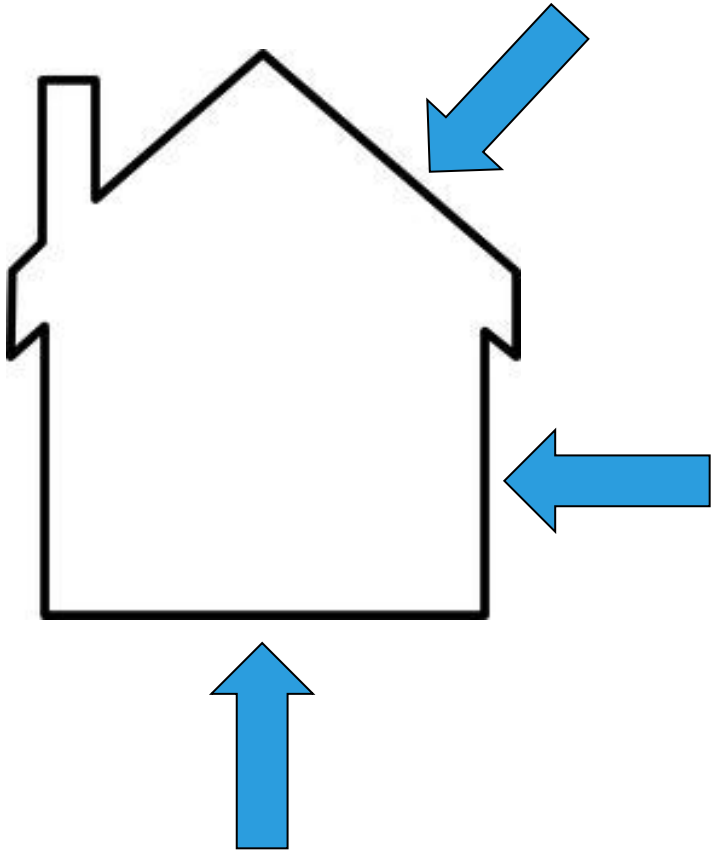
Could Likely Have Been Avoided!!

All Result In Lost $$$
INCREASED LIABILITY

DON’T FORGET!!!

FLOOR IS PART OF BUILDING ENVELOPE

- **Leaks Are NOT Acceptable**
- **Design and Build to Avoid *VAPOR* Intrusion From All Potential Sources**



VAPOR TRANSMISSION IS NOT JUST A GROUND FLOOR ISSUE

Elevated Floors/Concrete Mass

- **Light Weight Concrete Floors (Expanded Clay or Shale)**
- **Larger Structural Member/Components (Greater Mass)**
- **Both = More Moisture = High MVER & RH**
- **Plan or Budget For A MMS!**

WHY NOW…. I Seldom, If Ever Had Problems Before?!?!

Volatile Organic Content
EPA REQUIREMENTS
CHANGED IN THE LATE 1990's

The True Challenge Is High pH

NEWER GREEN PRODUCTS DO NOT PERFORM WELL IN HIGH pH ENVIRONMENTS

Accountable for Sharp Spike in Moisture Related Failures

MOISTURES ISSUES NOT SO NEW!

*Circa 1950's

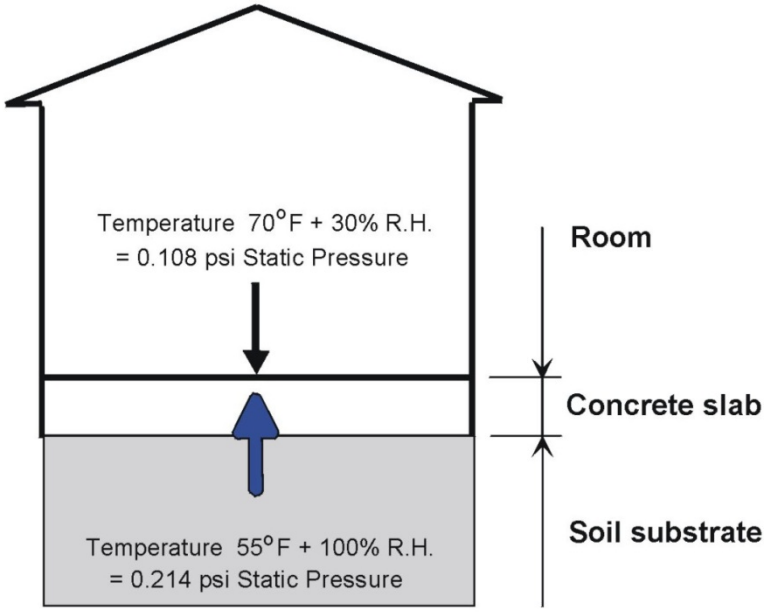
THE FORGOTTEN CHALLENGE

Due to Pre-1999 adhesive's ability to perform in high ph/moist conditions we were not generally required to address the issue of ph/moisture content in concrete floors for approximately 5 decades

WHY DOES MVER OCCUR?

Moisture Vapor Emission Through Interior Slabs

Result:
Moisture moves from lower temperature and high humidity to higher temperature and lower humidity



Data reference: U.S. Housing Authority

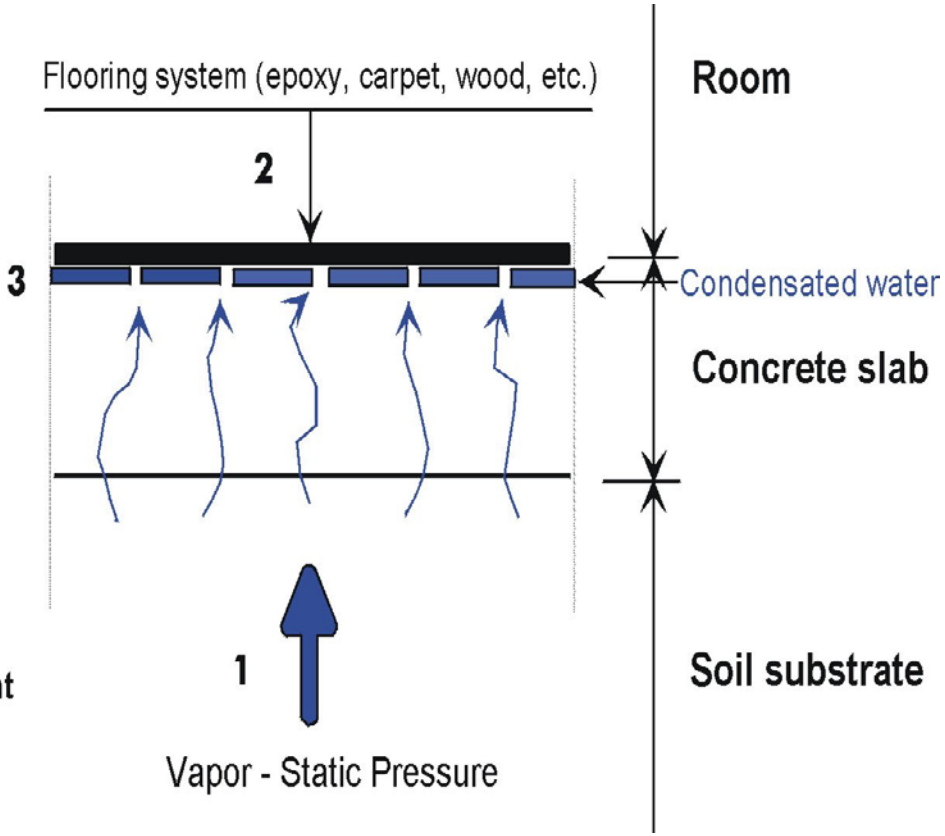
NOTE: VAPOR EMISSION May Vary Throughout The Slab

May Also Fluctuate During Different Times Of Year

WHAT IS HAPPENING?

Moisture Vapor Emission Transports Soluble Minerals Which Condense At Surface

1. Moisture vapor migrates through concrete
2. Flooring system = vapor barrier prevents moisture vapor from escaping
3. **Result:**
   Moisture vapor condensates to liquid (water) and reduces adhesion of flooring system. Liquid has high alkaline content in pore water (pH 13).



WHERE DOES HIGH pH COME FROM?

SOLUBLE METAL IONS

- Calcium Hydroxide: pH 12.5
- Potassium Hydroxide: pH 13
- Sodium Hydroxide: pH 14

Result: Dissolved metal ions can raise the pH levels in the condensate as high 14 which chemically attack the organic elements of the flooring system.

The pH Scale is Logarithmic

- pH 7 is Neutral
- pH 7 and Lower is Acid
- pH 7 and Higher is Alkaline
- A pH of 13 compared to a pH 7:

(1 MILLION TIMES GREATER!!)

- Adhesive Warranty Limits: pH 8.2 to 11

GENERALLY SPEAKING
VAPOR EMMISSION PROBLEMS
CAN BE CATAGORIZED IN ONE OF TWO WAYS

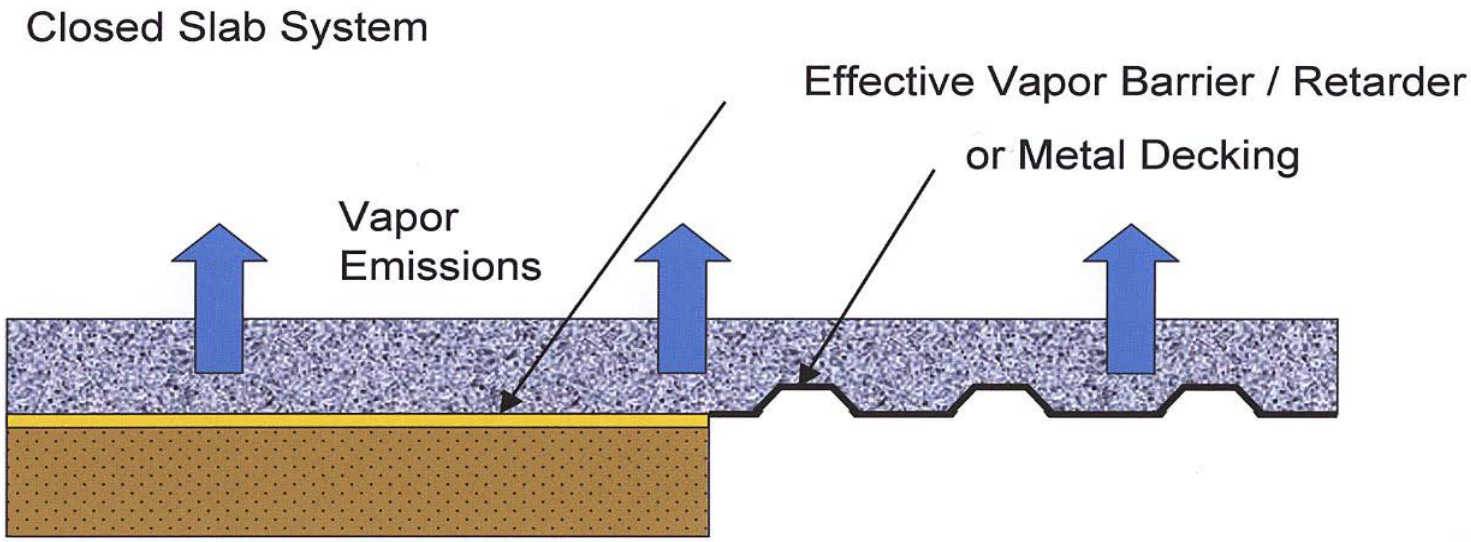
1. Concrete Drying Issues
   "Closed Slab or Above Grade Situations"

2. Chronic Diffusion Issues
   "Open Slab Situations"

CLOSED SLAB SYSTEM

A Closed Slab System is where an PERMANENT VAPOR BARRIER or non-perforated metal decking is in place directly beneath the concrete.

In a Closed Slab System the only source of moisture is free-water originating from within the concrete itself.



a. Total WATER in concrete mix = 34 gal/yd³

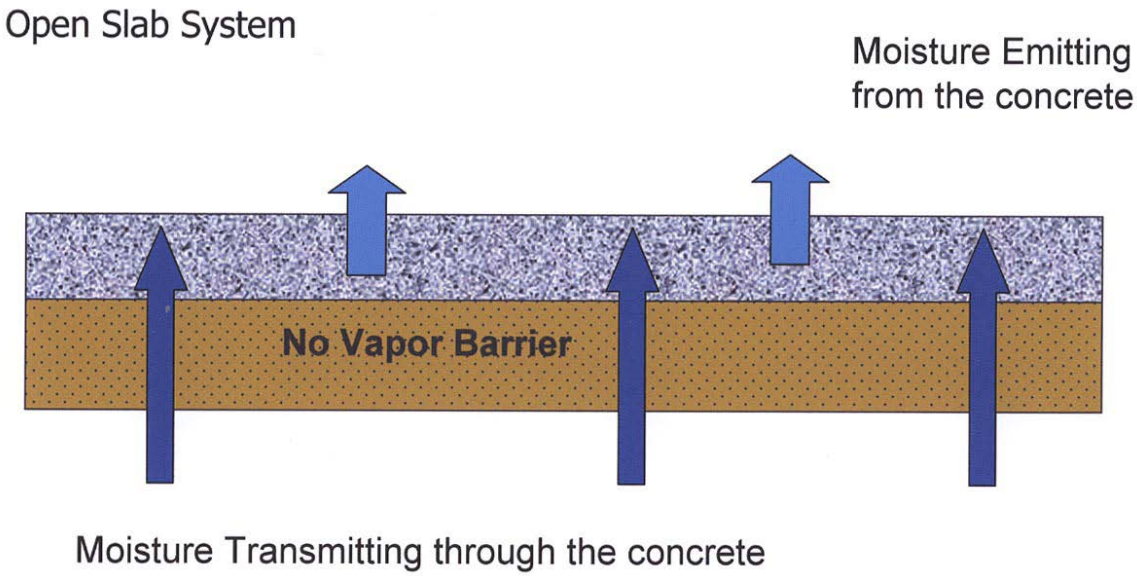
b. REQUIRED:
WATER for hydration of cement
~35% = 12 gal/yd³

c. RESULT:

~65% surplus WATER needs to evaporate = 22 gal/yd³

OPEN SLAB SYSTEM

An Open Slab System is a more challenging condition for a moisture mitigation system. The concrete slab is in direct contact with the ground. Therefore the source and amount of moisture is unknown and will typically differ from the originally tested levels over time.



Note: RH or Calcium Chloride testing provides limited value when performed on open slabs.

FREQUENTLY OVERLOOKED VAPOR EMISSION CONDITIONS

Renovation or Adaptive Use of Existing Space

A “Compromised” (Direct Contact) Vapor Barrier

Fill Saturated Prior To Concrete Pour (Indirect Contact)

FREQUENTLY IGNORED VAPOR EMISSION SITUATIONS

FAST TRACK OR NEW CONSTRUCTION PROJECT:

No Time Or Desire To Wait For Concrete To Dry

WHAT IS DRY CONCRETE ANYWAY?!?!

Isn't Concrete Is DRY In 28 Days?

NO!! Concrete Is Only **CURED** **In** 28 Days!

Rule Of Thumb For Concrete Drying Time:

AT LEAST ONE MONTH PER 1" OF THICKNESS

(Will Likely More Than Double In Winter)

Lightweight Concrete Mix Designs Dry At Rate

2+ Times Longer Than Normal Concrete

Structural Members Will Likely Never Dry Out

ALWAYS TEST TO BE SURE!!!

CALCIUM CHLORIDE TEST

ASTM F-1869

**Measured in Pounds, of the Amount of Water
Emitted from 1000 sq.ft. of Concrete Over 24 hours.
(8 lbs = 1 gallon) NOT PSI…..**

Proper Testing Requires 1 test per 1000 sq.ft. With a Minimum of Three Tests.

Space MUST Be “Climate Controlled” 48 Hours Prior to Kit Placement and Conditions Be Stable Throughout the Test.

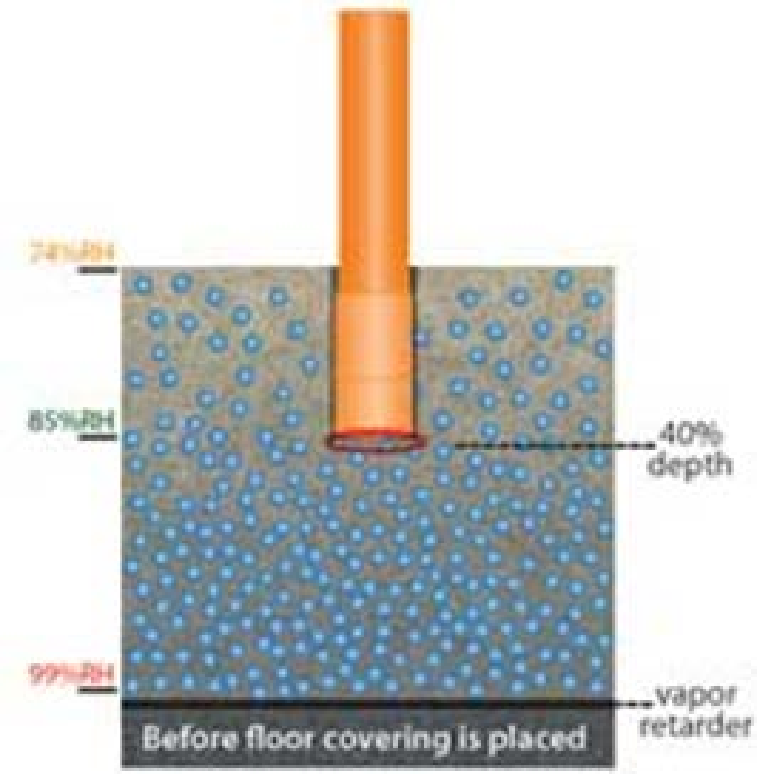
**The Surface Should be Ground, Clean and Remain “Open”
24 Hours Prior to Placement. Tests Require 62 to 70 hours.**

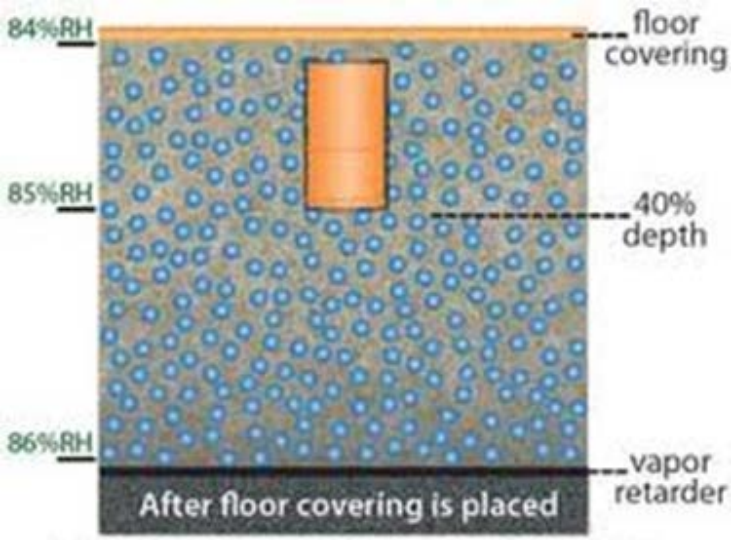
Note: As of 2010 Not Acceptable for Light Weight Concrete

A “Properly Installed” Calcium Chloride Test Kit!!

ASTM F-1869 Calcium Chloride Test Kit

Other Test Method Currently Being Adopted: ASTM F 2170 Test Method For Determining Relative Humidity In Concrete Floor Slabs Using R.H. Probes





Floor slab moisture equilibration example

Relative Humidity Probes

ASTM 2170

R. H. Probe Hole Depth 40% Of Slab Thickness

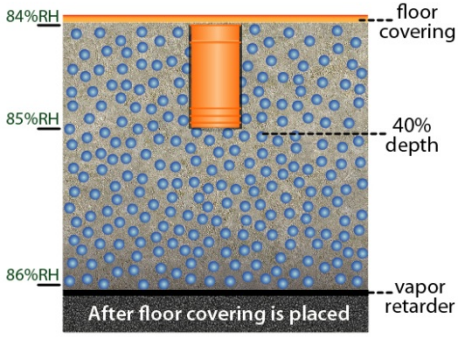
5” Thick Slab x .40” = 2 Inches Deep

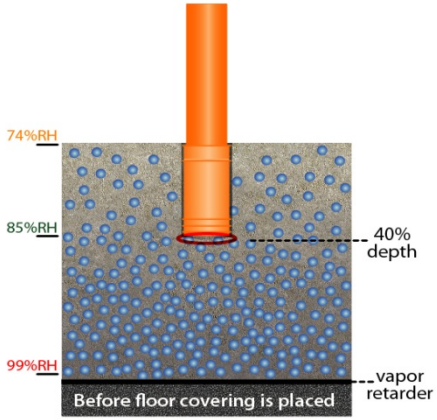
Drill & Clean Hole, Insert R.H. Probe

Allow R.H. Probe to Acclimate 72 Hours

WHY RH TESTING?

- ✓Precise, accurate
- ✓Can be quickly re-measured
- ✓Minimally influenced by ambient conditions
- ✓Cost effective
- ✓Easy to track drying
- ✓Proven accuracy
- ✓Allows Proactive Approach





Floor slab moisture equilibration example

USE AN ICRI CONCRETE SLAB MOISTURE TESTING TECHNICIAN

Qualifying Moisture Mitigation Systems

Currently there are 6 major system categories or treatments ranging from single coat applications to multi-stage systems that combine two or more categories of materials.

1. Reactive Penetrants

Reactive penetrants are fluid applied treatments designed to penetrate the concrete surface and react chemically with the concrete. The goal of such treatments is to reduce the moisture vapor emission rate (MVER) and to bind up soluble alkali such that high pH levels are not experienced at the concrete/adhesive interface.
The most common reactive formulations used for moisture & pH suppression are based on sodium silicate, potassium silicate or lithium silicate.
Before giving consideration to a silicate-based, reactive penetrant one must have thorough knowledge of the concrete composition and degree of surface carbonation. Concrete mixtures that contain pozzolanic materials such as Fly Ash or Slag can reduce available reactive material within the concrete and thus lead to incomplete reaction of the silicate-based treatment. Concrete that is more than superficially carbonated may produce a similar result. Not only will un-reacted silicates not achieve the desired reduction in the moisture vapor emission rate (MVER) but they can inhibit the bond of subsequent flooring or coating applications. *Reactive Penetrants as a stand alone treatment, are considered a very high risk approach to topical moisture and ph suppression.

Qualifying Moisture Mitigation Systems

2. Cementitious Densification

Modified cementitious overlays are intended to isolate the concrete surface from adhesives or coatings applied above. Such systems are intended to lower moisture transfer and restrict soluble alkalis within the concrete sub-floor from reaching the adhesive/overlay interface.

3. Sealers

Fluid applied sealers are available to help reduce moisture transfer and isolate the concrete from the adhesive applied above.

***Most sealers have warranty limits of 8 lbs and should be limited for closed slab systems only.**

4. Specialty Coatings

Hybrid epoxy-based or epoxy-modified coatings, specifically designed for high moisture/pH conditions, reduce the Moisture Vapor Emission Rate (MVER) and act as an isolation barrier to keep solutions of highly alkaline salts within the concrete from reaching the subsequently applied adhesive or coating.

One, two and three coat systems are available. Some systems may require multiple coats to achieve sufficient mil thickness on very aggressively shot blasted concrete.

***Additional leveling or cementitious substrate material may be required over the coating. When that becomes necessary the materials and processes to follow should be approved by the manufacturer of the suppressant system.**

Qualifying Moisture Mitigation Systems

5. Dispersement Membranes

Dispersement membranes were historically one of the first approaches to topical moisture suppression that experienced a reasonable measure of success. Such systems utilize a special fabric adhered to the surface of the concrete which provides a lateral avenue for water vapor to diffuse. *These membranes are generally used for floating systems.

6. Combination Systems

Several companies utilize a combination or "*Cocktail*" approach where two or more of the systems discussed above are combined. *This approach is usually cost prohibitive.

Characteristics Of INFERIOR Post Applied Moisture Mitigation Systems

1. **MANY ARE LIMITED & ONLY OFFER PROTECTION UP TO 8, 10 or 12 LBS MVER (NOT FOR OPEN SYSTEMS)**
2. **STILL LESS ARE 1-COAT SYSTEMS! 2-COAT & 3-COAT SYSTEMS ARE AVAILABLE….BUT WHY?!?**
3. **BE AWARE……MANY CAN NOT PERFORM IN HIGH ph ENVIRONMENTS (LIMITED TO 11ph)**
4. **MAY NOT REACT ADEQUATELY WITH CONCRETE**
5. **HAVE MOISTURE HYPERSENSITIVE CHARACTERISTICS**
6. **Do NOT Have A Perm Rating Of 0.1 Or Less (ASTM E-96)**
7. **No Measurable Performance Criteria**

Characteristics Of LEGITIMATE Post Applied Moisture Mitigation Systems

1. **Has The Ability To Be Applied To Both, “Fresh” or Old Concrete**
2. **Can Withstand Constant pH of 14 (Normal pH of fresh concrete is 12 – 13) (Aged concrete has a pH 9 – 10)**
3. **Provides Proper Surface pH For Floor Applications (Neutral = 7)**
4. **Capable of Tolerating High or Unknown MVER (25 LBS)**
5. **Moisture Tolerant Formulation**
6. **Possesses A Perm Rating of Less Than 0.1 per ASTM E-96**

High Performance Adhesives

- **Should Have Ability To Be Applied To Both, “Fresh” or Old Concrete**
- **Should Withstand Constant pH of 14**
  (Normal pH of fresh concrete is 12 – 13)
  (Aged concrete has a pH 9 – 10)
- **Should Tolerate High or Unknown MVER (25 LBS)**

PROACTIVE OPPORTUNITIES TO AVOID PROBLEMS

- Schematic Design (review floor coverings)
- Design Development (manage expectations)
- Specification Development (section 3)
- Pre-Bid (competent review & plan for mitigation)
- Pre-Construction (discuss & plan RH testing)
- Construction (implement RH testing)
- Quality Assurance (third party testing)

THE PROACTIVE APPROACH

Step 1: Place & Bull Float Concrete

Benefit: No Normal Finishing of Concrete Required

THE PROACTIVE APPROACH

Step 2 : Shot Blast, “Laser Level” Survey The Slab

Benefit: Extremely Consistent & Predictable Mapping & Preparation Results

THE PROACTIVE APPROACH

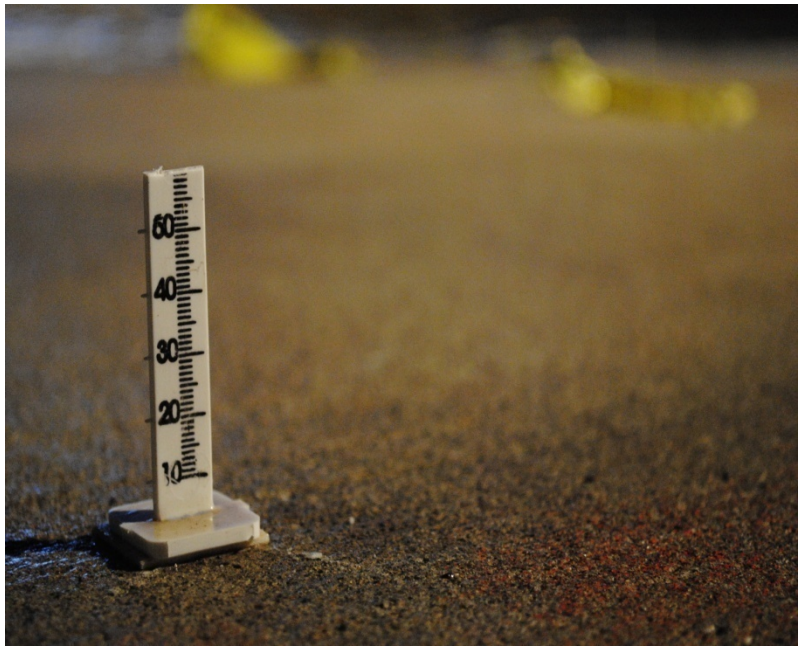
Step 3: Apply 100% Epoxy Moisture Mitigation System

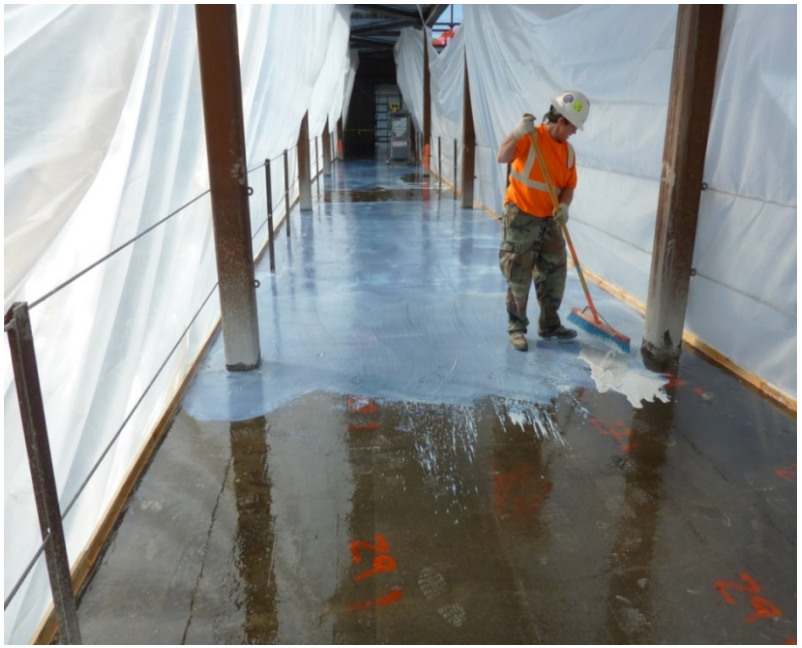
ASTM E-96 0.1 PERMS

Benefit: Monolithic & Complete Moisture Mitigation Throughout Structure

THE PROACTIVE APPROACH

Step 4: Set Grade Pins & Prime





Setting Finished Floor Elevations After Concrete Has Deflected allows both Division 3 and Division 9 Ff/Fl Specification Requirements Met & Exceeded

Benefit: Flat & Level Floor Advantageous For ALL Subcontractors To Follow

THE PROACTIVE APPROACH

Step 5: Place High Tech Topping Slab

High Output Production Equipment Allows The Topping Slab To Be Placed With Unequalled Quality Precision And Efficiency.

Benefit: Responsible Use Of Resources & Quick Access For Following Subs

WHY USE THIS PROACTIVE APPROACH?

- Manages the Interface Between Concrete Slab Placement and Floor Covering Needs
- Brings Harmony to Division 3 and Division 9 Specifications
- Eliminates Concrete Slab Quality Control Ff/FL Issues
- Speeds The Construction Schedule
- Manages/Reduces Risk
- Reduces Change Orders & Extras
- Essentially Pays For Itself
- Structure Into Service Faster!!

SOME REACTIVE APPROACHES

- Test Late in Construction Process
- Try to Dry Floor Out
- Ignore the Problem
- Employ a Patchwork Approach
- Risk Installing the Floor System
- Don’t Budget for MMS

STEPS TO

SUCCESSFUL

INSTALLATIONS

ALWAYS
Evaluate & Diagnose Your Floor

AVOID COSTLY MISTAKES!!!

TESTING = SUCCESS

- **Extract Core Samples From Both.. Affected & Unaffected Areas**
- **Analyze Cores Using Ion Chromatography**
- **Analyze Cores Using Infra Red Spectroscopy**
- **Analyze Cores Using X-Ray Defraction**

Surface Preparation

ACID ETCHING?

ABSOLUTELY NOT!!!

Proper Surface Preparation

Steel Shot Blast

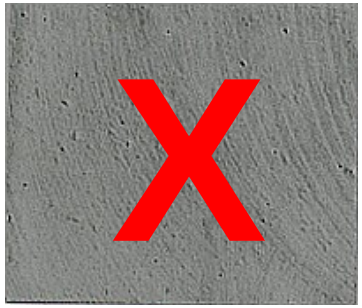
Proper Surface Preparation

Diamond Grind All

Detail Work

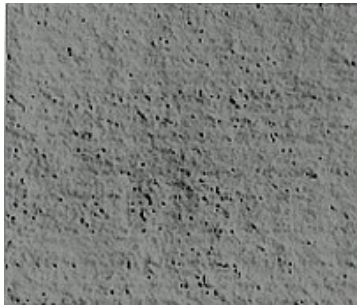
Use ICRI Concrete Surface Profile Chips

CSP- 2



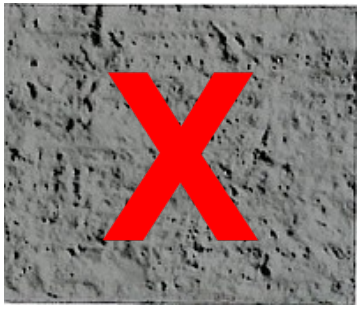
CSP- 3

CSP- 4



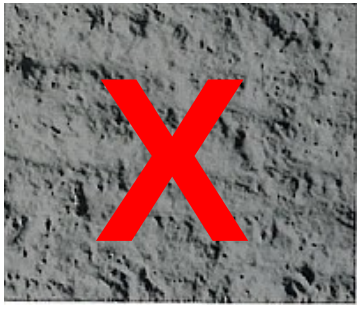
CSP- 5

CSP- 6



CSP- 7

CSP- 8



Remove All Contaminants

Allow Substrate To Dry

Mix Well & Spread at Prescribed Rate

Back Roll To Assure Uniform Mil Thickness

Call On Your Local

INTERNATIONAL
CONCRETE REPAIR
INSTITUTE

Specifying & Installing Professionals

Thank You!!

Questions??