Subfloor Preparation and Moisture Mitigation

“an ounce of prevention is worth a pound of cure”

Benjamin Franklin
Outline

• Concrete Basics
• Moisture Movement and Sources
• Testing Methodologies
• Treatments for Moisture Vapor Emission
• Repairing Defects in High Moisture Content Concrete Surfaces
Concrete Basics

- Cement
- Supplementary Materials
- Aggregates
- Water
Concrete Curing/Drying

• All concrete requires time to “dry”.
  – 4” concrete slab with a 0.5 w/c ratio over an impermeable moisture barrier will take approximately 92 days to get to a suitable level for wood floor installation

Reference: “Are your slabs dry enough for floor coverings?” By Bruce Suprenant and Ward R. Malisch, Copyright 1998
Concrete Curing/Drying

- Water to Cement ration (w/c) is the main driver for concrete drying
Concrete Curing/Drying

- Thickness of concrete slab impacts drying time

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<th>Thickness, in. (mm)</th>
<th>w/c</th>
<th>0.4</th>
<th>0.5</th>
<th>0.6</th>
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*Modified from Hedenblad (1997).*
Concrete Curing/Drying

- After curing and before drying begins, the moisture distribution in a hardened concrete slab is reasonably uniform throughout the member thickness (Hanson 1968). As concrete dries, the amount and distribution of moisture changes (Hedenblad 1997).
Concrete Curing/Drying

- Concrete slabs, properly prepared and under functional HVAC control typically take 50-90 days to reach moisture levels suitable for “normal” floor covering installation
  - Rewetting resets the dry time clock by several weeks

Fig. 2.12—Even with a low w/cm and a 3-day cure under plastic sheeting, these slabs took approximately 7 weeks to dry to a 3 lb/1000 ft²/24 h (1.5 kg/100 m²/24 h) emission rate. After rewetting, the slabs took several weeks to again reach the 3 lb/1000 ft²/24 h (1.5 kg/100 m²/24 h) emission rate (Suprenant and Malisch 1998c).
Moisture Impact on Adhesive Bond

- Effect of Moisture on Floor Covering Adhesive bond strength

Fig. 8.3—Pulloff test results for different adhesives on concrete slabs with different moisture vapor emission rates (Suprenant and Malisch 1999a). (Note: 1 lb/1000 ft²/24 h = 0.488 kg/100 m²/24 h.)
Basic Concrete Slab Construction

- Site evaluation
  - Compressed soil
  - Large aggregate (capillary break)
  - Smaller aggregate
- Moisture barrier specifications
  - 0.010” thick reinforced film
- Exterior Drainage and Landscaping concerns
Subfloor Documentation

Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring

1. Scope

1.1 This standard covers the determination of the acceptability of a concrete floor for the installation of resilient flooring.

1.2 This practice includes suggestions for the construction of a concrete floor to ensure its acceptability for installation of resilient flooring.

1.3 This practice does not cover the adequacy of the concrete floor to perform its structural requirements.

1.4 This practice covers the necessary preparation of concrete floors prior to the installation of resilient flooring.

2. Referenced Documents

2.1 ASTM Standards: 3
   C1650 Test Method for Determining Floor Tolerance Using Nivano, Whirl Puff, and Levelness Theodolite
   C1570 Specification for Plastic Water Vapor Permeability Test Methods of Concrete Slabs
   F1458 Terminology Relating to Resilient Floor Coverings

3. Terminology

3.1 Definitions—For definitions of terms used in this practice, see Terminology F1458.

4. General Guidelines

4.1 Concrete floors to receive resilient flooring shall be permanently dry, clean, smooth, and structurally sound. They shall be free of oil, solvent, paint, wax, oil, grease, roughness, or defects that may cause damage to the resilient flooring.

Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials

Reported by ACI Committee 302

Introduction and background, p. 302-2R-2

Chapter 2—Concrete moisture issues, p. 302-2R-5

Chapter 3—Concrete moisture testing, p. 302-2R-10

Chapter 4—Concrete moisture removal, p. 302-2R-15

Chapter 5—Concrete moisture testing, p. 302-2R-20
Moisture Movement & Sources

• Water of Hydration
  – Water required to complete chemical reaction
    • Typically considered ~25% of cement by weight

• Water of Convenience
  – Water used for ease of workability and placement
    • Usually another 25% to 40% of cement by weight

• Water or moisture vapor migrating through the unprotected concrete slab
Moisture Movement & Sources

• Free water
  – This water is found within the capillaries of the slab and will begin to evaporate if given the correct conditions.

• Bound water
  – This is the water that is permanently bound as an integral part of the concrete slab.
Moisture Movement & Sources

• Open system: Slab in contact with earth
  – Greater opportunity for introduction of water post construction.
  – It is prudent to consider any slab of age to be an open system. (compromised closed system design)

• Closed System: Slab separated with a vapor “barrier”
  – Recommended within ASTM F710
  – Greater protection from introduction of water post construction, but not bullet proof and often times not constructed according to ASTM F710.
Moisture Movement & Sources

- Capillary Membrane
- Humidity and Temperature Differential
- Hydrostatic pressure
- Salt Transport (Osmotic)
- Alkali Silica Reaction
Capillary Action
Humidity and Temperature Differential

Area of Low Humidity

Area of High Humidity
Hydrostatic Pressure
Salt Transport (Osmotic)
Alkali Silica Reaction

In order for alkali-aggregate reaction to occur, a dam or hydraulic structure must have concrete with a high alkali content, reactive materials in the aggregate, and sufficient moisture (at least 80 percent).
pH

- High pH (>11) indicates the presence of alkali salts and potential moisture problems.
- Neutral pH (7) may indicate the presence of a sealer because concrete will never be neutral.
- Low pH (<6) indicates a recent acid wash and a possible friable surface.

Eyes

• If it looks dry and there is no visible water and there is no evidence or history of hydrostatic pressure, proceed to install.
  – New positioning in the wood floor installation industry
What do the numbers mean?

Roughly 16 gallons of water over a 7 day period over an area approximately 31’x31’
Flooring Moisture Issues

Fig. 1.1—Debonded sheet flooring due to moisture in the concrete slab. (Courtesy of Peter Craig and Herman Protze III.)

Fig. 1.2—Blisters due to moisture in concrete. (Courtesy of Peter Craig.)

Fig. 1.3—Mold growth in carpet due to moisture in concrete. (Courtesy of Floor Seal Technology, Inc.)

Fig. 1.4—Adhesive degradation leading to debonded solid vinyl tile installed over asbestos tile. (Courtesy of Peter Craig.)
Solutions for Moisture Control

- Silicate Penetrating Sealers
- Topical Sealers
- Epoxy Coatings
- Loose lay systems
- Single system approach

Holding back the wave!
Penetrating Sealers

• Penetrating type reactive silicate based sealers are liquid applied treatments that chemically react with the concrete reducing the MVER.
  • Concrete must be porous
  • Silicate must saturate surface and penetrate
  • Reacts with free Ca-OH in concrete

• There are also products that are incorporated into the product at the time of pour. (mixed in the truck)

• Claims of MVER reduction and control are hard to prove.

http://www.concreteconstruction.net/concrete-construction/lithium-silicate-densifiers.aspx
Top Coat Sealers

- Typically used for lower MVER/PH conditions (approx. 8 lbs)
- May not require slab surface preparation depending upon surface condition of the slab
- Not typically recommended for open slab systems.
- May not be recommended for below grade slabs.
- Creates “non-porous” substrate
Epoxy Coatings

- Two component resin/hardener epoxy formulations
- Control up to 25lbs MVER/100% RH and pH >14
- Very low perm rates for minimal moisture migration
- Isolates PH from flooring system
- Typically covered with a skim coat or self leveling underlayment
ASTM F3010-13

- Must be 2 component resin based material
- Vapor permeance no greater than 0.1 grains/h/ft²/in. Hg, (perm) when tested in accordance with Test method E96 when applied at the recommended thickness designated by its manufacturer.
- Shall not contribute to indentations
- Concrete shall be mechanically prepared
Concrete Profiles for Epoxy Membranes

CSP 1 (acid etched)

CSP 2 (grinding)

CSP 3 (light shotblast)

CSP 4 (light scarification)

CSP 5 (medium shotblast)

CSP 6 (medium scarification)

CSP 7 (heavy abrasive blast)

CSP 8 (scabbled)

CSP 9 (heavy scarification)
Slip Sheet Membranes

- “Free floats” accommodating minor cracks and joints.
- Shot blasting or grinding is not required.
- Not necessarily compatible with all flooring systems.
- Effectively isolates floor covering away from the slab alleviating build up of vapor pressure.
- pH resistant
- Prep should be done with moisture resistant patching or leveling compounds
Dual Function Adhesive Systems

• New adhesive products designed to seal the slab and act as a bonding agent in one step.
  – Water based acrylic adhesive
  – Moisture cure urethane adhesive
• Typically designed for a maximum of 15lbs MVER and 90% RH
• May not be designed for certain types of floor covering
• May or may not be recommended for open slab systems or slabs with hydrostatic pressure.
Repairing Defects in High Moisture Content Concrete Surfaces
Questions to Ask

- What are the moisture test results?
- Is the building envelope closed?
- Is the HVAC system operational?
- What is the age of the slab?
- What is the condition of the slab?
- What is the floor covering to install?
- What building constraints exist?
Logic Tree

• What are the moisture test results?
  – If <10lbs MVER and/or 90% RH then topical sealers might be recommended
  – If >10lbs MVER and/or 90% RH then epoxy membranes or loose lay systems are recommended

• Is the building envelope closed and/or HVAC systems operational and running?
  – If yes, standard prep materials can be used over moisture mitigation systems.
  – If no, only exterior rated materials should be used over moisture mitigation systems

• What is the age of the slab?
  – <14 days
  – >14 days
Logic Tree

• What is the condition of the slab?
  – Minor repairs required
  – Major leveling required
  – Deep fills for trenches and/or elevation correction required

• What is the floor covering to install?
  – Moisture sensitive
  – Non-moisture sensitive

• What building constraints exist?
  – Un occupied
  – Occupied

• What materials are available?
  – Traditional monofunctional adhesives
  – Moisture controlling adhesives
Case Study 1: Office Building Retrofit

- Moisture Level: 20lbs MVER, 90% RH, pH >12
- HVAC System: Operational
- Building Envelope: Enclosed
- Age of Concrete Slab: 1 year+
- Solution:
  - Existing floor removal
  - Shot blast surface to remove all adhesive residue
  - Epoxy moisture membrane
  - Primer
  - Self Leveling Underlayment
  - Traditional Adhesive
  - Floorcovering
Case Study 2: Fast Track Construction

- Moisture Level: 25lbs MVER, 100% RH, pH<12
- HVAC System: Not installed
- Building Envelope: Open
- Age of Concrete Slab: 14 days
- Solution:
  - Shot blast open slab or leave as broom finish
  - Epoxy Moisture Membrane
  - Primer
  - Exterior Rated SLU
  - Enclose building
  - Traditional adhesives
  - Mixed floorcovering options
Case Study 3: School System Remodel

- Moisture Level: 8-10lbs MVER 80-90% RH, pH<11
- HVAC System: Operational
- Building Envelope: Enclosed
- Age of Concrete Slab: 6mo+
- Solution:
  - Remove flooring and adhesive residues
  - Topical Sealer
  - Patch/Skim Coat
  - Adhesive application
  - VCT flooring
Case Study 4: Planned Protection

- Moisture Level: Doesn’t Matter
- HVAC System: Operational
- Building Envelope: Enclosed
- Age of Concrete Slab: Doesn’t matter
- Solution:
  - Shot blast subfloor
  - Epoxy moisture membrane
  - Primer
  - High performance SLU
  - Traditional adhesives
  - Floorcovering
Case Study 5: Integrated Protection

- Moisture Level: 15-25lbs MVER, 90-100% RH, pH<12
- HVAC System: Operational
- Building Envelope: Enclosed
- Age of Concrete Slab: >28 days
- Solution:
  - Scarify substrate
  - Prime
  - Exterior rated SLU or patch
  - Moisture controlling adhesives
  - Floorcovering
Suggested Inspection Check Off Questions

- Were moisture tests taken and if so how many, which type and where are the records?
- Was the HVAC system fully operational and moisture tests performed per standards and by whom?
- What is the flooring type installed and the nature of the claim?
- Was a moisture mitigation system installed prior to floorcovering installation and if so what type and by whom?
- Were all expansion joints, cuts and repairs properly treated
- Is the issue wide spread or isolated?
“He who lives upon hope, dies fasting.”

Benjamin Franklin