Concrete in Practice
What, why & how?
NRMCA

CIP 28 - Concrete Slab Moisture

WHAT is the Problem

Concrete slab moisture can cause problems with the performance of floor-covering materials, such as vinyl tile, wood, resilient sheet flooring, carpet, and cause bond-related failures of non-breathable floor coatings. Installation guidelines of manufacturers of flooring materials and coatings require that the moisture levels of a hardened concrete slab be less than some threshold value prior to installation. In most cases newly placed concrete slabs cannot dry fast enough to comply with these moisture requirements. Fast-track construction schedules exacerbate the problem. Rapid-drying concrete mixtures are available.

WHAT are Sources of Slab Moisture

a. **Ground water**: Moisture in liquid form can rise upward from the water table by capillary action when fine-grained soil is present below the slab.

b. **Water vapor**: Regardless of the water-table depth, water in vapor form will rise and saturate the soil below the slab. Regardless of where a building is located, the relative humidity of the subgrade below a slab on ground will measure close to 100%.

c. **Fill course/blotter layer:** Granular fill material sandwiched between the vapor retarder and the slab can take on additional moisture prior to or after the slab is placed. This layer can act as a conduit for moisture through tears, punctures, or improperly sealed penetrations in the vapor retarder. A blotter layer directly under the slab is not recommended for interior slabs on ground if moisture-sensitive flooring materials are to be installed.

d. **Residual moisture in the slab:** Adequate water content is necessary in concrete mixtures for improved workability and finishability. It can take weeks to months in favorable interior ambient conditions for a concrete slab to dry to a level considered acceptable by flooring manufacturers and industry standards. Factors that affect the drying rate include the original water content in the concrete mixture, type of concrete, such as normal or lightweight, slab thickness, type of curing, and the ambient relative humidity and temperature from the time of placement to the time of installation of flooring.

e. **Moisture during construction:** Wetting of the slab after final curing from precipitation (if a roof is not installed) or construction activities will elevate moisture levels within the slab and lengthen the drying period.

Moisture-related Floor Covering Failure (PCA image)

HOW are Problems Avoided

Project personnel should be aware of the project schedule and factors related to slab moisture that impact successful floor installation. Moisture mitigation systems should be included in a bid, at least as a contingency item. Avoiding problems can be accomplished by the following means:

- Protect against ingress of water under hydrostatic pressure by ensuring that proper drainage away from the slab as part of the design.
- Use a 6 to 8 inch [150 to 200 mm] layer of coarse gravel or crushed stone as a capillary break in locations with higher water table and fine-grained soil subgrades.
- Use a vapor retarder that complies with ASTM E1745 directly beneath the slab to prevent moisture migration from the substrate. The vapor retarder should be installed in accordance with ASTM E1643. The membrane should be over-lapped, sealed at openings, and precautions should be taken to prevent damage during construction. (CIP 29).
- Use a concrete mixture with a moderately low water-cementitious material (w/cm) ratio (about 0.50). This reduces the amount of residual moisture in the slab, will require a shorter drying period, and result in a lower vapor transmission. Water reducing admixtures provide adequate workability with less water. Reduced moisture emission can be achieved by using pozzolans or slag cement in the concrete mixture.
- Rapid-drying concrete mixtures that are specifically designed for reduced moisture levels and a shortened drying period are available. Admixtures for concrete that reduce the relative humidity in concrete or moisture vapor reduction admixtures (MVRA) that

block pores within concrete are available. Conditions and validity of warranties of products and floor coverings should be assessed.

- Cure the concrete slab to retain moisture by using plastic sheeting or waterproof paper for 3 to 7 days; moist curing increases drying time. Avoid curing compounds on floors to receive coverings or coatings, unless otherwise stated by the manufacturer.
- Moisture and temperature impact drying time. Maintain slabs under actual service conditions for a sufficient period to naturally dry the concrete prior to installing flooring or coatings.
- Avoid operations that will wet the concrete floor. Use heat and dehumidifiers to accelerate drying.
- Test slab moisture condition and vapor emission prior to installing floor covering. If these test results exceeds requirements, use moisture mitigating products or systems approved by flooring or coating manufacturer.

When concrete slab moisture impacts floor covering options consider alternatives like decorative concrete, less moisture-sensitive floor coverings or adhesives, or breathable floor coatings.

HOW is Slab Moisture Measured

Qualitative and quantitative methods of measuring concrete slab moisture are described in ASTM F710. Test the moisture condition of the slab on a dry clean surface at service temperature and humidity conditions. Test at three random sample locations for areas up to 1000 ft^2 [100 m^2] and perform one additional test for each additional 1000 ft^2 [100 m^2].

Two quantitative methods establish acceptable moisture emission of a slab to receive floor covering:

Anhydrous Calcium Chloride Test (ASTM F1869): A measured amount of anhydrous calcium chloride is placed in a petri dish sealed under a plastic dome on the slab. The moisture absorbed by the salt in 60 to 72 hours is measured to calculate the moisture vapor emission rate (MVER). Maximum limits generally specified are 3 to 5 pounds of moisture per 1000 square feet per 24 hours. This test has some major shortcomings: it determines only a portion of the free moisture at a shallow depth of concrete near the surface of the slab; it is sensitive to the temperature and humidity; it provides only a *snapshot in time* of current moisture conditions and does not predict if the sub-slab conditions will cause a moisture problem later in the life of the floor. This is not considered to be an acceptable test for lightweight concrete.

Relative Humidity Probe (ASTM F2170): This procedure involves measuring the relative humidity of concrete at a specific depth from the slab surface inside a drilled or cast hole. The test hole is allowed to achieve moisture equilibrium for 72 hours after which relative humidity is measured. Typically a relative humidity of 75% to 80% is targeted for installation of floor coverings. With proper expertise, relative humidity probes can be used to determine the moisture profile from top to bottom in a slab, conditions below the slab, and can monitor the drying of a slab over time or to predict the moisture distribution after installing the floor covering.

Qualitative methods include:

Polyethylene Sheet Test (ASTM D 4263): An 18 by 18 inch [450 by 450 mm] square plastic sheet is taped tightly to the concrete and left in place for at least 16 hours. The presence of moisture under the plastic sheet is a positive indication that excess moisture is likely present in the slab. However, a negative indication is not an assurance that the slab is acceptably dry below the surface.

Concrete Surface Humidity (Hood Test) (ASTM F2420): The humidity inside a sealed dome on the slab surface is measured and is a non-evasive qualitative measure of slab surface RH level.

Mat Test: The adhesive is applied to a 24 by 24 inch [600 by 600 mm] area and a sheet vinyl flooring product is placed face down on the adhesive and sealed at the edges. A visual inspection of the condition of the adhesive is made after a 72-hour period. This test is not reliable and can produce false negative results.

Moisture meters: Electrical resistance or conductance measured between probes is proportional to moisture content and provides an approximation of relative moisture content in concrete. Other types of meters measure impedance, an alternating current measurement combining resistance and capacitance whereby the depth of signal penetration varies depending on the material and relative moisture content. Electronic meters are useful survey tools that provide comparative moisture readings across a floor .

Note: All slab-on-ground moisture tests for determining when floor covering materials can be applied are useful only when the slab has been placed in direct contact with an effective vapor retarder.

References

1. *Guide to Concrete Floor and Slab Construction*, ACI 302.1R, American Concrete Institute, Farmington Hills, MI.
2. *Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials*, ACI 302.2R, American Concrete Institute, Farmington Hills, MI.
3. Howard M. Kanare, *Concrete Floors and Moisture, 2nd Edition*, EB119.02, 176 pp., 2008, PCA (www.cement.org), NRMCA (www.nrmca.org).
4. ASTM Standards D4263, F710, F1869, F2170, E1745, E1643, F2420, ASTM International, West Conshohocken, PA, www.astm.org.
5. Peter Craig and George Donnelly, *Moisture Testing of Concrete Slabs,* Concrete International, September 2006, www.concrete.org.
6. Peter Craig and Bill Wolfe, *Another Look at the Drying of Lightweight Concrete,* Concrete International, January 2012, www.concrete.org.
7. Peter Craig, *The Rise and Fall of Moisture-Related Flooring Problems,* Concrete Construction, Jan-Feb 2016, www.concreteconstruction.net

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