NRMCA

What, Why & How?

Concrete Slab Moisture

CONCRETE IN PRACTICE

CIP 28

WHAT is the Problem?

Concrete slab moisture can cause problems with the adhesion of floor-covering material, such as tile, sheet flooring, or carpet and bond-related failures of non-breathable floor coatings. Adhesives used for installation of floor coverings are more water-sensitive due to restrictions on the use of volatile organic emissions (VOX) products. To warranty their products, manufacturers often require that the moisture emission from the hardened concrete slab be less than some threshold value prior to installing floor coverings or coatings. Fast-track construction schedules exacerbate the problem when floor-surfacing material is installed before the concrete slab has dried out to an acceptable level.

WHAT are the Sources of Concrete Slab Moisture?

Moisture in concrete slabs on grade can originate from:

a. Water due to hydrostatic pressure when the slab on grade is below a permanent or seasonal ground water table, or when the slab, particularly the edge, is in contact with wet soil from sources such as rain, irrigation systems, broken plumbing, or other recurring man-made source. The rate of moisture flow through the slab will depend on the hydrostatic pressure that causes it.

b. Water rising to the bottom of the slab from ground water by capillary action or *wicking*. The degree of saturation of the subgrade depends on the fineness of the soil and the depth of the water table. Capillary water will saturate the subgrade and move through the concrete slab. Fine-grained soils can draw water from considerable distances while coarse sand or gravel will not sustain this flow.

c. Water vapor from damp soil, which can diffuse through the concrete and condense on the slab surface when the subgrade has a higher concentration of water vapor than the slab surface. This generally occurs due to a vapor pressure gradient when the air on the concrete surface is cooler and at lower relative humidity than the damp soil below the slab.

d. Residual moisture in the slab from the original concrete mixing water. It may take anywhere from six weeks to one year or longer for a concrete slab to dry out to an acceptable level under normal conditions, as illustrated in Figure 1. Factors that affect the drying rate include the original water content of the concrete and the relative humidity and temperature of the ambient air during the drying period. This is the only source of moisture in elevated slabs.

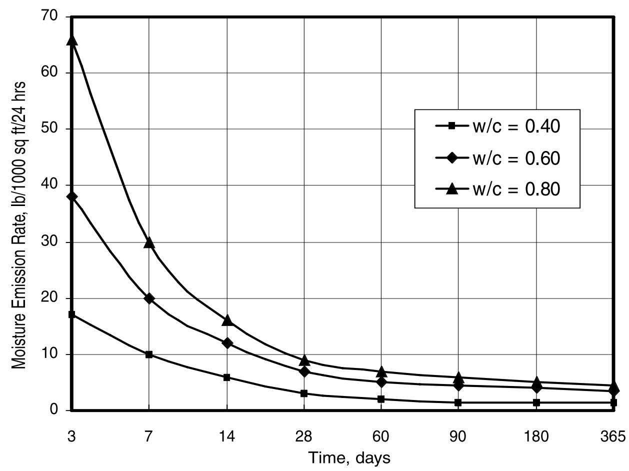

Figure 1 Drying rate of concretes sealed at the bottom (ref 3)

How Do You Avoid Problems?

Avoiding problems associated with high moisture content in concrete can be accomplished by the following:

- Protect against ingress of water under hydrostatic pressure by ensuring that proper drainage away from the slab is 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 fine-grained soil subgrades.
- Use a vapor retarder membrane under the slab to prevent water vapor from collecting at the base of the slab when the soil conditions are conducive to moisture retention. Ensure that the vapor barrier is installed correctly and not damaged during construction. Cover the vapor retarder with a 4-inch layer of a compactible, self-draining granular fill, such as a crusher run material. This layer should be relatively dry prior to placing concrete. Concrete placed directly on a vapor retarder is susceptible to cracking (see CIP 29).

- Use a good quality concrete mixture with a low water content. A low water content will reduce the amount of residual moisture in the slab, require a shorter drying period, and have a low permeability to moisture. The water tightness of concrete can be improved by using fly ash or slag in the concrete mixture. Place concrete at a moderate slump not exceeding 5 inches [125 mm]. Water reducing admixtures can be used to obtain adequate workability and maintain a low water content.
- Cure the concrete by ponding water, covering it with wet burlap, or spraying curing compounds, for a minimum 3 to 7 days. Curing is an important step in achieving a high quality slab with reduced moisture transmission. Avoid using wax-based curing compounds on floors where coverings or coatings will be installed.
- Allow sufficient time for the moisture in the slab to dry out naturally while the floor is under a roof and protected from the elements. Use heat and dehumidifiers to accelerate drying. Since moisture transmission is affected by temperature and humidity, maintain the actual service conditions for a long enough period prior to installing the floor covering.
- Test the slab moisture condition prior to installing the floor covering.

When concrete slab moisture cannot be controlled, consider using less moisture-sensitive floor coverings or breathable floor coatings.

How is Concrete Slab Moisture Measured?

Various qualitative and quantitative methods of measuring concrete slab moisture are described in ASTM E 1907. Test the moisture condition of the slab in the same temperature and humidity conditions as it will be in service. In general, test in three random sample locations for areas up to 1000 sq. ft. [100 m^2]. Ensure that the surface is dry and clean. Record the relative humidity and temperature at the time of testing. Some of the common tests are:

Polyethylene Sheet Test - is a simple qualitative test that is commonly used, where an 18 by 18 inch [450 by 450 mm] square plastic sheet is taped tightly to the concrete and left in place for a minimum 16 hours. The plastic sheet and the slab are then visually inspected for the presence of moisture.

Mat Test - where the adhesive intended for use 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.

Moisture meters - based on electrical resistance or impedance measurements are used to measure slab moisture. The resistance meters are subject to errors and are seldom used.

Gravimetric - This is a direct and accurate method of determining moisture content in the concrete surface. Pieces of the concrete surface are removed and dried in an oven to constant weight. The moisture content is then calculated as a percentage of the dry sample weight. Generally, moisture content less than 3 to 4% is considered suitable for application of non-breathable floor coatings.

Nuclear Density and Radio Frequency - These tests have a high degree of reliability, are nondestructive, but are expensive and take a longer period of time to properly correlate correction factors for each individual project.

Anhydrous Calcium Chloride Test - is a popular test chosen by several flooring manufacturers who specify criteria for flooring or carpet installation based on this method. A measured amount of anhydrous calcium chloride is placed in a sealed area on the surface and the amount of moisture absorbed by the salt in 60 to 72 hours is measured to calculate the moisture vapor emission rate (MVER). Maximum limits of vapor transmission generally specified are 3 to 5 pounds of moisture per 1000 square feet per 24 hours. This test is relatively inexpensive, yields a quantitative result, but is subject to errors when testing as the salt has a strong affinity for water.

Hygrometer – A test area of the floor is sealed off under a waterproof enclosure. The relative humidity of the pocket of air trapped above the slab is measured using a hygrometer or a relative humidity probe after at least 72 hours. Flooring can be installed if the relative humidity is less than 75%.

Test Strip – in which a test strip of the proposed primer or adhesive is evaluated for 24 hours to predict its behavior on the floor. This procedure is not very reliable.

References

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3. Bruce Suprenant, *Moisture Movement Through Concrete Slabs*, Concrete Construction, November 1997.
4. Thomas K. Butt, *Avoiding and Repairing Moisture Problems in Slabs on Grade*, The Construction Specifier, December, 1992.
5. Malcolm Rode and Doug Wendler, *Methods for Measuring Moisture Content in Concrete*, Concrete Repair Bulletin, March-April, 1996.
6. Steven H. Kosmatka, *Floor-Covering Materials and Moisture in Concrete*. Portland Cement Association, Skokie, IL.

Follow These Rules to Avoid Problems with Slab Moisture

1. Evaluate the site to determine the potential for moisture migration and incorporate mitigative measures in the design phase.
2. Use a good quality concrete with a low water content and a low permeability to moisture.
3. Follow good concrete practices for placing, finishing, and curing.
4. Allow the slab to dry out and test the moisture emission rate prior to installing floor coverings or coatings.

NATIONAL READY MIXED CONCRETE ASSOCIATION

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