

# Concrete in Practice

## What, why & how?



## CIP 28 - Concrete Slab Moisture

### 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. Many adhesives used for installation of floor coverings are more water-sensitive than in the past, due to restrictions on the use of volatile organic compounds (VOCs). To warranty their products, manufacturers 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 to an acceptable level.

### WHAT are the Sources of Concrete Slab Moisture?

- Ground water sources and when the floor slab is in contact with saturated ground, or if drainage is poor. Moisture moves to the slab surface by capillary action or wicking. Factors affecting this include depth of the water table and fineness of soil below the slab. Fine grained soil promotes moisture movements from considerable depths compared to coarser subgrade material.
- Water vapor from damp soil will diffuse and condense on a concrete slab surface that is cooler and at a lower relative humidity due to a vapor pressure gradient.
- Wetting of the fill course/blotter layer, if any, between the vapor retarder and the slab prior to placing the slab will trap moisture with the only possible escape route being through the slab. A blotter layer is not recommended for interior slabs on grade (CIP 29).
- Residual moisture in the slab from the original concrete mixing water will move towards the surface. It may take anywhere from six weeks to one year or longer for a concrete slab to dry 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, type of curing, and the relative humidity and temperature of the ambient air during the drying period. This is the only source of moisture in elevated slabs. Any wetting of the slab after final curing will elevate moisture levels within the slab and lengthen the drying period.

### HOW do You Avoid Problems?

Avoiding problems associated with high moisture content in concrete

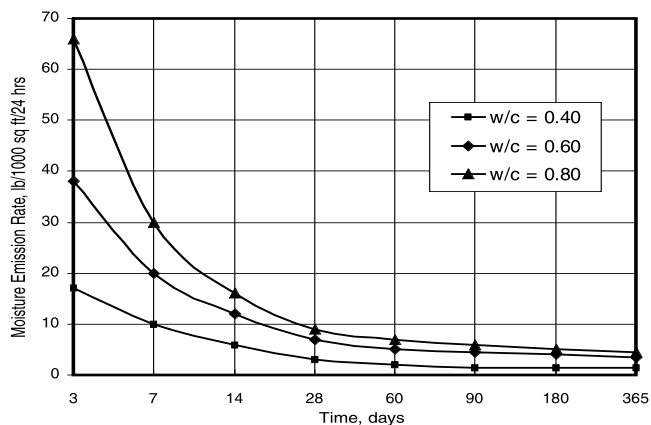


Figure 1 Drying rate of concretes sealed at the bottom (ref 3)

can be accomplished by the following means:

- 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 from entering the slab. Ensure that the vapor retarder is installed correctly and not damaged during construction. Current recommendation of ACI Committee 302 is to place the concrete directly on a vapor retarder for interior slabs on grade (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 permeability to vapor transmission. Water reducing admixtures can be used to obtain adequate workability and maintain a low water content. The water tightness of concrete can be improved by using fly ash or slag in the concrete mixture.
- Curing is an important step in achieving excellent hardened concrete properties. However, moist curing will increase drying time. As a compromise, curing the concrete under plastic sheeting for 3 days is recommended and moist curing times greater than 7 days must be avoided. Avoid using curing compounds on floors where coverings or coatings will be installed.
- Allow sufficient time for the moisture in the slab to dry naturally while the floor is under a roof and protected from the elements.

Avoid maintenance and cleaning operations that will wet the concrete floor. 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 decorative concrete, less moisture-sensitive floor coverings, breathable floor coatings, or install moisture vapor suppression systems (topical 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 at three random sample locations for areas up to 1000 sq. ft. [100 m<sup>2</sup>] and perform one additional test for each additional 1,000 sq ft. 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 (ASTM D 4263)** - is a simple qualitative test, 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 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.

**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. This test is no longer favored since it can produce false negative results.

**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.

**Moisture meters** - Measure electrical resistance or impedance to indicate slab moisture. Electronic meters can be useful survey tools that provide comparative readings across a floor but should not be used to accept or reject a floor because they do not provide an absolute measure of moisture conditions within the slab.

**Gravimetric** - This is a direct and accurate method of determining moisture content by weight in the concrete slab. Pieces of concrete are removed by chiseling or stitch-drilling and dried in an oven to constant weight. The moisture content is then calculated as a percentage of the dry sample weight. This is rarely recommended by floor covering manufacturers.

**Nuclear Density and Radio Frequency** - This nondestructive test instrument is relatively expensive and can take a long time to properly correlate correction factors for each individual project. The instrument has a radioactive source and therefore requires licensed operators.

**Anhydrous Calcium Chloride Test (ASTM F 1869)** - is specified by most floor covering manufacturers for pre installation testing. A measured amount of anhydrous calcium chloride is placed in a cup sealed under a plastic dome on the slab 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, and yields a quantitative result. However, it 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. The test is sensitive to the temperature and humidity in the building. 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.

**Relative Humidity Probe (ASTM F 2170)** - This procedure involves measuring the relative humidity of concrete at a specific depth from the slab surface inside a drilled or cast hole in a concrete slab. The relative humidity is measured after allowing 72 hours to achieve moisture equilibrium within the hole. Typically a relative humidity of 75% to 80% is targeted for installation of floor coverings. Relative humidity probes can 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, leading to predictions of future moisture conditions. These instruments have been used for many years in Europe and are becoming more popular in the United States.

---

## References

1. *Guide to Concrete Floor and Slab Construction*, ACI 302.1R, American Concrete Institute, Farmington Hills, MI.
  2. ASTM Standards E 1907, F 1869, D 4263, F 2170, ASTM International, West Conshohocken, PA, [www.astm.org](http://www.astm.org).
  3. Bruce Suprenant, *Moisture Movement Through Concrete Slabs*, Concrete Construction, November 1997.
  4. Bruce Suprenant, *Design of Slabs that Receive Moisture-Sensitive Floor Coverings*, Concrete International, Vol. 25, No. 3, April 2003, [www.concrete.org](http://www.concrete.org).
  5. Thomas K. Butt, *Avoiding and Repairing Moisture Problems in Slabs on Grade*, The Construction Specifier, December, 1992.
  6. Malcolm Rode and Doug Wendler, *Methods for Measuring Moisture Content in Concrete*, Concrete Repair Bulletin, March-April, 1996.
  7. Steven H. Kosmatka, *Floor-Covering Materials and Moisture in Concrete*, Portland Cement Association, Skokie, IL, [www.cement.org](http://www.cement.org).
- 

