Understanding, preventing, detecting and correcting moisture in concrete floors

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How maintenance and asset management helped it beat the odds.

I've often said, "Bad concrete has been very good to me." As a technical specialist in the commercial resilient flooring industry, concrete issues are an almost daily topic of discussion, and my clients need answers.

Flooring failures attributed to moisture-related concrete problems are at near epidemic proportions today. Coatings, carpet, vinyl, rubber, wood, laminates and most floor coverings are affected to one degree or another by pH issues and excess water vapor emissions through a concrete slab. Moisture causes gaps between tiles, adhesive oozing, bumps, dents, cupping, bubbles, indentations, wheel marks and more. Left uncorrected, these problems can evolve into health and safety issues caused by mold, mildew and floors lifting. Here's a crash course on concrete floors and the issues related to flooring installed over concrete. I hope it will go a long way to helping you to understand what could go wrong.

First, using the right terminology is helpful because words like "cement" and "curing" are often misused.

"Cement" isn't the finished product, but is the grey powdery ingredient in concrete. Cement powder, water, sand and aggregate (rocks) bond together to form concrete. There's no such thing as "a cement floor." Another common misunderstanding is that "cured" means the concrete is ready for floor coverings.

The term "28-day cure" is the approximate time a 4-in. slab takes to cure, and is often used as a guideline for when to install a floor. However, after 28 days, the concrete isn't dry because curing and drying aren't the same things. Curing is the chemical reaction that bonds those ingredients together to make concrete. Drying refers to evaporating the excess water (about 2/3 of the water in the mix) from the concrete after the curing process is complete.

The industry standard, ASTM F 710, Standard Practice for Preparing Concrete Floors to Receive Resilient Flooring, describes the process and uses the terms cure and dry in the same sentence - "New concrete slabs shall be properly cured and dried before installation of resilient flooring."

How long to dry?

The drying time before slabs are ready for moisture testing depends on atmospheric conditions and mix design, according to F 710. A 4-in. thick slab allowed to dry from only one side typically requires 90 days to 120 days to achieve a moisture vapor emission rate (MVER) of 3 lb. water/1,000 sq. ft. per 24 hr (the resilient flooring industry standard MVER). Suspended slabs -– the second floor and above -- often contain a lot more water, and take even longer to dry. As noted in ASTM F 710, lightweight concrete, floors containing lightweight aggregate or excess water, and those that dry from only one side, such as concrete on metal deck construction, may need a much longer drying time. One laboratory study found that at ideal conditions (70°F, 50% relative humidity) it took 46 days for a standard mix to dry and 168 days for a lightweight mix. Those were both under ideal conditions – concrete with the right amount of water at the perfect temperature and humidity. In the real world it takes even longer.

Just as important as sealing your building's roof is sealing the floor against moisture intrusion. ASTM F 710 says that every concrete floor slab on or below grade intended to receive resilient flooring should have a moisture retarder (often improperly called a vapor barrier) installed below the slab. The vapor retarder is often left out of the project to save money and speed the finishing of the concrete. Many failures on first-floor and lower-level slabs are caused by a missing or damaged vapor retarder.

Who's responsible for failures?

The concrete contractor sometimes gets blamed. But if the concrete is mixed and placed according to the architect's specifications, one can't blame the contractor, unless extra water gets added to the truck or the vapor retarder gets damaged. Bad adhesive is rarely the cause because adhesive is almost never defective, but it can be attacked by moisture and the elevated pH levels that come with it. The floor maintenance team often gets the rap, but a floor must be under a lot of water for a long time for the adhesive to let go. Most often, in new buildings, the flooring is installed before the concrete has completely dried, the curing compound was never removed, or the climate control system isn't yet operational. Then, when the building is occupied and the interior conditioned air is dry, the floor covering blocks the movement of excess moisture that migrates upward through the slab. In older buildings, a missing vapor retarder or external sources such as leaks, exterior grading or sprinklers can cause moisture to pass through a slab.

The good news is that testing can detect moisture movement long before a floor covering is installed.

Test when and where?

The short answer is everywhere and always. ASTM F 710 recommends testing concrete slabs for moisture, regardless of age or elevation. Every floor covering manufacturer and adhesive producer says the same thing about old or new concrete from the basement to the penthouse.

To say "It looks dry," "It feels dry" or "It smells dry" isn't enough. Taping a plastic sheet to the floor for a day or two also has been proven to be an inaccurate indicator. The easy-to-use electronic meters that test for moisture in concrete yield only a spot test that isn't a good basis for a global go or no-go decision for a flooring installation.

The floor covering industry recognizes two methods for testing concrete for moisture. The first is the 50-plus-year-old test now known as ASTM F 1869, Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride. This test uses a kit consisting of a dish of calcium chloride that is sealed on a clean section of concrete beneath a plastic dome for three days (Figure 1). Because the salt is hydroscopic, the weight gain can be used to establish the moisture vapor emission rate. Most resilient flooring and carpet can tolerate a maximum MVER of 3 lb. or 5 lb., depending on the product. If done correctly, F 1869 measures moisture emissions from the top 5 cm or so of the concrete. While this is a good test for surface moisture, it doesn't measure what's inside the slab.

Figure 1. The weight gain in a sample of calcium chloride correlates with the mass flow rate of water vapor leaving the concrete surface.

Getting that data requires using ASTM F 2170, Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using In-Situ Probes. This is probably the best predictor of future moisture problems (Figure 2). It involves drilling holes in the floor to measure the humidity inside the slab. This is truly the latest technology for moisture testing and is very quickly being recognized by flooring manufacturers throughout the world.

Figure 2. Drilling a hole is the first step in testing with ASTM F 2170.

What if it fails?

A number of measures can accelerate the drying process on a new slab. Get the building's climate control system up and running -- raise the temperature, reduce the humidity, get the air moving. If a curing compound was used on the floor, remove it. Commercial dehumidifiers and drying equipment are used in water damaged buildings and also can used to dry a new concrete slab.

Consider surface-applied vapor retarders to block moisture emission from the slab. These products need to be researched thoroughly before being used. Look at the manufacturer's reputation, track record, warranty and insurance coverage to be sure that you'll be covered if the product fails. Check with the floor covering or adhesive manufacturer for additional guidance.

Preventing moisture problems in new floors is all about the proper specification. Using concrete with less water and larger aggregate can make a difference, as can using the cover cure method instead of curing compounds. Always use a vapor retarder between a slab and the ground. Sealing beneath the slab is just as important as sealing above the roof. Placing the concrete beneath some roof-like structure prevents rain exposure and helps the concrete dry faster, as does getting the HVAC system up and running as soon as possible.

Concrete is an ancient material that can last for thousands of years. Placed correctly, concrete floors can accept any floor covering to yield a long-lasting and durable wearing surface in almost any type of space. However, because of the fast-track nature of a lot of today's construction projects, the installation often is rushed and failures occur. So, it's important to know what to ask for, how to test, and what to do if you discover a problem.

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