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## Increasing Concrete Knowledge of Floor Coverings



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How'd a flooring guy like you learn so much about concrete? I've often been asked this question. In my job as a technical specialist in the commercial resilient flooring industry, concrete issues became an almost daily topic of discussion as moisture-related flooring failures reached epidemic proportions. I have been lucky enough to attend seminars and serve on committees with some of the best minds in the

flooring and concrete industries, and that has helped me develop more of an understanding, although I feel like it's just the tip of the iceberg. The more I know, the more I realize I need to learn.

For the indoor air quality marketplace, mold and odor problems are often another byproduct of moisture in concrete, so an understanding of concrete and the issues related to flooring installed over concrete can go a long way to understanding

what goes wrong. It is my hope that a basic introduction to concrete floors and testing will help those in IAQ work to offer advice about the prevention and correction of concrete moisture problems.

Widely documented is the 1985 discovery of what is thought to be the world's oldest known concrete floor slab, at a site called Yiftah El in southern Galilee. "The 1,900-square-foot slab is part of a settlement that was dated to 7,000 B.C.," writes Howard Kanare of Construction Technology Laboratories in a book published in January by the Portland Cement Association, "Concrete Floors and Moisture." Kanare continues, "Laid on compacted sandy clay, the travertine-like lime concrete is one to three inches thick and contains 0.4-inch diameter aggregate, with a ground and polished surface. A sample of this concrete yielded 5,800 [pounds per square inch] compressive strength!" That's a far cry from the 3,000–4,000-psi concrete that is in common use today.

Often, I hear people talk about putting floor coverings on top of "cement floors." The right word is concrete, not cement! Cement is one of the ingredients in concrete; it is the gray powder in the mix. ASTM F 141 defines concrete as "a strong, hard material made by mixing a cementing material (commonly Portland cement) and a mineral aggregate (as washed sand and gravel or broken rock) with sufficient water to cause the cement to set and bind the entire mass." So, you can say that concrete is made of cement, sand, rocks and water, in addition to other additives that are sometimes a part of the mix.

Kenneth C. Hoover put it very well in an article called "The Roman Empire Fell – Its Concrete Endures," published November 2004 in *Concrete International*. He writes, "The word *concrete* derives from the Latin verb *concreescere*, 'to grow together', 'to congeal' or 'to harden'." He continues, "Those of us dedicated to correcting the general confusion between the terms *cement* and *concrete* might be surprised to learn that our word *cement* is a mistranslation of the Latin word *caementum*, which means 'crushed stone'. As a consequence, more than 2,000 years later, semantic confusion reigns: Concrete specialists say that a "cement truck" is a bulk transport tanker; the general public thinks a cement truck is a transit

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mixer, but a true Latin scholar will know that a cement truck is a dump truck full of crushed stone.

### **Curing and Drying**

So, once a new concrete floor slab is placed, what happens? The concrete begins to cure. Curing is the chemical reaction by which the cement paste (formed by cement powder and water) chemically bonds with the sand and the aggregate to begin to make concrete. The cement paste is the binding agent that holds it all together. Initially, the concrete needs the presence of water reaction, so curing is facilitated by not allowing water to escape. In the old days, this was achieved by spreading burlap on the floor and keeping it wet for up to seven days, a process known as a “seven-day wet cure.” I still see this today in some highway work, where soaker hoses or sprinklers are sometimes used to keep the burlap wet. After the initial cure, the concrete mix has used most of the water it needs, so the burlap is removed. The curing continues from there, and the term 28-day cure refers to the approximate time it takes for standard mix four-inch-thick concrete to cure fully. However, after 28 days, the concrete is neither dry nor ready for floor covering. Assuming cured means the concrete is ready

for floor coverings is a common mistake. However, cured is not dry; curing and drying are two different things! Drying takes about one month per inch after curing, so it could be five months before a standard mix concrete slab at four-inch thickness is dry enough for many floor coverings.

I use the term “standard mix” because there are two basic types of concrete being used for floor slabs: standard and lightweight. Standard mix comes directly out of the truck and is placed on ground floor or below ground-floor slabs. Lightweight is the “pumpable” variety that is pumped up to the upper floors. In the old days, standard mix concrete was hoisted by cranes to the upper floors, as in that documentary about the building of the Empire State Building and those big buckets of concrete.

Now, concrete can be pumped through hoses, which saves a lot of time. However, in order to make the concrete pumpable, more water is used, so lightweight concrete takes a lot longer to dry. In one particular laboratory study, a standard mix at 70 degrees Fahrenheit and 50 percent relative humidity (ideal conditions) took 46 days to dry. In the same test, the lightweight concrete took 168

days. That points out another common error: assuming that the upper floors of a building can't have a concrete moisture problem. While it is true that on-grade or below-grade slabs are the big culprits because the concrete is in contact with the ground, concrete on the upper floors is in no way immune to moisture problems.

Another point about drying is that once dry, a floor can become wet again due to rain, flooding or other circumstances. Rewetting can be a big problem because these slabs can take just as long to redry as a new slab does. Thus, when discussing the age of a slab and its readiness for a new floor covering, the question to ask is not “How old is the slab?” but “How long has the building been enclosed?” It is also important when analyzing a water-damaged building that the concrete is also examined and tested to be sure the floor is dry enough for reinstallation or replacement of the floor coverings.

### **Failures**

Have you ever seen a moisture-related floor covering failure? Carpet, vinyl, rubber, wood, laminates and most categories of floor covering are affected, to one degree or another, by excess moisture vapor emission from a concrete slab. Gaps between the tiles, adhesive oozing, or unusual-looking bumps or undulations in that supermarket floor are usually the result of moisture. Peaking or cupping of wood or laminate floors, bubbles in carpet, indentations or wheel marks in sheet vinyl can all be caused by a damp slab. Left uncorrected, these problems can continue to health and safety issues caused by mold, mildew and floors lifting.

When a floor covering fails due to moisture, fingers usually get pointed and the blame game is on. However, this blame is often misdirected. For example, blaming “the concrete guy” is usually unfair because the concrete is batched and placed according to specification. If “the concrete guy” follows the spec, then he's done his job, with exceptions like when the driver of the truck adds more water to keep the concrete mix “alive” on a hot day, or when the vapor retarder beneath a slab-on-grade is compromised, broken or not used at all.

Another common scapegoat is the floor-care technician. I have been on many jobs where the person with the mop gets blamed, but unless the floor is flooded and left wet for long periods, there is usually not enough water in the cleaning process

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to cause the adhesive to turn to mush. This is especially true in most of the large installations where an automatic scrubbing machine is used. Scrubbers suck the water up within seconds after the floor is wet.

“Bad adhesive” is another so-called cause that is rarely the case. It is very rare for an adhesive to be “defective,” so unless the adhesive is attacked by moisture and the elevated pH levels that come with it, they are rarely the cause.



*This resilient flooring material is showing wheel marks because the adhesive has softened due to moisture.*

Are some floor-covering products more prone to failure than others? Are floor coverings and adhesives more sensitive today than in years gone by? Well, I am not going to walk into the mine field of the adhesive discussion. Today’s water-based adhesives, compared to the solvent-based products of the past, have excellent strength and workability, but there is a lot of disagreement about whether they are more moisture sensitive. As far as flooring products, there are some excellent high-performance flooring products available today that weren’t even around a few decades ago.

Products like vinyl-backed carpet, rubber sheet flooring, vinyl-backed sheet vinyl flooring, and large-format resilient floor tiles all have excellent performance and visual characteristics. However, they may be more sensitive to moisture than “action back” polypropylene backed carpet, felt backed vinyl flooring and 12×12 vinyl composition tile, which are generally not as good a quality. As in any decision, there are compromises to be made, and the person specifying the job needs to look at the big picture and take all these factors into consideration.

Rather than blame flooring products or adhesives, what really needs to be looked at are construction practices. The two biggest causes of moisture-related failures are fast-track construction and adaptive reuse of older buildings.

Fast-track is just that. Buildings are being completed so quickly that concrete floor slabs are being covered before they are dry. The concrete hasn’t changed that much over the years. The flooring and adhesives have changed some, but they both work extremely well when the concrete is dry. Often, the best way to avoid concrete moisture-related failures is a four-letter word: Wait! Let it dry!

Adaptive reuse is the trend toward converting spaces that were not originally intended as finished space into spaces that are finished. For example, one of the worst moisture-related failures I have ever seen was where a 30-year-old warehouse was converted into a retail store. Because the warehouse was never intended to be occupied space, the concrete was placed without a vapor retarder and left bare for all those years. Once the conversion was done and the floor was covered with sheet vinyl, the moisture that had easily passed through the concrete for all those years was suddenly trapped between the flooring and the slab, turning the adhesive into pudding. This points out the importance of running moisture tests on all concrete slabs regardless of the age.

## Testing

When and where should a concrete floor be tested? Everywhere and always. As we have seen so far, even older concrete can have moisture problems, and slabs above grade can be as much of a problem as the ground floor. So, my rule is test whether it’s old or new, even if there is an existing floor down that looks to be in good shape. Test on-grade, above-grade or below, from the penthouse to the basement. If it’s concrete, test it!

There are a variety of methods of testing. Here are five of my favorites, some of which work and some of which do not:

1. The senses test: In this method, you use your senses of sight, touch or smell to decide whether or not to install floor covering (i.e., “it looks dry,” “it feels dry,” or “it smells dry.”). These methods, however, have not been proven any more accurate than flipping a coin to decide if the floor is ready.

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2. The plastic sheet or rubber mat test: This is an old-time test where you tape a sheet of plastic to the floor or leave a heavy rubber- or vinyl-backed mat on the floor for a day or two and then come back to see if the concrete looks damp. If it is damp, it may be time for some further testing. It has always been assumed that if it is dry after this test, you are probably “good to go.” However, there has been some scientific testing that showed a slab that was dry under the plastic sheet but had high moisture vapor emission rates, or MVERs, using other methods. This is an inaccurate method that is not approved by the floor-covering industry.

3. Moisture meters: There are a lot of easy-to-use electronic meters on the market that test for moisture in concrete, but this is just a “spot” test for surface moisture at that spot in the slab at that point in time. Meters can be useful for testing gypsum-based underlayment, for troubleshooting flooring failures or for identifying locations in a concrete slab that might need further testing. However, moisture meter testing on concrete is not a way to decide “go” or “no-go” for a flooring installation.

4. Relative humidity testing: ASTM F2170, “Standard Test Method for Determining Relative Humidity in Concrete Floor Slabs Using in situ Probes,” has been used in Europe for over 20 years and is now gaining some popularity in North America. With this method, holes are drilled to measure the percentage of humidity inside the slab, which is the best way to predict the future as far as moisture rising to the surface of the concrete. Usually, a reading of 75–80 percent is acceptable. This is truly the latest technology for moisture testing and is very quickly being recognized by flooring manufacturers throughout the world.



*Kits like the one shown here test concrete using the calcium-chloride method.*



*ASTM test F 2170 measures the internal relative humidity of a concrete slab.*

5. Calcium chloride test: This 40-year-old test method, recognized by virtually every carpet and resilient manufacturer, was originally published by the Rubber Manufacturers Association and is now known as ASTM F1869, “Standard Test Method for Measuring Moisture Vapor Emission Rate of Concrete Subfloor Using Anhydrous Calcium Chloride.” This test measures the top five centimeters or so of the concrete, so while this is a good test for surface dampness, it does not measure the internal dampness the way the F2170 test does. F1869 uses a kit consisting of a plastic dome and a dish of salt in the form of calcium chloride. The dish is sealed under the dome for three days, and because salt naturally absorbs water vapor, the weight gain can be measured, and the moisture vapor emission rate is established.

This MVER is expressed in pounds of water vapor per one thousand square feet per 24 hours (lbs/1,000 ft<sup>2</sup>/24h), or just pounds. Most of today’s resilient flooring and carpet needs a maximum MVER of three or five pounds, depending on the product.

Many people use a combination of these last three test methods to determine if the concrete is ready for a floor covering installation, and these methods are also used to troubleshoot a floor that has failed due to moisture.

### **Corrective and Preventative Measures**

If a floor fails a moisture test, what can be done? Well, as I said, that four-letter word *wait* goes a long way, but to accelerate the drying process, there are a number of steps that can be taken. One is to get the climate-control system in the building up and running. Raise the heat, lower

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the humidity, and get the air moving! If a curing compound was used on the floor, then remove it by sanding the floor to open up the pores. There is drying equipment available that is often used in water-damaged buildings.

Some of these machines are also useful in helping to dry a new concrete slab. There is also a growing industry of surface applied vapor retarders that are applied to concrete to block moisture emission from the slab. These products need to be thoroughly researched before use. Look at the manufacturer's reputation, track record, warranty and insurance coverage to be sure that you will be covered down the road if the product fails.

Preventing moisture problems in new buildings is all about the proper specification. Using concrete with less water and larger aggregate can make a difference, as can using wet cure or cover cure methods as opposed to curing compounds. Always use a vapor retarder under slabs in contact with the ground. Sealing beneath the slab is just as important as sealing above the roof! Placing the concrete with the roof on so the concrete is not exposed to rain helps the concrete dry faster, as does getting the HVAC system up and running as soon as possible.

### **Summary**

This is just the briefest of overviews of concrete from a floor-covering point of view. Concrete is an ancient material that, when built correctly, can last for thousands of years. Placed correctly, concrete floors can have any floor

covering installed over them and have a long-lasting and durable-wearing surface in almost any type of space. However, due to the fast-paced nature of a lot of today's construction projects, the process is often rushed, and failures occur. So, it is important to know what to ask for, how to test and what to do if there is a problem.

There is a great deal more information available from sources such as the American Concrete Institute ([www.aci-int.org](http://www.aci-int.org)), the Floor Covering Installation Contractors Association ([www.fcica.com](http://www.fcica.com)), ASTM International ([www.astm.org](http://www.astm.org)), and a variety of papers and articles that have been written on this subject. I would be happy to direct you if you care to learn more.

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