Background Information Part 1

The Unexpected Culprit - Moisture

by Richard Tanski
(http://www.floorprep.com/bulletins/Moisture%20Article%20Brochure.pdf)

Moisture. In the flooring industry, few words cause as much anguish. On many projects, no one has properly prepared to analyze or solve the problem. Just like the old commercial, if you want to catch someone's attention, mention high moisture.
Excessive moisture is the culprit on many failures and has created an entire segment within the construction industry. There are companies that manufacture equipment to dry the slab, test the moisture in or coming out of the slab, and seal or abate the slab. There are firms that test for moisture, and those that specialize in treating these slabs. It has provided much more work for inspectors and in some cases has created entirely new companies. […]
Excess moisture can be a problem in both new and existing concrete. This article will deal with new concrete.

Water in Concrete

Water is one of the main components in a concrete mix, along with cement, sand, and stone or gravel. The combination of water and cement creates a chemical reaction that is not fully understood. However, this reaction generates heat and leads to strength development. The water / cement combination creates the glue that holds the sand and stone together to create the concrete matrix. Some debate has occurred recently regarding the minimum amount of water needed to hydrate or chemically react with the cement, but in general it is felt that the minimum water cement ratio is .32 - .35. Most floors designed to receive floor covering are placed with a water / cement ratio of .5 - .65. The difference between the two ratios is referred to as water of convenience. In other words, it allows the concrete to be more "plastic" and easily placed. This extra water that the cement does not need must exit the concrete before floor covering can be installed.
Generally, more water in the mix means less strength and greater permeability (porosity). It is somewhat like a floor covering adhesive. When purchasing the cheaper "contract grade" the installer knows that this material has more water, and has a low solids content. It does not develop the same strengths, or have the overall performance of those adhesives with higher solids.

Curing Concrete

The retention of the water in the concrete, known as curing, is necessary to fully hydrate the cement. A minimum of three days cure is required to properly hydrate the cement to enable the concrete to achieve its designed strengths. Curing may be accomplished by covering with plastic, burlap, or burlene or by the application of chemical curing compounds. Lack of proper curing leads to an incomplete chemical reaction thus, producing weaker concrete that has greater permeability and less wear resistance. These characteristics usually lead to nothing but problems when trying to install a floor covering.
Although the standard governing curing compounds is designed for membrane forming materials, there are 2 types used within the concrete industry – membrane forming and penetrating (non-membrane forming & reactive). Chemical curing compounds often provide compatibility bonding problems. They do not allow penetration of adhesives into the substrate. Chemical curing compounds that efficiently cure the concrete also mean a delay in drying. Membrane forming materials often remain on the substrate for an extended period of time. If construction traffic does not remove the curing membrane, a removal method may be needed. Penetrating materials react with the calcium hydroxide and water in the concrete to form a gel which holds water in the concrete. This gel remains in the concrete and can also lead to bonding problems, as well as problems in mitigating moisture by preventing new materials from penetrating into the slab.

Concrete Placement and Vapor Barriers

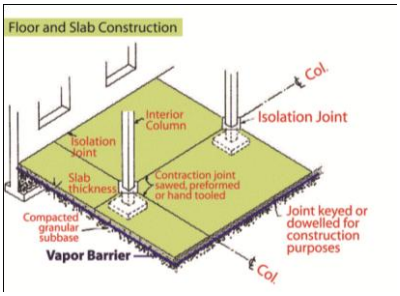

Figure 1

Concrete is obviously placed on many levels and substrates. It is placed below grade, on-grade and above grade or in suspended situations. It is placed over compacted gravel, precast concrete, and metal decking. When concrete is placed on or below grade and is designed to receive floor covering, the best practice, which is recommended by ACI 302 The Guide to Concrete Floor Slab Construction, is to **place the concrete directly over vapor barrier** (see **Figure 1**). Vapor barriers are designed to prevent ground moisture from entering the concrete where it will likely move to drier space at the top of the slab interfering with the floor covering system. Keep in mind, when concrete is placed over a vapor barrier or over metal decking the water in the concrete has only one place to go – up.

Drying Time of Concrete

So, how long does it take for new concrete to lose its excess water? What are the factors that influence or dictate drying time? Remember, the water actually needed by the cement to "hyrdrate" is used over a long time, so we only want to "dry' the excess without hurting the concrete's strength development. In 1965, Portland Cement Association researcher Harold Brewer studied moisture movement through concrete. This work has been used over the years to help understand drying time of concrete. His original work was reported in grains of moisture per square foot per hour which can be converted to pounds per 1,000 square feet per 24 hours – which is how the result is produced in the calcium chloride test (ASTM F1869). This work has been used to generate **Table 1**.

Table 1

Drying time in days, at 73 F and 50% relative Humidity for a 4-inch-thick specimen to reach 3 lbs/1,000 sq. ft./24 hrs.

Water-Cement Ratio	Bottom Sealed	Bottom Exposed to Water Vapor	Bottom in Contact with Water
0.4	46	52	54
0.5	85	144	199
0.6	117	365	>>365
0.7	130	>>365	>>365
0.8	148	>>365	>>365
0.9	166	>>365	>>365
1.0	190	>>365	>>365

Table 1

Concrete specimens were cast with various water cement ratios at a 4 inch thickness. Some specimens were sealed at the bottom to replicate a vapor barrier, where as others were exposed to water vapor. The specimens were allowed to dry at 73 degrees F and 50 percent relative humidity. A lot of commercial concrete is placed with a water cement ratio between .55 - .60. Using .60, we can see that under perfect conditions, the specimen required 117 days to reach 3 pound / 1,000 SF / 24 hours.

As **Table 1** shows, testing was conducted in perfect "laboratory" conditions. Factors affecting the drying of the concrete include substrate, concrete thickness, water / cement ratio, curing method, temperature and relative humidity. Changing any of these factors in this study will change the outcome. Cooler temperatures, higher humidity, thicker concrete, and higher w/c ratio will mean longer dry times.

As concrete dries it acclimates to its existing environment. If the building is not enclosed and is open to outside conditions, the concrete acclimates to those conditions. If the building is sealed, but no ventilation occurs, high humidity may slow or prevent drying. These conditions are different than what the building conditions will be once occupied. When the conditions change the concrete acclimates to its new settings. For example, if outside conditions are 80 F and 75 percent relative humidity, and building conditions once enclosed and operational will be 70 F and 50 percent relative humidity, the concrete will react by losing more moisture into the drier atmosphere.

It is these circumstances that will normally doom the unsuspecting builder or flooring contractor. Most new construction projects do not call for the building's HVAC systems to be operational prior to floor covering installation. This is indeed a problem. Furthermore, any moisture testing done prior to HVAC operation is not valid. We live in a time where job schedules have been greatly

compressed, allowing less drying time for concrete. Therefore, job schedules need to be reviewed. Can the HVAC systems be installed sooner to allow operation as soon as the building is enclosed? When you are bidding new construction work, ask about the schedule and notify the customer of the problems that occur when HVAC is not operational.
Most of these problems must be dealt with long before the flooring contractor first comes out to install a floor. It is vital that you communicate with the General Contractor early on about many of these things that can affect your ability to complete a timely, failure free floor. […]

References:

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