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Questions & Answers from Vermont Chapter CSI's November 2001 Program

Though he was not able to attend the November program due to an emergency room visit, Mr. Protze did volunteer to answer whatever questions arose out of the round-table discussion. Here are the questions that we supplied, and the answers that he and his colleague Peter Craig supplied.

1. Do you recommend pouring concrete slabs on a sand layer over a vapor barrier, or directly onto the vapor barrier?

I always recommend placing concrete directly on a qualified vapor retarder ("barrier") ONLY IF the slab is going to receive flooring materials (e.g. wood, VCT, carpet, epoxy, urethane, etc.). Although placing and finishing the concrete may be a bit more tedious using a vapor retarder (primarily due the increase in bleeding caused by the vapor retarder), it's one of the important factors in achieving a zero-problem floor covering system.

Placing the concrete on a sand layer over the vapor retarder is NOT RECOMMENDED by me, and is no longer recommended by ACI (American Concrete Institute). The sand layer (better to think compacted granular fill layer), of necessity, contains moisture (generally 6%, sometimes up to 12%). This moisture needs to dry out just like the overlaying concrete needs to dry before installing a floor covering. The compacted fill layer usually contains as much, or greater, free water than the concrete. Because the fill layer is deeper, the total dry time will be up to 3 times as long as the concrete alone. With the concrete on the vapor retarder, there is no additional depth of water needed to evaporate out of the system.

In addition, if the fill layer is above the vapor retarder, and then becomes inundated with water (such as rain, joint cutting water, curing water), the drying will be inordinately long.

The use of vapor retarders will increase the total shrinkage of the concrete and thereby exacerbate curling of the slab. Shrinkage cracks in conventional concrete slab construction is best avoided by installing enough control, or contraction, joints.

2. Is there a way to know if a calcium-carbonate test is valid?

I believe you are referring to the calcium chloride test to evaluate moisture vapor emission rate (MVER). (Ironically, calcium carbonate is used to evaluate moisture contents of aggregates for concrete, but is not germane to measuring MVER).

I believe a calcium chloride test would be considered valid if it meets the criteria established in ASTM Test Method F 1869. These include venting the surface of the concrete for 24 hours before initiating the test, and, most importantly, performing the test in the same ambient conditions (temperature and relative humidity) as the floor will function during use. I believe the temperature and the relative humidity should be constantly recorded during the test 'incubation' period to help lead to a meaningful interpretation of the results.

However, I have heard "horror stories" of technicians carry the dishes of calcium chloride in rain storms to a local drug store for weighing, of moisture domes not hermetically sealed to the concrete slab, of sloppy weighing techniques, etc. which certainly invalidates a MVER test. The real difficulty is measuring or validating the competency and integrity of the individual performing the test.

All that said, I'm concerned with what the test is actually measuring. Some learned folks believe the calcium chloride test is only measuring the MVER in the top 1" or so of the concrete. Thus, it's instructive to measure not only the MVER, but as well, the internal relative humidity of the concrete at three of four depths. Some other learned folks are concerned that an open concrete floor that shows low MVER's may act differently to moisture movements once the entire slab receives a floor covering. In this case, it may be meaningful to tape a 5 ft. by 5 ft. sheet of polyethylene film to the concrete slab in several locations, and performing the MVER test in a cut out area in the center of the polyethylene sheeting.

One final note, I do not agree with the ASTM 1869 requirement of subtracting the area of the petri dish, which mathematically increases the MVER by a significant amount. My reasoning is since the 1950's the industry has not been subtracting the dish area, and the flooring manufacturers have rated their products accordingly. We need to continue measuring apples vs. apples, not apples vs. pomegranates.

3. How long of a curing / acclimation period is needed before the calcium-carbonate test? Are there ASTM rules on this?

The calcium chloride test may be performed any time after the concrete has been cured (which for water curing, normally is a period of up to 7 days). There are no ASTM requirements for the timing. Early in it's drying life, the concrete will show a very high MVER (I have measured as high as 20 lbs./1,000 sq.ft./24 hours within 7 days after removing water curing). As the concrete dries, the MVER decreases. I have found it helpful and more economical to monitor the internal relative humidity of the concrete during the drying period to better adjudge the point in time when to perform the calcium chloride tests. There is not a definitive time period, inasmuch as drying time is a function of slab thickness, ambient temperature and

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relative humidity, air movement, strength classification of the concrete (actually water-to-cementitious ratio), the rating of the floor covering (and, at times I think drying time is function of the phase of the moon). It's not unusual for a 4000 psi strength classification concrete in an active construction environment to take over 5 months to dry to a MVER of 3 lbs./1,000 sq.ft./24 hours. The quick answer is there are many variables that influence drying time of concrete.

4. Is there any movement towards using more invasive tests than the calcium-carbonate test? What about a movement towards required testing by an independent agency, rather than by the GC or others?

There is consensus amongst some knowledgeable flooring consultants that the internal relative humidity tests are an important adjunct to the calcium chloride MVER tests (see #3 above). The invasive portion of the test involves drilling several 5/8" diameter holes into the concrete. At the conclusion of the invasive internal relative humidity test, the holes should be filled with a dry pack non-shrink cementitious grout (which will have permeability characteristics far less than the parent concrete).

Another important test that may be considered slightly invasive is performing a meaningful pH test for alkalinity of the concrete surface. The pH test should be performed by lightly abrading the surface of the concrete with #100 grit emery cloth, then soaking the resulting powder with distilled water for a period of 60 seconds before measuring the pH. It's best to use an electronic pH meter, primarily due to the difficulty in adjudging the actual green to deep purple color of standard pH indicating paper. I am being somewhat sarcastic when I call this an invasive test, inasmuch as we're removing less than 0.01" of a 3" long scar on the concrete.

For the second part of the question, the flooring industry recently released a 'white paper' recommending the moisture tests only be performed by an independent agency (testing firm). No matter who performs the test, it is critical that the person performing the test has a high degree of competency and integrity to properly perform the test. In addition, it is of paramount importance that the individual interpreting the test has a high level of knowledge regarding moisture conditions of concrete and flooring requirements.

5. Is there a recommended moisture content for the sand layer? Minimum / maximum allowed moisture? What is the compaction standard for the sand / cushion layer? Silt content standard?

The recommended amount of moisture in the sand layer is the optimum moisture content to provide 95% compaction. For sand, that may approach 10% by mass (weight); it actually would be better to use granular fill whose optimum moisture content may be around 6%. Even at 5% moisture, there is more water in the cushion layer than the concrete itself. Again, as in the first question, my counsel is DO NOT USE A CUSHION LAYER; CAST THE CONCRETE DIRECTLY ONTO THE VAPOR RETARDER.

6. Are there more reliable non-destructive tests than the calcium carbonate test?

I've not heard of any. The "mat test" is not fail safe and is only a qualitative test, compared to the calcium chloride test which is quantitative. I continue to believe an important adjunct to the calcium chloride tests are the invasive relative humidity tests taken at various levels within the cross section of the slab.

7. What are the best ways to avoid potential problems, i.e. what risky methods or procedures should be avoided if it's practical? (for example, winter pours w/forced drying).

Casting of concrete during cold weather may be successfully performed if the cold weather recommendations of ACI are followed. You are correct that caution must be exercised in the use of forced hot air heaters as to generation of excess carbon dioxide (as well as carbon monoxide). Other propane or gasoline burning engines may also produce excess carbon dioxide. The actual level of carbon dioxide (as well as carbon dioxide) needs to be monitored (measured) during the course of concrete construction. The problem with excess carbon dioxide is its influence in causing carbonation of the surface of the concrete, which will result in dusting. Of course, carbon monoxide will cause death.

Other factors during casting of concrete during cold weather include items such as concrete temperature, the difference in the concrete temperature compared to the substrate, and the difference in concrete temperature and the ambient air temperature. Although curing of concrete is always considered a critical step by me, extra attention often needs to be paid to details of curing during cold weather conditions.

Some of the same concerns, except for carbonation, apply to casting concrete in hot weather. Again, ACI has excellent guidelines to properly accomplish concrete casting during hot weather.

8. Is it true as a general rule of thumb that higher-strength concrete mixes will dry faster?

Yes. That's because more of the water added to the concrete is consumed by higher cementitious contents for hydration of the cement and thus the water is not available for evaporation (or drying). However, higher strength concretes are more prone to early stiffening, hardening, shrinkage, cracking, difficulty in finishing, etc. Judicious choice of materials and proportions are critical for producing 'quick dry' concrete.

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9. What are some recommended vapor barriers?

Peter Craig helps with this one:

There are presently three materials we recommend for critically sensitive flooring applications. They are:

1. Premoulded Membrane with Plasmatic Core, by W.R. Meadows
2. Stego Wrap (15 mil), by Stego Industries
3. Vaporguard, by Reef Industries

All of these materials are of low enough permeance to be considered as a vapor barrier, not just a retarder.

One has a bit more tolerance with VCT installations. However because of the problems we see, we are hesitant to compromise on the level of protection. There is but one opportunity to select the level of protection below a concrete slab and that is before it is built. That said, in addition to those materials listed above there are several other vapor-proofing materials that can be considered for VCT installations.

Materials that we recommend for use beneath with VCT installations today are:

1. Rufco 3000B, by Raven Industries
2. Stego Wrap (10mil), by Stego Industries

To comply with present and future ACI Committee 302 recommendations the vapor retarder material itself must be at least 10 mils thick. A puncture resistance study supporting the ACI recommendation has recently been published in the July issue of Concrete Construction Magazine.

I personally prefer vaporproofing materials where the physical properties are consistent across the entire body of material. I prefer a homogeneous sheeting that does not use string, fiber or fabric as reinforcement. Current ASTM standards do not test for puncture resistance between the reinforcing strands. When one does, the values drop dramatically. I also prefer virgin quality materials. The long-term resistance to decay of reprocessed material is quite suspect.

Based on manufacturer's published data, here is a comparison of the permeance properties for many of the popular vapor barrier and retarder materials available today:

Barrier Materials	Manufacturer	Water Vapor Transmission Rate (WVTR)
Premolded Membrane	W.R. Meadows	0.00 grains/sf/hr
VaporGuard	Griffolyn(Reef Ind.)	0.00 grains/sf/hr
15 mil Stego Wrap	Stego Industries	0.006 gr/sf/hr

VCT suitable vapor retarders that also comply with ACI 302 thickness recommendations:

10mil Stego Wrap	Stego Industries	0.016 perms
Rufco 3000B	Raven Industries	0.020 perms
Griffolyn T-105	Reef Industries	0.021 perms
Griffolyn T-85	Reef Industries	0.027 perms
Rufco D16WB	Raven Industries	0.040 perms

Retarder materials where the vapor retarder thickness itself is less than 10 mils:

Griffolyn T- 65 (c: 8mil)	Reef Ind.	0.037 perms
Griffolyn T-65G *	Reef Industries	0.037 perms
Rufco 400 (4 mil)	Raven Industries	0.045 perms
Moistop Plus *	Fortifiber	0.100 perms

10. What causes high alkalinity in test results, and how can it be remedied / avoided?

Portland cement concrete, by its very nature, is of high pH (high alkalinity); else it wouldn't do its thing. A method of reducing long term high alkalinity is by judicious choice of low alkali cements, as well as the use of cement enhancers, such as fly ash or granulated ground blast furnace slag (and maybe silica fume) which are used to replace some of the Portland cement while maintaining the other desired properties (strength, permeability, etc.). A vinegar wash is a method of reducing the pH (acid-base neutralization). It's too bad someone can't 'build a molecule' and provide floor-covering adhesives that are high pH tolerant.

11. If it's necessary to force-dry the slab, are there ways to keep that from causing a problem?

Problems may include drying of installed wooden casework to the point of cracking the wood. If forced drying is necessary, it's best to build a tent close to the floor and blow arid air across the slab (which avoids the casework problem, and is more economical from a total drying time point of view.

12. How does sealing the slab (for purposes of laying down the floor sooner) affect the vapor pressure for the slab as it continues to cure?

Sealing of the slab with known/approved methods of mitigating water vapor emissions provide a lowering of water vapor emissions. As the concrete continues to cure under the sealing system, the hydration process continues to consume more and more of the evaporable water.

There you have it: a huge thanks to Herman Protze and Peter Craig for providing all this information.

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