Drying Concrete

Three of Eight

Last month's article, *Drying Difficult Materials,* heavily emphasized the physics behind a material's release of moisture -- rather than the tools used to accomplish this. As a dense material, concrete is one of those materials that may be difficult to bring to a dry standard. Concrete is somewhat unique, however, since moisture plays such a vital role in its successful creation.

The strength found within a concrete slab is a result of surface forces between the cement particles. The greater the surface contacts between each of these particles, the greater the concrete's strength. Water plays a vital role in increasing this surface contact area between the cement particles. This increase in contact area between cement particles provides an increase in adhesion, and results in a stronger slab of concrete.

This role that water plays in the strength of a fresh concrete slab is of high importance, particularly during the curing of the concrete after it is poured. If the newly poured slab is dried too quickly, the concrete will crack similar to the way mud would dry. In extreme cases, the surface of the concrete slab will crack and crumble because it is shrinking with greater forces than the strength of the surface forces between the cement. This is why you will sometimes see contractors wetting the surface of a freshly poured slab of concrete to slow down the evaporation process, and produce a correctly 'cured' slab.

Concrete is in many ways similar to humans in that we are all individually unique, and so is each slab of concrete. This makes it difficult to evaluate a 'healthy' moisture content in our inspections. Different mix ratios, the materials used, the geographic characteristics and weather *all* influence the readings collected by the inspector during the evaluation. However, there are some important and useful rules of thumb for concrete inspections:

- If water were evenly distributed through a slab of concrete, a correctly cured slab would have a moisture content reading of 3.5%.
- Moisture content of 3.5% or less will not interfere with the adhesion and cure of most concrete coatings and floor adhesives. (Most manufacturers of flooring materials will not guarantee their products if the concrete has a moisture content in excess of 5%, with some as low as 3%.)
- In a water damage loss, it is possible for the moisture content of concrete to exceed 10%. (Excess moisture = 7% by weight)

Removing Water from Concrete

As water damage restoration experts, we frequently see structures that have concrete adsorb excess moisture from a water intrusion. Similarly to wood, a slab of concrete releases its moisture at different rates. A wet slab will release its free water easier than the 'bound' water as the slab dries. This bound water resists release from the slab because it is chemically bound to the concrete and requires forces greater than the bond to the cement itself. Therefore, *strong* physical forces and energy are required to *drive* the moisture out of the slab.

Reflecting on the forces available to restorers in driving out this moisture, we create a strategy in the use of *Momentum, vapor Pressure, and Heat (M.P.H.).*

Let's look at how these forces affect the influence on the drying rate of a concrete slab. According to a monograph published by the American Concrete Institute, "typical" concrete will lose water at a rate of 0.23 lbs/ft^2/hour (1.1 kg/m^2/hour), provided that air temperature is 90ºF (32ºC), concrete temperature is 90ºF (32ºC), relative humidity is 60%, and air velocity is 15 mph (24 km/hr).

The transference of *momentum* to the water deep within the slab plays the least powerful role in driving moisture out of a concrete slab. However, sweeping away the boundary layer of humidity at the surface of the concrete – with air movement – is highly important. If there is *no* air movement (velocity = 0), the drying rate may fall by a factor of 10, to 0.025 lbs/ft^2/hour (0.1kg/ft^2/hour).

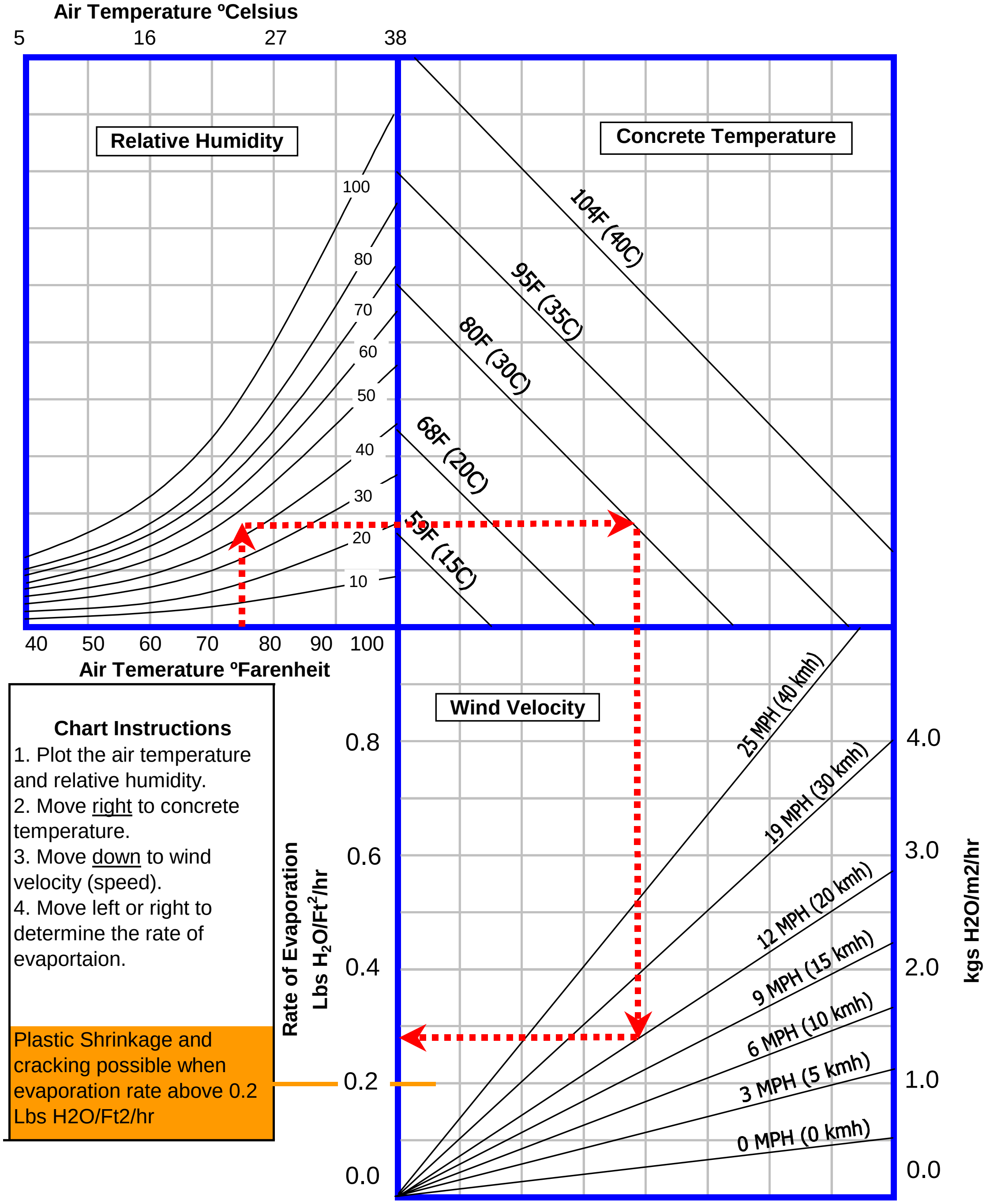
Vapor *pressure* plays a major role in driving out moisture. If we change the relative humidity from 60% Rh to 10% Rh (given the same concrete and air temperature of 90ºF / 32ºC), the drying rate should double to 0.45lbs/ft^2/hour (2.2 lbs/ft^2/hour).

Heat is a powerful force that will add energy to the excess water within this slab. If the air and slab are cooled from 90ºF (32ºC) down to 70ºF(21ºC) -- both still at 60%Rh -- the rate of evaporation is cut in half from .23lbs/ft^2/hour to .12lbs/ft^2/hour.

These principles are highly valuable when a restorer is challenged with effective concrete drying strategy. In short, the *warmer,* the *drier,* the more *rapid* the airflow, (provided permeance is not an issue), the *faster* the rate of drying. This is true of drying any dense structural material.

Concrete Rate of Evaporation

Adapted from the American Concrete Institute (ACI 305R-99)



Evaluating Concrete for Dry Standard

Establishing a universal method for evaluating the dry standard of concrete is controversial. This is partly due to the fact that the different formulations of concrete found across the country skew some evaluation methods. In addition, different inspectors often use different testing techniques. That's why it is prudent for the inspector to perform more than *one* type of the many concrete tests available, and to carefully document the testing protocol. *The more legs your chair has to rest upon… the less likely it is to tip over.*

Although there have been few studies comparing the many testing protocols for concrete, each type of test clearly answers different questions about the slab's quality and installation .

ASTM D4263 Plastic Sheet Test

Although this test is considered by many to provide the least conclusive results, it is popular since it is so easy to perform. Quite simply, an 18" square piece of clear plastic is taped to a clean concrete surface so that a sealed environment is created under the plastic. After 16 hours, if there is condensation under the plastic or if the concrete is darker in color than the surrounding concrete, it is considered 'too wet' to accept any coating. Since this is only a qualitative test and is subject to many criticisms, it has only limited value to the inspector and property owner. False negative results may produce expensive consequences.

ASTM F2170 Relative Humidity Test

This test for concrete provides quantitative results that are considered to be of high value when evaluating the potential for mold growth in organic materials placed directly against the concrete slab. Referred to by some as an equilibrium relative humidity test (ERH Test) or a Water Activity Test (a_w test), it quantifies the amount of moisture available within the concrete.

For the ASTM F2170 Test, a hole is drilled into the slab and, once acclimated, the relative humidity within the slab is evaluated. Some have found that this test can be successfully performed without drilling holes in the slab. An insulated dome is sealed to the surface of the concrete and, once acclimated, the Rh is determined within the environment under the dome.

This test is based on the fact that when concrete has a 5% moisture content @ 70ºF (21ºC), most concrete formulations will neither adsorb nor desorb moisture when the Rh above the concrete is 75%. With this understanding, we can conclude that an ERH of less than 75% *may* be acceptable for most floorings to be installed. However, if the question posed to the inspector is to determine the potential for mold growth, some have concluded that a Water Activity of less than .60 a_w (60% ERH) is prudent.

ASTM F1869 Calcium Chloride Test

This test is conducted similarly to the ERH test mentioned above, but the conclusions are different. A pre-measured amount of highly hygroscopic salt is placed in a dish, which in turn is placed on a thoroughly cleaned concrete surface. This is then covered and sealed to the concrete with a dome and the salt is left to adsorb the evaporating humidity from the slab. After 72 hours, the salt is accurately weighed, and the amount of moisture it has collected is determined.

The results of this test tell the inspector the desorption rate of water from the concrete slab, which is expressed in 'lbs. of water, per 24 hours, per 1000 sq. ft. of exposed concrete'. Most flooring manufacturers require a concrete slab to have less than 3lbs. to 5 lbs. H_2O/1000 ft^2/day.

Electronic Meters Radio Frequency or Capacitance Tests

Many recently introduced meters actually evaluate the quantity of moisture in concrete. Their value is clearly in the speed they provide to the inspector in conducting these tests. The owner's manuals for these units clearly caution the inspector to interpret the findings with attention to the different formulations found within concrete. It is therefore prudent to use these meters in conjunction with other tests.

Document it!

There are other less well-known tests like the *Gel Bridge Test,* and *Carbide – Acetylene Tests* for evaluating concrete. Regardless of the procedure followed, today's prudent restorer is aware that lowering moisture content in concrete *is* required in the return of a structure to a dry standard… and this restorer also *knows how* to evaluate this material and *accurately document* the moisture condition within the concrete.