



# Vapor Trails

## How Water Gets Through Slab-on-Grade Concrete

By Floyd Dimmick

Uncontrolled water vapor transmission through concrete causes millions of dollars of damage annually, creating problems for coatings applicators who haven't done their homework, and also creating opportunities for applicators who do, and know how to successfully repair and coat floors.

Over the years, excessive water vapor transmission through slab-on-grade concrete floors has caused adhesion failure of coatings, polymer overlays, cementitious grout beds, bonding ceramic tile, and other floor surfacing materials. Often the water movement is so aggressive that standing water will be on the floor surface, creating hazardous slippery conditions. Molds and mildews create health problems for workers in the area of transmission. Carpets and drapes in office areas are destroyed and products being manufactured in the general vicinity can be damaged beyond repair.

Unless the concrete is tested for vapor transmission prior to placement of the overlay, it is nearly impossible to know if the problem exists on new concrete floors. Older floors often exhibit defects — as shared in this article — that signal the need for testing.

To understand the dangers and solutions, it helps to know how water vapor travels through concrete, how this deteriorates the concrete and how the protective floor coatings or overlays are often damaged, as well.

### WILL CONCRETE TRANSMIT MOISTURE?

Yes. Regardless of the concrete composition, concrete is a hygroscopic material. Like a sponge, it will absorb moisture from the air and often expand. And if the humidity on one side of the slab is different from that on the other, it will transmit moisture, like a dry sponge dropped on a puddle of water.

The greater the cement content in relation to the original water content, the lower the rate of moisture transmission will be under given conditions.

### TWO IDENTIFIABLE METHODS OF WATER TRANSMISSION

1. **Hydrostatic Water Pressure.** Hydrostatic, or “head-pressure,” is the force caused by a column of liquid water. Imagine pushing an empty bucket into a basin of water and what you feel is head pressure. The deeper you push, the more pressure.

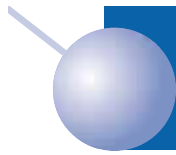
While hydrostatic water pressure typically will not harm solid concrete, denser concretes — those created with a water-to-cement (w/c) ratio of 0.40 or lower — have higher resistance to moisture transmission from hydrostatic and vapor pressures. However, hydrostatic water pressure will force itself as a liquid through quality concrete when defects such as sand streaking, honey combing, cracks and leaking joints have not been properly repaired.

Concretes with higher w/c ratios typically form more permeable cement paste, which encourages capillary movement of water as liquid and vapor. Hydrostatic pressure is only a problem when the water is in direct contact with the concrete surface.

2. **Water Vapor.** Water can exist with concrete as a solid (ice), liquid (water) or gas (vapor). Water vapor molecules more easily take the shape required to pass through the concrete mass, whereas the liquid state becomes a solid that maintains a definite volume or size.

Water vapor problems are typically associated with slabs-on-grade that are located in high water table areas, and where water membrane systems have been damaged and are holding water between the membrane and concrete slab.

Water in a liquid state is an essential part of portland cement concrete technology. It smears with about half the cement molecules in the concrete mix to create an adhesive cement paste — that bonds the sand and stone aggregates together. The other half is left as inert filler within the concrete mass. And of these filler molecules, about 25 to 40% are water-soluble.



# SOLUTIONS FOR CONCRETE REPAIRS

## WHAT CAUSES VAPOR TO MOVE WITHIN THE CONCRETE?

Since gases are capable of expanding and changing shape, they are capable of wiggling through the unused cement molecules and tiny voids as small as 5 micrometers within the concrete mass.

In general, the gas is harmless to the concrete mass as it moves through the structure. The problems start when the gas changes into a liquid state.

Typically, the gas does not turn into a liquid until the condensation process of reduction of matter into a denser state takes place. This is believed to only happen when sufficient size voids are present (see **Figure 1**). Concrete can only contain a certain amount of vapor at a given temperature. As the temperature of the concrete rises, so does the volume of vapor, and it decreases as the temperature falls. This is often referred to as the “yo-yo effect.” As the concrete cools further, the excess water vapor condenses within any surface void. If the temperature drops below the freezing temperature of water, frost is formed within the concrete.

As the condensation process takes place, the new water in liquid state contains a pH value of 7 or neutral. Water at a pH of 7 will attack other sources of ions that are available to change its chemistry. The weakest source of ions present within the void is the cement molecules. The cement molecules that are soluble are the first to be dissolved. As the process of condensation continues, so does the dissolving of the cement ions and the void continues to enlarge.

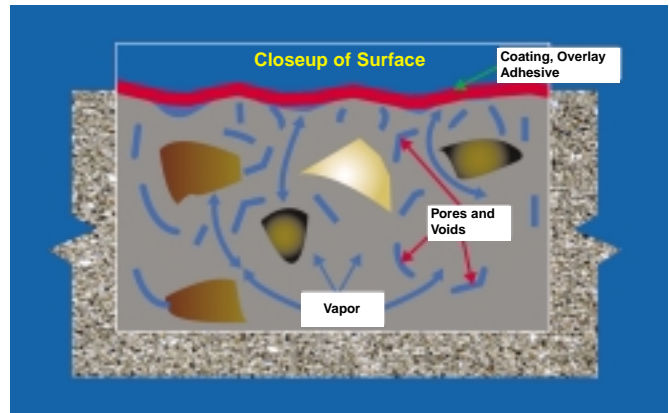
As the soluble molecules change their state, other molecules become exposed to the same destructive condition. Other insoluble cement ions and sand particles are affected by the loss of a solid material with which to bond. And when these voids within the concrete are closer to the floor surface, a large enough void causes overlay debonding, cracking or peeling (**Figure 2**).

## MORE DAMAGING FORCES

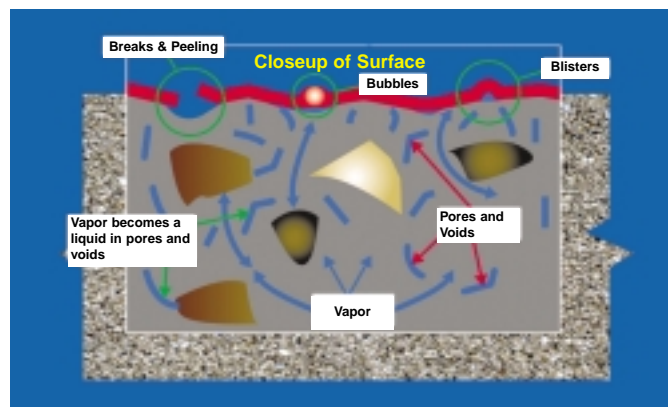
When the gas turns into a liquid, another new force is introduced, called capillary action. The liquid molecules are attracted more to the surrounding surfaces than its own surfaces. This force allows the liquid water molecules to travel in horizontal or vertical directions. Capillary action allows the water to travel through the deteriorating concrete surface just under the polymer overlay bond area. The liquid water molecules can actually force the coating to blister or bubble before final delamination occurs. This force also often causes considerable tension in the necks of coatings contractors who see their jobs going bad.

Water liquid molecules behave as though they have a delicate skin on their surface, and this holds them together in droplets. The water molecules that are closer to the outer concrete surface or to larger voids within the mass will exhibit another surface tension property, that of wetting out and dissolving the cement molecule to which they attach. Concrete is often subjected to wet and dry cycles. During the dry cycles, the water evaporates from the solution, leaving a dust or powder.

The result is that there is nothing fixed for the overlay to properly attach to and overlay failure is imminent.



**FIGURE 1: Voids in concrete provide space for condensation of water vapor to take place.**



**FIGURE 2: A void near the surface of a concrete slab can lead to overlay debonding, cracking or peeling.**

## CAN VAPOR TRANSMISSION BE STOPPED WITHIN AN EXISTING SLAB?

The good news is: Yes! In my next article, we'll look at the adverse effects of vapor transmission to concrete protective wear surfaces, how to identify vapor damage, the method most commonly used to detect and measure vapor transmission, how to stop vapor transmission, and provide a solid surface that the overlayment can adhere to without the affects of damaging vapor transmission.

CP

**Floyd Dimmick, Sr.** is co-founder and the Technical Director of Crown Polymers, an international polymer manufacturer of concrete repair products, and industrial and commercial floor systems. He has been actively in the design and application of polymer products for over 38 years and has developed new polymer technologies that are patented in the USA and Canada. He teaches 10 to 12 polymer classes for contractors annually and has numerous published papers and book chapters on concrete repair with polymers. He is currently an active member on many committees for ACI, and ASTM. His professional career is devoted to the performance of concrete repairs and preservation with polymers. He may be reached at [floyd@crownpolymers.com](mailto:floyd@crownpolymers.com).



**For more information call toll-free 1-888-732-1270.**

**CROWN POLYMERS, LLC.**

**44W104 Route 20 Hampshire, IL 60140 USA**

**Fax: 847-683-0890 [www.crownpolymers.com](http://www.crownpolymers.com)**

**e-mail: [info@crownpolymers.com](mailto:info@crownpolymers.com)**