FORMULA FOR DISASTER

IT'S A LITTLE-KNOWN PHENOMENON, BUT OSMOTIC

BY CHRIS WATTS

Imagine your client just spent thousands of dollars laying down a new concrete floor for his company's new headquarters. Your company installed the new floor, coating it with the latest decorative epoxy finish. But just days after the application, blisters start appearing and the tiles start lifting. Tragically, the floor is ruined.

Welcome to the costly effects of osmotic blistering, a little-known phenomenon in the construction industry.

People may remember osmosis from high school chemistry class. It's the phenomenon by which solutions try to reach equilibrium across a semi-permeable membrane. Water flows from a more diluted solution to a more concentrated one when separated by a semi-permeable membrane. Such membranes allow for the passage of water but not dissolved substances. When osmosis occurs in construction, the results are usually disastrous.

"We see a lot of cases of osmotic blistering in new construction because the bond interface of the newly coated concrete slab acts as a semi-permeable membrane, one of the key elements needed for osmosis to occur," Marc Schroeder, president of Liquid Plastics, Inc., a company that specializes in the formulation of protective coatings and membranes, says.

The osmosis process continues until either equilibrium is met or until the hydrostatic pressure generated by the increase in volume of the more concentrated solution equals that of the osmotic pressure. "In the case of a coated concrete floor, the pressure builds up at the interface between the coating and the concrete and causes blistering and progressive disbondment," Shroeder says. "The pressure generated by the osmosis can be as high as 3,000 pounds per square inch (psi), which is much greater than the bond of epoxies and other flooring systems to concrete substrates."

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Three construction materials must be mixed for osmotic blistering to occur. First is a semi-permeable membrane, which, in most cases, is the bond interface or the extreme upper layer of the concrete. The second is a concentration of water-soluble material (organic or inorganic), which can be anything from the resin ingredients in the epoxy coating to the material that can form at the surface of concrete when it is acid-etched or when workability or air-entraining admixtures (purposeful addition of air bubbles) are added to the concrete. Adding to the problem is the fact that Portland Cement has a naturally occurring soluble salt content that can act as a catalyst for osmotic blistering.

The third item needed to form osmotic blistering is water. "Even when we think

BLISTERING CAN RUIN CONCRETE JOBS

Osmotic blistering, as seen above, can occur in six-month-old projects or six-day-old projects. Seen here, the floor of an industrial warehouse has blistered where the concrete meets the drain.

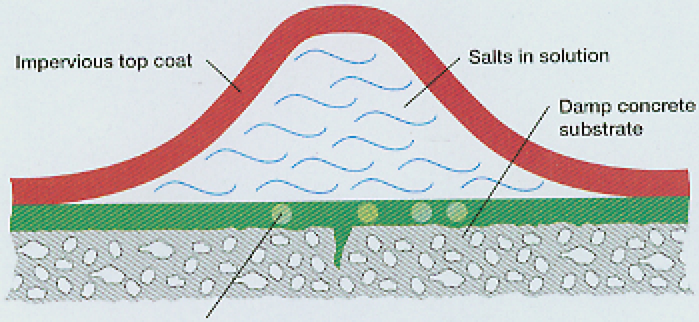
concrete is dry, it still contains up to 5 percent of free water by weight. This is enough moisture to start the osmotic blistering process," Shroeder says. Adding to the problem are other outside moisture sources like groundwater, drains, water left over from cleaning processes or condensation. "Once you have a combination of water, semi-permeable membrane and water soluble material, you have the perfect environment for osmotic blistering."

The worst part about osmotic blistering is there really is no litmus test to determine whether it will occur. Schroeder says he has seen it occur in projects six months old and six days old.

Moisture content in the concrete can be determined with the use of an anhydrous calcium chloride test kit. But even when the test reveals less than the usually acceptable upper limit of three pounds of moisture vapor emanating out of 1,000 feet in 24 hours, failures can occur.

"When osmotic blistering occurs, it's not necessarily because of a defective product from the epoxy manufacturers," Shroeder says. "Coating manufacturers usually expect their products to work with a moisture content of up to the three-pound limit, but the variable factors of solubility of entrained salts and driving forces (relative humidity and temperature differentials) can exacerbate the situation beyond anticipation," he said.

The osmotic process in concrete



AVOIDING OSMOSIS

So what can contractors do to prevent or minimize osmotic blistering? Some suggestions from Schroeder include:

- If possible, minimize the amount of soluble salts in the concrete design mix.
- Let the concrete dry for at least two months and/or ensure a fully functional water vapor barrier is underneath the slab when placed.
- Don't wash the concrete with detergent before applying coating.
- Accurately proportion and mix the epoxy coating resin constituents.

Obviously, some of those options aren't viable when it comes to timely construction. Most contractors don't have the option of letting slabs dry for at least two months. In some extreme cases, osmotic blistering will occur even if these suggestions are followed.

For example, when the floor lies below grade, it is extremely susceptible to osmotic blistering because of higher moisture content. Schroeder's company worked on such a project at the Hong Kong International Airport where the 600,000-square-foot baggage handling area lies 14 feet below sea level and is fully saturated with salt water.

"We were called in to consult on the Hong Kong problem five years ago when they were getting ready to open the new baggage handling facility," Schroeder says. "They were close to finishing the facility when they realized that a conventional epoxy coating system would not function over such a fully saturated slab."

HELP FROM TECHNOLOGY

But there are some new technologies that attempt to control osmotic blistering. Schroeder and his sister company, for example, developed a product called Cemprotec E-Floor. Based on an epoxy, metakaolin and a Portland Cement-modified polymer coating, the E-Floor creates a dense matrix that resists hydrostatic pressures up to 142 psi, yet can still allow the passage of water vapor. This allows the damp substrates to breathe by dissipating the water vapor into the coating without the build up of pressure and subsequent surface blistering. The water vapor migrating through the E-Floor to the epoxy topcoat is stopped by the epoxy film, but the vapor pressures generated are not sufficient to blister the epoxy topcoat. Since the application in Hong Kong, the coating system has been performing without blistering.

Last spring, Schroeder consulted on a 160,000-square-foot project in Haverhill, Mass., where the contractor had put down an epoxy coating system with an osmotic mitigating saturating primer underneath. The coating system started to fail after only six days. "The engineers were baffled. Calcium chloride tests indicated a range of three to six pounds of water per 1,000 square feet per 24 hours. The contractor had to strip 60,000 square feet of floor already coated and failed to recover the project."

There is no question in Schroeder's mind that osmotic blistering is one of the least-understood problems in the construction industry. He says many times contractors and engineers can take steps to reduce the chances of it happening by eliminating water sourcing into slabs and minimizing the presence of soluble salts.

Sometimes designers think that saturating the concrete surface with epoxy primer will close the pore structure, but that doesn't always work. "For some projects, it's just not possible to prevent osmotic blistering," Schroeder says. "Areas where water is a constant menace will always present a challenge."

"Whatever engineers choose to do, it's clear that they will always have to be on the look out for the conditions that can cause osmotic blistering and take proactive steps to prevent it from happening, or risk the consequences," Shroeder says.

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