Moisture Mitigation for Concrete Slabs

A brief description of alternative methods for dealing with slab moisture problems

By Peter A. Craig

Moisture-related problems with floor coverings and coatings applied over concrete slabs have become a serious and costly issue for designers, constructors, manufacturers, installers, and owners. Problems are being experienced on both new and renovation projects (Fig. 1).

With new construction, the challenge is to design and construct a concrete slab that will dry quickly to an acceptable level and stay sufficiently dry thereafter. For renovation projects, the contractor must deal with existing slabs that may emit higher levels of moisture than can be tolerated by the new floor covering system.

The Challenge

Under ideal conditions for floor construction, concrete having a practical low water-cement ratio (0.45 to 0.50) is placed on a true vapor barrier and cured 3 to 7 days using a method that retains mixing water but doesn't add additional water. The slab is placed with a watertight roof in place and no water from other sources contacts the floor during the ensuing drying period. Pre-installation moisture emission testing of the floor is conducted only after the HVAC system is operating and the temperature and relative humidity have stabilized at levels similar to those expected when the building is in service.

Typically, these conditions are unlikely to be fully met on most construction projects. For example, many tilt-up projects use the slab surface as a casting bed. The project may be months along before the walls are up and the roof installed and watertight. During the open period, the slab is subject to rewetting from rain or other construction activity and doesn't start drying until it's under roof and the HVAC system is operating or ambient conditions are conducive to drying. The construction schedule may require covering the floor soon after the building is enclosed, but the slab may not give up excess moisture as fast as the builder would like. When faced with meeting the completion schedule or waiting for the slab to dry, the decision is often made to meet schedule. The consequences of such a decision can be disastrous. Moisture vapor may move to the surface, condense beneath the floor covering, and dissolve soluble alkalis present in the concrete, thus increasing the pH level at the surface of the concrete. When floor coverings or adhesives are exposed to a prolonged, moist, high-pH environment, failures such as disbondment, blistering, adhesive breakdown, or adhesive bleed through seams occur. Liability exposure for such failures is seldom confined to one member of the construction team.

Fig. 1: Many flooring failures result when high moisture levels and a high pH beneath low-permeability floor coverings combine to produce adhesive failure

Problems with excessive moisture-vapor emission rates also arise on renovation projects. Many older facilities were constructed without a vapor barrier or retarder beneath the slab. In the days of solvent-based, cutback adhesives and asbestos tile, flooring problems were comparatively rare, even though the floor emitted moisture at a relatively high rate. The increased sensitivity of today's flooring materials to moisture and moisture-induced high pH levels, however, has lead to moisture-related failures occurring after new flooring has replaced flooring that performed well in service. In this case, the greater moisture-related sensitivity of the new flooring system has contributed to flooring failure.

In response to moisture-related flooring problems, several approaches are being promoted to mitigate moisture-related influences for new and remodel projects before the flooring is installed. These approaches include topical applications and alternative breathable finishes.

Fig. 2: Spray-applied reactive penetrants combine with alkalis within the concrete, reducing the pH and permeability to moisture vapor
(photo courtesy of SINAK Corp.)

Fig. 3: Moisture-retarding acrylic or specialized epoxy coatings slow moisture emission from the slab and help isolate the applied flooring material from the pH-raising effects of soluble alkalis in the concrete
(photo courtesy of Koester America)

Topical Applications

Topical applications used for moisture mitigation include the following:

- Reactive penetrants;
- Moisture-retarding coatings;
- Modified cementitious overlays;
- Dispersive membranes; and
- Combination systems.

Reactive penetrants. Reactive penetrants reduce moisture and soluble alkali transfer from the slab by reducing the surface porosity of the concrete and by chemically combining with hydroxides within the cement paste. The most common penetrants promoted for this use are based on sodium silicate, potassium silicate, or lithium silicate. They are generally spray applied (Fig. 2).

Applied properly, these materials have been used successfully and are often the least costly of the mitigative treatments. There are, however, several challenges to the success of these systems that must be considered. To be effective, reactive materials must first be capable of penetrating into the concrete surface. For moisture mitigation projects, the concrete surface must usually be shotblasted to open the surface. The reactive material must then find sufficient calcium hydroxide in the concrete to complete the intended reaction. Unfortunately, this doesn't always occur to an effective level. A pozzolanic material such as fly ash within the concrete can reduce the availability of calcium hydroxide needed by the reactive penetrant. In addition, reactive penetrants must not be overapplied. If a reactive penetrant is overapplied, material not properly reacted within the concrete will form an unstable film that can adversely affect the adhesion of subsequent treatments.

While several companies offer these systems as a stand-alone treatment, others use reactive penetrants only as the first step of a multistage system.

Moisture-retarding coatings. Moisture-retarding coatings in the acrylic and specialized epoxy family slow moisture emission from the slab and help isolate the applied flooring material from the pH-raising effects of soluble alkalis in the concrete (Fig. 3). The use of non-reemulsifying acrylics is generally limited to the least severe of moisture conditions, while several treatments in the epoxy group place no limit on the moisture emission rate they can be used to mitigate. It should be noted that the most successful mitigative treatments in the epoxy family are not simply off-the-shelf, conventional epoxy floor coatings. To be successful, an epoxy-based mitigation system must provide an effective combination and balance between moisture and alkali insensitivity and degree of permanence.

Modified cementitious overlays. Special epoxy- and copolymer-modified cementitious overlays (Fig. 4) are used to form a separation layer between the base concrete and the applied flooring system. Although not totally impermeable to water vapor, these extremely dense overlays are designed for condensate moisture to develop below the applied layer. By keeping solubilized salts within the concrete below the overlay, the potentially damaging effects of soluble alkali transfer and elevated pH levels at the adhesive or coating interface are avoided.

Dispersive membranes. These systems use a fiber mat membrane to provide a diffusion path beneath flooring materials. The membrane can be adhered directly to the prepared concrete surface or applied over certain penetrants and approved coatings (Fig. 5). The dispersive membrane concept was developed based on the observable effectiveness that asbestos fibers had when used in flooring materials. The theory is that the membrane isolates the flooring materials from

Fig. 4: Special epoxy- and copolymer-modified cementitious overlays are used as a separation layer between the base concrete and the applied flooring system
(photo courtesy of Liquid Plastics)

Fig. 5: Fiber mat membrane can be adhered directly to a prepared concrete surface or applied over certain penetrants and approved coatings to provide a moisture diffusion path

If an existing slab was built with no vapor retarder beneath it, a new slab, placed over a vapor retarder, is one renovation option

Other Renovation Options

For existing structures undergoing renovation, two other approaches can be considered when high levels of moisture are present and an effective vapor barrier is not in place beneath the floor. In the worst cases, the slab can be completely removed and replaced. Alternatively, in some cases, a new slab can be cast over the existing one. In either case, an effective vapor barrier should be installed directly beneath the new slab (as shown in the photo) and properly sized and spaced reinforcing steel should be used to help control curling and cracking. These approaches have been used successfully; however, considerable time is required for the new slab to dry prior to installing flooring.

direct contact with the concrete and provides an avenue for moisture to diffuse or travel horizontally within the membrane.

Combination approaches. Combination systems utilize two or more of the previously described approaches to moisture and alkali mitigation. Often the design of such systems is tailored to the measured moisture-vapor emission rate (MVER). Higher emission rates, for instance, may require multiple layering of coating and overlay or the use of a reactive penetrant with a moisture-retarding coating, dispersive membrane, or cementitious overlay.

All of these topically applied moisture mitigation systems are designed to overcome the effects of water vapor, condensate moisture, and moisture-induced high pH levels. They are not designed for projects where liquid water is directly in contact with the slab due to a hydrostatic condition or where capillary action in the soil brings water to the underside of the slab.

Alternative Finishes

Alternative finishes offer a different way to reduce moisture-related flooring problems without slowing the building schedule. Either they allow sufficient moisture to escape from the floor surface or they are not affected by high moisture levels.

Such finishes may include:

- Polished concrete;
- Stained overlays;
- Breathable coatings;
- Ceramic tile; and
- Nonadhered specialty tiles.

Polished concrete. Advances in diamond grinding equipment, grinding methods, and chemical surface treatments are combining to produce dense yet permeable floor surfaces with a high degree of sheen that doesn't wear off over

Fig. 6: Polished concrete surfaces serve a decorative function, while allowing moisture vapor to escape

time. Such floor finishes are easy to maintain and can be produced in colors or brought to a terrazzo appearance (Fig. 6).

Stained overlays. Stained cementitious overlays are being used to provide a durable, decorative surface for concrete slabs on and above grade. Such systems perform well in high pedestrian traffic areas and allow the designer and owner unlimited options as to patterns and colors (Fig. 7).

Breathable coatings. Coatings that allow moisture to pass through offer an approach to avoiding moisture-related problems associated with trapping moisture beneath a floor covering material.

Ceramic tile. Ceramic tile or quarry tile can be used as an alternative to more moisture-sensitive resilient floor coverings and adhesives. While prolonged exposure to high moisture and alkali levels can lead to joint staining, the frequency of joints and the mortar bed itself make these systems far more permeable and resistant to typical moisture-related flooring problems.

Specialty tiles. Certain types of nonadhered, interlocking tiles are designed to be used when high moisture emission levels are present (Fig. 8). To be effective, concrete beneath the tiles must be shotblasted to open the surface. If moisture condenses beneath these interlocking tiles, the opened concrete surface allows the condensate to be reabsorbed by the concrete.

The Best Approach?

The best approach for avoiding moisture-related flooring problems is designing and constructing a concrete slab for which ground moisture is taken completely out of play and ample time is provided for the concrete to dry internally to a safe level.

Fig. 7: Stained cementitious overlays provide a durable, decorative surface for concrete slabs on and above grade. They allow the designer and owner almost unlimited options of patterns and colors

(photo courtesy of Ardex, Inc.)

Many construction projects and schedules, however, simply cannot provide the time or environment needed for a concrete slab to dry naturally to an acceptable level. For the present time, such projects will be well served by including a topically applied moisture and/or alkalinity control system as a contingency item in the project specifications. An alternative may be found through the development of new adhesive formulations that offer a higher degree of moisture and alkali tolerance than first-generation, water-based materials.

The selection of the mitigation system itself should be made with great care and due diligence.

What About Accelerated Drying?

The time needed for a new concrete slab to dry to an acceptable level can be shortened by creating an environment above the slab that is favorable to moisture loss. Specialized heating and desiccant drying units are being used to create or circulate warm, low-humidity air over the slab surface to hasten drying.

This approach should not be considered as a stand-alone mitigation method unless an effective vapor barrier is in place directly beneath the slab. Without adequate sub-slab moisture protection, moisture within the slab will increase and can lead to flooring problems once the slab is covered.

In addition, moisture emission testing of the slab should not be conducted when the drying units are creating an abnormally dry ambient environment above the slab. Moisture emission testing must always be conducted in accordance with ASTM requirements, which include testing within the building's normal operational environment.

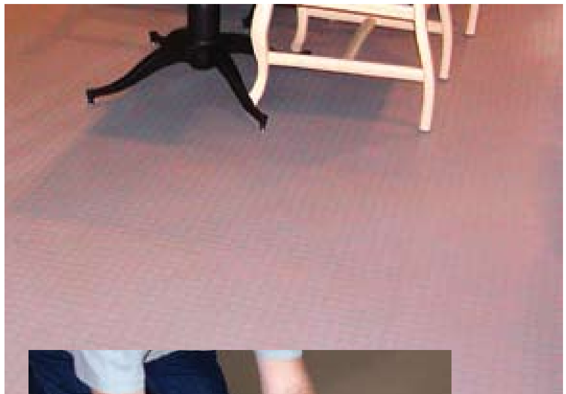

Fig. 8: Some nonadhered, interlocking tiles can be used when high moisture emission levels are present. Concrete beneath the tiles must be shotblasted to open the surface so any moisture condensing beneath the tiles can be reabsorbed by the concrete (photo courtesy of Flooring Adventures)

Many floor covering and coating manufacturers have experience with one or more systems and can help with the selection. The company providing the mitigation system should also provide a verifiable warranty that covers all costs associated with any flooring problem that may develop as a result of their system failing to perform. Typical full coverage warranties are available for periods up to 10 years.

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