VAPOR RETARDERS AND CONCRETE MOISTURE VAPOR TRANSMISSION

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Excessive concrete moisture vapor emission is known to cause distress or failure in modern floor covering and resinous coating systems. Most manufacturers of floor covering materials and adhesive systems have stated limits of tolerable concrete moisture content or vapor emission and concrete surface pH levels. While pH levels are primarily controlled by factors within the concrete itself, moisture vapor emission is not. Excessive concrete moisture vapor emission can be traced to four potential sources.

The first potential moisture source is the concrete itself. Construction schedules rarely contain sufficient time to facilitate natural drying of concrete. There exists an old "rule-of-thumb" regarding the time needed to achieve a dry slab. The "rule" suggests allowing one month of drying per inch of slab thickness, under ideal conditions. The ideal ambient conditions are a minimum temperature of 70 F, maximum 30% relative humidity and constant air movement at 15 m.p.h. The "rule" does not account for mix design water/cement ratio that will dramatically impact the required dry time. In his 1965 study entitled "Moisture Migration – Concrete Slab-On-Ground Construction" H.W. Brewer tracked moisture outflow of concrete as it dried. His study shows that high water/cement ratio concrete takes longer to achieve low level outflow than drier mix designs. This study alone justifies specifying concrete with a maximum water/cement ratio of between .45 and .50 on all projects that will require floor covering installation at slab ages of 6 months or less.

The second potential moisture source is water added to the concrete surface. This may take place during the drying process or years after the slab has been placed. Typically, we are looking at rainwater during construction and flooding after occupancy. Fire sprinkler systems that malfunction or pipes that burst may be significant sources of moisture that effect a concrete slab's ability to be viewed as an acceptable substrate for the installation of floor coverings. Surface originated moisture may be relatively easy to remove through the use of desiccant dehumidifiers and voluminous airflow.

The third potential source of moisture is the "blotter" course laid beneath the concrete slab but over the top of a vapor retarder. Moisture in the blotter course transmits vapor into the slab, which translates into excessive concrete moisture vapor emission. While some granular materials may be sufficiently compactable when dry, most materials used for this purpose must be wetted to achieve sufficient compaction. Field studies have shown that moisture content of blotter course material in excess of 1.5% - 2.0% will offer moisture vapor to the underside of a concrete slab. The rate at which this moisture enters and transmits through the slab is regulated by the permeability of the concrete and vapor pressure differentials that create motive force. ASTM E 1643 "Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs" contains an appendix that serves well in discussing pro and con the use of blotter courses under concrete slabs. We know that wetted blotter materials are a potential moisture source contributing to excessive concrete moisture vapor emission. The question remains; does the blotter course serve a useful purpose? For those who would argue the need for this layer as an aid in finishing the concrete, we need to look at suspended concrete, both structural and poured in pan lightweight, and note that no blotter course is found beneath either. The American Concrete Institute's ACI 302 "Guide for Concrete Floor and Slab Construction" contains a flow chart suggesting proper placement of vapor retarders. The flow chart calls for concrete to be poured/placed directly on top of a vapor retarder when moisture sensitive floor coverings or coatings are to be installed on the concrete slab surface. It is fair to say that all modern floor coverings and resinous coatings are moisture and or alkali sensitive. While the concept of removing the blotter course and associated moisture source is applauded, there are pitfalls to be avoided. Concrete slabs placed in "spec" buildings often have no idea of what future tenant needs may be. If for example a tenant needs drain services throughout a laboratory setting, numerous saw cuts through the concrete may be required. Saw blades may be held at a depth that cuts concrete but not vapor retarders when a blotter course separates the two. This will allow trench work to include repairs to the vapor retarder with relative ease. However, if concrete is poured directly on top of a vapor retarder the membrane will be cut along with the concrete during sawing operations and repairs may be quite difficult.

Consider the following information and example; Concrete moisture vapor emission is quantified through calcium chloride test kits. The test measures moisture adsorbed by salt in a test area that covers approximately ½ foot square. The measurements are extrapolated and reported as vapor emission per 1,000 square feet per 24 hours. Assuming we have a 2" thick blotter course of sand residing between the concrete slab and a vapor retarder we can make the following assessments. Dry sand weighs approximately 100 pounds per cubic foot. Wetted to achieve compaction, this sand could easily contain 10% moisture by weight, or 10 pounds of water per cubic foot of sand. One cubic foot of sand cut into 2" thick sections will cover 6 square feet of vapor retarder. It will take approximately 167 cubic feet of sand to cover 1,000 square feet of vapor retarder. Therefore, employing standard construction techniques, it may be said that each 1,000 square feet of concrete surface could easily have 1,670 pounds, or 200 gallons of water sitting in reserve just beneath it!

If isolated, all of the moisture sources discussed above will dissipate over time. The source that is most troublesome in older buildings and can equally impact newer ones is moisture naturally available in the earth or added through irrigation and drainage. This is the largest source of moisture transmission when it is not properly inhibited from reaching the concrete slab. In most cases this moisture source could be easily controlled by employing an effective sub-slab moisture vapor retarder. There are now numerous manufacturers with products to choose from. These materials offer stated permeance ratings, puncture resistance, decay resistance, installation and repair instructions. It is important to recognize the fact that standards for these products no longer refer to them as "vapor barriers", the term has been changed to "vapor retarder". While some of the best quality products may approach the concept of being barriers, all offerings have permeance ratings. All offerings pass some measurable amount of moisture vapor. Unfortunately and too often construction specifications regarding these materials call for "Visqueen" or simply require 6-mil plastic. VisQueen is a trademark of the Tredegar Corporation and they no longer manufacture sheet plastic for use as in ground moisture vapor retarders beneath concrete slabs. A company in the United Kingdom, Visqueen Building Products, does produce plastic film with the Visqueen name for use as a sub-slab vapor retarder. However, the distribution of this product is limited to Europe. Ultimately, most the materials used as vapor retarders and placed beneath concrete slabs in the United States are of unknown quality or permeability. Many re-cycled and re-ground materials are being placed in low cost films. Re-processed plastics can dramatically increase film permeance when compared to permeance of sheets comprised of high quality virgin materials. Construction specifications should refer to ASTM E 1745 "Standard Specification for Plastic Water Vapor Retarders Used in Contact with Soil or Granular Fill Under Concrete Slabs" when referring to vapor retarder selection and ASTM E 1643 "Standard Practice for Installation of Water Vapor Retarders Used in Contact with Earth or Granular Fill Under Concrete Slabs" when referring to proper installation practices. It is this author's opinion that vapor retarder selection should be limited, beyond the standards referenced above, to materials with water vapor permeance ratings of 0.050 perms or less when tested in accordance with ASTM E 154 "Standard Test Method for Water Vapor Retarders Used in Contact with Earth Under Concrete Slabs, on Walls, or as Ground Cover"

A new industry has developed that specializes in the topical control of excessive concrete moisture vapor emission and elevated pH levels. These products/services have been necessitated by government mandated changes in floor covering systems including the loss of asbestos from materials and solvents from adhesives and coatings. Concrete slabs that are already in place may require topically applied control products/systems to facilitate the installation of modern floor coverings. Concrete slabs that are in planning should be designed to achieve maximum strength with minimum permeability. They should be effectively protected from intrusive moisture sources and permitted to dry before floor coverings are installed. The minimal cost associated with reducing or eliminating excessive concrete moisture vapor emission through concrete slab system design pales against the remedial cost of moisture vapor driven floor covering system failure. Proper selection, specification and installation of an effective sub-slab moisture vapor retarder is a key ingredient in any concrete slab-on-grade system design.

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