Appendix III – Sand Layers Should Not Be Placed Between Polyethylene Vapor Barriers and Concrete Floor Slabs

Sand Layers Should Not Be Placed Between Polyethylene Vapor Barriers and Concrete Floor Slabs

by Joseph Lstiburek, Ph.D., P. Eng.

Excess slab moisture intrusion problems resulting in flooring failures, mold growth and other microbial contamination problems are typically due to sand layers located between polyethylene vapor barriers and concrete floor slabs.

The sand layers become reservoirs for water in the liquid state (bulk water) that enters the sand layers by gravity flow from the top, sides and bottom of the sand layers (**Figure 1**). The liquid water is both held in the sand layers and redistributed within the sand layers by capillarity (**Figure 2**). Additionally, due to these capillary forces, the liquid water is incapable of draining out of the sand layers. The only mechanism of drying of the sand layers is upwards through the concrete slabs by vapor diffusion and capillary draw (**Figure 3**).

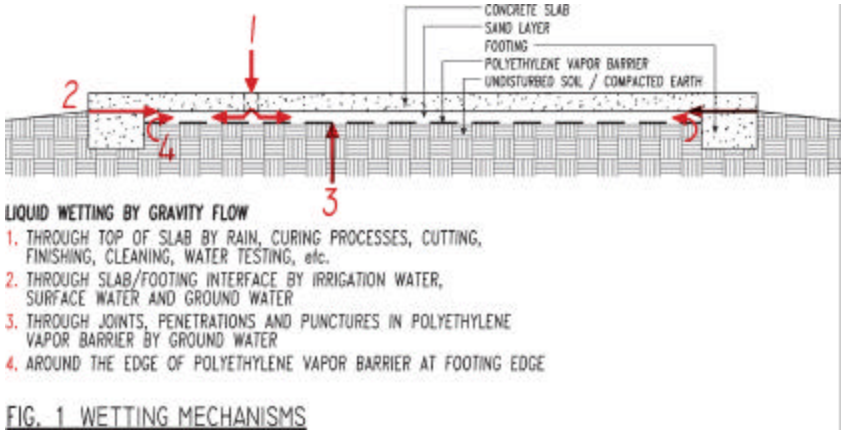

FIG. 1 WETTING MECHANISMS

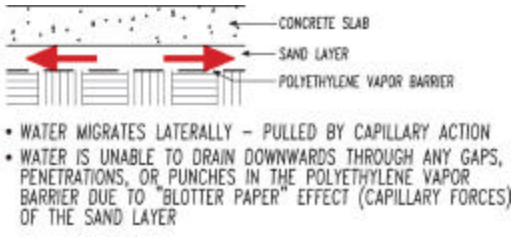

FIG. 2 WATER DISTRIBUTION IN SAND LAYER

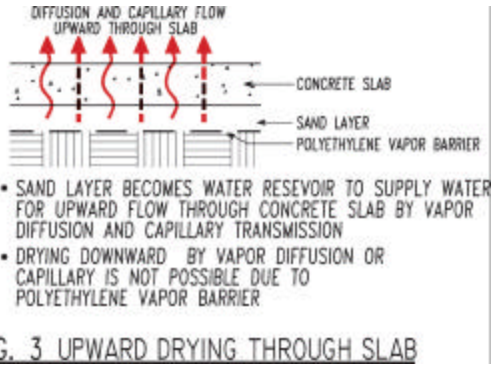

FIG. 3 UPWARD DRYING THROUGH SLAB

There is no barrier or protection for the upward moisture flow through the concrete slabs from the wetted sand layers. The intended protection for upward moisture flow from below grade are the polyethylene vapor barriers, but this intended moisture protection has been rendered ineffective by the gravity flow wetting mechanism that has saturated the sand layers that are located above the polyethylene vapor barriers.

The moisture flow upwards through the concrete slabs by vapor diffusion and capillary transmission passes through the top surface of the concrete slabs as well as through floor surface treatments and leads to mold and other microbial contamination problems.

The rate of wetting of the sand layers by the gravity flow wetting mechanism is several orders of magnitude greater then the rate of drying of the sand layers by the vapor diffusion and capillary transmission drying mechanism. The sand layers become water reservoirs that continually supply water for the upward flow through the concrete slabs by vapor diffusion and capillary transmission.

Picture the sand layers as "blotter paper" that once wetted do not let water drain out of them. The only method of drying available to the "blotter paper" is evaporation. In the case of the sand layers the only method of "evaporation" is upwards through the concrete slabs due to the presence of the polyethylene vapor barrier under the sand layers.

Concrete slabs should be placed in direct contact with polyethylene vapor barriers. A sand layer should not be installed between concrete slabs and polyethylene vapor barriers.

Where concrete slabs are in direct contact with polyethylene vapor barriers a reservoir is not created if rainfall occurs during the construction process and penetrates the slab, or if wet curing is used. Additionally, wet concrete cutting operations, cracks in slabs, gaps and penetrations in the polyethylene vapor barrier coupled with cleaning, water testing, ground water migration or irrigation do not affect slab moisture transmission if a reservoir is absent or cannot be created between the polyethylene and the concrete slab.

When concrete slabs are cast directly over polyethylene vapor barriers the concrete water-to-cement (w/c) ratio must be correctly specified in order to control bleed water and plastic shrinkage cracking. Bleed water will not be present if the w/c ratio is below 0.5 and plastic shrinkage cracking becomes negligible when the w/c ratio is below the range of 0.48 to 0.45. Differential drying and slab curl are controlled with either a curing compound or a temporary covering of plastic sheeting.

Concrete slabs with a w/c ratio of 0.45 or less should be placed directly on a polyethylene vapor barrier coupled with a curing compound or a temporary plastic sheeting slab covering in order to avoid problems.

The following 4 reasons are generally cited for using a sand layer over polyethylene vapor barriers is as follows:

1. The sand layer controls bleed water with high w/c ratio concrete slabs
2. The sand layer reduces curl with high w/c ratio concrete slabs when top-side curing is not controlled
3. The sand layer reduces plastic shrinkage cracking with high w/c ratio concrete slabs
4. The sand layer protects the polyethylene vapor barrier from punctures

The first three reasons are based on sound technical arguments. However, each of the first three are based on the condition that the sand layer be prevented from getting wet during the construction process and beyond and are typically associated with floor slabs that are placed "after the building is enclosed and the roof is watertight." Additionally, the first three are based on the condition that wet curing such as ponding or continuous sprinkling will not occur or that joint sawing using wet methods or power washing will not occur. The first three are also conditional on slab and foundation designs that will not be sensitive to ground water wetting from local water tables and local irrigation.

In the case of exposed slab construction, the first three reasons are rendered moot since the conditions for their use are not met ? nor can they be met. Accordingly, a sand layer should not be specified.

The fourth reason, "puncture protection", is based on incorrect physics. A sand layer is not necessary to protect polyethylene vapor barriers. Vapor diffusion is a direct function of surface

area. Rips, holes, tears and punctures in sheet polyethylene vapor barriers constitute a very small surface area of vapor transmission compared to the total floor slab area. If 95 percent of the surface area of the slab is protected by a vapor barrier, then that vapor barrier is 95 percent effective. This holds true only if air flow or air leakage is not occurring through the vapor barrier. Where concrete is in direct contact with the polyethylene vapor barrier this is the case. Air flow is not occurring. The concrete slab is an "air-barrier" and the polyethylene is the "vapor barrier" ? and an effective vapor barrier even if the polyethylene has numerous punctures.

In the case of exposed slab construction there is no justification for the use of a sand layer between the polyethylene vapor barrier and the concrete slabs.

The specification of a sand layer over a polyethylene vapor barrier is typically directly responsible for flooring failures, mold and microbial contamination problems.