SUB-SLAB VAPOR BARRIERS

by Bruce Suprenant

Workers place a vapor barrier over compacted sand before pouring a slab.

WHEN PLACED CORRECTLY, A VAPOR BARRIER REDUCES SLAB CRACKING, INCREASES CONCRETE STRENGTH, AND LIMITS CURLING AT THE EDGES

Many architects, engineers, and builders use a vapor barrier under concrete slabs, but the location of the vapor barrier varies. Sometimes the vapor barrier is placed directly under the slab. In other cases, a layer of sand or crushed gravel is placed over the vapor barrier before the concrete is placed. Each location affects slab performance; is one better than the other?

Why Use a Vapor Barrier?

Anyone who's ever damp-proofed a foundation knows that concrete is permeable. Water draining down through backfill material or rising up with a high water table will eventually make its way through a concrete wall to the living space inside.

The same is true of a slab. A concrete slab placed in direct contact with the soil will absorb moisture from a high water table. Even in well-drained soil, a relatively dry slab will wick up moisture through capillary action, the same way a dry sponge draws up water from a spill. A vapor barrier used under a slab reduces the flow of moisture up through the slab, protecting floor coverings and furnishings on the slab's surface from damage. Recently, vapor barriers have also been used to reduce the infiltration of radon.

While a vapor barrier may not always be necessary, it makes sense to use one anyway. It's less expensive to install a vapor barrier at the time of construction than to correct moisture problems later.

The most common vapor barrier is a 4-mil or 6-mil polyethylene sheet placed on a compacted subgrade. If the subgrade is crushed stone or a similar abrasive material, using a thicker poly sheet will reduce tears and punctures. In extreme conditions, sheet membranes, such as EPDM, are used because they stand up well to abrasive subgrades and allow less water vapor to pass through.

Regardless of the sheeting thickness, vapor barrier joints should be lapped at least 6 inches. When foot traffic is heavy or the wind is blowing, tape or fold the joints to keep them from coming undone.

How a Vapor Barrier Affects a Slab

Until recently, concrete slabs were placed directly on the vapor barrier. While this reduced water migration through the concrete, it often had a detrimental effect on slab quality. As a result, architects and engineers have begun to specify a 1-inch to 3-inch-thick layer of sand or gravel to be compacted on top of the vapor barrier before placing the concrete. This layer acts as a capillary break, reducing the effect of the vapor barrier on concrete quality while preserving moisture protection.

Each method has a different effect on finishing time, concrete strength, cracking of the slab, and the tendency of the slab to curl at the edges.

Finishing time. When concrete is placed directly on a vapor barrier, no water can escape downward into the soil. This increases the amount of "bleed water" that is pulled to the top surface by evaporation and bull floating. If the slab finishers do not wait for the bleed water to disappear completely before troweling, surface defects — such as crazing, dusting, and scaling — can occur (see Figure 1). Depending on the amount of water used in the concrete mix, excess bleed water can add hours to finishing time.

When a vapor barrier is not used, some mix water is lost to the subgrade below, reducing the amount of water that is pulled to the surface through evaporation. A granular layer placed between the vapor barrier and the concrete has a similar effect. By absorbing some of the mix water, the layer of sand or gravel reduces the amount of water that migrates to the slab surface.

Cracking. Slabs placed directly on a poly vapor barrier crack much more extensively than slabs placed on a vapor barrier covered with a granular layer. As is the case with bleed water, the capillary break absorbs some water from the concrete, allowing the slab to cure more evenly, thus reducing cracking. This is especially true of "wet" concrete mixes with a high slump of 8 or 9 inches.

Strength. Core samples taken from slabs placed using both methods have shown that concrete placed over a granular layer is about 30% stronger than the concrete cast directly on a poly vapor barrier. Again, the granular layer absorbs water, increasing concrete strength. There is little danger that the granular layer will absorb too much water and *reduce* slab strength. Most concrete mixed for residential slabs-on-grade has a high enough water-cement ratio to fully hydrate, or cure, all of the cement, even if some water is absorbed by the capillary break.

Figure 1. *Placing a slab directly on a vapor barrier can cause excess bleed water to rise to the surface (top). Troweling the slab before all the bleed water has disappeared can cause surface defects, such as crazing (middle) and scaling (bottom).*

Why Slabs Curl

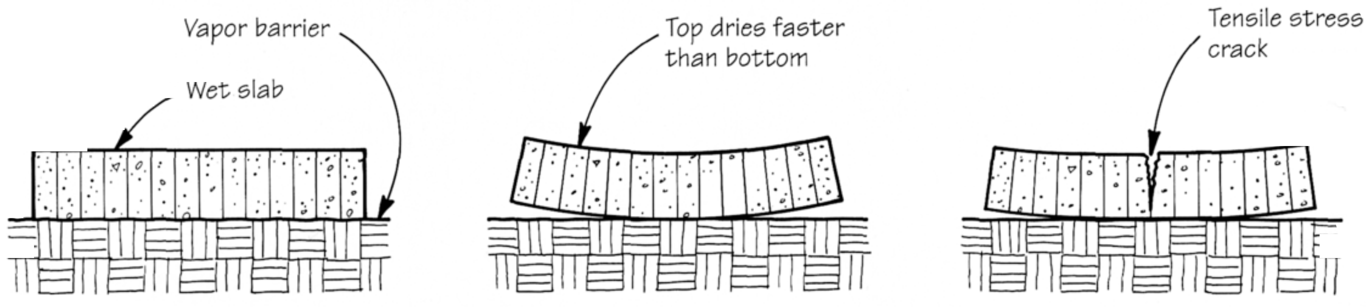

Figure 2. *Imagine a wet slab as a series of thin rectangular slices (left). If the top of the slab dries more quickly than the bottom, the slices become slightly narrower at the top. This can cause the slab to curl, especially at the edges (center). Eventually, the increased tensile stresses will also cause the slab to crack (right).*

Slab curling. When a slab is placed in direct contact with a poly vapor barrier, the bottom of the slab loses no moisture while the top dries rapidly. This causes shrinkage at the surface that pulls the edges of the slab upward (Figure 2). Placing the concrete on a granular layer helps reduce curling by balancing the moisture content at the top and bottom of the slab.

A granular layer may also reduce curling caused by puddles of water beneath a slab. A free-draining granular layer between the vapor barrier and the slab helps to distribute water more uniformly below the slab so that differences in moisture content aren't as great.

Using a Capillary Break

The location of the vapor barrier probably doesn't matter if a high-quality concrete with a low water content is used, and it's finished correctly. Under these conditions, concrete performance will be the same regardless of whether the concrete and vapor barrier are separated by a granular layer.

But conditions on site are rarely perfect. Using a granular layer, especially with concrete that has a high water content, can improve strength and surface quality. As with the vapor barrier itself, the cost of installing the granular layer is small compared with the cost of repairing problems with the slab.

There are also sound practical reasons for using a granular layer. When concrete is placed directly on the vapor barrier, the slab finishers may deliberately punch holes in the vapor barrier to reduce the rise of bleed water so the slab will set quicker. But puncturing the vapor barrier defeats its purpose. If you can't inspect site conditions at the time the concrete is placed, using a granular layer should reduce bleed water and deter the finishers from puncturing the vapor barrier.

Placing the concrete over a granular layer also helps protect the vapor barrier from being punctured accidentally while the concrete is being placed.

How thick a layer? The American Concrete Institute recommends spreading a 3-inch-thick sand or gravel layer over the vapor barrier (Figure 3). The layer should be fully compacted before the concrete is placed. Gravel is best because even a well-compacted 3-inch layer of sand can be easily displaced during concrete placement. The sand can mix with the concrete or vary the slab thickness, both of which result in a weaker slab. Gravel has a greater variety of particle sizes, making it more stable and harder to displace.

Another, more expensive, option is to spread a layer of crushed stone over 50-mil poly sheeting. The crushed stone can support heavy compaction equipment, and won't be disturbed during placement of the concrete. Place a thin layer of sand on top of the crushed stone base to reduce friction — called subgrade drag — between the crushed stone and the concrete slab. When there is less friction, the slab can shrink and contract uniformly, reducing the number of cracks that form. ■

Using a Capillary Break

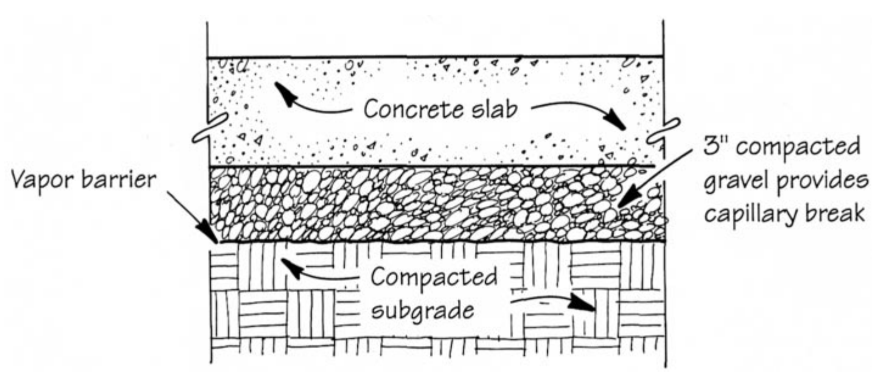

Figure 3. *To create a capillary break, use a 3-inch-thick layer of sand or gravel over the poly vapor barrier, and compact it before placing the concrete slab. Gravel works better than sand because it is less likely to mix with the concrete or create thin spots in the slab.*

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