FILLING THE GAPS

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Examining Puncture Resistance

Tests confirm ACI 302 recommendations for minimum vapor-retarder thickness

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When constructing a floor, concrete contractors often unroll a sheet of plastic vapor retarder over the subbase and cover it with a blotter layer of compacted granular fill before placing concrete on the fill. But how effectively do vapor retarders resist punctures during construction operations? The answer is important because moisture vapor easily passes through a punctured vapor retarder and can damage moisture-sensitive floor coverings (Ref. 1).

Using ACI 302-96 (Ref. 2) recommendations as a guide, we developed a test program in which we placed plastic sheets of different thicknesses on subbases and under fills composed of compacted rounded (natural) or angular (crushed) aggregates. When we removed the compacted fill and examined the sheets for punctures, we found out which thicknesses performed best.

Compacting a granular fill on top of a vapor retarder can cause punctures.

ACI 302 recommendations

Although contractors sometimes use plastic-sheet vapor retarders with a thickness of as little as 6 mils, ACI 302-96 strongly recommends a minimum 10-mil sheet thickness. The increased thickness reportedly provides more durability during and after installation.

For vapor retarders placed on a rough, granular subbase, ACI 302 recommends compacting a thin layer (about ½ inch thick) of fine-graded material on the subbase before placing the vapor retarder on it. This reduces the possibility of puncturing the plastic sheet. ACI 302 also recommends placing a layer of granular fill that can be trimmed and compacted over the vapor retarder to act as a blotter layer and to protect the vapor retarder during concrete placement.

We devised a testing program to evaluate vapor-retarder puncture resistance when ACI 302 recommendations were followed.

The tests

We ran two test series (A and B) using 6-, 8-, 10-, and 20-mil-thick vapor retarders and different combinations of rounded and angular aggregate subbases and fills. Maximum size for all aggregates was ¾ inch. For Series A, we placed the vapor retarder directly on either a rounded or angular compacted subbase before placing and compacting rounded or angular fill layers over the retarder. For Series B, we placed a ½-inch-thick sand layer over the compacted subbase containing angular aggregate and, in both cases, placed angular-aggregate fill layers over the vapor retarder. Following is a summary of the tests in each series:

Series A

- Rounded, compacted subbase; vapor retarder; rounded, compacted fill
- Angular, compacted subbase; vapor retarder; angular, compacted fill

Series B

- Rounded, compacted subbase; vapor retarder; angular, compacted fill
- Angular, compacted subbase; ½-inch sand layer; vapor retarder; angular, compacted fill

Both series included all four vapor-retarder thicknesses. After each test, technicians carefully removed the compacted fill by hand and retrieved the vapor retarder for visual inspection. The test setup for each series is further described in the sidebar.

Thicker is better

The 20-mil vapor retarders had no punctures regardless of the subbase or

Test details

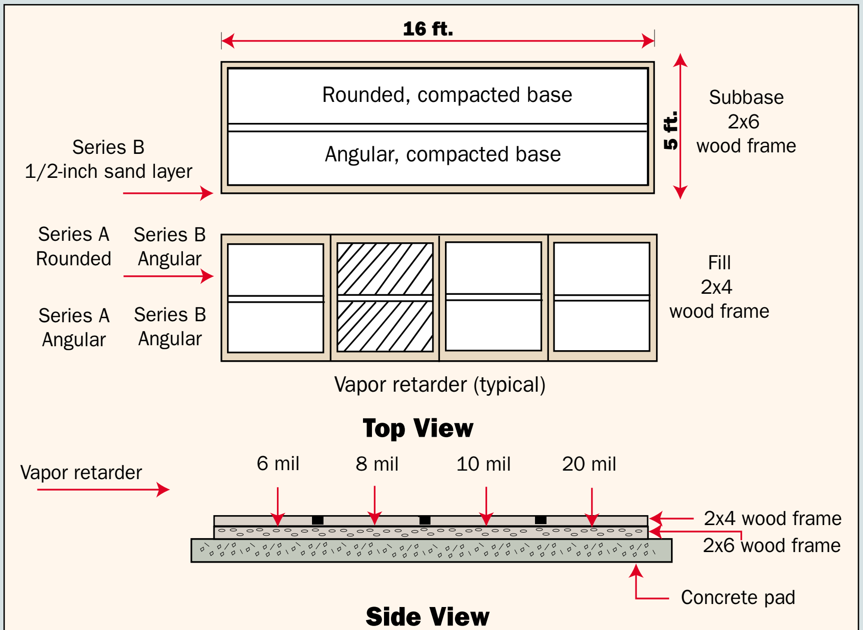
A 16x5-foot test section was divided into two strips, with the rounded subbase material placed and compacted in one strip and the angular subbase material placed and compacted in the other. A 2x6 wood frame contained and divided the subbase material (see drawing).

Technicians used a plate compactor to compact the subbase and subsequent fill to a minimum of 95% dry density at optimum moisture content. After the subbase was wetted and compacted, the plastic vapor retarders were placed. Each plastic sheet covered a quarter of the test section, or a 4x5-foot area. One-half of the sheet was on rounded, compacted subbase, and the other half on angular, compacted subbase. After technicians placed each sheet, they set a separate 2x4 wood frame over it, nailing the frame to the 2x6 frame below. They pulled the edges of the sheet up over the 2x4 wood frame, and then shoveled the loose fill material on top of the plastic.

Before examining the vapor retarder for punctures, we carefully removed the fill with a broom.

After compacting the fill, they lifted off the 2x4 wood top frame and removed the compacted fill by hand and with a broom. To avoid tearing the plastic, no shovels or other metal tools were used. Once the fill was removed, we visually observed the plastic for punctures.

After Series A tests, the procedure was repeated for Series B. For both series, technicians used sand-cone density tests to measure the percent compaction for the subbase and fill based on moisture-density curves developed for the rounded and angular materials.



Frames used for evaluating the effects of vapor-retarder thickness and aggregate angularity on puncture resistance.

Left: This vapor barrier had been damaged before it was placed on the subbase. Below: Visual examination revealed the number of punctures caused by compacting granular fill on top of a vapor retarder.

fill material used. And, as expected, the number of punctures increased with decreasing vapor-retarder thickness (see table below).

Also as expected, fewer punctures occurred when rounded subbase and fill materials were used and more punctures occurred with angular materials. The ½-inch sand layer over the angular subbase reduced the number of punctures.

These test results indicate that following ACI 302 recommendations significantly reduces the number of possible vapor-retarder punctures. A 6- or 8-mil vapor retarder may give satisfactory performance if both the subbase and fill material are rounded. However, the 10-mil vapor retarder recommended by ACI 302 is more likely to perform well with a wider range of subbase and fill material combinations.

In our tests, technicians placed the fill by hand before compacting it; there was no construction traffic on the vapor retarder, as might occur on a typical jobsite. Such traffic might cause more punctures than we got by simply compacting the fill. Thus, using the recommended 10-mil thickness, or greater, seems prudent.

We also found that construction operations may not be the only causes for punctures. The photo (above, left) shows 10-mil plastic sheeting that was damaged during manufacturing or shipping, resulting in larger holes than were produced by our puncture tests. ■

Vapor-retarder performance (punctures per square foot)

Vapor-retarder thickness	Subbase: / Fill:	Rounded / Rounded	Angular / Angular	Rounded / Angular	Angular* / Angular
6 mil		<1	>5	2 to 5	2 to 5
8 mil		<1	2 to 5	<1	2 to 5
10 mil		None	<1	None	<1
20 mil		None	None	None	None

*½-inch-thick sand layer over subbase

References

1. Bruce A. Suprenant and Ward R. Malisch, "Don't Puncture the Vapor Retarder," *Concrete Construction*, December 1998, pp. 1071-1075.

2. ACI 302.1R-96, "Guide for Concrete Floor and Slab Construction," American Concrete Institute, Farmington Hills, Mich., 1997.