Stiff Subfloor Protects Tile Job

by Robert Randall, P.E.

Repeatedly during inspections and troubleshooting investigations, I find ceramic tile floors with long crack lines that follow the joints in the plywood subfloor or underlayment below. Sometimes these cracks form a perfect trace of every joint throughout the room.

This cracking is caused by the edge rotation of the plywood sheets as they flex under load. Ceramic tiles, being inherently very stiff but not particularly strong, simply crack along these flex lines.

The problem can be prevented by increasing the stiffness of the subfloor and eliminating the flex points. A double layer of plywood, glued and screwed, and with all joints staggered, can do just this (see Figure 1).

Stiffness vs. Depth

The success of this technique derives from an engineering principle that says that the stiffness (*I*) of a bending member is directly proportional to the third power of its depth, or

$$I = \frac{BD^3}{12}$$

Translated, this means that doubling the *effective* thickness results in eight times the stiffness of the original member (see chart, page 54). Figure 2 on page 55 shows a simple demonstration I use to show doubters that two layers of plywood glued together are as stiff as eight unglued layers and eight times as stiff as a single layer. The glue provides a *shear connection*, by preventing the two layers from sliding in relation to one another. This causes the two layers to function with an effective thickness equal to their sum.

When properly executed, this laminated subfloor assembly is extremely

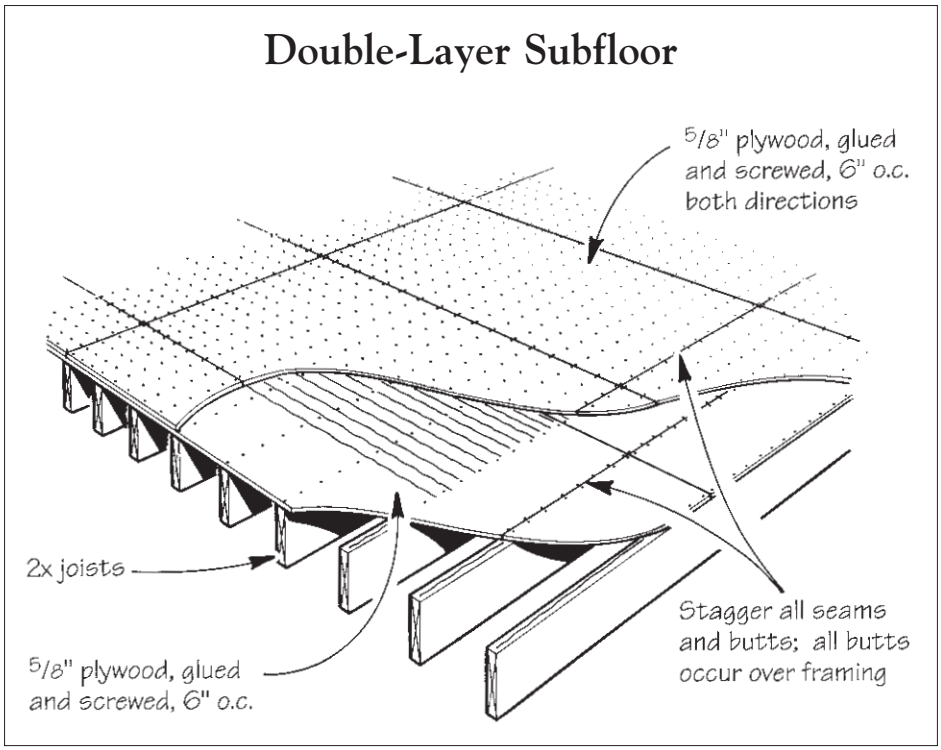

Figure 1. *A double layer of plywood, glued and screwed, is eight times stiffer than a single layer. Note that the grain of both layers runs in the same direction and that all butt joints must fall over a joist.*

Relative Stiffness of Plywood Subfloors

Plywood Thickness	Stiffness Factor
Single Layer Subfloor	
1/2"	1
5/8"	1.9
3/4"	3.37
Glued-and-Screwed Assemblies	
1/2" + 1/2"	8
1/2" + 5/8"	11.36
5/8" + 5/8"	15.36
5/8" + 3/4"	20.72

stiff, strong, and tough. It's even more dependable than most "mud jobs," which can crack unless mortar strength, thickness, and reinforcing are extremely well controlled. Once the mortar bed cracks, the tiles in turn may flex and crack.

About Cement Backerboard

Many contractors advocate using glass-fiber-reinforced cement backerboard over a plywood subfloor as a tile underlayment. While cement backerboard is a good tile substrate as far as its compatibility with tile goes, it depends on the plywood and floor structure beneath for stiffness and support. A subfloor assembly of plywood and cement board is not as strong as the glued-and-screwed double plywood assembly for two reasons: The plywood and backerboard expand and contract at different rates, and there is no good way to create a shear connection between the two materials. (The same is true of a mud bed over plywood.)

Do's and Don'ts

Here's how to build the double-plywood subfloor for a trouble-free tile installation:

- Use 5/8-inch or heavier plywood (APA Underlayment, C-C Plugged, or Plugged Crossbands grade).
- Sand the inner surfaces clean before applying glue.
- Use carpenter's glue, applying a 1/8-inch bead at 2-inch intervals.

Figure 2. *By hanging brick weights from plywood strips and measuring deflection with yardsticks, the author demonstrates that two layers of plywood glued together (in middle) deflect as much as eight layers unglued (top) and one-eighth as much as one layer (at bottom).*

- Place screws 6 inches on-center both directions.
- Stagger all joints.
- Align surface grain of both layers.
- Run surface grain across joists.
- Provide proper ventilation beneath the subfloor.
- Install a complete vapor barrier in crawlspaces.
- Allow 24 hours for glue to dry before tiling.

Here are some things to avoid:

- Don't allow sawdust or dirt to prevent bonding.
- Don't locate butts between joists.
- Don't apply glue below room temperature.
- Don't scrimp on screws or glue.
- Don't leave "expansion" gaps between sheets of plywood. ■

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Is there a building practice you've always wondered about? Or a lunchtime debate you'd like settled? Send your questions to Practical Engineering, JLC, RR 2, Box 146, Richmond, VT 05477; or e-mail to 76176.2053@compuserve.com.