A Cure for Bouncy Floors

by Robert Randall, P.E.

A recent letter from a remodeler describes a common problem: a springy great room floor, framed with 2x10s 16 inches on-center spanning 15 feet on both sides of a center girder. The existing condition poses no real safety issue; it's just plain too bouncy. What's the best way to stiffen this floor, the reader asks, with minimal disturbance to existing finishes? Upstairs there is tile in the great room kitchen area and carpet in the living and dining area; downstairs, in the basement, there is a dropped ceiling.

The usual methods would be to either double the joists or add a second girder in the middle of the 15-foot span. Adding joists becomes less attractive because of the presence of the kitchen plumbing pipes, while posts for a second girder would intrude upon the living space below.

There is another option worth considering: to "skin" the bottom of the joists with a layer of plywood, effectively turning the floor system into a plywood stressed-skin panel. I have used this technique successfully in a similar remodeling situation to protect a tile floor upstairs where existing plumbing, electrical, and structural conditions downstairs made sistering the joists difficult. The resulting floor system has strength and stiffness comparable to a floor framed with the next larger size of 2-by joists.

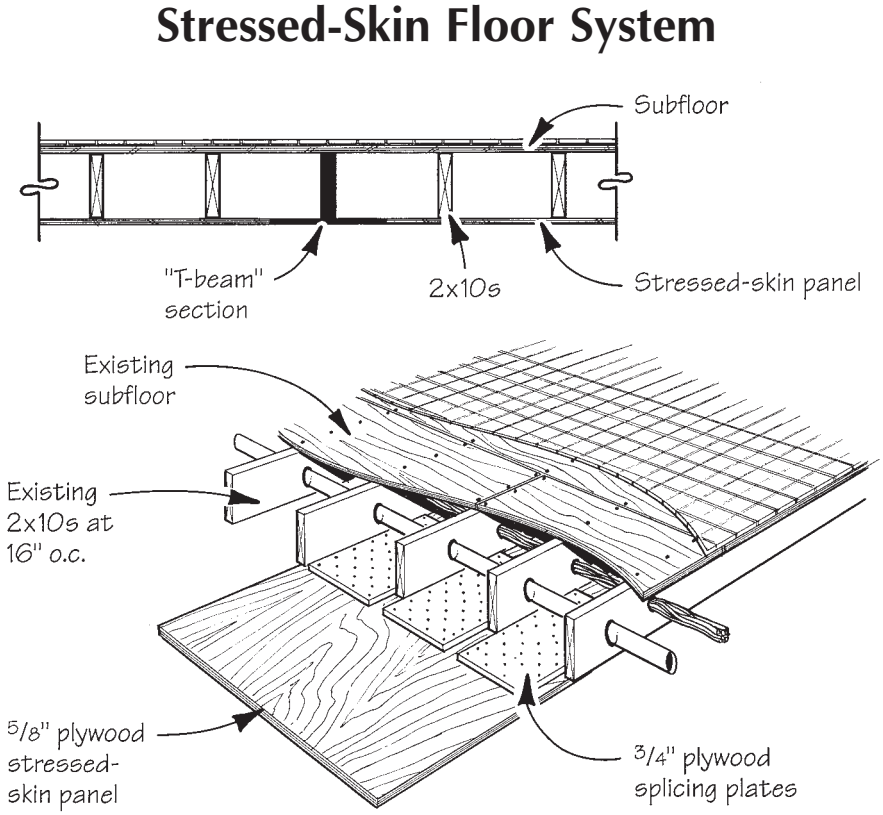

Figure 1. Applying a stressed-skin plywood panel to the bottom of the floor joists is a good way to stiffen a bouncy floor when plumbing and mechanicals prevent you from sistering the joists. The technique works because each lumber member acts as a T-beam (top). The plywood must be glued to the lumber with a waterproof structural adhesive to achieve this composite strength.

How Stressed-Skin Panels Work

The added strength of the stressed-skin panel comes from the composite action of the joists and plywood, which causes them to perform as if each joist were a T-beam or, in the case of two-sided panels, an I-beam. The plywood acts like the flange of the T (see Figure 1) while the lumber member acts as the web.

Two conditions must be met for this to work: The plywood must be laid with the strong direction (surface grain) parallel to the joist and continuous for the length of the joist, and the connection between the plywood and the joist must be strong enough to resist any slippage or shear between the joist and the plywood due to bending forces. This is accomplished using a combination of screws and epoxy or resorcinol glue. (Typical floor sheathing, which runs perpendicular to the joists and is nailed down, does not meet these criteria.)

In a case like the one described above, I chose 5/8-inch five-ply Group 1-Exposure 1 or Group 1/Exterior plywood. The APA rating ensures that the plywood veneers are of the highest-strength group and that the glues used are waterproof enough to resist delaminating in the event of a spill or plumbing leak.

Fabricating the Panels

Since it's usually hard to find a ready source for the extra-long plywood needed (15 feet, in this case) to extend continuously the length of the span, you can splice it on site (Figure 2, page 63). Make the butt joints carefully, with the joints placed as shown. Though it might seem like less work to use one splice right in the middle of the span, this is the point of maximum bending. Since the plywood in a stressed-skin assembly carries bending forces, I've placed the

Splicing Plywood

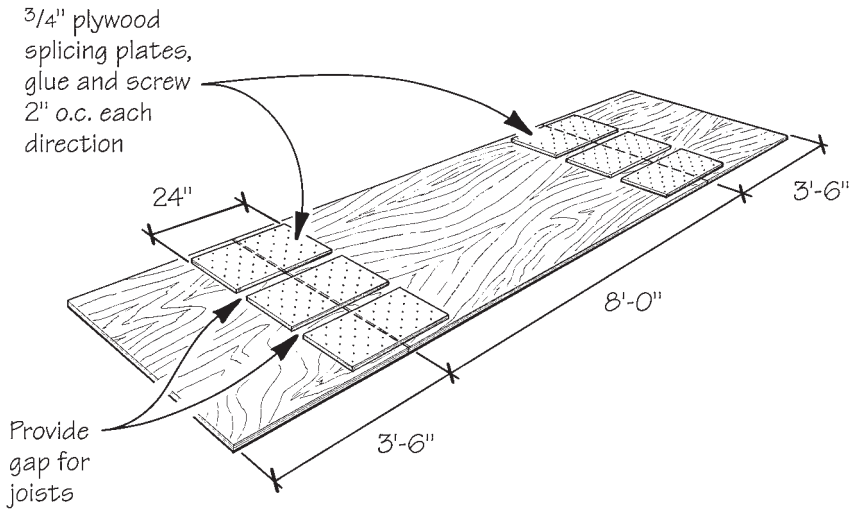

Figure 2. To make long plywood panels for retrofit stressed-skin applications, butt the shorter lengths of plywood and join them with glued-and-screwed splice plates. Avoid placing a splice at midspan, where bending forces are greatest.

Installing the Stressed Skin

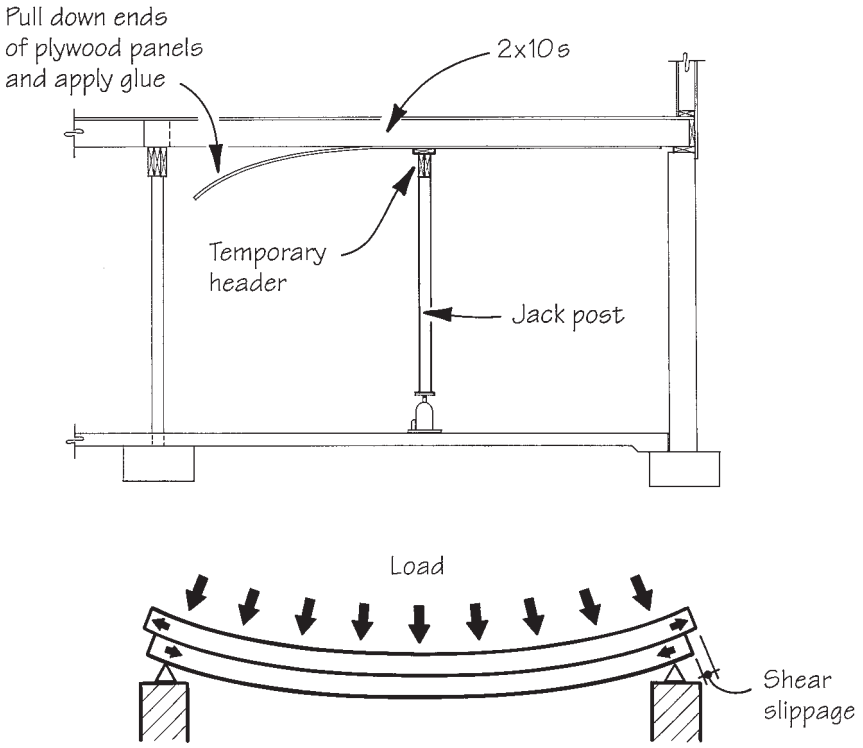

Figure 3. To install the plywood panels, tack them temporarily, then pull down the ends one at a time and apply glue to the joists and the plywood. Then reposition the plywood and screw it to the joists with 1 5/8-inch deck screws, working from the center out. If the existing floor has sagged, jack it to a little above level first, using a temporary header. Although it is impossible to spread glue under the header, this is of no consequence, because there is no shear slippage between the plywood and joists at midspan (bottom sketch).

splices at the quarterpoints where the bending moment is less.

Cut 24-inch-long splice plates from 3/4-inch plywood. For a flat ceiling that will be drywalled, arrange the splice plates so the floor joists can pass by, as shown in Figures 1 and 2. In the case described in the reader's letter, where there is a dropped ceiling to cover the plywood, one 4-foot-wide splice plate on the bottom may work. Make sure the plywood is clean, dry, and free of foreign material, then sand all mating surfaces at the splices parallel to the grain with medium grit sandpaper. (Because the plywood will later be glued to the underside of the joists, this is also a good time to sand 2-inch strips on the plywood where the joists will fall.)

Glue the splice blocks with epoxy or resorcinol, using screws 2 inches on-center in both directions to maintain clamping pressure while the glue cures. Follow the manufacturer's instructions for mixing and curing time and temperature.

Installation

Sand the underside of the joists with a belt sander and a medium-grit belt, keeping parallel to the grain. Remove all pitch, paint, and the dark oxidized surface to expose clean, fresh wood.

When the spliced panels have cured properly, lift them into place, position them, and tack them up with a few temporary nails. If the existing floor has sagged, install a temporary header with jack posts beneath the plywood, positioned to raise the center of the span a bit past level (Figure 3). I suggest overjacking about 1/1,000 of the span (in the case of a 15-foot span, this would be 180 inches/1,000 = .180, or about 3/16 inch).

With the panels thus positioned, you can then lower the ends of the sheets one at a time to spread the glue on both the plywood and the bottom of the joists. Again, use either epoxy or resorcinol glue. Because of the header, it may be difficult to get glue all the way to the center of the sheet. Don't worry about this: Shear slippage is practically zero at midspan (Figure 3).

Now raise the plywood back into place, and fasten it with 1 5/8-inch deck screws, working from the center outward to the ends. Place the screws on 6-inch centers in the middle but reduce the spacing to 2 1/2 inches on-center for the last 3 feet at each end, where the maximum shear forces occur. Leave the jack posts in place until the glue has completely cured. When the jacks are removed, the floor will drop slightly, ending up pretty close to level. However, the floor system will now be almost twice as stiff as before, or a bit stiffer than if the original floor had been framed with 2x12s.

Using 1x6s

As an alternative to the plywood stressed-skin, you can use No. 1 or 2 nominal 1x6 southern pine boards to get a comparable strengthening and stiffening effect. If 15-footers are locally available, their installation might be easier than the plywood method, because you could avoid splicing. Follow the same installation guidelines as for the plywood, installing one 1x6 per floor joist.

Limits

This technique can be expected to increase both the strength and the stiffness of 2x6, 2x8, or 2x10 floor framing to approximately the equivalent of the next larger size joist. However, it shouldn't be relied on where the existing floor framing is undersized for the usual design loads —at least, not without the guidance of an engineer.

For any structural designers interested in reading further, the *Plywood Design Specification Supplement 3, Design and Fabrication of Plywood Stressed-Skin Panels*, is available from APA — The Engineered Wood Association (206/565-6600). This is an excellent design guide for specific applications, but is probably of little use to the non-engineer.

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