Prepping Wood-Framed Floors for Tile

by Michael Byrne

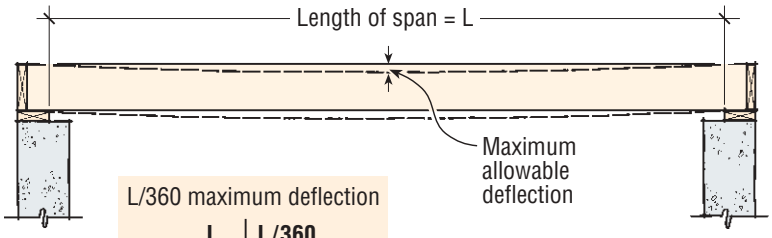
The long-term success of any tile floor installation depends on a number of factors: the adhesive bond that secures the tiles, the setting bed on which the tiles are installed, the structure that holds everything up, and a grid of flexible movement joints that help isolate the installation from normal, expected structural movement. Skimp on any one of these, and the installation is likely to fail.

This article will focus on the prep work that's required before any tile materials are installed. I will also limit the discussion to wood-framed floors — solid-sawn or wood I-joists with plywood subflooring — where problems with cracked tile are common.

Designing for Deflection

The best tile guide is the *Handbook for Ceramic Tile Installation,* published and distributed by the Tile Council of America (see "For More Information," page four). It costs

Calculating Floor Deflection

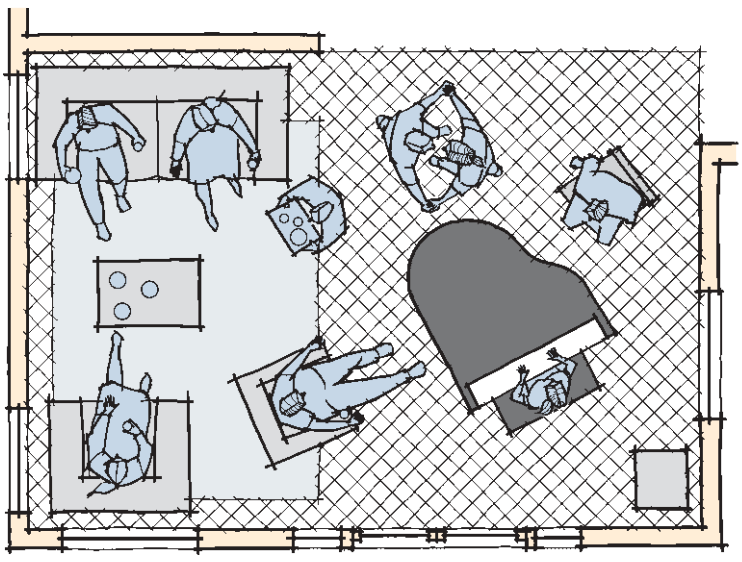


L/360 maximum deflection

L	L/360
8'	17/64"
10'	21/64"
12'	13/32"
15'	1/2"

Figure 1. The tile industry limits the deflection of floors receiving ceramic tile to 1/360 of the span. This amounts to approximately 1/2 inch of allowable deflection for a 15-foot span. For stone tiles requiring an L/480 installation, a 3/8-inch deflection is allowed. Some natural stone tiles may require an L/720 limit, or even L/1080.

Uniform Loading vs. Concentrated Loading



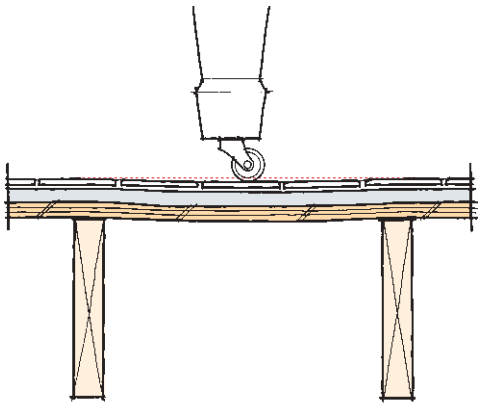


Figure 2. Wood floor joists are normally rated for uniform deflection (left) — meaning the floor joist's ability to carry an evenly distributed live load without flexing beyond a certain limit, typically the span/360. The problem is that applying uniform live loading to floor design does not account for points of concentrated loading that may occur between joists (above), which can cause cracks in tile floors.

only a few dollars but contains the practical information designers and builders need to ensure that the tile work will be done properly. Keep in mind when you use this guide that the details shown are *minimum* standards — they represent a point below which the installation may fail. There is always room to improve the strength and durability of your installation.

The Marble Institute of America references the TCA *Handbook* as a guide for installing stone tiles but amends it with appropriate changes for stone tiles. As an example, the maximum allowed deflection for ceramic tile is L/360 (see Figure 1, previous page). This amounts to approximately 1/2-inch maximum allowable deflection over a 15-foot span. By contrast, a particular stone tile may require L/480, L/720, or even L/1080! The properties of many natural stone tiles can change radically — even within a single tile — and therefore they require a stiffer setting bed. Most ceramic tiles, however, are manufactured to specific minimum standards, resulting in consistent properties throughout the tiles.

Uniform deflection is the overall distance a floor's surface is depressed when weight is applied and is a function of the strength of the joists (Figure 2, previous page).

Concentrated deflection is the movement that occurs on a setting bed surface located between two neighboring floor joists and is a function of the strength of the subflooring and the joist spacing. It pays to shop carefully, since some engineered floor systems that claim to meet the L/360 criteria do so only for uniform deflection and may fail to meet the criteria for concentrated loads.

The tile and wood products industries are working on this issue, and there may eventually be a concentrated load rating on subflooring and underlayment. Until then, if you're framing a floor for tile, limit joist spacing to 16 inches and use a minimum 23/32-inch subflooring.

Structure

It is the structure — the piers, beams, joists, and studs — that support the weight of a tile floor installation, plus all the live load it will carry. For most residential or light commercial structures, joists should be no less than 2x10s on maximum 16-inch centers. Reducing the 2x10 joist spacing from 16 to 12 inches or substituting 2x12s for the 2x10s is a good idea if a wood floor is being built to support natural stone tiles.

If you have any doubt about a structure you are about to tile, ask the tile or installation material manufacturers to write a specification for you that includes a complete structural detail; or consult your architect or structural engineer.

Isolation membranes. The long spans common in today's new houses may tax the limits of conventional installation methods and usually require crack isolation membranes. I tend to specify a membrane system for any ceramic tiles installed on spans greater than 12 feet, regardless of the type of tile, its setting bed, and the structure supporting it. Membranes also serve a waterproofing purpose (more on membranes below).

Subflooring

The industry minimum for subflooring thickness is 19/32-inch exterior-glue plywood (EGP). As you might expect, upgrading to 23/32-inch EGP provides a quieter floor with a more solid feel. That is the minimum I would use for any tile floor. Two screw-laminated layers of 23/32-inch are often specified for more demanding stone installations.

For now, it is still possible to get a relatively good selection of flat exterior-grade plywood — but in years to come? Tiles are now being installed over OSB subflooring, to be sure, but with mixed results. Failures as well as successes have been reported. The problems may actually be less OSB than *adhesive*. In any case, the wood products industry is very interested in successfully combining OSB and ceramic and stone tiles, and in the future, some excellent composite wood panels will probably be approved for use with tile. Until then, though, I prefer to stick with plywood.

In the TCA *Handbook*, a number of approved installations use plywood subflooring. Pay particular attention to the details surrounding orientation of the plywood sheets, fasteners, fastener schedules, gaps between sheets, gaps at abutting or restraining surfaces, the need for blocking, and closure of the T&G edge.

To gap or not to gap. Unfortunately, there is no clear agreement among manufacturers regarding subflooring installation details. Some manufacturers say you need to leave a gap; others say you don't. For that reason alone, you should follow specific directions for each product, rather than assuming that the instructions for one brand can be applied to all.

In my opinion, it is essential to do two things when installing subflooring: Leave a gap; then fill the gap with the same thinset mix used for placing the backerboard.

The most common failures I've seen on wood subfloors (even where it seems that everything has been done "right," or according to manufacturer recommendation) have been cracks that emanate from tight-fitted joints in the plywood. These cracks run right through the backerboard if there is one and right through the tiles. I have seen these cracks with both T&G subflooring and square-edged, though most of the contractors I work with avoid T&G in tile areas.

Though I can't cite research to prove it, I believe that filling the gap with thinset may allow stresses to continue from one plywood sheet to

the next, whereas stresses will *stop* (and become apparent as a crack) at a joint that is a void (a perforation in the substrate).

Underlayment and Membrane

Several tile backers are manufactured specifically for floor tile installations. These products have a relatively high compressive strength, but they add virtually nothing to the structural strength of the installation.

Not all tile backers are alike, and it's important to make a reasonable, conservative comparison of the available materials. Cement backerboards are unaffected by exposure to moisture, but they can transmit water. For that reason, on active wet-area installations, I always specify a waterproofing membrane, so that no moisture can pass through the cement boards and penetrate the structure.

In my opinion, the strongest underlayment for tile — provided it's first covered with a waterproofing–crack isolation membrane system — is a layer of $^{23}/_{32}$-inch exterior-glue plywood (Figure 3). Screw this to the subfloor with the face plies running perpendicular to the subflooring and with a 50% offset between joints. The screws should not penetrate the joists, only the subflooring. This assembly will be far stronger than a layer of tile backerboard, which is made of sand and cement, gypsum, or foam. The only downside is that the expansion and contraction rate of even the most stable plywood is significantly greater than that of ceramic or stone tiles. That problem can be easily overcome, however, with the application of a membrane system between the tiles and the plywood.

In the end, because of normal, *expected* movement in wood construction, and because we often use tiles in areas that are wet or damp, I specify a protective membrane system for most installations. Sometimes, depending on the brand, the membrane system may *be* the underlayment; otherwise, the membrane is usually applied to the surface of the backerboard, plywood, or mortar bed.

Every manufacturer of grout and mortar makes a membrane system, and there are numerous independent brands on the market. Some are premanufactured sheets, like NobleSeal TS, while others are composites made of a liquid or paste bonding

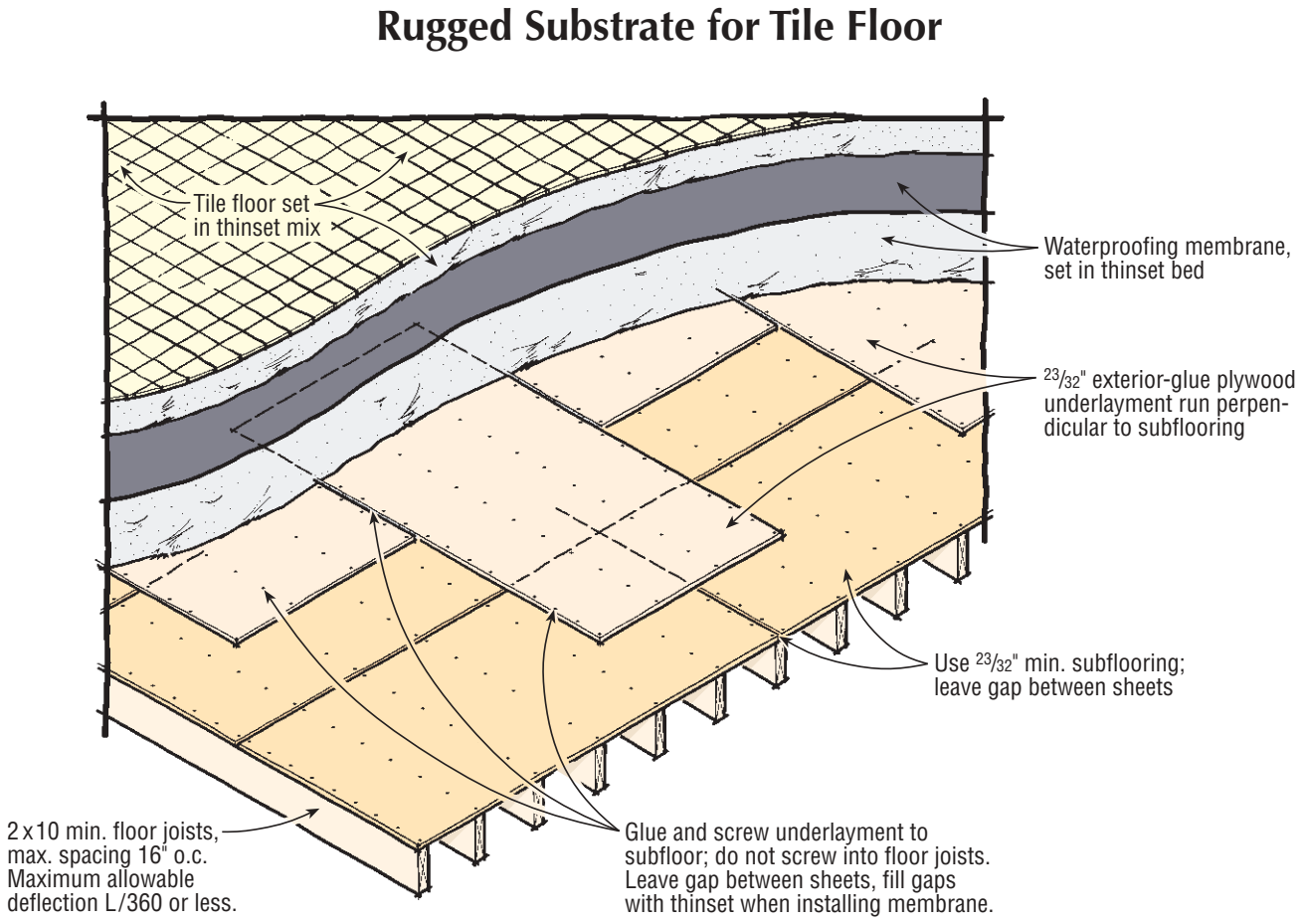


Figure 3. The author's preferred setting bed for thinset floor applications uses two layers of $^{3}/_{4}$-inch plywood and a waterproofing membrane rather than a backerboard.

agent and a separate reinforcing fabric, like Laticrete 9235. Latex, sheet rubber, and asphalt-based membranes are also available.

Flatness Standards

The tile industry standard for flat, plumb, and square is another problem. In the era when mortar bed installations were common (and when 4 1/4- and 6-inch tiles were typical), a flatness tolerance of 1/8 inch in 10 feet was considered acceptable. (Flatness refers to the differences in height between neighboring plywood subfloor panels, between neighboring backerboard panels, and between neighboring tiles.) If you could get the setting bed flat to within that tolerance, aligning all the trim and field tiles was relatively simple, because of the ability of smaller tiles to conform to a less than perfect surface.

Unfortunately, at the last ANSI A108 standards meeting, the tolerance was loosened to 1/4 inch in 10 feet, which will allow the safe installation of 6-inch tiles but doesn't work for the now popular large-format tiles — tiles measuring 10 inches or more.

For that reason, anyone installing large-format tiles up to 14 inches should use, at the very least, the old 1/8-inch tolerance. For larger tiles, a setting bed surface true to within 1/16 inch in 10 feet or less is needed. Without the traditional mortar bed, and its ability to flatten and true an irregular surface, installations using thin-bed materials need to be planned before construction begins, to ensure enough room for a self-leveling compound to true a floor's surface. The thickness of a typical self-leveling compound ranges from a minimum of 1/8 inch up to about 1 inch per pour. Some manufacturers allow for two pours.

Keep the Setting Bed Clean

Finally, after you've gotten all the structural and substrate details right, it's critical to keep the surface of the setting bed clean and dust free. This means no foot, ladder, or wheeled cart traffic until the curing time expires for all the materials used in the tile installation. If a worker has to get on a floor that's going to be tiled, the work should be protected with enough tarps to make sure that no contamination is deposited on a surface that's supposed to receive tiles or tile installation materials.

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