

Floor Framing

With production techniques and the right materials,
a solid, squeakless floor is a day's work

by Don Dunkley



Rough framing isn't measured in thirty-seconds of an inch, and for good reason. Although a shabby frame can put finish carpenters in a murderous mood, it gets covered up and forgotten behind siding, drywall and paneling. But floors, if done poorly, will come back to haunt you. That squeak just outside the bedroom door is an annoyance for which there is no quick fix. But the problems can go beyond the floor itself. The blame for eaves that look like a roller coaster once the gutters are hung often rests squarely on a carelessly built floor two stories below.

Haste doesn't usually create these problems; using inappropriate materials and not knowing where to spend extra time does. In fact, by using production techniques and materials, rolling second-story joists (tipping them up and nailing them in place) and sheathing them with plywood on a modest-sized house is a day's work for my partner and me.

What a floor does—Most builders are very aware when they hang a door of the abuse it will get, but they don't think in the same way about the floor they are framing. This skin is the main horizontal plane the building relies on to transfer live loads (ones that are subject to change, like furniture and people) and dead loads (primarily the weight of the structure itself) to the bearing walls, beams and foundation. Critical here is the amount of deflection in both the sheathing and the joists. The sub-floor must be stiff enough to handle both general and concentrated loading, and to support the finish floor that rests on it without too much movement. But at the same time it must be flexible enough for comfortable walking and standing, something a concrete slab can never be.

Floor systems—There are many different ways to build a floor, and the preference for one system over another has a strong regional flavor. Floor trusses—either metal or wood—are becoming popular because of their prefabricated economy, and because they can eliminate the need for bearing walls, beams and posts by free-spanning long distances. Girder systems are still used over crawl spaces in some areas. They are generally laid 4 ft. o. c. with their ends resting on the mudsill of the foundation wall, or in pockets cast into the wall itself, or on metal hangers attached to the foundation. The interior spans of the girders are typically posted down to concrete piers. Girders are decked with either 2x T&G or very heavy plywood designed for this purpose.

But most wood-frame houses still use joists. And whether a floor rests on foundation walls on the first story or on stud walls on a higher level, its elements are pretty much the same. Joists are typically 2x lumber, laid out on 12-in., 16-in. or 24-in. centers and nailed on edge. They are held in place on their ends by toenails to the sill or plate below, and then attached to a perimeter joist, or blocked in between. Blocking or bridging has also been used traditionally to stabilize a floor at unsup-

ported midspans. (For more on this, see the next page.)

The last element of any joist system is the skin—usually plywood sheathing. This decking not only forms the continuous horizontal surface, but is also the key to the integrity and structural continuity of any wood floor. I'll talk more about the choice of material and how to apply it later.

In the simplest floor system, joists rest on the mudsill of exterior foundation walls, or on the double top plate of the stud walls on higher stories. With the long spans found in most floor plans, joists have to be either very deep (say, 12 in. or 14 in.), or supported at or near the center of their length by beams or bearing walls, creating two shorter spans. In the case of even greater building widths, joists can come from either side of the building, lapping each other over these supports, with blocking nailed in between.

In much of the country where basements are used to get below the frost line, the joists bear on or lap over built-up beams of 2xs spiked together. These are usually supported by Lally columns—concrete-filled tubular steel posts with flanges top and bottom—or by hefty wood posts.

In the West, where I live, the first-story floor usually stretches over a crawl space. Perimeter support for the joists is provided either by stemwalls—mudsill-capped low foundation walls (most crawl spaces use the minimum allowable height of 18 in. from grade to the bottom of the joists)—or by cripple walls (sometimes called pony walls) that are framed up on hillside foundations to reach the first-floor level.

For supporting the joists in mid-length or for lapping them, floors over crawl spaces either use a carrying beam, or girder, on 4x posts that rest on concrete pier blocks, or use a crib wall—a low, framed wall studded up from an interior concrete footing that runs the length of the building.

Unlike girders, which are often crowned and leave a hump in the finish floor, crib walls can be plumbed and lined to make a perfectly straight, level surface. They will also shrink less than a large girder, and just feel a lot more solid to me. The posts under a girder are toenailed at the bottom to the wooden block that caps each concrete pier. This block inevitably splits, making the whole post-and-beam assembly feel a little cobbled together. I've also learned that concrete contractors get bored with straight lines at the point when they begin laying out piers, so supporting posts often get precious little bearing:

Bolting down the sill—Floors need to be level, square and precise in their dimensions. On a second floor, these conditions will depend on your accurately plumbing and lining the first-floor walls; but on the first floor, setting the mudsill is the critical step. First, check the perimeter foundation walls with a steel tape for the dimensions shown on the plans. Then pull diagonals to check for square. Run 3-4-5 checks on the corners for

square if the floor isn't a simple rectangle. Once you're sure of your measurements, snap chalklines that represent the mudsill's inside edge on the top of the foundation walls.

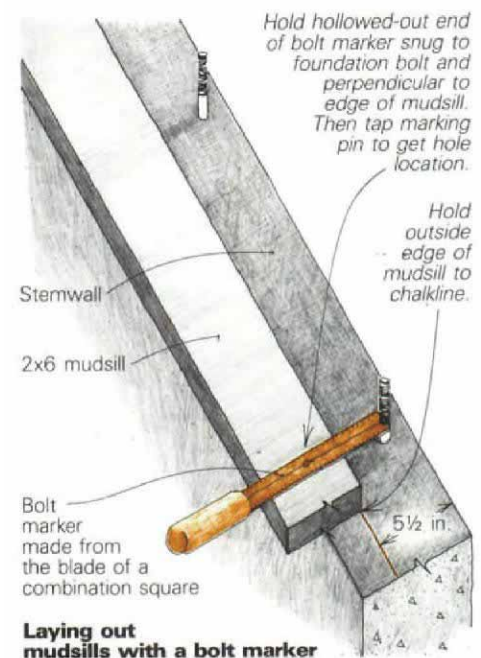
Be thinking ahead to the sheathing (called shear panel where I build) and siding if the foundation walls aren't arrow-straight. If these are one and the same, the plywood will need to hang down over the concrete foundation wall an inch or two. This means that you're better off having the mudsill overhang the foundation slightly, rather than the other way around. If finish siding is used over sheathing, this isn't as important, since the sheathing can butt the top of the foundation where it bows out from the mudsill.

Place the mudsill (either pressure-treated or foundation-grade redwood) around the perimeter of the foundation, and cut it to the lengths needed to fit on the stemwalls. You'll find foundation bolts placed on maximum 6-ft. centers; code requires each piece of sill to be held by at least two bolts. The cut sills should be laid in position on their edges along the top of the stemwalls so that they can be marked for where the anchor bolts fall along their length.

After carefully squaring these marks across the face of the sill, lay them flat so you can mark the bolt positions across their width. Measure the distance from the chalkline on the top of the stemwalls to the center of each bolt. Then transfer that measurement to the face of the mudsill, taking care to measure from the inside edge of the mudsill each time.

Production carpenters who do a lot of layout use a bolt marker. One of these can be made from an old combination-square blade, as shown in the drawing below. The end of the metal blade is notched so that it will index from the centerline of a ½-in. foundation bolt. At 5½ in. from this end for a 2x6 mudsill (or 3½ in. for a 2x4), a hole is drilled in the blade and fitted with a screw or nail.

To use this marking gauge, the mudsill has



Bridging midspans

Although the days when all carpenters learned the trade through a formal apprenticeship are gone, construction knowledge is still passed down through the ranks, from those who know to those who want to. This kind of conservatism is often valuable, but it also means that outmoded methods die hard. Bridging between joists at midspan is a good example. Even on relatively short spans, a lot of knowledgeable builders are convinced that bridging guarantees a suffer floor. But convincing studies show that it doesn't, and that information isn't new.

Bridging is a continuous line of bracing that runs perpendicular to the direction of the joists, and is installed between them. It can take the form of cross bridging (diagonal pairs of wood or metal braces that form an X in the joist space) or horizontal bridging (continuous, full-depth solid blocking).

A study done by the National Association of Home Builders Research Institute Laboratory in 1961 put most of the myths to rest. It proved with laboratory and field tests that bridging at midspan had little effect in stiffening a floor once it was sheathed. It was also of little help in transferring concentrated loads laterally to other joists, reducing floor vibration or preventing joists from warping. Bridging actually does all of those things as you install it,

but once the plywood subfloor is on, its net effect is negligible.

Still the myth persists. Building in the 1970s, I put in midspan solid blocking every 8 ft. on floors I built, to meet the code and because I was concerned with quality building. But there is only one way in which midspan bridging improves a floor substantially, and that is in providing lateral stability. Because joists are on edge, they tend to tip unless they are pinned in at their ends and at support points like girders and bearing walls. Plywood sheathing nailed and glued on top also helps. But over long spans, the joists can use a bit more help.

Of the three model codes in the U. S., only ICBO's Uniform Building Code requires using cross bridging or solid blocking with plywood sheathing under normal conditions, and that is only when the depth-to-thickness ratio is 6 or more, as with 2x12s. It is then required every 8 ft. along the span of the joists. BOCA requires bridging or blocking only if the joist depth exceeds 12 in. under normal loading conditions, and SBCC allows you to skip it entirely in single-family residential buildings.

If you do need to install midspan bridging or blocking on a floor you're building, a few simple tricks will make it go faster and eliminate some of the squeaks. First, you must decide between diagonal bridging, which can either be wood 1x3s or the newer sheet-metal bracing, and solid blocking.

I think that cutting and nailing the old wooden cross bridging is needlessly time-consuming, although all the standard construction texts cover it in detail. If I were going to use bridging, I would choose the metal variety that doesn't use nails. These straps have sharp prongs on their ends, and eliminate the squeaking you get from nails rubbing on the metal bridging when the joists flex underfoot. This kind of bridging can be installed from above or below the joists; a combination of the two is even better. Drive the upper ends of the bridging into the top of each joist face before sheathing, and return to drive the bottoms in from below when the joists have done most of their shrinking, and initial loading has flattened them some. Make sure to separate each member of the pairs to prevent contact squeaking.

Solid blocking has to be done just before sheathing, but it's straightforward. If you're going to insulate the floor yourself, it's the best choice. To begin, chalk a line across the joists where the blocking goes. This is typically at the center of any span under 16 ft., or in two rows equally spaced if the span is greater. Alternate the blocks on either side of this line so you can face-nail them through the joists.

Set a plank on top of the joists, parallel to the chalkline and about a foot away. Set it to the left of the line if you're right-handed. Spread out your blocks along this plank. Drive three 16d nails partway into the face of each joist down the line, alternating between the right and left side of the line. This allows you to position each block and then anchor it with a single blow of the hammer. Once you've traveled the entire length of the joists nailing the blocks on one end, you can turn around and travel back the way you came, nailing the other ends.

Construction adhesive recommended for solid blocking is supposed to cut down on squeaks, but it's messy and time-consuming. It's more practical to drive shims in any gaps that open up between the blocks and the joists. Don't use vinyl sinkers (vinyl-coated nails) or brights (uncoated steel nails). These will loosen up and squeak much sooner than ring-shanks, screw nails or hot-dipped galvanized. —Paul Spring

to be held flat with its outside edge on the chalkline. This is most easily done from inside the foundation. Make sure that the sill is exactly where you want it along its length. Then by holding the bolt marker perpendicular to the length of the sill, with the notch of the gauge pressing against the bolt, tap on the marking pin with your hammer. Whatever the location of the bolt, the correct bore center will be left on the sill.

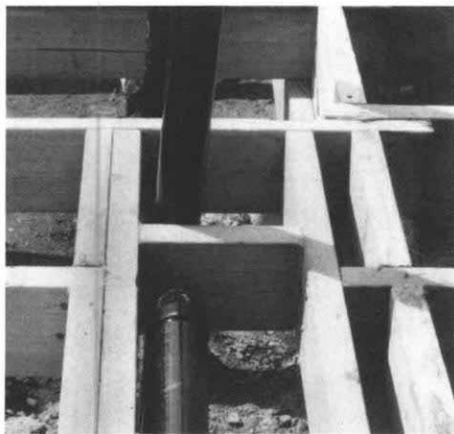
After the sills are laid out for bolts and drilled with a slightly oversize bit (a $\frac{9}{16}$ -in. bit for $\frac{1}{2}$ -in. bolts is a good compromise between requirements for a snug fit and giving the carpenter a break), place them on the stemwall and hand-tighten the nuts. If termite shields or sill sealers (wide strips of compressible insulation that act as a gasket to keep air from passing between foundation and framing) are to be used, be sure to lay them in underneath the mudsill. Now is also the time to adjust the foundation for level by shimming under the mudsill where necessary with grout. Go back and cinch the nuts down tight once everything is set.

With a hillside foundation where the joists will rest on a cripple or pony wall, adjustments for level are made in the cripple studs themselves rather than by shimming the plate. If the foundation is stepped down the hill, these cripple studs will be in groups of various lengths. If a grade beam that parallels the slope is used, then the cripples will have to be cut like gable-end studs. In this case the beveled end will be nailed to the mudsill and blocked in between. In either case, getting the top plates precisely level (and straight) is worth the trouble. Do this by shooting the tops of the studs with a transit, or by setting up a string-and-batterboard system. Using a spirit level for long runs just isn't accurate enough, and trusting a hillside foundation to be true is a mistake you'll make only once.

Joist layout—The first thing I do to lay out the sills for rolling joists is to get out the plans again and find all the exceptions to the standard layout. These include stair openings that have to be headed off, lowered joists for a thick tile-on-mortar finished floor, plumbing runs that need to stub up on a joist layout, and the double joists used for extra support. Even a simple floor will require doubters to pick up the weight of the building at its most concentrated points.

The first place to double is at each end of the foundation, parallel to the direction the joists run. When joisting a second story, sandwich short 2x spacer blocks between two joists for a tripler (drawing, facing page). This will give you backing for the ceiling drywall below. Locate all interior walls running parallel to the joists and lay out the sills (and carrying beams if you have them) for doublers too. Since some plumbers feel that joists have just as much integrity cut in half as they do whole, it's a good idea to have a chat with your pipe bender before you complete the joist layout. This will save a lot of headaches later. For instance, the doublers under plumb-

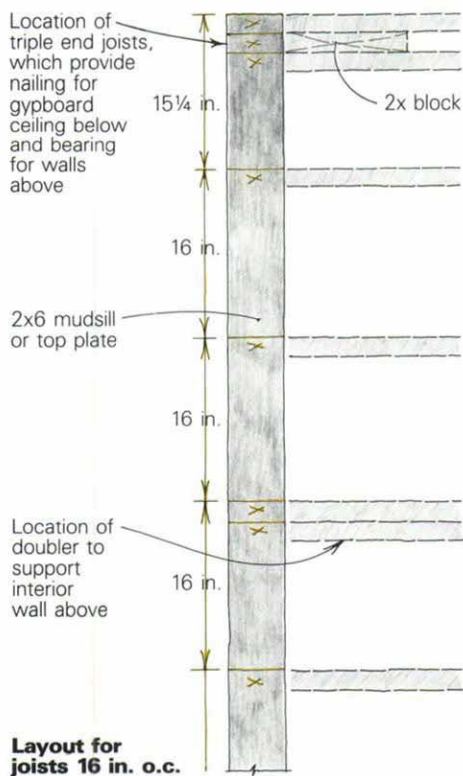




Heading off the joists to make room for DWV lines, as shown here, is a lot easier if plumbing runs are considered before framing begins.

ing walls will have to be spread for waste lines that run parallel to the joists, or headed off with solid blocking to accommodate perpendicular plumbing runs (photo above). Doubling joists under a heavy cast-iron bathtub is also a good idea.

Next, lay out the joist spacing shown on your plans. This layout has to be adjusted so that the butting edges of the decking will fall in the center of a joist, allowing two sheets to join over a single joist. Stretch your tape from



the outside edge of the sill and make a mark $\frac{3}{4}$ in. (or half the thickness of a 2x joist) shy of the joist-spacing dimension—15 1/4 for 16 in. o. c. Put your X on the leading side (far side) of this mark for the first joist. The rest of the layout can be taken from this first joist at the required centers without any further adjustment. If your floor has joists coming from each side that lap over a beam or wall, the layout on one side will need to be offset from

the layout on the other perimeter sill or plate by 1 1/2 in. to account for the lap.

After you have completed laying out the sills and midspan beams, check again to make sure that they jibe, and that the centers are accurate for the plywood. Now is the time to think; once you begin rolling joists, you just want to move.



Unlike rim joists, the end-blocking method requires cutting special-length blocks to correct for layout and accommodate double joists.

Getting ready to roll—There are two ways to secure the ends of the joists. The first is to run them the full width of the house, and block in between at their ends (photo above). This system has some structural advantages since the joist ends are locked in, but with all of those short, brittle pieces involved, it requires more fussing to get straight lines. The other way is to cut the joists 1 1/2 in. short on each end, and run a 2x rim joist (also called a header joist, ribbon or band joist) perpendicular to the joists and face-nail it to them.

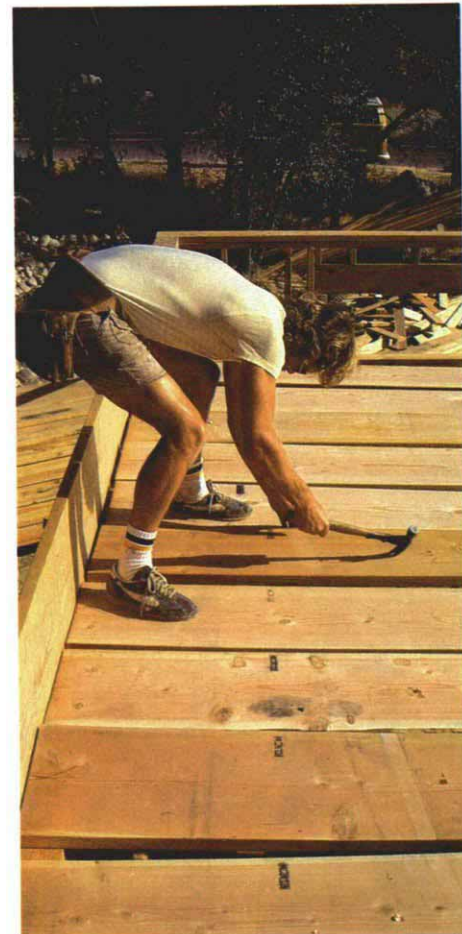
Whichever system you use, all the joists should be laid flat on the sills right next to their layout marks before you begin to frame. Stocking is basically a one-man job. As you pull each one up, sight it for crown. Many framers mark the crown with an arrow (make sure it points up), but it's not necessary if you start at one end of the building, and lay each joist down so that the crowned edge is leading. This way, when you return to the beginning point, you'll be able to reach for the leading edge of each one and tilt it up or roll it, leaving the crown up. Save the really straight lengths for rim joists. If any of the joists are badly crowned, cut them up for blocking.

Rim joists—The rim joist for one side of the building should be installed before any of the joists. Mark its top edge with the same layout as the sill it will sit on. If a large crown holds the rim up off the top plate or mudsill, cut the rim joist in half on a joist layout mark. Also, if this floor is over a crawl space, you will need to cut in vent openings. Place these every 8 ft., starting 2 ft. in from the corners, where air tends not to circulate. Typical vent openings are 5 in. high and 14 1/2 in. long; these fit nicely between joists on 16-in. centers.

Install the rim joist with toenails from the outside face of the board down through the sill or top plate every 16 in. Once nailed, string the outside edge to make sure it is

straight and adjust it in and out if necessary with a few more toenails. Now snug up the joists that are resting flat on the plate or sill so they butt the inside face of the installed rim joist (this is easily done by catching the face of the joist that's up with the claw of your rip hammer and pulling toward the outside of the building, as shown below). If any joist ends are badly out of square, trim them.

Using the perimeter mudsills or plates, which have already been carefully plumbed and lined, as a kind of tape measure, mark



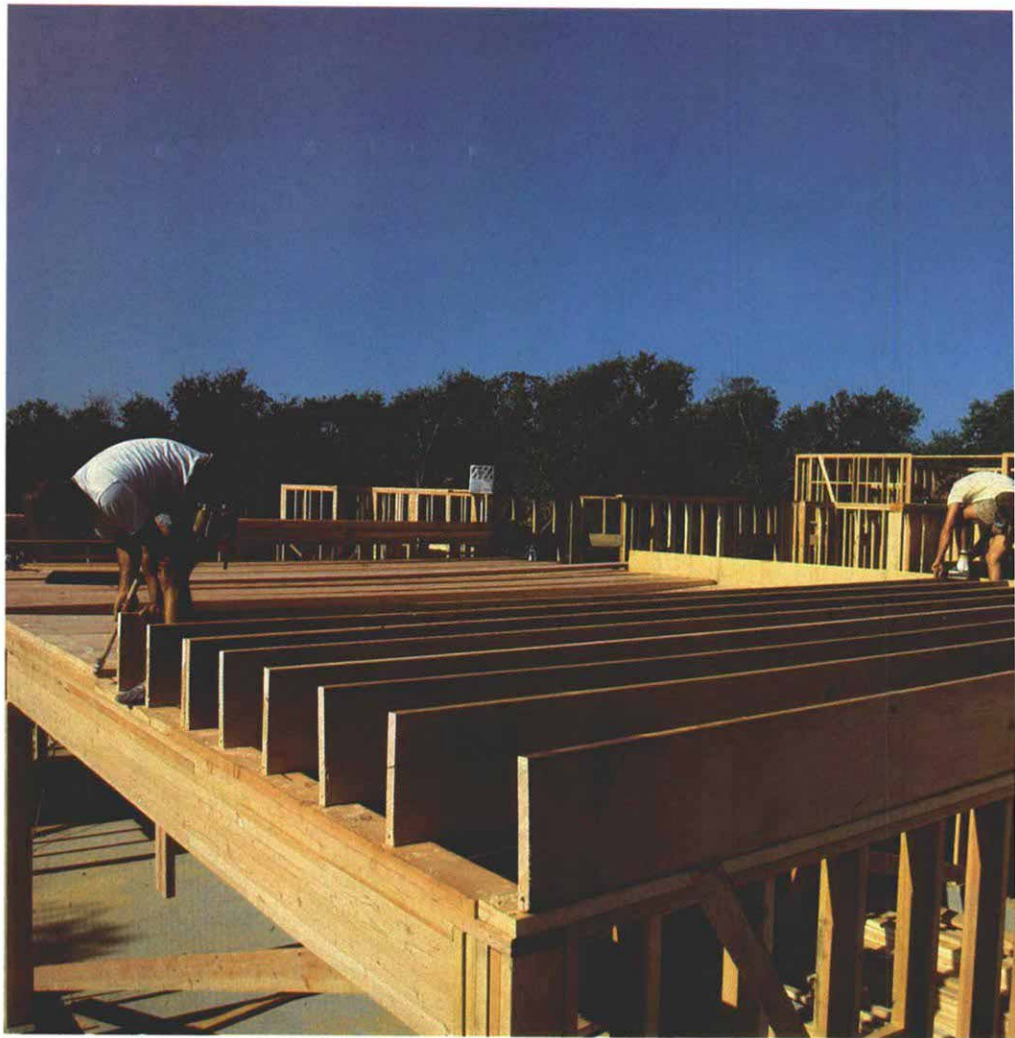
The author snugs a joist against the rim to check the end for square, using the building itself as a ruler for cutting the joists to length.

Kiln-dried framing makes better joists, but in the West green Douglas fir is much more common. Even so, the ideal moisture content of a joist is 15%. Many of the problems with floors—in particular squeaking and nail-pop—can be traced to wet joists shrinking away from nail shanks as the wood dries. Wet joists can permanently deflect once they begin to dry, causing a swale in the floor. Most of the so-called settling in a platform-framed house is due to the joists shrinking across the grain. Much of this can be eliminated by using dry lumber. Putting down a plastic moisture barrier over the earth in damp crawl spaces is a good way of keeping the floor above dry.

Cutting to length. The joists are squared up 1½ in. short of the building line (below) to leave room for the rim joist, and cut to length. With their crowns marked by an arrow, they are ready to be tipped up.

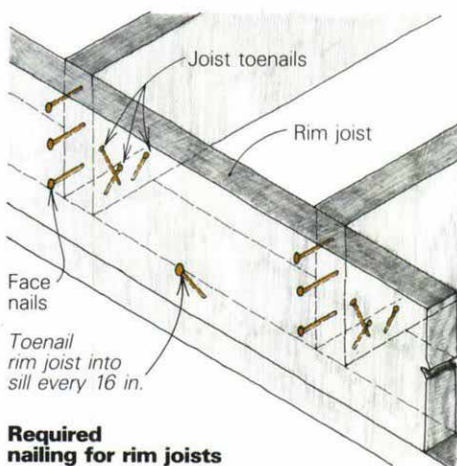
Rolling the joists. Joisting (right) is fast if a routine is established between partners. On the open side of the joists, an end toenail holds the joist on layout; toenailing the joist face to the plate will follow. On the other end, the rim joist is face-nailed to the joist with three 16d nails, then toenailed to the plate. The end joist in the foreground will be doubled later.

Installing the other rim. With joists nailed off, the open side gets its run (bottom). This floor uses 2x14s; 2x10s are more typical.



each joist where it extends over the perimeter wall opposite the installed rim. Square up a line $1\frac{1}{2}$ in. in from this outside mark, and cut. For a floor with more than one span, index off the outside of the girder or crib wall, and use the rule of thumb for lapped joists to determine if they will need to be cut. The joists are now ready for rolling.

With the rim joist installed, rolling goes fast, as the joists can be quickly tipped up and nailed in place—no special blocks to slow you down and no need to stretch a tape measure to make sure you're keeping the layout, as in end blocking. Rolling joists (photo facing page, top right) is a synchronized, almost fluid process that requires few words once partners are used to working together. With one of you on each side of the building, and beginning with the doublers at one end or the other, reach forward at the same time for the top of the joist, tip it up and place both ends of the joist on their layout marks. On the side of the building where the rim is already installed, drive three face nails through the rim into the end grain of the joist. If a joist is a little lower in height than the rim when tipped up, hold it up flush to the top edge and shim



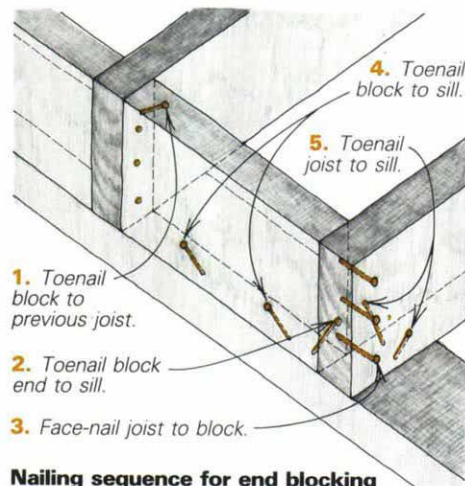
Required nailing for rim joists

up after the joists are rolled. The other member of your crew on the opposite side will drive a single toenail through the end of the joist, down near the bottom, into the top plate or mudsill. Then, both of you drive two toenails through the leading face of the joist down into the plate or mudsill (the side facing the joists that haven't yet been tipped up), as shown above. Once you've rolled all the joists, you can reverse direction, and work your way back toenailing the other face of the joists to the plate or mudsill. This is called backnailing. Then the rim on the open side of the joists should be hauled into place, toenailed to the plate or sill, and face-nailed to each joist (photo facing page, bottom).

End-blocking method—If you choose end blocking over a rim-joist system, each joist will need a block, which should be precut and stacked on top of its joist as it lies flat and ready to be rolled. A radial-arm saw set up with a stop gauge is the easiest way to gang-cut blocks, but a skillsaw will do. For a 16-in.

layout, the blocks should measure $14\frac{1}{16}$ in. The more accurate your blocks, the fewer specials you'll have to cut while you're joisting. The first block, however, will be a special to account for the outside doubler and the $\frac{3}{4}$ -in. adjustment that was made in the layout for the sheathing. After all blocks are cut, put them on the joists that are ready to be rolled. Proceed to roll the joists first by setting up the outside doubler. If you have to use more than one piece to make the length, then make sure that the butted splices are at least 4 ft. from each other for these double joists.

Once the doubler is in place, toenail the first special block to the doubler and to the sill or plate—first with a toenail through the

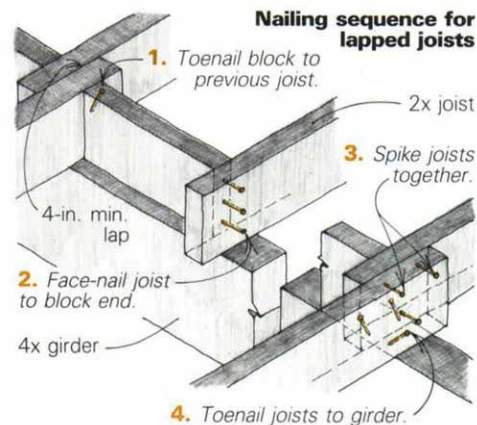


Nailing sequence for end blocking

top of the joist into the block it butts against; second, with a low toenail into the sill or plate through the end grain of the block on the leading end. Then tip up the next joist in front of you and face-nail through it into the end grain of the block with three nails. Finally, drive two toenails from the outside of the block into the sill or plate (drawing, above) and toenail the joist itself down. Tip up all joists in the same manner. Although the plate is laid out, it is a good idea to measure joists every 4 ft. or so to make sure they aren't wandering off the layout. Shorten a block or cut a longer one to adjust if needed. This will take a lot of frustration out of the sheathing later on.

Lapped joists—In most floor plans, the distance to be spanned is long enough to require that a girder or crib wall be used to support the joists, or as a bearing surface where two runs can lap. Double-check the height of this girder or wall to avoid the typical center hump that a lot of floors develop after a year or so. To tell the truth, this support is best set slightly too low than too high. Crib walls will shrink less than most beams, but using dry lumber will help in both cases.

Joists can be butted and a plywood or lumber splice-plate at least 24 in. long used to join them, but most often they are lapped. The rule of thumb I've always used is that the joists should lap each other by at least 4 in., but that neither one should extend beyond the far edge of the girder or crib wall that sup-



ports it by more than this joist's nominal depth. The joists should be toenailed to the support beam or plate through each face, and then blocked solid in between, as shown above. These blocks have to be shorter than end blocks to make up for the extra joist. Pay attention to the layout by pulling a measurement from the end of the building every 4 ft. to make sure that the joists aren't bowed in or out from the layout on the perimeter, and that the subfloor joints will fall on a joist. (Remember, you may be dealing with two layouts. If the joists lap, the layout on one side of the floor will differ from the other by $1\frac{1}{2}$ in.)

Schedule the rough plumbing after joisting is completed and before you begin the sheathing. If you are using forced-air perimeter floor heat, the ducts should be installed as well. Be sure to block around the heat registers in the floor to provide backing for the sheathing once the subs have finished the rough-in. Then call for inspection and get it signed off. This is also the time for insulation.

Sheathing—Joist systems can use either a single or double layer of sheathing. The traditional approach is to sheathe the joists first with subfloor—typically $\frac{1}{2}$ -in. or $\frac{5}{8}$ -in. square-edge plywood laid with its face grain (and long dimension) perpendicular to the joists. This forms a working platform for rough construction, but is covered over with underlayment (either plywood or dense particleboard) ranging from $\frac{3}{8}$ in. to $\frac{3}{4}$ in. This produces a thick floor with little flex, and more resistance to sound transmission so the patter of little feet is muffled in rooms below.

However, most of the houses I build use a single-skin, combination subfloor and underlayment. It requires half the labor and produces a serviceable floor. These plywood panels are tongue-and-grooved on their long sides (the ends will always fall on a joist for continuous support), and are structurally rated to span the joist spacing by themselves. It's possible to order square-edge panels, but with these, continuous edge-blocking between joists is required. Single-skin panels range in thickness from $1\frac{1}{2}$ in. to $1\frac{3}{4}$ in. (known as 2-4-1). Always use the thickest you can afford. While code allows $\frac{5}{8}$ -in. plywood on 20-in. centers, and some builders are already calling for its use with glue on 24-in. centers; $\frac{3}{4}$ -in. plywood on 16-in. centers has my vote. Inch-



Sheathing the floor. The first step in sheathing is to establish a course line 4 ft. in. from the rim with a snapline (top). Installing T&G plywood using a 2x4 beating block and a sledgehammer is a job for two. The author, in the rear of the photo above, is using both his shifting weight and his hammer to coax the tongue into the groove. This second course begins with a half sheet in order to stagger the joints. On this job, white glue was specified; construction adhesive is far superior.

and-an-eighth plywood (2-4-1) is even stiffer, and can be used on 16-in. or 24-in. centers even though it was designed for use over girders placed at 4 ft.

As in underlayment plywood, the voids in the face veneers and the plies directly beneath them in combination subfloor and underlayment are plugged so that the wood resists point loading (consider what high heels can do to plywood with interior voids). The panels are also drum-sanded to a precise thickness. With this plywood, about the only place a second layer is used around here is with vinyl flooring in baths and kitchens. Underlayment is particularly important with thin flooring because it provides a new dense surface that hasn't taken the abuse of construction traffic. Installed just before the finish flooring, it lessens the likelihood of joint lines or nailheads broadcasting through flooring. This extra layer also brings the level of these finished floors flush, or nearly so, with areas of the house that may have padding and carpet, tile or hardwood flooring.

Setting plywood—Check T&G plywood when it's delivered. If either long side is banged up, crushed by banding, or looks like it's been sitting out in the rain, don't even let them unload it. The tongue is difficult enough to thread into the groove without sabotage. Once you've got the material on site, treat it with care. Cover it even if clear skies are predicted.

To sheathe the floor using plywood, first snap a line 4 ft. in from one side of the building, using a level to plumb up from the mudsill or top plate of the outside wall below for accuracy. The butt joints of plywood have to be staggered between courses (there should never be an intersection of four corners), so you should begin either the first or second course with a half sheet. Remember that you are laying the plywood down with its length running perpendicular to the direction the joists run. Begin the first course with the tongue sitting on the rim joist at the perimeter of the building. This will leave the groove as the leading edge. The next course of plywood will have to be threaded onto the previous course by driving the new sheets with a 2x4 block and a sledge hammer. The grooved edge will take this abuse; the tongue won't.

If you have lapped joists, the layout for the sheathing will be different from one side of the floor to the other by 1½ in. If the lap occurs at a natural break for the plywood, the next course can just be slid back 1½ in. so that it continues to butt on a joist. But if a plywood course covers the joist lap, then you'll have to spike 2x4 scabs to each joist to get bearing for the plywood at this transition.

Gluing down the plywood with an elastomeric construction adhesive in addition to nailing enables the plywood and joists to act as one integral unit, creating what amounts to a T-beam. Using glue will lessen creep and squeaking and increase floor stiffness. It also lets you cut down the nailing schedule on plywood ¾ in. thick or less from 6 in. on the edges and 10 in. in the field, to 12 in. for both

using 6d (although I prefer 8d) screw nails or ring-shank nails. Construction adhesive comes in tubes that are used with a caulking gun. Using large tubes saves time, and buying by the case will save you a few bucks. White glue is better than nothing, but it won't bond as well as the neoprene-base adhesives do.

Apply a bead of adhesive continuously on every joist, but don't work too far ahead of yourself because it will skin over rapidly. Flop the plywood down carefully so that it's very close to where it belongs. On the first course, aim for the chalkline, and then nail off the sheet with the exception of the last 6 in. of width along the groove. Nail this little bit once the next course is driven into place or you will pinch the groove and make threading the tongue nearly impossible.

Plywood associations and textbook writers agree that this kind of combination subfloor and underlayment should be spaced ¼ in. at edges and ends. The climate where I build is very dry, and this practice isn't common, but I can see that you might need to allow for expansion in some climates. If you do use this recommended spacing, you will need to trim panels for length occasionally since you will be adding slightly to the layout each time. Or you can scab on a 2x4 to the existing joist to get more bearing. This technique is particularly useful at the end of a course of plywood when the floor is just slightly longer than the last full sheet will stretch. Although plywood should always span at least two joist spaces, the exception is where a small piece rests completely on solid joists such as a double or triple. If your layout falls just short of the end of the floor, you can add a scab to the end joists to support the last full piece of plywood, and fill in with a ripping.

After the first course of plywood is nailed off, you can begin the next course, remembering to stagger the joints. This is best done with three people. The first lays down the bead of adhesive ahead of the plywood and drops back occasionally to nail sheets that have been tacked before the adhesive sets up. The other two will be cutting and setting the plywood. The only trick to setting is a bit of coordination between the person handling the sledge on the leading edge of the new panel, and the person using his feet and body weight to thread the seam (photo bottom left).

Once set, each sheet should be nailed at all four corners and at each joist, which will help whoever is nailing off keep the nailing lines straight. Nail off the plywood with ring-shank or screw nails because they hold much better than conventional nails, particularly in slightly green joists. Make sure the nails go straight into the joists. Nails that break through the sides will cause squeaks. It's worth sending someone below to drive out any that miss.

Once all sheathing is nailed off, trim off overhanging edges where necessary with a circular saw. Your efforts will result in a good strong subfloor that will withstand all the wear and tear a household will give it. □

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