

Plumb and Line

Without this final step of straightening the walls, the care taken during framing will have little effect

by Don Dunkley



It's strange to think of a completed wall frame as being a kind of sculpture that needs final shaping. But that's just what it is. Until the walls have been braced straight and plumb, they can't be sheathed or fitted with joists or rafters without producing crooked hallways, bowed walls, ill-fitting doors and roller-coaster roofs.

The production name for getting the frame plumb, square and straight is *plumb and line*. The job doesn't take very long—three to six hours for most houses—but it's essential. After the frenzied pace of wall framing, plumb and line can be a welcome relief. It requires at least two carpenters (three's a luxury) working closely together. The work is exacting, but not hard, and there's a sense of casual celebration in having finished off the wall framing.

Stud-wall framing is based on things being parallel and repetitive (see *FHB* #21, pp. 69-77). If you plumb up the end of a wall, then all the vertical members in the wall will be plumb in that direction. And if the bottom plate of the wall is nailed in a straight line to the floor, then getting the top of the wall parallel to the bottom is easy: just plumb the face of the wall at both ends, and make the top plates conform to a line between these two points.

Plumb and line is a fluid process in which walls are braced individually, but the sequence of operations is important. Although you can start at any outside corner, walls should be plumbed and then lined in either a clockwise or a counterclockwise order, since each correction will affect the next wall. Once the bottom plates have been fully nailed to the floor or bolted and pinned to the slab, the exterior walls are plumbed up and the let-in braces are nailed off, or temporary diagonal braces are installed to prevent the wall from racking (the movement in a wall that changes it from a rectangle to a parallelogram, throwing the vertical members out of plumb). Then line braces are nailed to the walls to push or pull them into line at the top and to hold them there. Last, the interior walls are plumbed and lined with shorter 2x4 braces.

Plumbing and lining can begin once all the intersecting walls are well nailed to their channels or corners. On each of these walls,

Holding wall intersections tight while the lapping double top plate is nailed off can make the difference between a plumb frame and having to make a lot of compromises later on.

the end stud has to line up perfectly with the channel flat or corner studs. It's also wise to make sure that the heights of the walls match up. If they don't, it's usually because the end stud isn't sitting down on the bottom plate. Also, all double top plates must be nailed off where they lap at corners and channels. Be sure that there aren't any gaps here (a common defect in hastily framed houses), and that the end studs and plates are sucked up tight (photo facing page).

Fixing the bottom plates—The next job is to toss all the scraps of wood off the slab or deck and sweep up. This way you'll be able to read the chalklines on the floor. If the frame is sitting on a wood subfloor, the bottom plates have likely been nailed off. On a slab, though, you'll have to begin by walking the perimeter of the building putting washers and nuts on all the foundation bolts. Tighten the nuts a few turns before using a small hand sledge to knock the plates into alignment with their layout snaplines. The slight compression created by the nut will keep the plate from bouncing when you hit it.

Getting the plates right on the layout is critical, because the bottom of the frame determines the final position of the top of the wall. Once the plates are where you want them, run the nuts down tight. The fastest tool for doing this is an impact wrench, found mostly on tracts and commercial jobs. Next best is a ratchet and socket, with last place going to the ubiquitous adjustable wrench.

Wherever bottom plates butt end-to-end on a slab, both pieces must be fastened down with a shot pin (see *FHB* #21, pp. 30-34 for more on powder-actuated fasteners). The gun I like the best is the Hilti. Unlike many of the older guns, which have space-hogging spall shields, it is slim enough to get into tight spots between studs. The model that I've used (DX-350) is fitted with a multi-load magazine, so it can be reloaded in seconds. It also uses a pin and washer that are made as a single unit—a big advantage.

If there are two of you working, one person can set the pins into the top of the plate with a tap of a hammer. The other person can follow, slipping the gun barrel over the shaft of the pin and firing. The pins should be placed close to the inside edge of the plate so that you don't blow out the side of the slab. To prevent the bottom plate from splitting out at the ends, you can nail a $\frac{3}{8}$ -in. or $\frac{1}{2}$ -in. plywood scrap over it and then fire the pin through it. Since doorways take a lot of abuse, a pin should be shot into the sill at each side of the opening.

After all the outside walls are fastened down, you can line the bottom plates of the inside walls and shoot or nail them down. Be especially careful on long parallel runs like hallways—any deviation will really shout out when the drywall is hung and the baseboard installed. On interior partitions, one drive pin or nail every 32 in. should be sufficient. Make sure to hit the flanking bays of doorways, and both sides of bottom-plate breaks.

Setting up—Once all the bottom plates are secure, spread your bracing lumber neatly throughout the house. Interior walls will need 8-ft. and 10-ft. 2x4s. Exterior walls will need 14 and 16-footers for line braces, and shorter diagonal braces if the wall doesn't have let-ins. You'll have to guess how much bracing you'll need. More is always better than less, but figure that you'll need a line brace every 10 ft. and a diagonal brace on any wall over 8 ft. long without a let-in.

To plumb walls I use an 8-ft. level with two small aluminum spacer blocks that fit over the lip of the level near each end, and are tightened with handscrews. When the level is held vertically against a wall, the spacers butt the bottom plate and double top plate and prevent bowed studs from interfering. You don't need an 8-footer; any level that is dead-on accurate will do if you extend it a bit (photo right). Select the straightest 2x4 around, cut it to 8 ft., and tack a short piece of 1x to one edge of the 2x4 at each end for a spacer. Then attach the level to the other edge of the 2x4 using duct tape or bent-over 8d nails. (See p. 80 for a report on an extendable level.)

Plumbing the walls—Exterior walls are plumbed from their corners. Choose any one as a starting point. Position the level at the end of the wall so that you are measuring the degree to which it's been racked. The bubble will indicate which way you have to rack the wall back to plumb. To do this, you can make a push stick out of a 9-ft. to 10-ft. 2x4 that is largely free of knots. A more flexible push stick can be made from two 1x4s nailed together face-to-face. Cut a slight bevel on the bottom end to keep it from slipping. To use the push stick, place the top of it in a bay about midway down the length of the wall to be racked, up where the stud butts the top plate. The stick should angle back in the opposite direction from which the top of the wall should be moved. Plant the bottom end on the slab or deck right next to the bottom plate. Pushing down on the center of the stick will flex it, exerting pressure on the top of the wall. Keep pushing and the wall will creak into a plumb position.

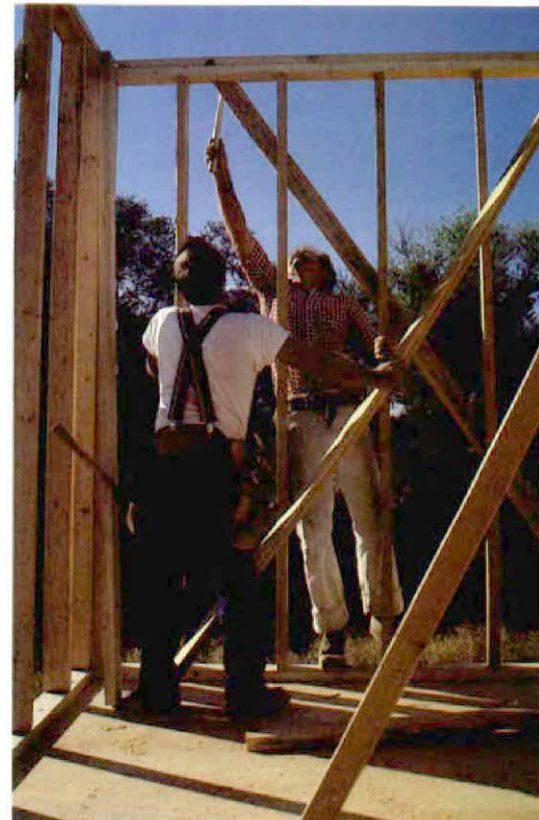
Racking walls takes coordinated effort. If you're on the smart end of the things (using the level), you need to shout out which way the wall must move and how far. Although overcompensation is usually a problem at first, soon your partner (who's on the push stick) will get used to what you mean by "just a touch" and be able to make the bubble straighten up as if he were looking at it.

Once you've racked the wall to plumb, hold it there permanently by nailing off the let-in bracing (photo right). But before you do that, have your partner keep the same tension on the push stick while you plumb the other end of the wall as a check. If it's plumb also, nail off the braces on the wall as fast as you can. Here it's handy to have a third person to do the nailing while you keep your eye on the bubble. If for any reason (poor plating or a gap where the top plates butt) the wall isn't



Plumbing. The length of the level you use is a lot less important than being sure that it is dead-on accurate. Here a 4-ft. level is attached to a straight stud with bent-over nails. Using 1x spacers at the top and bottom of the stud (or manufactured aluminum spacer blocks on an 8-ft. level) will ensure an accurate reading despite bowed wall studs.

Keeping it plumb. While the let-in brace that will keep the wall plumb is being nailed off, this short wall is being held plumb by tension on a push stick made of face-nailed 1x4s.





plumb on the opposite end, you'll have to split the difference.

Walls that are shorter than 8 ft., walls with lots of doors and windows, and exterior walls that will get shear panel, sheathing or finished exterior plywood won't have let-in bracing. For these walls, a temporary 2x4 brace must be nailed up flat to the inside of the wall at about 45°. Be sure that none of these braces extends above the top plate. Use two nails at the top plate, one nail each into the edges of at least three studs and two nails into the bottom plate. As with all plumb-and-line bracing, drive the nails home (you won't be pulling these braces until joists, rafters and sometimes sheathing are in place). Continue this process until all exterior walls are plumbed.

Lining—The next step is to get the tops of the exterior walls straight. If you've got a practiced eye, you can get the best line of sight on a wall by standing on a 6-ft. stepladder with your eye right down on the outside edge of the double top plate (photo above). This is the way I usually line, but for absolute accuracy you can't beat a dryline.

Set this string up by tacking a 1x4 flat to the

outside edges of the top plates at each end of the wall. Then stretch nylon string from one end of the wall to the other across the faces of the 1x4s, and pull it tight (see *FHB* #11, p. 27 for a twist knot that will hold a taut line). The 1xs hold the line away from the wall so that if the wall bows, the string won't be affected. To determine whether the wall is in or out at any given point, use a third scrap of 1x as a gauge between the string and the top plates. If an inside wall intersects with the outside wall, I plumb the end of the interior wall, and then check the rest of the wall with the 1x gauge.

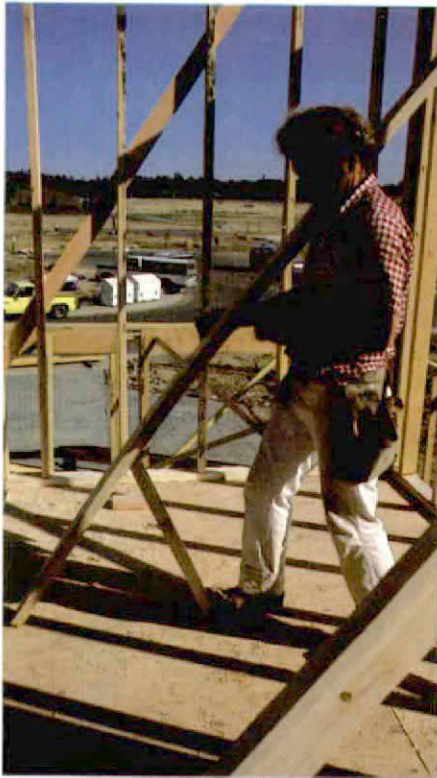
To make corrections in the wall and then hold it there, use line braces. These are 2x4s on edge that are nailed high on the wall and angle down to the floor or the base of an interior wall. To be most effective, they should be perpendicular to the plane of the wall. If a wall is at least 8 ft. long, it gets a brace—even if it's already straight. Braces not only correct the walls, but also make them secure enough to walk on while laying out and nailing joists or rafters, and keep these ceiling members from pushing the walls outward.

Usually, I begin lining a wall by sighting it quickly for bows. My partner nails braces

where the deviations are worst. Then we brace off the rest of the wall where needed. If the wall is pretty straight, we scatter braces every 10 ft. or so, and do them in order.

The top of the line brace is attached to the wall first. Face-nail it to a stud just under the top plate with two 16d nails, making sure that it doesn't run beyond the exterior plane of the wall. If a header is in the way, face-nail a vertical 2x4 cleat to the header with three or four 16d nails, and then edge-nail the brace to the cleat. Line-brace nailing is shown in the center and bottom drawing panels on the facing page. Trimming an eyeballed 45° angle on the top of the brace will allow it to hug the wall and give you better nailing.

Setting the braces also requires good communication. While you pay attention to the string, your partner either pulls or pushes the brace according to your directions, and then anchors the bottom end when you say that it's looking good. You can usually find an inside wall to tie the bottom of the brace to. This won't affect plumbing the inside wall (which will be done later) as long as you nail the line brace to the bottom of a stud down where it butts the bottom plate. Use at least two 16d



Persuading stubborn walls. Using a 2x scrap (a 3-footer is ideal) for a kicker under a line brace will bring a wall in at the top. Straightening walls quickly requires the carpenter setting the line braces to make adjustments in or out a little bit at a time with the constant direction of his partner who is eyeballing the wall.

Lining. For absolute accuracy, there is no substitute for a dryline. But if you've got a good eye and an experienced partner you can get straight walls in a hurry (facing you). Either way, use the top exterior corner of the double top plate to gauge the straightness of the wall.

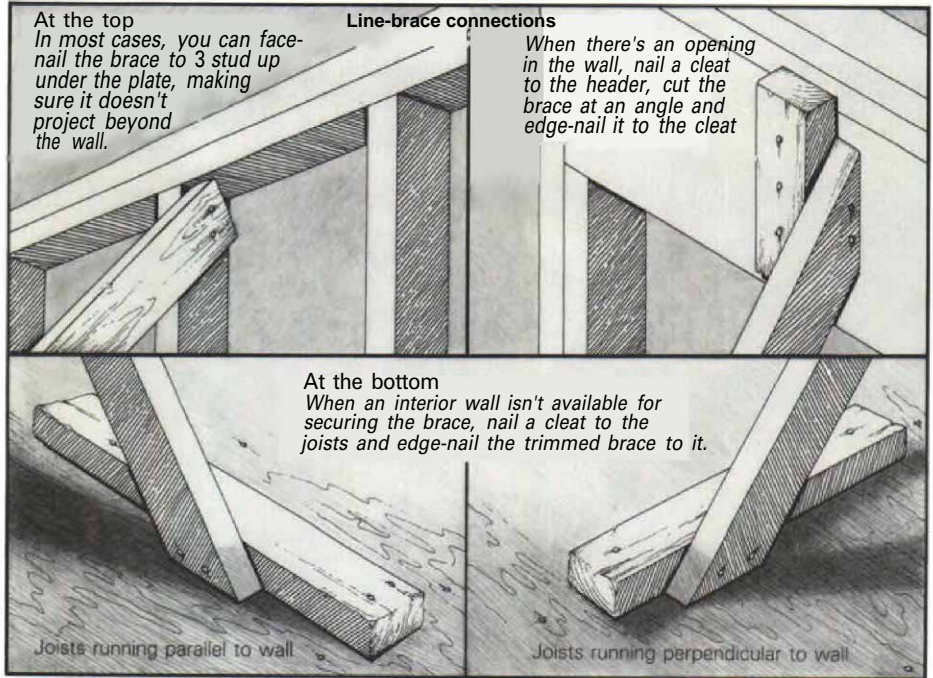
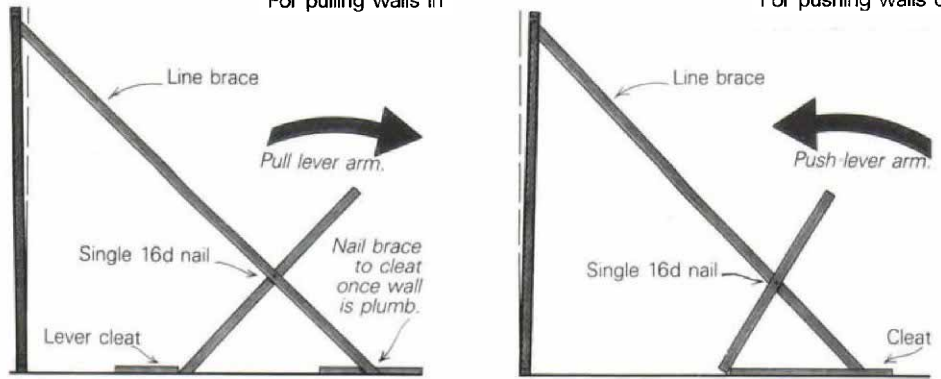
nails (or duplex nails) and drive them home. If an inside wall is not available, nail or pin a block to the floor, no closer to the outside wall than the wall's height. This will leave the brace at an angle of about 45°. Be sure to find a joist under the floor, since a floor cleat that is nailed only to the plywood will pull out. Trim the bottom of the brace in the same way you did the top, so that you can drive two good 16d nails through it into the cleat.

Most walls are relatively easy to move in or out, but every house has a notable exception or two. Walls full of headers can be a real pain to line because they are so rigid. Bringing the top of a wall back in is usually more difficult than pushing it out because you have to work exclusively on the inside of the wall. One effective technique is to use a *kicker* (photo above). Toenail the line brace flat (3½-in. dimension up) to the header and nail a block above it so it won't pull out under tension. Then toenail the bottom of the brace into a joist, and cut a 3-ft. 2x scrap. Toenail one end of it to the floor and wedge the top under the line brace so you have to beat on the kicker to get it perpendicular to the line brace. This bows the brace out, bringing the wall back in

Scissor levers for lining stubborn walls

For pulling walls in

For pushing walls out



(although occasionally it pulls the toenails loose on the line brace). When the wall lines up, end-nail the brace to the kicker.

You can also use a parallel interior wall to help pull in an exterior wall (see *FHB* #8, p. 10) or a scissor lever that nails temporarily to the line brace. Scissor levers can be used to push or pull, depending on where the blocks are nailed (top drawing panel, above).

Line the exterior walls one at a time until you come full circle. Try not to block off entries and doorways with braces, but don't skimp either. I've learned to double the normal bracing on exterior walls that will carry rafters for a vaulted or cathedral ceiling. Also, if this ceiling includes a 6x ridge beam or a purlin 18 ft. or longer, I like to place the beam on the walls just after I've plumbed them. This way you don't have to pick your way through a forest of braces with that kind of load.

Interior walls—The last step is to plumb up the inside walls. Start at one end of the house and work your way through. You'll develop a sense of order as you go, and soon find that the remaining walls are already nearly plumb, and that the frame is beginning to become rig-

id and to act as a unit. Quite a few of the interior walls will have let-ins; if they don't, use the 8-ft. and 10-ft. 2x4s as diagonal braces on the inside of rooms. Where there are long hallways, I usually cut 2x4 spreaders the exact width of the hall measured at the bottom, and nail them between the top plates every 6 ft. to 8 ft. The spreaders will keep the entire hall a uniform width, and when the wall on one side is plumbed, the wall opposite will be too.

Once all the interior walls have been plumbed, go back to any long walls to check for straightness, and then throw in one more line brace for good measure. This is also the time to make a last check on exterior walls to make sure the interior-wall plumbing you did hasn't thrown a hump in the works. Then go around the entire job, shaking walls to make sure there's no movement. This kind of precaution means that when you're rolling joists or cutting rafters you won't have to measure the same span or run every few feet along a wall for fear of a bow, or worry that the walls have acquired a lean over the weekend. □

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