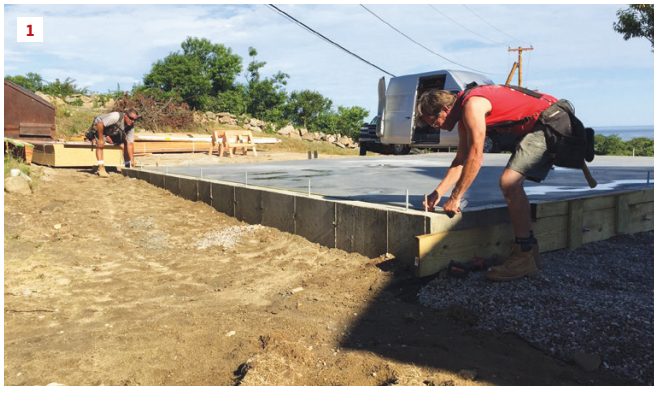
BY JOHN SPIER

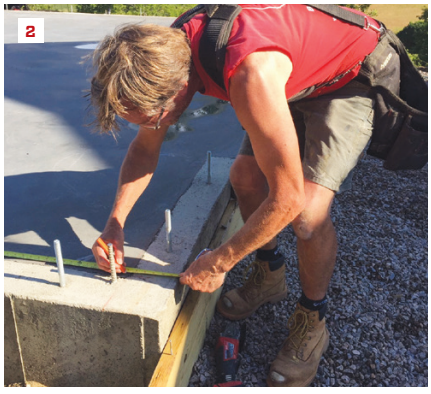
Level, Square, and Plumb

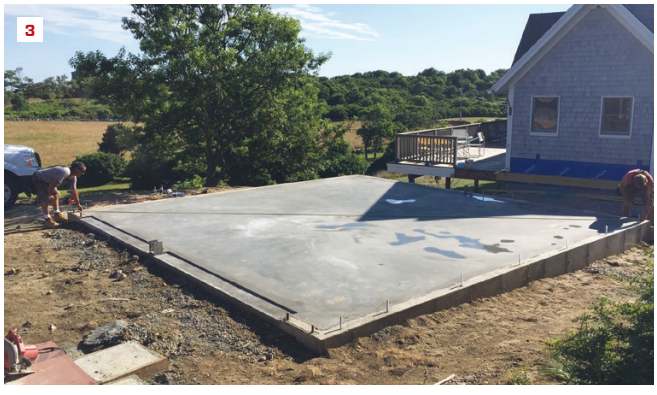
Framing straight and square buildings is simply a matter of following a few fundamental and interrelated rules. There are five basic concepts: level, square, plumb, parallel, and straight. Get any two of the first three, and the third will follow automatically; and anything you make parallel to those three will also be right. Straight is just a further refinement to doing a good job.

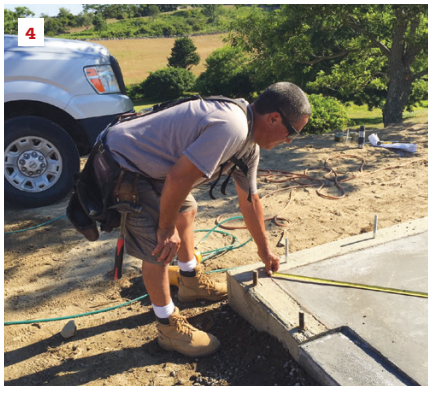
Level starts with the foundation or base. If the concrete crew does a good job, you can bolt the sill plates down, and everything you do from there up will be level. If the concrete crew doesn't do a good job, however, you need to start by shimming, planing, wet-setting, or otherwise leveling the plates **(1, 2)**.

A basic rule for tolerances in framing is to aim for perfection at the sills and to accept some inaccuracy as you go up. For example, sill plates and diagonals should be as close to perfect as you can get them, say within 1/8 inch of perfectly level



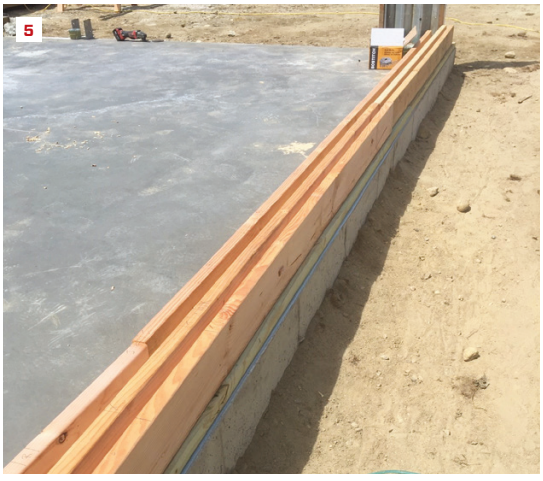






Start with a level foundation—no more than 1/8 inch out of level throughout the building. After confirming that the foundation walls are parallel **(1)**, lay out and snap chalk lines for the mudsills **(2)**. If the diagonal measurements for the opposing corners are equal, the foundation is square **(3)**. If not, you'll need to adjust the wall layout until the diagonals are equal **(4)**.

Photos by Gabriela Gazzo Spier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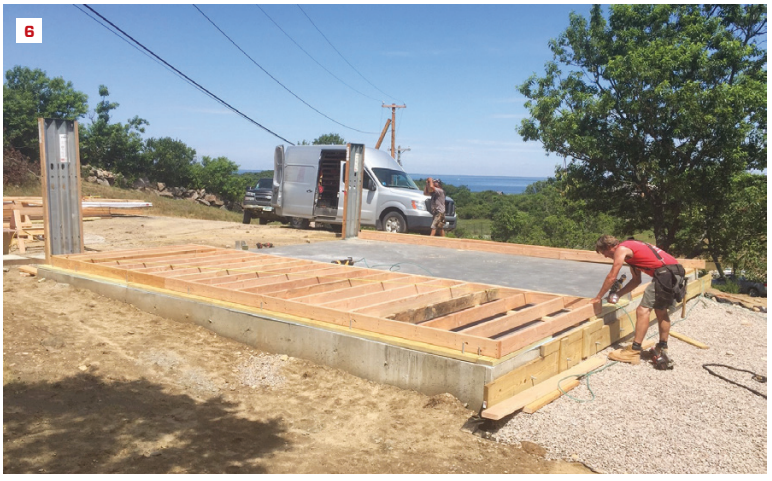
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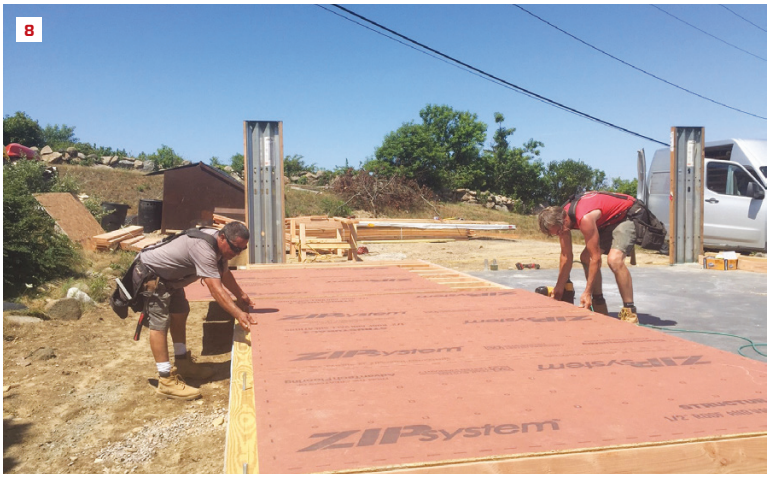

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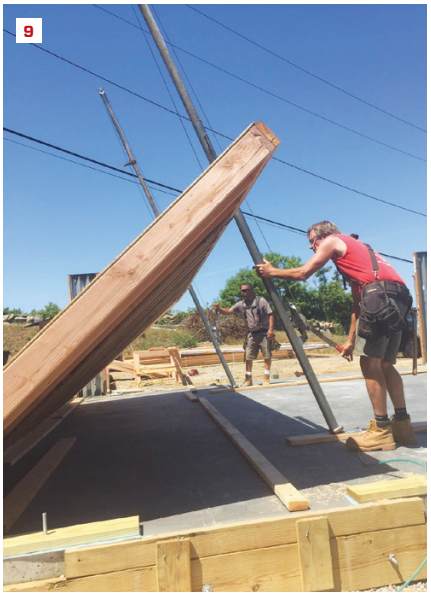
The plate measurements are determined by the layout lines **(5)**. To allow for slight adjustments, cut the plates 1/8 inch short and hold the end studs of butting walls 1/8 inch from the ends of the plates to allow corners to be pulled tight. Before starting to assemble the wall, pin or tack the bottom plate along a straight line. Square up the wall by measuring the diagonals from the corners of the plates **(6)**. As the sheathing is installed, use its edges to keep the studs **(7)** and plates **(8)** as straight as possible.

throughout the building. If things are out by 1/4 inch at the second or third floor, or 1/2 inch in the roof framing, most of us can accept that. There is an important corollary to this rule—errors always seem to multiply, not cancel each other. That's why we aim for perfection in the beginning.

Square and parallel begin at the layout stage. A basic rectangular building will have two pairs of sides of equal length, and the diagonal measurements across the corners will also be equal **(3, 4)**. More complex building shapes can usually be broken down into component rectangles, starting with the largest and adding the details.

You can create this perfect rectangle by starting with two parallel sides and using a construction calculator (or some trigonometry and geometry lessons that you remember from school) to obtain the diagonals. The Pythagorean Theorem ($a^2 + b^2 = c^2$) is the basic formula for square or rectangular buildings. So, if you have the length of a side and the length of an end, multiply each by itself, add the two results, and calculate the square root of the sum. That will be your diagonal measurement. Most of us have long since forgotten how to calculate a square root longhand, but any phone or calculator will do it for you. If you don't have an app that works in feet and inches, you'll need to convert.

Don't try to measure diagonals on a long, narrow rectangle, such as a wall 32 feet long and 8 feet high, because it will be difficult to adjust the diagonals so that they are equal. It's better to break a long wall section into two shorter rectangles, which will result in diagonals with less acute angles that are easier to accurately measure and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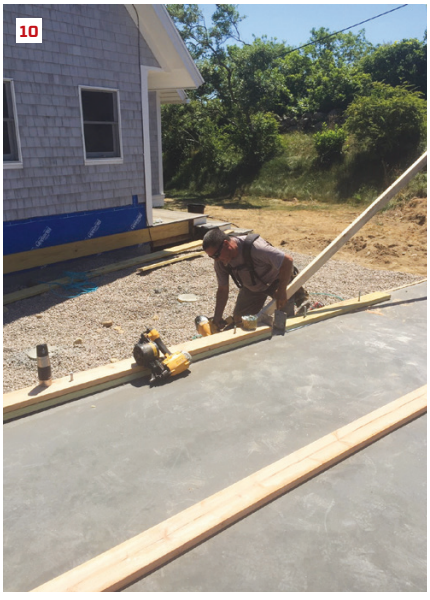
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After the wall sheathing is nailed off, the wall can be lifted into place on top of the sill plate (here, the author is using wall jacks) **(9)**; leaving the anchor bolts loose allows for adjustment as the remaining walls are raised. Diagonal bracing holds the walls in position **(10)** as the project moves into the next phase: roof framing **(11)**.

adjust. You can also start by trusting the foundation, snapping two sets of parallel sides, checking the diagonals, and adjusting to fit. I sometimes use blue chalk until I'm satisfied, and then permanent red chalk for my final layout.

I almost always snap the inside walls for the sill plates, because the outside lines are too close to the edge, and because I won't be able to see them when the walls are sheathed and stood. Remember that almost all pressure treated lumber is 1/8 to 1/4 inch wider than regular lumber. You can keep the extra inside or out, but be consistent and allow for it **(5)**.

When the foundation is less than perfect, you will have to shift, twist, or adjust the size of the entire layout to fit. It's almost always easiest to expand a building slightly if the foundation is a little bit out of square—that way, you don't need to fight with getting water table trim, siding, door thresholds, and other elements to fit. If it's way out of square, you need to figure out where to hide it, or where it'll be easiest to fix. Often, additions, bump-outs, and wings are not square to the main part of the foundation; you can shift the main rectangle to make these parts fit better.

Most walls are built lying flat, following the same process as for the plate layout. If the plates are exactly the same length, and the studs are all the same, then the top, bottom, and ends of the wall will be parallel. Then, if the diagonal measurements from the corners of the plates are the same **(6)**, the wall will be square. It's good to have the wall fairly square as you build it and to "fine-tune" the diagonals with a sledgehammer right before putting on the sheathing **(7, 8)**.

Plumb. If you start with a level sill plate, and you stand up a square wall on top of it, you will automatically have plumb (vertical) ends. And if everything in the wall—studs, doors, windows, nailers, partition posts—is parallel, then all of it will be plumb, too. If you then build and stand all four walls so that they are level and square, the four corners of your building will necessarily be plumb, and the tops of the walls will form exactly the same rectangle as the bottom sill plates. The corners will be square, the diagonals will match, and the opposite walls will be parallel **(9)**.

Straight is a relative quality control that is incorporated into every stage of the process. When laying out the plates, stretch your chalk lines very tight. Select the best material for your longest sill and wall plates, and the straightest studs for your corners. And before you start building the second floor or the roof on top of your new walls, use string lines and braces to hold them perfectly straight.

Don't trust short walls to stand perfectly plumb—check and brace them. You can tack the sheathing temporarily and nail it off after the wall is braced plumb. Long walls that are going to support opposing rafters should be braced with a slight bow inward in the middle (1/8 to 1/4 inch, depending on length, height, and pitch). The rafters will inevitably push them outward slightly as the building settles **(10)**. Finally, don't tighten anchor bolt nuts completely until everything is nailed together and checked for plumb **(11)**.

John Spier owns Spier Construction, a building and remodeling company on Block Island, R.I.