

Site Layout

On a flat lot, footings can be oriented with precision using batter boards, string and a water level

by Tom Law

Driving that first stake is always exciting. It doesn't matter whether you've been designing and dreaming about the house for years, or you're beginning the first day of actual work on what you hope will be a profitable contract. Laying out the site in preparation for foundation work is your first chance to visualize the house full scale in its setting. The accuracy of your layout and the foundation it defines will also determine how much you will have to struggle to make your house tight and square.

Unless you are building on a sloped site, all you will need to do the job right is a 100-ft. tape measure, a water level, a ball of nylon string, enough lumber for batter boards, a helper and the application of some practical geometry.

Let's assume that the house is a simple rectangle, and that one of the long walls faces south. If precise solar orientation is important, use a compass or one of the many commercially available siting devices (see *FHB* #5, p. 52). If such precision is unnecessary, stand facing the midday sun. Your outstretched left arm will point to the east and your right arm to the west. Unroll a ball of string along this axis for a distance a few feet greater than one of the long

walls of your building. I use braided nylon string because it will take an awesome amount of tension before it breaks, and because braided string doesn't unravel and can be used indefinitely. It comes in a highly visible yellow as well as in white.

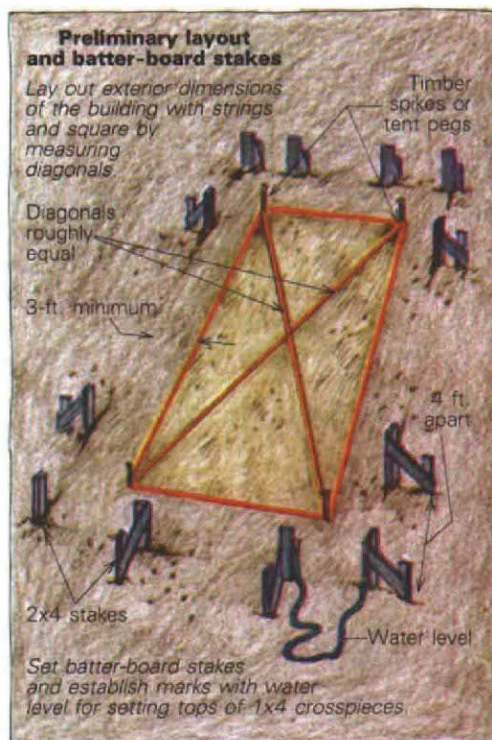
Preliminary layout—Select one end of the layout as a starting corner and drive a small stake into the ground. You can use almost anything for a stake—a timber spike or a tent peg—as long as it holds the string off the ground. Now measure back down the string the length of the wall, drive another stake, stretch the string between the two stakes and tie it off. This lets you adjust the placement of the house on the site, and gives you an idea of where to locate the batter boards. Taut strings and accurate squaring are not necessary at this point, as long as the outside dimensions of the house are accurate.

To lay out the rectangle, pull another string from the corner you just established, at a right angle to the long wall. This is where your helper is needed. One person pulls the string while the other guesses at 90°. Measure along

this second string the width of the house and drive the third corner stake. The fourth corner can be found by measuring. Now step back and study the house placement on the site. Stop and think on this one a while—it's a permanent decision. If you are satisfied, you can begin preliminary squaring.

With a 100-ft. tape, measure the diagonals. If they measure the same, then you have created a rectangle. If not, you have a rhomboid, and you will have to adjust the two corner stakes opposite the long, south wall until the diagonals are about equal. Getting to within one or two inches at this point is close enough. I use a steel tape because cloth tapes stretch. A leather thong tied to the metal loop on the zero end of the tape will help you to pull hard and hold a dimension at the same time.

Crouch with your forearms braced against your thighs, and use your body weight to pull against the person on the other end of the tape. On the zero end, hold the leather strap, not the tape, and when you are squaring strings that are suspended from batter boards later on in the layout, keep the tape from lying on the string and deflecting it. Another method of get-



Stringing level building lines

Nail crosspieces to stakes and string building lines directly above preliminary layout strings. If levels are correct, strings just touch at their intersection.

1x4 crosspieces

Nail
Twist knot

Outside of wall (building line)

ting an accurate reading on a tightly stretched tape is to hold the 1-ft. mark rather than the zero. This allows you to grasp the tape with both hands when holding it over a string intersection. With this method, remember to tell the person on the other end of the tape that you are "burning a foot," or "cutting a foot," so the measurement can be adjusted accordingly.

Once this preliminary layout is approximately square and located where you want it on the site, you can set up batter boards. Batter boards are fixed in the ground out beyond the excavation lines. They are temporary wooden corners used to tie the string that accurately defines the perimeter of the building at the outside-of-wall line, or *building line*, and the outside-of-footing line, or *excavation line*. If excavation is required within the perimeter of the structure, for an interior footing or a line of piers, you may want to establish batter boards to hold strings for these lines as well.

I use 2x4 stakes, 3 ft. to 4 ft. long, with 1x4 crosspieces. Usually this is lumber that has been used at least once before. Sharpen the stakes with a circular saw so they will drive easily with a sledgehammer. You'll need three stakes per corner, set about 4 ft. from each other, for a total of 12 for the rectangular house we're using as an example. Drive these stakes about 3 ft. outside the preliminary strings and parallel to them. This placement gives you enough room so that the excavation won't undermine the batter boards, and they can be used until the walls of the house are actually framed. It's a temptation to be exacting in placing your stakes, but you needn't take the time to be too fussy. A good foundation requires precision, but this comes from the strings the batter boards will eventually carry, not from the batter boards themselves. Be sure that the 2x4 stakes are rigid enough to withstand an occa-

sional bumping. If they aren't, nail 1x4 braces near the top of the 2x4 stakes, drive another stake where the brace touches the ground, and nail them together.

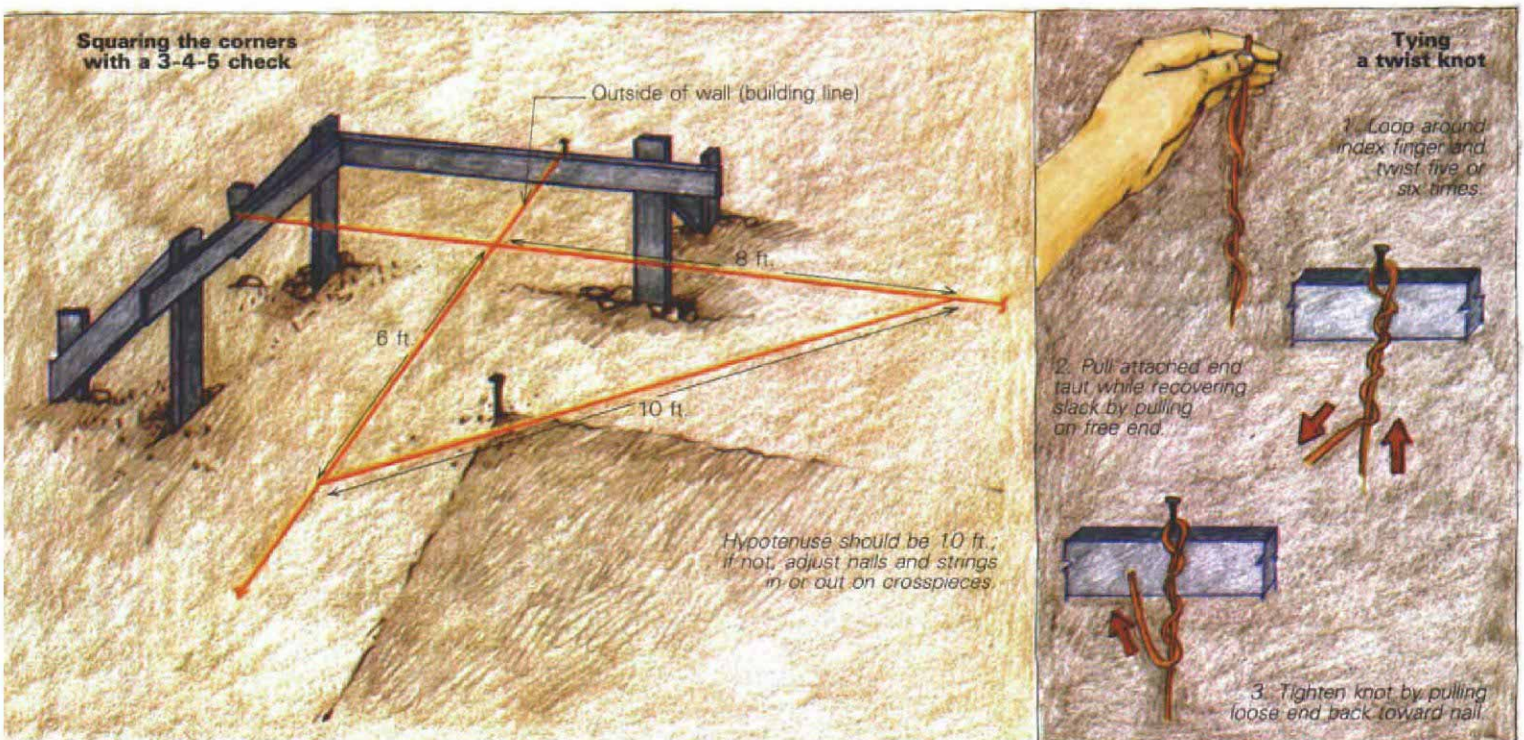
Stringing level building lines—I like to nail all the crosspieces at the same level whenever possible. When the strings are in place, this gives me a vertical reference anywhere on the perimeter, which is a real advantage in determining the depth of footings, or the height of foundation walls and concrete block. Since a lot of my foundations are block, I like to set my crosspieces (where the strings will eventually be tied) so that their top edges will be at the same height as the top course of block. To figure this, you must start at the bottom of the footings. In the colder parts of the country, the bottom of footings must always be at or below the frost line to prevent heaving during the winter. If the frost line is 32 in., for instance, and the depth of the footing itself is 8 in., then it will take 24 in., or three courses of 8-in. block to reach grade. Add another three courses, as a convenient and attractive foundation height, and you have a total of 56 in. from the bottom of the footing trench. Keeping this number in mind, measure 24 in. up from the ground on any of the batter-board stakes—the finished height of the block foundation—and make a level line.

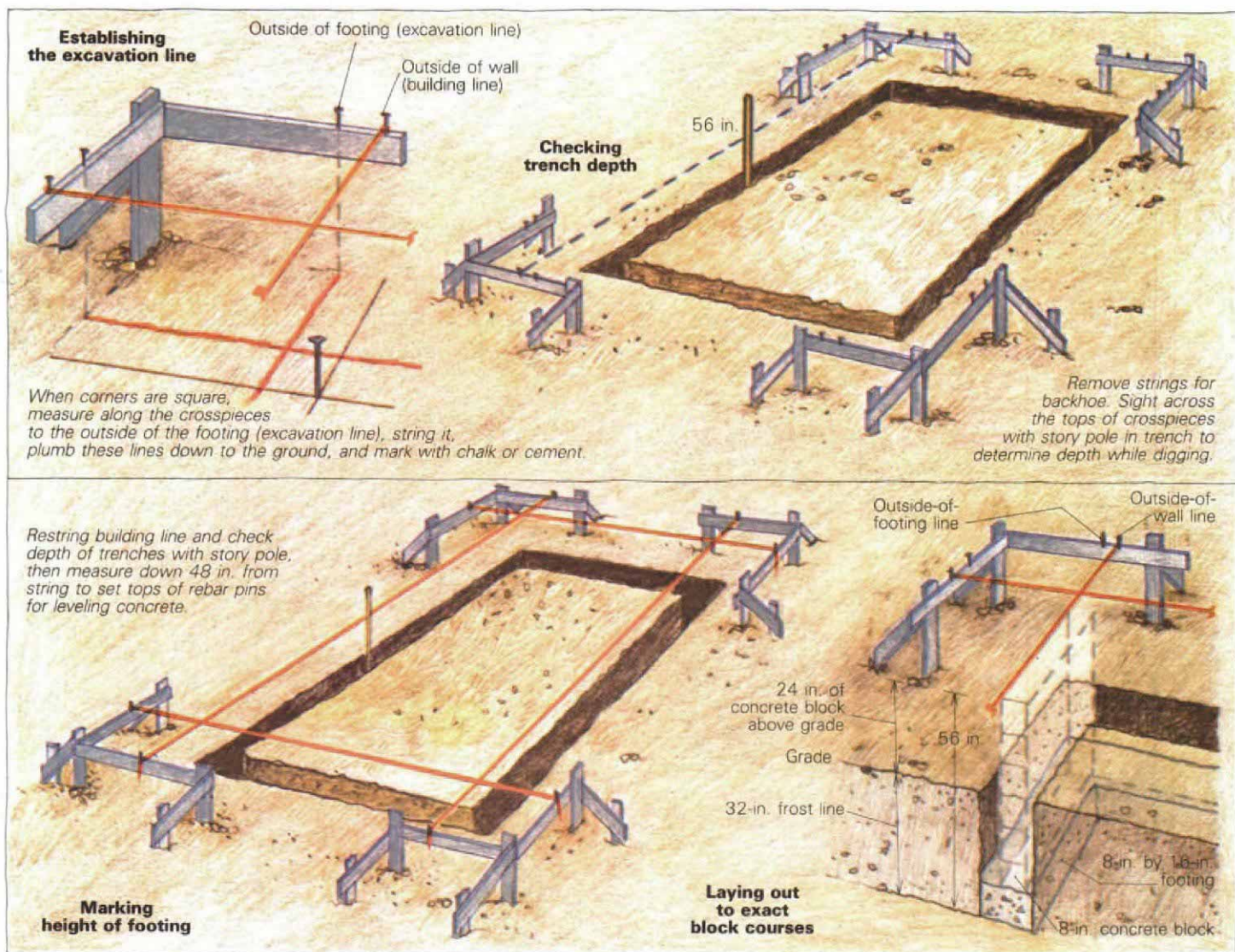
I don't own a builder's level or transit, and I've never needed one in my 20 years in the trades. Instead, I use a water level (see *FHB* #6, p.8). Whatever you use, mark level lines on all the batter boards at 24 in. Accuracy is very important here. Then nail the 1x4 crosspieces with their top edges even with the level marks.

When the crosspieces are up, pull a new string for the south side of the building over the crosspieces of batter boards on each end. Align

it directly above the preliminary layout string by sighting it from above or using a plumb bob. Tack a nail in the top of the cross member and tie one end securely. At the other end pull the string as tight as you can. This establishes a line of elevation, so you don't want it to sag. Use a twist knot to tie it off to another nail. The twist knot (drawing, below right) will keep a nylon string taut, while still allowing it to be released instantly for resetting. This knot doesn't work well with cotton line. Continue stringing until all the lines are up. If everything is level, the strings will just touch as they intersect a few feet in front of the batter boards.

Squaring the corners—The next step is to square the stringed corners, this time using the 3-4-5 check. These numbers refer to the sides and hypotenuse of a right triangle. Since 6-8-10 and 12-16-20 triangles are proportional to a 3-4-5, use the largest one you can for optimum accuracy. The intersection of the strings of each corner defines the 90° angle of the 3-4-5 triangle. You'll need a helper to measure and adjust the strings until the hypotenuse is exactly proportional. With one person holding zero (or 12 in., if you are "burning a foot") on the tape, the other person can mark the legs of the triangle on the string with a pencil, and then knot a short length of string loosely around the mark. Double-check the measurement, and then tighten this knot. Measure from knot to knot to get the hypotenuse, and adjust the strings on the batter boards if necessary. These adjustments will require driving new nails into the top edge of the crosspieces. Pull the previous nail as you correct the position of the string. If you don't, it can get very confusing when the strings come down temporarily for digging the footing trenches. When you take the string down and put it back up, check





Illustrations: Frances Boynton

the length to the knots, because nylon string stretches. To finish squaring up, use the 3-4-5 check on another corner, then check the diagonals again.

With the strings squared up to represent the eventual building lines (the outside-of-wall lines), and an elevation established, draw a plumb line down from the strings on the face of each cross-member, and write the wall thickness and the amount that the footing will project beyond the outside of the wall on the batter board. To reduce confusion, I drive nails and hang strings only on the outside-of-wall line and outside-of-footing line.

Excavation lines—Usually a footing is twice as wide as the foundation wall it supports, and as deep as the wall is thick. Footings are contained either by building a wooden form, or by digging a trench and using the undisturbed earth as formwork. I usually use the trench method. To show the backhoe operator where to dig, I plumb down to the ground from the outside-of-footing line and stretch a string at grade. I mark over this string with lime or cement dust as if I were marking out an athletic field. You can also use scouring powder with a shaker top. The backhoe operator should hold

the outside tooth of his bucket to the line, and dig to the inside.

Checking trench and footing depth—The batter boards give a quick vertical reference for determining how deep to trench. In our example, the bottom of the footing is 56 in. down from the top edge of the crosspiece. Instead of strings, which during excavation should be wound around a stick, use a story pole with a 56-in. mark on it. Stand the stick in the trench and sight from the top of one batter board to another. The mark on the story pole should line up with them.

When the machine work is finished, string the lines on the outside-of-wall line (the building line). Pull them very tight. Shape up the sides and corners of the trench with a shovel, maintaining the 56-in. depth you can now check by measuring from the string.

Next, set the depth of pour for the concrete. I use $\frac{3}{8}$ -in. or $\frac{1}{2}$ -in. steel reinforcing rods about 6 ft. to 8 ft. apart to indicate depth during the pour. Cut them about twice the depth of the footing so that you can drive them into the ground. Measuring down from the string to the top of the rebar, carefully tap them with a sledge until you read 48 in. on the tape. This

will give you an 8-in. footing at the 32-in. frost line, and six courses of block on top will bring you up to the string (drawing, above right). Then pour the concrete level with the top of the rebar. I use a garden rake to push the concrete around and for initial screeding. I hold the rake in a vertical position to smooth the top of the concrete and jitterbug the coarse aggregate down into the mix. You also might want to use a 2x4 screed short enough to fit between the rebar depth indicators, but it's not necessary to trowel the surface smooth. If you are pouring a foundation wall on top of the footing instead of laying block, the same techniques can be used, but remember to form a keyway in the footing to receive the next pour, and check with local codes to see if vertical rebar is required to tie the footing to the foundation wall.

The next day the concrete will be hardened sufficiently to begin working on the foundation walls. I usually drop a plumb bob down from the outside of wall lines and snap chalklines on the green footing. If the foundation is to be concrete block, then marking the corners will be enough since the mason will be pulling his own lines from corner to corner on each course. □

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