FOUNDATIONS

A Pier-and-Beam Foundation, the Jersey Way

Concrete, rebar, and 84 driven piles create solid support

BY NATHANIEL ELDON

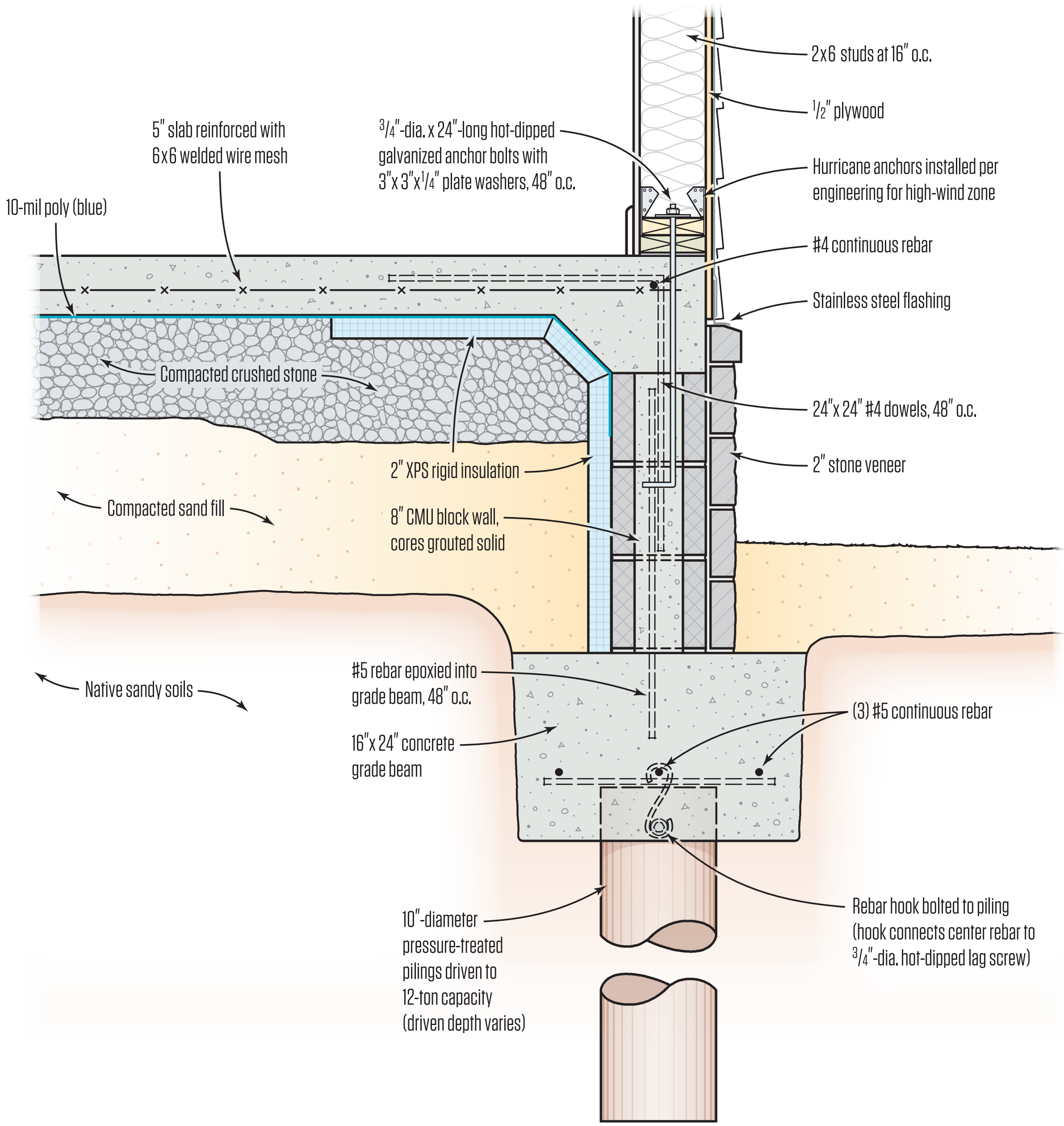
Most of the houses that my company builds are on the barrier islands of southern New Jersey, and most of those homes sit on grade-beams or footings supported by wood pilings or piers. These foundations are used in different configurations in many parts of the country to support buildings where soil conditions may be suspect. Here on the coast, the soil is typically sandy and low-lying. Coastal storms in these areas bring tidal surges and breaking waves that can wash away the sandy soil in a blink. Pier-and-beam foundations (see illustration, next page) ensure that buildings are properly supported and anchored on building lots that are just a few feet above sea level.

Photos by Nathaniel Eldon

These foundations work by distributing the weight of the building to piers (in this case, treated wooden pilings) that are driven into the ground to a specified distance to achieve proper bearing capacity. Reinforced concrete grade beams span between the piers to carry the building's structure. While this specialized type of foundation might not be necessary in most areas of the country, a look at the construction process can offer a valuable glimpse into some the challenges that face a contractor who builds on the coast.

For this project, the base flood elevation for the building lot was 8 feet above sea level, and the planned elevation of the first-floor slab was 11 feet above sea level. Plans called for short CMU walls

Piling-and-Grade-Beam Foundation



A piling-and-grade-beam foundation starts with pilings—in this case, 10-inch-diameter treated logs—driven into the sandy New Jersey coastal soil until each pile reaches a minimum bearing capacity (12 tons for this foundation). The soil is then excavated in a trench along each line of pilings to a prescribed width and depth. Rebar is added on top of the pilings and attached with hooks that bolt to the pilings. The trench becomes the form for the concrete grade beam. A short concrete block foundation sits on top of the grade beam; after the block foundation is filled with soil and that soil is compacted, a slab is poured over the concrete block as an alternative to conventional floor framing and a crawlspace. In a high-wind zone, like the New Jersey coast, all layers, including the wall framing, have to be tied together with engineered connections.

Illustration by Tim Healey

Piles in the ground. Before pilings are driven, an engineer lays out the positions of each one **(1)**. A dump truck delivers the pilings **(2)**, the length and diameter of which are based on the soil requirements. A long auger digs a hole at each location **(3)**. A crew member fastens a loop of chain around each piling **(4)**, and the crane lifts the piling and swings it to the hole. The crew member then guides the piling into the hole **(5)** and levels the ground around the piling with a shovel.

on top of the grade beams with a concrete slab on top of the walls for the first floor of the house. (Because of strict height restrictions, we chose a slab for this project to eliminate the thickness of the first-floor framing).

SETTING THE PILINGS

After we demolished an existing house on the property and cleared and rough-graded the building site, we were ready to lay out and auger in the pilings. Support for this house consisted of a total of 84 wood pilings. The engineer had set a stake at each piling location **(1)**. Once the holes for the pilings had been augered and the piles set, the engineer would return to witness and certify that the piles were driven to their proper bearing depth.

The foundation-piling contractor, Charlie Lord, has been driving piles on this island with his father (now retired) and his uncle, Dave Lord, for a long time, and they have a good understanding of the idiosyncrasies of the area's soil. Armed with this knowledge, they ordered 12-foot piles with 10-inch-diameter butts. When augered and driven in, this size piling would provide the 12-ton bearing capacity for each piling specified on the engineering plan.

There is an art to setting and driving piles, and the crew of three worked quickly and efficiently. They dropped their equipment at the site mid-morning on a Tuesday—they had already finished a smaller, "warm-up" job of 30 or so piles earlier that morning. Then they left to pick up the 84 pilings (two dump-truck loads) at a local yard **(2)** and returned to the site to begin installing piles just after noon.

Augering. Using a piling rig with a mounted auger, Charlie started drilling the pile locations in the southeast corner of the lot **(3)**. The auger cut holes about 10 feet deep in the sandy soil. This depth would leave the pilings about 2 feet out of the ground before being

Pounding the pilings. When all the pilings are in their holes, the crew attaches a sled with a 1-ton driving hammer to the crane. The crane positions the sled over each piling and a crew member marks 6-inch increments on the sled to monitor how deep the piling travels with each hit **(6)**. The crane raises the hammer and drops it on the piling **(7)**, while the engineer (slightly out of the photo) witnesses and records each piling.

driven. After drilling each hole, he pulled the auger out, spun the shaft to remove the soil, and quickly moved to the next location.

Placing piles. While Charlie dug the first hole, a third crew member rigged a chain around the end of a piling **(4)**. The chain attached to the boom of a crane operated by Dave. As the auger finished digging, the crane lifted and swung the piling over to the hole that had just been dug. The crew member on the ground helped guide the piling into the hole **(5)** and removed the chain from the top of the pile. Then he dashed over to rig up the next piling.

This hectic sequence continued for the next two hours until all 84 pilings were sitting in their holes. The engineer was scheduled to be at the site at 2 p.m. to certify the pilings. Standard practice is for the engineer to witness every pile being driven to capacity. He then produces a log noting the location, length, and bearing capacity of each piling.

DRIVING PILES

With all 84 pilings augered into their holes, the crew set up the driving hammer and sled on the crane. The hammer is a 1-ton block of steel that travels along grooves in the sled. The sled hangs from the boom of the crane. When the sled is in position over a pile, the crane's winch lifts the hammer and then releases it to drive the pile into the ground. Before the hammering begins, a crew member marks 6-inch increments from the bottom of the sled **(6)**. These marks let the engineer witnessing the pile driving determine when the piles have been driven deep enough to reach their bearing capacity.

The bearing capacity of the pilings is determined by a mathematical equation based on the piling length (in this case 12 feet), the butt diameter (10 inches for these piles), the drop distance of the hammer (a dozen feet), and the hammer's weight (1 ton). With these

8

9

10

Digging for the grade beam. A mini-excavator roughs out the trenches, digging between the pilings **(8)**. The crew follows, evening out the floor of the trench with shovels to prep for the concrete **(9)**. The crew keeps the depth of the trenches consistent using a laser level. As the trenches are finished, one crew member cuts the pilings 4 to 6 inches above the floor of the trench with a chain saw **(10)**.

parameters, once the hammer has hit a piling five consecutive times with the piling traveling less than 1 foot total distance, the 12-ton bearing capacity has been achieved for that piling.

With the first couple of hits, the piling moves a lot—sometimes a foot or more. By the third or fourth hit, the piling is moving only an inch or two each time. The hammer continues to hit the piling until it moves less than a foot in five shots **(7)**. Most of the pilings for this project took seven or eight hits total to achieve bearing capacity.

Pile driving was similar to augering the piles in that this same piling crew of three worked quickly. After achieving bearing capacity with one piling, they swung the hammer and sled to the next one, with the engineer checking off the pilings as they went. Occasionally, a piling achieved bearing capacity while still sticking out of grade a bit. To keep these taller pilings from getting in the way, they sawed off the piling to just above grade level.

Conversely, sometimes a pile required more than eight or nine hits before it provided enough resistance to verify the bearing capacity. In those cases, the crew had to dig out around the pile that went below grade level before it was set to the right depth. In the end, the crew was able to drive all 84 piles with the hammer in just over an hour. By the end of the afternoon, the piling crew was loading up their equipment and heading home for the day.

DIGGING OUT THE GRADE BEAM

A few days later, the foundation crew came to excavate for the grade beam. They started by digging a trench along each line of piles. This trench became the form for the beam. Layout for the grade beam was simple: It followed the layout of the pilings. Precision was not critical at this point as long as a minimum depth and

Grade beam reinforcement. The crew installs #5 rebar to reinforce the grade beam. The first pieces are short lengths of rebar that rest on each piling **(11)**. Next, three lengths of rebar sit atop the short pieces **(12)**. Where two or more lengths are needed for a straight run, the pieces overlap and are tied together. At intersections, the rebar from one trench sits on top of the other and they are tied together **(13)**. Finally, the crew bolts S-hooks to each piling to anchor the rebar **(14)**.

width of the concrete grade beam were maintained. Plans called for the beam to be 24 inches wide and 16 inches deep.

There was a pile at every corner of the building, so the easiest strategy was to find the corners and dig between them. The crew used a mini-excavator to do the bulk of the digging between piles **(8)**. Other crew members then followed, hand shoveling beside the piles while leveling the floor and squaring the walls of the trench **(9)**.

Once the crew had a good start on the trench, a couple of crew members broke off and started cutting the piles with a chain saw 4 to 6 inches above the floor of the trench **(10)**. (The bottom of the trench would also be the base of the grade beam).

REINFORCING THE GRADE BEAM

Once the excavation was finished and the piles cut to the proper height, the crew could begin placing reinforcement steel. First, they placed a piece of rebar (about 18 inches long) on top of each pile, oriented perpendicular to the length of the grade beam **(11)**. These short pieces of rebar supported a three-bar assembly of #5 rebar that served as the primary reinforcement for the grade beam.

The crew placed three lengths of rebar equally spaced about 8 inches apart on top of the short, perpendicular pieces **(12)**. They tied the lengths of rebar to the short crosspieces to secure them in position at every piling. At corners and intersections of perpendicular trenches, the rebar overlapped to tie the two directions together **(13)**.

The crew then secured the rebar grid to the pilings. For this project, the contractor used S-hooks made from prebent #3 rebar. The top of these hooks went over the center bar. A lag bolt and washer through the lower portion of the hook held it fast to the piling **(14)**. As a last step, the crew drove grade stakes into the top of each piling, using a laser to set the height **(15)**. These stakes

Bring on the concrete. To set the level for the top of the grade beam, the crew drives a rebar stake into the top of each piling, setting the depth with a laser **(15)**. A concrete truck places mix for each beam while the crew moves the mix around quickly to avoid cold joints in the grade beams **(16)**. After letting the beams cure, the masons build short foundation walls **(17)**. Lengths of rebar are drilled and epoxied to tie the block to the grade beams, and the concrete block is then fully grouted.

helped to keep the top of the grade beam level during the pour.

ADD THE CONCRETE

After an inspection of the rebar grid, we ordered concrete and poured the beam. The crew worked as quickly as possible to prevent any cold joints from forming during the pour **(16)**. On this job, the engineer specified a 4,000 p.s.i. mix for the pour.

After letting the grade beam cure for a few days, the engineer came back to the site to lay out the corners of the foundation. Building on postage-stamp lots such as this one, with strict zoning requirements—not atypical for the projects we do—requires pinpoint accuracy. The 2-foot-wide concrete surface of the beam allowed plenty of room to precisely align the foundation walls consisting of three courses of block.

To tie the block to the grade beam, the masons drilled and epoxied lengths of rebar into the grade beam every 4 feet as they set the block **(17)**. Waiting until after the pour allowed them to place the rebar where it would not interfere with block. The masons fully grouted the block to ensure maximum strength.

When the walls were finished, we placed 2-inch XPS insulation along the inside of the wall before backfilling and compacting the soil inside the walls. All the plumbing stubs also had to be located and placed. We added a layer of 2-inch XPS insulation on top of the compacted soil, followed by a layer of 10-mil poly to act as a vapor barrier. A 6-inch slab formed and poured on top of the block was the final layer for a rock-solid foundation to this house within earshot of the crashing waves on the shore.

Nathaniel Eldon owns Eldon Builders (eldonbuilders.com), a custom home-building and remodeling company in Cape May, N.J.