Helical Pier and Grade Beam Foundation

On a wet site, this design allows the footings to 'hover' above the water table

BY CHAD SMITH

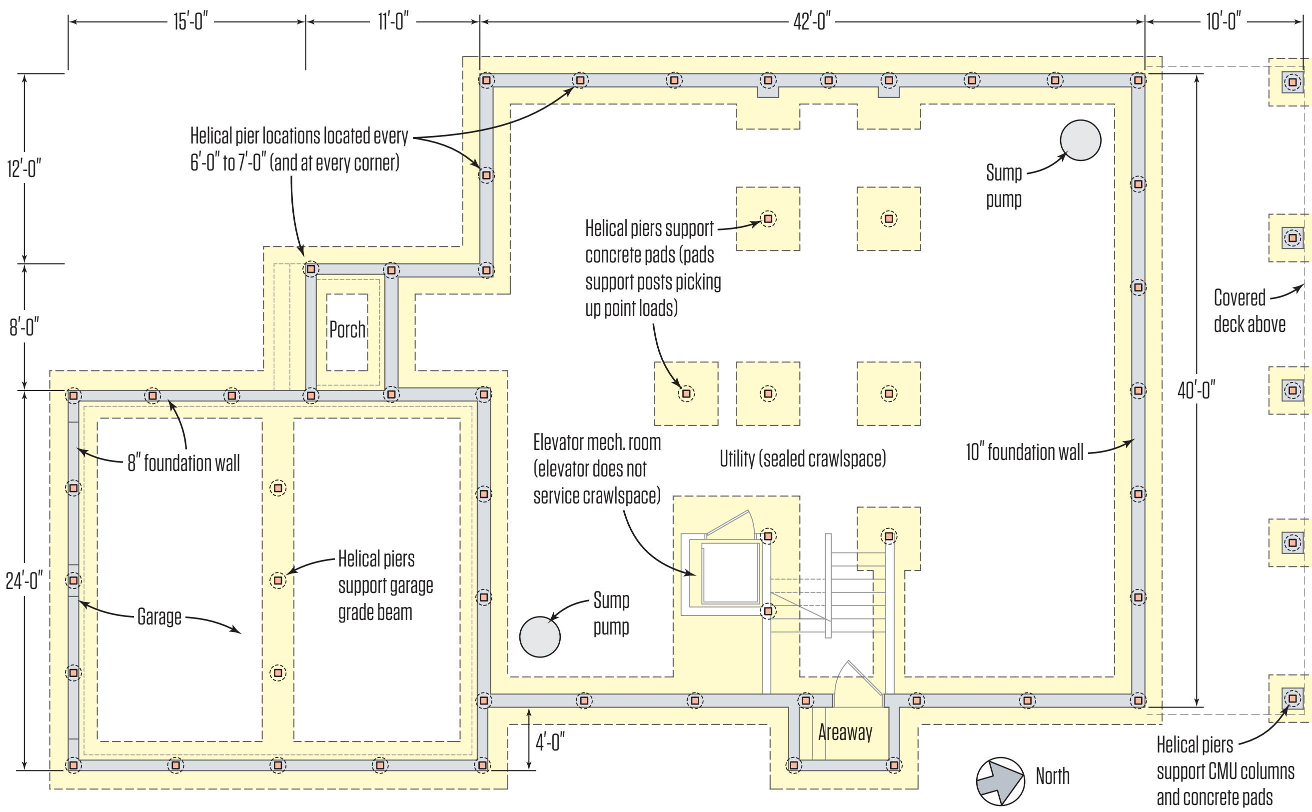
Photos by Chad Smith; illustrations by Tim Healey

My brother is currently building a house on the waterfront of the Magothy River, near Annapolis, Md., in an area where soil conditions are too inconsistent for a conventional foundation. The building site is about 60 feet from the water's edge, with significant groundwater at 3 to 4 feet below grade. To avoid any possibility that the foundation would settle in those saturated soil conditions, plans called for the new home to be supported by a concrete grade beam and a series of concrete pads bearing on 59 helical piers, each penetrating 17 to 18 feet below ground level. My company, which has about 20 years of experience using helical piers (we call them piles in my area) in a variety of applications, did the layout and pier installation and worked directly with the subcontractors and tradespeople who excavated the site and formed and poured the grade beam and walls.

HELICAL PIERS

On most of our projects, the helical pier supplier—typically either Pier Tech or Ideal—does the general engineering for loads based on the plans that we provide, and a local engineer then checks the loads and certifies the plans. The most common helical pier we install measures 2 7/8 inches in diameter and, when installed to 1,000-foot-pounds of torque, will support 9x loads (i.e., 9,000 pounds of weight). On this project, our target was 1,670-foot-pounds of torque for 15,000 pounds of load per pier. The load bearing range for

Foundation Plan



To deal with the building site's high water table, plans for the waterfront home called for a grade-beam footing bearing on helical piers driven 14 feet into the ground. In addition to being evenly spaced along the walls and at the corners as shown above, piers were located below load-bearing concrete pads for interior and exterior columns.

a helical pier is often referred to in terms of kips, or kilo-pounds. So, for example, 15,000 pounds of bearing equals 15 kips.

We installed the piers using our 10,000-pound mini-excavator, which is equipped with a torque head that's fitted with hydraulic pressure sensors coupled to a digital drive monitor. This allows us to do a calculated readout of the torque achieved based on the difference between the input hydraulic pressure and the return pressure. With our digital equipment, we then download the data and provide it to an engineer as proof of successful installation, which often saves on witness testing or having to hire an engineer to perform on-site witness verification, which can be costly.

EXCAVATION AND LAYOUT

On this job, the soil was so wet that we had to overdig the building footprint to a depth of about 7 to 7 1/2 feet below grade and fill the overdig with a 3-foot layer of #6 stone on top of geofabric. The stone was placed and the elevation of the grade beam was planned based upon the known elevation of the water table (I live 13 houses up the street, and my brother lived at this location for 16 years prior). After we placed the stone, we compacted it with a 5,000-pound vibratory roller.

All the helical-pier depth measurements were taken from the top of the stone, which acts as an underdrain, allowing water to flow freely beneath the grade beam and the flatwork, and as a firm base for driving the machine that we used to install the piers. The water table here can vary by as much as 30 inches, and we had record rains just prior to starting this job, so the water table was only 3 inches (not feet) from the top of the stone during the entire process. More typically, the water table would be 12 to 18 inches lower.

Once the grade beams were poured and the forms were stripped, we added another, 16-inch-thick layer of stone along with the drain tile before pouring a 4-inch-thick concrete slab. As a result, the top-

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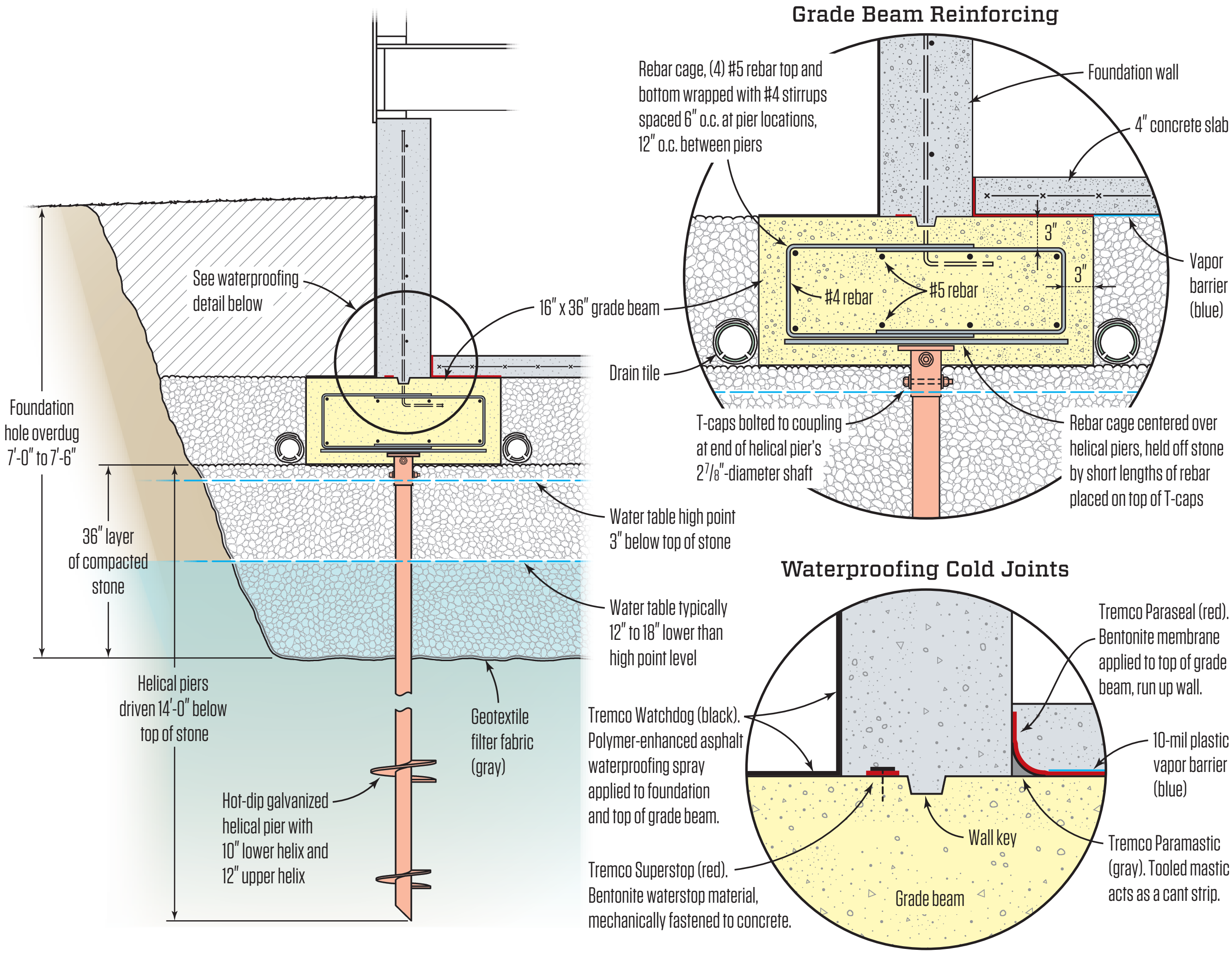
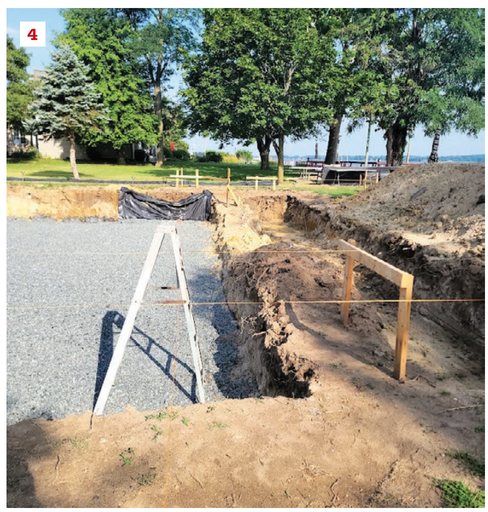


Roof and floor loads are transferred down through the walls to the concrete foundation and steel-reinforced grade-beam footing, which in turn bears on helical piers, each capable of supporting at least 15,000 pounds. Groundwater can move freely through the compacted stone base, while the waterproofing details shown above keep it from entering the crawlspace.

of-slab elevation was 23 inches (3 inches of water draft, 16 inches of additional stone, and 4 inches of concrete) above the water table high point elevation.

This system minimizes the need for interior and exterior drain tile because the sump basins can receive water directly from the stone. Still, to limit the amount of hydrostatic pressure on the foundation walls were the water table to rise high enough during a storm, we supplemented the existing sump basin (from a preexisting home) in the center of the foundation with two additional sump basins placed at opposite corners of the foundation to help rapidly drain off water and appease the local inspector. Drain tiles wrapped with a sock and covered in stone are located adjacent to the footing grade beams and empty into the sump basins, which have pumps and 1 1/2-inch piping for discharge.

Batter boards. During site layout, we used our survey points and offsets to place old-school batter boards to set up and establish the inside and outside lines of the foundation. This saved money on engineering and surveyor revisits, since we only paid for the offset points needed to set the batter boards. From the batter boards, we established the elevation for the top of foundation, which we used to calculate the downward measurements for the elevations of the helical piers, top of grade beam, and top of slab.



To account for the site's high water table, more than 7 feet of soil was excavated for the crawlspace foundation and replaced with a 3-foot layer of stone on top of filter fabric **(1)**. To install the helical piers **(2)**, the author uses a mini-excavator equipped with a torque head fitted with hydraulic pressure sensors that allow him to monitor the pier's installed torque **(3)**. Batter-board lines were used to lay out the grade beam and pier locations **(4)**.

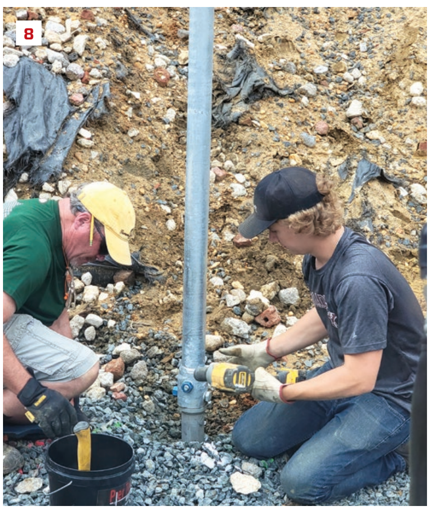
To locate the helical piers, we moved the actual footprint of the home inward from our outside-of-wall marks by 18 inches (grade-beam width is 36 inches, so 18 inches—or half the width—gives us the centerline of the grade beam). We then coordinated the pier locations by measuring off the running distance and placing marks on our lines. Doing this allowed us to use a plumb bob to locate the pier centers on the stone, which we marked in paint. Since the base was stone, we used 60d nails to pin the actual centers. This saved us another engineer visit.

Once the grade beams were poured, we would again use the batter boards to mark the wall corners as well as determine the top-of-wall height. The batter boards took a bit of time to set up perfectly in the beginning, but they were a critical element for accuracy and efficiency and saved us four extra engineer visits at $500 to $700 per visit (a savings of $2,000 to $2,800).

We laid out the helical pier locations based on the engineer's projected load for a center-to-center spacing of no greater than 7 feet. The hot-dip-galvanized piers are a twin-helix design by Pier Tech Systems using a cross-bolt link between each section, which minimizes deflection at the coupling joint. These twin-helix piers have a 10-inch-diameter lower helix and a 12-inch-diameter upper helix, with a 2 7/8-inch shaft diameter.

PIER INSTALLATION

Most of the time, we don't know what the soil conditions are or what we might hit unless we perform a soil boring or analysis near every pier location, which tends to be cost prohibitive. Due to our local experience—especially with waterfront construction and specifically with this community—we knew the soils would require at least 7 to 10 feet of depth before a helical pier would achieve the desired load capacity. While piers are available in a variety of lengths as a custom order, it's more economical to purchase standard,



During helical pier installation, a magnetic spirit level fixed to the shaft helps to ensure that it is plumb **(5)**. When the lead reaches full depth **(6)**, a 7-foot-long extension is fitted to the torque head **(7)** and cross-bolted to the top of the lead **(8)**. After the assembly has reached the target torque and then been driven to a full 14-foot depth below the surface of the stone, a worker bolts a T-cap to the top of the extension **(9)**. To make sure that the elevations of the T-caps were all within 1/8 inch of each other, the author first used the string line for reference when installing the piers, then used a rotary laser to fine-tune them.

7-foot-long piers and add extensions if more length is required.

For this project, we purchased enough leads and extensions for at least 59 locations throughout the foundation. Along with grade-beam support, pier locations include the mounting positions for structural posts and an elevator shaft, a grade beam in the garage, and porch support. Because we try to use the same size pier for most applications, we commonly have additional leads and extensions in stock, so a project isn't delayed should we require field alterations.

All the helical piers on this project were driven to at least 14 feet below the top of the stone, with a few needing to be driven to nearly 21 feet in the far north corner, which is on the waterfront. We began the installation by driving the first two piers to a measured torque of 1,667 foot-pounds to achieve the load rating of 15,000 pounds per pier—or 15 kips—as determined by the 9x yield specified by the supplier (1,670 x 9 = 15,030). With the piers spaced 7 feet on-center, this would provide the load-bearing capacity required by the engineer.

After driving the first few piers, we determined that we were achieving the target torque at a depth close to 12 feet. Since that was so near the 14-foot total length of a 7-foot lead plus a 7-foot extension, we decided to drive all the piers to 14 feet. This saved us from having to cut off 59 piers, which would then need holes drilled for bolts to attach the T-caps for support of the grade beam. Due to the strength of the steel, cutting a pier to length and drilling holes through it is not a quick and easy task, so we try to avoid it if possible.

We measured down from the batter-board string lines to the top of the helical piers to get the elevation roughly in range, then used a Hilti rotary laser for fine-tuning the installation so that the tops of all 59 piers are within 1/8 inch.

GRADE-BEAM FOOTINGS

Once all the piers were driven, we tied up a grid of #5 rebar to pairs of prefabricated #4 stirrups spaced approximately 6 inches apart

The torque, depth, and installation time and date of each helical pier were recorded on its T-cap and documented photographically **(10)**. A total of 59 helical piers—each with a minimum bearing capacity of 15,000 pounds—were installed to support the grade beam footing **(11)**.

During the project, an existing sump pit (from a previous structure) was used to help manage the water level on the wet site **(12)**. After assembling the rebar cage for the grade beam on top of the piers, the crew built 36-inch-wide-by-16-inch-deep forms in preparation for concrete **(13)**.

at the T-caps to reinforce the grade beam at the pier locations and about 12 inches apart between the piers. This cage was built on top of and centered over the pier T-caps and held off the stone by short lengths of rebar placed on top of the T-caps. This way, when we poured the concrete grade beam, the concrete would fill the gap between the stone and the rebar so that the steel would not be exposed.

We assembled the grade-beam cage from 534 stirrups prefabricated from 3,300 lineal feat of #4 rebar, 442 lineal feet of #4 hook dowels located 16 inches on-center, 2,136 lineal feet of #5 longitudinal rebar, 176 lineal feet of #6 transverse rebar installed 48 inches on-center, and 380 lineal feet of #5 rebar in the interior column footings to support point loads from structural posts and an elevator shaft.

We then built the forms for the 36-inch-wide-by-16-inch-high grade beam around the cage and on top of the stone, allowing approximately 3 inches of space between the rebar and the form. When we poured the concrete, we needed a truck-mounted boom pump with a 100-foot reach, but with an overhead power line near the site, we needed to build supports to keep the boom flat rather than up at an angle. We used 38 yards of concrete to pour the grade-beam footings and another 13 yards for the pads, columns, and post footings.

FOUNDATION WALLS

Once the grade beam was poured, the rest of the project took shape like a traditional poured foundation except for the amount of steel used. Because rebar is not too expensive, the homeowner decided to increase the amount of steel to create stiffer wall sections. While the engineer said this extra measure wasn't necessary, the additional rebar is cheap insurance to limit any cracking potential in the future. The total amount of rebar used in the walls included 876 lineal feet of #4 horizontal rebar, 402 lineal feet of #4 vertical rebar 16 inches on-center, and 156 lineal feet of #4 rebar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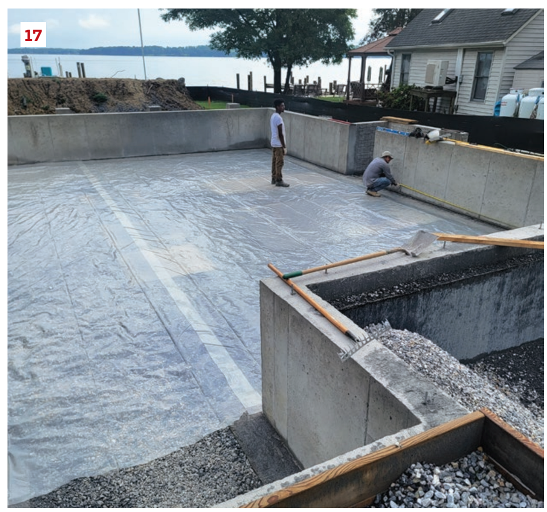
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A truck-mounted boom pump with a 100-foot reach delivered the 38 yards of concrete needed to pour the grade beam **(14)**. Ten-inch-wide foundation walls for the main house **(15)** and 8-inch-wide foundation walls for the garage **(16)** were formed and poured on top of the grade beam. After the forms were stripped, a waterproofing membrane was applied to the exterior of the walls and additional #6 stone brought in to bring the bottom of the slab level with the top of the grade beam **(17)**. A 10-mil vapor barrier was installed over the stone before the 4-inch-thick slab was poured.

at the corners. This steel reinforcement was tied to the vertical sections that extended up from the grade beams.

Prior to pouring the walls, we pinned an expandable granular bentonite waterstop called Tremco Superstop to the grade beam next to the key to seal the cold joint between the footing and the wall. Then the wall forms were filled with 44 yards of concrete.

After the forms were stripped and the concrete cured for a few days, we sprayed the exterior walls with several coats of Tremco Watchdog, a polymer-enhanced-asphalt-emulsion waterproofing membrane. On the interior, we formed a cant strip at the joint between the footing and foundation wall using Tremco Paraseal Paramastic, a putty-like bentonite compound that we applied with a duckbill trowel to form a 2-inch radius. Then we covered the joint with a Paraseal bentonite membrane that extended up the wall about 3 inches and covered the top of the grade beam.

With the waterproofing in place, we placed drain tile both inside and outside the grade beam and added more stone so that it was flush with the top of the grade beam. This allowed for normal placement of the 10-mil plastic vapor barrier, which overlapped the grade beam, followed by 6-by-6-inch welded wire mesh. The flatwork was then completed, with the 4-inch-thick concrete slab overlapping the grade-beam footing.

An area in the garage that had been part of the original home that was razed required compacted fill, so we had to wait a few weeks for the concrete to cure before doing that operation. Even though the garage backfill was compacted, we installed additional helical piers to support another grade beam in the center of the garage to help support the garage flatwork and ensure there would not be any future settling. At this point, we were able to backfill the foundation and begin the normal framing operation.

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