On the Beach: Coastal Construction

by Patricia Hamilton

Wood pilings are a time-tested foundation. In fact, they have been discovered intact below major buildings of the Roman Empire. They are also the foundation of choice for most of the homes our company builds along the coast of Delaware.

A home built in any flood zone must be elevated above the base flood level, whether it's on pilings or a masonry foundation. For homes built in a Flood Insurance Rate Map flood zone rated for "velocity wave action" (V zone), piles or columns are required. For many other homes in less exposed zones along the coast, piling foundations are recommended but not required. We prefer to use piling foundations on *all* coastal homes, and even on inland homes where the soils are sandy or the site marshy.

Well-braced pilings and engineered framing connections protect coastal homes from high water and hurricane winds

Piling Choices

Although steel and concrete pilings are available, most builders in our area use wood pilings for homes. They come as either round, peeled logs or square-sawn 8x8s and 10x10s. The preference for one shape or the other seems to vary by region. In our area, round poles from tree farms in the Carolinas are most common.

The typical piling we use is a Class B 12-3-8 CCA-treated (1-lb. retention) southern pine, 20 to 60 feet long. The "12-3-8" denotes that the diameter 3 feet from the butt is 12 inches, while the tip diameter is 8 inches. We avoid creosoted pilings because the sawdust can burn exposed skin. Also, the noxious odor of the creosote will persist for years — not acceptable if sections of pilings are enclosed within the living space.

Piling length. Pilings resist loads by surface friction against the soil, not at the base the way a post on a footing does. So the length of a pile is determined by the depth necessary to resist vertical uplift and horizontal loads, as well as the potential for erosion, or scouring, around the pile at grade, the ground elevation, and the base flood elevation. Since soil conditions vary, we try during the design stage to speak to a pile driver who has driven piles at a nearby site to determine the expected bearing capacity. This can range from 10 to 20 tons per piling. In our region, most beachfront homes are designed for

Figure 1. *By counting the number of blows required to drive the piling a given distance, the builder can determine the pile's bearing capacity. A driving log is usually kept to show the inspector.*

15 tons. Sites with marshy soils along bays are designed for 10 tons.

Embedment. Another criterion that must be satisfied is embedment depth. It's occasionally possible to get the bearing you need without going deep enough to provide the necessary lateral support for the pilings. My engineer usually requires at least 20 to 25 feet of embedment.

Driving. Piles are driven into the ground, tip first, by a crane-mounted diesel- or air-powered hammer (see Figure 1). Our subcontractor uses a double-acting hammer, which automatically rebounds from each blow at the piling. The double-acting hammer is faster and usually more precise than a single-acting hammer, which must be raised by cable after each blow.

The installed cost of the pilings is about $8.50 to $9 per lineal foot of piling (not including the cost of notching pilings or setting girders). The average house we build has forty to fifty 30-foot pilings (around $12,000 total).

Although it is possible to statically test the bearing capacity of each pile after it is driven, this is also expensive. So as a matter of general practice, the bearing capacity is determined by counting the number of hammer blows required to drive the piling a given distance. The accepted formula for this is $R = 2(Eg) \div (S + 0.1)$, where R is the bearing in pounds, Eg is the force in psi delivered by the hammer, and S is the pile set per blow in inches. Eg is established by testing the operating rebound pressure at the hammer with a pressure gauge. Operating pressures range from 10 to 25 psi, depending on how fast the diesel motor is run. After the vertical bearing is determined, lateral bearing is figured at one-half the vertical.

We always keep a driving log for each pile, recording the number of blows per foot. Sometimes the building inspector may require that all or part of this log be kept and certified by a licensed engineer.

Prepping the Site

Before pilings can be driven, the lot must be cleared and leveled. A piledriver crane runs on tracks, but needs fairly level terrain for maneuvering and stability. Once the lot is cleared, we have a surveyor set a stake for each piling, and for the major corners of the house. If the final tip or butt elevations of the pilings vary, the stakes are color coded.

The average charge to stake the pilings and set an elevation benchmark is $7 to $15 per piling, plus $75 for the elevation benchmark. Before the project gets its Certificate of Occupancy, the house has to be surveyed again for lot placement, first-floor elevation, and total height. We sometimes negotiate a package deal for all the surveying — usually $500 to $700 per house. Because the typical oceanfront lot is small and we're building within a fraction of an inch of setbacks, the expense of the surveyor is well justified.

A piling is then driven at each stake. The complications start here because pilings are rarely perfectly straight and underground obstructions may divert the piling from a truly vertical path. As the pilings are being driven, we align the tops, which are often 10 or more feet above grade, by eye. Slightly deviant pilings can be realigned with some effort — by digging out the top with the backhoe and pushing it sideways, for example — but wildly crooked pilings have to be redriven. After all the pilings have been driven but before the pile driver leaves, we use string lines to check the alignment of piles. The specs usually require the centers of the tops of all pilings to be within 3 to 6 inches of their staked location.

Building the First-Floor Deck

Houses built on pilings are in essence hybrid post-and-beam houses. Ultimately, all loads must resolve to the pilings by way of beams, girders, and cross-bracing. Because of the complex load paths involved, and the likelihood that the home will be tested by high winds, water, and impact from waterborne debris, it is essential that the entire structure be engineered. Although we can design very simple houses ourselves in accordance with

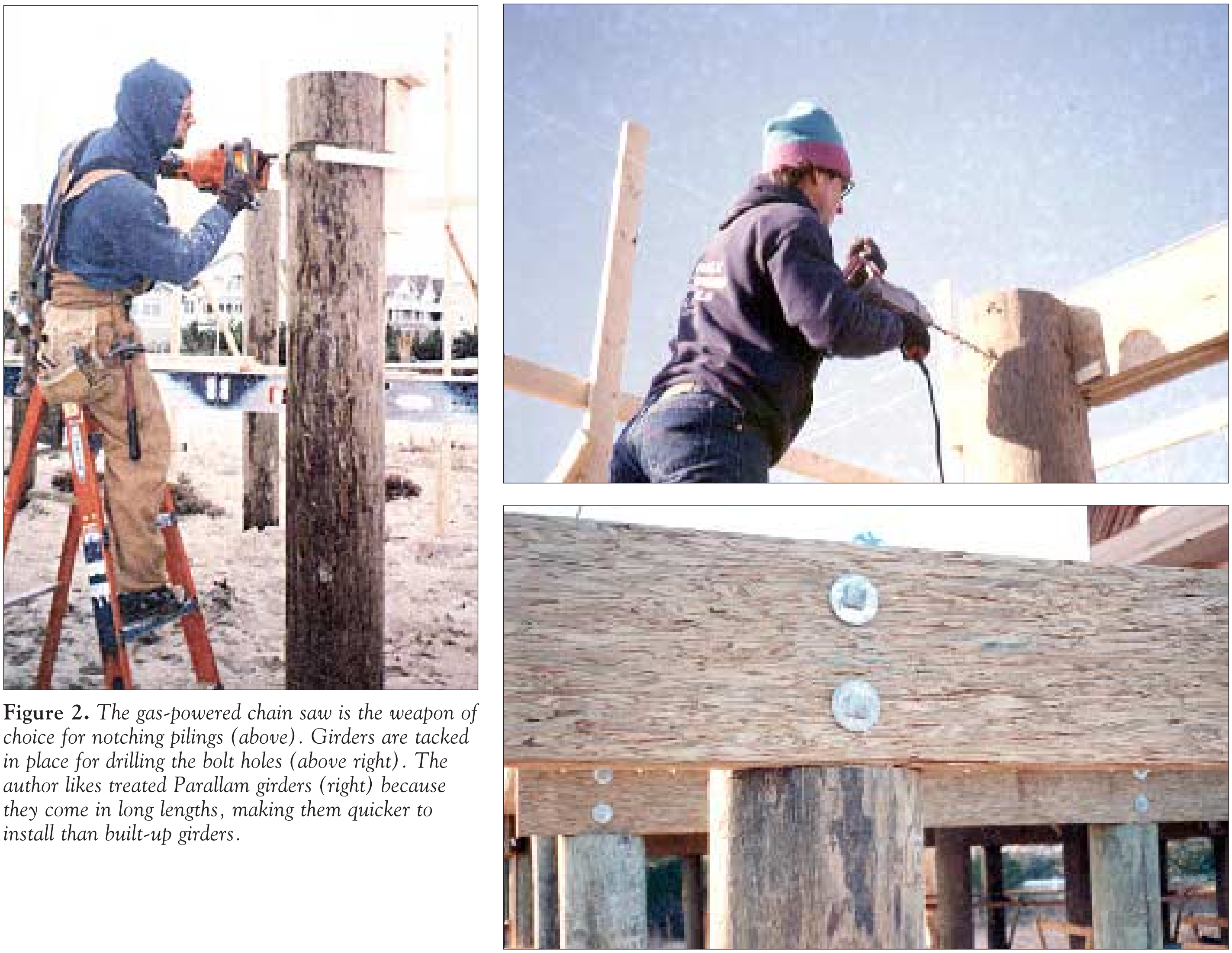

Figure 2. *The gas-powered chain saw is the weapon of choice for notching pilings (above). Girders are tacked in place for drilling the bolt holes (above right). The author likes treated Parallam girders (right) because they come in long lengths, making them quicker to install than built-up girders.*

the SBCCI *Standard for Hurricane-Resistant Residential Construction* (formerly called *Deemed to Comply*), larger houses typically require an engineer familiar with the unique demands of coastal areas.

Girders. The foundation girders — treated Parallams or built-up treated 2x12 beams — are attached to the pilings with bolts (Figure 2). These connections must be engineered. The piling should be notched only deep enough to provide a shelf for the beam to bear on, while still leaving at least 50% of its cross-section for securing the bolts. If the piling is cut flat instead of notched, steel straps are usually required to secure the beams to the pilings.

Notching. As a practical matter, laying out and cutting flat notches in round piles while working 6 to 10 feet above grade can be extremely difficult. We build a working platform by nailing framing lumber from piling to piling about 3 feet below the final top elevation of the poles, and use walk planks and guardrails where necessary.

The gas-powered chain saw is the tool of choice for cutting pilings. Sharp chains are essential. We usually have to resharpen the chain about every 20th piling. And though it's easy to forget, we try to avoid placing the saw in the sand.

The first cut establishes the top of the piling. We always mark and cut each piling $3/4$ inch below the elevation of the bottom of the floor joist to make it easier install the crawlspace ceiling in later stages of the project. The next step is to establish the house corners and girder lines on the tops of the pilings. We use conventional batter boards and string lines for this, and extend the corner point up to a block nailed to the top of the piling with a plumb bob. The outer pilings are usually placed 6 to 12 inches in from the edge of the footprint. At outside walls, we cantilever the floor joists $3^1/2$ inches beyond the girders. This leaves us plenty of room to attach enclosure walls or lattice below to enclose the girders — a zoning requirement in some communities.

After establishing the corners, we establish a string line for each row of pilings. The layout marks for the notches at each piling are then measured from the string lines. The girder lines sometimes need to be adjusted slightly to ensure adequate bearing at each piling. Once the line is established, we snap it across the tops of the pilings.

Next, we locate the seat of each notch with a transit. After marking out the notch cut, it's then a matter of holding the chain saw steady enough to create a flat, plumb vertical cut and a smooth, level horizontal cut. It takes care not to overcut. Although it might seem easier to simply flat-cut the tops of the pilings and use metal straps to

Figure 3. *Bolted two-by X-bracing (top) and interior shear walls (above) help stiffen houses built on pilings. Both details must be engineered.*

secure the girders, this entails the added cost of additional bolts and metal straps, plus the added labor of drilling the extra bolt holes and cutting flat sections on the sides of the pilings for the metal straps. However, there are occasional pilings where this detail cannot be avoided — where girders meet at corners, for instance.

Once the pilings are notched, the beams can be bolted on. We tack or clamp the beams in place on the pilings for drilling. Drilling one-inch-diameter holes through 12 or 14 inches of piling and girder is no picnic. A $1/2$-inch or $3/4$-inch electric or air-powered drill is required. An air-powered drill is expensive but less dangerous to use, because there's no kickback from torque when the bit seizes in the hole.

We typically use two $3/4$- or $7/8$-inch bolts at each piling/girder connection. If two girders meet at their ends on a piling, each one needs two bolts. With built-up 2x12 beams, we overlap at joints. Though they're more expensive, Parallams are easier to install because one continuous beam can run the length of the house. On occasion, concentrated loads will dictate the use of Parallam beams, or sometimes even steel I-beams. Steel beams and flitch plates have to be protected from corrosion, of course, by hot-dip galvanizing.

Bracing. Cross-bracing at the pilings is necessary to resist lateral loads from wind or water (Figure 3). Once again, we let the engineer do the head scratching. If pilings top out any more than 2 or 3 feet above grade, we usually need 3x8 or 3x10 treated timbers bolted to the pilings in an X pattern, with two $3/4$-inch bolts at each connection.

Cross-bracing is easiest to install with one brace on each side of the pilings. This makes a very thick brace/piling sandwich. Unfortunately, if the area below the first floor is to be enclosed or partitioned, the cross-bracing may conflict with wall locations. Sometimes the two pieces can be installed on the same side of the pile, and half-notched into each other. This detail needs to be carefully considered at the design stage.

Even with bracing in place, a piling foundation is not an absolutely rigid structure. When concrete slabs are poured around the foundation, expansion joints are needed at each piling.

First-Floor Platform

Layout and installation of floor joists is the next step. A "highlift" (four-wheel drive, extendible forklift) can be a real timesaver in this and subsequent steps, especially if the house is more than one story (Figure 4). We cut joists to length on the ground, then lift them in groups onto the beams.

Because the girders are rarely directly below the exterior wall lines, and may be slightly out of parallel, the trick is to securely fasten the joists to the band joist but only tack them to the girders. Then, when all the joists are in place, we can square the whole floor and then fasten the joists to the girders. Each joist/girder connection needs a huricane tie (actual loads engineered) like the Simpson H6 (Simpson Strong-Tie, 4637 Chabot Dr., Suite 200, Pleasanton, CA 94588; 800/999-5099). It is easiest to install huricane ties before the subfloor is installed, though they can go in later (Figure 5). We use only corrosion-resistant fasteners and hot-dipped galvanized nails. If the metal straps were galvanized before fabrication, all the edges will begin to corrode immediately. We field paint all such straps with a cold galvanizing compound, available in spray cans. Other options are stainless steel or Simpson's new Z-Max fasteners with triple zinc coating.

Figure 4. *Because homes on pilings are typically quite tall, highlifts are indispensable timesavers when it comes to moving materials.*

Framing continues in a conventional manner upwards from the first-floor deck, but special attention must be paid to point loads and to bracing the structure against wind loads. We frame standard stud walls, except that plywood is installed after the walls are raised. We always follow the engineer's plan for stud size and spacing.

Gable ends are best framed with continuous studs. This avoids a weak hinge point at the ceiling line. For cathedral ceilings, this detail is required. For extremely high ceilings, it is sometimes necessary to increase the stud size to 2x8 or larger. Double top plates are standard, and we take special care to stagger the laps and to secure the plates to the studs.

Sheathing

We use $1/2$-inch minimum APA-rated structural sheathing, following the engineer's recommended nailing pattern — typically 8-penny nails on 3-inch centers at the edges and 12-inch centers in field. With multistory houses, the plan often calls for lapping the plywood over the band joist, tying the studs below to the studs above. If the plywood breaks right at the band joist, metal straps like the Simpson LFTA are needed to transfer the uplift loads from studs above to studs below.

All plywood edges need to fall on solid blocking for maximum shear strength. We sometimes have to build interior shear walls as well. For interior shear walls, we've found that plywood or let-in 1x4 bracing provides much stiffer wall sections than using metal bracing. In some cases, we add shear walls beyond what the specs call for. Houses on pilings have a peculiar and disturbing way of shaking or vibrating. Traffic on the steps or breezy days make the house seem to shimmy. It's better to write a change order sooner for additional bracing than to deal with seasick owners after they move in.

Up on the Roof

By the time the house is ready for the rafters, the structure is often quite tall. Local codes limit the height of the house to 35 feet measured from the flood elevation to the midpoint of the main roof. Windy days can be dangerous when you're walking plates 30 feet up, so we usually allow some extra down time in the schedule for houses more than two stories tall.

Roof framing is mostly conventional. Once again, metal framing connectors are needed to secure each rafter to the studs below. If the rafters don't align with the wall plates, two connectors are needed — one to tie the rafter to both top plates and one between the top plates and stud. So we try where possible to align the studs with

Strong Connections

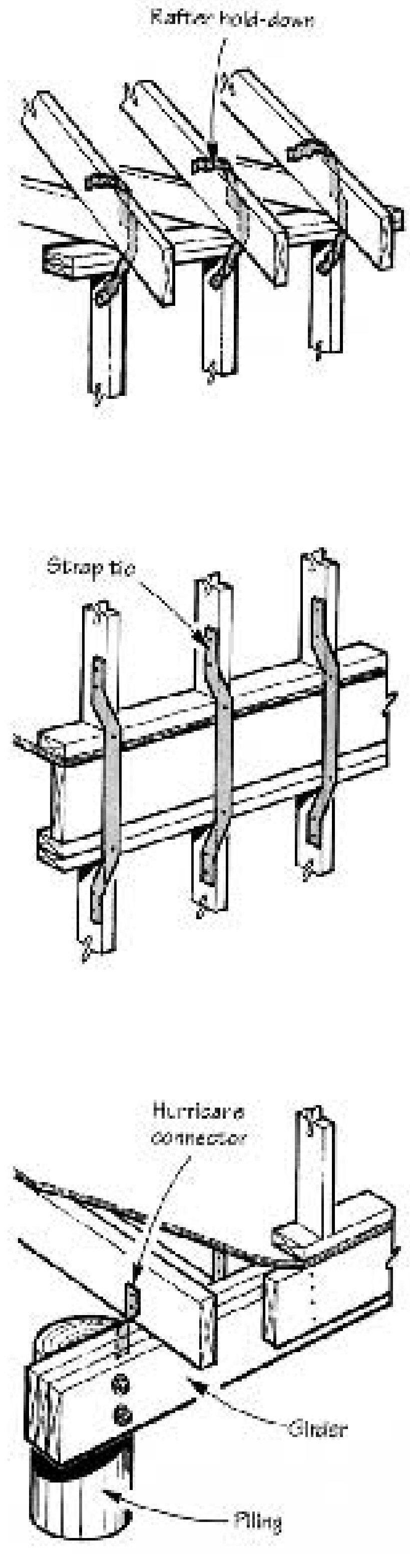

Figure 5. *Metal connectors help resist the huge uplift forces coastal homes are subjected to. Hurricane connectors secure joists to girders, strap ties connect first-floor studs to second-floor studs, and rafter hold-downs tie rafters to top plates and studs.*

Figure 6. *Coastal builders must take special care to seal openings against wind-driven rain. To install a window (left), the housewrapped opening is first covered with tar paper. The window is then installed in a bed of caulk. The author uses only clad windows rated for coastal conditions. The author recommends storm shutters (right) for all coastal homes to prevent hurricane winds and flying debris from bursting the glass in windows and doors.*

the rafters. Since stud spacing is usually on 16-inch centers, framing the roof 16 inches on-center means fewer connectors of a lower capacity.

Our typical rafter tie is a Simpson H7, which must be installed before sheathing the roof. If loads are concentrated by dormers or other roof openings, special consideration is given to concentrated uplift loads. In general, uplift loads from high winds are usually figured at about 1,000 pounds per rafter. Concentrated loads (at hip rafters or girder trusses, for example) can run into thousands of pounds, meaning custom hardware may be required.

Roof sheathing installs normally (once you wrestle it 40 feet in the air), but once again careful attention must be given to nailing patterns.

Weatherproofing

Making a house weathertight is difficult in an oceanfront environment. Along our part of the coast, "Northeaster" storms blow through about once every two weeks, bringing heavy rains and winds around 80 mph. It's an understatement to say we have to pay careful attention to caulking and flashing details to prevent leaks.

We use Typar housewrap, lapping it from the bottom up and taping all the joints. Typar holds up extremely well to the wind and weather, and the gray color is easy on the eyes (when you're building along the beach, you don't need any added sources of glare).

Windows. We use only the highest-quality windows, preferably aluminum clad. We prefer to use at least Grade 60 windows, as rated by NWWDA (National Wood Window & Door Assn.). These are usually casement or awning type. When the client insists on double-hungs, it's necessary to settle for Grade 40. In addition, the cladding and hardware must be rated for seacoast exposure.

We always bed the window flanges in caulk, then tape them to the Typar with housewrap tape. We back all exterior trim at windows and doors with tar paper and use drip cap flashing above (Figure 6).

Storm shutters. Since we are building in a hurricane zone, we recommend that all coastal houses include storm shutters. The three basic types available are hand-applied modular panels, roll-down shutters, and folding (accordion) shutters. These are all engineered shutters. None of them is aesthetically pleasing, although roll-down shutters can be hidden in soffits.

For any of these shutters, an extra layer of trim is needed around windows and doors so that the shutter isn't obstructed by the window frame or hardware. With sliding glass and outswinging doors, you have to clear the door handle. Screen doors can also be a problem. This is best thought through early in the design to avoid reworking the trim later.

Utilities. Utilities need to be elevated above the base flood elevation or somehow protected from inundation. Hvac units are usually built on separate, elevated decks, and electrical meters and panel boxes may be mounted higher than normal.

Closing in underneath. Many communities require that pilings be enclosed. Depending on the budget, we may box in individual pilings with siding and trim or enclose the entire perimeter with lattice or spaced 1x4s.

In a traditional home, the crawlspace insulation can be left exposed, but for a piling house it is necessary to install a ceiling underneath. Our usual choice is a 3/8-inch roughtex plywood, although if there are carports or parking areas below the house, we sometimes use exterior gypsum. In crawlspaces, we choose materials for durability with less concern for aesthetics, typically 3/8-inch CDX or OSB.

Cost Considerations

The overall expense of placing a house on a piling foundation runs between $5 and $10 per square foot higher than placing the house on a concrete block crawlspace. The added expenses include the pilings, girders, bolts, cross-bracing, crawlspace ceiling, lattice enclosure, additional framing expense, and equipment rental. ■

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