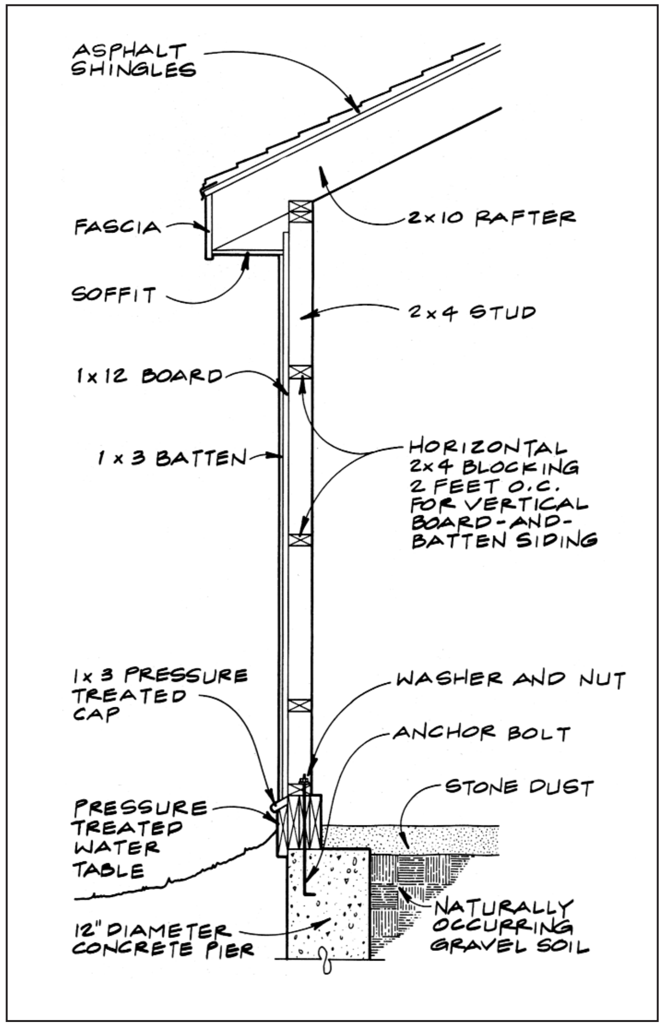
The author built this garage on a concrete-pier and wood-beam foundation — an effective answer to the project's tight budget. The section drawing (below) shows the pressure-treated water table and cap detail used to keep the weather out.



CASE STUDY: A WOODEN GRADE BEAM

This low-cost alternative can save you money if the site has the right soil

by Paul Fisette

The design goals for my most recent project were clear from the start: build a detached 2-car garage with ample room for storage, and do it on a limited budget. After considering several preliminary sketches my clients and I decided to build a 32x24-foot structure with a hip roof (see lead photo).

The original estimate for a wood-frame garage on a poured concrete foundation (material only) was $6,500. But with excavation at $450, a poured perimeter footing and 4-foot frost wall at $2,100, and a slab at $750, more than half the cost of the building was in the ground.

Not wishing to spend $3,300 before even getting started, we looked at alternative foundations. We settled on pouring a series of concrete piers to grade, bolting a triple 2x8 pressure-treated beam on top of the piers, and laying a 6-inch-thick stone-dust pad as a garage floor. This trimmed $2,100 from the cost of materials.

At first glance it seemed that a grade-beam system would force us to compromise quality. It would admit weather and be less durable. And stone dust wouldn't provide a hard surface to drive on. But, we reasoned, if the grade-beam was laid directly on grade and the inside was filled with stone dust it would be adequately weathertight. Pressure-treated lumber is guaranteed to last more than 40 years in contact with soil. And if the owners tired of the stone dust pad they could pour a slab. I've been impressed with the dense-grade stone dust I've used as a driveway top coat.

Calculations

To determine a pier-and-beam foundation's ability to carry a structure's load to the ground, you must know your soil type.

We lucked out. The soil at this site was coarse-grained gravel with plenty of large rocks mixed in. It's the best soil you can have when it comes to foundation systems (the worst when it comes to driving in batter-board stakes!). It supports five tons per square foot, resists frost action, and provides excellent drainage. This type of soil forms a stable base because it is not likely to change volume as its moisture content changes. It also resists settling.

Knowing what load the soil will carry leads to the all-important question: What total load are we asking the soil to carry? Here we are concerned with *dead load*, *live load*, and, in cold climates, *snow load*.

Live loads, the weight of transitory loads like people or furnishings, was not factored into the calculation of this building because the weight of people, automobiles, and stored garden equipment would bear directly on the stone-dust pad. However, dead loads, the weight of the building materials themselves, and snow loads had to be considered.

It's easiest to calculate the total load in two parts: first roof loads and then loads for the remainder of the structure. Many handbooks list loading allowances for various roof assemblies. I used information provided by the Western Wood Products Association, which specs high-slope roofs (over 3/12 pitch) with no finished ceiling as having a dead load of 7 pounds per square foot (psf) when light-weight roofing (such as the asphalt shingles used here) is applied to the roof deck.

I also factored in an additional 10psf as the roof system's dead load for ceiling joists with limited attic storage, yielding a total dead load of 17psf for the roof assembly. Snow load is determined by the local building code, which in my area is spec'd as 35psf.

All loads are based on the square footage of the footprint of the structure (as viewed in a plan drawing), not the actual square footage of the

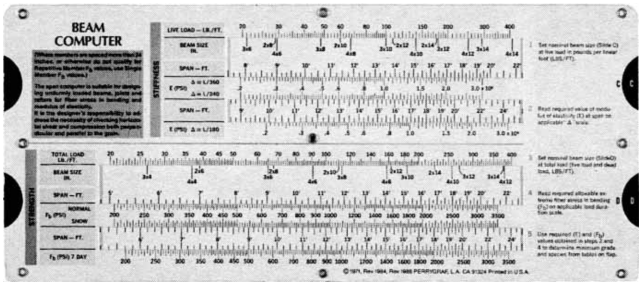
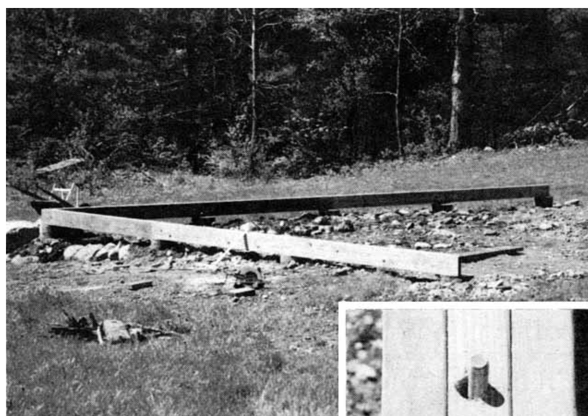


Figure 1. *The Western Wood Products Association's Span Computer simplifies the task of sizing rafters, joists, and beams carrying uniform loads.*

Figure 2. *After placing the builders tubes and backfilling around them (above), the author used a transit to accurately mark the tubes for cutting at grade. Anchor bolts were placed (right) after the ready-mix truck filled the tubes.*



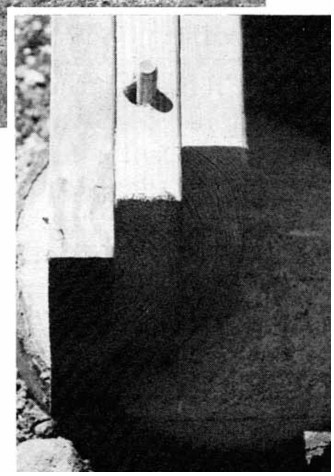


Figure 3. *The triple 2x8 pressure-treated beam rests at grade on top of the piers (above). The beam is bolted to each pier, and lap joints are used at the corners (right).*

roof deck. So the total roof load for this garage (combined dead and snow loads) is 52psf x 24ft x 32ft = 39,936 pounds.

Several elements contribute to the remainder of the structural load: wall sheathing, siding, wall frame, grade beam and concrete piers. Again, weights of various building materials are listed in several handbooks; I used *Architectural Graphic Standards*. It's easiest to calculate the weight of one square foot of wall and translate that figure to the weight per running foot of wall.

The dead load of the garage walls, beams, and piers totaled 13,650 pounds, bringing the total load of the garage to 53,586 (roof load 39,936 + remaining load 13,650 = 53,586 pounds).

So, how many square feet of soil is required to support 53,586 pounds if every square foot of soil can support 10,000 pounds? (Sound like one of those math problems you had in school?) The answer: About $5\frac{1}{2}$ square feet of bearing surface was needed to hold the weight of the garage.

One more piece of information was needed to finish the design calculations: the allowable span between concrete piers. For the grade beam I had decided to spike together three CCA-treated, southern-yellow-pine 2x8s. The top of a triple 2x8 beam would stick up above the 6-inch-thick pad and provide the lateral rigidity needed at the base of the wall.

Sizing beams is usually left to engineers. But for a small-scale project like this one, you might want to do what I did: Use the Span Computer slide rule that the Western Wood Products Association (1500 Yeon Bldg., Portland, OR 97204; 503/224-3930) sells for $2.00. It comes with instructions that enable you to use the slide rule to size wood joists, rafters, and beams for different loads, spans, deflection limits, and species (see Figure 1).

Because hip roofs deliver more weight to the center portion of their supporting walls where the peak is highest and roof area is greatest, the load transferred to the grade-beam is not uniformly distributed. So taking the heaviest loading point and plugging in the design values for No. 2 southern yellow pine, the WWPA span computer indicates that a triple-laminated 2x8 beam could easily span 7 feet for the loads imposed by this building.

Because of the beam's span limitations, a total of 13 piers were required: five piers along the 32-foot-long back wall, but only four piers along the front since the design called for three stalls. Two piers were placed on each side between the front and back corners.

Footing size was based on anticipated load and soil bearing capacity. Since $5\frac{1}{2}$ square feet of bearing area was required, I determined that the base of each pier had to cover at least .43 square feet of soil. Nine-inch-diameter builder's tubes would do the trick, even without footings, but I used 12-inch-diameter tubes (.79 square foot area) to provide my own safety factor.

As I mentioned before, we were fortunate to have a gravelly soil at this site. If the soil had been, for instance, a silty-sand or sand-clay mixture with a bearing capacity of two tons per square foot, then $13\frac{1}{2}$ square feet of bearing area would have been needed. In that case I would probably have used the same number of piers, but poured square footers for the piers.

Putting It All Together

Fabrication is the acid test for any design, and as expected this design worked neatly.

We conventionally squared the four corners of the garage using diagonal measurements and laid out the sides of the structure using batter boards and line. I drove stakes along the lines to mark the center of each pier.

The lines were temporarily removed while a backhoe excavated the 13 holes to a depth below the frost line, 4 feet in our area. Once the holes were excavated, lines were restrung and the builder's tubes carefully leveled and positioned. One disadvantage of using builder's tubes instead of formed walls is that you have to backfill the tubes by hand, which in this case took 16 man-hours. We placed several inches of fine soil around the bottom of the tubes, tamping to secure the bottom of the tubes before backfilling.

Once all the tubes were backfilled, the grade-beam height was shot with a transit (see Figure 2). Fortunately, this building site was fairly level. I cut the first builder's tube flush with the level of soil at the grade's highest point, and the top of the severed tube became my benchmark. Based on transit readings, I cut the four corner tubes and snapped lines between the corners to mark the heights of the intermediate tubes.

The rest of the project was straightforward. After the ready-mix truck filled the tubes, we positioned the anchor bolts. When the concrete had set up, we bolted the grade beam onto the piers (see Figure 3) and the garage frame was erected on top of the beam.

Later, a 6-inch-deep layer of stone dust was spread within the perimeter of the beam, sealing the inside space. To trim out the bottom on the exterior we used a water table made of pressure-treated stock. Finally the exterior soil was graded to meet the bottom edge of the water table.

For this project the grade-beam system worked well and saved a good chunk of change. It certainly doesn't lend itself to all designs and applications. But for low-cost, small building projects it's an option worth considering. ■

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