Keeping Walls Steady in the Wind

With one-third of the exterior given over to windows, it took multiple shear panels, hold-downs and a wind beam to keep this home steady

by Glenn M. Carter

Fifteen years ago, Sumner, Washington, was considered too remote from Seattle for commuting. But Tom Wooding bought a steep, nearly unbuildable little lot there on Lake Tapps anyway. He'd just graduated from college, had no immediate plans and just liked the area.

By the time Tom was ready to build, the Lake Tapps area had transformed from a cluster of camps, cabins and mobile homes to one of the most popular lakefront communities south of Seattle. His lakefront lot was now worth at least six times what he paid for it. That increased value meant that it would be worth building on, even if the building was difficult. Also by then, Tom and his fiancée, Tami, wanted to raise a family on the shores of Lake Tapps.

Ordinarily, their program would be fairly straightforward. But in this case, their dream home was to be built on a site that's 120 ft. from the lake and under strict code requirements for wind resistance. Also, the site has a 73% slope.

Architect Todd Lawson's solution was to give the Woodings a tall house full of windows. The house would be tightly engineered in a framework of hold-downs and shear panels, which would include a steel wind beam. Todd designed the house to sit—after much excavation—at the bottom of the steep hill that overlooks the lake (photo right). The top of the house would reach the hill, which is where the Woodings would park their cars and enter the house via a small bridge. My job was to build the house.

More than one-third glass. With its roof at a dapper tilt and with 35% of the walls covered with glass, this lakeside house near Seattle needed more than conventional framing to keep it from shifting in high winds.

Glazing is 35% of the exterior, so the framing had to be strong—Given the height of the house, its lakeside location and its large area of windows—glazing accounts for 35% of the square footage of exterior walls—the need for resisting lateral loads and transferring those loads was the most significant design and construction concept of the project (drawings facing page).

Because the house would be on a lake, code required an exposure-D rating for all construction. Section 1614 of the Uniform Building Code (UBC) defines exposure D as an area subjected to "basic wind speeds of 80 mph or greater."

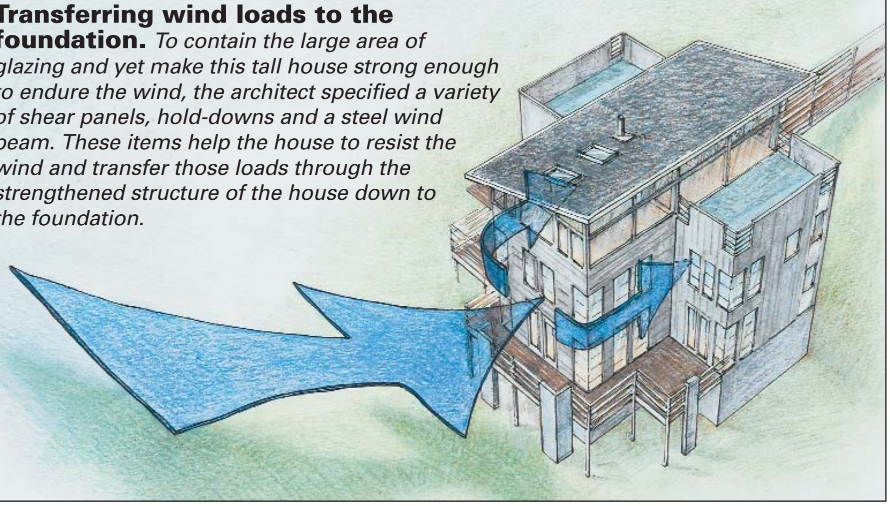
The code extends this exposure inland from the shoreline ¼ mi., so the Woodings' house was within the zone. This situation posed some serious issues for a house of this height that would include such a large number of windows. However, we were confident that the design was sound and that, tightly built, the house would be, too.

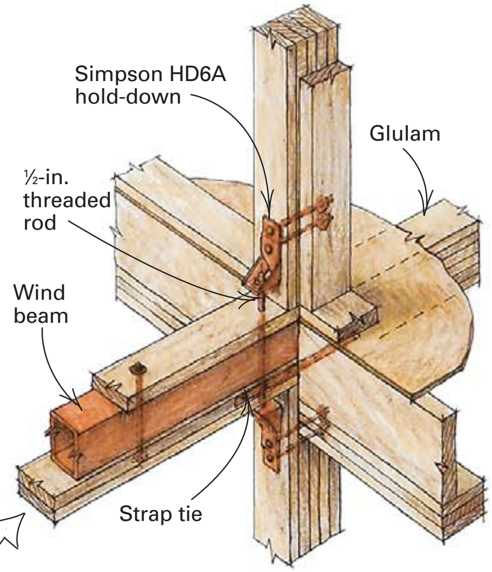
Hold-downs and shear panels are a must—Basically, all loads to which a house is subjected are transferred to the foundation. When loads are applied straight down, such as snow loads, the transfer is pretty straightforward. But when loads are applied laterally, such as wind loads, transferring them to the foundation becomes more complicated. Tying the framing securely to the foundation is a critical first step. So the first challenge in the framing occurred during the foundation work. This was the coordination and placement of the threaded rods in the footings for the shear walls that would be built above. There were 22 hold-downs at the foundation level, and each required special consideration.

For example, a Simpson HD6A hold-down bolted to three vertical 2x6 studs with threaded rod

Photo this page: Fred Housel

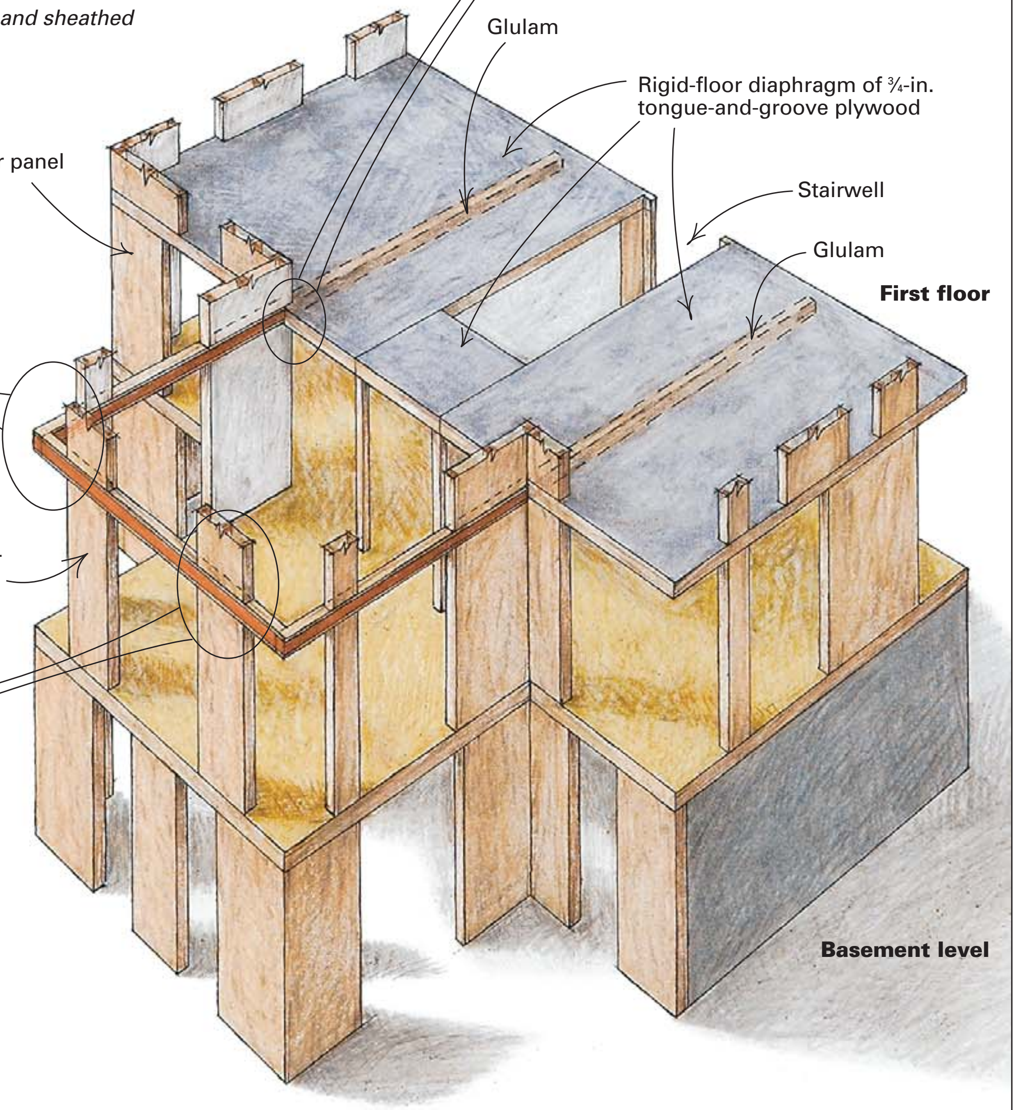
Transferring wind loads to the foundation. *To contain the large area of glazing and yet make this tall house strong enough to endure the wind, the architect specified a variety of shear panels, hold-downs and a steel wind beam. These items help the house to resist the wind and transfer those loads through the strengthened structure of the house down to the foundation.*

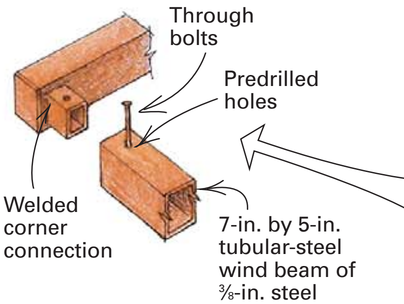


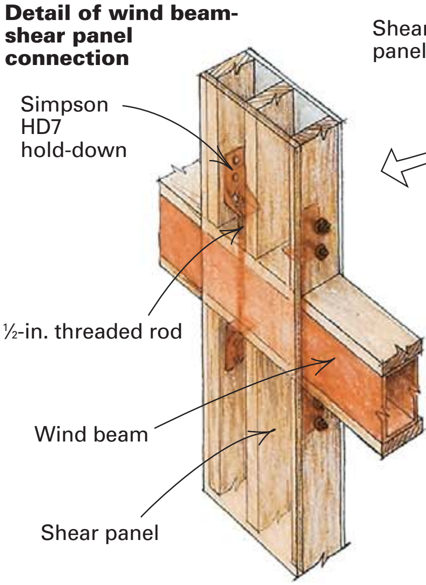


Rigid construction in the face of destructive winds

Without the right kind of bracing and support, the frame of this house could buckle beneath blasts of 80-mph winds. Bracing includes multiple shear panels and a horizontal 7-in. by 5-in. wind beam of ⅜-in. steel that wraps around the open, two-story section of the house, keeping it steady and secure in high winds. Even the stairwell walls are built as shear panels, framed with 2x6 lumber and sheathed on both sides with ⅝-in. plywood.







Drawings: Christopher Clapp

A patchwork of small shear panels. Nearly every exterior surface shown in this construction photograph is a shear panel of ⅝-in. plywood over 2x6 framing. Already framed in is the horizontal steel wind beam, which wraps around the two-story space shown here between the first and second floors.

required a different dimension from the corner than an HD9 bolted to a 6x6 post. The difference between all these would be only a matter of inches, but those inches would be a major headache for the framer if not solved up front.

This phase was successfully executed thanks to a book of coordination details from Todd in the form of simple sketches. These sketches called out hold-down type, rod or bolt size, framing condition at the point of each hold-down and dimensions.

There were also hold-downs between floors that went from large Simpson HD types—ranging from 11-in. high HD6s to 24-in. high HD9s—to simple straps at the upper level, which was framed with hefty glulams.

The large number of windows, the anticipated wind loads and the height of the house that would face the lake also made shear walls a necessity (photo above). Unlike ordinary walls, shear walls or panels often have plywood nailed to both sides, which dramatically increases their shear strength over ordinary walls. Shear panels also require a tighter nailing schedule and, in this case, hold-downs tying each panel to the panels above and below.

We framed the shear panels with Douglas-fir studs at the edges for added nail support. For the sheathing, we used ⅝-in. plywood on one or both sides of the framed panels (bottom drawing, p. 87).

We used a variety of nailing patterns; some of the lower shear panels had nailing as intense as 10d at 2 in. o. c. at outside edges. We needed a special inspection for this part of the framing.

Tubular-steel wind beam steadies two-story walls—The shear panels were adequate for simple floor-to-floor connections when height was limited to 10 ft. But Todd had to create a more complex system for resisting and transferring wind loads in the living room, which included an 18-ft. ceiling and many windows (photo facing page). Given the increased height, even shear panels would be too flexible for adequately transferring wind loads to the foundation.

This tall space created a couple of framing considerations. First, 18-ft. studs are hard to find. Second, even if they were readily available, they wouldn't make good shear walls and couldn't withstand high-magnitude wind loads without significant deflection. Besides, code doesn't allow a bearing wall framed with lumber that tall. Todd's solution was a tubular-steel wind beam that wraps horizontally around the middle of the two-story living room's exterior wall. The wind beam breaks this wall into two short walls, one 10 ft. and one 8 ft. The wind beam accepts half the load from each section of the wall. The rest of the wind load is transferred to a floor diaphragm and down to the foundation.

The steel wind beam would connect to the second level of the house, where the floors would be rigid diaphragms covered with ¾-in. tongue-and-groove plywood. Because the wind loads could also transfer through the floor diaphragms, Todd called for the center stairwell to be framed with shear panels to ensure stiffness throughout the house. In short, the wind beam would act as a horizontal ship's mast and the walls as a sail. The walls would catch the wind, and the heavily anchored wind beam would absorb that stress and transfer it through a series of engineered shear panels and glulams to the foundation.

To transfer dead loads and live loads better, glulams were framed into the floor diaphragms—a fancy name for a horizontal shear panel—in line with the wind beam at each end (detail drawing top right, p. 87). Glulams became what are called a "drag strut," which dragged the resistance of the wind beam horizontally back into the floor diaphragm.

Here's how we put this critical section of the house together. The bottom half of the living-room walls was framed to the top-plate line, and the wind beam was lifted in place in three pieces (bottom drawing, p. 87). Where it terminated, the wind beam was secured to the floor diaphragms using HD7 hold-downs and strap ties. Next, a second level of shear panels was framed on top of the first level and secured to the wind beam with threaded rods at 24 in. o.c.

All holes in the wind beam for through bolts and threaded rods were predrilled at the fabrication shop. That made it a lot easier to work with the wind beam on site. Sections were lifted into place a piece at a time, then bolted together and into the framing.

Hold-downs were installed at each corner of the shear panels. The threaded ½-in. rods ran through the wind beam—and through the 2x6 plates that sandwich the wind beam—then connected to the upper and lower hold-downs, which were then fastened tight. Also, we fastened Simpson LSTA 36 strap ties horizontally where the wind beam connected to the glulam portion of the floor diaphragms.

After months of heavy wind, there are no cracks in the walls—In general, engineers design a structure to be at least two times stronger than what's needed, which almost always leads to overbuilding. However, facing similar site conditions, I would be reluctant to build any house that's engineered to a set of minimal standards.

As designed, the surfaces of the house are so finely finished and the corners so square that if the walls moved a quarter-inch, cracks would appear all over the place.

Since the Woodings moved in, there have been many powerful wind storms. Thanks to careful, conservative design and engineering, there have been no cracks. □

Glenn M. Carter is a builder in Renton, Washington. Todd Lawson, an architect in Seattle, Washington, contributed to this article.

Photo this page: Todd Lawson

There's more keeping these walls stiff than meets the eye. Buried within the shear-paneled framing of this two-level living room is a steel wind beam that separates the top tier of windows from the bottom.

Photo this page: Steve Culpepper