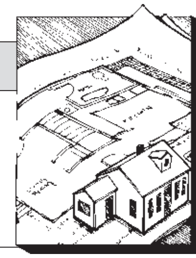

The Whole Story on Half-Walls

by Gordon Tully

Many builders and designers shy away from roof designs that use half-high, second-story walls, because they are worried about the structural problems. Actually solving those problems is not very difficult, and worth the effort, since story-and-a-half houses have so many design advantages.

Outside, such a building looks like a tall, elegant, one-story house, while inside, for all practical purposes, it has two full stories. Assuming the half-high wall is 4 feet and the roof is pitched at 12/12, there is room for closets or stairs under the eaves, and dormers rise gracefully along the plane of the outside walls. The second story costs less than in a full two-story design, and its slanted ceilings add an interesting architectural detail. The design's classic simplicity also fits with many decorative styles. It can look contemporary or traditional, depending on window size, placement, and trim.

The Structural Problem

One-and-a-half story designs, however, present a unique structural problem. A sloping roof creates an outward thrust at the eaves, which must be resisted to keep the walls from bowing and the roof from sagging. Typically, joists at the level of the eaves tie the outside walls together and prevent roof thrust.

But if you spring the rafters from a half-high wall, you can't insert joists or rafter ties at the level of the rafter ends without making the space unusable.

Balloon Framing Can Work

One solution is to balloon frame the side walls with full-height studs rising from the first floor plate. This is how many mid-19th century houses with half-walls were built. The engineering, however, is tricky.

First, you need plenty of full-height sticks to resist the thrust; studs that don't extend down the full one-and-one-half floors from the eaves will not resist the thrust. This means openings in the wall below must be narrow and few, which severely limits window size and placement. Picture windows are not possible.

Also, these studs must be deep — at a minimum you should use 2x6s.

In addition, you can:

- Further strengthen studs by using 2x8s; spacing them closer together; or doubling them up.
- Add securely-fastened collar ties or plywood gussets to the rafters above ceiling level. This eliminates some of the roof thrust before it gets to the plate. Collar ties alone won't work, but they can help by working together with plenty of stiff studs.
- Reduce the roof thrust by adopting a steeper pitch.
- As a last resort, reduce the height of the half-wall to less than 4 feet. This greatly reduces the bending stress in the studs, but it also compromises many of the advantages of the one-and-a-half story design.

Hold the studs in. Assuming the studs are not overloaded, we must work out a detail at the second floor that will hold these studs in against the outward thrust at the eaves. You can do this by bolting a 2x ledger to the studs flush with the second-floor joists, as in Figure 1 on the next page. Frame the joists with hangers into the ledger, and hold everything together by nailing the floor deck to the tops of the ledger and joists.

This approach avoids the need to align the studs with the floor joists, as would be the case if you anchored each joist into the side of a stud. It also provides a nailing edge for the floor. Run the joists across the building, perpendicular to the ridge, so they can help transfer the thrust across the building and keep the eaves in. Also, remember to install fire stops between the studs at the second floor.

Ask an engineer. You will have to use every available source of strength and reduce the design loads to the allowable minimum in order to make balloon framing work. If you try the balloon framing approach, get some advice from a professional engineer instead of copying some local example, which may be underdesigned.

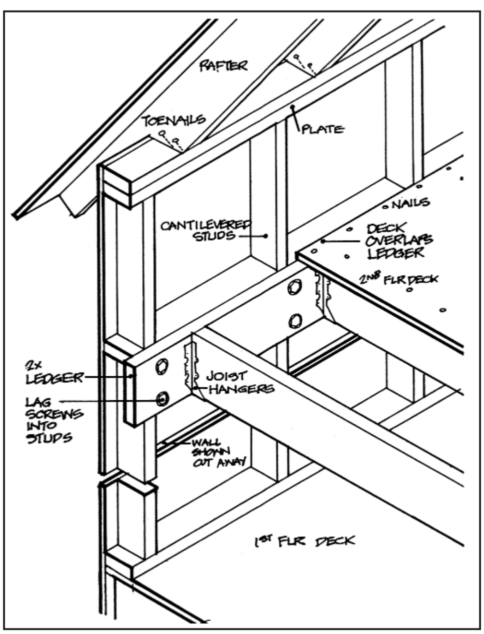

Figure 1. *Story-and-a-half walls are less likely to bow under roof thrust if they are balloon framed with 2x6 or larger studs. Lag bolting a 2x ledger to the wall helps stiffen the full-height studs.*

Supporting the Ridge

A second solution is to support the roof on beams, which eliminates the outward thrust on the half-walls. (You'll still need to deal with horizontal and earthquake loads, just as you do in any house.) With a beam-supported roof, you need not worry so much about whether first floor windows and doors will weaken the side walls, since you aren't relying on full-height studs to keep the half-walls from bowing out.

The easiest way to support a roof on beams is to use a structural ridge beam. For example, consider a ridge beam that spans 16 feet and supports a 24-foot-wide roof. With a live load of 40 pounds per square foot (psf) and a dead load of 10 psf, each end of the beam must be able to carry a load of 4,800 pounds. The total load is determined by multiplying half the length of the ridge by half the width of the roof by the combination of the live and dead loads; in this case, 16/2 x 24/2 x 50 psf = 4,800 pounds.

Use the right beams and posts. Like any beam, a ridge beam must be sized correctly for bending, deflection, compression, and shear. In this example, ordinary 2x12s would be too limber to span 16 feet; but two $1\frac{3}{4}$ x $11\frac{7}{8}$ inch laminated veneer lumber (LVL) beams would carry the load nicely.

The supporting posts are the tricky part. Wood is very strong when you push on it along the grain (providing it is braced so that it doesn't bend to the side), but wood is much weaker when you squeeze it from the side. So you don't size wood posts based on the longitudinal compressive strength of the wood, which is considerable. Instead you make the post footprint wide, to distribute the load so that it doesn't crush the soft wood it pushes on.

Eastern spruce framing has a horizontal compression (crushing) strength of 255 pounds per square inch (psi). (Your local lumberyard will have grading rule books listing this kind of data.) So in the example, the post under the ridge beam must be $18\frac{3}{4}$ square inches (4,800 pounds divided by 255 psi) if it is not to crush the horizontal plates and sills it bears on. This requires four 2x4s or three 2x6s nailed together to make the post.

What about the ridge beam itself — will it be crushed? In a 4-inch wall, the two LVL beams will rest only on the middle pair of the four 2x4s that make up the post. The "footprint" at the top of the column on which the beam sits will be only $3\frac{1}{2}$ x $3\frac{1}{2}$ inches, or $12\frac{1}{4}$ square inches. However, LVL beams have about double the crushing resistance of spruce at 500 psi. So we are safe, since we need only $9\frac{1}{2}$ square inches (4,800 lbs. divided by 500 psi) of bearing area under the beam.

However, since the full $18\frac{3}{4}$ square inches are needed below where the post rests on spruce, the load must be distributed from the center 2x's into the whole post. This is done by simply spiking together the multiple 2x's that make up the post so that it acts as a unit.

Follow that load. Keep track of the post loads all the way to the foundation; don't count on the loads getting spread out within the wall. Suppose the post supporting the ridge sits on a header over a window. Short, heavily loaded beams are normally limited by the extremely low allowable horizontal shear stress in most woods. (Shearing is just like it sounds: the tendency for a material to slide apart when it is pushed down on one side and pushed up on the other, as if cut by blunt scissors.) In this example, the 60 psi allowable shear stress for spruce requires a header made of three 2x10s.

Make sure you support the header with an extra jack stud at either end to spread the load out over four 2x4s, just as you did in the post under the

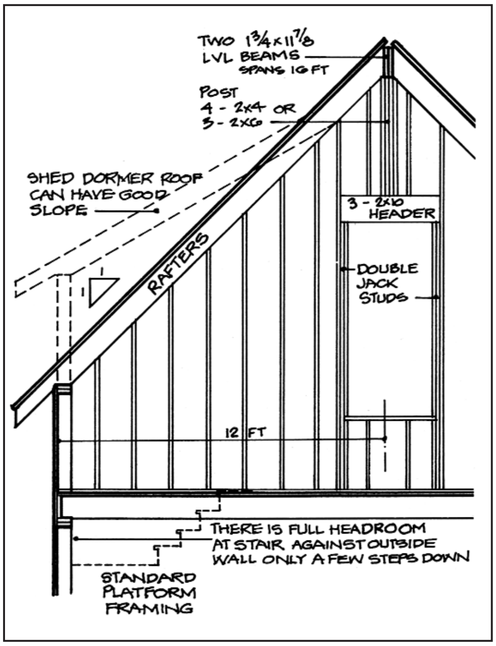

Figure 2. *A structural ridge made of LVL beams and supported by posts can prevent bowing in half-walls that are platform framed. The posts and headers should be sized to carry the beam's load down through the house to the foundation.*

ridge beam. From there, you can double the corresponding studs in any lower wall sections to carry the load to the sill (see Figure 2).

A longer roof. Suppose in the above example that the ridge beam is twice as long — 32 feet — broken into two 16-foot spans by a center post that runs down through the house. This center post carries 9,600 pounds, twice the load on the end columns. If the post is freestanding, it needs to be stiff enough to avoid buckling. Six 2x6s, two 6x6s, or a steel column would work if carried uninterrupted through to the foundation.

It's a good idea to have a structural engineer help you work out the framing on a house with a half-wall. But whether you use balloon framing or a structural ridge, the benefits of a story-and-a-half design are worth the extra trouble. ■

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