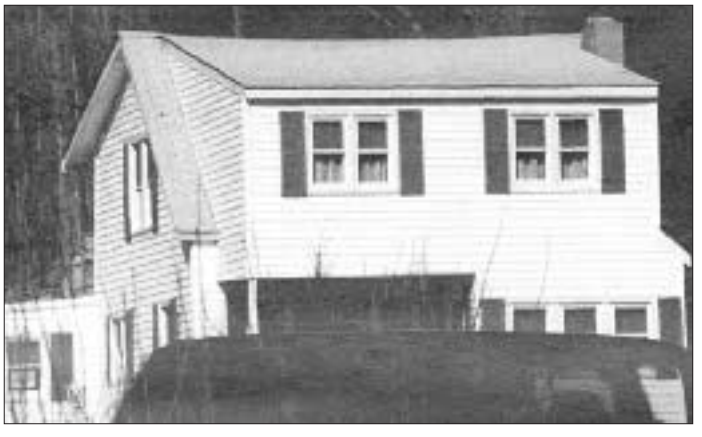
Taking the Sag Out of Shed Dormers

To avoid unsightly deflection in dormer additions, use strong connections and support the new loads all the way to the foundation

by Robert Randall

The shed dormer remains a popular remodeling project because it is such a simple and inexpensive way to enlarge a too-small house. But frequently shed dormers are retrofitted without proper concern for whether or not the structure can handle the new and different loads being introduced. In this article, I'll examine some of the structural concerns that must be considered before retrofitting a shed dormer to an existing roof. Of course, the same concerns and recommendations apply equally to new construction as well.



Shed dormers are often retrofitted in roofs where the framing is undersized. The result is a sagging ridgeline.

Shed Dormer Basics

Consider a basic frame roof, like the one in Figure 1. Assuming its members are correctly sized, this roof is a rigid triangle. The rafters lean against each other at the ridge with a force equal to their outward thrust, which is resisted by the ceiling joists. All vertical loads are transferred to the walls, which (we hope) safely carry them down to the foundation.

However, if you introduce a shed dormer on one side of this roof, you upset the balance of forces in this stable triangle. Unless proper precautions are taken, the roof will tend to deflect, as indicated by the dashed lines in Figure 1B. This kind of deflection is not usually apparent within weeks, or even months, of the completion of a shed dormer project. But my observations in the field have shown me that over many years houses will experience this kind of movement. In several cases, I've seen exterior walls leaning out by as much as 1 1/2 inches, and in many cases I've seen sagging ridge lines that are noticeable from the street (see photo, above).

Undersized framing. There are several causes of deflection in shed dormers. A common one is that shed dormers are often added to roofs that already have undersized rafters. Many 19th-century capes — common choices for shed additions — have 4x4 rafters 3 or 4 feet on-center, often without a structural ridge beam. And many modern frame houses have 2x8 or even 2x6 rafters — where 2x10s or 2x12s should have been used.

In these situations, retrofitting a shed dormer without providing for the new loads is asking for trouble. These undersized rafters simply don't have any reserve strength to accommodate the bending loads which can be imposed by the dormer. Not only is a noticeable sag in the roof possible, but very high bending moments can create a real risk of cracking in the rafters.

Also, attic floor joists are usually sized smaller than main floor framing. With the addition of a shed dormer, the attic joists must support living space loads. And in many cases, the outside wall of the dormer is set in from the outside wall of the house (Figure 2), bringing additional roof loads onto the joists. Often, a kneewall is incorporated somewhere near the eaves along the non-dormered side of the roof; this, too, transfers roof loads. All of these conditions can greatly increase bending loads on the attic floor joists, causing visible deflection — often as much as an inch — in the floor and the ceiling below.

Creeping deflection. Another reason that shed dormer roofs deflect is that creeping deflection takes place. Over the years the rafters develop a permanent sag from continued loading. This is especially true in snow climates. And since shed dormer roofs usually have a fairly shallow pitch, they tend to hold more snow.

Loosening connections. A third cause of deflection is that over time nails begin to slip and bend, loosening the connections. This is especially true of the ceiling joist/rafter connection at the shed dormer eaves.

Supporting Dormer Loads

There are some basic precautions you can take to make sure your shed dormer addition doesn't sag with time:

- Provide a continuous path to the foundation for all roof loads. This may mean adding structural elements.
- Use properly-sized framing members. For dormers where you're adding new loads onto existing framing, this may mean sistering new members to the old.
- Make strong connections. Adequate nailing, bolts, metal conectors, and plywood can all help here.

The simplest solution — on paper at least — is to fully support the new dormer loads all the way to the foundation. There are two common ways to do this: a structural ridge or a center bearing wall. Which you use depends on the design and layout of the particular house you are remodeling.

Structural ridge. Though they can be troublesome to retrofit, structural ridge beams can solve most of the loading problems associated with shed dormers (Figure 3, page 34). The structural ridge can either replace the existing ridge or be installed below it. The table in Figure 3 offers guidance in sizing structural ridges. The table is based on a 24-foot-wide house, with 30-psf snow loads.

Take special care to provide adequate support at ends of the structural ridge. In the case described in the table in Figure 3, two 2x4 studs in a plywood sheathed wall would adequately support each end of the ridge beam. Without the lateral support of plywood sheathing, however, more careful examination of stud buckling would be required. A triple 2x6 post, properly nailed, would suffice in any case. Be sure that load path is continuous to foundation.

A structural ridge design requires nothing of ceiling joists, other than supporting the ceiling; they can be omitted if you like.

Center support wall. In many cases, interior support is provided by walls located at or near the center of the structure (Figure 4, page 34). The advantages are the same as for the structural ridge, but the need for a sturdy beam with double or triple 2x posts is eliminated.

As with the structural ridge design, continuity of load paths to the foundation is important. Ideally, the support wall should stand direct-

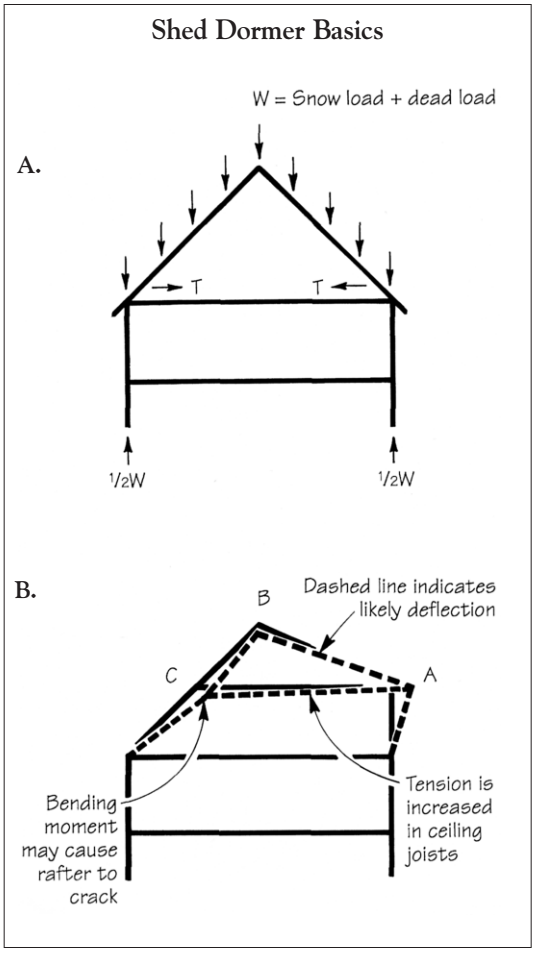


Figure 1. *A properly built gable roof is a stable triangle (A). The rafters lean against each other with a force equal to the tension, T, carried by the joists, which resist the tendency of the roof to spread. Install a shed dormer, though, and the stable triangle is upset (B). The tension in the dormer ceiling joists increases considerably, adding bending stress at the rafter/joist connections. In situations where the triangle ABC is less than 4 feet in height, the author recommends two 1/2-inch carriage bolts each at connections A and C.*

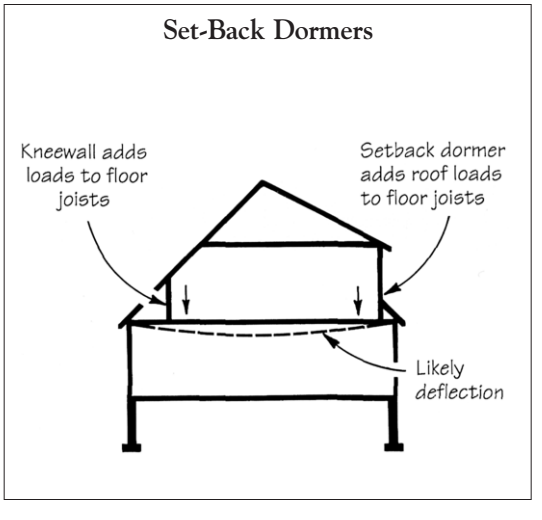
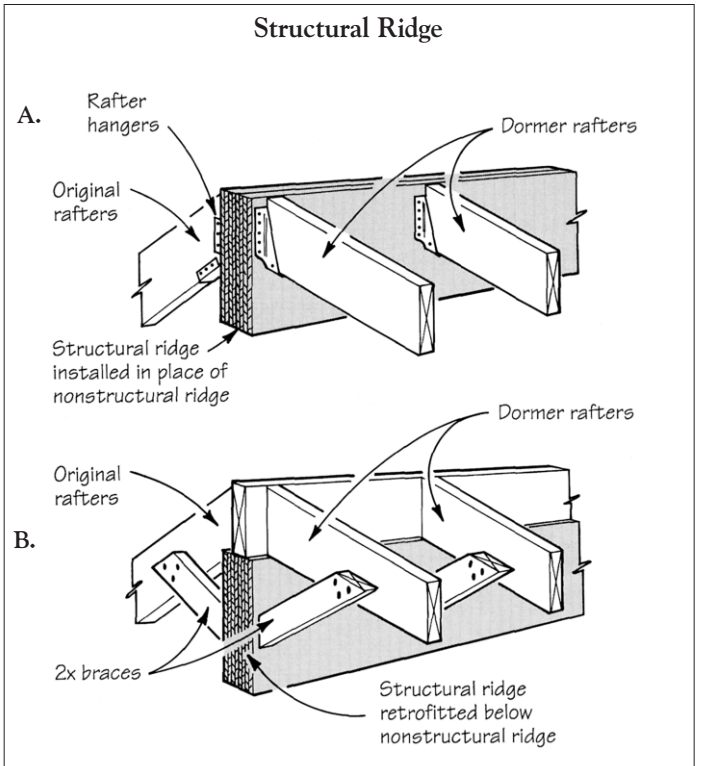


Figure 2. *If you set back the front wall of a shed dormer for aesthetic reasons, make sure the floor joists can handle the additional roof loads. A kneewall on the non-dormered side of the roof shortens the rafter span but also adds roof loads to the floor.*



Sizing Structural Ridge Beams

Ridge length	*LVL beam*	*2x beam**
8′	LVL 1 3/4 x 9 1/2	(2) 2x10
9′	"	
10′	LVL 1 3/4 x 11 7/8	(3) 2x10, (2) 2x12
11′	"	(2) 2x12
12′	"	(3) 2x12
13′	LVL 1 3/4 x 14	Not recommended
14′	"	"
15′	(2) LVL 1 3/4 x 14	"
16′	"	"

Note: *This table is based on a sample house 24 feet wide (eaves to eaves), with design snow loads of 30 psf.*
** Fb = 760 psi min. (new grading tables), or 1,000 psi with the old tables*

Figure 3. *Structural ridge beams are a good solution for the loads introduced by a shed dormer addition. The author prefers to install them in place of the nonstructural ridge (A), but they can also be retrofitted below the existing ridge (B). The table gives the author's sizing recommendations for LVL and laminated 2x ridge beams.*

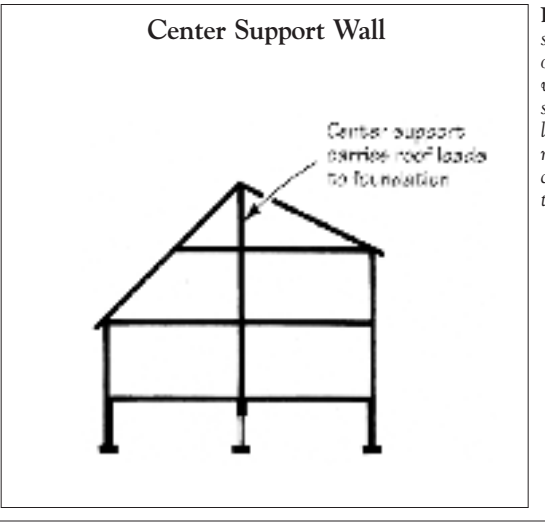


Figure 4. *Center support walls are often the easiest way to handle shed dormer loads, but they must provide a continuous path to the foundation.*

ly below the ridge line, and be in line with walls or girders all the way to the foundation. It's okay if the support wall is a few inches out of line with the wall below, but in this case you should align the studs over the floor joists or use a double sole plate. If the walls are more than a few inches out of alignment, have an engineer check the joists to avoid sagging and ceiling distress.

But Can I Do It Without Additional Support?

Admittedly, many shed dormers have been built in roofs without structural ridges or where no center support wall exists. And many of these dormers, which under engineering analysis with code loads would seem deficient, have fared well.

In many of these cases, the main factor that saves an otherwise troubled design is the relatively short length of the dormer (parallel to the ridge). Also, partition walls may provide some vertical support and even an existing ridge beam, if it's 2x8 or larger, may serve for spans between partitions of less than 12 feet. In general, a small shed dormer may work without a structural ridge or center bearing wall if the following conditions are met:

• Set the exterior wall of the shed

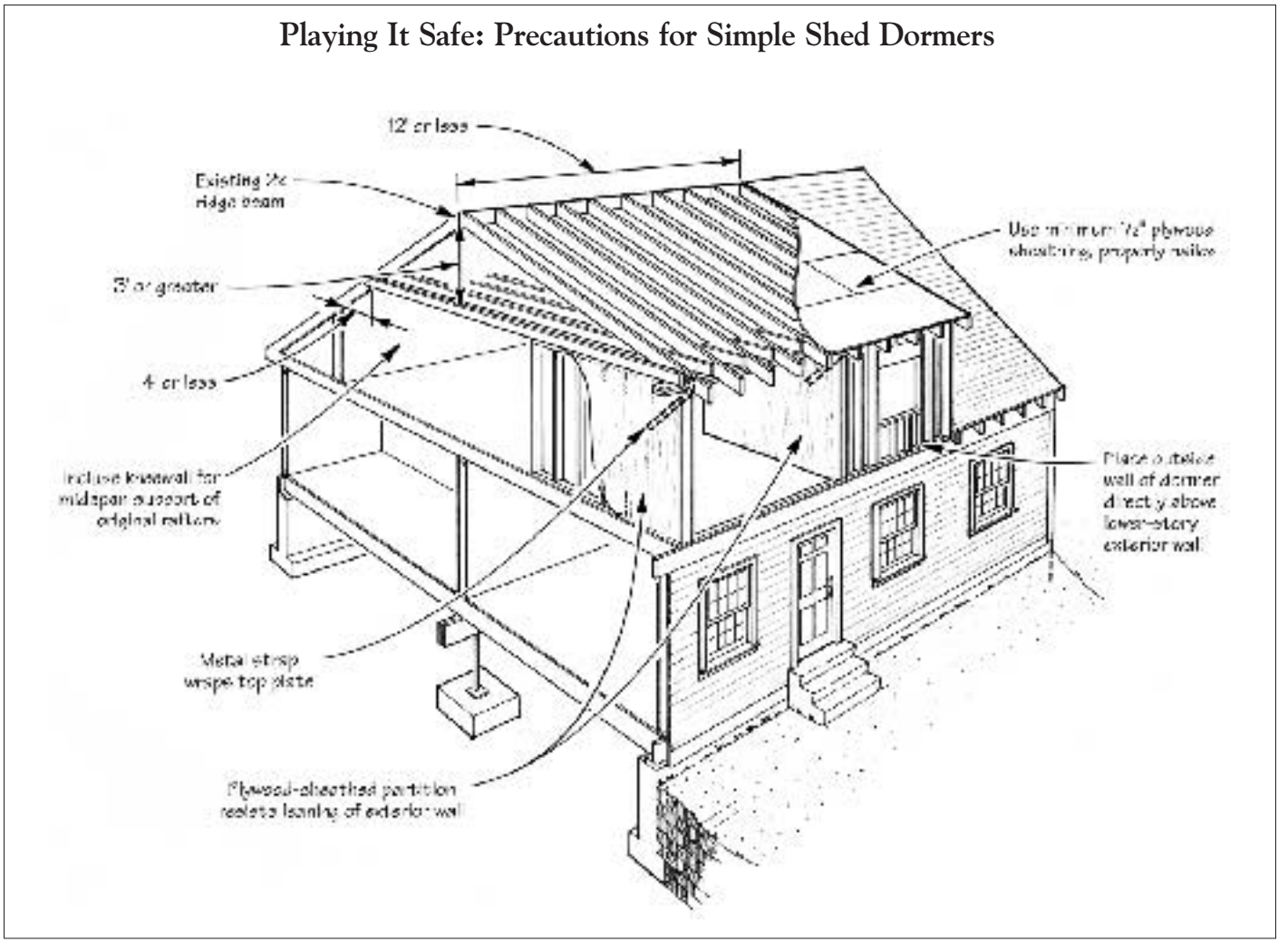


Figure 5. *Although it's safer practice to include a structural ridge or center support wall when retrofitting a shed dormer, it's possible to add a dormer without these structural elements as long as certain conditions are met, as shown above.*

dormer directly above the first-floor exterior wall (Figure 5). This ensures that at least half the dormer roof loads are carried safely to the foundation — assuming the wall below is well-built, with properly sized door and window headers.

- Include a kneewall at the rear (non-dormered side of the roof). This provides midspan support to the rafters on that side. Keep the horizontal distance between the kneewall and the dormer's ceiling joist/rafter intersection to less than 4 feet, unless the rafters are 2x10s or larger. Also, make sure the floor joists below the kneewall are large enough — if less than 2x10, they will usually have to be sistered.
- The vertical distance between the ridge and the dormer ceiling should be 3 feet or more. The dormer ceiling joists act in tension to resist the roof spread. As they go higher, the tension increases, as does the bending moment at the connection. This increases the risk that the rafter will crack or that the connection will slip.
- Use perpendicular interior walls to brace the dormer's exterior wall against leaning out. This will not work well if the partitions are covered only with drywall. Sheathe these partitions with plywood and use strap ties to tie them to the top plate of the dormer's exterior wall, as shown in Figure 5.
- Use minimum 1/2-inch plywood roof sheathing, properly nailed, to develop diaphragm action in the dormer roof. Also, an existing ridge beam 2x8 or larger will help maintain ridge alignment.

Taken collectively, these features may prevent deflection problems, where any single feature would be inadequate.

Other Design Considerations

There are many small variations on shed dormer design that have strucutural implications.

Supporting set-back dormers. As mentioned above, many dormer designs set the outside wall of the dormer back from the line of the main wall of the house for the sake of appearance. The problem common to these designs is the transfer of roof loads to the floor joists. Where the floor joists are 2x6s, this set-back design should not be considered without sistering the floor joists. Where 2x8 floor joists exist, a setback no greater than one foot is suggested. With 2x10 floor joists, a 2-foot setback is probably reasonable. (Have your design reviewed by a licensed engineer to verify these recommendations.) Where you have a structural ridge or a center support wall, the setback distances can be increased somewhat.

Drop-ridge dormers. If aesthetic considerations lead you to drop the shed dormer ridge (because practical considerations are not likely to!), then all the previous guidelines still apply. Where you have a structural ridge or center support, this detail is easy. Just tie the dormer rafters in at the ridge or center wall and finish the roof off with short nonstructural rafters above the shed (Figure 6, next page).

If you're retrofitting a dormer where there's no structural ridge or center support wall and you want to drop the ridge, an added challenge lies in making careful connections at the ridge. I would recommend two 1/2-inch carriage bolts at each connection.

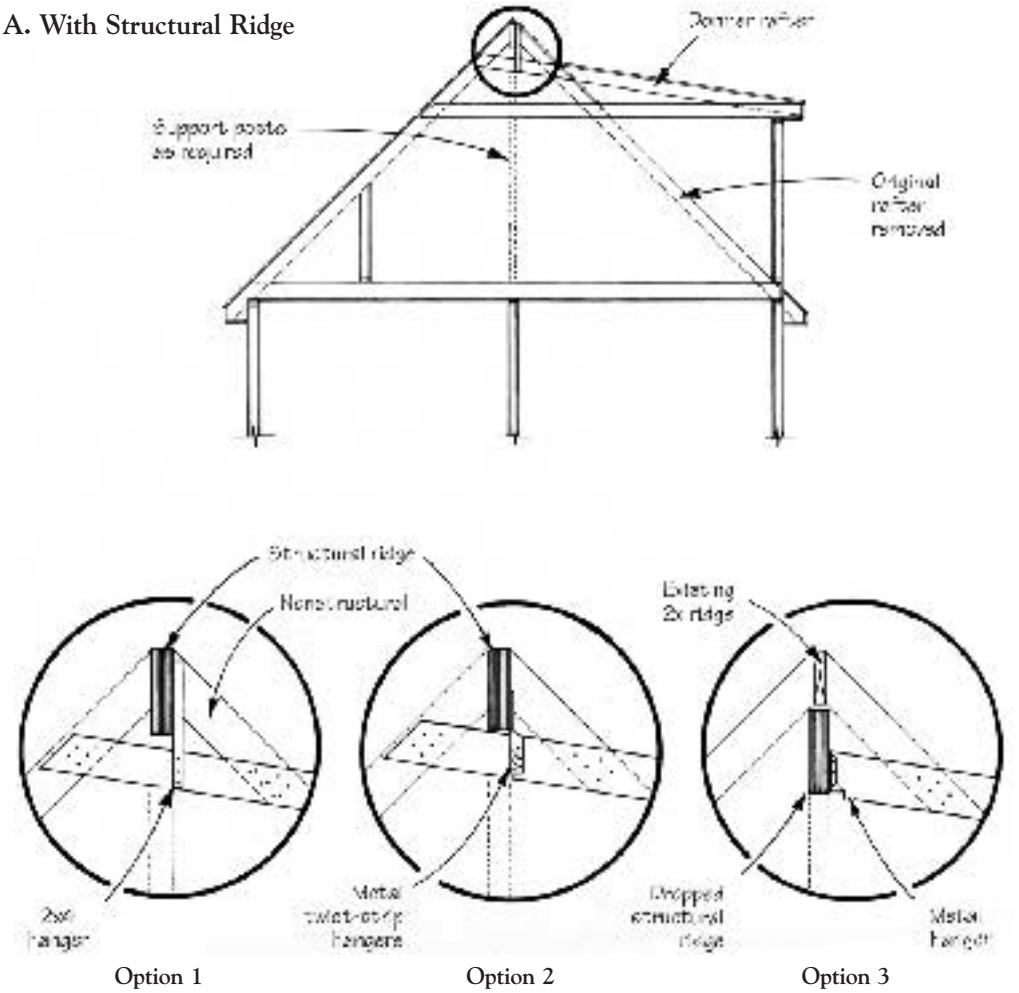
Except for very small dormers, I would not recommend using a header between doubled rafters to support the top of drop-ridge dormer rafters. Although this practice is common, these headers are usually undersized and a sagging roof or cracked rafters can result.

Dormers over half-walls. Often the existing construction has second-story half-walls, either balloon-framed or of platform construction (Figure 7, page 37). Resist the temptation to scab on to the half-wall when raising the shed roof — it's never a good idea to have a weak wall splice midway between floor and ceiling. Instead, remove the top plate of balloon-framed half-walls and add stud extensions, splicing them together with an overlapping 2x member. Or you can cut the balloon studs off flush with the floor deck and add a top plate, then build a new full-height stud wall on top. Remove platform-framed half-walls altogether and replace them with full-height stud walls.

There is another problem that can occur when a shed dormer is added over half-walls. Because a half-wall affords some access under

Drop-Ridge Dormers

A. With Structural Ridge



B. Without Structural Ridge

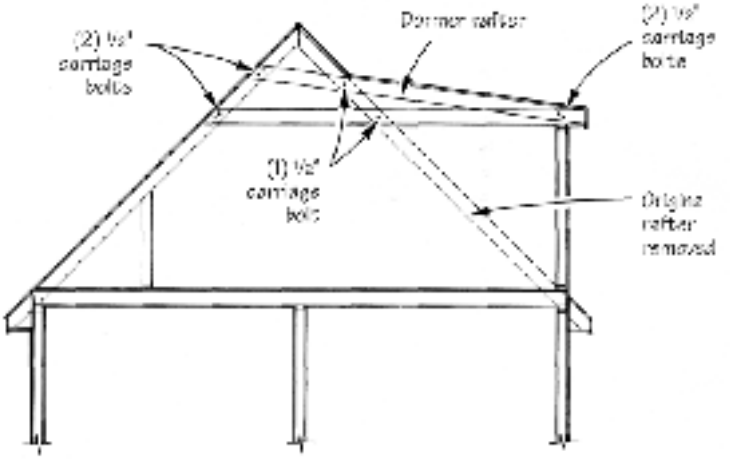


Figure 6. *Shed dormer designs sometimes drop the shed ridge below the main ridge of the house. With a center bearing wall or structural ridge (A), this presents no problem; just tie in the dormer rafters and add short nonstructural rafters above. The drawing shows three options for tying the dormer rafters to the structural ridge. However, in situations without a structural ridge (B), special attention must be given to connecting the dormer rafters. The author recommends 1/2-inch carriage bolts at all connections.*

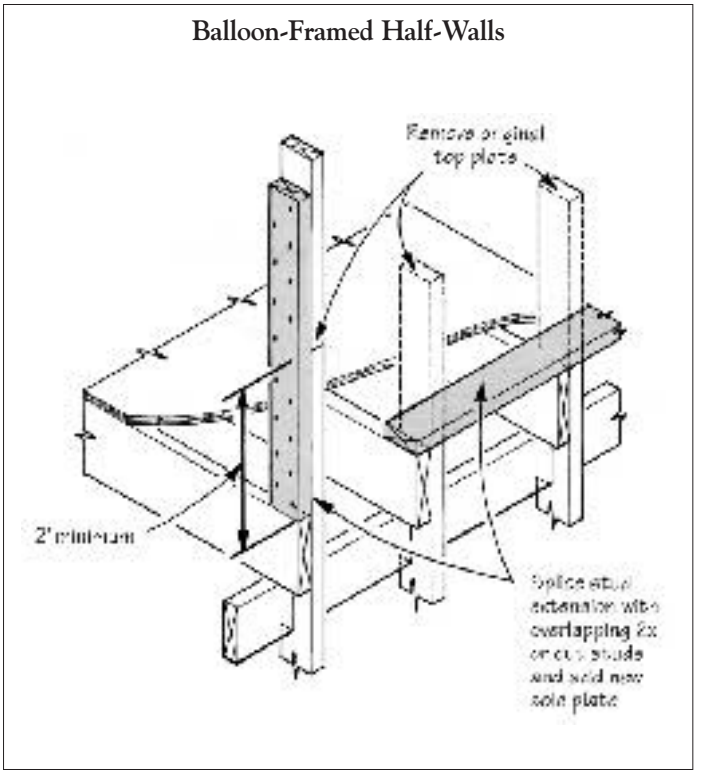


Figure 7. *When adding a shed dormer above balloon-framed half-walls, don't build the wall extension directly on top of the balloon wall top plate. Instead, either remove the top plate and carefully splice on stud extensions or cut the balloon studs flush and build a new full-height stud wall.*

the non-dormered side of the roof, the kneewall on that side is often omitted, leaving a clear-span roof and no load transfer to floor joists (good). Unfortunately, the resulting bending moments applied to rafters at ceiling joist connection points are likely to be unacceptable (very bad). In this situation it's best to provide a structural ridge or center bearing wall, or to seek the help of an engineer.

Hybrid dormers. In many cases, a long dormer may incorporate two or three of the basic designs described above, selected according to interior wall placement and available load paths below. There is really little to worry about with such combinations as long as each section, taken alone, is structurally adequate.

Final Precautions

Regardless of the type of dormer being built, it is important to verify the strength of the existing framing beneath the new construction, and to consider flashing and ventilation details for the new roof:

- ***Floor joists*** may require sistering if the new construction adds significant bending loads to the floor. Two-by-sixes should always be sistered and 2x8s will often need to be. Two-by-tens may not need sistering if the new loads are not excessive.
- ***Interior walls***, if used to carry vertical loads, should be inspected to make sure the headers are adequate. Check the alignment of support walls with walls and girders below. If more than a few inches of misalignment exists, seek professional review.
- ***Girders*** should be analyzed for the new loads. Examine them for signs of twisting, lateral instability, or excessive sagging or crushing of wood members at points of support.
- ***Columns*** should be checked for deformation at the top, for proper attachment, and for any settlement. Inspect steel columns for corrosion as well.
- ***Footings*** are usually adequate to carry additional loads, but should be inspected just in case they were poorly constructed in the first place.
- ***Ventilation*** may be needed where you're finishing previously unfinished attic space. Don't forget to pay proper attention to details of insulation and ventilation of the new roof.
- ***Roofing*** may require special thought, depending on the slope of the dormer roof. Shingles will not drain as well as they did on the original steeper roof. If the roof cannot be readily seen from the ground, or if the slope is less than 4:12, I recommend a single-ply material, such as modified bitumen. And regardless of the slope, you should incorporate an ice and water membrane for the first 36 inches of the roof above the eaves to avoid ice dams. ■

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