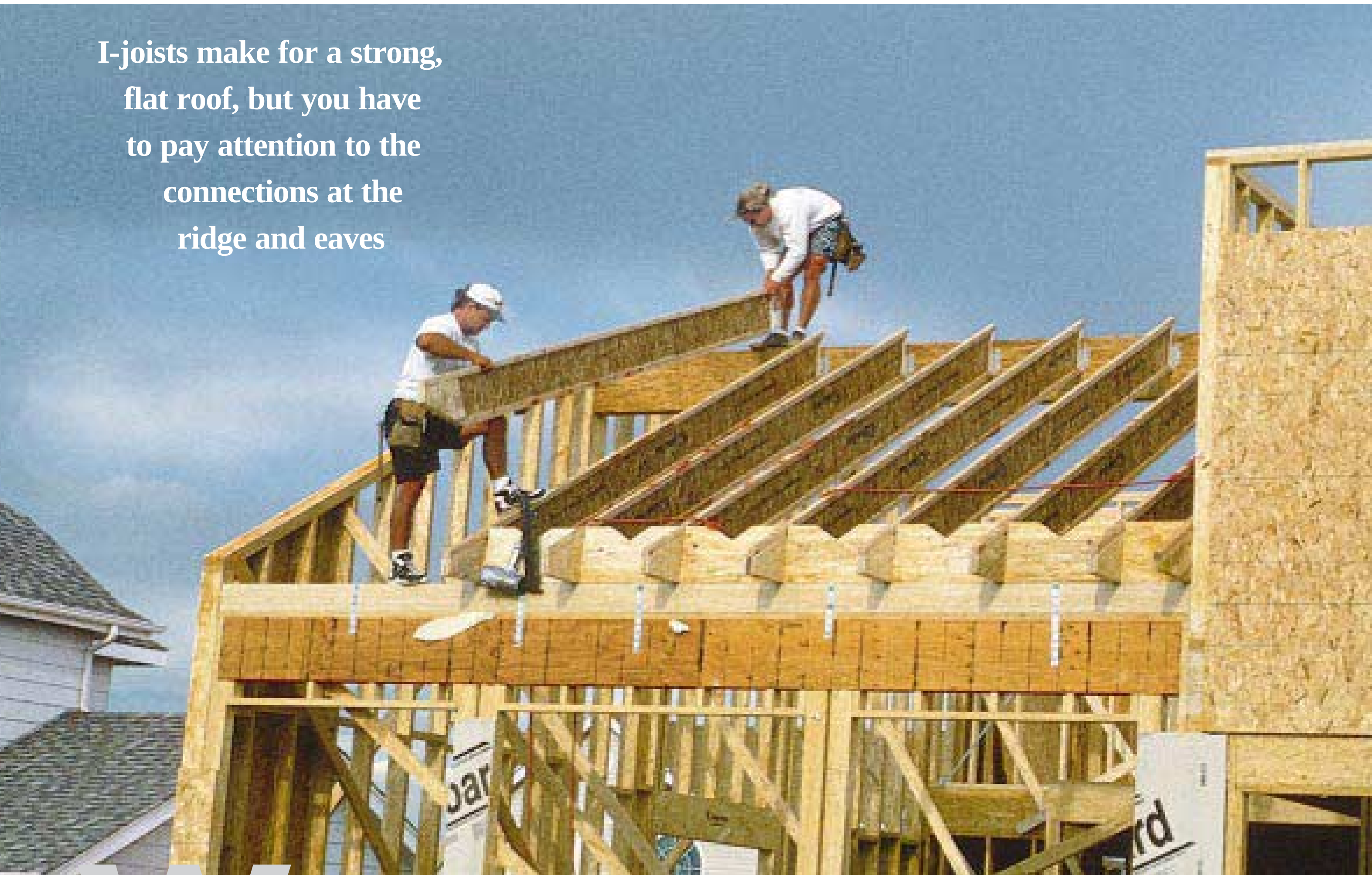
Roof Framing with Wood I-Joists

by Curtis Eck, P.E.

I-joists make for a strong, flat roof, but you have to pay attention to the connections at the ridge and eaves



While many builders have incorporated I-joist floor systems into their standard construction, roof framing with wood I-joists remains somewhat of a mystery. Roofs tend to be more complicated than floors, so it's natural that builders accustomed to stick framing might be cautious about using wood-I's instead of solid-sawn rafters. But for certain kinds of roof configurations, wood I-joists may work better than dimension lumber — long-span cathedral ceilings are a good example. My purpose here is to clarify the differences between solid lumber and wood I-joists, and to provide some hints to make roof framing with wood I-joists easier.

I-Joist Roof vs. Conventional Framing

The first thing to understand is how a roof framed with wood I-joists differs structurally from a traditional stick-framed roof.

In a typical roof framed with dimension lumber, the rafters rest on the exterior wall top plate at the lower end and bear against a ridge board at the top. Continuous ceiling joists or collar ties span from rafter to rafter. There is no need for bearing posts under the ridge board, which is nonstructural. The roof loads are carried to the top plates of the bearing walls, where the floor joists, acting in tension,

Figure 1. **Sloped-seat hangers can be adjusted in the field to match the slope of the roof. These hangers require a plywood or lumber web stiffener on both sides of the I-joist to fill out the space between the hanger and the web.**

Figure 2. **When supporting I-joists on a beveled plate, install metal straps across the tops of the butting joists for all roof slopes. When using hangers, straps are necessary for slopes above 7/12.**

Figure 3. **Sloped-seat connectors like the Simpson VPA or the USP TMP can provide bearing at the top plate if the roof loads are not too great.**

keep the rafter ends from spreading out. What you have here is essentially a truss, built on site. The strength of the roof system depends a lot on the connections between the joists and the rafter ends: As long as those nails are adequate for the loads and don't slip, the rafters are restrained from pushing out, the ridge board is compressed in place at the top, and the roof doesn't sag (see *Practical Engineering*, 5/96, for more on this topic).

With wood I-joists, there is no practical way to make a strong shear connection between the floor joists and the rafter ends. Instead, a wood I-joist roof system is framed with either a central bearing wall or a structural ridge — a beam that carries the roof load to posts. The load from the top half of the roof is carried by the bearing wall or structural ridge; the bottom half is carried by the exterior bearing walls. The loads are primarily gravity loads, which push down, not out, on the bearing walls. So there is no need to engineer a connection between the floor or ceiling joists — if there are any — and the rafter ends.

In my work as a field rep for Trus Joist MacMillan, most of the wood I-joist roofs I see use a structural ridge beam rather than a center bearing wall. But whether you use a ridge beam or a bearing wall, there are two ways to support the joists at the upper end: with hangers or a beveled bearing plate (see "Wood I-Joist Details"). The important point to remember is that no birdsmouth cuts are allowed at the high end of the I-joist. This would mean cutting through the bottom flange at the bearing point, which would damage the I-joist.

Using Hangers at the Ridge

The most common method is to use a face-mount hanger with a sloped seat (see Figure 1, above, and "Hanging an I-Joist From a Ridge Beam"), such as the Simpson LSSU series or the USP (Kant-Sag) TMU. These hangers can be adjusted in the field to match the I-joist slope, and can be skewed side to side up to 45° for hip-and-valley jack rafters.

Web stiffeners. The sloped-seat hanger requires a beveled web stiffener on both sides of the I-joist to fill out the space between the hanger and the web. You can rip stiffener material out of plywood (the thickness depends on the I-joist size), then production-cut it on a chop saw to the right length. For larger I-joists, use 2x4s for the stiffeners. Make sure you check the manufacturer's literature for the proper stiffener size and thickness — it may vary from brand to brand.

Plywood stiffeners should be attached with three 8d nails with points clinched. For 2x4 stiffeners on the larger I-joists, use three 16-penny nails. It's a good idea to drive two nails from one side.

It's important to install stiffeners with a gap at the top (we recommend 1/4 inch). This prevents the top flange from prying off the joist web under load.

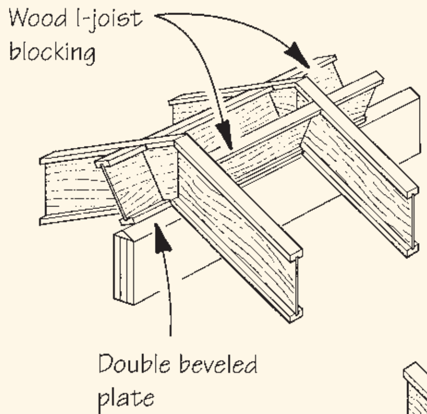
Strapping for steep slopes. With a ridge beam and hangers, no additional lateral bracing is needed at the top end of the rafters. But for roof slopes greater than 7/12, you may need to install a metal strap tie, like the Simpson LSTA 15, across the top of each pair of opposing I-joists to resist the tendency for the joists to "slide" downhill.

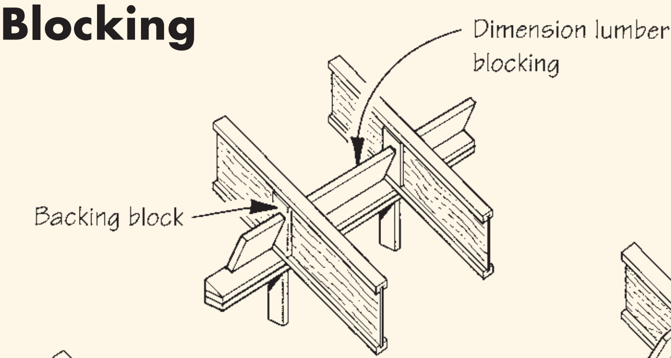
Beveled Plate Details

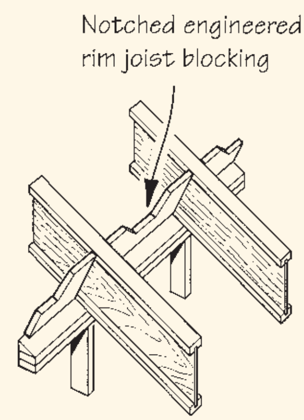
The other method used at the ridge is to nail a double-beveled plate on top of the ridge beam (or bearing wall top plate) to provide the sloped bearing sur-

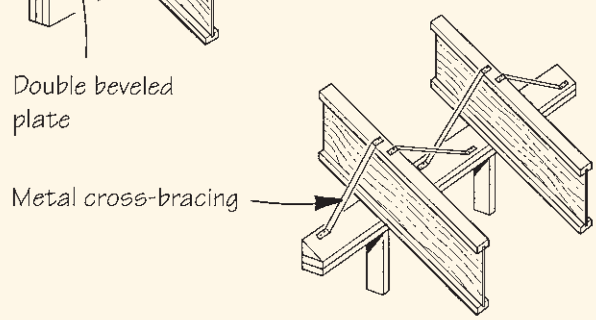
Wood I-Joist Details

Blocking



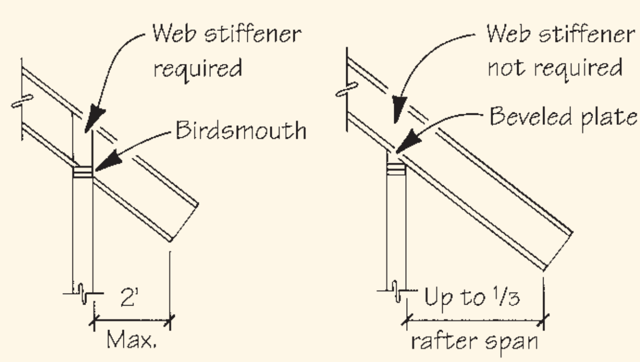






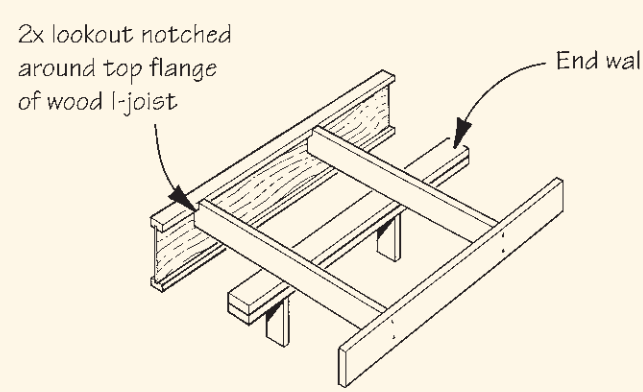
I-joists require blocking at end supports to prevent joist rollover. Short pieces of I-joist work well and provide good shear blocking for diaphragm designs (above left). Where a ventilation channel is needed, use dimension lumber (above center), metal cross-bracing (left), or notched engineered rim joist material (above right).

Birdsmouth vs. Beveled Plate



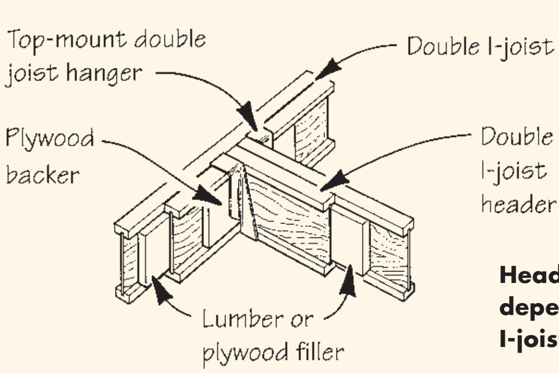
Though a beveled plate requires special fabrication, it has some advantages over cutting a birdsmouth.

Gable-End Overhangs



Frame gable-end overhangs with dimension lumber outriggers notched around the I-joist top flange. If the overhang exceeds the I-joist spacing, check with the manufacturer to see if a doubled I-joist is required.

Headers



Headers at openings may require double joists, depending on the loads. Use filler blocks between the I-joists and a backer block to support the hanger.

Figure 4. **Many soffit profiles are possible with an I-joist roof system. Shown here are dimensional lumber rafter tails (left), a level soffit (middle), and an I-joist used as backing for fascia (bottom).**

face for the joists. (A single-beveled plate can be similarly used at the low end of the rafter.) Once the plumb cuts have been made, the I-joists are installed by butting them at the ridge and nailing them to the beveled top plate with at least two 10d nails.

Blocking. In order to provide lateral stability for the I-joists, you must also install blocking between them on each side of the ridge. This can be metal cross-bracing, dimensional lumber, or I-joist material (see illustration, page 25). Probably the simplest and sturdiest is to use I-joist blocking, installed at the angle of the roof. This provides flange-to-flange support without the need for any filler pieces, and also makes a good shear block for transferring forces from the roof diaphragm to the ridge beam. In a cathedral ceiling, where continuous roof ventilation is needed, you can use narrower-width dimension lumber, metal cross-bracing, or engineered rim joist material notched to allow airflow.

Strapping required. Finally, metal straps should be nailed across the tops of the butting joists for all roof slopes (Figure 2). As an alternative, some manufacturers show a plywood gusset connecting the webs of the butting joists. Both methods will work, but metal strapping is faster.

Bottom Bearing Details

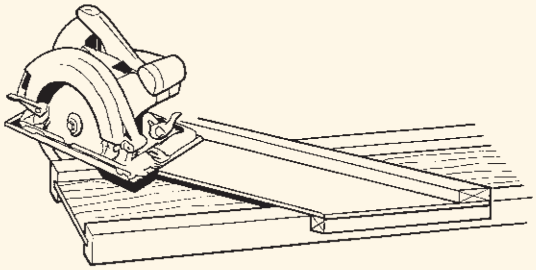
You can use a variety of details at the exterior wall plate, depending on the the roof profile you want.

Birdsmouth. The most common detail is to make a birdsmouth cut at the plate (see illustration, page 25). But be careful: There's definitely a right and a wrong way to do this (see "I-Joist Mistakes"). When laying out a birdsmouth, make sure the seat cut does not overhang the inside face of the bearing wall. The bottom flange must get full bearing on the plate. If this cut is not made properly, the joist's strength can be significantly reduced. With a birdsmouth cut, you'll have to use web stiffeners on both sides of each I-joist, as at the ridge.

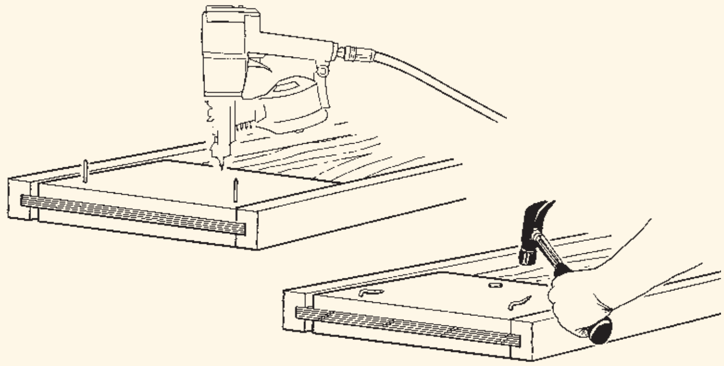
Beveled plate. Another option at exterior walls is to use a beveled plate instead of a birdsmouth. This can save time, because there's less cutting to do and web stiffeners are usually not necessary (except in cases of very large roof loads). Using a beveled plate also provides more design flexibility, as the joists can cantilever up to one-third of the rafter span. The only possible drawback is the additional cost and availability of the beveled plates, although these can be ripped from dimensional stock on a band saw.

Sloped-seat connector. A third option at the low end is a sloped-seat connector attached at the bearing point (Figure 3, page 24). These metal connectors, such as USP's TMP or the Simpson VPA, provide a field-adjustable sloped bearing surface. Depending on the manufacturer and type of connector, the allowable slopes range from 1/12 to 12/12. Installation varies by manufacturer, so always check the instructions for the specific connector you are using. The advantages of these connectors are that no birdsmouth cut and no web stiffen-

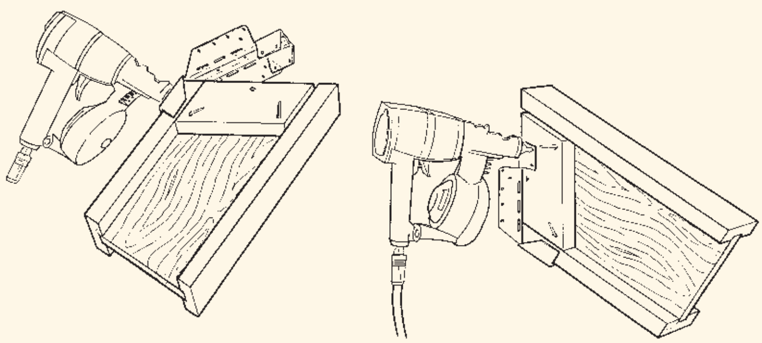
Hanging an I-Joist From a Ridge Beam



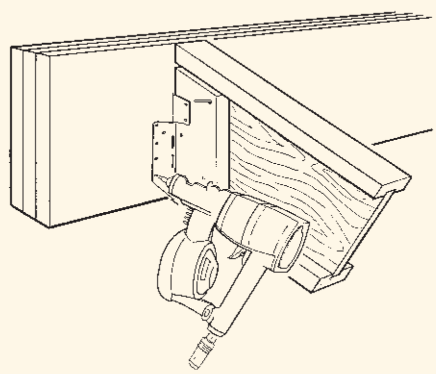
1. Cut the plumb cut at the top of the I-joist. Use a piece of plywood in the web or a cutting jig for the saw shoe to ride on.



2. Attach the web stiffeners to each side with three 8d nails, leaving a 1/4-inch gap at the top. Clinch the nail points.



3. Attach the hanger to the I-joist. First, nail the sloped seat to the bottom of the rafter. Next, bend the hanger against the plumb cut and put the rest of the nails into the web stiffener and bottom flange.



4. Lift the I-joist into place and nail the hanger to the ridge beam.

I-Joist Mistakes

The photos at right, sent in by a *JLC* reader, show great examples of how *not* to frame a roof with wood I-joists. The bottom flange of the I-joist — the part that is most critical for carrying the bending forces — has no bearing, either at the top or the bottom.

It will not take a large load for this roof to fail. What will the failure look like? Most likely, at the upper end the I-joist webs will tear away from the top flanges. At the bottom end, the webs will split and the roof will come down.

COURTESY OF GARY LOZOWSKI

Figure 5. Sloped-seat hangers can be skewed up to 45° for hip and valley jack rafters. Compound cuts are not necessary; only the plumb cut needs to be made.

ers are needed. The disadvantages are that their loading capacity is somewhat limited (see manufacturer's catalog for specifics) and that installation can be time consuming.

Blocking. Regardless of the method you use at the low end, blocking or cross-bracing is required to prevent joist rollover.

Soffits and Overhangs

Soffit treatments seem to concern a lot of the contractors I meet in the field. "How can I nail my fascia to that skinny little piece of OSB?" is a question I hear a lot. The truth is, there are several details that work, depending on the roof profile you want (Figure 4, page 26). One typical detail is to sister on dimensional lumber rafter tails. You can also use plywood, an engineered rim board material, or even another I-joist for fascia backing. To frame a flat soffit, you can extend the birdsmouth cut to the end of the joist, then attach 2x4 blocking for a soffit nailer. Just about any traditional profile is possible with proper planning at the design stage.

The rules for overhangs are straightforward. All the manufacturers' design guides show many details. One point to remember is that if a birdsmouth cut has been made, the maximum allowable overhang for any of the details is 2 feet. If you want a longer overhang, use a beveled plate or sloped-seat connector.

Gable-end overhangs. Gable-end outriggers are framed by cantilevering dimension lumber across the gable-end top plate, similar to stick-framing techniques (see illustration, page 25).

Hips and Valleys

Hips and valleys are possible with wood I-joists, but the only practical way to frame them is to use the field-adjustable hangers mentioned above. The techniques are identical to the methods mentioned earlier, except that when the hanger is installed to the beam, the hanger must be skewed (Figure 5). Although hangers can get expensive, one advantage of this technique is that compound cuts are not needed on the jack rafter ends. The only cut required is the plumb cut.

Header Details

Framing headered openings for skylights and dormers is also straightforward. As with dimension lumber, the size of the opening determines how many I-joists are needed to support the header. If the header hangs from a single I-joist, you nail a backer block (typically plywood) to the joist, then nail the hanger to the backer block (see illustration, page 25). Double I-joists require a filler between them — either plywood or dimension lumber — and a backer block for the hanger. For really large openings, it makes sense to use an LVL or Parallam beam to support the headers instead of multiple I-joists.

Keep in mind that all these connection details, whether for headers, hangers, or whatever, have been engineered by the I-joist manufacturer. It's critical that you read and understand — and follow — the application guide. If you have a question or a tricky installation problem, call the manufacturer for technical support. ■

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Sources of Supply

Wood I-Joists

Boise-Cascade
P.O. Box 2400
White City, OR 97503
800/232-0788

Georgia-Pacific
2300 Windy Ridge Pkwy.
Atlanta, GA 30339
800/423-2408

Louisiana-Pacific
325 Industrial Dr.
Fernley, NV 89408
800/223-5647

Trus Joist MacMillan
P.O. Box 60
Boise, ID 83707
800/628-3997

Willamette Industries
2550 Progress Way
Woodburn, OR 97071
800/942-9927

Hangers and Connectors

Simpson Strong-Tie
4637 Chabot Dr., Suite 200
Pleasanton, CA 94588
800/999-5099

United Steel Products
(USP, Kant-Sag, Silver)
P.O. Box 80
Montgomery, MN 56069
800/328-5934, ext. 235