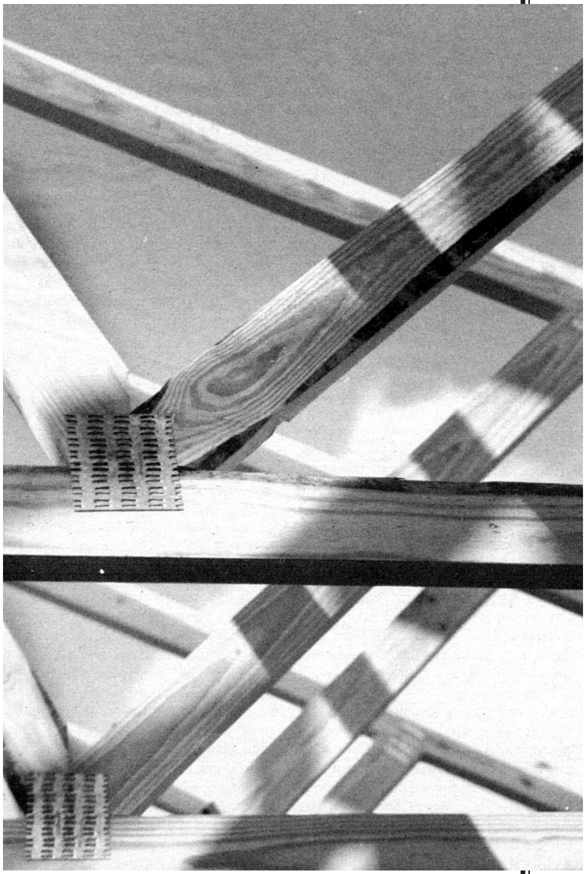
When You Have To Cut A Truss

Residential remodelers can safely modify a single truss if they understand the load and closely follow basic rules

by Clayton DeKorne



The warnings from truss manufacturers are very clear: you are risking structural failure if you cut into a truss. The warning shouldn't be taken lightly. However, on some remodeling jobs, trusses have to be modified.

When you must cut into a truss, the only path offered by the Truss Plate Institute is to "consult an engineer." That's fine when you need to modify a number of trusses for a large addition. But for small projects when you're only dealing with a single truss—to fit a skylight, chimney or HVAC duct—it isn't likely you'll have the time or the budget to go that route.

One alternative to going to the full expense of hiring a consulting engineer is to go to a truss manufacturer. Most large truss fabricators have a fulltime design staff that can advise on repairs. The Wood Truss Council of America (111 East Whacker Drive, Chicago, IL 60601; 312/644-6610) can put you in touch with a truss fabricator in your area that offers design assistance. Some fabricators might extend the help as a professional courtesy, even if they did not build the original truss.

Another alternative is to learn how trusses support loads (see "How Do Trusses Work?" last page), follow some basic rules of thumb, and then liberally overbuild. This does mean taking on some liability, something you should give some hard thought to.

Some Basic Rules

This article examines two possible ways to restructure a roof when a single truss has been cut. The first case, from a truss designer, relies on new bearing walls to support the cut ends of the truss. The second, from a builder, shows how the cut ends can be headed off to the adjacent trusses. Both examples involve similarly sized, W-type trusses which are commonly used for residential buildings. Other types of trusses must be looked at separately. But regardless of the type of truss involved, keep these basic rules in mind:

1. Trusses must be considered as a whole. Whether a single chord or an entire section is cut, the top and bottom chords (the outer members) must be tied back together so that the remaining sections form rigid triangles.
2. In addition, the webs (the members inside the truss) should all "triangulate," that is, form complete triangles within each section of the truss.
3. If trusses carry greater loads after the modification, they must be reinforced. This applies particularly to trusses that support headers from a cut truss. (The second case study gives an example of this.)
4. New connections made between truss members must be as strong as the metal plates they are replacing.

The application of these general guidelines can be seen in the following examples.

A Chimney Chase

David Matychowiak is the head of design at Wood Structures, in Biddeford, Maine. In addition to designing trusses, Matychowiak regularly advises on the repair of trusses. He described to me a job he was called to after a

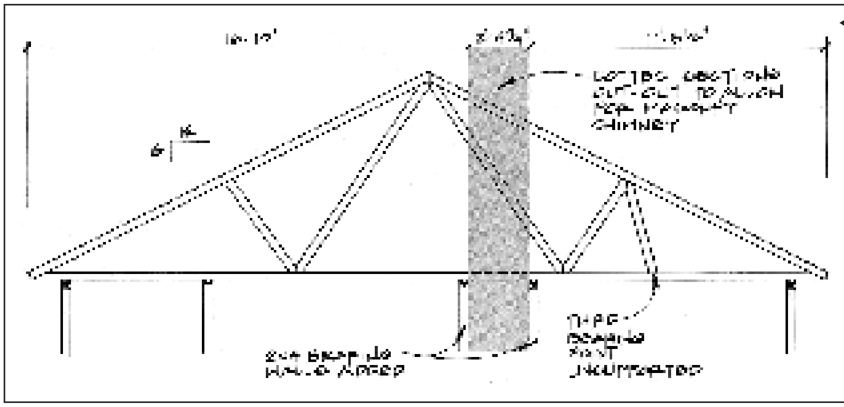
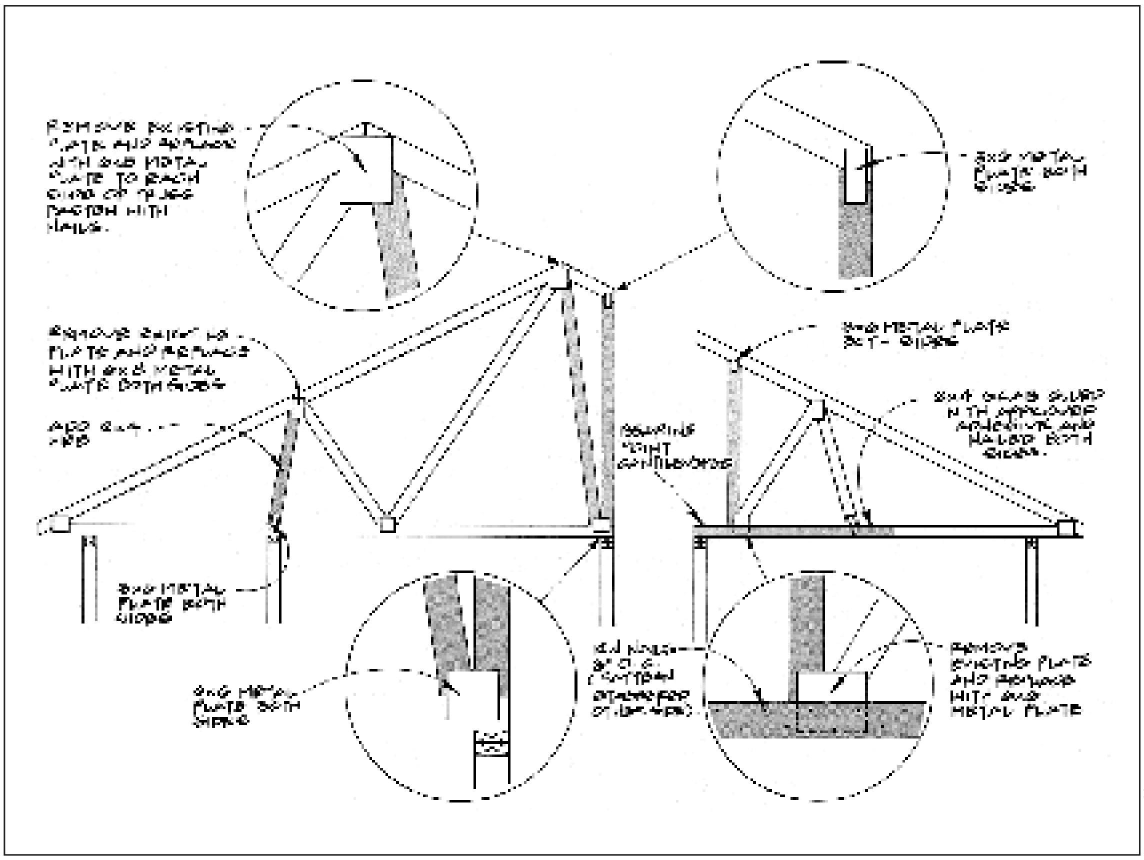


Figure 1. *To make room for a chimney, this W-type truss was cut in half. The contractor built bearing walls to support the cut ends, but the truss still needed rebuilding. To make matters worse, the truss, which was designed to have three bearing points, had originally been installed backwards: the third bearing point on the right should have been placed over the partition on the left.*

Figure 2. *To patch up the wounded truss, the engineer called for new 2x4s to tie together the cut ends of the top and bottom chords on both sides of the chimney. New web members were also added to form complete triangles inside the truss (all new work is shaded). The new configuration let each section function as a smaller, but complete, truss. Note the "scab" on the right-hand section to strengthen the cantilevered bearing point.*



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local code officer issued a stop work order. When Matychowiak arrived at the job site, he found a 30-foot W-truss that had been cut to make room for a chimney. Figure 1 shows the truss as he found it. The chimney had been built and bearing walls erected to close in the chimney and support the cut ends of the truss, but nothing had been done to restructure the truss itself.

Cutting this truss completely interrupted its transfer of forces. According to Matychowiak, the bearing walls were a step in the right direction, but nothing had been done to tie the top and bottom chords together or retriangulate the web members. The top and bottom chords on either side of the chimney now functioned as undersized rafters and ceiling joists and would probably have sagged over time.

To further complicate matters, the truss had originally been installed backwards. It was designed as a "tri-bearing truss," with three bearing points—two on the outside walls and a third on an off-center interior wall. Note in Figure 1 that the interior bearing wall is on the left-hand side of the truss while the bearing point is on the right-hand side.

To repair this truss, Matychowiak suggested removing the remaining pieces of the cut web member on both sides of the chimney. He treated each section of the truss separately, essentially creating two separate smaller trusses (see Figure 2).

On the left-hand section, Matychowiak called for removing the old plate at the peak, and adding a new web extending to the bottom chord to retriangulate this section of the truss. A new 6x8 NailRite plate, nailed off with N11 (10dx1-1/4) nails, replaced the plate at the peak. NailRite plates are made by Hydro-Air, the company that supplies the truss plates to Wood Structures. Kant-Sag (U.S. Steel), Simpson, and Teco also make similarly sized steel mending plates which are widely available at lumberyards.

Plywood gussets can also be used and are often preferred because plywood is more readily at hand. Matychowiak emphasizes that plywood gussets should be sized to equal the strength of the steel plates they replace. "Too often the strength of a metal plate is underestimated," he says. For example, he notes that a 4x4-inch steel nailing plate is equivalent to about a 2x2-foot plywood gusset nailed every 3 inches on-center along the truss members with 43 10d nails. The plywood may have to be even larger than this depending on how much nailing surface it covers on the truss.

Also on the left-hand section of the truss, Matychowiak recommended adding a vertical web member to tie the cut ends of the truss together. He used a 6x6 plate to tie both new webs to the bottom chord and a 3x6 plate to secure the joint at the top chord. Once secured, the new webs created a small "truncated truss" which worked as a self-supporting right triangle, much like a shed roof truss.

To correct the bearing problem originally caused by installing the truss backwards, Matychowiak replaced the missing web on the far left-hand side. This web formed a new bearing point over the load-supporting partition wall. Note that this new member joins the top and bottom chords at an angle to form a complete triangle in that section of the webbing.

The right-hand section of the truss was treated much the same way. Here a new vertical web was placed at the joint

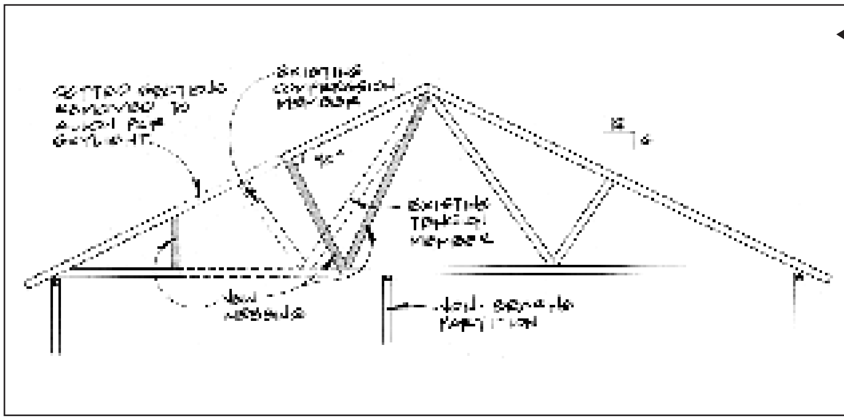
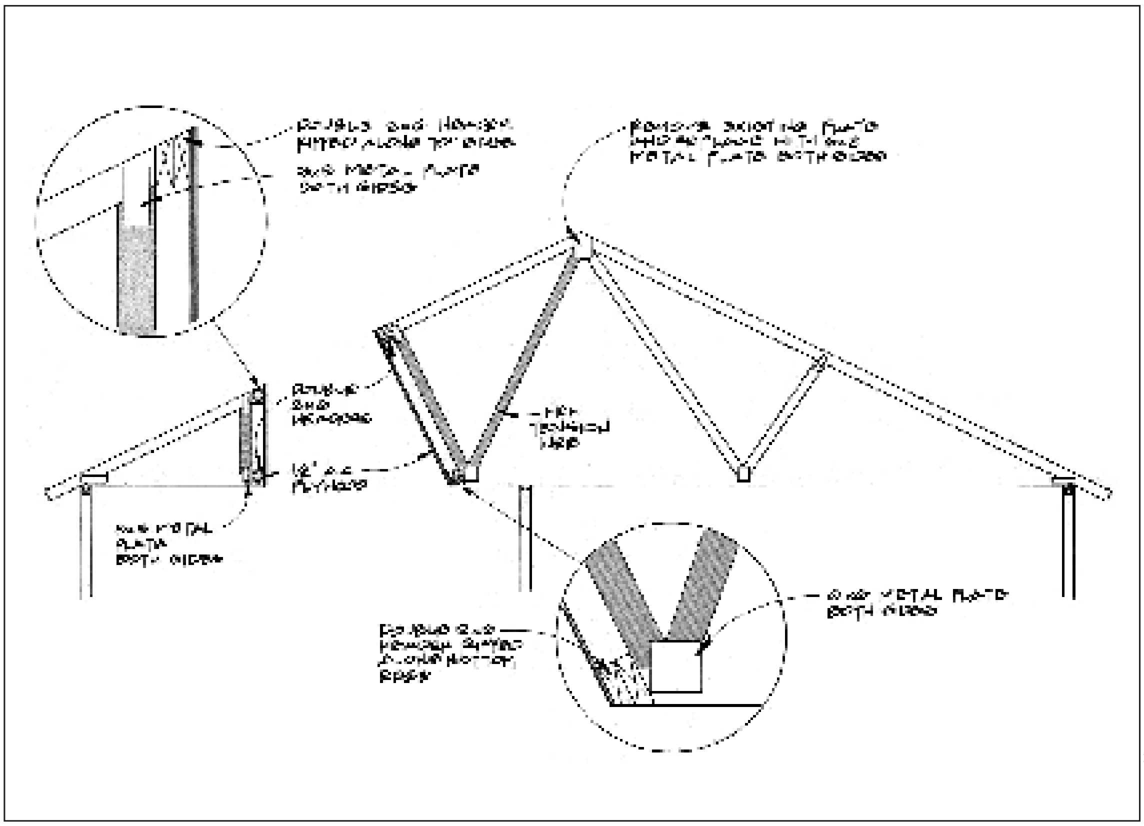


Figure 3. *To retrofit a skylight in a truss roof, a builder removed the section of one truss and headed off the cut ends to the adjacent trusses. Note how the back wall of the skylight well flares to form a right angle with the slope of the roof (new work is shaded).*

Figure 4. *The builder cut the top and bottom chords 3 inches back from the rough openings to allow for double 2x6 headers. To restructure the cut truss, he installed a new web behind each wall of the skylight well and replaced one tension web at the peak to complete the triangle in that section of the truss. Half inch AC plywood was installed around the inside of the light well to tie the structure together.*



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of the old cut web after the original plate was removed. Matychowiak called for scabbing an additional 2x4 along the bottom chord. This chord needed reinforcement because the bearing point would be cantilevered about 12 inches to the new wall. This created what Matychowiak calls a "bottom-chord tail bearing."

Matychowiak used the scab in this way because he wanted to minimize the time the builders spent crawling around in the webbing of the truss roof—kicking up cellulose and jabbing their scalps on roofing nails. An alternative, but more complicated, approach would have involved placing the vertical member directly over the wall and then replacing the next web member to form a complete triangle with the webbing.

The scab was installed after the web members were in place, and was nailed every 3 inches in a zig-zag pattern as shown in Figure 2. This pattern was reversed on the other side so that each 3-inch section of the scab had two nails in it. In addition to this nailing, Matychowiak recommended securing the scab with a construction adhesive that conformed to the American Plywood Association (APA) Performance Standard AFG-01. (The APA publishes a list of specific name brands that conform to this standard. Single copies of the list— publication V-450, "Adhesives for APA Glued Floor Systems"—are free from the American Plywood Association, P.O. Box 11700, Tacoma, WA 98411; 206/565-6600.)

A Skylight Well

In a simple bathroom remodel, David Pell of Hinesburg, Vt., had to remove a section of a truss in order to center a skylight over a bathroom vanity.

The bearing on the right-hand side of the truss might have been transferred to the nearby interior partition using a scab, as in the previous example. However, the partition was not load-bearing.

Furthermore, the bathroom was on the second floor, so providing bearing would have required posting all the way down to the basement slab. Pell thought it would be simpler to head off the cut truss chords to the adjacent trusses. Here, as in Matychowiak's example, the remaining parts of the cut truss would be made to function as individual smaller trusses. However, instead of bearing on walls, the ends of each truss section would be supported by the adjacent trusses.

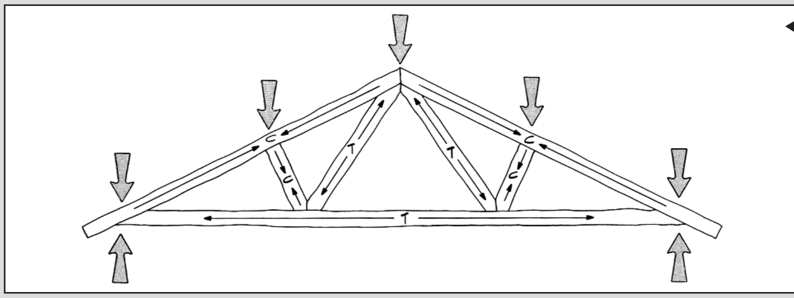
To position the skylight over the vanity, Pell needed to cut the top and bottom 2x4 chords of one 26-foot W-type truss. He designed the light well to flare open along the top wall so that it made a 90° angle with the slope of the roof (see Figure 3). This meant that one web in compression would be completely removed and a second one in tension would be cut.

Before cutting through the truss, Pell's carpenters installed new webbing. Eighteen inches uphill from the existing compression member, they installed a new 2x4 parallel to the old one (see Figure 4). On the downhill side, a new web was installed plumb. In addition, they nailed a new web from the end of the bottom chord to the peak to triangulate the remaining truss section.

Pell cut the new webs long enough to overlap the top and bottom chords and face-screwed the connections from both directions. He used steel corner clips to further reinforce the connection.

After installing the new webs, Pell then cut the chord 3 inches back from the rough openings on the top and bottom of the light well. This allowed him to install doubled 2x6 headers across

How Do Trusses Work?



Truss forces: a balancing act. *Under load, the top chords are in compression and the bottom chord is in tension. The web members lend support to both the top and bottom chords: those leaning into the peak are pulled in tension while those leaning away from the peak are in compression.*

If you've ever watched a roof truss bow and flex at the end of a crane cable, you know this collection of spindly members is playing by a different set of rules than the rafters it has replaced on many homes. A look at the general principles of how a truss works will help differentiate these engineered components from their site-assembled cousins.

Rafters are sized like simple beams. That means they rely primarily on the strength of their wood fibers to resist bending and to transfer loads to the supporting walls. Rafters are sized large enough to do their job without additional support along their length.

Trusses, on the other hand, rely on their connections for strength. Trusses use the combined strength of many short, small-dimension members, each of which have relatively low fiber strength.

Collectively, the truss members have a great deal of strength because they are joined into a series of rigid triangles. A triangle is a naturally stable structure: the stresses acting along the length of any one side produce counter stresses along the adjacent sides. The whole configuration is thus held in a balance of tension and compression. Cutting even one member of a truss will offset this balance.

One way to visualize the forces at work in each member of a truss is to imagine that the top chords are connected with a hinge. Under load, the top chords are in compression. These stresses are working to open the hinge. The bottom chord is held in tension to keep the roof from spreading. The webs lend support to both the top and bottom chords. The web members that are leaning into the peak are pulled in tension (see illustration). The web members that are leaning away from the peak are in compression, and they bear the load placed along the length of the top chords.

It's All In The Connections

Without those little metal plates to hold the truss in a series of rigid triangles, the members would pull apart. The metal plates have a big job to do since the truss configuration amplifies the amount of tension along the bottom chord and in some webs. This puts great tensile stress on the connections. To complicate matters, tension joints are difficult to construct in wood. While wood is very strong in tension parallel to the grain, nails tend to pull out easily when tension is exerted along their length. And when the tension is exerted across a fastener, the small section of wood directly behind it tends to shear out. A bigger nail is even more likely to fail because it is more likely to split the wood. For this reason, steel truss plates have numerous small prongs to distribute the load over a greater area of wood.

According to Dave Matychowiak, of Wood Structures, in Biddeford, Maine, the strength of a 4x4 steel truss plate is rated at about 1,000 psi in tension. This is equivalent to over 40 10d nails loaded in shear. To get this many nails into a truss connection, the nails have to be distributed far enough apart to keep the wood from splitting and to get away from the end grain. Therefore, plywood gussets are sized according to the number and spacing of the nails needed.

Stressed Out

Just as stress-rated lumber is more predictable than standard visually graded material, so metal plates are viewed as more predictable than nails banged in on site. Trusses often use both metal plates and stress-rated lumber, so they are considered to be very predictable.

As a result, members are sized with very small allowances. In fact, it's not uncommon for the top chord of a truss to be designed so that, when fully loaded, it's using 97% of the wood strength of that member. Trusses are, quite literally, stressed out. This doesn't mean that trusses are underdesigned. Rather, they are designed just right.

In practice, this means that if a truss is cut and headed off, the adjacent trusses carrying the added load must be reinforced. Similarly, if you are going to add load to a truss roof by any means, whether adding tile, plastering the drywall ceilings, or tying in an addition roof, a "repair" would be necessary. But for these larger projects that involve more than one truss, you should (you guessed it) consult an engineer.—*C.D.*

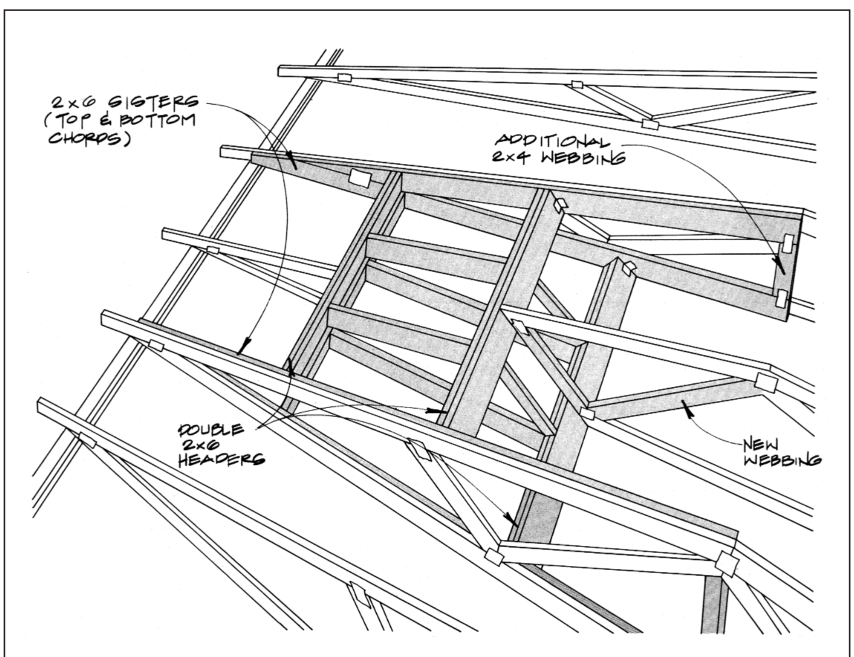


Figure 5. *The load on the cut truss is transferred to the adjacent trusses along double 2x6 headers. The headers tie in to 14-foot 2x6 "sisters" nailed along the top and bottom chords of the two adjacent trusses. Additional 2x4 webs were added to tie together the top and bottom sisters on each side.*

each cut end of the truss. These tied in to 2x6 "sisters" that ran along the top and bottom chords of the two adjacent trusses (see Figure 5). The sisters were glued and nailed every 3 inches on-center along the top and bottom chords and joined together over the wall plates with Simpson 4x5-inch steel plates. Near the peak of the truss, additional webbing was added to support the reinforced chords.

To further strengthen the opening, Pell sheathed the inside faces of the light well with 1/2-inch plywood. This extra step required careful cutting and extra time, but the plywood tied the framework together securely. With a little sanding and three coats of oil-based paint, the plywood finished up nicely and no drywall was needed. It also provided a sturdy nail base for hanging plants.

David Matychowiak looked at a diagram of Pell's repair. He suggested that the new web connections could have been stronger and "more predictable" if the webs were placed in the plane of the truss and secured with flat nailing plates or plywood gussets. Figure 2 and 3 show the joints made correctly with steel mending plates. However, this was not a fatal flaw in Matychowiak's judgement, since the loads are relatively small, only one truss was cut, and Pell's overall approach was correct. ■

Clayton DeKorne is an associate editor for The Journal of Light Construction.