Permanent Bracing for Piggyback Trusses

by Frank Woeste, P. E.

I recently gave a class on bracing of metal-plate-connected roof trusses, attended by about 50 structural engineers. What I learned there about bracing piggyback trusses literally left me sleepless that night. In case you're not familiar with the term, piggyback trusses are used when the height of a required roof truss exceeds the width limit allowed by a state's transportation department for transport on the back of a truck. Depending on the state, the limit is usually around 12 to 14 feet.

So say you need a 12/12 gable roof truss for a 40-foot span. The 20-foot ridge height will force the truss manufacturer to provide the truss in two parts — a bottom truss with a horizontal top chord, and an upper truss that completes the gable triangle (see Figure 1).

Immediately after the presentation on bracing of piggyback systems, one structural engineer produced a set of photographs of a piggyback truss roof in a heap on the hardwood floor of a school gymnasium. The roof collapse occurred with only 5 inches of snow on the roof — there was no ice nor any other load factors. Fortunately, there were no children playing in the gym at the time of the collapse.

All the engineers that spoke up agreed that the sole cause of the collapse was

Incorrect Piggyback Bracing

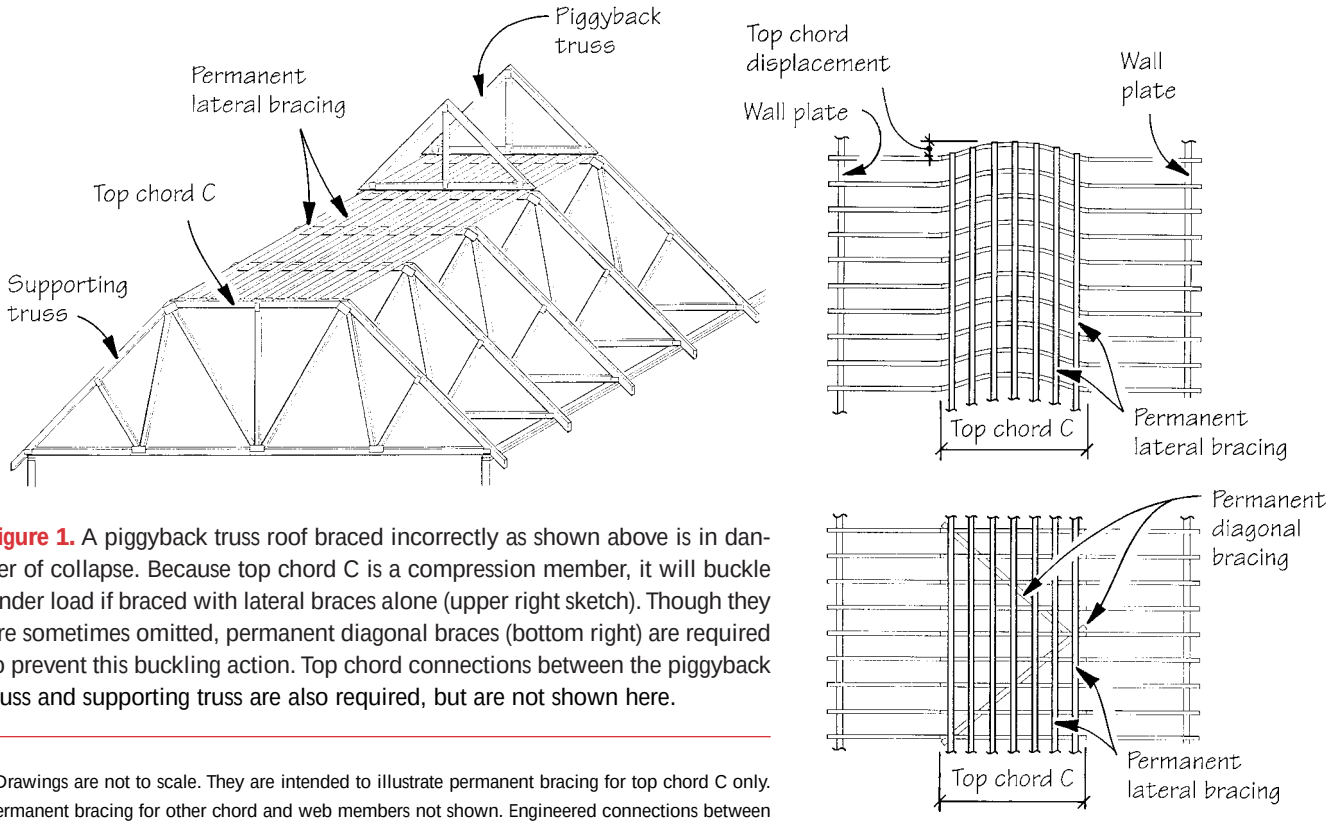

Figure 1. A piggyback truss roof braced incorrectly as shown above is in danger of collapse. Because top chord C is a compression member, it will buckle under load if braced with lateral braces alone (upper right sketch). Though they are sometimes omitted, permanent diagonal braces (bottom right) are required to prevent this buckling action. Top chord connections between the piggyback truss and supporting truss are also required, but are not shown here.

*Drawings are not to scale. They are intended to illustrate permanent bracing for top chord C only. Permanent bracing for other chord and web members not shown. Engineered connections between piggyback and supporting trusses are not shown.

incomplete bracing of the piggyback system. Lateral bracing had been installed on the supporting truss as depicted in Figure 1. What was lacking was diagonal bracing.

Confusion About Truss Bracing

Temporary and permanent bracing of trusses are critical to the success of a wood truss system from the day of installation through the life of the roof. Yet confusion about bracing is common among builders and architects. The term "truss bracing" is ambiguous because it does not differentiate between *temporary* bracing and *permanent* bracing.

To help clear up the confusion, I suggest we avoid using the term "truss bracing" altogether, and refer instead to "temporary bracing" and "permanent bracing." Temporary bracing is the bracing used by the contractor to safely erect the trusses, and it may include elements of the permanent bracing system. Permanent bracing is the bracing required in the roof system to stabilize the trusses throughout the life of the structure.

For example, 2x4s used on the top chords of simple gable trusses to prevent the top chords from buckling during construction are temporary bracing. When the 2x4s come off and the structural sheathing goes down, the sheathing becomes the permanent bracing for the top chord. (Other permanent bracing may be required for other chord and web members.) When trusses are erected in sections on the ground with the plywood already attached, the sheathing serves both functions — temporary bracing and permanent bracing.

Contractors are responsible for determining the necessary temporary bracing, but not the permanent bracing. Permanent bracing should be specified by the building designer.

Back to the Gym

So what happened to the school gym trusses? Under the snow load (as small as it was), truss chord C in Figure 1 is in compression. Imagine what happens when you hold a yardstick on edge between your hands and push your hands together: The yardstick buckles.

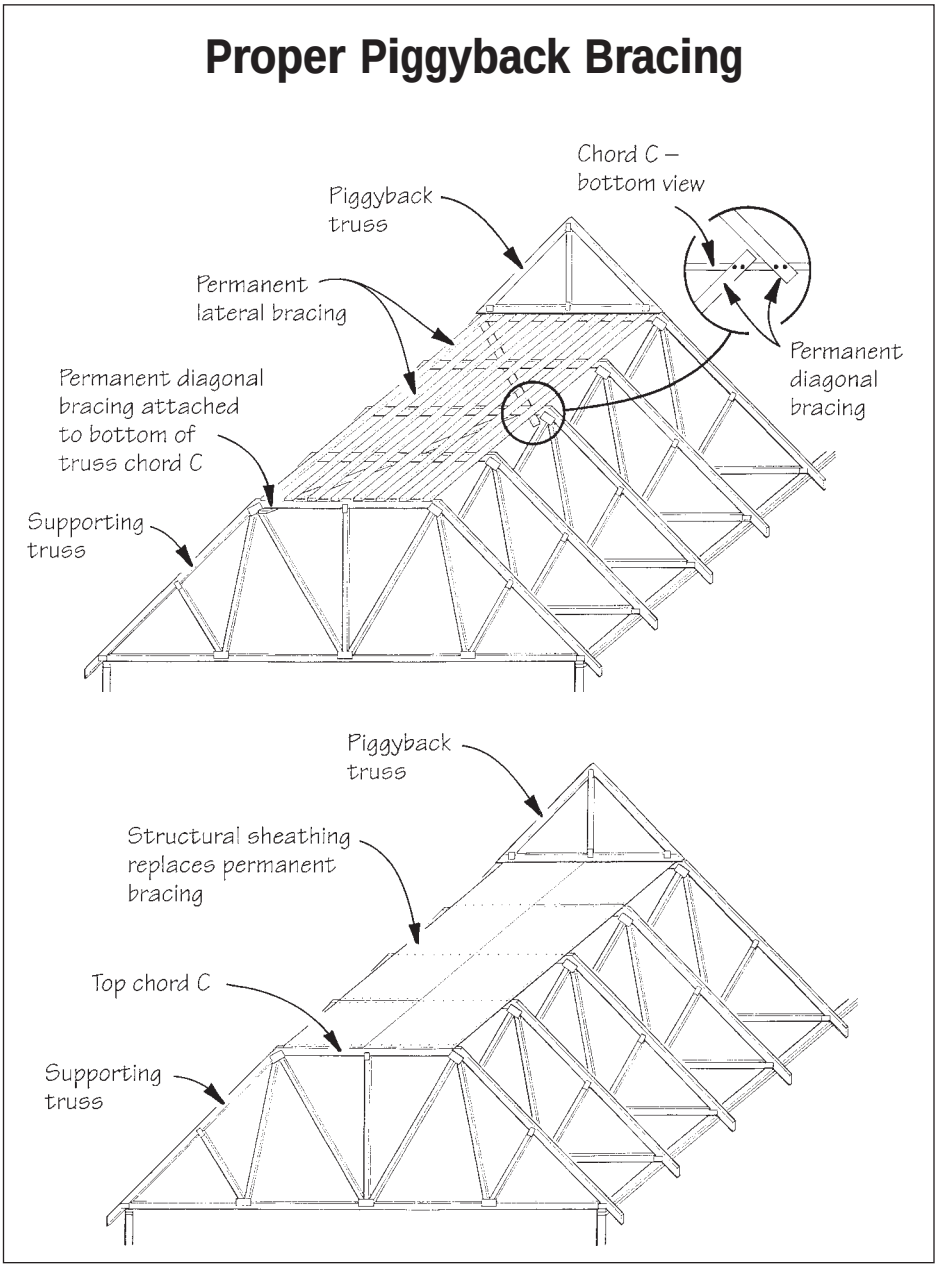

Figure 2. Permanent cross-bracing installed on the bottom of chord C (top) will stabilize the lateral braces attached to the top of chord C. The diagonal braces should be installed at about 45 degrees to chord C. Structural sheathing (bottom) is also a simple and reliable method to provide permanent bracing for chord C. With the proper nailing, the sheathing provides diaphragm action, serving as both lateral and diagonal bracing.

The same thing happened to chord C. Chances are the failure happened suddenly, without warning. When the chord buckled, the truss lost its integrity and fell in on itself. The piggyback section fell to the floor with the supporting truss.

Note the lateral braces in Figure 1. This is how some builders incorrectly brace chord C in a piggyback system, assuming perhaps that the roof sheathing on the rest of the roof will prevent lateral movement. This is not the case, however. As the top chord C displaces under load, the lateral braces simply move with the top chord. What is required are additional *diagonal* braces, nailed to the bottom of chord C, which act with the lateral braces to form a series of triangles stiffening the top chords. Without the diagonals, the lateral braces across the top chords are like

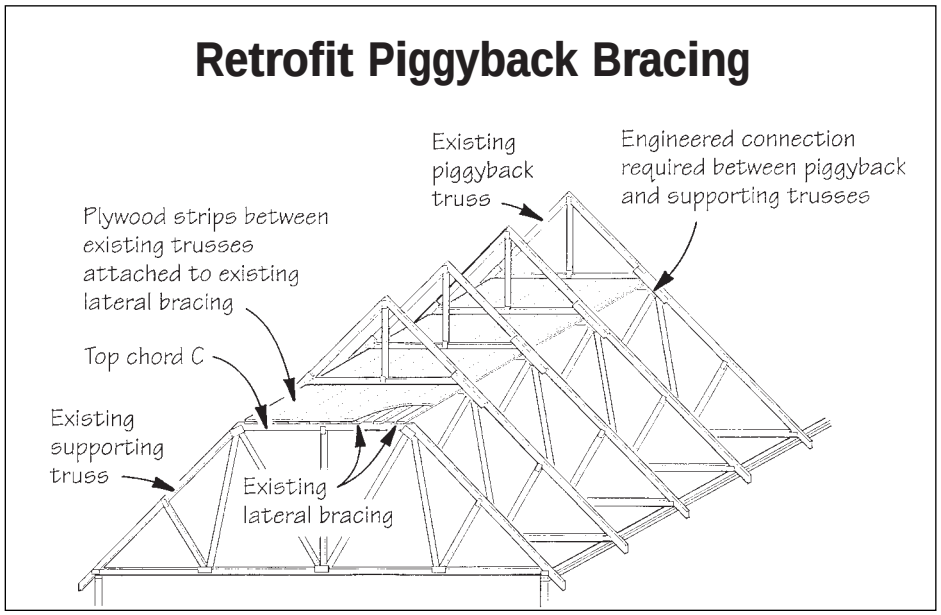

Figure 3. In some cases, installing strips of plywood between existing piggyback trusses may serve to stabilize the permanent lateral braces. The building designer or engineer should specify the proper nailing.

a stud wall standing up without sheathing: Push on it and it racks easily; add a diagonal brace or sheathing and the stiffening effect is dramatic.

Proper Permanent Bracing

Figure 2, previous page, illustrates two ways to provide proper permanent bracing for chord C. (Note that this article is concerned only with bracing top chord C, because this is the most common problem area for piggyback systems. Other chord and web members also require permanent bracing.)

The top sketch shows how to use diagonal 2x4s to stabilize lateral braces like the ones used in the gym trusses. The cross-bracing is attached to the bottom of chord C, installed at about a 45-degree angle to chord C.

The bottom sketch in Figure 2 shows my preferred method of piggyback bracing — installing structural sheathing across the top chords of the lower truss (you may have to make some allowance for ventilation). After the sheathing is installed on chord C, the piggyback truss can be installed and attached to the supporting truss in accordance with the truss designer's specifications. It is the responsibility of the truss designer to specify the connection between the piggyback truss and the supporting truss. If this connection has not been spelled out on the truss design drawings, contact the truss manufacturer for the detail.

What If You've Built It Wrong?

Over the years, I have heard contractors comment that permanent bracing requirements appear excessive and that there seems to be as much lumber used for bracing as for the trusses. This is an exaggeration, of course, but it is an attitude that may lead builders to ignore the permanent bracing specifications.

So, what if you've built a piggyback roof that's braced like the roof in Figure 1? "If it hasn't collapsed yet, it's probably okay" is flawed logic. Whether that top chord C buckles or not is dependent on the compressive load level present in the chord under gravity load. It may take 50 years to get the load level needed to buckle the chord, but it might also happen next week. If you have piggyback trusses with only lateral braces as shown in Figure 1, you should put down this magazine and contact the building designer immediately.

Retrofit Piggyback Bracing

It is possible to install bracing in a piggyback roof that wasn't braced properly when it was built. You should follow specifications provided by the building designer. The retrofit may take the form of cross-bracing, as in Figure 2, or you might be able to install plywood strips between the trusses, nailed directly to the lateral braces, as in Figure 3. Again, you should follow the designers nailing recommendations, and you may have to provide for roof ventilation.

Summary

Using a piggyback truss system versus a standard truss system is not an incidental framing decision. The contractor should determine the temporary bracing to safely erect the trusses and the building designer should specify the permanent bracing needed to support in-service loads.

A point to remember is that the building designer cannot complete the permanent bracing drawings until he approves the truss design shop drawings used to manufacture the trusses.

It is not uncommon for an architect to specify roof truss bracing "per HIB-91." This specification should alert you to a problem because HIB-91, "Handling, Installing, & Bracing Metal-Plate-Connected Wood Trusses" (published by the Truss Plate Institute; 608/833-5900), is about temporary bracing, not permanent bracing. Any note by the building designer that does not tell you specifically what permanent truss bracing to install should also be a warning. The truss manufacturer may not be able to respond to your questions since they are not responsible for design of permanent truss bracing.

Do not install piggyback trusses unless the building designer specifies the necessary permanent bracing for the roof system. If you are both the contractor and the building designer, but not an engineer with truss bracing experience, you should contact an engineer familiar with permanent bracing design. Your truss manufacturer should know a local or regional engineer.

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