Technical Q & A

Solar Panel Weights

Learn how to justify solar panel loads when working with vendors, homeowners and building inspectors.

by Ryan J. Dexter, P.E.

Roof trusses are pre-engineered to resist and transfer a given design load throughout their members and connections into the bearings. It is extremely important to know what the accurate loads are so the members and connections can be properly sized.

We recently received a few questions on adding solar panels (devices that collect and convert solar energy into electricity or heat) to roofs. Obviously, this is an added weight that the trusses may not have been designed to handle. It should also be noted that solar panels are added to roofs that are framed with rafters and beams just as frequently, a factor that is raised in the question below.

Question

I am a component manufacturer who was recently contacted by a homeowner wanting to install a solar panel system on their residential rooftop. The solar panel company had installed their panels on many conventionally framed roofs without any performance issues or questioning from building officials. This homeowner's roof is trussed and the building officials have questioned mounting these systems onto truss rooftops.

Based on our discussions with the solar panel company, the panels are mounted on one side of the rooftop using an aluminum rail system that is attached with 3/8" lag screws placed every 4' vertically. A rail is attached to every other truss and then the panels are attached to the rails. The whole set-up adds roughly 3 PSF of weight to about 80 percent of the roof surface area. The rail system is very strong and it seems to me that it would make a truss stronger if anything. Unfortunately, the building officials do not seem to agree. The inspector's perception is that a truss is a fragile structure and that the penetrations may weaken it. Are there any reasons why there would be a problem making these alterations to trussed roofs?

Answer

Sometimes building officials put more requirements on metal plate connected wood trusses than on conventional framing. WTCA is in frequent contact with jurisdictions with the goal of creating or maintaining a level playing field for all types of construction. Metal plate connected wood trusses are designed to withstand and transfer certain loading conditions that include live loads, dead loads and environmental loads. Trusses need to be designed to a load measured in pounds per square foot (PSF) that depends on where you are in the country, what the worst case loading condition is, and what the intended use for your building is. ASCE 7, *Minimum Design Loads for Buildings and Other Structures* is the standard used to determine loads for all structural materials including truss design.

ASCE 7 is referenced in all the major building codes and the current edition is 2005. It provides engineers and architects with guidelines on dead loads among other things. ASCE 7 lists the following dead load weights of roofing materials:

Asbestos cement shingles - 4 PSF
Asphalt shingles - 2 PSF
Cement tile - 16 PSF
Clay tile - up to 30 PSF with mortar
Copper or tin - 1 PSF
Metal deck, 18 ga. - 3 PSF
Slate, 1/4 in. - 10 PSF
Wood shingles - 3 PSF
Plywood (per 1/8 in. thickness) - 0.4 PSF
3-ply roofing - 1 PSF
Four-ply felt and gravel - 5.5 PSF
Five-ply felt and gravel - 6 PSF
Cellular glass insulation (per in. thickness) - 0.7 PSF
Fibrous glass insulation (per in. thickness) - 1.1 PSF
Polystyrene foam insulation (per in. thickness) – 0.2 PSF

For standard residential type projects (asphalt/wood shingles or metal roofing), truss designers will use a top chord dead load of around 10 PSF which will incorporate all these construction elements and then a little extra. The question is: Is the "little extra" more than 3 PSF?

A way to check the top chord dead loads is to add up the weight of each element of the assembly. We'll go through a typical top chord dead load (TCDL) assumption with 10 PSF as the starting point. As an example, we will assume the roof assembly contains:

- 7/16" plywood (1.4 PSF),
- 3-ply roofing (1 PSF), and
- 4" Polystyrene foam insulation (0.8 PSF)
- Top chord dead load for 2x4 roof truss (4.4 PSF/2 = 2.2 PSF)
- TOTAL: 5.4 PSF

Figure 1.

The typical dead load for a roof truss consisting of 2x4 chords and webs is around 4.4 PSF. Half of this load—2.2 PSF—should be included in the top chord dead load total. Adding all these loads together gives 5.4 PSF (see Figure 1 for breakdown). If the dead load of the added solar panel is around 3 PSF, the actual dead load is around 8.4 PSF—less than the 10 PSF TCDL.

What should be done if the weight of the solar panel adds more to the top chord than the existing design dead loads? Consider if the roof was composed of 4-ply felt and gravel (5.5 PSF) instead of 3-ply roofing (1 PSF). The actual dead load without adding the solar panel load would be around 9.9 PSF. If the truss was designed for a 10 PSF TCDL, it may cause the truss design to be overstressed. If this is the case, another engineering evaluation should be done to ensure that the truss as installed will not experience any serviceability or load transfer problems.

From an engineering perspective if the solar panel application can be applied to a conventionally framed roof system that has the same design load capacity as a truss roof system (i.e., any roof in the same general locale/neighborhood will have

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at a glance

- ❑ Solar panels—devices that convert solar energy into electricity or heat—are often installed in trussed and conventionally framed roofs.
- ❑ To determine if a truss can withstand the load of a solar panel, add the value of the panel to the maximum top chord dead load capacity.
- ❑ If a panel can be applied to a conventionally framed roof with the same design load capacity as a truss system, the application should also work in the trussed roof.

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the identical applied load requirements), the application would be identical because the design loads on the roof system are identical. If the building official is not questioning the additional load on the conventionally framed roof, there is no reason to question it on the trussed roof. Use of the following points for discussion with the inspector may be helpful in moving forward:

- There is no difference between a conventionally framed roof system and a trussed roof for solar panel applications. The additional applied load will be identical for both roofs.
- Be prepared with the answers to these questions before moving forward with applying solar panels to the roof:
  - What are the typical roof loads (live and dead) in your area?
  - How much additional load will the solar panels add?
  - What is the impact of adding those applied loads to the trusses and is the existing design dead load sufficient to accommodate the new imposed loads?
  - How does the connection system of the 3/8" bolts affect the lumber rafter or truss chord material?
  - What does the solar panel supplier's warranty say?
  - What do the solar panel installation instructions say?
  - Who is responsible for determining if the roof system can accommodate the added applied loads?
  - Does common sense indicate that the application of the solar panel will cause any roof system performance issues?

The answers to these questions can be applied to both trusses and conventional framing. Solar panel companies may find out that their products work with truss or conventional roof systems in some cases, but may not work at all when the specific roof system is looked at in other cases. This will best be determined by working with the solar panel supplier and carefully assessing the applied loads onto the roof system.

The building official is the final authority in terms of whether or not the application of the solar panel complies with their building code. Given this, the solar panel company needs to find a way to satisfy the code requirements for the application of the product to a trussed roof system.

Finally, if the direction to take is not clear through the process suggested here, strongly consider hiring an engineer to ensure that the conventionally framed or truss roof system can adequately carry the load. An engineer can verify the adequacy of the existing roof trusses to carry the point loads from the legs of the solar panel frame including the wind uplift.

WTCA offers a helpful resource on its website, www.sbcindustry.com. Here you will find a list of consulting engineers that are familiar with the structural building components industry and timber engineering. SBC

To pose a question for this column, call the WTCA technical department at 608/274-4849 or email technicalqa@sbcmag.info.

Simpson Strong-Tie Showcases New Possibilities at BCMC

There was much to be discovered at Simpson Strong-Tie's BCMC booth this year with several new and expanded products for the Component Industry. Visitors to the booth saw first hand how these products offer new possibilities for building faster, safer or more cost effectively.

"The BCMC Show is a highlight for us every year," said Tawn Simons, National Manager for the Engineered Wood Industry at Simpson Strong-Tie. "It's the perfect opportunity to showcase our new products and applications for the coming year, giving attendees a sneak preview of what's ahead. In addition we also enjoy networking with our valued customers and industry leaders at the Show and this year was no different. Even with the slowed building economy, the quality of attendees made the Show a big success. We already look forward to next year's BCMC in Denver!"

A few of the products Simpson Strong-Tie showcased at BCMC were:

Quik Drive® Systems for Girder Attachments
Live demonstrations allowed BCMC attendees to experience how fast, easy and safe it is to use Quik Drive Auto-Feed Systems for attaching 2-ply and 3-ply girders. The holding power of Quik Drive screws—a stronger, safer alternative to collated nails—can improve the strength and quality of the girder.

THJU Hip/Jack Hanger
Simpson-Strong-Tie's new U-shaped hip/jack hanger offers the most flexibility and ease of installation without sacrificing performance. Available in two standard sizes and in a range of intermediate widths, THJU series hangers can accommodate hip skews up to 65 degrees and various single- and two-ply hip/jack combinations.

Steel Strong-Wall® Shearwalls
Simpson's booth reached new heights this year thanks in part to its new Steel Strong-Wall shearwalls for two-story stacked and balloon framing applications.

If you missed BCMC or would like more information about Simpson Strong-Tie products, visit **www.strongtie.com**.

Thank You!
Simpson would like to thank Stark Truss, Contract Building Components and Contract Framing for helping make the Simpson Strong-Tie booth, and the show, so successful!

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Truss Publications, Inc.

6300 Enterprise Lane • Suite 200 • Madison, WI 53719
608/310-6706 phone • 608/271-7006 fax
www.sbcmag.info • admgr@sbcmag.info