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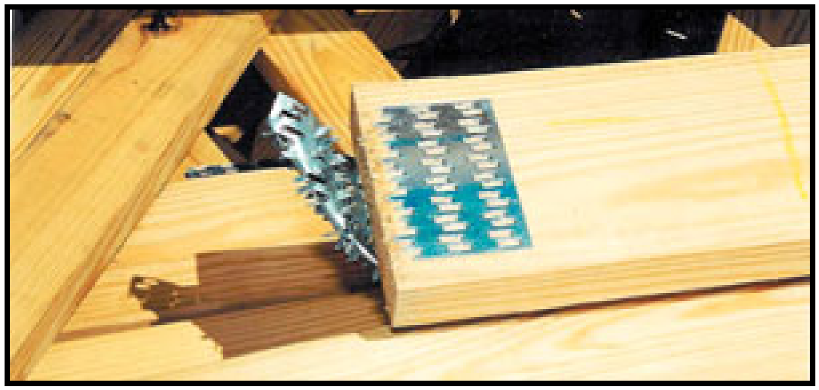
Design Is Not Limited to Truss Software by Dan Smith, P.E.

My engineering experience has crossed many industries and includes design, analysis, research, and testing with numerous types of materials. As a structural engineer with both metal plate connected wood truss design and field installation experience, I have discovered that the design of a structure involves structural configuration, material selection, maintenance access, design loads, structural rigidity, inspection, and maintenance of the structural components.


BROKEN BC SPLICE PLATE


60' SCISSOR TRUSSES WITH PLYWOOD SPLICE AND BRACED WALLS

It is important for everyone involved in the truss design process to truly understand the significance that each design element listed above has on the complete design and how they interrelate. For example, design loads include dead, live, snow, wind and seismic loads, as well as appropriate load combinations. In addition, live loads include construction loads, which, among other things, can include men and tool loads, rigging point loads, and temporary material loads.

In the truss industry, the design software has simplified and standardized many of the design element considerations. The design software in the industry is so specialized and sophisticated that nearly anyone can design a truss without the need for in-depth knowledge of wood, loads, or load combinations.

However, I have recently come across the following field situations that shed light on software performance versus design knowledge. The photos further illustrate the importance of having adequate design knowledge when utilizing some software.

Here are the design and wind load requirements that apply to the following three cases:

- Design Loads:
  - Top chord live load - 20 psf
  - Top chord dead load - 10 psf
  - Bottom chord live load - 0 psf
  - Bottom chord dead load - 10 psf
- Wind Load:
  - 80 mph and 100 miles from the hurricane coast

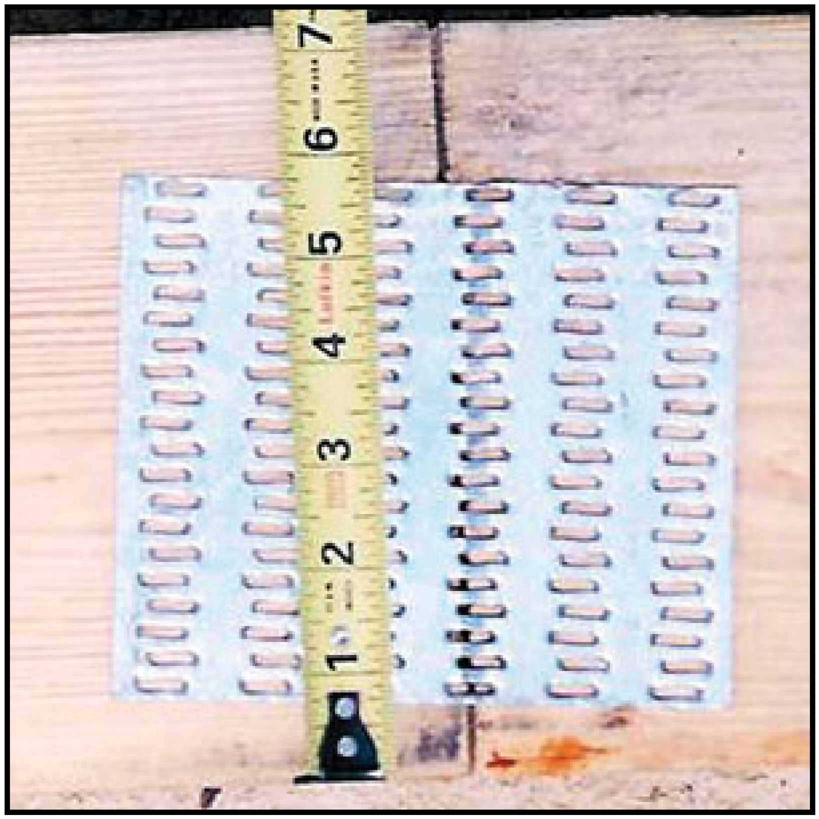
CASE 1

This example demonstrates the importance of applying learned field skills while utilizing truss design software. It is evident that this truss was designed correctly according to the program, but circumstances in the field changed the effectiveness of the software design.

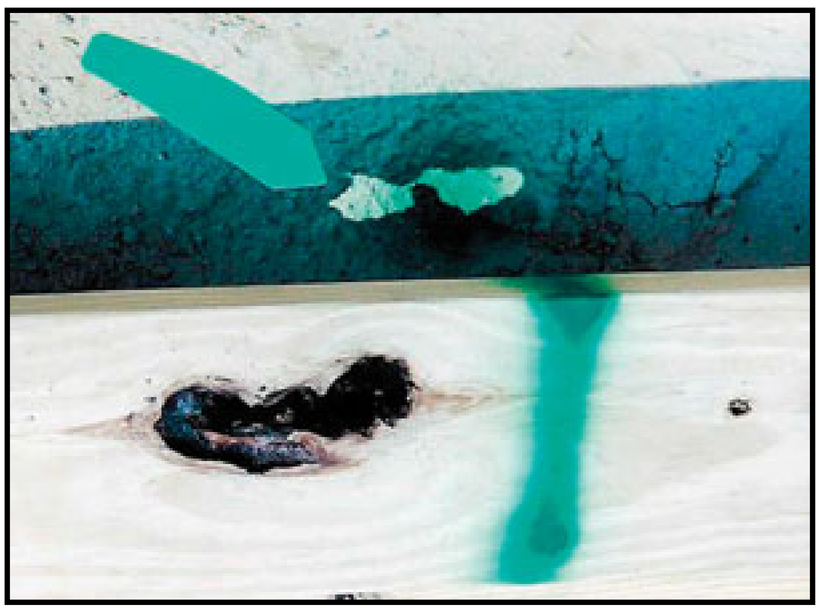
The roof trusses clear spanned 52' with no interior partition walls. The roof pitch was 6/12 and the trusses were spaced 24" on center. The building was a single story structure with masonry block walls.

The top and bottom chords were 2x4 Southern Pine lumber. The bottom chord was composed of 8-foot pieces of lumber. The bottom chord had five splice plates with no splice blocks; this caused the erection contractor problems.

During installation, the increased flexibility of the truss from the five



2X8 CHORD 5' METAL CONNECTOR PLATE
TRUSS IS STRUCTURALLY ADEQUATE - IS VERY FLEXIBLE



2X6 CHORD USING #2 LUMBER NOTICE
SUNLIGHT TRHOUGH KNOT HOLE

splices loosened and damaged some of the metal connector plates. The erection contractor tried to strengthen the splices by fastening 2"x 4"x 24" scabs on the sides, which proved to be ineffective in strengthening the truss. The computer program adequately designed these roof trusses to support the dead, live, and wind loads specified by the building codes. Somehow these trusses ended up with five splices. Although the truss design software allows such a design, practical field experience should not. Some truss manufacturers establish limits to chord sizes based on spans. A local company limits 2x4 chords to 50-foot spans.


2X4 CHORD - #2 LUMBER WITH KNOT

The damage may have been less had the erection contractor used a spreader bar while handling these trusses. According to the WTCA Jobsite Warning Poster (WTCA B-1), a spreader bar should be used when handling trusses that span between 30' and 60'.

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CASE 2

Similar to Case 1, the following also describes a situation in which the designer used the truss design software correctly, but failed to apply practical field experience in the process.

In this case, the roof trusses clear spanned 62' with no interior partitions. The roof pitch was 5/12 and the trusses were spaced 24" on center. The building was a single story structure. The bottom chords were 2x4 Select Structural Southern Pine lumber. These trusses also proved problematic to the erection contractor. During erection, several webs came apart from their web-chord connector plates.

Repairing these trusses was complicated and the narrow 3-½" chords compounded the problem.

Again, the computer program successfully designed the truss to support the loads required by the building code.

I did an investigation to determine if the 2x4 bottom chord was required by other design considerations and there were none. The building superintendent was unaware of any plumbing or electrical requirements that would restrict the chord depth.

This situation could have been avoided if there was more knowledge about truss handling and repair and what takes place in the field, thus designing the trusses with a deeper bottom chord.

CASE 3

This is yet another classic case of inexperience. As previously mentioned, it is important to understand the significance each design element has on the total design and how they interrelate. This example illustrates that one element of the design process was overlooked, causing costly damage in the end.

Scissors roof trusses spanning 60' were placed on a single story building with metal stud walls. The top chord had a 10/12 pitch while the bottom chord had a 5/12 pitch. The roof trusses were spaced 19.2" on center. The top and bottom chords were both 2x6 Southern Pine lumber. The truss chords were constructed from #2 grade lumber. The Southern Pine Inspection Bureau allows a centerline wide face knot of up to a diameter of 2-7/8." A knot of this size would reduce the 5-½" chord width to 2-5/8."

In this case, the scissors trusses had to be spliced together with large plywood gussets on both sides. In order to fasten these scabs, the trusses had to be lifted and flipped over to apply the back side gusset, using a two-point lift. The trusses were braced with a stiffener bar to reduce truss flexibility. Even with these precautions, the erection contractor had occasional difficulties due to the flipping process and the lateral bending that resulted.

The trusses were inspected prior to erection. Although within the #2 lumber grade criterion, several trusses were observed to have large knots. The knots were scabbed on both sides with the same size lumber, 14- to 20-foot long, while on the ground.

After the trusses were installed, two trusses were observed to be vertically deflecting more that the adjacent trusses. Cracks were found in the bottom chords at medium sized knots. In one case, the chord depth was reduced to 1-¼."

The truss technician or truss designer should have recommended and the architect, or structural engineer (building designer) should have considered specifying #1 or Select Structural lumber for the steep pitched scissors trusses in order to eliminate the possibility of this happening. This is really a team approach and good communication amongst team members will help to catch some of these issues prior to them becoming a problem.

Truss design encompasses a very broad arena—engineering software, customer needs, shipping, knowledge of the material, and truss erection and bracing. Truss technicians should have engineering classes, professional training, knowledge of wood trusses, and some field experience. Tech-nicians also should be well versed in appropriate handling, installing, and bracing techniques. This information and good communication on the part of all in the design process would help to catch problems early and limit the above examples from occurring.

Professional Engineers are required by state laws to “protect the health and safety of the public.” Implicit in this requirement is the requirement for everyone in the design and construction process to be properly trained, with Professional Engineers held to the highest standard. Training involves many crucial elements: hands-on professional engineering review of truss design work, getting out to the field to investigate damaged trusses, professional and industry training, involvement in association technical committees and scheduling work relative to experience and have a solid review process.

PE's are required by a growing number of states to complete continuing education courses each year, the focus of which is to refresh and expand the engineer's technical knowledge. To ensure a quality product, truss manufacturers need to allot time for their technical staff, technical salespeople and others in their organization that they feel would benefit from increased knowledge to take part in additional training to obtain knowledge of wood truss design, wood engineering, and the investigation of field installation problems.

Editor’s Note: WTCA’s Truss Technician Training (TTT) aims to bridge the gap of knowledge between individuals working in the industry. The preceding article reveals just one of the many reasons WTCA feels an obligation to promote education on behalf of the industry and to undertake its TTT program to encourage continuing education among professionals. The TTT certification program is offered at four different levels and is designed to accommodate design technicians at all skill levels and aims to guide students from the most basic truss terminology through the most complex engineering fundamentals of truss design. The WTCA TTT programs have proved invaluable for designers, engineers or other staff in establishing effective communication with customers and other industry professionals.

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