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Frequently Asked Questions

Truss Design Factors of Safety? by Ryan J. Dexter

When I was asked to prepare this month's column, I could not think of a better opportunity to answer a regularly posed question on truss design safety factors than in an issue focused on safety. It is inevitable that during a Truss Technician Training (TTT) course or a seminar, one of the questions asked is “How much safety is built into a truss?” We also continue to receive similar questions by email. One such question follows:

QUESTION:

I am currently working on a project where a wood truss system was loaded with a heavy spring snow. I do not believe the load was beyond the truss's design capacity. But how do you know? Is there safety built into wood trusses? If the trusses were loaded beyond their design capacity, it would not have been for a long duration. Any assistance would be appreciated.

ANSWER:

Structures and structural members must always be designed to carry some reserve load beyond what is expected under normal use. Under allowable stress design, safety is provided by using an allowable stress that is low enough to protect against (1) variation in material properties, (2) errors in design theory, and (3) uncertainties as to the exact load. The ratio of the load that would cause failure to the load for which the structure is designed is called the factor of safety.[1]

Metal plate connected wood trusses are designed with factors of safety. Metal connector plates are designed with a factor of safety of 3.2 for withdrawal, 1.44 for steel shear yield strength and 1.67 for steel tension yield strength. Both these factors result in a steel factor of safety of 2.0 on overall steel strength. Often it is a tooth withdrawal resistance failure that is seen due to overloading; but steel and lumber failures occur as well.[2]

Because wood is a heterogeneous product, the factor of safety varies depending on the direction of the applied load to the direction of lumber grain. According to ASTM D245 Standard Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber and ASTM D1990 Standard Practice for Establishing Allowable Properties for Visually Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens, the following factors of safety should be applied to the lower fifth percentile exclusion limit on clear softwood properties: 2.1 in bending and tensile strength parallel to grain, 1.9 in compressive strength parallel to grain, and 1.67 in compressive strength perpendicular to grain.

Overall, the factor of safety of the composite truss should be in the conservative range of 2 to

2.5, depending on the failure mode, and can easily be as high as 3 to 3.5. When overloaded, plates may exhibit “peeling.” The gap be-tween plate and lumber will be at a maximum at the outside of the plate and taper off towards the inside. Lumber may exhibit hairline fractures that are not visible with the naked eye when trusses are overloaded.

According to Wood Engineering and Construction Handbook, fatigue is defined as the progressive damage and failure than can occur when a member or structure is subjected to cyclic, repeated loading at levels less than the static strength. It is directly related to the duration of the load. Fatigue properties are generally of little concern in many applications of wood but can become important in applications where there are many repetitions of stress. Long term fatigue can cause damage to lumber if it is not considered in the truss design when repetitions of design stress or near-design stress are expected to be more than 100,000 cycles during the normal life of the structure.[3] Contact the Forest Products Laboratory (www.fpl.fs.fed.us) to obtain data on the fatigue properties of wood.

We suggest that you contact a local engineer experienced in wood design to look at the trusses and determine if there has in fact been any damage due to overloading.

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[1] Stalnaker J & Harris E. Structural Design in Wood. Van Nostrand Reinbhold, New York, 1989.
[2] Truss Plate Institute ANSI/TPI 2-1995 Truss Plate Institute ANSI/TPI 2-1995 Standard for Testing Performance of Metal Plate Connected Wood Trusses.
[3] Faherty K & Williamson T. Wood Engineering and Construction Handbook: 2nd Edition, McGraw-Hill, Inc, New York, 1989.

To pose a question for this column, email us at faq@woodtruss.com. To view other questions visit the WTCA website.

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