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Tension perpendicular: the evil of all wood connections

In my previous life as a truss detailer, I simply accepted any anti-split plates the software designed without too much thought. Since becoming a qualified engineer, I don't often get queried why they are necessary either. I can only assume that other detailers also include anti-splits into their designs without question, just like I did.

But what are they really there for?

Put bluntly, it's primarily there to resist tension force perpendicular to grain, which would otherwise literally tear the timber section apart. As a naturally-grown organic material, timber is made up of long strands of fibre which are "glued" together. The strands are very effective in resisting longitudinal forces, but they separate easily when the strands are pulled apart in perpendicular tension. This force was described in 2001 by the American Wood Council as, "The evil of all wood connections".

While undertaking my engineering studies at the University of Southern Queensland in 2012, I had the opportunity of investigating this effect on truss joints. I now know what a critical issue they are in trusses!

A tension perpendicular failure has the potential to lead to sudden catastrophic collapse, and should therefore be avoided at all costs. For this reason, the Timber Design Standard assigns conservatively low strength for this effect, and when it's likely to be exceeded, other ways of holding the cross section together must be found.

So, in what situations are we likely to encounter significant tension perpendicular to grain force? In trusses, they are commonly found at bottom chords of girders where it intersects with webs, where hangers are located and where they are tied down to supports with very high uplift. The forces in these joints try to tear (or split) the bottom chord fibres apart, hence the name for anti-split plates.

A Gang-Nail plate in a truss joint is usually centred equally between the webs and the bottom chord. If the bottom chord is a deep member, the bite depth of the plate into the bottom chord may be relatively shallow (Figure 1). This results in an upward force acting at the top half of the bottom chord. When there is an opposite force pulling down the bottom half of the bottom chord, such as from short hangers or support tie downs, tension perpendicular occurs, which tries to pull the timber fibres apart.

There are several possible ways to combat this effect. One is to apply anti-split plates on both sides of the joint to hold the bottom chord member together. Another more effective method is to increase the size and bite of the Gang-Nail plate deep into the lower half of the bottom chord.

Figure 2 shows a tension perpendicular failure which occurred under test conditions when there was only a 45mm bite depth into a 140mm bottom chord. Should this occur to a real truss on site it could result in catastrophic failure to the roof structure. According to Hanson and Eva (2011), 11 percent of building failures which occurred in Germany during heavy snow in the winter of 2005/2006 were attributed to tension perpendicular to grain failure.

So whenever you see anti-split plates in your truss designs, you can rest assured that they have been placed there for a very good reason. T

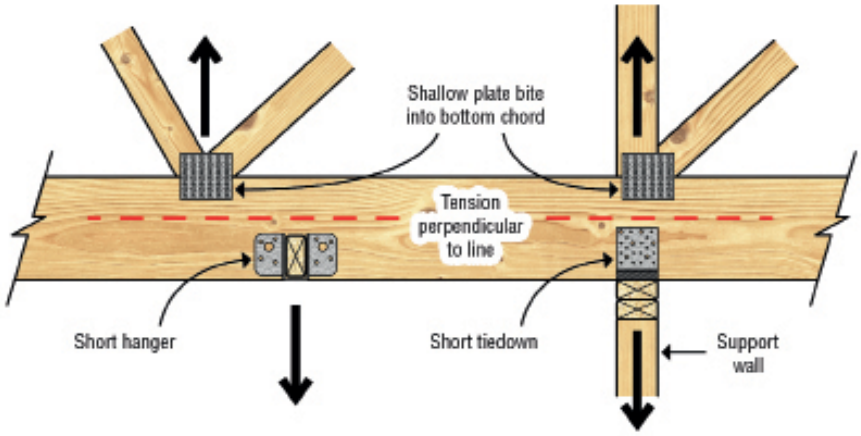

Figure 1: *Tension perpendicular line*

Figure 2: *Tension perpendicular failure*

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