FTMA TECH Talk

MiTek

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THE RELATIONSHIP BETWEEN RESTRAINT & COMPRESSION BUCKLING

Virtually all builders favour handling timber components over structural steel because of their natural ease of use and lightweight advantage. It should therefore come as no surprise that we receive a builder's request from time to time, to replace a specified structural steel beam with a timber parallel chord truss instead.

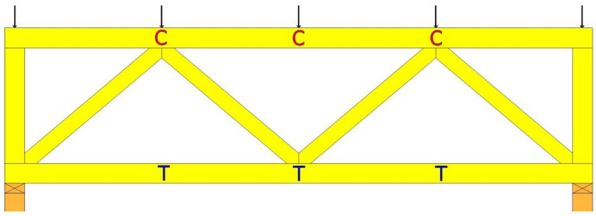
To be a suitable replacement, it is helpful to understand the basic conditions that would greatly assist the successful design of a parallel chord truss to work as a beam, such as:

- Available depth. To achieve a comparable strength and stiffness of the steel beam, a timber parallel chord truss needs to be deeper. They typically will not fit within the depth of a floor system without protruding below the ceiling, whereas a shallower solid LVL beam make a better substitute for steel beams in these situations.
- Adequate lateral restraints. Sometimes there is a wall directly above and along the length of the beam, such as an external wall over beam opening. In this case, the expectation is for the replacement truss to project above the floor level, and into the wall cavity. Both steel beams and parallel chord trusses require adequate lateral restraints along the compression zone at the top of the member to prevent buckling. Therefore, the critical issue to address with a "trussed beam" into the wall above, is how to provide effective top chord restraint.

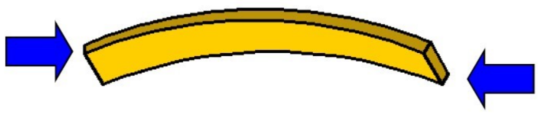
In this article, I would like to delve a bit deeper into the way lateral restraints work, and underscore their importance to truss stability.

Fundamental Truss Theory:

When dead and live loads are imposed on a steel beam, the top flange goes into axial compression whilst the bottom flange experiences axial tension. Likewise, a timber truss (whether it is pitched or parallel chord) will incur axial compression on the top chord and axial tension on the bottom chord.



Any part of a truss (or beam) that is loaded in axial compression will have a tendency to buckle about its weak axis if it is not adequately laterally restrained. Buckling is characterized by the sudden sideway deflection of a member which drastically reduces the natural compressive strength of the material, causing it to give way before it reaches its full potential.



The ability of a timber top chord to resist axial compression is referred to as its compressive strength capacity. In most instances, its ultimate strength is governed by member buckling. The exception to this statement are very short and stocky compression members, which crush in compression failure before they buckle. This situation is rarely encountered in timber trusses.

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The susceptibility to compression buckling is directly proportional to the distance (L_{ay}) between effective lateral restraints affixed to the member, divided by the breadth or width (b), whichever is the smaller cross sectional dimension of the compression member. This ratio ($\frac{Lay}{b}$) is referred to as the slenderness ratio. The bigger the ratio, the more prone the member is to compression buckling. For a lateral restraint to be effective in preventing lateral movement (i.e. buckling) of the compression member, it has to be capable of resisting at least 2.5% of the maximum axial force in the compression member.

When the slenderness ratio ($\frac{Lay}{b}$) decreases either by a decrease in the distance between lateral restraints (L_{ay}), and/or an increase in the thickness (b) of the cross section, it increases the effective compressive capacity of the member.

The reverse is equally true, that if the distance between lateral restraints increases, and/or there is a reduction in the thickness of the cross section, there will be a corresponding decrease in the compressive capacity of the member.

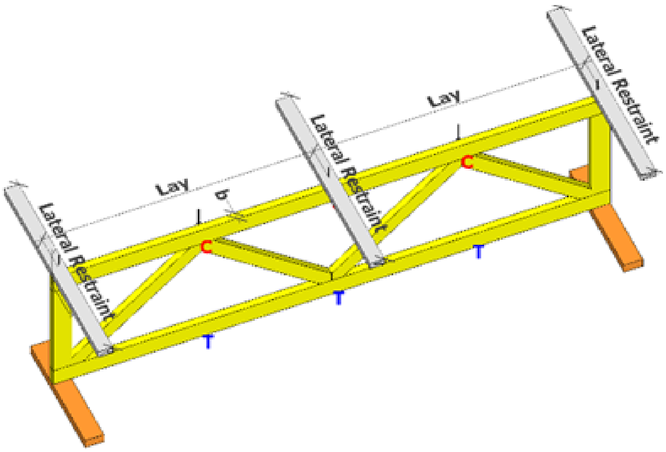

Diagram A: Increased top chord compressive capacity compared with Diagram B due to additional lateral restraint.

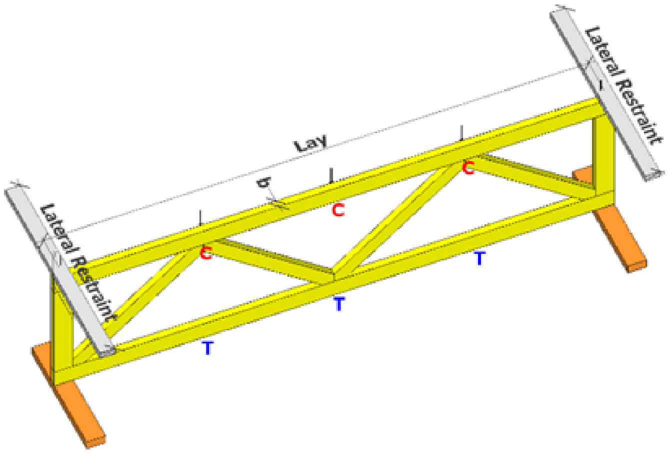

Diagram B: Decreased top chord compressive capacity when compared with Diagram A, due to an increase in the distance between top chord lateral restraints.

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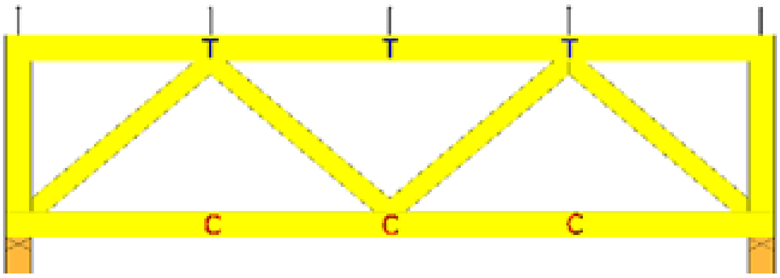
So what does it mean when someone talks about a compression member having adequate lateral restraints? It means making sure the member has enough binders attached to it, so it does not buckle under axial compression at maximum design load.

In cases where the wind uplift exceeds the dead loads, and there is effective load reversal, the top chord will end up being in axial tension and the bottom chord in axial compression. In this situation, the bottom chord also requires adequate lateral restraints to prevent it from buckling.



If the trussed beam described at the beginning were to project below the ceiling, or into the wall below instead of up into the wall above, the critical issue to address is then where the bottom chord restraint is to come from.

To find the best solution for your particular situation, the engineers from your nail plate supplier would be glad to help you.

For more information on lateral restraints, please refer to MiTek GN Guidelines 108 & 186.

This edition of FTMA Tech Talk was written by Stuart Branch, Design Engineer of our Gold Sponsor, MiTek.

If you have any questions for Stuart, please don't hesitate to contact him.

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