FTMA TECH Talk

MiTek

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EFFICIENT TRUSS DESIGN AND BUILDING GEOMETRY

As articulated by the American Architect Buckminster Fuller, “The best way to predict the future is to design it.”

Building design is a blend of cost and aesthetics. In other words, the goal is to make a building look as visually appealing as possible, whist working within the set budget restraints. When it comes to the structural aspect of the building, efficiency is the key to effective design.

Trusses are very efficient. They result in less material being used when compared to solid structural elements. They span much further than solid elements, without increasing material costs, and provide plenty of room to accommodate services.

Keeping that in mind, there is a right and wrong way to use roof or floor trusses. More specifically, it is critical to consider how the shape of a building will affect how efficiently the trusses will be working, and the resulting costs of these structural elements.

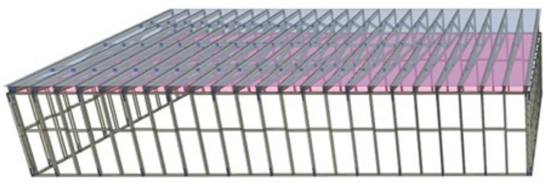
Below are the three most important considerations to make when drawing buildings that will incorporate truss elements.

Truss Depth

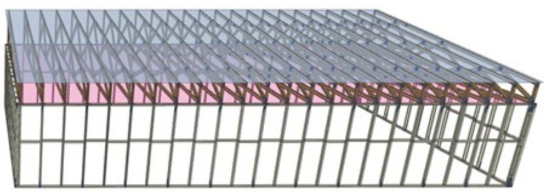
Trusses get their strength from the webs along their span balancing out their alternating compression and tension forces. For trusses to have a chance in balancing this effectively and the building resulting in efficient structural elements each truss needs to have an adequate span to depth aspect ratio.

Generally speaking, if roof trusses are kept below an aspect ratio of 9:1 they are working efficiently. As the aspect ratio increases above this the members are working harder and are getting closer to performing similarly to solid members. Essentially the efficiency of the truss is reduced.

Below are the results of two comparative runs of truss elements. Both spanning 8m, but with varying depths. As is clear to see, the first run of trusses is working much harder, will cost more, and will contain larger timber chords, webs and connector plates.



8000mm span
540mm average height
15:1 ratio
16mm camber
120mm top chord



8000mm span
940mm average height
9:1 ratio
3mm camber
70/90mm timber

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Truss Bearings

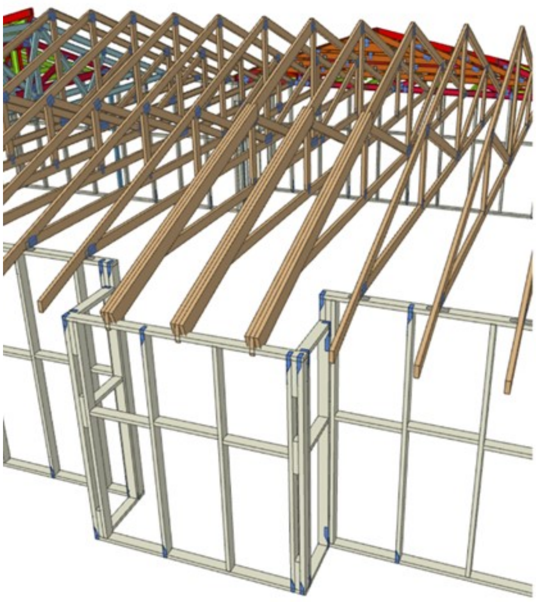
Loads are transferred through trusses along their members, intersecting at each of the nodes along the span. These loads are greatest at the outermost extents of a truss, and therefore it is critically important to consider where the bearing elements are in relation to the heels of the truss.

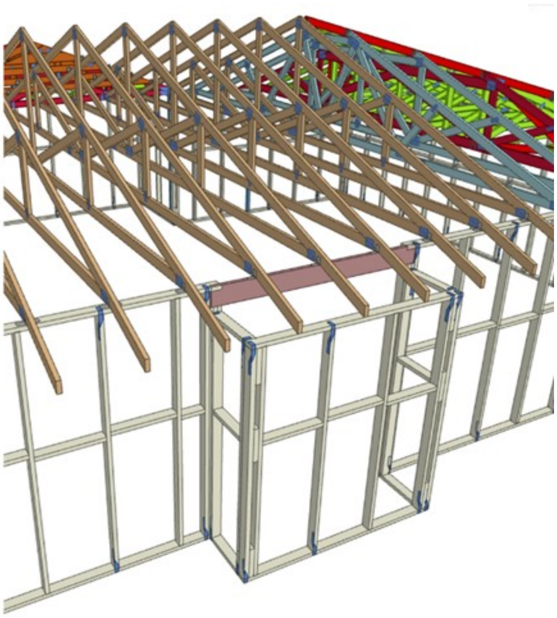
To achieve the most efficient design, the bearing is ideally located directly under the heel. This allows the loads to be passed from the heel along the trusses span, via its web elements.

The next most efficient bearing location is to place the bearing some distance into the truss span. Far enough into the span for the geometry of the truss to mean the depth at the bearing location is adequate to deal with the loads being transferred into the web elements.

Trusses that are top chord supported, especially if the distance to the support is large, and trusses that are supported with the bearing a short distance into the span from the heel, where the truss is shallow, will result in a less efficient design.

In the below two examples, making one small change to the heel detail of the three trusses results in a difference of 33m of 170mm EWP beam material being used.





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Truss Manufacturing Labour

There is nowhere that the theory behind economies of scale is more relevant than in manufacturing.

When we consider using timber trusses within buildings the manufacturing process must be considered. This is the key to achieving cost effective factory manufactured timber components.

Truss costing is comprised of material costs (timber and nail plates) plus manufacturing labour. If the two design principles mentioned earlier in this article are considered then the material costs will be minimised effectively, leaving the only consideration being the cost of manufacturing.

Trusses are built on specialised presses. The process of moving these jigs into the starting position is called the 'setup', and the building and pressing of each truss of the same shape is called the 'processing'. Given the goal of factory fabricated structures is to be more cost effective than site-built ones, it is critical to consider manufacturing when designing the building, to take advantage of the efficiencies that be gained within the factory environment.

If the building is designed with the suitability of factory-built components in mind, then the result will be factory labour costs that will easily compete with that of the tedious task of building the structure on site.

In essence, if designers can maximise the number of trusses that have the same or similar shape, the result will be a drastic increase in cost-effectiveness.

Modern Construction Methods

Given how efficiently trusses carry loads, if buildings are designed to utilise them correctly, they can be constructed faster, and more cost effectively when compared to the older method of stick framing.

But this is not the whole picture.

For example, features like raked ceilings, curved roof lines, much larger open plan living areas utilising larger clear spans, internal box gutters, and increased roof void space for services, especially in low pitch roofs.

By realising the advantages of trusses early in the design process, building designers can incorporate many geometrical features that were previously expensive or not possible.