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# MINIMISING CANTILEVER MAGNIFICATIONS

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Perhaps without knowing it, truss designers deal with cantilever mechanisms in virtually every roof structure. Most associate cantilevers with trusses on walls set in from the pitching line.

But in fact, cantilevers regularly feature in overhangs, verge outriggers, fascia corners, creeper jacks and so on.

To avoid its pitfalls, a competent truss detailer must be familiar with the peculiar behaviour of cantilevers.

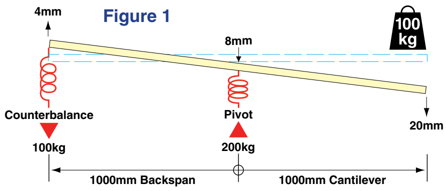

Figure 1

We will focus here on its "Magnification" attribute and how it can be "Minimised".

## PRINCIPLE OF MAGNIFICATION

**Imagine the cantilever as a "Seesaw" shown in Figure 1, supporting a 100kg weight.**

When the backspan is equal to the cantilever, the counterbalancing support has to pull down with an identical 100kg force to achieve equilibrium and the pivot in the middle has to support the combined (200kg) weight.

But in the real world, supports and their connections are not infinitely rigid and will move under load. Just like a coil spring, their displacement will be proportional to the load.

So in this example, the counterbalancing spring extends 4mm upwards in tension whereas the pivoting spring compresses down 8mm.

As a result, the end of the cantilever accumulates a drop of 20mm.

If we shorten the backspan to half the cantilever (Figure 2), the counterbalance has to work twice as hard to achieve stability and the load on the central pivot escalates to 300kg.

The extension and compression of springs also increase by the same proportion and results in 52mm deflection at the cantilevered end.

So by cutting the backspan in half, it nearly triples the cantilever deflection.

Instead, if we increase the backspan to twice the cantilever (Figure 3), it halves the counterbalance and lowers the load on the pivot as well as all spring displacements.

In this case, the cantilever deflection diminishes to a mere 10mm. What a difference!

## FACTORING MEMBER CURVATURE

**By having a short backspan, the resisting forces are magnified 150% - 200% and the cantilever deflection by a whopping 260%!**

This assumes a very rigid member. But if the member bends under load (as in real life), the magnification would be even worse and probably exceed 300%.

By contrast, if bending effects were included in the calculations of the larger backspan, the proportional reduction in deflection would be even better than the numbers quoted above.

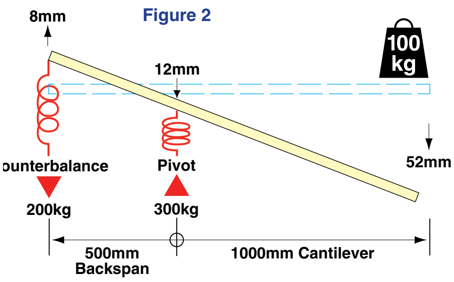

Figure 2

## CANTILEVER UPON CANTILEVER

**All magnifications are further compounded if cantilevers are in turn supported by other cantilevers.**

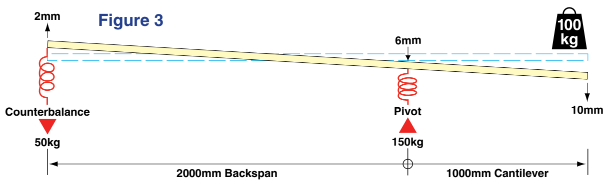

Figure 3

An example of this is structural fascias and barges that cantilever off eaves overhangs and verge outriggers to support corners of gable overhangs.

The magnification percentages quoted above could easily quadruple without too much imagination.

Most truss calculations assume unyielding supports to work out member deflections. As a result, cantilever magnifications can be underestimated.

Solid wall supports are reasonably stiff but beam supports aren't because they deflect under load. Outriggers are also supported by flexible rafters or trusses.

This makes the deflection in overhang corners very difficult to predict.

## IN SUMMARY

1. Backspans less than cantilevers magnify the forces required to resist their loads and magnify the accumulated cantilever deflections even more.
2. Increasing backspan reduces loads on supports and shrinks the cantilever deflection.
3. Increasing or decreasing loads on supports affect their design and cost.
4. If you have been noticing problems with your jobs, consider the following steps:
    a. Scrutinize the backspan/ cantilever ratio; 100% is okay for very short cantilevers, 150% is better for short-medium cantilevers but ideally aim for 200% with large cantilevers.
    b. Choose rigid connections and avoid flexible connections like loose straps.
    c. Make sure the cantilever support is capable of supporting a magnified load and is as stiff as possible to counteract magnified deflections; the RLW calculation method in AS1684 is simplistic and underestimates support loads, which is why gable end trusses should have much higher reactions than other standard trusses.
    d. Keep away from supporting cantilevers by other cantilevers; but if it cannot be avoided, stiffen the components beyond minimum requirements.

For further advice, consult your truss engineer. TTN