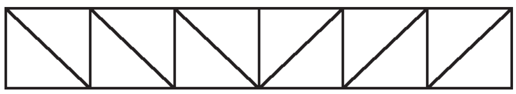
STEEL INDUSTRY GUIDANCE NOTES

Truss design

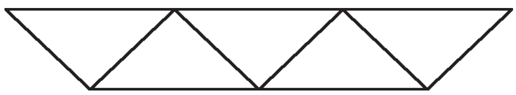
Common practice in steelwork design is to leave the connection design to the steelwork contractor – and in most situations this works well. When designing trusses, the situation should be different, with the structural engineer investigating the joint capacities as part of the design process. This SIGNS offers simple advice on truss design.

Types of truss

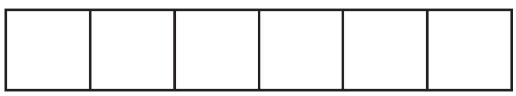
There are three main types of truss, the Warren truss, the Pratt truss and the Vierendeel truss, as shown below. The Vierendeel truss is a moment-resisting frame, and significant moments are produced, particularly near the supports. It is common that the more highly loaded members (near the supports) are larger than those towards mid-span, and carefully designed moment-resisting connections are essential. Vierendeel trusses can be useful when large openings must be provided in the depth of the truss. The Warren and Pratt trusses both carry the load primarily as axial loads (only) in the members. Compression members in a Pratt truss are generally shorter than in a Warren truss, though the latter has fewer members and joints than a Pratt Truss.



Pratt Truss



Warren Truss



Vierendeel Truss

Truss analysis

In orthodox construction, it is recommended that triangulated trusses are designed with simple, pin-jointed members, even when the truss connections are welded. This practice has been successfully followed for decades, and is enshrined in design Standards. BS 5950 Clause 4.10 states that for the purpose of calculating the forces in members (of lattice frames and trusses) the connections may be assumed to be pinned.

Assuming pinned connections is obviously ideal for hand analysis. Computer analysis may be used, but care should be taken to make appropriate choices about joint fixity, to avoid unwarranted and unwelcome results.

Some analysis packages allow a frame to be described as a truss – in which case the connections are all pinned, which results in a solution identical to a hand analysis. Analysing trusses with fully rigid joints is not generally recommended, as the transfer of moments at the joints makes the connection design much more involved.

It may be that the consideration of the joint capacity inspires a slight adjustment of the setting out, to provide a gap or overlap joint, which introduces some modest eccentricity. This is generally taken in the chord members. When eccentricities are introduced, it can be convenient to analyse the truss with continuous chords, but still retain the pinned end connections to the internal members. Whatever approach is taken, the recommended option is to avoid moments at the ends of internal members of triangulated trusses.

Vierendeel trusses must be analysed as rigid frames.

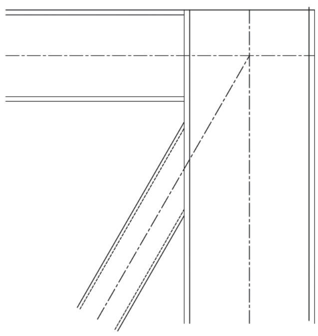
Global design and member design

Generally, trusses will be designed to carry vertical loads due to gravity. For the chords, the key design case will be tension in the bottom chord, and compression in the top chord. For the compression chord, buckling may take place between nodes (in the plane of the truss) and between restraints out of plane. Restraints may be purlins or some other members, or possibly the compression chord may be continuously restrained by decking or similar – but the out of plane restraint is very important and should not be overlooked!

Often, trusses may experience reversal under wind load design cases. The bottom chord will be in compression, and the important buckling check is likely to be out of plane – it is not uncommon to see lines of ties introduced across the bottom chords of trusses to provide this important restraint.

Truss end details

It is always wise to consider how the real truss connects to the support. It is easy to assume setting out of the truss that has the first diagonal intersecting with chord on the centre line of the supporting member. In reality, the physical depth of the members may mean that a revised setting out is appropriate, which may introduce additional shears and bending moments in some of the members. The real connection should be considered at the design stage.



Hollow section trusses

Hollow sections are often chosen for trusses – they are lightweight, structurally efficient, and look good, often being exposed. The joints are generally welded. With hollow section trusses, checking the joint resistance is crucial, since the selection of member, geometry and internal forces fixes the joint resistance – it will either be of sufficient strength or it won't. There is little a steelwork contractor can do at this late stage, except provide expensive strengthening to the joint if required.

At the design stage, however, there is a real opportunity to produce a cost-effective solution by judicious choice of members and truss geometry. Judicious choice of members may not lead to heavier weight – so for example, a larger, but thinner walled hollow section used as an internal truss member may lead to a stronger joint that a smaller, but thicker walled member of the same weight. Similarly, the choice of geometry to provide overlap or gap joints changes the joint resistance.

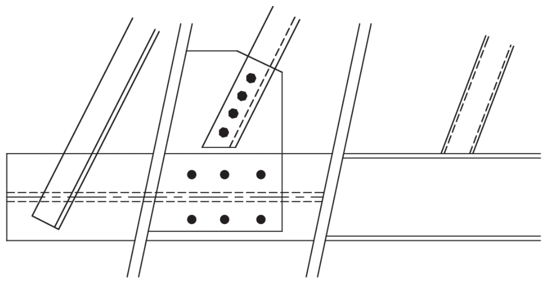
In some cases, there are conflicting demands on the choice of member. For example, a smaller, thicker walled chord member will increase joint strength, but a larger, thinner walled member may be preferred for increased resistance to buckling. It is generally true that the most cost effective solution involves the least strengthening.

The important feature is that the joint resistances are checked at the design stage, not as a subsequent, unconnected operation.

Checking joint resistances in hollow section connections can be laborious by hand – but not with software. Joint capacity software for hollow sections is available from Corus Tubes – see the contact details below.

Trusses from open sections

Trusses designed to carry significant loads are often constructed using open sections – for example with UKC chords. Internal members may be hollow sections or open sections. Connection details are again key – and the judicious choice of section sizes will be important. If hollow sections are used as internals, then the chords should be orientated so that the connections are to the chord flanges. If both chords are the same size (or close) it may be convenient to use angles connected to either flanges, or channels (of the same depth as the chord).



Bolted truss connections

Ordinary bolts in clearance holes will slip into bearing and may produce unexpected and unwelcome deflection. HSFG assemblies or welded connections will not suffer in this way.

Key Points

1. Consider joint resistance as part of the design process, and make judicious choices of sections to avoid extensive strengthening.
2. Hollow section joint resistances can be calculated using software from Corus Tubes, Telephone 0500 123 333
3. Assume that internal members are pin-jointed in triangulated trusses, and thus the connections carry no bending moment.
4. Consider HSFG assemblies (non-slip) to avoid unwelcome deflection in bolted truss connections and in splices.
5. Carefully consider the real details when reviewing the intersection of members with each other, and with any supports.

Further sources of Information

1. **Corus Tubes 0500 123 333**
2. **Design for manufacture guidelines, SCI, 1995**
3. **Modelling of steel structures for computer analysis, SCI, 1995**