



STEEL INDUSTRY
GUIDANCE NOTES

Design of Welded Joints using Structural Hollow Sections

Structural hollow sections are widely used within the construction industry for both their economics (strength to weight ratio) and aesthetics. Whilst tubular trusses/frames are carefully designed and member sizes economically selected according to member forces, little thought is usually given to how they connect together and their structural strength as a welded joint. Yet welded joints are an integral part of the structure, serving to hold the individual members of that frame together.

The capacity of structural hollow section welded joints is determined by member sizes, steel grades and joint geometry (ratios, angles, etc.). As all these factors are determined at the initial design stage, the design engineer has already determined the welded joint capacity. All too often it is left to the steelwork contractor to check and if necessary strengthen the welded joints. A much better approach is to consider the joint strength at the initial design stage, and thus avoid expensive strengthening at the joints.

This SIGNS describes the types of joints found between hollow sections, and offers advice about calculating joint strengths. Joint strengths can be calculated in accordance with BS EN 1993-1-8, which covers a range of joint configurations. Many of the expressions in BS EN 1993-1-8 are based on experimental test programmes.

Types of joints

There are five main classifications of joint types – ‘T’, ‘Y’, ‘X’, ‘N’ and ‘K’ joints. ‘N’ and K-joints can be sub-divided into ‘gap N- or K-joints’ and ‘overlapping N- or K-joints’, depending on whether the bracings gap or overlap. Whilst there are more complex joint types, all joints can be categorized as one of these types for simplicity.

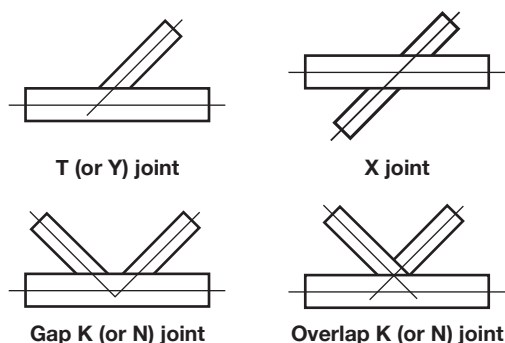


Figure 1. Typical welded joint designs

Design Parameters

Having identified the type of specified joint(s) in the structure to be checked, a number of design parameters must next be considered. Failure to ensure the selected sections comply with the joint parameter limits often means that sections must be changed at a later stage. The joint design parameters and limits for welded joints in

structural hollow sections are given in BS EN 1993-1-8 (1). As the expressions for joint strength were developed from test results, their validity is limited to arrangements falling within the test programme.

The following parameters should be considered:

Eccentricity, gap and overlap: (Applicable to N- and K-joints). Zero eccentricity (centrelines of bracings intersecting on the chord centreline) is assumed in the initial design - usually a wire frame. Ideally, zero eccentricity is what designers desire as eccentricity generates additional moments.

Design is a compromise, and when gap or overlap parameters are considered, it may be necessary to create some joint eccentricity to bring the gap or overlap within the limiting parameters. Providing the eccentricity is within the parameter limits (expressed as a proportion of the chord depth, the eccentricity must be between 0.25 ‘below’ and 0.55 ‘above’ the centre line), moments due to joint eccentricity need not be considered in the calculation of joint strength. Exceeding the eccentricity limits requires the additional moments to be taken into consideration in the calculation of joint strength. In both cases, the chord member should be checked for the additional moments due to eccentricity.

After establishing the eccentricity and gap or overlap of a joint, there are then a number of additional parameters that need to be considered. These parameters affect the joint capacity and are all related to the member sizes, grades and geometry, so the importance of carefully selecting the appropriate structural hollow sections at the initial design stage can clearly be seen.

T-, Y-, X- and K-joints with a gap

Fig. 2 shows how the ratios of various parameters affect the joint capacity.

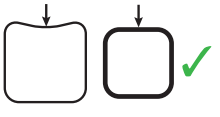
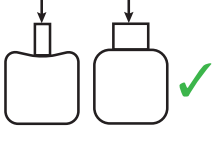
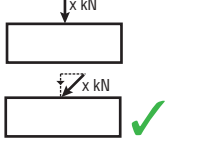
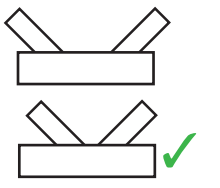
Joint parameter	Change required to increase joint capacity	
Chord width to thickness ratio		Use a smaller, thicker chord
Bracing width to chord width ratio		Use a wider brace and narrower chord width
Bracing angle		Reduce the brace angle
Bracing angle		Reduce the gap

Figure 2. Effect of parameters on joint capacity for T-, Y-, X-, K- or N-joints with a gap

K-joints with an overlap

K-type joints with overlap benefit from increased strength compared to an equivalent gap joint. The design parameters to be checked are similar to those for gap joints (see Fig.2). In addition to the checks shown in Fig. 2 the three additional parameters shown in Fig. 3 should also be checked.

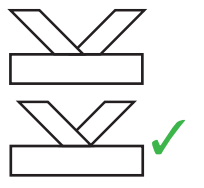
Joint parameter	Change required to increase joint capacity	
Overlapped bracing width to thickness ratio	$\frac{\text{Overlapped brace width}}{\text{Overlapped brace thickness}}$	Use a small, thick overlapped brace
Overlapped bracing to chord strength ratio	$\frac{\text{Overlapped brace yield} \times \text{thickness}}{\text{Chord yield} \times \text{thickness}}$	Use a high yield, thick chord compared to the overlapped bracing
Overlap		Increase the overlap

Figure 3. Effect of parameter changes on joint capacity for K- or N-joints with an overlap

Reference needs to be made to BS EN 1993-1-8:2005 for the specific design parameter limits.

Summary

Taking care to consider joint resistance as part of the initial design of hollow section fabrications will lead to a cost-effective, aesthetically pleasing solution. This important part of structural design should not be omitted.

A good design will involve making compromises between choice of hollow section and the need to ensure adequate joint strength. The ideal structural choice may not deliver the necessary joint resistance, and alternative members, joint configurations of geometry selected.

Joints can be checked in accordance with BS EN 1993-1-8. Software is available to allow rapid calculation of joint resistance.

Key Points

- Design of welded joints between hollow sections is an integral part of the structural analysis.
- There is a design compromise to be made between choice of members and joint resistance.
- Joint parameters & failure modes of the joints should be considered at the earliest opportunity and alternative arrangements considered if necessary.
- Joint resistance can be increased by careful selection of member sizes with regard to joint parameters i.e small thick chord with large thin brace.
- Software may be used to enable rapid calculation of joint resistance.

Further Sources of Information

1. **British Standards Institution: BS EN 1993-1-8:2005: Eurocode 3: Design of Steel Structures, Part 1-8: Design of Joints**
2. **CIDECT: Design Guide, Circular Hollow Section (CHS) Joints Under Predominantly Static Loading**
3. **CIDECT: Design Guide, Rectangular Hollows Section (RHS) Joints Under Predominantly Static Loading**
4. **Corus, Tubes: Structural Hollow Sections: Design of Welded Joints**
5. **Corus, Tubes: Structural Hollow Sections Joint Software**
6. **Corus Tubes – hot finished and cold formed structural hollow sections. Telephone 01536 404561**