

3. Column and Beam Structures

3.1. Introduction

Steel support structures for most applications are simple frames of vertical columns and horizontal beams. These are arranged in a regular, usually rectangular grid plan. These structures are extremely widely used for commercial and industrial buildings of all types, including single and multi-storey offices, workshops, warehouses, mineral processing plants, petrochemical refineries, pipe racks and power stations.

Probably the single most important component of these support structures is the single span beam, which is mostly subjected to bending moments. The beams are supported on columns, which are subject to compression with secondary bending forces. Columns are designed to resist buckling under this combination of loads.

Column and beam structures may contain other elements, including space frames or trusses. These last two can be considered to act as fabricated lightweight beams or decks. Steel structures can be connected to concrete structure or mechanical items, such as machinery and pressure vessels.

3.2. Columns and Beams

Columns and beams are essentially long straight members that may have a complex section shape, but the section shape is usually constant along the length of the member. The most common shapes are hot rolled universal sections and welded plate I-sections. Box sections are sometimes used for columns because of their higher stiffness, but have the disadvantage that the inside of the box is inaccessible, which makes connections difficult. Complex sections are used for heavy loads and can be fabricated where necessary.

Beams may have higher bending loads in the centre of the span than at the edges. It is possible to increase rigidity in two ways; either the flanges are made thicker and/or wider or the web is made deeper.

3.2.1. Fabrication of Columns and Beams

Most of the material for steel support structures is in the form of I-sections, channels and angles, which is used for columns, beams and bracing. These items are usually fabricated as lengths convenient for transport. Workshops that are most efficient in building structure fabrication are laid out to process these members along a production line.

I-sections have the advantage that access is available to bolt and weld both sides, whereas hollow sections including boxes have limited access inside the section. For further information on tubular construction, refer to Section 4.

Material is delivered as hot rolled universal sections or welded plate sections to AS/NZS 3679 [Reference 1]. Each stage of the production line is allocated for specific functions: marking out, guillotining, sawing or flame cutting to length, cope cutting, punching or drilling of boltholes, inspection and dispatch. Many fabricators are using CNC machines for cutting copes at the ends of beams, and drilling boltholes. Other operations, such as welding, forming or straightening are commonly treated as side operations, carried out in a jobbing workshop. However, there is consideration to automating welding of attachments using robots as part of the production line.

Welding operations include manufacture of compound sections, attaching minor members such as cleats, gussets, stiffeners and base plates. Moment connections between columns and beams are more complicated to weld. The welding processes most commonly used are FCAW and GMAW. SAW has limited application, except for longitudinal welds in columns or beams. MMAW was used extensively until recently, but is now only used where access to semi-automatic welding equipment is inconvenient or impossible. The most popular process is FCAW. This is more forgiving of contamination such as scale on the steel surface. GMAW is more productive because the consumables are cheaper and there is no slag to remove. However, it is preferable for the steel to be sand blasted, to minimise the risk of incomplete fusion.

Whereas most joints between components made in the workshop are welded, bolted connections are preferred for site joints. It is usual to deliver shop-fabricated beams and columns to site for erection. For best economy, the size of elements delivered to site should be as close to the maximum permitted by transport requirements. It is sometimes economic to deliver frame modules, but only over routes with minimum transport restrictions.

3.2.2. Compound Members

Compound members are sections that are not available as stock items. They are usually chosen for large members where a saving in material is worth while. The cost of fabricating compound members is not justified for smaller sections, which could make use of standard sections. Typical sections that are fabricated include I-sections of non-standard dimensions made from plate. Some sections that are more complex are shown in Figure 36.

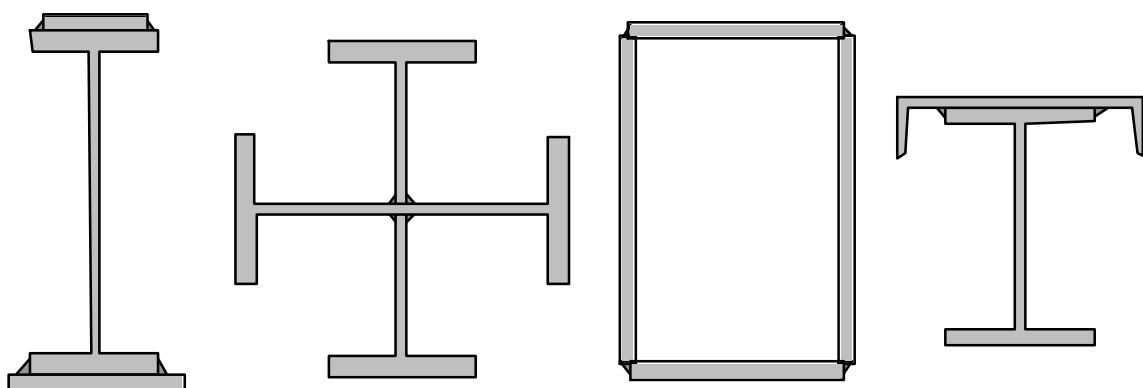


Figure 36 Typical Compound Sections

The manufacture of these members involves long tee joints that are usually fillet welded. These are most efficiently made using submerged arc welding, and the designer should ensure that access is available to use this process.

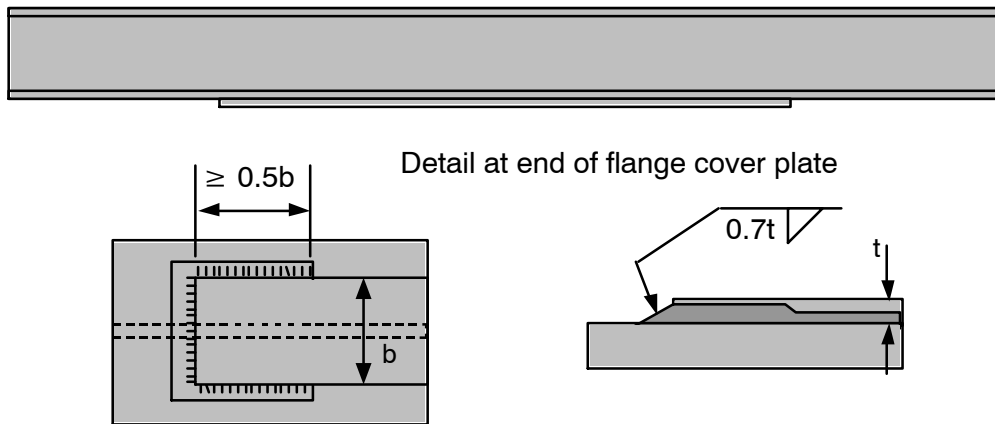


Figure 37 Stiffening of Flange in Centre of Beam

Compound members include those that vary along the length. I-beams may be stiffened between the columns by widening the web or reinforcing (plating) the flange. Column transitions may be required to allow the section size to be reduced. Typical details are shown in Figures 37 and 38.

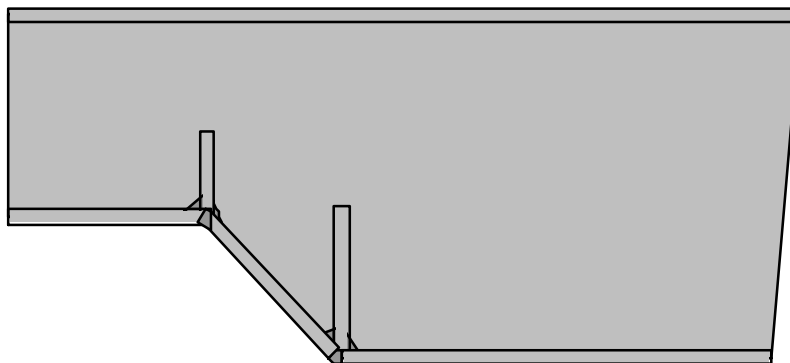


Figure 38 Increase of Beam Depth

3.2.3. Fully Welded Splices in Columns and Beams

It is best to use sections in the lengths supplied than to splice lengths together. However on occasions splicing is used to produce long lengths.

If an I-section is fabricated from plate, it is best to butt weld flange and web plates together before welding the flanges to the web. However, it is sometimes necessary to join fabricated sections, in which case the flange and web butts in welded beams are staggered to avoid stress concentrations in the corners and to break up a possible fracture path. This is accomplished using the Z-configuration joint as shown in Figure 39. This also allows the flanges to be fitted with minimum misalignment.

Note that mouse holes are required in the web to access the butts in the flange. These are usually left as permanent holes through the web, but may be closed with cover plates if necessary. It is necessary to seal weld the exposed ends of the fillets between the flanges and web if corrosion is a problem.

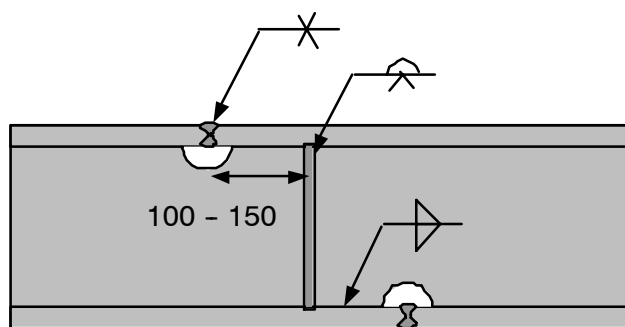


Figure 39 Fully Welded Splice in Beam

Splices between two identical rolled sections are simple with the butt welds in the flange, in the same plane as the butt weld in the web. Hot rolled sections of the same nominal width will have flanges that match inside the web. It means that splices between two sections of the same nominal width can be simply butted together. This is because the rolls used for finishing sections of the same width are identical, even though the thicknesses may vary. These details are shown in Figure 40.

Bolted and welded joints as used for field connections are detailed in Section 3.2.4.

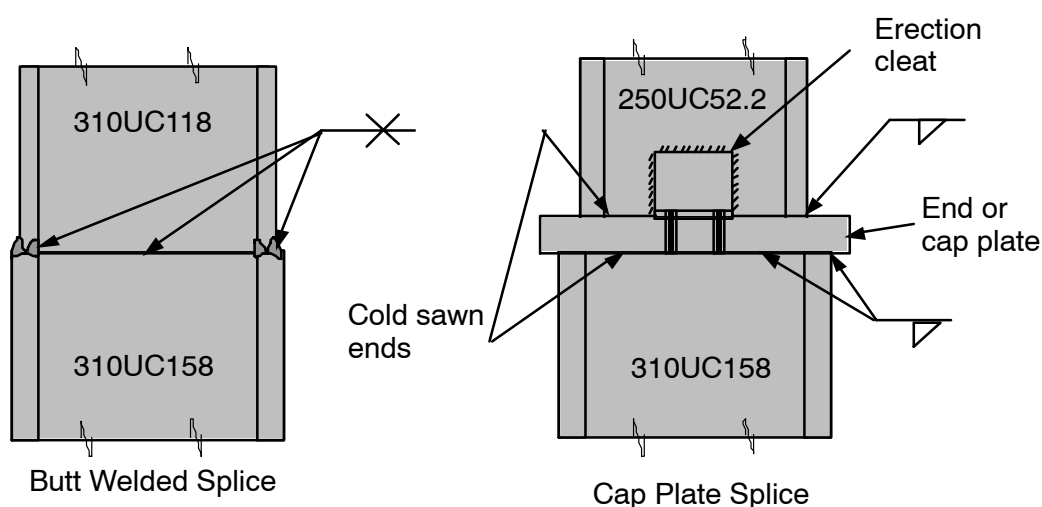


Figure 40 Typical Welded Column Joints

3.2.4. Bolted and Welded Column and Beam Splices

The splice shown in Figure 39 is suitable for shop welding or field welding of identical sized I-sections subject to high load or corrosive conditions. The ASI standard connection shown in Figure 41 for beam splices is cheaper to fabricate and field erect by making use of web doubler plates, however it is not seal welded and therefore should not be used in corrosive environments. This connection uses doubler plates bolted and fillet welded on both sides of the joint. Note the use of a backing bar for the flange butt welds. If a backing bar joint or a double welded butt joint is used, the web must have a cope hole to access the flange butt weld and allow the backing bar to be fitted.

An Engineer's Guide to Fabricating Steel Structures

Volume 2 Successful Welding of Steel Structures

By

**John Taylor
BSc, Sen.MWeldI**



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