Economical Structural Steelwork

edited by

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Fifth edition - 2009

AUSTRALIAN STEEL INSTITUTE

Contents

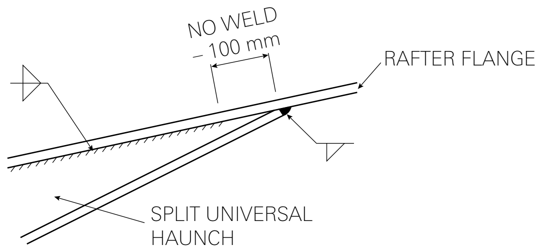
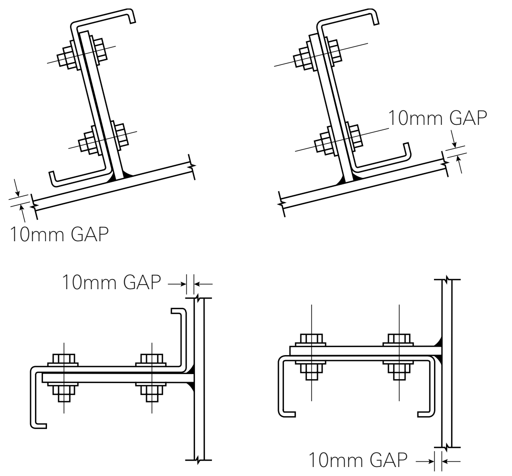


FIGURE 8.26: Termination of haunch



Notes:

1. Place girts and purlins to most effectively shed water and debris with due consideration to ease of erection.
2. Ensure adequate clearance to avoid interference with cleat welding.
3. Design cleats to accommodate standard punching – refer to manufacturers' brochures.
4. Ensure adequate capacity in top girt to carry load from sag rods.

Figure 8.27: Attachment of purlins and girts

8.5.2 PORTAL FRAME PRE-SET

In order to ensure that the columns of a portal frame will be within the basic erection tolerances in the flnal erected position, it is necessary to provide a 'pre-set' of the frame during fabrication.

This is done by determining the de ection at the frame ridge under dead loads and calculating the resultant horizontal de ection at the knee joints. This latter dimension is then used in the set-out for fabrication to pre-set the geometry of the frame – see Figure 8.28.

8.6 Connection Detailing

8.6.1 GENERAL

In general, the greatest economy in detailing of beam-to-column and beam-to-beam connections is achieved by selecting combinations of connections to require only one type of operation to be executed on each member in the fabrication shop. Preferred ways in which this can be achieved are suggested in Figure 8.29.

Such a method of selecting connections enables the fabricator to reduce the handling operations required to fabricate the member and lends itself readily to a ' ow-through' system in the shop.

The designer and detailer should look at rationalising the selection of details and connections in this way. Naturally, holing operations on any group of similar members would use the same set-out parameters (gauge lines, pitch, hole diameter, etc.).

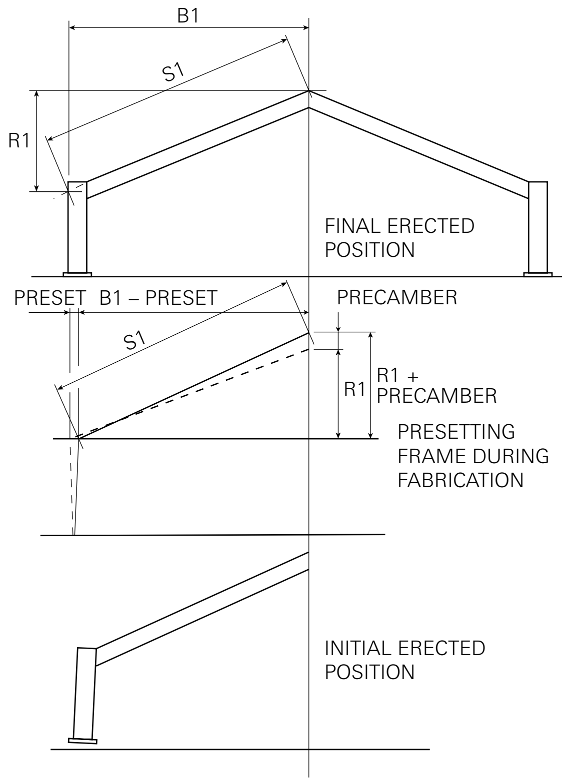


FIGURE 8.28: Precambering details of a rigid frame

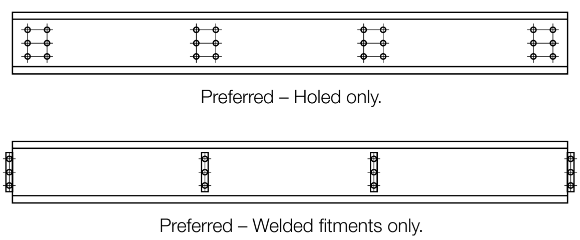


FIGURE 8.29: Typical beam details for fabrication economy

An example of this type of selection process can be illustrated using the beam marking plan shown in Figure 8.30. In this instance, the frame is braced in both planes and exible connections only are to be used.

In this frame the critical connections are those to the two box columns. If these columns are small they cannot accept connections requiring bolting through their walls. If they are large, bolting through may be possible (with some difflculty and expense) but the connections must be of a type where the beams can be entered without the need to ‘spring’ the very rigid columns.

On both grounds the logical choice is Figure 8.34, web side plate (WP), for every connection to the box columns.

By the rule of symmetry (Clause 4.4.4) use the WP connection at the other end of the beams in question, B1, B4, B8 and B9. By the rule of standardisation use the WP connection on both ends of the other longitudinal beams B7 and B10, checking that there will be adequate clearance at those ends of B7, B8, B9 and B10 which frame into the webs of the I-section columns. Standardise further by using the WP connection also at both ends of B3 and at the column end of B6 (see Summary below).

For the connections selected so far, the beams require only to be cut to length and drilled. Therefore the connections for the transverse members framing into them should be chosen so that the beams require only further drilling (as in Figure 8.29 upper).

Choosing Figure 8.33, angle cleat (AC) will achieve this aim. Another option is Figure 8.32, exible end plate.

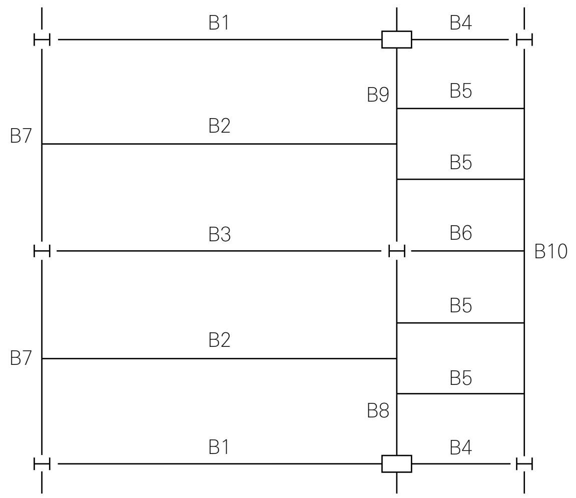


FIGURE 8.30: Typical floor beam layout

Summary:

We now have a frame requiring only two different connection types, selected in such a way as to minimise fabrication and erection costs.

The columns themselves require welded fltments only. Beams B1, B3, B4, B7, B8, B9 and B10 require only cutting to length and drilling. Beams B2, B5, and B6 again require only cutting to length and drilling (assuming the AC connection).

All beams have the same type of connection at each end except B6 where it is necessary to make a minor compromise of WP at one end and AC at the other.

8.6.2 SPECIFIC CONNECTIONS

This Clause presents notes on the efflcient and economic detailing of a variety of individual connection types, as follows:

Figure 8.31 Angle seat connection
8.32 Flexible end plate connection
8.33 Angle cleat connection
8.34 Web side plate connection
8.35 Bearing pad connection
8.36 Welded moment connection
8.37 Moment end plate connection
8.38 Welded splice connection
8.39 Bolted splice connection
8.40 Stiffener connections
8.41 Bracing connections
8.42 Connections to concrete cores

8. Detailing for Economy

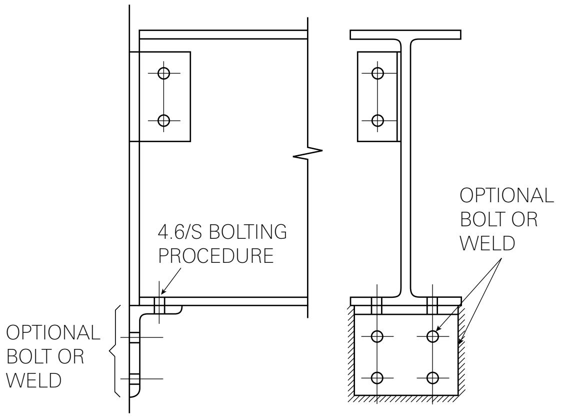


FIGURE 8.31: Angle seat connection

- Use bolted restraint cleats for maximum economy and to allow margin for rolling tolerances on rolled section beams.
- For welded seats, it may be necessary to taper the vertical leg of the seat in cases where the seat is welded to an H-section column web between   anges to allow access for welding (see Figure 7.6(b)).
- Check length of seat to ensure satisfactory fit onto column. Where the seat is wider than the column   ange, welded angle seats require welding from behind the column   ange. This involves turning the column and may prove costly – (see Figure 7.10).
- Observe recommendations on economical aspects of the use of bolting (Section 6) and welding (Section 7).

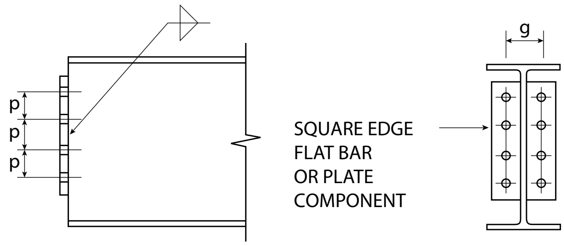


FIGURE 8.32: Flexible end plate connection

- Select gauge ‘g’ to ensure bolt clearance (usually 90mm).
- Fabrication of this type of connection requires close control in cutting the beam to length. Adequate consideration must be given to squaring the beam ends such that both end plates are parallel and the effect of any beam camber does not result in out-of-square end plates which makes erection and fleld flt-up difflcult. Shims may be required on runs of beams to compensate for mill and shop tolerances.
- The use of this connection for two sided beam-to-beam connections should be considered carefully. Installation of bolts in the end plates can cause difflculties in this case.
- When unequal sized beams are used, special coping of the bottom   ange of the smaller beam may be required to prevent it fouling the bolts.
- Since the end plate is intended to behave flexibly, damage of the end plate during transport is not normally of concern and may be rectifled on site.
- Observe recommendations on economical aspects of the use of bolting (Section 6) and welding (Section 7).

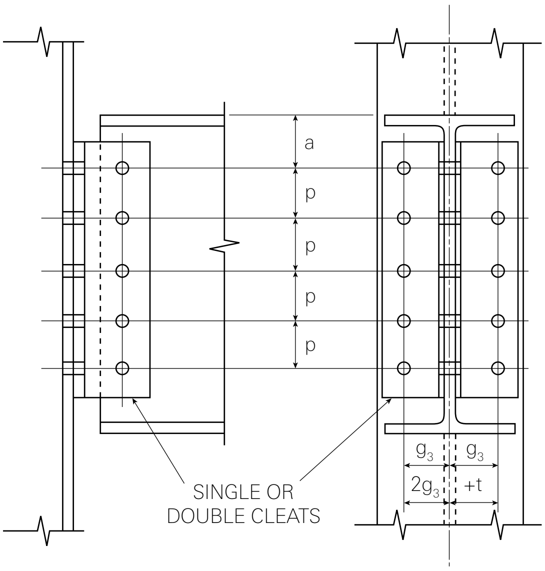


FIGURE 8.33: Angle cleat connection

- Cleat holes must allow for variations in beam depth due to standard rolling tolerances and also provide for erection tolerances. Standard holes (2mm larger than nominal bolt diameter) are usually sufflcient.
- Check that cleat components will fit between column anges for connections to column webs.
- The use of this connection for two sided beam-to-beam connections should be considered carefully. Installation of bolts in the outstanding legs of the angle cleats can cause difflculties in this case. When unequal sized beams are used, special coping of the bottom ange of the smaller beam may be required to prevent fouling the bolts.
- For double angle cleats, the nominal gauge required in the supporting member is (2 g_3 + t). Standard gauges can hence accommodate only certain web thicknesses (t) of the supporting member when using normal holes (2mm clearance). Drifting widens the range of web thicknesses that can be accommodated, but may result in some distortion of the cleat. Alternatively, a special gauge may be used in the supporting member.
- In order to obviate both drifting or the use of a special gauge, custom detailed horizontal slotted holes may be used in the outstanding leg of the angle cleat component. Alternatively, oversize (4mm larger than nominal bolt diameter) holes could be used, but this may complicate levelling the supported member during erection.
- Observe recommendations on economical aspects of the use of bolting (Section 6).

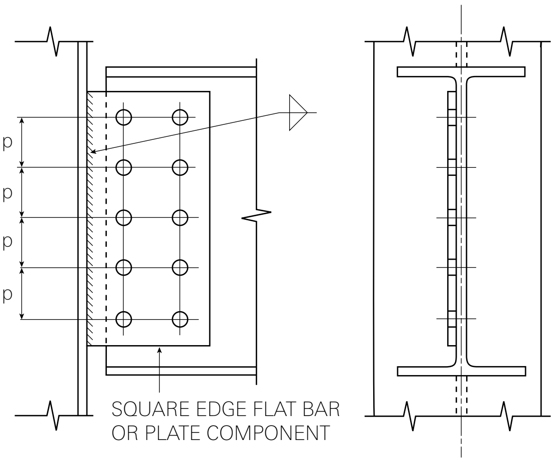


FIGURE 8.34: Web side plate connection

- Bolt holes must allow for variations in beam depth due to standard rolling tolerances and also provide for erection tolerances. Standard holes (2mm larger than nominal bolt diameter) are usually sufflcient.
- In connections to column webs, a check must be made on the length of bolt to ensure sufflcient clearance is available between the side plate and the inside of the column ange to permit the bolt to be installed.
- Erection clearances must be especially considered for this detail because of the necessity to angle beams into place during erection. This consideration is most important for the case of a series of beams in the one row, all connected between the same main supporting members.
- Observe recommendations on economical aspects of the use of bolting (Section 6) and welding (Section 7).

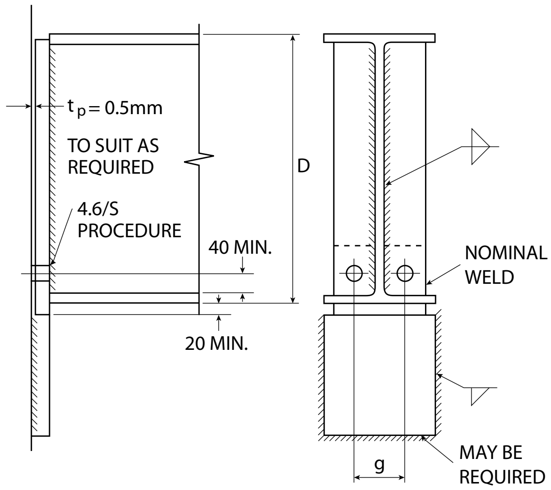
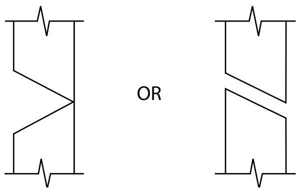
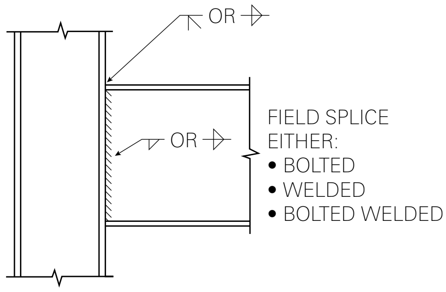


FIGURE 8.35: Bearing pad connection

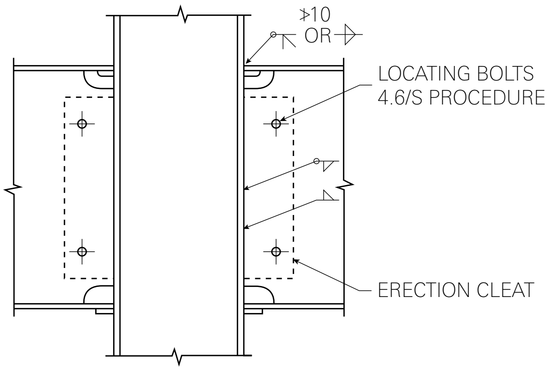
- The connection may need to be shimmed to suit during erection. The connection detail consequently includes provision for shims of 0-5mm nominal thickness. Shims will need to be holed to the same gauge as the end plate.
- Sawn or machine flame cut edges are recommended at the bearing interface in order to avoid edges with slopes, such as



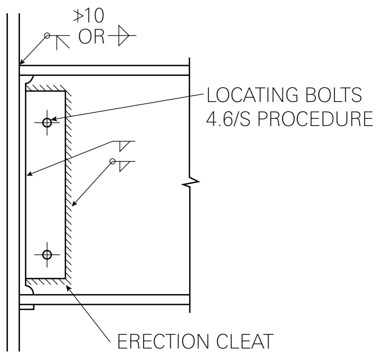
- Check width of components when welding to H-section column web to allow access for welding – see Figure 7.6(b). Where the bearing pad is wider than a column ange, welding is required from behind the column. This involves turning the column and may prove costly.
- Observe recommendations on economical aspects of welding (Section 7).



(a) Stub Girder Connection, Fully shop welded beam stub, spliced on site.



(b) Field Welded Moment Connection – including erection cleat.



(c) Field Welded Moment Connection – using fillet welded web cleat(s).

FIGURE 8.36: Welded moment connection

- The economics of field welding should be checked with the fabricator before it is specifed.
- Flange weld preparation assumes the use of a backing strip – which requires coping of the beam web.
- Details (b) and (c) are not considered as economical in Australia.
- Observe recommendations on economical aspects of welding (Section 7).
- Site welding should be kept to a minimum and should be used in an integrated manner.
- Partial penetration butt welds should be considered rather than automatically adopting full penetration butt welds.

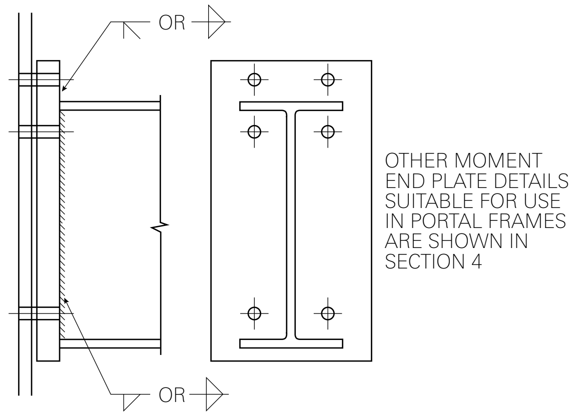
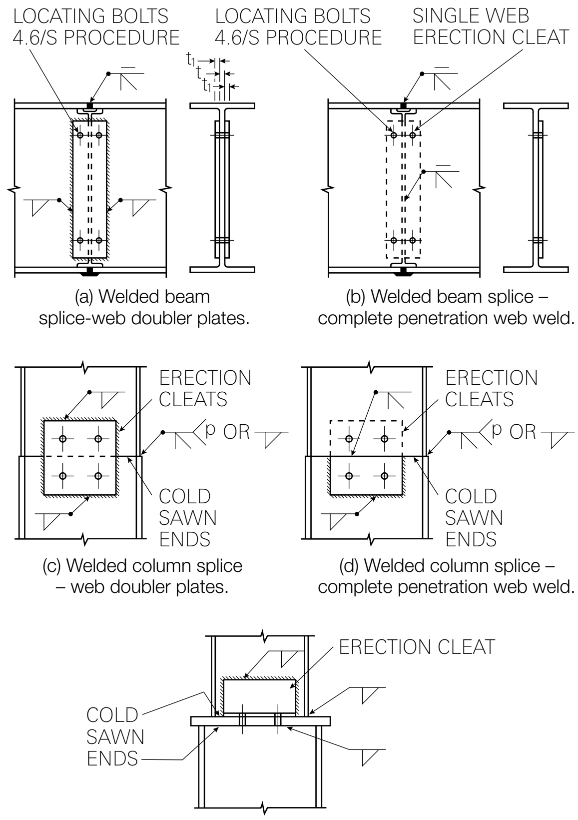


FIGURE 8.37: Moment end plate connection

- Holes are normally 2mm larger than the nominal bolt diameter, although oversize or slotted holes may be used.
- Fillet welds or butt welds may be used as the beam ange to end plate weld. A discussion of the use of filllet welds larger than 8mm as related to available welding processes is contained in Section 7.
- Fillet welds only are recommended for the beam web to end plate weld.
- Fabrication of this type of connection requires close control in cutting the beam to length and adequate consideration must be given to squaring the beam ends such that end plates at each end are parallel and the effect of any beam camber does not result in out-of-square end plates which makes erection and fleld flt-up difflcult. Shims may be required to compensate for mill and shop tolerances.
- Select a gauge for the end plate bolts which allows sufflcient clearance to install the bolts.
- Bolts adjacent to the tension flange should be as close as possible to the ange. Dimensions must be sufflcient to ensure that bolts can be installed and tensioned – sufficient clearance must be provided, (see Table 8.1).
- Stiffeners on the end plate should be avoided – a thicker end plate is recommended instead.
- Observe the recommendations on economical aspects of the use of bolting (Section 6).



(a) Welded beam splice-web doubler plates.

(b) Welded beam splice – complete penetration web weld.

(c) Welded column splice – web doubler plates.

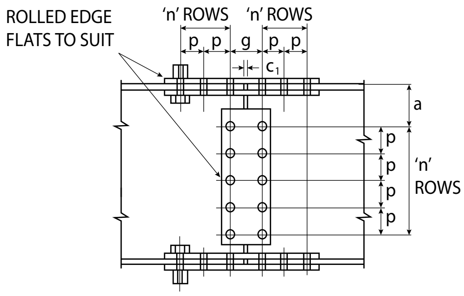
(d) Welded column splice – complete penetration web weld.

(e) Welded column splice – cap plate.

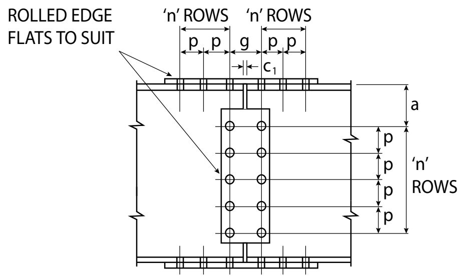
FIGURE 8.38: Welded splice connection

- The economics of fleld welding should be checked with the fabricator before it is specifled.
- Flange weld preparation assumes the use of a backing strip – which requires coping of beam web. The backing strip should be required to be removed only in special instances.
- Details avoid accurate fitting up of member sections.
- A shop splice with complete penetration welding without web plate is a detail used at the discretion of a fabricator and is not a detail in use as a site connection.
- Edges required to be prepared for bearing can be obtained satisfactorily and economically by cold sawing.
- Column splices should be located in positions where access can be easily obtained for site welding – as in Figure 8.13.

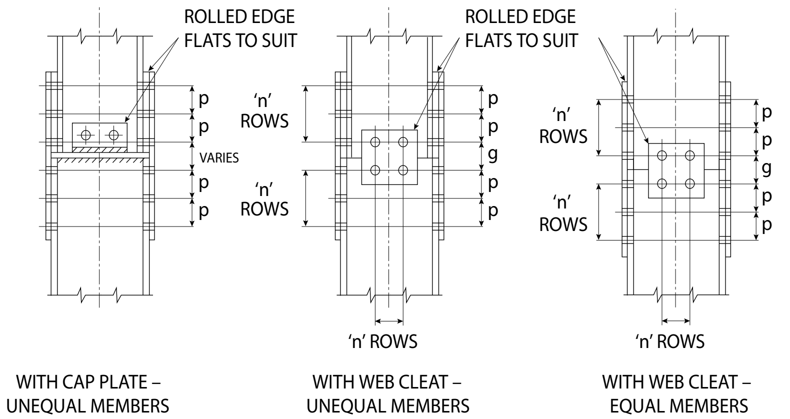
8. Detailing for Economy



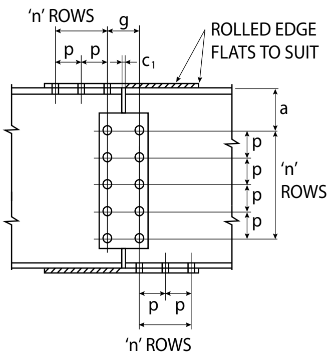
(a) Bolted moment splice in beam – three plate flange splice.



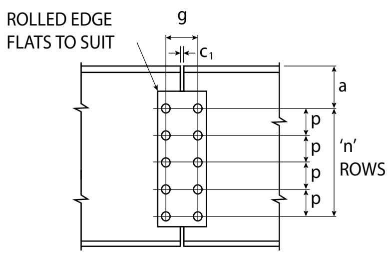
(b) Bolted moment splice in beam – one plate flange splice.



(c) Bolted column splice – prepared for bearing.



(d) Combination bolted and welded flange splice.



(e) Bolted shear splice in beam.

FIGURE 8.39: Bolted splice connection

- Where flange splice plates are used, assemble joints with nuts to outside of splice plate as in (a). This arrangement is recommended for ease of tensioning, since in universal sections sufficient clearance is not always available between flanges for a standard air wrench.
- Members can be prepared for bearing satisfactorily and economically by cold sawing.
- The cap plate detail of (c) is usually reserved for column splices between members with significant differences in member depth.
- In order to accommodate out-of-alignment of member webs at a splice, the use of shims may be necessary. To mitigate the effects of any out-of-alignment, holes in member flanges should be located using the centre-line of the member web as a reference point.
- In order to accommodate out-of-square of member flanges at a splice, the use of tapered shims may be necessary.
- Column splices should be located in positions where access can be easily obtained for the installation of the bolts – as in Figure 8.13.

8. Detailing for Economy

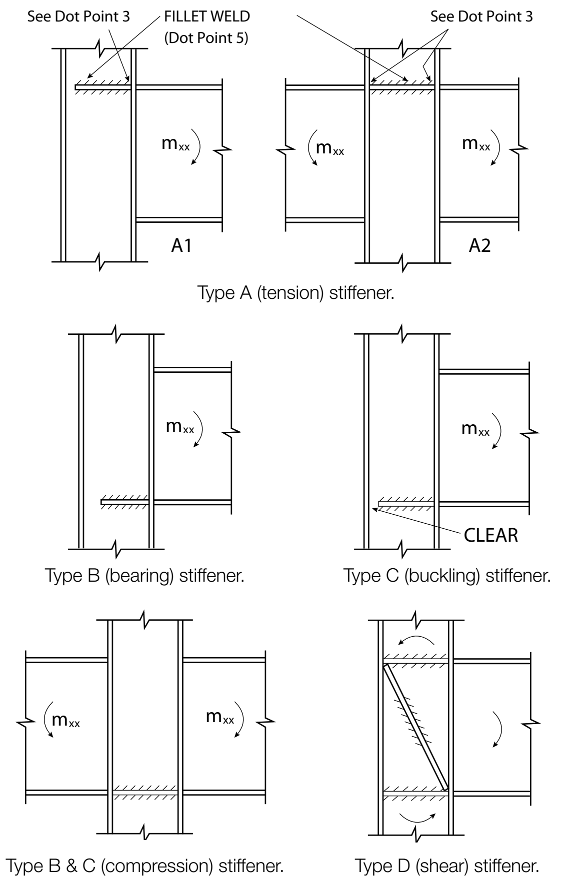


FIGURE 8.40: **Stiffener connections**

- The use of column stiffeners should be kept to a minimum for maximum economy, commensurate with design requirements.
- All welding of stiffeners should be shop welding.
- Only tension stiffeners need be welded to the inside face of the column ange(s). Compression stiffeners may be fltted against the inside face of the column ange.
- Fillet weld sizes on stiffeners should be 6 or 8mm, to ensure single pass welds. Welds to column web may be one-sided.
- Where tension stiffeners extend across the full column depth (A2), the tension stiffeners should be (flllet) welded to the column ange and only flllet welded to the column web where ange flllet welds have insufflcient capacity to transmit the design force in the stiffener. Where tension stiffeners extend only part way across the column depth (A1), welding to the column web is required.
- Compression stiffeners should be flllet welded to the column web. When diagonal shear stiffeners are used, it is recommended that compression stiffeners be flllet welded to the column ange adjacent to the shear stiffener.
- Tension and compression stiffeners need to be cropped 30mm to clear column section radiused flllets.
- Shear (diagonal) stiffeners are flllet welded at their ends. Fillet welding along the stiffener length may be introduced either to increase the capacity and/or to reduce the l/r of the stiffeners.

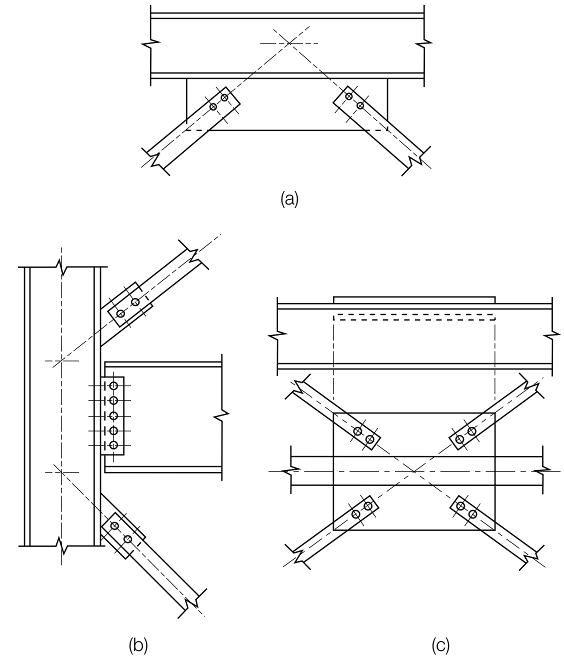
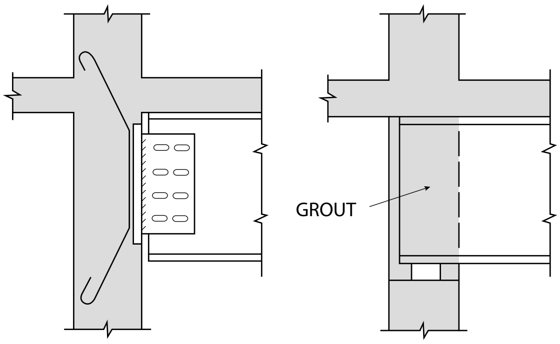


FIGURE 8.41: **Bracing connections**

- Bracing gussets should be detailed as rectangular shapes to reduce marking-off and cutting time.
- In braced frames it will generally prove more economic to weld bracing gussets to columns rather than to beams. The eccentricity caused by spreading intersection points can usually be easily accommodated by the column section.
- For roof bracing, the most economic solution will be to weld gussets to the rafter top ange. Where this cannot be done, the gusset can be welded to the rafter web but sufflcient clearance must be provided for welding electrode access.



(a) (b)

FIGURE 8.42: Connections to concrete cores

- A steel plate of fairly generous proportions is presented flush with the exterior wall of the core to which is welded a web side plate at the time of erection. Such a connection does not impose strict tolerances on (i) beam overall length (by using slotted holes in the web side plate) or (ii) beam level and lateral location (catered for in the site positioning of the web side plate provided the embedded plate is reasonably oversize). If anchor lugs are tack-welded into the general reinforcement cage, little drift of the embedded plate will occur during slip forming.
- The older method employed for this connection is that of leaving a cored hole in the wall of the slip-formed core. Originally it was thought necessary to embed a steel seating in this opening in which to bolt the bottom flange of the beam. This is not now recommended since the accurate positioning of this cored hole, including an embedded seating, is almost impossible to achieve on site. It is now considered better to leave a simple cored opening in the wall, pack the beam to level alignment during the erection phase, and fully grout up the remaining opening.
- From an economy viewpoint the alternative (b) should normally be better. However, in the overall building design it is suggested that designers consult with the slip-core contractor to check the more economical method. It is possible that in some cases a large number of cored openings, with resultant complication of reinforcement pattern, would be more expensive than the embedded plate shown in alternative (a).