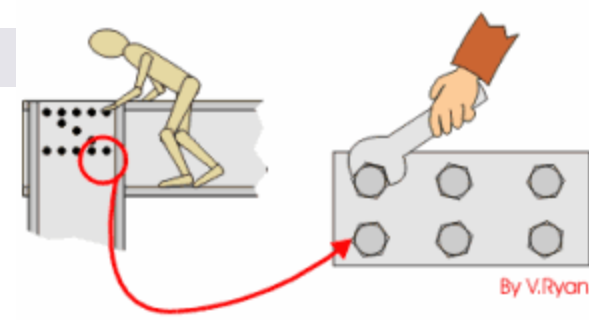


Typical Steel Connections

Dr. Seshu Adluri



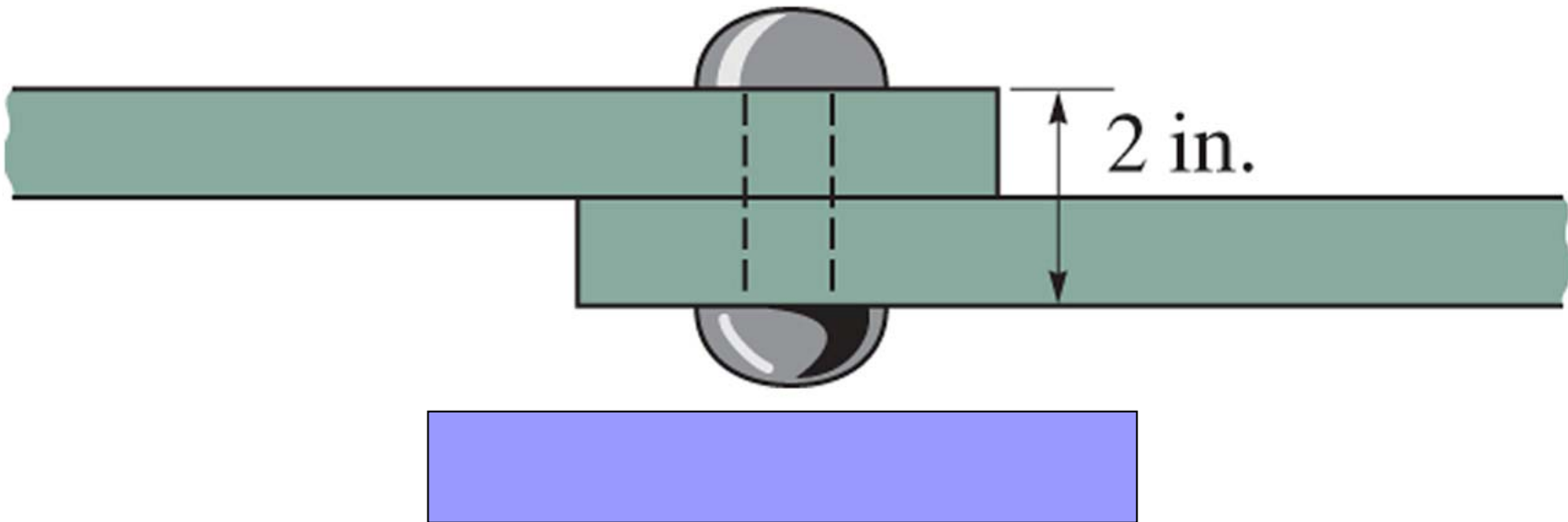
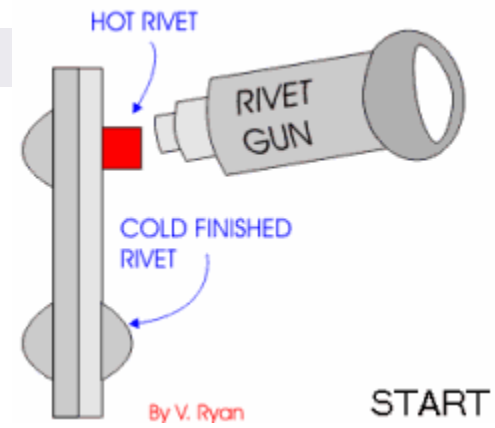
Introduction



■ Steel Connections

- Many configurations are used for force transfer in connections. The configuration depends upon the type of connecting elements, nature and magnitude of the forces (and moments), available equipment, fabrication and erection considerations, cost, etc.

Rivets



Bolts

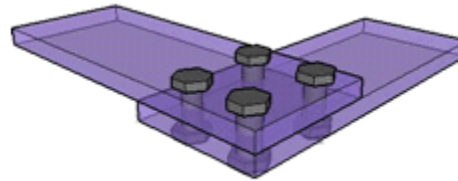
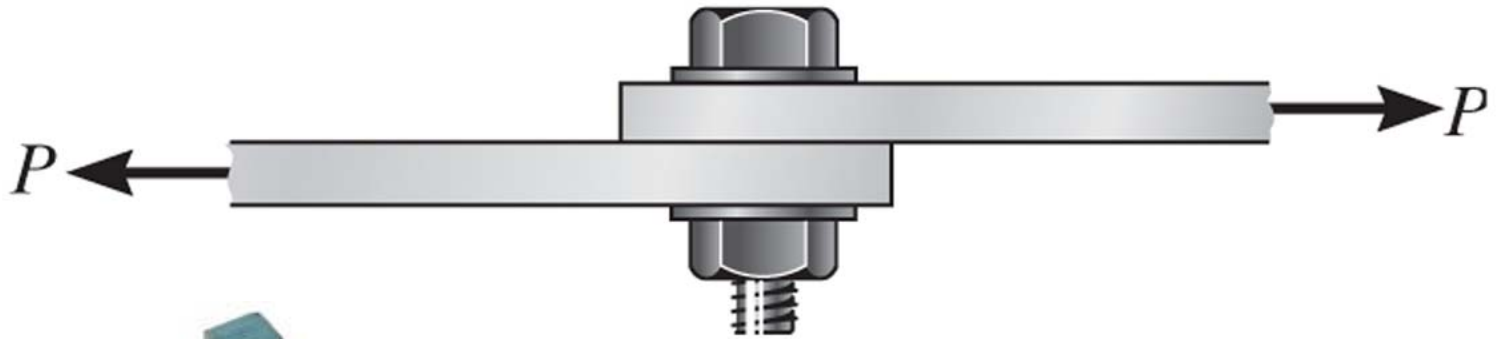


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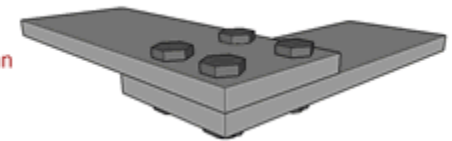


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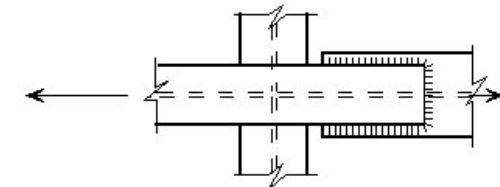
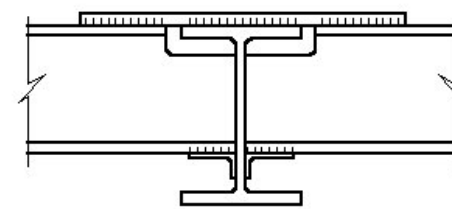
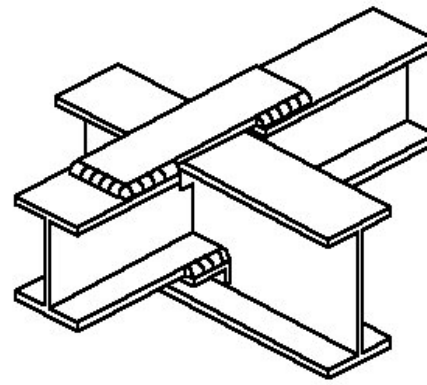
By V.Ryan



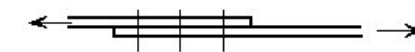
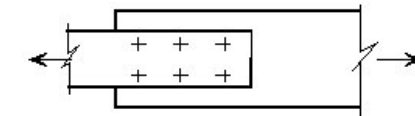
Connections

- Many types based on function
 - Beam-to-Beam Connections
 - Beam-to-Column Connections
 - Column-to-Column Connections
 - Column Base Plates
 - Pocket Beam
 - Gusset plate connections (truss type, frame type, bracings, ...)
 - Splices (cover plates, ...)

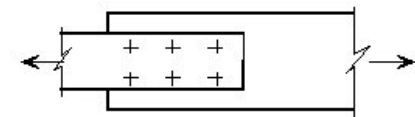
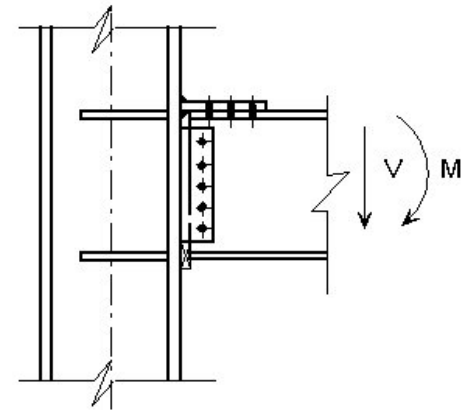
Cover plates



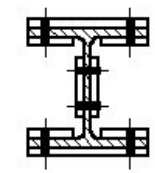
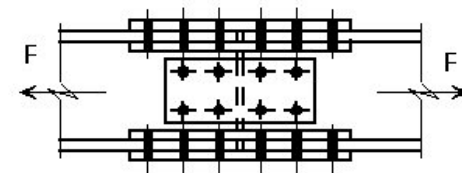
Single sided cover plate: welded



Single sided cover plate: bolted



Two sided cover plate: bolted



Details

Basic forms

Figure 2 Transfer of axial forces through cover plates

Cover plates

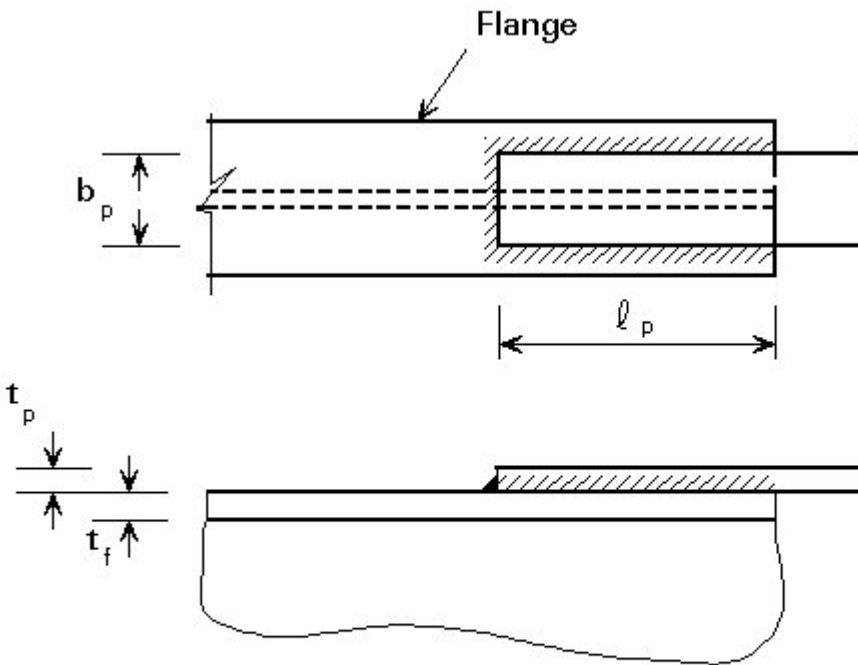
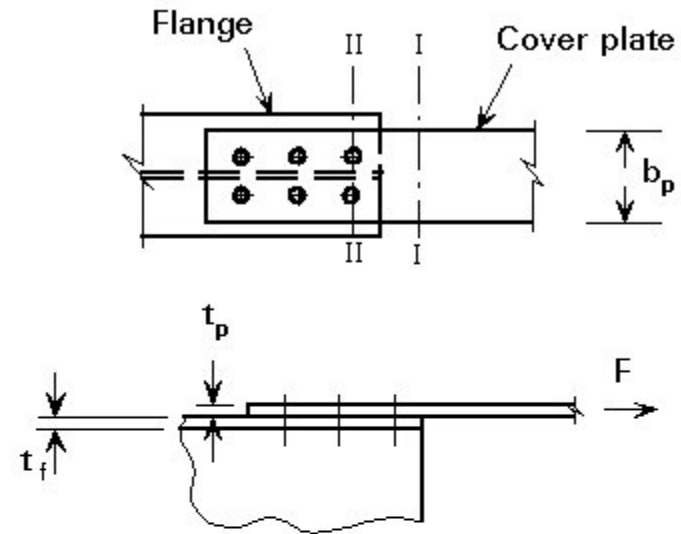
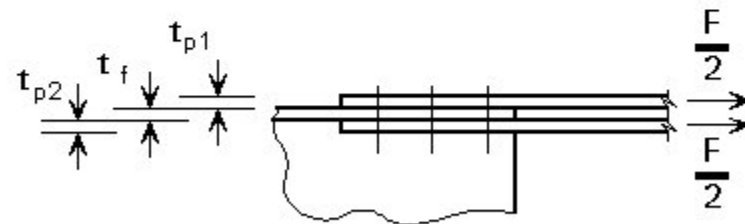


Figure 3 Welded cover plate

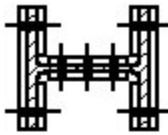


(a) Single cover plate



(b) Double cover plates

Figure 4 Bolted cover plates



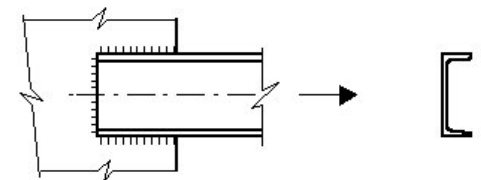
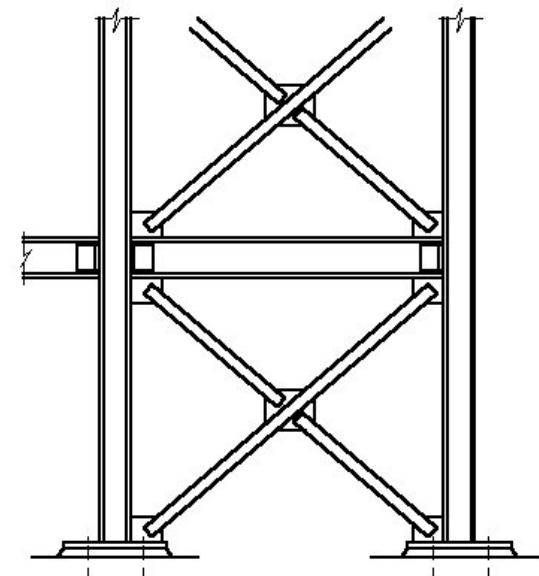
Bolted Column Splice

Moment Connection

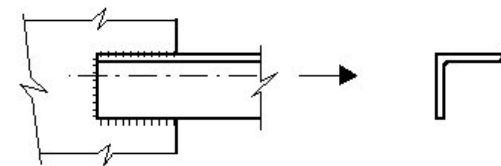


Gusset plate connections

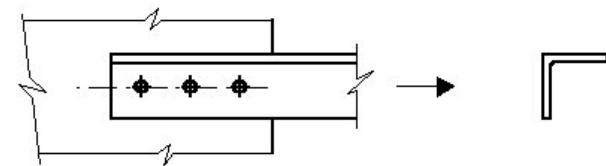
Bolted Connection



Concentric, welded



Eccentric, welded



Eccentric, bolted

Figure 7 Connection of tension members to gusset plates

Gusset plate connections

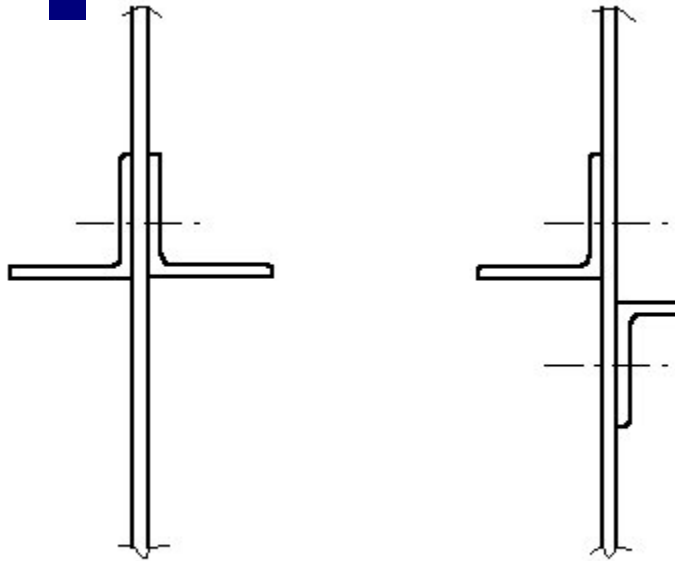


Figure 12 Member with two angle sections

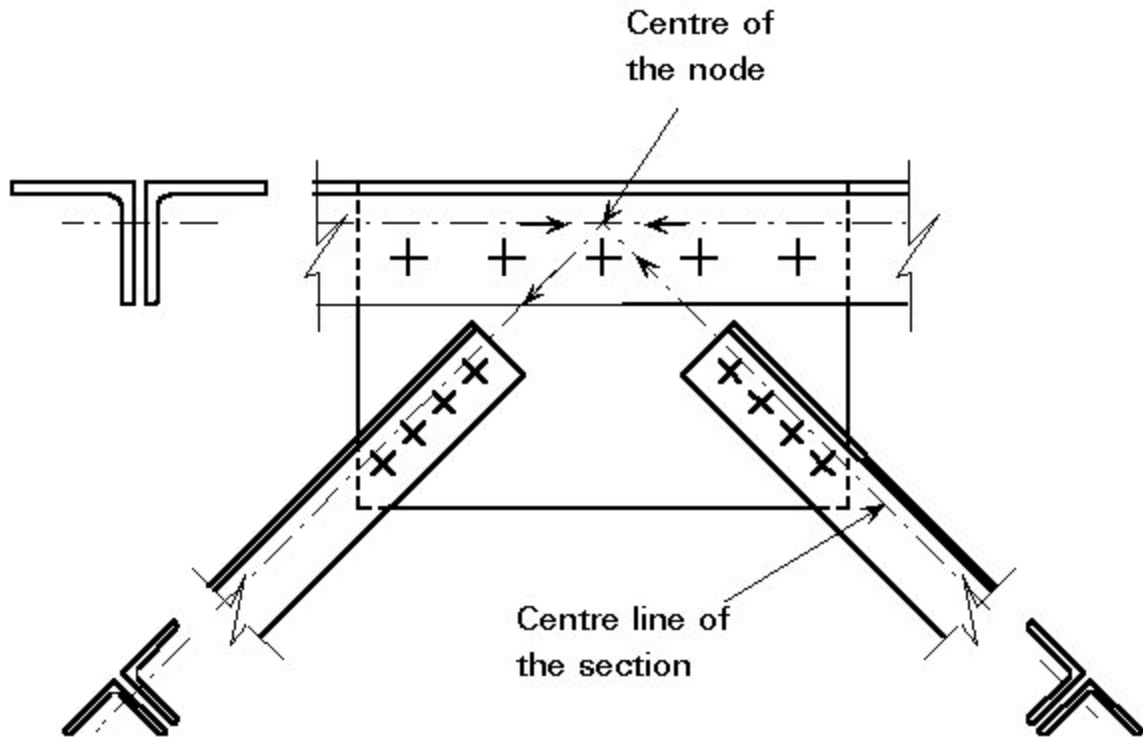


Figure 10 Bolted connection between angles



Gusset plate connections



Force dispersion to gusset plates

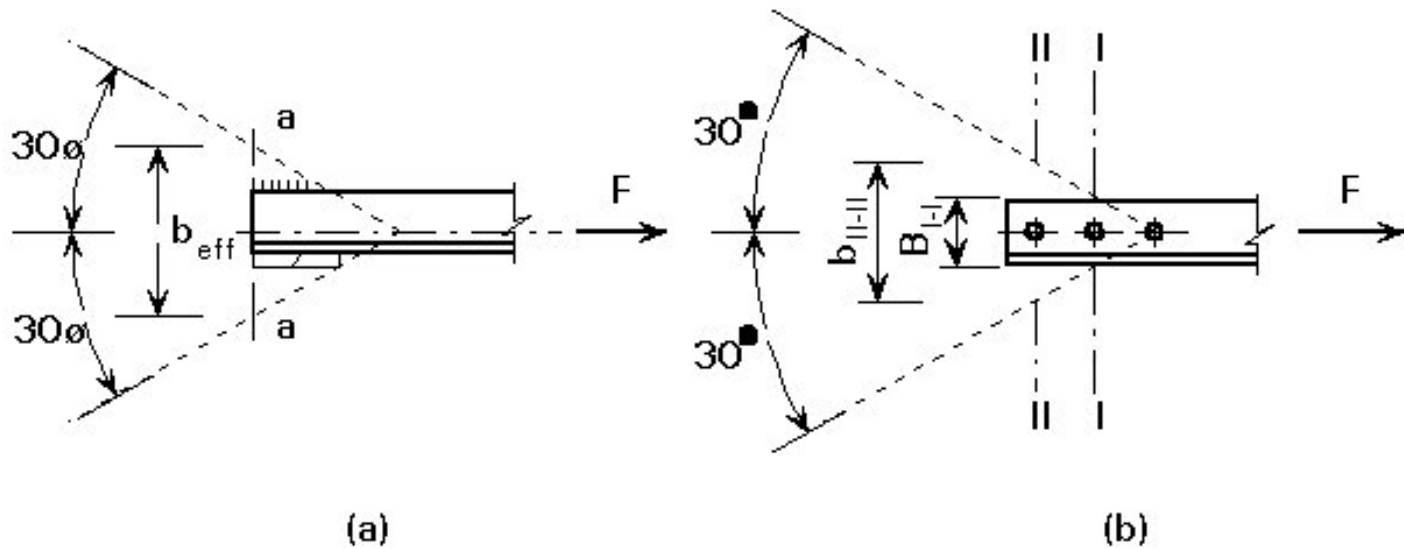
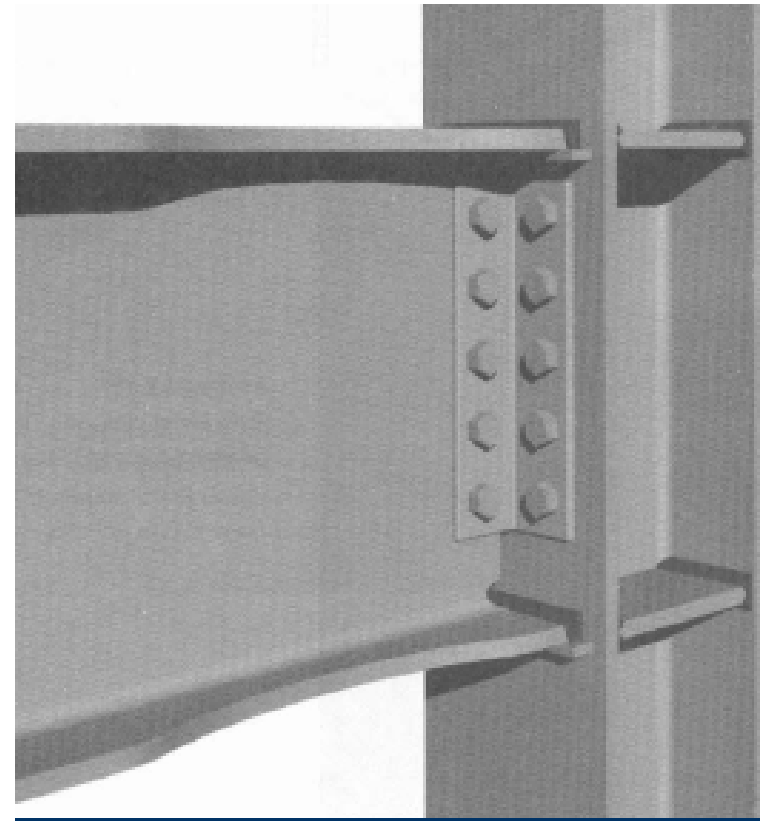


Figure 16 Spread and effective breadth in a welded and a bolted connection

Steel Framing Connections

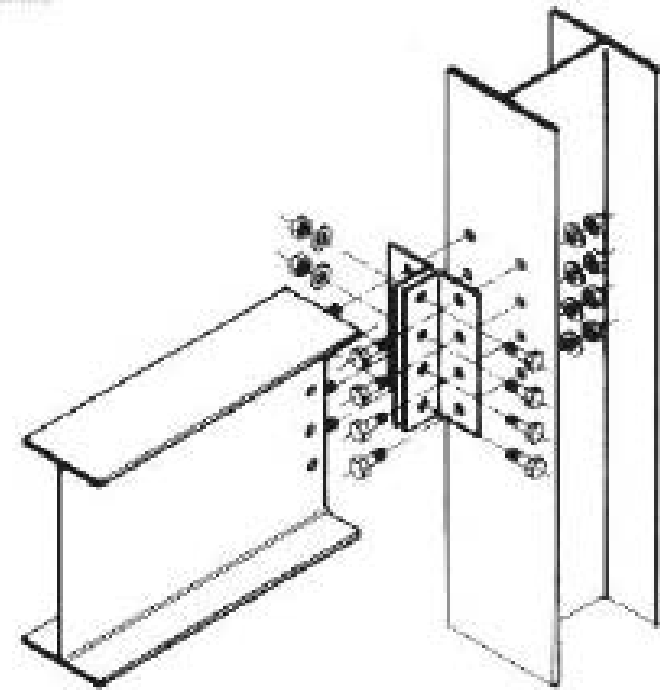
- Framed Connections
 - Bolts only in web, not the flanges
 - Transmits only shear
 - Not bending moment
 - Accomplished with
 - clip angles & bolts/welds
- Moment Connections
 - Transmit shear & moment
 - Flanges must be connected
 - Bolt/Weld Flanges
 - May require column stiffeners



Framed connections

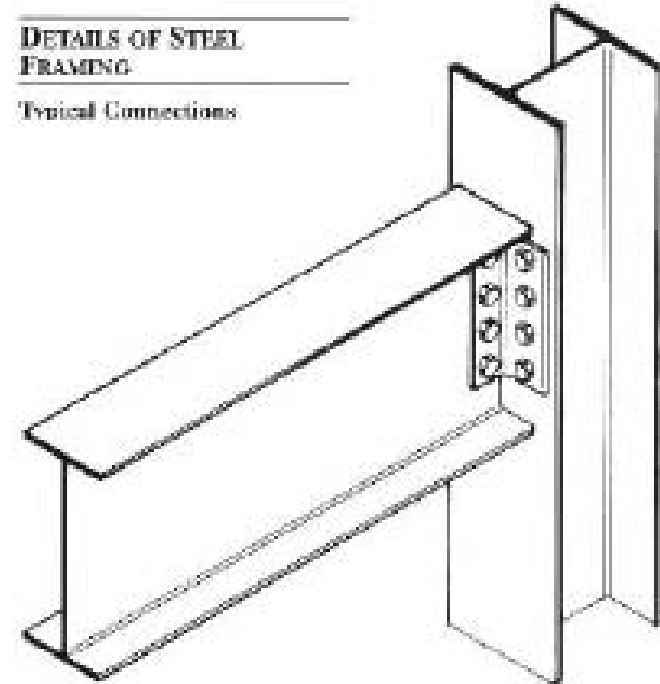
- Only shear transfer
 - Equivalent to pinned end for the beam
 - No moment at the beam end
 - Rotation is freely (?) allowed

STEEL FRAMING – SHEAR CONNECTION



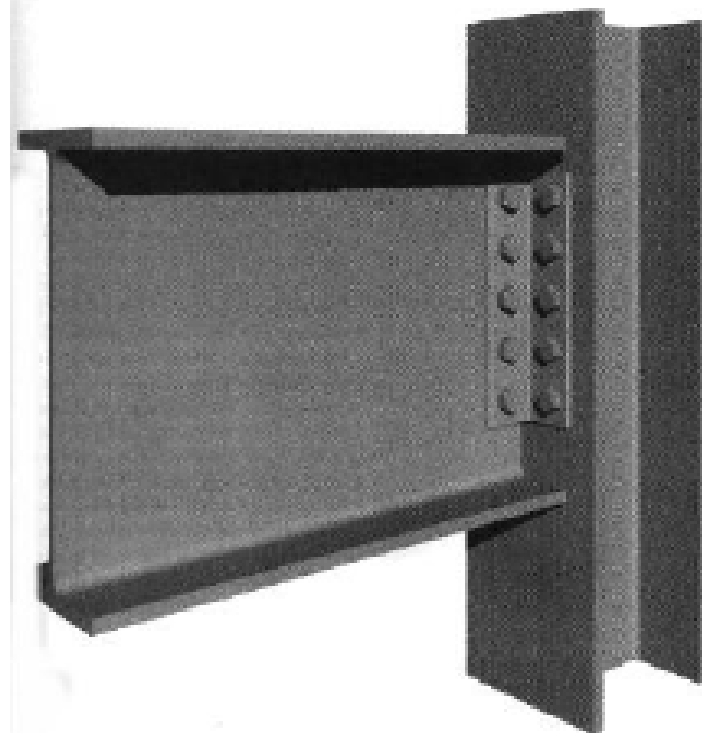
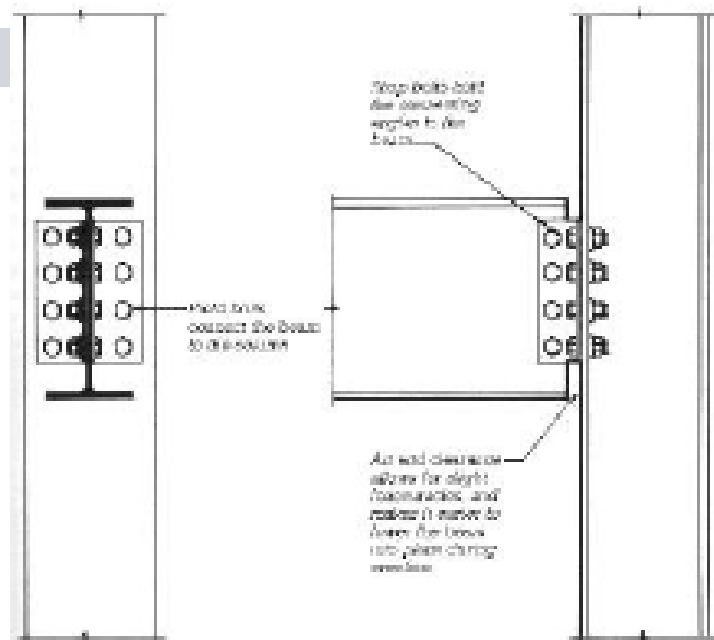
DETAILS OF STEEL FRAMING

Typical Connections



Framed connections

- End reaction only
 - Web of the beam is connected
 - No connection for the flanges



Transfer of shear force in frames

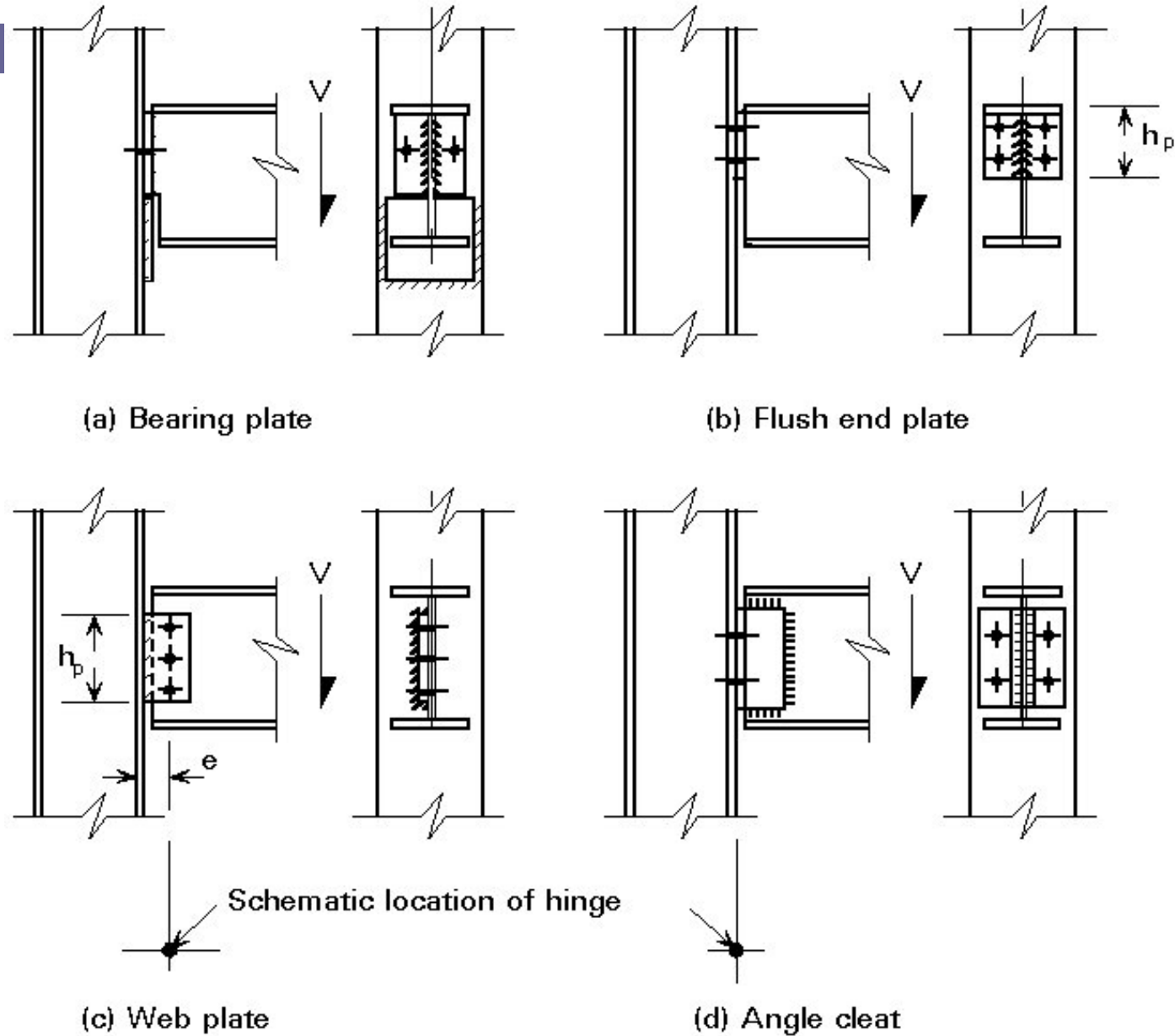
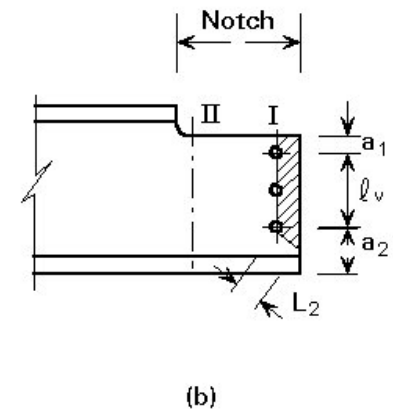
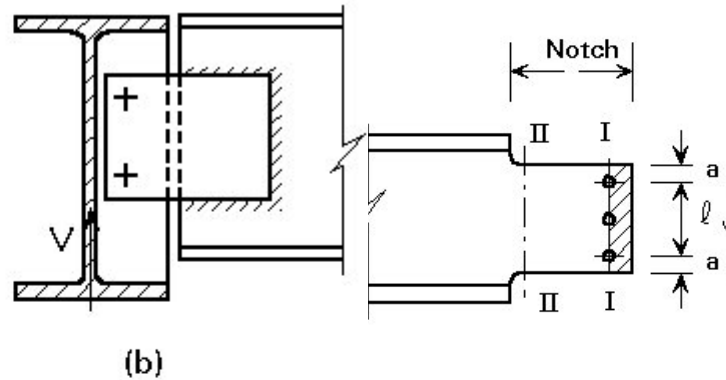
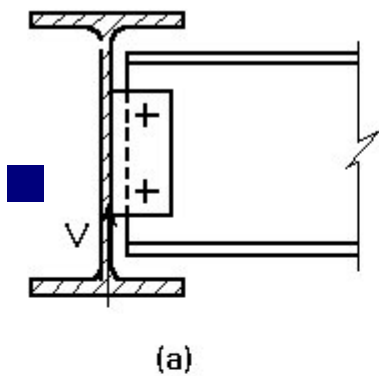
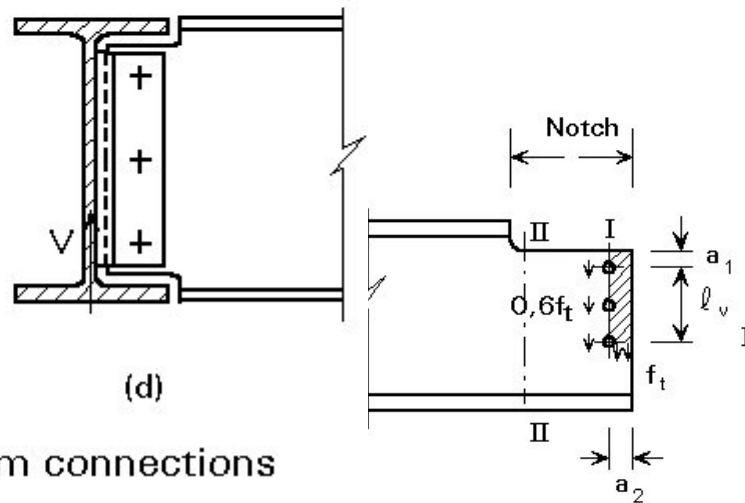
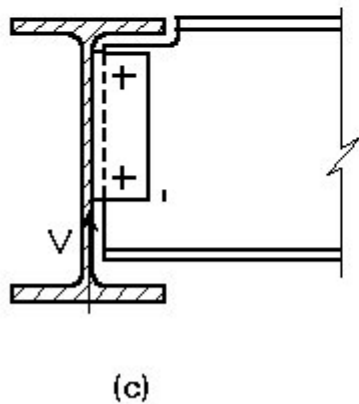


Figure 17 Connections to transfer beam loading into column by means of shear

Beam-to-beam connections



(b)



(c)

For I- I:

$$A_{net} = t(L_v + l_1 + l_2 - n d)$$

n = number of bolt holes

(according to Eurocode 3)

$$l_1 = 5d \text{ but } l_1 \leq a_1$$

$$l_2 = 5d \text{ but } l_2 \leq a_2$$

Figure 20 Beam-to-beam connections

Figure 21 Possible critical sections at the ends of secondary beams

Beam-to-beam connections

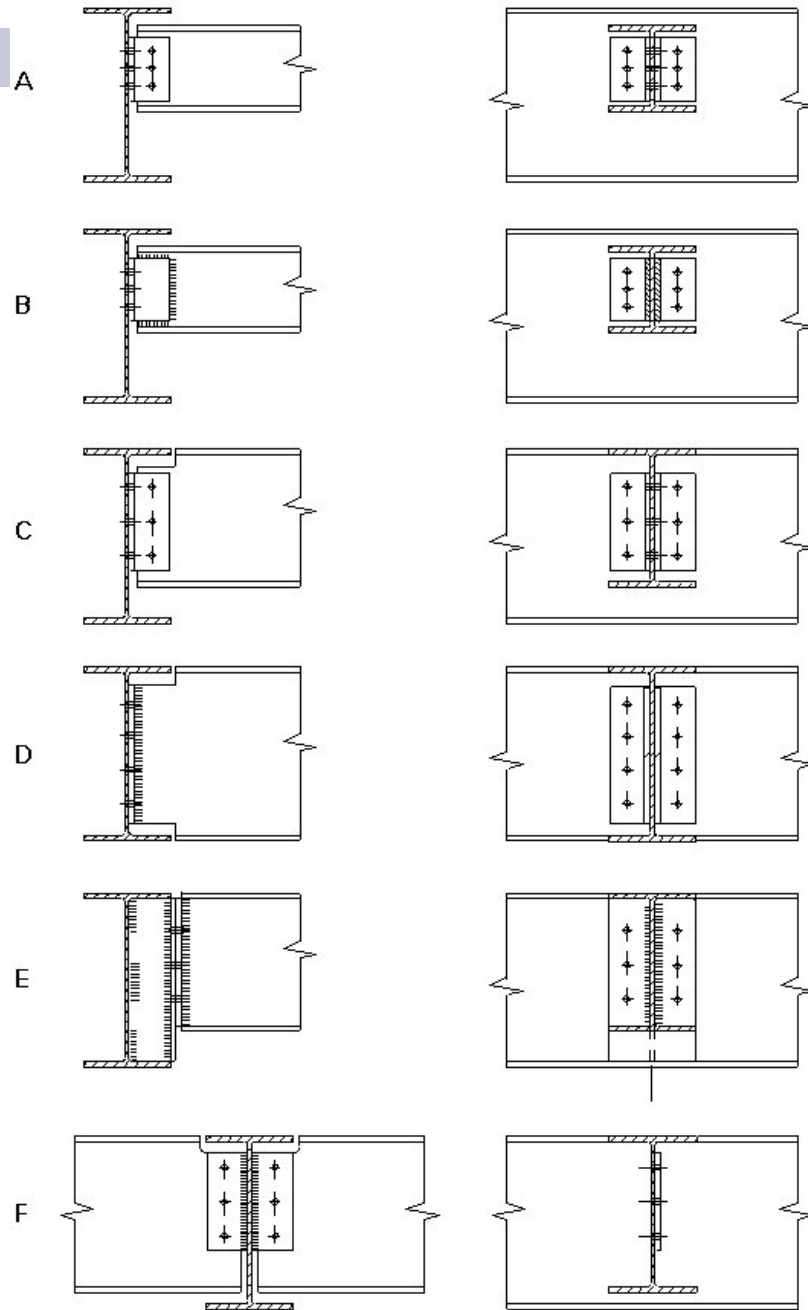
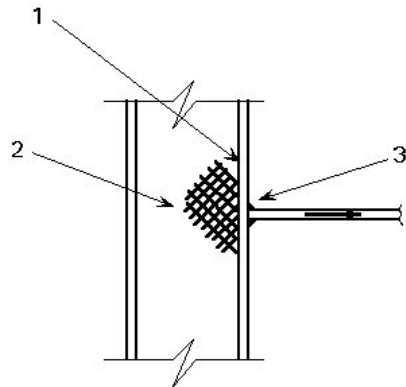
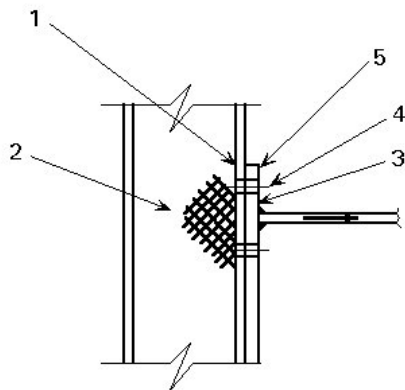


Figure 2 Beam-to-beam connections

Beam-to-column connections

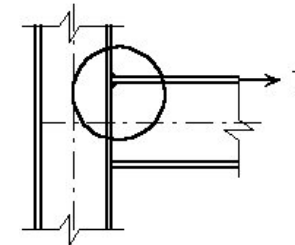


1. Plastic failure of the column flange
2. Yield / rupture of the column web
3. Rupture of the welds

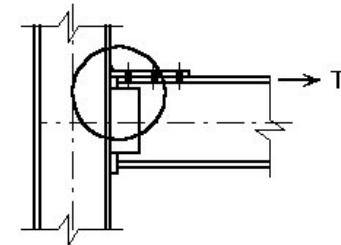


4. Rupture of the bolts
5. Plastic failure of the end plate, respectively angle cleat of T-section

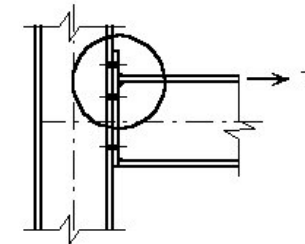
Figure 2 Checking criteria for the tension zone of unstiffened connections



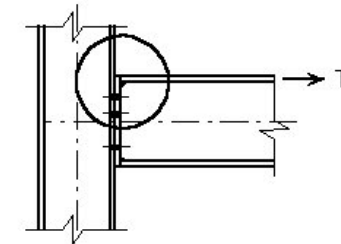
(a) Welded



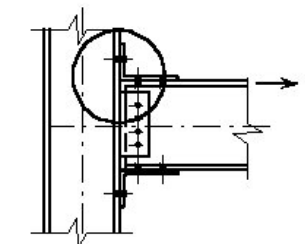
(b) Welded flange plate



(c) Extended end plate



(d) Flush end plate



(e) Angle cleats

Figure 1 The tension zone of beam - to - column connections

Beam-to-column connections

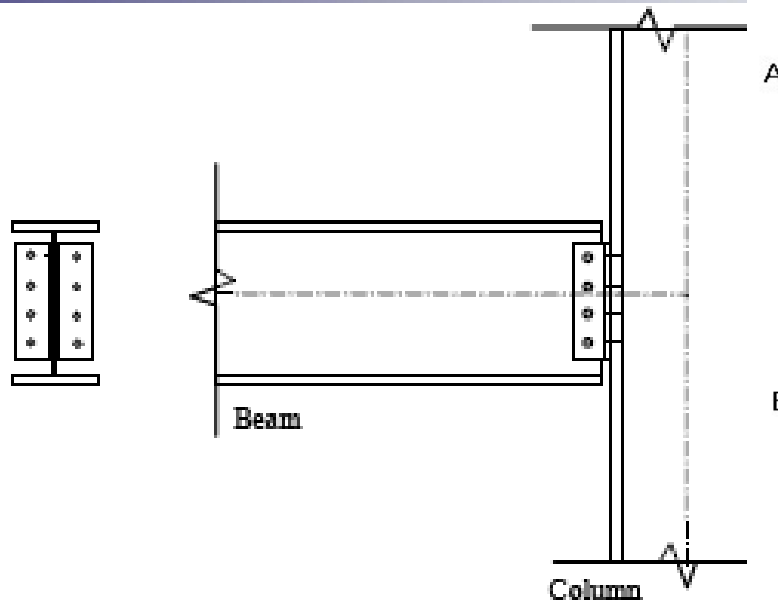


Figure 6. All-bolted double angle shear connection.

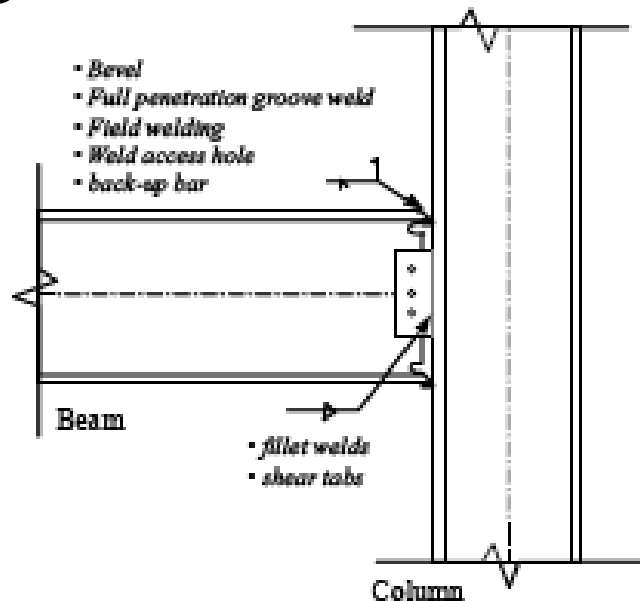


Figure 7. Directly welded flange fully restrained moment connection

A

B

C

D

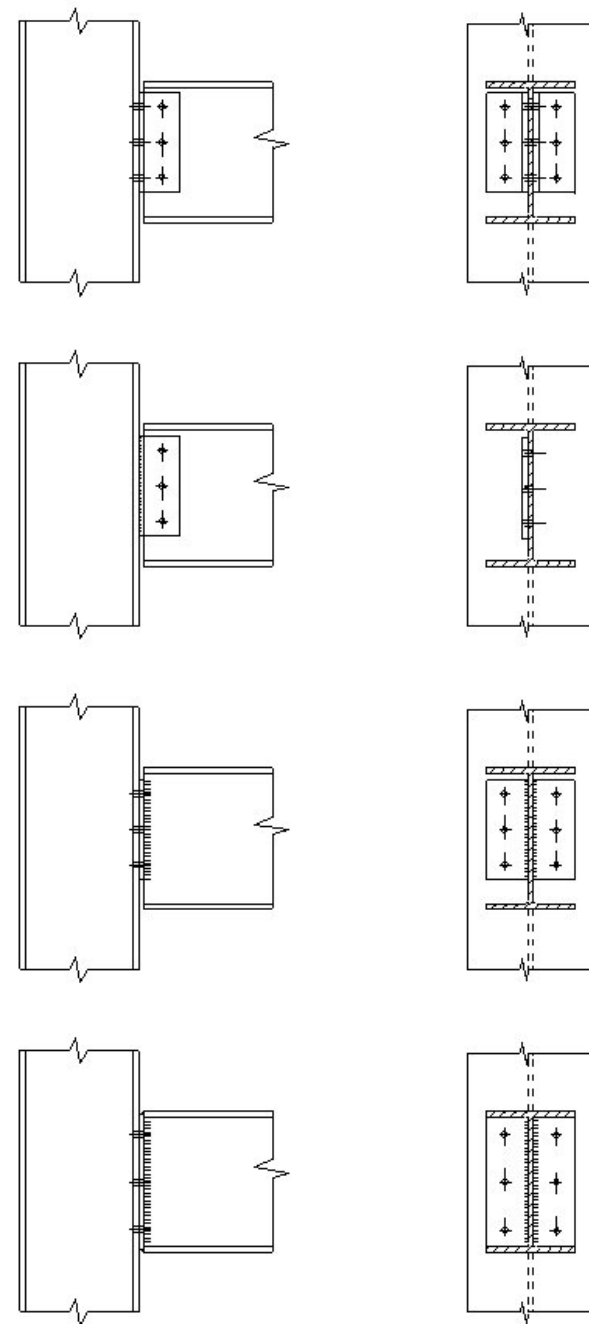


Figure 3. Beam-to-column connections

Beam to column joints

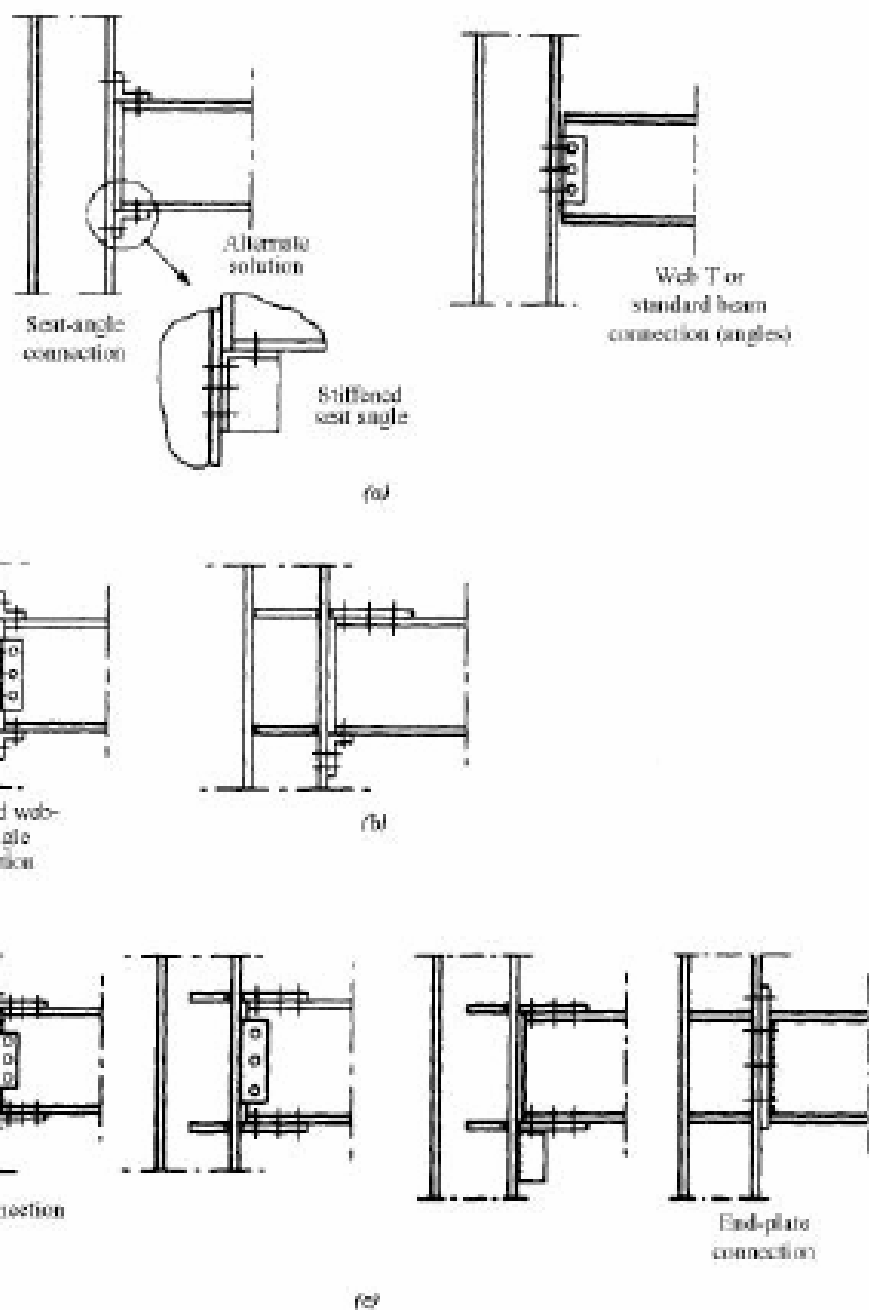
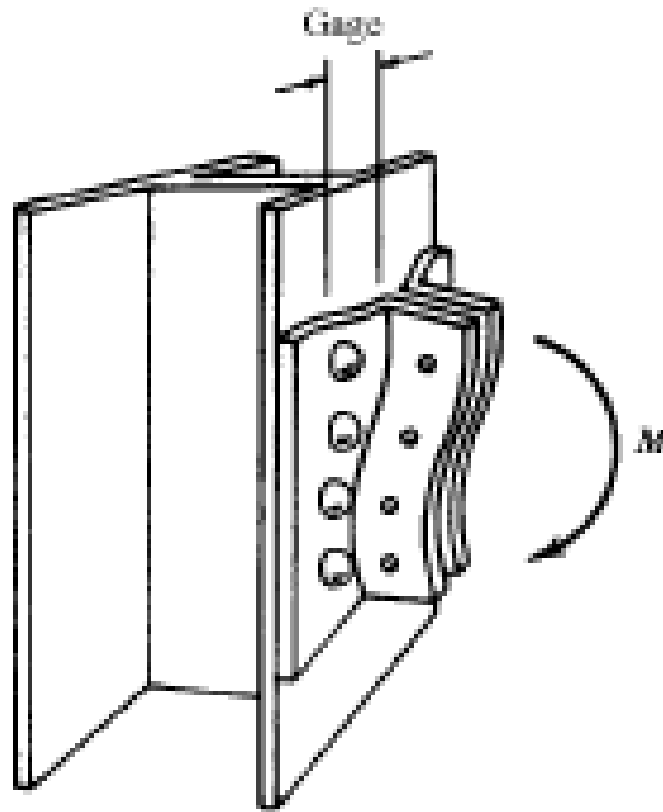


Fig. 18.1. Types of beam-to-column connections. Note. The need for column stiffeners in any of these connections must be checked. (a) Flexible connections. (b) Semi-rigid connections. (c) Rigid connections.

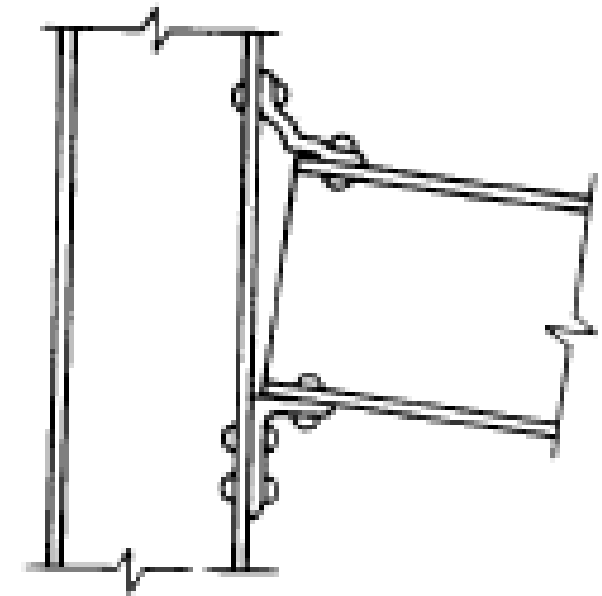
Beam to column joints



Beam to column joints



Deformation of
web angle connection



Deformation of seat
angle connection

Fig. 18.3. Deformations of flexible beam-to-column connections.

Beam to column joints



Fig. 18.5. Angle in standard beam connections described in Fig. 18.4. (Courtesy of University of Illinois.)

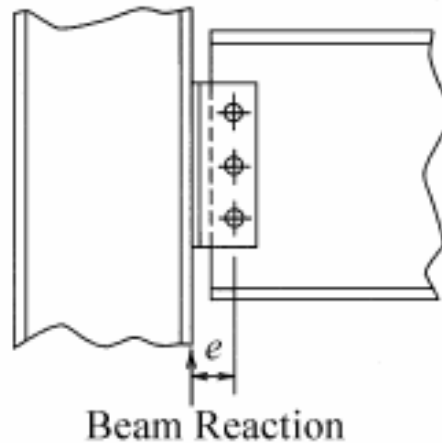


Fig 18.6. Eccentric shear acting on bolt group

Beam-to-column connections

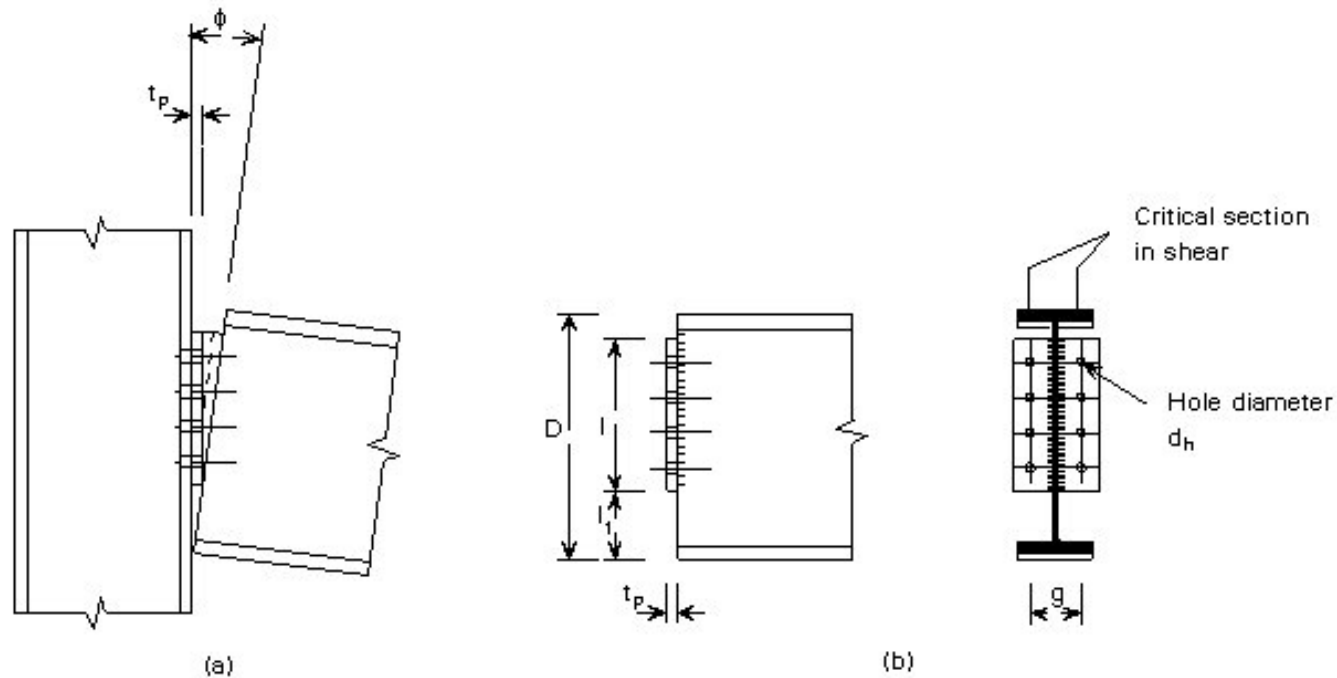


Figure 4 Flexibility and rotation capacity for simple end plates

Beam-to-column connections

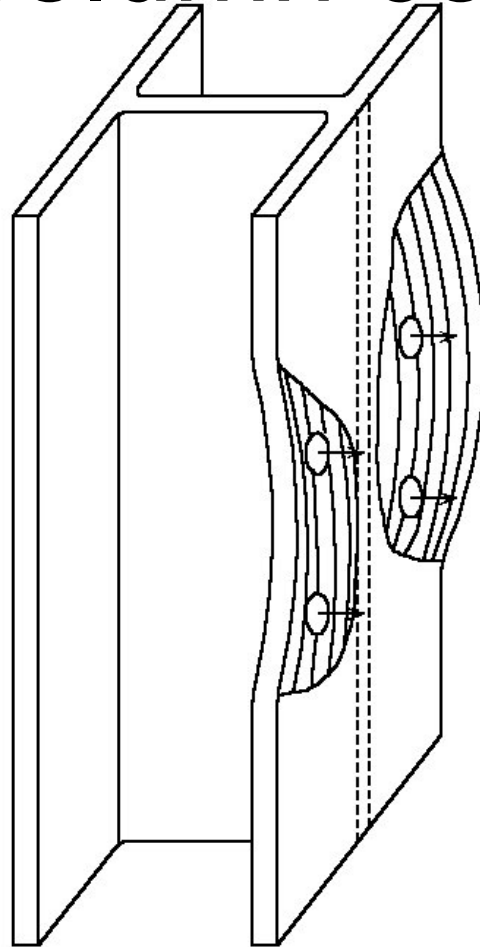
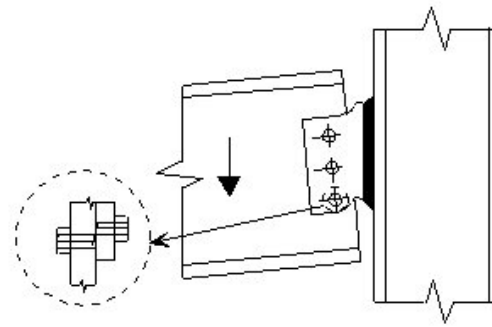
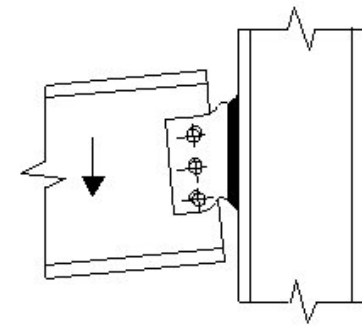


Figure 5 Transfer of tensile force via bending of the column flange in a bolted connection

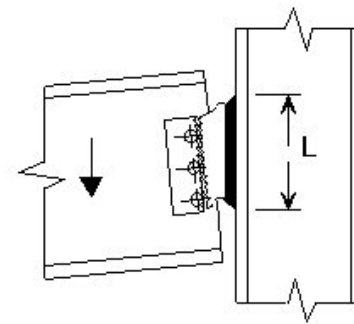
Beam-to-column connections



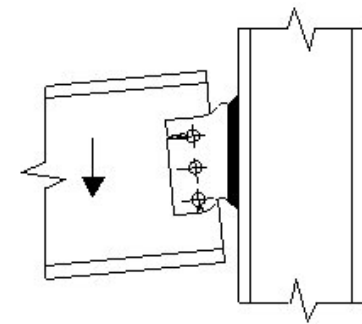
(a) Bolt fracture



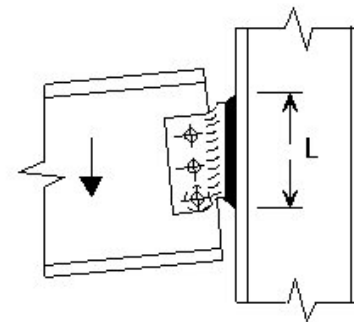
(b) Bearing yielding



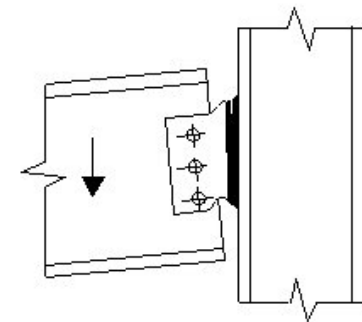
(c) Net-section fracture



(d) Edge distance fracture



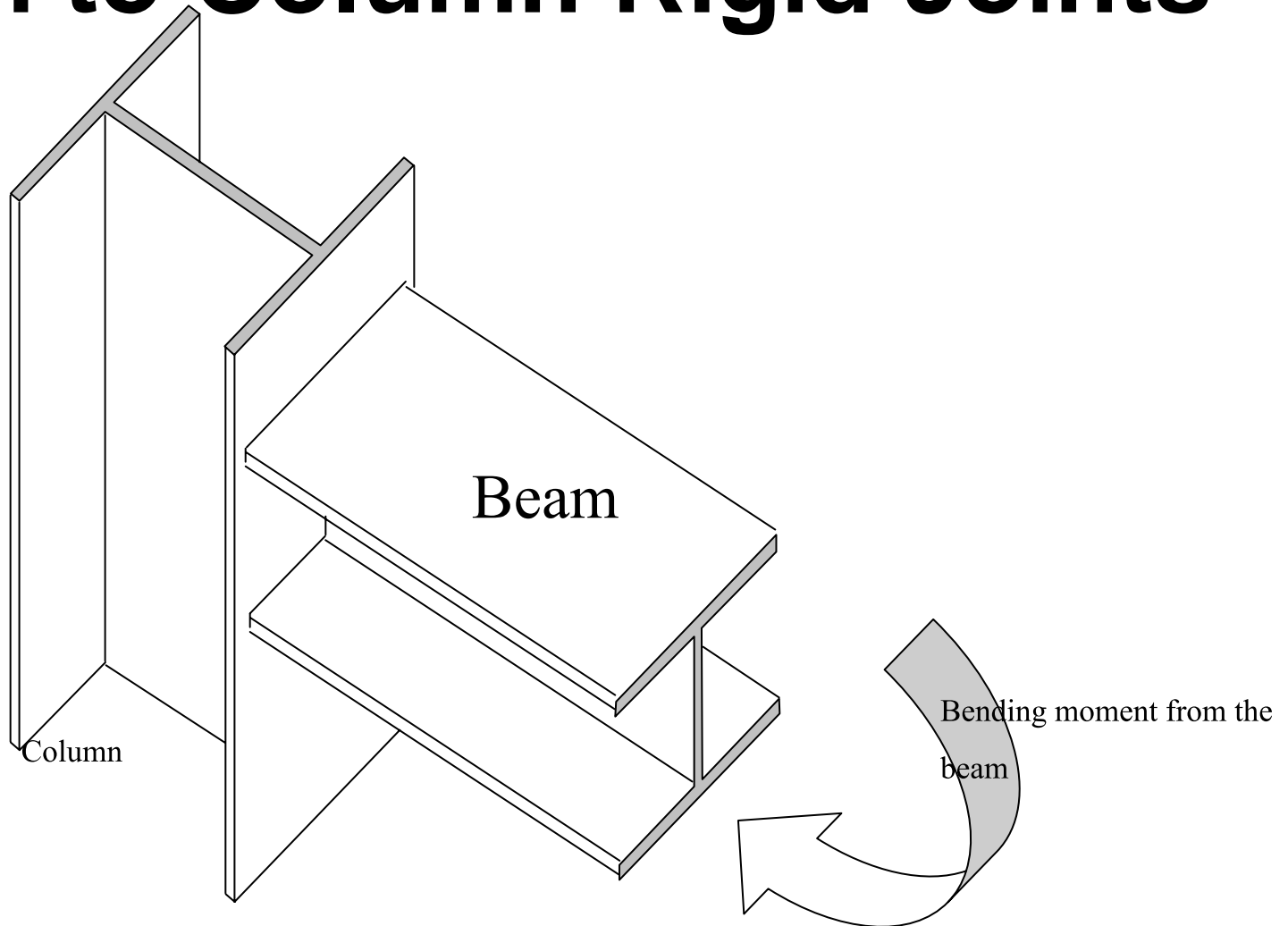
(e) Plate yielding



(f) Weld fracture

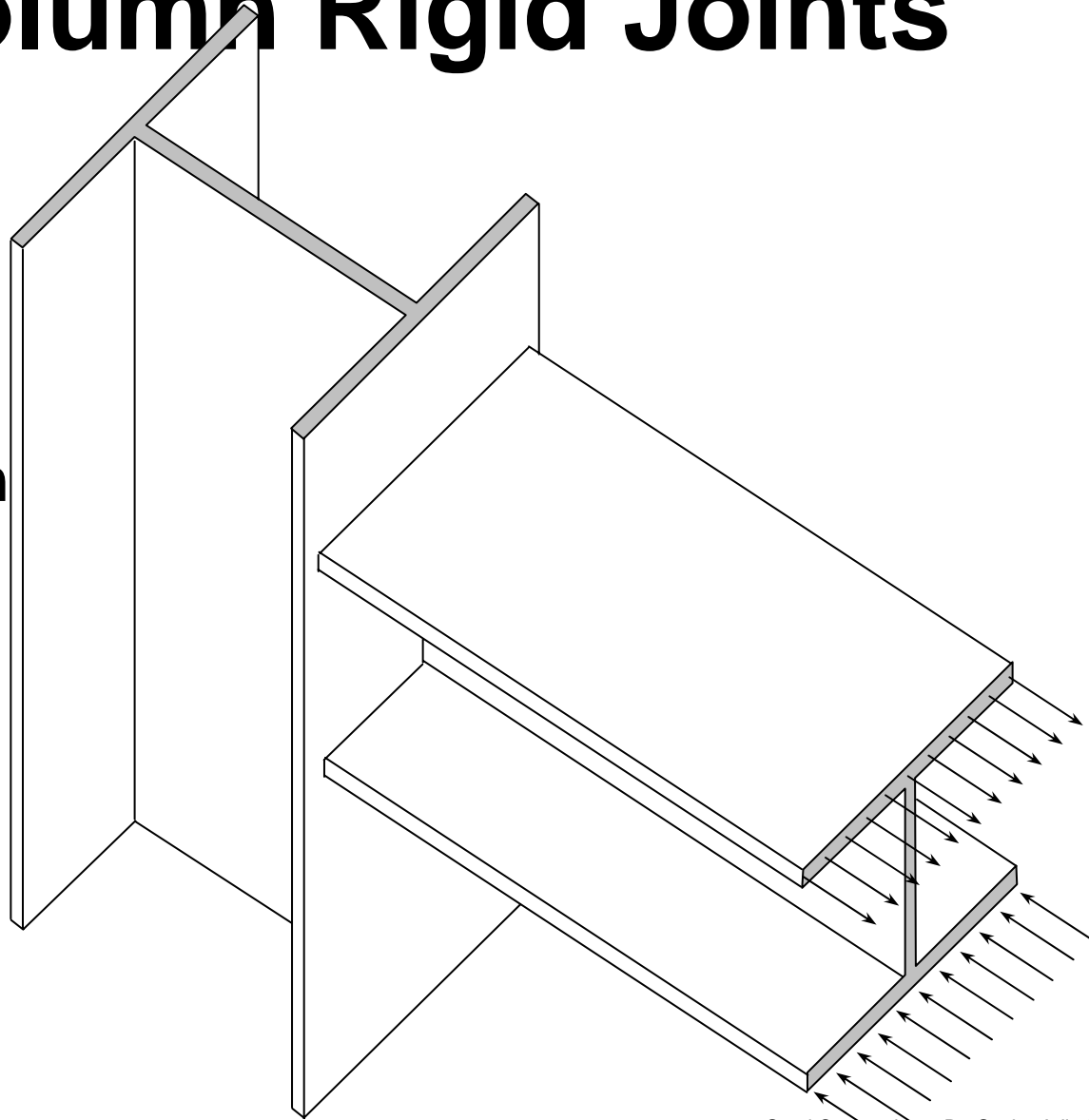
Figure 5 Modes of failure for fin plates

Beam to Column Rigid Joints



Beam to Column Rigid Joints

- The bending moment of the beam is primarily taken by the flanges in the form of tension and compression forces



Beam to Column Rigid Joints

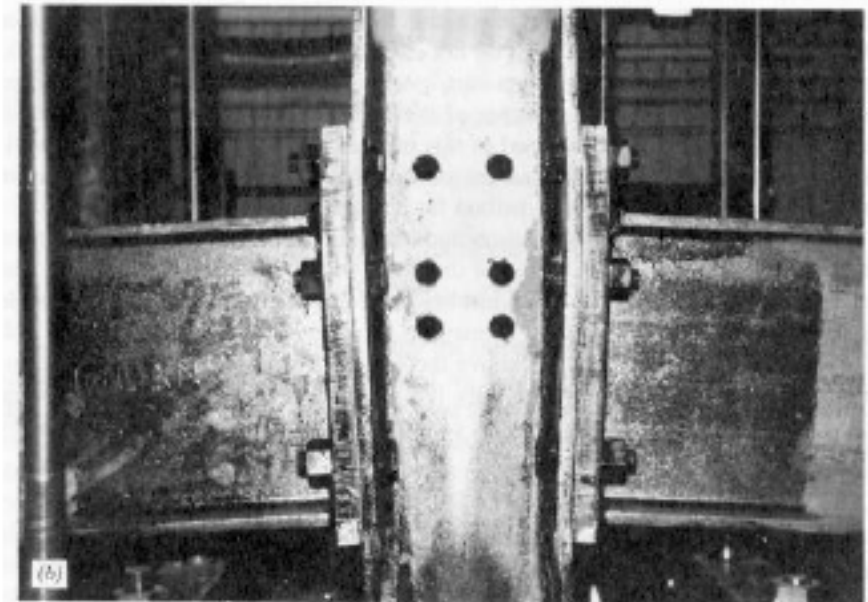
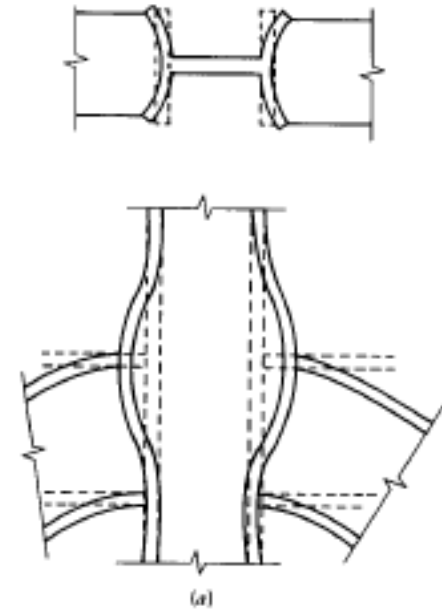


Fig. 18.19. Deformation of column in moment resistant connection. (a) Distortion of unstiffened column. (b) Web crippling in beam-to-column connection. (Courtesy of British Steel Corp.)

Beam to Column Rigid Joints

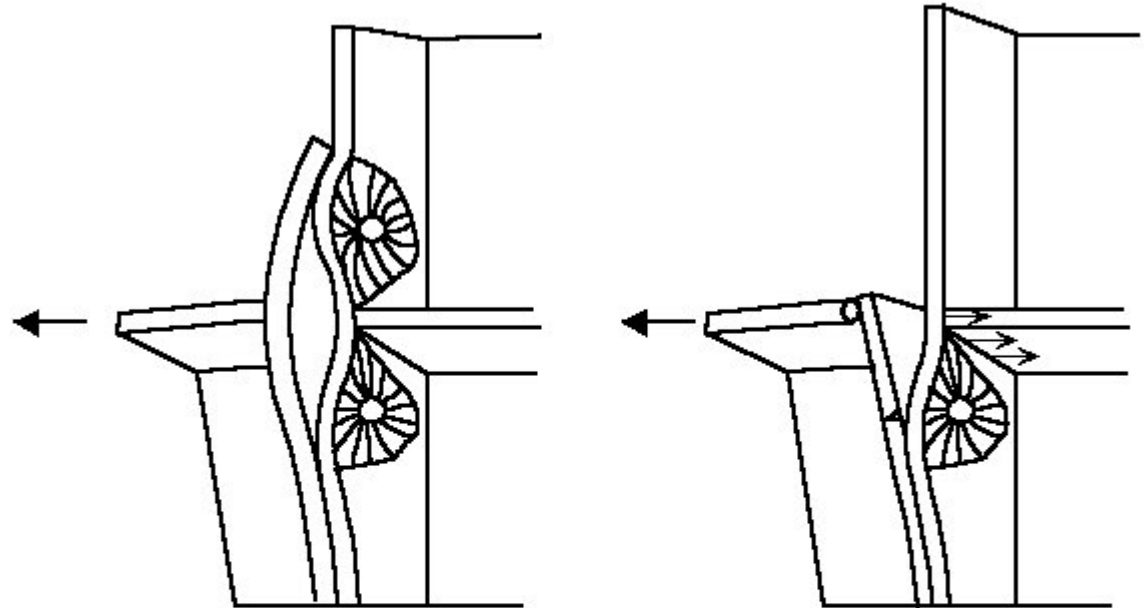


Figure 12 Strengthening the column flange
with stiffening plates

Beam-to-column connections

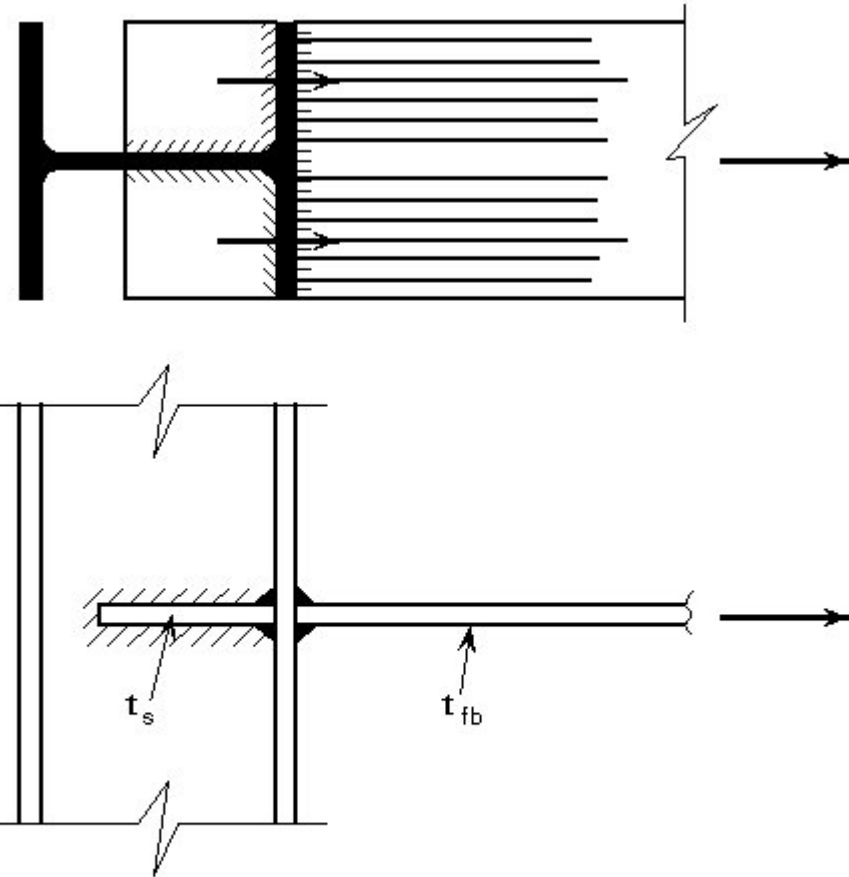
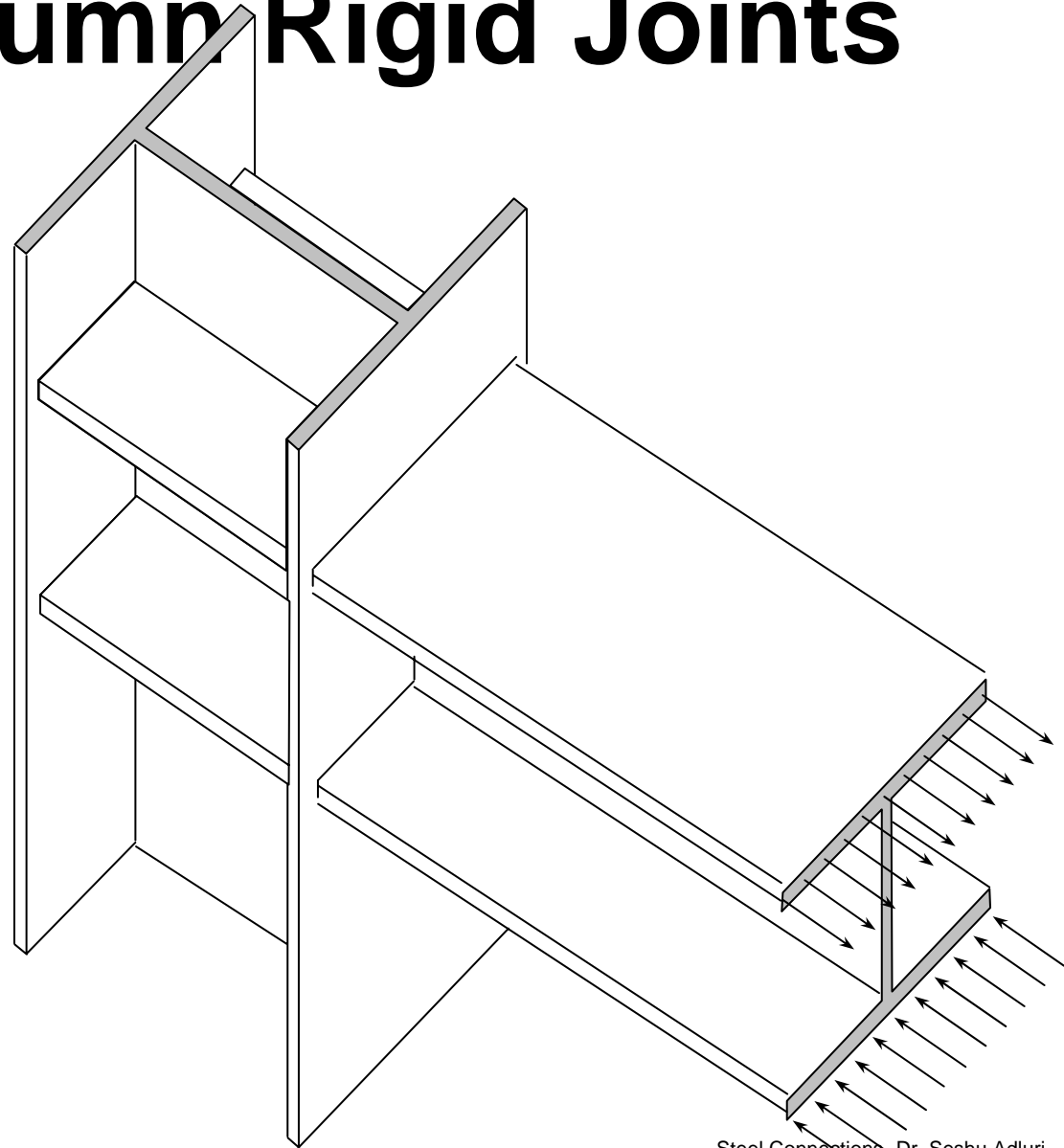


Figure 4 Stiffening plates to strengthen the column flange

Beam to Column Rigid Joints

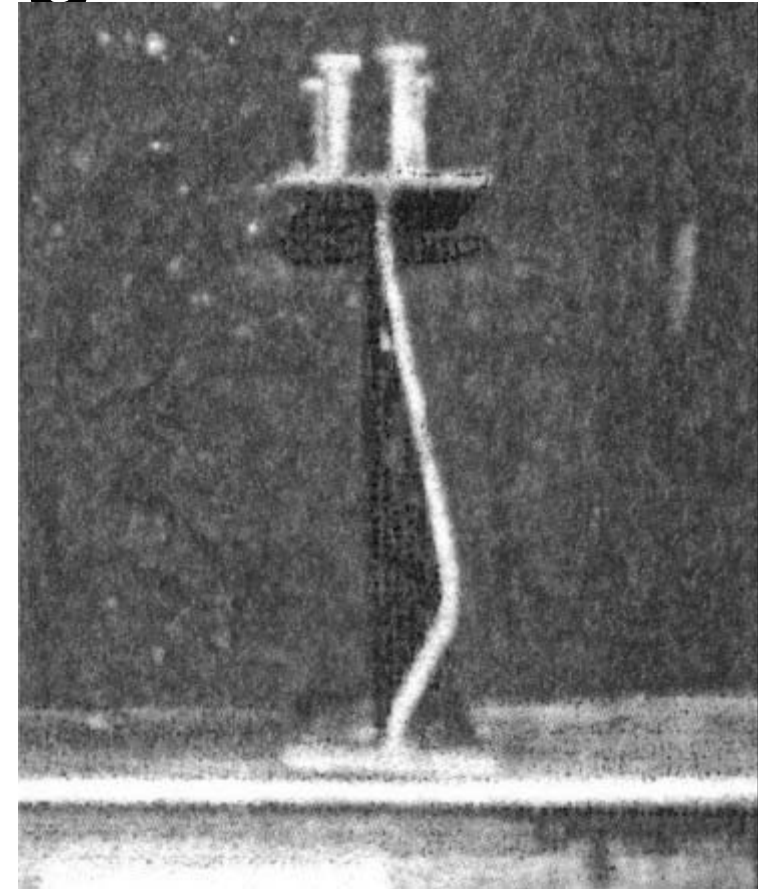
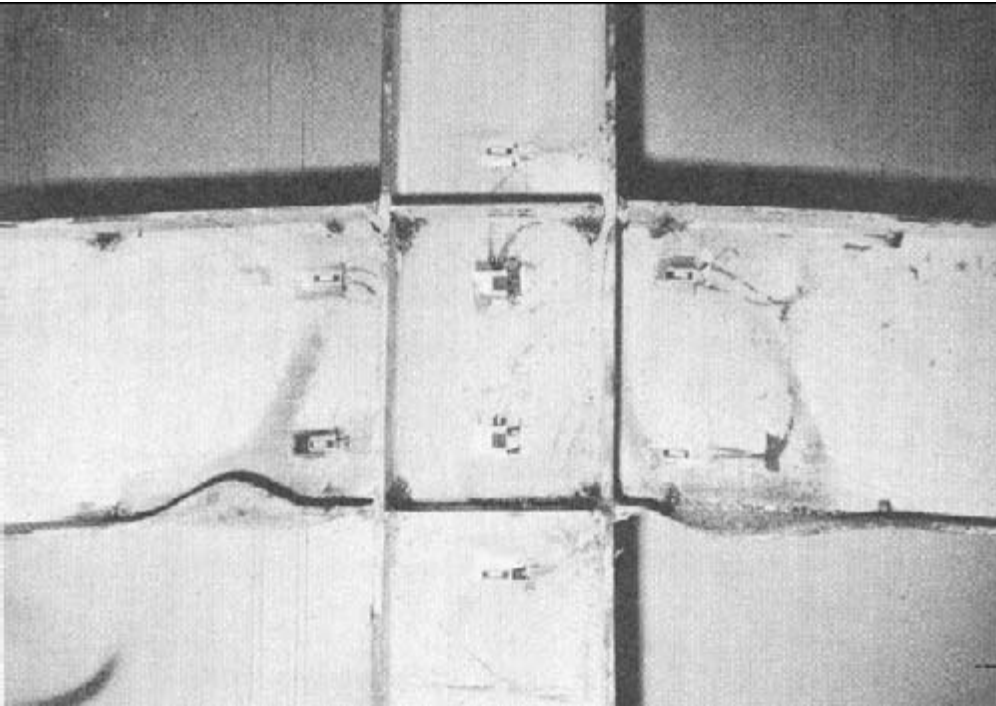
- Stiffener plates are used to 'shore up' the column flanges against the forces transmitted by the beam flanges. The stiffeners may be full length or may extend only part of the column web depth.



Beam plate buckling



Beam flange local buckling

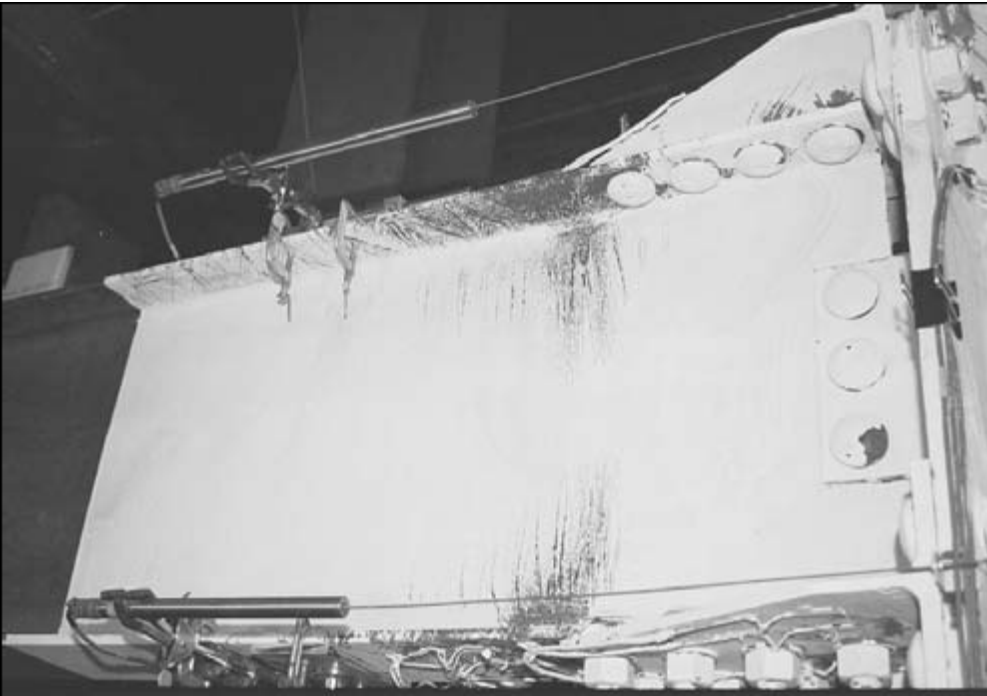


Beam web crippling

Beam plate buckling



Beam web local yielding



Beam web buckling (look closely)

Concentrated forces on webs

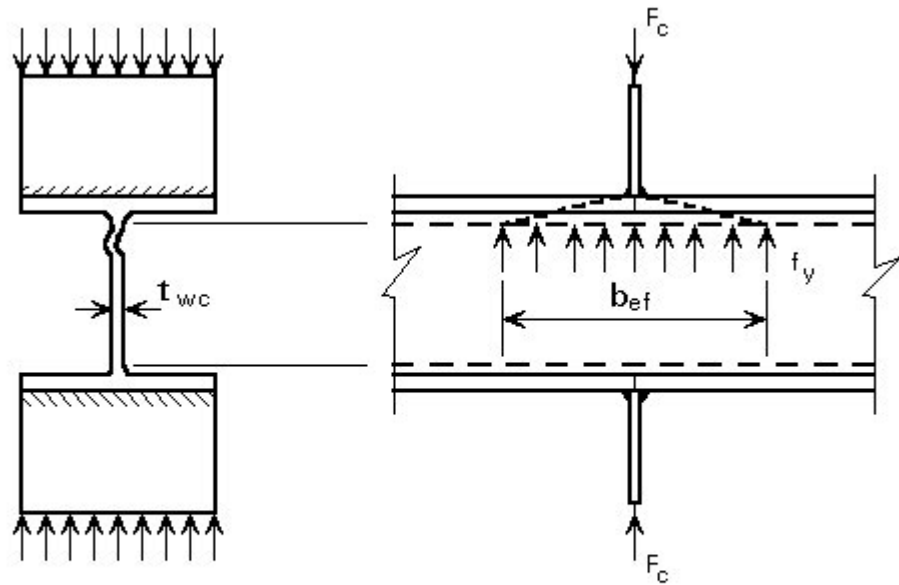
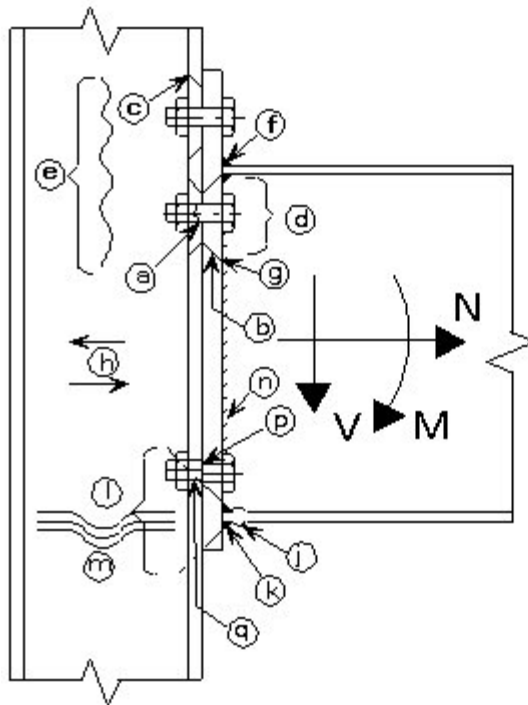


Figure 17 Tests for the determination of b_{ef} in the compression zone

Beam to Column Rigid Joints



Zone	Ref	Checklist item
Tension	a	Bolt tension
	b	End plate bending
	c	Column flange bending
	d	Beam web tension
	e	Column web tension
	f	Flange to end plate weld
	g	Web to end plate weld
Horizontal shear	h	Column web shear
Compression	j	Beam flange compression
	k	Beam flange weld
	l	Column web bearing
	m	Column web buckling
Vertical shear	n	Web to end plate weld
	p	Bolt shear
	q	Bolt bearing

Figure 3 Critical components in moment connection

Beam to Column Semi-Rigid Joints

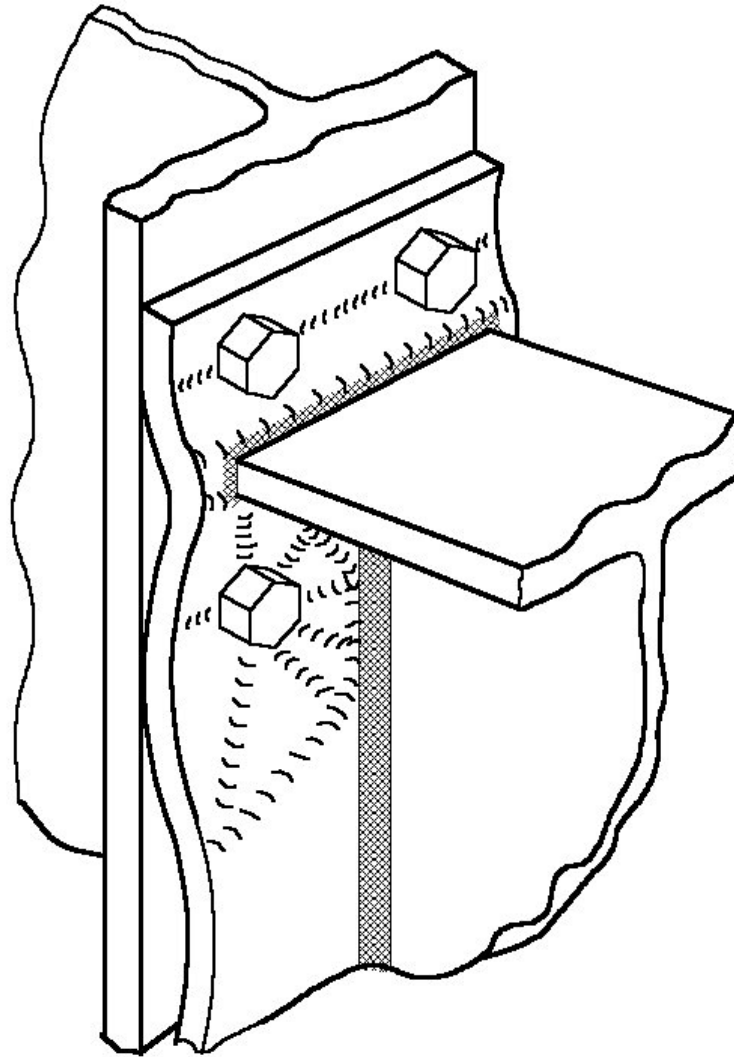


Figure 4 Controlled yielding of end plate protects brittle components (bolts & welds) from overloading

Beam to Column Rigid Joints

- Stiffener plates are used to 'shore up' the column flanges against the forces transmitted by the beam flanges. The stiffeners may be full length or may extend only part of the column web depth.

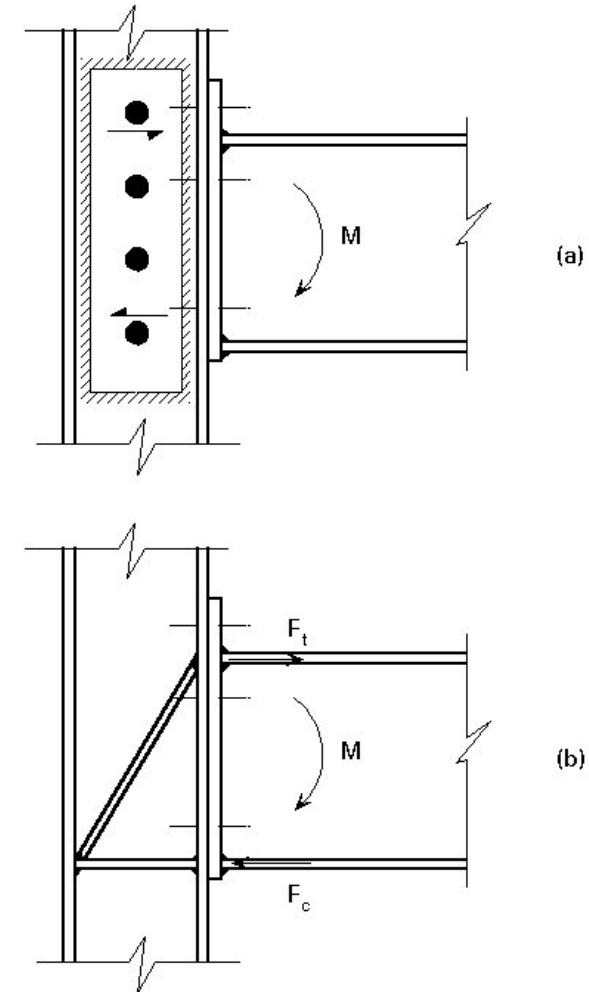
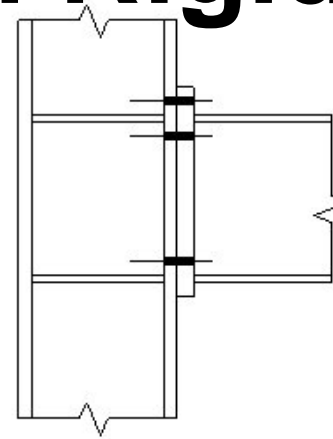
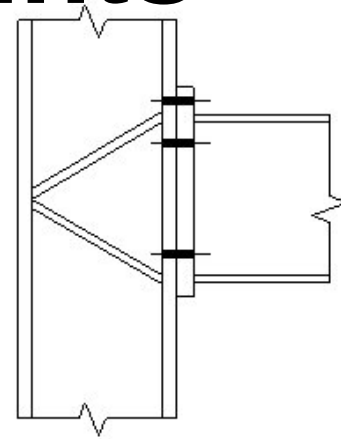


Figure 21 Strengthening of the column web in the shear zone

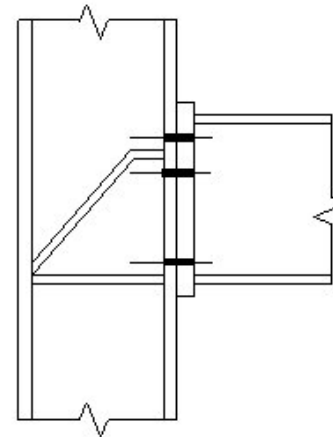
Beam to Column Rigid Joints



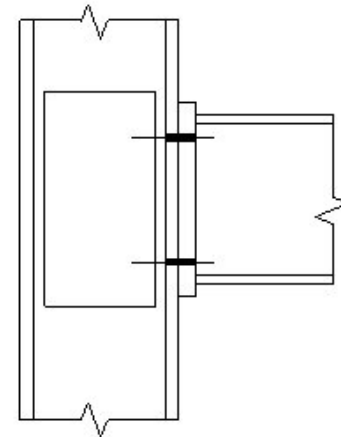
(a) Conventional horizontal stiffeners



(b) 'K' pattern



(c) 'Morris' stiffener
(with compression stiffener)

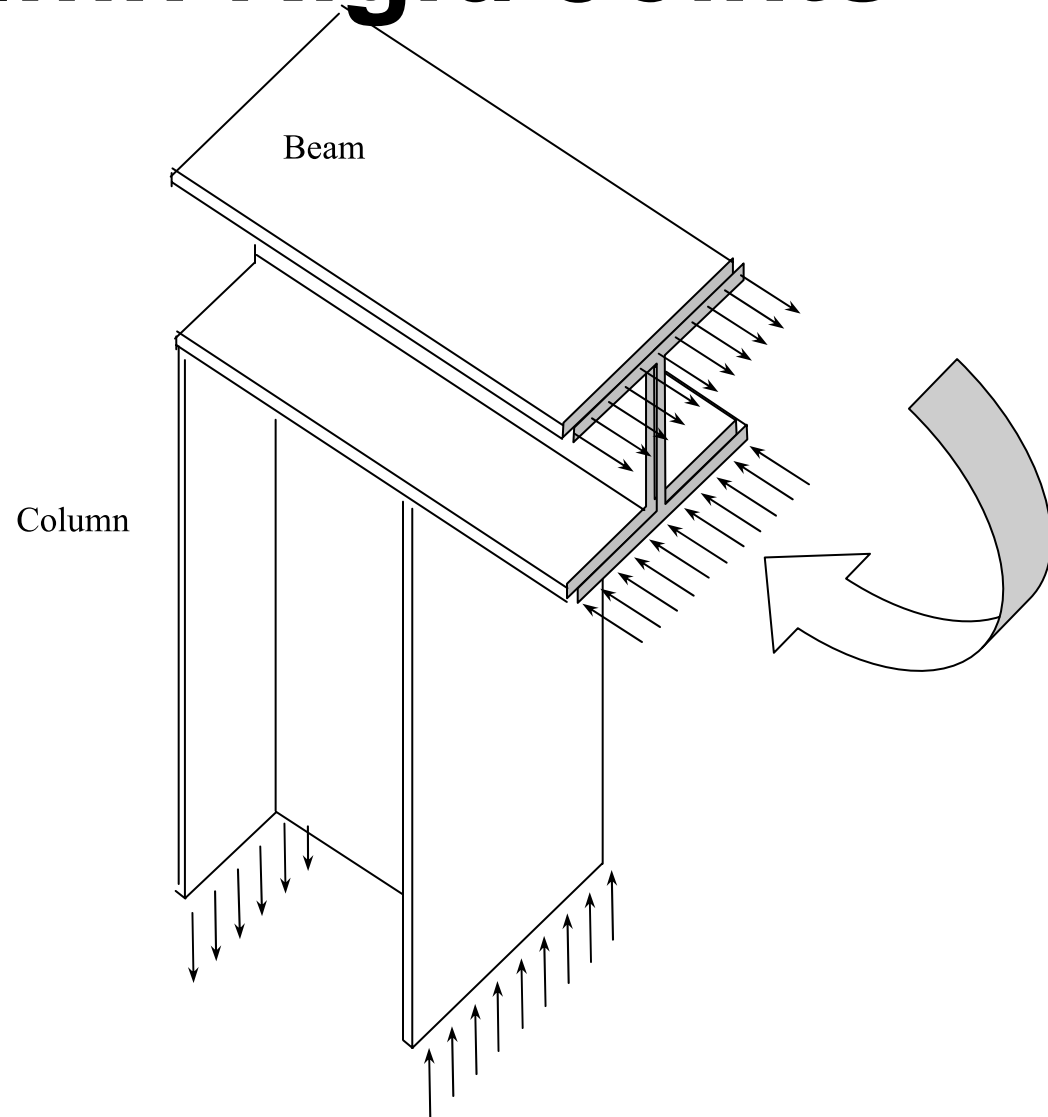


(d) Supplementary web plates

Figure 4 Stiffening/strengthening possibilities

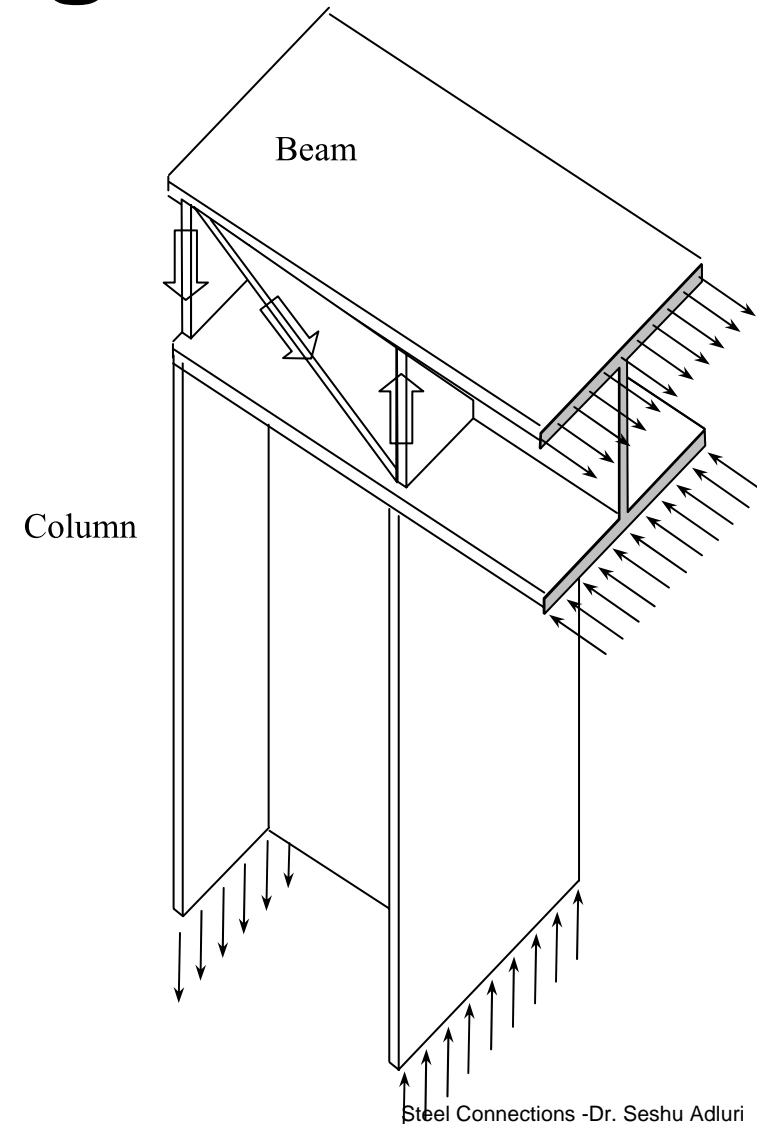
Beam to Column Rigid Joints

- The bending moment of the beam is primarily taken by the flanges in the form of tension and compression forces
- The bending moment of the column is also resolved as a force couple

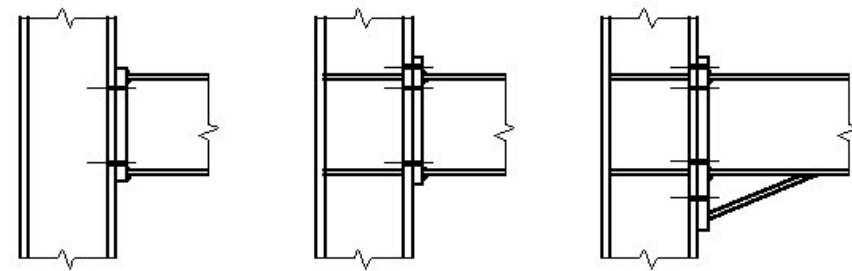


Beam to Column Rigid Joints

- Stiffeners help in distributing the forces in the connection zone and in avoiding local rupture, crushing or buckling of the beam web.



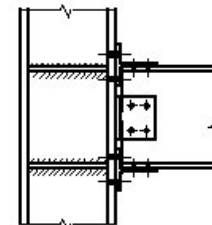
Beam to Column Rigid Joints



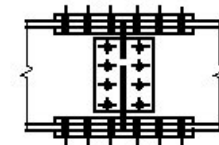
(a) Flush end plate

(b) Extended end plate

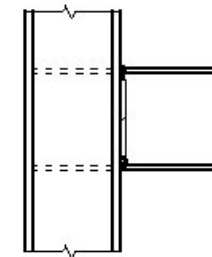
(c) Haunched end plate



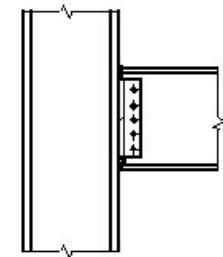
(d) T-sections with preloaded bolts to flanges



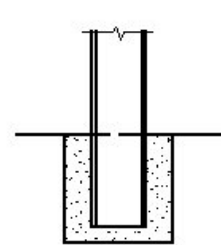
(e) Cover plate splice



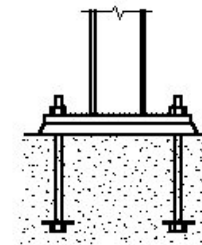
(f) All welded



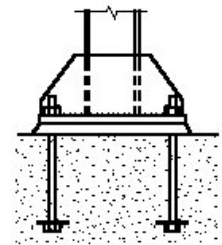
(g) Hybrid (welded flange/bolted web) site connection



(h) Pocketed base



(j) Unstiffened base plate

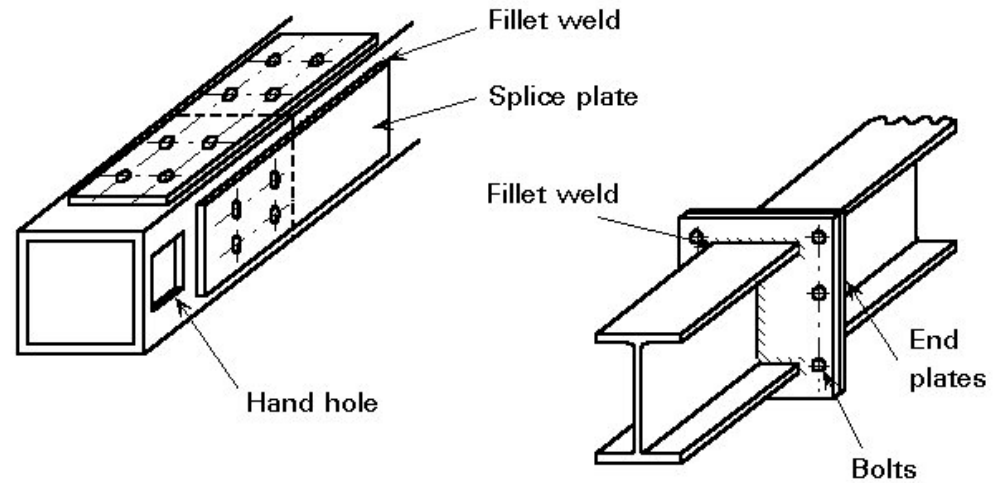


(k) Stiffened base plate

Figure 2 Typical moment connections

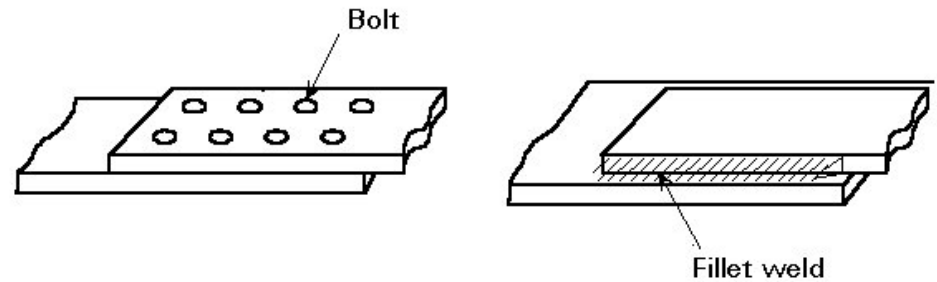


Beam Splices



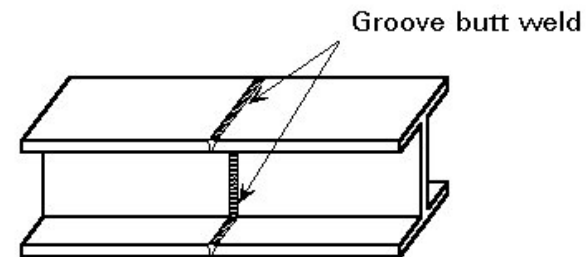
(a) Splice plated

(b) End plated



(c) Overlapped

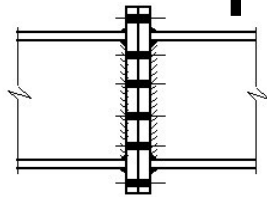
Fillet weld



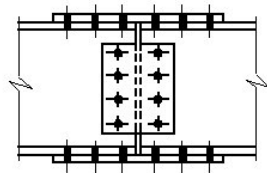
(d) Butt welded

Figure 1 Types of splice arrangements

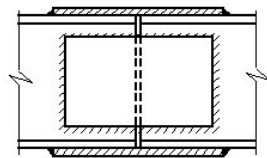
Beam Splices



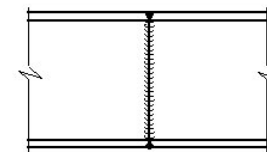
(a) End plated



(b) Bolted cover plates



(c) Fully welded one sided cover plates



(d) Fully butted welded

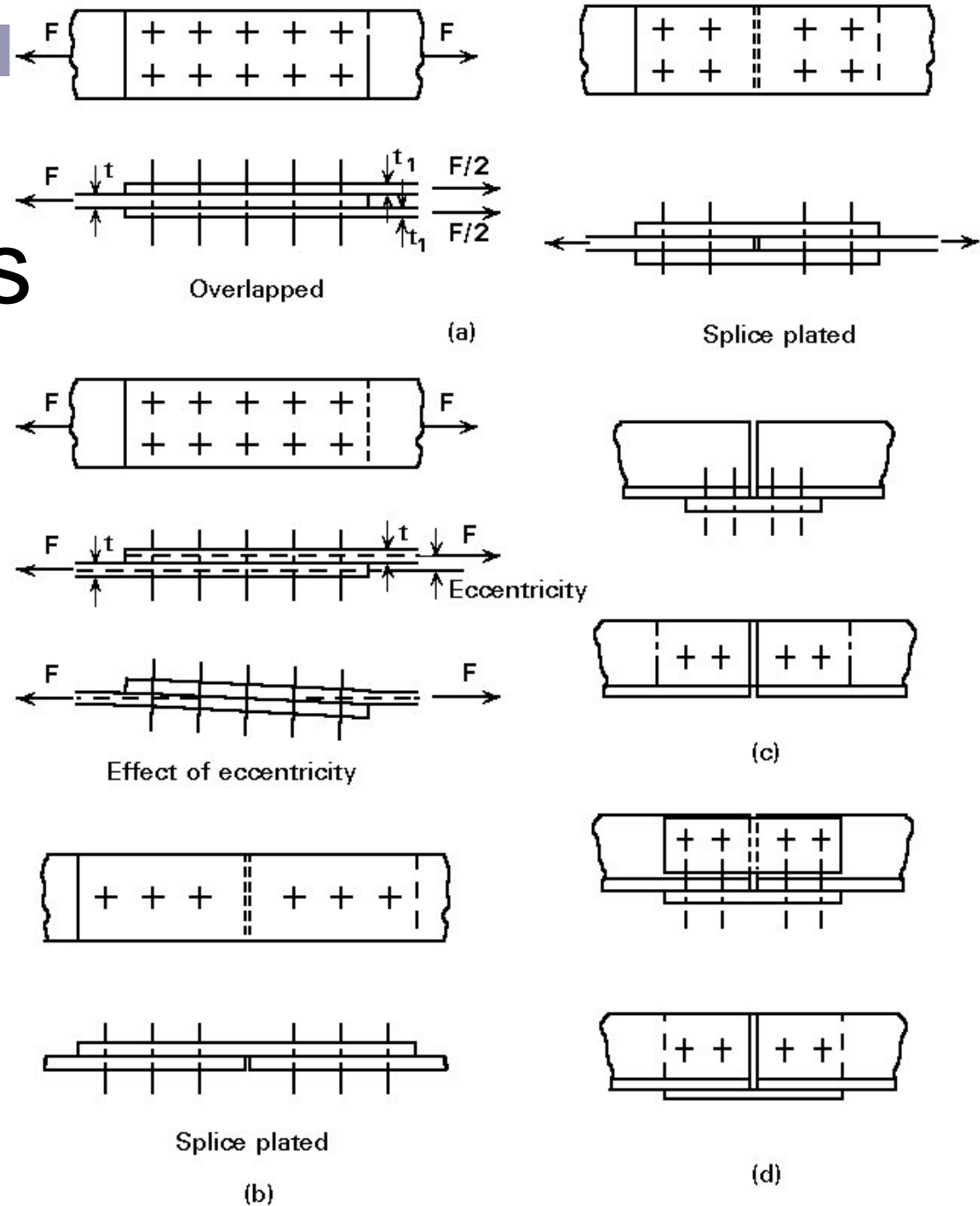


Figure 2 Bolted splices

Figure 5 Splices in beams

Column Splices

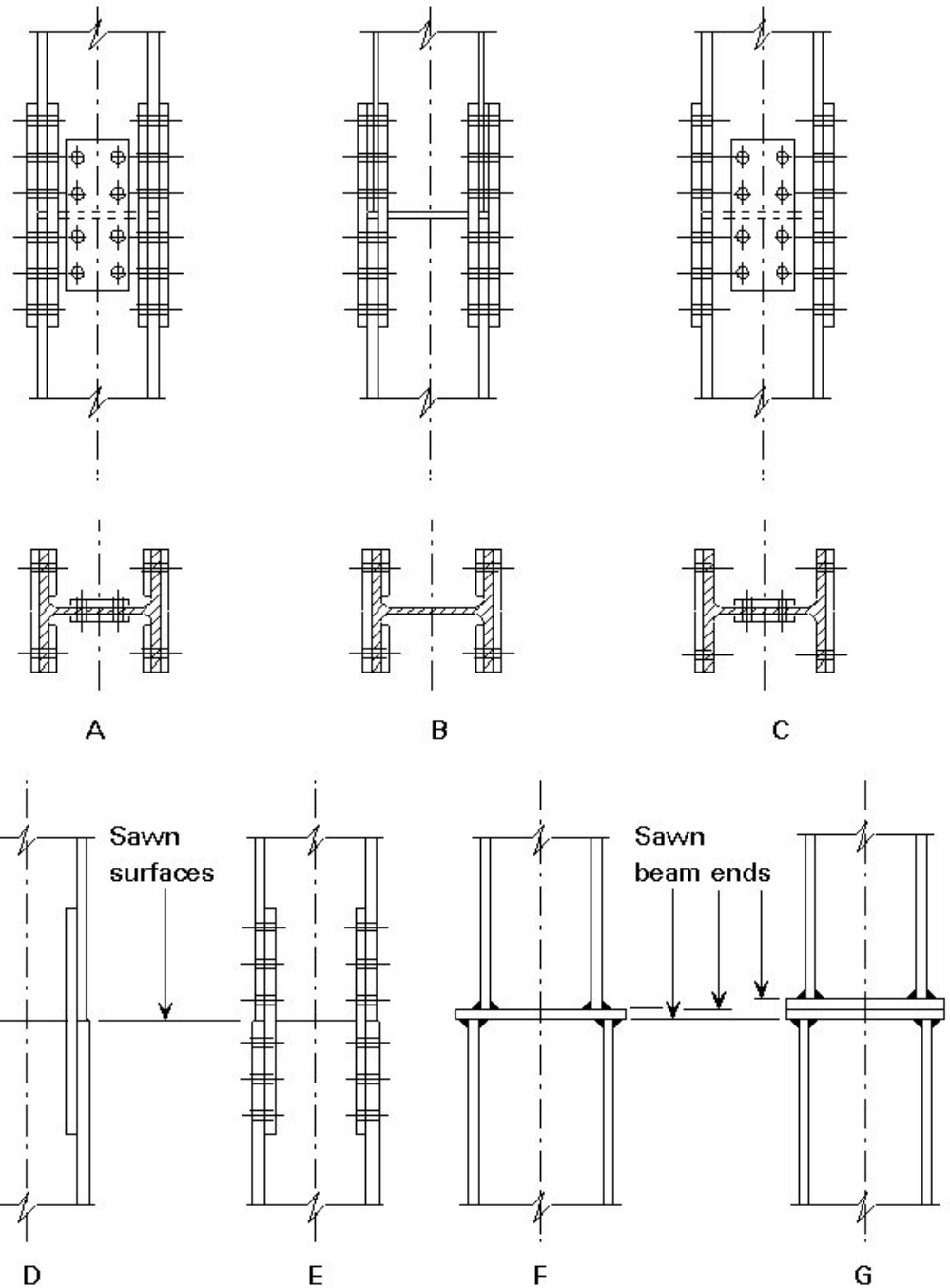


Figure 6 Column splices

Column Splices

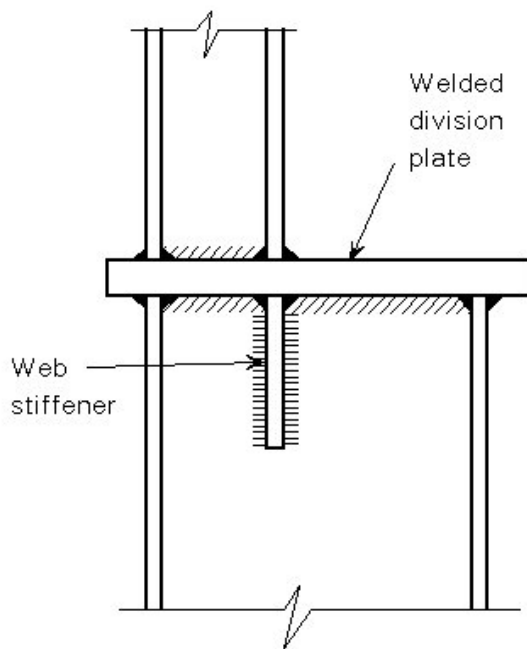


Figure 4 Welded column splice for sections of differing serial size

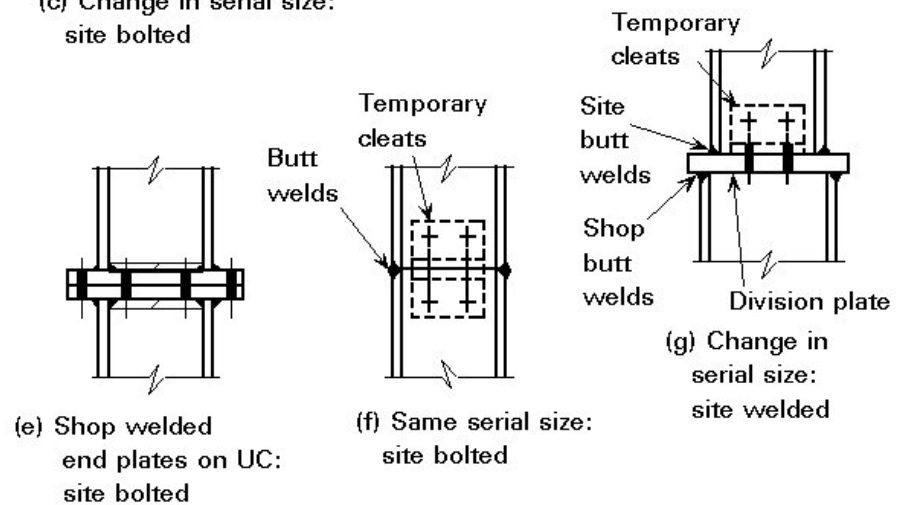
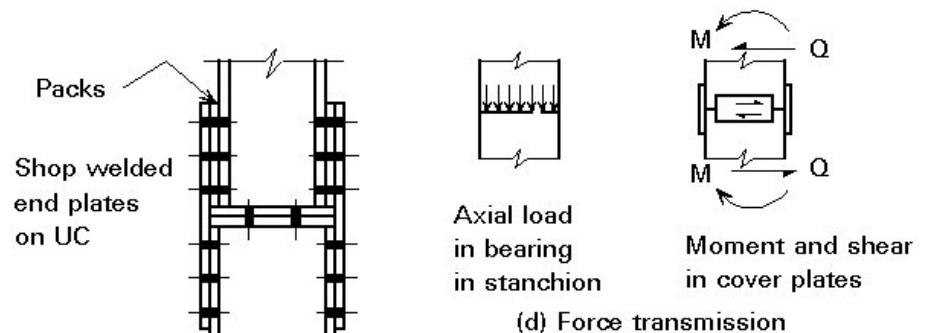
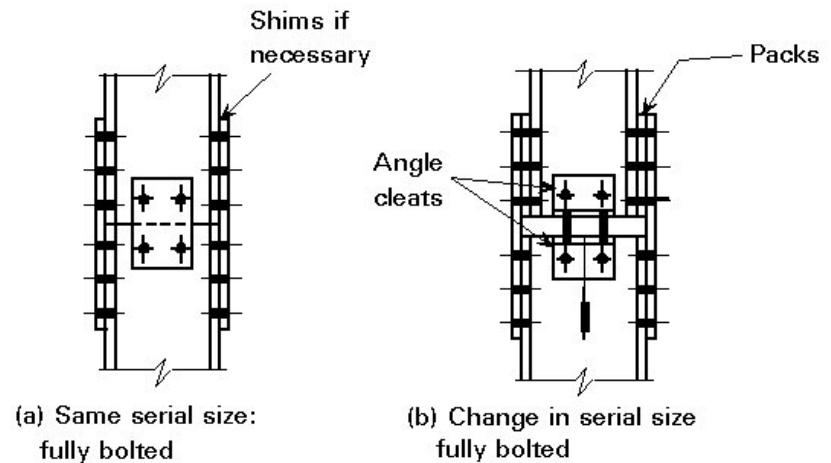


Figure 3 Column splices

Connections for Bents (Eaves)

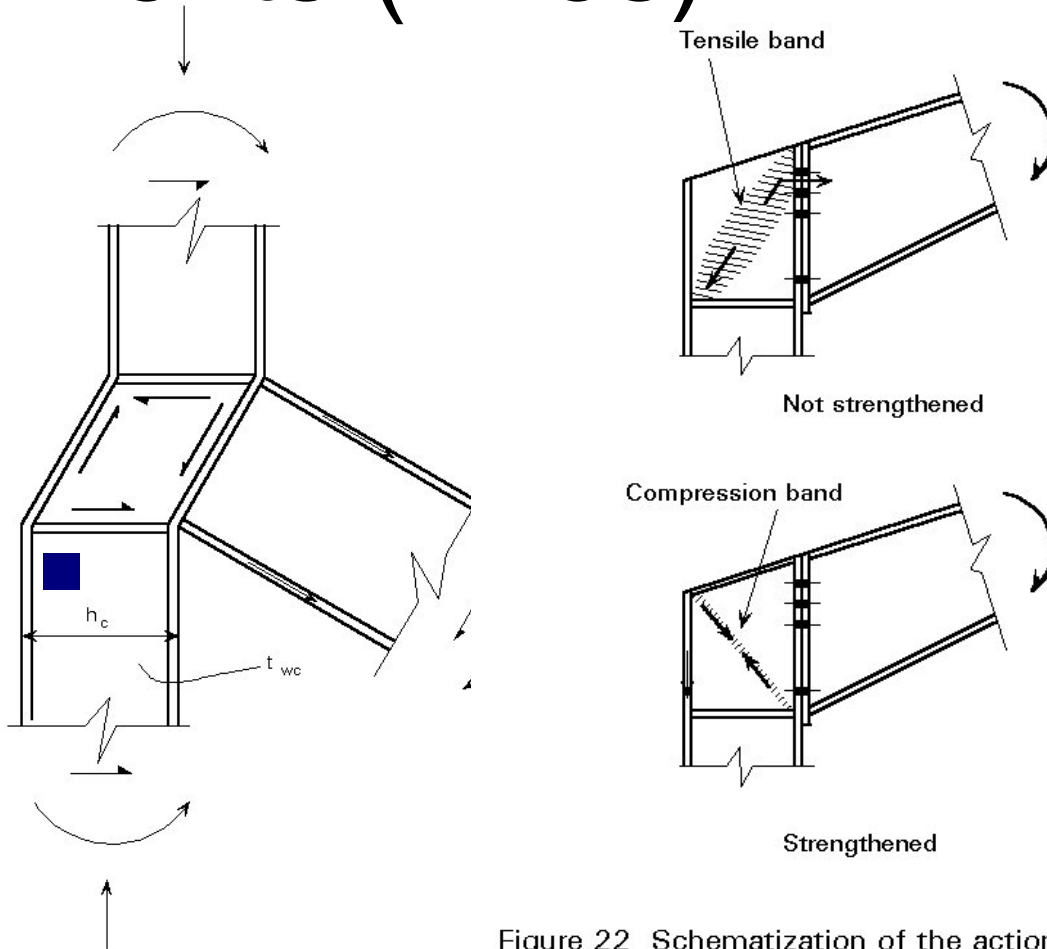


Figure 20 Shear panel of a T-connection

Figure 22 Schematization of the action in the shear zone with tension and compression

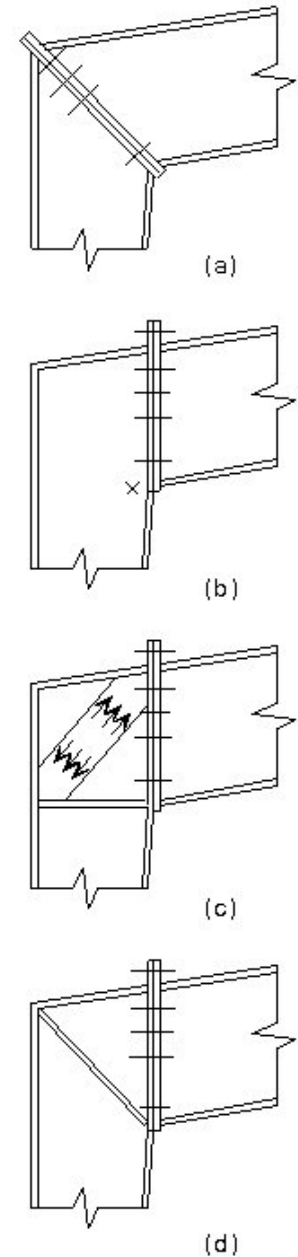
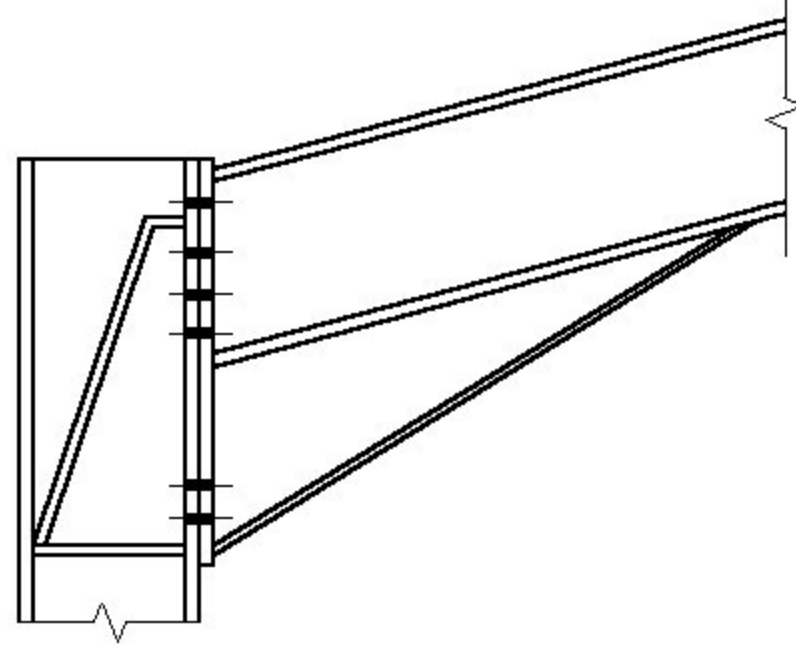
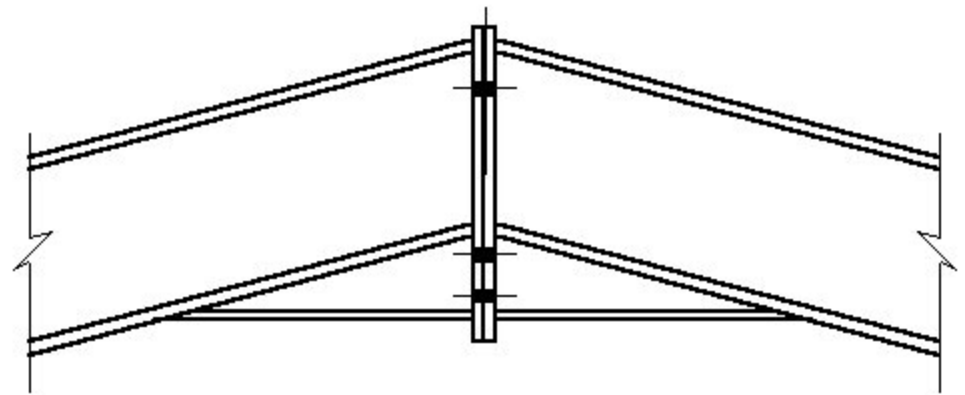


Figure 12 Types of eaves connection

Connections for Bents (Eaves)



(a) Eaves connection



(b) Apex connection

Figure 6 Portal frame connections

Connections in frames

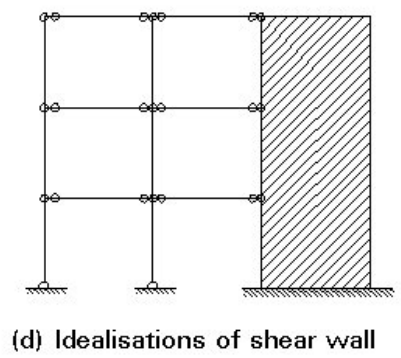
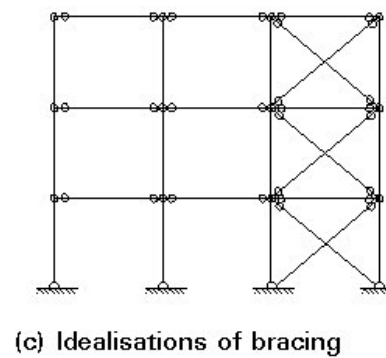
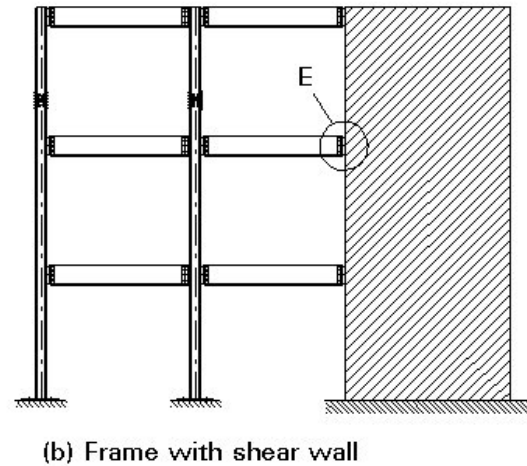
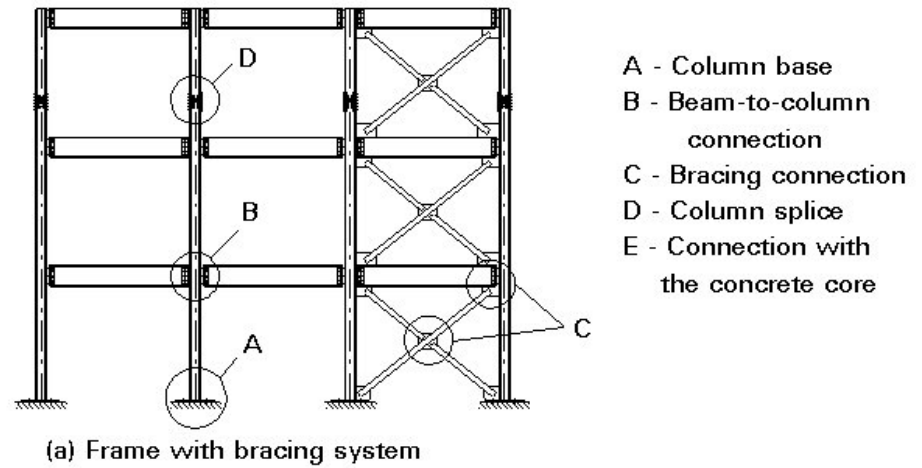


Figure 1 Simple frames

Bracing Connections in frames

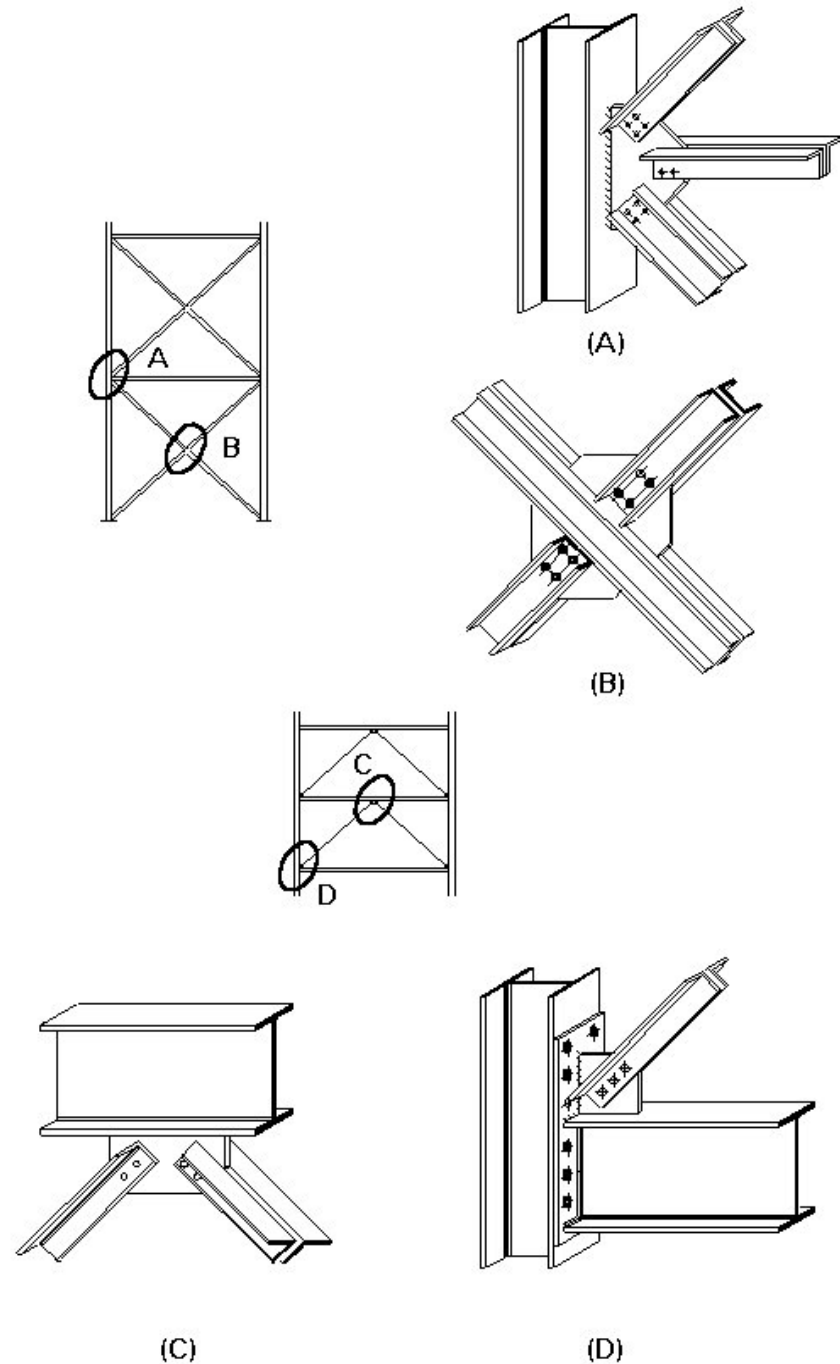


Figure 7 Bracing connections

Column Bases

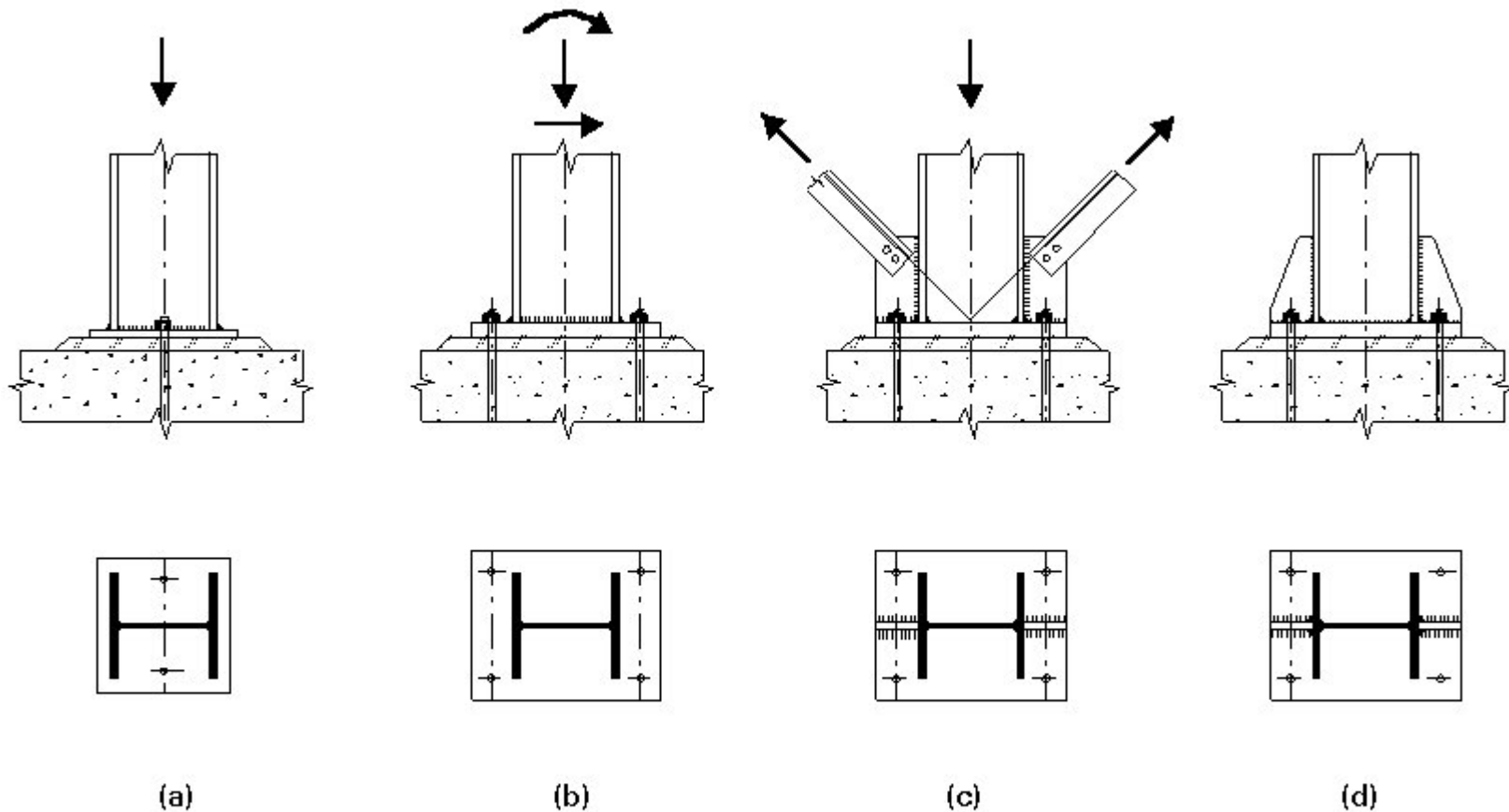


Figure 8 Column bases

Column Base Anchors

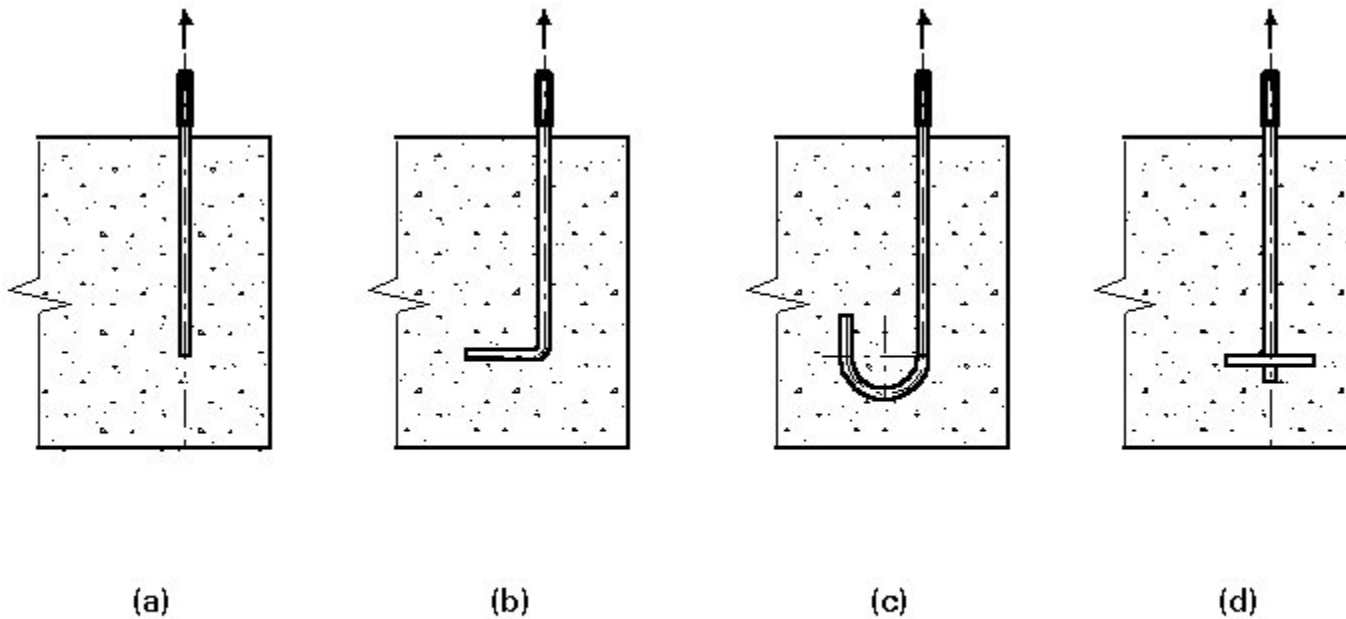


Figure 9 Anchorages of holding down bolts

Beam-to-wall connections

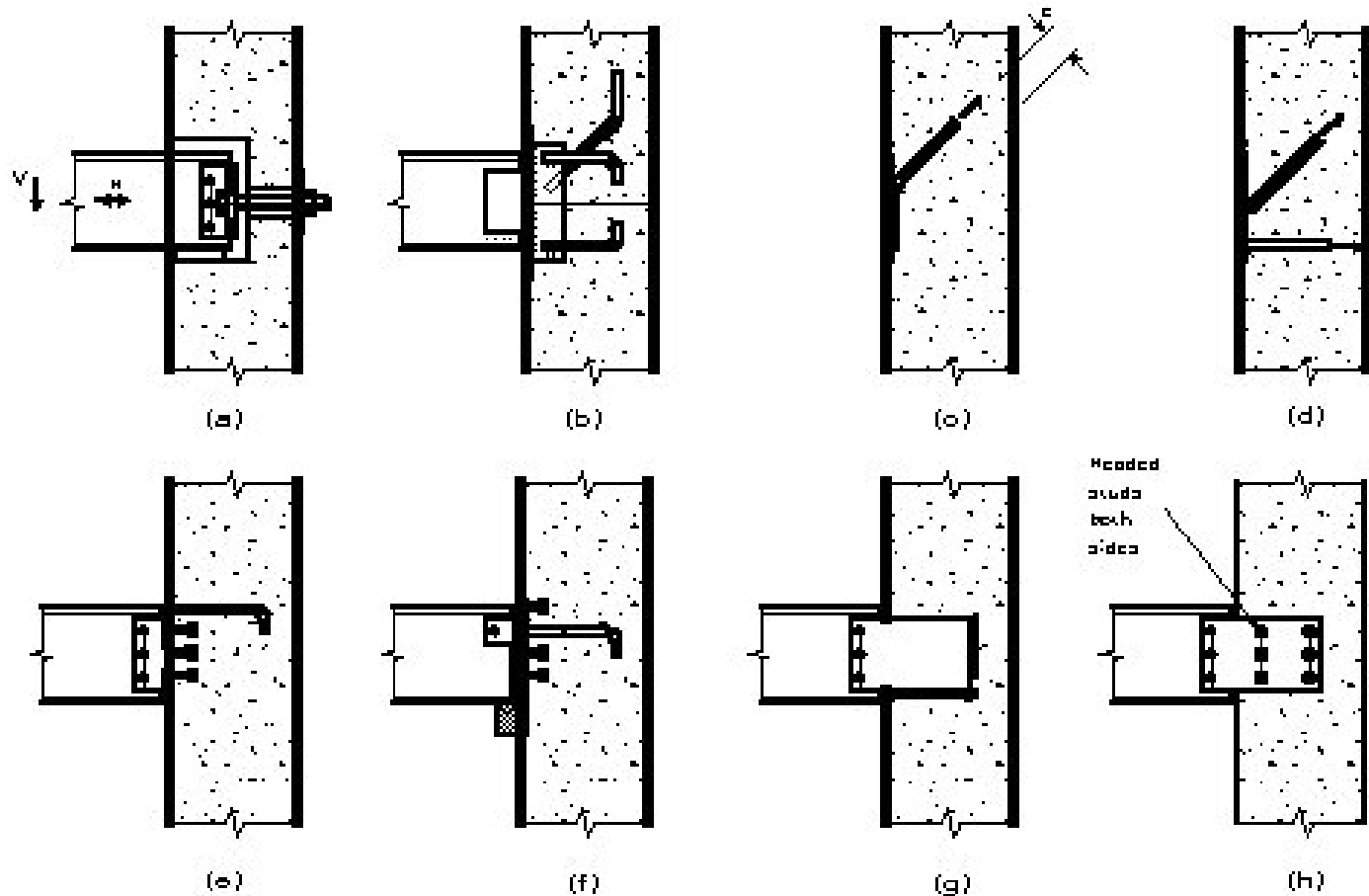


Figure 10 Beam-to-concrete wall connections

Beam-to-wall connections

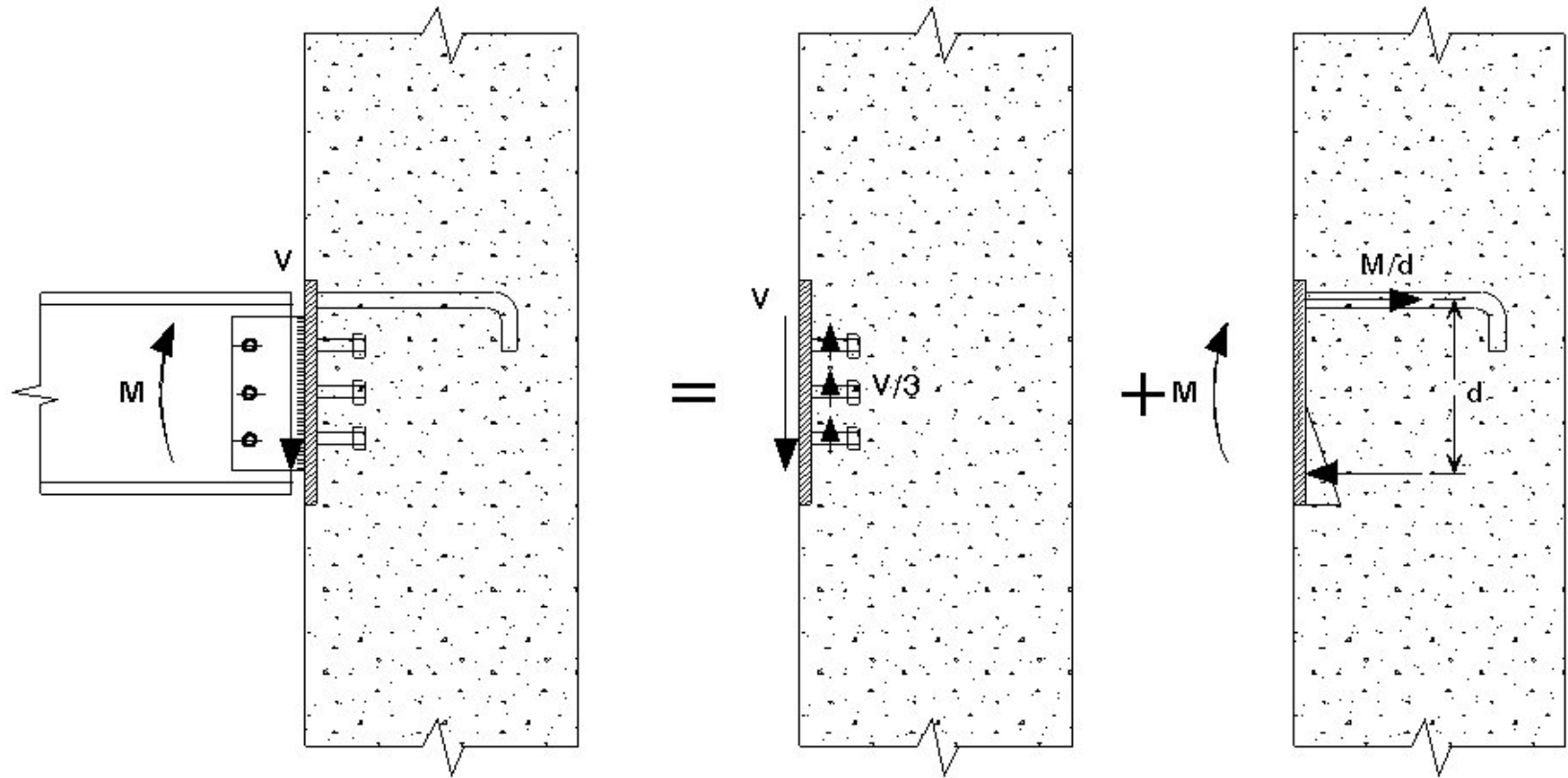


Figure 11 Design model for connection of figure 10(e) subject to shear and moment

References

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