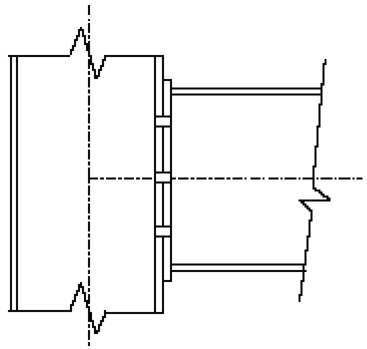
STRUCTURAL JOINTS CONNECTING H OR I SECTIONS

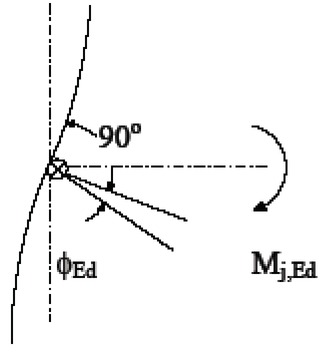
JOINT MODELLING

- Detailed rules are given to determine the structural properties of beam-to-column joints and base-plate joints for I and H section based on **component method**
- Component method
  - Identification of the active components
  - Evaluation of the stiffness and resistance characteristics for each individual basic component
  - Assembly of the components for evaluating the response of the whole joint

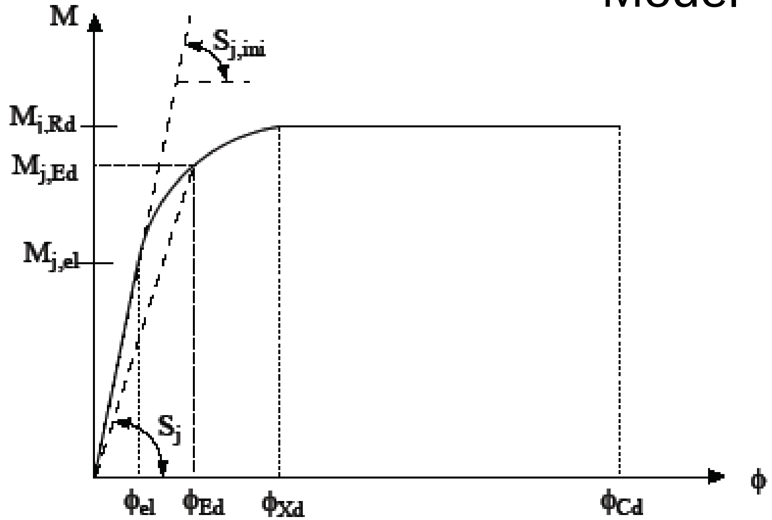
Design moment-rotation characteristic



Joint



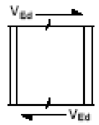
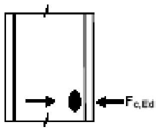
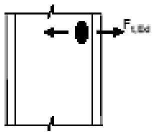
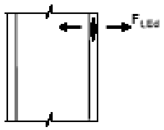
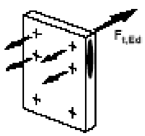
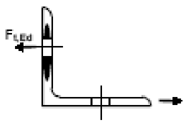
Model

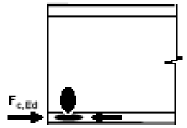
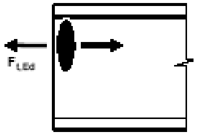
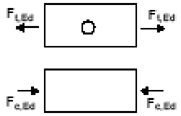
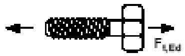
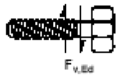
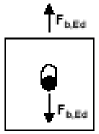


Design moment-rotation characteristic

Basic components of joint

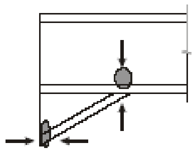
Table 6.1: Basic joint components

	Component		Reference to application rules: Design Resistance	Stiffness coefficient	Rotation capacity
1	Column web panel in shear		6.2.6.1	6.3.2	6.4.2 and 6.4.3
2	Column web In transverse compression		6.2.6.2	6.3.2	6.4.2 and 6.4.3
3	Column web in transverse tension		6.2.6.3	6.3.2	6.4.2 and 6.4.3
4	Column flange in bending		6.2.6.4	6.3.2	6.4.2 and 6.4.3
5	End-plate in bending		6.2.6.5	6.3.2	6.4.2
6	Flange cleat in bending		6.2.6.6	6.3.2	6.4.2

	Component		Reference to application rules: Design Resistance	Stiffness coefficient	Rotation capacity
7	Beam or column flange and web in compression		6.2.6.7	6.3.2	*)
8	Beam web in tension		6.2.6.8	6.3.2	*)
9	Plate in tension or compression		in tension: - EN 1993-1-1 in compression: - EN 1993-1-1	6.3.2	*)
10	Bolts in tension		With column flange: - 6.2.6.4 with end-plate: - 6.2.6.5 with flange cleat: - 6.2.6.6	6.3.2	6.4.7
11	Bolts in shear		3.6	6.3.2	6.4.2
12	Bolts in bearing (on beam flange, column flange, end-plate or cleat)		3.6	6.3.2	*)

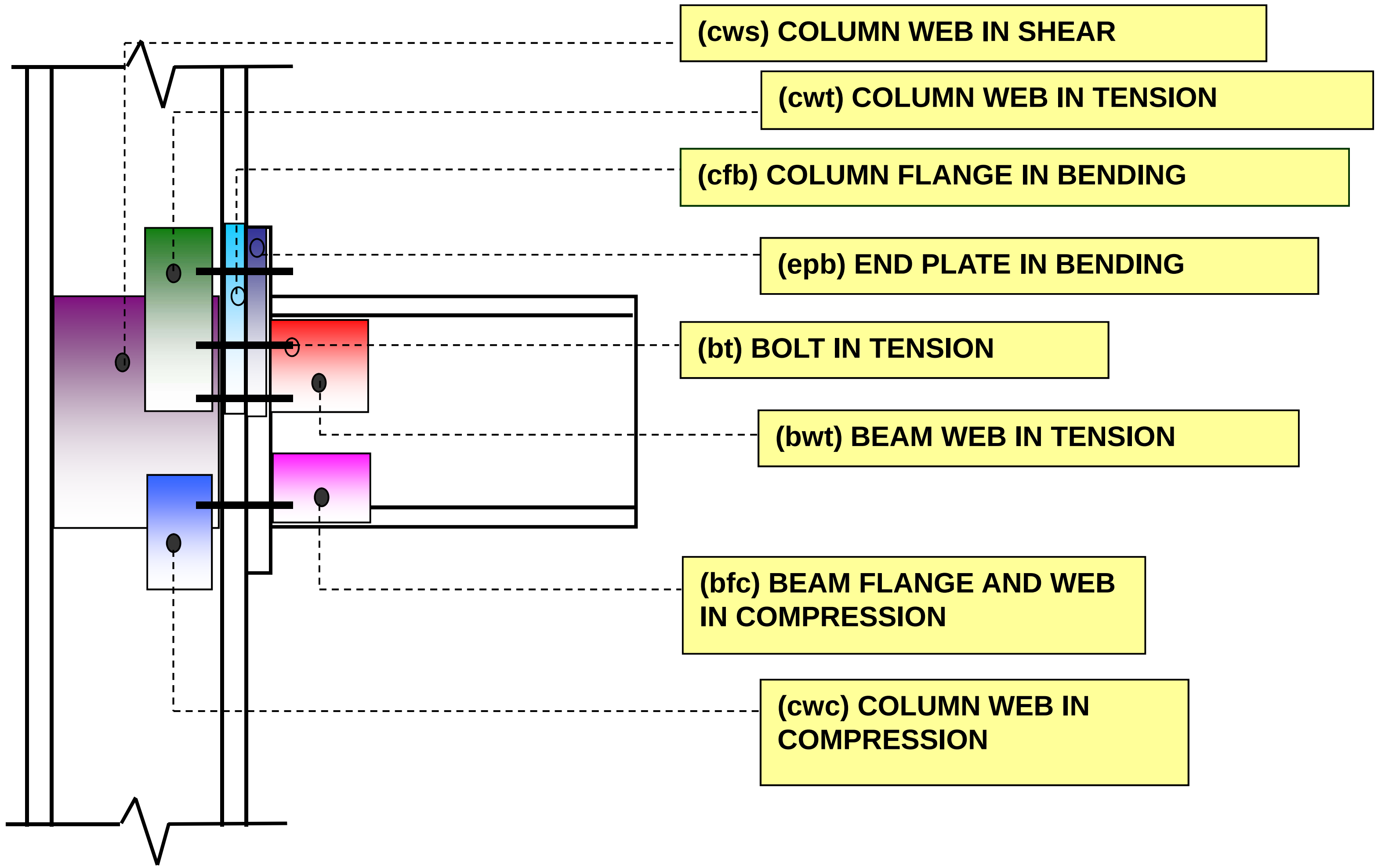
*) No information available in this part.

Basic components of joint

Component			Reference to application rules		
			Design Resistance	Stiffness coefficient	Rotation capacity
13	Concrete in compression including grout		6.2.6.9	6.3.2	*)
14	Base plate in bending under compression		6.2.6.10	6.3.2	*)
15	Base plate in bending under tension		6.2.6.11	6.3.2	*)
16	Anchor bolts in tension		6.2.6.12	6.3.2	*)
17	Anchor bolts in shear		6.2.2	*)	*)
18	Anchor bolts in bearing		6.2.2	*)	*)
19	Welds		4	6.3.2	*)
20	Haunched beam		6.2.6.7	6.3.2	*)

*) No information available in this part.

Basic Components in Extended Endplate Connection



Design Resistance

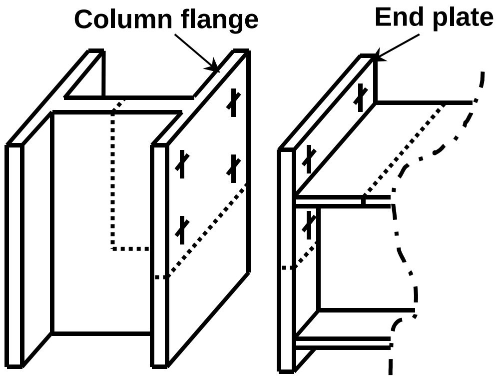
- Equivalent T-stub in tension

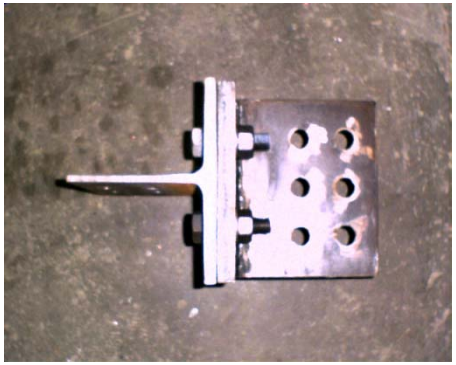
  a) Column flange in bending

  b) Endplate in bending

  c) Flange cleat in bending

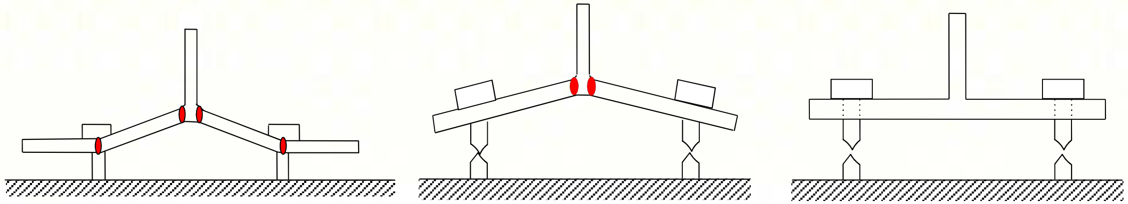
  d) Base plate in bending under tension





T-stub identification and orientation for extended end-plate joint

Failure modes for the T-stub flange

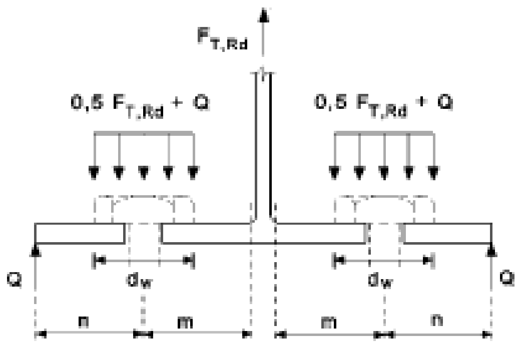


Mode 1   Mode 2   Mode 3

- Mode 1: Complete yielding of the flange
- Mode 2: Bolt failure with yielding of the flange
- Mode 3: Bolt failure

Design resistance of T-stub

	Prying forces may develop, i.e. $L_b \leq L_b^*$		No prying forces
Mode 1	Method 1	Method 2 (alternative method)	$F_{T,1\text{-}2,Rd} = \frac{2M_{pl,1,Rd}}{m}$
without backing plates	$F_{T,1,Rd} = \frac{4M_{pl,1,Rd}}{m}$	$F_{T,1,Rd} = \frac{(8n - 2e_w)M_{pl,1,Rd}}{2mn - e_w(m+n)}$	
with backing plates	$F_{T,1,Rd} = \frac{4M_{pl,1,Rd} + 2M_{bp,Rd}}{m}$	$F_{T,1,Rd} = \frac{(8n - 2e_w)M_{pl,1,Rd} + 4nM_{bp,Rd}}{2mn - e_w(m+n)}$	
Mode 2	$F_{T,2,Rd} = \frac{2M_{pl,2,Rd} + n\Sigma F_{t,Rd}}{m+n}$		
Mode 3	$F_{T,3,Rd} = \Sigma F_{t,Rd}$		



Other basic components

Basic components	Design Resistance
Column web panel in shear	$V_{wp,Rd} = \frac{0,9 f_{y,wc} A_{vc}}{\sqrt{3}\gamma_{M0}}$
Column Web in compression	$F_{c,wc,Rd} = \frac{\omega k_{wc} b_{eff,c,wc} t_{wc} f_{y,wc}}{\gamma_{M0}}$
Column web in tension	$F_{t,wc,Rd} = \frac{\omega b_{eff,t,wc} t_{wc} f_{y,wc}}{\gamma_{M0}}$
Beam flange and web in compression	$F_{c,fb,Rd} = \frac{M_{c,Rd}}{h - t_{fb}}$
Beam web in tension	$F_{t,wb,Rd} = \frac{b_{eff,t,wb} t_{wb} f_{y,wb}}{\gamma_{M0}}$

Design moment resistance of joints

- Design moment resistance of a joint $M_{j,Rd}$ *do not take* account of any co-existing axial force N_{Ed} *in the connected member.*
- *They should not be used if the* axial force in the connected member exceeds 5% of the design plastic resistance $N_{p\ell,Rd}$ *of its cross section.*

$$M_{j,Rd} = \sum_r h_r F_{tr,Rd}$$

- where:
  - $F_{tr,Rd}$ *is the effective design tension resistance of bolt-row r ;*
  - h_r *is the distance from bolt-row r to the centre of compression;*
  - *r is the bolt-row number.*

Rotational Stiffness

- The rotational stiffness, S_j should be determined from the flexibilities of its basic components, each represented by an elastic stiffness coefficient k_i obtained from 6.3.2
- For a moment $M_{j,Ed}$ less than the design moment resistance $M_{j,Rd}$:

$$S_j = \frac{Ez^2}{\mu \sum_i \frac{1}{k_i}}$$

Z is the lever arm, see 6.2.7

μ is the stiffness ratio $S_{j,ini/}$ S_j, see 6.3.1(6)

Extract from Table 6.11 Stiffness coefficients for basic joint components

Component	Stiffness coefficient k_i	
Column web panel in shear	Unstiffened, single-sided joint, or a double-sided joint in which the beam depths are similar	stiffened
	$k_1 = \dfrac{0{,}38 A_{VC}}{\beta z}$	$k_1 = \infty$
	z is the lever arm from Figure 6.15; β is the transformation parameter from 5.3(7).	
Column web in compression	unstiffened	stiffened
	$k_2 = \dfrac{0{,}7\, b_{eff,c,wc}\, t_{wc}}{d_c}$	$k_2 = \infty$
	$b_{eff,c,wc}$ is the effective width from 6.2.6.2	
Column web in tension	stiffened or unstiffened bolted connection with a single bolt-row in tension or unstiffened welded connection	stiffened welded connection
	$k_3 = \dfrac{0{,}7 b_{eff,t,wc}\, t_{wc}}{d_c}$	$k_3 = \infty$
	$b_{eff,t,wc}$ is the effective width of the column web in tension from 6.2.6.3. For a joint with a single bolt-row in tension, $b_{eff,t,wc}$ should be taken as equal to the smallest of the effective lengths ℓ_{eff} (individually or as part of a group of bolt-rows) given for this bolt-row in Table 6.4 (for an unstiffened column flange) or Table 6.5 (for a stiffened column flange).	
Column flange in bending (for a single bolt-row in tension)	$k_4 = \dfrac{0{,}9 \ell_{eff}\, t_{fc}^{\,3}}{m^3}$ ℓ_{eff} is the smallest of the effective lengths (individually or as part of a bolt group) for this bolt-row given in Table 6.4 for an unstiffened column flange or Table 6.5 for a stiffened column flange; m is as defined in Figure 6.8.	
End-plate in bending (for a single bolt-row in tension)	$k_5 = \dfrac{0{,}9 \ell_{eff}\, t_p^{\,3}}{m^3}$ ℓ_{eff} is the smallest of the effective lengths (individually or as part of a group of bolt-rows) given for this bolt-row in Table 6.6; m is generally as defined in Figure 6.11, but for a bolt-row located in the extended part of an extended end-plate $m = m_x$, where m_x is as defined in Figure 6.10.	
Flange cleat in bending	$k_6 = \dfrac{0{,}9 \ell_{eff}\, t_a^{\,3}}{m^3}$ ℓ_{eff} is the effective length of the flange cleat from Figure 6.12; m is as defined in Figure 6.13.	

Rotation Capacity

- The clauses in the code only valid for S235, S275 and S355
- The design value of the axial force N_{Ed} in the connected member does not exceed 5% of the design plastic resistance $N_{pl,Rd}$ of its cross-section
- For bolted joints:
  - If the design moment resistance is governed by the design resistance of the column web panel in shear, adequate rotation capacity is assumed when $d / t_w \leq 69\varepsilon$
  - When the design moment resistance is governed by the column flange in bending and endplate or angle in bending, sufficient rotation capacity if the thickness, t for these components are:

$$t \leq 0{,}36d\sqrt{\frac{f_{ub}}{f_y}}$$

Rotation Capacity

- For welded joints:
  - The rotation capacity of a welded beam-to-column connection is given as:

$$\phi_{Cd} = 0{,}025\frac{h_c}{h_b}$$

  - Provided that its column web is stiffened in compression but unstiffened in tension, and its design moment resistance is not governed by the design resistance of the column web panel

Example 1 : Connections

Thank You