4. BEAMS

A beam is designed to resist maximum bending moment and is checked for shear stress and deflection, and also for web crippling and web buckling.

DESIGN FOR BENDING

- The maximum permissible compressive or tensile bending stress σ_{bc} or $\sigma_{bt} = 0.66\, f_y$
  where f_y = yield stress of steel
  The permissible bending stress (compressive or tensile) σ_{bc} or σ_{bt} as per IS: 226-1975 is as follows:

Nominal plate thickness	Yield stress f_y (MPa)	$s_{bc} = s_{bt}$ (MPa)
Angle, tee, I, channel and flat sections Up to and including 20 mm	250	165
Over 20 mm up to and including 40 mm	240	158.4
Over 40 mm	230	151.8

EFFECTIVE LENGTH OF COMPRESSION FLANGE

(i) Effective Length of Compression Flange :

End Connections	Effective length, l
(i) each end restrained against torsion.	
(a) ends of compression flange unrestrained for lateral bending	l = span
(b) ends of compression flange partially restrained for lateral bending	$l = 0.85 \times$ span
(c) ends of compression flange fully restrained for lateral bending	$l = 0.7 \times$ span

(ii) Cantilever beams of projecting length L,	
(a) Built-in at the support, free at end	$l = 0.85L$
(b) Built-in at the support, restrained against torsion at the end by continuous construction.	$l = 0.75L$
(c) Built - in at the support, restrained against lateral deflection and torsion at the free end	

by continuous cross members over several beams	$l = 0.5L$
(d) Continuous and unrestrained against torsion at the support and free at the end	$l = 3L$
(e) Continuous and partially restrained against torsion at the support and free at end	$l = 2L$
(f) Continuous at the support, restrained against torsion at the support and free at the end	$l = L$

NOTE

The above values are increased by 20% if the ends of beam are not restrained against torsion.

If there is a degree of fixity at the end, the effective length should be multiplied by $\frac{0.5}{0.85}$ in (b) and (c) above and by $\frac{0.75}{0.85}$ in (d), (e) and (f) above.

(ii) Check for Shear

- Max permissible, shear stress

$$\tau_{vm} = 0.45 f_y$$

- For design purpose, the above condition is deemed to be satisfied if the average shear stress in an unstiffened member calculated on the cross section of web does not exceed the value

$$\tau_{va} = 0.4 f_y$$

(iii) Check for Deflection

- The maximum deflection $\not> \frac{l}{325}$ of the span in general.

(iv) Check for web crippling and web buckling:

BUILT UP BEAMS

(i) Symmetrical built-up beams

- Area of each cover plate

$$A_p = \frac{Z - Z_1}{d}$$

where, Z_1 = Section modulus of rolled I section available,

d = depth of beam

(ii) Unsymmetrical built-up beam

- The area of cover plates $A_p = \frac{1.2 \times (Z - Z_1)}{d}$

GANTRY GIRDERS

(i) The gantry girders are subjected to unsymmetrical bending due to lateral thrust.

(ii) The deflection of gantry girders under dead and imposed loads should not exceed the following values as per IS : 800-1984.

(a) Where cranes are manually operated	$\frac{L}{500}$
(b) Where electric overhead travelling crane are operated upto 50t	$\frac{L}{750}$
(c) Where electric overhead travelling cranes are operated, over 50t	$\frac{L}{1000}$
(d) Other moving loads such as charging cars etc.	$\frac{L}{600}$

Where, L = span of crane runway girder

BEAM COLUMN

- Members subjected to axial compression and bending are proportional to satisfy the Eq.(1)

$$\frac{\sigma_{ac,cal}}{\sigma_{ac}} + \frac{C_{mx} \times \sigma_{bcx,cal}}{\left[1 - \frac{\sigma_{ac,cal}}{0.6 f_{ccx}}\right] \sigma_{bcx}} + \frac{C_{my} \times \sigma_{bcy,cal}}{\left[1 - \frac{\sigma_{ac,cal}}{0.6 f_{ccy}}\right]} \leq 1.0 \quad \text{...(i)}$$

However if the ratio $\frac{\sigma_{ac,cal}}{\sigma_{ac}}$ is less than 0.15, Eq (ii) may be used in lieu of Eq. (i)

$$\frac{\sigma_{ac,cal}}{\sigma_{ac}} + \frac{\sigma_{bcx,cal}}{b_{bcx}} + \frac{\sigma_{bcy,cal}}{\sigma_{bcy}} \leq 1.0 \quad \text{... (ii)}$$

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