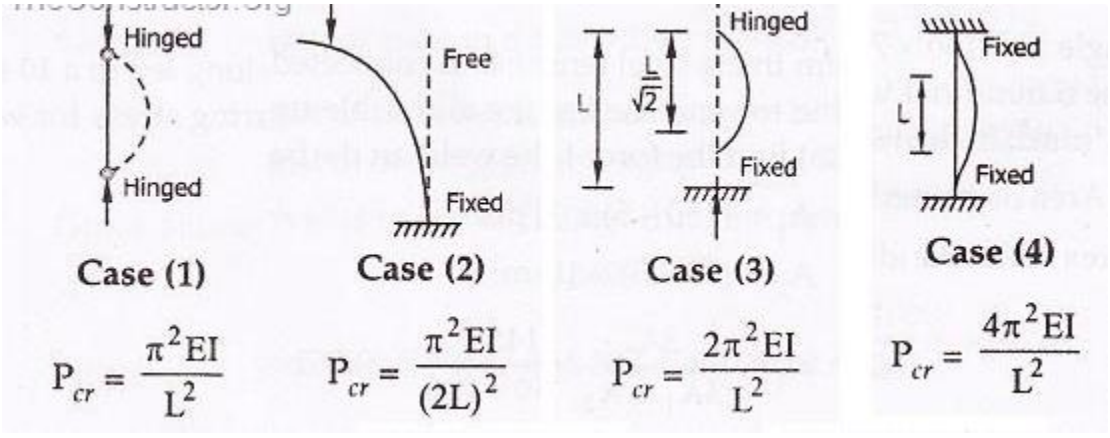
2.4 Euler's column theory

$$P_{cr} = \frac{\pi^2 EI}{L^2}$$

Euler's formula for critical load for a pin-ended column subjected to axial load isWhere, L = length of column between the hinged ends, E = modulus of elasticity, and I = moment of inertia of the column section. The column will become unserviceable if the loads are larger than P_{cr}. In the Euler equation, it is assumed that stress is proportional to strain, therefore, Critical Stress = $\frac{P_{cr}}{A} = \frac{\pi^2 EI}{AL^2} = \frac{\pi^2 EI}{\left(\frac{L}{r}\right)^2} = \frac{\pi^2 E}{\lambda^2}$ Where, A= area of cross-section, and r = radius of gyration about the bending axis λ = slenderness ratio

VARIOUS END CONDITIONS

Columns with length L and effective length l are shown in figure below:



Strength of an Axially Loaded Compression Members

Maximum axial compression load permitted on a compression member, $P = \sigma_{ac} \times A$ Where, P = axial compressive load (N), σ_{ac} = permissible stress in axial compression (MPa) A = effective cross-sectional area of the member (mm^2) **Indian Standard IS 800: 2007** It stipulates that the direct stress on

the cross-sectional area of axially loaded compression members should not exceed $0.6 f_y$ nor the permissible stress calculated using Merchant – Rankine formula. Permissible stress in axial compression (MPa):

$$\sigma_{ac} = 0.6 \times \frac{f_{cc} \times f_y}{\left[f^n_{cc} \times f^n_y \right]^{1/n}}$$

Where f_y = yield stress of steel in MPa f_{cc} = elastic critical stress in compression = $\frac{\pi^2 E}{\lambda^2}$ $\lambda = \frac{l}{r}$ = slenderness ratio of the member Where, l = effective length of the member r = appropriate radius of gyration of the member E = modulus of elasticity = 200000 MPa, and n = a factor assumed as 1.4

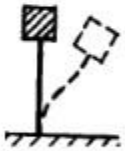
EFFECTIVE LENGTH OF COMPRESSION MEMBER Table below gives the values of effective length recommended by the Indian Standard, IS 800. The actual length L of the compression member should be taken as the length from centre-to-centre of intersection of supporting members or the cantilevered length in the case of free standing struts.

Following are the end restraints:

- Effectively held in position and restrained against rotation in both ends
- Effectively held in position at both ends, restrained against rotation at one end
- Effectively held in position at both ends, but not restrained against rotation
- Effectively held in position and restrained against rotation at one end, and at the other restrained against rotation but not held in position
- Effectively held in position and restrained against rotation in one end, and at the other partially restrained against rotation but not held in position
- Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position

- Effectively held in position and restrained against rotation at one end but not held in position nor restrained against rotation at the other end

Table.Effective length of compression member

Sl. No.	Degree of End Restraint of Compression Members	Figure	Theo. Value of Effective Length	Reco. Value of Effective Length
1	Effectively held in position and restrained against rotation in both ends		0.50 l	0.65l
2	Effectively held in position at both ends, restrained against rotation at one end		0.70 l	0.80l
3	Effectively held in position at both ends, but not restrained against rotation		1.0 l	1.0l
4	Effectively held in position and restrained against rotation at one end, and at the other restrained against rotation but not held in position		1.0 l	1.20l
5	Effectively held in position and restrained against rotation in one end, and at the other partially restrained against rotation but not held in position		-	1.5l
6	Effectively held in position at one end but not restrained against rotation, and at the other end restrained against rotation but not held in position		2.0 l	2.0l
7	Effectively held in position and restrained against rotation at one end but not held in position nor restrained against rotation at the other end		2.0 l	2.0l