Design of compression members

As per IS 800 : 2007

Satish Kumar
Lecturer
Govt. Polytechnic
Mandi Adampur

Compression members

- Structural Members subjected to axial compression/compressive forces
- Design governed by strength and buckling.
- Columns are subjected to axial loads through the Centroid.
- The stress in the column cross-section can be calculated as

$$f = \frac{P}{A}$$

where, f is assumed to be uniform over the entire cross-section

Failure modes of an axially loaded column

- Local buckling
- Squashing
- Overall flexure buckling
- Torsional buckling

- This ideal state is never reached. The stress-state will be non-uniform due to:
- Accidental eccentricity of loading with respect to the Centroid.
- Member out-of –straightness(crookedness), or
- Residual stresses in the member cross section due to fabrication processes

Types of Compression member

- In addition to most common type of compression members (vertical Members in structure),compression may include the
  - Arch ribs
  - Rigid frame members inclined or otherwise
  - Compression elements in trusses

Compression Members

Elastic buckling of slender compression members

- Slender columns have low crippling load carrying capacity.
- Consider one such column having length 'L' and uniform cross section A hinged at both ends A and B. Let P be the crippling load at which the column has just buckled.

Compression Members Vs Tension Members

- The longer the column, for the same x-section, the greater becomes its tendency to buckle and smaller becomes its load carrying capacity.
- The tendency of column to buckle is usually measured by its slenderness ratio

$$\text{Slenderness Ratio} = \frac{L}{r}$$

$$\text{where } r = \sqrt{\frac{I}{A}} = \text{radius of gyration}$$

Compression Members Vs Tension Members

Effect of material Imperfections and Flaws

- Slight imperfections in tension members are can be safely disregarded as they are of little consequence.
- On the other hand slight defects in columns are of great significance.
- A column that is slightly bent at the time it is put in place may have significant bending resulting from the load and initial lateral deflection.

Compression Members Vs Tension Members

- Tension in members causes lengthening of members.
- Compression beside compression forces causes buckling of member.

Compression Members Vs Tension Members

- Presence of holes in bolted connection reduce Gross area in tension members.
- Presence of bolts also contribute in taking load An = Ag

WHY column more critical than tension member?

- A column is more critical than a beam or tension member because minor imperfections in materials and dimensions mean a great deal.

WHY column more critical than tension member?

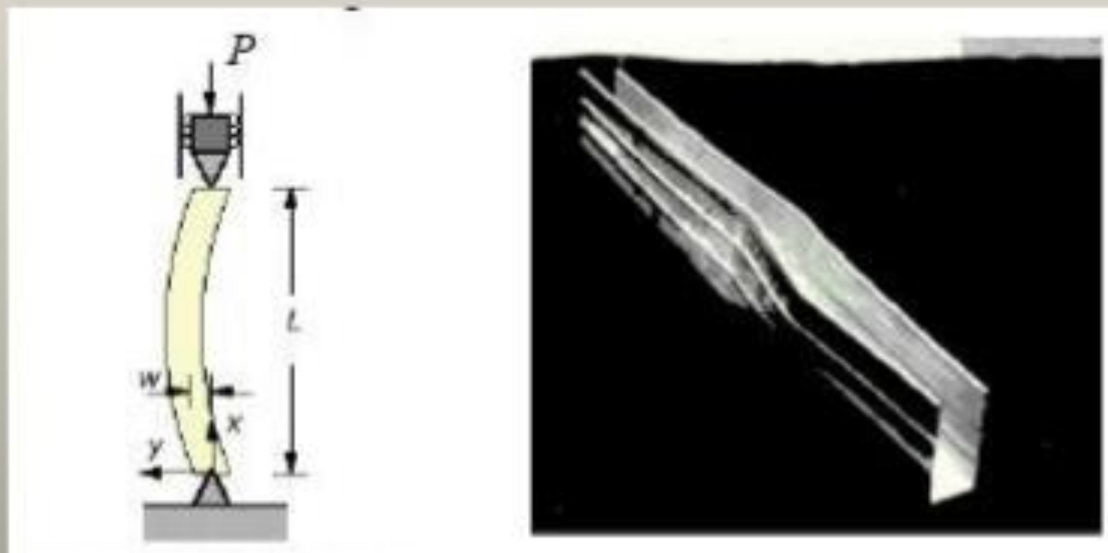
- The bending of tension members probably will not be serious as the tensile loads tends to straighten those members, but bending of compression members is serious because compressive loads will tend to magnify the bending in those members.

Compression Member Failure

- There are three basic types of column failures.
- One, a compressive material failure(very short and fat).
- Two, a buckling failure,(very long and skinny).
- Three, a combination of both compressive and buckling failures.(length and width of a column is in between a short and fat and long and skinny column).

Compression Member Failure

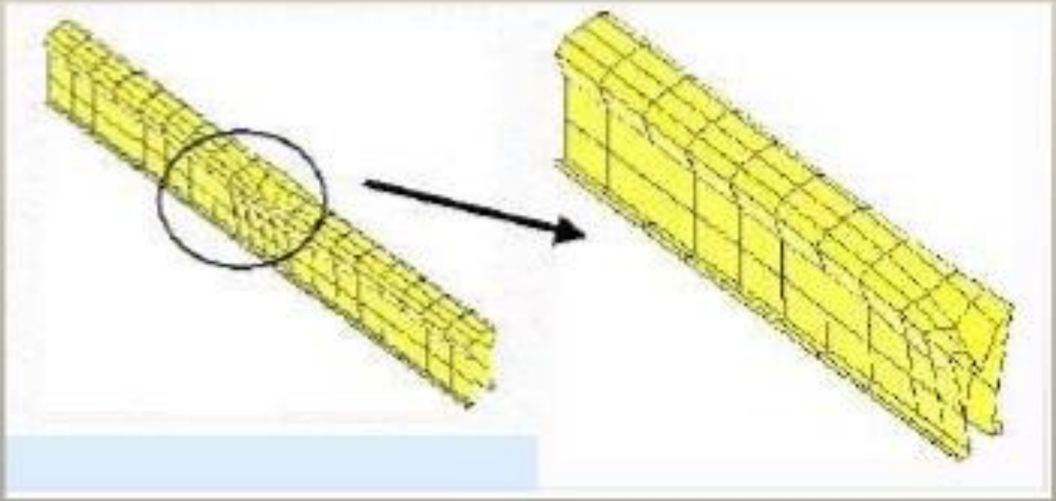
- **<u>Flexural Buckling</u>** (also called Euler Buckling) is the primary type of buckling.members are subjected to bending or flexure when they become unstable



Simply supported column subjected to axial load P

Compression Member Failure

- **Local Buckling** This occurs when some part or parts of x-section of a column are so thin that they buckle locally in compression before other modes of buckling can occur



Compression Member Failure

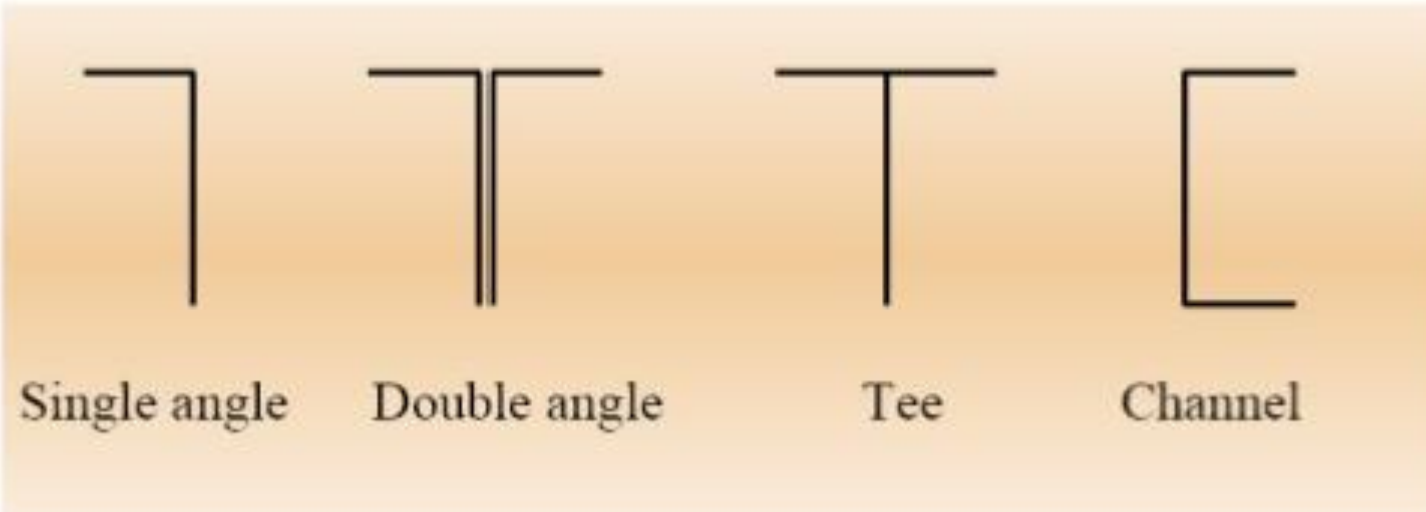
- **Torsional Buckling** These columns fail by twisting(torsion) or combined effect of torsional and flexural buckling.

Sections used for Compression Member

- In theory numerous shapes can be used for columns to resist given loads.
- However, from practical point of view, the number of possible solutions is severely limited by section availability, connection problems, and type of structure in which the section is to be used.

Sections used for Compression Member

Figure 1. Types of Compression Members



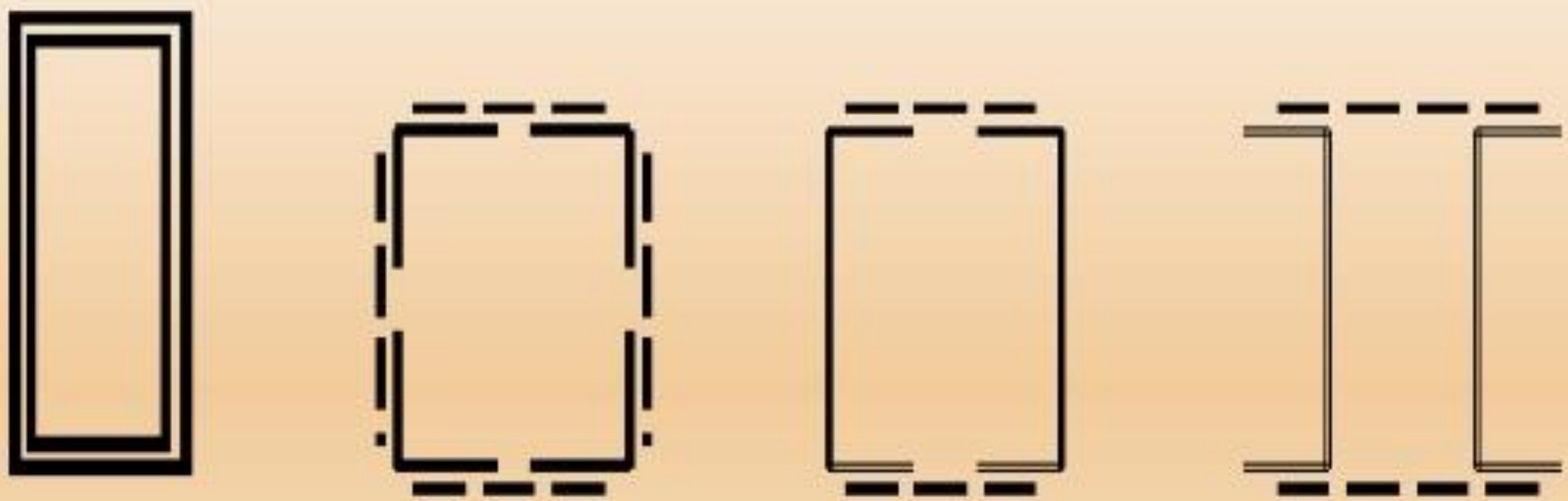
Sections used for Compression Member

I Column

Pipe or round HSS tubing

Square HSS tubing

Sections used for Compression Member



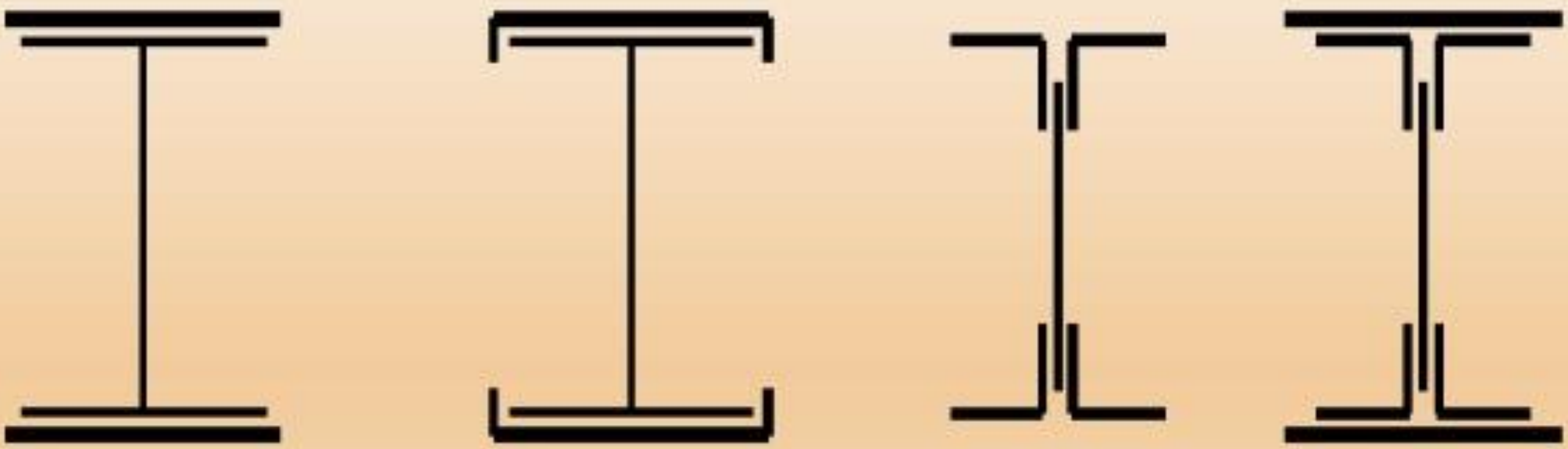
Rectangular HSS tubing

Four angle box section

Box section

Box section

Sections used for Compression Member



W with Cover Plats

W and channels

Built-up

Built-up

Column Buckling

- Buckling
- Elastic Buckling
- Inelastic Buckling

Column Buckling

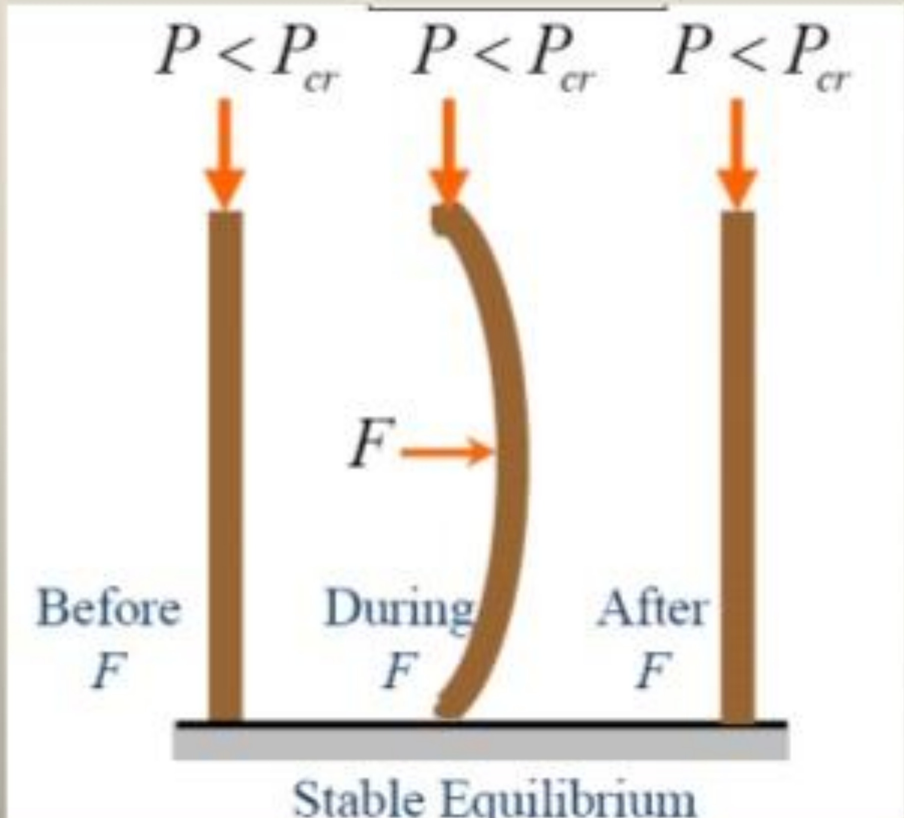
- Buckling is a mode of failure generally resulting from structural instability due to compressive action on the structural member or element involved.
- Examples of commonly seen and used tools are provided.

Mechanism of Buckling

- Let us consider Fig 1, 2, 3 and study them carefully.
- In fig1 some axial load P is applied to the column.
- The column is then given a small deflection by giving a small force F.
- If the force P is sufficiently small, when the force F is removed, the column will go back to its original straight position.

Mechanism of Buckling

Fig 1

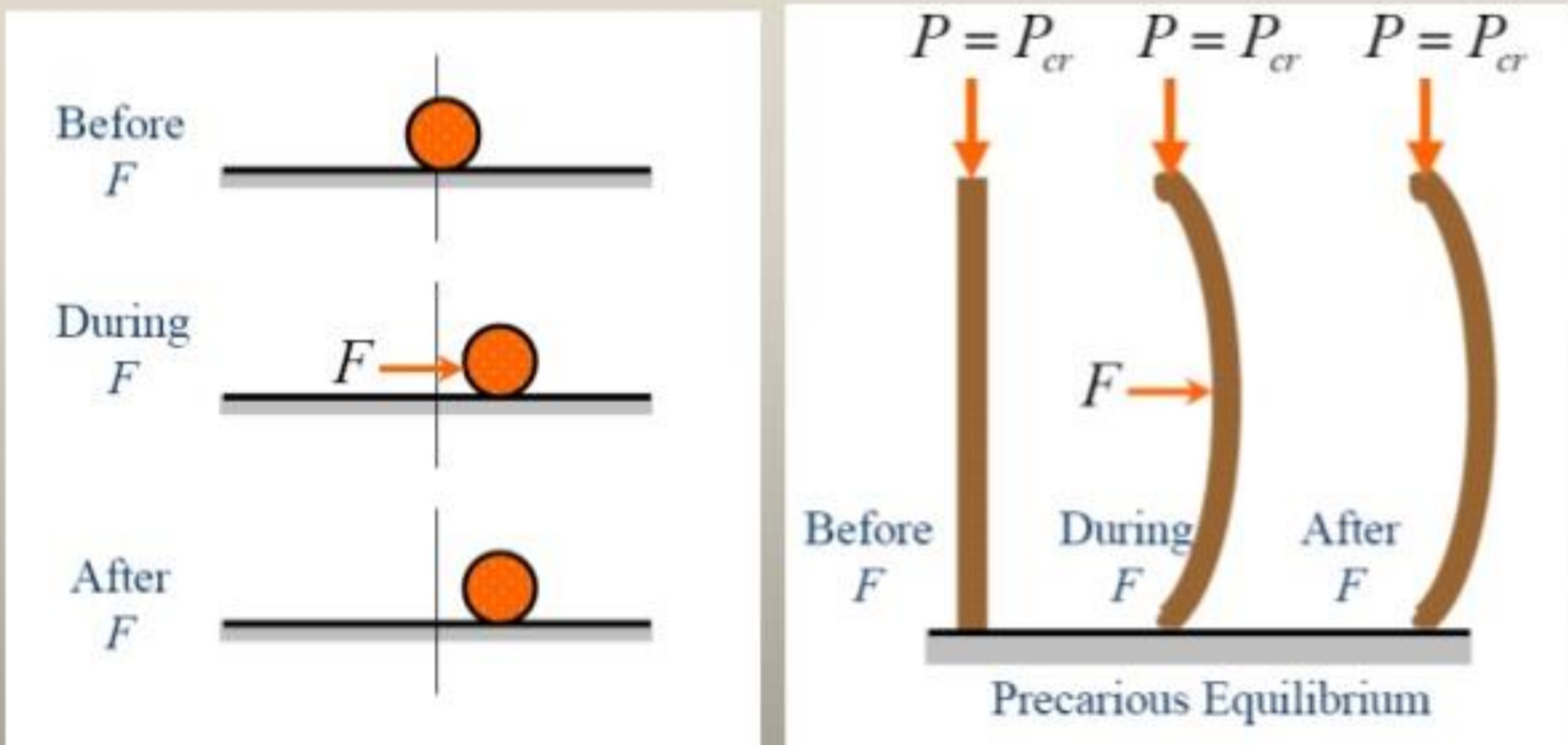


Mechanism of Buckling

- The column will go back to its original straight position. Just as the ball returns to the bottom of the container.
- Gravity tends to restore the ball to its original position while in columns elasticity of column itself acts as a restoring force.
- This action constitutes stable equilibrium.

Mechanism of Buckling

Fig 2

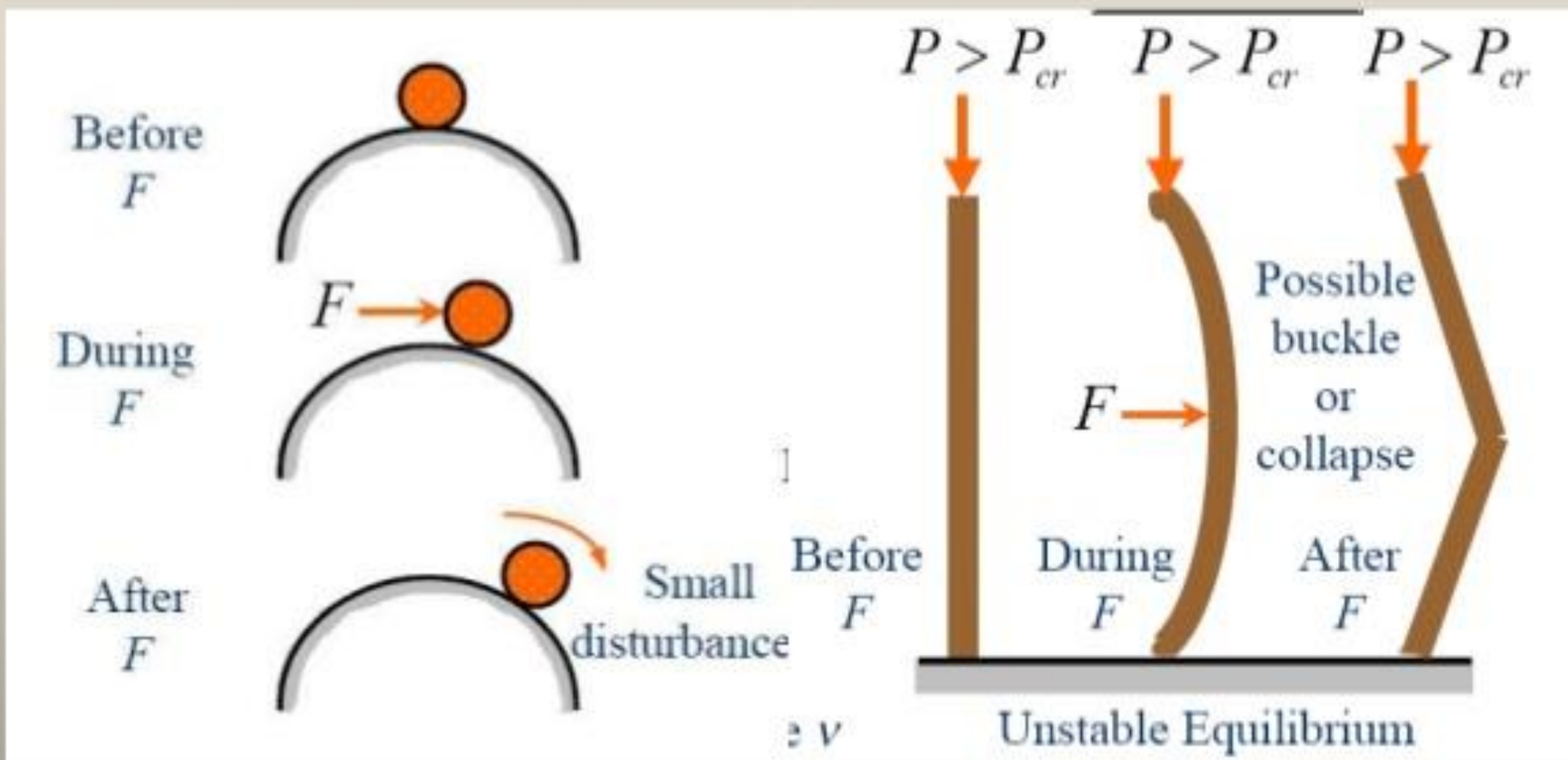


Mechanism of Buckling

- The amount of deflection depends on amount of force F.
- The column can be in equilibrium in an infinite number of bent position.

Mechanism of Buckling

Fig 3



Mechanism of Buckling

- The elastic restoring force was not enough to prevent small disturbance growing into an excessively large deflection.
- Depending on magnitude of load P, column either remain in bent position, or will completely collapse or fracture.

Mechanism of Buckling

Conclusions

- This type of behavior indicates that for axial loads greater than P_{cr} the straight position of column is one of unstable equilibrium in that a small disturbance will tend to grow into an excessive deformation.
- Buckling is unique from our other structural elements considerations in that it results from state of unstable equilibrium.

Mechanism of Buckling

Conclusions

- Buckling of long columns is not caused by failure of material of which column is composed but by determination of what was stable state of equilibrium to an unstable one.

Design of compression members

- Assumptions made
- The column is assumed to be absolutely straight.
- The modulus of elasticity is assumed to be constant in a built- up column
- Secondary stresses are neglected

Design steps

- For beginners , for an average column size of 3-5 m the slenderness ratio of 40 to 60 is selected. For very long column a λ of 60 may be assumed. For column with very heavy factored load a smaller value of slenderness ratio should be assumed.
- Choose a trial section by assuming an appropriate slenderness ratio from following table

Type of member	slenderness ratio
Single angle	100-50
Single channel	90-110
Double angles	80-120
Double channels	40-80
Single I -Section	80-100
Double I - section	30-60

- Select a trial section by referring the table above and from steel tables
- Calculate KL/r for the section selected. The calculated value of slenderness ratio should be within the max limiting value given by IS 800-2007 (page 20)

•Calculate fcd and the design strength Pd = A. fcd

•For the estimated value of slenderness ratio, calculate the design compressive stress (fcd) , by any method i.e. using buckling curve or by using equations given by IS 800: 2007 (refer Cl. 7.1.2)

•The design strength of member is calculated as

•Pd = fcd effective cross-sectional area

•The value Pd should be more than the factored load Pu for safe design

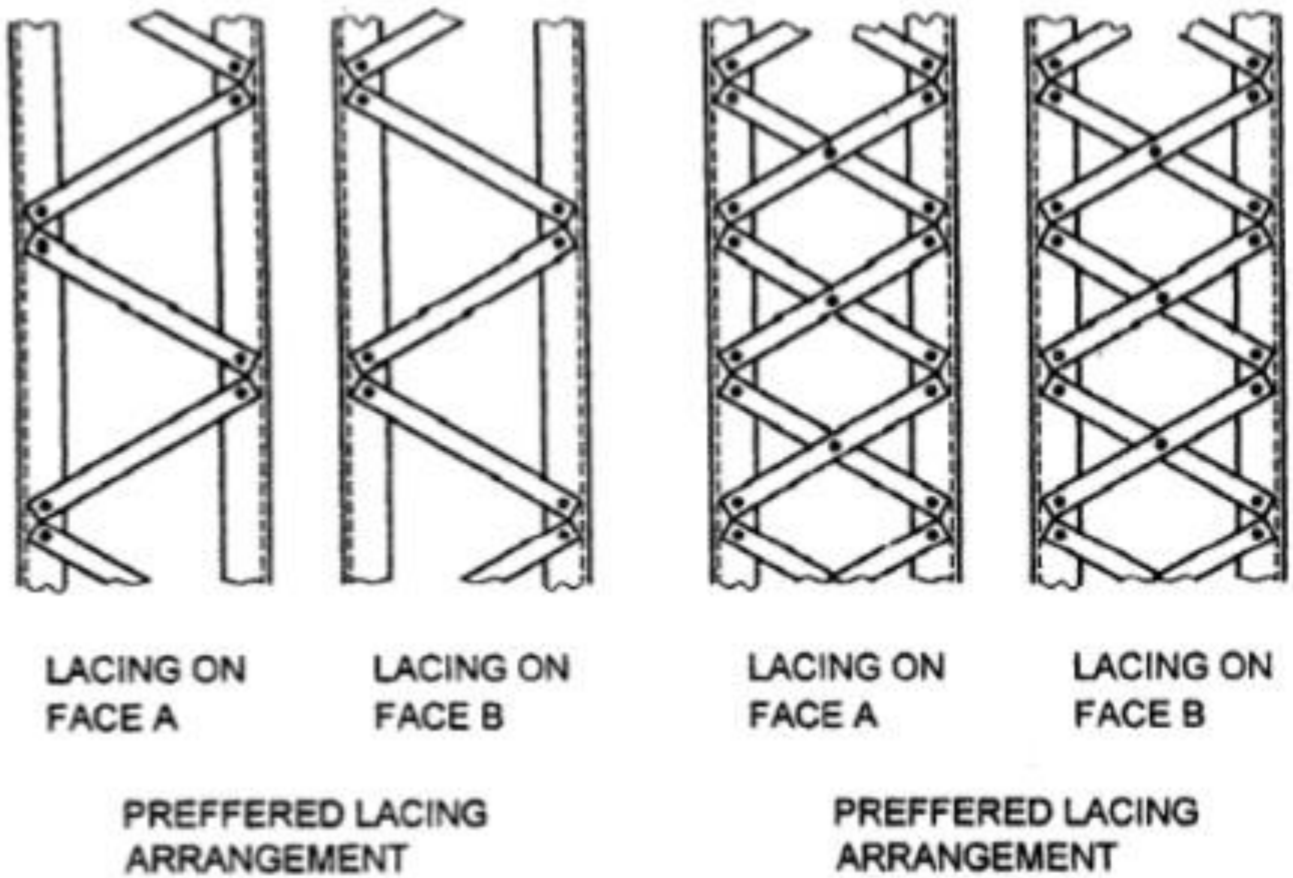
Sl No.	Member	Maximum Effective Slenderness Ratio (*KL/r*)
(1)	(2)	(3)
i)	A member carrying compressive loads resulting from dead loads and imposed loads	180
ii)	A tension member in which a reversal of direct stress occurs due to loads other than wind or seismic forces	180
iii)	A member subjected to compression forces resulting only from combination with wind/earthquake actions, provided the deformation of such member does not adversely affect the stress in any part of the structure	250
iv)	Compression flange of a beam against lateral torsional buckling	300
v)	A member normally acting as a tie in a roof truss or a bracing system not considered effective when subject to possible reversal of stress into compression resulting from the action of wind or earthquake forces[1)]	350
vi)	Members always under tension[1)] (other than pre-tensioned members)	400

[1)] Tension members, such as bracing's, pre-tensioned to avoid sag, need not satisfy the maximum slenderness ratio limits.

Built-up Column members

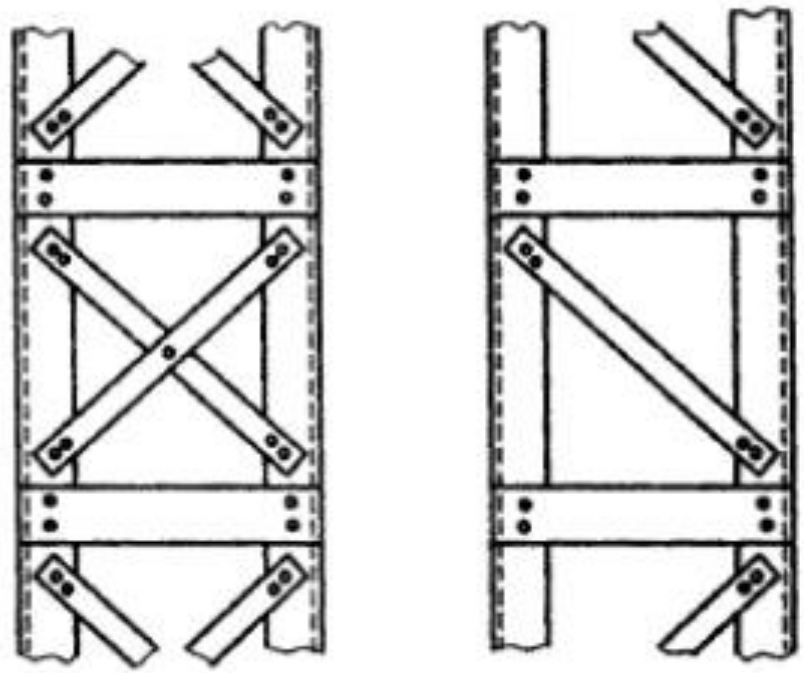
- Laced member
- Struts with batten plates
- Battened struts
- Members with perforated cover plates

Built- up compression member



10A Single Laced System

10B Double Laced System



10C Double Laced and Single Laced System Combined with Cross Numbers

FIG. 10 LACED COLUMNS

Thanks………..