IES MASTER

Civil Engineering

Toppers Handwritten Notes

STRUCTURAL ANALYSIS

- Theory BY-KANCHAN SIR
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

Structural Analysis

(1) Introduction

obj (2) Deflection of beams & Frames

obj (3) Determinacy and Indeterminacy

obj + conv* (4) Force method of analysis

(5) Displacement method of analysis
- (a) slope deflection method — obj + conv*
- (b) Moment distribution method — obj + conv*

obj + conv. (6) Trusses

obj (7) Influence line diagram

obj (8) Matrix method of Analysis

obj (9) Cable & Arches.

① Introduction

- In structural analysis our aim is to

(a) Find out internal member forces

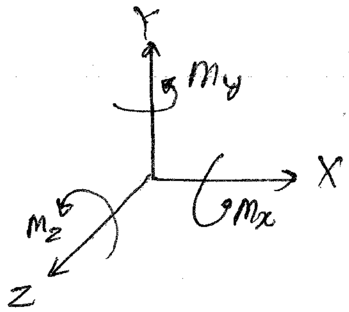
(b) Find out slopes and deflections

Equilibrium Equations:⇒

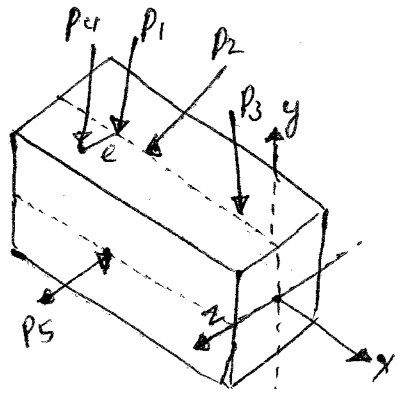
$\Sigma F_x = 0$	$\Sigma M_x = 0$
$\Sigma F_y = 0$	$\Sigma M_y = 0$
$\Sigma F_z = 0$	$\Sigma M_z = 0$

⇓

General case (3D)



External and internal forces:⇒



Internal forces

F_x → axial forces

F_y, F_z } → shear forces

M_x → Twisting moment

M_y, M_z } Bending moment.

P_1, P_2, P_3, P_4, P_5 → external forces

- under general loading (3D); Maximum no. of internal force = 6

In 2D cases:⇒ P_4 & P_5 will not exist

⇒ M_x, M_y, F_z will not exist

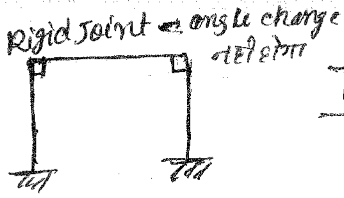
Hence in 2D case, Max no of internal forces are ③.

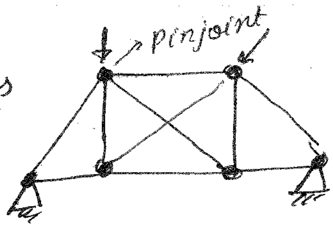
F_x → axial force

F_y → shear force

M_z → Bending moment.

Beam 

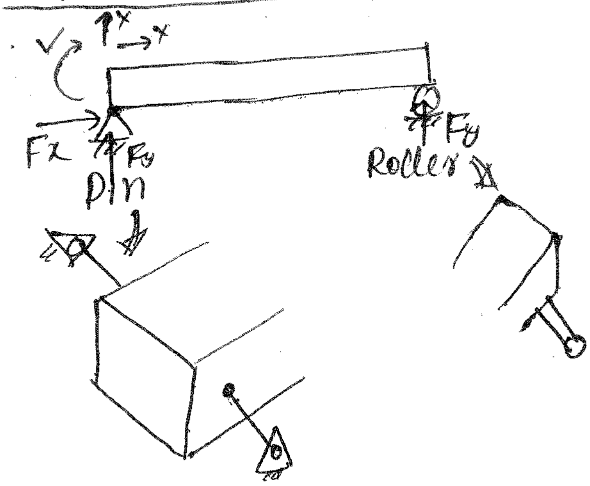
Frame 

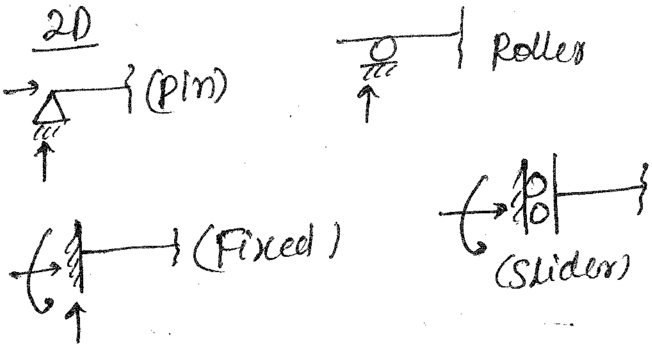
Truss 

- For Normal Proportion beam & Frame, major deformation is due to B.M.
- For Truss, maj deformation is due to axial force.
- Unless given otherwise, we will treat members in beam & frames to be a Axially rigid.

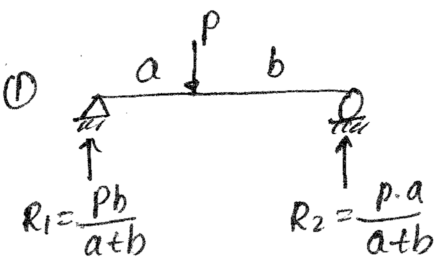
In Truss → इसे design करते सारे force, axial force से convert करते

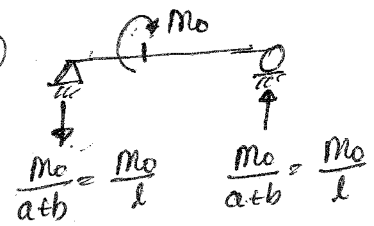
Support Reactions :⇒ • Reactions develops on account of restraining of deformations.

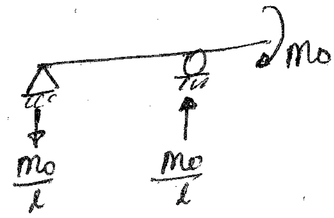


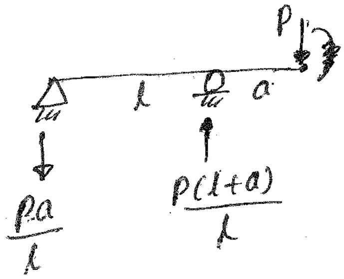


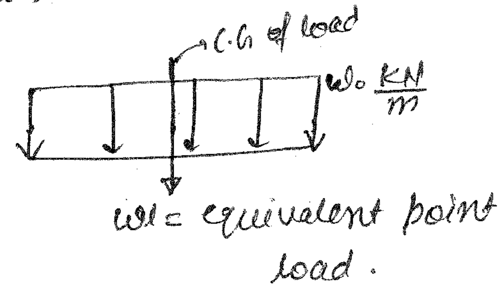
Note:⇒ In case of beams if supports are at same level & load is purely vertical then horizontal reaction will not develop. However if supports are not at same level in the beams & even if load is vertical horizontal reaction does level. The above statement is true for beams only not for trusses & frames.

① 

② 

③ 

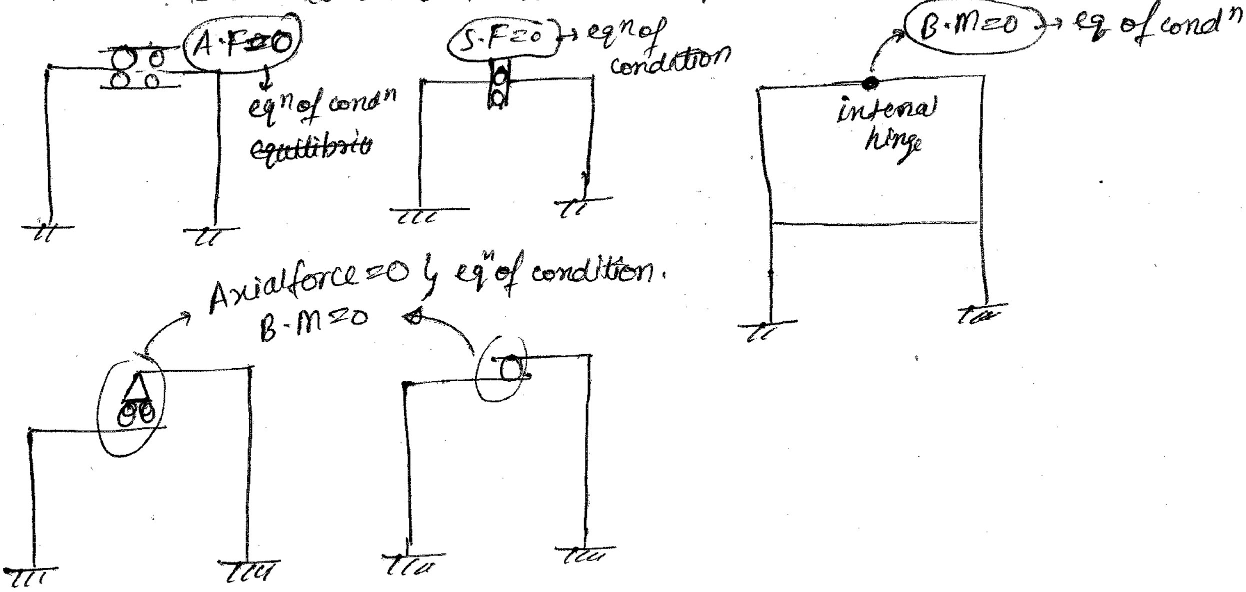
④ 

⑤ 

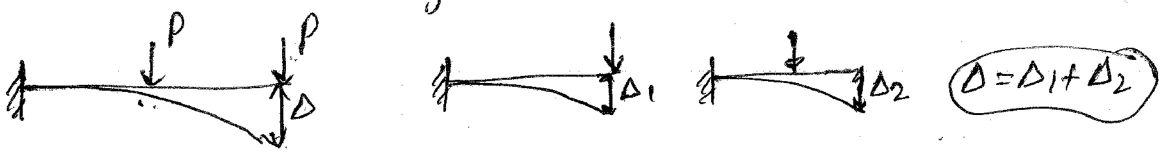
- Distributed loading like UDL, UVL etc can be treated as a point load having magnitude equal to area of the load distributed diagram & passing through the C.G of load distributed diagram (only for reactions calculation).

Determinate & Indeterminate Structure

- If all of the support reactions & member forces can be calculated only by using equilibrium equations and equation of conditions then the structure is said to be determinate otherwise indeterminate.



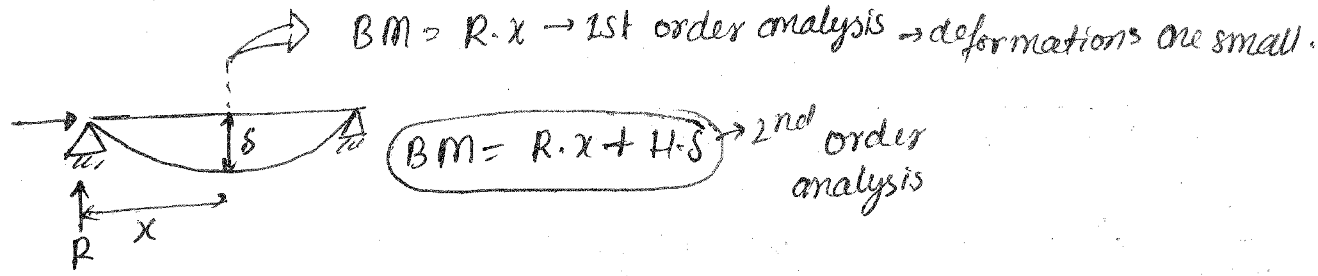
Principale of Super position:⇒ • As per principal of super position, each of the loading produces its effect independent of others and total effect is equal to the summation of effects due to individual loading.



For the validity of principle of superposition

(a) Material should be behave as linearly elastic (stress ∝ strain i.e. Hooks law valid)

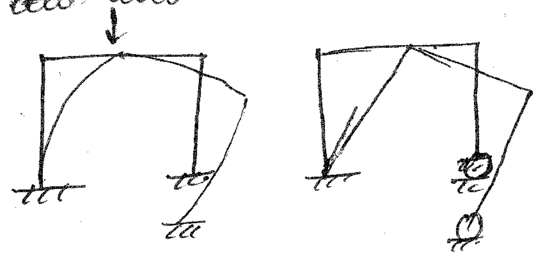
(b) deformations are small.



Note:⇒ If deformations are large, action of loading will be affected by deformation of structure.

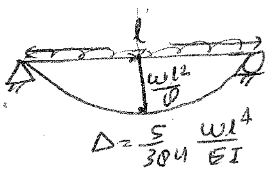
Advantage and disadvantages of Indeterminate structures

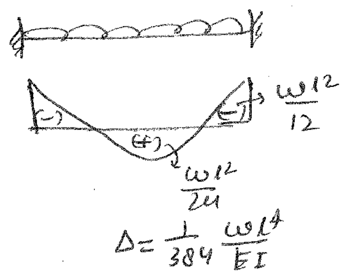
- In-determinate structure needs to smaller B.M development & hence small c/s requirement. Thus there is saving in material and DL.
- Indeterminate structures are more rigid & hence deformed less.
- There are multiple path of load transfer available in indeterminat structure & hence localized failure may not lead to complete collapse of the structure.



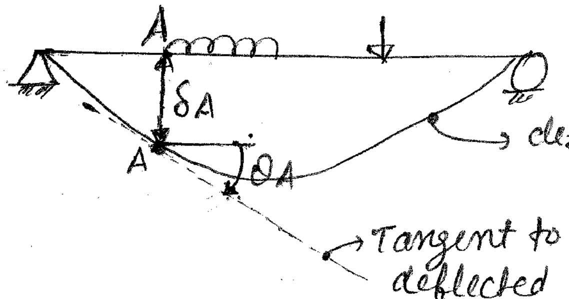
- Indeterminate structures required rigid support & hence part of saving in material is compensated.
- Settlement of supports & temperature changes will lead to additional stress development

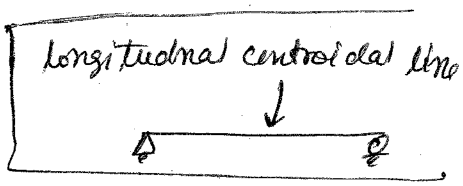
⇒ Overall is economical to adopt indeterminate structures.



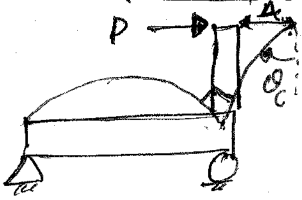


Chap ② Deflection of Beams & Frames





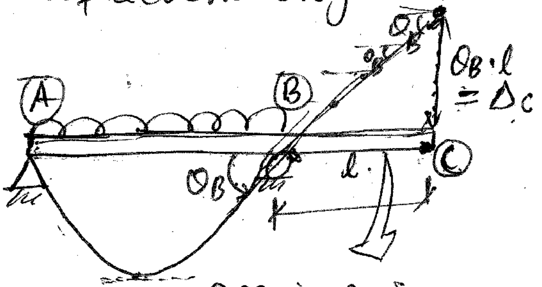
- deformation leads to deflection & slope.



δA = deflection at (A)

θ_A = Slope at (A)

- Internal forces in the Beams & frames produce deformations which lead to slope and deflection. However majority of slope & deflection is only due to B.M. hence in our course we will calculate slopes and deflections only due to B.M unless specified otherways.

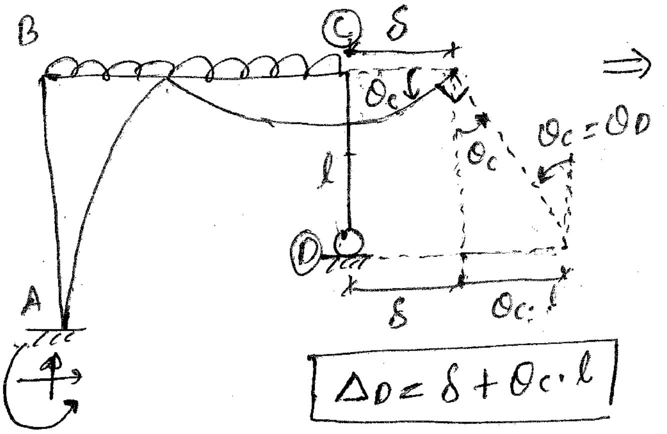


- ✓ Hence if B.M in any part of the structure is zero, the ~~beam~~ structure will not deform in that part and hence will remains straight.

BM in BC is zero.

⇒ BC will remains straight.

$\theta_C = \theta_B$, $\Delta_C = \theta_B \cdot l$



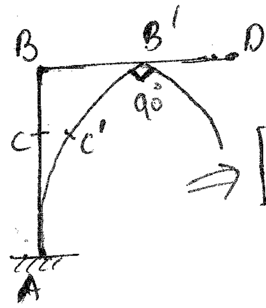
⇒ B.M in part CD = 0

$$\boxed{\Delta_D = \delta + \theta_c \cdot l}$$

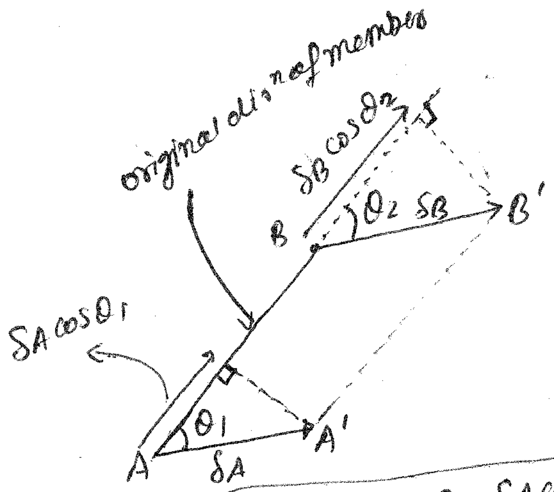
~~Assum~~ Assumptions and Important Points :-

(1) Principale of super position is valid i.e. linearly elastic condition & small displacement theory is valid.

Small displacement theory

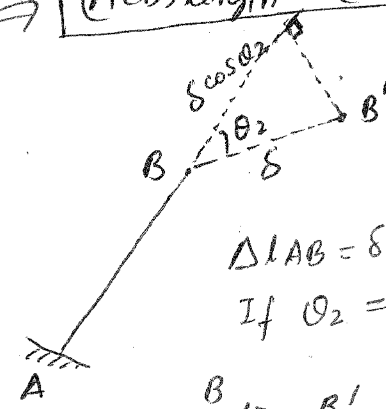


$\Rightarrow$ **(ACB) length = (AC'B') length.**



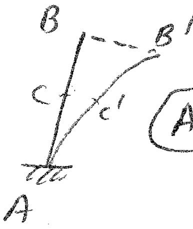
$$\Delta l_{AB} = \delta_B \cos\theta_2 - \delta_A \cos\theta_1$$

If $\theta_1 = 90°$; $\theta_2 = 90° \Rightarrow \boxed{\Delta l = 0}$

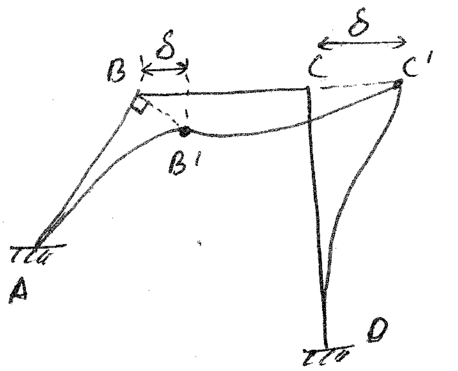


$\Delta l_{AB} = \delta \cos\theta_2$

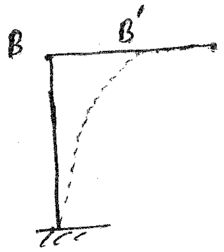
If $\theta_2 = 90°$, $\Delta l_{AB} = 0$



$ACB = AC'B'$

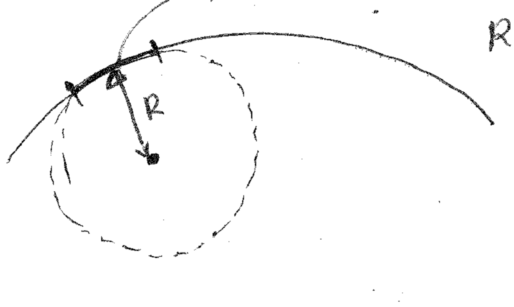


(2) Rigid joints will remain rigid after deformation.



(3) Curvature of beam will be as per the nature of B.M.

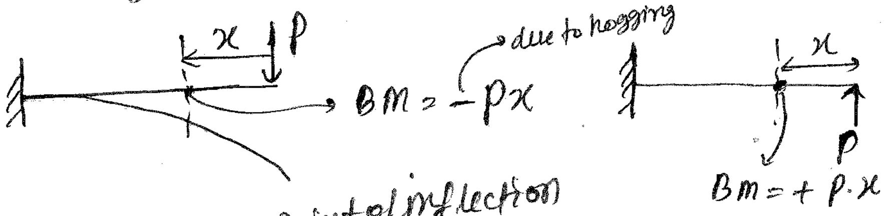
$\rightarrow$ curvature $= \frac{1}{R}$

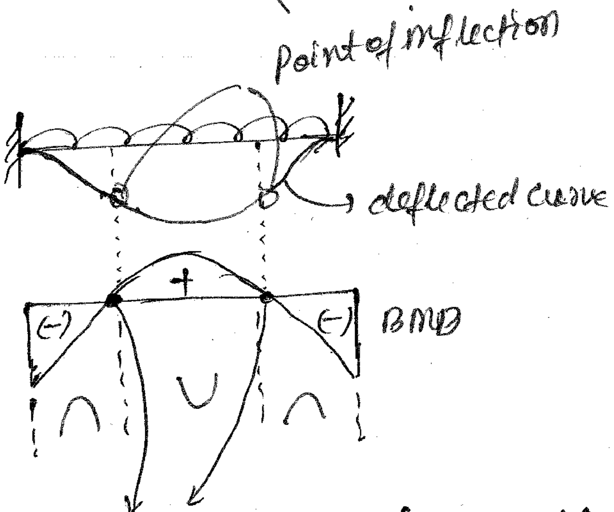


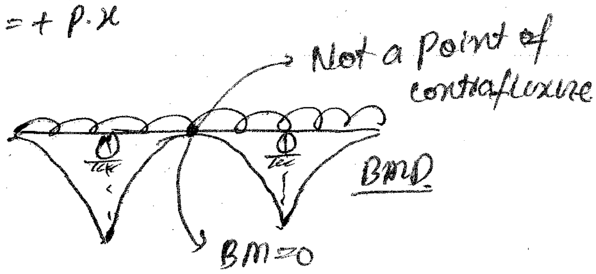
R = Radius of curvature

$$\frac{1}{R} = \frac{M}{EI}$$ M = Bending moment

- Sagging BM causes → concave ↑ curvature (sagging BM)
- Hogging BM causes → concave ↓ curvature (Hogging BM)







Point of contraflexure [At this point BM=0]

⇓

BM changes sign

Symmetry
(a) material
(b) loading
(c) C/S
(d) support

① On the symmetry condition, deflected shape and BMD may be symmetrical but SFD will be antisymmetric.

- ② on the antisymmetric condition, deflected shape & BM will be antisymmetric but SFD will be symmetric.