IES MASTER

Civil Engineering

RSSHU UL H R

STRUCTURAL ANALYSIS

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

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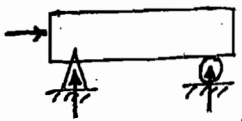
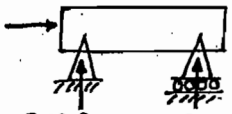
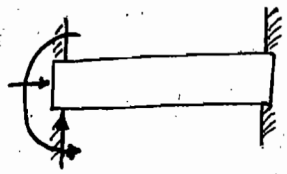
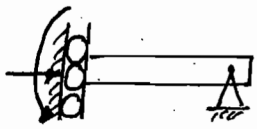
1. FUNDAMENTALS



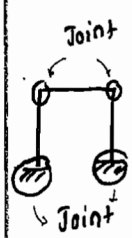


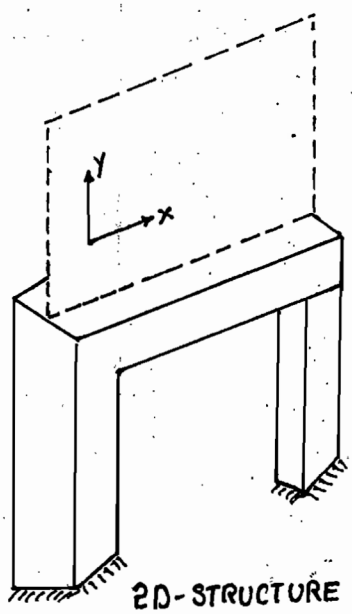


FIXED SUPPORT

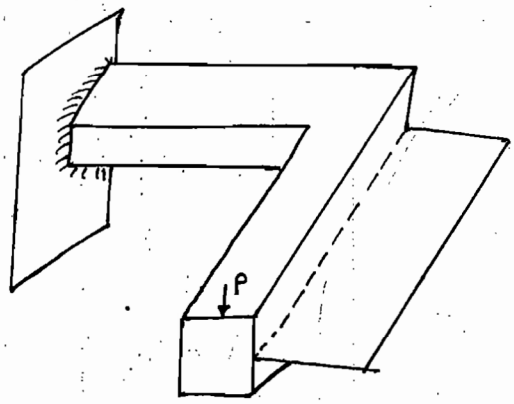


SLIDER SUPPORT



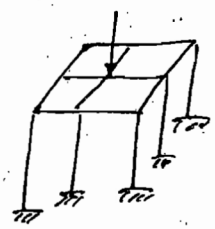


2D-STRUCTURE OR PLAN STRUCTURE



3D-STRUCTURE OR SPACE STRUCTURE

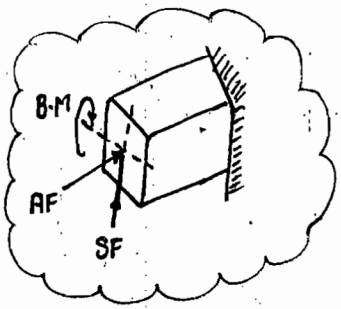
- If loading and structure are in same plane, the structure is called Plane structure or 2D structure.

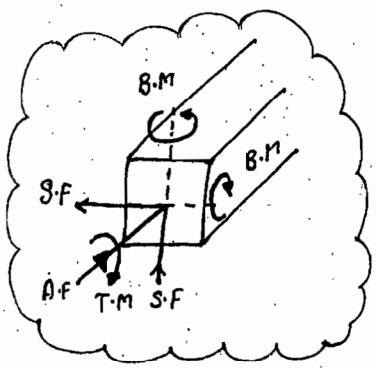


3D

- In 2D in x, y plane the possible displacement at the joint are Δx
- In 3-D structure max. possible joint displacement are six $\Delta x, \Delta y, \Delta z, \theta x, \theta y, \theta z$.
- Reaction developed in structure to prevent joint displacement.

* In 3-D condition
  - At pin support: Max. no. of support reactions is 3. (R_x, R_y, R_z)
  - At roller support: Max. no. of support reactions is 1
  - Fixed / Built in support: Max. number of support reaction is 6 (R_x, R_y, R_z & M_x, M_y, M_z)





- In case of 2-D structure max. no. of internal forces is 3 (Axial forces, shear forces, Bending moment)
- In cas of 3-D structure max. number of internal forces is 6 (S.F, B.M, T.M, S.F, A.F, B.M)

- Purpose of analysis of structure is to find out the internal forces in the structure (i.e member forces) and support reactions.

* EQUILIBRIUM EQUATIONS:-

- In 2D (X-Y Plane)

$\Sigma F_x = 0$

$\Sigma F_y = 0$

$\Sigma M_z = 0$

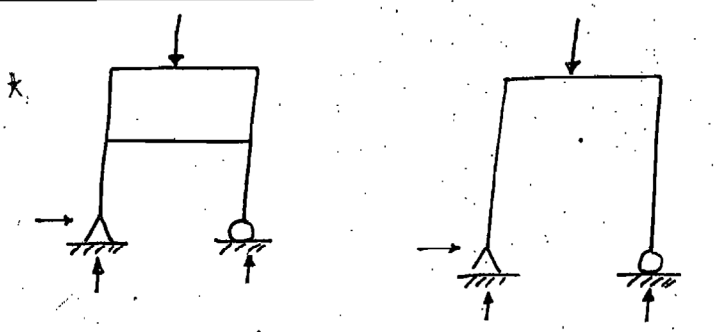
- In 3D

$\Sigma F_x = 0$ $\quad \Sigma M_x = 0$

$\Sigma F_y = 0$ $\quad \Sigma M_y = 0$

$\Sigma F_z = 0$ $\quad \Sigma M_z = 0$

* DETERMINANT AND INDETERMINANT:-



Indeterminant structure

DETERMINANT

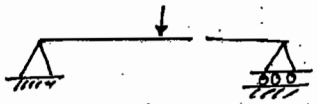
- If all of the member and all support reactions can be determine only by using equilibrium equation then the struct. is called determinant structure otherwise indeterminant.

- In structure analysis we generally cover indeterminate structure.

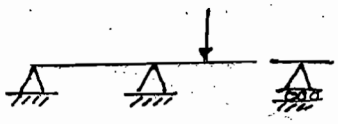
Advantage and disadvantage of indeterminant stu: :-

- **Advantage:-**

- Indeterminate struc. are more rigid and deformation are less.
- The member force development would be lesser in indeterminate structure and hence size of cross-sectional requirement will be lesser. Thus dead load will also be lesser.
- In indeterminate stru. there are multiple path of load transfer available hence collapse of 1 part of the structure may not lead to complete collapse of the structure.



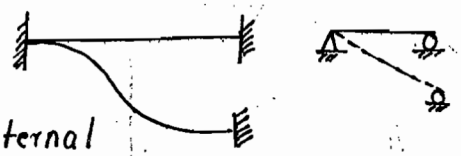
Determinate



Indeterminate

- **Disadvantage:-**

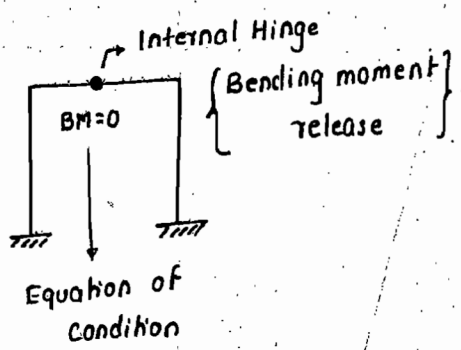
- Settlement of support, change in temp. and fabrication error may lead to internal forces in the structure, in indeterminate structure.

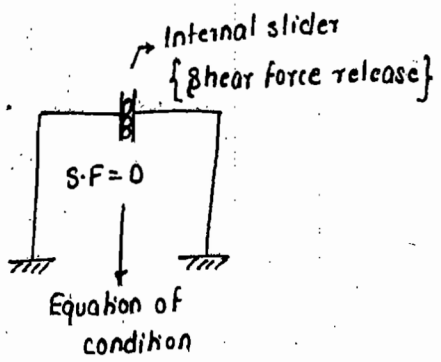


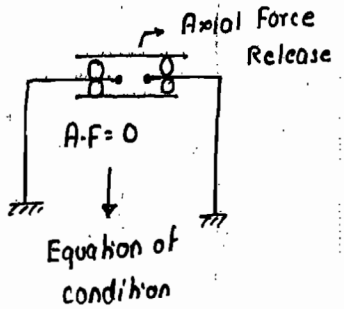
- Internal forces will not develop in these structure in-determinate structure on account of this.

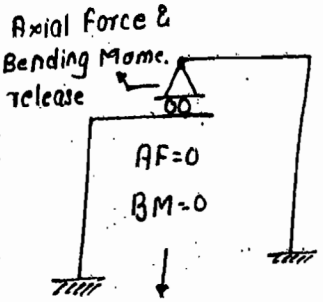
* In case of indeterminate stru. supports are to be made stronger however there would be an overall economy in the structure since member sizes and dead load gets reduced.

INTERNAL RELEASES



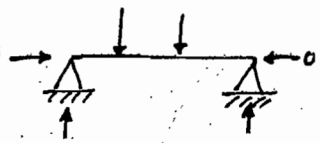




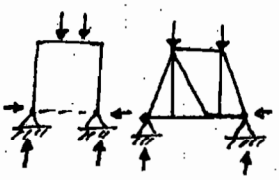


VERTICAL LOADING EFFECT:

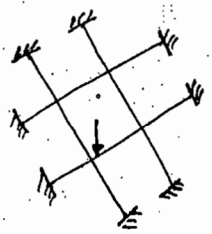
In case of beams if all supports are at same level and load is purely vertical then horizonal reactions do not develop.

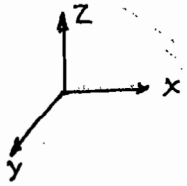


But this statement is not true for frames and structure.



Horizontal Grid with vertical loading





F_z
M_x
M_y
} Only the internal force develop

2. DITERMINACY & INDETERMINACY

→ There are two methods of analysis of inderminate structure:

a) Force method

b) Displacement method

→ In force method of analysis we require compatibility equation.

→ No. of compatibility equation required is equal to degree of static indeterminacy of structure.

→ In displacement method of analysis we require equilibrium equations.

→ No. of equilibrium equation required is equall of/to degree of kinemetic indeterminecy of the structure.

* STATIC INDETERMINACY DETERMINATION:-

$$\text{Degree of static indeterminacy } (D_s) = \left\{\begin{matrix}\text{No. of member forces} \\ \text{and support reactions}\end{matrix}\right\} - \left\{\begin{matrix}\text{No. of equation of} \\ \text{static equilibrium}\end{matrix} + \begin{matrix}\text{No. of equation} \\ \text{of conditions}\end{matrix}\right\}$$

* Generally joint should be choosen at the following location

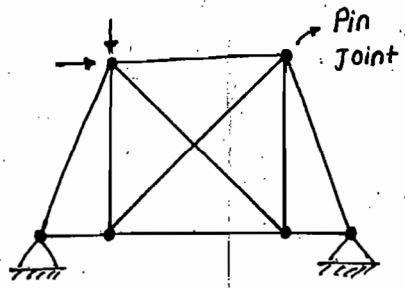
1. Member End
2. Change in cross-section location.
3. Change in material.
4. Change in the orientation of member.
5. Location where curved member meets the straight member.
6. Internal release locations.

* Element blw two joint is called a member.

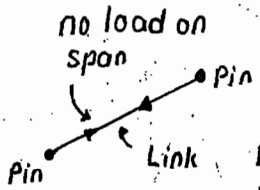
* For beams and frames in 2D

$$D_s = 3m + r - 3J - \text{No. of internal release.}$$

- m = No. of member
- r = No. of support reaction
- J = No. of joints



All members of a truss be a link and carry only axial force.



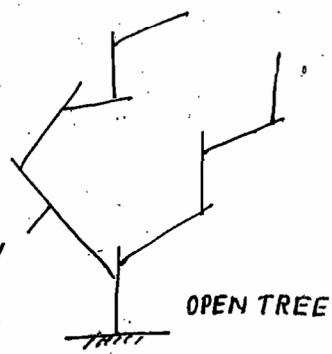
BM = 0
SF = 0
A.F = exist

$$D_s = m + r - 2J$$

* **STATIC INDETERMINACY FOR FRAME :-**

1. **Open tree concept:**

- A rigid jointed frame has all joints rigid and hence to find out static indeterminacy we restrain all the joints to make them rigid, and then the structure is cut to make open tree like structure, hence



$$D_s = 3C - R' \quad \{2D\}$$

C = No. of cut req. to make open tree like stru.

R' = No. of restrain req. to make all joint rigid

- Truss ke har ek end pr pin joint hota hai.
- Jbb 2 pin joint ops me connected ho to wo link member bolte h our usme keval axial force hi lgta ha.

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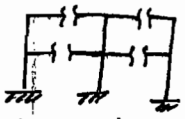
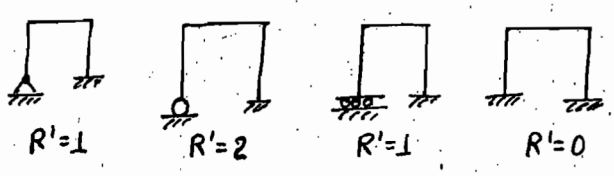
For making open tree like structure following point must be cosider:

Dsc = 8-3
Dsi =

1. One tree can have only one root.
2. A tree cannot have looped branches.



3. None of the branch should fall off while making the open tree.

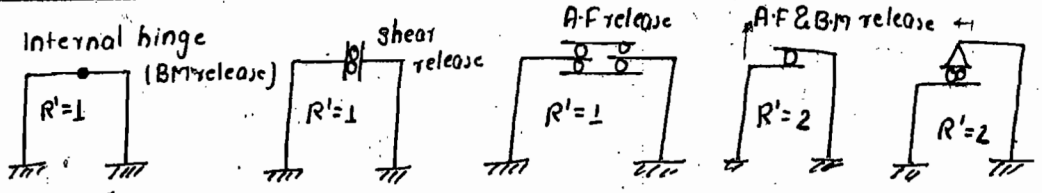


* **RESTRAINT REQUIRER (R'**

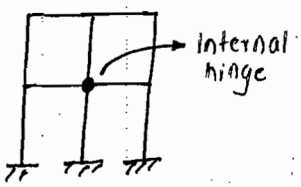
1. **Support restraint:**

No. of restraint req. at support	=	{ No. of reaction if support is fixed }	−	{ No. of existing support reaction }

2. **Restraint required at internal releases:**



No. of restraint require = No. of internal forces / releases.



$\therefore R' = [m' - 1]$

$\because m'$ = No. of members meeting at hinge