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UNACADEMY
CIVIL ENGINEERING
STRUCTURE ANALYSIS
BY-JASPAL SIR

- Theory
- Explanation
- Derivation
- Example
- Shortcuts
- Previous Years Question With Solution

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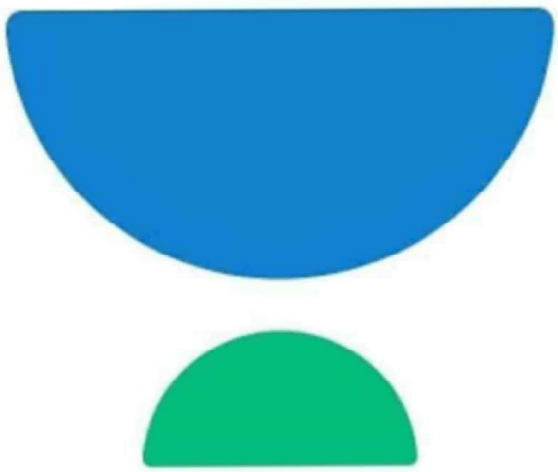

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Jaspal Sir's Structure Analysis

Handwritten Notes

Written
By
Roopali Rai

Lesson 1 Feb 16

Structural Analysis

- Structure can be defined as body of connected parts that is designed to carry loads even it is not intended to be occupied by us.

For eg: Bridges, dams, Railways, Retaining wall, tunnel, canals etc.

- The aim of structural analysis is to find force/moments in various components/parts of the structure.
- For the structure to remain in equilibrium, net forces (force & moments) acting on it must be zero in all directions.

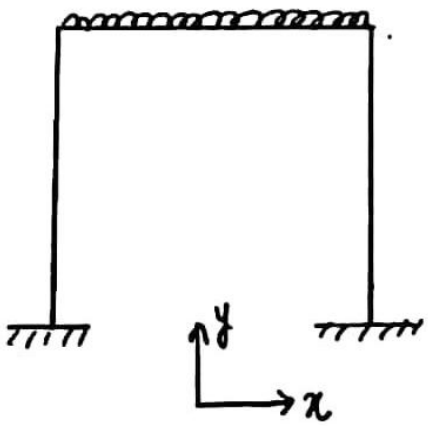
Note:→ If net force acting on body is zero & that body is at rest then it is termed to be in static equilibrium.

For eg:→ Aircraft flying, train running, vessel sailing, car moving with const speed: Equilibrium.
But, Bridge, Dam, canal, retaining wall: static Equilibrium

- In a 2D structure or planner structure (in which all the members & forces are in one plane only), the equations of equilibrium are

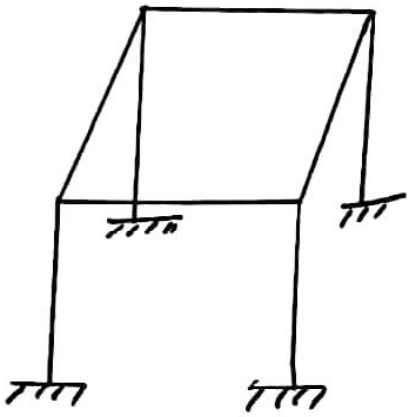
$$\left.\begin{aligned} \Sigma F_x &= 0 \\ \Sigma F_y &= 0 \\ \Sigma M_z &= 0 \end{aligned}\right\} \text{3no's}$$

The above structure is assumed to be in x-y plane.



- In 3D structure or space structure (in which members & forces are in ~~3D~~ not in single plane) or are in 3D), the equations of equilibrium are :-

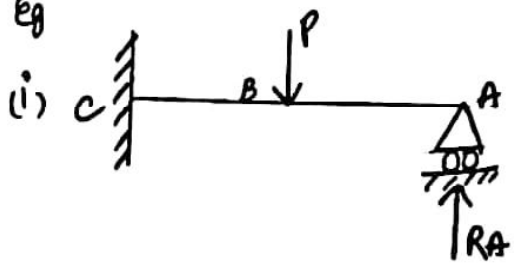
$$\left.\begin{aligned} \Sigma F_x &= 0 \\ \Sigma F_y &= 0 \\ \Sigma F_z &= 0 \\ \Sigma M_x &= 0 \\ \Sigma M_y &= 0 \\ \Sigma M_z &= 0 \end{aligned}\right\} \text{6 no.'s}$$



- In the analysis of structure can't be done just by using equations of equilibrium, then compatibility & energy equations are used.

Eg

(i)



$\delta_A = 0$

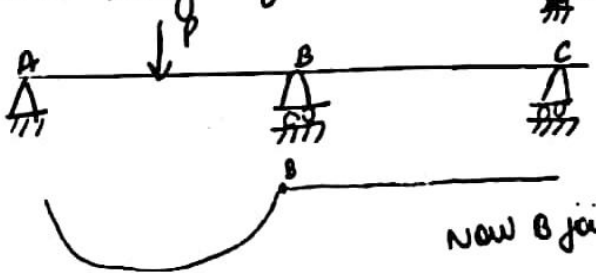
$\downarrow \delta_{load\ P} - \uparrow \delta_{R_A} = 0$

(ii)

$\Delta_{AB} = 0$

$\Delta_{Temp} - \Delta_R = 0$

- Here compatibility may be termed as continuity or good fit of material or structure or member or joint while being deformed under loading.



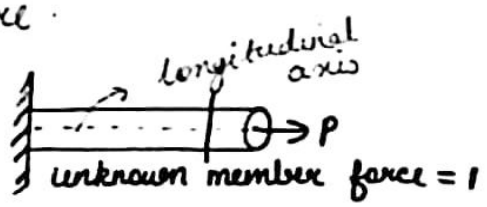
Compatibility eq^n not satisfy because support cannot be lifted.

Now B joint is not continous.

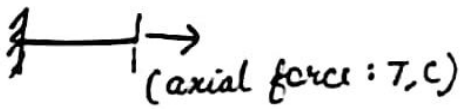
. It is not compatible due to lifting of joint C

Types of Members Forming structure.

A) Axial member



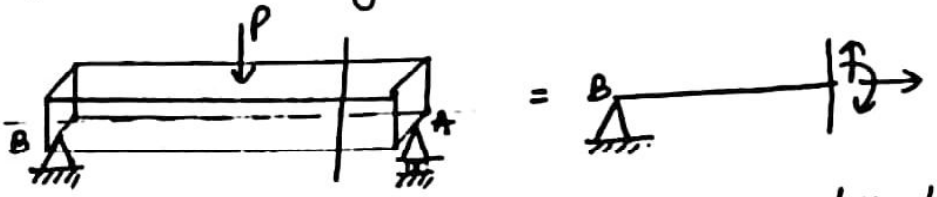
- It is the simplest structural member
- for eg. bar or rod
- An axial member is a long straight body on which the forces are being applied along the longitudinal axis.
- An axial member can support axial force. (both tensile or compressive)



B) Beam / Frame Member

- It is a line element / member (element whose one dimension (length) is comparatively more than other two dimension (width, depth)) which is designed to resist SF & BM due to transverse load / moment.

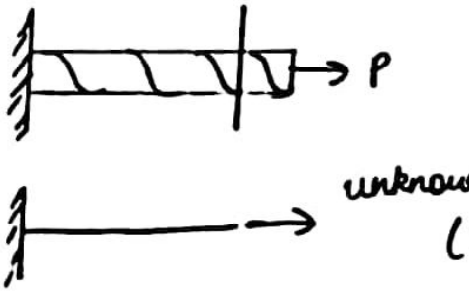
Note :→ Transverse load is that load which is applied normal (⊥r) to the longitudinal axis.



unknown member force = 3
(axial force, SF, BM).

C) Cable.

- It is made of rope, chain or wire that serves different functions (according to the application)
- A cable can support axial force only, nature of which is tensile.



Lesson 2 Feb 17.

Types of support

- It is the boundary arrangement that can restrain movement of any point of the structure
- Due to the restrainment of the movement, reactions are developed at the support in the direction opposite to the expected movement.
- Supports are generally of following types :→

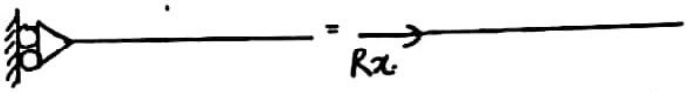
A) Roller / Simple / Rocker support.

- It is the simplest support that gives only one reaction because only one movement is restrained.

Reaction developed = 1 (Ry)

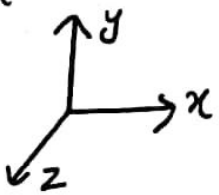
- Rollers can also have different orientations as :→

a)

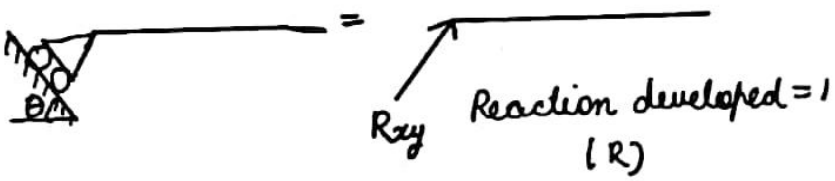


Movement restrained "x"

Reaction developed = 1 (Rx)



b)



Movement restrained "xy"

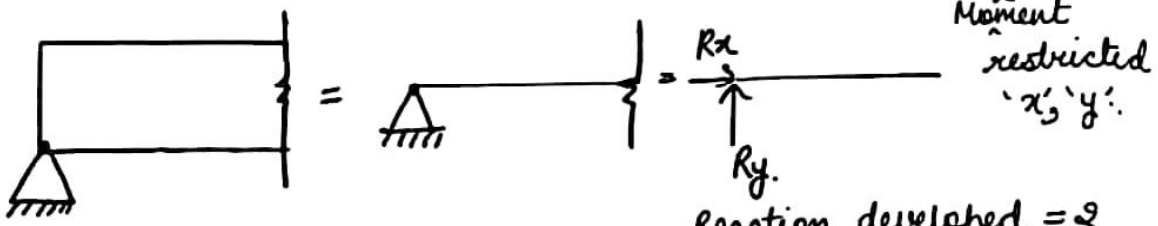
Reaction developed = 1 (R)

$Rx = Rxy \sin\theta$

$Ry = Rxy \cos\theta$

B) Hinged / Pinned support

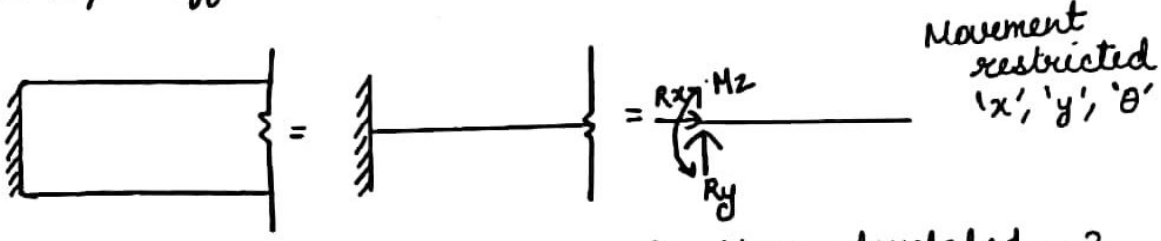
- A pin/hinge gives resistance against <u>two</u> movement, hence offers two reactions



Reaction developed = 2
(Rx, Ry.)

C) Fixed support

- It is the support that <u>restrains</u> <u>complete</u> <u>movement</u> of the point of structure.
- Hence, it offers three reactions

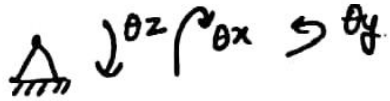


Reactions developed = 3.
(Rx, Ry, Mz)

Note:→ <u>Number of reactions</u> in 3D or space structure

① No. of reactions

1 (Ry)



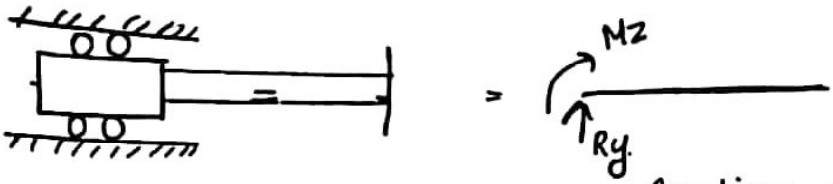
3 (Rx, Ry, Rz).

6 (Rx, Ry, Rz, Mx, My Mz)

② Inclined roller support & hinge support both restrict the movement in x & y direction but inclined roller support offers 1 reaction (as θ is known) & hinged support offers 2 reaction (as θ is unknown)

d) Guided Roller Support

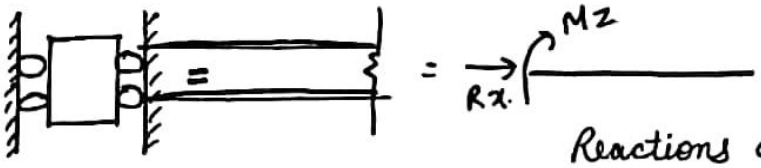
- It is the type of roller support, movement of which is guided / restrained in a particular direction, hence it offers 1 additional reaction



Movement restricted
(y, θ)

Reactions developed = 2.
(Ry, Mz)

or

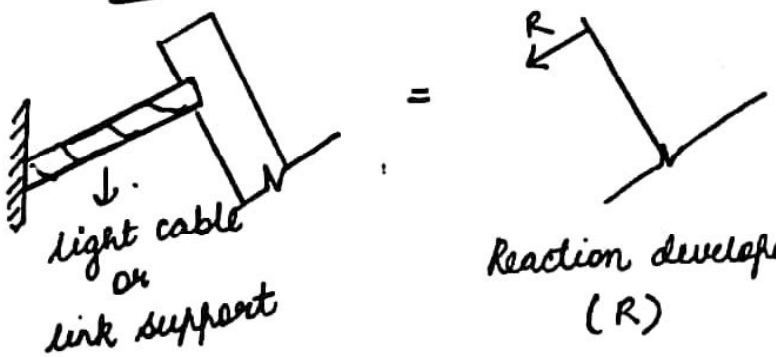


Movement restricted
(x, θ).

Reactions developed = 2
(Rx, Mz)

e) Link support

- It is the type of support in which reaction is developed in the direction of cable or link



Light cable
or
link support

Movement restricted
(axial pull)

Reaction developed = 1
(R)

Determinacy & Indeterminacy

- The structure in which all member forces & support reactions cannot be found using only the equations of static equilibrium are termed as Indeterminate structure.

- In structures, we generally use indeterminate structure.
- In Indeterminate structures, Bending moment developed is smaller, hence the C/S requirement is less also dead load of the structure reduces and there are multiple paths of load transfer available.
- Hence, failure of one member does not lead to the collapse of complete structure.
- However, in case of Indeterminate structure, we need to make stronger supports & this requires additional cost.
- Also the settlement of support or change in temperature gives rise to additional stress.

- If all the support reactions can be calculated only by using equations of static equilibrium, the structure is said to be "externally determinate" or else "externally indeterminate".

- If by knowing ~~the~~ all the support reactions we can find all the member forces using equations of equilibrium, the structure is said to be "internally determinate" or else "internally indeterminate".

Degree of Static Indeterminacy ($D_s = D_{se} + D_{si}$)

External static Indeterminacy (D_{se})

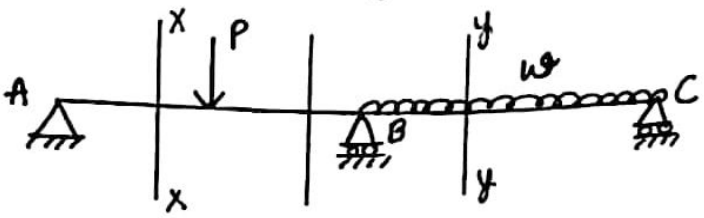
- It deals with support reactions only.
- It is the no. of support reactions in excess of equilibrium equations.

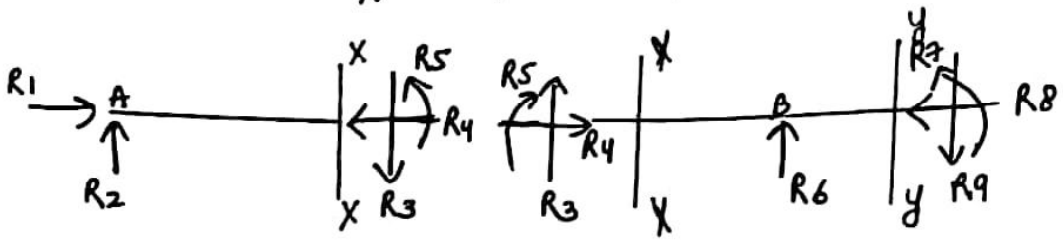
Internal static Indeterminacy (D_{si})

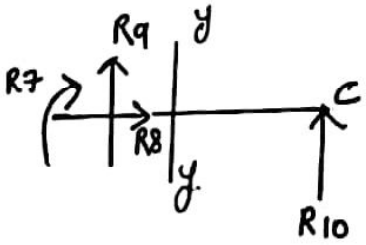
- It deals with internal member force (AF, SF, BM)
- It is the total no. of internal forces in excess of equilibrium eqn.

Hence, it can be stated that total no. of unknown forces (including support reaction & internal forces) in excess of total no. of static equilibrium equations is termed as degree of static Indeterminacy (Ds)

for eg.







- Total number of unknown forces (Internal & External reaction (support reaction)) = 10
- Total number of available equilibrium eq^n = 9 (3 for each 3 members)
- Hence number of unknown force required to be known to complete structural analysis (to find the forces/moments in the member & supports) = 10 − 9 = 1
- Hence, degree of static Indeterminacy signifies the minimum no. of unknown forces (support reactions & internal force) required to be known to calculate all the other unknown forces.