UNIT-I. FLEXIBILITY METHOD. Date :- 22-03-2022.

→ one of matrix method to determine the unknown forces.

Static indeterminacy :- without movement

Kinematic indeterminacy :- with movement.

STATIC EQUILIBRIUM EQUATIONS :- Based on Sir Isaac Newton's law of motion,

(i) Sum of all forces in any axis is zero.

$$\Sigma F_x = \Sigma F_y = \Sigma F_z = 0.$$

(ii) Sum of all moments above any axis is equal to zero.

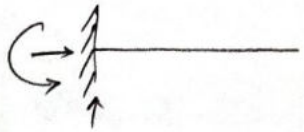
$$\Sigma M_x = \Sigma M_y = \Sigma M_z = 0.$$

DETERMINATE STRUCTURE :- Equations of static equilibrium ($\Sigma F_x = \Sigma F_y = \Sigma M = 0$) are sufficient to determine unknown forces and ~~members~~ moments in a member.

INDETERMINATE STRUCTURE :- Equations of static equilibrium ($\Sigma F_x = \Sigma F_y = \Sigma M = 0$) are not sufficient to determine unknown forces and moments in a member.

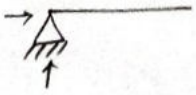
TYPES OF SUPPORT :-

(i) Fixed support



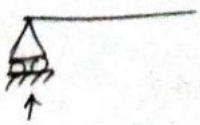
No. of reactions = 3.

(2) Hinged Support.



No. of reactions = 2.

(3) Roller support.



No. of reactions = 1.

(4) Free end

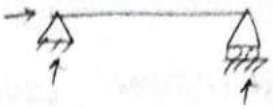
No. of reactions = 0.

DEGREE OF STATIC INDETERMINACY (D_s) :-

D_s = Total unknowns − Equilibrium equations.

(i) Determinate and Stable.

$D_s = 0$



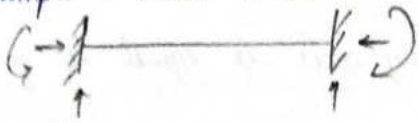
$D_s = 3-3$
$= 0.$

R = unknown reactions.
r = equations

[(ii)] Example :- Simply supported beam.

(ii) $D_s > 0$, Indeterminate and Stable.

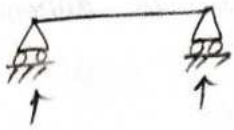
Example :- Fixed beam.



$D_s = 6-3$
$= 3.$

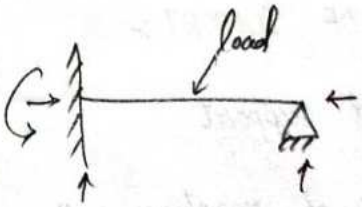
(iii) $D_s < 0$, Determinate and Stable.

Example :- Both ends are roller.



$D_s = 2-3$
$= -1.$

Q. Find out the indeterminacy of a given beam of both vertical and general loading conditions :
(upward & downward direction loads)



General loading :-

$R = 5,\ r = 3$ $(\Sigma V = 0, \Sigma H = 0, \Sigma M = 0)$

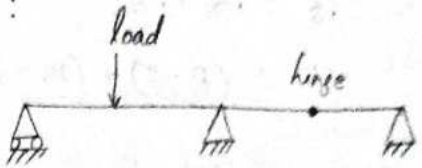
$D_s = 5-3$
$= 2.$

Vertical loading :-

$R = 3,\ r = 2$ $(\Sigma V = 0, \Sigma M = 0)$

$D_s = 3-2$
$= 1.$

Q2. Determine the degree of indeterminacy of a given beam for general & vertical loading condition :

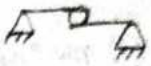


$D_s = R - r - h.$

General loading :- $R = 5, r = 3.$

$D_s = 5 - 3 - 1$

$= 1.$



$h = m - 1.$

↑ No. of members joint at hinge joint.

Vertical loading :- ~~$R = 3$~~, $r = 2.$

$D_s = ~~3~~ - 2 - 1.$

$= 20.$

Vertical loading :- $R = 3, r = 2, h = 1.$

$D_s = 3 - 2 - 1$

$= 0.$

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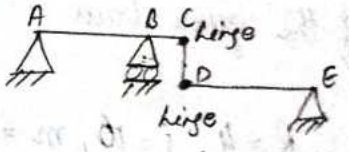
Q3. Determine the static indeterminacy of a given beam :-



General loading :- $= (m-1) + (m-1) = 2$

$R = 5, r = 3, h = (2-1) + (2-1) = 2.$

$D_s = R - r - h.$

$= 5 - 3 - 2$

$= 0.$ (Determinate & Stable).

Vertical loading :- $R = 3, r = 2, h = 2.$

$D_s = 3 - 2 - 2$

$= 0 - 1.$

DETERMINACY OF TRUSSES :- $m = 2j - 3$.

(Pin jointed frames)

$D_s = D_{se} + D_{si}$ ← external, ← internal, ← joints.

$= (R - 3) + (m - 2j + 3)$.

If $m = 0$, sufficient to be able to carry loads.

(i) $m = 2j - 3 \rightarrow$ Perfect truss.

(ii) $m < 2j - 3 \rightarrow$ Deficient truss.

(iii) $m > 2j - 3 \rightarrow$ Redundant truss.

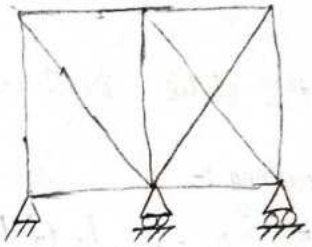
There are two types of indeterminancy

(i) Internal Indeterminancy.

(ii) External Indeterminancy.

$$\boxed{D_s = R + m - 2j}$$

Q. Find the total static indeterminancy of the given truss :-



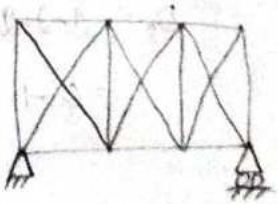
$R = 4$, $j = 10$, $m = 10$

$D_s = 4 + 10 - 12$.

$= 2$.

Q. Find the static indeterminacy of the given truss :-

$R = 3$, $j = 8$, $m = 16$.



$D_s = R - 2j + m$.

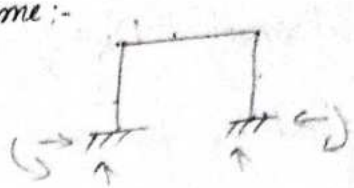
$= 3 - (2 \times 8) + 16$.

$= 3$.

PLANE FRAMES :- (Truss) Rigid jointed frames.

$$D_s = 3m + R - 3j$$

Q. Find the static indeterminacy of a given frame :-



$m = 3,\ R = 6,\ j = 4.$

$$D_s = (3 \times 3) + 6 - (3 \times 4).$$

$$= 9 + 6 - 12.$$

$$= 3.$$

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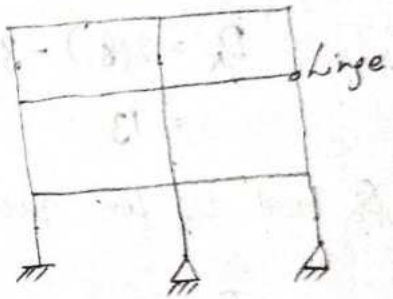
Q. Find the static indeterminacy of the given frame :-



$$D_s = R - 3j + 3m.$$

$R = 7,\ m = 15,\ j = 12,\ h = 3 - 1 = 2.$

$$D_s = 7 - (3 \times 12) + (15) \cdot 3 - 2$$

$$= 52 - 38$$

$$= 14$$

52
38
14

KINEMATIC INDETERMINANCY :-

For beams, $D_k = 3j - R.$

Q. Find D_k for the given beam :-

$$D_k = 3(2) - 3.$$

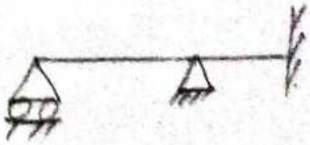
$$= 3.$$

Q. Find D_k for fixed beam :-

$$D_k = 3(2) - 6.$$

$$= 0.$$

Q. Find D_k for fixed beam :-



$$D_k = 3(3) - 6.$$

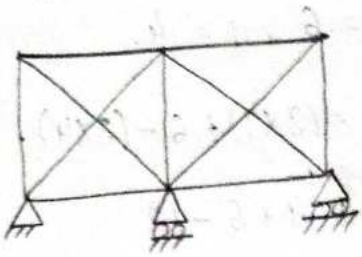
$$= 3.$$

Beam $D_K = 3j - R$ $\quad D_S = R - r.$

Truss. $D_K = 2j - R + h$ $\quad D_S = m - 2j + R.$

Frames. $D_K = 3j - (m+R) + h$ $\quad D_S = 3j - (m+R) - h.$

Q. Find D_K for given truss :-

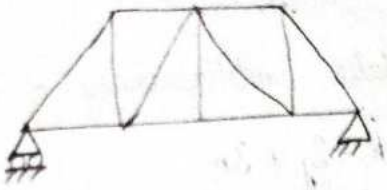


$D_K = 2j - R.$

$= 2(6) - 4.$

$= 8.$

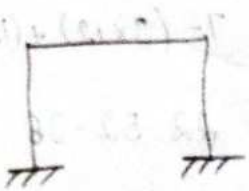
Q. Find D_K for given truss :-



$D_K = 2(8) - 3.$

$= 13.$

Q. Find D_K for given frame :-



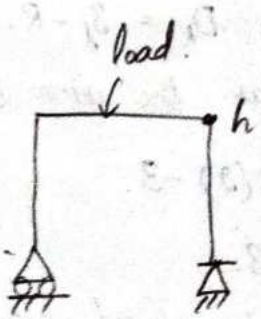
$D_K = 3j - (m+R) + h$

$= 3(4) - (3+6)$

$= 12 - 9$

$= 3.$

Q. Find D_K for given frame :-



$D_K = 3(4) - (3+3) + 1.$

$= 12 - 6 + 1.$

$= 7.$