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CE-2.

Structural Analysis

Tutorial- II
Statically Indeterminate Structures.

Statical Indeterminacy → $(m + r) - 2j$. (for truss)
Other formula → $(\alpha m + r) - (\beta j + \gamma) = SI$.
Degree of freedom $= n+2$.
$\gamma = n-1$

FOR BEAM,
$\alpha = 3$
$\beta = 3$.

For Truss.
$\alpha = 1$ (only Axial)
$\beta = 2$ $(\Sigma F_x = 0, \Sigma F_y = 0)$

For Frame.
$\alpha = 3$
$\beta = 3$

External Indeterminacy $= R - 3$.
Internal " =
Beam = 0
Frame $= M - 2j - 3$ / (3 × closed loop)
Truss $= M - 2j - 3$.

α = No. of unknown action in mem.
m = No. of member
r = No. of ext. support reac.
β = No. of equilibrium eqn available at each joint
j = No. of joint
γ = No. of internal releases

$\gamma = n - 1$, if n is no. of member meeting at the internal hinge.
$\alpha = 3 \Rightarrow$ [AFD, BMD, SFD]

For space structure.
$\alpha = 6$ $\gamma = 3(n-1)$
$\beta = 6$

Kinematic Indeterminacy :
$KI = (\beta j + \gamma) - (\alpha m + r)$
$\alpha = 0$, for extensible mem. condition
$\alpha = 1$, for inextensible member condition.

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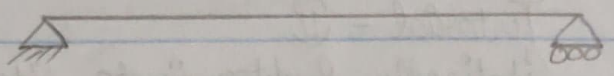
Determine Static Indeterminacy of following :-

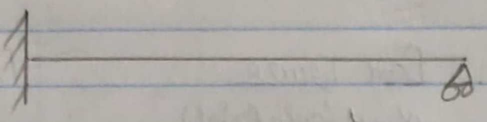
(1)



$M = 1.$
$r = 3.$
$j = 2$

$SI = (M + r) - 2j$
$= 1 + 3 - 2\times2$
$= \underline{\underline{0}}$

(2)



$m = 1$
$r = 4.$
$j = 2$

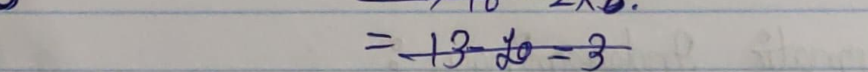
$SI = 1 + 4 - 2\times2$
$= \underline{\underline{1.}}$

$\alpha = 3$
$\beta = 3$
$\gamma = 0.$

$SI = (3\times1 + 4) - 2\times3.$
$= 7 - 6 = \underline{\underline{1}}$

$EI = r - 3$
$= 4 - 3 = \underline{\underline{1.}}$

(3)

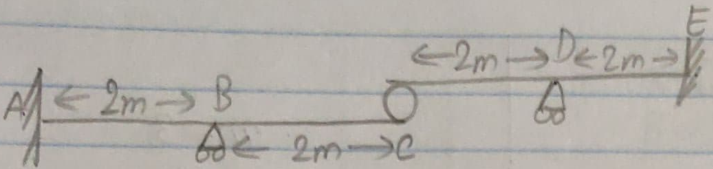


$m = 7$
$r = 6.$
$j = 8$
$\alpha = 3$
$\beta = 3$
$\gamma = 3.$

$\cancel{SI = (m + r) - 2j}$
$\cancel{= 7 + 6 - 2\times8.}$
$= \cancel{13 - 10 = 3}$

$SI = (3\times7 + 6) - (3\times8 + 3).$
$= 21 + 6 - (15 + 3 + 6)$
$= \underline{\underline{0}}$

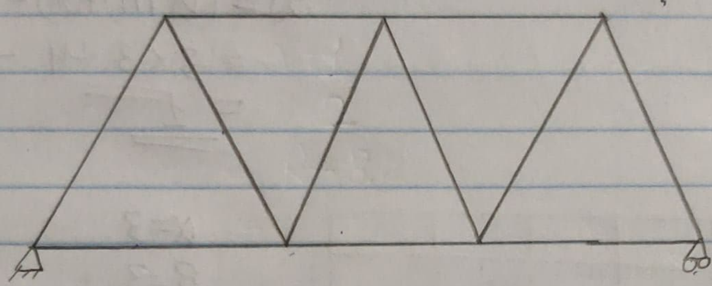
(4)



$M = 4.$
$r = 8$
$\alpha = 3$
$\gamma = 2.$
$\beta = 3.$
$j = 5$

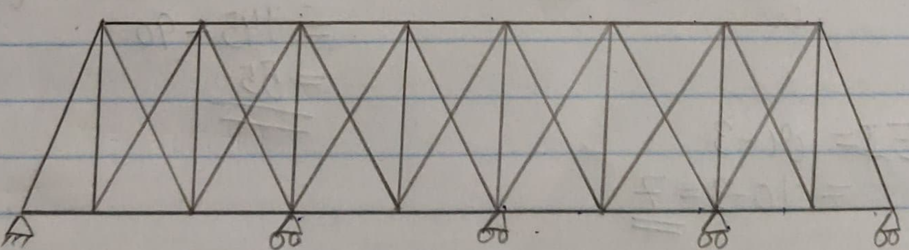
$SI = (4\times3+8) - (3\times5+2).$
$= 20 - 17$
$= \underline{\underline{3}}$

(5)



$SI = m + r - 2j.$
$m = 11$
$r = 3.$
$j = 7$
$SI = 11 + 3 - 14 = \underline{\underline{0}}$

(6)



$SI = m + r - 2j.$
$m = 40$
$r = 6$
$j = 18.$
$SI = 40 + 6 - 2\times18 = 4 + 6 = \underline{\underline{10}}$

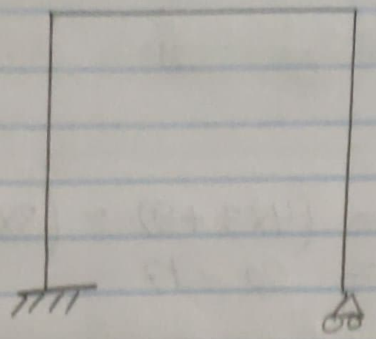
$EI = 6 - 3 = 3.$
$IJ = 40 - 2\times18 + 3$
$= \underline{\underline{7}}$

(11) Radius

$\alpha = 3 \quad \gamma = 0$
$\beta = 3$

$3 \times m + r - 3 \times j$

7



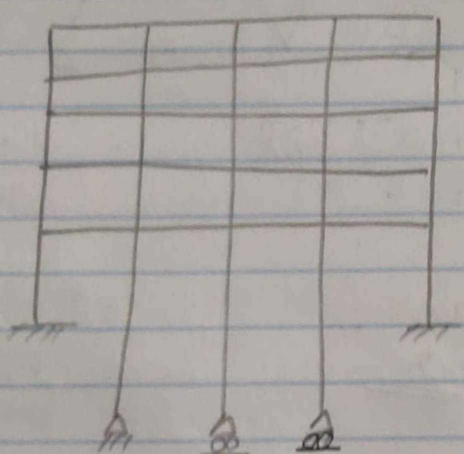
$m = 3.$
$r = 4$
$j = 4.$

$SI = (3m + r) - 3j.$
$= 3 \times 3 + 4 - 3 \times 4.$
$= \underline{\underline{1}}$

$\alpha = 3, \beta = 3, \gamma = 0$

$SI = (\alpha m + r) - (\beta j + \gamma)$
$= 3 \times 3 + 4 - 3 \times 4$
$= \underline{\underline{1}}$

8



$\alpha = 3$
$\beta = 3.$
$\gamma = 0.$
$m = 45.$
$r = 10.$
$j - 30.$

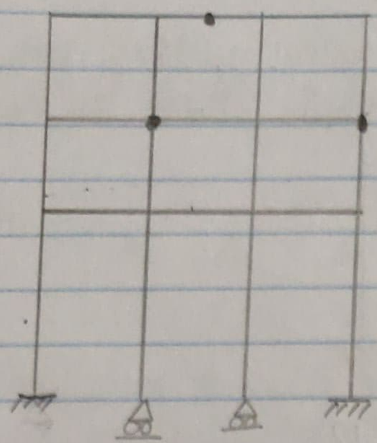
$SI = (3 \times 45 + 10) - (3 \times 30 + 0)$
$= 145 - 90$
$= \underline{\underline{55}}$

$EI = r - 3.$
$= 10 - 3 = \underline{\underline{7}}$

$II = 3 \times 45 - 3 \times 30 + 3.$
$= \underline{\underline{48}}$

Produs

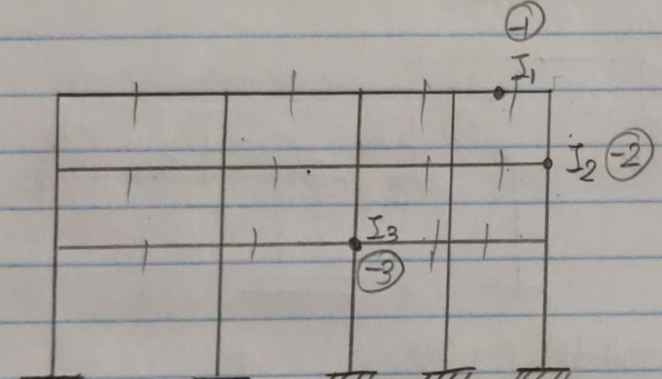
9



$\alpha = 3$
$\beta = 3$
$\gamma = \Sigma(n-1)$
$= (2-1)+(3-1)+(4-1)$
$= 1+2+3 = 6.$
$m = 22.$
$r = 8.$
$j = 17.$

$SI = (3\times22+8) - (3\times17+6)$
$= 66+8-51-6.$
$= 74-57 = 17$

10



$\alpha = 3$
$\beta = 3$
$\gamma = \Sigma(n-1) = (2-1)+(3-1)+(4-1) = 6.$
$m = 28$
$r = 15.$
$j = 21.$

$SI = (3\times28+15) - (3\times21+6)$
$= 99-69$
$= 30$

Using tree method,
No. of internal release = $2-1+4-1+3-1 = 6.$
No. of cut = 12.

$SI = 3\times12-6$
$= 36-6 = 30$

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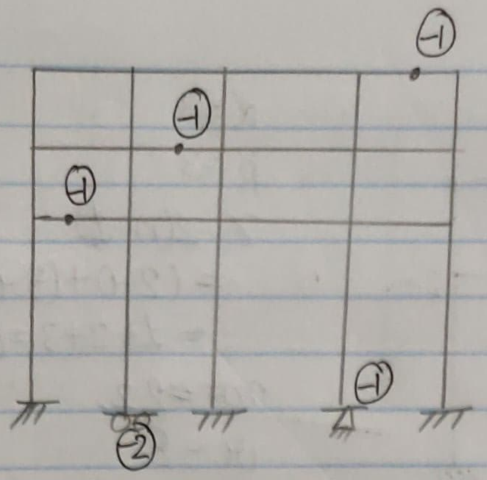
11.

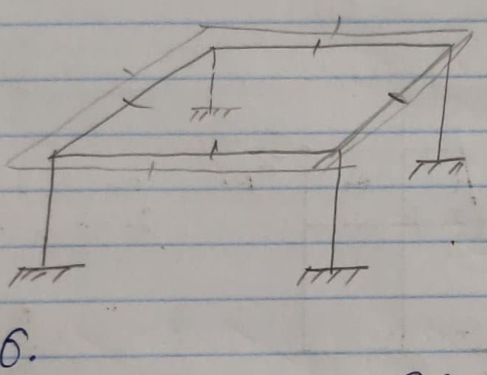


No. of cut $= 3\times4 = 12$.

No. of internal releases $= 1+1+1+2+1 = 6$.

$SI = 3\times12-6 = 36-6 = \underline{\underline{30}}$

12.



$\alpha=6$.

$\beta=6$.

$\gamma=3(n-1)=0$.

$m=8$.

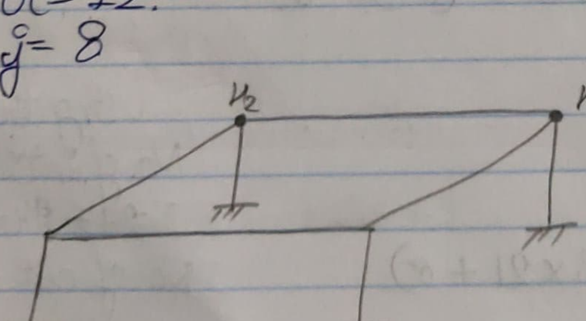
$r=12$.

$j=8$

$SI = (6\times8+12)-(6\times8+0)$

$= \underline{\underline{12}}$

13.



$\alpha=6$

$\beta=6$

$\gamma=3(2)\times2=12$

$m=8$

$r=12$.

$j=8$.

$SI = (6\times8+12)-(6\times8+12)$

$= \underline{\underline{0}}$

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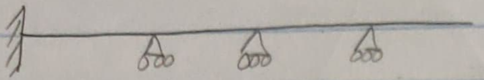
For the follbing diagrams, calculate Kinematic Indeterminacy as well as Static indeterminacy:

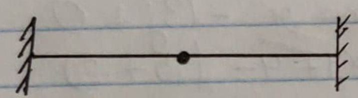
(1)



$SI = 3m + r - (3j + r)$
$= 3 \times 4 + 6 - 3 \times 5$
$= 12 + 6 - 15 = \underline{\underline{3}}$

$KI = 3j + r - r.$
$= 3 \times 5 - 6 = 15 - 6 = \underline{\underline{9}}$

(2)



$m = 2$ $\quad r = 6$
$j = 3$ $\quad r = 1.$

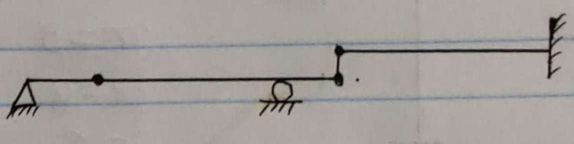
Static Indeterminacy ⇒

$SI = 3m + r - (3j + r)$
$= 6 + 6 - (9 + 1)$
$= 2$

Kinematic Indeteminacy

$KI = 3j + r - r$
$= 3 \times 3 + 1 - 6 = \underline{\underline{4}}$

(3)



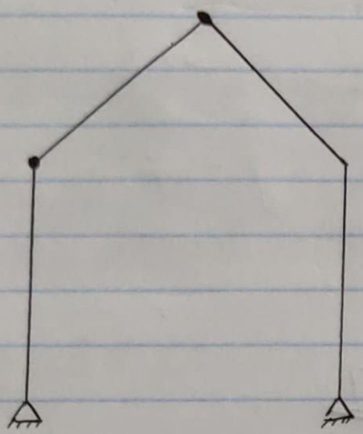
$m = 5$
$r = 6$
$r = 3.$
$j = 6$

$SI = 3m + r - (3j + r)$
$= 3 \times 5 + 6 - (3 \times 6 + 3).$
$= \underline{\underline{0}}$

Hence, statically determinate beam.

$KI = 3j + r - R$
$= 3 \times 6 + 3 - 6$
$= \underline{15}$

4



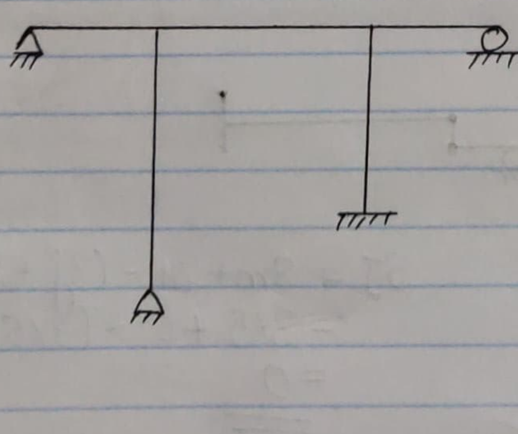
$m = 4$
$r = 2$
$R = 4$
$j = 5$

$SI = \alpha m + R - (\beta j + r)$
$= 3m + R - (3j + r)$
$= 3 \times 4 + 4 - (15 + 2)$
$= \underline{-1 < 0}$

Unstable frame.

$KI = (\beta j + r) - R$
$= 3 \times j + r - R$
$= 3 \times 5 + 2 - 4$
$= \underline{13}$

5.

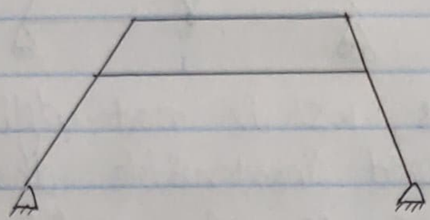


$m = 5$
$R = 8$
$j = 6$
$r = 0.$
$SI = 3m + R - (\beta j + r)$
$= 3m + R - (3j + 0)$
$= 23 - 18 = \underline{5}$

Prodid

$$KI = (3j + r) - \sigma$$
$$= 18 - 8$$
$$= 10$$

6.



$m = 6$

$j = 6$

$r = 0$

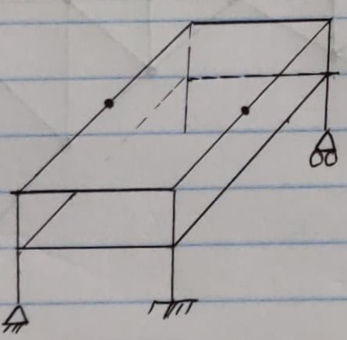
$\alpha = 3$.

$\sigma = 4$.

$$SI = 3m + \sigma - (3j + r)$$
$$= 3 \times 6 + 4 - 3 \times 6$$
$$= 4$$

$$KI = 3j + r - \sigma = 18 + 0 - 4 = 14$$

7



$\alpha = 6$

$\beta = 6$

$m = 18$

$j = 14$

$r = 3 \times 2 = 6$

$\sigma = 6 \times 2 + 1 + 3 = 16$

$$SI = \alpha m + \sigma - (\beta j + r)$$

$$SI = 6 \times m + \sigma - (6j + r)$$
$$= 18 \times 6 + 16 - (6 \times 14 + 6)$$
$$= 124 - 90 = 34$$

TREE METHOD.

SI = 6 x No. of cut − 3 x No. of hinge − 5 x No. of roller − 3 x No. of hinge.

$$= 6 \times 8 - 3 \times 2 - 5 - 3 = 34$$

$$KI = (\beta j + r) - (\alpha m + \sigma)$$
$$= 6j + r - \sigma. \quad (\alpha = 0)$$
$$= 6 \times 14 + 6 - 16$$
$$= 84 + 6 - 16 = 74$$

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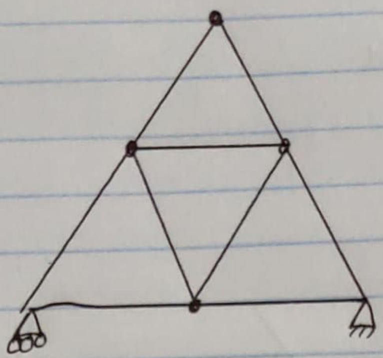


In Trusses, KI is not defined because if mem. are considered inextensible then there is nothing to calculate KI as only axial forces are presents at each members.

SI =

$m = 6$

$j = 6$

$r = 3$

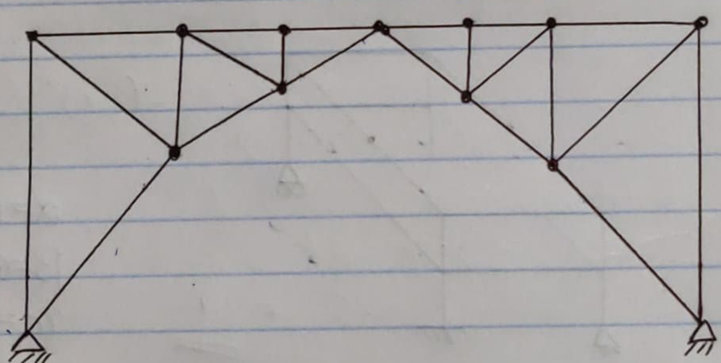
$SI = m + r - 2j$

$= 9 + 3 - 12$

$= 0$

Statically determinate.

9



$m = 22$

$j = 13$

$r = 4.$

$SI = m + r - 2j$

$= 22 + 4 - 26 = 0$

Statically determinate.