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Ans1: Static Indeterminacy

General Formula → $(\alpha m + x) - (\beta j + r)$ $\alpha = 3$
$SI = (3m + x) - (3j + r)$ $\beta = 3$

Here, x → total no. of reaction forces.
m → member
j → joints
r → internal releases.

By observation − $x - 3 - r = SI$

So, $SI = (3m + x) - (3j + r)$ $m = 2$ $j = 3$
$= 6 + 5 - 9$ $x = 3 + 1 + 1 = 5$ $r = 0$
$= 11 - 9 = 2$

and CHECK:
$SI = 5 - 3 - 0$
$= 2$

So, static indeterminacy of beam = 2

Kinematic Indeterminacy

General Formula − $(\beta j + r) - (\alpha m + x) = KI$
Here, $\beta = 3$
$\alpha = 0$

So, $KI = 3j + r - x$

By observation −
Total degree of freedom (DOF) available at each joint.

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$KI = 3(3) + 0 - 5 = 4$

CHECK :

$KI =$ total DOF $= 4 = (2+2)$.

Ans 2. Static Indeterminacy

By formula →

$$SI = 3m + r - (3j + r)$$

$$SI = 6 + 6 - (9 + 1)$$

$$= 2$$

$\left\{ \begin{array}{l} m = 2 \\ j = 3 \\ r = 6 \\ r = 1 \end{array} \right\}$

CHECK :-

$$SI = r - 3 - r = 6 - 3 - 1 = 2$$

So, static Indeterminacy of Beam = 2

Kinematic Indeterminacy

Formula → $KI = 3j + r - r$

$$= 9 + 1 - 6$$

$$= 4$$

CHECK - KI = DOF at joints.

= 4 [i.e. in x, y and two BM's at two beams joined at B].

So, Kinematic Indeterminacy of Beam = 4

Ans 3. Static indeterminacy

$m = 2$

$r = 2$

$x = 4$

$j = 3$

$$SI = x - 3 - r$$
$$= 4 - 3 - 2$$
$$= -1 < 0$$

structure unstable.

By Formula :- $SI = 3m + x - (3j + r)$
$$= 6 + 4 - (3(3) + 2)$$
$$= 10 - 11$$
$$= -1 < 0$$

So, structure is unstable in nature.

Kinematic Indeterminacy

$KI =$ total dof at joints

$= (2+2+1) + 2$

$= 7$

at B
- 2-axial
- 2-BM
- 1-vertical

Formula - $KI = 3j + r - x$
$$= 9 + 2 - 4$$
$$= 11 - 4$$
$$= 7$$

So, Kinematic Indeterminacy of structure $= 7$

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Ans 4. Static Indeterminacy

By Formula. -

$$SI = 3m + x - (3j + r)$$
$\left[m = 5 \quad r = 2 \quad x = 5 \quad j = 6 \right]$

$$SI = 15 + 5 - (18 + 2)$$
$$= 20 - 20$$
$$= 0$$

By observation -

$$SI = x - 3 - r = 5 - 3 - 2 = 0$$

Statically determinate Beam.

Kinematic Indeterminacy.

By Formula. -

$$KI = 3j + r - x$$
$$KI = 18 + 2 - 5$$
$$KI = 15$$

CHECK -

KI = total DOF

$$KI = 1 + 4 + 4 + 2 + 2 + 2$$
$$KI = 15$$

So, Kinematic Indeterminacy = 5.

Ans 5. Static Indeterminacy $\{m = 5, r = 3, x = 6, j = 6\}$

By Formula -

$$SI = \cancel{3m + j - (3}, \; 3m + x - (3j + r)$$
$$SI = 15 + 6 - (18 + 3)$$
$$= 21 - 21$$
$$= 0$$

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CHECK :- $SI = r - 3 - 3$
$= 6 - 6 = 0$

statically determinate beam

Kinematic Indeterminacy.

Formula -

$KI = 3j + r - r$
$= 18 + 3 - 6$
$= 15$

CHECK :- $KI = DOF$
$= 4 \times 3 + 2 + 1$
$= 15$

Kinematic Indeterminacy = 15 for this beam.

Ans 6. Static Inditerminacy.

By formula. –

$SI = 3m + r - (3j + r)$
$= 3(3) + 6 - (12 + 0)$
$= 9 + 6 - 12$
$= 3$

$$\left\{ \begin{array}{l} m = 3 \\ r = 6 \\ j = 4 \\ r = 0 \end{array} \right\}$$

CHECK :- $SI = r - 3 - r$
$= 3$

Static Indeterminacy = 3.

Kinematic Indeterminacy

By formula –

$$KI = 3j + r - n$$

$$KI = 12 + 0 - 6$$

$$= 6$$

CHECK – $KI = \text{total DOF}$

$$= 1 + 1 + 2 + 2$$

$$= 6$$

Kinematic Indeterminacy $= 6$.

SOLUTION FRAMES

For (2-D)

Static Indeterminacy -

General formula - $SI = (\alpha m + x) - (\beta j + r)$

$$SI = 3m + x - (3j + r)$$

Here, m = no. of members

x = no. of reactions

j = joints

r = total no. of releases.

Kinematic Indeterminacy -

$\hookrightarrow$ Inextensible member

General Formula - $KI = -(\alpha m + x) + (\beta j + r)$

$$KI = 3j + r - x$$

By formula -

Ans 1: $SI = 3m + x - (3j + r)$

$SI = 9 + 4 - (12 + 2)$

$= \cancel{16-8}\ 13 - 14$

$= \cancel{8}\ -1 < 0$

m = 3

x = 4

j = 4

$r = 2(n-1) = 2(2-1) = 2$

n = total members meeting at IH.

by tree method $\rightarrow$

$SI = (\text{no. of cuts} \times 3) - 2 - 1 - 1$

$= 1 \times 3 - 4$

$= -1 < 0$

structure / frame is unstable.

$KI = 3j + r - x$

$= 12 + 2 - 4$

$= 10$

Kinematic Indeterminacy = 10

Ans 2. $m = 4$, $r = 2$, $x = 2\times2 = 4$, $j = 5$

$$SI = \alpha m + x - (\beta j + r)$$
$$= 3m + x - (3j + r)$$
$$= 12 + 4 - (15 + 2)$$
$$= 16 - 17$$
$$= -1 < 0$$

By tree method $\longrightarrow$

$$SI = (\text{no. of cuts} \times 3) - 2 - 2$$
$$= 3 - 4$$
$$= -1 < 0$$

Ans. unstable frame.

$$KI = (\beta j + r) - x$$
$$= 3j + r - x$$
$$= 15 + 2 - 4$$
$$= 13$$

Ans 3. $m = 2$, $j = 3$, $r = 1$, $x = 5$

$$SI = 3m + x - (3j + r)$$
$$= 6 + 5 - (9 + 1)$$
$$= 11 - 10$$
$$= \cancel{10}\ 1$$

(statically Indeterminate)

By tree method —

$$SI = 3\times1 - 1 - 1$$
$$= 1$$

$$KI = (3j + r) - x$$
$$= 9 + 1 - 5$$
$$= 5$$

Ans4. $m = 5$, $x = 8$, $j = 6$, $r = 0$

$SI = 3m + x - (pj + r)$

$= 3m + x - (3j + r)$

$= 15 + 8 - 18$

$= 5$ (statically Indeterminate)

Tree method $\longrightarrow$

$SI = \text{no. of cuts} \times 3 - 2 - 1 \times 2$

$= 3 \times 3 - 4$

$= 9 - 4$

$= 5$

$KI = (3j + r) - x$

$= 18 - 8$

$= 10$

Ans5. $m = 4$, $j = 4$, $x = 3$, $r = 0$

$SI = 3m + x - (3j + r)$

$= 12 + 3 - 12$

$= 3$ (statically Indeterminate)

Tree method —

$SI = 3 \times \text{no. of cuts} - 2 - 1$

$= 3 \times 2 - 2 - 1$

$= 6 - 3$

$= 3$

Loop method —

II = Internal Indeterminacy $= 3 \times \text{no. of loops} - 1$ KI

$= 3$

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EI = External Indeterminacy $= r - 3$
$= 3 - 3$
$= 0$

$SI = II + EI = 3 + 0 = 3$

$KI = 3j + \gamma - r$
$= 12 + 0 - 3$
$= 9$

Ans 6. $m = 6$, $\alpha = 3$, $j = 3 \times 2 = 6$, $r = 4$, $\gamma = 0$

$SI = 3m + r - (3j + \gamma)$
$= 18 + 4 - (18 + 0)$
$= 4$ (statically indeterminate)

Tree Method –

$SI = 3 \times$ no. of cuts $- 1 \times 2$
$= 3 \times 2 - 2$
$= 4$

Loop Method –

$II = 3 \times$ no. of loops $- \gamma$
$= 3 \times 1 - 0$
$= 3$

$EI = r - 3$
$= 4 - 3 = 1$

$SI = 3 + 1 = 4$

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

Ans 7. $m = 5, j = 6, x = 4, r = 2$

$SI = 3m + x - (3j + r)$
$= 15 + 4 - (18 + 2)$
$= 19 - 20$
$= -1 < 0$

Tree Method -

$SI = 3 \times$ no. of cuts $- 1 \times 2 - 1 \times 2$.
$= 3 \times 1 - 4$
$= 3 - 4 = -1 < 0$

Unstable frame.

$KI = 3j + r - x$
$= 18 + 2 - 4$
$= 16$

Ans 8. $m = 7, x = 6, r = 1, j = 7$

$SI = 3m + x - (3j + r)$
$= 21 + 6 - (21 + 1)$
$= 5$

Tree Method -

$SI =$ no. of cuts $\times 3 - 1$
$= 2 \times 3 - 1$
$= 5$ (statically Indeterminate)

Loop Method -

$II =$ no. of loops $\times 3 - r$
$= 1 \times 3 - 1$
$= 2$

$EI = r - 3 = 6 - 3 = 3.$

$SI = EI + II$

$= 3 + 2 = 5$ //

$KI = 3j + r - r$

$= 21 + 1 - 6$

$= 22 - 6$

$= 16$ //

Ans 9. $m = 6,\ j = 6+1 = 7,\ r = 1,\ r = 3$

$SI = 3m + r - (3j + r)$

$= 18 + 3 - (21 + 1)$

$= 21 - 22$

$= -1 < 0$

Tree Method -

$SI = \text{no of cuts} \times 3 - 1 - 3\times2 - 1 - 2$

$= 3 \times 3 - 1 - 6 - 3$

$= 9 - 10$

$= -1 < 0$

unstable structure

$KI = 3j + r - r$

$= 21 + 1 - 3$

$= 19$ //

Ans. 10. General Formula -

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

$\alpha = 6$, $\beta = 6$

$$SI = 6m + x - (6j + r)$$

General Formula - (assuming axially inextensible)

$$KI = (\beta j + r) - (\alpha m + x) \qquad \alpha = 0$$

$$KI = 6j + r - x$$

so,

$$SI = 6m + x - (6j + r) \qquad m = 18$$

$$= 18 \times 6 + 16 - (6 \times 14 + 6) \qquad j = 14$$

$$= 108 + 16 - (84 + 6) \qquad r = 3 \times 2 = 6$$

$$= 124 - 90 \qquad x = 6 \times 2 + 1 + 3$$

$$= 34 \qquad = 12 + 4 = 16$$

Tree Method -

SI = 6 × no. of cuts - 3 × no. of hinges - 5 × no. of rollers - 3 × no. of hinges.

$$= 6 \times 8 - 3 \times 2 - 5 \times 1 - 3 \times 1$$

$$= 48 - 6 - 5 - 3$$

$$= 48 - 14$$

$$= 34$$

~~Loop Method -~~

~~II = no. of loops × 6 - r~~

~~$= \cancel{4 \times 6 = 6}$~~

~~$= \cancel{12 - 6 = 6}$~~

~~EI = x - 6~~
~~= 16~~

$KI = 6j + r - x$
$= 6 \times 14 + 6 - 16$
$= 84 + 6 - 16$
$= 90 - 16$
$= 74$

SOLUTION TRUSSES

For ~~frames~~ trusses, KI is not defined because if members are considered inextensible, then there is no sense to calculate KI because for trusses only axial forces are present at each member.

Static Indeterminacy. (SI)

General formula → $(\alpha m + r) - (\beta j + r')$

$\alpha = 1, \ \beta = 2$

$SI = m + r - (2j + \cancel{r'}^{0})$

r - reactions
m - total members
j - joints
r' - release $= 0$ (because all joints are smooth pin joints)

$SI = m + r - 2j$

Ans 1. $m = 6, \ j = 4, \ r = 3$

$SI = 6 + 3 - 8$
$= 1$

$\left\{ \begin{aligned} EI &= r - 3 = 3 - 3 = 0 \\ II &= m - (2j - 3) \\ &= 1 \end{aligned} \right\}$

Statically Indeterminate.

Ans 2. $m = 9, \ j = 6, \ r = 3$

$SI = m + r - 2j$
$= 9 + 3 - 12$
$= 0$

Statically determinate.

Ans3. $m = 9, j = 6, r = 3$

$SI = 9 + r - 2j$

$SI = 0$

statically Indeterminate.

Ans4. $m = 16, \ r = 3, \ j = 8$

$SI = m + r - 2j$

$= 16 + 3 - 16$

$= 3$

statically indeterminate

$II = m - (2j - 3)$

$= 16 - (16 - 3)$

$= 3$

$II = 3$ .//

$EI = 3 - 3 = 0$

Ans5. $m = 15, j = 9, \ r = 3$

$SI = m + r - 2j$

$= 15 + 3 - 18$

$= 0$

statically determinate

Ans6. $m = 9, \ j = 6, \ r = 3$

$SI = m + r - 2j$

$= 9 + 3 - 12$

$= 0$

statically determinate.

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Ans 7. $m = 22$, $j = 13$, $r = 2 \times 2 = 4$

$SI = m + r - 2j$
$= 22 + 4 - 26$
$SI = 0$

$II = m - (2j - 3)$
$= 22 - (26 - 3)$
$= -1$
$EI = 1$

$SI = EI + II$
$= 0$.

Statically determinate structure.

Ans 8. $m = 16$, $j = 9$, $r = 3$

$SI = m + r - 2j$
$= 16 + 3 - 18$
$= 1$

$II = m - 2j + 3$
$= 16 - 18 + 3$
$= 1$

$EI = 0$