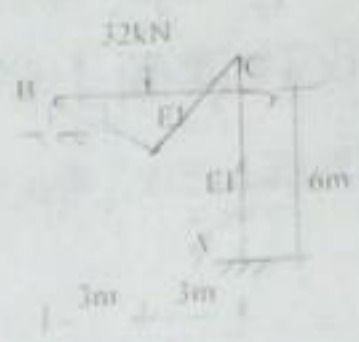


4. 图示结构, 内力 M_c , Q_c 分别为:

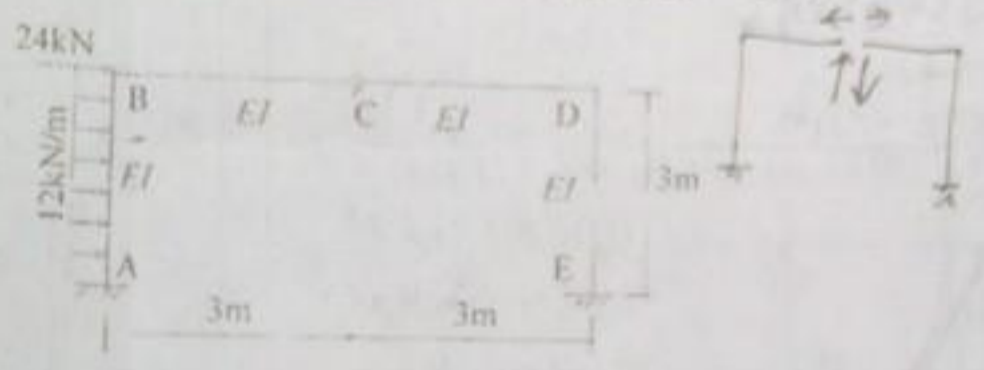
- A. $9\text{kN}\cdot\text{m}$ (左侧受拉); -17.50kN
- B. $9\text{kN}\cdot\text{m}$ (右侧受拉); 14.50kN
- C. $20.57\text{kN}\cdot\text{m}$ (右侧受拉); 12.57kN
- D. $20.57\text{kN}\cdot\text{m}$ (左侧受拉); -19.43kN



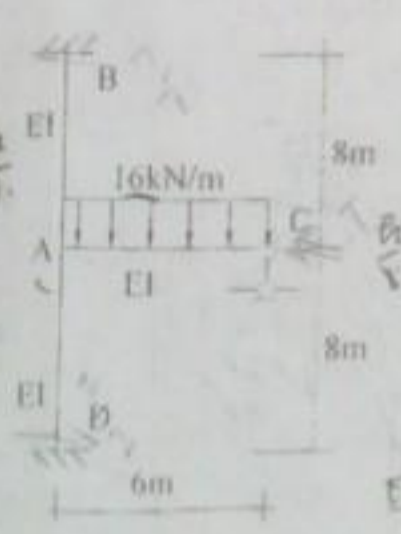
5. 三铰拱在法向均布荷载作用下的合理拱轴为:

- A. 二次抛物线;
- B. 悬链线;
- C. 双曲线;
- D. 圆。

二、用力法计算图示结构并作其弯矩图。(22分)



三、用位移法计算图示结构并作其弯矩图。(22分)



Handwritten calculations and diagrams for the displacement method analysis of the frame structure. The calculations include:

- Stiffness coefficients: $k_{11} = \frac{3EI}{8}$, $k_{12} = \frac{3EI}{8}$, $k_{21} = \frac{3EI}{8}$, $k_{22} = \frac{3EI}{8}$
- Fixed-end moments: $M_{1P} = -72$, $M_{2P} = 24$
- Displacement equations: $Z_1 = -\frac{M_{1P}}{k_{11}} = 72$, $Z_2 = -\frac{M_{2P}}{k_{22}} = 24$
- Moment distribution: $M = M_{1P} + k_{11}Z_1 + k_{12}Z_2$, $M = -72 + \frac{3EI}{8} \cdot 72 + \frac{3EI}{8} \cdot 24 = 24$

The final bending moment diagram shows moments of 12, 24, and 24 at various points in the structure.

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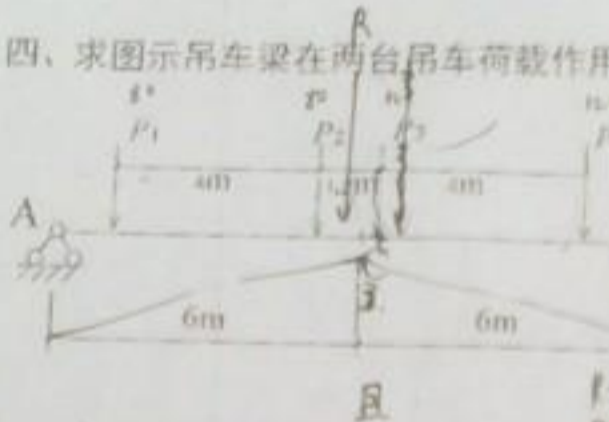
2009 年招收攻读硕士学位研究生入学考试试题

(答案书写在本试题纸上无效。考试结束后本试题纸须附在答题纸内交回) 共 4 页

考试科目: (802) 结构力学

适用专业: 结构工程、防灾减灾、岩土工程、桥梁与隧道、现代结构理论、固体力学、工程力学

四、求图示吊车梁在两台吊车荷载作用下的绝对最大弯矩 M_{max} 。 $P_1=P_2=80kN$, $P_3=P_4=120kN$ 。(21 分)



当 P_2 在 C 点时

$$M_{max} = \frac{P}{4} \left(\frac{l}{2} \right)^2 - Pa$$

$$= \frac{80}{4} \left(\frac{10+4}{2} \right)^2 - 80 \times 4$$

$$= 704.05 \text{ kN}\cdot\text{m}$$

且 $R_B = \sum P_i = 120 + 80 + 120 + 80 = 400 \text{ kN}$
 $R_A = 120 + 80 - 400 = -200 \text{ kN}$

五、求图示结构的自振频率及主振型，画出主振型草图。已知 $EI_1 = EI$, $EI_2 = \infty$ 。(22 分)



刚度 $k_1 = \frac{3EI}{l^3}$, $k_2 = \frac{6EI}{l^3}$

$$k_{11} = 2 \times \frac{3EI}{l^3} = \frac{6EI}{l^3}$$

$$k_{22} = 2 \times \frac{6EI}{l^3} = \frac{12EI}{l^3}$$

$$k_{12} = -2 \times \frac{3EI}{l^3} = -\frac{6EI}{l^3}$$

$$k_{21} = -2 \times \frac{3EI}{l^3} = -\frac{6EI}{l^3}$$

特征方程 $\det(K - \omega^2 M) = 0$

$$\begin{vmatrix} \frac{6EI}{l^3} - \omega^2 \frac{m}{2} & -\frac{6EI}{l^3} \\ -\frac{6EI}{l^3} & \frac{12EI}{l^3} - \omega^2 m \end{vmatrix} = 0$$

$$\left(\frac{6EI}{l^3} - \frac{\omega^2 m}{2} \right) \left(\frac{12EI}{l^3} - \omega^2 m \right) - \left(\frac{6EI}{l^3} \right)^2 = 0$$

$$\frac{6EI}{l^3} \left(\frac{12EI}{l^3} - \omega^2 m \right) - \frac{\omega^4 m^2}{2} - \frac{36E^2 I^2}{l^6} = 0$$

$$12EI - \omega^2 ml - \frac{\omega^4 m^2 l^3}{2} - 36EI = 0$$

$$-24EI - \omega^2 ml - \frac{\omega^4 m^2 l^3}{2} = 0$$

$$\omega^4 + \frac{24EI}{ml^3} \omega^2 + \frac{48EI}{m^2 l^3} = 0$$

$$\omega^2 = \frac{-\frac{24EI}{ml^3} \pm \sqrt{\left(\frac{24EI}{ml^3}\right)^2 - 4 \times \frac{48EI}{m^2 l^3}}}{2}$$

$$\omega^2 = \frac{-\frac{24EI}{ml^3} \pm \sqrt{\frac{576E^2 I^2}{m^2 l^6} - \frac{192E^2 I^2}{m^2 l^6}}}{2}$$

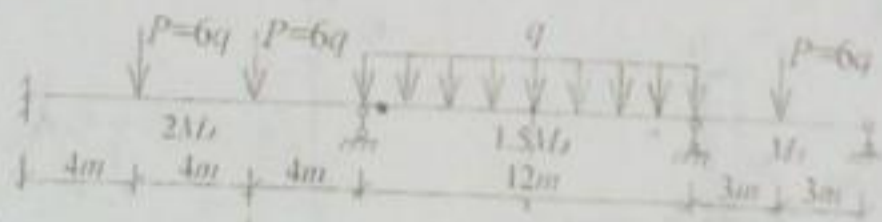
$$\omega^2 = \frac{-\frac{24EI}{ml^3} \pm \sqrt{\frac{384E^2 I^2}{m^2 l^6}}}{2}$$

$$\omega^2 = \frac{-\frac{24EI}{ml^3} \pm \frac{19.5959EI}{ml^3}}{2}$$

$$\omega_1^2 = \frac{-\frac{24EI}{ml^3} + \frac{19.5959EI}{ml^3}}{2} = -\frac{2.20205EI}{ml^3}$$

$$\omega_2^2 = \frac{-\frac{24EI}{ml^3} - \frac{19.5959EI}{ml^3}}{2} = -\frac{21.79795EI}{ml^3}$$

六、求图示结构的极限荷载。已知 $M_p = 360kN\cdot m$ 。(18 分)



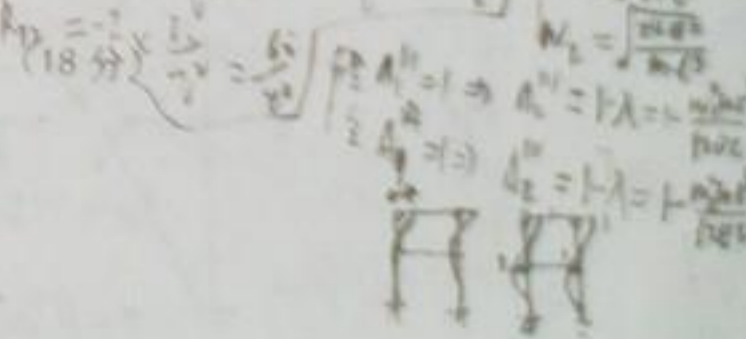
$$4M_1 + 2M_1 + 2M_1 = P \cdot 8 + P \cdot 4$$

$$7M_1 = 72q \Rightarrow M_1 = \frac{72q}{7}$$



$$2M_1(4+3) + 1.5M_1(2) = 6q(4+3)$$

$$11M_1 = 72q \Rightarrow M_1 = \frac{72q}{11}$$



$$M_1 + M_2 = 62.30$$

$$\Rightarrow M_1 = 121$$

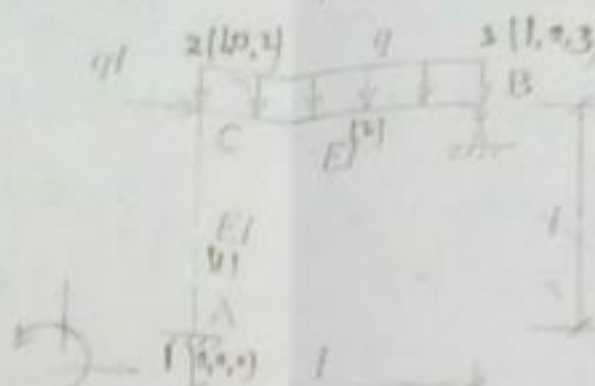
$$\Rightarrow q = 62 \text{ kN/m}$$

$$\Rightarrow P_1 = P_2 = 55 \text{ kN}$$

$$C = \begin{pmatrix} 192EI & 32EI & 192EI \\ 32EI & 32EI & 32EI \\ 192EI & 32EI & 192EI \end{pmatrix}$$

七、用矩阵位移法计算图示结构，作弯矩图和剪力图。已求得结点位移

$$\varphi_C = \frac{5ql^3}{32EI}, \quad \varphi_B = \frac{19ql^3}{192EI}, \quad \Delta_B = \frac{31ql^3}{192EI} \quad (20 \text{分})$$



$$[k]^{II} = [0 \ 0 \ 12]^T$$

$$[k]^{IV} = [0 \ 2 \ 0]^T$$

$$[\bar{F}]^{III} = [0]$$

$$[\bar{F}]^{IV} = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$[k]^{II} = [k]^{IV} = \begin{bmatrix} \frac{12}{l} & 0 & 0 \\ 0 & \frac{24}{l} & 0 \\ 0 & 0 & 12 \end{bmatrix}$$

$$[\bar{F}]^{III} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$[\bar{F}]^{IV} = \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix}$$

$$[\bar{F}]^{III} = [\bar{F}]^{III} + [k]^{III} \{\delta\}^{III} = \begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$$

$$[\bar{F}]^{IV} = [\bar{F}]^{IV} + [k]^{IV} \{\delta\}^{IV} = \begin{bmatrix} 0 \\ \frac{19ql^3}{192EI} \\ \frac{31ql^3}{192EI} \end{bmatrix}$$

附录：

$$[k]^{III} = \begin{bmatrix} \frac{EI}{l} & 0 & 0 & \frac{EI}{l} & 0 & 0 \\ 0 & \frac{12EI}{l^3} & \frac{6EI}{l^2} & 0 & \frac{12EI}{l^3} & \frac{6EI}{l^2} \\ 0 & \frac{6EI}{l^2} & \frac{4EI}{l} & 0 & \frac{6EI}{l^2} & \frac{2EI}{l} \\ \frac{EI}{l} & 0 & 0 & \frac{EI}{l} & 0 & 0 \\ 0 & \frac{12EI}{l^3} & \frac{6EI}{l^2} & 0 & \frac{12EI}{l^3} & \frac{6EI}{l^2} \\ 0 & \frac{6EI}{l^2} & \frac{2EI}{l} & 0 & \frac{6EI}{l^2} & \frac{4EI}{l} \end{bmatrix}$$

