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ESE- 2018 (Prelims) - Offline Test Series Test-9

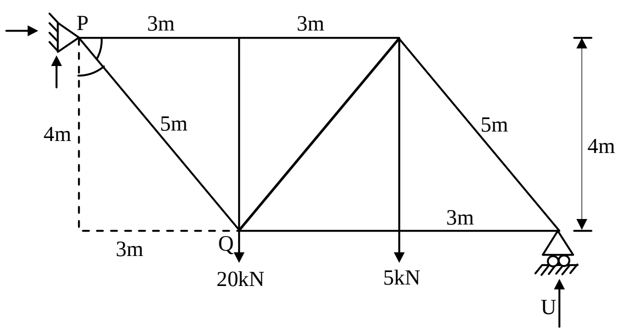
CIVIL ENGINEERING

SUBJECT: STRUCTURAL ANALYSIS AND DEISGN OF STEEL STRUCTURES

SOLUTIONS

01. Ans: (a)

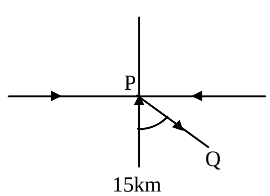
Sol:



$V_U \times 9 - 5 \times 6 - 20 \times 3 = 0$

$V_U = 90/9 = 10$ kN

$V_P = 15$ kN



$15 = PQ \times 4/5$

PQ = 18.75 kN (Tensile)

02. Ans: (b)

03. Ans: (d)

Sol:

$$\frac{P^2\ell}{2AE} = 500 \text{ N-m}$$

$$\frac{P}{2}\left(\frac{P\ell}{AE}\right) = 500$$

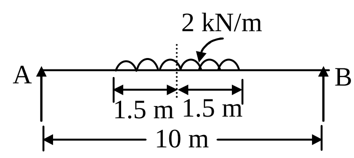
$$\frac{P}{2}(\delta) = 500\times10^3 \text{ N-mm}$$

$$\delta = \frac{1000\times10^3}{100\times10^3}\text{mm}$$

$$= 10 \text{ mm}$$

04. Ans: (c)

Sol: U.D.L is placed symmetrically for absolute bending moment



$V_A+V_B = 2\times3 = 6$ kN

$\therefore\ V_A = V_B$

$\therefore\ V_A = V_B = 3$ kN

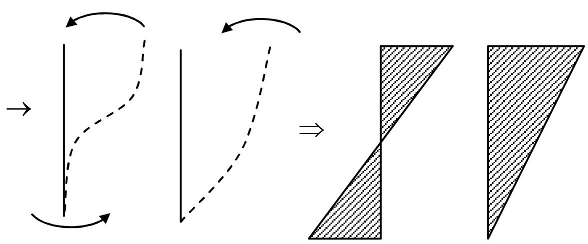
$$M_{max} = [V_A\times5]-\left(2\times1.5\times\frac{1.5}{2}\right)$$

$= 3\times5-2.25$

$= 15-2.25 = 12.75$ kN

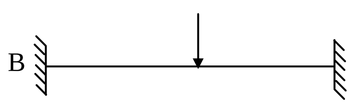
05. Ans: (a)

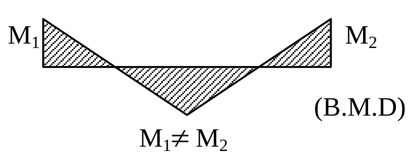
Sol: These will be sway to left



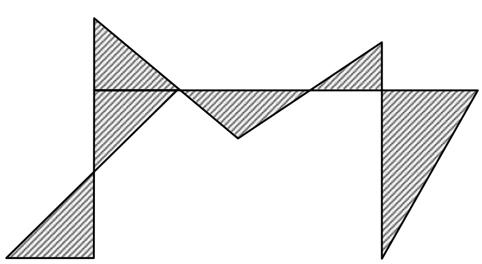
13. M.D in columns
(Drawn on tension..)

In case of beam





Superimpose all diagrams



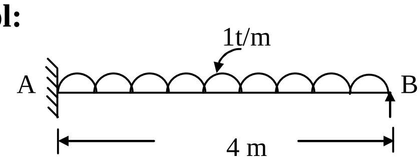
06. Ans: (b)

Sol: The variation of horizontal thrust is 2nd degree curve

$\therefore$ Option b is proper one

07. Ans: (d)

Sol:



$$\frac{wL^4}{8EI} = \frac{RL^3}{3EI}$$

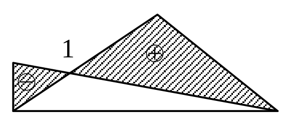
$$R = \frac{3wL}{8}$$

$$V_B = \frac{3wL}{8} = \frac{3\times(1)\times(4)}{8} = 1.5 \text{ tonnes}$$

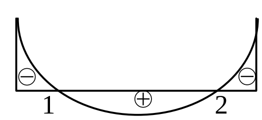
08. Ans: (a)

Sol:

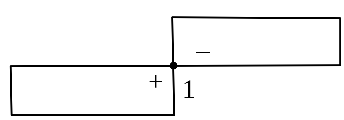
1. For propped

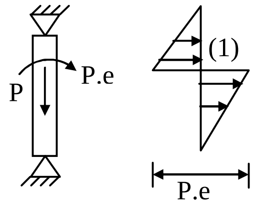


2. For fixed beam with UDL



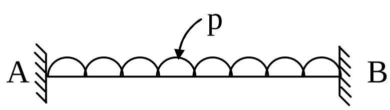
3. For fixed beam with moment at mid point



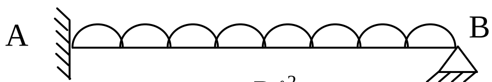
4. 

09. Ans: (b)

Sol:



$$M_{A1} = M_{B1} = \frac{P\ell^2}{12}$$



$$M_{A2} = \frac{P\ell^2}{8}$$

So,

$$\frac{M_{A2}}{M_{A1}} = \frac{\frac{PL^2}{8}}{\frac{PL^2}{12}}$$

$$= \frac{3}{2} = 1.5 = 50\%$$

10. Ans: (c)

Sol: For joint B

BA stiffness (relative) = $\frac{I}{5}$

BC stiffness (relative) = $\frac{I}{8}$

$$\text{D.F for BA} = \frac{\left(\frac{I}{5}\right)}{\left(\frac{I}{5}\right)+\left(\frac{I}{8}\right)} = 0.615$$

At joint C

Relative stiffness of CB = $\frac{I}{8}$

Relative stiffness of CG = $\frac{I}{7}$

Relative stiffness of CD = $\frac{I}{4}$

$$\therefore \text{ D.F of CD} = \frac{\left(\frac{I}{4}\right)}{\left(\frac{I}{4}\right)+\left(\frac{I}{8}\right)+\left(\frac{I}{7}\right)} = 0.48$$

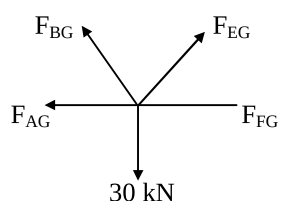
11. Ans: (b)

12. Ans: (a)

Sol: $W_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{64}{16}} = 2\,\text{rad/sec}$

13. Ans: (b)

Sol:



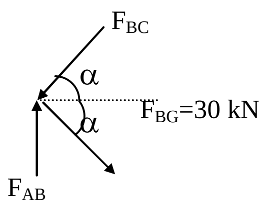
As the truss is symmetrical

$$F_{BG} = F_{EG}$$

$$\therefore\ F_{BG} \sin 30° = \frac{30}{2} = 15 \text{ kN}$$

F_{BG} = 30 kN

Joint equilibrium at B



$\therefore F_{BC}\cos\alpha = 30\cos\alpha$

F_{BC} = 30 kN (compression)

14. Ans: (d)

Sol: Since, the BC section will behave like a thread. Joint B will be displaced to $\frac{Ph^3}{3EI}$ and joint C will become zero.

15. Ans: (a)

Sol: F11 $\rightarrow$ rotation in the direction of 2 due to unit moment in the direction of 1

$$\therefore f_{11} = \frac{1\times L}{EI} = \frac{L}{EI}$$

$f_{21} \rightarrow$ deflection in the direction of 2 due to unit moment in the direction of 1

$$f_{21} = \frac{1\times L^2}{2EI} = \frac{L^2}{2EI}$$

$f_{21} = f_{12}$

$f_{22} \rightarrow$ deflection in the direction of 2 due to unit load in the direction of 2.

$$f_2 = \frac{1\times L^3}{3EI} = \frac{L^3}{3EI}$$

$$[F] = \begin{bmatrix} f_1 & f_{12} \\ f_{21} & f_{22} \end{bmatrix} = \begin{bmatrix} \frac{L}{EI} & \frac{L^2}{2EI} \\ \frac{L^2}{2EI} & \frac{L^3}{3EI} \end{bmatrix}$$

16. Ans: (d)

Sol: It is $\frac{L}{3+\sqrt{3}}$ or 0.211L try to remember it .

Also absolute maximum negative moment occurs at $\frac{L}{4}$.

17. Ans: (a)

Sol: Option a is more appropriate though all other statements are true

18. Ans: (b)

Sol: $M_{BC} = MF_{BC} + \frac{2EI}{L}(2\theta_B + \theta_C)$

$$= 0 + \frac{2EI}{10}\left[2\times\frac{400}{EI} + \frac{400}{EI}\right]$$

$$= \frac{6EI}{10}\times\frac{400}{EI} = 240 \text{ kN-m}$$

19. Ans: (a)

Sol: D_{se} = R – 3

= 5 – 3 = 2

D_{si} = 0

One internal hinge is there

2-members are meeting

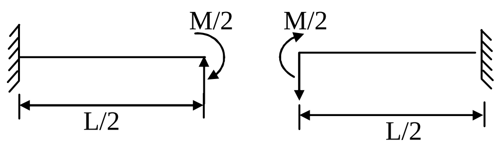
$\therefore$ 1 reaction is released

$\therefore D_s$ = 2 – 1 = 1

20. Ans: (c)

Sol: As the beam is symmetric about applied moment

Half moment is shared by each part



$\therefore$ Net deflection would be zero.

21. Ans: (b)

Sol:

For two hinged arch, the bending moment influence line diagram due to horizontal thrust will be non linear and beam bending moment influence line diagram will be linear. So (b) represents correct diagram.

22. Ans: (d)

Sol: Increase in dip $dh = \frac{3}{16}\alpha t \times \frac{\ell^2}{h}$

$$= \frac{3}{16} \times 12 \times 10^{-6} \times 20 \times \frac{100^2}{5}$$

$= 0.09$ m

23. Ans: (b)

Sol: A two hinged stiffening girder is statically indeterminate

Bending moment at any section

$(BM)_{section} = (BM)_{beam} - Hy$

24. Ans: (b)

25. Ans: (a)

Sol: For simply supported beam

$$M_{max} = \frac{w\ell^2}{8}$$

$$w = \frac{8M_{max}}{\ell^2}$$

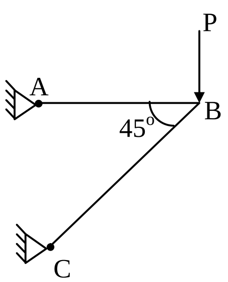
For fixed beam, $M_{max} = \dfrac{w\ell^2}{12}$

$$w = \frac{12M_{max}}{\ell^2}$$

$$\frac{(w)_{fixed}}{(w)_{SSB}} = \frac{\dfrac{12M_{max}}{\ell^2}}{\dfrac{8M_{max}}{\ell^2}} = 1.5$$

26. Ans: (c)

Sol:



$\Sigma F_y = 0$

$F_{BC} \sin 45^o = P$

$$F_{BC} = \frac{P}{\sin 45^o}$$

$$F_{BA} = F_{BC} \cos 45^o$$

$$= \frac{P}{\sin 45^o} \times \cos 45^o$$

$F_{BA} = P$

Strain energy due to axial loading

$$U = \frac{P^2\ell}{2AE}$$

$$U = \left(\frac{1}{2}\right)\left(\frac{P^2\ell}{AE}\right)$$

K = 0.5

27. Ans: (d) **28. Ans: (c)**

29. Ans: (d)

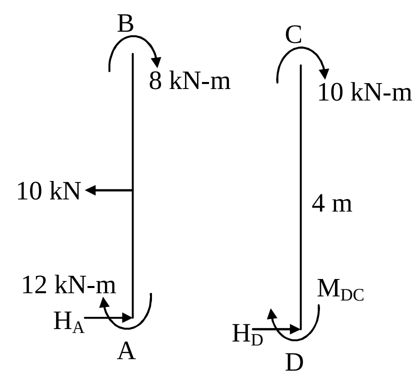
Sol: $D_K = 2j - r$

j = 6, r = 3

$\therefore D_k = 2 \times (6) - 3 = 9$

30. Ans: (a)

Sol:



For column AB, $\Sigma M_B = 0$

$4H_A = 12 + 8 + 10 \times 2$

$\Rightarrow H_A = 10$ kN $(\rightarrow)$

Applying $\Sigma H = 0$

$H_A + H_D = 10$

$H_D = 10 - 10 = 0$

$\therefore H_D \times 4 = M_{DC} + 10$

$M_{DC} = -10$ kN-m (Anti-clockwise)

31. Ans: (d)

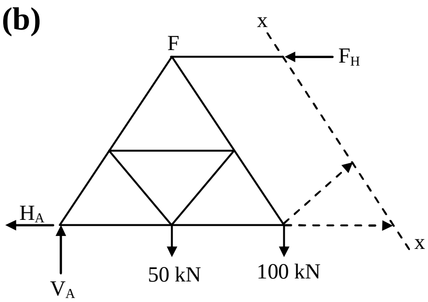
Sol: $D_s = D_{si} + D_{se} = 3C + r - 3$

$= 3(1) + 8 - 3 = 3 + 8 - 3$

$D_s = 8$

32. Ans: (b)

Sol:



By symmetry

$V_A = V_E = 100$ kN

Take moment at C;

$\Sigma M_C = 0$

$100 \times 6 - 50 \times 3 - F_{FH} \times 3 = 0$

$F_{FH} = 150$ kN (Compression)

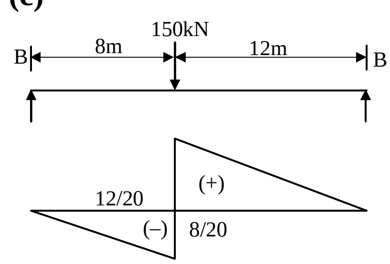
33. Ans: (c)

34. Ans: (d)

Sol: See that 90^o is maintained at all rigid joints.

35. Ans: (c)

Sol:



$\therefore$ Maximum negative shear force

$$= 150 \times \frac{8}{20} = 60 \text{ kN}$$

36. Ans: (d)

37. Ans: (c)

Sol: Impact moment due to vertical loads for EOT:

0.25% of maximum static wheel load

$= 0.25 \times 400 = 100$ kNm

So, total design moment

= moment due to static wheel load

+ Impact moment + Moment due to self weight of girder

$= 400 + 100 + 20$

$= 520$ kNm

38. Ans: (c)

Sol: For electrically operated cranes upto 500 kN, maximum deflection is [Span/750]

$$\Rightarrow 20 = \frac{\text{Span}}{750}$$

$$\Rightarrow \text{Span} = 750 \times 20 \text{ mm}$$

$= 15$ meter

39. Ans: (d)

40. Ans: (a)

Sol: Transverse stiffeners are provided to eliminate shear buckling failure of web.

Longitudinal stiffeners are provided to eliminate compression buckling failure of web.

41. Ans: (c)

Sol: For cantilever bean, maximum allowable deflection is $\frac{2 \times \ell}{325} = \frac{\ell}{162.5}$

42. Ans: (d)

Sol: For double angle which are placed on each side of gusset plate and tack riveted along the length

$A_{net} = A_g$ – Area of Rivet hole

$A_{net} = A_g$

43. Ans: (d)

Sol:

(i) When the effect of wind (or) seismic load is taken into account, the permissible stresses in rivets are increased by 25%

(ii) As per IS 800:1984 permissible maximum shear stress shall be $0.45\ f_y$

(iii) Minimum thickness of 8 mm is required if main steel section is directly exposed to weather and not accessible for cleaning and painting

44. Ans: (a)

Sol: If wind is primarily design load, permissible stress ϕ in rivet cannot be increased.

45. Ans: (c)

Sol: As per IS 800-1984 maximum permissible bending stress is $0.66\ f_y$

$\therefore\ 0.66 \times 350 = 231$ MPa

46. Ans: (a)

Sol:

i) $P_{cr} = \dfrac{\pi^2 EI}{\ell^2_{eff}}$ (EI = flexural rigidity)

ii) $P_{cr} \alpha \dfrac{1}{\ell^2_{eff}}$

$$P_{cr} = \frac{\pi^2 E(I)}{\ell^2_{eff}}\left(\frac{I}{A}\right).A$$

$$P_{cr} = \frac{\pi^2 E}{\ell^2_{eff}} \times r^2.A \qquad \left(\because \frac{I}{A} = r^2\right)$$

P_{cr} α r^2

Here r = radius of gyration

P_{cr} = buckling load

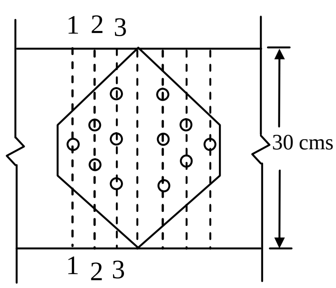
47. Ans: (d)

Sol: Maximum allowable slenderness ratio for lacing = 145

Maximum allowable slenderness ratio for a member carrying compressive loads due to dead load and live load is 180.

48. Ans: (c)

Sol:



Nominal diameter of rivet (ϕ) = 22 mm

Gross diameter of rivet (d) = 23.5 mm

Rivet value (R_v) = 53.15 kN

Strength of Cover plate at Section 1-1:

$= [B - d] \times t\ \sigma_{at} + 5 \times R_v$

$= [300 - 23.5] \times 16 \times 142 + 5 \times 53.15$

= 628.473 kN

Strength of Cover plate at Section 2-2:

$= [B - 2d] \times t\ \sigma_{at} + 3 \times R_v$

$= [300 - 2\times 23.5] \times 16 \times 142 + 3 \times 53.15$

= 574.975 kN

Strength of Cover plate at Section 3-3:

$= [B - 3d] \times t\ \sigma_{at} + 0 \times R_v$

$= [300 - 3\times 23.5] \times 16 \times 142 + 0$

= 521.42 kN

Strength of cover plate

= min (628.47, 574.97, 521.42)

= 521.42 kN

So critical section for cover plate is section 3-3.

49. Ans: (b)

Sol: Vertical shear Force in Bolt:

$$= \frac{2P - P}{n} = \frac{P}{4}\ \text{kN}$$

Twisting moment (or) couple

M = P [100 + 100 – 100]

= 100 P kN-m

Maximum shear force in bolt due to M:

$$F_m = \frac{Mr_i}{\Sigma r_1^2}$$

$$= \frac{100P \times \sqrt{30^2 + 40^2}}{4 \times (30^2 + 40^2)} = \frac{100P}{4 \times 50} = \frac{P}{2}$$

Maximum Resultant Shear Force (F_R):

$$= \sqrt{F_a^2 + F_m^2 + 2F_a F_m \cos\theta}$$

$$= \sqrt{\left(\frac{P}{4}\right)^2 + \left(\frac{P}{2}\right)^2 + 2\left(\frac{P}{4}\right)\left(\frac{P}{2}\right)\times\frac{3}{5}}$$

$$= P\sqrt{\frac{37}{80}} = 0.68P \simeq 0.7\ P$$

50. Ans: (c)

Sol: Effective length of discontinuous strut with double riveted = 0.85 × L = 3.825 m

Slenderness ratio: $\frac{K\ell}{r_{min}} = \frac{0.85\times 4500}{29.3}$

$= 130.54$

51. Ans: (d)

Sol: Shear stress is uniformly distributed over its gross area of rivet

Friction between plates is ignored.

Contact area is d ×t for rivet design.

52. Ans: (c)

Sol: Maximum grip length of bolt shall not be greater than 8 times nominal shank diameter.

53. Ans: (b)

Sol: P = Strength of fillet weld

$\Rightarrow 280 \times 10^3 = L_o \times (KS) \times \tau_{vf}$

$\Rightarrow 280 \times 10^3 = [200 + 2 \times L] \times [0.7 \times 8] \times 100$

$\Rightarrow L = 150$ mm

54. Ans: (c)

Sol: Nominal diameter of rivet as per unwin formula

$$= 6.04\times\sqrt{16} = 24.16 \text{ mm} \simeq 25 \text{ mm}$$

Provide rivet of 27 mm [usually next available size in market]

Gross diameter of rivet (d) = 27 + 2 = 29 mm

Minimum edge distance = 1.5 d = 43.5 mm

[Even if we consider ϕ = 25 mm, d = 25 + 2 = 27 mm, min. edge distance = 1.5 × 27 = 40.5 mm;

By looking at options, most suitable option is 43.5 mm]

55. Ans: (a)

Sol: Self-weight of truss $= \left(\frac{\text{span}}{3} + 5\right)\times 10$

$$= 10\left(\frac{16}{3} + 5\right)$$

$$= 103.33 \simeq 104 \text{ Pa}$$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3 EE
4 EE HARSHIT KUMAR SINGH
5 EE NIKHIL KUMAR
6 EE DUSHYANT SINGH
8 EE APOORVA GUPTA
9 EE KIRAN BABU KONERU
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56. Ans: (b)

Sol: We know $z = \frac{M_p}{M_y}$

$$1.2 = \frac{M_p}{M_y} \quad \_\_\_\_ (1)$$

$$M_p = \frac{W_u L^2}{16}$$

$$M_y = \frac{W_y L^2}{12}$$

W_u = ultimate load

W_y = yield load

$$1.2 = \frac{\frac{W_u L^2}{16}}{\frac{W_y L^2}{12}}$$

$$\therefore \frac{W_u}{W_y} = 1.2 \times \frac{16}{12} = 1.6$$

57. Ans: (b)

Sol: $M = \frac{VC}{2N}$

V = 2.5% of 2000

V = 50 kN

C = 800 mm = 0.8 m

N = 2

$$M = \frac{50 \times 0.8}{2 \times 2} = 10 \text{ kN-m}$$

58. Ans: (b)

59. Ans: (a)

60. Ans: (d)

Sol:

Least or minimum stressed point is ‘S’

At point S, the combined shear stress due to concentrated load and shear stress due to torsion is minimum and bending stress due to bending moment is zero. Hence least stressed point is ‘S’.

61. Ans: (a)

62. Ans: (c)

Sol: In case of welded plate girders the effective are a resisting both tension and compression would be same.

$\therefore$ Depth of web is less compared to riveted/bolted plate girders.

63. Ans: (b)

64. Ans: (c)

Sol: Longitudinal bracings are provided when wind load is perpendicular to transverse bent.

65. Ans: (a)

Sol: Statement II is the perfect definition of “train hardening”

66. Ans: (b)

Sol: Reaching full plastic moment will depend upon many factors like end conditions, thickness of flanged web, type of steel etc.

$\therefore$ So sections can't have full plastic moment capacity.

67. Ans: (a)

Sol: Compound trusses minimise deformations/deflections effectively with less cost.

68. Ans: (d)

Sol: In suspension roots, bridges, and trolley wheels, the weight of the cable is neglected. In radio antennas, electrical transmission lines, and derricks, the cable weight may be considered.

69. Ans: (a)

70. Ans: (b)

Sol: The unit load method for evaluating deflection and slopes at individual points was developed by employing the principle of virtual work (strain energy principle).

71. Ans: (a)

72. Ans: (a)

73. Ans: (a)

Sol: Smaller moment, develop in indeterminate structures and therefore they require smaller sections which saves the material.

74. Ans: (c)

Sol: Binding moment at any

Section = Beam Bending moment – Hy

$\therefore$ Bending moment is also contributed by vertical reaction also

$\therefore$ Reason is wrong

Statement is a theoretical statement.

75. Ans: (a)