TEST ID: 409

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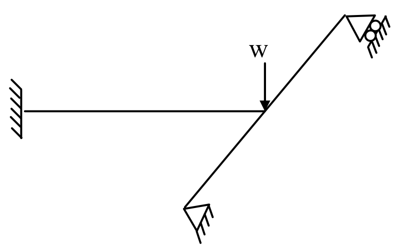
ESE- 2018 (Prelims) - Offline Test Series Test-17

CIVIL ENGINEERING

SUBJECT: BUILDING MATERIALS + STRUCTURAL ANALYSIS + DESIGN OF STEEL STRUCTURES
SOLUTIONS

01. Ans: (c)

Sol:



There will be same deflection in simply supported beam and cantilever beam at the point of junction

Stiffness of S.S beam $K_{ss} = \frac{48EI}{L^3}$

Stiffness of cantilever beam $K_c = \frac{3EI}{L^3}$

Since deformation is same, these are in parallel

$\therefore K_{eq} = K_{ss} + K_c = \frac{48EI}{L^3} + \frac{3EI}{L^3} = \frac{51EI}{L^3}$

$\therefore$ Natural frequency, $w = \sqrt{\frac{K_{eq}}{m}} = \sqrt{\frac{51EI}{mL^3}}$

02. Ans: (a)

Sol:

$r_e = 3$

No. of equilibrium equation = 3

$D_s = r_e - 3 = 3 - 3 = 0 \Rightarrow$ Externally determinate

m = 10

j = 7

$D_{si} = m - (2j - 3) = 10 - (2 \times 7 - 3)$

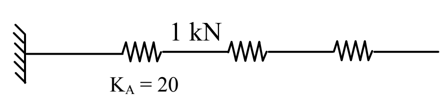
$D_{si} = -1$

$\Rightarrow$ Internally unstable

03. Ans: (d)

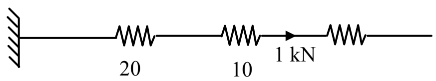
04. Ans: (b)

Sol:

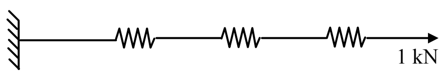


$P = K\,\Delta \Rightarrow \Delta = P/K = 1/20 = 0.05.$

$f_{11} = 0.05$



$$f_{22} = \frac{1}{20} + \frac{1}{10} = 0.15 \qquad (\because \text{ Springs are in series})$$



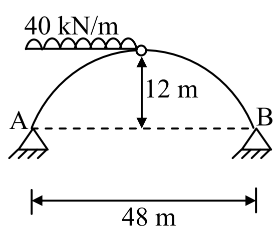
$$f_{33} = \frac{1}{20} + \frac{1}{10} + \frac{1}{5} = 0.35$$

05. Ans: (b)

06. Ans: (c)

Sol:

$$\text{Central rise} = \frac{48}{2} - \frac{\left(\frac{48}{2}\right)^2}{48} = 12 \text{ m}$$



$\Sigma M_B = 0 \Rightarrow R_A \times 48 - 40 \times 24 \times 36 = 0$

$\Rightarrow R_A = 720$ kN

$\Sigma M_C = 0$ (Left portion)

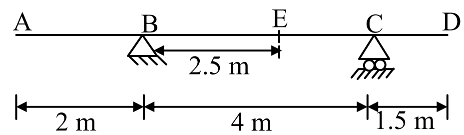
$-H_A \times 12 - 40 \times 24 \times 12 + R_A \times 24 = 0$

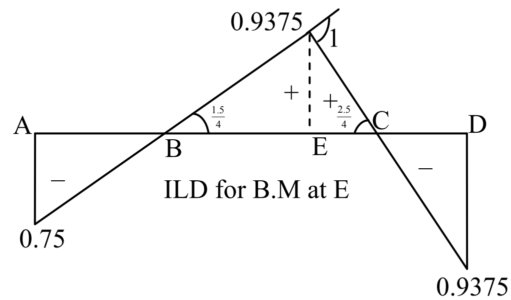
$\Rightarrow H_A = 480$ kN

$$R = \sqrt{H^2 + R^2} = \sqrt{720^2 + 480^2} \simeq 865 \text{ kN}$$

07. Ans: (b)

Sol:

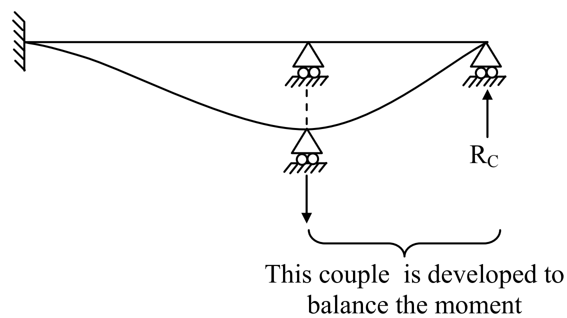




08. Ans: (c)

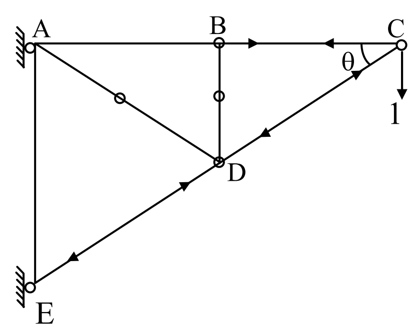
Sol:

Due to settlement of support B, the moment will be developed as shown below



09. Ans: (d)

Sol:



Since only member CD is 10 mm short we required to find only force in member CD due to unit load

$\delta_{CD} = 10$ mm

$$\sin\theta = \frac{6}{\sqrt{6^2+8^2}} = \frac{6}{10} = \frac{3}{5}$$

F sinθ = 1

$$F = \frac{5}{3} = 1.67'$$

∴ Deflection = $\delta_{CD} \times F_{CD}$ = 10 × 1.67 = 16.7

+ve sign indicates displacement is in the direction of applied load

∴ δ = 16.7 mm downwards

10. Ans: (b)

Sol:

Rotational stiffness $\Sigma K = \frac{M}{\theta}$

$$\frac{M}{\theta_B} = \frac{4EI}{L} + \frac{3EI}{L}$$

$$\frac{M}{\theta_B} = \frac{7EI}{L}$$

$$\theta_B = \frac{ML}{7EI}$$

Slope deflection equation for the member BC

$$M_{CB} = \frac{2EI}{L}(2\theta_C + \theta_B) = 0$$

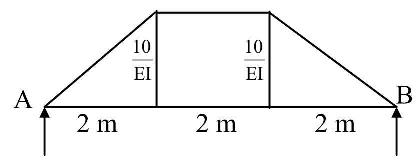
$$2\theta_C + \frac{ML}{7EI} = 0$$

$$\theta_C = -\frac{ML}{14EI} = -0.5\theta_B$$

$\theta_C = -0.5\theta_B$

11. Ans: (a)

Sol:



In conjugate beam method, slope at A = shear force at A

$$= \frac{2\times\frac{1}{2}\times 2\times\frac{10}{EI} + \frac{10}{EI}\times 2}{2}$$

$$= \frac{\frac{20}{EI}+\frac{20}{EI}}{2} = \frac{20}{EI}$$

Relation at A is $\theta_A = \frac{20}{EI}$

12. Ans: (c)

Sol:

For distribution factor at joint B, C are as follows

Joints	Members	Relative stiffness (K)	$D.F = \frac{K}{\Sigma K}$
B	BA	$\frac{2I}{4} = \frac{I}{2}$	0.66
	BC	$\frac{I}{4}$	0.33
C	CB	$\frac{I}{4}$	0.4
	CD	$\frac{3}{4}\left(\frac{2I}{4}\right)$	0.6

13. Ans: (a)

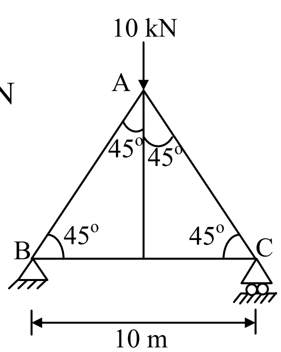
Sol:

Consider the joint at 'A'

$\varepsilon v = 2F \cos 45^o = 10$

$F = \frac{10}{\sqrt{2}}$

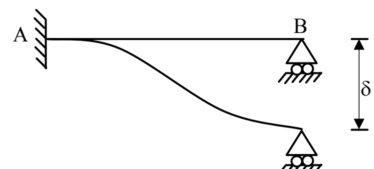
$F = 7.07 \simeq 7$ kN



14. Ans: (a)

15. Ans: (b)

Sol:



$$M_{BA} = \frac{2EI}{L}\left[2\theta_B + \theta_A - \frac{3\delta}{L}\right] \quad (\theta_A = 0)$$

$$0 = \frac{2EI}{L}\left[2\theta_B - 3\frac{\delta}{2}\right]$$

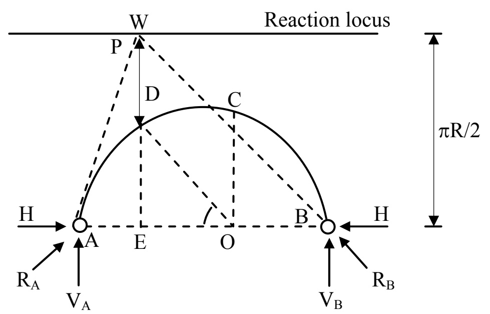
$$2\theta_B = \frac{3\delta}{L}$$

$$\theta_B = \frac{3}{2}\frac{\delta}{L}$$

16. Ans: (c)

17. Ans: (a)

Sol:



Statement (3):

$$H = \frac{15EI_o \propto t}{8h^2}$$

$H \propto t$

H increase when temperature increases

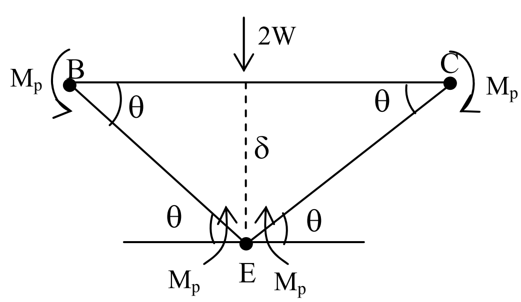
18. Ans: (b)

19. Ans: (a)

Sol:

Compared to the columns, the beam has double the length and double the load. Hence practically the beam mechanism will govern the collapse.

Beam Mechanism BC:



$$W_e = 2W.\delta = 2W.\left(\frac{L}{2}\right).\theta$$

$W_i = 4M_p.\theta$

$W_i = W_e$

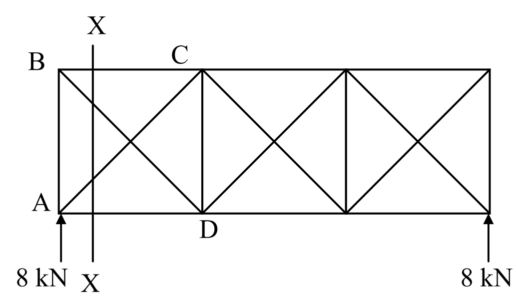
$$\Rightarrow W = \frac{4M_P}{L}$$

20. Ans: (a)

Sol:

The diagonal members are slender member and they are not support any compressive loads

The bottom chord member is always subjected to tensile and top chord member is always subjected to compression cut a section X-X.



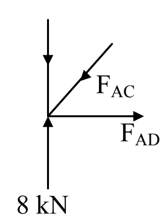
Joint A:

$\Sigma F_x = 0$

F_{AC} is compression

$\therefore\ F_{AC} = 0$

$F_{AD} = 0$



21. Ans: (d)

22. Ans: (c)

Sol: $L_p = L\sqrt{1-\frac{1}{S}}$

Shape factor for diamond section is 2

$$= 10\sqrt{\left(1-\frac{1}{2}\right)}$$

$$= 5\sqrt{2} = 7.07$$

23. Ans: (a)

Sol:

In (force method/flexibility method) unknown are forces measured quantity's are displacements.

In stiffness method unknowns are displacements and measured quantities are forces.

Welded connections are rigid connections.

In rigid connections $D_s > D_k$. If $D_s > D_k$ we are using stiffness method/displacement method.

24. Ans: (b)

25. Ans: (a)

Sol:

$X = 0.5 + 4 \times 0.13 \qquad \therefore (b + 4t)$

$= 0.5 + 0.52$

$X = 1.02 \simeq 1$ m

$X = 1$ m

26. Ans: (c)

27. Ans: (c)

Sol:

Gauged mortar = lime + cement + sand

= 25 + 20 + 30 = 75 kg

28. Ans: (b) **29. Ans: (c)**

30. Ans: (c) **31. Ans: (b)**

32. Ans: (d)

Sol: For massive concrete structure which remain continuously under water, the W/C ratio by weight should be 0.65.

33. Ans: (d)

34. Ans: (d)

Sol:

Sap wood takes active part in the growth of the tree.

Heart wood gives a strong and firm support to the tree.

35. Ans: (b)

36. Ans: (c)

Sol:

The age of timber can be predicted by counting annular rings.

37. Ans: (a)

Sol:

1. A good brick, when immersed in water both for 24 hours, should not absorb more than 20% of its dry weight.
2. Efflorescence of bricks is due to soluble salts present in clay for making bricks.
3. Modular size of brick is 20 × 10 × 10 cm and standard size of brick is 19 × 9 × 9 cm.

38. Ans: (c)

Sol:

A good soil for making bricks should contain about 20-30% alumina.

39. Ans: (c) **40. Ans: (b)**

41. Ans: (d)

Sol:

$$M_{max} = \frac{w\ell^2}{8} = \frac{50\times10^2}{8} = 625 \text{ kN-m}$$

$$Z_{p(required)} = \frac{M\times\gamma_{mo}}{f_y}$$

$$= \frac{625\times10^6\times1.1}{250}$$

$$= 2.75\times10^6 \text{ mm}^3$$

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42. Ans: (a)

Sol:

Since the ends are milled, 50% of the axial load is transferred through bearing and remaining 50% of the load is transfer by splice plate.

Load to be transferred by splice plate

$$= \frac{750}{2} = 375 \text{ kN}$$

Load to be transferred by each splice

$$\text{Plate} = \frac{375}{2} = 187.5 \text{ kN}$$

$$\text{Lever arm} = 300 + \frac{8}{2} + \frac{8}{2} = 308 \text{ mm}$$

Force in each plate due to moment

$$= \frac{60\times10^6}{308} = 194.8 \text{ kN}$$

Total load on each splice plate = 187.5 + 194.8 = 382.3 kN

43. Ans: (d)

Sol:

$$\text{Number of rivets required (n)} = \sqrt{\frac{6M}{n^1.P.R_v}}$$

M = 15 × 30 ton-cm

R_v = rivet value = 4 tonnes

n^1 = number of rows of rivets = 1

$$\therefore n = \sqrt{\frac{6\times15\times30}{1\times6\times4}} = \sqrt{112.5} = 10.60$$

∴ Nearest answer is 11

44. Ans: (c) **45. Ans: (c)** **46. Ans: (d)**

47. Ans: (c)

Sol:

For double angles placed on same side (or) opposite sides of gusset plate effective length varies between 0.70L to 0.85L

∴ C is correct.

48. Ans: (c)

49. Ans: (b)

Sol:

Centre of base plate is critical section for shear in grillage footings.

50. Ans: (b)

Sol:

We know for axial and bending combination

$$\frac{(\sigma_{axial})_{actual}}{(\sigma_{axial})_{allowable}} + \frac{(\sigma_b)_{actual}}{(\sigma_b)_{allowable}} < 1$$

$$\Rightarrow \frac{60}{160} + \frac{\sigma_b}{180} < 1$$

$\sigma_b < 112.5$ MPa

51. Ans: (a)

Sol:

Bearing stress under a concentrated load

$$(f_b) = \frac{W}{(b + 2h\sqrt{3}) \times t_w}$$

W = load

b = = length of bearing plate

h = depth of root of fillet weld

$$= \frac{100 \times 10^3}{(20 + 2 \times 30 \times \sqrt{3}) \times 12} \text{ N/mm}^2$$

f_b = 67.24 MPa

52. Ans: (c) **53. Ans: (c)**

54. Ans: (d)

Sol:

B, H, A, G all are at maximum distance from the centre of rotation but B, H are close to the applied load.

∴ B, H are subjected to maximum stress.

55. Ans: (b)

Sol:

Members do get distorted due to high heat during weldings.

56. Ans: (d)

Sol:

It doesn't give actual unit stress developed in the member

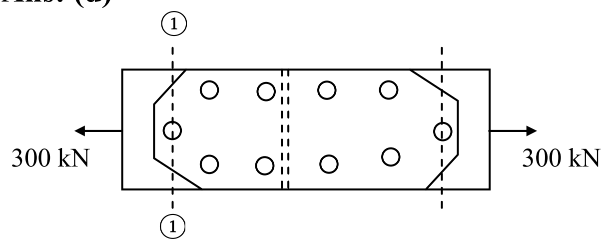
57. Ans: (d)

Sol:

All the conditions are considered while designing a built-up column.

58. Ans: (d)

Sol:



Section (1)-(1) is critical section

Let b be the width of the plate

Then

$[b - (20 + 1.5)] \times t \times \sigma_{at} = 300 \times 10^3$

$(b - 21.5) \times 12 \times (0.6 \times 250) = 300 \times 10^3$

$b - 21.5 = 166.66$

$b = 188.16 \simeq 200$ mm

59. Ans: (b)

Sol:

Effective length of web = $(l) = d_1/2$

(web is assumed as restrained against rotation & displacement)

$$\therefore \lambda = \frac{\ell}{r_{yy}} \qquad r_{yy} = \sqrt{\frac{I_{yy}}{A}}$$

$$= \sqrt{\frac{\frac{B \times t^3}{12}}{B \times t}} = \frac{t}{2\sqrt{3}}$$

$$\lambda = \frac{(d_1)/2}{t/2\sqrt{3}} = \frac{d_1\sqrt{3}}{t}$$

60. Ans: (c)

Sol:

Tensile Strength (P_t) = $A_{eff} \times \sigma_{at}$

$\sigma_{at} = 0.6 \times f_y = 0.6 \times 260$

$A_{eff} = A_1 + k_1.A_2$

A_1 = Area of connected leg = $\left(100 - \frac{10}{2}\right) \times 10 = 950\ mm^2$

A_2 = Area of out stand leg $\left(75 - \frac{10}{2}\right) \times 10$

$= 700\ mm^2$

$$k_1 = \frac{3A_1}{3A_1 + A_2} = \frac{3 \times 950}{3 \times 950 + 700} = 0.80$$

$\therefore\ 950 + 0.8 \times 700 = 1510\ mm^2$

$p_t = 1510 \times 0.6 \times 260$

$= 235.56$ kN

61. Ans: (d)

Sol:

In dynamic loading both magnitude of loading and natural frequency will be varied along with time.

62. Ans: (b)

Sol:

Both the statements are correct but reason is not correct explanation. Correct explanation is in determinate frame members are free to move so no stresses (or) forces are developed when members are stretched.

63. Ans: (d)

Sol:

Two hinged arches are structurally more efficient than three hinged arches. In three hinged arches construction of central hinge may involve additional expenditure and hence are uneconomical.

64. Ans: (a)

Sol:

Working stress method produce safe but large size of structures. As allowable stresses are much lesser than yield stress of material, it gives higher sizes of elements (beam, column etc)

65. Ans: (d)

Sol:

Deflection is checked for service load condition not for factored load.

66. Ans: (b)

67. Ans: (c)

Sol:

The tension member does not susceptible to buckling. Near the joint, the out standing leg does not takes its full stress, due to which effective area is reduced.

68. Ans: (d)

Sol: The stiffness method can be used to analyze both statically determinate and indeterminate structures.

69. Ans: (a)

Sol:

The centre of gravity of the load causes torsion in the curved beams.

70. Ans: (a) **71. Ans: (a)** **72. Ans: (b)**

73. Ans: (a) **74. Ans: (a)** **75. Ans: (b)**