ACE
Engineering Academy

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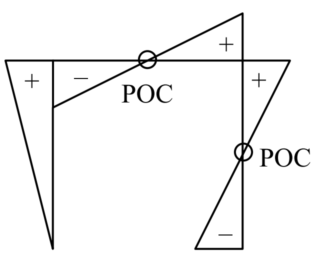
ESE- 2018 (Prelims) - Offline Test Series Test-22

CIVIL ENGINEERING

FULL LENGTH MOCK TEST – 1 (PAPER – II)
SOLUTIONS

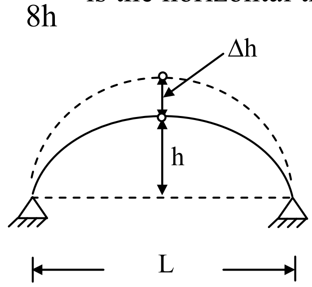
01. Ans: (c)

Sol:



02. Ans: (a)

Sol: $H = \frac{w\ell^2}{8h}$ is the horizontal thrust



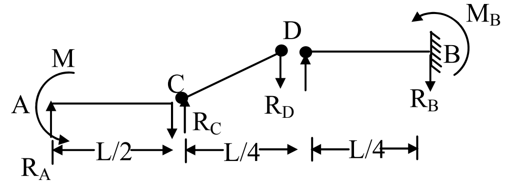
It temperature increases; h increases

Therefore Horizontal thrust decreases

But B.M and S.F will be no change

03. Ans: (c)

Sol:



Free body diagram

$R_A = –R_C = R_D = –R_B$

$M + R_A \times L/2 = 0$

$$R_A = -\frac{2M}{L}$$

$\sum M_D = 0$

$$R_B \times \frac{L}{4} - M_B = 0$$

$$M_B = \left(\frac{2M}{L}\right) \times \frac{L}{4} = \frac{M}{2}$$

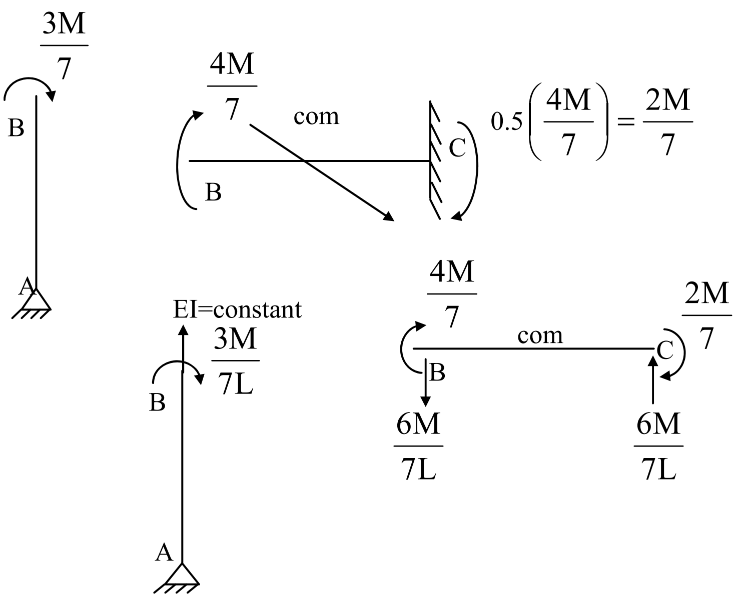
$\therefore$ Carry over moment at B = $\frac{M}{2}$

04. Ans: (b)

05. Ans: (a)

Sol:

Joint	Members	Stiffness (K)	ΣK	Distribution factor
B	BC	$\frac{4EI}{L}$	$\frac{7EI}{L}$	$\frac{4}{7}$
	BA	$\frac{3EI}{L}$		$\frac{3}{7}$



$\therefore$ Axial force in member (AB) = $\frac{6M}{7L}$

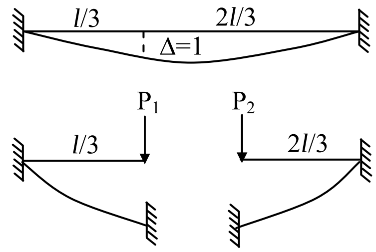
06. Ans: (c)

Sol:

As per IS-456 c.26.2.5.1, lap splices are not used for bars > 36 mm. Instead welding can be done.

07. Ans: (d)

Sol:



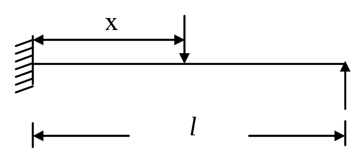
Unit displacement only translation without rotation

$\Rightarrow$ Just like sinking of support

$$\therefore\ P = P_1 + P_2 = \frac{12EI\Delta}{\left(\frac{\ell}{3}\right)^3} + \frac{12EI\Delta}{\left(\frac{2\ell}{3}\right)^3} = \frac{729EI}{2\ell^3}$$

08. Ans: (d)

Sol:



Reaction $\frac{R_B\ell^3}{3EI} = \frac{x^3}{3EI} + \frac{x^2}{2EI}(\ell - x)$

$$R_B = \frac{x^3}{\ell^3} + \frac{3x^2(\ell - x)}{2\ell^3}$$

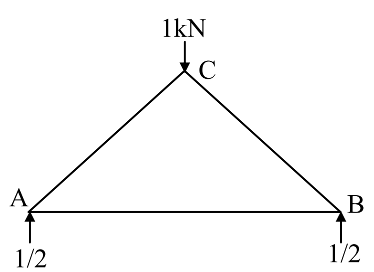
$$\therefore\ R_B = \frac{2x^3 + 3x^2(\ell - x)}{2\ell^3}$$

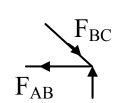
$R_B \propto x^3$

Shape of ILD for reaction R_B is cubic parabola.

09. Ans: (b)

Sol: By virtual –work method





$F_{BC}\sin 60 = 1/2$

$F_{BC} = \frac{1}{\sqrt{3}}$

$$F_{BC}\cos 60° = F_{AB}$$

$$\frac{1}{\sqrt{3}} \times \frac{1}{2} = F_{AB}$$

Only member AB undergoes a change in length,

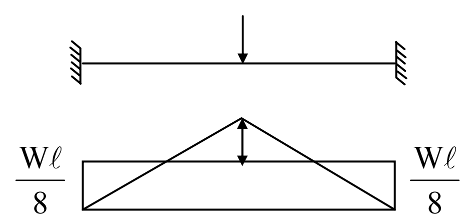
$\delta_{AB} = 1.732$ mm

$$\delta = \sum K\delta = K_{AB}\delta_{AB}$$

$$= \frac{1}{2\sqrt{3}} \times 1.732 = 0.5 \text{ mm (up wards)}$$

10. Ans: (d)

Sol:



Elastic moment $M_e = \frac{W\ell}{8} \Rightarrow W = \frac{8M_e}{\ell}$

Plastic moment at collapse load $W_C = \frac{8M_P}{\ell}$

$$\frac{W_C}{W_e} = \frac{\frac{8M_P}{\ell}}{\frac{8M_e}{\ell}} = \frac{M_P}{M_e}$$

$$W_c = S \times W_e = 1.7 \times 9 = 15.3 \text{ kN}$$

Deformation is just observed means the beam is subjected to elastic failure with yield load

11. Ans: (a)

Sol: Length of hinge also depends on shape of the cross-section.

12. Ans: (c)

Sol: As per Betti's theorem

$200 \times 20 + 150 \times 15 = 250 \times \delta_A$

$$\delta_A = \frac{4000 + 2250}{250}$$

$$= \frac{6250}{250} = 25 \text{ mm}$$

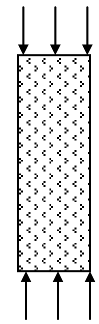
13. Ans: (d)

Sol: $0 + \frac{3EI}{L} + \frac{4EI}{L} + \frac{3EI}{L} = \frac{10EI}{L}$

14. Ans: (d)

15. Ans: (a)

Sol: Timber will offer resistance upto certain point when it is subjected to compression parallel to the grains after that even small increase in load there will be more displacement



16. Ans: (a)

Sol: $K_{11} = \frac{AE}{L}$

$K_{21} = 0 = K_{12}$

$K_{31} = 0 = K_{13}$

$$\therefore [k] = \begin{bmatrix} k_{11} & k_{12} & k_{13} \\ k_{21} & k_{22} & k_{23} \\ k_{31} & k_{32} & k_{33} \end{bmatrix} = \begin{bmatrix} \frac{AE}{L} & 0 & 0 \\ 0 & \frac{4EI}{L} & \frac{6EI}{L^2} \\ 0 & \frac{6EI}{L^2} & \frac{12EI}{L^3} \end{bmatrix}$$

17. Ans: (a)

Sol:

1. Shear strength of wood 10-15% of its tensile strength in the direction of grain.
2. Shearing strength is weakned by knots and faults and cracks will appear in the wood.

18. Ans: (a)

19. Ans: (b)

20. Ans: (c)

Sol: Rapid hardening of High Alumina Cement due to presence of calcium aluminates.

Extra rapid hardening cement prepared by adding calcium chloride and not decreasing the gypsum.

Extra rapid hardening is obtained by inter grinding about 2% calcium chloride by weight with rapid hardening portland cement.

21. Ans: (a) **22. Ans: (b)**

23. Ans: (a)

Sol:

- Excess of magnesia makes the cement unsound
- Setting time of low heat cement is same as OPC. Setting time are independent of strength.

24. Ans: (b)

25. Ans: (a)

26 Ans: (c)

Sol: $\eta = (0.21 + 0.3) \times 100 + 28 \times \dfrac{0.25}{0.35} + 21 \times \dfrac{0.3}{0.35}$

$= 51 + 20 + 18$

$= 89\%$

27. Ans: (b)

Sol: Colloidal particles have mostly negative charge on them.

They repel each other and remain in suspended/ stable form.

28. Ans: (c)

Sol: Back washing is not done for slow sand filters

Rate of filtration for slow sand filter is about 100-200 $l$it/hr/m^2 while for pressure filter is about 6000-15000 $l$it/hr/m^2.

29. Ans: (a)

Sol: BOD_5 = DO last in sample × Dilution factor

$$BOD = (DO_i - DO_f) \times DF = (9-5) \times \frac{300}{2}$$

$BDO_5 = 600$ mg/$l$it

30. Ans: (a)

Sol: Break point dosage is 1.0 mg/lit

Cl_2 demand = Cl_2 dose – Residual chlorine

$= 1 - 0.2 = 0.8$ mg/lit

Cl_2 demand is constant after break point because after break point if we add Cl_2 that will goes to free chlorine.

31. Ans: (a)

Sol: Sound Level in dB $= 20\log_{10}\left(\dfrac{L_i}{20}\right)$

$$= 20\log_{10}\left(\frac{20\times10^4}{20}\right) = 80 \text{ dB}$$

32. Ans: (d)

Sol: $$\frac{F}{M}=\frac{Qy_o}{VX}\text{(mg/mgday)}$$

$$=\frac{0.2\times75\times24\times60\times60}{900\times2400}$$

$$\frac{F}{M}=0.6\text{ day}^{-1}$$

33. Ans: (b)

Sol: **Merits of incineration:**

1. Ensures complete destruction of pathogenic bacteria and insects
2. No odour troubles (or) dust nuisance
3. Some cost can be cover by selling the stream power and dinkess
4. It requires very less space for refuse disposal

Demerits

1. Costly method
2. Solid waste to be burnt should have high calorific value

34. Ans: (d)

Sol: Venturi scrubbers can efficiently remove gaseous as well as particulate contaminants. Electrostatic precipitatiors can be operated at high temperatures (upto 300 to 450°C).

35. Ans: (b)

Sol: $$\text{HOCl}=\frac{1}{1+\frac{K}{H^+}}$$

$$=\frac{1}{1+\frac{2.5\times10^{-8}}{10^{-7}}}=0.80$$

36. Ans (b)

Sol: $$\text{Surface area}=\frac{Q}{\text{rate of filtration}}$$

$$=\frac{24\times10^6}{24\times5000}\text{m}^2=200\text{ m}^2$$

$$\text{No. of filters}=\frac{\text{S.A}}{\text{area of each filter}}=\frac{200}{5\times10}=4$$

37. Ans: (d)

Sol:

- The load is increased to 2 ½ times the estimated allowable load (or) to a load that causes a settlement equal to one-tenth of the pile diameter.
- Allowable load can also be taken as half of the final load which cause a settlement equal to 10% of pile diameter.

38. Ans: (c)

Sol: $G=2.70$, $\frac{\gamma_d}{\gamma_w}=1.80$

$$\gamma_d=\frac{\gamma_w.G}{1+e};\quad 1.80=\frac{2.70}{1+e}$$

$e=0.50$

39. Ans: (c)

Sol: In case of isolated spread footing (or) raft foundation, depth of exploration is one and a half times the width.

40. Ans: (c)

Sol: Infact, Geo-synthetics are used to protect soil surface from being damaged by surface water flow, weather, light traffic and erosion. Hence statement 3 is wrong

41. Ans : (a)

Sol: I = 0.005

n = 8

q = 500 kPa,

$\sigma_z = I.n.q = 0.005 \times 8 \times 500 = 20$ kPa

42. Ans: (b)

Sol: $$F.O.S = \frac{C\hat{L} + (\Sigma N - \Sigma U)\tan\phi}{\Sigma T}$$

$$= \frac{20\times 18 + (320-50)\tan 0^{o}}{150}$$

$$= \frac{20\times 18}{150} = 2.4$$

43. Ans: (d)

Sol: $\gamma_{sat} = 20$, $\gamma_w = 10$

$\gamma' = 20 - 10 = 10$ kN/m^3

$$k_p = \frac{1+\sin 30^{o}}{1-\sin 30^{o}} = 3$$

Intensity of passive earth pressure

$P_p = k_p.\ \gamma'.\ H + \gamma_w H$

$= 3 \times 10 \times 8 + 10 \times 8 = 320$ kN/m^2

44. Ans: (a)

Sol: Given $C' = 0$ and $\phi' = 30^{o}$

$\sigma_3 = 100$ kN/m^2, $\sigma_d = 60$ kN/m^2

$\sigma_1 = \sigma_3 + \sigma_d$

$= 100 + 60$

$\sigma_1 = 160$ kN/m^2

$$\sigma_1' = \sigma_3' \tan^2\left(45 + \frac{\phi'}{2}\right)$$

$$(160 - u) = (100 - u)\tan^2(45 + 15)$$

$160 - u = (100 - u)3$

$u = 70$ KPa

45. Ans: (b)

Sol: As the mass of water is kept constant, the moisture content (w) remains constant

$$S_r = \frac{wG}{e};\quad S_1 = \frac{wG}{e_1};\quad S_2 = \frac{wG}{e_2}$$

$$\therefore\ S \propto \frac{1}{e} \quad \therefore\ \frac{S_1}{S_2} = \frac{e_1}{e_2}$$

$$\%\ \text{change in}\ S = \frac{S_2 - S_1}{S_1}\times 100 = \left(\frac{S_2}{S_1} - 1\right)\times 100$$

$$= \left(\frac{e_1}{e_2} - 1\right)\times 100$$

e_1 = void ratio of borrow pit = 1.1

e_2 = void ratio of compacted fill = 0.7

$$\%\ \text{change} = \left(\frac{1.1}{0.7} - 1\right)\times 100 = 57.14\%$$

46. Ans: (a)

Sol: $m_v = \dfrac{\Delta e}{1+e} \times \dfrac{1}{\Delta\sigma'}$

$\Delta\sigma' = 400 - 200 =$ constant for both specimen

$$\frac{(m_v)_A}{(m_v)_B} = \frac{\left(\dfrac{\Delta e}{1+e_o}\right)_A}{\left(\dfrac{\Delta e}{1+e_o}\right)_B}$$

For specimen A

$(\Delta e)_A = 0.62 - 0.44 = 0.18$

$e_o = 0.62$

for specimen B

$\Delta e = 0.72 - 0.62 = 0.10$

$e_o = 0.72$

$$\frac{(m_v)_A}{(m_v)_B} = \frac{\left(\dfrac{0.18}{1+0.62}\right)}{\left(\dfrac{0.10}{1+0.72}\right)} = \frac{0.18}{1.62} \times \frac{1.72}{0.1} = 1.91$$

47. Ans: (a)

48. Ans:(b)

Sol: Q = K.i.A

K, Q = constant throughout the length of the sample

At section B-B; $A = \dfrac{\pi}{4}5^2 = 19.63\ \text{cm}^2$

$$\therefore \frac{20}{60}\left(\frac{\text{cm}^3}{\text{sec}}\right) = (0.02) \times i_B \times \left(\frac{\pi}{4}5^2\right)$$

$$i_B = \frac{20}{60 \times 0.02 \times 19.63} = 0.8488 \simeq 0.85$$

49. Ans: (d)

Sol: $\sigma' = \sigma - u$

$\sigma = \gamma_w \times 6 + \gamma_{sat} \times 12$

$U = \gamma_w(6+12) = 18\gamma_w$

$\sigma' = (6\gamma_w + 12\gamma_{sat}) - 18\gamma_w = 12\,(\gamma_{sat} - \gamma_w)$

$= 12 \times \gamma'$

$\gamma' = \left[\dfrac{G-1}{1+e}\right]\gamma_w = \dfrac{2.65-1}{1+1.0} \times 10$

$e = 1.0$

$\sigma' = 12 \times \left(\dfrac{2.65-1}{1+1.0}\right) \times 10 = 99\ \text{kN/m}^2$

50. Ans: (d)

Sol: Primary consolidation is due to squeezing of water from the voids leads to decrease in volume of soil.

Secondary consolidation does not obeys Terzaghi's theory of consolidation.

51. Ans: (c)

Sol: 70% of soil is retained on 75μ sieve indicates, it is coarse grained soil. 60% of the coarse fraction is retained on 4.75 mm sieve, indicates it is gravel because more than 50% is retained.

C_u of gravel is > 4

C_c = 1 to 3

$\therefore$ It is GW

52. Ans: (a)

Sol: The area ratio of a good quality undisturbed soil sample should be less than 10%.

53. Ans: (d) **54. Ans: (d)**

55. Ans: (c)

Sol: For semi-circular arc

Distance of shear centre from the centre

$$= \frac{4r}{\pi} = \frac{4\times\pi}{\pi}\text{cm} = 4\text{ cm}$$

56. Ans: (a)

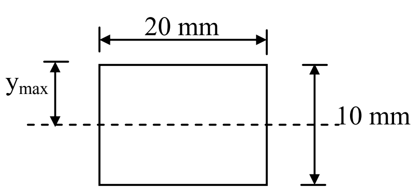
Sol: Maximum lateral deflection occurs when load on column reaches the critical value

$$\frac{M}{I} = \frac{\sigma}{y}$$

$$\frac{[P_{cr}\times e]}{I_{min}} = \frac{\sigma_y}{y_{max}} \text{ [Euler neglects axial stress]}$$

$$e = \frac{\sigma_y \times I_{min}}{P_{cr}\times y_{max}}$$

Buckling occurs on weaker axis



$$y_{max} = 5\text{mm}$$

$$I_{min} = \frac{20\times 10^{-3}}{12}\text{mm}^4,$$

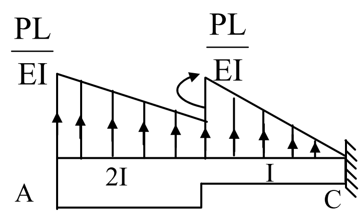
σ_y = 300 N/mm^2

$$e = \frac{300\times\left(\frac{20\times10^3}{12}\right)}{3000\times5} = \frac{300\times20\times10^3}{3000\times5\times12}$$

$$= \frac{400}{12} = 33.33\,\text{mm}$$

57. Ans: (d)

Sol:



δ_V = moment at C

$$= \left(\frac{1}{2}\times L\times\frac{PL}{EI}\right)\times\frac{2L}{3} + \left(\frac{0.5PL}{EI}\right)\times(1.5L)$$

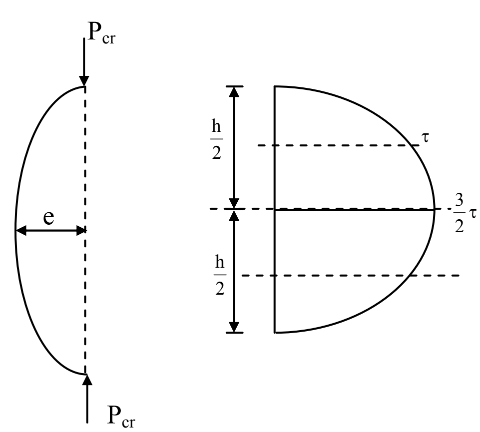
$$+\left(\frac{1}{2}\times L\times\frac{0.5PL}{EI}\right)\times\left(\frac{5L}{3}\right)$$

$$= \frac{PL^3}{3EI} + \frac{0.75PL^3}{EI} + \frac{2.5PL^3}{6EI}$$

$$\delta_V = \frac{1.5PL^3}{EI} = \frac{3}{2}\frac{PL^3}{EI}$$

58. Ans: (b)

Sol:



Shear stress distribution on rectangular section follows parabolic distribution

$\left(\frac{x^2}{y}\right) = \text{constant (c)}$

$x = \frac{h}{2} \qquad y = \frac{3}{2}\tau$

$$c = \frac{\left(\frac{h^2}{4}\right)}{\frac{3}{2}\tau} = \frac{h^2}{6\tau}$$

$x = ? \quad y = \tau$

$x^2 = \frac{h^2}{6\tau} \times \tau \Rightarrow \left(x = \frac{h}{\sqrt{6}}\right)$ from top fibre

$\therefore$ Shear stress at $\frac{h}{\sqrt{6}}$ from the top fibre is equal to nominal shear stress.

59. Ans: (b)

Sol: Let T_s and T_A are torsional resisted by steel & Aluminum

$\because$ No slip at joint

$\theta_s = \theta_s$

$$\frac{T_s L}{G_s J_s} = \frac{T_A L}{G_A J_A}$$

$$\frac{T_s}{T_A} = \frac{G_s}{G_A} \times \frac{I_s}{I_A}$$

$$= 2 \times \frac{\frac{\pi}{32}\left(50^4 - 30^4\right)}{\frac{\pi}{32} \times \left(30^4\right)}$$

$$= 2 \times \left(\left(\frac{5}{3}\right)^4 - 1\right) = 13.43$$

60. Ans: (a)

Sol: We know in distortion theory

$$\frac{(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_1 - \sigma_3)^2}{2} \le \sigma_y^2$$

In pure shear

$\sigma_1 = \tau;\ \sigma_2 = -\tau;\ \sigma_3 = 0$

$$\frac{[\tau - (-\tau)]^2 + (-\tau - 0)^2 + (\tau - 0)^2}{2} \le \sigma_y^2$$

$$\frac{4\tau^2 + \tau^2 + \tau^2}{2} \le \sigma_y^2$$

$$3\tau^2 \le \sigma_y^2$$

$$\tau \le \frac{\sigma_y}{\sqrt{3}} \le \frac{250}{\sqrt{3}}\text{MPa}$$

$$\tau_{max} = \frac{250}{\sqrt{3}}\text{MPa}$$

$$= 144.33 \text{ MPa}$$

61. Ans: (d)

Sol: Radius of Mohr's circus

$$= \sqrt{\left(\frac{\varepsilon_x + \varepsilon_y}{2}\right)^2 + \left(\frac{\phi_{xy}}{2}\right)^2}$$

$$= \sqrt{\left[\left(\frac{600 + 200}{2}\right) \times 10^{-6}\right]^2 + \left[\left(\frac{600}{2}\right) \times 10^{-6}\right]^2}$$

$$= 10^{-6} \times \sqrt{400^2 + 300^2} = 500 \times 10^{-6}$$

62. Ans: (b)

Sol: $\varepsilon_V = \varepsilon_x + \varepsilon_y + \varepsilon_z$

$$\varepsilon_x = \frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E} - \mu\frac{\sigma_3}{E}$$

$$\varepsilon_y = \frac{\sigma_2}{E} - \mu\frac{\sigma_1}{E} - \mu\frac{\sigma_3}{E}$$

$$\varepsilon_z = \frac{\sigma_3}{E} - \mu\frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E}$$

$$\varepsilon_v = \frac{\sigma_1 + \sigma_2 + \sigma_3}{E}(1-2\mu)$$

$$= \frac{(150+100-50)}{2\times10^5}(1-0.5)$$

$$= \frac{100}{2\times10^5}\times\frac{1}{2} = 0.25\times10^{-3}$$

63. Ans: (c)

Sol: $$\epsilon_1 \le \frac{\left(\frac{\sigma_y}{E}\right)}{F.O.S} \qquad \to (1)$$

$$\epsilon_1 = \frac{\sigma_1}{E} - \mu\frac{\sigma_2}{E} - \mu\frac{\sigma_3}{E}$$

$$= \frac{1}{E}(200 - \mu(150+100))$$

$$= \frac{200 - 0.3\times250}{E} = \frac{125}{E}$$

From (1)

$$F.O.S = \frac{\left(\frac{\sigma_y}{E}\right)}{\varepsilon_1} = \frac{\left(\frac{250}{E}\right)}{\left(\frac{125}{E}\right)}$$

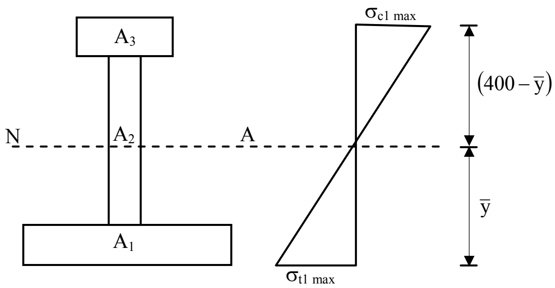
$$F.O.S = 2$$

64. Ans: (a)

Sol: It is not applicable for hydrostatic loading.

65. Ans: (d)

Sol:



∴ Using similar triangles

$$\frac{\sigma_{c_1\,max}}{\sigma t_1\,max} = \frac{400-\bar{y}}{\bar{y}}$$

$$= \frac{400-160}{160} = 1.5$$

66. Ans: (b)

Sol: As the loading is symmetric S.F.D is also symmetric

Also slope of S.F.D at supports must be "zero" as the intensity of loading is zero at supports the degree of S.F.D must be 3° as intensity of load is of 2°

∴ Option B is correct

67. Ans: (b)

Sol:
$$\Delta\ell = \frac{FL}{AE} = -\alpha\Delta t$$

$$\Delta t = \frac{F}{AE\times\alpha}$$

$$= \frac{2000}{2\times10^{6}\times12\times10^{-6}}$$

$$= \frac{2000}{24} = 83.33$$

68. Ans: (c)

Sol: Presence of notches cause uneven distribution of stresses which causes brittle failures.

69. Ans: (c)

Sol: for real fluid viscosity zero

Ideal fluid is inviscid i.e. it has zero viscosity

For Newtoneaon fluid $\tau = \mu\frac{du}{dy}$

70. Ans: (b)

Sol: $P_{air} = -0.25\times13.6 = -3.4$ m of water

Now $P_{air} + 4\times0.8 = P_A$

$\therefore P_A = -3.4 + 3.2$

$P_A = -0.2$ m of water

$P_A = 9.81\,(-0.2) = -1.962$ kPa

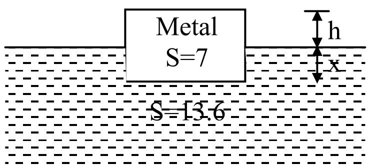
71. Ans: (a)

Sol: Magnitude of hydrostatic force on plane surface is independent of the inclination of the surface, as long as depth of its centroid remains same.

$F = \rho g A\bar{h}$ where $\bar{h}$ = depth of centroid

72. Ans: (c)

Sol:



Volume of metal piece V = A(h + x)

Let x be depth of metal piece under mercury under equilibrium,

(Buoyancy force = weight of the block)

$\rho_m gAx = \rho_s gA(h+x)$

$13.6\times Ax = 7(h+x) A$

$$\frac{h+x}{x} = \frac{13.6}{7}$$

$\therefore$ Fraction of volume under mercury

$$= \frac{Ax}{A(h+x)} = \frac{7}{13.6} = 0.515$$

73. Ans: (d)

Sol: Velocity potential function: It is defined as a scalar function of space & time

74. Ans: (a)

Sol: $\rho = 1.2\ kg/m^3$

$P_{dyn} = P_{stagnation} - P_{st} = 380$ Pa

$P_{dyn} = \rho gh$

$\therefore 380 = 1.2 \times 9.81 \times h$

$h = 32.279$ m

$$\therefore\ V = \sqrt{2gh} = \sqrt{2\times 9.81\times 32.279} = 25.17\,m/s$$

75. Ans: (b)

Sol: $h_L = \dfrac{32\mu\overline{V}L}{\rho g D^2} = \dfrac{32\times 0.0869\times 1\times 45}{869\times 9.81\times 0.15^2} = 0.652\,m$

76. Ans: (c)

Sol: $\sigma_c = \dfrac{H_a - H_v - H_s}{H}$

$(0.33 \times 27) = 10.6 - 0.323 - H_s$

$H_s = 1.367$ m

Maximum height $= H_s + 0.77$

$= 1.367 + 0.77$

$= 2.137$ m.

77. Ans: (b)

Sol: Volute casing of a centrifugal pump has following function.

1. Directs the flow towards the delivery pipe
2. Convents a part of velocity head to pressure head.

78. Ans: (d)

Sol: $n_o = \dfrac{\rho QgH}{P} = \dfrac{1000\times 0.0125\times 9.81\times 30}{5000}$

$= 0.7357 = 73.57\%$

79. Ans: (a)

Sol: $h_f = \dfrac{fLV^2}{2gd} = \dfrac{0.0098\times 400\times 5^2}{2\times 9.81\times d}$

$h_f = 4.99$ m

$\therefore\ H = H_G - h_f = 300 - 4.99 = 295$ m

80. Ans: (b)

Sol: For a given specific energy (or) Force: Discharge is maximum at a critical depth.

81. Ans: (c)

Sol:

$$\frac{dy}{dx} \text{ is + ve}$$

$$\frac{dE}{dx} = S_o - \overline{S}_f$$

$$\frac{dy}{dx} = \frac{S_o - \overline{S}_f}{1 - F_r^2}$$

If $\frac{y}{y_c} > 1$, sub critical flow

$F_r < 1$

for $\frac{y}{y_c} > 1 \,\&\, F_r < 1$

$$\frac{dy}{dx} = \frac{S_o - \overline{S}_f}{1 - F_r^2}$$

Denominator is positive

$\therefore$ $\frac{dE}{dx}$ is +ve if

$S_o - \overline{S}_f$ is +ve & $\frac{y}{y_c} > 1$

82. Ans: (d)

Sol: $\frac{y_2}{y_1} = \frac{1}{2}\left[-1 + \sqrt{1 + 8F_n^2}\right]$

$$16.48 = \frac{1}{2}\left[-1 + \sqrt{1 + 8 \times F_n^2}\right]$$

$\Rightarrow F_{r1} = 12$

Note:

(Approximate formula)

$$\frac{y_2}{y_1} = 1.41 F_{r1}$$

83. Ans: (b)

Sol: More is the swing angle more time will be taken for swinging the load which will increase the cycle time.

Less swing, less cycle time

84. Ans: (a)

Sol: The output is less, it is around 75 to 80, for the same size of bucket capacity

85. Ans: (c)

86. Ans: (d)

Sol:

$$\sigma_{AB} = \left(\frac{5-3}{6}\right) = \frac{1}{3}; \quad \sigma_{BC} = \left(\frac{10-6}{6}\right) = \frac{2}{3}$$

$$\sigma_{CD} = \frac{2}{6} = \frac{1}{3}$$

Standard deviation $\sigma = \sqrt{\sigma_{AB}^2 + \sigma_{BC}^2 + \sigma_{CD}^2}$

$$= \sqrt{\left(\frac{1}{3}\right)^2 + \left(\frac{2}{3}\right)^2 + \left(\frac{1}{3}\right)^2} = \frac{\sqrt{6}}{3}$$

87. Ans: (d)

Sol: Conventional rainfall is formed when air on the surface is heated, it becomes lighter (water vapour) and rises, as the water vapour rises, it converges and condenses to form clouds. Which later drops as rainfall. If the air is not enough, it rises very quickly and can cause thunderstorms. Usually, it is of short duration and highly localized.

88. Ans: (a)

Sol:

Isohyet mean rainfall	**Area between isohytes**	$\sum A_i x_i$
10 cm	30 km^2	300
9 cm	30 km^2	270
7 cm	20 km^2	140
Total	80 km^2	710 (km^2-cm)

$\therefore$ Mean precipitation $= \frac{710}{80} = 8.875$ cm

89. Ans: (c)

Sol: Hydrograph depicts the flow in all the phases of runoff i.e., surface runoff, base flow, interflow. Thus it depends both on rainfall and the catchment characteristics and the interaction between them. Therefore two different storms for the same catchment produces two different hydrographs. Similarly same storm in two different catchments produces two different hydrograph.

90. Ans: (c)

Sol: Area under direct runoff hydrograph

= total volume of runoff

= (area under unit hydrograph)

$\Rightarrow$ area under DRH

$$= \left(\frac{1}{2}\times 24\times 100\right)\times 3600$$

$= 4.32 \times 10^6$ m^3 = 4.32 Mm^3

91. Ans: (a)

Sol: Probability of failure of structure = $P = \frac{1}{50}$

$$\therefore \ q = 1-\frac{1}{50} = \frac{49}{50}$$

Probability of structure failing in 4th year

$\Rightarrow$ It is safe for 3 years and fails in 4th year

$$\Rightarrow \frac{49}{50}\times\frac{49}{50}\times\frac{49}{50}\times\frac{1}{50} = \left(\frac{49}{50}\right)^3\times\frac{1}{50}$$

92. Ans: (d)

Sol: d_w = Sd (F.C – PWP)

$$= 1.7\times 1(0.25-0.15)\times\frac{50}{100}$$

= 0.085 m = 85 mm

CIR = $C_u - P_e$ = 85 – 15 = 70

FIR = NIR + Field losses

NIR = $C_u - P_e + L_e$

[Assume leaching = 0)

FIR = 70 + 5 = 75 mm

$$\eta_a = \frac{CIR}{FIR} = \frac{70}{75}\times 100 = 93.33\%$$

93. Ans: (b)

94. Ans: (d)

Sol: $h = \dfrac{f_c}{\gamma_w (G+1)}$

$= \dfrac{7.5\times 10^6}{10000\times(3.4)} = 220.58 \text{ m} = 220 \text{ m}$

95. Ans: (d)

96. Ans: (c)

Sol: In general, $\dfrac{d}{t_w}$ is used to select the type of stiffners to be provided.

$\dfrac{d}{t_w} \le 200\varepsilon_w$ transverse stiffners

$\dfrac{d}{t_w} \le 250\varepsilon_w$ transverse & one level of longitudinal stiffners

97. Ans: (c)

Sol: Web crippling occurs only under the concentrated load if the thickness of web is not sufficient to control the "bearing stress".

98. Ans: (c)

Sol: Prying action is a phenomenon, the deformation of a fitting under a additional increase of tensile force in the bolt. The effect of prying action is relevant to the designer of bolts, it is a primarily a function of strength and stiffness of the connection elements.

99. Ans: (b)

100. Ans: (b)

Sol: Super elevation for mixed traffic condition

$= \dfrac{V^2}{225R}$

$= \dfrac{90^2}{225\times 500}$

$= 7.2\%$

Equilibrium super elevation

$e = \dfrac{v^2}{gR}$

$= \dfrac{25^2}{9.81\times 500} = 12.7\%$

101. Ans: (d)

102. Ans: (c)

Sol: Hauling capacity = μ. nw

μ = coefficient of friction

w = weight on each driving axle

n = number of pairs of driving wheels

$= \dfrac{8}{2} = 4$

Hauling capacity $= 0.25 \times 4 \times 24$

$= 24$ tonnes

103. Ans: (c)

Sol: Angularity number $= 67 - \dfrac{100 \times w}{C \times G_a}$

$$AN = 67 - \frac{100 \times 2500}{1700 \times 2.60}$$

$$= 10.43 \simeq 11$$

104. Ans: (c)

Sol: Subgrade is bottom layer.

Wearing course (or) surface course is top layer of flexible pavement

105. Ans: (a)

Sol: Deviated angle, $\Delta = 60^o$

Length of long chord, $L = 2R \sin \dfrac{\Delta}{2}$

$$= 2 \times 500 \times \sin\left(\frac{60}{2}\right)$$

$$= 500 \text{ m}$$

106. Ans: (d) **107. Ans: (c)**

108. Ans: (a)

Sol: The graduations are engraved erect from 0^o to 90^o in four quadrants. The zero points are marked with N and S

The readings are taken directly by looking downward through the glass cover and reading the north end of needle.

109. Ans: (c)

110. Ans: (b)

Sol:

$$\text{Area} = \frac{d}{3}\{(O_1 + O_7) + 4(O_2 + O_4 + O_6) + 2(O_3 + O_5O)\}$$

$$= \frac{5}{3}\{(2 + 2) + 4(3 + 5 + 3) + 2(4 + 4)\}$$

$$= 106.7 \text{ m}^2 \simeq 107 \text{ m}^2$$

111. Ans: (d) **112. Ans: (b)**

113. Ans: (a)

Sol: For the given beam, actual depth of neutral axis is

$0.36 \times 25 \times 300 \times x_a = 0.87 \times 500 \times 2000$

$\Rightarrow x_a = 322.22$ mm

The maximum depth of neutral axis

$X_{u\,max} = 0.46$ 'd' for Fe 500

$= 0.46 \times 500 = 230$ mm

Since $x_a > x_{u\,max}$

Failure takes place due to the crushing of concrete.

114. Ans: (b)

Sol: As per IS-456, for ultimate limit state or limit state of collapse, partial safety factor for concrete = 1.5 and for steel = 1.15

For serveciability limit state, partial safety factor for concrete = 1.0 and for steel = 1.0.

Since the actual deflections and crack widths are to be calculated under service loads and not conservative values.

115. Ans: (c)

Sol: For isolated T-beams:

Effective width of flange

$$b_{eff} = \frac{\ell_o}{\left(\frac{\ell_o}{b}\right)+4} + b_w$$

And should be less than actual flange width.

l_o= distance between points of contraflexure

= 0.7 (eff. span) for continuous beams

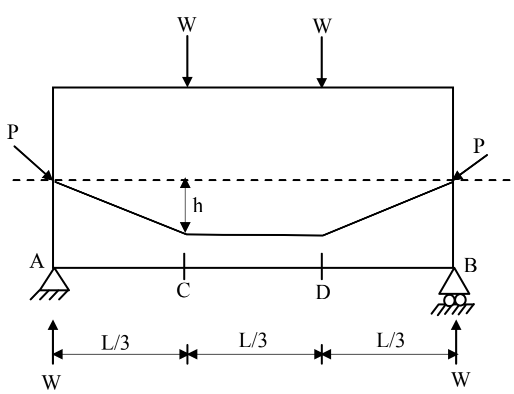
= 0.7 × 8000

$$\therefore \quad b_{eff} = \left(\frac{5600}{\left(\frac{5600}{1000}\right)+4}\right) + 400$$

= 983.33 mm and < 1000 mm

116. Ans: (d)

Sol:



Due to symmetry

$V_A = V_B = W$

Maximum bending moment is at midspan

$$= W\left(\frac{L}{2}\right) - W\left(\frac{L}{2}-\frac{L}{3}\right)$$

$$= \frac{WL}{3}$$

Now $\quad ph = \dfrac{WL}{3}$

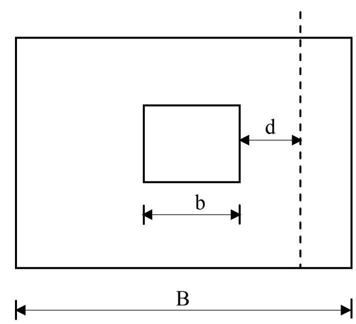
$$\therefore \quad h = \frac{WL}{3P}$$

117. Ans: (b)

Sol: Shear resistance of concrete in a reinforced concrete beam depends on percentage of tension reinforcement and grade of concrete.

118. Ans: (b)

Sol:



Net soil pressure $w_o = \dfrac{P}{A}$

$$= \frac{1600\times1000}{2000\times2000}$$

$= 0.8$ N/mm^2

Critical section for shear is at a distance ‘d’ from the face of column,

Shear force (per unit width (V_u))

$$= w_o \times 1\text{m} \times \left(\frac{B-b}{2} - d\right)$$

$$= 0.4 \times 1000 \times \left(\frac{2000 - 500}{2} - 200\right)$$

$$= 0.4 \times 1000 \times 550$$

$$\text{Shear stress} = \frac{V_u}{bd} = \frac{0.4 \times 1000 \times 550}{1000 \times 200}$$

$$= 1.1 \text{ N/mm}^2$$

119. Ans: (c)

Sol: As per IS-456, minimum diamtre of the bar is maximum of

(i) 6 mm

(ii) ¼ (maximum dia of main reinforcement

$$= \frac{1}{4} \times 25 = 6.25 \text{ mm}$$

$\therefore$ 8 mm or 10 mm dia bars may be used.

Spacing of the reinforcement is minimum of

(a) Least lateral dimension = 250 mm

(b) 16 (ϕ) = 16 × 25 = 400 mm

(c) 300 mm

$\therefore$ 250 mm spacing can be adopted.

Economic provision is 8 mm dia bars @ 250 mm c/c

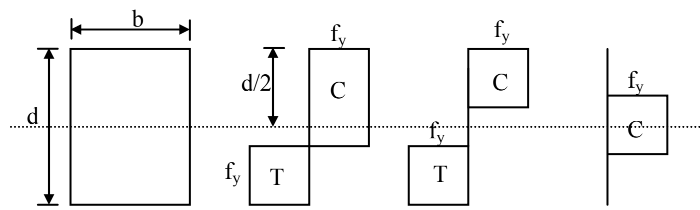
120. Ans: (b)

Sol: The slenderness ratio of a freely standing wall will be more than the wall that supports RCC slab so the allowable stresses will be less for free standing wall. Hence, the load carrying capacity is also less.

A column can buckle around either of the two horizontal axes but a wall can buckle around horizontal axis only. Hence the limiting values of slenderness ratio or column is less than that of walls.

121. Ans: (a)

Sol: Due axial load the neutral axis moves away from the equal area axis providing an additional area in tension or compression depending on the type of loading.



Total stress = Bending + axial compression

122. Ans: (a) **123.Ans: (b)** **124.Ans: (b)**

125. Ans: (d)

Sol: In a spherical triangle, the sum of 3 sides of triangle is less than circumference of great circle. Sum of angles in spherical triangle is greater than 2 × 90 and less than 6 × 90.

126 . ans: (a)

127. Ans: (c)

128. Ans: (d)

Sol: Storm water sewers are not designed for the peak flow for occurrence such as once in 10 years or more but it is necessary to provide sufficient capacity to avoid too frequent flooding of the drainage area.

29. Ans: (b) 130. Ans: (b) 131. Ans: (c)

132. Ans: (c)

133. Ans: (a)

Sol: Brittle materials, like cost-iron, are weak in tension. And, when a material is subjected to torsion, the tension develops at 45° to the axis of the specimen.

134. Ans: (d)

Sol: Flat slabs are usually two way reinforced concrete slabs that do not have beams and are supported by columns with (or) without drop panels.

Since no beams are used, floor height can be reduced this the required storey height is also reduced.

135. Ans: (d)

Sol: High tension steel has more yield strength and more modulus of resilience

So springs (suspension) are made with high tension steel.

136. Ans: (a)

Sol: For rectangle $\tau_{max} = \frac{3}{2}\tau_{avg}$, For circle

$\tau_{max} = \frac{4}{3}\tau_{avg}$

τ_{avg} is same for both as $\tau_{avg} = F/A$

Both F and A are same

$$(\tau_{max})_{rectangle} > (\tau_{max})_{circle}$$

137. Ans: (d)

Sol: When shear force changes sign at a section then BM at that section is either maximum (or) minimum but converse is not true.

138. Ans: (a)

Sol: Torsion induces shear stresses. The pure shear induces diagonal compressive and tensile stresses.

In concrete, when the diagonal tensile stresses reacth with the tensile strength of concrete, cracks appear i.e., failure occurs. So, to prevent this failure, reinforcement has to be provided in the form of spirals around the member along the direction of principal stresses. Hence it is provided in the form of longitudinal reinforcement and stirrups (transverse reinforcement).

139. Ans: (b)

140. Ans: (c)

Sol: Sudden expansion $h_{L_1} = \frac{(V_1 - V_2)^2}{2g}$

Sudden contraction $h_{L2} = \frac{KV_2^2}{2g}$

Where $K = \left[\frac{1}{C_c} - 1\right]$

$\therefore h_{L1} > h_{L2}$

141. Ans (d)

Sol: If the time of value closer is more than critical time.

(T_c = 2L/C) then the pressure developed will be $\frac{T_c P_{max}}{T}$

Where,

T is actual time of closure

142. Ans: (c)

Sol: Speed become infinity when density tends to zero

143. Ans: (b)

Sol: In case of A-O-N arrows are used only to show the dependency relationship between activity nodes.

$\therefore$ Events are not shown at all

144. Ans: (b)

Sol: Due to the effect of the storage, the peak of the outflow hydrograph is loss than the peak of inflow hydrograph is this reduction is called attenuation. Hence, the storage capacity of the reservoir and characteristics of spillway, outlets etc. Controls the attenuation of the inflow hydrograph.

If there are any lateral inflows, storage of reservoir increases, hence the attenuation of the flood wave decrease, sometimes, even results in the amplification of flood wave.

145. Ans: (b) **146.Ans: (c)** **147.Ans: (b)**

148. Ans: (a)

149. Ans: (c)

Sol: Minimum length is specified to account for slight tapering at start and end of weld length.

150. Ans: (c)

Sol: In case of stress reversal due to wind (or) transportation, the stability is to be taken care that's why there is a limit on slenderness ratio.

Also stiffness criteria is considered to limit the deflections by limiting slenderness ratio.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