ESE- 2020 (Prelims) - Offline Test Series Test- 24

CIVIL ENGINEERING

FULL LENGTH MOCK TEST-4 (PAPER-II)
SOLUTIONS

01. Ans: (c) **02. Ans: (a)**

03. Ans: (c)

Sol: P = 200 mm A = 6 km^2

K = 0.6 T = 20 hours

Runoff (R) = K × P

= 0.6 × 200 = 120 mm

$$Q = \frac{V}{T} = \frac{A \times R}{T} = \frac{6 \times 10^6 \times 120 \times 10^{-3}}{20 \times 60}$$

= 600 m^3/min

04. Ans: (b)

Sol: D = 10 hrs

A = 10000 ha = 100 km^2

$$Q_e = 2.778 \frac{A}{D}$$

$$Q_e = 2.778 \times \frac{100}{10}$$

Q_e = 27.78 m^3/sec

05. Ans: (d)

06. Ans: (b)

Sol: In alignment of hilly roads

More number of hill drains are preferred to provide adequate drainage to the roads.

Since the construction of cross drainage structure is not economical, its number should be kept minimum

Resisting length is the effective length considering the total work done against resistance. i.e ineffective rise and fall should be kept minimum. Hence resisting length has to be minimum.

07. Ans: (a)

Sol: A good joint must not allow infiltration of rain water.

08. Ans: (b)

Sol: Spacing between the contraction joints

= $2S_c$/Wf = 2 × 1 × 10^4/(2400 × 1.4)

= 5.95 m

As per IRC maximum spacing is 4.5m. Hence adopt spacing of 4.5m.

09. Ans: (b)

Sol: Actual specific gravity = 1080/450 = 2.4

VMA = V_v % + V_b%

VMA= 100 – Percent volume of aggregates and filler

$$= 100 - \left[\frac{\dfrac{W_{agg+filler}}{G_{agg+filler}}}{\dfrac{W_{total}}{G_{actual}}}\right] \times 100$$

Specific gravity of aggregates + filler :

$$\frac{W_{agg+filler}}{G_{agg+filler}} = \frac{2000}{2.5} + \frac{480}{2.4} = 1000$$

$$VMA = 100 - \left[\frac{1000}{\dfrac{2000 + 480 + 120}{2.4}}\right] \times 100 = 7.69\%$$

10. Ans: (c)

Sol: Peak hour factor considering peak 10 minute flow rate

= peak hour volume/(6*volume during peak 10 minutes)

$$= \frac{4000}{(6 \times 800)} = 0.833$$

11. Ans: (d)

Sol: Traffic volume data can be presented in the form of

AADT or ADT

Trend charts

Variation harts

Traffic flow maps

Volume flow diagram

30th highest hourly volume

12. Ans: (b)

Sol: Deviation angle N = $\left|\left(\frac{-1}{20}\right) - \left(\frac{1}{40}\right)\right| = |-0.075|$

$= 0.075$

Hence valley curve is provided.

Design speed V = 80kmph

Length of the curve = L = 200m

Impact factor

$$= \frac{1.59 NV^2}{L} = \frac{1.59 \times 0.075 \times 80^2}{200} = 3.816$$

13. Ans: (b)

Sol: Temporary bench marks are fixed in detailed survey at all drainage and under ground drainage structures.

When the area to be covered for preliminary survey is large, aerial photographic survey is suitable.

Soil survey can be done using geo physical method and electrical sensitivity methods.

Index map shows the general topography of the area.

14. Ans: (a)

Sol: Number of axles = $\frac{8}{2} = 4$

Hauling capacity = no. of axles $\times$ axle load $\times$ coefficient of friction

$= 4 \times 24 \times 0.25$

$= 24$ tn

15. Ans: (c)

Sol: Docks which are used for repair and maintenance purpose are

Dry dock or graving dock

Floating dry dock

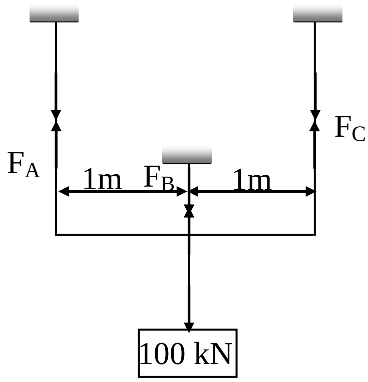
Slipway and marine railway

Ship lift

Moorings are anchors for ships.

16. Ans: (c)

Sol: Due to symmetry the force in rod A and C will be equal. i.e $F_A = F_C$



$\therefore F_A + F_B + F_C = 100$ kN

$\Rightarrow 2F_C + F_B = 100 \rightarrow (1)$

Deflection will be constant as the bar is rigid

$$\Rightarrow \frac{F_A}{A_A} = \frac{F_B}{A_B}$$

$$\Rightarrow \frac{F_A}{20\times 20} = \frac{F_B}{10\times 10}$$

$\Rightarrow F_A = 4F_B = F_C$

$\therefore$ From (1) $\Rightarrow$ $2(4F_B) + F_B = 100$

$$\Rightarrow F_B = \frac{100}{9}$$

$$\text{Stress} = \frac{F_B}{A} = \frac{100\times 10^3}{9\times 10\times 10}$$

$$\sigma = \frac{1000}{9}\text{ MPa}$$

$$\text{Maximum shear stress} = \frac{\sigma}{2} = \frac{500}{9}\text{ MPa}$$

17. Ans: (a)

Sol: $\sigma_1 = 18$ MPa

$\sigma_2 = -8$ MPa

$\tau_\theta = 5$MPa

$$\tau_\theta = \left(\frac{\sigma_1 - \sigma_2}{2}\right)\sin 2\theta - \tau_{xy}\cos 2\theta$$

$$\Rightarrow 5 = \left(\frac{18-(-8)}{2}\right)\sin 2\theta$$

$$\Rightarrow \sin 2\theta = \frac{5}{13}$$

$$\therefore \cos 2\theta = \frac{12}{13}$$

$$\sigma_\theta = \left(\frac{\sigma_x + \sigma_y}{2}\right) \pm \left(\frac{\sigma_x - \sigma_y}{2}\right)\cos 2\theta + \tau_{xy}\sin 2\theta$$

$$\Rightarrow \sigma_\theta = \left(\frac{18-18}{2}\right) \pm \left(\frac{18-(-8)}{2}\right)\times\frac{12}{13} + 0$$

$= 5 \pm 12$

$= 17$ MPa (or) -7 MPa

18. Ans: (c)

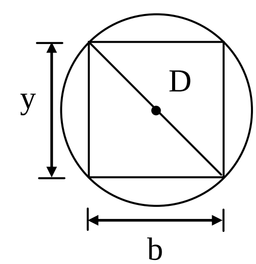
Sol: For a given cross-section, rectangle has maximum flexural strength

$\therefore y^2 + b^2 = D^2$

$\Rightarrow y^2 = D^2 - b^2$

$$\text{Section modulus} = \frac{by^2}{6} = \frac{b(D^2 - b^2)}{6}$$

$$\frac{dz}{db} = \frac{D^2 - 3b^2}{6} = 0$$



$$\Rightarrow b = \frac{D}{\sqrt{3}}$$

$$\therefore y = D\sqrt{\frac{2}{3}}$$

$$\text{Area} = by = \frac{\sqrt{2}D^2}{3}$$

19. Ans: (d)

Sol: Maximum tensile stress due to eccentricity

$$= \frac{P}{A} - \frac{M}{Z} = \left(\frac{P}{\frac{\pi d^2}{4}}\right) - \frac{Pe}{\left(\frac{\pi d^3}{32}\right)}$$

Stress due to direct compression = $\dfrac{P}{A} = \dfrac{P}{\frac{\pi}{4}d^2}$

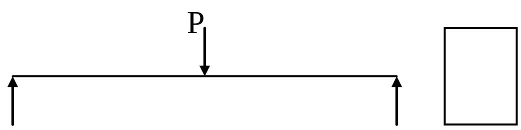
$$\frac{P}{\frac{\pi d^2}{4}} - \frac{Pe}{\frac{\pi d^3}{32}} = \frac{1}{2}\left[\frac{P}{\frac{\pi d^2}{4}}\right]$$

$\Rightarrow e = \dfrac{d}{16}$

$\therefore$ Diameter of core or kern $= 2e = \dfrac{d}{8}$

20. Ans: (b)

Sol:



Rotation $= \dfrac{P\ell^2}{16EI} = \dfrac{P\ell^2}{16E \times \frac{bd^3}{12}}$

$\therefore\ \theta_1 = K\dfrac{\ell^2}{bd^3}$

$$\theta_2 = \frac{K \times \left(\frac{\ell}{2}\right)^2}{(4b)\left(\frac{d}{2}\right)^3}$$

$$= \frac{\theta_1}{2}$$

21. Ans: (a)

Sol: $\delta = \dfrac{w\ell^4}{8EI} = 30\,mm$

$\theta = \dfrac{w\ell^3}{6EI} = 0.01$

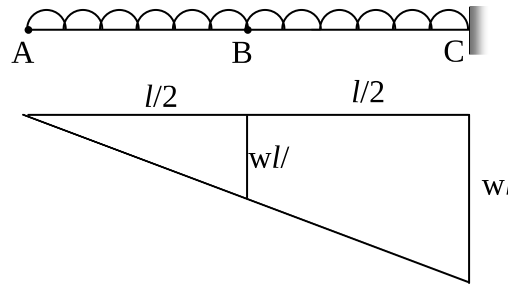
$\dfrac{\delta}{\theta} = \dfrac{6\ell}{8} = \dfrac{30}{0.01}$

$\Rightarrow l = 4000$ mm

$= 4$ m

22. Ans: (c)

Sol:



$M_B - M_A$ = Area under SFD between A,B

$$= \frac{1}{2} \times \frac{\ell}{2} \times \frac{w\ell}{2} = \frac{w\ell^2}{8} = x$$

Difference between the moments at the point B & C

$$M_C - M_B = \frac{1}{2} \times \frac{\ell}{2} \times \left(w\ell + \frac{w\ell}{2}\right)$$

$$= \frac{3w\ell^2}{8} = 3x$$

23. Ans: (d)

Sol: $E = 2G(1 + \mu)$

Range of poisons ratio is from – 1 to 0.5

Maximum E = 2G (1.5) = 3G

Minimum E = 2G (1 – 1) = 0

24. Ans: (c)

Sol: For buckling failure $\dfrac{2\sqrt{2}\pi r}{\sqrt{\alpha T}}$

$P = \dfrac{\pi^2 EI}{\ell_{eff^2}}$

For fixed beam $l_{eff} = \dfrac{\ell}{2}$

$\Rightarrow P = \dfrac{4\pi^2 EI}{\ell^2}$

Stress $= \dfrac{P}{A} = \dfrac{4\pi^2 EI}{\ell^2 \times A} = 4\pi^2 E\left(\dfrac{r}{\ell}\right)^2$

FOS = 2, Permissible stress = $2\pi^2 E\left(\frac{r}{\ell}\right)^2$

Stress due to thermal stress expansion = EαT

$\therefore\ 2\pi^2 E\left(\frac{r}{\ell}\right)^2 = (E\alpha T)$

$\Rightarrow \ell^2 = \frac{2\pi^2 r^2}{\alpha T}$

$\Rightarrow \ell = \left[\frac{2\pi^2 r^2}{\alpha T}\right]^{1/2}$

$\Rightarrow \ell = \frac{\sqrt{2}\pi r}{\sqrt{\alpha T}}$

25. Ans: (a)

Sol: Deflection of prismatic bar under self weight

$= \frac{\gamma L^2}{2E} = 3\text{mm}$

Deflection of conical bar under self weight =

$\frac{\gamma L^2}{6E} = \frac{\left(\frac{\gamma}{3}\right)(3L)^2}{6\times\left(\frac{E}{3}\right)} = \frac{3\gamma L^2}{2E}$

$= 3 \times 3 = 9$ mm

26. Ans: (c)

Sol: Equivalent Young's modulus = $\frac{\Sigma AE}{\Sigma A}$

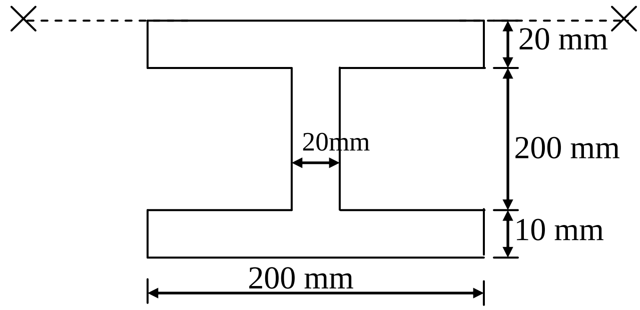
$= \frac{(AE)+(2A\times 2E)+(3A\times 3E)}{A+2A+3A}$

$= \frac{14AE}{6A}$

$= \frac{7}{3}E$

27. Ans: (b)

Sol: Equivalent steel beam



Depth of neutral axis from top =

$$\frac{(200\times 20\times 10)+[20\times 200\times(20+100)]+(200\times 10\times 225)}{(200\times 20)+(20\times 200)+(200\times 10)}$$

= 97 mm

28. Ans: (b)

Sol: Strain energy = $\frac{1}{2}T\theta = \frac{\tau^2}{4G}\times \text{Volume}$

$\Rightarrow \frac{1}{2}\times 2\times 2\times 10^{-2} = \frac{\tau^2\times 10^{-3}}{4\times 2\times 10^5\times 10^6}$

$\Rightarrow \tau^2 = 16\times 10^{12}$

$\Rightarrow \tau = 4\times 10^6$ N/m^2

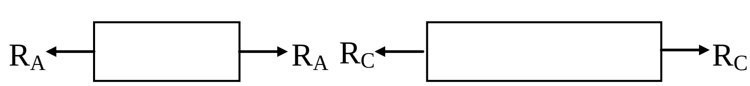
= 4 MPa

29. Ans: (c)

Sol: Net deflection = 0

$R_A + R_C = 100$ kN

$\therefore\ \frac{R_A\times\left(\frac{\ell}{4}\right)}{AE} + \frac{(R_C)\left(\frac{3\ell}{4}\right)}{AE} = 0$



$\Rightarrow R_A = -3R_C \rightarrow (2)$

From (1) & (2)

$\Rightarrow -3R_C + R_C = 100$

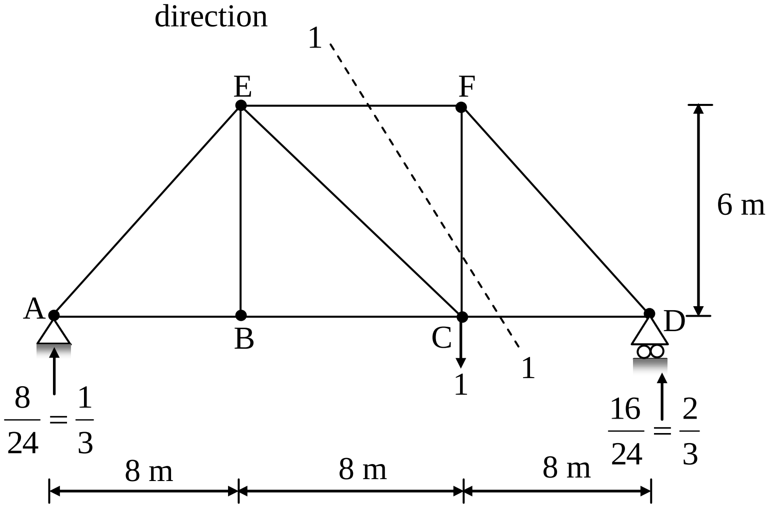
$\Rightarrow R_C = -50$ kN

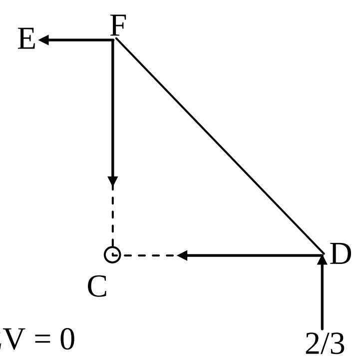
$\Rightarrow R_A = 150$ kN

30. Ans: (a)

Sol: Using unit load method:

Apply vertical unit load at joint C in vertical direction





$\Sigma V = 0$

$F_{FC} = \frac{2}{3}[\text{Tension}]$

Vertical deflection at 'C'

$\delta_{VC} = \Sigma k\,\Delta$

$\Delta_{CF} = L \propto T = 6 \times 10 \times 10^{-6} \times 20^{o}C$

$= 1.2 \times 10^{-3}$ m

$\delta_{VC} = \frac{2}{3} \times 1.2 \times 10^{-3} = 8 \times 10^{-4}$ m $= 0.8$ mm

31. Ans: (a)

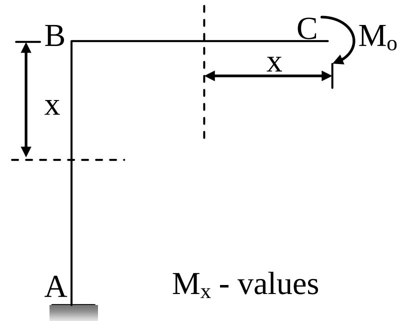
Sol: Using unit load method

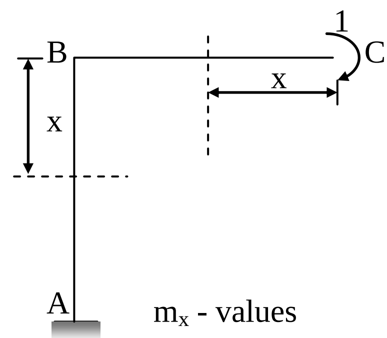
$$\theta_c = \int_0^L \frac{M_x m_x}{EI} dx$$

Where,

M_x = Bending moment at a section x-x due to actual load

m_x = Bending moment at a section x-x due to unit moment applied where we want to find the displacement.





Sagging BM is positive & hogging BM is negative

Member	M_x – values	m_x – Values	$\int_0^L \frac{M_x m_x}{EI} dx$
CB	$-M_o$	-1	$\int_0^L \frac{(-M_o)(-1)}{EI} dx$
BA	$-M_o$	-1	$\int_0^L \frac{(-M_o)(-1)}{EI} dx$

$$\theta_c = \int_0^L \frac{M_o}{EI} dx + \int_0^L \frac{M_o}{EI} dx$$

$$= \frac{M_o L}{EI} + \frac{M_o L}{EI}$$

$$\theta_c = \frac{2M_o L}{EI}$$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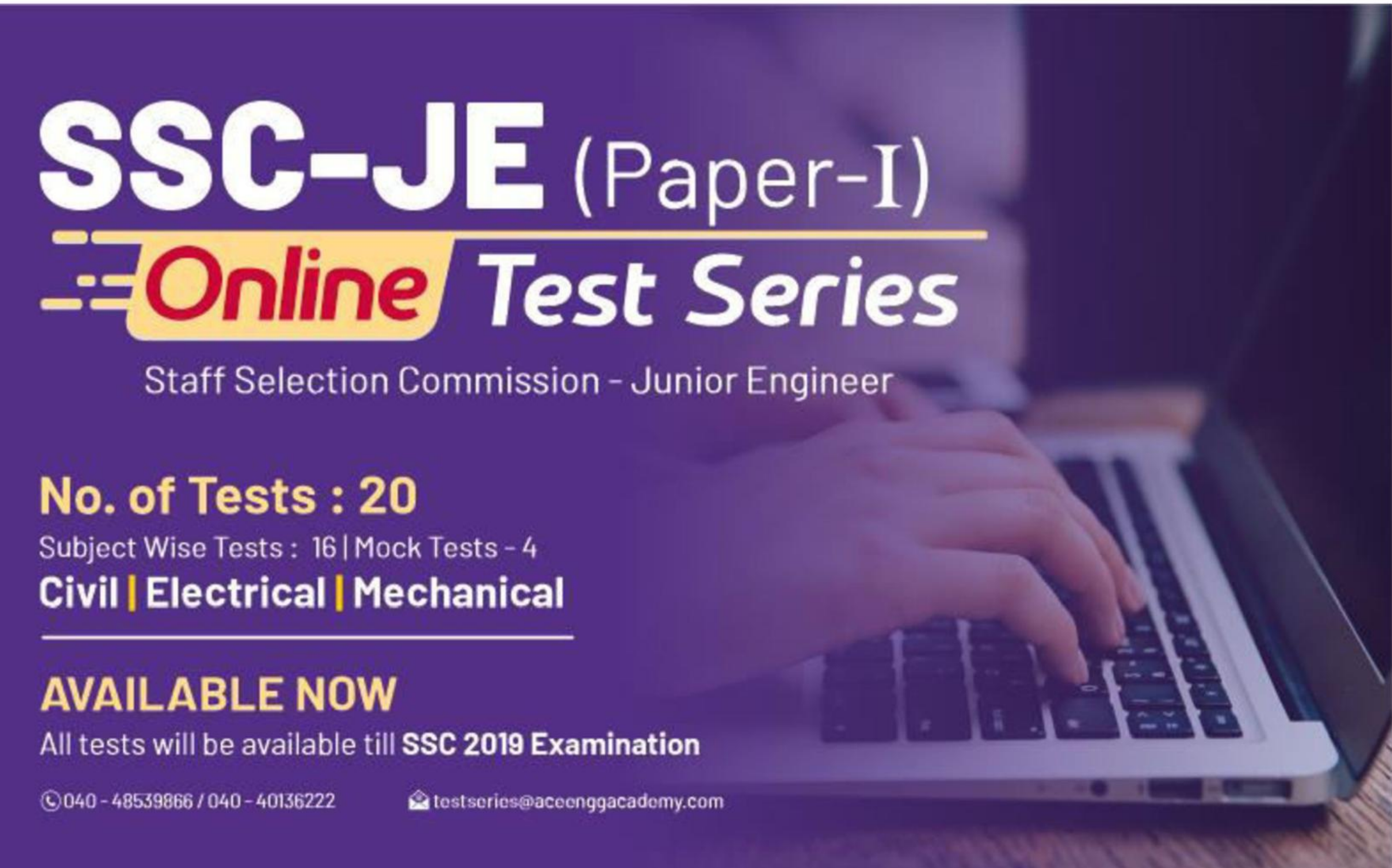
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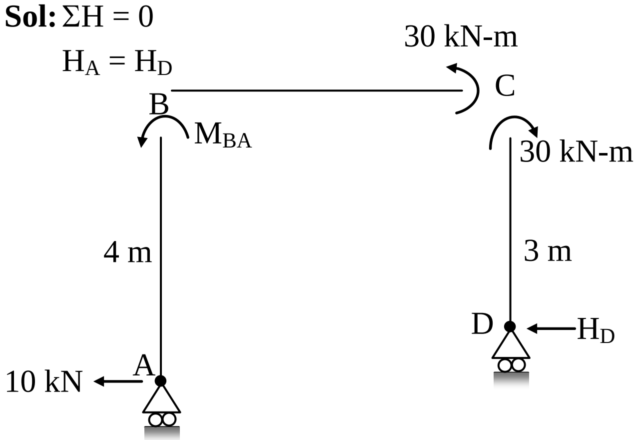
32. Ans: (b)

Sol: $\Sigma H = 0$

$H_A = H_D$



$\Sigma M_C = 0$ ↳ –ve ↲ + ve

$H_D \times 3 + 30 = 0$

$H_D = -10$ kN (→)

$H_A = 10$ kN (←)

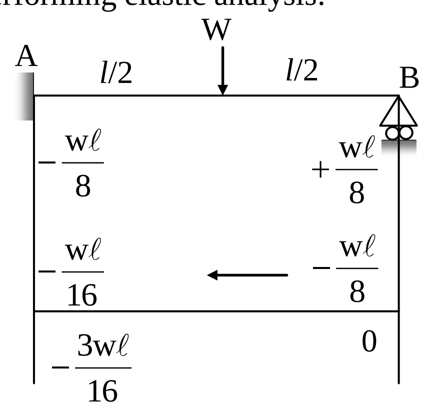
$\Sigma M_B = 0$ ↳ –ve ↲ + ve

$10 \times 4 - M_{BA} = 0$

$M_{BA} = 40$ kN-m (↳)

33. Ans: (a)

Sol: By performing elastic analysis:



$$M_{AB} = \frac{3W\ell}{16} = M_p$$

→ First plastic hinge formation

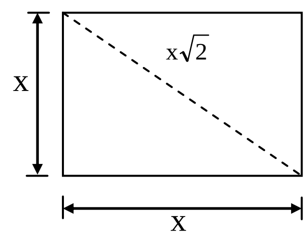
The value of collapse load for propped cantilever beam carrying concentrated load at mid span is

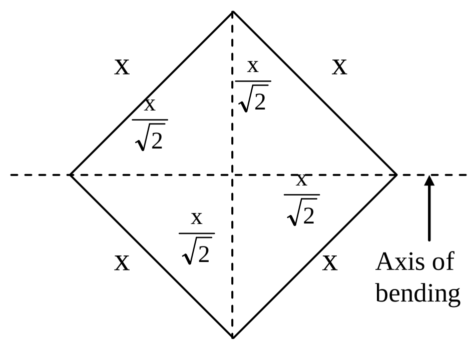
$$= W_c = \frac{6M_p}{\ell} = \frac{6}{\ell}\left[\frac{3W\ell}{16}\right] = \frac{9W}{8}$$

Thus, $W_c = \dfrac{9W}{8}$

34. Ans: (a)

Sol:



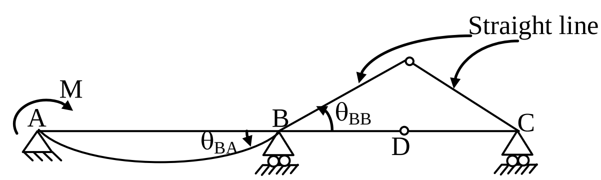


$Z_p = A_1 y_1 + A_2 y_2$

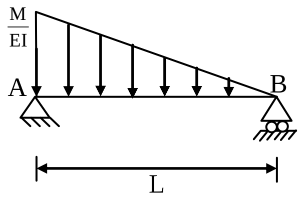
$$= \left\{\frac{1}{2}\times x\sqrt{2}\times\frac{x}{\sqrt{2}}\times\frac{x}{3\sqrt{2}}\right\}\times 2 = \frac{x^3}{3\sqrt{2}}$$

35. Ans: (c)

Sol: Deflected shape of the beam is



$\theta_{BA} = \theta_{BD}$



Conjugate beam of AB with $\frac{M}{EI}$ diagram

$\therefore\ \theta_{BA}$ = shear force at B

$$\therefore R_B \times L = \frac{1}{2}\frac{M}{EI}\times L \times \frac{L}{3}$$

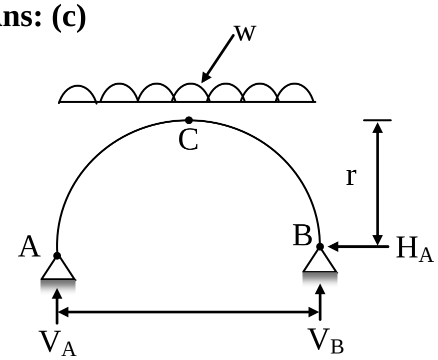
$$\therefore R_B = \frac{ML}{6EI}$$

$$\therefore \theta_{BA} = R_B = \frac{ML}{6EI}$$

$$\therefore \theta_{BA} = \theta_{BD} = \frac{ML}{6EI}\ \text{(Anticlockwise)}$$

36. Ans: (c)

Sol:



$H_A = H_B$

Take $M_A = 0$

$$V_B \times \ell = w \times \frac{\ell^2}{2}$$

$$V_B = \frac{w\ell}{2} = V_A$$

$M_C = 0$

$$\frac{w\ell}{2}\times\frac{\ell}{2} = w \times \frac{\ell}{2}\times\frac{\ell}{4} + H \times r$$

$$\frac{w\ell^2}{4} - \frac{w\ell^2}{8} = H \times r$$

$$\Rightarrow \frac{w\ell^2}{8} = H \times r \quad (\ell = 2r)$$

$$H = \frac{wr}{2}$$

37. Ans: (a)

38. Ans: (c)

39. Ans: (a)

40. Ans: (b)

Sol: $D = \sqrt{\frac{C}{0.06735}} = \sqrt{\frac{40}{0.06735}}$

D = 24.37 km

Dip of horizon $\theta = \frac{D}{R} = \frac{24.37}{6370} = 0.0038$

41. Ans: (a)

Sol: $\frac{\delta D}{D} = \frac{-\delta\beta}{\beta}$

$\beta = 615''$; $\delta\beta = 120''$

$$\delta_D = -500 \times \frac{120}{615} = -97.561 \text{ m}$$

$\therefore$ Correct horizontal distance = 500 – 97.561

= 402.44 m

42. Ans: (d)

43. Ans: (b)

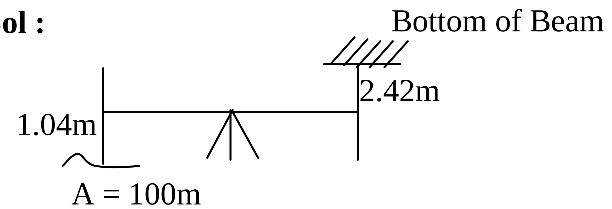
Sol: $W = (1-p_w)\times\frac{w}{S}$

$$= (1-0.4)\times\frac{(25\times10^{-2})}{\left(\frac{1}{10{,}000}\right)} = 1500\text{ m} \quad = 1.5 \text{ km}$$

44. Ans: (b)

45. Ans: (d)

Sol :



RL of bottom of beam = RL of A + BS + FS

= 100 + 1.04 + 2.42m

= 103.46m

46. Ans: (d)

Sol: $V = \left(\frac{Qf^2}{140}\right)^{1/6}$, $S = \frac{f^{5/3}}{3340Q^{1/6}}$

$$V = \sqrt{\frac{2}{5}.f.R} \Rightarrow V \propto f^{1/2} \text{ ---------- (1)}$$

$$V = \left(\frac{Qf^2}{140}\right)^{1/6} \Rightarrow V \propto Q^{1/6} f^{1/3} \text{ --------- (2)}$$

$$S = \frac{f^{5/3}}{3340Q^{1/6}} \Rightarrow Q^{1/6} \propto \frac{f^{5/3}}{S_o} \text{ ---------- (3)}$$

From (2) and (3)

$$V \propto \frac{f^{5/3}}{S_o}.f^{1/3}$$

$$V \propto \frac{f^2}{S_o}$$

By using (1)

$$V \propto \frac{V^4}{S_o}$$

$$S_o \propto V^3$$

$$\therefore V \propto S_o^{1/3}$$

47. Ans: (d)

Sol:

- Streamlines are confocal ellipsi
- if d = 0, G_E is ∞
- Khosla's theory must be used to calculate u anywhere

48. Ans: (b)

Sol: Siphon will dispose off large heads of water comfortably.

49. Ans: (c)

Sol: Area of soil cut = Area of soil filled

$$\frac{(B+B+2my)}{2} = 2(H-y)[T+n(H-y)]$$

$\Rightarrow$ $y^2 - 12.6\,y + 10.4 = 0$

y = 0.9 m and 11.7 m

11.7 m is absurd

$\Rightarrow$ 0.9 m is correct

50. Ans: (d)

Sol: According to Mitra's transition theory

$$B_x = \frac{B_n B_f L_f}{L_f B_n - (B_n - B_f)}$$

$\therefore$ Depth and discharge remains constant and rate of change of velocity per meter length is constant.

51. Ans: (c)

Sol: Lever arm = $H_1 + \frac{3}{8}h_w$

$$= H_1 + \frac{3}{8}0.032\sqrt{VF}$$

$$= (240-120) + \frac{3}{8}(0.032)\sqrt{100(100)}$$

= 121.2 m

52. Ans: (b)

Sol: looseness factor = $\frac{\text{Actual width}}{\text{Regime width}}$

Actual width

$= \text{looseness factor} \times \text{Regime width}$

$= \text{looseness factor} \times 4.75\sqrt{Q}$

$= 311.6 \text{ m} \approx 312 \text{ m}$

53. Ans: (a)

Sol: $L_R = \frac{E_{ci}}{E_{cd}} \times 100 = \frac{1.8}{24} \times 100 = 7.5\%$

$D_i = \frac{D_c}{1 - L_R} = \frac{60}{1 - 0.075} = 64.86 \text{ mm} \approx 65 \text{ mm}$

54. Ans: (c)

55. Ans: (b)

56. Ans: (b)

Sol: When everything else is constant, the workability of concrete increases with increase in size of aggregates. As larger aggregates have less total surface area compared to same mass of smaller aggregates.

57. Ans: (d)

Sol: For consistency test vicat apparatus fitted with a cylindrical plunger is used. Le Chatelier's test is used to determine the soundness of cement due to free lime only. In sieve analysis of cement, % reside is determined not specific surface area. Hence, all the three statements are incorrect.

58. Ans: (c)

Sol: Though the heat of hydration of C_3A is high, its proportion in cement is very less (around 10%). Hence, we can say that weightage of C_3A in the heat of hydration of cement not high.

59. Ans: d)

Sol: Internal partition walls are generally constructed with Stretcher Bond.

60. Ans: (b)

Sol: The colour of cement is because of Iron oxide in the raw material. White cement is prepared using raw materials which has very low proportion of Iron Oxide. Since, Iron Oxide is not present, Sodium Alumino Ferrite is used as catalyst in the fusion of ingredients.

61. Ans: (a)

Sol: Retarder, generally increase the setting times and also the workability of concrete.

62. Ans: (b)

Sol: High strength concrete has high density values and hence less Pulse Velocity.

63. Ans: (d)

Sol: Phenol Formaldehyde increases the electrical insulation property of timber, not the fire resistance of timber.

64. Ans: (d)

Sol: Aluminium has high strength to weight ratio, even better than steel. Hence, it is very suitable for aircraft manufacturing.

65. Ans: (c)

Sol: Type C fly ash has both Pozzolanic as well as Cementitious properties. Type-F fly ash has only Pozzolanic properties.

66. Ans: (c)

Sol: Both Flakiness and Elongation index test are done only on coarse aggregates.

67. Ans: (d)

Sol: E-coli Index = $\frac{1}{0.1}$ = 10 no/ 100 m*l*

68. Ans: (d)

Sol: $\eta = \frac{C_{in} - C_{out}}{C_{in}} \times 100 = \frac{200 - 40}{200} \times 100 = 80\%$

$$\eta = \frac{V_s}{V_o} \times 100 \Rightarrow 80 = \frac{0.8 \times 10^{-3}}{V_o} \times 100$$

$$V_o = \frac{0.8 \times 10^{-3} \times 100}{80} = 10^{-3}\ \text{m/sec}$$

= 0.001 m/sec

69. Ans: (c)

Sol: Alum is not effective as pH < 6.5 and pH > 8.0

Alum removes colour, odour and improve taste of water.

70. Ans: (a)

Sol: Dose of quick lime = $\frac{56}{100}$ × Alkalinity deficiency.

$$= \frac{56}{100} \times 5 = 2.8\ \text{mg}/l$$

71. Ans: (b)

Sol: $Z_c = Z + \frac{20}{100} \times Z = 1.2\ Z$

$$\frac{Z_e}{Z} = \frac{1-n}{1-n_e}$$

$$\frac{1.2 \times Z}{Z} = \frac{1-0.4}{1-n_e} \Rightarrow 1 - n_e = \frac{0.6}{1.2} = 0.5$$

$n_e = 1 - 0.5 = 0.5$

72. Ans: (c)

Sol: Total Bleaching power (BP) consumed = Q × dose of BP = 20 kg/day

10 × dose of BP = 20 kg/day

Dose of BP = $\frac{20}{10} = 2\ \text{mg/l}$

Cl_2 dose = BP dose × Available Cl_2 in BP

$$= 2 \times \frac{35}{100} = 0.7\ \text{mg}/l$$

Cl_2 demand = Cl_2 dose – Residual Cl_2

= 0.7 – 0.2 = 0.5 mg/*l*

73. Ans: (b)

Sol: Population equivalent

$$= \frac{\text{Total BOD}}{\text{Per Capita BOD}} = \frac{1600}{80 \times 10^{-3}} = 20000$$

74. Ans: (a)

Sol: Grit chamber remove → Sand Particles (Grid)

Screen → Large floating objects

Skimming tank → Oil and grease

Primary Clarifier → Organic solids

75. Ans: (c)

Sol: Q = 10000 m^3/day, y_i = 150 mg/*l*, X = 3000 mg/*l*, $\frac{F}{M} = 0.2\ d^{-1}$

$\because$ y_e is not given $\therefore$ $y_e = 0$

$$\frac{F}{M} = \frac{Q(y_i - y_e)}{VX}$$

$$0.2 = \frac{10000 \times (150 - 0)}{V \times 3000}$$

$$V = \frac{10000 \times 150}{0.2 \times 3000} = \frac{500}{2} \times 10 = 2500\,m^3$$

76. Ans: (c)

Sol: Fanning plume behaviour occurs during inversion.

77. Ans: (c)

Sol: $L_1 - L_2 = 20$ $x = 0$

$L_T = L_1 + x = 60 + 0 = 60$ dB

78. Ans: (c)

Sol: Q = 3 MLD $y_i = 300$ mg/l

BOD loading factor = 300 kg/m/day

Plan area = $\frac{Qy_i}{OLR} = \frac{3 \times 300}{300}$ ha (OCR) = 3ha

79. Ans: (c)

Sol: $$C_{min} = \frac{Q_R C_R + Q_w C_W}{Q_R + Q_W}$$

$$= \frac{18 \times 0 + 2 \times 10}{18 + 2} = \frac{20}{20} = 1\,mg/l$$

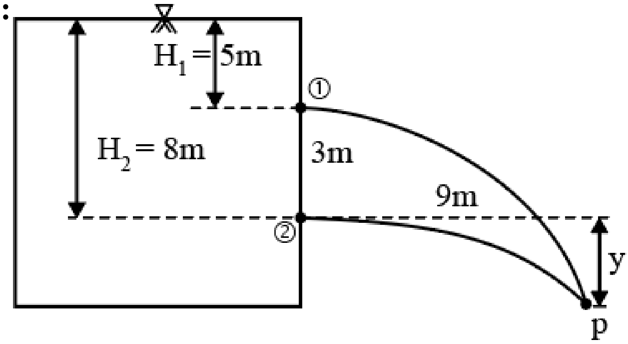
Time taken to dissipate

$$= \frac{C_{min}}{\text{Rate of dissipation}}$$

$$= \frac{1}{0.25} \frac{mg/\ell}{mg/\ell/day} = 4 \text{ days}$$

80. Ans: (b)

Sol:



As two jets intersect at same point with same horizontal distance ($x_1 = x_2$)

$$C_{V_1} = C_{V_2}$$

$$\sqrt{\frac{x_1^2}{4H_1y_1}} = \sqrt{\frac{x_2^2}{4H_2y_2}}$$

$H_1 \times y_1 = H_2 \times y_2$

$5 \times (3 + y) = 8 \times y$

$15 + 5y = 8y \Rightarrow 3y = 15$ m

$y = 3$ m

81. Ans: (d)

Sol:

1. For non - uniform velocity distribution

   $\alpha > 1$ and always $\alpha > \beta$

   $\beta > 1$

   $\therefore\ \alpha > \beta > 1$
2. For uniform velocity distribution, no correction is required $\alpha = \beta = 1$
3. For large and deep channels with fairly straight channels, velocity distribution variation is very less, so α,β exhibit lower values, whereas in natural/unlined canals, due to more irregularities α, β exhibit high value upto 2 and average of $\alpha = 1.75$ and $\beta = 1.25$

82. Ans: (b)

Sol: y = 0.75 m

$F_r = 2$

Rectangle

$$F_r = \frac{V}{\sqrt{gy}}$$

$$F_r^2 = \frac{V^2}{gy}$$

$$\frac{F_r^2 . y}{2} = \frac{V^2}{2g}$$

$$\therefore \frac{V^2}{2g} = \frac{2^2 \times 0.75}{2} = 1.5$$

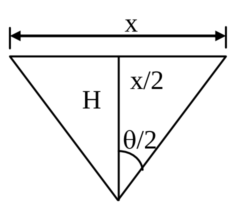
$$E = y + \frac{V^2}{2g}$$

$$E = 0.75 + 1.5$$

E = 2.25 m

83. Ans: (d)

Sol:



Given

Same 'c_d' and H

$Q_{Rectangle} = Q_{V\text{ - notch}}$ $\qquad \tan\frac{\theta}{2} = \frac{x}{2H}$

$$\frac{2}{3} C_d \sqrt{2g} L.H^{3/2} = \frac{8}{15} C_d \sqrt{2g} \tan\frac{\theta}{2} H^{5/2}$$

$$LH^{3/2} = \frac{4}{5} \times \frac{x}{2H} . H^{5/2}$$

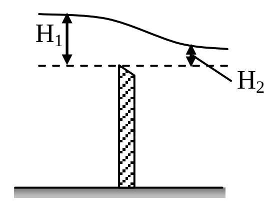
$$\frac{x}{L} = \frac{10}{4} = 2.5$$

84. Ans: (c)

Sol: In triangular notch, there is no base to cause contraction and contraction is due to sides only and wetted perimeter also depends on length of sides, in turn depends on head. So, C_d is fairly constant for all heads in a triangular notch.

On other hand, wetted perimeter does not vary directly as the head because the length of base. Hence, the C_d will not be constant for all heads in rectangular notch.

A triangular notch is very accurate for measurement of low discharge



submerged weir

In submerged weir, liquid level in the channel on the downstream is above the crest of weir /notch.

85. Ans: (c)

Sol: Newtonian fluids: water, air, kerosene mercury Glycerin

86. Ans: (d)

87. Ans: (d)

Sol: Hydrostatic pressure force (F) = $\gamma . A\bar{x}$

$$= \gamma \times L^2 \times L/2 = \frac{\gamma L^3}{2}$$

$\therefore$ This hydrostatic pressure force acting a distance L/3 from bottom edge.

Moment at the bottom edge

$$= F \times \frac{L}{3} = \gamma L^3 \times \frac{L}{3} = \frac{\gamma L^4}{6}$$

88. Ans: (a)

Sol: $V_f = \psi\sqrt{2gH}$

$= 0.65\times\sqrt{2\times10\times5} = 6.5$ m/s

89. Ans: (b)

Sol: $\eta_o = \frac{P_{water}}{P_{shaft}} = \frac{\gamma.Q.(H+h_f)}{P_{shaft}}$

$0.8 = \frac{10\times0.1\times(15+5)}{P_{shaft}}$

$\therefore P_{shaft} = 25$ kW

90. Ans: (c)

91. Ans: (a)

Sol: $N_s = \frac{N\sqrt{P}}{H^{\frac{5}{4}}} \Rightarrow \frac{400\sqrt{1444}}{(256)^{\frac{5}{4}}}$

= 14.84 which is less than 30.

So, turbine is Pelton turbine.

92. Ans: (c)

93. Ans: (c)

Sol: The equation $\frac{\delta u}{\delta x}+\frac{\delta v}{\delta y}+\frac{\delta w}{\delta z}=0$ is valid for both steady and unsteady flow.

94. Ans: (a)

95. Ans: (d)

Sol: As per codal priovision minimum reinforcement

$A_{st} = \frac{0.15}{100}\times b\times D$ (For mid steel)

96. Ans: (a) **97. Ans: (d)**

98. Ans: (c) **99. Ans: (b)**

100. Ans: (c) **101. Ans: (a)**

102. Ans: (b)

Sol: Minimum pitch = 2.5d = 2.5×16 = 40mm

Maximum pitch for comp. member

= 12t or 200 mm whichever is less

= 12 ×12 = 144 mm

(or) 200mm whichever is less

103. Ans. (b)

Sol: Bearing Strength of the bolt

$P_b = dt\sigma_{pf}$

d = 16 mm (Effective diameter (or) hole diameter)

= 16 × 5 × 250

= 20×10^3N = 20 kN

104. Ans: (c)

105. Ans: (c)

Sol: Strength of solid plate per pitch length

= $p.t.\sigma_{at}$

= $60 \times 14 \times 0.6 \times f_y$

= 126 kN

$$\eta = \frac{\text{strength of joint per pitch length}}{\text{strength of solid plate per pitch length}}\times100$$

Strength of joint per pitch length is lesser of 88 kN, 98 kN, 78 kN

$\therefore \eta = \frac{78}{126}\times100 = 61.9\%$

$\simeq 62\%$

106. Ans: (c)

107. Ans: (c)

Sol: Minimum size of fillet weld (for 16 mm gusset plate) = 5 mm

t_t = K.S = 0.7 × 5 = 3.5 mm

$P_s = L_w \times t_t \times \tau_{vf}$

$150 \times 10^3 = L_w \times 3.5 \times 100$

$\therefore L_w = 428.57$ mm

$\simeq 430$

Overall length = 430 + 2 × S

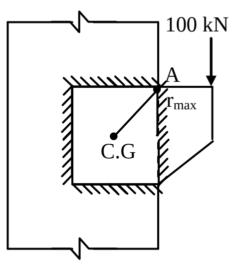
= 430 + 2 × 5

Overall length = 440 mm

108. Ans: (c)

109. Ans: (b)

Sol:



C.G of weld at middle (i.e 150 mm from weld)

$\therefore$ M = P.e $=100 \times 10^3 \times (150 + 200)$

$= 35 \times 10^6$ N-mm

Shear stress in weld due to twisting moment at heavily stressed point is

$$q_2 = \frac{M}{I_p} \times r_{max}$$

$$= \frac{35\times10^6 \times \sqrt{150^2 + 150^2}}{150\sqrt{2}\times10^6}$$

$$= \frac{35\times10^6 \times \sqrt{2}\times150}{150\times\sqrt{2}\times10^6}$$

$q_2 = 35$ N/mm^2

110. Ans: (a)

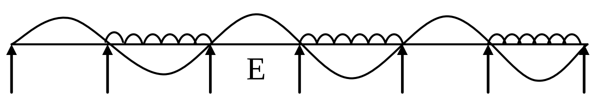
Sol: A square slab with $\left(\frac{\ell_y}{\ell_x} = 1\right)$ will also act as one way slab if it supported only on two opposite edges.

111. Ans: (d)

Sol: In a two-way simply supported slab corners are allowed to lift freely therefore no torsion at corners.

112. Ans: (c)

Sol:



Maximum negative span moment on span E.

113. Ans: (b)

Sol: As per IS 456 – 2000

114. Ans: (d)

115. Ans: (b)

Sol:

$$\overset{15}{\underset{30}{(i)}} \xrightarrow{t_{ij} = 20} \overset{35}{\underset{50}{(j)}}$$

$T_E^i = 15$ $T_L^i = 30$

$T_E^j = 35$ $T_L^j = 50$

Total float = $\left(T_L^j - T_E^i\right) - t_{ij}$

= (50 – 15) – 20 = 15

Free float = $\left(T_E^j - T_E^i\right) - t_{ij}$

= (35 – 15) – 20 = 0

Independent float = $\left(T_E^j - T_L^i\right) - t_{ij}$

= (35 – 30) – 20

= – 15 =0

$\therefore$ Total float × Free float × independent float

$= 15 \times 0 \times -15$

$= 0$

116. Ans: (d)

Joint venture helps in combining the past projects data, incumbent technology and financial data of two or more separate companies to satisfy the prequalification.

117. Ans: (b)

Sol: Variance, $\sigma^2 = \left(\dfrac{t_p - t_o}{6}\right)^2$

$$\sigma^2 = \left(\frac{10-6}{6}\right)^2$$

$= 0.444$ months

$= 0.444 \times 30 = 13.33$ days

118. Ans: (a) **119. Ans: (b)**

120. Ans (a) **121. Ans: (d)**

122. Ans: (d)

Sol: Negative skin friction is the downward drag on the piles due to compaction and consolidation of the surrounding freshly placed fill.

Lowering of ground water table will increase the effective stress and cause consolidation of strata.

123. Ans: (b)

Sol: Ratio of pore water pressure developed to the applied confining pressure is called B-parameter.

124. Ans: (d)

Sol: $D_{min} = \dfrac{q}{\gamma}\left(\dfrac{1-\sin\phi}{1+\sin\phi}\right)^2$

$$D_{min} = \frac{36}{18}\left(\frac{1-\sin 30°}{1+\sin 30°}\right)^2 = \frac{36}{18}\times\frac{1}{9}$$

$D_{min} = 0.22$ m

125. Ans: (b)

Sol: In cantilever sheet pile, the point of rotation is below the dredge line. Hence the statement 2 is correct.

126. Ans: (b)

Sol: Hydrometer test is used to calculate specific gravity of liquids.

Pycnometer method is used for calculating specific gravity of soils/ solids.

127. Ans: (c)

Sol: I_p = liquid limit – plastic limit

$= 96\% - 16\% = 80\%$

% clay = 40%

Activity $A_c = \dfrac{I_p}{\%\text{clay}}$

$$= \frac{80\%}{40\%} = 2 > 1.25$$

Soil is very active

Most probable mineral would be montmorillonite

128. Ans: (d)

Sol: Providing sheet piles which act as impervious blanket to lengthen the flow path.

Providing protective filters for preventing the migration of finer particles with very little loss in head.

Provide a cutoff wall or trenches to stop seepage.

129. Ans: (b)

Sol: We know that

$$T_v = C_v \times \frac{t}{d^2}$$

Given the layer has a double drainage

$$\therefore\ d = \frac{4m}{2} = 2\,m$$

$$C_v = T_v \times \frac{d^2}{t}$$

$$= 0.196 \times \frac{2^2}{1}$$

C_v = 0.784 m^2/year

130. Ans: (c)

Sol: Toughness index helps in analyzing shear strength of soil at plastic limit.

131. Ans: (d)

132. Ans: (b)

Sol: We know

Q = k.i.A

Seepage velocity, $V_s = \frac{V}{n}$

V = average velocity = k.i

$$\therefore\ k.i = \frac{Q}{A} = \frac{\left(\frac{450\,cm^3}{10\,min}\right)}{50\,cm^2}$$

$$\Rightarrow\ v = k.i = \frac{45}{50}\ cm/\,min$$

$$v_s = \frac{v}{n} = \frac{45}{50x0.4}$$

= 2.25 cm/ min

133. Ans: (d)

Sol: $F = \frac{\tau_c}{\tau} = \frac{\tan\phi}{\tan i} = \frac{\tan 30°}{\tan 12°} = 2.72$

134. Ans: (b)

Sol: Permeability (k) = $D_{10}^2\ \frac{e^3}{1+e}\ \frac{\gamma}{\mu}$

135. Ans: (b) **136. Ans (a)**

137. Ans: (c)

Sol: Statement I True

Statement II False

138. Ans: (a)

Sol: With increase in the elevation, the air density reduces, hence lift on the aircraft wing reduces. So the aircraft requires more speed to rise. To achieve more speed, the length of the runway must be increased

139. Ans: (a)

Sol: Principle of superposition is valid for linearly elastic systems upto proportionality limit, stress is proportional to strain. Hence principle of superposition can be applied.

Beyond proportionality limit, since stress-strain variation is not linear, it is not valid.

140. Ans: (b)

Sol: In plane stress situation $\sigma_2 = 0$; $\sigma_x \neq 0$;

$\sigma_y \neq 0$

In plane strain situation $\varepsilon_z = 0$

$$\Rightarrow \frac{\sigma_z - \mu(\sigma_x + \sigma_y)}{E} = 0$$

For a plane stress to give a plane strain condition;

$$\Rightarrow \frac{\sigma_z - \mu(\sigma_x + \sigma_y)}{E} = 0$$

$$\Rightarrow 0 - \frac{\mu(\sigma_x + \sigma_y)}{E} = 0$$

$$\Rightarrow \mu = 0$$

In hydrostatic pressure system

$\sigma_x = \sigma_y = \sigma_z = \sigma$

$$\text{Volumetric strain} = \frac{(\sigma_x + \sigma_y + \sigma_z)}{E}(1 - 2\mu)$$

$$\Rightarrow 0 = \frac{3\sigma}{E}(1 - 2\mu)$$

$$\Rightarrow \mu = 0.5$$

141. Ans: (c)

Sol: Both statement (I) and statement (II) are individually true and statement (II) is the correct explanation o statement (I).

142. Ans : (d)

Sol: In the preparation of fiber-reinforc concrete, only discreet fibers of steel, gla ad polymers are allowed. Continuous shee and meshes are not allowed.

143. Ans: (c)

Sol: Both the samples are not slender. The strength difference between these two samples is because of end friction effect in cube testing. End friction effect does not influence the test results of cylinder sample. Because of this, cube strength measurement comes out to be more than that of cylinder strength measurement, for the same concrete.

144. Ans:(a)

Sol: Intakes are located deep inside to collect constant amount of water.

145. Ans: (c)

146. Ans: (c)

Sol: For rapid sand filters $C_u \simeq 1$ therefore uniformly graded sand is used as filter media. Uniformly graded sand improve ROF not water quality.

147. Ans: (d) **148. Ans: (c)**

149. Ans: (c) **150. Ans: (d)**