TEST ID: 511

ACE Engineering Academy

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ESE- 2019 (Prelims) - Offline Test Series Test-22

CIVIL ENGINEERING

FULL LENGTH MOCK TEST-1 (PAPER – II)

Solutions

01. Ans: (b)

02. Ans: (c)

Sol: Wind load = (shape factor) × P × $A_{projected}$

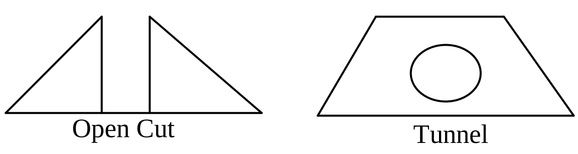
= 0.7 × 1200 × (3 × 15)

= 37,800 N

= 37.8 kN

03. Ans: (b)

Sol: If the depth of open cut is > 60 feet (or) 18.3m tunnel is economical



04. Ans: (d)

Sol: Euler's equation of turbo machine is given by:

$$H_e = \frac{1}{g}\left(u_1V_{W1} - u_2V_{w2}\right) \text{ (for turbine)}$$

$$= \frac{1}{g}\left(u_2V_{W2} - u_1V_{w1}\right) \text{ (for pump)}$$

Thus, it is the relation between head and velocities.

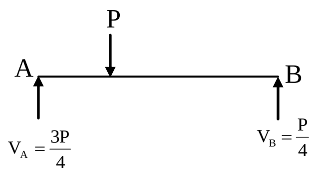
05. Ans: (c)

Sol:

- Most commonly used drilling pattern is centre wedge cut for square and rectangular sections.
- For circular sections, sometimes wedge cut/pyramid cut is also used.
- When shafts are very large, drilling may be done in alternate steps.
- There is no vertical wedge cut recommended by Indian Standards.

06. Ans: (b)

Sol:



$$\therefore\ V_{max} = \frac{3P}{4}$$

$$\therefore\ \tau_{max} = \frac{3}{2}\tau_{avg} = \frac{3}{2} \times \frac{\frac{3P}{4}}{bh} = \frac{9P}{8bh}$$

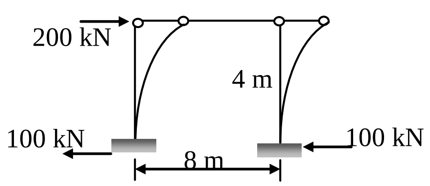
07. Ans: (b)

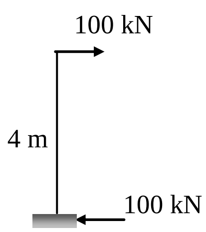
Sol: As per Indian Railways BG Railway lines are categorised into 15 groups as follows

Group	**A**	**B**	**C(suburban section)**	**D**	**E**
Sanctioned speed	160 kmph	130 kmph	-	100 kmph	<100 kmph
Sleeper Density	1660 no's/ 1cm	m+7	m+7	m+7 (heavy traffic) m+4 (less traffic)	m+4
Ballast cushion	30 cm	25 cm	25 cm	20 cm	15 cm
Min. Rail section	52 (or) 60 kg/m	52 (or) 60 kg/m	52 (or) 60 kg/m	60 (or) 52 (or) 44.5 kg/m	60 (or) 52 (or) 44.5 kg/m

08. Ans: (d)

Sol:





Deflected slope

Only 100 kN force will act on one column

So maximum bending moment in column

= 100 × 4 = 400 kNm

09. Ans: (a)

Sol: By providing minimum edge distance, the following three failures can be checked

(i) Shear failure of plate

(ii) Bearing failure of plate

(iii) Splitting failure of plate (or) edge cracking

10. Ans: (c)

Sol: As per Indian Railways, vertical curves are to be provided if Net slope/Net deflection angle/algebric difference of gradients at point of vertical Intersection is ≥ 0.4% (or) 4 mm/m

11. Ans: (a)

Sol: Volume of water supplied by 10 cumecs of water applied for 3 hours = $10\times3\times60\times60\ m^3$

= 1, 08, 000 m^3 = 10.8 ha. m

($\because 10^4 m^2 = 1$ hect)

Input = 10.8 ha-m

Output = 24 hectres land is storing water upto 0.3 m depth

= 24 × 0.3 = 7.2 ha. m

Water application efficiency

$$(\eta_a) = \frac{\text{out put}}{\text{in put}}\times100 = \frac{7.2}{10.8}\times100 = 66.67\%$$

12. Ans: (d)

Sol: All the three parameters will be used in general. But most commonly preferred classification as per IRC for roads & Indian Railways is based on cross slope of country.

13. Ans: (c)

Sol: When $\delta_{gap} \le 0.1$ mm

$R_E = 0$

$R_A = 2$ P

$\therefore \delta_{AB} + \delta_{BC} + \delta_{CD} = \text{gap}$

$$\frac{2PL}{AE} + \frac{PL}{\frac{A}{2}\times E} + \delta_{CD} = 0.1$$

$$\frac{4PL}{AE} = 0.1\text{ mm} \qquad (\delta_{CD} = 0)$$

$$\frac{4P(500)}{200\times100\times10^3} = 0.1\text{ mm}$$

P = 1 kN

14. Ans: (b)

Sol: Shear strength/Resistance = μ.T

= 0.4 × 900

= 360 kN

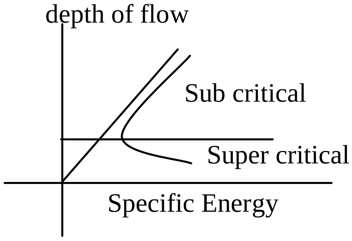
15. Ans: (a)

Sol:

- Endurance limit is the threshold limit at which fatigue life becomes infinite.
- If the depth of asphalt layer becomes so high that the tensile strain below the bituminous layer becomes equal to (or lower than) the endurance limit, the bituminous layer in principle will have infinite fatigue life.

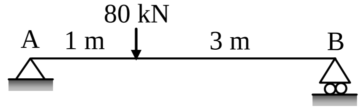
16. Ans: (b)

Sol:



17. Ans: (c)

Sol: $M_{AB} = M_{F_{AB}} + \frac{2EI}{L}\left(2\theta_A + \theta_B - \frac{3\delta}{L}\right)$



$$M_{F_{AB}} = \frac{-80\times1\times3^2}{4^2} - 45 \text{ kN-m}$$

$$M_{F_{BA}} = \frac{80\times3\times1^2}{4^2} = 15 \text{ kN-m}$$

$$M_{AB} = -45 + \frac{2EI}{4}\left[2\theta_A - \frac{\theta_A}{2}\right] \quad \left(\theta_B = \frac{-\theta_A}{2}\right)$$

$$= -45 + \frac{EI}{2}\left(\frac{3}{2}\theta_A\right)$$

$$= -45 + \frac{EI}{2}\left(\frac{3}{2}\times\frac{EI}{1000}\right)$$

$$= -45 + \frac{3}{4}\left(\frac{EI}{1000}\right)EI$$

$$= -45 + \frac{3}{4}\frac{(5\times10^4)^2}{1000} = -7.5 \text{ kN-m}$$

$$M_{BA} = 15 + \frac{2EI}{4}(2\theta_B + \theta_A)$$

$$= 15 + \frac{2EI}{4}\left(-\frac{2\theta_A}{2} + \theta_A\right) = 15 \text{ kN-m}$$

18. Ans: (a)

Sol: As per IRC SP 49, water used for mixing and curing should have pH value upto 9.

19. Ans: (a) **20. Ans: (b)**

21. Ans: (b)

Sol: Current velocity doesn't exceed 7.4 kmph (or) 4 knots as per IS 4651, while selecting site for harbour location.

22. Ans: (c)

Sol: Vertical pressure below a point is given by formula

$$q_u = \frac{3Q}{2\pi z^2}\left[\frac{1}{1+\left(\frac{x}{z}\right)^2}\right]^{5/2}$$

Here Q = 1000 tonnes

x = 0

and z = 7 metres

$$q_u = \frac{3\times1000}{7^2\times2\pi}\left[\frac{1}{1}\right]^{5/2}$$

$$= \frac{3\times1000}{49\times2\pi} = \frac{3\times500}{49\times\pi}$$

$$= \frac{1500}{\pi\times49} = 97.5 \text{ t/m}^2$$

23. Ans: (b)

Sol: As per ICAO and Aerodome standards and licensing by Government of India

S.No	Aeroplane reference filed length (m)	Code letter	Wing span
1.	Less than 800 m	A	Upto 15 m (not including)
2.	800 m upto but not including 1200 m	B	15 m upto but not including 24 m
3.	1200 m upto but not including 1800 m	C	24 m upto but not including 36 m
4.	1800 m and over	D	36 m upto but not including 52 m
		E	52 m upto but not including 65 m
		F	65 m upto but not including 80 m

24. Ans: (a) **25. Ans: (c)**

26. Ans: (c)

Sol: $H_L = \dfrac{f}{w(S-C+1)} = \dfrac{40\times10^4}{1000(2.5+1)}$

$= 114.2$ m $(\because C = 0)$

$H = 150$ m $> H_L$ High dam

Both major and minor forces must be considered

27. Ans: (d)

Sol:

- Actual forces that appear on structures during earthquakes are much greater than the design forces. However, ductility, arising from inelastic material behaviour and detailing, and over strength, arising from the additional reserve strength in structures over and above the design strength, are relied upon to account for this difference in actual and design lateral loads. For this reason, design against earthquake effects is called as earthquake resistant design and not earthquake proof design.

28. 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) 200 mm whichever is less

29. Ans: (c)

Sol: Impounding reservoir : It is a reservoir with gate controlled outlets where water is stored for considerable period of time and is released when the supply is not meeting the demand.

Infiltration galley is a horizontal well that intercepts shallow ground water flow (3-5 m) when conditions are such that normal vertical wells are not feasible.

The main source of water in a water supply scheme is surface sources like rivers, ponds, lakes impounding reservoirs etc.

Sub surface sources like wells, springs etc also contribute but the quantity is less.

30. Ans: (a)

Sol: For AB, $L_e = \frac{L}{\sqrt{2}}$

For BC, $L_e = L$

$$(P_{cr})_{AB} = \frac{2\pi^2 EI}{L^2}$$

$$(P_{cr})_{BC} = \frac{\pi^2 EI}{L^2}$$

$\Rightarrow (P_{cr})_{BC} < (P_{cr})_{AB}$

31. Ans: (d)

Sol: Column splice is a joint of column is usually provided for extending height (or length) of a column member. It is usually located just above the floor level. Theoretically the column splice should be located at the point of contra flexure of the column.

32. Ans: (a)

Sol: $Re_x = \frac{U_\infty x}{\nu} = \frac{1\times 1}{2.5\times 10^{-5}} = 4\times 10^4$

$\Rightarrow$ Flow is laminar

$$\frac{y\,Re_x^{0.5}}{x} = \frac{1\times 10^{-3}\left(4\times 10^4\right)^{0.5}}{1} = 10^{-3}\times 2\times 10^2$$

$$= 0.2$$

From table, we get $\frac{u}{U_\infty} = 0.067$

corresponding to $\frac{y\,Re_x^{0.5}}{x} = 0.2$

Thus, u at 1 mm from the surface = 0.067 m/s.

33. Ans: (b)

Sol: $I(t) = \frac{1}{i}\frac{ds}{dt}$

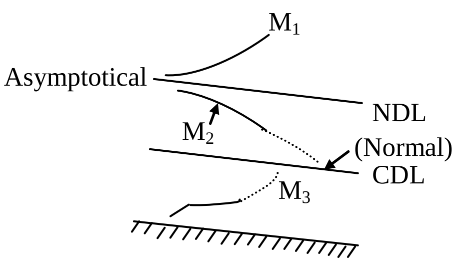
When i = 1 cm/hr

$I(t) = \frac{ds}{dt}$ = slope of S-curve

34. Ans: (c)

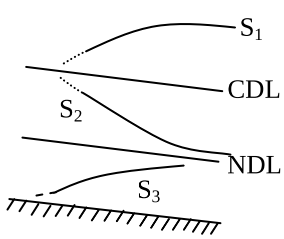
Sol: For **mild slope** (M),

normal depth y_o > critical depth y_c



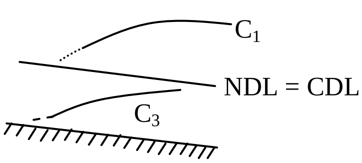
Mild Slope ($S_o < S_C$)

For steep slope $y_c > y_o$



Steep Slope ($S_o > S_C$)

For critical slope $y_c = y_o$



Critical Slope ($S_o = S_C$)

First profiles will be above normal depth line and critical depth line.

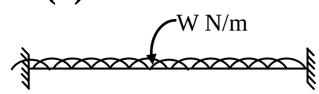
Second profiles will be between normal depth line and critical depth line.

Third profiles will be below normal depth line and critical depth line.

35. Ans: (c)

36. Ans: (b)

Sol:



Let W_a= ultimate load at collapse

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

At yielding W = W_y = yield load

We know at yield point mid-span moment is half of support moment

$$\frac{W_y L^2}{8} = M_y + \frac{M_y}{2}$$

$$W_y = \frac{12M_y}{L^2} \quad \text{------------(2)}$$

$$\frac{W_u}{W_y} = \frac{4}{3}\times\frac{M_p}{M_y}\left[\because \frac{(1)}{(2)}\right]$$

$$= \frac{4}{3}\times S \quad [\text{Shape factor} = \frac{M_p}{M_y}]$$

$$= \frac{4}{3}\times 1.2 \qquad = 1.6$$

37. Ans: (b)

Sol: $\tau = \dfrac{Sa\bar{y}}{Ib}$

$$= \frac{200\times10^3\times(160\times20)\times(140+10)}{1.719\times10^8\times15}$$

= 37.23 N/mm^2

38. Ans: (d)

39. Ans: (b)

Sol: Stability number = $\frac{C}{\gamma.H}$

$\because$ [F_C = 1 for maximum slope angle]

$$= \frac{0.2\times10000}{1.92\times6\times1000} = 0.174$$

Now depth factor $D_f = \frac{H+D}{H} = \frac{6+3}{6} = 1.5$

Now using given data,

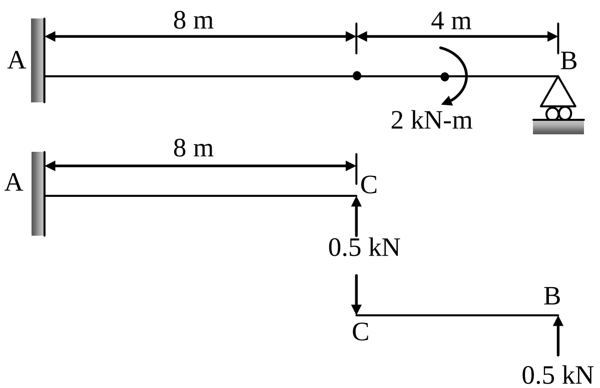
At depth factor 1.5 and Stability number 0.174 corresponding value of slope α is 45^o

Maximum permissible slope angle for the embankment is 45^o.

40. Ans: (a)

41. Ans: (a)

Sol:



42. Ans: (c)

Sol: Rainfall volume = Area × Precipitation

= 300 ha × 10 cm

= $300 \times 10^4 \times 10 \times 10^{-2}$ m^3

= 300×10^3 m^3

$\therefore$ Runoff volume

= Runoff coefficient × Runoff volume

= $0.2 \times 300 \times 10^3$ m^3

$$\text{Streamflow rate} = \frac{\text{Runoff volume}}{\text{Time}}$$

$$= \frac{0.2\times300\times10^3}{10\,\text{hr}}\,m^3$$

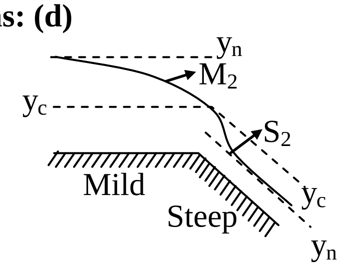
= 6000 m^3/hr

= 100 m^3/ minute

43. Ans: (a)

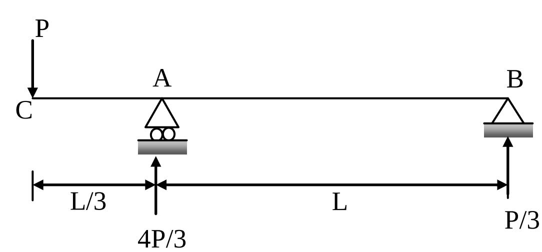
44. Ans: (d)

Sol:



45. Ans: (c)

Sol:



$U = U_{CA} + U_{AB}$

$$U = \int_0^{L/3} \frac{(Px)^2 dx}{2EI} + \int_0^{L} \frac{(-\frac{P}{3}x)^2 dx}{2EI}$$

$$U = \frac{P^2}{2EI}\frac{(L/3)^3}{3} + \frac{P^2}{18EI}\frac{(L)^3}{3}$$

$$U = \frac{P^2L^3}{18EI}\left(\frac{1}{9}+\frac{1}{3}\right)$$

$$U = \frac{4P^2L^3}{162EI}$$

$$y_c = \frac{dU}{dP} = \frac{4PL^3}{81EI}$$

46. Ans: (d)

Sol: Crack widths in Reinforced concrete members subjected to flexure (and/or) tension are influenced by various factors like

- Thickness of concrete cover: (Increased cover increases surface crack width but is it desirable from durability concern)
- Depth of the member and location of neutral axis: Increasing the depth of the member reduced the crack widths.
- Diameter and spacing of bars: Providing smaller diameter bars of less spacing reduces the crack width
- Bond strength and tensile strength in concrete: Cracking occurs when tensile stress exceeds the tensile strength of concrete. Hence concrete with more tensile strength is preferred
- Tensile stress inn steel bars: lower stress levels in steel bars ensures less crack widths.

47. Ans: (a)

Sol: Outside dia of one smaller pipe = 2.5 + 0.5
= 3 cm

Hence, $Q = \frac{\pi}{4}\left[0.08^2 - 3\times 0.03^2\right]\times 10$

$= \frac{\pi}{4}\left[0.0064 - 3\times 0.0009\right]\times 10$

$= \frac{\pi}{4}\left[0.0064 - 0.0027\right]\times 10$

$= \frac{\pi}{4}\left[0.0037\right]\times 10$

$= \frac{\pi \times 0.037}{4}$

$= \pi \times 0.00925\ m^3/s$

$= 9.25\pi$ lit/s

48. Ans: (c)

Sol: 90% dependable flow is lesser than a 50% dependable flow

49. Ans: (a)

Sol: Tensile test data

d = 10 mm, P = 23.55 kN

δ = 0.2 mm, l = 200 mm

Strain $e = \frac{\delta}{\ell} = \frac{0.2}{200} = 0.001$

Stress, $f = \frac{23.55 \times 10^3}{\frac{\pi}{4} \times 10^2} = 300\ \text{N/mm}^2$

$\therefore$ Modulus of Elasticity,

$$E = \frac{f}{e} = \frac{300}{0.001} = 3 \times 10^5\ \text{N/mm}^2$$

Torsion test data,

d = 32 mm, l = 250 mm, $f_s = 62.8\ \text{N/mm}^2$

$\theta = 0^{o}27' = \frac{27}{60} \times \frac{\pi}{180} = \frac{9}{20} \times \frac{\pi}{180}$ rad

$\frac{f_s}{R} = \frac{C\theta}{\ell} \Rightarrow C = \frac{\ell}{\theta}\frac{f_s}{R}$

$$= \frac{250}{\frac{9}{20} \times \frac{\pi}{180}} \times \frac{62.8}{16}$$

$$= \frac{250 \times 20 \times 20 \times 20}{16}$$

$C = 1.25 \times 10^5$

$\because E = 2C\left(1 + \frac{1}{m}\right)$

$1 + \frac{1}{m} = \frac{E}{2C}$

$$= \frac{3 \times 10^5}{2 \times 1.25 \times 10^5}$$

$$= \frac{3}{2.5}$$

$\frac{1}{m} = \frac{3}{2.5} - 1 = \frac{0.5}{2.5} = \frac{1}{5}$

$\therefore$ Poisson's Ratio $= \frac{1}{5} = 0.2$

50. Ans: (b)

Sol: Diameter of the tie bars should not be less than

- One-fourth of the largest longitudinal bar = 16/4 = 4mm
- 6mm

  Hence 6mm bars can be used.

  Pitch of the lateral ties should not be more than

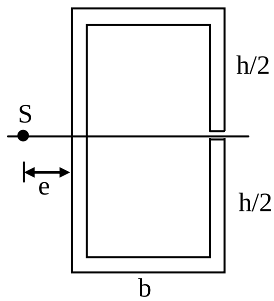
- Least lateral dimension = 400mm
- 16(minimum diameter of longitudinal bar) = 16 x 12 = 192mm
- 300mm

Hence spacing should be less than 192mm

From the given options 6mm at 180mm spacing is economical.

51. Ans: (c)

Sol:



$$e = \frac{b(2h+3b)}{2(h+3b)}$$

$$= \frac{100(2\times300+3(100))}{2(300+3(100))}$$

$$= \frac{100(600+300)}{2\times600} = 75 \text{ mm}$$

Now b + e = 100 + 75 = 175 mm = 17.5 cm

52. Ans: (b)

Sol: Wind is also dynamic loading.

53. Ans: (a)

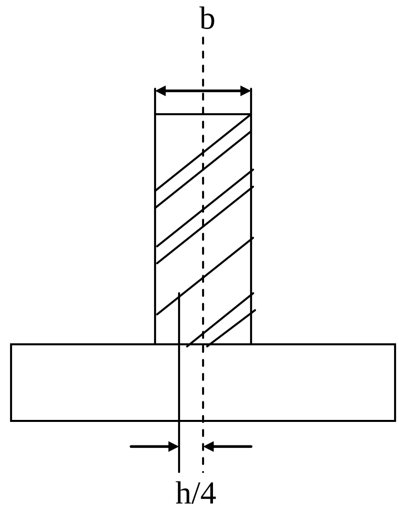
54. Ans: (d)

Sol: Factored load = 1.5 x 200 = 300kN/m

Factored net soil pressure = 300 /1.5

= 200kN/m^2 = 0.2MPa

Critical section for bending moment for footing under masonry is located hallway between the centreline and edge of the wall



i.e at a distance of (1500/2)-(240/4) from edge of the wall = 690mm

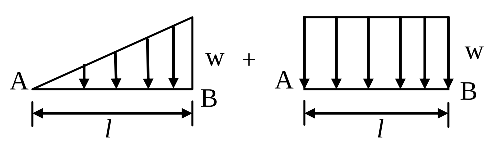
Considering 1m long footing Design bending moment

= 0.2 x 1000 x 690^2/2 Nmm

= 47.61kNm

55. Ans: (a)

Sol: The above loading can be taken as



∴ Taking moment about A

$$R_B \times \ell = w\times\ell\times\frac{\ell}{2}+\frac{1}{2}\times w\times\ell\times\frac{2\ell}{3}$$

$$= \frac{w\ell^2}{2}+\frac{w\ell^2}{3} = \frac{5w\ell^2}{6}$$

$$\therefore R_B = \frac{5w\ell}{6}$$

Total load

$$R_A + R_B = \frac{1}{2}\times w\times \ell + w\times \ell = \frac{2w\ell}{2}$$

$$R_A = \frac{3w\ell}{2} - R_B = \frac{3w\ell}{2} - \frac{5w\ell}{6} = \frac{2w\ell}{3}$$

∴ Shear force at the centre of the span

$$= R_A - w\times\frac{\ell}{2} - \frac{1}{2}\frac{w}{2}\times\frac{\ell}{2}$$

$$= \frac{2}{3}w\ell - \frac{w\ell}{2} - \frac{w\ell}{8}$$

$$SF = \frac{w\ell}{24}$$

Bending moment at the centre of the span

$$= R_A\times\frac{\ell}{2} - w\times\frac{\ell}{2}\times\frac{\ell}{4} - \frac{1}{2}\times\frac{w}{2}\times\frac{\ell}{2}\times\frac{\ell}{3}$$

$$= \frac{2w\ell}{3}\times\frac{\ell}{2} - \frac{w\ell^2}{8} - \frac{w\ell^2}{24}$$

$$= \frac{w\ell^2}{3} - \frac{w\ell^2}{8} - \frac{w\ell^2}{24} = \frac{w\ell^2}{6}$$

56. Ans: (b)

Sol: It is known that:

$$(a_s)_{max} = \left(\frac{A}{A_s}\right)\omega^2 r\text{, and}$$

$$(a_d)_{max} = \left(\frac{A}{A_d}\right)\omega^2 r$$

Thus, the ratio

$$\frac{(a_s)_{max}}{(a_d)_{max}} = \left(\frac{A}{A_s}\right)\omega^2 r\times\left(\frac{A_d}{A}\right)\times\frac{1}{\omega^2 r} = \frac{A_d}{A_s}$$

$$= \left(\frac{20}{15}\right)^2 = \left(\frac{4}{3}\right)^2 = \frac{16}{9} = 1.78$$

57. Ans: (a)

Sol: e. S = w.G

e.S = 0.22× 2.65 = 0.583

$$\gamma = \gamma_w\left[\frac{G+e.S}{1+e}\right]$$

$$19.6 = 9.81\left[\frac{2.65+0.583}{1+e}\right]$$

e = 0.618

e.S = 0.583

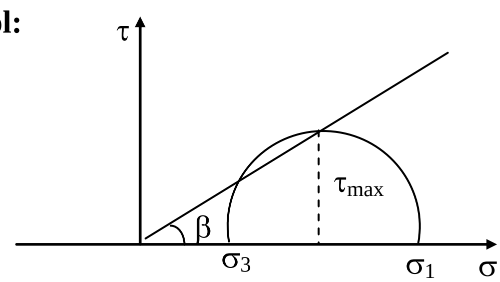
0.618× S = 0.583

∴ S = 0.943

58. Ans: (b)

59. Ans: (a)

Sol:



The angle of obliquity on the plane of maximum shear stress is given by

$$\tan\beta = \left[\frac{\tau_{max}}{\left(\frac{\sigma_1+\sigma_3}{2}\right)}\right]$$

$$\tan\beta = \left[\frac{\frac{\sigma_1-\sigma_3}{2}}{\frac{\sigma_1+\sigma_3}{2}}\right]$$

$$\tan\beta = \frac{150-50}{150+50} = \frac{1}{2}$$

$$\beta = \tan^{-1}(1/2)$$

60. Ans: (a)

Sol: Load bearing wall is considered to be stable if (height/width) $\leq$ 2

Width $\geq$ (4000/2)

$\geq$ 2000mm

61. Ans: (c)

Sol: $\theta_h = \theta_s \Rightarrow \frac{T_h \ell_h}{G_h J_h} = \frac{T_s \ell_s}{G_s J_s}$

$\because l_h = l_s$, $G_h = G_s$

$$\frac{T_h}{J_h} = \frac{T_s}{J_s} \Rightarrow \frac{T_h}{T_s} = \frac{T_h}{J_s}$$

$$\frac{T_h}{T_s} = \frac{\frac{\pi}{32}\left(D^4 - d^4\right)}{\frac{\pi}{32}D^4}$$

$$= 1 - \frac{d^4}{D^4}$$

$$= 1 - \left(\frac{1}{2}\right)^4$$

$$= \frac{15}{16}$$

$16T_h = 15\ T_s$

$T_h + T_s$ = 3.1 kN-m

$$\Rightarrow \frac{15 \times T_s}{16} + T_s = 3.1$$

$$\Rightarrow \frac{31}{16} T_s = 3.1$$

T_s = 1.6 kN-m

T_h = 3.1 – 1.6 = 1.5 kN-m

62. Ans: (c)

63. Ans: (b)

Sol: Length of the tank L = 5m

Width of the tank B = 5m

L/B =1 and < 2

Therefore, Bending moment at the centre of the san = $pL^2/16$

P is the water pressure corresponding to a height 'h' from bottom,

H = max (H/4 , 1m) = max (4/4, 1) = 1m

Water pressure p = w(H-h) = 10 (4-1) = 30kN/m^2

Bending moment at the centre of the span = 30 x 5^2/16 = 46.875kNm

64. Ans: (c)

Sol: Power input, $P_1 = T_1\omega_1 = 50\times250$ W

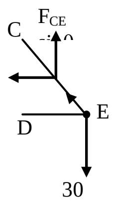
Power output, $P_2 = T_2\omega_2 = 110\times95$ W

Efficiency of torque converter, $\eta_{TC} = \frac{P_2}{P_1}$

$$\eta_{TC} = \frac{110\times95}{50\times250} = \frac{11\times19}{250} = 0.836 \approx 84\%$$

65. Ans: (c)

Sol: At joint E:



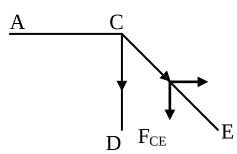
$\Sigma V = 0$ @ E

$F_{CE}\sin\theta = 30$ kN

$$F_{CE} = \frac{30}{\sin\theta} \qquad \because \sin\theta = \frac{3}{5}$$

$$F_{CE} = \frac{30\times5}{3} = 50 \text{ kN(T)}$$

At joint C:



$\Sigma V = 0$ @ C

$F_{CE}\sin\theta + F_{CD} = 0$

$$F_{CD} = (-)50\times\frac{3}{5}$$

$= (-)$ 30 kN

$\therefore F_{CD} = 30$ kN (Compression)

66. Ans: (b)

Sol: Since liquid limit lies between 35 and 50 it is intermediate compressible (I)

Height of A-Line = 0.73 (W_L–20)

= 14.6%

Since I_P of soil is more than 14.6%, it falls above A-line, Hence it is clay (c)

$\therefore$ Soil is CI

67. Ans: (b)

Sol: In case of toe slab, the forces acting are

- self weight of the concrete in toe slab
- gross soil pressure acting upwards

Hence the net loading is acting upwards .

In case of heel slab, the forces acting are

- self weight of the concrete in heel slab
- gross soil pressure acting upwards
- downward pressure due to retained soil

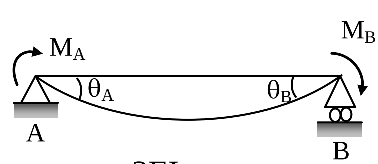
Hence the net loading is acting downwards .

The stem of retaining wall is designed to support the retained soil. It is designed as vertical cantilever fixed at base. Hence the tension is produced on the soil face of the wall. So, the reinforcement is placed near soil face of the wall

68. Ans: (d)

69. Ans: (a)

Sol:



$$M_{AB} = 0 + \frac{2EI}{L}(2\theta_A + \theta_B)$$

$$M_{BA} = 0 + \frac{2EI}{L}\left(2\theta_B + \theta_A\right)$$

$$\frac{\theta_A}{\theta_B} = 2$$

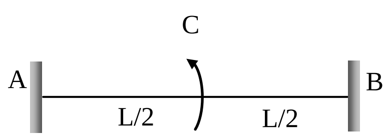
$\theta_A = 2\theta_B$

$$\frac{M_{AB}}{M_{BA}} = \frac{2\theta_A + \theta_B}{2\theta_B + \theta_A} = \frac{4\theta_B + \theta_B}{2\theta_B + 2\theta_B} = \frac{5}{4} = 1.25$$

70. Ans: (b)

71. Ans: (b)

Sol:



Stiffness of AC $= \dfrac{4(0.25EI)}{\frac{L}{2}} = \dfrac{2EI}{L}$

Stiffness of $CB = \dfrac{2EI}{L}$

Moment required for unit rotation at 'C' is sum of stiffness of beam

$$= \frac{2EI}{L} + \frac{2EI}{L} = \frac{4EI}{L}$$

72. Ans: (d)

Sol: Z_c = 1 m

After the formation of crack, the force on the wall is caused only by the pressure below depth of tension crack. i.e. tensile stresses are neglected.

∴ Difference of between active force after formation of crack and before formation of crack

= Negative pressure

$$= \frac{1}{2} \times 1 \times 6$$

= 3 kN

73. Ans: (a)

Sol: Atmospheric pressure head, $H_a = \dfrac{P_a}{\gamma} = \dfrac{100}{10}$

= 10 m (absolute)

Vapour pressure head, $H_v = \dfrac{P_v}{\gamma} = \dfrac{3.5}{10}$

= 0.35 m (absolute)

Critical cavitation coefficient,

$$\sigma_c = \frac{H_a - H_v - H_s}{H}$$

Hence, net head, $H = \dfrac{10 - 0.35 - (-1.5)}{0.9}$

$$= \frac{11.15}{0.9}$$

= 12.39 ≈ 12.4 m

74. Ans: (d)

Sol: Statement 1 and statement 3 are correct.

Hence, option (d) is correct.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75. Ans: (c)

Sol: Francis turbine - For maximum efficiency, the velocity of whirl at outlet is zero.

Kaplan turbine - Low head and high discharge

Impulse turbine - $N_s < 30$

Draft tube - Recovery of lost head

76. Ans: (a)

Sol: The second class bricks are ground-moulded and they are burnt in kilns.

The percentage of good quality bricks is about 90% achieved in kiln burning.

The compressive strength of refractory bricks varies from 200 to 220 N/mm^2.

77. Ans: (d)

78. Ans: (d)

Sol: Given data:

$C_{D1} = 0.4,\ C_{D2} = 0.35$

Drag accounts for 20% of fuel consumption (Given)

Hence, % reduction in fuel consumption

$$= 0.2 \times \frac{(0.4-0.35)}{0.4} \times 100$$

= 2.5%

79. Ans: (c) **80. Ans: (b)**

81. Ans: (b)

Sol: Let r = variable radius

$$dA = 2\pi r dr$$

and $\tau = \mu \frac{du}{dy} = \mu . \frac{\omega r}{\Delta h}$

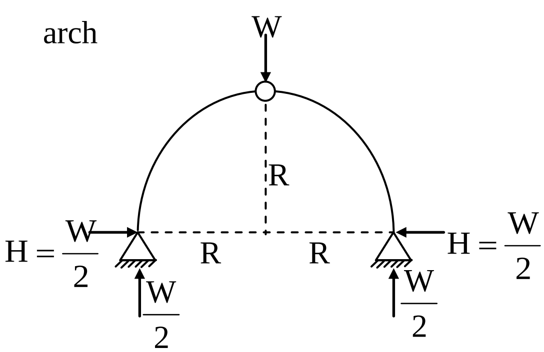
$$\text{Torque} = \int r \times \tau dA = \frac{2\pi\mu\omega}{\Delta h} \int_o^{d/2} r^3 dr$$

$$= \frac{2\pi\mu\omega}{\Delta h}\left[\frac{r^4}{4}\right]_o^{d/2} = \frac{2\pi\mu\omega}{\Delta h} \times \frac{d^4}{64}$$

$$\text{Torque} = \frac{\pi\mu\omega d^4}{32\Delta h}\ \text{N.m}$$

82. Ans: (b)

Sol: $H = \frac{W}{2}$ independent of radius of circular arch



83. Ans: (c)

Sol: $\eta = \frac{Q_g}{n.Q_i} \times 100$

$$0.8 = \frac{Q_g}{9 \times 100}$$

$$Q_g = 7.2 \times 100 = 720\ \text{kN}$$

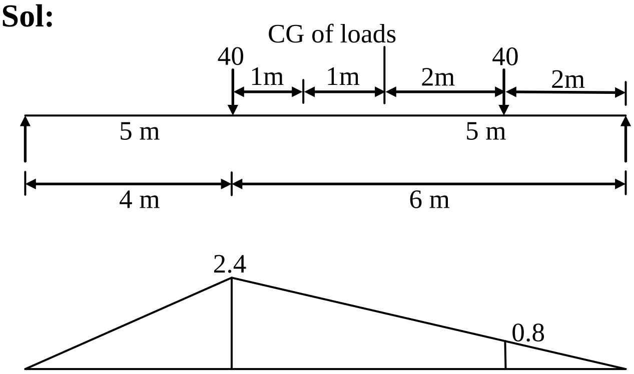
84. Ans: (a)

85. Ans: (b)

Sol: These soils are insensitive to vibrations because of net attractive forces.

86. Ans: (a)

Sol:



Absolute maximum bending moment will occur when a load of 50 kN and C.G of loads are equidistant from the centre of the span and under that load

$M_x = 2.4 \times 40 + 0.8 \times 40$

$= 128$ kN-m

87. Ans: (c)

88. Ans: (b)

Sol: For critical stability centre of pressure must be at B.

Thus, B will be $\frac{5.4}{3} = 1.8$ m above N.

Now, $F = 10\left(\frac{4}{2}\right) \times 4 \times 1$

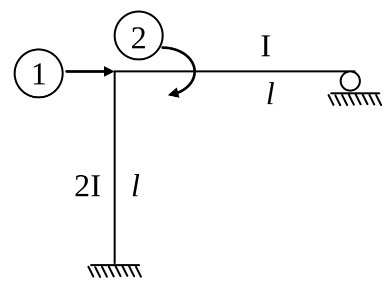
$= 80$ kN acting at a distance $\frac{4}{3}$m from N.

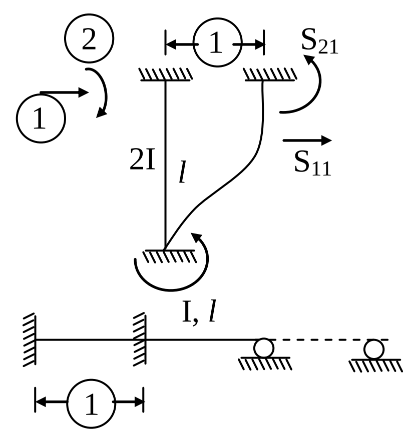
$\Sigma M_B = 0 = 80\left(1.8 - \frac{4}{3}\right) - N_x \times 1.8$

$\Rightarrow N_x = \frac{80 \times 1.4}{3 \times 1.8} = 20.74$ kN

89. Ans: (a)

Sol: First fix the ordinates (1) & (2) then apply unit displacement in the direction (1)

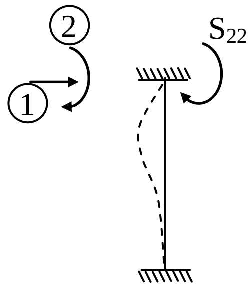


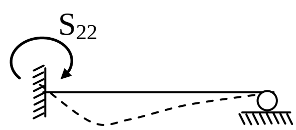


$$S_{11} = \frac{12E(2I)}{L^3} = \frac{24EI}{\ell^3}$$

$$S_{21} = \frac{-6E(2I)}{\ell^2} = \frac{-12EI}{\ell^2}$$

Now apply unit rotation in the direction (2)





$$S_{12} = S_{21} = \frac{-12EI}{\ell^2}$$

$$S_{22} = \frac{4E(2I)}{L} + \frac{3E(I)}{L} = \frac{11EI}{\ell}$$

Stiffness matrix

$$[S] = \begin{bmatrix} S_{11} & S_{12} \\ S_{21} & S_{22} \end{bmatrix}$$

$$[S] = \begin{bmatrix} \frac{24EI}{\ell^3} & \frac{-12EI}{\ell^2} \\ \frac{-12EI}{\ell^2} & \frac{11EI}{\ell} \end{bmatrix}$$

$$[S] = \frac{EI}{\ell}\begin{bmatrix} \frac{24}{\ell^2} & \frac{-12}{\ell} \\ \frac{-12}{\ell} & 11 \end{bmatrix}$$

90. Ans: (b)

Sol: As we know that

$V_{half} = V_{full}$

As per manning's equation

$$V = \frac{1}{N} R^{2/3} \quad S^{1/2}$$

$$= \frac{1}{0.013} \times \left(\frac{D}{4}\right)^{2/3} \quad S^{1/2}$$

Where

D = Dia of sewer

S = Bed slope

Here

D = 600 mm = 0.6 m

As $V_{half} = V_{full} = 0.6$ m/sec

91. Ans: (d)

Sol: At 3 m depth

$\sigma' = \sigma - u$

σ = Total stress = 1800 × 2.5 + 2000 × 0.5

= 5500 kg/m^2

u = neutral stress = – (1000 × 0.5)

[∵ capillary tension]

= –500 kg/m^2

∴ σ' = 5500 – (–500) = 6000 kg/m^2

92. Ans: (c)

Sol:

- The deflection (x) in the mercury manometer is expressed as

$$h = x\left(\frac{\rho_m}{\rho_{water}} - 1\right)$$

Discharge through venturimeter is given by,

$$Q = C_d \frac{a_1.a_2}{\sqrt{a_1^2 - a_2^2}}\sqrt{2gh}$$

For the same discharge, h will remain same for inclined as well as horizontal venturimeters.

- $(C_d)_{venturimeter} > (C_d)_{nozzle\ meter} > (C_d)_{orfice\ meter}$

93. Ans: (c)

Sol: Engineering news formula

$$Q_q = \frac{w.H}{F(S+C)}$$

$\therefore$ Factor of safety = 6, C = 2.54 cm

Given Set (S) = 2.5 cm

According to SPT, w = 65 kg , H = 75 cm

Potential energy, E = w × H

= 65 × 75 kg-cm

$$\therefore Q_R = \frac{5\times(65\times75)}{6(2.5+2.54)} = \frac{5\times4875}{6\times5.04} \simeq 800 \text{ kg}$$

94. Ans: (c)

Sol:

- Alumina in brick helps in moulding the brick in an easy manner (A-2)
- Silica keeps the shape of brick at high temperature and also reduces shrinkage (B-4)

95. Ans: (a)

Sol: $M_A = \frac{Mb(3a-\ell)}{\ell^2}$

$\therefore$ By superposition

$$M_A = \frac{+10\times6(3\times2-8)}{8^2} + \frac{-10\times2(3\times6-8)}{8^2}$$

$$= \frac{10\times6(6-8)}{64} + \frac{-20(18-8)}{64}$$

$$= \frac{-120}{64} + \frac{-200}{64}$$

$$= \frac{-320}{64} = -5 \text{ kN-m}$$

96. Ans: (b)

Sol: SOR = 1 m^3/m^2/hr = 1m/hr = V_o

Particle type	V_s(settling Velocity)	$\eta = \frac{V_s}{V_o}\times100$
1	1	100%
2	0.5	50%
3	0.1	10%
4	0.05	5%

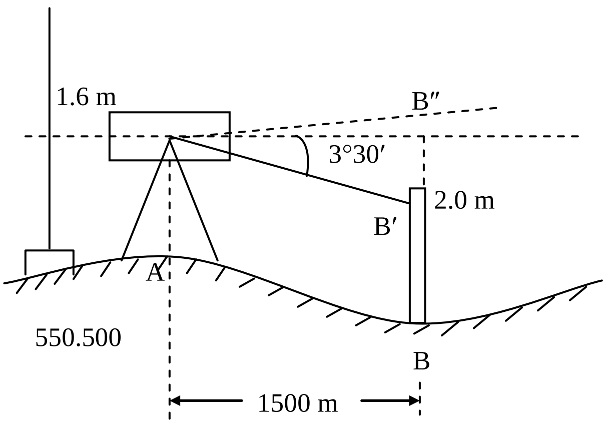
i.e., of removed particle

$$\left(100\frac{mg}{lt}+100\times\frac{50}{100}+100\times\frac{10}{100}+100\times\frac{5}{100}\right)$$

= 165 mg/lit

97. Ans: (b)

Sol:



$B'B'' = 1500 \tan 3°\,30' = 91.744$ m

Corrected staff reading $BB' = 2 - 0.06735 \times 1.5^2$

$= 1.848$ m

RL of B = 550.500 + 1.6 – 91.744 – 1.848

= 458.508 m

98. Ans: (c)

99. Ans: (c)

Sol: From linear momentum equation, the force required to hold the plate stationary is,

$$F = \rho A_j V_{jet}^2$$

The average pressure on the plate

$$P_{avg} = \frac{F}{A_{plate}} = \frac{\rho A_j V_{jet}^2}{A_{plate}} \text{ ------(1)}$$

The dynamic pressure of the jet is given as:

$$P_{dynamic} = \frac{1}{2}\rho V_{jet}^2 \text{ --------------- (2)}$$

Thus, the required ratio is

$$\frac{P_{avg}}{P_{dynamic}} = \frac{\rho A_j V_{jet}^2}{A_{plate}\times\frac{1}{2}\rho V_{jet}^2} = \frac{2A_j}{A_{plate}} = \frac{2\times A_j}{20A_j}$$

$$= \frac{1}{10}$$

100. Ans: (a)

Sol: DO_i = 8 mg/lit

DO_f = 2 mg/lit

Dilution = 1%

Df = Dilution factor

BOD = $(DO_i - DO_f) \times Df$

= (8–2) × 100 = 600 mg/lit

101. Ans: (a)

Sol: PP′ = K× e

K = scale in R.F = $\frac{1}{2000}$; e = 400 mm

$$PP' = \frac{1}{2000}\times 400 = 0.2\,\text{mm}$$

102. Ans: (b)

103. Ans: (c)

Sol: CFC (Chlorofluorocarbon)

104. Ans: (d)

Sol: Difference in longitude = 90°E – 82°30′E

= 7°30′

360° – 24 hr

7°30′ –?

⇒ 30 min

Hence the place is East of meridian.

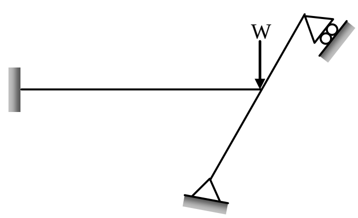
Standard time

= LMT – difference in longitudes

LMT = 8 hr 30 min + 30 min = 9 hr 00 min

105. Ans: (c)

Sol:



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

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

Stiffness in cantilever beam $k_c = \frac{3EI}{L^3}$

Since Deformation is same, these are in parallel

∴ Equivalent stiffness $k_{eq} = K_{ss} + k_c$

$$= \frac{48EI}{L^3} + \frac{3EI}{L^3}$$

$$k_{eq} = \frac{51EI}{L^3}$$

∴ Natural frequently

$$W = \sqrt{\frac{k}{m}} = \sqrt{\frac{51EI}{mL^3}}$$

106. Ans: (a)

Sol: First RL = 172.00 m

Last RL = 184.500 m

ΣBS = 226.405 m

ΣFS = 212.650 m

Measured value = ΣB.S –ΣF.S

= 226.405 – 212.650

= 13.755 m

True value = Last RL – First RL

= 184.500 – 172.00

= 12.50 m

Error = Measured value – True value

= 13.755 – 12.500

= 1.255 m

107. Ans: (d)

Sol: The stiffening of cement without strength development (flash setting of cement) is caused because of C_3A

108. Ans: (d)

109. Ans: (c)

110. Ans: (d)

Sol: As we know that

$$R_{half} = \frac{D}{4}\left[1 - \frac{360 \sin\theta}{2\pi\theta}\right]$$

For half filled θ = 180°

Sin180° = 0

$$R_{half} = \frac{D}{4} = R_{full}$$

$$V_{half} = \frac{1}{N}(R_{half})^{2/3} S^{1/2}$$

N and S constant

$$V_{half} \propto (R_{hlaf})^{2/3}$$

$\because R_{half} = R_{full}$

$V_{half} = V_{full} = 0.8$ m/sec

111. Ans: (c)

Sol: Turbidity in silica scale – 5-10 ppm

Colour (on cobalt scale) – 5-20 ppm

BOD < 3 mg/lit

112. Ans: (a)

113. Ans: (a)

114. Ans: (a)

115. Ans: (a)

116. Ans: (c)

Sol: The efficiency of the pump is

$$\eta_{pump} = \frac{\gamma Q H_m}{P_{in}}$$

$$= \frac{10^4 \times 250 \times 10^{-3}(2.5 + 125)}{435 \times 10^3} = 0.733$$

117. Ans: (c)

Sol: Dust and dirt can't be removed by soaking.

118. Ans: (a)

Sol: When the reinforcement is not symmetrically placed in the cross section, differential strains are induced across the cross section with locations with less reinforcement shrinking more than the locations with relatively more reinforcement.

Eg: In simply supported beam, the shrinkage is more at top than at bottom.

Hence, this difference in shrinkage induces a curvature, in the same direction as due to the flexure under loading.. Thus it enhances the deflection due to loads.

119. Ans: (a)


INDIA

120. Ans: (c)

Sol: Foxiness is caused due to over maturity and unventilated storage of the wood during its transit.

121. Ans: (c)

122. Ans: (b)

Sol:

- To describe shear strain rate completely at a point, nine parameters are required. Because, shear strain rate is a tensor quantity. Mathematically,

$$\dot{\varepsilon} = \begin{vmatrix} \dot{\varepsilon}_{xx} & \dot{\varepsilon}_{xy} & \dot{\varepsilon}_{xz} \\ \dot{\varepsilon}_{yx} & \dot{\varepsilon}_{yy} & \dot{\varepsilon}_{yz} \\ \dot{\varepsilon}_{zx} & \dot{\varepsilon}_{zy} & \dot{\varepsilon}_{zz} \end{vmatrix}$$

  Thus, statement (I) is correct.

- Statement - II is the definition of the shear strain rate at a point. However, it is not the correct explanation of statement - I.

123. Ans: (a)

124. Ans: (a)

125. Ans: (a)

126. Ans: (b)

Sol: The increase in deviator stress becomes progressively smaller as the air in soil voids is compressed and dissolved. The increase in the deviator stress later ceases when large stresses cause full saturation. That is why the failure envelope is not linear.

127. Ans: (b)

128. Ans: (d)

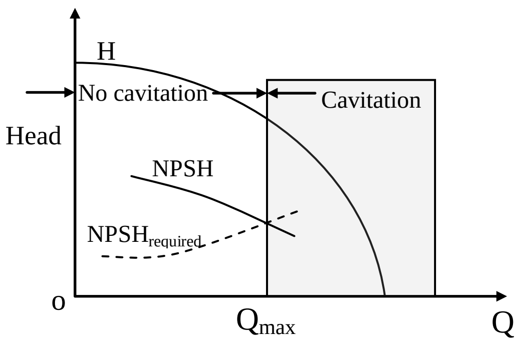
Sol: HGL is the sum of pressure head and datum head. It is drawn with reference to some reference line, may be the centre line of the duct. It slopes downwards in the direction of flow except at the abrupt expansion point of the duct. At this point the pressure rise will take place and HGL will be modified accordingly. Hence, the statement - I is wrong. However, the statement - II is correct.

129. Ans: (b)

130. Ans: (c)

131. Ans: (a)

Sol: Refer to the figure shown below.



It is evident from the above figure that both the statements are correct and statement - II is the correct explanation of statement - I.

132. Ans: (a)

Sol:

- Incompressible Navier-Stokes equation is given by

$$\rho\frac{D\vec{V}}{Dt} = -\vec{\nabla}P + \rho\vec{g} + \mu\nabla^2\vec{V}$$

It can be seen that the above equation is an unsteady, nonlinear, second order, partial differential equation.

- The Inertia terms in the Navier-Stokes equation are:

$$\rho\left(\frac{\partial\vec{V}}{\partial t} + \vec{V}.\nabla\vec{V}\right)$$

The first term in the above equation is for unsteady flow while the second term is nonlinear.

Thus statement (II) is correct and it is the correct explanation of statement (I) as well.

133. Ans: (d)

Sol: The hydrograph will result in fast receding of peak.

134. Ans: (c)

Sol: A clay will be hard when there is no water or small water content. Hence high pore pressure will not develop.

135. Ans: (a)

136. Ans: (b)

137. Ans: (b)

138. Ans: (a)

139. Ans: (a)

Sol: In prestressed concrete beam , C line i.e prestressing tendons line is constant

Pressure line is the locus of point of application of the resultant force.

If the external moments are increased, then the P line shifts upwards

$x = M/P$

i.e force (P) is constant and point of ation of force i.e P line shifts.

Hence the load carrying mechanism is constant force with changing lever arm until the section gets cracked.

Note: If the prestressed beam cracks, it behaves like an RCC section where the stresses increase with moments.

140. Ans: (a)

141. Ans: (a)

142. Ans: (b)

Sol: Miscellaneous measures of track modernization

1. **Modernization of traction:** Instead of steam traction, diesel-electric tractions will be effective in carrying heavy loads at high speeds and with many other advantages.
2. **Modernization of locomotives and Coaches:** Modified design for locomotives and coaches to be suited for modified traction will be used.
   Axle hung/nose suspended motors and heat treated wheels also will be used.
3. **Signalizing and Train Control System:** For effective control to ensure high speeds, high intensity light beams for signals ATC and CTC systems will be used.
4. Train lubrication
5. Other general measures like reducing no. of halts etc., will be taken.

Hence Statement I and II are true.

143. Ans: (a)

Sol: When it is not possible to avoid slope changes along runway and taxiway, they shall be such that there will be an unobstructed line of sight from

(i) Any point 1.5 m above a runway to all other points 1.5 m above the runway within a distance of atleast half the length of runway for class 'A' type airports.

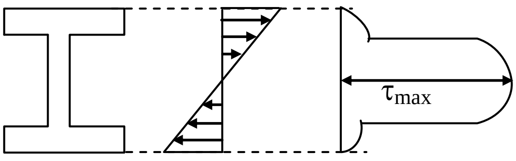
(ii) Any point 1.5 m above the taxiway, for a distance of atleast 150 m from that point for class 'A' type airport.

Hence Statements (I) & (II) is correct explanation of (I).

144. Ans: (c)

145. Ans: (d)

Sol:



For 'I' section beam flanges carry maximum bending load where as web carries maximum shear load. The distribution of bending stress and transverse shear stress is shown above.

146. Ans: (b)

Sol:

- Since corner is discontinuous along two directions, wheel load stress is highest. The edge stress is lower than that at the corner, being discontinuous in one direction, while interior stress is the minimum among all these because it is continuous in both directions. Hence Statement (I) is true.
- Self weight of concrete slab will resist warping/temperature stresses, effect of self weight at interior is highest, edge is lower and at corner it is least, so more resistance/more stress at interior, less at edge and least at corner. Statement (II) is correct.

147. Ans: (c)

Sol: $P = \dfrac{\pi^2 EI}{L^2}$

P is inversely proportional to effective length.

148. Ans: (a)

149. Ans: (a)

Sol:

- As per IS4651-5, Harbour entrance should be on leeward side of the harbour where possible.
- If, however, the entrance must be located on the wind ward end of the harbour, adequate overlap of the break water should be provided so that vessel should have passed through the restricted entrance and be free to turn.
- The effect of crosswinds and current should be carefully considered.
- Hence Both Statements are true and II is correct explanation of (I).

150. Ans: (a)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