Solutions

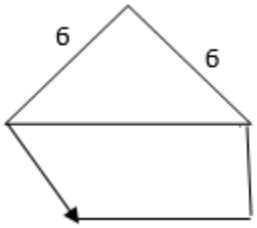
1. Ans. B.
The official answered respectfully that the complaints of the citizen would be looked into.

2. Ans. B.
insured-the person, group, or organization whose life or property is covered by an insurance policy.
ensured- to secure or guarantee

3. Ans. B.
There are 4 kings in a pack of 52 cards.
If 2 cards are selected and both are kings, remaining cards will be 50 out of which 2 will be kings.

4. Ans. C.
vernacular- expressed or written in the native language of a place indigent -deficient in what is requisite

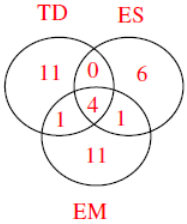
5. Ans. A.
$\sqrt{2^2+2^2}=2\sqrt{2}$



6. Ans. C.
In thousands place, 9 digits except 0 can be placed
In hundreds place, 9 digits can be placed (including 0, excluding the one used in thousands place)
In tens place, 8 digits can be placed (excluding the ones used in thousands and hundreds place)
In ones place, 7 digits can be placed (excluding the one used in thousands, hundreds and tens place)
Total number of combinations = 9×9×8×7 = 4536

7. Ans. D.
dreary- depressingly dull and bleak or repetitive.

8. Ans. A.



9. Ans. D.
Type-I achieved a growth of 53% in the period which is higher than any other type of battery

10. Ans. D.
Statement I can be used to solve the question if capacity of both tanks is already known
Statement-II can be used if it is known what quantity of each tank is full/empty.
Therefore, by using both statements
Let capacity of tank B is x

$$\frac{70}{100}x=14000$$

$$=x=20000\,gallons$$

$$\text{Solution in tank A}=\frac{80}{100}\times 14000=11200\,gallons$$

$$\text{Solution in tank A}=\frac{40}{100}\times 20000=8000\,gallons$$

$$\therefore\text{Total solution }=11200+8000=19200\,gallons$$

11. Ans. B.

$$e_{\min}=\frac{L}{500}+\frac{D}{30}(or)\,20\text{mm which ever is minimum.}$$

$$e_{xx}=\frac{3000}{500}+\frac{600}{30}=26mm$$

$$e_{yy}=\frac{300}{500}+\frac{450}{30}=21mm$$

12. Ans. D.

$$\text{Fround number}=\frac{V}{\sqrt{gy}}$$

$$V\alpha\sqrt{y}$$

$$V.\alpha\sqrt{L_r}\quad\because$$

13. Ans. B.

$$I=\int_0^{\pi/2}\frac{\cos x+i\sin x}{\cos x-i\sin x}dx\,is:$$

$$=\int_0^{\pi/2}\frac{e^{ix}}{e^{-ix}}dx=\int_0^{\pi/2}e^{2ix}dx$$

$$=\left(\frac{e^{2ix}}{2}\right)_0^{\pi/2}$$

$$=\frac{1}{2}\left[e^{\frac{2ix}{2}}-e^0\right]$$

$$=\frac{1}{2}\left[e^{\pi i}-e^0\right]$$

$$=\frac{1}{2}\left[\cos\pi+i\sin\pi-1\right]$$

$$=\frac{1}{2}\left[-1+0-1\right]=-1$$

14. Ans. C.
Carbon monoxide effects the bloods carrying capacity

15. Ans. A.
As rotation and horizontal deflection in zero as per given figure. Therefore its stiffness is '∞' as deflection = 0.
stiffness= $\frac{Force}{deflection}$ and stiffness is zero in y direction

16. Ans. B.
$Given\ A=\left[a_{ij}\right]1\le i,j\le n, n\ge 3\ and\ a_{ij}=i,j$

$$\Rightarrow A=\begin{Bmatrix}1 & 2 & 3 & ---\\ 2 & 4 & 6 & ---\\ 3 & 6 & 9 & ---\\ - & - & - & ---\end{Bmatrix}$$

If we apply R_2-2R_1, R_3-3R_1.....
Every row will be zero row, except first row in echelon form
$\therefore \rho(A)=1$

17. Ans. B.

18. Ans. A.
According to IS : 800 – 1984 Under Clause 3.7 and in Table 3.1, Maximum slenderness ratio in M due to live loads = 180 And M aximum slenderness ratio in N due to windload = 350 Hence, $\lambda for\ M\ <\lambda for\ N$

19. Ans. D.
$$\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{2x}$$
$$=\left(\lim_{x\to\infty}\left(1+\frac{1}{x}\right)^{x}\right)^{2}$$
$$=e^2$$

20. Ans. A.
$\sum BS=3.085\quad \sum F.s=5.645m$
$Fall=\sum Fs-\sum BS=5.645-3.085=2.560$
$R.L$ of last station = R.L first-fall
= -100-2.560=97.440m

21. Ans. A.
Friction Circle method assumes circular slip sur face of radius (r). The resultant reaction between the two portions of the soil mass is tangential to a concentric smaller circle of radius of r sin ϕ which is called friction circle

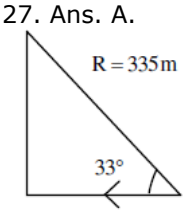
22. Ans. D.
Because $q_u=CN_c+8DN_q+0.5\gamma BN_r$
It is clay $\therefore \phi=0\Rightarrow N_r=0, N_q=1$
$q_u=CN_C+\gamma D$
$q_{nu}=CN_C+\gamma D-\gamma D=CN_C$

23. Ans. C.
Total dissolved solids (TDS) = 500 mg/l
TDS % = (500 *100) /(1000 *1000) = 0.05

24. Ans. B.
$f(x)=-2+6x-4x^2+(0.5)x^3$
$x_0=0$
$f'(x)=6-8x+1.5x^2$
$f(0)=-2\quad f(0)=6$
By Newton-Raphson method
$$x_1=x_0-\frac{f(x_0)}{f(x_0)}=0-\frac{(-2)}{6}$$
$$=\frac{2}{6}$$
$$=0.3333$$
$\Delta x=x_1-x_0=0.3333-0=0.3333$

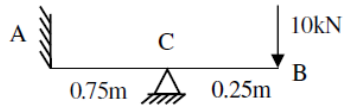
25. Ans. B.
Prying forces are t ensile forces due to the flexibility of connected parts.

26. Ans. D.
$$\tau_\theta=\frac{\sigma_x-\sigma_y}{z}\sin 2\theta+\tau_{xy}\cos 2\theta$$
$+\tau_{xy}=0\,\&\,\sigma_x\ \&\ \sigma_y$ are equal
$\therefore \sigma_x-\sigma_y=0$
$\therefore \tau_\theta=0$ in any direction

27. Ans. A.


$R\ =\ 335\ m$
$e\ =\ tan\theta=\ tan\ 33°=\ 0.649$
$e\ +f\ =V^2\div 127\ R$
$0.649\ +f\ =320^2\div(127*335)$
$f=1.756=1.76$

28. Ans. B.



$D_S = 1$

Let us take R_C as redundant
Deflection at B due to load at C
Deflection at C due to load at $B\ (\Delta BC)$
[By Marshall reciprocal theorem]

$$so, \Delta_{BC} = \frac{10\times(.75)^3}{3E_I} + \frac{10\times(.75)^2}{2E_I}0.25$$

$$= \frac{2.11}{E_I}\downarrow$$

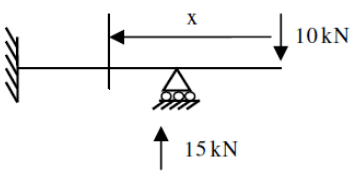
Deflection at C due to Redundant R_C

$$\Delta_{cc} = R_C \times \frac{(.75)^3}{3E_I} = \frac{0.141R_C}{E_I}\uparrow$$

$\because$

$$\Rightarrow \frac{2.11}{E_I} - \frac{.141R_C}{E_I} = 0$$

$$\Rightarrow R_C = 15kN$$

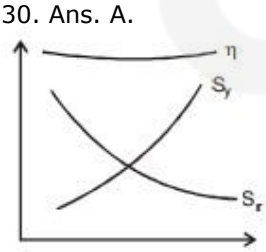


M_x = 10×x-15×(x-.25) = 0
⇒ 10x-15x-3.75 = 0
⇒ x = 0.75m
So, distance of point of contraflexure from end A = 1-0.75 = 0.25m

29. Ans. B.

$$S = 100\% e = \frac{wn}{S_r} = e = \frac{100G}{100} = G$$

30. Ans. A.



∴ Sy + Sr = η

31. Ans. D.

$f'(x_0) = 0 and\ f''(x_0) > 0$ are the necessary and sufficient conditions for a particular point

32. Ans. A.

$C = 0.0673d^2 = 0.0673\times 1$

33. Ans. D.

Surcharge load to be placed as $= \frac{2c}{\sqrt{k_a}}$

34. Ans. B.

$$\text{Convective acceleration} = u\frac{du}{dx} + v\frac{du}{dy} + w\frac{du}{dz}$$

$$= 1.5\frac{(15-1.5)}{0.375} = 54\,m/s^2$$

35. Ans. A.
Lengths of turning lanes should be maximum of (2 times the average number of vehicles (by vehicle type) that would store in turning lane per cycle during the peak hour & Average number of vehicles (by vehicle type) that would store in the adjacent through lane per cycle during the peak hour)

36. Ans. C.

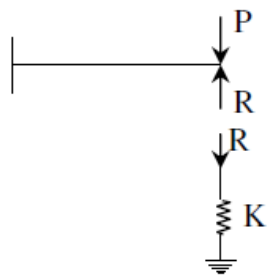
$y_u = 20mg/L$

$After\ 7\ days = y_u e^{-kt} = 20\times e^{0.15\times 7} = 7$

$\%\,is = \frac{7}{20} = 35\%$

$exerted = 100 - 35 = 65\%$

37. Ans. D.



$k = F/\delta\ k = R/\delta\ \delta = R/K$

δ for cantilever

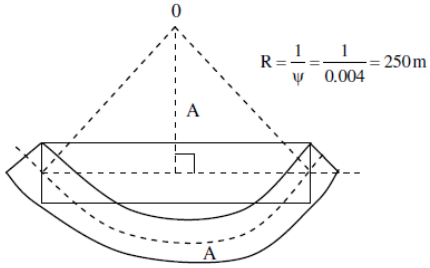
$$\delta = \frac{(P-R)L^3}{3EI} = R/K$$

$$\frac{(50-R)200^3}{3\times 200\times 10^5 \times \frac{5\times 10^5}{12}} = R/z$$

$R = 3N$

38. Ans. B.
Resistance to impact → Toughness
Resistance to wear → Hardness
Resistance to weathering → Soundness
Resistance to crushing → Strength

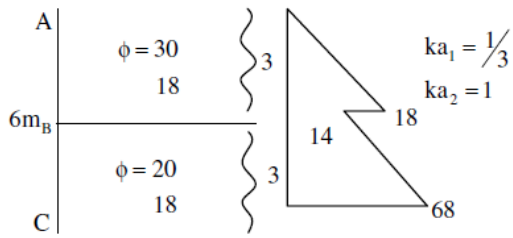
39. Ans. C.



$$OA = \sqrt{(250)^2 - \left(\frac{1}{2}\right)^2} = 249.9995m$$

$$\Delta AA' = 0.0005m$$

40. Ans. A.



$$above = B = ka_1 8H = \frac{1}{2} \times 18 \times 3 = 18\,ka1$$

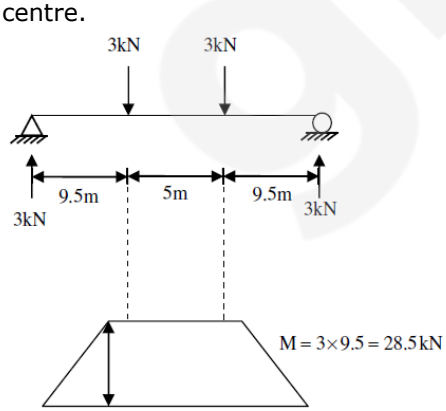
$$below\,B = ka_2 8E - 2c\sqrt{ka_2}$$

$$= 1 \times 18 \times 3 - 2 \times 20\sqrt{1} = 14KN/m^2$$

$$P_C = Ka_2 \gamma z - 2c\sqrt{Ka_2} = 18 \times 6 - 2 \times 20$$

$$P_a = \frac{1}{2} \times 18 \times 3 + \frac{1}{2}(14 + 68) \times 3 = 150kN/m^2$$

41. Ans. A.
Maximum bending stress occurs at the point of maximum bending moment. Maximum B.M. will occur under one of the point load such that resultant of the load system and point load under consideration is equidistant from the centre.



$$\sigma = \frac{M}{I}.y\frac{M}{Z} = \frac{28.5 \times 10^6}{16.2 \times 10^3} = 1759.2\,GPa$$

42. Ans. A.

$$f(x) = \frac{x}{4}(4 - x^2)\ for\ 0 \le x \le 2$$

$$mean = \mu_x = E(x)$$

$$= \int_0^2 xf(x)dx$$

$$= \int_0^2 x\left(\frac{x}{4}\right)(4 - x^2)dx$$

$$= \frac{1}{4}\int_0^2 (4x^2 - x^4)dx$$

$$= \frac{1}{4}\left[\frac{4x^3}{3} - \frac{x^5}{5}\right]_0^2$$

$$= \frac{1}{4}\left[4.\frac{8}{3} - \frac{32}{5}\right]$$

$$= \frac{32}{4}\left[\frac{1}{3} - \frac{1}{5}\right]$$

$$= 8\left[\frac{2}{15}\right] = \frac{16}{15} = 1.0667$$

43. Ans. D.
Loss = 10%
Find force = 750 kN

$$\text{Initial force} = \frac{750}{0.9} = 833.33\,kN$$

$$\text{Top \& Bottom stress} = \frac{P}{A} \pm m/z$$

$$= \frac{833.33}{250 \times 400} \times 10^3 \pm \frac{833.33 \times 10^3 \times 100 \times 6}{250 \times 400^2}$$

$$= 8.33 \pm 12.5$$

Top = -4.166 (T)

Bottom = 20.833 (C)

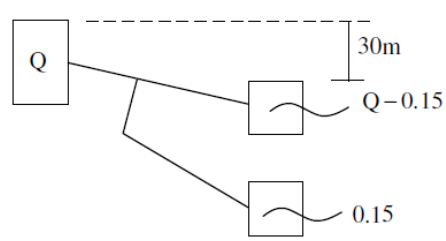
44. Ans. C.
e = ?

$$\gamma_{\text{moist sand}} = \frac{1010}{588} = 1.717\,\text{g/cc} \qquad \gamma_d = \frac{G\gamma_\omega}{1+e}$$

$$\gamma_d = \frac{918}{588} = 1.561\,\text{g/cc} \qquad 1.561 = \frac{2.67 \times 1}{1+e}$$

$$e = 0.71$$

45. Ans. A.



$$h_f = \frac{flQ^2}{12.1d^5}$$

$$h_{f_1} + h_{f_2} = 30m \rightarrow in\ parallel$$

$$\frac{0.024 \times 3000 \times Q^2}{12.1 \times 0.7^5} + \frac{0.024 \times 3000(Q-0.15)^2}{12.1 \times 0.7^5} = 30$$

$$Q = 0.7216\,m^3/s$$

$$Q_B = Q - 0.15 = 0.5716\,m^3/s$$

46. Ans. B.

$$\Delta H = \frac{C_C}{1+e_0} H_0 \log_{10}\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right)$$

$$= \frac{0.6}{1+1.3} \times 4\log_{10}\left(\frac{\sigma_0 + \Delta\sigma}{\sigma_0}\right)$$

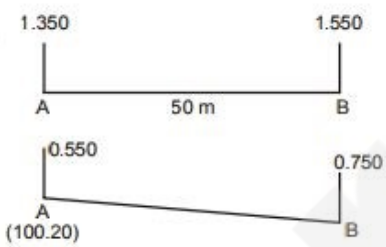
$$= 0.314m$$

$$\Delta_H = 314mm$$

47. Ans. A.
As we consider fck as the value of compressive strength for a sample below which not more than 5% specimen are expected to fail. ∴
Chances of no failure = 100 – 5 = 95%
So, probability of failure =

$$= \left[1 - P^2\right] = \left(1 - 0.95^2\right) = 0.0975$$

48. Ans. D.



Difference in elevation of A and B

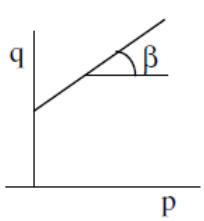
Reciprocal leveling

$$\Delta_h = \frac{(b_1 - a_1) + (b_2 - a_2)}{2} = \frac{(1.55 - 1.35) + (10.75 - 0.55)}{2}$$ RL

$$\Delta h = 0.20$$

of B = RL of A – 0.20 = 100m
From the reading, we can see A is at higher level than B.

49. Ans. B.
Stress path equations



$$\frac{\sigma_1 - \sigma_3}{2} = C\cos\phi + \frac{\sigma_1 - \sigma_3}{2}\sin\phi$$

$$q = 10\sqrt{3} + 0.5P$$

$$C\cos\phi = 10\sqrt{3}$$

$$\text{Tan}\,\beta = \sin\phi = 0.5 \quad \phi = \sin^{-1}\cos 7 = 30°$$

$$C\cos 30 = 10\sqrt{3} \qquad C = 20°$$

50. Ans. A.

For incompressible flow. $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \quad ...(i)$

For irrotational flow. $\frac{1}{2}\left(\frac{\partial v}{\partial x} + \frac{\partial u}{\partial y}\right) = 0 \quad ...(ii)$

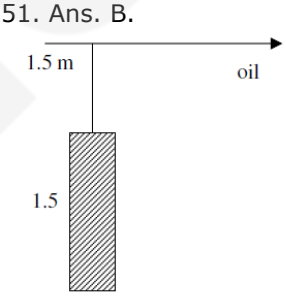
(1) $\frac{\partial}{\partial x}\left(\frac{y^3}{3} + 2x - x^2 y\right) + \frac{\partial}{\partial y}\left(xy^2 - 2y - \frac{x^3}{3}\right) = 0$

$$2 - 2xy + 2xy - 2 = 0$$

(2) $\frac{\partial}{\partial x}\left(xy^2 - 2y - \frac{x^3}{3}\right) - \frac{\partial}{\partial x}\left(\frac{y^3}{3} + 2x - x^2 y\right)$

$$y^2 - x^2 - y^2 + x^2 = 0$$

51. Ans. B.

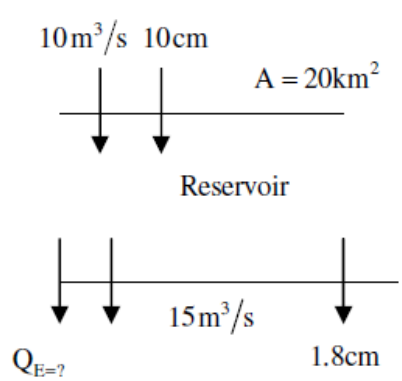


$$\text{Force on gate} = \frac{1}{2} \times 1.5 \times 2 \times G\gamma_\omega\left(1.5 + \frac{2}{3} \times 1.5\right)$$

$$= 0.8 \times 9810 \times 2.5 \times 1.5$$

$$= 29.43\,kN$$

52. Ans. B.



$\because$ in storage = inflow-outflow

$\Delta S = Q_i + Q_R - Q_0 - Q_S - Q_E$

$\Rightarrow 16\times10^6 = (10\times86400\times30) + (0.1\times20\times10^6)$

$-(15\times86400\times30) - (1.8\times10^{-2}\times20\times10^6)$

$\Rightarrow Q_E = \frac{27320000}{20\times10^6} = 1.366m \simeq$

53. Ans. D.

$Let\ A = \begin{bmatrix} 2 & 1 \\ 1 & p \end{bmatrix}$

Given that two eigen values of A are in 3:1

Ratio for p = 2

$\Rightarrow$ Characteristic equation $\lambda^2 - 4\lambda + 3 = 0$ (by substituting p=2)

$\Rightarrow \lambda = 1,3$

If we take $p = \frac{14}{3}$ then A= $\begin{bmatrix} 2 & 1 \\ 1 & \frac{14}{3} \end{bmatrix}$

$\Rightarrow \lambda^2 - \left(2 + \frac{14}{3}\right)\lambda + \left(\frac{28}{3} - 1\right) = 0$

$\Rightarrow \lambda^2 - \frac{20}{3}\lambda + \frac{25}{3} = 0$

$\Rightarrow 3\lambda^2 - 20\lambda + 25 = 0$

$\lambda = 5, \frac{5}{3}$

Eigen values $5, \frac{5}{3}$ are in ratio 3:1

$\therefore p = \frac{14}{3}$

54. Ans. A.

Given

$\frac{d^2y}{dx^2} = -12x^2 + 24x - 20$

$y(0) = 5\, y(2) = 21$

$y(1) = ?$

Auxillary equation $m^2 = 0$

$m = 0,0$

$y_c = (c_1 + c_2x)e^{0_x} = c_1 + c_2x$

$y_p = \frac{1}{D^2}\left(-12x^2 + 24x - 20\right)$

$= -12\frac{x^4}{12} + 24.\frac{x^3}{6} - 20.\frac{x^3}{2!}$

$= -x^4 + 4x^3 - 10x^2$

$y = c_1 + c_2x + 10x^2 + 4x^3 - x^4$

$y(0) = 5 \quad \Rightarrow c_1 = 5$

$y(2) = 21 \Rightarrow 21 = 5 + 2c_2 + 40 + 32 - 16$

$21 = 2c_2 + 61$

$c_2 = -20$

$y = 5 - 20x + 10x^2 + 4x^3 - x^4$

$y(1) = 5 - 20 + 10 + 4 - 1$

$= -2$

55. Ans. D.

$Given\ h = \Delta x = 0.4$

$f(x) = 0.2 + 25x - 200x^2 + 675x^3$

$-900x^4 + 400x^5$

$x_0 = 0 \quad x_n = 0.8 \Rightarrow n = \frac{0.8 - 0}{0.4} = 0$

x	0	0.4	0.8
$y = f(x)$	0.2	24.456	-126.744

By Simpson's $\frac{1}{3}$ *Rule*

$\int_0^{0.8} f(x)ds = \frac{0.4}{3}\left[(0.2 - 126.744) + 4(24.456)\right] = -3.8293$

56. Ans. C.

Rafi crops Gran and wheat

$Q_1 = \frac{A_1}{D_1} = \frac{200\times0.3}{8.64\times\frac{18}{0.12}} = 0.463\,\text{m}^3/\text{s}$; Duty=$8.64\frac{B}{\Delta}$

$Q_2 = \frac{A_2}{D_2} = \frac{2000\times0.5}{8.64\times\frac{18}{0.15}} = 0.964\,\text{m}^3/\text{s}$

$\therefore Q_1 + Q_2$ is required =0.964+0.463=1.427 m^3/s

57. Ans. B.

u = 70 −7k

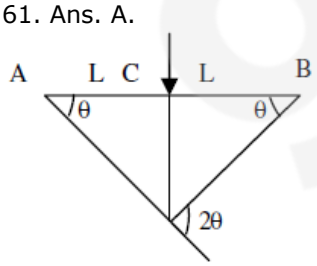
$$\text{Capacity} = u \times k, q = uk$$
$$q = (70 - 0.7k)k$$
$$\frac{dq}{dk} = 70 - 0.7 \times 2k = 0 \Rightarrow k = 50V/km$$
$$q = (70 - 0.7 \times 50) \times 50 = 175V/hr.$$

58. Ans. D.
Total water filters = 24× 3600×1 = 86400m³/ day.
$$S.A = \frac{86400}{120} = 720m^2.$$
$$\text{Area of one filter} = 6 \times 10 = 60\,m^2.$$
$$\text{Total no. of filters} = \frac{720}{60} = 12\ filters.$$
$$2\,\text{out of services, total filters=10.}$$
$$\text{S.A of filters} = 60 \times 10 = 600m^2.$$
$$\text{Total loading rate} = \frac{86400}{600} = 144\,m^3/day/m^2.$$

59. Ans. A.
Ultimate Bearing capacity, Q_u
$$= \lambda\left(\sigma_{v.avg} + 2c_u\right)A_s$$
$$= 0.15[18 \times 12.5 + 2C_u] \times [\pi \times 0.4 \times 25]$$
$$w = 0$$
$$\Rightarrow q_u = 1060.29\,kN$$

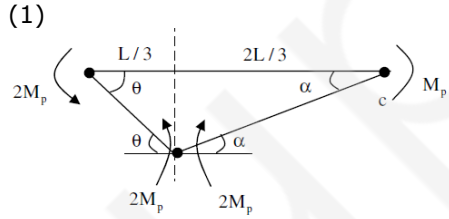
60. Ans. A.
$$G_t = \frac{w_1 + w_2 + w_3 + w_4}{\frac{w_1}{G_1} + \frac{w_2}{G_2} + ...}$$
$$= \frac{100}{\frac{55}{2.0} + \frac{35.8}{2.7} + \frac{3.7}{2.65} + \frac{5.5}{1.01}} = 2.424$$
Eff 'G' of aggregates G (fine+coarse)
$$G = \frac{(55.26) + (35.8 \times 27)}{55 + 35.8} = 2.64$$

61. Ans. A.

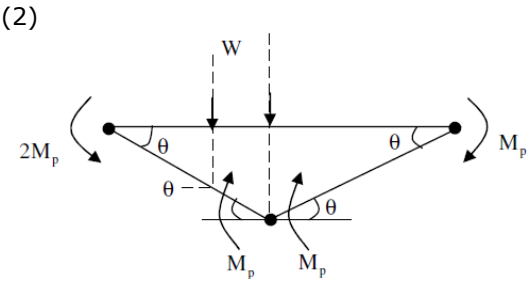


External work done
$$= \frac{1}{2} \times \rho \times L.\theta \_\_\_\_(i)$$
Strain energy stored in spring
$$= \frac{1}{2} \times k \times (2\theta) \times (2\theta)$$
$$= 2k.\theta^2 \_\_\_\_\_(ii)$$
$$(i) = (ii)$$
$$\Rightarrow \frac{1}{2}PL\theta = 2k.\theta^2$$
$$\Rightarrow \theta = \frac{PL}{4k}$$

62. Ans. C.
Plastic hinges formed =3
(1)



$$\alpha = \frac{\theta}{2}$$
$$\theta = 2\alpha$$
$$\theta = \frac{\Delta}{L/3}$$
$$\Delta = \frac{L}{3}\theta$$
$$\Delta = \frac{\alpha 2L}{3}.$$
$$\theta = 2\alpha.$$
$$2M_p\theta + 2M_p\theta + 2M_p\alpha + M_p\alpha = W\Delta$$
$$2M_p\theta + 2M_p\theta + M_p\theta + M_p\frac{\theta}{2} = Q \times \frac{L}{3}\theta$$
$$5.5M_p = \frac{WL}{3} \Rightarrow W = \frac{16.5}{L}M_P$$
(2)



$$2M_P\theta + M_P\theta + M_P\Delta + M_P\theta = W \times \Delta$$
$$5M_P\theta = W\frac{L}{3}\theta$$
$$15\frac{M_P}{L} = W$$
$$\text{Lowest is collapse load}\frac{15M_P}{L}$$

63. Ans. C.

$Q = 32.5 m^3 / d / m^2$

$L = 32.5m$

$B = 8m$

$D = 2.25m$

$V_0 = \frac{Q}{BL}$

$Q = V_0 BL$

$= 32.5 \times 32.5 \times 8$

$= 8450 m^3 / d$

$Weir\ length = 75m.$

$q = \frac{8450}{75} = 112.67 m^3 / d / m$

64. Ans. C.

Total soild waste generated = $2kg \times 2 \times 10^5$

$= 400000\, kg / day$

$For\ 25\ years = 400000 \times 365 \times 25$

$= 3.65 \times 10^9\ kg$

$$\text{compaction ratio} = 0.4 = \frac{\text{volume after compaction}}{\text{volume before compaction}}$$

$V = \frac{3.65 \times 10^9}{100} = 3.65 \times 10^7 m^3$

$V' = 0.4 \times 3.65 \times 10^7 = 1.46 \times 10^7 m^3$

$\frac{\text{sw + cover}}{sw} = \frac{sw}{sw} + \frac{\text{cover}}{sw} = 1.5$

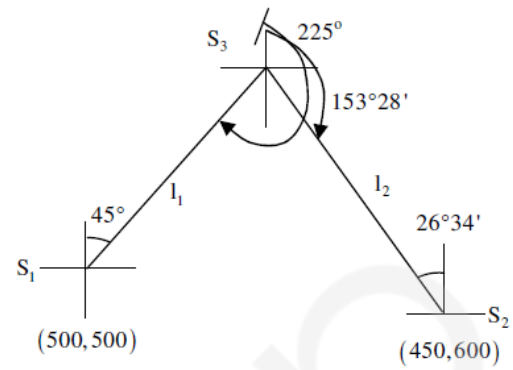
$\Rightarrow \frac{\text{cover}}{sw} = 0.5$

$\Rightarrow \text{cover} = 0.5 \times 1.46 \times 10^7 = 0.73 \times 10^7 m^3$

Total volume $= \left(1.46 + 0.73 \times 10^7\right) = 21.9 \times 10^6 m^3$

$= 21.9 \text{ million } m^3$

65. Ans. C.



$Let\ s_1 s_3 = 1_1, s_2 s_3 = 1_2$

Northing of $S_3 = 500 + 1_1 \cos 45°$

$= 450 + 1_2 \cos 26°34'$

$\Rightarrow 1_1 \cos 45° - 1_2 \cos 26°34' = -50$

Easting of S_3

$500 + 1_1 \sin 45° = 600 - 1_2 \sin 26°34'$

$1 \sin 45° + 1_2 \sin 26°34' = 100$

$\Rightarrow 1_1 = 70.71, 1_2 = 111.80$

Easting of $S_3 = 500 + 70.71 \times \sin 45°$

$= 549.99 m \simeq$

***