ACE
Engineering Academy

Hyderabad | Delhi | Bhopal |Pune | Bhubaneswar | Bengaluru |Lucknow | Patna | Chennai | Vijayawada | Visakhapatnam | Tirupati | Kukatpally| Kolkata

H.O: 204, II Floor, Rahman Plaza, Opp. Methodist School, Abids, Hyderabad-500001,
Ph: 040-23234418, 040-23234419, 040-23234420, 040 - 24750437

ESE- 2018 (Prelims) - Offline Test Series Test-24

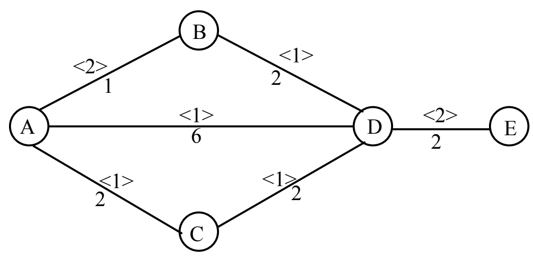
CIVIL ENGINEERING

FULL LENGTH MOCK TEST – 2 (PAPER – II)
SOLUTIONS

01. Ans: (b)

Sol:

Optimum number of weeks required for this network = 8 weeks



Activity	Persons required per week							
	1st	2nd	3rd	4th	5th	6th	7th	8th
AB	2	-	-	-	-	-	-	-
BD	-	1	1	-	-	-	-	-
AD	1	1	1	1	1	1	-	-
AC	1	1	-	-	-	-	-	-
CD	-	-	1	1	-	-	-	-
DE	-	-	-	-	-	-	2	2
	4	3	3	2	1	1	2	2

02. Ans: (c)

Sol:

$t = 6,\ t_m = 12\ ,\ t_p = 24$

$$t_e = \frac{t_o + 4t_m + t_p}{6} = \frac{6 + 4 \times 12 + 24}{6} = 13 \text{ days}$$

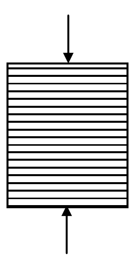
$$\sigma = \frac{t_p - t_o}{6} = \frac{24-6}{6} = 3 \text{ days}$$

03. Ans: (c) **04. Ans: (c)**

05. Ans: (a)

Sol:

When we apply compressive force on the timber perpendicular to the grains force displacement curve is option (a). The timber subjected to crushing failure.



06. Ans: (a) **07. Ans: (c)**

08. Ans: (c)

Sol: $f_{cm} = f_{ck} + 1.65\,\sigma$

$= 20 + 1.65 \times 4$

$= 26.6\ \text{N/mm}^2$

09. Ans: (b)

Sol:

$$A = F \times \left[\frac{i}{(1+i)^n - 1}\right]$$

Sinking fund factor

$= 15,00,000 \times 0.0627/-$

$= 94,050/-$

10. Ans: (c)

Sol: Mason:

$\gamma_c = 2400\ kg/m^3$

For 1 m^3 = 2400 kg

Ratio of mix = 1:3:6

Proportion of cement $= \frac{1}{10} \times 2400$

= 240 kg

W/C = 240 × 0.6 = 144 kg

Volume of water $= \frac{144}{1000}$

= 0.144 m^3 = 144 lit

Engineer:

Ratio of mix = 1:3:4

Proportion of cement $= \frac{1}{8} \times 2400$

$\Rightarrow \left(\frac{2400}{8}\right) kg$

$W/C = \frac{2400}{8} \times 0.6$

= 30 × 6 = 180 lit

Change in amount of water = 180 – 144

= 36 lit

11. Ans: (a)

Sol: Visco-elastic Behaviour:

Materials that have a viscous as well as elastic behaviour is called Visco-Elastic Materials the properties are

1. Time dependent behaviour of loading rate and time
2. Hysteresis in stress strain diagram
3. Relaxation / creep when deformed/ loading

Similarly: Cement concrete is a Visco-plastic material

12. Ans: (c)

13. Ans: (b)

Sol: Split tensile strength - 10 to 15% of cube strength

Compressive strength of cylinder – 0.8 × strength of cube

0.5 × modulus of rapture - Direct tensile stress

14. Ans: (c)

Sol: Volume of soil = 4^3 = 64 cm^3 (before and after)

Mass of water after saturation = 134 – 110

= 24 gms.

$\therefore$ Volume of voids $= \frac{24}{1} = 24\ cm^3$

Volume of solids = 64 – 24 = 40 cm^3

Total mass of dry solids = M_s = 110 gm

$$\therefore\ G = \frac{\gamma_s}{\gamma_w} = \frac{\rho_s}{\rho_w}$$

$$= \frac{(M_s / V_s)}{1 gm/cm^3}$$

$$= \frac{(110/40)}{1} = 2.75$$

15. Ans: (a)

Sol:

Thixotropy property helps remoulded clays to gain strength with time but not to the original undisturbed strength.

16. Ans: (a)

Sol:

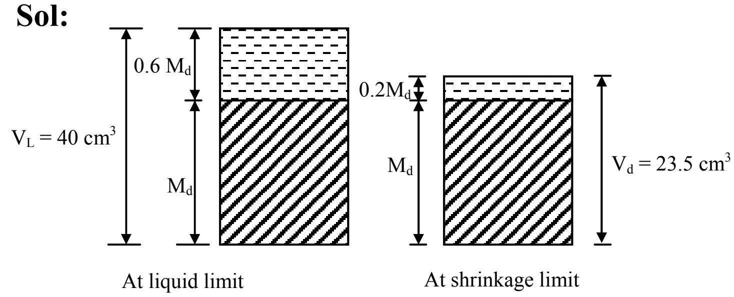
If T > 27°, temperature correction will be positive

Meniscus correction is always positive.

Dispersion agent correction is always negative.

17. Ans: (b)

Sol:



Change in mass of water = $0.6\ M_d - 0.2\ M_d$

$= 0.4\ M_d$

$0.4\ M_d = (V_L - V_d) \times \rho_w$

$0.4\ M_d = (40 - 23.5) \times 1$

$$M_d = \frac{16.5}{0.4} = 41.25\ \text{gms}$$

Mass of water at shrinkage limit = $0.2\ M_d$

$= 0.2 \times 41.25 = 8.25$ gms

18. Ans: (b)

Sol: "Let the thickness of the top layer be z" and k be the permeability

Total thickness of deposit = 4z

$$k_1 = k,\ k_2 = \frac{k}{3},\ k_3 = \frac{k}{2},\ k_4 = 2k$$

$$k_z = \frac{4z}{\frac{z}{k} + \frac{3}{k}(z) + \frac{2}{k}(z) + \frac{z}{2k}}$$

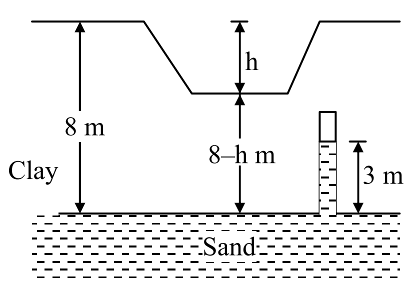
$$k_z = \frac{8}{13}k$$

$$k_z = \frac{16}{13} \times 10^{-4}$$

$$k_z = \frac{16}{13} \times 10^{-4} \text{ cm/sec}$$

19. Ans: (a)

Sol:



h = depth of excavation

Thickness of clay below excavation = 8 – h

Upward hydraulic pressure = effective pressure due to height of clay

$3\,\gamma_w = (8 - h)\,\gamma_{sat}$

$$8 - h = \frac{3 \times 10}{20}$$

h = 6.5 m

20. Ans: (a)

Sol: The vertical stress distribution on a vertical line at distance 'r' from the axis of load 1st increases, attains a maximum, and then decreases.

Statement 3 is wrong since after certain radial distance $\left(\frac{r}{z} > 1.5\right)$, the stress by westergaard's equation is slightly more than that of Boussinesq equation.

21. Ans: (b)

Sol: $U_1 = \frac{3}{12} \times 100 = 25\%$

$$U_2 = \frac{6}{12} \times 100 = 50\%$$

$$T_v = C_v \times \frac{t}{d^2} = \frac{\pi}{4}\left[\frac{U}{100}\right]^2$$

Both C_v and d are constant

$$\frac{t_1}{t_2} = \frac{U_1^2}{U_2^2}$$

$$\frac{1}{t_2} = \frac{25^2}{50^2} \Rightarrow t_2 = 1 \times \left[\frac{50}{25}\right]^2 = 4 \text{ months}$$

$$= 120 \text{ days}$$

22. Ans: (c)

Sol: We know for modified envelops

$\sin\phi' = \tan\psi'$

$$C^1 = \frac{d'}{\cos\phi'}$$

Given $d' = 20$ kN/m^2, $\phi' = 30^o$

$$\therefore C^1 = \frac{20}{\cos 30^o} = 23\ kN/m^2$$

23. Ans: (d)

Sol: The value of maximum stress (σ_1) is γz in active state

Where as in passive case (σ_3) is $\sigma_v = \gamma z$

$\therefore$ Passive state Mohr's circle is much bigger than active state.

Soil particles are not under the verge of failure in at rest case and hence the

Theory of plasticity is not applicable for the rest case

Lateral earth pressure magnitude also depends on type of soil along with wall movement.

24. Ans: (a)

Sol: Option (b) is corresponding to submerged case.

25. Ans: (d)

26. Ans: (a)

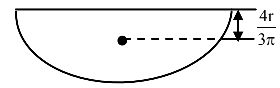
Sol: Vibro-expanded piles are used for low bearing capacity of soils at a given depth.

Pressure piles are formed with the help of a casing tube, boring anger and compressed air equipment.

27. Ans: (a)

28. Ans: (d)

Sol: Moment of thrust = pressure × Area × $\frac{4r}{3\pi}$



$$= 420 \times \frac{\pi}{4} \times \frac{1}{2} \times 1^2 \times \frac{4 \times 0.5}{3 \times \pi}$$

= 35 kNm

29. Ans: (a)

Sol: $T + F_B = mg$

$F_B = \rho \times V_{Al} \times g$

$= 0.8 \times \frac{12}{2.4} \times 10$

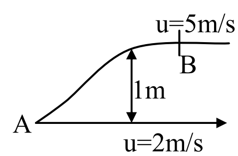
= 40 N

T + 40 = 120

T = 80 N

30. Ans: (c)

Sol:



$$a_B = u_B . \frac{\Delta u}{\Delta x} = 5 \times \frac{(5-2)}{\ell} = 5 \times 3 = 15\, m/s^2$$

31. Ans: (c) **32. Ans: (b)**

33. Ans: (a)

Sol: Among four groups

$$\frac{\rho N d^2}{\mu} = \frac{ML^{-3}T^{-1}L^2}{ML^{-1}T^{-1}} = M^o L^o T^o$$

$\therefore \frac{\rho N d^2}{\mu}$ is a dimensionless group

34. Ans: (d)

35. Ans: (b)

Sol: Negative slip may happen in the case of pumps having long suction pipe and low delivery head. Especially when these are running at high speed.

36. Ans: (c)

Sol: Unit speed $N_u = \frac{N}{\sqrt{H}}$

$$50 = \frac{400}{\sqrt{H}} = 64 \text{ m}$$

37. Ans: (b)

Sol: $A = \sqrt{3}y_e^2 = \sqrt{3} \times 0.6^2 = 0.624\,\text{m}$

$$R = \frac{y_e}{2} = \frac{0.6}{2} = 0.3\,\text{m}$$

$$\therefore\ Q = CA\sqrt{RS} = 60 \times 0.624 \times \sqrt{0.3 \times \frac{1}{360}}$$

$$= 1.08 \text{ m}^3/\text{s}$$

38. Ans: (d)

Sol: $E_L = \frac{(y_2 - y_1)^3}{4y_1y_2}$

$$= \frac{(3.2 - 0.2)^3}{4 \times 0.2 \times 3.2}$$

$$= 10.55 \text{ m}$$

39. Ans: (c)

40. Ans (b)

Sol: $\tau = \mu \frac{du}{dy}$

$$= 10^{-3} \times 0.01\ (2 \times 1000) \times y$$

$$\tau = 0.02 \times y$$

At y = 0.01 m $\Rightarrow$ = 0.02×0.01

$$= 0.0002 \text{ N/m}^2$$

41. Ans: (b)

Sol: Slack is associated with events net activities

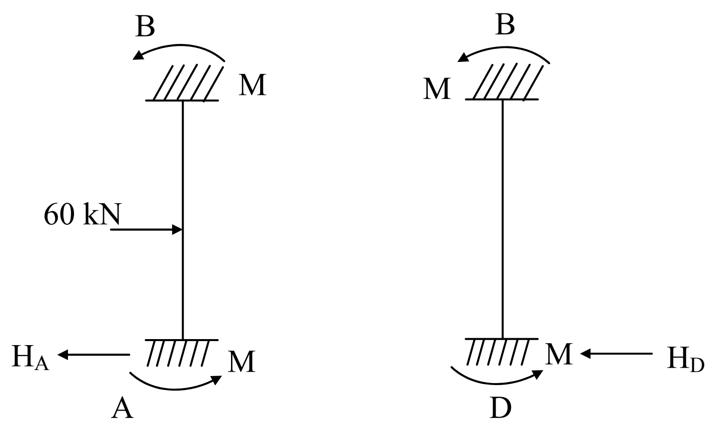
Slack is minimum for critical activities in general

Total float ≥ free float ≥ independent float

One time estimate in CPM three time estimate in PERT

42. Ans: (c)

Sol: As beam is very stiff there will be very little rotation at joints B, C



The moment at A, B, C, D will be

Given since both columns sway

An equal amount and its like a fixed beams one end getting sinked

From column AB

$\sum M_A = 0$

$M = 60$ kN-m ______ (1)

From column CD

$2M = H_A \times b$

$$H_D = \frac{2\times 60}{6}$$

$H_D = 20$ kN

From equilibrium equation

$60 = H_A + H_D$

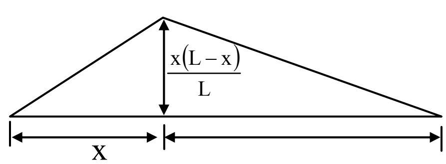
$\therefore\ H_A = 60 - H_D = 60 - 20 = 40$ kN

43. Ans: (c)

Sol: In case of 3-hinged arches BM at a any section is superposition of simple bending and negative bending due to horizontal reaction

When unit load is at C

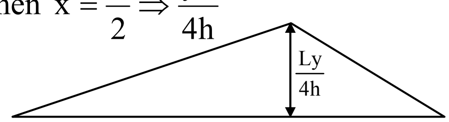
$$BM = \frac{x(L-x)}{L}$$



Also BM due to horizontal reactions will be

$\frac{yx}{2h}$ will be maximum

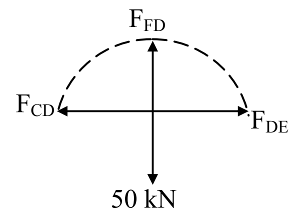
When $x = \frac{L}{2} \Rightarrow \frac{yL}{4h}$



Super position of (1) and (2) is option (c)

44. Ans: (b)

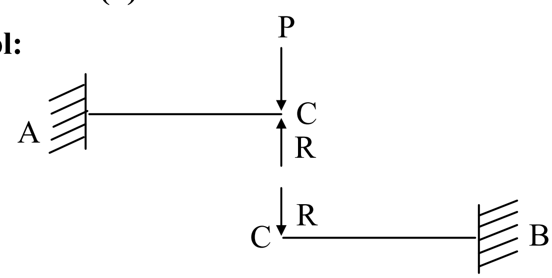
Sol: Cut the section at D as shown below



$\Sigma F_y = 0 \Rightarrow F_{FD} = 50$ kN tension

45. Ans: (d)

Sol:



Deflection at "C" must be same in both beams

$$\left(\frac{(P-R)\ell^3}{3EI}\right)_{AC} = \left(\frac{R\ell^3}{3EI}\right)_{CB}$$

$$\frac{P-R}{E_1} = \frac{R}{E_2} = 2R$$

$$P - R = \frac{E_1}{E_2}\times R = \frac{200}{100}R$$

$P = 3R$

$P = P/3$

From beam AC

$M_A = (P - R)\times l$

$$= \left(P - \frac{P}{3}\right)\times \ell = \frac{2P\ell}{3}$$

46. Ans: (b)

Sol: $W_D = W_n\sqrt{1-\xi^2}$

Given

$$\delta = \ell n\frac{y_1}{y_2}$$

$$= \ell n\left(\frac{1.00}{0.91}\right) = 0.094$$

$$\xi = \frac{\delta}{2\pi} = \frac{0.094}{2\times 3.14} = 0.015$$

$$W_n = \sqrt{\frac{K}{m}} = \sqrt{\frac{32\times 10^3}{20}}$$

$= 40$ rad/sec

$$W_d = 40\sqrt{1-(0.013)^2} \simeq 39.99$$

47. Ans: (b)

Sol: No. of joints = 8

Reactions = 3 + 2 + 2 = 7

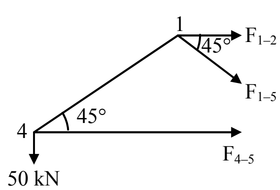
$D_k = (3 \times 8 - R) + 1$ (due to internal hinge)

$= (24 - 7) + 1$

$= 18$

48. Ans: (c)

Sol: Get the section as shown below



$\sum F_y = 0$

$\Rightarrow F_{1-5}\sin 45° + 50 = 0$

$F_{1-5} = -50\sqrt{2}$ kN (C)

$(\sum M)_{\text{about joint 1}} = 0$

$\Rightarrow F_{4-5}\times 3 + 50 \times 3 = 0$

$\Rightarrow F_{4-5} = -50$ kN

$\sum F_x = 0$

$F_{1-2} + F_{4-5} + F_{1-5}\cos 45° = 0$

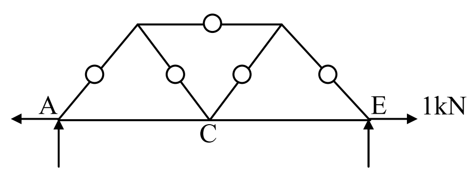
$F_{1-2} + (-50) + (-50\sqrt{2}\times\frac{1}{\sqrt{2}}) = 0$

$F_{1-2} = 100$ kN (T)

49. Ans: (c) **50. Ans: (c)**

51. Ans: (b)

Sol: **Unit load method:** Remove external loads apply unit load at E



$\sum F_y = 0,\ R_A = R_E = 0$

$F_{AB} = F_{BC} = F_{BD} = F_{DE} = F_{CD} = 0$

$\sum F_x = 0$

$F_{CE} = 1$ kN (T)

$F_{AC} = 1$ kN (T)

In real beam:

Joint E

$\sum F_y = 0$

$F_{DE}\sin 60 = P$

$$F_{DE} = \frac{2P}{\sqrt{3}}$$

$\sum F_x = 0$

$F_{DE}\cos 60° = F_{CE}$

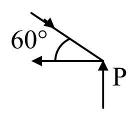
$$\frac{2P}{\sqrt{3}}\times\frac{1}{2} = F_{CE} \quad \Rightarrow F_{CE} = \frac{P}{\sqrt{3}}$$

Due to symmetry $F_{AC} = \frac{P}{\sqrt{3}}(T)$

∴ Horizontal deflection

$$\delta_b = \Sigma\frac{PKL}{AE} = \frac{\frac{P}{\sqrt{3}}\times 1\times\ell}{AE} + \frac{\frac{P}{\sqrt{3}}\times 1\times\ell}{AE}$$

$$= \frac{2P\ell}{\sqrt{3}AE}$$



52. Ans: (a)

Sol: $\delta\ell = \left(\frac{\ell^2+4y}{4y}\right)^2 \alpha T$

$$= \left(\frac{24^2+4\times 8^2}{4\times 8}\right)\times 12\times 10^{-6}\times 30$$

$= 9360 \times 10^{-6}$ m = 9.36 mm up

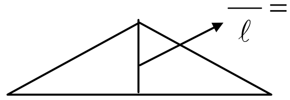
53. Ans: (c)

54. Ans: (c)

Sol: Maximum moment occur at midpoint

ILD for moment at mid point

$$\frac{ab}{\ell} = \frac{5\times 5}{10} = 2.5$$



∴ Total moment created

= moment due to dead load + moment due to live load

$$= \frac{1}{2}\times 2.5\times 10\times 1 + 2.5\times 40$$

= 112.5 kN-m

55. Ans: (d)

Sol: Stiffness matrix not exist for unstable structures and for stable structures stiffness matrix is non-singular matrix (det of matrix is non-zero).

56. Ans: (a)

Sol: Distribution system should be designed for maximum hourly draft (or) coincident draft with fire, which ever in more. Pipe mains filters and other treatment units are designed for maximum daily demand.

Pumps are designed for maximum daily demand + some additional reserve for breakdown and repairs.

57. Ans: (b)

Sol: Globe valves are normally used in small bore pipe work and as taps, although a variation is used as a control valve

Needle and cone valves are not commonly used in water supply but are occasionally used as water hammer releases valves. Pilot valves controls high pressure (or) high flow feed.

Butterfly valves are used to regulate and stop the flow especially in large size conduits.


GATE TOPPERS
GATE 2017
1 EC PRAMOD
1 ME SUDHEER
1 ME HASAN ASIF
1 EE SHIVAM SINGH
1 CE
1 CS DEVAL N PATEL
1 IN NAVEEN
2 EC SREE KALYANI
2 CE PUNEET KHANNA
2 IN RAHUL MAHATO
2 IN SHUBHAM BANSAL
2 PI
3 EC KARUN
3 EE RAVI TEJA
3 ME PRADIP BOBADE
3 CS RAVI SHANKAR
3 CE ANKUR TRIPATHI
4 EC SONU SHARMA
4 EE SARFRAJ NAWAZ
4 CE CHIRAG MITTAL
4 ME GAUSH ALAM
4 IN MONTI
4 PI
5 IN VRAJESH SHAH
5 PI ANKIT TIWARI
6 EC
6 CS MEGHASHAYAM
6 EE RAJASEKHAR REDDY
6 IN RAMESH KAMULLA
6 PI
7 IN PANKAJ MISHRA
8 ME DIVYANSHU JHA
8 PI
9 EC
9 CS
9 ME
10 EC AMIT RAWAT
10 ME
10 EE SURAJ DASH
10 IN
10 IN
ESE TOPPERS
ESE 2017
CE
1 CE NAMIT JAIN
2 CE PRAVIND SINGH
3 CE ANKIT
6 CE
8 CE ADITYA SINGH
9 CE HIMANSHU GAUTAM
10 CE AYUSH DUBEY
7 IN TOP 10 RANKS
E&T
2 E&T
3 E&T
5 E&T AMIT GAUTAM
6 E&T
7 E&T
8 E&T DEEPALI GOYAL
9 E&T
10 E&T UMESH
EE
2 EE PREETI KUMARI
3 EE
4 EE HARSHIT KUMAR SINGH
5 EE NIKHIL KUMAR
6 EE DUSHYANT SINGH
8 EE APOORVA GUPTA
9 EE KIRAN BABU KONERU
ME
3 ME SAURABH
4 ME AMIT KUMAR RAI
6 ME ANKAN GUPTA
7 ME DHRUW JHA
9 ME ACHARAJ GUPTA
5 IN TOP 10 RANKS
7 All India 1st Rank in ESE.
8 IN TOP 10 RANKS
7 IN TOP 10 RANKS
and many more...
27 Ranks in Top 10 in ESE-2017
ACE Engineering Academy
Leading Institute for ESE/GATE/PSUs
Since 1995
204, Rahman Plaza, Abids, Hyderabad Ph : 040-23234418/19/20

58. Ans: (d)

Sol: Area of clarifier

$$= \frac{\text{Average flow}}{\text{Overflow rate}} = \frac{5200}{40} = 130\,m^2$$

$$\frac{\pi}{4}d^2 = 130 \Rightarrow d = \sqrt{\frac{130\times 4}{\pi}}$$

d = 12.86 m ≃ 13 m

59. Ans: (d)

Sol: For drinking water purposes alum is used most frequently where as iron salts are used in case of sewage treatment because iron salt produces iron bacteria and also impacts corrosiveness

Sodium aluminate reduces both temporary and permanent hardness so it is used for boiler feed water which permits very low value of hardness.

60. Ans: (c)

Sol: Total hardness of water removed by ion exchange resins in a day

$= 1000 \times 200 \times 10^{-6}$

= 0.2 kg/day

Total capacity of ion exchanges to remove hardness

= 0.2 × 60 = 12 kg

Time between regeneration cycles

$$= \frac{12}{0.2} = 60 \text{ days}$$

61. Ans: (d)

Sol: $Q_1 = Q_2$

$$A_1R_1^{2/3} = A_2R_2^{2/3}$$

$$\frac{\pi}{4}D^2\left(\frac{D}{4}\right)^{2/3} = b^2\left(\frac{b}{4}\right)^{2/3}$$

$$\Rightarrow \frac{D}{b} = \left(\frac{4}{\pi}\right)^{3/8} = 1.095$$

62. Ans: (b)

Sol: Anaerobic treatment of complex wastes involves three stages. In the first stage organic matter is hydrolyzed. Particle matter is converted into soluble compound. In the second stage (known as acid fermentation), complex organic materials are broken down mainly to short chain acids and alcohols. In the third stage (known as methane fermentation), these materials are converted to gases, primarily methane and CO_2. The proper design of anaerobic ponds must result in environmental conditions favourable to methane formation.

63. Ans: (c)

Sol: BOD load = 864 kg/day = 36 kg/hr

As there are two installed pumps, the load of each pump = 18 kg/hr

∴ Oxygen transfer capacity of each pump = 0.8 kg of O_2/HP hr

∴ Capacity of each aerator $= \frac{18}{0.8} = 22.5\,HP$

64. Ans: (b)

Sol: Sludge bulking is due to high sludge age, low F/M ratio and higher waste temperature

∴ It can be reduced by maintaining low sludge age, high F/M ratio also by chlorination of returned activated sludge.

65. Ans: (a)

Sol: Avg sewage = 95×10^6 lit/day

∴ Total BOD_5 sewage = 300 mg/l × 95 MLD

= 28500 kg/day

Population equivalent

$$= \frac{\text{Total } BOD_5 \text{ in kg/day}}{0.08}$$

$$= \frac{28500}{0.08} = 356250$$

66. Ans: (d)

Sol: Sanitary land filling is a site for disposal of waste material by burial

It is a process of dumping of solid waste in a scientifically designed, dried, area by spreading waste in form of thin layers. It is economical, simple and efficient measure of natural decomposition of wastes.

67. Ans: (c)

Sol: Overall efficiency = $\eta_1 + (1 - \eta_1) \times \eta_2$

= 0.65 + (1 – 0.65) × 0.65

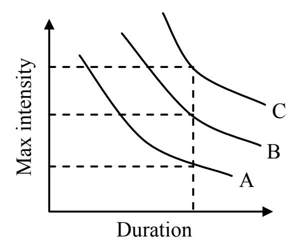
= 87.75%

68. Ans: (a)

Sol: Confined aquifers are confined between two impervious beds such as aquicludes and aquifuges. Since, the water is present between impermeable layers, it is difficult for the contaminants to pass through these layers. Hence, the have a natural protection against contamination. Due to overburden pressure, when a well is tapped water is forced upwards against gravity. Hence, energy required to pump the water is less.)

69. Ans: (b)

Sol:



Assuming a constant duration, we can say

$i_A < i_B < i_C$

Return period of A < B < C

$$\therefore \quad \text{frequency} = \frac{1}{\text{Return period}}$$

$\Rightarrow f_A > f_B > f_C$

70. Ans: (b)

Sol: Infiltration capacity $f_p = \dfrac{0.5 \times S}{\sqrt{t}} + k$

Total infiltration depth

$$= \int_o^t f_p dt = \int_o^t \left(\frac{0.5 \times S}{\sqrt{t}} + k \right) dt$$

$F_p = S\sqrt{t} + kt$

t is in hours $\Rightarrow \frac{15}{60} = 0.25hr$

$\therefore \quad F_p = 6\sqrt{0.25} + 1.5 \times 0.25$

$= 3.375$ cm

71. Ans: (d)

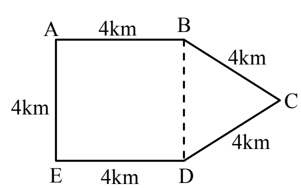
Sol:

If the relation between stage-discharge relationship changes with time I is called as shifting control. It is mainly due to

- scouring and filling in an streambed materials ·
- growth and decay of aquatic weeds ·
- Dredging and channel encroachments
- Over spilling and pending in areas adjoining the stream channel.
- Backwater effects
- Unsteady flows that result in frequent change of gauge

72. Ans: (a)

Sol:



Area of catchment

= area of square ABED + area of triangle BCD

$= (4 \times 4) + \left(\frac{\sqrt{3}}{4} \times 4 \times 4\right)$

$= 16 + 6.928 = 22.928$ sq.km

Total runoff = area under hydrograph

$\Rightarrow 22.928 \times 10^6 \times 4 \times 10^{-2}$

$= \frac{1}{2} \times (20 \times 3600) \times Q$

$\Rightarrow \quad Q = \frac{22.928 \times 4 \times 10}{36}$

= 25.47 cumecs

73. Ans: (d)

Sol:

(i) Instantaneous unit hydrograph is a fictitious, conceptual unit hydrograph which represents the runoff characteristics due to an instantaneous precipitation of 1 cm rainfall excess. For a given catchment, IUH being independent of rainfall characteristics, it indicates the catchment storage characteristics.

(ii) Synthetic unit hydrographs are derived from empirical equations which are valid for a region duly the hydrograph characteristics and basin characteristics.

(iii) Distribution graph is similar to a D-hr hydrograph but the coordinates shows the percentage of surface runoff occurring in a particular equal successive time intervals and duration of each time interval is the duration of rainfall excess. These are useful for comparing the runoff characteristics of different catchments.

(iv) S-curve is a hydrograph produced by a continuous effective rainfall at a constant rate for an infinite period. It is obtained by summation of infinite series of D-hr unit hydrographs spaced D-hr apart.

74. Ans: (b)

Sol: Residual strain = actual strain – elastic strain

= 0.0028 –0.002

= 0.0008

Permanent deformation = residual strain × Length

= 0.0008 × 6000 = 4.8 mm

75. Ans: (c)

Sol: $E = \frac{9KG}{3K+G}$

$= \frac{9\times120\times100}{3\times120+100}$

= 234.78 GPa

= 2.35×10^5 MPa

76. Ans: (d)

Sol: $\delta = \frac{W_1L_1}{2A_1E_1}$ has cylinder

Let the deflection of cone is δ'

$\delta' = \frac{W_2L_2}{2A_2E_2}$ for cone

Given

$W_1 = W_2 = W$

$L_2 = 2L_1$

$A_1 = A_2$ & $E_1 = E_2$

$\therefore \frac{\delta}{\delta'} = \frac{L_1}{2L_1}$

$\delta' = 2\delta$

77. Ans: (a)

Sol: Considering a small element (dx) at a distance x from P

Free expansion of this small element

$\Delta x = l'\alpha\,\Delta T$

$= dx\times\alpha\times\frac{20\times x^2}{\ell^2}$

Total free expansion = $\int_0^\ell \Delta x$

$= \alpha\int_0^\ell dx\,\frac{20x^2}{\ell^2}$

$= \frac{20\alpha}{\ell^2}\times\left.\frac{x^3}{3}\right|_0^\ell$

$= \frac{20\times\alpha\times\ell}{3}$

But the net deflection is zero

$$\frac{\sigma_c\ell}{E} = \frac{20\times\alpha\times\ell}{3}$$

$$\sigma_c = \frac{20\times\alpha\times E}{3} = \frac{20\times18\times10^{-6}\times1\times10^5}{3}$$

$\therefore \sigma_c = 12$ MPa

78. Ans: (d)

Sol: $U_1 = \frac{P^2L_1}{2EA_1} + \frac{P^2L_2}{2EA_2}$

$= \frac{P^2}{2E}\left[\frac{L_1}{A_1} + \frac{L_2}{A_2}\right]$

$$U_1 = \frac{P^2}{2E}\left[\frac{10}{\frac{\pi}{4}\times 2^2} + \frac{20}{\frac{\pi}{4}\times 4^2}\right]$$

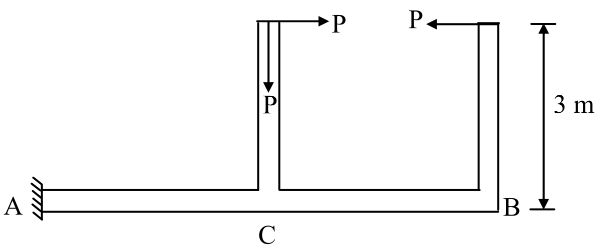
Similarly

$$U_2 = \frac{4P^2}{2\pi E}\left[\frac{20}{2^2} + \frac{10}{4^2}\right]$$

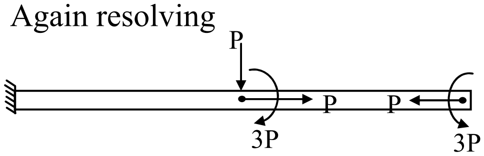
$$\frac{U_1}{U_2} = \frac{\left[\frac{10}{4} + \frac{20}{16}\right]}{\left[\frac{20}{4} + \frac{10}{16}\right]} = \frac{2}{3}$$

79. Ans: (a)

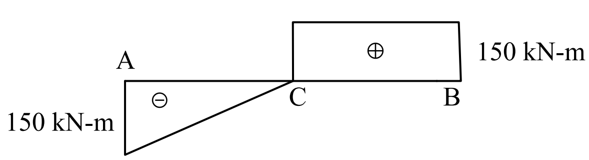
Sol: FBD after resolving forces in pulling



Again resolving



P = 50 kN



80. Ans: (d)

Sol: The slope of BMD at point B must be more than zero and also must be more than the slope at "D".

Also BMD must be a straight line for AB and BC portions since shear force is constant.

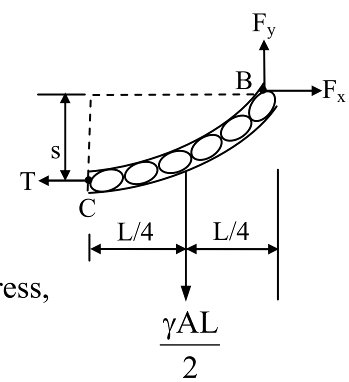
81. Ans: (d)

Sol: By taking moment at point B,

$\sum M_B = 0$

$T.s - \frac{\gamma AL}{2}.\left(\frac{L}{4}\right) = 0$

$T = \frac{\gamma AL^2}{8s}$

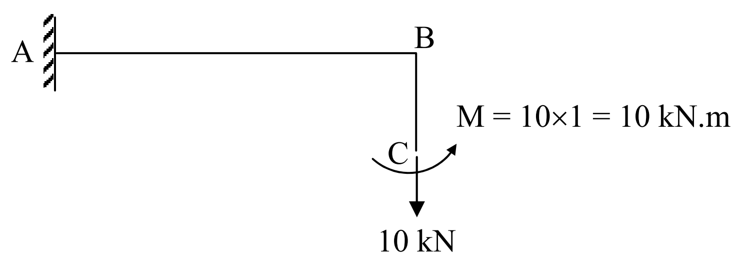


Average normal stress,

$\sigma_n = \frac{T}{A} = \frac{\gamma L^2}{8s}$

82. Ans: (d)

Sol: After transferring the load 10 kN to point C

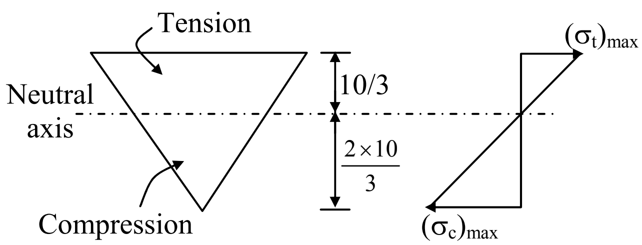


At point C, due to moment M = 10 kN.m and axial load 10 kN, no shear force will be induced.

So, at any section on length BC, shear force is zero.

83. Ans: (c)

Sol: Stress distribution at the fixed end across cross section due to bending is as shown in the figure below.



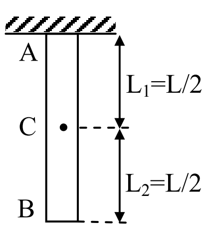
$$\sigma = \frac{M}{I}y \Rightarrow \sigma \,\alpha\, y$$

$$\therefore \frac{(\sigma_c)_{max}}{(\sigma_t)_{max}} = \frac{(y_c)_{max}}{(y_t)_{max}} = \frac{\frac{2\times10}{3}}{\frac{10}{3}} = 2$$

84. Ans: (d)

Sol: Downward displacement of point C,

$$\delta_c = (\delta_{AC})_{\text{Due to its own weight}} + (\delta_{AC})_{\text{Due to external weight of BC}}$$



$$= \frac{W_1L_1}{2A_1E} + \frac{W_2L_1}{A_1E}$$

$$= \frac{(W/2)(L/2)}{2AE} + \frac{(W/2)(L/2)}{AE}$$

$$= \frac{WL}{8AE} + \frac{WL}{4AE} = \frac{3WL}{8AE}$$

85. Ans: (c)

Sol: $\Sigma F_v = 0$

$\therefore$ Reaction of load intensity × beam length AB = 3000 × length of CD

$\therefore W_R \times 3.2 = 3000 \times 1.6$

$\therefore W_R = 1500$ N/m

Shear forces:

$(SF)_A = 0$ N

$(SF)_C = W_R \times 0.8 = 1500 \times 0.8 = 1200$ N

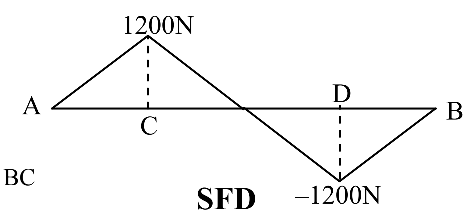
$(SF)_D = -W_R \times 0.8$

$= -1500 \times 0.8$

$= -1200$ N

$(SF)_B = 0$

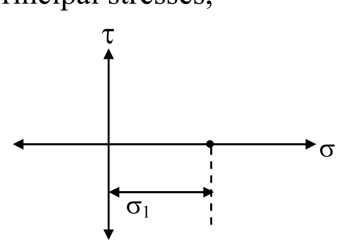
The shear force diagram from above values is drawn as shown in the figure given below.



86. Ans: (d)

Sol: In a given state of stress, the element is subjected to equal and positive normal stresses of 100 MPa with zero shear stress.

So, principal stresses,



$\sigma_1 = \sigma_x = 100$ MPa

and $\sigma_2 = \sigma_y = 100$ MPa

This represents Mohr circle as a point as shown in the figure.

So, all the planes in an element are subjected to same normal stress of 100 MPa.

87. Ans: (b)

Sol:

- For a closed helical spring,

  Deflection, $\delta = \dfrac{8WD^3n}{Gd^4}$

  Where, W = Axial load
  D = Mean coil diameter
  n = number of coils
  G = Modulus of rigidity
  d = wire diameter

  $\therefore \quad \delta \propto \dfrac{1}{G}$

  So, statement (1) is correct.

- Stiffness, $K = \dfrac{W}{\delta}$

  $\therefore \quad K = \dfrac{Gd^4}{8D^3n}$

  $\therefore \quad K \propto G$

  So, statement (2) is also correct.

- Stiffness, $K = \dfrac{Gd^4}{8D^3n}$

  $\therefore \quad K \propto \dfrac{1}{D^3}$

  $\therefore \quad K \propto \dfrac{1}{R^3}$

  As radius of spring (coil) increases, stiffness decreases. So, statement (3) is incorrect.

88. Ans. (a)

Sol: Strain in Z-direction,

$$\varepsilon_z = \frac{\sigma_z}{E} - \frac{\mu}{E}\left(\sigma_x + \sigma_y\right)$$

For a plane stress condition, $\sigma_z = 0$

And for a plane strain condition, $\varepsilon_z = 0$

$$\therefore \quad 0 = -\frac{\mu}{E}\left(\sigma_x + \sigma_y\right)$$

$$\therefore \quad \mu = 0 \quad \text{or } \sigma_x + \sigma_y = 0$$

Plane stress and plane strain conditions can occur simultaneously when either Poisson's ratio, $\mu = 0$ or element is subjected to equal and opposition normal stresses ($\sigma_x = -\sigma_y$).

89. Ans. (b)

Sol: Radius of curvature of beam,

$$\frac{1}{R} = \frac{M}{EI}$$

To have a circular deflection curve, $\dfrac{1}{R}$ should be constant.

So, bending moment and cross section of the beam should be uniform to have constant value of $\dfrac{M}{EI}$.

So, conditions 2 and 3 are required.

90. Ans: (b)

Sol: When a thick cylindrical pressure vessel is subjected to pressure at outer surface,

- Radial stress,

$$\sigma_r = \frac{PR^2}{x^2}\left(\frac{x^2 - r^2}{R^2 - r^2}\right)$$

$\sigma_r = 0$ at $x = r$

σ_r is maximum when $x = R$ i.e., at outer surface and is tensile in nature.

- Hoop stress,

$$\sigma_h = \frac{PR^2}{r^2 - R^2}\left(\frac{r^2 + x^2}{x^2}\right)$$

where, r and R are inner and outer radius respectively.

here, $r \le x \le R$

σ_h is compressive in nature and is maximum when 'x' is minimum σ_h is maximum at $x = r$ i.e., at inner surface.

- Longitudinal stress is always constant.

91. Ans: (c)

Sol: Given data:

$P = 60 \times 10^{-3}$ MPa

$D = 240$ mm

$t = 1.5$ mm

$E = 4$ MPa

$\mu = 0.45$

Maximum strain for sphere

$$\varepsilon_{max} = \frac{Pr}{2tE}(1-\mu)$$

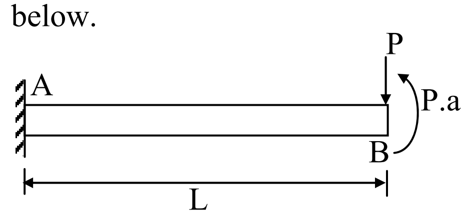
$$= \frac{60\times10^{-3}\times120}{2\times1.5\times4}(1-0.45)$$

$= 20 \times 10^{-3} \times 30 \times 0.55$

$= 0.33$

92. Ans: (c)

Sol: The given loading condition can be represented to B point as shown in the figure below.



Angle of rotation of point B is given by,

$$\theta_B = \frac{PL^2}{2EI} - \frac{(P.a)L}{EI} = 0$$

$$\therefore \frac{PL^2}{2EI} = \frac{PaL}{EI}$$

$$\therefore \frac{a}{L} = \frac{1}{2}$$

93. Ans: (c)

Sol: For a given beam,

Reaction at A,

$$R_A = \frac{\text{Net moment}}{\text{Span length}} = \frac{M_o}{L}$$

Moment at a section at distance 'x' from A is given by,

$$M = M_o - R_A x = M_o - \frac{M_o x}{L}$$

$$= M_o\left(1 - \frac{x}{L}\right)$$

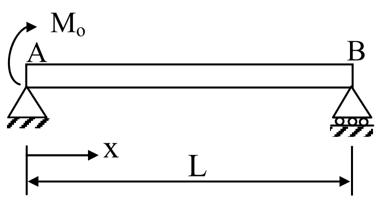
Strain energy for gradually applied load,

$$U = \int \frac{M^2 dx}{2EI}$$

$$= \frac{M_o^2}{2EI}\int_0^L \left(1-\frac{x}{L}\right)^2 dx$$

$$= \frac{M_o^2}{2EI}\left[\frac{\left(1-\frac{x}{L}\right)^3}{3}\right]_0^L \left(\frac{1}{0-\frac{1}{L}}\right)$$

$$= \frac{M_o^2}{2EI}\left[\frac{0-1}{3}\right](-L) = \frac{M_o^2 L}{6EI}$$



94. Ans: (a)

95. Ans: (c)

Sol: $\sigma_h = \frac{pd}{2t}$

$$\frac{2\times1000}{2\times t} = 50$$

$\Rightarrow t = 20$ mm

96. Ans: (c)

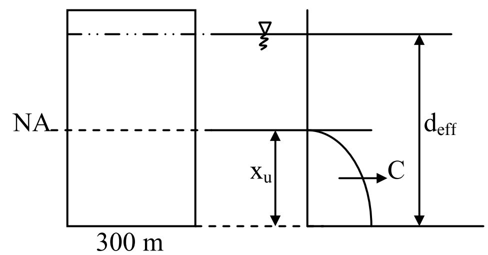
Sol: $f = 1.75\sqrt{d}$

$= 1.75 \times 0.4 = 0.7$

97. Ans: (b)

98. Ans: (a)

Sol:



Actual depth of neutral axis

$\Rightarrow 0.36\ f_{ck}\ b\ x_u = 0.87\ f_y\ A_{st}$

$$\Rightarrow 0.36\times25\times300\times x = 0.87\times500\times4\times\frac{\pi}{4}\times16^2$$

$\Rightarrow x = 129.57$ mm

Distance of neutral axis from top = D – x

= 450 – 129.57

= 320.43 mm

99. Ans: (d)

Sol: Limit state of collapse is a probabilistic approach as it considers the probability of failure of structure relating the load and resistance of structure.

Limit state of serviceability is a deterministic approach where the actual deflections and crack widths under service loads are calculated.

100. Ans: (b)

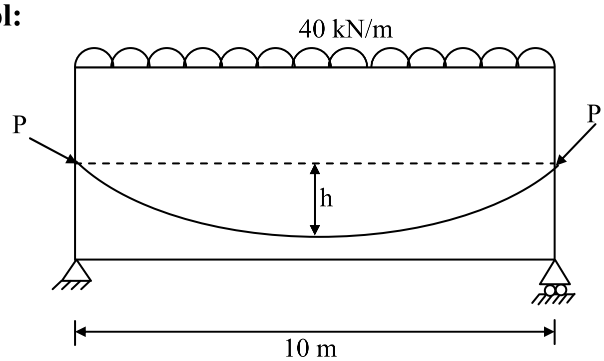
Sol: $S_v = \frac{0.87 f_y A_{sv} d}{V_u}$

$$\Rightarrow V_u = (0.87 f_y) A_{sv}\left(\frac{d}{S_v}\right)$$

$$= \left(0.87 \times 250 \times A_{sv} \times \frac{d}{0.7d}\right) N = 0.31\ A_{sv}\ kN$$

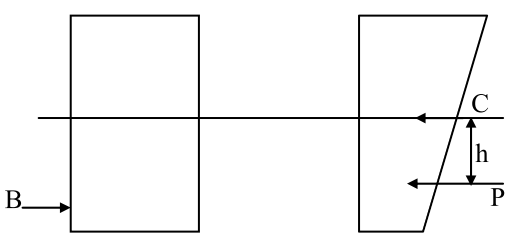
101. Ans: (a)

Sol:



Bending moment at midspan

$$= \frac{w\ell^2}{8} = \frac{40 \times 10^2}{8} = 500\ kNm$$



Lever arm

$$= \bar{x} = \frac{M}{p} = \frac{500}{2000} = 0.25\ m = 250\ mm$$

Since 'C' line coincide with centroid (i.e zero eccentricity)

Lever arm = eccentricity of prestressing force

= h = 250 mm

102. Ans: (c)

Sol: Bonds are majorly of two types

(i) **Flexural bond:** It is due to variation of shear force (on bending moment in a flexural members. This variation causes a change in axial tension along length of bar.

(ii) **Anchorage/Development Bond:** it arises over the length of anchorage provided for bar (or) at the end of bar. It resists the pulling out of bar if bar is in tension and pushing in of bar if bar is in compression.

103. Ans: (a)

Sol: Total equivalent bending moment due to flexural moment M_u and torsional moment M_t is

$M_{e1} = M_t + M_u$

$M_{e2} = M_t - M_u$

Reinforcement required to resist M_{e1} is placed in the flexural tension side.

If $M_{e2} > 0$; i.e $M_t > M_u$ then reinforcement required to resist M_{e2} is placed in compression zone.

104. Ans: (c)

Sol: $\frac{P_u}{f_{ck} bd} = \frac{800 \times 1000}{25 \times 400 \times 400} = 0.2$

From the P-M curve, for $\frac{P_u}{f_{ck} bd} = 0.2$, Corresponding value of $\frac{M_u}{f_{ck} bd^2} = 0.4$

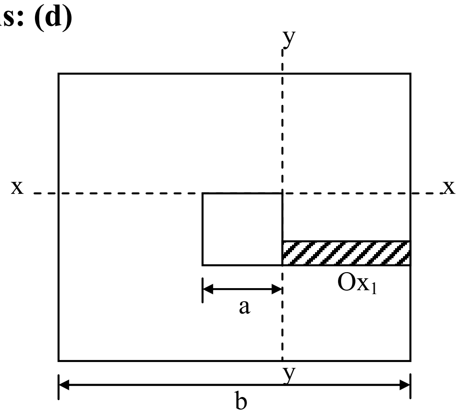
$$\Rightarrow \frac{P_u e}{f_{ck} bd^2} = 0.4$$

$$\Rightarrow 0.2\frac{e}{d} = 0.4$$

$$\Rightarrow e = 2d = 2 \times 400 = 800 \text{ mm}$$

105. Ans: (d)

Sol:



Since both the footing and column are square. Maximum bending moment about 'x' and 'y' axes are same and is considered at face of column.

$$M_x = p \times b \times (OX_1)\left(\frac{OX_1)}{2}\right)$$

$$= pb\frac{(b-a)}{2}\frac{(b-a)}{4} = \frac{pb(b-a)^2}{8}$$

106. Ans: (b)

Sol: In design of earthquake resistant structures

(i) Simple plans are preferred so that load transfer is direct and effective

(ii) Re-entrant corners are not preferred to avoid stress concentrations which may cause failure.

(iii) Larger heights are not preferred as they are more prone to damage due to more slenderness ratio and as the height increases analysis becomes more difficult.

(iv) Foundations are preferred on hard ground and are avoided on loose sand with high water table.

107. Ans: (c)

108. Ans: (a)

Sol: $I = 4 \times G \times t^3$

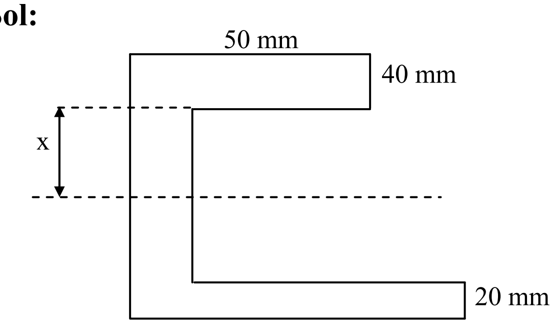
(G = distance between vertical stiffner)

$= 4 \times (2000) \times (15)^3$

$= 27 \times 10^6 \text{ mm}^4$

109. Ans(a)

Sol:



Equal area axis

$50\times40+x\times40 = (100-x)\,40+20\times100$

$x = 100-x$

$2x = 100$

$x = 50$ mm

Plastic moment capacity MP = $\sigma_y \times Z_p$

$Z_p = 50 \times 40 \times 70 + 50 \times 40 \times 25 + 50 \times 40 \times 25 + 100 \times 20 \times 60 = 36 \times 20^4\ mm^3$

$\therefore M = Z_p \times \sigma_y = 360 \times 10^3\ \sigma_y$

110. Ans: (c)

Sol: For EOT with load 5500 kN

Permissible deflection $(\delta) = \dfrac{L}{1000}$

$= \dfrac{15\times 10^3}{1000}\ mm$

$= 15$ mm

111. Ans: (b)

Sol: Horizontal angle between the two points sighted by the instrument will be equal to the angle between index glass and horizontal glass.

112. Ans: (c)

Sol: $L = \dfrac{g_1 - g_2}{r}$

$= \dfrac{-1.2-(-4.2)}{\left(\dfrac{0.1}{20}\right)} = 600\,m$

113. Ans: (d)

114. Ans: (c)

115. Ans: (a)

Sol: Total error, $e = -\dfrac{1}{2}[(h_P - h_Q) - (h'_R - h'_S)]$

$e = -\dfrac{1}{2}\left[(1.400 - 3.500) - (0.600 - 2.200)\right]$

$= 0.25$

$e = e_{col} + (e_{cur} + e_{ref})$

$\because (e_c + e_R) = 0$ no distance given

$e_{col} = e = 0.25$ m

116. Ans: (b)

Sol: Length $= \sqrt{3^2 + 3^2} = 3.23$ m

Closing error, $\theta = \tan^{-1}\left(\dfrac{2}{2}\right) = 45°$

$180° - 45° = 135°$

117. Ans: (c)

Sol: Minimum length of transition curve = e N $(w + w_e)$

Consider, no extra widening

$\ell_s = \dfrac{1}{15} \times 120 \times 7$

$= 56$ m

118. Ans: (b)

Sol: $(CBR)_{2.5} = \dfrac{60}{1370} \times 100 = 4.37\%$

$(CBR)_{5.0} = \dfrac{80}{2055} \times 100 = 3.9\%$

Use higher i.e. 4.37%

119. Ans: (a) **120. Ans: (a)**

121. Ans: (a)

Sol: Bleeding of concrete leads to formation of pores inside the concrete which will decrease the strength

122. Ans: (d)

Sol: Open excavations can obtain both disturbed and undisturbed samples, soils can be inspected in their natural condition also suitable for depths upto 3m ((or) shallow depths)

123. Ans: (b)

Sol: Due to the chemical reactions, the alternation in the nature of the adsorbed layer through base exchange phenomenon cause the change in OMC and maximum compacted density.

124. Ans: (a)

Sol: An under-consolidated soil is a soil which is not fully consolidated under the existing overburden pressure but with time it will become fully consolidated so once it is fully consolidated it is nothing but a normally consolidated since it has not been subjected to an effective pressure greater than the existing overburden

125. Ans: (b)

Sol: By virtue of the viscous friction exerted by water flowing through soil pores, an energy transfer is effected between the water and soil. The force corresponding to this energy transfer is called the seepage force (or) seepage pressure. No viscosity no seepage pressure.

126. Ans: (b)

127. Ans: (d)

Sol: Geometric method is used for developing city not for developed city.

128. Ans: (a)

Sol:

Because of availability of Oxygen, BOD gets removed at fast rate and it is also due to settlement of organic matter.

So Statement I and II are correct and Statement II supports I.

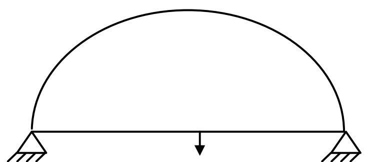
129. Ans: (b)

Sol: Vermicompost is the end product of the breakdown organic matter by earthworms and is generally used in municipal solid waste management.

130. Ans: (a)

131. Ans: (a)

Sol:



A tied-arch bridge is an arch bridge in which the outward-directed horizontal forces of the arch is borne as tension by a chord tying both arch ends rather than by the ground or the bridge foundation.

132. Ans: (d)

Sol: In tension area of cross section decreases.

$\therefore$ True stress is more than nominal (or) average stress.

133. Ans. (a)

Sol: Mohr's circle is a general formulation that represents transformation of 2nd order tensor. 2nd order tensor can be plane stress tensor or in-plane area moment tensor.

Thus, both the statements are true and statement (II) is correct explanation of statement (I).

134. Ans. (c)

Sol: In an isotropic and homogeneous material, when a material is heated uniformly only normal strain induces. Uniform temperature rise does not induce any shear strain.

So, shape of the material remains the same and only size changes. Hence, statement (I) is true and statement (II) is false.

135. Ans: (d)

136. Ans: (c)

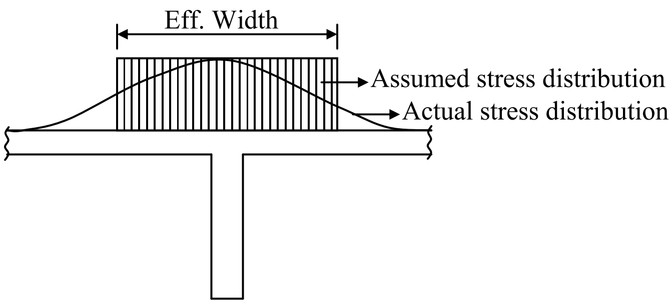
Sol: High strength concrete is required mainly to resist large bursting stresses at the ends. Also it reduces the size of concrete member required thereby resulting in reduction of self weight of member.

High strength concrete has high modulus of elasticity $(E = 5000\sqrt{f_{ck}})$ and hence lesser creep strains.

137. Ans: (a)

Sol: According to theory of flexure, stress distribution must be uniform. But when the flanges are too wide compressive stress distribution is not uniform over the entire width (i.e. maximum in the web and decreases at point away from the web).

To apply flexure theory it is necessary to reduce it to uniform stress distribution. Hence effective width of flange concept used assuming that the stress distribution is uniform and is equal to maximum stress in original wide flange in such a way that longitudinal compressive force is same in both cases.



138. Ans: (c)

Sol: If the lacing is too steep ($\theta < 40^o$), it will transmit some axial force in the column from component to another component through secondary truss action.

139. Ans: (b)

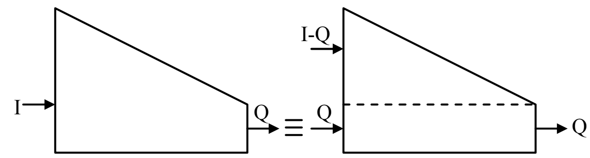
Sol: Unlike the elastic method of design in which moments produced by different loading systems can be added together, plastic moment obtained by different loading systems cannot be combined, i.e the plastic moment calculated for a given set of loads is only valid for that loading condition. This is because the 'principle of super position' becomes invalid. When the parts of the structure have yielded.

140. Ans: (a)

Sol: Total storage = Prism storage + wedge storage

= kQ + kz (I – Q)

For advancing flood



k = proportionality const

x = weighing factor on inflow V_s outflow

'x' depends on the shape of wedge storage. For a reservoir type of storage, since storage is a function of only outflow ie. Independent of inflow x = 0

141. Ans: (a)

Sol: In rigid pavement, reinforcement placed just below 50 to 60 mm of top surface. If crack develop at top surface, water can enter into pavement and leads to corrosion of steel bars.

142. Ans: (a)

Sol: It is an arrangement in which railway track run parallel on a single track bed, such that only one pair of rails may be used at a time.

143. Ans: (a) **144. Ans: (a)**

145. Ans: (a)

Sol: Theoretical maximum capacity

$$= \frac{1000V}{S} = \frac{3600}{h}$$

V = speed kmph

S = space headway, m

h = maximum time headway

146. Ans: (c)

Sol: $a = fg$

$a = 0.35 \times 9.81$

$= 3.43\ \text{m/sec}^2$

147. Ans: (a) 148. Ans: (b) 149. Ans: (d)

150. Ans: (d)

Sol: For higher specific speed axial flow pumps are used as they give higher efficiency when flow is axial and specific speed is high.