ESE-2018 PRELIMS TEST SERIES

Date: 24 December, 2017

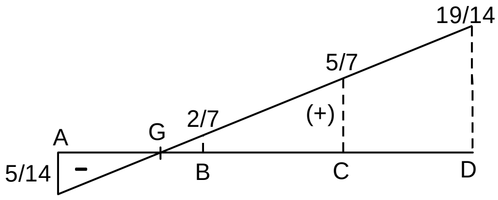
CE–Test 14(OBJECTIVE SOLUTION)...

ANSWERS

1.	(c)	31.	(a)	61.	(c)	91.	(a)	121.	(c)
2.	(c)	32.	(b)	62.	(d)	92.	(c)	122.	(b)
3.	(b)	33.	(c)	63.	(b)	93.	(d)	123.	(b)
4.	(a)	34.	(d)	64.	(d)	94.	(d)	124.	(b)
5.	(b)	35.	(d)	65.	(d)	95.	(d)	125.	(c)
6.	(b)	36.	(a)	66.	(b)	96.	(c)	126.	(b)
7.	(d)	37.	(b)	67.	(a)	97.	(a)	127.	(b)
8.	(a)	38.	(c)	68.	(b)	98.	(b)	128.	(b)
9.	(a)	39.	(a)	69.	(b)	99.	(d)	129.	(a)
10.	(c)	40.	(c)	70.	(c)	100.	(d)	130.	(b)
11.	(d)	41.	(b)	71.	(c)	101.	(b)	131.	(b)
12.	(c)	42.	(d)	72.	(b)	102.	(c)	132.	(d)
13.	(c)	43.	(c)	73.	(c)	103.	(d)	133.	(b)
14.	(c)	44.	(b)	74.	(c)	104.	(d)	134.	(a)
15.	(c)	45.	(b)	75.	(d)	105.	(b)	135.	(d)
16.	(b)	46.	(a)	76.	(b)	106.	(a)	136.	(b)
17.	(c)	47.	(b)	77.	(d)	107.	(a)	137.	(a)
18.	(b)	48.	(b)	78.	(c)	108.	(c)	138.	(c)
19.	(a)	49.	(c)	79.	(c)	109.	(d)	139.	(a)
20.	(d)	50.	(b)	80.	(b)	110.	(d)	140.	(b)
21.	(a)	51.	(a)	81.	(b)	111.	(b)	141.	(c)
22.	(c)	52.	(b)	82.	(c)	112.	(b)	142.	(b)
23.	(b)	53.	(b)	83.	(d)	113.	(a)	143.	(a)
24.	(c)	54.	(c)	84.	(a)	114.	(d)	144.	(a)
25.	(d)	55.	(c)	85.	(a)	115.	(b)	145.	(a)
26.	(a)	56.	(b)	86.	(c)	116.	(d)	146.	(b)
27.	(d)	57.	(c)	87.	(c)	117.	(d)	147.	(a)
28.	(b)	58.	(a)	88.	(c)	118.	(c)	148.	(d)
29.	(b)	59.	(b)	89.	(c)	119.	(a)	149.	(a)
30.	(b)	60.	(a)	90.	(c)	120.	(a)	150.	(a)

1. (c)

ILD for R_F



- Unit load at A

$$\sum M_E = 0$$

$$\Rightarrow \quad R_F \times (28) + 1 \times 10 = 0$$

$$\therefore \quad R_F = -\frac{10}{28} = \frac{-5}{14}\text{KN}$$

- Unit Load at B

$$\sum M_E = 0$$

$$\Rightarrow \quad R_F = \frac{8}{28} = \frac{2}{7}\text{KN}$$

- Unit load at C

$$R_F = \frac{20}{28} = \frac{5}{7}\text{KN}$$

- Unit Load at D

$$R_F = \frac{38}{28} = \frac{19}{14}\text{KN}$$

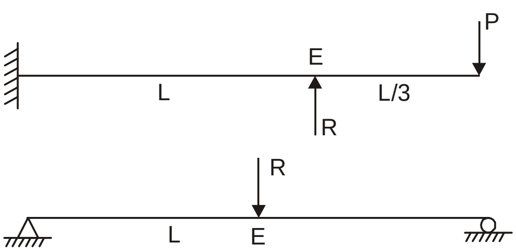
2. (c)

To obtain the absolute maximum shear, we position the loads such that the rear wheel load 114 KN is next to the support B.

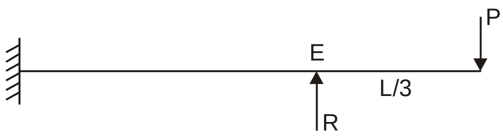
$$\therefore \text{ Maximum } V_A = 114 \times 1 + 114 \times \frac{14.8}{16} + 27 \times \frac{11.6}{16} + 27 \times \frac{10.5}{16}$$

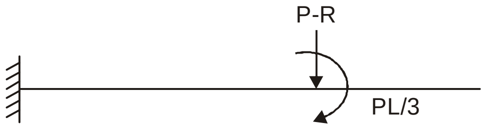
$$= 256.75 \text{ KN}$$

3. (b)



Compatibility condition total deflection at E in cantilever beam = total deflection at E in simply supported beam.





Total deflection at E in cantilever beam

$$= \frac{(P-R)L^3}{3EI} + \frac{\left(\frac{PL}{3}\right) \times L^2}{2EI}$$

Total deflection at E in simply supported beam

$$= \frac{R \times (2L)^3}{48EI}$$

From compatability condition :

$$\frac{(P-R)L^3}{3EI} + \frac{\left(\frac{PL}{3}\right) \times L^2}{2EI} = \frac{R \times (2L)^3}{48EI}$$

$$\Rightarrow \quad \frac{(P-R)}{3} + \frac{P}{6} = \frac{R}{6}$$

$$\Rightarrow \quad \frac{P}{3} + \frac{P}{6} = \frac{R}{6} + \frac{R}{3}$$

$$\Rightarrow \quad R = P$$

Hence reaction at E is R = P.

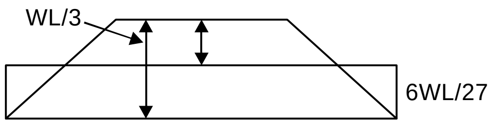
4. (a)

$$FEM_{AB} = \frac{-W \times \left(\frac{L}{3}\right)^2 \times \frac{2L}{3}}{L^2} - \frac{W \times \frac{L}{3} \times \left(\frac{2L}{3}\right)^2}{L^2}$$

$$= -\frac{WL^3 \times 2}{27L^2} - \frac{W \times L^3 \times 4}{27L^2}$$

$$= \frac{-2WL}{27} - \frac{4WL}{27} = \frac{-6WL}{27}$$

$$FEM_{BA} = \frac{6WL}{27}$$



Bending moment at mid span

$$= \frac{WL}{3} - \frac{6WL}{27} = \frac{9WL - 6WL}{27}$$

$$= \frac{3WL}{27} = \frac{WL}{9}$$

5. (b)

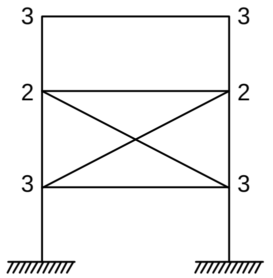
$$K_{BA} = \frac{4EI}{6}$$

$$K_{BC} = \frac{4 \times E \times 2I}{6} = \frac{8EI}{6}$$

$$\sum K = \frac{4EI}{6} + \frac{8EI}{6} = \frac{12EI}{6} = 2EI$$

$$\theta_B = \frac{30}{2EI} = \frac{15}{EI}(\text{anticlockwise})$$

6. (b)



Total D_K = 3 + 3 + 3 + 3 + 2 + 2 = 16

7. (d)

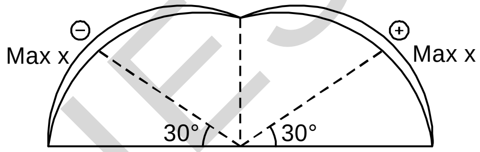
Consider X_1 = 1 and $X_2 = X_3$ = 0 for row 1. This will give force $K_1 + K_2$ at free body diagram of 1 and a force $-K_2$ at 2 FBD of 3 will have no force.

Similarly for X_1 = 0, X_2 = 1 and X_3 = 0

We will get result corresponding of option (d).

9. (a)

$$M_\theta = \frac{WR^2}{2}(\sin\theta - \sin^2\theta)$$



$$M_{max} = \frac{WR^2}{8}$$

at θ = 30° (Hogging)

10. (c)

Thinner the slab more is the increase in shear strength due to plate action.

11. (d)

L_d for Fe-250 plain bars,

$$= \frac{0.87 fy\phi}{4\tau_{bd}} = \frac{0.87 \times 250 \times \phi}{4\tau_{bd}}$$

$$Ld_1 = 250 \text{ K.}$$

Ld for Fe415 deformed bars, Ld_2

$$= \frac{0.87 \times 415 \times \phi}{4 \times 1.6 \times \tau_{bd}} = \frac{415}{1.6}K$$

$$Ld_2 = 259.375 \text{ K}$$

where $K = \frac{0.87\phi}{4\tau_{bd}}$ in both the cases.

% change in development length

$$= \frac{259.375 - 250}{250} \times 100\%$$

= 3.75% increase

15. (c)

Transverse reinforcement

$$\text{dia. is max of} \begin{cases} 1/4 \times \text{dia. of largest} \\ \text{longitudinal bar} \\ \text{or } 6\text{mm} \end{cases}$$

$$= \max\begin{cases} 1/4 \times 25 = 6.25\text{mm.} \\ 6\text{mm} \end{cases} \Rightarrow \text{provide 8 mm}$$

$$\text{Spacing} = \min\begin{cases} \text{Least lateral dimension} \\ 16 \times \text{smallest dia. bar} \\ 300 \text{ mm.} \end{cases}$$

$$= \min\begin{cases} 350 \text{ mm} \\ 16 \times 16 = 256\text{mm} \\ 300 \text{ mm} \end{cases}$$

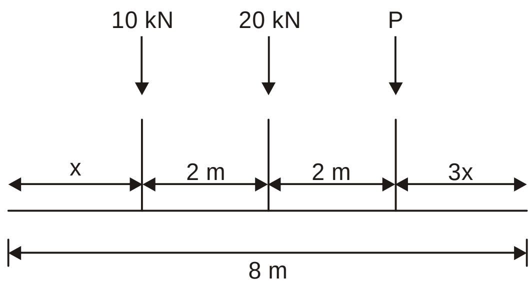
= 250 mm c/c

16. (b)

$$Pu = 40(20 \times 20 - 4 \times 20) + 300 \times 20 \times 4$$

= 36800 kg.

17. (c)



C.G. of loads = C.G. of footing

$$\frac{8}{2} = \frac{10x + 20(x+2) + P(x+4)}{(10+20+P)}$$

$$x + 3x + 2 + 2 = 8$$

$$x = 1 \text{ m}$$

$$3x = 3 \text{ m}$$

$$4 = \frac{70 + 5P}{P + 30}$$

$\Rightarrow$ $120 + 4P = 70 + 5P$

$P = 50$ kN

19. (a)

Higher toughness value provides ability to steel structures to absorb the impact loads.

20. (d)

On cooling, tension is developed at surface of concave fillet weld leading to development of crack. In addition it has smaller throat thickness and penetration.

21. (a)

Thickness of main plate are 12 mm and 4 mm.

Thickness of packing plate = 8 mm

Bolt is in double shear in which one shear plane passes through thread.

Design shear capacity

$$= (Anb + Asb)\frac{f_{ub}}{\sqrt{3}\gamma_m}\beta_{lg} \times \beta_{lj} \times \beta t_{pkg}$$

Here $l j < 15d$ and $l g < 5d$

$$\therefore \quad \beta_{lg} = \beta_{lj} = 1$$

$$\because \quad t_{pk} > 6 \text{ mm}, \quad \beta_{pkg} = 1 - 0.0125 t_{pkg}$$

$$\beta_{pkg} = 1 - 0.0125 \times 8 = 0.9$$

Design shear capacity

$$= [1 + 0.78] \times \frac{\pi}{4} \times 14^2 \times \frac{400}{\sqrt{3} \times 1.25} \times \frac{1 \times 1 \times 0.9}{1000}$$

$$= 45.56 \text{ KN}$$

22. (c)

For lacing system $\frac{\ell}{r_{c\,min}} \not> 50$ or 0.7 times slenderness ratio of the compression member as a whole, whichever is less

$$\frac{\ell}{r_{c\,min}} = \min(50, 0.7 \times 50)$$

$$\frac{\ell}{10} = 35$$

$$L = 350 \text{ mm}$$

L is the distance between the centre of connections of the lacing bars.

23. (b)

$(FoS)_{given} = 1.5$

$(FoS)_{new}$ after increasing allowable stress by 30%

$$(FoS)_{new} = \frac{(FoS)_{given}}{1.3}$$

$(\text{Load Factor})_{new} = (FoS)_{new} \times$ shape factor

$$= \frac{1.5}{1.3} \times 1.1 = 1.269$$

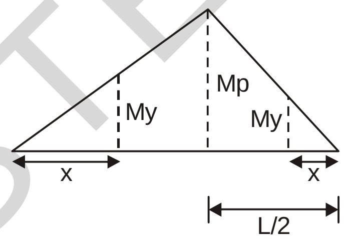
24. (c)

After providing all the stiffeners lesser clear dimension of a web panel $\not>$ 180tw and greater clear dimensioning of web panel $\not>$ 270tw.

25. (d)

In case of purlin the plane of loading is inclined to the minor principal axis and hence it is subjected to unsymmetrical bending.

26. (a)



For a square beam, shape factor = 1.5

Hence $M_P = 1.5$ My

From similar triangle

$$\frac{M_P}{L/2} = \frac{M_y}{x}$$

$$\frac{1.5M_y}{L/2} = \frac{M_y}{x}$$

$$x = \frac{1}{3} \times L$$

27. (d)

Length of plastic zone

$$l_p = L\left(1 - \frac{1}{SF}\right)$$

SF = Shape factor

For circular cross-section SF = 1.7

$$lp = L\left(1 - \frac{1}{1.7}\right) = \frac{7L}{17}$$

28. (b)

Brake horse power

$$BHP = \frac{\rho Q H}{745\eta}$$

$$BHP = \frac{1000 \times 2.8 \times (7.5 + 0.25)}{0.8 \times 745}$$

$$BHP = \frac{1000 \times 2.8 \times 7.75}{0.8 \times 745}$$

$\rho \rightarrow$ Density of water

$Q \rightarrow$ Discharge

$H \rightarrow$ Total Head

$\eta \rightarrow$ Efficiency

29. (b)

$$t_e = \frac{t_0 + t_p + 4t_m}{6}$$

$$= \frac{15 + 40 + (4 \times 20)}{6} = 22.5$$

$$\sigma = \frac{(t_p - t_0)}{6}$$

$$= \frac{(40 - 15)}{6} = 4.167$$

30. (b)

1. Event have no place in this network.
3. DEBUT is used when number of activities start together.

31. (a)

Salient points about PERT analysis.

(i) Uses probabilistic approach which absorbs uncertainities in estimation of time.

(ii) It is used for projects where there is no background information i.e. of non-repetitive type e.g. R & D type of projects.

(iii) As there is not much information available about the activities hence events are established for the planning purpose and emphasis is given to the event of the project.

33. (c)

Cyanides (CN) ties up with the haemoglobin sites that bind oxygen to red blood cells. This results in oxygen deprivation. A characteristic symptom is that the patient has a blue skin color. This condition is called cyanosis. Cyanide causes chronic effects on the thyroid and central nervous system.

34. (d)

The upper layer of the filter bed become the dirtiest and any inadequate washing will lead to the formation of mud balls, cracks and clogged spots in the filters. These troubles are overcome by adequate surface wash which can be accomplished by stirring the expanded filter bed mechanically with rakes, hydraulically with jets of water directed into the suspended sand or pneumatically with air, either during or more commonly before expansion.

35. (d)

The equivalent weight of $CaCO_3$ is 50g.

Molecular weight of Liquid Alum ($Al_2(SO_4)_3 \cdot 18H_2O$)

$= 2 \times 27 + 3 (32 + 4 \times 16) + 18 \times (2 \times 1 + 16)$

$= 666$ g

Equivalent weight of Alum $= \frac{666}{6} = 111\,g$

Dosage of alum in terms of $CaCO_3$ equivalent

$$= 60 \times \frac{50}{111} = 27.027 \text{ mg/L as } CaCO_3$$

36. (a)

All pipes in the system should form a grid that prevents the establishment of dead ends. Dead ends cause sediments to build up, since the pipes at these places are not subjected to a continuous flow of water. When the system is disinfected after repairs, disinfectants cannot go into dead ends, since there is no continuous flow there. On the other hand, water flows continuously in the grid system form of distribution. Hence sediments cannot build up and the system can be easily disinfected after repairs.

37. (b)

Nitrogen in any soluble form i.e. NH_3, NH_4^+, NO_2^- and NO_3^- excluding N_2 gas is a nutrient and may need to be removed from wastewater to help control algal growth in the receiving body.

38. (c)

Sample size is equal to the reciprocal of dilution factor.

BOD_5 = Oxygen demand × Dilution factor

$$BOD_5 = 2 \times \frac{100}{1} = 200 \text{ mg/L}$$

39. (a)

Decimal volumetric fraction and sample used

$$\Rightarrow \quad P = \frac{15}{300} = 0.05$$

$$BOD_5 = \frac{(DO_i - DO_f) - (B_i - B_f)(1 - P)}{P}$$

$$= \frac{7.2 - 1\times(1-0.05)}{0.05} = 125 \text{ mg/l}$$

40. (c)

1. Circular sewer section are mostly used for separate sewage system. But the advantage of circular sewer is obtained only when the section runs atleast half full.
2. If a circular sewer is used for combined system it will be effective only during maximum rain water flow, but during dry weather flow, velocity generated would be very less.

41. (b)

According to shield's formula

$$V = \frac{1}{n} R^{1/6} [K_s (G_s - 1) \times d_p]^{1/2}$$

$$V = \frac{1}{0.002} \times (1)^{1/6} [0.04 (2-1) 1 \times 10^{-3}]^{1/2}$$

$$= \frac{1}{0.002} \times [0.04 \times 10^{-3}]^{1/2}$$

$$= \frac{0.00632}{0.002} \text{ m/s}$$

$$V = 3.16 \text{ m/sec}$$

42. (d)

High rate aeration is a process modification in which high MLSS concentration are combined with high volumetric loadings. This combination allows high F/M ratios and long mean cell residence time with relatively short hydraulic detention time.

Krauss process is a variation of the step aeration process used to treat wastewater with low nitrogen levels. Digestor supernatant is added as a nutrient source to a portion of the return sludge in a separate aeration tank designed to nitrify. The resulting mixed liquor is then added to the main plug-flow aeration system.

High-purity oxygen is used instead of air in the activated sludge process. Oxygen is diffused into covered aeration tanks and is recirculated. A portion of the gas is wasted to reduce the concentration of carbon dioxide. pH adjustment may also be required. The amount of oxygen added is about four times greater than the amount that can be added by conventional aeration systems.

43. (c)

$$\frac{F}{M} = \frac{QS_o}{VX} \text{ (mg/mg.day)}$$

$$0.5 = \frac{0.1\times 75 \times (24\times 60\times 60)}{840\times X}$$

$$X = 1542.85 \approx 1550 \text{ mg/L}$$

45. (b)

Actual distance

$$= \frac{\text{Actual tape length}}{\text{nominal tape length}} \times \text{measured length}$$

$$= \frac{30.1}{30} \times 300$$

$$= 301 \text{ m}$$

46. (a)

Relief displacement

$$d = \frac{rh}{H - h_1}$$

$$0.0514 = \frac{0.11\times 116.82}{500 - h_1}$$

$$h_1 = 250 \text{ m}$$

47. (b)

Error in latitude $\Delta L = \Sigma L$

= 400.75 + 100.25 – 199 – 300 = 2

Error in departure $\Delta D = \Sigma D$

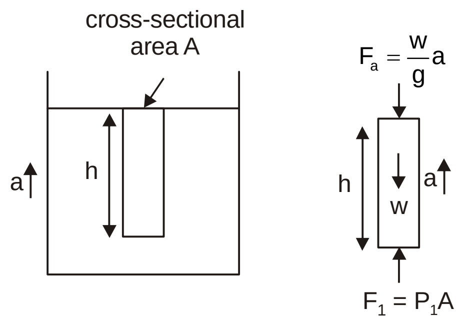
= 199.25 + 299.75 – 300.5 – 200.5 = –2

Closing error = $\sqrt{2^2 + (-2)^2}$ = 2.82 m

48. (b)

Magnifying power of the eyepiece is kept high

50. (b)



$$\Sigma F_y = 0 \uparrow$$

$$P_1A = \frac{w}{g}a + w \qquad w = \gamma Ah$$

$$P_1A = \frac{\gamma Ah}{g}a + \gamma Ah$$

$$P_1 = \gamma h\left(1+\frac{a}{g}\right)$$

$$= 9.81\times 1\left(1+\frac{5}{9.81}\right)\times 10^3$$

$= 14.81$ kPa

51. (a)

Velocity of water emerging from orifice A and B

$$V_A = \sqrt{2g\,h_A} \qquad V_B = \sqrt{2gh_B}$$

$$h_A = 6-2 = 4\text{ m} \qquad h_B = 6-5 = 1\text{m}$$

x_A = horizontal distance covered by stream from orifice A

$X_A = V_A\, t_A$, (t_A – time taken to reach the ground)

$$2 = 0 + \frac{1}{2}gt_A^2 = t_A = \sqrt{\frac{4}{g}}$$

$$x_A = \sqrt{2g\times 4}\times\sqrt{\frac{4}{g}} = \sqrt{2\times 16}$$

Similarly $x_B = V_B t_B \Rightarrow t_B = \sqrt{\frac{10}{g}}$

$$x_B = \sqrt{2g\times 1}\times\sqrt{\frac{10}{g}} = \sqrt{10\times 2}$$

$$\frac{x_A}{x_B} = \sqrt{1.6} = 1.265$$

52. (b)

Power required for pumping

$$P = \gamma Qh_f = \gamma Q\left(\frac{f/Q^2}{12.1d^5}\right)$$

$$\frac{P_1}{P_2} = \frac{f_1}{f_2}\left(\frac{d_2}{d_1}\right)^5$$

$$\frac{P_1}{P_2} = \frac{0.025}{0.02}\left(\frac{250}{200}\right)^5 = 3.81$$

53. (b)

Lift efficiency = $\frac{C_L}{C_D}$

$$\frac{F_L}{F_D} = \frac{C_L\times A_L}{C_D\times A_D}$$

$$\frac{625}{25} = \frac{C_L\times A_L}{C_D\times A_D}$$

$$\frac{C_L}{C_D} = \frac{25}{4} = 6.25$$

54. (c)

$$Q = \frac{2}{3}C_d\, L_e\,\sqrt{2g}\,H^{3/2}$$

where L_e = L – 2 × 0.1 × 0.2 = 2.5 – 0.04

= 2.46

$$Q = \frac{2}{3}\times 0.6\times 2.46\sqrt{2\times 10}\times(0.2)^{3/2}$$

$$= \frac{2}{3}\times 0.6\times 2.46\times 4.47\times 0.09$$

$= 0.39$ m³/s

55. (c)

$$\frac{L_e}{D^5} = \frac{L_1}{D_1^5}+\frac{L_2}{D_2^5}+\frac{L_3}{D_3^5}$$ (for series connection)

$$D_1 = D \quad D_2 = \frac{D}{2},\quad D_3 = 2D$$

$$L_1 = L \quad L_2 = \frac{L}{2},\quad L_3 = 4L$$

$$\frac{L_e}{D^5} = \frac{L}{D^5}+\frac{\frac{L}{2}}{(D/2)^5}+\frac{4L}{(2D)^5}$$

$$= \frac{L}{D^5}\left[1+\frac{1}{\left(\frac{1}{2}\right)^4}+\frac{4}{32}\right]$$

$$L_e = 17\frac{L}{8}$$

56. (b)

$$T = 2\pi\sqrt{\frac{I}{wG\bar{M}}}$$

Small $G\bar{M}$ decreases the stability of ship, if comfort is to be increased the size of ship should be made larger so that moment of inertia I increases and thus time period increases.

57. (c)

$$\frac{\text{Circulation}}{\text{Area}} = 2w_z = \text{vorticity}$$

Velocity potential function exists only for irrotational flow.

58. (a)

Velocity gradient = 0.21 s^{-1}

Shear stress $\tau = 0.2\text{ N/m}^2$

$$\tau = \mu\frac{du}{dy} \Rightarrow \mu = 0.9524\text{ N-s/m}^2$$

Kinematic viscosity $\nu = \frac{\mu}{\rho}$

$$= \frac{0.9524}{950} = 10.02 \times 10^{-4} \text{ m}^2/\text{s}$$

$$= 10.02 \text{ stokes}$$

59. (b)

$\chi > 500$ flow is unstable

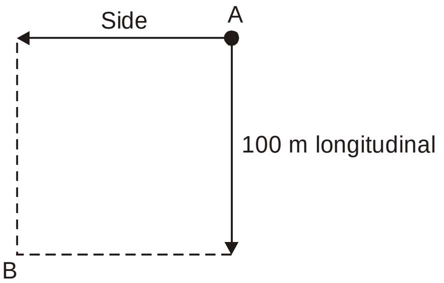
60. (a)

The nagpur road plan formulae were prepared assuming star and grid pattern.

61. (c)

Side slope = 3% $\rightarrow$ 3 in 100

Longitudinal slope = 4% $\rightarrow$ 4 in 100



$$AB = \sqrt{100^2 + 100^2} = 100\sqrt{2} \text{ m}$$

Elevation difference of A and B = 3 + 4 = 7 m

So diagonal gradient = $\frac{7}{100\sqrt{2}} \times 100$ = 4.95%

62. (d)

Bitumen is obtained from fractional distillation of petroleum

Tar is obtained from destructive distillation of coal

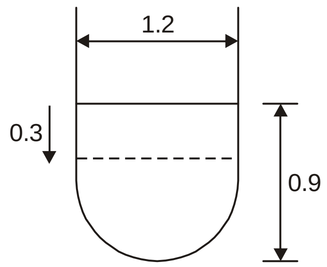
Bitumen is soluble in CS_2

Tar is not soluble in CS_2, only soluble in toluene.

63. (b)

Cant deficiency is the difference between the theoretical cant required for such high speeds and the actual cant provided.

68. (b)



$$A = \left[\frac{\pi \times (0.6)^2}{2} + (1.2 \times 0.3)\right] = 0.925 \text{ m}^2$$

$$P = \pi \times 0.6 + 2 \times 0.3 = 2.485 \text{ m}$$

$$R = \frac{A}{P} = \frac{0.925}{2.485} = 0.372$$

Conveyance $K = \frac{Q}{\sqrt{S}}$

$$K = CA\sqrt{R} = 54 \times 0.925 \times \sqrt{0.372}$$

$$K = 30.5$$

69. (b)

This is a case of unsteady flow and continuity equation

$$\frac{\partial Q}{\partial x} + T\frac{\partial y}{\partial t} = 0$$

$$\frac{\partial Q}{\partial x} \Rightarrow -T\frac{\partial y}{\partial t}$$

$$T\frac{\partial y}{\partial t} \Rightarrow \frac{20 \times 0.10}{60 \times 60} = 0.000556$$

$$\frac{Q_2 - Q_1}{\Delta x} \Rightarrow -T\frac{\partial y}{\partial t}$$

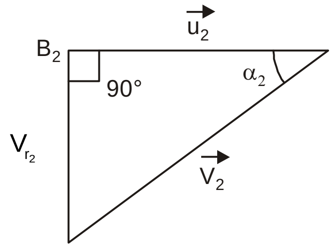
$Q_1 \Rightarrow$ Discharge at upstream section

$$Q_1 = Q_2 + T\frac{\partial y}{\partial t}\Delta x$$

$$= 20 + 1000 \times 0.000556$$

$$Q_1 \Rightarrow 20.556 \text{ m}^3/\text{s}$$

70. (c)



$$V_{f2} = V_{r_2} \qquad V_2 \cos\alpha_2 = V_{w_2} = u_2$$

$$u_2 = \frac{\pi D_2 N}{60} = \pi \times \frac{0.3 \times 1450}{60} = 22.77 \text{ m/s}$$

$$n_m = \frac{gH_m}{V_{w_2} u_2}$$

$$0.9 = \frac{9.81 \times H}{(22.77)^2}$$

$$H \Rightarrow 47.6 \text{ m}$$

71. (c)

In frames, major deflection is due to bending moment.

72. (b)

1. Kern of rectangular section is of Rhombus shape
2. Diameter of hollow circular Kern is $\frac{D^2+d^2}{4D}$.

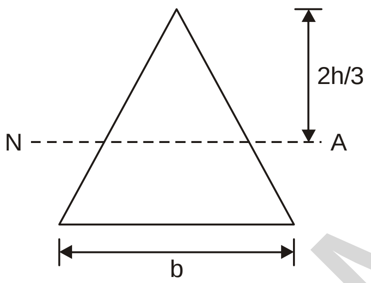
   where D and d are outer and inner diameter respectively.

73. (c)

Shear stress at the level of NA

$$\tau = \frac{VA\bar{y}}{Ib}$$

$$\tau = \frac{F\times\left(\frac{1}{2}\times\frac{2}{3}\times b\times\frac{2}{3}h\times\frac{1}{3}\times\frac{2h}{3}\right)}{\frac{bh^3}{36}\times\frac{2}{3}b} = \frac{8}{3}\frac{F}{bh}$$



74. (c)

$$M = 720\text{Nm}$$

$$T = 300\text{ Nm}$$

$$M_{eq} = \frac{1}{2}\left(M+\sqrt{M^2+T^2}\right)$$

$$M_{eq} = \frac{1}{2}\left(720+\sqrt{720^2+300^2}\right)$$

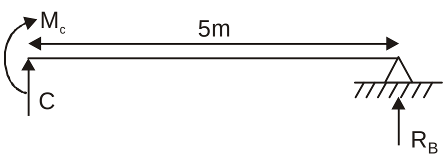
$$\Rightarrow 750\text{N}-\text{m}$$

$$T_{eq} = \sqrt{M^2+T^2}$$

$$T_{eq} = 780$$

$$\frac{M_{eq}}{T_{eq}} = \frac{750}{780} = 0.96$$

75. (d)



$$\sum M_A = 0$$

$$10R_B - \frac{1}{2}W\times\left(\frac{X}{3}\right) = 0$$

$$R_B = 1.5\text{KN}$$

$$M_C = 1.5\times 5 = 7.5\text{ KN–m}$$

$$I = \frac{1}{12}\times 60\times 120^3 - \frac{(40)\times 100^3}{12}$$

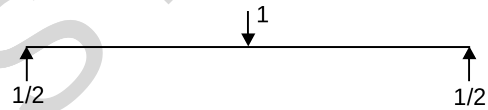
$$I = 53.07\times 10^5\text{ mm}^4$$

$$\sigma = \frac{My}{I} = \frac{7.5\times 10^6\times 60}{53.07\times 10^5} = 84.79\text{ MPa}$$

76. (b)

Apply unit load method

$$1\cdot\Delta = \int\frac{m\alpha\Delta T dx}{D}$$

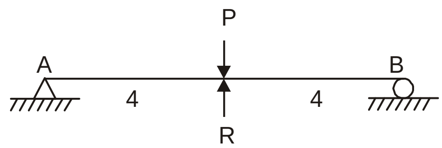


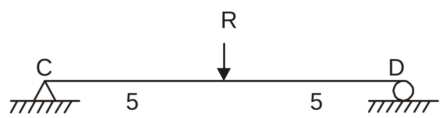
$$1\cdot\Delta = 2\int\frac{\frac{x}{2}3\times 10^{-6}\times\Delta T\,dx}{0.25}$$

$$\Delta = \frac{2\times 3\times 10^{-6}\times 144}{2\times 0.25}\left[\frac{x^2}{2}\right]_0^5$$

$$\Delta = 21.6\text{ mm}$$

77. (d)





$$\frac{(P-R)(8)^3}{48EI} = \frac{R(10)^3}{48EI}$$

$$\frac{P-R}{R} = \left(\frac{5}{4}\right)^3 = \frac{P-R}{R} = 1.95$$

$$R = \frac{P}{2.95}$$

Reaction at C equals to $\frac{R}{2} = \frac{P}{2\times 2.95} = 0.17\text{ P}$

78. (c)

$$\theta = \frac{TL}{GJ}$$

$$3\times\frac{\pi}{180} = \frac{12\times 6\times 1000^3}{\frac{\pi d^4\times 83000}{32}}$$

$d^4 = 16.87 \times 10^7$,

$d = (16.87 \times 10^7)^{0.25} = ((16.87 \times 10^7)^{0.5})^{1/2}$

$= \sqrt{13000}$

d = 113.98 mm

d = 114 mm

79. (c)

$$A = \frac{\pi}{4}(24^2 - 20^2) \Rightarrow 138.23\,cm^2$$

$$I_{min} \Rightarrow \frac{\pi}{64}(24^4 - 20^4)$$

$I_{min} = 8432.035\ cm^4$

$$r = \sqrt{\frac{I}{A}} = \sqrt{\frac{8432.035}{138.23}} = 7.81cm$$

$$P = \frac{f_C A}{1 + a\left(\frac{L}{r}\right)^2} = \frac{320\times 10^3\times 0.013823}{1+\left(\frac{1}{7500}\right)\times\left(\frac{150}{7.81}\right)^2}$$

P = 4216 N

80. (b)

Given d = 5 mm

θ = one complete revolution = 2π radian

$R = 2.5mm$

$\tau = 60N/mm^2$

We know, $\frac{T}{J} = \frac{\tau}{R} = \frac{G\theta}{L}$

$$\Rightarrow \quad L = \frac{G\theta R}{\tau}$$

$$= \frac{2.7\times 10^4\times 2\pi\times\left(\frac{5}{2}\right)}{60}$$

= 7.068 m

81. (b)

Energy is conserved in the process.

Let x = maximum extension of spring.

Increase in elastic potential energy = $\frac{1}{2}Kx^2$

Loss of gravitational potential energy = Mgx

$$\therefore \quad Mgx = \frac{1}{2}Kx^2 \Rightarrow x = \frac{2Mg}{K}$$

82. (c)

Shearing strain

$$\epsilon_{45^\circ} = \left(\frac{\epsilon_x + \epsilon_y}{2}\right) + \left(\frac{\epsilon_x - \epsilon_y}{2}\right)\cos 2\theta + \left(\frac{\phi_{xy}}{2}\right)\sin 2\theta$$

$$\Rightarrow \quad 400 = 200 + \frac{\phi_{xy}}{2}$$

$$\Rightarrow \quad \phi_{xy} = 400$$

83. (d)

Endurance limit is the stress level below which even large number of stress cycle can not cause fatigue failure.

- Thus it is an indication of stress level and not strain level.
- Endurance limit for structural steel is almost half of the ultimate strength.

84. (a)

Hoop stress is constant throughout the thickness in thin shells. However in thick shells it is maximum at inner face and minimum at outerface.

Radial presence is max inside = P and min = 0, outside. Radial pressure is normally neglected being very small as compared to hoop stress and longitudinal stress.

85. (a)

F > 32 Km.

$h_w = 0.032\sqrt{FV} = 0.032\sqrt{36\times 36}$

$= 36 \times 0.032 = 1.152$ m

86. (c)

Actual water supplied to field

$= 6\times 0.7 = 4.20$ cumecs

Area that can be irrigated

$= (\text{duty at field})\times\text{discharge}$

= 200 × 4.2 = 840 hectares

87. (c)

Storage capacity of soil

$$d = D\frac{\gamma_D}{\gamma_w}[F_C - \phi] = 0.10\times 80\times 1.5 = 12cm$$

88. (c)

Sinuosity of meander

$$= \frac{\text{Curve length of meander}}{\text{Straight length of meander}}$$

89. (c)

The infertility of the soil when an area becomes water logged is usually due to the following reasons :

1. Inhibiting activity of soil bacteria
2. Decrease in available capillary water
3. Fall in soil temperature.
4. Defective air circulation
5. Rise of salt
6. Delay in cultivation operations
7. Growth of wild flora
8. Adverse effect on community health.

90. (c)

Let $V_s = 1$

Initially :

$$e_1 = \frac{V_{v1}}{V_s}$$

$$V_{T1} = V_s(1+e_1) = 1.8$$

Finally :

$$e_2 = \frac{V_{v2}}{V_s}$$

$$V_{T2} = V_s(1+e_2) = 1.5$$

$$\therefore \text{ \% Volume loss} = \frac{1.8-1.5}{1.8}\times 100 = 16.67\%$$

92. (c)

Colluvial soils are formed near sloping ground due to gravity.

93. (d)

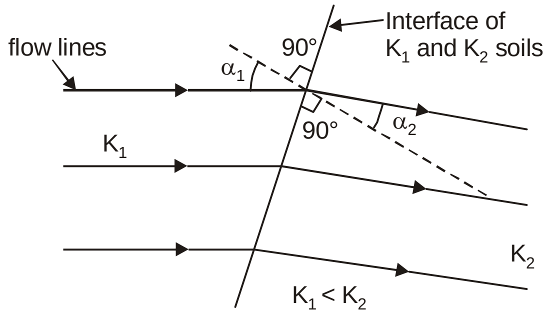
Load carried by skin friction

$$P = \alpha.C\times(\text{Perimeter}\times\text{length})$$
$$= 0.8\times 5\times(0.2\times 4\times 12)$$
$$= 38.4 \text{ KN}$$

94. (d)

Liquefaction is generally associated with sandy soil and not possible in normal clays due to cohesion between particles. However highly sensitive clays may undergo liquefaction under vibration.

95. (d)



- Flow lines get deflected at the junction because of change in permeability.
- Principle of continuity remains valid, so rate of flow is same in both soils.

$$\frac{K_1}{K_2} = \frac{\tan\alpha_1}{\tan\alpha_2}$$

$\therefore$ If $K_1 < K_2$ then $\alpha_2 > \alpha_1$.

$\therefore$ Flow lines are deflected away from normal.

96. (c)

$$T_V = \frac{\pi}{4}(U)^2$$

$$0.2 = \frac{\pi}{4}(U)^2$$

$U = 0.504$

$$U = \frac{\Delta h}{\Delta H}$$

$\Delta h = 0.504 \times 1$

≈ 0.5 m

97. (a)

Based on principle of effective stress, effective stress is equal to total stress minus pore-water pressure. It is the most important principle in soil mechanics.

Deformations of soils are a function of effective stress not total stresses.

Pore water pressure is isotropic and only can cause volumetric changes of soil solids, which is nearly incompressible. Pore water pressure does not cause displacement of soil solids or deformation of solids.

98. (b)

For filter criteria

$$5 < \frac{D_{15}(\text{filter})}{D_{15}(\text{Protected material})} < 20$$

D_{15} filter $> 5\ D_{15}$ (protected)

$$(D_{15})_f > 5 \times 0.01$$

$$(D_{15})_{filter} > 0.05\,mm$$

$$(D_{15})_{filter} < 20 \times D_{15}$$

$$D_{15} < 20 \times 0.01$$

$$D_{15} < 0.2\ mm$$

$$\frac{D_{15}(\text{filter})}{D_{85}(\text{protected})} < 5$$

$$(D_{15})_{filter} < 5 \times 0.1$$

$$(D_{15})_{filter} < 0.5\ mm$$

Hence D_{15} of filter material should be between 0.05 mm – 0.2 mm.

99. (d)

$$K = CD_{10}^2$$

$$= 0.4 \times 0.07 \times 0.07$$

$$= 1.96 \times 10^{-3}\ cm/sec$$

100. (d)

	Activity Value
Calcite	0.2
Quartz	0
Halloysite (hydrated)	0.1

101. (b)

Thrust of soil per unit length

$$\Rightarrow P = \frac{1}{2}K_a \gamma H^2$$

$$K_a = \frac{1-\sin\phi}{1+\sin\phi},\ K_{a1} = \frac{1}{3},$$

$$K_{a_2} = \frac{1-\frac{\sqrt{3}}{2}}{1+\frac{\sqrt{3}}{2}} = \frac{2-\sqrt{3}}{2+\sqrt{3}} = 7-4\sqrt{3}$$

Change in thrust per unit length

$$\Delta P = [K_{a1}\gamma_1 - K_{a2}\gamma_2] \times \frac{1}{2} \times H^2$$

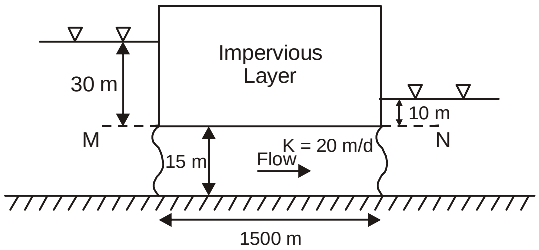
$$= \left[\frac{1}{3} \times 18 - (7-4\sqrt{3}) \times 15\right] \times \frac{1}{2} \times 25$$

$$= (6 - 105 + 60\sqrt{3}) \times \frac{1}{2} \times 25$$

$$= 4.923 \times \frac{1}{2} \times 25$$

$$= 61.538\,KN/m$$

104. (d)



$$i = \frac{30-10}{1500} = \frac{1}{75}$$

$$V = Ki = 20 \times \frac{1}{75} = 0.266\,m/day$$

$$V = nV_s \Rightarrow V_s = \frac{0.266}{0.30} = 0.88\,m/day$$

$$t = \frac{L}{V_s} = \frac{1500}{0.88} \times \frac{1}{365} = 4.6\,years$$

105. (b)

Effective Rainfall = $7.5 - 6 \times 0.25$ = 6 cm

Direct Runoff = 120 – 30 = 90 m^3/s

Peak Ordinate (Q_P) = $\frac{90}{6}$ = 15 m^3/s

106. (a)

The checking for inconsistency of a record is done by the double mass curve technique. This technique is based on principle that, when each recorded data comes from the same parent population, they are consistent.

In double mass curve technique datas are arranged in the reverse chronological order, and

$$P_{cx} = P_x \times \text{Correction Ratio}$$

where, P_{cx} = Corrected precipitation at any time period t_1 at station X.

P_x = Original recorded precipitation at time period t_1 at station x.

Here $t_1 < t$, where t is the time at which change in regime has been indicated. For $t_1 > t$, no adjustments are made.

$$P_{CX} = P_X$$

Therefore, year 1962 $P_{CA} = P_A$ = 163 mm

107. (a)

Hardwoods are from broad-leaved and seed producing trees which are usually ever green and found in the tropics.

108. (c)

Strictly speaking, plaster of paris is not a lime product but it has some similarities with lime.

109. (d)

Rapid hardening cement contains more C_3S and less C_2S than the OPC.

110. (d)

The clay and fines contents can be determined by immersing the aggregate in water and examining the suspended particles.

112. (b)

Air-cooled crystalline slag has no cementing properties.

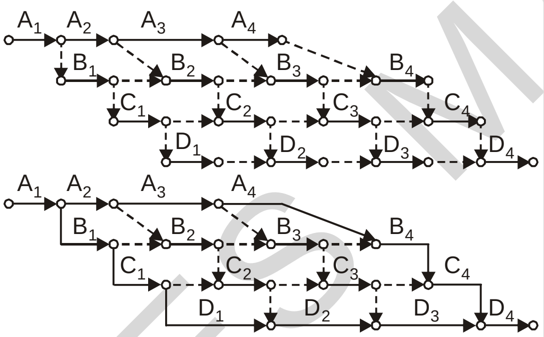
113. (a)

Use of well-dressed finished and polished stones on external walls provide better weathering resistance than rough stones.

116. (d)

Due to high thermal expansion of plastic which up to ten times that of steel, joints for plastics components require the provision for sufficient movement.

117. (d)



119. (a)

High toughness; Toughness index > 19

Moderate toughness; Toughness index 13–19

Not tough; Toughness index > 13

120. (a)

$$E_{cc} = \frac{E_c}{1+\theta} = \frac{50}{1+1.1} = \frac{50}{2.1} = 23.8 \text{ GPa}$$

121. (c)

Castigliano's theorem in applicable for analysis of linear structure.

123. (b)

Bent up bars are not satisfactory as they do not provide resistance to reversal of stresses.

125. (c)

When the level of prestressing is such that under tensile stresses due to service loads, the crack width is within allowable limit. It is called partial prestressing.

126. (b)

Both statements are true.

For example : corrosion is covered by specifying forms of protecting (like painting) and brittle fracture is covered by material specifications.

127. (b)

The prying force do not develop in case of ordinary bolts since when bolt failure take place, contact between the two connecting plates is lost.

128. (b)

The removal of phosphorous to prevent or reduce eutrophication is accomplished by chemical precipitation of ferric chloride, alum and lime.

When ferric chloride and alum are used, the chemicals may be added directly to the aeration tank in the activated sludge system. Thus, the aeration tank serves as a reaction basin. The precipitate is then removed in the secondary clarifier. This is not possible with lime since the high pH required to form the precipitate is detrimental to the activated sludge organisms.

129. (a)

Nitrification bacteria are autotrophs. They derive carbon for their growth from CO_2. Hence they have to spend energy reducing 'CO_2' to 'C'. Thus energy available for their reproduction is less, thereby growth rate is less.

130. (b)

Main sewer, is a sewer that collects all sewage from one or more laterals and conveys it to the trunk sewer. The trunk sewer conveys the sewage either to an intercepting sewer or directly to a sewage treatment plant through an outfall sewer. The trunk sewer is analogous to a tree trunk.

An intercepting sewer is a sewer that intercepts flows. It is a large conduit that intercepts flows from a number of trunk or main sewers. The sewer that conducts the sewage to a treatment plant is called an outfall sewer.

An outfall sewer is also the sewer that conducts the treated effluent from a treatment plant or the sewage from the collection system to a point of final discharge.

131. (b)

$$\underset{\text{(organic compound)}}{C_aH_bO_cN_d} + nH_2O \rightarrow mCH_4 + SCO_2 + dNH_3$$

132. (d)

Resection method of orientation is employed when the plane table ocupies a position not yet plotted on the drawing sheet.

133. (b)

In distorted models similarity is not met in all aspect between model and prototype and thus interpretation is difficult and largely depends on skill and experience of investigator.

135. (d)

Apparent viscosity decrease with $\frac{du}{dy}$ for pseudo plastic.

137. (a)

During strain hardening the material undergoes changes in crystalline structure, resulting in increased resistance of material to further deformation by loosing its ductility.

In order to bring back the lost ductility the process named Annealing is done which restores ductility and malleability.

138. (c)

In I-section more area is located farther away from neutral axis. Generally more than 80% of BM is resisted by the flanges only.

139. (a)

Submerged groynes gives better results if made permeable as compared to impermeable ones.

141. (c)

Assertion is correct.

Forces considered in friction circle method are

1. Weight of sliding mass
2. Total frictional force on slip surface.
3. Cohesive resistance along slip surface.

148. (d)

Wet milling usually requires a two-step process. In this process, the tile goes through a low-temperature firing called biscuit firing before glazing. The body and glaze are then fired together in a process called glost firing.

149. (a)