ESE-2017 PRELIMS TEST SERIES

Date: 13th November, 2016

CE–Test 9(OBJECTIVE SOLUTION)...

ANSWERS

1.	(a)	28.	(a)	55.	(c)	82.	(a)	109.	(d)	136.	(b)
2.	(c)	29.	(d)	56.	(d)	83.	(d)	110.	(c)	137.	(c)
3.	(b)	30.	(c)	57.	(a)	84.	(b)	111.	(d)	138.	(b)
4.	(b)	31.	(c)	58.	(b)	85.	(b)	112.	(b)	139.	(d)
5.	(c)	32.	(d)	59.	(c)	86.	(d)	113.	(d)	140.	(a)
6.	(b)	33.	(c)	60.	(b)	87.	(a)	114.	(b)	141.	(c)
7.	(b)	34.	(d)	61.	(b)	88.	(a)	115.	(c)	142.	(d)
8.	(b)	35.	(c)	62.	(d)	89.	(c)	116.	(c)	143.	(a)
9.	(d)	36.	(b)	63.	(d)	90.	(b)	117.	(c)	144.	(d)
10.	(d)	37.	(d)	64.	(c)	91.	(a)	118.	(d)	145.	(a)
11.	(a)	38.	(a)	65.	(c)	92.	(a)	119.	(d)	146.	(b)
12.	(a)	39.	(d)	66.	(d)	93.	(c)	120.	(c)	147.	(a)
13.	(b)	40.	(a)	67.	(c)	94.	(b)	121.	(a)	148.	(a)
14.	(b)	41.	(b)	68.	(b)	95.	(c)	122.	(b)	149.	(a)
15.	(d)	42.	(d)	69.	(c)	96.	(a)	123.	(c)	150.	(b)
16.	(c)	43.	(d)	70.	(b)	97.	(c)	124.	(b)	151.	(a)
17.	(b)	44.	(c)	71.	(a)	98.	(c)	125.	(d)	152.	(b)
18.	(c)	45.	(d)	72.	(b)	99.	(c)	126.	(a)	153.	(a)
19.	(b)	46.	(d)	73.	(b)	100.	(b)	127.	(d)	154.	(b)
20.	(a)	47.	(c)	74.	(b)	101.	(d)	128.	(c)	155.	(a)
21.	(a)	48.	(a)	75.	(b)	102.	(b)	129.	(d)	156.	(d)
22.	(b)	49.	(b)	76.	(d)	103.	(c)	130.	(c)	157.	(a)
23.	(b)	50.	(d)	77.	(b)	104.	(b)	131.	(c)	158.	(d)
24.	(c)	51.	(d)	78.	(d)	105.	(d)	132.	(d)	159.	(a)
25.	(c)	52.	(b)	79.	(b)	106.	(c)	133.	(d)	160.	(d)
26.	(b)	53.	(a)	80.	(b)	107.	(b)	134.	(b)		
27.	(c)	54.	(d)	81.	(a)	108.	(d)	135.	(d)		

1. (a)

$1\ \text{kgf/cm}^2 = 1 \times 9.81 \times 10^4\ \text{N/m}^2$

$= 98.1\ \text{kN/m}^2$

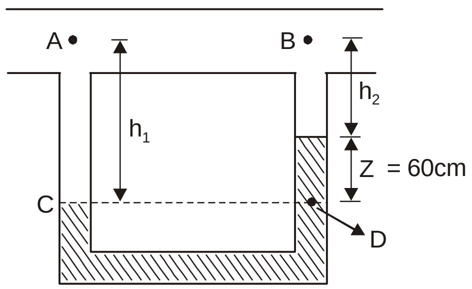
In terms of head of water $\rightarrow$

$\gamma_w \times H = 98.1$

$9.81 \times H = 98.1$

$H = 10\text{m of water}$

2. (c)



Equating the pressure at C and D,

$P_A + h_1\gamma_w = P_B + h_2\gamma_w + z \times 13.6 \times \gamma_w$

$h_1 = h_2 + Z$

$h_2 - h_1 = -Z$

$P_A - P_B = (h_2 - h_1)\gamma_w + Z \times 13.6\ \gamma_w$

$P_A - P_B = -Z\ \gamma_w + 13.6 \times z\gamma_w$

$P_A - P_B = Z\gamma_w\ (13.6 - 1)$

$\frac{P_A - P_B}{\gamma_w} = Z \times 12.6 = 60 \times 12.6$ cm of water

3.(b) Magnetic bearing of line OE

= 185 – 1.5

= 183.5

TB = M.B ± Declination = (183.5 + 3.5° E) = 187°

[T.B = 187°]

4. (b) Euler's equation of pressure gradient

$-\frac{dp}{dx} = pa_x$

So $\frac{dp}{dx} = -1000\ a_x$

$a_x = \frac{\text{change in velocity}}{\text{time}}$

Charge in velocity

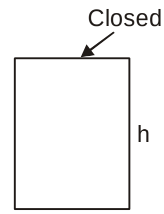
$= \frac{Q_2 - Q_1}{A} = \frac{0.5 - 0.1}{\frac{\pi}{4} \times 0.3^2} = 5.6588\ \text{m/sec}$

$a_x = \frac{5.6588}{5} = 1.1317\ \text{m/sec}^2$

So $\frac{dp}{dx} = -1000 \times 1.1317 = -1131.7$

$= -1132$ Pa/m

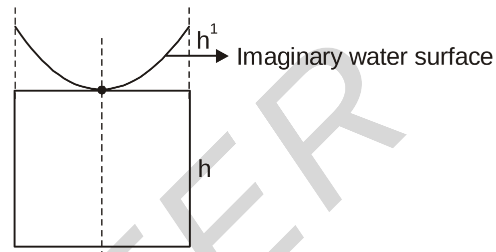
5. (c) When cylinder was stationary



Pressure at bottom at centre = ρgh

When cylinder rotated at any speed

Pressure at centre of bottom = ρgh



So unchanged

6. (b) $T = 2\pi\sqrt{\frac{I}{w\ GM}}$ [I = mass moment of inertia]

GM = BM–BG

BG = 2m

$BM = \frac{I}{V}$

For volume, $\gamma_w \times V = 4000 \times 1000$

$V = 4000\text{m}^3$

So $BM = \frac{10000}{4000} = 2.5\text{m}$

So $GM = 2.5 - 2 = 0.5\text{m}$

$I' = mK^2$

$\frac{I'}{m} = K^2$

$T = 2\pi\sqrt{\frac{I'}{mg \times 0.5}}$

$T = 2\pi\sqrt{\frac{K^2}{g \times 0.5}}$

$T = 2\pi\sqrt{\frac{4^2}{10 \times 0.5}}$

$T = 2\pi\sqrt{3.2}$

T = 11.24 second

7. (b)

$\rightarrow$ A object will sink more in lighter liquid.

$\rightarrow$ $I_{\text{pitching}} > I_{\text{rolling}}$

So more stable in pitching.

$\rightarrow$ If small displacement in vertical direction is given to a floating body, a restoring force will be generated in vertical direction so it would be in stable condition.

→ A submerged body will have constant Buoyant force so it can not generate additional restoring force.

It would be in neutral equilibrium

8. (b) Minimum area will be when the top surface of ice block will coincide with water surface and block is on the verge of submergence.

So $h = 1m$

Volume = Ah

$5000 + Ah \times 0.69 \times 1000 = Ah \times 1000$

$A = 16.13m^2$

9. (d) $a_n = \dfrac{dV_n}{dt} + \dfrac{V^2}{r}$

or $a_n = \dfrac{\partial V_n}{\partial t} + V_s \dfrac{\partial V_n}{\partial s}$

So V_n = normal velocity

= 0

$a_n = \dfrac{V^2}{R} = \dfrac{2^2}{1} = 4$

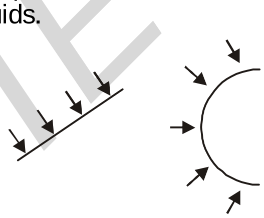
10. (d) The fluid which has viscosity, will generate shear stress when flow. This shear stress will generate a torque on fluid particles and there will be rotation of fluid particles.

It is not necessary that cirular path flow is rotational and linear path flow is irrotational.

So (d) option is correct.

11. (a)

→ Pressure force will always act perpendicular to the surface in static fluids.



→ C.P. = $\bar{h} + \dfrac{I\sin^2\theta}{A\,\bar{h}}$

$\bar{h}$ = centroid of surface.

So C.P. will always lie below the centroid of the surface except when the surface is horizontal ($\sin\theta = 0$) in the which case both, C.P and centroid of surface will coincide.

12. (a) $F = \bar{h} \times \gamma_w \times A$

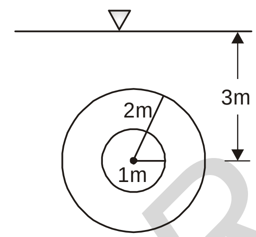
A is same in both cases

C.G. of area will lie towards the longer side b

So $\bar{h}$ will be greater in case I

So F will be higher in case I

13. (b) $F = \bar{h} \times \gamma_w \times A$

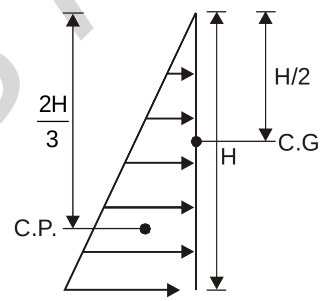


$F = 3 \times 10 \times \pi(2^2 - 1) \times 0.8$

$F = 90 \times 0.8\pi$ kN

$F = 72\pi$ kN

14. (b)



So C.P. will be at the centroid of the pressure prism.

15. (d)

16. (c)

Let total BOD to be applied to the first stage = 100 mg/l

∴ BOD in the effluent of first stage

$= 100 \times \dfrac{(100-65)}{100} = 35$ mg/l

∴ BOD in the effluent of 2nd stage

$= 35 \times \dfrac{(100-65)}{100} = 12.25$ mg/l

∴ Overall BOD removal efficiency of these filters

$= \dfrac{(100-12.25)}{100} \times 100 = 87.75\%$

17. (b)

BOD load = 768 kg/day = 32 kg/hr

As there are two installed pumps, then load for each pump = 16 kg/hr

∵ Oxygen transfer capacity of each pump = 0.8 kg of O_2/HP/hour

$\therefore$ Capacity of each aerator = $\frac{16}{0.8}$ = 20 HP

18. (c)

Let its volume be v_1 at a moisture content of p_1(%) and v at a moisture content of p(%).

∵ $v(100 - p) = v_1(100 - p_1)$

$\Rightarrow$ $14(100 - 94) = v_1 \times 16$

$\Rightarrow$ $v_1 = \frac{14 \times 6}{16} = 5.25 \text{ m}^3$

19. (b)

Septic tanks : A septic tank may be defined as a primary sedimentation tank with a longer detention period (12 to 36 hrs, against a period of 2 hrs in an ordinary sedimentation tank) and with extra provision for digestion of the settled sludge. Since the digestion of the settled sludge is carried out by anaerobic decomposition process, the septic tank unit is generally classified under the units which work on the principle of anaerobic decomposition of the settled sludge.

Imhoff tank : An imhoff tank is an improvement over septic tank in which the incoming sewage is not allowed to get mixed up with the sludge produced and the outgoing effluent is not allowed to carry with it large amount of organic load as in the case of a septic tank.

Sludge digestion tank : The sludge withdrawn from the sedimentation basins contain a lot of putrescible organic matter and if disposed of without any treatment the organic matter may decompose producing foul gases and a lot of nuisance, pollution and health hazards. In order to avoid such pollutions, the sludge is first of all, stabilised by decomposing the organic matter under controlled anaerobic conditions and then disposed of suitably after during on drying beds, etc.

Trickling filter : The decomposition of the organic matter and the resultant purification of the sewage is brought about by a population of micro-organisms. Micro-organisms and bacteria get attached to the filter media. In order to ensure the large scale growth of the aerobic bacteria in the biofilm, sufficient quantity of oxygen is supplied by providing suitable ventilation facilities in the body of the filter.

20. **(a)**

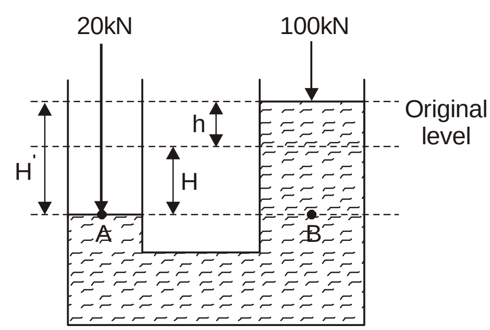
- Effluent obtained from the trickling filters is sufficiently nitrified and stabilised. They can remove about 75% of BOD and about 80% of suspended solids.
- Oxidation ditch : The quality of the effluent obtained is quite good with suspended solids removal at about 95% and BOD removal at about 98%.
- **Aerated lagoons:** The efficiency obtained ranges between 65 to 90%.
- Oxidation pond : Properly operated ponds may be as effective as trickling filters in reducing the BOD of sewage. The BOD removal is upto 90% and coliform removal is upto 99% or so.

21. (a) Volume displaced by plunger

$P_1 = H \times 1$

$\Rightarrow$ Volume added to limb of plunger

$P_2 = h \times 10$



$H \times 1 = h \times 10 \quad h = \frac{H}{10}$

$\Rightarrow$ Writing pressure equality at A and B

$$\frac{20}{1} = \frac{100}{10} + H' \times 10 \Rightarrow H' = 1\text{m}$$

22. **(b)** Chemical Coagulation is adopted in treating raw water supplies and helps in sedimentation of unsettleable micro and colloidal impurities which get absorbed in the gelatinous flocs formed by the chemical reactions between coagulants or between the coagulant and the alkalies present in raw water.

However, in treatment of industrial waste - water such chemicals are generally added to help out the precipation of dissolved and troublesome impurities such as phosphorous or phosphoric compounds, etc. This process is then popularly known as chemical precipitation. The alum or ferric salts like ferric chloride or ferric sulphate may be used to directly precipitate out phosphorous. Lime will initially react with natural bicarbonate alkalinity to precipitate $CaCO_3$ and then excess lime will react with phosphorous to precipitate hydroxylapatite as given below-

$$10Ca^{++} + 6PO_4^{--} + 20H^- \rightleftharpoons \underset{\text{Hydroxylapatite}}{Ca_{10}(PO)_6(OH)_2} (\downarrow)$$

Chemical precipitation, though introduces additional chemicals in wastewater and produces larger quantity of sludge, yet is generally adopted these days for removing organic compounds like phosphorous and also sometimes for removing nutrients like nitrogen from specific industrial waste water. Toxic metals may also sometimes be precipitated out by using and developing appropriate chemical processes.

23. (b) Primary sewage treatment in a septic tank is anaerobic because any oxygen in the tank is rapidly consumed. Some organic material, called biochemical oxygen demand (BOD), is removed in the septic tank by anaerobic digestion and settlement. For typical residential wastewater, primary treatment by septic tanks can provide for approximately 40% to 60% removal of both BOD_5 and TSS if the tank is sized for a detention time of three to four days.

24. (c)

25. (c)

correction = $l\alpha\Delta T$

= 0.0000112 (15–20) × 30

= – 0.00168 m

error = + 0.00168 m

26. (b) Aberration leads to formations of indistinct (or blurred) image of an object or an indistinct image with prismatically coloured images. They are of two type spherical aberration and chromatic aberration.

Achromatism is the absence of chromatic aberration. Applanation is the absence of spherical aberration. These two are not the errors but the desired characteristics of a telescope.

Parallax is the defect of telescope due to which image formed by objective is not in the same plane with cross hairs.

27. (c)

$$\text{Incomming BOD} = 2000\,\frac{m^3}{day} \times \frac{400\times10^{-6}\,kg}{10^{-3}\,m^3}$$

$= 800$ kg/day

VSS produced = 0.25 × 0.9 × 800

= 180 kg/day

$\Rightarrow$ Phosphorus removal along with

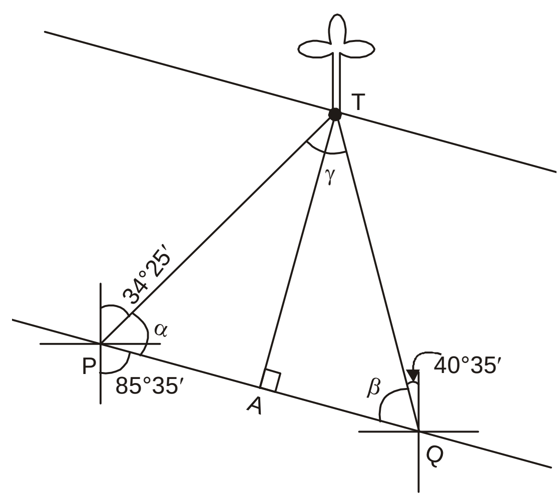
$$\text{VSS} = \frac{2}{100}\times 180 = 3.6 \text{ kg/day}$$

28. (a)

29. (d)

30. (c) Hypsometric levelling is indirect levelling in which difference of elevation is determine by noting down the temperature at which water start boiling.

31. (c)



$$\alpha = 180 - 34°25' - 85°35' = 60°$$

$$\gamma = 34°25' + 40°35' = 75°$$

$$\beta = 180 - 60 - 75$$

$$= 45°$$

$$\frac{PT}{\sin\beta} = \frac{PQ}{\sin\gamma}$$

$$PT = PQ \times \frac{\sin\beta}{\sin\gamma}$$

$$TA = PT \sin\alpha$$

$$= pQ\frac{\sin\beta}{\sin\gamma}\sin\alpha = \frac{367 \times \sin 45° \times \sin 60°}{\sin 75°}$$

= 232.62 m

32. (d) Correction due to mean sea level

$$C_n = -\frac{Lh}{R} \text{ (R>>h)}$$

$$= \frac{3500 \times 200}{7000 \times 1000} m$$

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

= –10 cm

So correct/equivalent lenth

= 3500 m – 10 cm

= 3499.9 m

33. (c) Random error $\propto \frac{1}{\sqrt{N}}$

levelling random error $\propto \sqrt{L}$

34. (d)

35. (c)

36. (b) Detention time, $t = \frac{\text{Volume of the tank}}{\text{Rate of flow}}$

$$= \frac{2500}{25 \times 10^6 \times 10^{-3}} = 0.1 \text{ day} = \frac{24}{10} \text{ hr}$$

37. (d)

Volume of septic tank = 7 m^3

Rate of accumulation of sludge = 70 lit/capita/year

∴ Rate of accumulation of sludge = 70 × 5 lit/year

= 350 lit/year = 0.35 m^3/year

∵ Sludge is removed when it occupies 50% of its volume (i.e. 3.5 m^3)

∴ Interval of cleaning = $\frac{3.5}{0.35}$ = 10.00 year

38. (a)

39. (d)

$$S_f = S_p\left[\frac{B_f\,(B_p + 0.3)}{B_p\,(B_f + 0.3)}\right]^2$$

$$= 12\left[\frac{1.2\,(0.4 + 0.3)}{0.4\,(1.2 + 0.3)}\right]$$

= 23.52 mm

40. (a) Combined correction C = 0.0673 d^2

C = 0.0673 × $(1.8)^2$

C = 0.218 m

41. (b) From Arithmetic check, we know

$\sum B.F. - \sum F.S =$ Last R.L. – First R.L

So Last R.L.$= (\sum B.F. - \sum F.S) +$ First R.L

=(11.395 – 10.956) + 100

=0.439 + 100

=100.439 m

42. (d)

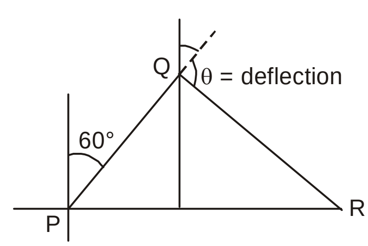
43. (d) The sensitivity of a level tube can be increased by:

1. Increasing the radius R
2. Decreasing the viscosity of the liquid
3. Increasing the length of tube
4. Increasing the diameter of the tube
5. Decreasing the ronghness of inner walls of the tube

44. (c)

45. (d)

46. (d)



Q = 130 – 60 = 70°

47. (c) In facultative ponds, both aerobic and anaerobic zones exist.

48. (a)

49. (b)

50. (d) In dumply level telescope is non-movable and in wye level telescope is movable

51. (d)

52. (b) Temprary adjustment of a level consist:

1. Setting up of the level
2. Levelling up
3. Elimination of parallax

53. (a)

1. If the tank is not properly functioning, which happen many a times then the effluents will be very foul, dark and even worser than influenct.
2. They require to large areas and sizes for serving many people.
3. The working of the septic tank is highly unpredicable as is covered entirely which makes it difficult to know & understand its operation.
4. The sludge to be disposed of is quite less as compared to that in normal sedimentation tak. The quantity is reduced due to digestion taking place in tank itself.

54. (d) The initial Carbon/Nitrogen ratio and the moisture content are the two important factors controlling success of anaerobic digestion and composting.

C/N of input material in compost heap is an important factor for the bacterial activity to continue and for proper development of anaerobic digestion. C/N ratio of the digestive material should be 30–50 for optimum digestion.

An optimum moisture content of say about 55% has to be maintained for proper digestion.

55. (c) If C_P is the correction for pull, we have

$$C_P = \frac{(P - P_0)\,L}{AE}$$

where P = Pull applied during measurement (N)

P_0 = Standard pull (N)

L = Measured length (m)

A = Cross-sectional area of the tape (cm^2) E = Young's modulus of elasticity (N/cm^2)

Here L = 1500 m, P_0 = 100 N, P = 150 N

$$\therefore \quad C_P = \frac{(150-100)\,1500}{AE} = \frac{50 \times 1500}{AE}$$

56. (d) On the upstream slope, the seepage forces are directed inwards and hence tend to increase the stability. However, on the downstream slope, the direction of the seepage forces is such that they decrease the stability. The steady seepage condition is, therefore, critical for the downstream slope of an earth dam.

57.(a) True bearing of the line = 6º32' + 1º = 7º32'

As the true bearing of the line never change, the present true bearing will also be 7º32'

present true bearing = maganetic bearing + 9º42'

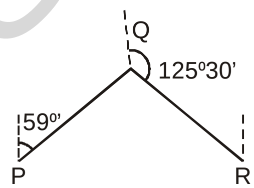
$\therefore$ 7º32' = magnetic bearing + 9º42'

$\therefore$ magnetic bearing = 7º32' – 9º42' = – 2º10'

= 360º – 2º10'

= 357º50'

58. (b)



Station Q is locally attracted.

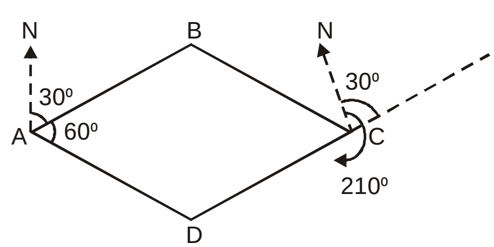
Line	FB	BB	Correction at Q
PQ	59º0'	239º0'	+ 4º0'
QR	129º30'	309º30'	

$\therefore$ ∠PQR = FB of line QR – BB of PQ

= 129º30' – 239º0' = – 109º30'

(interior included angle)

59. (c)



$\because$ AB||DC

$\therefore$ bearing of line DC is 30º

$\therefore$ bearing of CD = 30º + 180º = 210º

60. (b)

61. (b)

62. (d)

63. (d)

64. (c)

$q_u = CN_c + qN_q + 0.5\gamma\ BN\gamma$

$q_u = 50 \times 8 + 20\times1 \times 3 + 0.5 \times 20 \times 2.0 \times 2.0$

$q_c = 500\ kN/m^2$

Net ultimate bearing capacity

$q_{nu} = q_u - 20 \times 10$

$q_{nu} = 480\ kN/m^2$

Safe bearing capacity

$$q_{ns} = \frac{q_{nu}}{F.O.S.} = \frac{480}{3}$$

$q_{ns} = 160\ kN/m^2$

$q_s = q_{ns} + \gamma D_f = 160 + 20 \times 1$

$q_s = 180\ kN/m^2$

Total safe load = $q_s \times A$

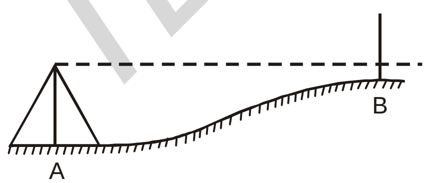
= 180 × 10 × 2

$\boxed{F_{safe} = 3600\ kN}$

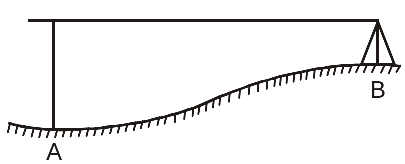
65. (c)

66. (d) It is not necessary that n_f and n_d be integers. The flow under a sheet pile wall and flow under a concrete dam are cases of confined flow since all the boundary conditions are completely defined. The flow through an earth dam is unconfined flow since the top line is not definitely defined (in advance of constructing the flow net).

67.(c)



Point B = 1.540–0.705 = 0.835 m above A



Point B is 2.195 – 1.490 = 0.705 m above point A

∴ Difference in level between A and B

$$= \frac{0.835 + 0.705}{2} = 0.77\ m$$

68.(b) here,

S = 0.05 m

L = 100 m

n = 10

∴ sensitivity of the bubble tube

$$\phi = \frac{s}{L \times n} = \frac{0.05}{100 \times 10}\ \text{radians}$$

$$= \frac{0.05}{100 \times 10} \times 206265\ \text{second}$$

= 10.31" of arc.

69. (c) Clasc 5.3.1 of IS 456 : 2000

70. (b) Instrument at A. Apparent difference

= 2.550 – 1.753 = 0.797 m

Instrument at B. Apparent difference

= 2.895 – 2.080 = 0.815 m

$$\text{Therefore true difference} = \frac{0.797 + 0.815}{2}$$

= 0.806 m

Therefore RL of Y = 90.37 – 0.81

= 89.56 above datum

71. (a) $B_\omega = 300\ mm = \text{width of web}$

$d = 120 + 300 - 40 = 380\ mm$ effective depth

percentage of steel,

$$\rho = \frac{100As}{b_\omega d} = \frac{100 \times \frac{\pi}{4} \times 22^2 \times 4}{300 \times 380}$$

= 1.33%

$$\tau_c = 0.67 + \frac{0.72 - 0.67}{1.50 - 1.25}(1.33 - 1.25)$$

$= 0.69\ N/mm^2$

$$\tau_c = \frac{V_a}{bd} = \frac{200 \times 1000}{300 \times 380} = 1.75\ N/mm^2$$

$\tau_{us} = 1.75 - 0.69 = 1.06 N/mm^2$

Design shear stress for vertical strips

$\tau_{us} = 1.06 N/mm^2$

72. (b)

73. (b)

74. (b) $$\tau_V = \frac{V_u}{t_w d_w}$$

$$t_w = 150\,mm$$

$$d_w = 0.8\, l_w = 0.8 \times 3000 = 2400\,mm$$

$$\tau_v = \frac{240 \times 10^3}{150 \times 2400} N/mm^2$$

$= 0.67\ N/mm^2$

75. (b) Using compression steel provides ductility.

Section with high tensile steel ratio may become over reinforced (less ductile)

76. (d) In case of beam member it is difficult to define a unique ductility ratio, it could be in terms of (a), (b) or (c).

77. (b) The induced force is less in elastoplastic response than that is elastic response but the maximum deflection is more.

78. (d) Minimum reinforcement prevents sudden failure due to transfer of stresses to steel on cracking.

79. (b) Option (a) corresponds to minor earthquake case

Option (c) corresponds to major earthquake case

80. (b)

81. (a)

$$b_f = \frac{l_0}{\frac{l_0}{b} + 4} + b_w$$

$= 1050$

82. (a) For SS deep beam, $\frac{l}{D} < 2.0$

83. (d) clause 23.2 (b) of IS 456

84. (b)

$$\frac{\text{span}}{\text{effective depth}} = 20 \times \frac{10}{\text{span}} \times mf_f \times m_{f_c} \times m_{f_b}$$

m_{ft} = modification factor for tension reinforcement

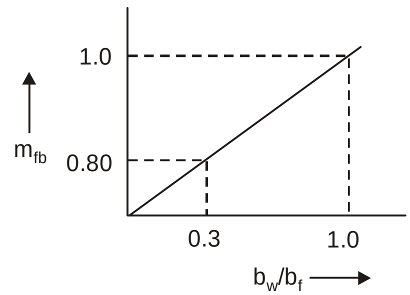
m_{fc} = modification factor for compression reinforcement

m_{fb} = modification factor for type of beam

$m_{ft} = 1.0$

$m_{fc} = 1.2$

$$\frac{b_w}{b_f} = \frac{150}{300} = 0.5$$



$\therefore$ m_{fb} for $\frac{b_w}{b_f} = 0.5$ is

$$m_{fb} = 0.80 + \frac{1.0 - 0.80}{1.0 - 0.3} \times (0.5 - 0.3)$$

$= 0.857$

$$\therefore \quad \frac{12}{d} = 20 \times \frac{10}{12} \times 1.0 \times 1.2 \times 0.857$$

$\Rightarrow$ $d = 0.700\ m$

$$\boxed{d = 700\,mm}$$

85. (b) For cold worked deformed bars, minimum (internal) turning radius 'r' is specified as 4ϕ.

86. (d) Minimum strain in steel at collapse ensures ductile failure i.e., under reinforced section. This restricts depth of neutral axis.

87. (a) $A_{st} = 8 \times \frac{\pi}{4} \times 25^2 = 3927\ mm^2$

$$x_u = \frac{0.87 \times fy \times A_{st}}{0.36 f_{ck} b} = \frac{0.87 \times 415 \times 3927}{0.36 \times 20 \times 400}$$

$x_u = 492.30\ mm$

$x_{u.lim} = 0.48 \times 550 = 264\ mm$

$x_u > x_{u.lim} \Rightarrow$ over reinforced section,

$\therefore\ x_u = x_{u.lim} = 264\ mm$

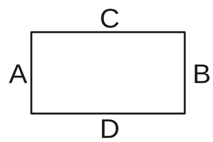
$mu = 0.36 \times fc_k\ b\ x_u\ (d - 0.42\ x_u)$

$m_{u.lim} = 0.36 \times 20 \times 400 \times 264 \times (550 - 0.42 \times 264)$

$= 333.87\ kNm.$

88. (a) Limiting depth of neutral axis does not depend on stress strain variation.

89. (c) Secondary reinforcement are provided in direction perpendicular to main reinforcement and main reinforcement are provided in the direction of bending which depends upon support conditions.



If the slab support on edges A and B only then longer span will be direction of main reinforcement and distributory steel will be provided in shorter span.

90. (b) When the cantilever is continuous

$$l_{eff} = l_{clear} + \frac{a}{2}$$

a = support thickness

When the cantilever terminate to support

$$l_{eff} = l_{clear} + \frac{d}{2}$$

d = depth of cantilever

So, $$l_{eff} = 2000 + \frac{200}{2}$$

$$= 2100 \text{ m}$$

91. (a) $$K \propto \frac{\gamma_w}{\mu_w} \left(\text{i.e., } \frac{\text{unit wt. of fluid}}{\text{viscocity of fluid}} \right)$$

$$k \propto \frac{\gamma_1}{\mu_1}$$

$$k_2 \propto \frac{0.9\gamma_1}{0.8\mu_1}$$

$$k_2 = 1.125\ k_1$$

92. (a) Length of Arc AB,

$$L_a = \frac{2\pi \times 24}{360} \times 65$$

$$= 27.21 \text{ m}$$

Acting moment, $m_0 = 2518 \times 11$

$= 27698$ kN-m

Resisting moment, $m_r = cL_a r = 50 \times 27.21 \times 24$

$= 32652$ kN-m

$$\text{Factor of safety} = \frac{32652}{27698} = 1.18$$

93. (c)

- In case of confined flow between two water bodies hydralic grade line varies linearly h_0 to h_1

$$h = h_0 + \frac{x}{L}(h_1 - h_0)$$

- water surface in case of unconfined aquifer is a parabola.

$$h^2 = h_0^2 - (h_0^2 - h_1^2) \times \left(\frac{x}{L}\right)$$

94. (b) Length of aquifer between two observation wells

$$= \frac{60}{\cos 10°} = 60.61\text{m}$$

$$\frac{h}{L} = i = \text{hydraulic gradient} = \frac{5.0}{60.61} = 0.0825$$

From Darly's law, discharge per unit width

q = kiA

$= 0.7 \times 10^{-3} \times 0.0825 \times (2.95 \times 1)$

$= 0.70 \times 10^{-3}$ m³/sec.

$= 0.170$ lit./sec.

95. (c)

$$k_0 = 1 - \sin\phi = 1/3$$

$$\Rightarrow \sin\phi = 1 - 1/3 = 2/3$$

$$K_a = \frac{1 - \sin\phi}{1 + \sin\phi}, \quad K_P = \frac{1 + \sin\phi}{1 - \sin\phi}$$

$$K_a = 1/5 \qquad K_P = 5$$

$$K_p/K_a = 25$$

96. (a)

97. (c) The dynamic formulas are useful for determining the ultimate load carrying capacity of coarse grained soils, for which the shear strength is independent of the rate of loading, because they allow no development of excess pore pressure around the pile during driving, if saturated or dry.

The static formulas are used for clayey soils, while the static as well as dynamic formulas both, are used for sandy soils.

98. (c) $$V_a = \frac{V}{n} = \frac{k\left(-\frac{dh}{dl}\right)}{n}$$

$$= \frac{12.5\left[-\frac{(206.25 - 210.5)}{350}\right]}{0.15}$$

$= 1.012$ m/day

99. (c)

100. (b)

101. (d) $N_c = 6\times\left(1+0.2\frac{D_f}{B}\right)$

$N_c = 6\times\left(1+0.2\times\frac{1.5}{2}\right)$

$= 6.9$

$q_{nu} = 5 \times 6.9 = 34.5 \text{ t/m}^2$

$q_{ns} = \frac{34.5}{3} = 11.5 \text{t/m}^2$

102. (b) Let spacing = S

Width of pile block = 2s + d = 2s + 0.2

$Q_g = \cancel{q_p}^{0} Ag + \propto C(P_g \times L)$

$\left[\begin{array}{l} A_g = \text{base area of group} \\ P_g = \text{Perimeter of group}\end{array}\right.$

$C_u = \frac{q_u}{2}$

$Q_g = 0.6 \times \frac{100}{2} (2s + 0.2) \times 4 \times 10$

$= 1200 (2s + 0.2)$

Individual pile capacity = $0.6\times\frac{100}{2}(\pi\times 0.2)\times 10$

= 188.50 kN

Since there are 9 piles

$\Rightarrow$ Total capacity = 9 × 188.50

= 1696.46 kN

1200 (0.2 + 2s) = 1696.46

S = 0.61 m

103. (c) N value is noted after 150 mm penetration

$\therefore$ Initial N value =12 + 12 + 16 + 20 = 60

After overburden correction N_o = 60 × 1.1

= 66

$\therefore$ After Dilatency correction

$N = 15 + \left(\frac{66-15}{2}\right)$

= 40.5

104. (b)

$\gamma_d = \frac{G_s\gamma_w}{(1+e)} = \frac{9.81\times 2.65}{1.6} = 16.25 \text{ kN/m3}$

$\gamma_{sat} = \frac{(G_s+e)\gamma_w}{(1+e)} = \frac{9.81(2.65+0.6)}{1.6}$

$= 19.93 \text{ kN/m}^3$

$\gamma_{sub} = 19.93 - 9.81 = 10.12 \text{ kN/m}^3$

$\sigma'_H = 0.5 \times 16.25 \times 2 + 0.5 \times 10.12 \times 3$

= 31.43 kN/m2

$\upsilon_H = 9.81 \times 3 = 29.43 \text{ kN/m}^2$

$\sigma_H = 31.43 + 29.43 = 60.86 \text{ kN/m}^2$

105. (d)

106. (c)

$K = \frac{2.303\, a\cdot L}{A\cdot t}\log\frac{H_1}{H_2} \Rightarrow \left[\frac{2.303\times 1\times 10}{20\times 380}\log_{10}\frac{100}{10}\right]$

= 0.00303 cm/s.

107. (b)

The factor of safety of slope against shear failure is given by $F_S = \frac{\tan\phi}{\tan\beta}$, from which

if $\phi = \beta$ Slope is just stable

$\phi < \beta$ slope is unstable

$\phi > \beta$ slope is stable

108. (d)

Face failure or slope failure can occur when the slope angle β is very high and the soil close to toe is quite strong.

Base failure occur when the soil below the toe is relatively weak and soft.

Toe failure occur in steep slopes when the soil mass above the base and below the base is homogenous.

109. (d)

110. (c)

Depth of tension crack = $\frac{2Cu}{\gamma}$

$= \frac{2\times 1000}{2} = 1000 \text{ cm}$

= 10 m

111. (d)

As per terzhagi

$a_u = cN_c + \gamma D_F N_q + 0.5\, B\gamma N\gamma$

For Purely cohesive soil,

$N_\rho = 1$ and $N_\gamma = 0$

$\therefore \; \gamma_{uH} = CN_C + \gamma D_F$

$\rho_{net\ ultimate} = \rho_u - \gamma D_F$

$= CN_C$

112. (b)

113. (d)

114. (b)

115. (c)

load carried by skin friction only = $\alpha \times C \times P \times L$

$= 0.8 \times 5 \times 0.4 \times 4 \times 10$

$= 64$ kN

116. (c)

$Q_u = cN_C A_p + \alpha \bar{c} A_S$

$Q_u = (40 \times 9.0) \times \frac{\pi}{4} \times (0.3)^2 + 0.7 \times 40 \times (\pi \times 0.3) \times 10$

$= 289.2$ kN

$Q_a = \frac{Q_u}{2.5} = \frac{289.2}{2.5} = 115.7$ kN

117. (c)

118. (d)

Change in ground water storage

$= 160 \times 10^6$ m^3

$160 \times 10^6 = 80 \times 10^6 \times 4 \times S_y$

$S_y = 0.5$

$n = S_y + S_R = 0.5 + 0.15$

$= 0.65$

119. (d)

- Coefficient of transmissibility is defined as the discharge through aquifer per unit length of aquifer.
- Specific storage of an aquifer is solely due to compression of aquifer and expansion of water.
- In confined aquifer, the ground water occurs under pressure known as artesian pressure.

120. (c) Apparent velocity of seepage = Ki

$= 12 \times \frac{5}{60}$

$= 1$ mm/sec.

121. (a)

122. (b)

- Aquitard is a formation through which only seepage is possible but yield is insignificant example sandy clay.

123. (c)

- The unconfined aquifer is in direct contact with atmosphere through zone of aeration.

124. (b) **Specific yield :** Volume of water that can be extracted by force of gravity from a unit volume of acquifier material

Specific retention: Fraction of water held back in acquifer after extraction by force of gravity from a unit volume of acquifer.

Porosity (n) = Specific yield + Specific retention storage coefficient aka storativity : it represents volume of water released by a column of a confined acquifer of unit cross-sectional area under a unit decrease in piezometric head.

It is a dimensionless parameter.

125. (d) Trap efficiency = $f_n\left(\frac{\text{Capacity}}{\text{Inflow}}\right)$

126. (a)

127. (d)

- Clark's method of IUH also known as Time-area histogram aims at developing IUH.
- A isochrone is a line on the catchment map joining points having equal time of travel of surface runoff.

128. (c) Convert 2 h unit hydrograph to 6-h unit hydrograph

Time	2 h UH	lag by 2h	lag by 4h	Ordinate of DRH	6 h UH
0	0	-	-	0	0
2	3	0	-	3	1
4	7	3	0	10	3.33
6	5	7	3	15	5
8	2	5	7	14	4.66
10	1	2	5	8	2.66
12	0	1	2	3	1
		0	1	1	0.33

129. (d) $Q = \left(\frac{2.303}{10}\log\frac{3}{0.3}\right)\times 10\times 1.0$

$= 2.303\ m^3/min$

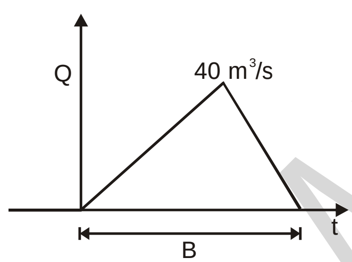
$= 138\ m^3/hr$

130. (c) $\frac{\theta_{S4}}{\theta_{S6}} = \frac{2.778A_4/D_4}{2.789A_6/D_6} = \frac{D_6}{D_4} = \frac{6}{4} = 1.5$

131. (c)

132. (d)

133. (d)



$$\frac{1}{2}\times 40\times B = 1\times 250\times 10^6\times 10^{-2}$$

$$B = \frac{250\times 10^4\times 2}{40} = 12.5\times 10^4\ sec$$

$$A\times 1\times 10^{-2} = \frac{1}{2}\times 80\times 12.5\times 10^4$$

$A = 40 \times 12.5 \times 10^6$

$= 500 \times 10^6\ m^2$

$= 500 km^2$

134. (b)

$\because$ $n = s_y + s_r$

$= 0.1 + 0.2 = 0.3$ porosity

$\therefore$ Total ground water storage

$= 0.3 \times 10 \times 10^6 \times 1.5$

$= 4.5\ Mm^3$

$\therefore$ Available ground water storage

$= 0.1 \times 10 \times 10^6 \times 1.5$

$= 1.5\ Mm^3$

where s_y = specific yield

s_r = specific retention

135. (d)

$M_{ulim} = .36\ F_{ck}\ b\ x_4\ (d - .42\ x_4)$

$x = 0.46$ d for Fe 500

So $M_{ulim} = 0.36 \times 25 \times b \times 0.46\ d$

$(d - 0.42 \times 0.46 \times d)$

$= 3.34\ bd^2$

so $k = 3.34$

136. (b) Sedimentation/ clarification is unit operation, not unit process.

137. (c)

138. (b)

139. (d)

140. (a)

141. (c)

142. (d) Two contour lines intersect in case of cave also.

143. (a)

144. (d)

145. (a)

146. (b) The reduced soundings are the reduced levels of the sub-marine surface in terms of the adopted datum. When the soundings are taken, the depth of water is measured with reference to the existing water level at that time. If the gauge readings are also taken at the same time, the soundings can be reduced to a common unvarying datum. The datum most commonly adopted is the mean level of low water of spring tides and is written either as L.W.O.S.T (law water, ordinary spring tides) or M.L.W.S (mean law water springs). For reducing the soundings, a correction equal to the difference of level between the actual water level (read by gauges) and the datum is applied to the observed soundings.

147.(a) The height of the instrument (or collimation level) method is more rapid, less tedious and simple. However, since the check on the calculations for intermediate sights is not available, the mistakes in their levels pass unnoticed. The rise and fall method though more tedious, provides a full check in calculations for all sights. However, the height of instrument method is more suitable in case, where it is required to take a number of readings from the same instrument setting, such as for constructional work, profile levelling etc.

148. (a) Shear wall (also called flexural walls) are reinforced concrete structural walls cantilevering vertically from foundation.

149. (a) Water and air irreversibly rise towards top of concrete mass and tends to get trapped beneath the horizontal reinforcement thereby weakening the bond at underside of these bars. Therefore codes specify a lower bond resistance for top reinforcement in a beam.

150. (b) $Q_u = CN_C + \gamma D_F N_q + u.5 B\gamma N\gamma$

For non-cohesive soil $\phi \simeq 30°$ and $N_q \simeq 22.5$. It means with increase in depth bearing capacity increase

For cohesive soil $N_\gamma = 0$ therefore the dimension of tooting doesn't affect the ultimate bearing capacity. The statement of reason is also correct but does not explain the assertion correctly

151. (a) Method of slices proposed by W. Fellenius assumes the forces on opposite sides of each slice are equal and opposite. This leads to a statically determinate problem. The error due to this assumption on the mass as a whole is not significant. The factor of safety obtained is generally less than that obtained from the more accurate methods, such as Bishop's method which also consider the forces on the sides of vertical strips.

152. (b) Unit weights (dry, moist or saturated) of most of the sands lie within a narrow range compared to clays because the voids in sand are less than that in clays. For sand difference of $(\gamma_{sat} - \gamma_d)$ may be (2 to 4) kN/m^3 while for clays it may extent from 48kN/m^3.

The position of W.T. effects the ettective stress in soil and there by shear strength also.

153. (a)

154. (b)

155. (a)

156. (d) When the GWT is above the bed of stream, the ground water feeds the stream, such streams are called effluent streams.

157. (a)

158. (d)

159. (a) Method of repetition is used to measure horizontal angles only, as there are two number of rotation first one with telescope normal and another with telescope inverted.

But vertical angles cannot be measured by method of repetition because only one rotation possible in the vertical plane.

160. (d) $Q = kiA$

if i is constant then $Q \propto A$

if area of aquifer changed from 50 m^2 to 75 m^2 then yield change from 10 m^3/d to 15 m^3/d