DETAILED SOLUTIONS

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ESE 2022 : Prelims Exam
CLASSROOM TEST SERIES

CIVIL ENGINEERING

Test 2

Section A : Geo-technical & Foundation Engineering

Section B : Environmental Engineering

1.	(c)	16.	(c)	31.	(d)	46.	(a)	61.	(b)
2.	(c)	17.	(b)	32.	(b)	47.	(a)	62.	(d)
3.	(b)	18.	(c)	33.	(a)	48.	(b)	63.	(d)
4.	(d)	19.	(d)	34.	(b)	49.	(c)	64.	(b)
5.	(d)	20.	(c)	35.	(a)	50.	(d)	65.	(a)
6.	(a)	21.	(b)	36.	(d)	51.	(b)	66.	(c)
7.	(d)	22.	(c)	37.	(a)	52.	(b)	67.	(a)
8.	(a)	23.	(c)	38.	(a)	53.	(a)	68.	(b)
9.	(c)	24.	(b)	39.	(c)	54.	(a)	69.	(a)
10.	(b)	25.	(a)	40.	(c)	55.	(c)	70.	(d)
11.	(c)	26.	(d)	41.	(c)	56.	(c)	71.	(b)
12.	(d)	27.	(c)	42.	(b)	57.	(b)	72.	(a)
13.	(c)	28.	(b)	43.	(a)	58.	(d)	73.	(a)
14.	(a)	29.	(b)	44.	(c)	59.	(b)	74.	(d)
15.	(b)	30.	(a)	45.	(d)	60.	(a)	75.	(b)

DETAILED EXPLANATIONS

1. (c)

Alluvial deposit: Soils that have been deposited from suspension in running water.

Aeolian deposit: Soils that have been transported by wind.

Lacustrine deposit: Soils that have been deposited from suspension in still, fresh water of lakes.

Glacial deposit: Deposit that have been transported by ice.

2. (c)

Given: $(\gamma_d)_{min} = 14.71\text{ kN/m}^3$

$(\gamma_d)_{max} = 16.68\text{ kN/m}^3$

Density index, $$D_r = \frac{(\gamma_d)-(\gamma_d)_{min}}{(\gamma_d)_{max}-(\gamma_d)_{min}} \times \frac{(\gamma_d)_{max}}{(\gamma_d)}$$

$$\Rightarrow \quad 0.5 = \frac{(\gamma_d)-14.71}{16.68-14.71} \times \frac{16.68}{\gamma_d}$$

$$\Rightarrow \quad (0.5)\gamma_d = [(\gamma_d) - 14.71] \times 8.47$$

$$\Rightarrow \quad \gamma_d = 15.63\text{ kN/m}^3$$

3. (b)

Clay *B* has higher liquid limit than clay *A* and higher the liquid limit, higher will be its compressibility. So clay *B* will experience larger settlement.

$$(I_p)_A = 44 - 20 = 24\%$$

$$(I_p)_B = 55 - 35 = 20\%$$

Clay *A* has higher plasticity index and hence, more plastic than clay *B*.

Consistency index, $$(I_c) = \frac{w_L - w_n}{w_L - w_p}$$

$$\therefore \quad (I_c)_A = \frac{44-30}{44-20} = \frac{14}{24} = 0.583$$

$$(I_c)_B = \frac{55-50}{55-35} = \frac{5}{20} = 0.25$$

I_c of clay *B* is less than I_c of clay *A* and hence, clay *B* is more softer than clay *A*.

4. (d)

$$e = 0.54$$

For shrinkage limit, degree of saturation(s) = 1

As soil will be just saturated.

We know, $$eS = w_s G$$

$$\Rightarrow \quad 0.54 \times 1 = w_s(2.7)$$

$$\Rightarrow \quad w_s = 0.2 \text{ or } 20\%$$

5. (d)

- Subgrade of pavement should be compacted on wet side of OMC to limit the volume change.
- Relative compaction cannot be used interchangeably with relative density.

$$\text{Relative compaction} = \frac{(\gamma_d)}{(\gamma_d)_{max}}$$

$$\text{Relative density or density index} = \frac{\gamma_d - (\gamma_d)_{min}}{(\gamma_d)_{max} - (\gamma_d)_{min}} \times \frac{(\gamma_d)_{max}}{\gamma_d}$$

- Clayey soil is used in the construction of the core of earth dams and hence, sheepfoot rollers are used for compaction.

  Compactive energy in IS heavy compaction test

$$= \frac{4.9(\text{kgf}) \times 4.5\text{ m} \times 5(\text{layers}) \times 25(\text{blow/layer})}{10^3 \times 10^{-6}}$$

$$= 275625 \text{ kgfm/m}^3$$

$$\text{In IS light compaction test} = \frac{2.6\text{ kgf} \times 0.31\text{ m} \times 3(\text{layers}) \times 25(\text{blow/layer})}{10^3 \times 10^{-6}\ (\text{m}^3)}$$

$$= 60450 \text{ kgf m/m}^3$$

$$\text{Ratio} = \frac{275625}{60450} = 4.56$$

6. (a)

As soil is in series arrangement, discharge through soil A and soil B will be same.

$\because \quad Q = kiA$

$\Rightarrow \quad (kiA)_A = (kiA)_B$

$\Rightarrow \quad k_A \times i_A = k_B \times i_B$ (as A is same)

$$\Rightarrow \quad 10^{-2} \times \frac{(h_L)_A}{1} = 10^{-1} \times \frac{(h_L)_B}{1}$$

$\Rightarrow \quad (h_L)_A = 10(h_L)_B$

Total head loss (h_L) = 66 cm = 0.66 m

$(h_L) = (h_L)_A + (h_L)_B$

$0.66 = 10(h_L)_B + (h_L)_B$

$0.66 = 11\ (h_L)_B$

$\therefore \quad (h_L)_B = 0.06 = 6$ cm

and $\quad (h_L)_A = 0.6$ m $= 60$ cm

$$\text{Discharge per unit area,} \quad q = \frac{Q_B}{A} = k_B \times \frac{(h_L)_B}{L_B}$$

$$= 10^{-1} \times \frac{0.06 \text{ m}}{1 \text{ m}} = 0.006 \text{ m}^3/\text{s}/\text{m}^2$$

7. (d)

Permeability, $$k = k_k \left(\frac{\gamma}{\mu}\right) \frac{e^3}{1+e} d^2$$

Absolute permeability, $$\frac{k}{\left(\frac{\gamma}{\mu}\right)} = k_k \frac{e^3}{1+e} d^2$$

Also, k_k is a constant which depends upon the shape of soil grains.

8. (a)

- Zone of sand beach adjacent the sea where capillary pressures are acting is called capillary zone and these pressures increase the effective stress of the sand and consequently increases the shear resistance of soil.
- Quicksand is a viscous liquid with a unit weight of about twice as that of water. Hence, any person can easily float in it instead of getting sucked into.

9. (c)

$$q = k'H \frac{n_f}{n_d}$$

$\left(\frac{n_f}{n_d}\right)$ is also known as shape factor of flownet.

Here, shape factor $\left(\frac{n_f}{n_d}\right)$ = 0.25 (given)

$$k' = \sqrt{k_x k_y}$$

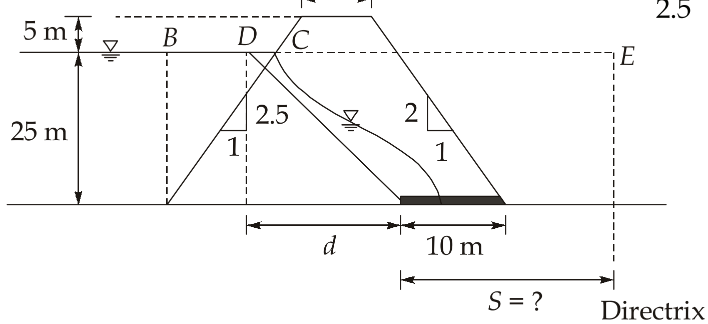
$$= \sqrt{\left(2 \times 10^{-6}\right) \times \left(8 \times 10^{-6}\right)} = 4 \times 10^{-6} \text{ m/s}$$

$$\therefore \quad q = k'H \times \frac{n_f}{n_d}$$

$$= (4 \times 10^{-6}) \times (21.5 - 1.5) \times 0.25$$

$$= 20 \times 10^{-6} \text{ m}^3/\text{s/m}$$

10. (b)



$$d = 3 + 15 + \frac{5}{2.5} + \frac{30}{2} - 10 = 25 \text{ m}$$

Using the propertie of parabola.

$$DF = DE$$

$$\Rightarrow \quad \sqrt{d^2 + H^2} = S + d$$

$$\therefore \quad S = \sqrt{d^2 + H^2} - d$$

$$= \sqrt{25^2 + 25^2} - 25 = 25\sqrt{2} - 25$$

$$= 25\left(\sqrt{2} - 1\right) = 10.35 \text{ m}$$

$$\simeq 10.4 \text{ m}$$

11. (c)

Piping begins near the downstream toe but may lengthen progressively towards the upstream side as the seeping water gradually sashes away more and more soil particles, leaving voids or pipes in the soil.

12. (d)

Newmark developed influence charts to compute the vertical stresses due to loaded area of any shape, irregular or geometric, below any point either inside or outside the loaded area.

13. (c)

For the lab sample, $t_{50} = 10$ min

$$H = \frac{20}{2} = 10 \text{ mm (For double drainage)}$$

For clay layer at site, $H = 5 \times 10^3$ mm (For single drainage)

$$T_v = \frac{C_v t}{H^2}$$

Since U% = 50% for both the sample and clay layer, T_v is same in both cases.

Since stress increment is same, C_v is also same.

Hence, $\frac{t}{H^2}$ ratio must be same for both cases

$$\frac{t_1}{H_1^2} = \frac{t_2}{H_2^2}$$

$$\Rightarrow \quad t_2 = 10 \text{ min} \times \frac{\left(5\times10^3\right)^2}{10^2} = 25\times10^5 \text{ min}$$

$$= \frac{25\times10^5}{60\times24\times365} \text{ years } = 4.76 \text{ years}$$

14. (a)

For a normally consolidated clay

$$\Delta H = \frac{H_0 C_c}{1+e_0}\log\left(\frac{\bar{\sigma}_0+\Delta\bar{\sigma}}{\bar{\sigma}_0}\right)$$

$$\Delta H \propto \log\left(\frac{\bar{\sigma}_0+\Delta\bar{\sigma}}{\bar{\sigma}_0}\right)$$

$$\frac{(\Delta H)_2}{(\Delta H)_1} = \frac{\log\left(\frac{160+(320-160)}{160}\right)}{\log\left(\frac{80+(160-80)}{80}\right)}$$

$$\frac{(\Delta H)_2}{2\text{cm}} = \frac{\log 2}{\log 2}$$

$$(\Delta H)_2 = 2 \text{ cm}$$

Hence, further settlement will be 2 cm.

15. (b)

- In floating ring cell apparatus, both top and bottom porous stones are allowed to move while in fixed ring cell apparatus, bottom porous stone is fixed which increases the skin, friction between soil specimen and inside surface of the apparatus.
- Initial consolidation or immediate settlement is determined by using elastic analysis.

$$S_i = \frac{qB\left(1-\mu^2\right)}{E_s}\times I_t$$

16. (c)

As liquid limit increases, compressibility increases

$$C_v = \frac{k}{m_v \gamma_w}$$

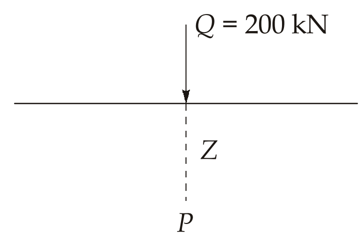
Hence, as compressibility increases, C_v decreases.

For compression index, $C_c = 0.009\,(w_L - 10)$

So as liquid limit increases, compression index increases.

17. (b)

According to Boussinesq



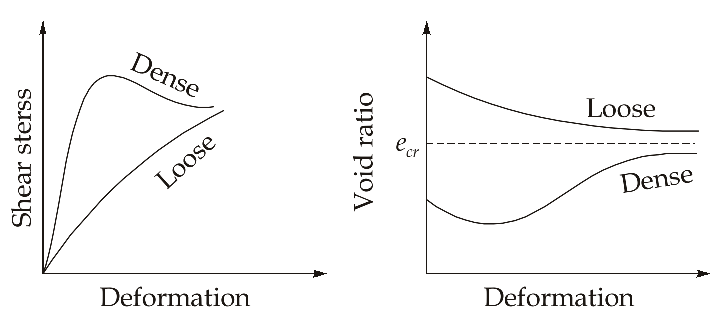
$$(\sigma_z)_p = 0.4775\frac{Q}{Z^2}$$

$$\Rightarrow \quad 47.75 = 0.4775 \times \frac{200}{Z^2}$$

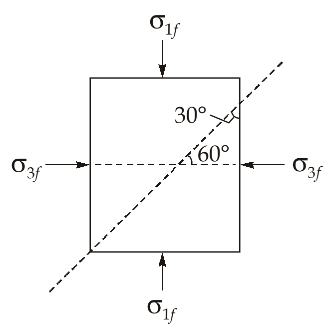
$$\Rightarrow \quad Z = \sqrt{2} = 1.4 \text{ m}$$

18. (c)

Typical stress-strain and volume change curves for granular soil are shown below.



19. (d)



Failure angle, $\theta_c = 90° - 30° = 60°$

Also,
$$\sigma_{1f} = \sigma_{3f}.\tan^2\left(45° + \frac{\phi}{2}\right) + 2c\tan\left(45° + \frac{\phi}{2}\right)$$
$$= \sigma_{3f}\tan^2\theta_c \qquad (\because c = 0; \text{ since soil is dry sand})$$

But,
$$\sigma_{1f} = \sigma_{3f} + \sigma_{df}$$
$\Rightarrow$
$$\sigma_{3f} + \sigma_{df} = \sigma_{3f}.\tan^2\theta_c$$
$$\sigma_{3f} = \frac{\sigma_{df}}{\tan^2\theta_c - 1}$$
$$= \frac{400}{\tan^2 60° - 1} = \frac{400}{(\sqrt{3})^2 - 1} = 200 \text{ kN/m}^2$$

20. (c)

Given: Radius of slip circle, $r = 7.2$ m

Angle of shearing resistance, $\phi = 37°$

$\therefore$ Radius of friction circle $= r\sin\phi$
$$= 7.2 \times \sin 37° = 7.2 \times \frac{3}{5} \qquad \left(\because \sin 37° = \frac{3}{5}\right)$$
$$= 4.32 \text{ m}$$

21. (b)

Slope of bank, $i = 45°$

$\phi = 14°$

From table given for $i = 45°$, $\phi = 14°$
$$S_n = 0.108 + \frac{0.083 - 0.108}{15 - 10}(14 - 10) = 0.088$$
$$\gamma_{sub} = \left(\frac{G_s - 1}{1 + e}\right)\gamma_w = \left(\frac{2.7 - 1}{1 + 0.8}\right) \times 9.81 = 9.265 \text{ kN/m}^3$$

When canal runs full

$\therefore$
$$F_C = \frac{C}{S_n\gamma_{sub}H} = \frac{15}{0.088 \times 9.265 \times 5} = 3.679 \simeq 3.7$$

22. (c)

Pore pressure parameters are empirical coefficients which are used to express the response of pore pressure to changes in total stress under undrained condition.

Value of A may be as large as 2 to 3, for very loose saturated fine sands and it can be less than zero for over consolidated clays.

23. (c)

We know,
$$\frac{C_u}{\bar{\sigma}_z} = 0.11 + 0.0037 I_P \%$$

$$\therefore \quad \frac{q_u}{\bar{\sigma}_z} = 0.22 + 0.0074 I_p \% \qquad \left(\because C_u = \frac{q_u}{2}\right)$$

$$I_p = w_l\% - w_p\%$$
$$= 45 - 25 = 20\%$$

$$\therefore \quad \frac{q_u}{\bar{\sigma}_z} = 0.22 + 0.0074 \times 20 = 0.368$$

24. (b)

Slope failure occurs when the slope angle 'β' is very high and the soil close to the toe is quite strong or the soil in the upper part of the slope is relatively weak.

26. (d)

$$(p_a)_A = k_a (\bar{\sigma}_z)_A + \gamma_w H \qquad (\because \text{soil is sand})$$

$$\Rightarrow \quad 96 = \frac{1 - \sin\phi}{1 + \sin\phi}(q + \gamma_{sub} Z) + \gamma_w H$$

$$\Rightarrow \quad 96 = \frac{1 - \sin 30°}{1 + \sin 30°}\{q + (20 - 10) \times 6\} + 10 \times 6$$

$$\Rightarrow \quad 96 = \frac{1}{3}(q + 60) + 60$$

$$\Rightarrow \quad q = (96 - 60) \times 3 - 60$$
$$= 48 \text{ kN/m}^2$$

27. (c)

Clay backfills should be avoided as far as possible, essentially because they are susceptible to swelling and shrinkage during rainy and summer reasons, respectively.

Swelling is likely to cause unpredictable earth pressures and wall movements while shrinkage may lead to tension cracks in soil.

28. (b)

As per Terzaghi's

$$q_u = CN_c + qN_q + \frac{1}{2} B\gamma N_\gamma$$

$$q_{nu} = CN_c + q\left(N_q - 1\right) + \frac{1}{2}B\gamma N_\gamma$$

For pure clay (ϕ = 0°)

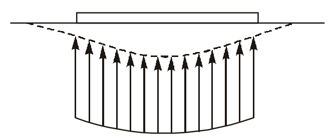
$$N_c = 5.7$$
$$N_q = 1$$
$$N_\gamma = 0$$
$$\therefore \quad q_{nu} = 5.7C$$

This is independent of width and depth of footing.

29. (b)

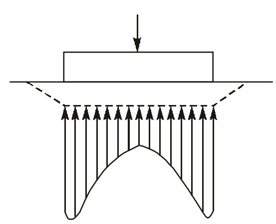
(i) Flexible footing on clayey soil

- In flexible footing, the contact pressure i.e. pressure at the interface between the footing and the soil is uniformly distributed.
- A uniform pressure produces a dish shaped pattern of displacement.



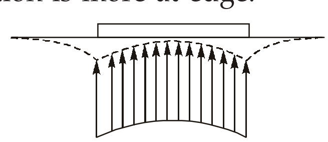
(ii) Rigid footing on clayey soil

- For rigid footings, the settlement has to be uniform over the contact area. Since, a flexible footing produces a dish shaped pattern in clay soil, the contact pressure must be more near the edge of the loaded area and less near centre, in order to produce a uniform settlement.



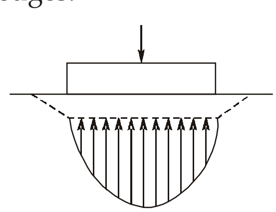
(iii) Flexible footing on granular soil

- In granular soil, modulus of elasticity (E) varies across the width being maximum at the centre and minimum at edge. As E is maximum at centre, deflection is less at centre and E is less at edge, hence deflection is more at edge.



(iv) Rigid footing on granular soil

- For a rigid footing, where the settlement has to be uniform, the contact pressure is more near the centre than near the edges.



30. (a)

Given:

$$q_u = 100 \text{ kN/m}^2$$
$$\gamma = 20 \text{ kN/m}^3$$

Size of footing, $(B \times L) = (1 \text{ m} \times 2 \text{ m})$

Depth of footing, $D_f = 2\text{m}$

$$\frac{D_f}{B} = \frac{2}{1} = 2 \leq 2.5$$

∴ Using Skempton's formula

$$q_{nu} = 5\left(1+0.2\frac{B}{L}\right)\left(1+0.2\frac{D_f}{B}\right)C$$
$$= 5\left(1+0.2\times\frac{1}{2}\right)(1+0.2\times 2)\times 50$$
$$= 5.5 \times 1.4 \times 50 = 385 \text{ kN/m}^2$$

∴ Safe bearing capacity of soil, $q_s = \frac{q_{nu}}{\text{FOS}} + \bar{\sigma} = \frac{385}{2.5} + 20\times 2$

$$= 194 \text{ kN/m}^2$$

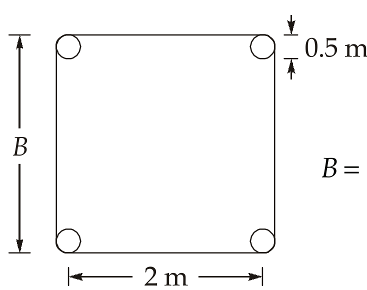
31. (d)

Given for a square pile group:

Centre-to-centre spacing of piles = 2 m

Diameter = 0.5 m

Length = 10 m



$$B = 2 + \frac{0.5}{2} + \frac{0.5}{2} = 2.5 \text{ m}$$

∴ Ultimate load capacity of pile group:

$$Q_{ug} = C_u N_c A_b + \bar{C}_u A_s$$
$$= 100\times 9\times(2.5)^2 + \left(\frac{60+100}{2}\right)\times 4\times 2.5\times 10$$
$$= 13625 \text{ kN}$$

32. (b)

Negative skin friction occurs when the surrounding soil settles more than the pile.

33. (a)

Inside clearance, $$C_i = \frac{d_i - D_i}{D_i} \times 100$$

Note: Area ratio, $$A_r = \frac{D_o^2 - D_i^2}{D_i^2} \times 100$$

Outside clearance, $$C_o = \frac{D_o - d_o}{d_o} \times 100$$

34. (b)

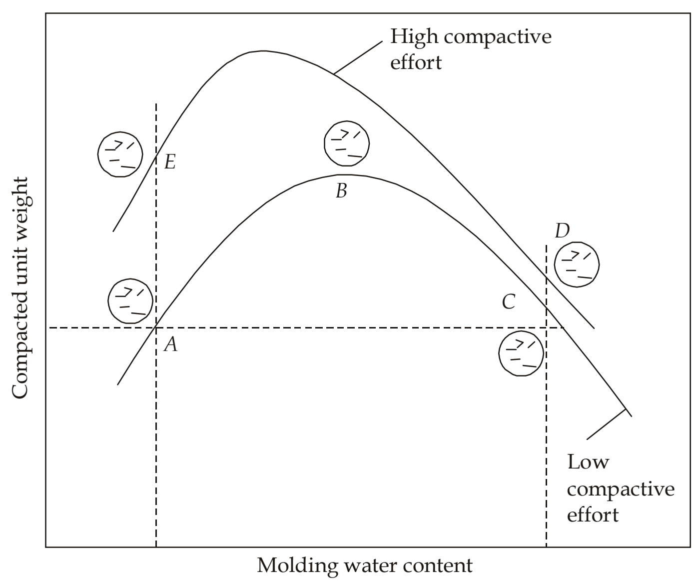
A soil is said to be normally consolidated when the existing stress (p_0) 'or' effective over burden pressure is the maximum that it has ever experienced in its stress history.

The maximum value of stress that the soil has ever experienced is called perconsolidation pressure.

If $p_0 \geq p_c \rightarrow$ for NC-soil

$p_0 < p_c \rightarrow$ for OC-soil

35. (a)



The more orderly, nearly parallel orientation of particles allows the particles (point *C* and *D*) to pack more efficiently as compared to the randomly oriented particles on the dry side of optimum.

36. (d)

A steeper flow curve possesses lower shear strength when compared to a flatter flow curve.

39. (c)

Nephelometer turbidity measurement is based on colour matching technique. NTU measures scattered light at 90° from incident light beam, but FTU is measured with infrared light source as per ISO 7027. NTU is measured with white light.

40. (c)

Alkalinity determined upto pH 8.3 is called phenolphthalein alkalinity

$$= \frac{ml \text{ of } H_2SO_4 \text{ of } 0.02\text{ N} \times 1000}{ml \text{ of water sample}}$$

$$= \frac{20 \times 1000}{100} = 200 \text{ mg/lit.}$$

$$\text{Total alkalinity} = \frac{60 \times 1000}{100} = 600 \text{ mg/lit.}$$

$$\therefore \quad \text{Difference} = 600 - 200 = 400 \text{ mg/lit.}$$

41. (c)

Gravity thickening — For primary sludge
Air floating — For activated sludge
Centrifugation — Used when there is space restriction.

43. (a)

For application to ion exchanges, the raw water should be relatively free from turbidity, as otherwise the exchange material gets coating which affects the exchange capacity of the bed.
Metal ions like iron and manganese, if present are likely to be oxidized and can coat the zeolites, thus deteriorating the exchange capacity steadily since the reagent cannot remove these coatings.
Oxidizing chemicals like chlorine and carbon dioxide as well as low pH in the water will have a tendency to attack the exchange resin material, the effect being more pronounced on the synthetic inorganic zeolites.

44. (c)

E-coli infection is bacterial infection. Enteric fever is also called as typhoid fever.

45. (d)

$$\text{Pack aquifer ratio} = \frac{D_{50} \text{ of gravel pack}}{D_{50} \text{ of aquifer}}$$

46. (a)

$$\text{Total flow} = 150 \times 2000 = 0.3 \text{ MLD}$$

$$\text{BOD}_5 \text{ of the sample} = (DO_i - DO_f) \times \text{Dilution factor}$$

$$= (75 - 25) \times 6 = 300 \text{ mg}/l$$

$$\therefore \quad \text{Surface area} = \frac{0.3 \times 10^6 \times 300 \times 10^{-6}}{200} = 0.45 \text{ ha}$$

47. (a)

$$\text{Maximum daily consumption} = 1.8 \times \text{Average daily consumption}$$

$$= \frac{1.8 \times 7.2 \times 10^6}{10^3} = 12.96 \times 10^3 \text{ m}^3$$

$$\text{Capacity of chamber} = \text{Flow required in 20 minutes}$$

$$= \frac{12.96 \times 10^3 \times 20}{24 \times 60} = 180 \text{ m}^3$$

$$\text{Plan area} = \frac{180}{2.25} = 80 \text{ m}^2$$

$\because$ Width = 5 m (Given)

$$\therefore \quad \text{Length} = \frac{80}{5} = 16 \text{ m}$$

$\therefore$ Option is (a).

48. (b)

For power per unit volume, $V = 1 \text{ m}^3$ should be used

We know, velocity gradient, $G = \sqrt{\dfrac{P}{\mu V}}$

$\Rightarrow$ $P = G^2 \mu V$

$\Rightarrow$ $P = 700^2 \times 1.002 \times 10^{-3} \times 1 \times 10^{-3}$ kW

$\Rightarrow$ $P = 0.49 \simeq 0.5$ kW

49. (c)

Total solids produced = S.S. concentration × Discharge

$$= \frac{100 \times 10^{-6}}{10^{-3}} \times 10000 = 1000 \text{ kg}$$

Sludge remove by PST = 0.6 of 1000 kg = 600 kg

Volatile solids = 0.7 × 600 = 420 kg

Volatile solids converted to gas = 0.65 × 420 = 273 kg

Amount of gas produced = 0.9 × 273 = 245.7 m^3

50. (d)

- Zeolite process is costlier
- The increased causticity may help in killing pathogenic bacteria, especially when alkalinity caused by calcium, magnesium or sodium hydroxide of 20 to 50 mg/l is maintained for 4 to 5 hours.

52. (b)

Recirculation ratio is zero and thus recirculation factor = 1 and BOD removal is 80-90% means BOD remaining is 10-20%.

54. (a)

Molecular mass of $CH_2(NH_2)COOH$

= 12 + 2 + 14 + 2 + 12 + 16 + 16 + 1 = 75 gm/mole

$\therefore$ Moles of $CH_2(NH_2)COOH$ $= \dfrac{200}{75} = 2.67$

$\therefore$ Carbonaceous BOD (CBOD) $= \dfrac{3}{2} \times 2.67 \times 32 \simeq 128$ mg/l

$$\text{Nitrogeneous BOD (NBOD)} = 2.67 \times 2 \times 32 = 170.88 \text{ mg}/l$$

$$\text{BOD} = \text{CBOD} + \text{NBOD}$$

$$= 128 + 170.88 = 298.88 \text{ mg}/l$$

55. (c)

Brazin's coefficient,
$$C = \frac{157.6}{1.81 + \frac{K}{\sqrt{R}}}$$

$$R = \frac{A}{P} = \frac{400}{4} = 100 \text{ mm} = 0.1 \text{ m}$$

$$C = \frac{157.6}{1.81 + \frac{0.5}{\sqrt{0.1}}} = 46.47$$

$$V = C\sqrt{RS} = 46.47\sqrt{0.1 \times \frac{1}{200}} = 1.04 \text{ m/s} \simeq 1 \text{ m/s}$$

56. (c)

$$L_{eq} = 10\log\left\{\sum_{i=1}^{N} 10^{4/10} . t_i\right\}$$

$$L_{eq} = 10\log_{10}\left[\frac{10}{50} \times 10^{\frac{80}{10}} + \frac{30}{50} \times 10^{\frac{60}{10}} + \frac{10}{50} \times 10^{\frac{90}{10}}\right]$$

$$= 10\log_{10} 10^5\left[\frac{1000}{5} + \frac{30}{5} + \frac{10^4}{5}\right]$$

$$= 10\log_{10} 10^5 [200 + 6 + 2000]$$

$$= 10\log_{10}\left[2206 \times 10^5\right]$$

$$= 10\log_{10}\left[2.206 \times 10^8\right]$$

$$= 10\left[\log_{10} 10^8 + \log_{10} 2.206\right]$$

$$= 10[8 + 0.34] = 83.4 \text{ dB}$$

57. (b)

$$\text{Total dry mass of waste sample} = 10 + 40 + 33.6 + 4.6 + 9.8 + 22 = 120 \text{ kg}$$

$$\text{Total weight of solid waste sample} = 225 \text{ kg}$$

$$\text{Hence moisture content} = \frac{225 - 120}{225} \times 100 = 46.67\%$$

58. (d)

- Ozonized water becomes tasty and pleasant unlike the chlorinated water which becomes bitter to tongue.
- Statement 2 is an advantage of ozonation.
- Complicated ozone manufacturing apparatus called ozoniser is required to be installed at the treatment plants, because it cannot be supplied in cylinders as chlorine can be.

59. (b)

Sodium Azide (NaN_3) is a reducing agent which is used in the Winkler's test when other oxidizing agents are present in water, to reduce these agents so that correct amount of dissolved oxygen can be determined.

This method is also known as modified Winkler's test.

60. (a)

Fungi are the most familiar filamentous microorganisms.

61. (b)

Height of chimney, $h = 14(Q_s)^{1/3}$

where $Q_s = SO_2$ in kg/hr

$$SO_2 \text{ emission} = 60 \text{ t/year/M}l \text{ of oil burnt}$$

$$= \frac{60 \times 1000}{365 \times 24} \text{ kg/hr/M}l \text{ of oil}$$

$$= \frac{60 \times 1000}{365 \times 24} \times (12 \times 0.6)$$

$$= 49.32 \text{ kg/hr}$$

$$\therefore \quad h = 14\,(49.32)^{1/3} = 51.34 \text{ m}$$

Nearest option is 50 m.

62. (d)

All the given options are the natural self-cleansing properties of the environment.

In the natural absorption process, the gaseous as well as particulate pollutants from the air get collected in the rain or mist, and may settle out with that moisture. This phenomenon takes place below the cloud level, when falling raindrops absorb pollutants and is also known as washout or **Scavenging**.

63. (d)

Sources at (a), (b) and (c) all, will yield underground water, which is saline, and hence only 'River' can give us good quality of water.

64. (b)

Ferrous hydroxide reacts with the dissolved oxygen to form ferric hydroxide [$Fe(OH)_3$]. The ferric hydroxide is in the form of insoluble red precipitate and gets deposited on the pipe surface. This deposit of ferric hydroxide formed on the interior surface of the pipe is known as tuberculation.

65. (a)

Since diameter of particle > 0.1 mm and Reynold's no. > 1

So, flow is transitional flow,

$$\therefore \quad C_D = \frac{24}{Re} + \frac{3}{Re^{1/2}} + 0.34$$

Put Re = 4 in above equation we get,

$$C_D = 7.84$$

Now, we know that, settling velocity

$$V_s = \sqrt{\frac{4}{3}\frac{(G_s-1)gd}{C_D}} = \sqrt{\frac{4}{3}\frac{(1.75-1)\times 10\times\left(0.25\times 10^{-3}\right)}{7.84}}$$

$$= \sqrt{\frac{4}{3}\times\frac{(0.75)\times 0.25\times 10^{-2}}{7.84}}$$

$$= \frac{0.05}{\sqrt{7.84}}$$

Here one can take $\sqrt{7.84} \simeq \sqrt{8} = 2.828$

$$\therefore \quad V_s = 0.0177 \simeq 0.018 \text{ m/s}$$

By taking $\sqrt{8}$ {for the ease of calculation}

$$V_s = \frac{0.05}{\sqrt{8}} = \frac{0.05}{2.828} = 0.01768 \simeq 0.018 \text{ m/s}$$

66. (c)

(i) Among all aerosols, only black carbon has direct effect on global warming.

(ii) Major greenhouse gases are:

Water vapour = 36-70%

CO_2 = 9-26%

CH_4 = 4-9%

O_3 = 3-7%

67. (a)

Detention period in days, $t_D = \frac{1}{k_D}\log_{10}\left(\frac{L}{L-y}\right)$

where, L = 500 mg/l

y = BOD removed = 0.9 × 500 = 450 mg/l

So, $t_D = \frac{1}{0.1}\log_{10}\left(\frac{500}{500-450}\right) = 10$ days

68. (b)

Recirculating factor, $F = \dfrac{1+R}{\left[1+(1-f)R\right]^2}$

where, f = Treatability factor

$\therefore$ $F = \dfrac{1+1.5}{\left[1+(1-0.85)1.5\right]^2} = 1.67$

69. (a)

- Fanning plume is caused by inversion, where pollutant does not rise above the released point.
- Motion of air is subsiding in high pressure area surrounded by low pressure area.
- Both may occur simultaneously and is known as double inversion.

70. (d)

- Statement (1) is true if **carbon/nitrogen is too high**.
- If carbon/nitrogen is less, then carbon is exhausted prior to nitrogen and left over nitrogen combines with the hydrogen leading to the formation of ammonia which is **disastrous** to the methane formers leading to **incomplete composting**.

72. (a)

Unit process refers to biological and/or chemical reaction. Sequential batch reactors (SBRs) have following steps.

(i) Filling of reactor with waste water
(ii) Aeration
(iii) Sedimentation
(iv) Withdrawal of effluent
(v) Idle when waste sludge is removed

In conventional activated sludge process (ASP) there are following three steps:

(i) A reactor in which microorganisms are kept in suspension and aerated.
(ii) Liquid-solid separation in sedimentation tank
(iii) A recycle system

Thus basic process is same in both SBR and ASP.

73. (a)

Because of lesser release of energy in anaerobic reaction, the synthesis of new cells is very much less than in aerobic reaction and hence anaerobic stabilization produces less sludge.

74. (d)

When the distribution system is long and complex, it may be difficult to maintain the minimum chlorine residual of 0.2 mg/l at the farthest end.

To achieve this, a very high dosage is applied at the post chlorination stage. It would apart from being costly, makes the water unpalatable, at the reaches close to the point of chlorination.

The maintenance of the required residual, in such cases can be accomplished by a stagewise application of chlorine in the distribution system which is called rechlorination.

Rechlorination is carried out in service reservoirs, booster pumping stations or at points where mains supply to distribution zones.

75. (b)

Chlorine is also an oxidizing agent so it will oxidize organic matter but if activated carbon is used before applying chlorine then being a oxidizing agent activated carbon oxidizes organic matter reducing chlorine demand of water.

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