Civil Engineering-II (Subjective)

DETAILS EXPLANATIONS

1. **(A) Given :** Width of channel $b = 5$ m

Specific energy, $E = 4$ Nm/N = 4 m

Discharge, $Q = 20\ m^3/s$

The specific energy (E) is given by following equation,

$$E = h + \frac{V^2}{2g}$$

Where, $V = \frac{\text{Discharge}}{\text{Area}} = \frac{Q}{b \times h} = \frac{20}{5 \times h} = \frac{4}{h}$

$\therefore$ Specific energy, $E = h + \frac{V^2}{2g} = h + \left(\frac{4}{h}\right)^2 \times \frac{1}{2g} = h + \frac{8}{g \times h^2}$

But $E = 4.0$

Equating the two values of E, $4 = h + \frac{8}{9.81 \times h^2} = h + \frac{0.8155}{h^2}$

$$4h^2 = h^3 + .8155 \text{ or } h^3 - 4h^2 + .8155 = 0$$

This is cubic equation solving by trial and error, we get

$$h = 3.93 \text{ m and } 0.48 \text{ m}$$

(B) Given, Width of Channel $b = 10$ m

Depth of Channel $h = 3$ m

Velocity of flow, $V = 1$ m/s

Bed slope, $i_b = \frac{1}{4000} = .00025$

Slope of energy line, $i_e = .00004$

Let rate of change of depth of water $= \frac{dh}{dx}$

$$\frac{dh}{dx} = \frac{(i_b - i_e)}{\left(1 - \frac{V^2}{gh}\right)} = \frac{.00025 - .00004}{\left(1 - \frac{1 \times 1}{9.81 \times 3}\right)}$$

$$= \frac{.00021}{.966} = .000217.$$

OR

(A) Efficiency of plant = $\frac{\text{Generated power}}{\text{Design capacity}} = \frac{10\times10^4}{1.23\times10^5}$ = 0.813 i.e. 81.3 %

Plant capacity = 1.60 × Design capacity = 1.60 × 1.23 × 10^5 = 1.97 × 10^5 kW

Plant factor = $\frac{\text{Average output}}{\text{Plant capacity}} = \frac{10\times10^4}{1.97\times10^5}$ = 0.51 i.e. 51%

Total energy produced = (10 × 10^4) × (365 × 24) = 8.76 × 10^8 kWh

(B) **(i)** ***A canal head regulator serves the following purposes :***

(a) It regulates the supply of water into the canal.

(b) It controls the entry of silt into the canal.

(c) It prevents the river floods from entering the canal.

(d) It can be used to stop the canal supplies when the silt charge in the river water exceeds a certain limit.

(ii) ***Advantages of Barrage :***

(a) The barrage has a good control on the river during floods. The outflow can be easily regulated by gates.

(b) The afflux during floods is small and, therefore, the submerged area is less.

(c) There is a good control over flow conditions, shoal formations and cross-currents on the upstream of the barrage.

(d) There are better facilities for inspection and repair of various structures.

(e) A roadway can be conveniently provided over the structure at a little additional cost.

(iii) ***The functions of undersluices may be summarised as follows :***

(a) They maintain a well-defined river channel near the canal head regulator.

(b) They are used to scour away the silt deposited in front of the head regulator.

(c) They can be used to pass small floods to the downstream, without dropping the shutters of the main weir.

(d) They may be designed to pass a portion of flood, about 10 to 20 % of the design flood, during rainy season.

(e) They are useful for quick lowering the upstream high flood level because the discharge intensity over the sluice portion is greater than that in the weir portion.

(f) They create a still pocket of water near the head regulator and therefore, the effect of the main river current on the head regulator is minimised.

2. **(A) Quantity of water applied** = 5 × 6 × 3600 = 10.8 × 10^4 m^3 = 10.8 ha-m

Quantity of water stored in the root zone = 30 × 0.25 = 7.5 ha-m

Water application efficiency = $\frac{7.5}{10.8}\times100$ = 69.44%

(B)

$$\text{Average duty for rice} = \frac{8.64\times140}{1.20} = 1008 \text{ ha/cumec}$$

$$\text{Average duty for wheat} = \frac{8.64\times160}{0.40} = 3456 \text{ ha/cumec}$$

Discharge for rice = 1500/1008 = 1.49 cumecs

$$\text{Discharge for wheat} = \frac{3000}{3456} = 0.87 \text{ cumecs} < 1.49 \text{ cumecs}$$

Design discharge = 1.49 cumecs.

OR

(A) Water retained in the soil = 90% of the water applied = 0.90 × 500 = 450 m^3

Water retained per unit area = 450/900 = 0.50 m^3

Weight of water retained = 0.50 × 9.81 kN

Dry weight of the soil per unit area = 1.50 × 15 = 22.5 kN

$$\text{Percentage of water retained} = \frac{0.50\times9.81}{22.5} = 0.22 \text{ or } 22\%$$

Existing water content = 8%

Field capacity = 22 + 8 = 30 %.

*[**Note :** It has been assumed that the moisture content after irrigation is equal to the field capacity]*

(B) Depending upon the factors responsible for lifting and cooling of air, there are five types of precipitation :

1. Convective precipitation
2. Orographic precipitation
3. Cyclonic precipitation
4. Frontal precipitation
5. Precipitation due to turbulent ascent

1. Convective precipitation : Convective precipitation occurs due to heating of air. The air close to the earth surface gets heated, and its density decreases. Consequently, the air rises upward in the atmosphere and it gets cooled adiabatically to form a cloud. Precipitation caused by such clouds is called convective precipitation.

2. Orographic precipitation : Orographic precipitation occurs due to lifting of moist air over mountains. It results in cooling, condensation and precipitation.

3. Cyclonic precipitation : A cyclone is a large zone of low pressure which is surrounded by circular wind motion. Air tends to move into the low pressure zone from surrounding areas and displaces low-pressure air upwards. The winds blow spirally inward counter-clockwise in the northern hemisphere and clockwise in the southern hemisphere.

4. Frontal precipitation : Frontal precipitation is a type of cyclonic precipitation. A frontal surface (or a front) is a surface which separates a warm air mass and a cold air mass. A front is called a warm front when warm air displaces cold air. It is called a clod front when cold air displaces warm air.

5. **Precipitation Due to Turbulent Ascent :** This type of precipitation occurs when an air mass is forced to rise up due to friction of the earth surface. The friction of the earth surface is greater than that of the water surface. The air mass, after its travel over ocean, rises up because of increased turbulence and friction. Precipitation occurs after cooling and condensation. The winter rainfall in Tamil Nadu is mainly due to this type of turbulent ascent.

3. (A) The given data in above table-I is extended in next table-II, so as to compute the increase in population (x) for each decade (col. 3), the total increase and average increase per decade $(\bar{x})$ **as shown (Col. 3) ,**

Table-II

Year (1)	**Pupulation (2)**	**Increase in Population (3)**
1930	25,000	
		3000
1940	28,000	
		6000
1950	34,000	
		8000
1960	42,000	
		5000
1970	47,000	
Total		22,000
Average increase Per decade $\bar{x}$		$\bar{x} = \frac{22000}{4} = 5,500$

The future populations are now computed by using following equation

$$P_n = P_0 + n \cdot \bar{x}$$

∴ (a) Population after 1 decade beyond 1970,

$$= P_{1980} = P_1 = P_{1970} + 1 \ . \ \bar{x}$$
$$= 47,000 + 1 \times 5500 = 52,500$$

(b) Population after 2 decade beyond 1970,

$$= P_{1990} = P_2 = P_{1970} + 2 \ . \ \bar{x}$$
$$= 47,000 + 2 \times 5500 = 58,000$$

(c)Popultion after 3 decades beyond 1970,

$$= P_{2000} = P_3 = P_{1970} + 3. \ \bar{x}$$
$$= 47,000 + 3 \times 5,500 = 63,500$$

OR

(A) Advantages of R.C.C. Pipes are given below :

(i) They can resist external compressive loads and do not collapse under nominal vacuums and traffic loads.

(ii) They are not corroded from inside by normal potable water and from outside by ordinary soils.

(iii) They are quite strong and their useful life is of the order of 75 years or so.

(iv) They are easy to construct either at site or at factories and with local ingredients.

(v) The coefficient of expansion being low, expansion joints may not be needed when laid above the ground.

(vi) If laid under water, the empty pipes do not float because of their heavy weights

Disadvantages of R.C.C. Pipes are given below :

(i) They are likely to corrode by ground waters due to the presence of acids, alkalis or sulphur compounds.

(ii) They are difficult to be repaired.

(iii) They are heavy and bulky, and hence difficult to transport.

(iv) Making of connections in them is a little difficult job.

(v) They tend to leak due to shrinkage cracks and porosity.

(B) Assume that the given rate of supply is an average demand, and also assuming that the maximum daily demand is 1.8 times the average daily demand, we have, by ignoring wash water requirements ;

The maximum water demand per day

= Population × Max. daily rate of supply

$= 50{,}000 \times 1.8\ (180) = 16.2 \times 10^6$ litres

= 16.2 million litres

Water demand per hour (ignoring time lost in cleaning)

$$= \frac{16.2 \times 10^6}{24} \text{ litres/hr} = 675 \times 10^3 \text{ litres/hr}$$

Rate of filtration = 5000 litres/hr/sq.m

∴ Area of filter beds required

$$= \frac{\text{Water demand}}{\text{Rate of filtration}} = \frac{675 \times 10^3}{5000} \text{ sq.m} = 135 \text{ sq.m}$$

Assume area of each tank $= 10 - 80\ m^2$

Since two units are required to be designed,

$$\text{The area of each unit} = \frac{135}{2} = 67.5 \text{ sq.m}$$

Assuming $L = 1.5\ B$, we have

$$1.5\ B^2 = 67.5$$

or $B^2 = 45$ or $B = 6.75$ m.

Choose 6.45 m width and 10 m length. Hence, two units of size 10 m × 6.75 m are required. One additional unit as stand-by may also be provided for breakdowns, repairs or cleaning operations.

4. (A) **Area of filter = 4.5 × 9.0 m²** = 40.5 m²

Filtered quantity in 24 hours = 10000 cum/day

$$\text{Area of filter} = \frac{\text{Water filtered}}{\text{Rate of filtration}}$$

Rate of filtration in *l*/hr/sq.m

$$= \frac{10,000 \times 1000}{24 \times 40.5} l / \text{hr} / \text{m}^2$$

$$= 10,288 \; l/\text{hr}/\text{m}^2$$

Av. rate of filtration (be counting 1/4 hr. lost in cleaning)

$$= \frac{10,288}{24.25} \times 24 = 10182 \; l/\text{hr}/\text{m}^2$$

Amount of water used in cleaning @ 10 $l/\text{m}^2/\text{sec}$ for 15 min

$$= 10 \times (4.5 \times 9.0) \times (15 \times 60) l$$

$$= 364500 \text{ litres} = 364.5 \text{ cum.}$$

Qty. of wash water expressed as percentage of total filtered water

$$= \frac{364.5 \times 100}{10,000} = 3.645\%$$

Wash water discharge through each trough

$$= \frac{\text{Total wash water discharge through the filter}}{\text{No. of troughs}}$$

$$= \frac{10 l / \text{m}^2 / \text{sec} \times (4.5 \times 9) \text{m}^2}{4} = 101.25 \; l/\text{sec.}$$

OR

(A) ***Advantages of traffic signals :***

Properly designed traffic signals at intersections have the following advantages:

(1) Provide orderly movement of traffic at the intersection.

(2) The quality of traffic flow is improved by forming compact platoons of vehicles, provided all the vehicles move at approximately the same speed.

(3) Reduction in accidents due to crossing conflict, notably the right angled collisions.

(4) Traffic handling capacity is highest among the different types of intersections at-grade.

(5) Provide a chance to traffic of minor road to cross the continuous traffic flow of the main road at reasonable intervals of time.

(6) Pedestrians can cross the roads safely at the signalised intersection.

(7) When the signal system is properly co-ordinated, there is a reasonable speed along the major road traffic.

(8) Automatic traffic signal may work out to be more economical when compared to manual control.

Disadvantages of traffic signals :

(1) The rear-end collisions may increase.

(2) Improper design and location of signals may lead to violations of the control system.

(3) Failure of the signal due to electric power failure or any other defect may cause confusion to the road users.

(4) The variation in vehicle arrivals on the approach roads may cause increase in waiting time on one of the roads and unused green signal time on other road, when fixed time traffic signals are used.

(B) Given : Speed, v = 40 kmph

Braking distance,

$$L = 12.2 \text{ m}$$

Skid resistance,

$$f = 0.7$$

$$v = \frac{40}{3.6} = 11.11 \text{ m/sec}$$

Average skid resistance developed

$$f' = \frac{v^2}{2gL} = \frac{11.11^2}{2\times9.8\times12.2} = 0.516$$

Brake efficiency, %

$$= \frac{100f'}{f} = \frac{100\times0.516}{0.70} = 73.7\%$$

5. **(A) Given:** V = 65 kmph,

f = 0.36,

Reaction time, t = 2.5 sec

Stopping sight distance,

$$SSD = 0.278\ Vt + \frac{V^2}{254f} = 0.278\times65\times2.5 + \frac{65^2}{254\times0.36} = 91.4 \text{ m}$$

(a) Head light sight distance

$$SSD = 91.4\text{m}$$

(b) Intermediate sight distance

$$ISD = 2\ SSD = 2\times91.4 = 182.8 \text{ m, say } 183 \text{ m}$$

(B) Given data: Ruling gradient = 6.0%

Radius of horizontal curve, R = 60 m

$$\text{Grade compensation, \%} = \frac{30+R}{R} = \frac{30+60}{60} = 1.5\%$$

Maximum limit of grade compensation

$$= \frac{75}{R} = \frac{75}{60} = 1.25\%$$

Therefore provide a grade compensation = 1.25%

Compensated gradient = (Ruling gradient – grade compensation)

$$= 6.0 - 1.25 = 4.75\%$$

OR

(A) Given: **N = 2750**

r = 6.5% = 0.065

F = 5.4

D = 0.75

n = 10 years

Design traffic,

$$CSA = \frac{365\{NFD[1+r]^n - 1\}}{r} = 54.857 \times 10^6 = \text{Say } 55 \text{ msa}$$

(B) (a) For **K = 3.0**

$$l = \left[\frac{Eh^3}{12K(1-\mu)^2}\right]^{1/4} = \left[\frac{210000 \times 15^3}{12 \times 3(1-0.15^2)}\right]^{1/4} = 0.67 \text{ cm}$$

(b) For K = 7.5

$$l = \left[\frac{210000 \times 15^3}{12 \times 7.5(1-0.15^2)}\right]^{1/4} = 53.3 \text{ cm}$$

It may be noted here that the influence of modulus of subgrade reaction on the radius of relative stiffness of the slab is relatively small.

(C) **P = 4200kg**

p = 6.0 kg/cm^2

P = p πa^2

Radius of loaded area,

$$a = \left(\frac{4200}{6\pi}\right)^{1/2} = 14.92 \text{ cm}$$

E = 150 kg/cm^2

Permissible deflection,

Δ = 0.25 cm

Pavement thickness,

$$z = \left[\left(\frac{3P}{2\pi E\Delta}\right)^2 - a^2\right]^{1/2}$$

Substituting, the relevant values as above, pavement thickness

= 51.4 cm

❍❍❍