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Test ID:- C26



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Full Length Test - C26

Exam Date :- 15 March 2026

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2 Marks

Q.1

Sol. **Blistering of plastered surface :** The small patches swell out beyond the plane of the plastered surface and this defect is particularly seen in case of plastered surfaces inside the building.

Peeling : The plaster from some portion of the surface comes off and patch is formed. Such formation is termed as the peeling and it is also mainly due to bond failure between successive coats of plaster.

Q.2

Sol. The principal constituents of fly ash are silica, alumina, iron oxide and calcium with varying amounts of carbon as measured by loss on ignition.

Q.3

Sol. Wing walls are essential structural components in bridge and culvert construction, acting as extensions of the abutment to retain earth, control water flow, and prevent soil erosion.

Q.4

Sol.

For K = 3.0

$$l = \left[\frac{Eh^3}{12K(1-\mu^2)} \right]^{1/4} = \left[\frac{210000 \times 15^3}{12 \times 3(1-0.15^2)} \right]^{1/4} = 67.0 \text{ cm}$$

Q.5

Sol. Cutback bitumen is a liquid bitumen obtained by dissolving bitumen in a volatile solvent. It is very useful in colder region. Cutback bitumen can be classified into three types:

Slow-Curing (SC)

Rapid-Curing (RC)

Medium-Curing (MC)

Q.6

Sol.

$$AI = \frac{PET - AET}{PET} \times 100 \quad . \quad 0 \leq AI \leq 1$$

Where PET = Potential Evapotranspiration

AET = Actual Evapotranspiration

Q.7

Sol. Inconsistency of Record can be corrected by double - mass curve technique.

It is a graph is plotted between accumulated rainfall of station 'x' whose data is inconsistent & accumulated rainfall of average of group of base station, in reverse chronological order.

Q.8

Sol. Coagulation is the process in which certain chemicals called as coagulants are added in the water, so as to neutralize the negative protective charge present over the suspended impurity in order to increase the opportunity of these particles to come in contact with each other, thus, grow in size and get easily settled in following sedimentation, whereas, Flocculation is the process in which neutralised particles are brought in intimate contact with each other so as to promote their agglomeration which results in increased size of particles that can get easily settled.

Q.9

Sol. $\Delta (\Delta) = 8.64 \frac{B}{D}$

where,

Δ = Delta in meter

B = Base period in days

D = Duty in hectares/cumec

Q.10

Sol.
$$E_L = km(e_s - e_a) \left(1 + \frac{u_9}{16}\right)$$

Where, km = a constant defining type of water body

e_s = Saturation vapour pressure a water (in mm of Hg)

e_a = Actual vapour pressure of prevailing air (in mm of Hg)

u_9 = Wind velocity in kmph @ 9m above ground

Q.11

Sol. An Aqueduct is a cross drainage work, which is used when canal flowing over the drainage and high flood level (HFL) of the drain is much below the bottom of the canal.

Q.12

Sol. **Specific Gravity (SG):** It is the ratio of the density of a substance to the density of a standard substance (usually water). It is a dimensionless value.

Relation to Density:

specific gravity = density of the substance (fluid)/density of a standard fluid.

Hence, density of the substance can be calculated as:

Density = SG × Density of standard substance (water).

Q.13

Sol. **Resultant Hydrostatic Force:**

It is the **total pressure force** exerted by a static fluid on a submerged plane surface.

$$F = \rho g \bar{h} A$$

Where $\bar{h}$ = depth of centroid, A = area of surface.

Center of Pressure:

It is the **point of action** of the resultant hydrostatic force, where the total pressure may be assumed to act.

$$\bar{h}_{cp} = \frac{I_{GXX} \times \sin^2 \theta}{\bar{h} A} + \bar{h}$$

Q.14

Sol. **Flakiness Index** is the percentage by which weight of particle whose least dimension (thickness) of aggregate is less than 0.6 times their mean dimension.

Q.15

Sol. The moisture in timber can be present either in the cell cavities or in the cell walls. The former is known as free moisture. The major part of moisture in timber is present as free moisture. The latter is known as the bound moisture and it is closely associated with the body of timber.

Q.16

Sol. Self-cleansing velocity is defined as the minimum velocity at which sewage should flows such that there is no deposition or accumulation of particles along the drain length and also at which the scour of the deposited particles will take place so that the sewer will be kept clean.

Q.17

Sol. The average time for which the biomass stays in the system is known as sludge age (θ_c) and it is given by.

$$\theta_c = \frac{\text{Mass of biomass in the system}}{\text{Mass of biomass leaving the system per day}}$$

$$\Rightarrow \theta_c = \frac{200 \times 10^3 \times 2000}{50 \times 10^6}$$

$$\Rightarrow \theta_c = 8 \text{ days}$$

Q.18

Sol. **Hydrophilic aggregates :** The aggregates which are electro-negative and have greater attraction with the polar liquid like water are called hydrophilic aggregates.

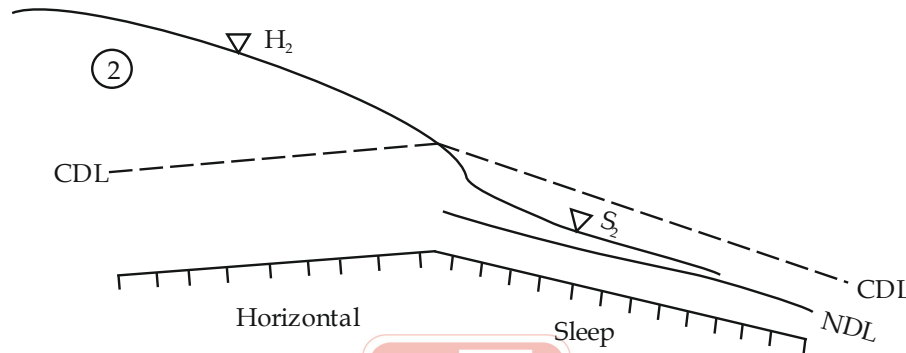
For ex.: Aggregates containing silica.

Hydrophobic aggregates: These aggregates have positive charge and have a dislike for water and greater attraction to bitumen.

For ex:- Limestone.

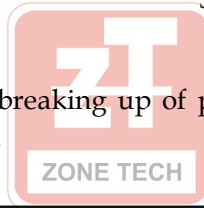
Q.19

Sol.



Q.20

Sol. Pugging or tempering of clay means breaking up of prepared clay, watering and kneading till the earth becomes a homogeneous mass.



5 Marks

Q.21

Sol.

$$B = 2\text{m}$$

$$Q = 2 \text{ m}^3/\text{s}$$

$$q = \frac{2}{2} = 1 \text{ m}^3/\text{s}$$

Given that velocity head after jump is 5% of that of before jump.

$$\frac{v_2^2}{2g} = 0.05 \frac{v_1^2}{2g}$$

$$v_2 = 0.22 v_1 \quad \dots(i)$$

For rectangular channel

$$\frac{q^2}{g} = \frac{y_1 y_2 (y_1 + y_2)}{2}$$

$$\frac{1}{9.81} = \frac{y_1 y_2 (y_1 + y_2)}{2} \quad \dots(ii)$$

$\Rightarrow$

$$q = v_1 y_1 = v_2 y_2$$

$$v_1 y_1 = 0.22 v_1 y_2$$

Putting value of y_1 is (ii)

$$0.2 = 0.22 y_2 y_2 (0.22 y_2 + y_2)$$

$$0.2 = 0.2684 y_2^3$$

$$y_2 = 0.90 \text{ m}$$

$$y_1 = 0.199 \text{ m}$$

Q.22

Sol. Mass batching gives the correct measurement of materials.

When volume batching is used, the precautions to be taken are :

- Materials should not be heaped in measuring boxes.
- Bulking of sand should be taken into account.
- Water-cement ratio should be suitably modified.

The flow up of these precautions is usually left to the non-technical labours. Thus mass batching is superior to the volume batch mixing.

Q.23

Sol. **Criteria for Selection of Bridge Site**

1. Topography

- Select narrow river stretch to reduce span and cost.
- Prefer straight approaches; avoid skew crossings.

2. Foundation Conditions

- Prefer hard strata (rock/ dense soil).
- Avoid loose sand, marshy soil, expansive clay – may require deep foundations.

3. River Characteristics

- Stable banks, well-defined bed, absence of sharp bends or confluences.
- Check scour depth using Lacey's formula where applicable.

4. Approach Conditions

- Minimum earthwork; safe embankment away from erosion-prone edges.
- Ensure ease of access for construction and maintenance.

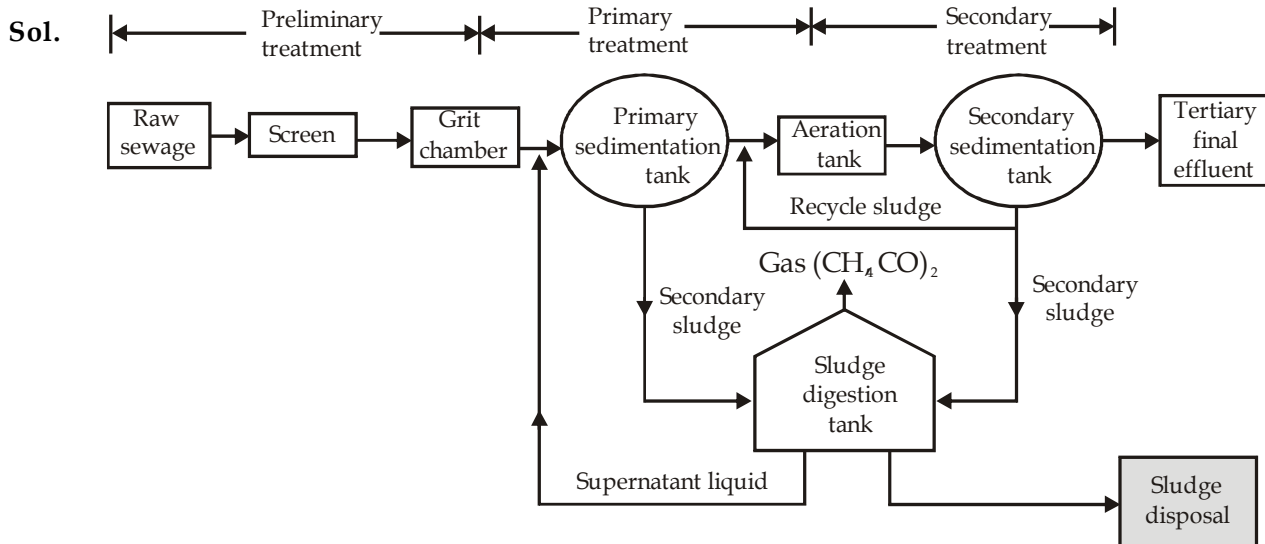
5. Material & Labour Availability

- Prefer location where construction materials and labour are easily available to reduce project cost.

6. Environmental & Social Impact

- Avoid forest, wildlife, and densely populated areas.
- Minimum displacement and minimal environmental disturbance.

Q.24



Q.25

Sol. the approximate time required to cover a given area with water can be calculated as

$$t = 2.303 \times \frac{y}{f} \times \log_{10} \left(\frac{Q}{Q - fA} \right)$$

where,

Q = Discharge

y = Depth of water flowing over border strip

f = Rate of infiltration

A = Area of land strip to be irrigated

Given data

$$A = 0.04 \text{ ha} = 0.04 \times 10^4 \text{ m}^2 = 400 \text{ m}^2$$

$$Q = 0.02 \text{ cumecs} = 0.02 \times 60 \times 60 = 72 \text{ m}^3/\text{hr}$$

$$f = 5 \text{ cm/hr} = 0.05 \text{ m/hr}$$

$$y = 10 \text{ cm} = 0.1 \text{ m}$$

∴

$$t = 2.303 \times \frac{y}{f} \times \log_{10} \left(\frac{Q}{Q - fA} \right)$$

$$t = 2.303 \times \frac{0.1}{0.05} \times \log_{10} \left(\frac{72}{72 - 0.05 \times 400} \right) = 0.651 \text{ hrs} = 39.06 \text{ minutes}$$

maximum area that can be irrigated,

$$A_{\max} = \frac{Q}{f} = \frac{72}{0.05} = 1440 \text{ m}^2 = 0.144 \text{ ha}$$

Q.26

Sol. Here, $P = \frac{1}{50} = 0.02$,

$$Q = (1 - P) = (1 - 0.02) = 0.98$$

$$P_{r,n} = \frac{n!}{(n-r)!r!} P^r Q^{n-r}$$

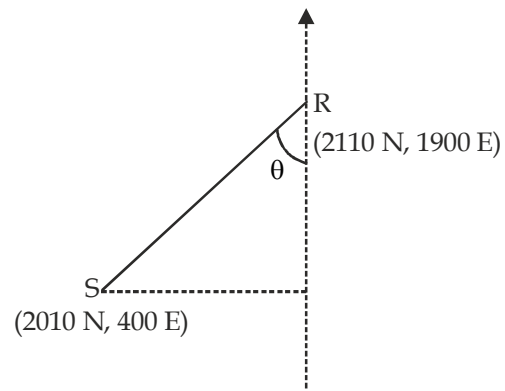
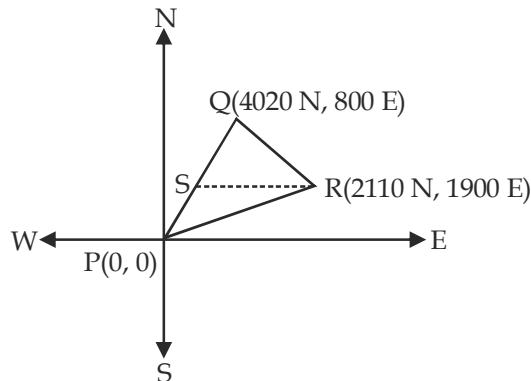
$$(a) \ n = 20, r = 1 : P_{1,20} = \frac{20!}{(20-1)!1!} P^1 Q^{20-1} = \frac{20!}{19!1!} \times 0.02 (0.98)^{19} \\ = 20 \times 0.02 \times 0.68123 = 0.272$$

$$(b) \ n = 15, r = 2 : P_{2,15} = \frac{15!}{(15-2)!2!} P^2 Q^{15-2} = \frac{15!}{13!2!} \times (0.02)^2 \times (0.98)^{13} \\ = \frac{15 \times 14}{2} \times 0.0004 \times 0.769 = 0.323$$

$$(c) \ P_1 = 1 - (1 - 0.02)^{20} = 0.32$$

Q.27

Sol.



Given 'S' is the mid-point of PQ.

$$\therefore \text{Coordinates of point, S} = \left(\frac{4020+0}{2} \text{N}, \frac{800+0}{2} \text{E} \right) = (2010 \text{ N}, 400 \text{ E})$$

$$\text{Length RS} = \sqrt{(2010 - 2110)^2 + (400 - 1900)^2} = 1503.33 \text{ units}$$

$$\tan \theta = \frac{1900 - 400}{2110 - 2010} = \frac{1500}{100}$$

$$\therefore \theta = 86.19^\circ$$

$$\therefore \text{Bearing of RS} = 180^\circ + \theta = 266.19^\circ$$

Q.28

Sol. (a) Submerged body (completely under water)

- If B lies above G = Stable equilibrium
- If B lies below G = Unstable equilibrium
- If B and G lies at same point = Neutral equilibrium

Where, B = Center of buoyancy and G = Center of gravity of body

(b) Floating body (partly submerged, G above B)

- If M lies above G = Stable equilibrium
- If M lies below G = Unstable equilibrium
- If M and G lies at same point = Neutral equilibrium

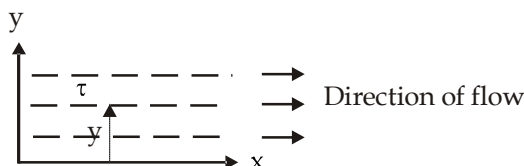
Where, M = Metacenter and G = Center of gravity of body

For floating bodies center of gravity (G) is always above the center of buoyancy (B) when it is in rest condition.

Q.29

Sol.

- (a) It has been experimentally verified that the shear stress on the layer at a distance 'y' from the surface is directly proportional to the rate of shear strain or the rate of angular deformation.



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

- (b) When the plate is moving with a uniform velocity of 2 m/sec, the viscous resistance to the motion is equal to the component of the weight of the plate along the sloping surface. Component of the weight of the plate along the slope = $25 \sin 30^\circ = 12.5 \text{ kg(f)}$

$$\text{Viscous resistance} = (\tau \times A)$$

$$= \mu \frac{dv}{dy} \times A = \mu \frac{V}{y} \times A$$

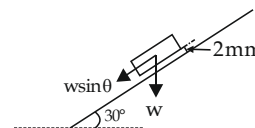
$$V = 2 \text{ m/sec}; y = 2 \times 10^{-3} \text{ m}; \text{ and } A = (0.25 \times 0.5) \text{ m}^2$$

By substituting these values, we get

$$\text{Viscous resistance} = \mu \times \frac{2}{2 \times 10^{-3}} (0.25 \times 0.5) = 125 \mu \text{ kg(f)}$$

Equating the two, we get $125\mu = 12.5$

$$\mu = 0.1 \text{ kg(f)-sec/m}^2$$



Q.30

Sol. Field tests performed on bricks for its suitability:

1. **Shape and size:** Brick is closely observed. It should be of standard size 190mm x 90mm x 90mm. Its shape should be truly rectangular with plane faces, sharp edges and right angles.
2. **Water absorption test:** A brick is weighed dry. It is then immersed in water for a period of 24 hours. It is weighed again and difference in weight indicates the amount of water absorbed by the brick. It should not be more than 20% of weight of dry brick.
3. **Hardness:** A scratch is made on brick surface with a finger nail. If no impression is left on the surface then brick is treated sufficiently hard.
4. **Soundness:** Two bricks are taken and they are struck with each other. Brick should not break and clear ringing sound should be produced.
5. **Color Test:** Brick should have deep red, cherry or copper colored and free from cracks, holes, and lumps.
6. **Structure:** A brick is broken and structure inside should be uniform, compact, and homogeneous.
7. **Presence of soluble salts:** Brick is immersed in water for 24 hours. It is then taken out and allowed to dry in shade. The absence of white deposits on its surface indicates absence of soluble salt.

Q.31

Sol. Given, at 30°C

$$BOD_5 = 110 \text{ mg/l}$$

$$K_{20} = 0.1 \text{ day}^{-1}$$

$$K_T = K_{20} (1.047)^{T-20}$$

$$K_{30} = 0.1 (1.047)^{30-20} = 0.158 \text{ day}^{-1}$$

Now,

∴

When T = 30°C

$$BOD_5 = L_0 (1 - 10^{-k_{30}t})$$

⇒

$$110 = L_0 (1 - 10^{-0.158 \times 5})$$

⇒

$$L_0 = 131.29 \text{ mg/l}$$

Ultimate BOD (L_0) remains the same irrespective of temperature.

∴ When T = 20°C,

$$L_0 = 131.29 \text{ mg/l}$$

∴

$$BOD_5 = L_0 (1 - 10^{-k_{20}t})$$

⇒

$$BOD_5 = 131.29 (1 - 10^{-0.1 \times 5}) = 89.77 \text{ mg/l}$$

∴

$$BOD_5 \text{ at } 20^\circ = 89.77 \text{ mg/l}$$

Q.32

Sol. Space headway is given by,

$$S = 60t - 60t^2$$

$$\frac{dS}{dt} = 60 - 120t = 0$$

$$t = 0.5 \text{ hr} = 30 \text{ minutes}$$

$$\frac{d^2S}{dt^2} = -120 \times 0 \text{ (Maxima)}$$

∴ Maximum space head,

$$S_{\max} = 60 \times 0.5 - 60 \times (0.5)^2 \\ = 15 \text{ km}$$

20 Marks

Q.33

Sol.

Water required per day = 4 M.L.

Assuming that 4% of filtered water is required for washing of the filter, every day, we have

Total filtered water required per day

$$= 1.04 \times 4 \text{ M.L.} = 4.16 \text{ M.L./day}$$

Now, assuming that 0.5 hour is lost everyday in washing the filter, we have

Filtered water required per hour

$$= \frac{4.16}{23.5} \text{ M.L./hour} = 0.177 \text{ M.L./hr}$$

Now, assuming the rate of filtration to be 5000 litres/hr/sq.m, we have

The area of filter required

$$= \frac{0.177 \times 10^6}{5000} \text{ m}^2 = 35.4 \text{ m}^2$$

Now, assuming the length of the filter bed (L) as 1.5 times the width of the filter bed (B), and two beds, the total area provided

$$2 \times (L.B) = 35.4$$

$$\text{or } 2 \times (1.5 B) (B) = 35.4$$

$$\text{or } B^2 = \frac{35.4}{3} = 11.8$$

$$\text{or } B = 3.43 \text{ m}$$

$$\therefore L = 1.5 B = 1.5 \times 3.43 = 5.14$$

say 5.2 m

or use the length of the filter bed as = 5.2 m, and

$$B = \frac{35.4}{2 \times 5.2} = 3.4 \text{ m}$$

Hence, adopt 2 filter units, each of dimensions

$$5.2 \text{ m} \times 3.4 \text{ m} \text{ Ans.}$$

Design of under-drainage system. Let a "manifold and lateral system" be provided below the filter bed, for receiving the filtered water and to allow back washing for cleaning the filter. This consists of a central manifold pipe, with laterals having perforations at their bottom.

To design this system, let us assume that the area of the perforations is 0.2% of the total filter area.

 $\therefore$ Total area of perforation

$$= 0.2\% \times \text{Filter area}$$

$$= \frac{0.2}{100} \times (5.2 \times 3.4) \text{ m}^2 = 0.035 \text{ m}^2$$

Now, assuming the area of each lateral

$$= 2 \text{ times the area of perforations in it}$$

(for 13 mm dia perforations) we have,

$$\text{Total area of laterals} = 2 \times \text{Total area of perforations}$$

$$= 2 \times 0.035 \text{ m}^2 = 0.070 \text{ m}^2$$

Now, assuming the area of the manifold to be about twice the area of laterals, we have

The area of manifold

$$= 2 \times 0.070 = 0.14 \text{ m}^2$$

 $\therefore$ Dia of manifold (d) is given by

$$\frac{\pi}{4} \cdot d^2 = 0.14$$

or
$$d = \sqrt{\frac{0.14 \times 4}{\pi}} = 0.42 \text{ m}$$

Hence, use a 45 cm dia manifold pipe laid length wise along the centre of the filter bottom. Laterals running perpendicular to the manifold (i.e. widthwise) emanating from the manifold may be laid at a spacing of say 15 cm (max. 30 cm). The number of laterals is then given as

$$= \frac{5.2 \times 100}{15} = 34.6; \text{ say } 35$$

on either side of the manifold. Hence, use 70 laterals in all, in each unit.
Now, length of each lateral

$$= \frac{\text{Width of filter}}{2} - \frac{\text{Dia of manifold}}{2}$$

$$= \frac{3.4}{2} - \frac{0.45}{2} = \frac{2.95}{2} = 1.475 \text{ m}$$

Now, adopting 13 mm dia perforations in the laterals, we have
Total area of perforations

$$= 0.035 \text{ m}^2$$

$$= 350 \text{ cm}^2 = x \cdot \frac{\pi}{4} (1.3)^2$$

where x = Total no. of perforations in all 70 laterals.

$$\therefore x = 350 \times \frac{4}{\pi (1.3)^2} = 263.8; \text{ say } 264$$

$\therefore$ No. of perforations in each lateral www.zonetech.in

$$= \frac{264}{70} = 3.8; \text{ say } 4$$

$\therefore$ Area of perforations per lateral **ZONE TECH**
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$$= 4 \times \left[\frac{\pi}{4} \times (1.3)^2 \right] \text{ cm}^2 = 5.30 \text{ cm}^2$$

Now, area of each lateral

$$= 2 \times \text{Area of perforations per lateral}$$

$$= 2 \times 5.30 = 10.60 \text{ cm}^2$$

$\therefore$ Dia of each lateral

$$= \sqrt{10.60 \times \frac{4}{\pi}}$$

$$= 3.67 \text{ cm; say } 3.7 \text{ cm}$$

Hence, use 70 laterals each of 3.7 cm dia, @ 15 cm c/c, each having 4 perforations of 13 mm size, with 45 cm dia manifold.

Check:

$$\frac{\text{Length of each lateral}}{\text{Dia of lateral}} = \frac{1.475 \text{ m}}{3.7 \text{ cm}} = \frac{147.5}{3.7} = 39.9$$

(which is less than 60, and hence O.K.)

Now, let us assume that the rate of washing of the filter be 45 cm rise/minute or 0.45/minute.

$\therefore$ The wash water discharge

$$= \frac{0.45 \times (5.2 \times 3.4)}{60} \text{ m}^3/\text{sec}$$

$$= 0.133 \text{ m}^3/\text{sec}$$



∴ Velocity of flow in the lateral for wash water

$$= \frac{0.133}{70 \times \left[\frac{\pi}{4} \times \left(\frac{3.7}{100} \right)^2 \right]}$$

$$= \frac{0.133 \times 10000}{70 \times 10.75} \text{ m/sec}$$

$$= \frac{1330}{70 \times 10.75} = 1.77 \text{ m/sec}$$

Similarly, velocity of flow in the manifold

$$= \frac{\text{Discharge}}{\text{Area}}$$

$$= \frac{0.133}{\frac{\pi}{4} \times (0.45)^2} = \frac{0.133}{0.158}$$

= 0.84 m/sec, which is less than 1.8 to 2.4 m/sec (max. permissible), and hence O.K.

Q.34

- Sol.**
- Workability is referred to as the ease with which concrete can be transported, placed and consolidated without excessive bleeding or segregation.
 - Workability can also be defined as the internal work done in overcoming the frictional forces between concrete ingredients for full compaction.
 - The optimal workability of concrete will depend upon the given job and hence will vary from situation to situation.

FACTORS AFFECTING WORKABILITY :

(i) **Water Content :**

- In order to obtain higher degree of workability higher water content is required but with the increase in water-cement ratio, the strength of the cement concrete is decreased hence in order to maintain the strength, along with water content, proportion of cement should be increased.

(ii) **Mix Proportions :**

- Aggregate-cement ratio influences the workability to a large extent. The higher the ratio leaner will be the concrete, hence the workability is less

(iii) **Aggregate Size :**

- For big size aggregates the total surface area to be wetted is less, also less paste is required for lubricating the surface to reduce internal friction. So, for a given water content big size aggregates give high workability.

(iv) **Shape of Aggregates :**

- At a given water content, round and cubical shape aggregates are more workable than rough, angular or flaky aggregates, because the former type of aggregates require less cement paste for lubrication as these have less surface area and lesser voids.
- In round aggregates frictional resistance is small, so less lubrication is required. For this reason, river sand and gravel provide greater workability than crushed sand and aggregates.

(v) **Surface Texture :**

- Rough surface aggregates will have more surface area than a smooth round textured aggregate. Therefore smooth textured aggregates will be more workable.

(vi) **Grading of Aggregates :**

- Well graded aggregates are more workable. Because, such a mix will have least voids and thus excess cement paste will be available as lubricant.



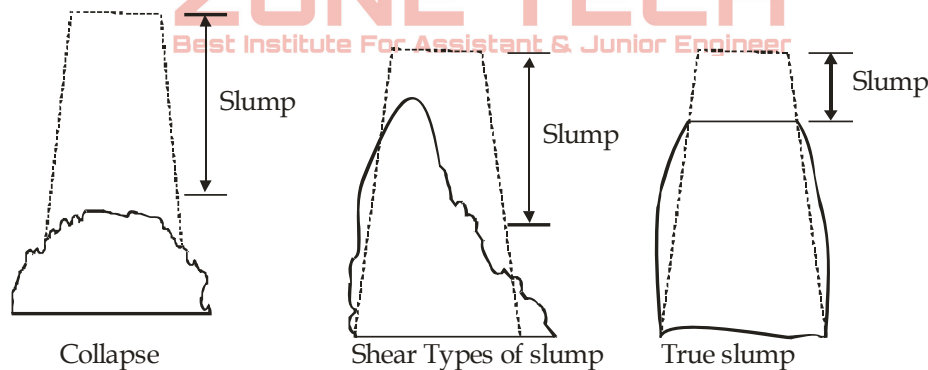
(vii) **Admixtures :**

- At given water content, air-entraining admixtures improve the consistency and cohesiveness of the concrete by increasing the volume of paste.
- Air entrained concrete is more workable. Because air forms bubbles, on which the aggregates slide past each other increasing the workability.
- For a given water content and strength, workability can be increased by addition of water reducers (plasticizers or super plasticizers)
- Pozzolanic admixtures tend to improve the cohesiveness of concrete. Fly ash, when used as partial replacement for fine aggregate, generally improves the workability at given water content.

SLUMP TEST : Slump test is used for in-situ determination of workability.

The procedure is as follows :

- The apparatus used is a metallic mould in the form of frustum of a cone having internal dimensions as : Top diameter - 10 cm Bottom diameter - 20 cm Height - 30 cm
- A steel tamping rod of 16 mm dia, 0.6 m long with bullet end is used.
- The mould is placed on a smooth, horizontal, rigid and non-absorbent surface.
- It is then filled in 4 layers, each approximately $\frac{1}{4}$ of height of mould.
- Each layer is tamped 25 times by the tamping rod evenly.
- After the top layer has been rodded, the concrete is struck off level with a trowel and tamping rod.
- The mould is removed immediately by lifting it vertically carefully.
- The difference between the height of mould and the highest point of subsided concrete in mm is taken as slump of concrete.
- The pattern of slump also indicates the characteristics of concrete.
- An even slump is called true slump, and if one half of concrete slides down, it is called shear slump. It may collapse in case of very wet concretes.
- In case of shear slump, the slump value is measured as difference between the height of mould and average value of subsidence.
- Shear slump indicates a non-cohesive concrete and may lead to segregation.



Degree of Workability	Slump (in mm)	Use of Concrete
Low	25-75	• Roads vibrated by hand operated machines.
		• Mass concrete foundation without vibration or lightly reinforce sections with vibration.
Medium	20-100	• Manually compacted flat slabs using crushed aggregates.
		• Normal reinforced concrete, manually compacted and heavily reinforced sections with vibration.
High	100-150	• For sections with congested reinforcement.

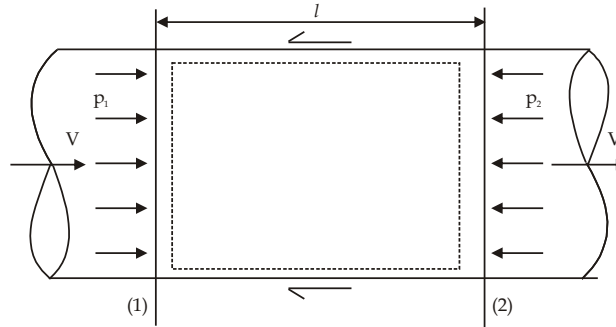
Q.35

Sol. The frictional loss for the flow through a pipe can be evaluated by the force balance on the control volume.

Let us assume,

Average flow velocity = V

Area of cross-section = A



p_1 and $p_2 \rightarrow$ intensities of pressure at section (1) and (2)

Writing energy equation between section (1) and (2)

$$\frac{p_1}{\gamma} + \frac{V_1^2}{2g} + z_1 = \frac{p_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + h_f$$

$$V_1 = V_2 \text{ and } z_1 = z_2$$

$$\Rightarrow h_f = \left(\frac{p_1 - p_2}{\gamma} \right) \quad \dots(i)$$

i.e. pressure intensity will be reduced by the frictional resistance in the direction of flow and the difference of pressure heads between any two section is equal to the loss of head due to friction between these sections,

Further let f' be the frictional resistance per unit area at unit velocity, then frictional resistance (f)

$$f = f' \times \text{area} \times v^n$$

$$f = f' \times p_l \times v^n$$

Where, p = Wetted perimeter of the pipe

The pressure force at the section 1 and 2 are ($p_1 A$) and ($p_2 A$) respectively.

Thus resolving all the force horizontally, we get

$$p_1 A = p_2 A + \text{frictional resistance}$$

$$(p_1 - p_2) A = f' p_l V^2$$

$$h_f \gamma_w A = f' p_l V^2 \quad [\text{from equation (i)}]$$

$$h_f = \frac{f' p_l V^2}{\gamma_w A}$$

For circular pipe running full, $A = \frac{\pi d^2}{4}$ and $P = \pi d$

$$\Rightarrow h_f = \frac{f' (\pi d) V^2}{\gamma_w \frac{\pi d^2}{4}} = \frac{4 f' V^2}{\rho g d} = \frac{8 f' V^2}{\rho \cdot 2 g d}$$

$$\Rightarrow h_f = \frac{f V^2}{2 g d} \quad [\text{where friction factor, } f = \frac{8 f'}{\rho}]$$

Q.36

Sol. Pull correction $\frac{(P - P_0) \times \sum l}{AE}$

$$= \frac{(178 - 89) \times 119.632 \times 1000}{3.24 \times 2.07 \times 10^5} = 15.875 \text{ mm}$$

$$C_p = 0.0158 \text{ m}$$

Correction for temp. (C_t) = $\alpha \sum (t - t_0) l$

$$C_t = 1.1 \times 10^{-5} \{ (-2) \times 29.899 + (-2) \times 29.901 + (-1.9) \times 29.882 + (-2.1) \times 29.950 \}$$

$$C_t = -0.003 \text{ m}$$

(III) Correction for sag (C_s) = $\frac{-W^2 l}{24 n^2 p^2}$

$$C_s = \frac{-w^2 \sum l^3}{24 p^2}$$

$$C_s = \frac{-(0.026 \times 9.81)^2}{24 \times (0.178)^2} \times [(29.899)^3 + (29.901)^3 + (29.882)^3 + (29.950)^3]$$

$$C_s = -0.009 \text{ m}$$

(iv) Correction for slope (C_{slope}) = $-\sum \frac{h^2}{2L}$

$$\Rightarrow \left[\frac{(0.064)^2}{2 \times 29.899} + \frac{(0.374)^2}{2 \times 29.901} + \frac{(-0.232)^2}{2 \times 29.882} + \frac{(0.238)^2}{2 \times 29.950} \right]$$

$$C_{\text{slope}} = -0.004 \text{ m}$$

(v) Correction for M.S.L. ($C_{\text{M.S.L.}}$) = $-\frac{hL}{R}$

$$= -\frac{26.89 \times (119.632)}{6370 \times 1000} = -0.001 \text{ m}$$

Now absolute length (C_l) = Measured length & Correction

$$= 119.632 + 0.016 - 0.003 - 0.009 - 0.004 - 0.001 = 119.631 \text{ m}$$

Q.37

Sol. (i) Advantages of rotary

- Crossing manoeuvre is converted into weaving or merging and diverging operations, hence possible number of accidents and the severity of accidents are quite low because of low relative speed. Further weaving, merging and diverging manoeuvres are easier and less dangerous operations than crossing.
- All traffic including those turning right or going straight across the rotary have equal opportunity as those turning left.
- The variable vehicle operation cost of motor vehicles is lower at a traffic rotary than at a signalized intersection where the vehicles have to stop and proceed. Though the distance to be traversed by vehicles which are to turn to the right or proceed straight across is higher, still the fuel consumed in the process of crossing the rotary intersection is likely to be lower.

- (d) Traffic rotaries can be constructed with advantage when the number of intersecting roads is between four and seven.
- (e) When the proportion of right turning traffic exceeds 30 percent at a four legged intersection, a rotary is more advantageous than a signalized intersection
- (f) The rotary intersection can efficiently handle up to about 3000 vehicles per hour entering from all intersecting legs. The capacity of the rotary intersection can be increased up to 5000 vehicles per hour, by appropriate design.

Limitations of rotary

- (a) Rotary requires comparatively a large area of land and so where space is limited and costly as in built up areas, the total cost may be very high..
- (b) Where pedestrian traffic is large as in urban areas, the rotary by itself cannot control the traffic and hence will need grade separated pedestrian crossing; alternatively pedestrians crossing has to be supplemented by traffic police.
- (c) Where the angle of intersection of two roads is too acute or when there are more than seven intersecting roads, rotaries are unsuitable.
- (d) When the distance between intersections on an important highway is less, rotaries become troublesome,
- (e) When the traffic volume is very low construction of a rotary cannot be justified

(ii)

Given: normal flow on roads A & B: $q_a = 400$ PCU/hr and $q_b = 250$ PCU/hr

Saturation flow, $S_a = 1250$ and $S_b = 1000$ PCU/hr; all - red time, $R = 12$ sec, number of phases, $n = 2$ $q_a 400$.

$$y_a = \frac{q_a}{S_a} = \frac{400}{1250} = 0.32$$

$$y_b = \frac{q_b}{S_b} = \frac{250}{1000} = 0.25$$

$$Y = y_a + y_b = 0.32 + 0.25 = 0.57$$

$$\text{Total lost time, } L = 2n + R = 2 \times 2 + 12 = 16 \text{ sec}$$

$$\text{Optimum cycle time, } C_o = \frac{1.5L + 5}{1 - Y} = \frac{1.5 \times 16 + 5}{1 - 0.57} = \frac{29}{0.43} = 67.4, \text{ say } 67.5 \text{ sec}$$

$$G_a = \frac{y_a}{Y} (C_o - L) = \frac{0.32}{0.57} (67.5 - 16) = 29 \text{ sec}$$

$$G_b = \frac{y_b}{Y} (C_o - L) = \frac{0.25}{0.57} (67.5 - 16) = 22.5 \text{ sec}$$

Provide an all-red time, R for pedestrain crossing = 12 sec

Providing Amber times of 2.0 sec each for clearance, total cycle time

$$= 29 + 22.5 + 12 + 2 + 2 = 67.5 \text{ sec.}$$

Q.38

Sol.

Column 2 = ordinates of 4-h UH starting from zero

Column 3 = ordinates of 4-h UH lagged by 4-h

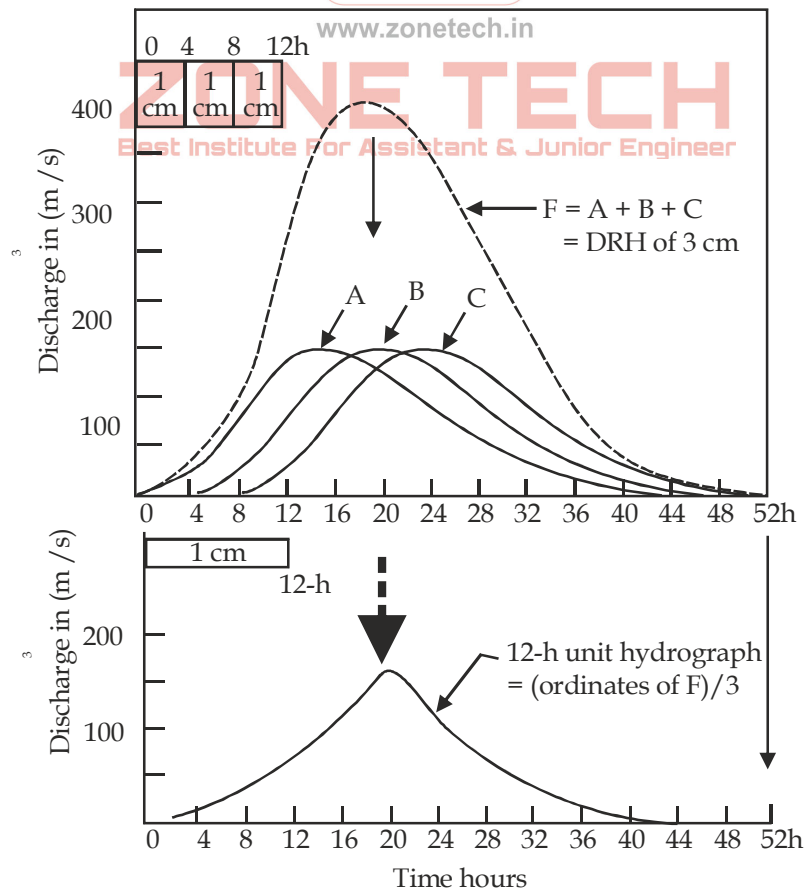
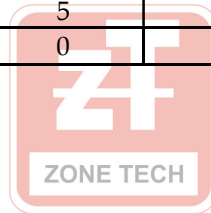
Column 4 = ordinates of 4-h UH lagged by 8-h

Column 5 = ordinates of DRH representing 3 cm ER in 12-h

Column 6 = ordinates of 12-h UH = (Column 5)/3



Time (h)	Ordinates of 4-h UH (m ³ /s)			DRH of 3 cm in 12-h (m ³ /s) (Col. 2+3+4)	Ordinate of 12-h UH (m ³ /s) (Col. 5)/3
	A	B Lagged by 4-h	C Lagged by 8-h		
1	2	3	4	5	6
0	0	-	-	0	0
4	20	0	-	20	6.7
8	80	20	0	100	33.3
12	130	80	20	230	76.7
16	150	130	80	360	120.0
20	130	150	130	410	136.7
24	90	130	150	370	123.3
28	52	90	130	272	90.7
32	27	52	90	169	56.3
36	15	27	52	94	31.3
40	5	15	27	47	15.7
44	0	5	15	20	6.7
48		0	5	5	1.7
52			0	10	0



Name of the force	Designation if given	Magnitude in kN	Lever arm in m	Momenta about toe in kN.m
Vertical forces	W_1	(+) $84 \times 6 \times 1 \times 23.5 = 11,844$	53.0	(+) 6,27,732
Downward Weight of the Dam	W_2	(+) $\frac{1}{2} \times 50 \times 75 \times 1 \times 23.5 = 44,063$	33.33	(+) 14,68,620
Weight of water Supported on d/s face	-	(+) $\frac{1}{2} \times 4 \times 6 \times 1 \times 9.81 = 118$	1.33	(+) 157
		$\Sigma V_1 = 56,025$		$\Sigma M_1 = (+)20,96,509$
Uplift pressures	U_1	(-) $300.8 \times 8 \times 1 = 2406$	52.0	(-) 1,25,112
	U_2	(-) $\frac{1}{2} \times 484 \times 8 \times 1 = 1936$	53.33	(-) 1,03,247
	U_3	(-) $58.9 \times 48 \times 1 = 2827$	24.0	(-) 67,848
	U_4	(-) $\frac{1}{2} \times 241.9 \times 48 \times 1 = 5806$	32.0	(-) 1,85,792
		$\Sigma V_2 = (-)12,975$		$\Sigma M_2 = (-)4,81,999$
		$\Sigma V = 56,025 - 12,975 = 43050$	""	
Horizontal Water pressure On u/s face	P	(-) $\frac{1}{2} \times 784.8 \times 80 \times 1 = 31,392$	26.67	(-) 8,37,225
On d/s face	P	(-) $\frac{1}{2} \times 58.9 \times 6 = (-)177$	2.0	(+) 354
		ΣH (towards downstream) = 31,215		$\Sigma = (-)8,36,871$
$\Sigma M = \text{Net}(+) \text{moment} = 20,96,509 - 4,81,999 - 8,36,871 = 7,77,639 \text{ kN} - \text{m}$				

$\therefore$ Max. vertical stress = $P_{\max}$ at toe = $768.8 \times 2.065 = 1587.6 \text{ kN/m}^2$

$\therefore$ Min. vertical stress = $p_{\min}$ at heel = $768.8 \times (-) 0.065 = (-) 49.97 \text{ kN/m}^2$