MADE EASY
India's Best Institute for IES, GATE & PSUs

# RPSC Main Exam 2019 : Test Series

## Assistant Engineer

## Civil Engineering

## Compulsory Subject : Paper-II

**Test No. 8** | Date of Exam. : 11-08-2019 (9 AM to 12 Noon)

**Part-A** **[Marks : 40]**

**1. Solution:**

1. Optical square
2. Prism square

**2. Solution:**

Electronic distance measuring instrument is a surveying instrument for measuring distance electronically between two points through electromagnetic waves.

**3. Solution:**

$$\Sigma BS - \Sigma FS = \text{Last } RL - \text{First } RL$$

$$\Rightarrow \quad 16.26 - \Sigma FS = 23.50 - 23.47$$

$$\Rightarrow \quad \Sigma FS = 16.23 \text{ m}$$

**4. Solution:**

**No Slip Condition:** When a real fluid flows over a boundary, the layer of fluid in contact with the boundary comes to a complete relative halt due to viscosity of the real fluid. This layer of fluid cannot slip away from the boundary and attains the same velocity as that of the boundary. This is called as "no-slip" condition.

**5. Solution:**

It is the difference between absolute pressure and local atmospheric pressure. It can be positive or negative.

Gauge pressure = Absolute pressure – Local atmoshpheric pressure.

**6. Solution:**

A grid obtained by drawing a series of equipotential lines and stream lines is called flow net.

**7. Solution:**

Shotcrete is placed and compacted at the same time, due to the force with the nozzle. It is also known as spray concrete as the force of jet impacting on the surface compacts it, so as to make itself supporting.

**8. Solution:**

The bull's trench kilns are constructed in trenches excavated in ground whereas Hoffman's koln's are constructed over ground.

**9. Solution:**

1. ASCU
2. Solignum paints

**10. Solution:**

An arch dam is most suitable for narrow gorges or canyons with steep walls of stable rock to support the structure and stresses.

**11. Solution:**

The stilling basin is a hydraulic structure located between the outlet works of a dam and the tail water, from where the return excess flows safely. The stilling basin is a structure in which a hydraulic jump is generated and has been designed economically in terms of length, tail water level and scour.

**12. Solution:**

Intensity of irrigation is defined as the percentage of the irrigation proposed to be irrigated annually. Usually the areas irrigated during each crop season (Rabi, Kharif, etc) are expressed as a percentage of the CCA which represents the intensity of irrigation for the crop season.

**13. Solution:**

**True regime:** A channel is said to be in true regime if there is no silting and no scouring. This condition is attained when silt load entering the channel must be carried through the channel section.

**14. Solution:**

**Bitumen:** It is a heavy residue from the fractional distillation of crude oil. Once all the major components have been extracted from crude oil, the dark, thick sticky liquid left behind is called as bitumen.

**Asphalt:** It is a mixture of bitumen and aggregates (inorganic heavy fillers, sands, grits etc.) used for road construction.

**15. Solution:**

The different kind of traffic surveys generally carried out are :

(a) Traffic volume studies
(b) Spot speed studies
(c) Speed and delay studies
(d) Origin and destination studies
(e) Parking studies
(f) Accident studies

**16. Solution:**

**OSD (Overtaking Sight Distance):** The minimum distance open to the vision of the driver intending to overtake slow vehicle ahead with safety against the traffic of opposite direction is known as the minimum overtaking sight distance.

**17. Solution:**

Ground water containing excess fluoride is treated by **NALGONDA** technique. It uses aluminium salt (alum) for removing fluoride. It also helps in the removal of colour, odour, turbidity, bacteria and organic contaminants.

**18. Solution:**

Aerosols refer to the dispersion of solid or liquid particles of microscopic size in gaseous media, such as duct, smoke or moist.

**19. Solution:**

Whenever a sewer pipe has to be dropped below the hydraulic gradient line for passing beneath a valley, a road, a railway, a stream, a tidal estuary or any other depression in the earth's surface or where it passes beneath some other obstructions in its path, it is known as an inverted siphon or a depressed sewer or a sag pipe.

**20. Solution:**

**Flood routing** is the technique of determining the flood hydrograph at a section of a river by employing the data of flood flow of one or more upstream sections.

**21. Solution:**

For general community purpose, the total draft is not taken as the sum of maximum hourly demand and fire demand, but is taken as the sum of maximum daily demand and fire demand, or the maximum hourly demand, whichever is more.

So the sum of maximum daily demand and fire demand is termed as coincident draft.

**22. Solution:**

$$\text{Population equivalent} = \frac{\text{Total 5 days oxygen demand}}{\text{Per capita BOD of sewage per day}}$$

$$\Rightarrow \quad \text{Total 5 days oxygen demand} = 3{,}17{,}000 \times \left(\frac{80}{1000}\right) = 25360 \text{ kg}$$

$$\text{Daily sewage flow} = 75 \times 10^6 \; l/\text{day}$$

$$\therefore \quad 25360 = (\text{Avg. 5 days BOD}) \times 75 \times 10^6$$

$$\Rightarrow \quad \text{Avg. 5 days BOD} = \frac{25360}{75 \times 10^6} \text{ kg}/l = \frac{25360 \times 10^6}{75 \times 10^6} \text{ mg}/l = 338.13 \text{ mg}/l$$

**23. Solution:**

The uses of contour maps in civil engineering projects are as follows:

1. **Drainage area estimation :** The extent of drainage area may be estimated on contour map by locating the ridge line around the watershed.
2. **Capacity of Reservoir :** Reservoirs are made for water supply and for power or irrigation projects. A contour map is very useful to study the possible location of a dam and the volume of water to be confined. All contour lines are closed within the reservoir area.
3. **Site of structures :** The most economical and suitable site for the structure such as buildings, bridges, dams etc. can be found from large scale contour maps.
4. **Earthwork Estimates :** On the contourlines of original surface, the contours of the desired altered surface are drawn. The volume of a cut or a fill is found by multiplying the average by the contour interval.
5. **Route location :** By inspection a contour map, the most suitable site. For road, railway, canal etc. can be selected. By following the contour lines, steep gradients, cutting and filling etc. may be avoided.

**24. Solution:**

**Bulk Modulus:** It is a measure of compressibility of a fluid. It is a ratio of change in pressure to change in volume per unit volume. It is the ratio of pressure to volumetric strain

Bulk modulus, $$k = \frac{\Delta P}{\left(-\frac{\Delta V}{V}\right)}$$

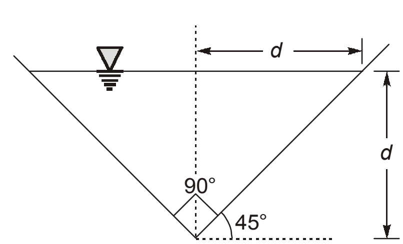
SI unit of bulk modulus of elasticity is expressed in terms of $N/m^2$ i.e., Pascal

**Factors affecting bulk modulus:**

1. As pressure of fluid increases, bulk modulus of elasticity of fluid increases.
2. With increase in temperature of a liquid the bulk modulus of liquid decreases.
3. With increase in temperature of a gas the bulk modulus of gas increases.

As in case of liquid the bulk modulus of elasticity is very high. So even with very large increase in pressure change in volume is very small, so liquid are considered incompressible.

**25. Solution:**



$$A = \frac{1}{2} \times d \times (2d) = d^2$$

For critical flow, $$\frac{Q^2}{g} = \frac{A^3}{T}$$

$$\Rightarrow \quad \frac{(16)^2}{9.81} = \frac{(d^2)^3}{2d}$$

$$\Rightarrow \quad d = \left(\frac{16^2 \times 2}{9.81}\right)^{\frac{1}{5}} = 2.2 \text{ m}$$

**26. Solution:**

**Given:** Diameter of pipe = $d$ = 3 m, Length of pipe = $l$ = 8000 m, Time of closure = $t$ = 4 sec

Velocity of flow = $V$ = 3 m/s

Velocity of wave, $$C = \sqrt{\frac{k}{\rho}} = \sqrt{\frac{2.25 \times 10^6 \times 10^3}{995.7}} = 1503.24 \text{ m/s}$$

Critical time of closure, $$t_c = \frac{2L}{C} = \frac{2 \times 8000}{1503.24} = 10.645$$

Since the valve is closed in 4 sec which is less than critical time of closure therefore the value closure is rapid.

**Pressure generated in pipe**, $P = \rho CV = 995.7 \times 1503.24 \times 3 = 4.49 \times 10^6 \text{ N/m}^2$

**27. Solution:**

**Given:** $p$ = 0.72, $L$ = 55 m, $W$ = 13.5 m, $e$ = 10 m

Capacity, $$Q = \frac{280W\left(1+\frac{e}{W}\right)\left(1-\frac{p}{3}\right)}{\left(1+\frac{W}{L}\right)} = \frac{280 \times 13.5 \times \left(1+\frac{10}{13.5}\right) \times \left(1-\frac{0.72}{3}\right)}{\left(1+\frac{13.5}{55}\right)} = 4015 \text{ PCU/hr}$$

**28. Solution:**

Given: Length of skid marks, $L$ = 12.2 m,

Average of pavement skid resistance, $f$ = 0.70

Speed of vehicle, $$v = 40 \times \frac{5}{18} = 11.11 \text{ m/sec}$$

Now,

Average skid resistance developed, $$f' = \frac{v^2}{2gL} = \frac{(11.11)^2}{2g \times 12.20} = 0.516$$

Brake efficiency, $$\% = \frac{100 f'}{f} = \frac{100 \times 0.516}{0.70} = 73.71\%$$

**29. Solution:**

1. The strength of mortar must be sufficient for development of good bond with building units.
2. ***Mobility and place ability:*** It should be workable enough.
3. It should set quickly to ensure speed of construction.
4. The mortar should be cheap and durable and should not affect the durability of building units in contact.
5. ***Water Retention :*** The mortar should not stratify during transportation and able to retain humidity in thin layer spread over a porous bed.
6. ***Resistance to penetration of rain:*** It should protect the masonary joints and units by forming an impermeable sheet. A satisfactory bond between the building units, mortar and plaster should be ensured.

**30. Solution:**

**Given data:**

Precipittion, $P = 15$ cm

Run-off, $R = 8.7$ cm

Average infiltration rate during rainfall period,

$$W\text{-index} = \frac{P-R}{t} = \frac{15-8.7}{8} = 0.7875 \text{ cm/hr}$$

For average infiltration rate during rainfall excess,

$$\text{Using } \phi \text{ index} \geq W \text{ index} = 0.7875 \text{ cm/hr}$$

$$\phi\text{-index} = \frac{(15-0.6-0.75)-8.7}{6} = 0.825 \text{ cm/hr}$$

As $\phi$ index < 1.35 cm/hr (No further calculation is required).

So average infiltration index for basin ($\phi$ index) is 0.825 cm/hr.

**31. Solution:**

A weir is an impervious barrier constructed across a river to raise the water level on the upstream side. The water is raised up to the required height and the water then flows over the weir. In a weir the water overflows the weir; it is used to prevent flooding, measure discharge, and help render a river navigable. Weirs can be built of wood, concrete or moraine material (rocks, gravel, boulders).

A barrage is a type of low-head, diversion dam which consists of a number of large gates that can be opened or closed to control the amount of water passing through the structure, and thus regulate and stabilize river water elevation upstream for use in irrigation and other systems. The gates are set between flanking piers which are responsible for supporting the water load of the pool created.

Due to following advantages a barrage is better than a weir:

| Weir | Barrage |
|---|---|
| Low control on flow | Relatively high control on flow and water levels by operation of gates |
| No provision for transport communication across the river | Usually, a road or a bridge can be conveniently and economically combined with a barrage wherever necessary |
| Chances of sitting on the upstream in more | Sitting may be controlled by judicial operation of gates |
| Afflux created is high due to relatively high weir crests | Due to low crest of the weirs (the ponding being done mostly by gate operation), the afflux during high floods is low. Since the gates may be lifted up fully even above the high flood level |

**32. Solution:**

According to Engineering News formula,

Load carrying capacity, $Q_a = \dfrac{WH}{6(S+C)}$

Where, $W$ = Weight of hammer, kN

$H$ = Free fall, cm

$S$ = Penetration in last blow, cm

$C$ = Constant = 2.5

Given, $W = 20$ kN, $H = 1.0 \times 100 = 100$ cm

$S = 5 \times 10^{-1} = 0.5$ cm, $C = 2.5$

$\therefore$ $$Q_a = \frac{20 \times 100}{6(0.5+2.5)} = 111.1 \text{ kN}$$

**33. Solution:**

**Given data** Safe column load ($Q$) = 800 kN, Depth of footing ($D_f$) = 1.3 m, Void ratio ($e$) = 0.55, Degree of saturation ($S_r$) = 50%, Specific gravity ($G_s$) = 2.67

$c = 8$ kN/m$^2$

Angle of shearing resistance, $\phi = 30°$

Factor of safety, FOS = 3

$N_c = 37.2$; $N_q = 22.5$; $N_\gamma = 19.7$

The unit weight of the soil is given by

$$\gamma = \left(\frac{G_s + Se}{1+e}\right)\gamma_w = \left(\frac{2.67 + 0.5 \times 0.55}{1 + 0.55}\right) \times 9.81 = 18.639 \text{ kN/m}^3$$

We know that ultimate bearing capacity of square footing as given by Terzaghi is

$$q_u = 1.3\, cN_c + \gamma D_f N_q + 0.4\, \gamma B N_\gamma$$

$\Rightarrow$ $$q_u = 1.3 \times 8 \times 37.2 + 18.639 \times 1.3 \times 22.5 + 0.4 \times 18.639 \times B \times 19.7$$

$\Rightarrow$ $$q_u = 932.07 + 146.875\, B$$

$\therefore$ $$q_{nu} = q_u - \gamma D_f$$

$\Rightarrow$ $$q_{nu} = 932.07 + 146.875B - 18.639 \times 1.3 = 907.84 + 146.875B$$

and $$q_{ns} = \frac{q_{nu}}{FOS} = \frac{907.84 + 146.875B}{3}$$

Thus, $q_s = q_{ns} + \gamma D_f$

$\Rightarrow \quad q_s = \dfrac{907.84 + 146.875B}{3} + 18.639 \times 1.3 = 326.84 + 48.958B$

Since $q_s$ should be greater than $\dfrac{Q}{B^2}$

$\therefore \quad q_{safe} \geq \dfrac{Q}{B^2}$

$\therefore \quad 326.84 + 48.958\,B \geq \dfrac{800}{B^2}$

$\Rightarrow \quad 48.958B^3 + 326.84B^2 - 800 \geq 0$

$\Rightarrow \quad B = 1.42$ m

**Note:** Here $\dfrac{D_f}{B} = \dfrac{1.3}{1.42} < 1$

**Hence, Terzaghi's theory is applicable here.**

**34. Solution:**

∠A = Bearing of AE – Bearing of AB = 135°15′ – 80°10′ = 55°05′
∠B = Bearing of BA – Bearing of BC = 259° – 120°20′ = 138°40′
∠C = Bearing of CB – Bearing of CD = 310°50′ – 170°50′ = 140°00′
∠D = Bearing of DC – Bearing of DE = 350°50′ – 230°10′ = 120°40′
∠E = Bearing of ED – Bearing of EA = 49°30′ – 310°20′ + 360°
= 99°10′

∴ Sum of all the internal angles = ∠A + ∠B + ∠C + ∠D + ∠E
= 55°05′ + 138°40′ + 140°0′ + 120°40′ + 99°10′ = 553°35′

Theoretical sum = (2n – 4) 90° = 540°

Error = +13°35′

Hence a correction of $-\dfrac{13°35'}{5} = -2°43'$ is applied to all the angles. The corrected angles are:

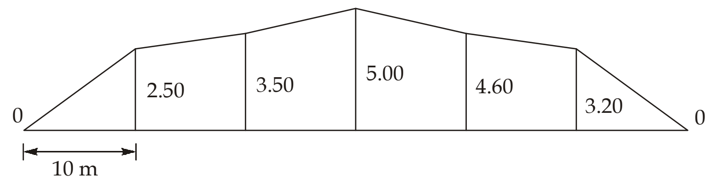
∠A = 52°22′; ∠B = 135°57′;
∠C = 137°17′; ∠D = 117°57′ and ∠E = 96°27′

Starting with the corrected bearing of CD, all other bearings can be calculated as under:

Bearing of DE = Bearing of DC – ∠D = 350°50′ – 117°57′ = **232°53′**
∴ Bearing of ED = 232°53′ – 180° = **52°53′**
∴ Bearing of EA = Bearing of ED – ∠E = 52°53′ – 96°27′ + 360° = **316°26′**
∴ Bearing of AE = 316°26′ – 180° = **136°26′**
Bearing of AB = Bearing of AE –∠A = 136°26′ – 52°22′ = **84°4′**
∴ Bearing of BA = 84°4′ + 180° = **264°4′**
Bearing of BC = Bearing of BA – ∠B = 264°4′ – 135°57′ = **128°7′**
∴ Bearing of CB = 128°7′ + 180° = **308°7′**
Bearing of CD = Bearing of CB – ∠C = 308°7′ – 137°17′ = **170°50′**
∴ Bearing of DC = 170°50′ + 180° = **350°50′**

**35. Solution:**




(i) By mid-ordinate Rule: The mid-ordinate are

$$h_1 = \frac{0+2.50}{2} = 1.25 \text{ m}$$

$$h_2 = \frac{2.50+3.50}{2} = 3.00 \text{ m}$$

$$h_3 = \frac{3.50+5.00}{2} = 4.25 \text{ m}$$

$$h_4 = \frac{5.00+4.60}{2} = 4.80 \text{ m}$$

$$h_5 = \frac{4.60+3.20}{2} = 3.90 \text{ m}$$

$$h_6 = \frac{3.20+0}{2} = 1.60 \text{ m}$$

Required area = 10 (1.25 + 3.00 + 4.25 + 4.80 + 3.90 + 1.60)

= 10 × 18.80 = 188 $m^2$

(ii) By average-ordinate rule

Here, $d$ = 10 m and n = 6 (no. of divs)

Base length = 10 × 6 = 60 m

Number of ordinates = 7

$$\text{Required area} = 60 \times \left\{\frac{0+2.50+3.50+5.00+4.60+3.20+0}{7}\right\}$$

$$= 60 \times \frac{18.80}{7} = 161.14 \text{ m}^2$$

(iii) By trapezoidal rule

$d$ = 10

$$\text{Required area} = \frac{10}{2}\{0+0+2(2.50+3.50+5.00+4.60+3.2)\}$$

= 5 × 37.60 = 188 $m^2$

(iv) By Simpson's rule

$d$ = 10

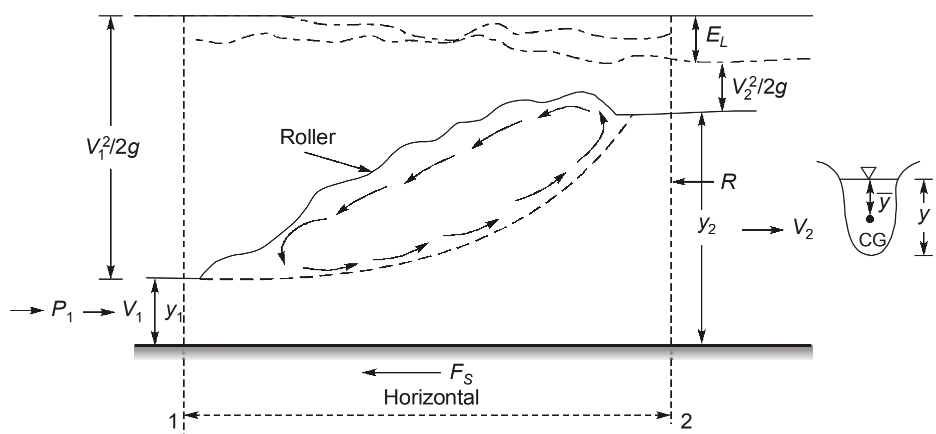
$$\text{Required area} = \frac{10}{3}[0+0+4(2.50+5.00+3.20)+2(3.50+4.60)]$$

$$= \frac{10}{3}\{42.80 + 16.20\} = \frac{10}{3} \times 59.00$$

$$= \frac{10}{3} \times 59.00 = 196.66 \text{ m}^2$$

**36. Solution:**

**Hydraulic Jump :** A hydraulic jump occurs when flow changes from a supercritical flow (unstable) to a sub-critical flow (stable). There is a sudden rise in water level at the point where the hydraulic jump occurs. Rollers (eddies) of turbulent water form at this point. These rollers cause dissipation of energy. The below figure shows a schematical sketch of a typical hydraulic jump in a horizontal channel.




In fact, the hydraulic jump is a typical example where a judicious use of the momentum equation yields meaningful results.

A hydraulic jump primarily serves as an energy dissipator to dissipate the excess energy of flowing water downstream of hydraulic structures such as spillways and sluice gates. Some of other uses are:

(a) Efficient operation of flow measurement flumes.

(b) Mixing of chemicals

(c) to aid intense mixing and gas transfer in chemical processes

(d) in the desalination of sea water

(e) in the aeration of streams which are polluted by biodegradable wastes.

**Assumptions:**

(i) A channel is horizontal, frictionless and rectangular channel.

(ii) A hydraulic jump is rapidaly-varied flow phenomenon.

(iii) A frictional force is neglected.

Considering unit width of channel, the momentum equation is channel boundary.

$$P_1 - P_2 - F_s = M_2 - M_1$$

$P_1, P_2$ = Pressure force at control section 1 and 2

$F_s$ = shear force on control surface adjacent to channel boundary.

$$\frac{1}{2}\gamma y_1^2 - \frac{1}{2}\gamma y_2^2 = \rho q V_2 - \rho q V_1$$

$$q = \text{discharge per unit width} = V_1 y_1 = V_2 y_2$$

$$(y_2^2 - y_1^2) = \frac{2q^2}{g}\left(\frac{1}{y_1} - \frac{1}{y_2}\right)$$

i.e., $$y_1 y_2 (y_1 + y_2) = \frac{2q^2}{g} = 2y_c^3$$

On dimensionalising, $$\frac{1}{2}\left\{\frac{y_2}{y_1}\left(1 + \frac{y_2}{y_1}\right)\right\} = \frac{q^2}{g y_1^3} = F_1^2$$

where $F_1$ = Froude number of the approach flow $= \dfrac{V_1}{\sqrt{g y_1}}$

Solving for $(y_2/y_1)$ yields, $$\frac{y_2}{y_1} = \frac{1}{2}\left(-1 + \sqrt{1 + 8F_1^2}\right)$$

**37. Solution:**

**Given data:** $E = 3 \times 10^5$ kg/cm², $\alpha = 10 \times 10^{-6}$/ °C, $t = 15.8$°C, $\mu = 0.15$, $h = 32$ cm, $k = 8$ kg/cm²/cm

$c_x = 0.57$, $C_y = 0.03$

Radius of relative stiffness, $$l = \left[\frac{Eh^3}{12K(1-\mu^2)}\right]^{1/4} = \left[\frac{3 \times 10^5 \times 32^3}{12 \times 8 \times (1 - 0.15^2)}\right]^{1/4} = 101.17 \text{ cm}$$

Radius of contact area, $$a = \sqrt{\frac{P}{p\pi}} = \sqrt{\frac{8000}{8\pi}} = 17.84 \text{ cm}$$

(i) Interior warping stress, $$s_i = \frac{E\alpha t}{2}\left[\frac{c_x + \mu c_y}{1-\mu^2}\right] = \frac{3 \times 10^5 \times 10 \times 10^{-6} \times 15.8 \times}{2}\left[\frac{0.57 + 0.15 \times \cdot 30}{1 - 0.15^2}\right]$$

$$= 14.91 \text{ kg/cm}^2$$

(ii) Edge stress, $$s_t = \max\left[\frac{c_x E\alpha t}{2}, \frac{c_y E\alpha t}{2}\right]$$

$$= \left[\frac{0.57 \times 3 \times 10^5 \times 10 \times 10^{-6} \times 15.8}{2}, \frac{0.30 \times 3 \times 10^5 \times 10^{-5} \times 15.8}{2}\right]$$

$$= 13.51 \text{ kg/cm}^2$$

(iii) Corner stress, $$S_c = \frac{E\alpha t}{3(1-\mu)}\sqrt{\frac{a}{l}} = \frac{3 \times 10^5 \times 10 \times 10^{-6} \times 15.8}{3(1 - 0.15)}\sqrt{\frac{17.84}{101.17}} = 7.81 \text{ kg/cm}^2$$

**38. Solution:**

Efficiency of BOD removal required = $E = \frac{360 - 25}{360} = 93\%$

For Recirculation ratio $(R/I) = 1:1$

$$\text{Recirculation factor } F = \frac{1+(R/I)}{(1+0.1\,(R/I))^2} = \frac{1+1}{(1+0.1)^2} = 1.65$$

$$BOD_5 \text{ influent loading} = 20000 \times 225 \times 360 \times 10^{-6} = 1620 \text{ kg/d}$$

$$\eta = \frac{100}{1 + 0.44\sqrt{\frac{W}{VF}}}$$

where, $y$ = BOD loading rate in kg per day, $V_m$ = Volume of filter (in $m^3$)

But here, $V$ = Volume is in $m^3$

$$93 = \frac{100}{1+0.44\sqrt{\frac{1620}{V \times 1.65}}}$$

$\Rightarrow$ $V = 33551.06 \text{ m}^3$

For $(R/I) = 2$

$$\text{Recirculation factor } F = \frac{1+2}{(1+0.2)^2} = 2.083$$

$$93 = \frac{100}{1+0.44\sqrt{\frac{1620}{V \times 2.083}}}$$

$$V = 26576.7 \text{ m}^3$$

**39. Solution:**

Major air pollutant found in a city, with their sources and effects are listed below:

**Carbone monoxide (CO)**

- It is a colourless, odouless gas that is produced by the incomplete burning of carbon-based fuels including petrol, diesel, and wood.
- It is also produced from the combustion of natural and synthetic products such as cigarettes.
- It lowers the amount of oxygen that enters our blood.
- It can slow our reflexes and make us confused and sleepy.

**Carbone dioxide ($CO_2$)**

- It is the principle greenhouse gas emitted as a result of human activities such as the burning of coal, oil and natural gases.

**Chloroflorocarbons (CFC)**

- These are gases that are released mainly from air-conditioning systems and refrigeration.
- When released into the air, CFCs rise to the stratosphere, where they come in contact with

few other gases, which lead to a reduction of the ozone layer that protects the earth from the harmful ultraviolet rays of the sun

**Lead**

- It is present in petrol, diesel, lead batteries, paints, hair dye products, etc. lead affects children in particular.
- It can cause nervous system damage and digestive problems and, in some cases, cause cancer.

**Ozone**

- It occurs naturally in the upper layers of the atmosphere.
- This important gas shields the earth from the harmful ultraviolet rays of the sun.
- However, at the ground level, it is a pollutant with highly toxic effects.
- Vehicles and industries are the major source of ground-level ozone emissions.
- Ozone make our eyes itchy, burn, and watery. It also lowers our resistance to cold and pneumonia.

**Nitrogen oxide**

- It causes smog and acid rain. It is produced from burning fuels including petrol, diesel, and coal.
- Nitrogen oxide can make children susceptible to respiratory disease in winters.

**Suspended particulate matter (SPM)**

- It consists of solids in the air in the form of smoke, dust, and vapour that can remain suspended for extended periods and is also the main source of haze which reduces visibility.
- The finer of these particles, when breathed in can lodge in our lungs and cause lung damage and respiraory problems.

**Sulphur dioxide ($SO_2$)**

- It is a gas produced from burning coal, mainly in thermal power plants.
- Some industrial processes, such as production of paper and smelting of metals, produce sulphur dioxide.
- It is a major contributor to smog and acid rain. Sulphur dioxide can lead to lung diseases.

■■■■