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RPSC Main Exam 2019 : Test Series
Assistant Engineer
Civil Engineering

Compulsory Subject : Paper-II

Test No. 4 | Date of Exam. : 14-07-2019 (9 AM to 12 Noon)

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

1. Solution:

Survey is done from whole to part so that if large main frame is precisely established consisting of widely spaced control points, their subsidery small frameworks can be established with less accuracy thereby confining the errors in a localised region and avoiding accumulation of errors.

2. Solution:

True bearing of a line is horizontal angle which it makes with the true meridian.

3. Solution:

Precision is the degree of perfection used in the instruments, the methods and the observations while accuracy is the degree of perfection obtained.

4. Solution:

Fluids which show an increase in apparent viscosity with time.

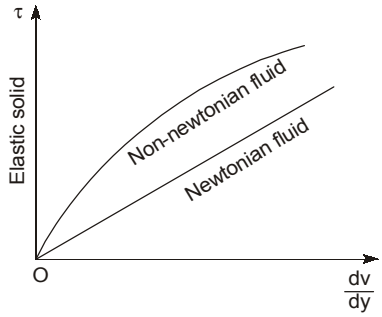
5. Solution:

Newtonian Fluid: From Newton's law of viscosity,

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

Fluid which follow the Newton's law of viscosity (as described above) are called as Newtonian fluids.

However, there are certain fluids like non-polar liquid, air etc. which do not follow the above law.



6. Solution:

This is the region in the turbulent boundary layer zone, where velocity variation is influenced only by viscous effects.

7. Solution:

The ability of cement to maintain a constant volume is known as soundness of cement.

8. Solution:

Plaster of Paris: Chemically it is calcium sulphate with half molecule of water of crystallization i.e. $CaSO_4$. $(1/2)H_2O$.

9. Solution:

Maturity of concrete: Strength of concrete depends up on both time of curing and curing temperature. Thus curing can be considered as a function of temperature and time i.e. f(time, temperature). The quantity **'temperature X time'** is called as maturity of concrete and its unit is °Ch or °Cdays.

10. Solution:

Lift irrigation is a method of irrigation in which water instead of being transported by natural flow (as in gravity-fed canal systems) requires external energy through animal, fuel based or electric power using pumps or other mechanical means.

11. Solution:

In this process, land is flooded with adequate depth of water. The alkali salts present in the soil gets dissolved in this water which percolate down to join the watertable. The process is repeated till the salts in the top layer of the land are reduced to such an extent that some salt resistant crop can be grown. This process is known as leaching.

12. Solution:

Diversion headworks: These are the works which are constructed at the head of the canal in order to divert the river water towards the canal so as to have a regulated and continuous supply of silt free water with a certain minimum head in to the canal.

13. Solution:

It is the slope of total energy and it is expressed as sine of the angle which the line makes with the horizontal.

14. Solution:

National highways are main roads running through the length and breadth of India, connecting major ports, foreign highways, capitals of large states and large industrial and tourist centres including roads required for strategic movements for the defence of India.

Expressways are highway with 6 to 8 lanes controlled access road network and are highest class of roads in India. The expressway are very high quality with modern features like access ramps, grade separation, lane dividers and elevated section.

15. Solution:

Amount of gradient is reduced, wherever a curve and gradient has to be provided together.

16. Solution:

It is a standard vehicle unit used to convert the other vehicle classes.

17. Solution:

1. Domestic water demand
2. Industrial water demand
3. Institution and commercial water demand
4. Demand for Public use
5. Fire demand
6. Water required to compensate losses in wastes and theft.

18. Solution:

Disinfection: In disinfection, it is tried to kill the pathogenic micro-organisms.

Sterilization: In sterilization, complete disinfection of all the living matter occurs.

19. Solution:

Population equivalent or unit per capita loading, (PE), in waste-water treatment is the number expressing the ratio of the sum of the pollution load produced during 24 hours by industrial facilities and services to the individual pollution load in household sewage produced by one person in the same time.

20. Solution:

Assumptions involved in UH theory are

(a) Time Invariance : It means that the direct runoff response to a given effective rainfall in a catchment is time-invariant

(b) Linear Response : The direct-runoff response to the rainfall excess is assumed to be linear.

Part-B **[Marks : 60]**

21. Solution:

Assuming 80% of water supplied is converted into sewage.

So, quantity of sewage produced = 0.8 × 100 × 120 = 9600 litres per day.

As detention period = 8 hours

Volume of sewage produced during detention period = $9600 \times \frac{8}{24} = 3200$ litres

Taking rate of sludge accumulation as 30 litres per capita per year and cleaning period as 1 year.

Volume of sludge deposited = 30 × 100 = 3000 litres (in one year)

Total capacity of septic tank = 3200 + 3000 = 6200 litres

Assuming depth of tank as 1.5 m

$$\text{Surface area of tank} = \frac{6200 \times 10^{-3}}{1.5} = 4.13\ \text{m}^2$$

Taking length to width ratio as 3 : 1

$$L \times B = 4.13$$

$$3B^2 = 4.13$$

Width, $B = 1.17$ m

Length, $3B = 3 \times 1.17$

$= 3.51$ m

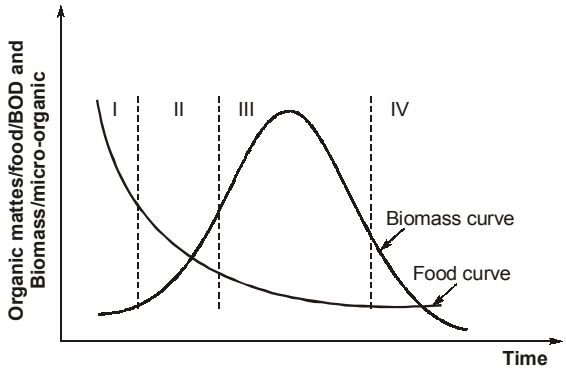
So, size of septic tank will be (taking 0.3 m as free board) 3.51 m × 1.17 m × 1.8 m

22. Solution:

The entire process of biological decomposition is believed to take place in four phases.

I. **Lag phase:** In this phase microorganisms get acclimated to food and environment given to them. If the microorganism are already familiar with the environment and food given to them then, duration of lag phase is less. The growth of biomass in this phase is very less hence it is termed as lag phase.

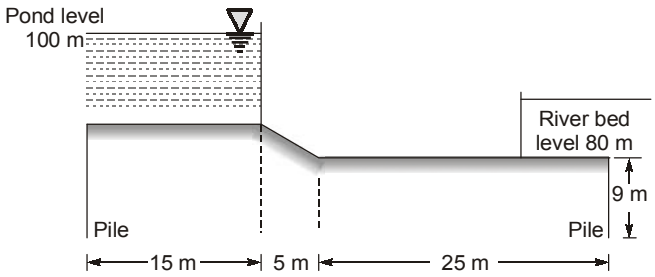
II. **Log phase:** In log phase, microorganisms reproduce rapidly by cell division leading to the rapid increase in the growth of biomass at corresponding decrease in the organic matter in wastewater. In ASP, we try to maintain system in log phase.



III. **Stationary phase:** In this phase growth of biomass is slightly decreased due to endogenous respiration resulting from scarcity of food.

IV. **Endogenous phase:** In this phase endogenous process of respiration starts due to depletion of organic matter from system.

23. Solution:



Max. seepage head available

$$H = 100 - 80 = 20 \text{ m}$$

Depth of downstream cut-off = 9 m

Total flow length, $b = 15 + 5 + 25 = 45$ m

$$\therefore \quad \alpha = \frac{b}{d} = \frac{45}{9} = 5$$

$$\therefore \quad \lambda = \frac{1+\sqrt{1+\alpha^2}}{2} = 3.04951$$

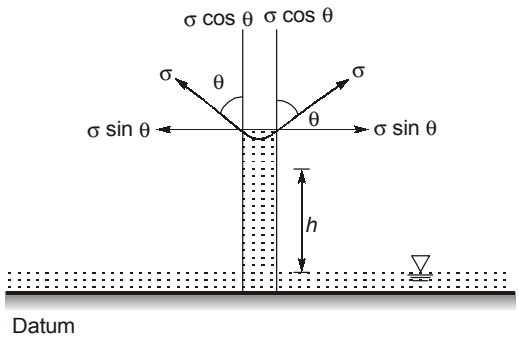
$$\therefore \quad \frac{1}{\pi\sqrt{\lambda}} = 0.1823$$

$$\therefore \quad \text{Exit gradient } (G_E) = \frac{H}{d}.\frac{1}{\pi\sqrt{\lambda}} = \frac{20}{9}(0.1823) = 0.40511$$

Given safe exit gradient $= \frac{1}{6} = 0.16778 < 0.40511$

Thus barrage is not safe against piping.

24. Solution:



It is a phenomenon of rise or fall of liquid surface related to adjacent general level of liquid, due to surface tension, when it is passing through tubes of small thickness.

Height of capillarity rise, $h = \frac{2\sigma\cos\theta}{\rho g t}$

For $\sigma = 0.075$ N/m and $h = 60$ mm

Assuming $\theta = 0°$ i.e., $\cos\theta = 1$

$$0.06 = \frac{2 \times 0.075 \times 1000}{9.81 \times 1000 \times t}$$

$$t = 0.255 \text{ mm}$$

25. Solution:

$$E = y + \frac{V^2}{2g} = y + \frac{Q^2}{2gA^2} = y + \frac{q^2}{2gy^2}$$

$\Rightarrow$ At critical depth $E = \frac{3}{2} y_c$ for rectangular channel

So, $$\frac{q^2}{2gy^2} = \frac{3}{2} y_c - y$$

$$q^2 = \left(3y_c y^2 - 2y^3\right) g \quad \text{...(i)}$$

Also $$q_c^2 = g y_c^3 \quad \text{...(ii)}$$

Equation (i) and (ii),

$$\left(\frac{q}{q_c}\right)^2 = 3\left(\frac{y}{y_c}\right)^2 - 2\left(\frac{y}{y_c}\right)^3$$

$$\frac{q}{q_c} = \sqrt{3\left(\frac{y}{y_c}\right)^2 - 2\left(\frac{y}{y_c}\right)^3}$$

26. Solution:

For 2-*D* steady incompressible flow, the continuity equation should be satisfied i.e.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

Here $u = x + y; \quad \frac{\partial u}{\partial x} = 1$

$v = x - y; \quad \frac{\partial v}{\partial y} = -1$

$\therefore$ $\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 1 + (-1) = 0$ (Hence ok)

Thus the velocity components satisfy the possible two dimensional incompressible flow.

27. Solution:

The characteristics of site of bridge across river must be:

(a) straight reach of river.
(b) steady river flow without cross currents.
(c) A narrow channel with firm banks.
(d) Suitable high banks above flood level.
(e) Rock or other in erodible strata close to riverbed level.
(f) Economical approaches, danger of floods.
(g) Absence of expensive training works.
(h) Absence of excessive underwater construction.

28. Solution:

Given: $V = 60 \text{ kmph} \times \frac{5}{18} = 16.67 \text{ m/sec}$

Rate of change of centrifugal acceleration,

$C = 0.52 \text{ m/sec}^3$

Reaction time, $t = 2.5$ sec

Beam angle, $\alpha = +1.5°$

Height of headlight above ground, $h_1 = 0.8$ m

Comfort condition:

$$N = -\frac{1}{22.5} - \frac{1}{25} = -0.0844$$

$$\text{Length of valley curve, } L = 2\left[\frac{Nv^3}{C}\right]^{1/2} = 2\left[\frac{0.0844 \times (16.67)^3}{0.52}\right]^{1/2}$$

$$= 54.86 \text{ m}$$

29. Solution:

Seasoning of timbers : It is the process by which the moisture content of timber reduced to a suitable level depending upon use. Timber should be seasoned as early as possible after felling because felled timber is nothing but dead vegetation will rot and decay due to many environmental agencies.

Three methods of artificial seasoning are as follows:

1. Boiling
2. Chemical seasoning
3. Electrical seasoning

30. Solution:

For catchment:

Average annual rainfall, $\bar{X} = \frac{75 + 90 + 82 + 98 + 105}{5} = 90 \text{ cm}$

Given: $\sigma = 12$ cm

Coefficient of variation, $C_v = \frac{\sigma}{\bar{X}} \times 100 = \frac{12}{90} \times 100 = 13.33\%$

Allowable percentage error, $\varepsilon = 5\%$

Number of raingauge required, $N = \left(\frac{C_V}{\varepsilon_0}\right)^2 = \left(\frac{13.33}{5}\right)^2 = 7.11 \simeq 8$

Additional raingauge required = 8 – 5 = 3

31. Solution:

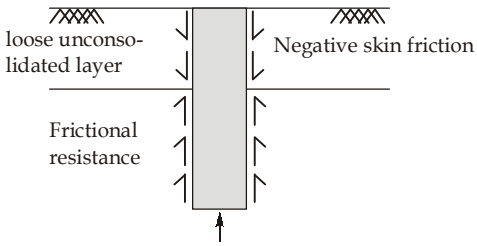
For given data:

Average rainfall, $\bar{P} = \dfrac{P_A W_A + P_B W_B + P_c W_c + P_D W_D}{W_A + W_B + W_C + W_D}$

$\Rightarrow \quad 45 = \dfrac{P_A \times 0.16 + 55 \times 0.24 + 40 \times 0.32 + 45 \times 0.28}{0.16 + 0.24 + 0.32 + 0.28}$

$\Rightarrow$ Rainfall at 'A', $P_A = 40$ mm

32. Solution:



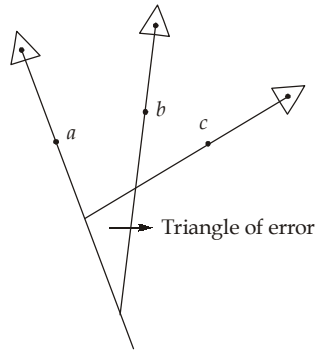
Piles installed in freshly placed fills of soft compressible deposits are subjected to a downward drag, a consequence of the consolidation of the strata after the piles are installed. This downward drag on the pile surface, when the soil moves down relative to the pile, adds to the structural loads and is called negative skin friction. This is in contrast to the usual shaft friction which is mobilised when the pile moves down relative to the soil. Thus, negative skin friction has an effect of reducing the allowable load on the pile.

Part-C [Marks : 100]

33. Solution:

Three point problem : (Resection after orientation by three points): The three-point problem consists of locating the position of the plane table station on the drawing sheet by means of the observation of three well-defined points, whose positions have already been plotted on the plan. Let A, B and C be three well defined points and let their plotted positions be a, b and c. It is required to fix ground station T on the plan as t.

Lehmann's Method or (Trial and Mirror Method): This method is very commonly used in the field measurements as it is very accurate. The position of plane table is estimated by judgement. Let it be t'. The alidade is kept against $t'a$ and table is oriented. Pivot the alidade on b on sight B. Draw the back ray. If the orientation is correct, the three rays resect at one point t, otherwise a triangle of error is formed.



Trial and Error Method

This triangle is reduced to a point by trial and error.

Lehmann's Rules: The adjustment in orientation is facilitated by **Lehmann's rules** for estimating the exact position of t from triangle of error.

1. The distance of the point t to be fixed from each of the rays aA, bB and cC is proportional to the respective distances of the stations A, B and C from station T.
2. While looking towards the station the points t to be fixed will either be to the left or the right of each of the ray.

From the above two rules it follows that the plotted position of the instrument station t lies within triangle of error only when the ground station T lies within the triangle ABC. These two rules are sufficient to reduce the triangle of error to one point.

1. When T is outside the great circle ABC, t is always on the same side of the ray drawn to the most distant station as the intersection of the other two rays.
2. When T falls within any of three segments of the great circle ABC, formed by the side of triangle ABC, the ray towards the middle station lies between t and intersection of other two rays.
3. If plane table station T lies on great circle (passing through the points A, B, C) the correct station is not possible because the three rays will always meet at a point even if the table is not oriented.

34. Solution:

In traverse $ABCDE$, the points A, D and E are on the same line.

Let CA be an imaginary line so as to form a closed traverse ABC.

Line AB: Length of line AB = 110 m

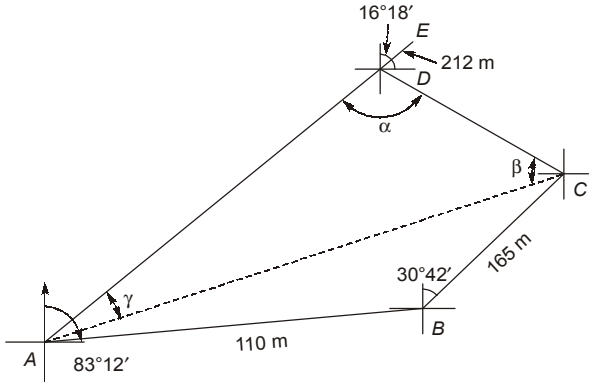
Latitude of line AB = +110 cos 83° 12′ = +13.03

Departure = +110 sin 83°12′ = +109.23

Line BC: Length of line BC = 165 m

Latitude = +165 cos 30° 42′ = +141.88

Departure = 165 sin 30°42′ = +84.24



Now, for the traverse ABC

$$\Sigma\text{Latitude} = 0$$

So, Latitude of $CA = 0 - 13.03 - 141.88 = -154.91$

and $\Sigma D = 0$

Thus, departure of $CA = 0 - 109.23 - 84.24 = -193.47$

Since, the latitude and departure are both negative, the line CA lies in the SW quadrant. Its bearing is given by,

$$\tan\theta = \frac{\text{Departure}}{\text{Latitude}} = \frac{193.47}{154.91}$$

or, $\theta = S51°18' W$

$$\text{Length of } CA = \sqrt{\text{Lat}_{CA}^2 + \text{dept}_{CA}^2}$$

$$= \sqrt{(154.91)^2 + (193.47)^2} = 247.78 \text{ m}$$

Since A, D and E are on the same line so,

Bearing of AD = bearing of $DE = 16°18'$

From triangle ACD, $\alpha = (360° - 346°6') + 16°18' = 13°54' + 16°18' = 30'12'$

$\beta = 346°6' - (51°18' + 180°) = 114°48'$

$\gamma = 51°18' - 16°18' = 35°0'$

From sine rule, $\frac{CD}{\sin\gamma} = \frac{CA}{\sin\alpha}$

$\Rightarrow$ $CD = CA\frac{\sin\gamma}{\sin\alpha} = 247.78 \times \frac{\sin 35°}{\sin 30°12'}$

or, $CD = 282.53$ m

35. Solution:

There are four main factors which influence compaction and they are as follows:

(i) Water Content: There are two theories to explain the typical water content-dry unit weight relationship. They are the Lubrication theory by Proctor and the Electrical Double Layer theory by Lambe.

As per electric double layer theory, the maximum expansion of the double layer is at the OMC, beyond that, the addition of water does not add any further to the expansion of double

layer but the water tends to occupy space which otherwise would have been occupied by soil particles. Hence a decrease in unit weight.

(ii) Compactive Effort: For a given type of compaction, the higher the compactive effort, the higher the maximum dry unit weight and lower the OMC. And lower the compactive effort lower maximum dry density and higher optimum moisture content.

(iii) Types of Soil:

(a) Coarse grained, well graded soils compact to high dry unit weight especially if they contain some fines.

(b) Poorly graded sands lead to lowest dry unit weight values.

(c) In clay soils, the maximum dry unit weight tends to decrease as plasticity increases.

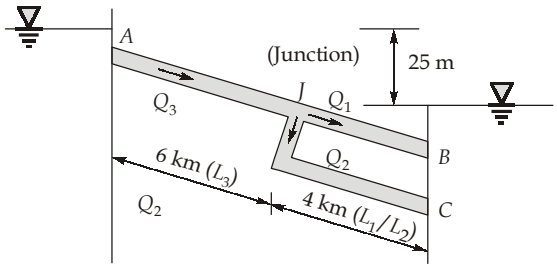
(d) Cohesive soils have generally high values of OMC.

(e) Heavy clays with high plasticity have very low maximum dry density and very high OMC.

(iv) Methods of Compaction:

Ideally speaking, the laboratory test must reproduce a given field compaction procedure, because the mode of compaction does influence somewhat the shape and the position of the 'γ_d' vs 'w' plot. Since the field compaction is essentially a kneading type compaction or rolling type compaction and the laboratory tests use the dynamic impact type compaction, one must expect some divergence in the OMC and $\gamma_{d(max)}$ in the two cases.

36. Solution:



Let d be the diameter of pipe used throughout the pipe network.

Given, $f = 0.03$

and maximum velocity $= 1.25$ m/s

For the parallel pipes, BJ and CJ

$$\frac{f_1 L_1 V_1^2}{d \times 2g} = \frac{f_2 L_2 V_2^2}{d \times 2g}$$

$\because$ $f_1 = f_2$,

$L_1 = L_2$,

d = constant

Hence, $V_1 = V_2$ and $Q_1 = Q_2$

$\therefore \quad Q_3 = Q_1 + Q_2 = 2Q_2 = 2Q_1$

Head loss, $H = 25$ m $\quad 25 = \dfrac{f_3 L_3 V_3^2}{d \times 2g} + \dfrac{f_1 L_1 V_1^2}{d \times 2g} = \dfrac{f L_3 V_3^2}{d \times 2g} + \dfrac{f L_1 V_1^2}{d \times 2g}$

Also, using continuity equation $Q_3 = 2Q_1$

$\Rightarrow \quad V_3 = 2V_1$

$\because$ Maximum velocity ≤ 1.25 m/s

$\therefore \quad V_3 = 1.25$ m/sec

Hence, $\quad V_1 = \dfrac{1.25}{2} = 0.625$ m/sec

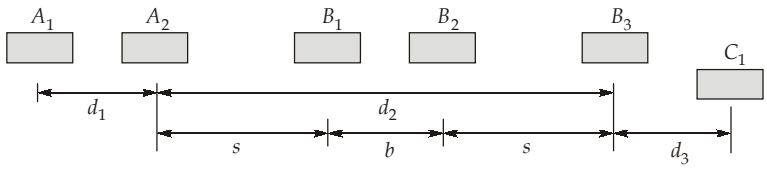
$\therefore \quad 25 = \dfrac{0.03 \times 6000 \times (1.25)^2}{d \times (2 \times 9.81)} + \dfrac{0.03 \times 4000 \times (0.625)^2}{d \times (2 \times 9.81)}$

$= \dfrac{14.335}{d} + \dfrac{2.3891}{d}$

or, $\quad \dfrac{16.724}{d} = 25$

or, $\quad d = 0.669 \text{ m} \simeq 670 \text{ mm}$

37. Solution:



Let $\quad t$ = reaction time = 2 sec

V_b = velocity of overtaken vehicle

= 70 kmph = 19.44 m/s

$s = 0.7\ V_b + 6$

$= 0.7 \times 19.44 + 6$

$= 19.6$ m

$T = \sqrt{\dfrac{4s}{a}}$

$a = 2.5 \times \dfrac{5}{18} = 0.694 \text{ m/sec}^2$

$\therefore \quad T = \sqrt{\dfrac{4 \times 19.6}{0.694}} = 10.63$ sec

Now $\quad d_1 = V_b \times t = 19.44 \times 2 = 38.88$ m

$d_2 = b + 2s$

$= (19.44 \times 10.63) + 2 \times 19.6$

$= 245.85$ m

$$d_3 = vT = 85 \times \frac{5}{18} \times 10.63 = 250.986 \text{ m}$$

$\therefore$ $\quad OSD = d_1 + d_2 + d_3$

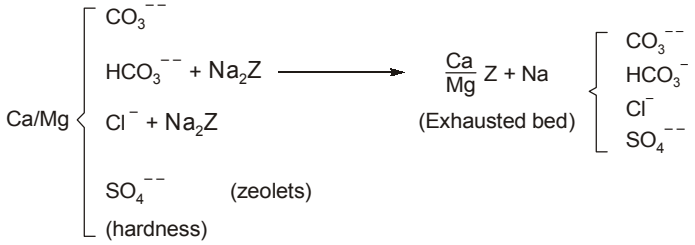
$= 38.88 + 245.85 + 250.986$

$= 535.72$ m

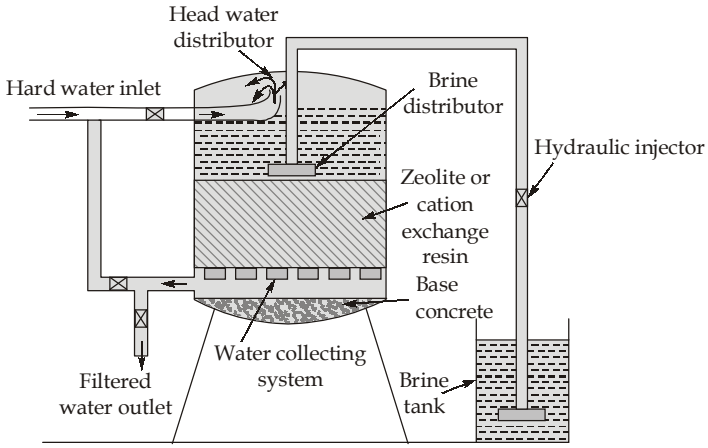
38. Solution:

Softening: The reduction or removal of hardness from water is known as water softening.

A zeolite softener (or a cation exchanges unit) resembles a sand filter in which the filtering medium is a zeolite rather than sand. The hard water enters through the top, and is evenly distributed on the entire zeolite bed. The softened water is collected through one strainers at the base. When a significant portion of the sodium in the zeolite has been replaced by calcium and magnesium, it is regenerated by first washing it with water by reversing the flow, and then treating it with 10 per cent solution of brine (NaCl). The excess brine solution retained in the zeolite after the treatment is removed by again washing it with good water. The regenerated zeolite can be used afresh for softening.



Now, Regeneration,



Sectional view

The advantages and disadvantages of this method are given below:

Advantages:

1. Water of zero hardness can be obtained, and hence, useful for specific uses in textile industries, boilers, etc.
2. The plant is compact, automatic and easy to operate.
3. No sludge is formed, and hence, there is no problem of sludge disposal.
4. The RMO (Running, maintenance and operation) cost is quite less.
5. It also removes ferrous iron and manganese from water.
6. There is no difficulty in treating water of varying quality.
7. There is no problem of incrustation of pipes of the distribution system, as is there in the lime soda process.

39. Solution:

Year	Population	Increase in population	Percentage increase in population	Decreases in the percentage increase
1990	80000			
		40000	$\frac{40000}{80000}\times100 = 50\%$	
2000	120000			10%
		48000	$\frac{48000}{120000}\times100 = 40\%$	
2010	168000			4%
		60580	$\frac{60580}{168000}\times100 = 36\%$	
2020	228580			
Total				14%
Average per decade				$\frac{14}{2} = 7\%$

(a) The expected population at end of year 2030

$$= 228580 + \left[\frac{36-7}{100}\right]\times 228580$$

$$= 228580 \times 1.29$$

$$= 294868 \simeq 294870$$

(b) The expected population at the end of year 2040

$$= 294870 + \left[\frac{29-7}{100}\right]\times 294870 = 359740$$

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