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. 12 | Date of Exam. : 15-09-2019 (9 AM to 12 Noon)

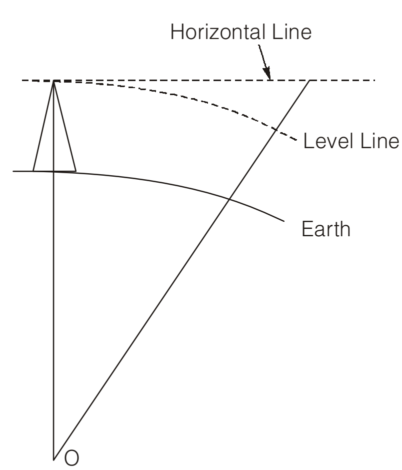
---

1. Solution:

A Plan or Map is the graphical representation to some scale. If scale is small it is called Map and when scale is large it is called Plan. On a plan only horizontal distance and directions are shown while in Map the vertical distances are shown as well.

2. Solution:

Level Line: It is a line which always remains normal to the direction of gravity.
Horizontal Line: At any point, it is tangential to the level line.



3. Solution:

Theodolite is an instruments which is primarily used to measure angles both horizontal and vertical. It is also used for many other subsidiary work during surveying such as setting up of intermediate points between inter visible points, establishment of inter visible points, prolonging a line, laying out transverse etc.

4. Solution:

A Cipolletti weir is a special case of trapezoidal weir with sides sloping at 1 H: 4 V. The sides are sloped at 14° so that the decrease in discharge through a rectangular weir due to end corrections is compensated by increase in discharge through the two triangular portions of the trapezoidal weir. The discharge through the Cipolletti weir is same that of a rectangular weir without end corrections i.e.

$$Q = \frac{2}{3} C_d \sqrt{2g} L H^{3/2}$$

5. Solution:

Since $$\frac{P_1}{D_1^2 H_1^{3/2}} = \frac{P_2}{D_2^2 H_2^{3/2}}$$

$\Rightarrow$ $$\frac{150}{D_1^2 (16)^{3/2}} = \frac{750}{D_2^2 (25)^{3/2}}$$

$\Rightarrow$ $$D_r = 1.6$$

6. Solution:

Stream line: It is an imiginary curve drawn through a flowing fluid such that tangent to any point on it gives the direction of velocity at that point.

Path line: Line traced by a single fluid particle as it moves over a period of time is called as path line.

7. Solution:

Ordinary portland cement is susceptible to the attack of sulphates. To remedy the sulphate attack, the use of cement with low C_3A content is found to be effective. Such cement with low C_3A and comparatively low C_4AF content is known as sulphate resisting cement.

8. Solution:

Plasticizers are the substance which can help for obtaining high workability without using excess water. Excess water will only improve the fluidity but not workability whereas the plasticized concrete shows desirable qualities of plastic concrete.

9. Solution:

(i) Stretcher bond
(ii) Header bond
(iii) English bond and
(iv) Flemish bond

10. Solution:

The crop area is divided into some plots which are relatively leveled by checks or bunds. Water from field channels is allowed to enter to each plot or check basin and the plot are flooded to the required depth.

11. Solution:

Scour depth by Lacey's formula,

$$d = 1.35\left(\frac{q^2}{f}\right)^{1/3} \qquad \left[q = \frac{12}{10} = 1.2\right]$$

$$= 1.35 \times \left(\frac{1.2^2}{1}\right)^{1/3} \simeq 1.52\text{ m}$$

12. Solution:

Theissen polygon method is only a mechanical and mathematical process and do not require any special skill, but on the contrary isohyetal method requires a lot of extra special judgement for drawing the contours. Theissen polygon method is inferior to isohyetal method in terms of accuracy and precision.

13. Solution:

The following are the limitation of a siphon spillway.

- It is unable to pass ice and debris.
- There is a possibility of clogging of the siphon duct and siphon breaker vents with debris or leaves.

14. Solution:

Traffic signs have been categorised into 3 group:

1. Regulatory signs
2. Warning signs
3. Informatory signs

15. Solution:

Flexible progressive system.

16. Solution:

There are following purposes to conduct *O* & *D* studies are as follows:.

1. To judge the adequacy of existing routes and to use in planning new network of roads.
2. To plan the transportation system and mass transit facilities in cities including routes and schedules of operation.
3. To locate expressways or major routes along the desire lines.

17. Solution:

$$SVI = \frac{\text{Volume of settled sludge (in m}l\text{)}}{\text{Weight of settled sludge (in gm)}}$$

$$SVI = \frac{64 \times 10^{-6} \times 10^{6}}{4} = 16\text{ m}l/\text{gm}$$

18. Solution:

Productivity is a measure of its ability to support food chain. It is a measure of algal growth.

19. Solution:

Non-carbonate hardness: If sulphates, chlorides and nitrates of calcium or magnesium are present in water, they cannot be removed at all by simple boiling and therefore, such water requires special treatment for their hardness removal. Such a hardness is known as permanent hardness or non-carbonate hardness.

20. Solution:

A hyetograph is a graphical representation of the distribution of rainfall intensity over time.

21. Solution:

Pith : The innermost central portion or core of the tree.
Heartwood: The inner annual rings surrounding the pith constitute the heart wood.
Sap wood: The outer annual rings between heart wood and cambium layer.
Cambium layer: The thin layer of sap between sap wood and inner bark.
Medullary rays: The thin radial fibres extending from pith to cambium layer.

22. Solution:

We know that 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: $A = 0.04 \text{ ha} = 0.04 \times 10^4 \text{ m}^2 = 400 \text{ m}^2$
$Q = 0.02 \text{ cumecs} = 0.02 \times 60 \times 60 = 72 \text{ m}^3/\text{hr}$
$f = 5 \text{ cm/hr} = 0.05 \text{ m/hr}$
$y = 10 \text{ cm} = 0.1 \text{ m}$

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

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

It may be noted that after irrigating this much of area, surface flow will stop and deep percolation will start.

23. Solution:

The desirable properties of soil as a highway material are:

1. The soil should possess adequate stability or resistance to permanent deformation under loads and should possess resistance to weathering, thus retaining the desired subgrade support.

2. Incompressibility
3. Permanency of strength
4. Minimum changes in volume and stability under adverse conditions of weather and ground water.
5. It is essential to avoid excessive moisture retention and to reduce the potential frost action.
6. It ensures higher dry density and strength under particular type and amount of compaction.

24. Solution:

$$\text{The pressure applied}, P = \frac{5\times10^4}{\pi\times300^2} = 0.176\ \text{N/mm}^2$$

$$\delta = \frac{1.18\times P\times a}{E}$$

$$1.2 = \frac{1.18\times0.176\times300}{E}$$

Therefore, $E = 51.92$ MPa

25. Solution:

The major operational troubles of a standard rate trickling filter are :

(i) Fly Nuisance:

- The filter fly psychoda which develops in the filter particles, may prove to be nuisance, as the same may be carried away into the habitation.
- This problem may be controlled by flooding the filter with sewage for 24 hours or more. The flooding will destroy the larvae, and usually interferes slightly with the results of operation.
- Another method of controlling fly nuisance is by using insecticides such as DDT, Chlorodane and BHC in the filter plant.

(ii) Odour Nuisance:

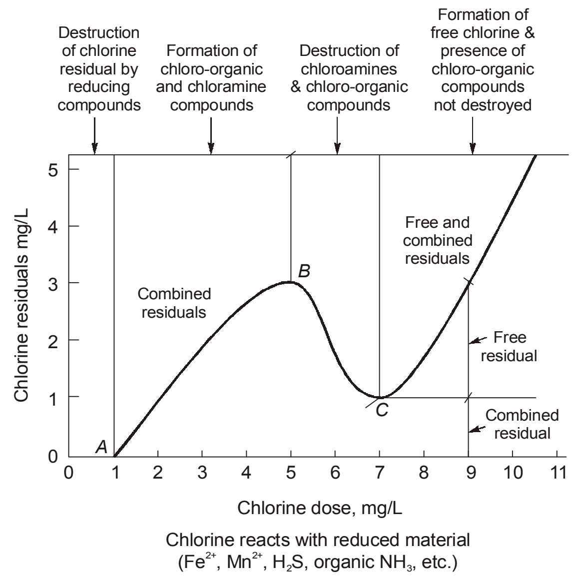
- Odours generally do not prevail in trickling filters using rotary distributors; but however when fixed nozzles are used, H_2S and other odorous gases are frequently released from the sprays into the atmosphere.
- The usual remedy is to chlorinate the sewage to prevent formation of H_2S or to neutralize that already formed.

(iii) Ponding trouble:

- Sometimes, the voids in the filter media gets clogged due to heavy growth of fungi and algae. This may result in ponding of the sewage over the filter bed.
- This trouble can be controlled by chlorinating the sewage which kills the algae, thus causing unloading of the accumulated material.

26. Solution:

It is a term which gives an idea of the extent of chlorine added to water. It represents that much dose of chlorination, beyond which any further addition of chlorine will appear as free residual chlorine. It provides a safety shield to prevent the re-growth of pathogens.



Breakpoint Chlorination

27. Solution:

Given $u = 2y - y^2$

and μ = Dynamic viscosity of fluid = 0.8 Ns/m^2

$$\text{Shear stress } (\tau) = \mu\frac{\partial u}{\partial y} = \mu(2-2y)$$

$$\therefore \quad \tau|_{y=0.2\text{ m}} = 0.8(2 - 2 \times 0.2) = 1.28 \text{ N/m}^2$$

$$\text{and} \quad \tau_{1_{y=0}} = 0.8 \times 2 = 1.6 \text{ N/mm}^2$$

28. Solution:

Distorted models follows Froude Law's

(i) Velocity scale ratio:

$$\frac{V_m}{V_p} = \sqrt{\frac{2gh_m}{2gh_p}} = \sqrt{\frac{h_m}{h_p}} = \sqrt{(L_r)_v}$$

$$V_r = \sqrt{(L_r)_v}$$

(ii) Area scale ratio:

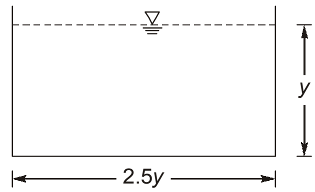
$$A_r = \frac{A_m}{A_p} = \frac{b_m \cdot h_m}{b_p \cdot h_p} = \left(\frac{b_m}{b_p}\right) \times \left(\frac{h_m}{h_p}\right)$$

or $A_r = (L_r)_H \cdot (L_r)_v$

$\therefore$ Discharge scale ratio, $Q_r = A_r \cdot V_r$

$$\frac{Q_p}{Q_m} = (L_r)_H (L_r)_v \cdot \sqrt{(L_r)_v} = (L_r)_H \times \left[(L_r)_v\right]^{3/2}$$

29. Solution:



For rectangular channel of depth '*y*'

Width, $B = 2.5\,y$

Manning's coefficient, $n = 0.0125$

Bed slope, $S = \frac{1}{400}$

$$Q = A \times \frac{1}{n} \times R^{2/3} S^{1/2}$$

$$= 2.5 \times y \times y \times \frac{1}{0.0125} \times \left(\frac{2.5y \times y}{2.5y + 2y}\right)^{2/3} \times \left(\frac{1}{400}\right)^{1/2}$$

$$= 6.758 y^{2+\frac{2}{3}}$$

$$= 6.758 y^{8/3}$$

30. Solution:

Height of instrument, *HI*

= R.L. of floor + staff reading from floor

= 40.500 + 0.645

= 41.145 m

R.L. of bottom of beam

= *HI* + inverted staff reading taken from bottom of beam

= 41.145 + 2.960

= 44.105 m

31. Solution:

For footing

Width of foundation, $B = 2$ m

Pressure, $q = 140$ kN/m^2

$\mu = 0.5$

$E = 5 \times 10^4$ kN/m^2

(i) For flexible foundation,

Influence factor, $I_f = 1.36$

Settlement of soil, $$S_i = \frac{qB(1-\mu^2)I_f}{E} = \frac{140 \times 2 \times (1 - 0.5^2) \times 1.36}{5 \times 10^4}$$

$= 5.712 \times 10^{-3}$ m $= 5.712$ mm

(ii) For rigid foundation,

Influence factor, $I_f = 1.06$

Settlement of soil, $$S_i = \frac{qB(1-\mu^2)I_f}{E} = \frac{140 \times 2 \times (1-0.5^2) \times 1.06}{5 \times 10^4}$$

$$= 4.452 \times 10^{-3} \text{ m} = 4.452 \text{ mm}$$

32. Solution:

Following are the methods:

(a) Storage reservoirs of more depth and less surface area.

(b) By growing tall trees like casuarina on the windward side of the lakes.

(c) By spraying chemicals, spreading a **manomodular** larger of acetyl alcohol (hexadecanoic)

(d) By removing the water loving weeds and plants from periphery.

(e) By providing mechanical carrying like thin polythene sheets.

33. Solution:

There are 2 sets of methods for finding value of discharge.

(a) Direct Methods:

(i) Area Velocity Method:

→ The stream should have a well defined cross section which does not change in various seasons.

→ The gauging site should be free from backwater effects.

→ For purpose of discharge estimation, the cross-section is considered to be divided into a large no. of subsections by verticals.

→ Average velocity in these subsections are measured by current meter/floats.

→ $W \rightarrow$ width of river

$w \rightarrow$ segment width

$$w \not> \left(\frac{1}{15} \text{ to } \frac{1}{20}\right) \text{of } W$$

→ The discharge in each subsection $\not>$ 10% of total discharge.

→ The difference in velocities in adjacent sections should not be more than 20%.

(ii) Moving Boat Method:

→ Suitable for estimating flow in large alluvial rivers such as Ganga.

→ Suitable for estimation of very fast flow.

→ A special propeller type current meter which is free to move about a vertical axis is towed in a boat at a velocity V_b at right angles to stream flow.

→ The meter will align itself in direction of resultant velocity V_R making an angle Q with boat direction.

(iii) Dilution Technique:

→ Also known as chemical method, depends upon the continuity principle applied to a tracer which is allowed to mix completely with flow.

→ Tracer in small volume with high concentration is injected.

→ Dilution method technique is based on assumption of steady flow. If flow is unsteady then systematic errors may arise.

→ The length of reach between dosing and sampling section should be adequate to have complete mixing of tracer with flow.

→ Mixing length becomes very large for large rivers and high discharge, major constraints of this technique.

→ Very beneficial method for estimating flow from small turbulent streams in mountainous areas.

→ Tracer should be cheap, non reactive (chemically inert) and non toxic.

(iv) Ultrasonic Method:

→ An area velocity method with the average velocity being measured by using ultrasonic signals.

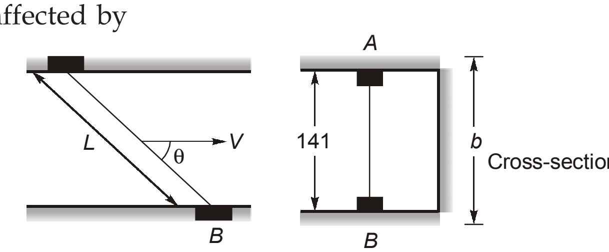
→ Rapid method and gives high accuracy.

→ Cost of installation is independent of size of rivers.

→ It can handle rapid changes in magnitude and direction of flow, as in tidal and floody rivers.

→ Accuracy of this method is liable to be affected by

- unstable cross section
- fluctuating weed growth
- high loads of suspended solids
- air entrainment
- salinity and temp. changes



(v) Electromagnetic Method:

→ Based on Faraday's principle that an emf is induced in the conductor when it cuts a normal magnetic field.

→ Method requires sophisticated and expensive instrumentation.

→ Specially suited for field condition where cross sectional properties can change with time due to weed growth, sedimentation etc.

→ Specific application is in tidal channels where flow undergoes rapid changes both in magnitude as well as in direction.

(b) Indirect Methods:

(i) Flow Measuring Structures:

→ These structures produce a unique control section in the flow.

$$Q = f(H)$$

The discharge Q is a function of water surface elevation.

- Thin plate structures
- Long base weirs
- Flumes

(ii) Slope Area Method:

→ Iterative method requiring the use of energy equation.

→ Selection of reach in which cross-section properties I/C bed elevations are known at its ends, value of manning's n and water surface elevation at both ends.

→ Useful method for determining flood flow with the help of high water marks left by flood after subside.

→ longer the reach, greater is the accuracy in estimated discharge.

34. Solution:

(i) Terzaghi's method

For $\phi = 0°$, $N_c = 5.70$, $N_q = 1.0$ and $N_\gamma = 0$

$$q_u = C_u N_c\left(1+\frac{0.3B}{L}\right)+qN_q+0.5B\gamma N_\gamma\left(1-\frac{0.2B}{L}\right)$$

$$= 45.24\times 5.7\left(1+0.3\times\frac{3}{6}\right)+\gamma_{sub}D_f\times 1$$

$$= 45.24 \times 5.7 \times 1.15 + (18 - 9.81) \times 2 = 312.93 \text{ kN/m}^2$$

or, $$q_{nu} = q_u - \gamma' D_f = 312.93 - (18 - 9.81) \times 2 = 296.55 \text{ kN/m}^2$$

or, $$q_{na} = \frac{q_{nu}}{F_s} = \frac{296.55}{3} = 98.85 \text{ kN/m}^2$$

(ii) Skempton's method,

We know,

$$q_u = C_u N_{cr} + qN_q$$

For $\phi = 0$, $$N_{cr} = 5\left(1+0.2\frac{D_f}{B}\right)\left(1+\frac{0.2B}{L}\right)$$

$$= 5\left(1+0.2\frac{2}{3}\right)\left(1+\frac{0.2\times 3}{6}\right) = 6.23$$

$$q_u = C_u \times N_{Cr} + \gamma_{sub}D_f$$

$$= 45.24 \times 6.23 + (18 - 9.81) \times 2$$

$$= 298.23 \text{ kN/m}^2$$

$$q_{nu} = 298.23 - (18 - 9.81) \times 2 = 281.84 \text{ kN/m}^2$$

$$q_{na} = \frac{q_{nu}}{F_s} = \frac{281.84}{3} = 93.95 \text{ kN/m}^2$$

35. Solution:

Except that one of the intermediate sights was taken with an inverted staff, the other sights were taken as usual and since we need only the RLs of the change points, the height of collimation system can be used.

BS (m)	IS (m)	FS (m)	Height of collimation (m)	RL (m)	Remarks
2.650			126.100	123.450	A (starting BM)
	3.740			122.36	
	–2.830			128.930	B (Inverted staff reading)
4.640		4.270	126.47	121.830	C (Change point)
	0.380			126.09	
1.640		0.960	127.15	125.510	D (Change point)
	2.840			124.31	
4.680		3.480	128.35	123.670	E (Change point)
		4.260		124.090	F (Bench mark)
∑BS = 13.610		∑FS = 12.970		Rise = 0.640	

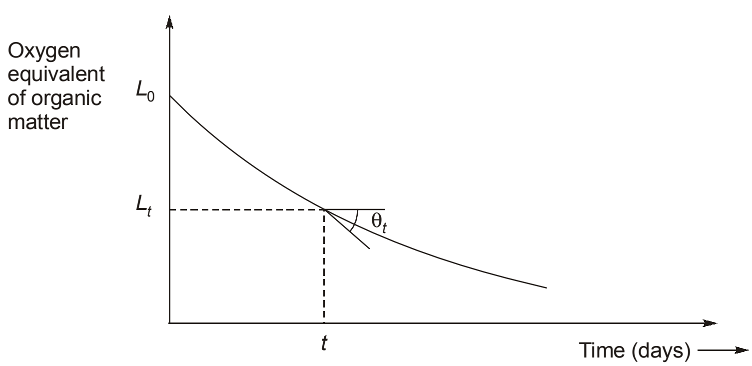
Arithmetical checks

$$\Sigma BS - \Sigma FS = 13.610 - 12.970$$

$$= 0.640\text{(Rise)} = \text{Last RL} - \text{First RL} = 0.640 \text{ (Rise)} \qquad \text{(OK)}$$

36. Solution:

Let us consider the following curve,



here, $$\theta_t = \frac{dL_t}{dt} \alpha - L_t$$

$$\Rightarrow \quad \frac{dL_t}{L_t} = -k.dt$$

Integrating both sides, $$\int_{L_t = L_0}^{L_t = L_t} \frac{dL_t}{L_t} = -k\int_{t=0}^{t=t} dt$$

$$\left|\ln(L_t)\right|_{L_0}^{L_t} = -k\left|t\right|_0^t$$

$$\ln\left(\frac{L_t}{L_0}\right) = -kt \quad \text{or} \quad 2.303\log_{10}\left(\frac{L_t}{L_0}\right) = -kt$$

$$\ln\left(\frac{L_t}{L_0}\right) = -kt \quad \text{or} \quad \log_{10}\left(\frac{L_t}{L_0}\right) = -0.434\,k.t$$

Let $0.434\,k = k_D$

$\Rightarrow$ $L_t = L_0\,e^{-kt}$ or $L_t = L_0 \times (10)^{-k_D \cdot t}$

Now, $BOD_t = L_0 - L_t$

$\therefore$ $t \text{ day BOD} = L_0\left(1-e^{-kt}\right) \text{ or } L_0\left(1-10^{-k_D.t}\right)$

k and k_D are deoxygenation constant at base 'e' and '10' respectively.

L_0 is oxygen equivalent of organic matter just before the start of decomposition. 'L_0' is also equal to ultimate BOD.

Given: BOD at 20°C = 400 mg/l and $k = 0.1$

$$400 = L_0(1 - e^{-0.1 \times 3}) = 0.259\,L_0$$

$\Rightarrow$ $L_0 = 1543.3183$ mg/l

5-day BOD at 20°C, $BOD_5 = L_0(1 - e^{-0.1 \times 5})$

$$= 1543.3183(1 - e^{-0.5})$$

$\therefore$ $BOD_5 = 607.2484$ mg/l

37. Solution:

(i) Superelevation

From practical consideration of mixed traffic conditions, superelevation should be designed with 75% of design speed.

$$e = \frac{(0.75V)^2}{127R} = \frac{V^2}{225R}$$

Here V is design speed in kmph = 80 km/h

$$= \frac{80^2}{225 \times 350} = 0.081 > 0.07$$

As the value of e is greater than maximum permissible superelevation of 0.07, so the actual superelevation to be provided is restricted to 0.07.

Hence $e_{provided} = 0.07$ or 7%

(ii) Length of transition curve, L_S :

(a) By rate of change of centrifugal acceleration:

Allowable rate of change of centrifugal acceleration C

$$= \frac{80}{75+V} = \frac{80}{75+80} = 0.516 \text{ m/sec}^3$$

$\therefore$ Length of transition curve $L_S = \frac{V^3}{RC} = \frac{(0.278 \times 80)^3}{350 \times 0.516} = 60.76$ m

(b) By rate of introduction of superelevation e :

Assume pavement width for 4-lane National Highway

$$= 4 \times 3.5 = 14 \text{ m}$$

Extra widening of pavement, W_e :

$$W_e = \frac{nl^2}{2R} + \frac{V}{9.5\sqrt{R}}$$

Here,

n = no. of lanes = 4

V = speed in kmph = 80 km/h

l = length of wheel base = 6.0 m

$$\therefore \quad W_e = \frac{4 \times 6^2}{2 \times 350} + \frac{80}{9.5\sqrt{350}} = 0.206 + 0.45 = 0.656 \text{ m.}$$

∴ Total pavement width including extra widening on curve,

$$B = W + W_e = 14 + 0.656 = 14.656 \text{ m}$$

$$\Rightarrow \quad B \simeq 14.66 \text{ m}$$

∴ Total superelevation $E = B \times e = 14.66 \times 0.07$

$= 1.026$ m

Assuming that superelevation is provided by rotating the pavement about centre line, the total superelevation to be distributed along the length of transition curve = $E/2$.

The rate of introduction of superelevation may be taken as 1 in 100, being built up area.

so, length of transition curve, $L_S = \frac{E}{2} \times 100 = \frac{1.026}{2} \times 100 = 51.3$ m

(c) By IRC formula, the minimum length of transition curve is,

$$L_S = \frac{2.7V^2}{R} = \frac{2.7 \times 80^2}{350} = 49.37 \text{ m}$$

Taking highest of above three values, length of transition curve may be taken as about 61 m.

The most suitable shape of transition curve as suggested by IRC is **spiral or clothoid** which is an ideal transition curve.

38. Solution:

(i) If y_n is the normal depth of flow, then according to Manning's formula,

$$\text{Discharge, } Q = \frac{A}{n} R^{2/3} S^{1/2}$$

$$2 = \frac{1}{0.014} \times (2 \times y_n) \times \left(\frac{2y_n}{2 + 2y_n}\right)^{2/3} (0.0004)^{1/2}$$

$$\Rightarrow \quad 0.7\,(1 + y_n)^{2/3} = y_n^{5/3}$$

Solving by trial,

$$y_n = 1.082 \text{ m}$$

Further, if y_c is the critical depth, then

$$y_c = \left(\frac{q^2}{g}\right)^{1/3} = \left\{\frac{(2/2)}{9.81}\right\}^{1/3} = 0.467 \text{ m}$$

Since, in this case, y_n is greater than y_c, the bed slope of the flume is mild. Further, the given depths of flow viz. 1.0 m and 0.90 m are between y_n and y_c, M_2 type surface profile is formed.

(ii) The length of the surface profile between the sections where depths of flow are 1.0 m and 0.90 m, may be computed by step method as follows:

At section 1, where the depth of flow is 1 m, the specific energy is

$$E_1 = y_1 + \frac{v_1^2}{2g} = 1 + \left[\frac{\left(\frac{2}{2\times 1}\right)^2}{2\times 9.81}\right] = 1.051 \text{ Nm/N}$$

Similarly, at section 2 where the depth of flow is 0.90 m, the specific energy is,

$$E_2 = y_2 + \frac{v_2^2}{2g} = 0.90 + \left[\frac{\left(\frac{2}{2\times 0.9}\right)^2}{2\times 9.81}\right] = 0.963 \text{ Nm/N}$$

$$\therefore \quad \Delta E = (E_2 - E_1) = (0.963 - 1.051) = -0.088 \text{ Nm/N}$$

According to Manning's formula at section 1;

$$S_{f1} = \frac{V^2 n^2}{R^{4/3}} = \frac{\left\{\frac{2}{2\times 1}\right\}^2 \times (0.014)^2}{\left(\frac{2\times 1}{2+2\times 1}\right)^{4/3}} = 4.94\times 10^{-4}$$

Similarly at section 2,

$$S_{f2} = \frac{\left\{\frac{2}{2\times 0.9}\right\}^2 \times (0.014)^2}{\left(\frac{2\times 0.90}{2+2\times 0.90}\right)^{4/3}} = 6.55\times 10^{-4}$$

$$\therefore \quad \overline{S_f} = \frac{S_{f1} + S_{f2}}{2}$$

$$= \frac{\left(4.94\times 10^{-4} + 6.55\times 10^{-4}\right)}{2} = 5.745\times 10^{-4}$$

Now, the distance between sections 1 and 2 is,

$$x = \frac{\Delta E}{S_0 - \bar{S}_f} = \frac{-0.088}{\left(4\times10^{-4} - 5.745\times10^{-4}\right)}$$

$$= 504.30 \text{ m}$$

The downstream section where depth of flow is 0.90 m is 504.3 m away from the given section where depth of flow is 1 m.

39. Solution:

Given, P = 4000 kg, l = 70 cm, h = 25 cm, Δ = 2 cm, F_S = 1000 kg/cm², F_f = 1400 kg/cm² and F_b = 100 kg/cm², d = 2.5 cm.

Step 1 : Length of dowel bar:

$$L_d = 5d\sqrt{\frac{F_f\left(L_d + 1.5\Delta\right)}{F_b\left(L_d + 8.8\Delta\right)}}$$

$$= 5\times2.5\times\sqrt{\frac{1400\left(L_d + 1.5\times2\right)}{100\left(L_d + 8.8\times2\right)}}$$

Solving L_d by trial and error method.

$$L_d = 40.46 \text{ cm}$$

∴ Required length of dowel bar

$$(L_d + \Delta) = 40.46 + 2 = 42.46 \text{ cm} \simeq 45 \text{ cm (say)}$$

So, provide 45 cm long and 2.5 cm diameter dowel bar:

Step 2 : Find the load transfer capacity of single dowel bar :

$$p_s = 0.785\, d^2 F_s = 0.785 \times (2.5)^2 \times 1000 = 4906.25 \simeq 4906 \text{ kg}$$

$$p_j = \frac{2d^3 F_f}{L_d + 8.8\Delta} = \frac{2\times(2.5)^3\times1400}{42.46 + 8.8\times2} = 728.4 \text{ kg}$$

$$p_b = \frac{F_b L_d^2 d}{12.5\left(L_d + 1.5\Delta\right)} = \frac{100\times(42.46)^2\times2.5}{12.5(42.46 + 1.5\times2)} = 793.2 \text{ kg}$$

∴ The required load transfer capacity

$$= \text{Max}\left(\frac{0.4\times4000}{4906}, \frac{0.4\times4000}{728.4}, \frac{0.4\times4000}{793.2}\right)$$

$$= \text{Max } (0.33, 2.2, 2.02) = 2.2$$

Step 3 : Required spacing:

Effective distance for load transfer= 1.8 × l = 1.8 × 70 = 126 cm

Assuming spacing of 35 cm

$$\text{Actual capacity} = 1 + \frac{126-35}{126} + \frac{126-70}{126} + \frac{126-105}{126} = 2.33$$

$\therefore$ $2.33 > 2.2$ (the required capacity)

$\therefore$ Provide 2.5 cm diameter mild steel dowel bars with,

Length = 45 cm, spacing = 35 cm

■■■■