RPSC AEn-2024 Main Test Series

CIVIL ENGINEERING

Test 4

Test Mode : • Offline • Online

Subjects : Irrigation Engineering + Engineering Hydrology

DETAILED EXPLANATIONS

1. **Solution:**

   When irrigation water is lifted from surface or underground sources by manual, mechanical or electrical power, it is known as lift irrigation.

2. **Solution:**

   Field capacity is the maximum moisture soil retains against gravity after excess water drains away.

3. **Solution:**

   Well development is the process of removing fine particles around the well screen to increase formation permeability and improve the yield and efficiency of the well.

4. **Solution:**

   A design flood is the selected peak discharge used for designing hydraulic structures, representing the maximum flood that can be safely passed without causing structural damage. In other words, design flood is the flood adopted for design of structures.

5. **Solution:**

   Potential evapotranspiration for a plant is the rate of evapotranspiration that would occur from a vegetated surface if adequate moisture is always available, representing the total demand for water by a plant under ideal conditions.

6. Solution:

Water stops are impervious strips placed across construction and contraction joints of dams to prevent seepage through joints and ensure the watertightness of the dam body.

7. Solution:

Intensity of irrigation may be defined as the ratio of cultivated land for a particular crop to the total culturable command area i.e..

$$\text{Intensity of irrigation} = \frac{\text{Area of land under a particular crop}}{\text{Total cutterable command area}}$$

8. Solution:

$$\text{Lacey's wetted perimeter, } P = 4.75\sqrt{Q}$$

$$\Rightarrow \quad P = 4.75\sqrt{20}$$

$$\Rightarrow \quad P = 21.243 \text{ m}$$

9. Solution:

$$\text{Rainfall excess} = 2.7 - 0.3 \times 3 = 1.8 \text{ cm}$$

$$\text{Peak discharge of DRH} = 210 - 20 = 190 \text{ m}^3/\text{s}$$

$$\text{Peak of 3-h UH} = \frac{190}{1.8} = 105.56 \text{ m}^3/\text{s}$$

10. Solution:

Cumulative infiltration at the end of 2 hrs,

$$f_p(t = 2\text{ hr}) = \int_0^2 \left(1.34 + 6.28e^{-4.182t}\right) dt$$

$$= 1.34(2) - \frac{6.28\left[e^{(-4.182\times 2)} - 1\right]}{4.182}$$

$$= 4.18 \text{ cm}$$

11. Solution:

1. Irrigation may raise the water table of soil thereby causing soil alkalinity.
2. Excess seepage forms marshy lands and develops humid conditions which encourages mosquito breeding.
3. The weather may become damp and unhealthy, increasing disease risk.
4. Over-irrigation leads to waterlogging and reduces crop yields.
5. Construction of canals and reservoirs can also submerge valuable land, causing permanent loss of asset.

12. Solution:

1. A recording type rain gauge automatically measures rainfall and continuously indicates rainfall intensity.
2. It provides time-distribution of rainfall, unlike non-recording gauges that show only total rainfall.
3. Since no attendant is required, it can be installed in remote and inaccessible locations.
4. Continuous recording also eliminates human observation errors, improving accuracy and reliability of rainfall data.

13. Solution:

Subsidiary canals are smaller channels taken off from the same river to supplement the main canal's supply. When the head of the main canal reduces due to siltation or low river stage, these subsidiary canals are opened to increase the discharge in the main canal. Their length is kept minimum and alignment avoids cultivable land.

14. Solution:

A defective head regulator allows excessive or improperly regulated entry of sediment-laden water into the distributary. It makes the off-taking channel to draw a higher percentage of coarser sediment. This increases the silt factor and sediment load beyond the channel's carrying capacity. As a result, sediment begins depositing in the head reaches, thereby reducing the flow efficiency and initiating progressive silting of the channel.

15. Solution:

The size and shape of a catchment strongly influence the runoff behaviour.

- Smaller catchments produce higher runoff per unit area because rainfall concentrates quickly, while large catchments yield delayed and attenuated peaks.
- A fan-shaped catchment generates sharp peak runoff since tributaries join the main stream almost simultaneously.
- In contrast, a fern-leaf shaped catchment produces lower, broader peaks because tributaries are of unequal lengths and deliver flow at staggered intervals, reducing concentration.

16. Solution:

Undersluices are deep pockets provided upstream of the canal head regulator to flush deposited sediment from the riverbed. By drawing relatively clear water towards the regulator, they minimise silt entry into the canal. They also pass floodwater without raising the weir shutters and maintain adequate scouring capacity for safe river approach conditions.

17. Solution:

A unit hydrograph represents the direct runoff produced by one unit depth of uniformly distributed effective rainfall over a catchment for a specified duration. The basic assumptions are:

1. The excess rainfall has a constant intensity throughout the effective storm duration.
2. The excess rainfall is uniformly distributed over the entire catchment area.

18. Solution:

For a current meter,

$$V = aN_s + b$$

For $V = 0.25$ m/s

$N_s = 12$

$\therefore \quad 0.25 = 12a + b \quad$ ...(i)

For $V = 0.46$ m/s

$N_s = 30$

$\therefore \quad 0.46 = 30a + b \quad$ ...(ii)

Solving eq. (i) and (ii), we get,

$$a = 0.01167$$

$$b = 0.11$$

For 50 revolutions in one minute,

$\therefore$ Number of revolutions in 50 seconds

$$= \frac{50 \times 50}{60} = 41.67$$

$\therefore$ Velocity indicated by current meter,

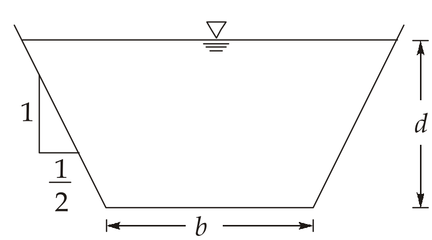
$$V = aN_s + b$$

$$= 0.01167 \times 41.67 + 0.11 = 0.596 \simeq 0.60 \text{ m/s}$$

19. Solution:

Discharge, $Q = 10 \text{ m}^3/s$

Lacey silt factor, $f = 0.9$



Side slope of channel = $\frac{1}{2} H : 1V$

Let, the width and depth of channel are b and d respectively.
As per Lacey's theory

$$\text{Velocity, } V = \left(\frac{Qf^2}{140}\right)^{\frac{1}{6}}$$

$$\Rightarrow \quad V = \left(\frac{10\times 0.9^2}{140}\right)^{\frac{1}{6}} = 0.62 \text{ m/s}$$

$$\text{Now, flow area required, } A = \frac{Q}{V} = \frac{10}{0.62} = 16.13 \text{ m}^2$$

$$\text{Wetted perimeter, } P = 4.75\sqrt{Q} = 4.75\sqrt{10} = 15.02 \text{ m}$$

Now,
$$P = b + \sqrt{5}y$$
$$A = (b + 0.5y)y$$

$$\therefore \quad 15.02 = b + \sqrt{5}y \quad \text{...(i)}$$

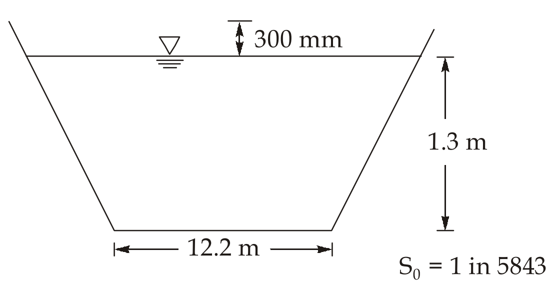
$$\text{and} \quad 16.13 = by + 0.5\,y^2 \quad \text{...(ii)}$$

Solving (i) and (ii), we get

$$y = 1.26 \text{ m} \simeq 1.3 \text{ mand } b = 12.2 \text{ m}$$

Assuming 300 mm free board, overall depth of channel is 1.3 + 0.3 = 1.6 m
(Neglecting y = 7.4 m, being too large.)

$$\text{Bed slope, } S_0 = \frac{f^{5/3}}{3340\,Q^{1/6}} = \frac{0.9^{5/3}}{3340\times 10^{1/6}} = 1 \text{ in } 5843.53 \simeq 1 \text{ in } 5843 \text{ (say)}$$



20. Solution:

The calculations for unit hydrograph are tabulated below:

Time (h) (1)	Ordinate of storm hydrograph (m^3/s) (2)	Base flow (m^3/s) (3)	DRH Col.(2) – Col.(3) (m^3/s) (4)	3h-unit hydrograph col. 4 ÷ 26.9 (m^3/s) (5)
0	50	50	0	0
3	50	50	0	0
6	75	50	25	0.9
9	125	50	75	2.8
12	225	50	175	6.5
15	290	50	240	8.9
18	270	50	220	8.2
21	145	50	95	3.5
24	110	50	60	2.2
27	90	50	40	1.5
30	80	50	30	1.1
33	70	50	20	0.7
36	60	50	10	0.4
39	55	50	5	0.2
42	51	50	1	0.04
45	50	50	0	–
		Total	996	

$$\text{Direct runoff depth} = \frac{\text{Volume of DRH}}{\text{Drainage area}}$$

$$\text{Volume of DRH} = (\text{Sum of DRH ordinates}) \times \text{Time of rainfall}$$

$$= 996 \times 3 \times 60 \times 60 = 10756800 \text{ m}^3$$

$$\text{Drainage area} = 40 \text{ km}^2 = 40 \times 10^6 \text{ m}^2$$

$$\therefore \quad \text{Direct runoff depth} = \frac{10756800}{40 \times 10^6} = 0.26892 \text{ m} \simeq 26.9 \text{ cm}$$

Thus the ordinates of DRH (Col. 4) are divided by 26.9 cm to obtain the ordinates of 3h unit hydrograph.

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