Part B

5) **Rooftop harvesting:**

Catchment area = $40\ m^2$
per capita demand = 15 lpcd
no. of members = 5
max. rainfall intensity = 12 mm/hr

past 10-yr rainfall data → min. rainfall depth = 300 mm
next value = 310 mm.

scarce period = 5 months at least.

soln:

Available water harvesting potential

= area of catchment × Rainfall depth × runoff coefficient.

(step 1) = $40\ m^2$ × 300 mm × 0.8

300 mm ↓ min value which is most likely to be equalled & exceeded.

0.8 ↓ assumption

$= 40 \times \frac{300}{1000} \times 0.8\ m^3 = 9.6\ m^3$

(step 2) water demand = per capita demand × no. of persons × scarce period.

or $V = t \times n \times q$

or $t = \frac{V}{n \times q} = \frac{9.6 \times 10^3\ L}{5 \times 15\ lpcd}$

or $t = 128$ days. ≈ 4.26 months.

≈ 5 months of scarce period.

(step 3) Since the available water harvesting potential is going to be sufficient for the scarce period of 5 months, we will design our storage to this capacity.

$\therefore$ capacity of the tank $= V = 9.6\ m^3$

Assuming the house in rural setting, let ht. of the storage tank be $H = 1.6\ m$.

Assuming a circular tank of diameter D,

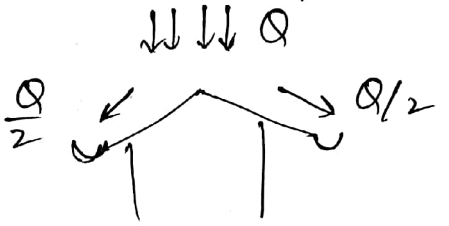
$$\therefore \quad \text{Volume} = \frac{\pi D^2}{4} \times H$$

$$\text{or} \quad 9.6\ m^3 = \left(\frac{\pi D^2}{4} \times 1.6\right) m^3$$

$$\text{or} \quad D = 2.763\ m \approx 3\ m.$$

Hence provide a tank of 1.6 m ht. & 3m diameter.

(step 4)



max. rate of runoff $= Q$. (m^3/s)

$$Q = \frac{\text{runoff depth}}{\text{time}} \times \text{area of catchment}$$

$$= \frac{(\text{rainfall depth} \times \text{runoff coeff})}{\text{time}} \times C.A.$$

$$= \frac{12\ mm \times 0.8}{hour} \times 40\ m^2$$

$$= \frac{12}{1000 \times 60^2} \times 40 \times 0.8 = 1.066 \times 10^{-4}\ m^3/s$$

flow coming in each gutter = $\frac{Q}{2} = 5.33 \times 10^{-5}\ m^3/s$

Design of gutter :

using manning's formula :

(steps)

$$Q = A \times V$$

$$= \frac{\left(\frac{\pi \phi^2}{4}\right)}{2} \times \frac{1}{N} r^{2/3} S^{1/2}$$

→ assuming slope of gutter as $\left(\frac{1}{200}\right)$

→ assuming manning's constant as 0.025 for uniform flow.

$$\left[\text{hyd. mean depth, } r = \frac{A}{P} = \frac{\left(\frac{\pi \phi^2}{8}\right)}{\left(\frac{\pi \phi}{2}\right)}\right]$$

$$5.33 \times 10^{-5}\ m^3/s = \frac{\pi \phi^2}{8} \times \frac{1}{0.025} \left(\frac{\phi}{4}\right)^{2/3} \left(\frac{1}{200}\right)^{1/2}$$

or $\phi = 0.0347\ m.$

$= 34.78\ mm.$

width of G I sheet to make gutter = $P = \frac{\pi \phi}{2} =$

54.63 m.

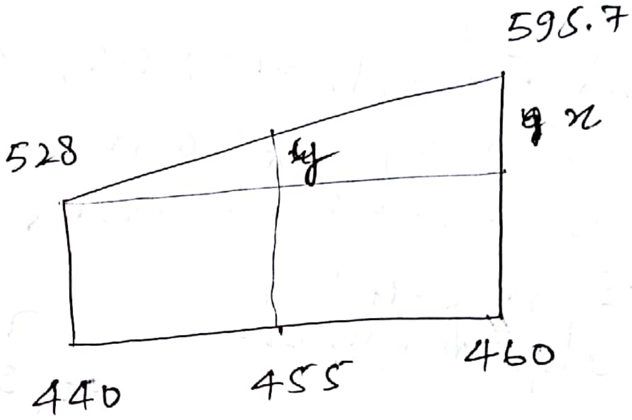
providing 25 mm extra for fixing rafters, purlins etc,

width = 54.63 + 25 mm = 79.6 mm.

6. Percolation tank

Catchment area = 1.7 km^2 (Good catchment)
RL of ground = 99 m
soil = sandy
rainfall = 455 mm.

Using strange's table & linear interpolation,



yield for ~~460~~ 455 mm
= 528 + y

$\frac{y}{x} = \frac{455-440}{460-440}$ (similar Δs)

or $y = 50.775$

∴ yield for 455 mm rainfall = 528 + 50.775
= 578.775 m^3/ha.

total yield = 578.78 m^3/ha × area in ha

(1 km^2 = 100 ha)

= 578.78 × 1.7 × 100
= 98392.6 m^3

Assuming 5% utillisation rate,

capacity of pond = total yield × util. rate
= 98392.6 m^3 × 5%
= 4919.63 m^3

stage for capacity of 4920 m^3 is 102 m.

$\therefore$ FTL (full tank level) = 102 m.

MWL (max. water level) = FTL + max. head

$= 102 + 0.5 = 102.5\,m$

Top bund level (TBL) = MWL + free board

$= 102.5 + 0.5$

$= 103\,m$

Design flood:

$Q = C_D A^{3/4}$ (dicken's formula)

$= 14\,(1.7)^{3/4}$

$= 20.84\ m^3/s$

discharge over rectangular weir $= C_d \frac{2}{3}\sqrt{2g}\, L H^{3/2}$

or $20.84\ m^3/s = 0.62 \times \frac{2}{3}\sqrt{2 \times g} \times L \times (0.5)^{3/2}$

or $L = 32.195\ m$

(length of spillway)

Horizontal floor:

length $= L + 0.5 = 32.69\ m.$

width $\geq 2(D + H)$ or $2\left[(FTL - GL) + H\right]$

$\geq 2\left[3 + 0.5\right]$ or $7\ m.$

ht. of embankment, h = TBL − GL = 103 − 99 m
= 4 m.

providing 5% consolidation settlement allowance, $h = 4 + \frac{4 \times 5}{100}$
= 4.2 m.

width of embankment, $w = \frac{h}{5} + 1.5$
= 2.34 m.

since it is sandy soil, u/s slope = 3:1
d/s slope = 2.5:1

1. A farm pond is a large hole dug out in the earth, usually square or rectangular in shape, which harvests rainwater and stores it for future use. It has an inlet to regulate inflow and an outlet to discharge excess water. The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. The size and depth depend on the amount of land available, the type of soil, the farmer's water requirements, the cost of excavation, and the possible uses of the excavated earth. Water from the farm pond is conveyed to the fields manually, by pumping, or by both methods.

— (1)

Uses of farm pond

- They provide irrigation water during dry spells between rainfalls. This increases the yield, the number of crops in one year, and the diversity of crops that can be grown.
- They check soil erosion and minimize siltation of waterways and reservoirs.
- They supplies water for domestic purposes and livestock
- They recharge the ground water.
- They improve drainage.

Components of a farm pond

1. Inlet channels and spillway

The inlet channels have to be constructed in such way that, all the surface runoff generated in catchment area should reach the pond. The inlet channels can be laid all along the slope but care should be taken that, it should be with safe velocity. The grasses can be grown on constructed channel to avoid the channel erosion. A silt trapper is also provided to remove the suspended particles entering the pond.

2. **Soil**

The soils must have low hydraulic conductivity with minimum seepage and percolation so that water can be retained. Soils with a low infiltration rate are most suitable for construction of pond. The black soils have good potential for rain water harvesting without lining as the seepage losses are minimum. The seepage losses are more in sandy soils and their mixed textures and they require lining for storing water for more time

3. Storage pond

Excavated farm ponds may normally be of three shapes, viz; (a) square, (b) rectangular, and c) inverted cone. However, as curved shape offers difficulties in construction, either square or rectangular ponds are normally adopted. The depth of the pond must be in such a way to balance between evaporation losses and seepage losses. A side slope of 1:1 to 1.5:1 is recommended for practical purposes.

4. Outlet structure /Waste weir

The outlet or waste weir for the pond is designed to remove the surplus runoff above the maximum capacity of the pond. Generally, outlet is located at one end of pond in undisturbed soil and should be well vegetated with grass to reduce erosion. The outlet position will be a little lower than the elevation of the inlet to avoid backing up of the water.

5. Bund

The pond is surrounded by a small bund, which prevents erosion on the banks of the pond. — 3

1. What is rainwater harvesting and why is it Important ?

2.

Rain water harvesting (RWH) is a technique of collection and storage of rainwater into natural reservoirs or tanks, or the infiltration of surface water into subsurface aquifers (before it is lost as surface runoff).

Objectives of Rainwater Harvesting:

6x1=6

a. To meet the increasing demand of water.

b. To reduce the run-off which chokes the drains.

c. To avoid the flooding of roads.

d. To raise the underground water table.

e. To reduce ground water pollution.

f. To reduce soils erosion.

g. Supplement domestic water needs.

3 **Microcatchments:**

a. Micro-catchment systems are those in which surface runoff is collected from a small catchment area with mainly sheet flow over a short distance.

b. Runoff water is usually applied to an adjacent agricultural area, where it is either stored in the root zone and used directly by plants, or stored in a small reservoir for later use.

c. The target area may be planted with trees, bushes, or with annual crops. The size of the catchment ranges from a few square meters to around 1000 m^2 . Land catchment surfaces may be natural, with their vegetation intact, or cleared and treated in some way to induce runoff, especially when soils are light. Non-land catchment surfaces include the rooftops of buildings, courtyards and similar impermeable structures.

d. Suitable land-based micro-catchment techniques exist for any slope or crop. However, these systems generally require continuous maintenance with a relatively high labor input. Unlike macro-catchment systems, the farmer has control within his farm over both the catchment and the target areas. All the components of the system are constructed inside the farm boundaries.

They are subdivided into two types: 3

Macro Catchment:-

a. Macro-catchment and floodwater-harvesting systems are characterized by having runoff water collected from a relatively large catchment. Often the catchment is a natural rangeland, the steppe, or a mountainous area. Catchments for these systems are mostly located outside farm boundaries, where individual farmers have little or no control over them.

b. The predominance of turbulent runoff and channel flow of the catchment water contrasts with the sheet or rill flow typical of micro-catchments.

c. runoff capture is much lower than for micro-catchments, ranging from a low percentage to 50% of annual rainfall. Water is often stored in surface or subsurface reservoirs, but may also be stored in the soil profile for direct use by crops. Sometimes water is stored in aquifers as a recharge system.

d. Water rights, affecting the distribution of water between the catchment and the cultivated areas and to the various users in the upstream and downstream areas of the watershed, are among the most important problems associated with these systems. (3)

(4)

4. Write a note on yield from catchment. Explain how it can be enhanced. What are the ways to determine yield from catchment?

The amount of runoff expected to come to the catchment from rainfall is known as yield of catchment. A catchment may be classified as good, bad or average catchment depending upon the runoff generated in the catchment. Hills or plains with little cultivation will have high yield (runoff) and hence may be known as a good catchment. A bad catchment is the one which generates very less yield and a flat and cultivated sandy soil is an example.

Following are the methods to enhance yield from catchment. — 2

1. **Vegetation management** – Yield may be improved by proper management of vegetation. It has been found that water yield from grass cover is much greater than from a forest cover (Grass gives quick runoff).

— 1

2. **Land alteration** – Relatively impervious soils are good for more runoff. If it do not exists, removing the vegetation and providing paved surfaces with proper drains can enhance the runoff yield. Also for an undulating terrain proper arrangements must be done to channel the runoff. —/

3. **Treatment of soil** – Chemical treatment of soil with Sodium salts decreases the permeability of soil and helps in increasing runoff. Physical treatment includes providing soil covers with impermeable materials like concrete, asphalt, plastic films etc. —/

4. **Small storages** – Excavating small pits, constructing collection tanks etc helps in storing runoff water. —/

7. 5. Differentiate between rainwater harvesting methods for urban v/s rural setting.

The techniques used for rain water harvesting in rural and urban areas is given below.

Urban Area	Rural area
Roof top rain water harvesting through:	Rain water harvesting through:
Recharge pit	Gully Plug
Recharge trench	Contour bunding
Tube well	Check dam
	Percolation tank
	Recharge shaft

-3

Salient features of urban area recharge:

- The quantum of water is comparatively small
- Rain water available from rooftop of building , paved and unpaved areas needs to be harvested.
- The collection and recharge system In urban areas needs to be designed in such a way that it does not occupy large space.

— 2

Recharge pit –

- To recharge shallow aquifers.
- Used in alluvial areas, where permeable rocks are at shallow depth, this technique is used.
- Recharge pits are generally, 1-2m wide and 2-3m deep.
- Filled with boulders at the bottom, gravel in between and course sand at the top.
- Suitable for buildings having a roof area of 100s square meters.
- A mesh is also provided at the roof to avoid leaves/debris etc.

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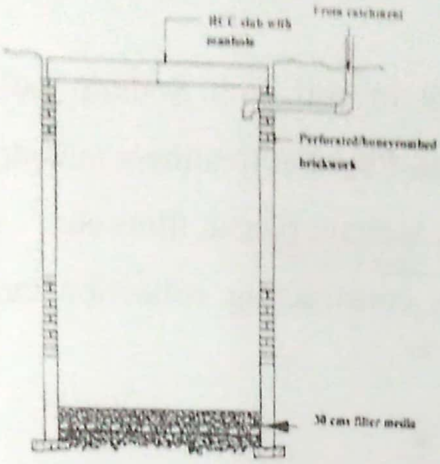
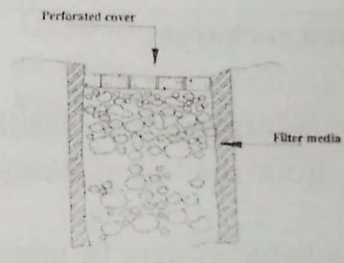


Typical recharge pit

Recharge Trench-

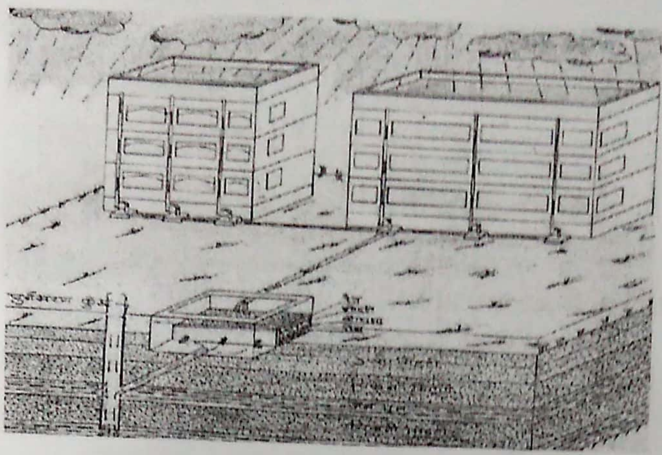
- Suitable for permeable strata having shallow depths
- Suitable for buildings having roof area of 200- 300 square meter
- Trenches to be backfilled with boulders at bottom , gravel in between and graded course sand at top
- Top sand layer to be periodically cleaned
- Bypass arrangement to be provided before collection chamber to reject water of first shower.



Recharge Trenches

Tube well-

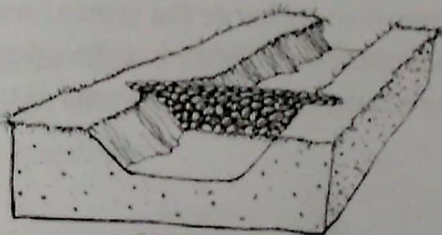
- Suitable for areas where shallow aquifers have dried up and existing tube-wells are tapping deeper aquifers.
- PVC pipes are connected to roof drains to collect rainwater
- After rejecting rain water of first shower, subsequent rain showers are taken through a T to an online PVC filter
- Filter is divided into 3 chambers - Chamber 1 filled with gravels(6- 10mm), middle one with pebbles(12-20mm) and last one with stones 20-40mm



Salient features of rural area recharge:

Gully Plug –

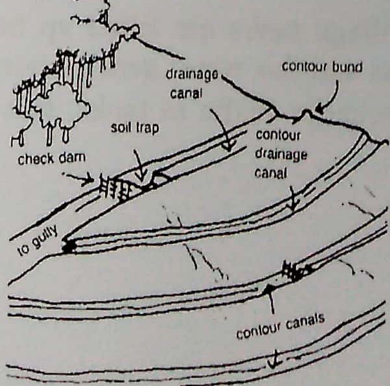
- Built along hilly slopes across gullies/ small streams using locally available stones, clay etc.
- Prevents soil erosion and conserves soil moisture
- Better selection where slope breaks so as to have some storage behind



GULLY PLUG

Contour bunding –

- These are suitable in low rain fall areas by constructing bunds on sloping grounds all along the contour of equal elevation
- Spacing between two bunds depends on slope, area and permeability of soil

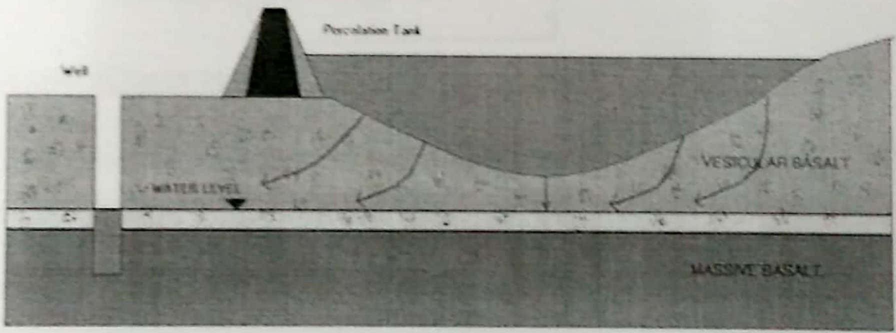


Check dam –

- Constructed across streams with gentle slopes

Percolation tank –

- Percolation tanks are artificially created surface water bodies, submerging a land area with adequate permeability to facilitate sufficient percolation of impounded surface runoff to recharge the ground water.
- To be constructed in highly weathered and fractured rocks.
- Helps in recharging aquifers around 1km downstream.



Recharge shaft -

- In rainy season, village tanks are filled up but water does not percolate due to siltation in the tanks and this water gets evaporated after some months.
- By constructing recharge shafts in tanks, this water can be recharged to ground water.