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Design of Rainwater Harvesting Structures in S.V. University Campus

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Abstract: Population in India is increasing at an alarming rate, this leads to increasing in the demand of water for different purposes. The present work is focused on the design of rainwater harvesting structures, collected from different rooftops from all departments of engineering college and engineering men's hostel block at S V UNIVERSITY CAMPUS. For the design of rainwater harvesting, the catchment areas & hydrological rainfall data were collected. To store the groundwater in underground, sump is designed for CIVIL ENGINEERING DEPARTMENT and VISVESWARA HOSTEL BLOCK. Volume of tank has been calculated by using appropriate method. The design of recharge pit and location of recharge pit was determined using Remote Sensing and GIS.

Keywords: Rainwater Harvesting, Remote sensing and GIS, catchment area,

I. INTRODUCTION

Water is one of the most vital natural resources for supporting life. With the increase of population, the demand of freshwater is increasing rapidly. Water is available in this earth both in surface and groundwater. The pollution of surface water is more when compared to groundwater. So, we need to take care of this resources by recharging the surface and groundwater. In our country the major source of water is precipitation but it is not uniform and is inadequate. Hence to meet the quenching water demands, Rain Water Harvesting has now-a-days become a most handily and economical solution to solve such problems. Rainwater Harvesting is a simple technique of catching and holding rainwater where its falls. Either, we can store it in tanks or we can use it to recharge groundwater depending upon the situation. Rainwater harvesting is the ideal situation for those areas where there is inadequate groundwater supply or surface resources. The quantity of water which can be collected by RWH depends on the local rainfall (quantity, density, and frequency), the temperature, and the morphology of the site, the outcropping rocks, the soil cover, and the size of the catchment area. During rainfall most of the water runs downwards as surface runoff and executes erosion, but it should be used for wetting the soil of cultivated land. The morphology of an area determines the kind and size of RWH installations and governs the collectable quantity of water as well as the amount of soil which is eroded at higher altitudes and precipitated at lower locations. There are two methods of rain water harvesting based on water collection that is rooftop rainwater harvesting and sub-surface rainwater harvesting. Therefore, the design of rainwater harvesting structure is very important to meet the demands of the for different purposes.

II OBJECTIVES

The main objectives of the study are

- Planning and designing of roof top rain water harvesting system for **CIVIL ENGINEERING DEPARTMENT and VIVESWARA BLOCK (MAIN WING ONLY).**

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- Identifying the suitable site for surface rain water harvesting structure in the study area. Design of surface rain water harvesting structure in the study area.

III LITERATURE REVIEW

3.1 Roof Top Rainwater Harvesting:

Roof-based harvesting, on the other hand, involves collecting the rainwater that falls on a roof before the water even reaches the ground.

3.1.1 Components of Roof Top Rainwater Harvesting System

A rainwater harvesting system comprises of components for - transporting rainwater through pipes or drains, filtration, and tanks for storage of harvested water.

- Catchment area
- Coarse Mesh
- Gutters
- Conduits
- First-flushing
- Filters
- Storage facility
- Recharge structure

3.1.2 Surface Rain Water Harvesting System

In urban area rainwater flows away as runoff. This runoff could be caught and used for recharging aquifers. We use recharge pits in this process.

- Recharging of bore wells
- Recharging of dug wells.
- Recharge pits
- Recharge Trenches
- Soak ways or Recharge Shafts
- Percolation Tanks

3.2 Case Study

A very decant work is being done by P.SaiRukesh Reddy and A.K.Rastogi in their paper entitled, Rainwater Harvesting in hostel 12 and hostel 13 of IIT Bombay

The Indians society for Hydraulics and Journal of Hydraulic Engineering (2008). In this paper, rainwater is being conserved/harvested only for hostel areas.

R.C.C. Designs, By: - Punmia B.C., Jain Ashok, & Jain Arun Kumar, was referred. These books has carried complete structural analysis of underground sump.

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Estimation and costing in civil engineering by : - B N Dutta

A very decant work is being done by P.Sai Rukesh Reddy and A.K.Rastogi in their paper entitled, Rainwater Harvesting in hostel 12 and hostel 13 of IIT Bombay

IV STUDY AREA

The Study area falls under S .V UNIVERSITY CAMPUS. The details of location map and roof areas of buildings considered in our project. The area was delineated from India Water Resource Information System. The location map of the study area were shown in Figure 1 and geographical details are shown in Table 1

Figure.1: Location Map of the Study Area

Table.1 Geographical Details of Study Area

Latitude	13°37’35.57” E to 13°36’59.36” E
Longitude	79°23’18” N to 79°24’1.78” N
Total Area	963742 sq.mts
Monsoon period	June to December
	June to September (SW monsoon)
	October to December (NE monsoon)
Non-monsoon period	January to May
Climate	Semi- arid
Discharge	1156490.4 cm^3
Assumed no of rainy days	50
Runoff on each rainy day	23129.8 cm^3
Total runoff that can be collected in each rainy day in Litres	2,31,29,808 litres

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4.1 Data Collection

The dataset used in the present study and their characteristic relevant to the aim of the study is briefly as follows

4.2 Rainfall Data

Daily rainfall datasets were acquired from the grid date for the period of 1995 to 2015. The Indian Meteorological Department (IMD) and statistical department have set up a rainfall monitoring stations for basin. Thus there are nine Meteorological stations (Pemmur, Puthalapattu, Irala, Pulicherla, Rompicherla, Yeravaripalem, Ramasamudram, Chittoor.) with in the study area and are selected for the present study.

The total population including institutional, residential, hostel and floating population is estimated to be 20,000. To fulfil objective of the project it is required to have latest version of software which will alone can be used for all types of analysis. It is found that the ArcGIS software version10.2.2 have all the features. MS EXCEL also used in the project analysis.

Table 2: Monthly Rainfall Data for the Period (1995-2015)

Year/Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1995	34.2	7.4	10.0	0.0	195.0	57.8	289.7	116.3	79.0	237.9	47.7	3.2	1078.2
1996	0.0	0.0	1.1	159.9	19.5	214.6	126.6	185.8	204.8	331.8	123.2	461.6	1828.9
1997	43.2	0.0	0.0	42.8	48.8	72.2	59.5	53.9	153.5	184.4	356.3	163.3	1177.9
1998	0.0	0.0	0.0	23.2	21.8	20.5	144.4	193.0	127.9	99.1	251.4	232.5	1113.8
1999	0.0	0.0	0.0	4.0	76.8	17.4	44.6	27.0	6.0	88.6	0.0	0.0	264.4
2000	0.0	16.0	0.0	0.0	108.1	42.8	42.6	169.2	114.8	134.8	122.7	59.4	810.4
2001	0.0	0.0	0.0	69.6	17.2	45.3	137.4	22.8	168.3	297.0	88.3	130.7	976.6
2002	25.8	0.0	0.0	1.0	77.2	196.7	8.2	106.6	288.5	267.7	89.0	27.8	1088.5
2003	0.0	0.0	22.2	11.8	23.0	222.0	289.4	98.7	145.4	146.7	19.7	13.4	992.3
2004	0.0	3.2	0.0	81.4	207.9	57.5	100.2	35.4	279.5	163.4	132.4	0.0	1060.9
2005	0.0	9.8	0.0	27.0	50.9	66.4	153.5	73.4	134.2	328.8	517.9	164	1525.9
2006	0.0	0.0	48.7	19.4	124.8	126.2	4.8	75.6	108	165.2	150.2	14.2	837.1
2007	0	0	0	1.8	17.6	101.0	42.8	207.8	106.0	337.2	60.6	234.6	1109.4
2008	17.0	0.0	57.3	14.2	167.0	20	44.6	63	115.8	282.1	385.2	20	1186.2
2009	2	0	0	3.8	16.8	124.2	44	221.8	151.4	28.8	201.4	89	883.2
2010	0	0	0	0	99.4	85.2	206.4	195.8	190.6	149.4	162	67	1155.8
2011	0	28.6	0	26	35.8	25	115.4	145.6	76.8	102.2	263.4	121	939.8
2012	0	0	0	41.6	63.6	39.4	100.8	224.6	108.6	205.4	122.6	232.2	1138.8
2013	0	39.6	19	45.4	10.8	86.0	78.0	114.4	325.2	194	119.2	1.6	1033.2
2014	2.2	0	0	86.6	101.6	53.1	116.9	239.7	86.7	61.5	46.2	63.25	857.7
2015	0.0	0	51.0	79.48	48.2	101.9	36.1	88.1	86.7	222.5	744.3	99.1	1557.4
AVG	5.9	5.0	10.0	35.2	72.9	84.5	104.1	126.6	145.6	191.8	190.7	104.7	1077.0

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V Planning and Design of Rain Water Harvesting Structures

The details of underground tank for collection and storage of roof top run-off water from buildings in S.V.University.

5.1 Roof Top Area of Different Buildings in S V U College Of Engineering

The roof top areas the different buildings are shown in the Table 2.

Table 2 Roof Top Areas of Different Buildings

SL NO.	NAME	AREA(m^2)
1	MAIN BUILDING	1269
2	CE	969.8
3	ECE	704
4	Ch.E	555.5
5	ME	506.3
6	EEE	650.3
7	CSE	752

5.2 Volume Estimation of Roof Top Runoff

Volume of rainfall over the entire catchment under considered is calculated as

=Average Annual Rainfall*Area*Runoff coefficient

Average annual Rainfall is obtained from above is 1077 mm

Area =Total roof area of building=970 m^2

Run off coefficient varies for different types of catchments which was given by Central Ground Board. The roof of CIVIL ENGINEERING BUILDING is impervious. Hence, runoff coefficient is 1.

5.3 Design of Roof Top Rain Water Harvesting for Civil Engineering Department:

Roof Area =970 Sq.M

Average Annual Rainfall=1077 Mm/Year

Volume=1200m^3

Total Number of Students =500

Amount of Water Stored During A Month= 0.1918 X970 = 186 = 220 M^3

Dimensions of Underground Sump 4 m X5 m X 11 m

Problem Statement:

Height of tank= 4 m

Area of base = 55 m^2

Taking subsoil consists of sand, angle of repose = 30°

Saturated unit weight of soil = 17 KN/m^3

Water table likely to rise up to ground level M20 concrete, HYSD bar Unit weight of water = 9.81 KN/m^3 Solution:

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There are four components of design:
i) Design of long wall
ii) Design of short wall
iii) Design of roof slab
iv) Design of base slab

By using the structural analysis, the design of walls, roof slabs and base slab was evaluated and longitudinal section and plan of sump in Civil Engineering Department was shown in Figure 2 and Figure 3

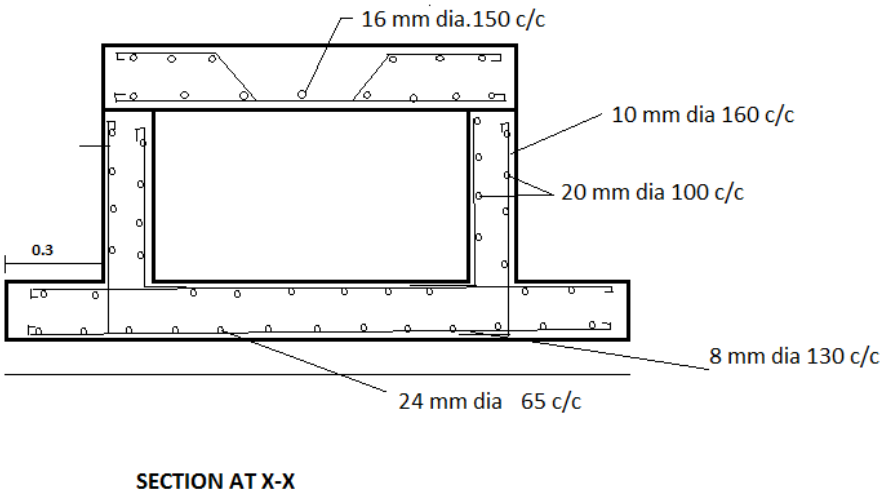

Figure 2 Longitudinal Section of Sump For Civil Engineering Department

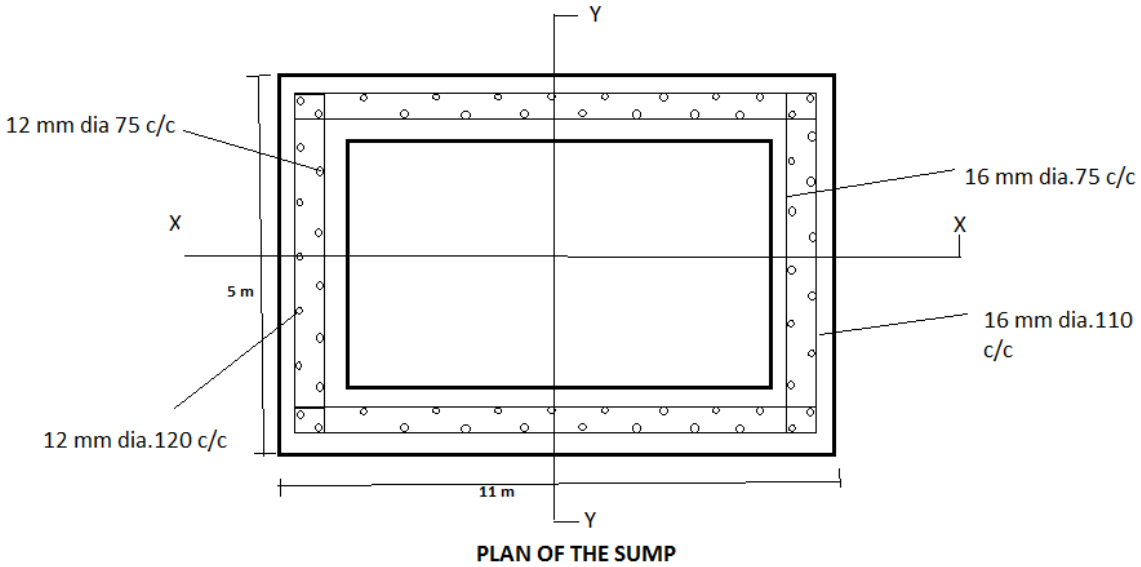

Figure 3 Plan of Sump For Civil Engineering Department

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Design Of Filter For Civil Engineering Department

PEBBELS = 20% of 2 m = 0.4 m
SAND = 40% of 2 m = 0.8 m
LIME STONE = 5% of 2 m = 0.1 m
COAL = 5% of 2 m = 0.1 m
FREE BOARD = 30% of 2 m = 0.6 m

Design Of Roof Top Rain Water Harvesting For Visveswara Hostel Block (Main Wing Only)

Roof Area =454.46 Sq. M=460 Sq. M
Average Annual Rainfall=1077 Mm/Year
Volume=500 M^3
Total Number of Students =200
Amount of Water Stored During A Month= 0.1918 X470 = 90.146 = 120 M^3
Amount of Water Stored During A Month=120 M^3
Dimensions of Underground Sump 3 M X 4 M X 10 M

VI Designing of Surface Rain Water Harvesting Structure

The surface rainwater harvesting structure was designed based on drainage basin in S. V. University campus. The surface rainwater harvesting in the campus was recharge pit. The various components of recharge pit were discussed below.

6.1 Components of Recharge Pit:

- ✓ Silt Trap
- ✓ Inlet
- ✓ Recharge Pit
- ✓ Outlet

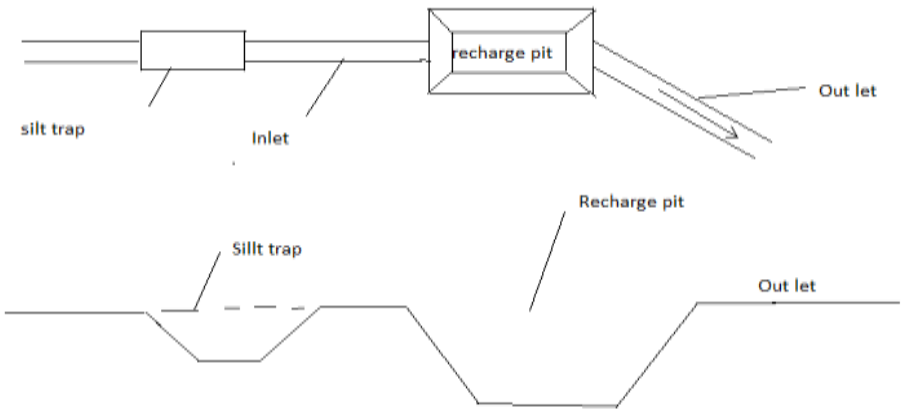

Figure 4: Components of Recharge Pit

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6.2 Design of Recharge Pit

Assume top width=12 m
The length of pit is assumed to be 1.5 times to width =18 m
Top length (along the slope) =18 m
Top width (across the slope) =12 m
Assume depth of pond=3 m
Assuming the following
Side slope of pond=1:1(three sides)
Side slopes of pond (water entry side)=4:1
Base length of pond at 3 m depth=20-(4*3)-(1*3) =5 m
Base width of pond at 3 m depth=12-2*1*3=6 m

6.3 Design of Silt Trap

Assume top width=2 m
The length of pit is assumed to be 1.5 times to width =3 m
Top length (along the slope) =3 m
Top width (across the slope) =2 m
Assume depth of pond=1 m
Assuming the following
Side slope of pond=1:1(three sides)
Side slopes of pond (water entry side)=4:1
Base length of pond at 3 m depth=0.5 m
Base width of pond at 3 m depth=0.6 m

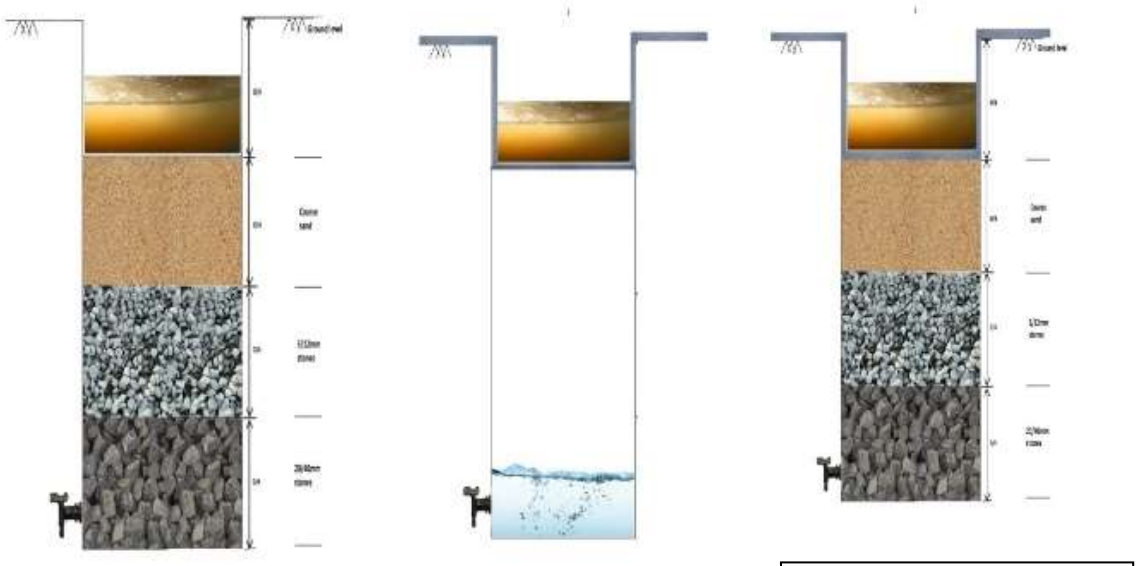

Figure 5 Tank With Various Filters

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6.4 Design Of Filter For Recharge Pit

Bottom 33 % of width is filled with 40 mm stones
Middle 33 % of width is filled with 20 mm stones
Top 33 % of width is filled with sand
Top layer is covered with Geo membrane

VII CONCLUSIONS

- The present study dealt with all aspects of improving the water scarcity problem in S.V. University campus by implementing ancient old technique of rain water Harvesting. The underground storage tank should have to build for the storage of water. Hence this tank has huge capacity of getting rain water and on proper storage, water can be supplied almost throughout year.

- It is concluded that RCC tank which is to be constructed should be an underground one, so that upper surface of the tank can be utilized economically for any land purpose such as playground or cycle stands or any such small structure.

- Hence it was finally concluded that implementation of MULTI PRONGED APPROACH FOR RAIN WATER CONSERVATION PROJECT to the buildings in S.V.University campus will be the best approach to fight the present scenario of water scarcity in all aspects, whether it is from financial point of view or from optimum utilization of land surface. Therefore, water is highly a precious natural resource which is always in high demand in the campus of S.V. University.

- Roof Top Rain Water Harvesting Structure Details of Civil Engineering Department
  Catchment area = 970 Sq.m
  Conveyance system through pipes of dia 110 cm
  Filter unit = 1 m X 1 m X 2 m
  Storage capacity = 4 m X 5 m X 11 m =220 m^3
  Total cost estimation = Rs 6,72, 823.6
- Roof Top Rain Water Harvesting Structure Details of Visveswara Hostel Block (Main Wing Only)
  Catchment area = 460 Sq.m
  Conveyance system through pipes of dia 110 cm
  Filter unit = 1 m X m 1 m X 1 m
  Storage capacity = 3 m X 4 m X 10 m=120 m^3
  Total cost estimation = Rs 4,49,728.2
  SURFACE RAINWATER HARVESTING DETAILS OF STUDY AREA
  Volume of recharge pit = 369 m^3
  Total cost estimation = Rs 1,75,978

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