Planning and Designing of Roof Top Water Harvesting System for SKIT, Jaipur

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Received 26.07.2019 received in revised form 10.09.2019, accepted 12.09.2019

Abstract: Although Water is one of the most important resources for survival of life on earth, yet there is a very little potable water available for us. And this potable water is getting reduced day by day making the situation more critical, thus it is the high time now to take appropriate actions. The main source of water on earth is the rain, and even the major percentage of this rain water becomes unpotable after joining the sea in the form of runoff. Thus harvesting the rain water is one of the solutions to this critical problem. The study area for this paper is Swami Keshvanand Institute of Technology Management and Gramothan, Jaipur, which is spending a lot on water supply through tankers. The main objectives of the study are to estimate the rooftop rain water harvesting potential of the institute, planning and designing the rooftop rain water harvesting system. The institute has a present potential to harvest more than twenty five lakh of rain water from roof top which is enough to supply around fifty eight percent of total drinking water of the institute. But constructing and maintaining such a huge tank is very expensive and future research is needed to investigate the cost-benefit balance along with the invention of a cheap storage tank as they may affect the potential contribution of rain water harvesting from rooftops, so initially a tank to harvest two lakh seventy three thousand litre is designed which can supply around six percent of drinking water to institute.

Keywords: Harvesting, potential, potable, roof top.

1. INTRODUCTION

With the increasing population, demand of quality drinking water is also increasing. The rate of recharging of surface and groundwater sources is much higher than their rate of consumption. So finding a solution to this problem is very important. Individual rainwater harvesting systems are one of the many tools to meet the growing water demand [1-2]. The size of the water tank required for fulfilling the drinking and cooking water demand of a family from rooftop area of different sizes, as expressed by mathematical equations is exclusively for area of study [3-4].

The Rainwater Harvesting will not only maintain the water level of the groundwater of the region but also save the water resources and power consumption for future use[4]. Results obtained from the present study suggested that Rooftop roof top rainwater harvesting (RWH) method is more applicable in campus which is located in drought prone zones of Maharashtra that would enable to solve the problem of water scarcity to certain extent [5]. The harvested rainwater can be used for non-potable purposes after employing filtration from the designed composite rainwater harvesting unit. When the quality aspects of main source of drinking water is looked into, rainwater harvesting is an economical option to overcome dependency on water supply [6].

Rainfall is the primary source of water on earth and harvesting rain water may reduce the pressure on water supply system as well as on drainage system.

This paper presents rainwater harvesting as “one of the most promising alternatives for supplying freshwater in the face of increasing water scarcity and escalating demand” (United Nations Environmental Programme, 1997).

Rain Water Harvesting, is basically a deep-rooted arrangement of gathering of water for future utilization [7]. Rain water harvesting can be done in the following ways:

- Collecting rain water from paved surfaces (such as rooftop) and storing it in tanks for future use.
- Recharging ground through through recharge pits, recharge trenches, etc. (Ground water recharge)

2. STUDY AREA

Swami Keshvanand Institute of Technology Management and Gramothan (SKIT) which is located in Jaipur, Rajasthan, India has been undertaken for the present study. The Latitude and Longitude of the study area is 26.83530 N and 75.82430 E respectively. Jaipur has a hot semi-arid climate under Koppen's climate classification. It receives over 55.86 cm of rainfall annually. Most of the rainfall occurs in the months between June and September. Jaipur experiences high summer

Temperatures remain relatively high during summer from April to early July having average daily temperatures of around 27.6°C (82°F). The winter months of November to February are mild and pleasant, with average temperatures ranging from 18° C (64°F) and with high humidity, but with occasional cold waves. [8]

3. OBJECTIVES OF STUDY

The current study attempts to

- Estimate the rooftop rain water harvesting potential of the institute,
- Planning and designing the rooftop rain water harvesting system.

4. METHODOLOGY

- Estimation of total drinking water requirement for SKIT
- Estimation of average annual rainfall
- First attempt: At first it was decided to collect the roof top rain water from M. Visvesvaraya block, Vishvakarma block, Vikram Sarabhai block, Nirwana boys and Noram girls hostel of SKIT.
- Second attempt: In second attempt it was decided to design the storage tank only for storing the rooftop water of Vikram Sarabhai block of SKIT. After visiting the site at which tank has to be designed it was found that water from Vikram Sarabhai block falls directly to the suggested location through already installed PVC pipes under the gravity flow.

5. CALCULATIONS

5.1 Estimation of total drinking water for hostel

Table 1 : Estimation of total drinking water for hostel

S.No.	Data	Amount
1.	Total number of students in hostel	737 Students
2.	Daily water required per capita for hostel	4 Litre
3.	Days consider in one year for water requirement	300 Days

Requirement of water for students of hostel = (total number of students in hostel) x (water required per capita for hostel) x (days consider in one year for water requirement)

= 737 x 4 x 300 = 8,84,400 litre

5.2 Estimation of total drinking water for staff

Table 2 : Estimation of total drinking water for staff

S.N.	Data	Amount
1.	Total number of staff in SKIT	500 Staff
2.	Daily water required per capita for staff	4 Litre
3.	Days consider in one year for water requirement	250 Days

Requirement of water for staff = (total number of staff in SKIT) x (water required per capita for staff) x (days consider in one year for water requirement) = 500 x 4 x 250 = 5,00,000 litre.

5.3 Estimation of total drinking water for other students

Table 3 : Estimation of total drinking water for other students

S.N.	Data	Amount
1.	Total number of other students	4000 Students
2.	Daily water required per capita for other students	4 Litre
3.	Days consider in one year for water requirement	200 Days

Requirement of water for other students = (total number of other students in SKIT) x (water required per capita for other students) x (days consider in one year for other students) = 4000 x 4 x 200 =32,00,000 litre.

5.4 Estimation of total drinking water for SKIT

Table 4 : Estimation of total drinking water for SKIT

S.N.	Data	Amount
1.	Total number of students in hostel	737 Students
2.	Daily water required per capita for hostel	4 Litre
3.	Days consider in one year for water requirement	300 Days

(water requirement for other students)

Total water requirement = (water requirement for hostel) + (water requirement for staff in SKIT) +
= 8,84,400 + 5,00,000 + 32,00,000
= 45,84,400 litre

5.5 Estimation of average annual rainfall for the study area

Average annual rainfall of the nearest rain gauge station, Sanganer : (26° 48''N, 76° 47''E), is taken for a period 36 years (1973 to 2008).

Table 5 : Average annual rainfall [9]

S.N.	Year	Rainfall (mm)	S.N.	Year	Rainfall (mm)
1.	1973	754.40	19.	1991	611.70
2.	1974	578.20	20.	1992	724.80
3.	1975	888.90	21.	1993	489.60
4.	1976	539.00	22.	1994	569.80
5.	1977	846.10	23.	1995	604.30
6.	1978	648.50	24.	1996	706.50
7.	1979	241.10	25.	1997	808.00
8.	1980	206.00	26.	1998	619.00
9.	1981	1080.90	27.	1999	316.1
10.	1982	210.40	28.	2000	455
11.	1983	862.40	29.	2001	582
12.	1984	329.40	30.	2002	237
13.	1985	403.00	31.	2003	563
14.	1986	467.50	32.	2004	805
15.	1987	283.60	33.	2005	392
16.	1988	516.80	34.	2006	407
17.	1989	571.70	35.	2007	553.3
18.	1990	666.50	36.	2008	572

Hence, average annual rainfall = 558.625 mm

5.6 First attempt

At first it was decided to collect the roof top rain water from M. Visvesvaraya block, Vishvakarma block, Vikram Sarabhai block, Nirwana boys and Noram girls hostel of SKIT.

Table 6 : Area calculation

S.No.	Location	Area (m^2)
1.	M. Visvesvaraya block	1836.81
2.	Vishvakarma block	1343.84
3.	Vikram Sarabhai block	706.97
4.	Nirwana Boys hostel	1358.80
5.	Noram Girls hostel	357.13

Hence, Total Area = 5603.55 m^2

- Calculation of volume of water to be collected

The value of runoff coefficient is 0.85 for Asphalt or concrete pavement. This runoff coefficient is selected because the roof top area under consideration is paved by concrete [6-9].

Volume of water that can be stored in tank = (Calculated Area) x (Average Annual Rainfall) x Runoff coefficient

= 5603.55 x 0.558625 x 0.85 (hard surface)
= 2660.74065 m^3
= 2660740.65 litre

Note: This is nearly 58.04% of total drinking water requirement of, SKIT

- Tank size according to calculated volume

Suitable Depth of Tank at SKIT = 4 m
Hence, Volume of Tank = 12 X 55 X 4 m^3
Suggested tank location on SKIT map

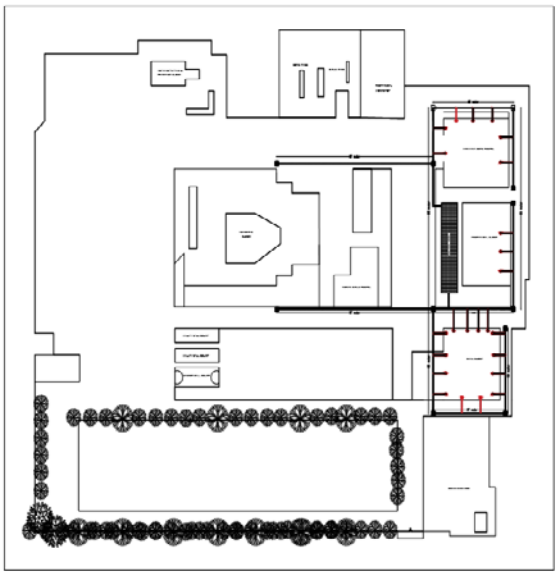

Figure 1: Tank Location on SKIT Map

- Problems with first attempt
  - Estimated the cost and found that constructing such a huge tank will be very expensive.
  - Cleaning and maintenance of such a huge tank is also very costly.
  - It also found that the tank size will be close to a small dam, so this idea is discarded.

5.7 Second attempt

In second attempt it was decided to design the storage tank only for storing the rooftop water of Vikram Sarabhai block. After visiting the site at which tank is to be designed it was found that water from the roof of Vikram Sarabhai block falls directly to the suggested tank location through already installed PVC pipes under the gravity flow.

Total water collection from Vikram Sarabhai block

Total Water Collection = (Area of Vikram Sarabhai Block) x (Average Annual Rainfall) x Runoff coefficient
= 577 x 0.558625 x 0.85
= 273.97763 m^3 or 273977.63 litre

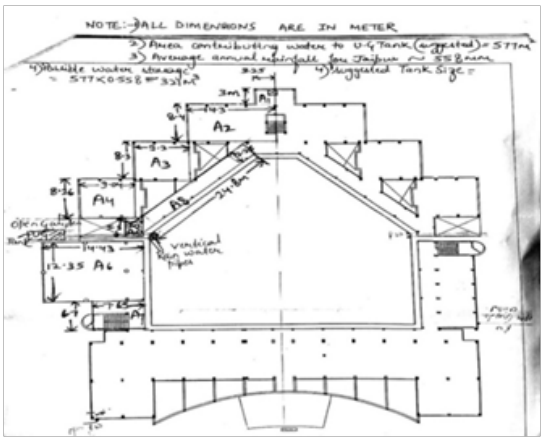

Figure 2: Tank Location on Vikram Sarabhai Block Map

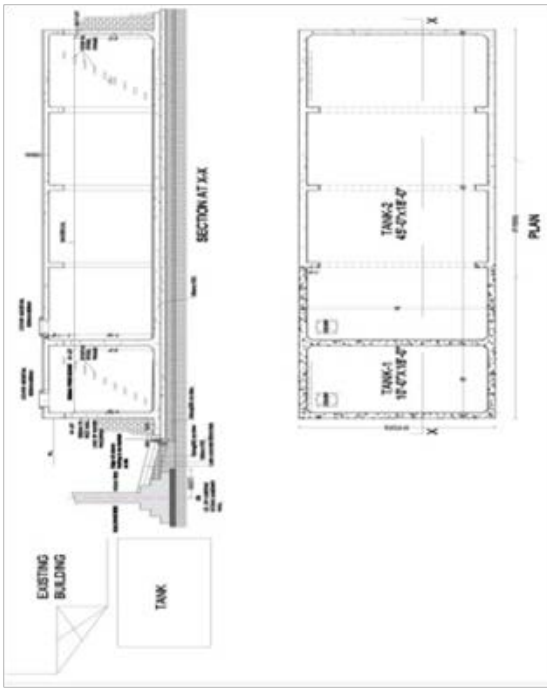

Figure 3: Tank Location

6. RESULTS

6.1 Total estimation cost of project

- **Architectural Plan of Under Ground Tank**

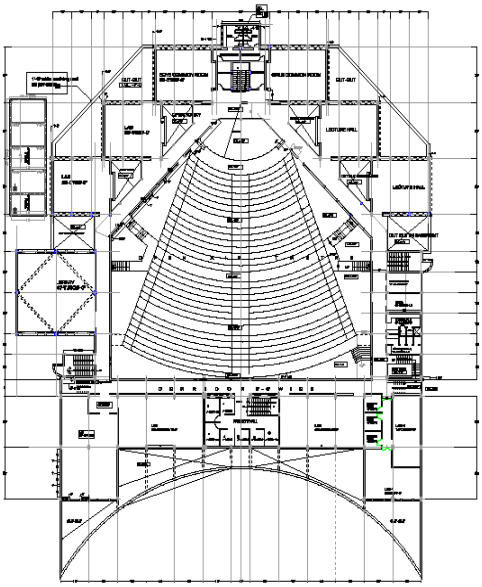

Figure 4: Architectural Plan of Under Ground Tank

- **Structural Drawing of Under Ground Tank**

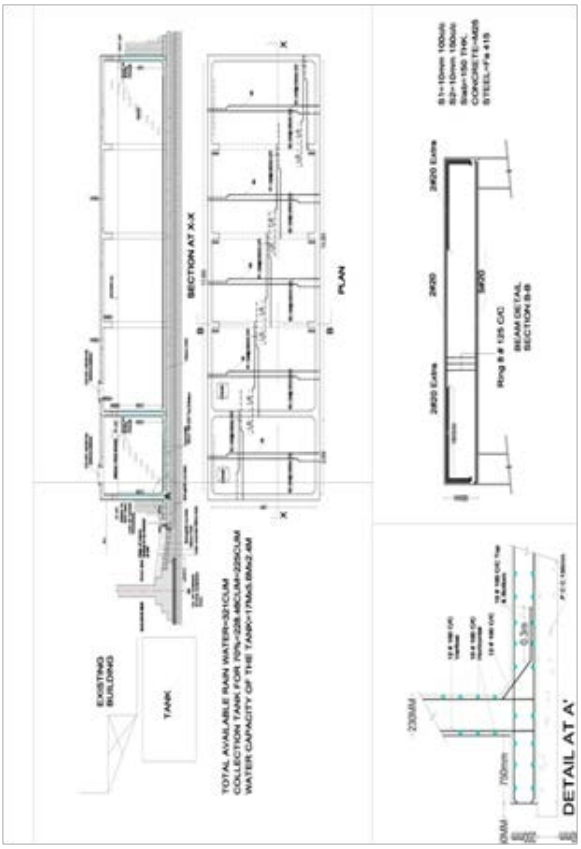

Figure 5: Structural Drawing of Under Ground Tank

6.2 Finalised design of underground tank

Table 7 : Estimation cost of designed water harvesting tank

	Estimate by Site				Estimate by office				
Description	**Quantity**	**Unit**	**Rate**	**Amount**	**Quantity**	**Unit**	**Rate**	**Amount**	**Difference**
Excavation	17820.68	CFT	3	53462.04	20416.36	CFT	3	61249.09	7787.0471
Soling 9"	1162.21	CFT	26	30217.46	1209.656	CFT	26	31451.06	1233.6025
P.C.C. 6"(M10)	774.81	CFT	100	77481	806.4375	CFT	100	80643.75	3162.75
R.C.C.(M25)	2914.78	CFT	120	349773.6	2992.66	CFT	120	359119.2	9345.6
Plaster Inner	4257.75	SFT	20	85155	4170.07	SFT	20	83401.4	-1753.6
Plaster Outer	2145.24	SFT	25	53631	2201.22	SFT	25	55030.5	1399.5
Water Proofing	5413	SFT	25	135325	4856.22	SFT	25	121405.5	-13919.5
Shuttering	5002	SFT	40	200080	5098.07	SFT	40	203922.8	3842.8
Refilling & Compaction	12	Loader	400	4800	4983	CFT	3	14949	10149
A.T.T.	1295.37	SFT	5	6476.85	1355.625	SFT	5	6778.125	301.275
Steel	12500	KG	48	600000	12500	KG	48	600000	0
Tile	2901	SFT	50	145050	2886.44	SFT	50	144322	-728
Kota Stone	1059.12	SFT	75	79434	1116.37	SFT	75	83727.75	4293.75
MS Cover	3	Nos	500	1500	2	Nos	500	1000	-500
Steel Ladder	2	Nos	10000	20000	2	Nos	10000	20000	0
				1842386				**1867000**	**24614.225**

- The total estimated cost of the project is 1867000 rupees.
- Total water collection from Vikram Sarabhai block is 273.97763 m^3 or 273977.63 litres which can supplement the water requirement of potable water for SKIT campus by 5.97 %.

5. CONCLUSION

A rain water harvesting tank is planned to collect 273.97763 m^3 or 273977.63 litre of rain water from Vikram Sarabhai block of SKIT which can supplement the water requirement of potable water for SKIT campus by 5.97 %. The total estimated cost of the project is 1867000 rupees.

It may be concluded that implementation of rain water harvesting system at SKIT campus will a good approach to deal with present scenario of water scarcity. Huge quantity of water as can be collected in a year in college campus, which would require a huge rain water harvesting system. However, planning and constructing such a huge system needs complete cost benefit ratio study along with the invention of a cheap storage tank, this opens the scope for future researchers. Future researches may also focus on linking storm water management with rain water harvesting.

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