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Jay Gohel
Assistant Professor, Department of Civil Engineering, School of Engineering, RK University, Rajkot, Gujarat, India

Hina Bhatu
Assistant Professor, Department of Agricultural Engineering, School of Engineering, RK University, Rajkot, Gujarat, India

Parth Kapupara
Assistant Professor, Department of Agricultural Engineering, School of Engineering, RK University, Rajkot, Gujarat, India

Barath R
Students of Agricultural Engineering, School of Engineering, RK University, Rajkot, Gujarat, India

Corresponding Author:
Jay Gohel
Assistant Professor, Department of Civil Engineering, School of Engineering, RK University, Rajkot, Gujarat, India

Designing rooftop rainwater harvesting system at RK University

Jay Gohel, Hina Bhatu, Parth Kapupara and Barath R

Abstract
With Advancement in industries and a huge increment in population, The Gap between water demand and Water supply is continuously broadening. According to a United States geological survey, the availability of total water on earth is estimated as 1.386 billion km^3 with 97.5% saltwater and 2.5% fresh water. Only 0.3% of total freshwater is available in liquid form. Population of human beings is around 7.6 billion and 2 billion more people will be added in 2050. It has led to increase emphasis on optimal management of water resources. Rainwater harvesting is the engineering solution to water problem in urban area. In the proposed work, School of Engineering (SOE), RK University Building is taken as a study area to plan, analyze and design rainwater harvesting system to conserve the roof top water for the use in dry seasons. Detailed survey had been carried out in SOE building using QGIS and Effective design of tank had been given to store rainwater during whole year. By adopting this water conservation method, one can use rainwater for drinking and other purpose in dry season also.

Keywords: Water harvesting, rainwater, rooftop

Introduction
Water is one of the most important elements in the daily routine life. If there is no water, there would be no life on earth. Shortage of water is biggest challenge in 21st century (Ali and Jain). Groundwater table decline due to over drafting of water. Water conservation plays an important role to meet water demand. Rainfall is most directly accessible water supply source (Ming *et al*). Rain water harvesting is solution of water shortage. RWH comprises of the collection, storage and subsequent use of caught rainwater as potable and non-potable application (Fewkes, 2006) [3]. Rain water can be used for domestic use, drinking, irrigation, ground water recharge etc (Chandramouli and Prasad). The RWHS helps in utilizing the primary source of water and prevents the runoff from going into sewer or storm drains and recharges water in to aquifer (Kumar). Recharge should be enhanced with artificial recharge for present day.

There are many methods of RWH but collecting water from rooftop is in good quality than other method. This study is limited to design rooftop rain water harvesting system for school of engineering building, RK University, Rajkot, Gujarat, India. The total area of RKU campus is around 13hectares. It is situated in Saurashtra Agro-climatic zone. The major part of the Saurashtra region falls under semi-arid and arid types with varying climatic as well as soil conditions. The average annual rainfall of Rajkot is 620 mm.

Materials and Methods
The roof of building is used as a catchment area for collecting the rainwater. Roof top area of building was calculated using Quantum GIS (QGIS) and Google Earth. The rainfall data is collected from Rajkot Municipal Corporation (1917-2018) and yearly data downloaded from Indian Water Portal (1901-2010) to analyses the average monthly rainfall amount. The total sum of water (in litre) that is received from precipitation over the proposed area is determined as following equation.

$Q = C * I * A$

Where,
Q = Rainwater Harvesting Potential, litre
A = Area of roof top Catchment, (m2)
I= Amount of rainfall (mm)
C= Runoff coefficient

Water Demand and Supply Analysis Based on Roof Water Harvesting. Here the attempt is made to evaluate how much water demand can be fulfilled from estimated roof water

harvesting potential. Water Requirement for drinking purpose as 5 lit/capita/day as per Indian Standard Code of Basic Requirements for Water Supply, Drainage and Sanitation (Fourth Revision) December 2010.

Results and Discussions

Rainwater harvesting systems is the collection of rainwater from rooftop area during the rainy days. In Gujarat, mostly the rainfall received during June to September. Average Monthly Rainfall of June, July, August and September month is 122mm, 261mm, 147mm and 92 mm respectively. The rooftop area of school of engineering building is calculated with the help of QGIS and it is found as 7093.5109 m2.

Rainwater Harvesting Potential

A rooftop area of building is cement concrete so; runoff coefficient was taken as 0.70 for this study. Monthly Rainwater Harvesting potential for SOE building is show in table 1.

Table 1: Monthly Rainwater Harvesting potential

Month	Rain water Harvesting potential (litre)
June	605785.8
July	1295984.4
August	729922.3
September	456822.1
Total	3088514.6

Demand and Supply

Analysis of water demand and supply from the rooftop water harvesting was done design for average monthly rainfall. For School of Engineering, total no. of capita including students, teaching and nonteaching faculty and workers was taken as 1781. The water year is designated by the calendar year in which it ends, so the 2018 water year started on June 1, 2017 and ended on May 31, 2018. The table 2 shows Demand-Supply Analysis for SOE building based on Monthly Average Rainfall.

Flow Pipe

The conveyance pipe is made up of PVC material is provided in building to drain off the roof top water with suitable size. It carries the rainwater from roof top to the storage tank. This pipe is joined with the first flush pipe and filter to remove the impurities. And it was connected to the storage tank to store the rainwater. From the calculations, It is found that the PVC pipe of 110 mm is effective to convey water from roof to the storage tank.

Storage Tank

Size of the tank should be considered varies factors such as number of persons in the buildings, duration of rainfall, water uses, type of roof for taking runoff coefficient and the status of existing water sources from the buildings.

As per Indian standard for drinking use of water is 5 liters per day per capita the capacity of storage tank which refers the total persons required to drink and checked with the amount of water available from rooftop during rainy season. The calculation and design of tank is based on IS 3370 code of practice for concrete structures for the storage of liquids.

Table 2: Demand and supply for SOE building at Monthly Average Rainfall

SOE (Capita=1781, Liters/Day/Capita=5, Liters/Day=8905, Per Month=267150 L)									
Month	**No. of days**	**Monthly Supply from Rooftop (L)**	**Monthly Demand (L)**	**Cumulative Demand (L)**	**Cumulative Supply (L)**	**Water Available at The End of Month (L)**	**Cumulative water availability at the end of month (L)**	**Storage at the end of month (L)**	**Water available for ground water recharge (L)**
June	30	605786	267150	267150	605786	338636	338636	338636	0
July	31	1295984	276055	543205	1901770	1358565	1358565	1358565	0
August	31	729922	276055	819260	2631693	1812433	1812433	1812433	0
September	30	456822	267150	1086410	3088515	2002105	2002105	**2002105**	0
October	31	0	276055	1362465	3088515	1726050	1726050	1726050	0
November	30	0	267150	1629615	3088515	1458900	1458900	1458900	0
December	31	0	276055	1905670	3088515	1182845	1182845	1182845	0
January	31	0	276055	2181725	3088515	906790	906790	906790	0
February	28	0	249340	2431065	3088515	657450	657450	657450	0
March	31	0	276055	2707120	3088515	381395	381395	381395	0
April	30	0	267150	2974270	3088515	114245	114245	114245	0
May	31	0	276055	3250325	3088515	-161810	-161810	-161810	0

Table 3: Storage tank design

Tank size	20.00 x 10.00 x 10.00 m
Tank capacity	2000000ltr
Concrete grade	M25
Steel grade	Fe415
Thickness of wall	270 mm
Thickness of Base slab	150 mm
Reinforcement in long wall and short wall	20 mm ϕ bars @ 100 mm c/c.
Reinforcement in Base slab	8 mm ϕ bar, @ 160 mm c/c

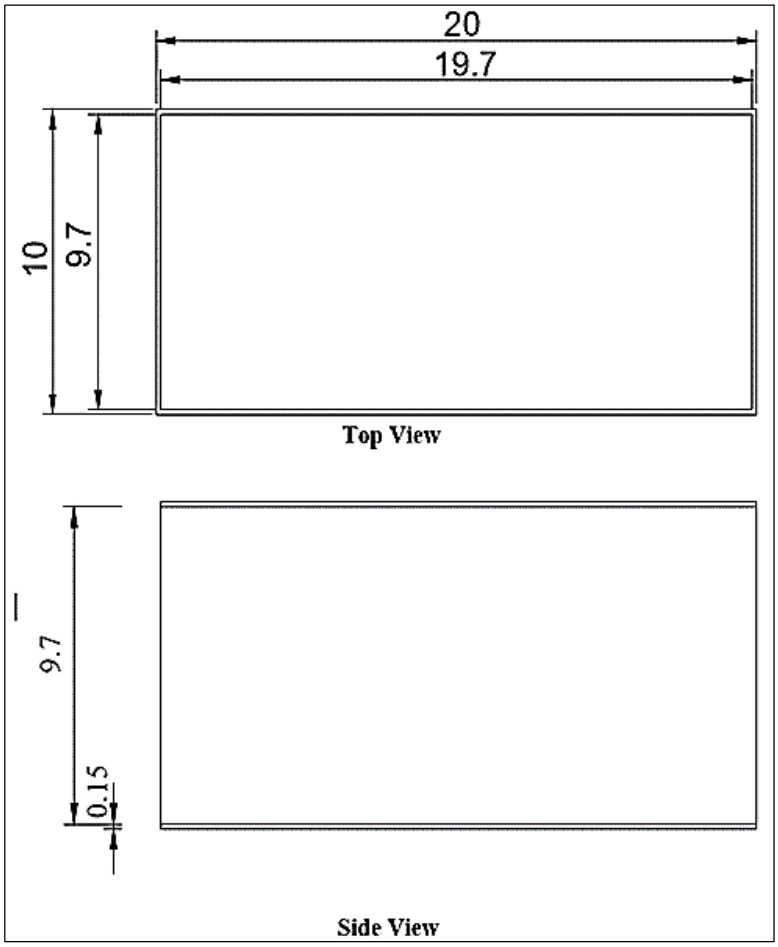

Fig 1: Storage tank (All dimensions are in meter)

Conclusions

This study was conducted to designing Rain water Harvesting system in School of Engineering, RK University, Rajkot, Gujarat. The average rainfall in study area is 620 mm between June to September. The Water demand for drinking purpose of SOE building is 3230525 litres/year. The water available in storage tank at the end of September month is 2002105 Litres. So it is possible fulfill drinking water demand with rooftop harvesting system for the whole year. The storage tank is design of dimensions 20 x 10 x 10 m to store water for future water demand.

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