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Rain Water Harvesting System for College of Engineering, Teerthanker Mahaveer University, Moradabad

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ABSTRACT: Over the years, the rising population, growing industries and expanding agricultural practices have raise the demand of water supply. Monsoon is still the main hope and source of our agriculture. Hence water conservation had become need of the time. Rainwater harvesting is a way to capture the rainwater at the time of downpour, store that water above the ground or charge the underground water and use it later. As the groundwater resources are depleting, the rainwater harvesting is the only way to solve the water problem. Rainwater harvesting will not only be helpful to meet the demand of water supply but also be helpful to improve the quantity and quality of water. Here, in this paper our focus is to design a tank to store rainwater from rooftop of the building to cater the need of water requirement for College of Engineering, Teerthanker Mahaveer University, Moradabad.

KEYWORDS: water, monsoon, rainwater harvesting, groundwater, demand, population

I. INTRODUCTION

One of the biggest challenges of the 21st century is to overcome the growing water shortage. Rainwater harvesting (RWH) has thus regained its importance as a valuable alternative or supplementary water resource, along with more conventional water supply technologies. Water shortages can be relieved if rainwater harvesting is practiced more widely. People collect and store rainwater in buckets, tanks, ponds and wells. This is commonly referred to as rainwater harvesting and has been practiced for centuries. Rainwater can be used for multiple purposes ranging from irrigating crops to washing, cooking and drinking. Rainwater harvesting is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits. Rainwater harvesting is one of the alternative technology for delivering drinking water. In fact, through the ages, this has been a traditional way of enhancing domestic water supply. Rainwater harvesting systems are viable options both for storing water for domestic use and for recharging groundwater aquifers.

Nature has endowed India with huge water resources. We have perennial rivers like Ganga, Brahmaputra, Yamuna, Beas and other along with their tributaries and distributaries besides in North and Eastern India, we have spring and rain fed rivers in central and peninsular India. The major rivers among these are Godavari, Krishna, Narmada, Tapti and Kaveri. These huge potential water resources notwithstanding, we are facing a water crisis across the country. Over the years, rising population, growing industrialization and expanding agriculture have pushed up the demand for water. Monsoon is still the main hope of our agriculture.

Water conservation has become the need of the day. Rainwater harvesting is a way to capture the rainwater at the time of downpour, store that water above the ground or charge the underground water and use it later. This happens in open areas as well as in congested cities through the installation of required equipment. The collection and storage of rainwater from run-off areas such as roofs and other surfaces has been practiced since ancient times in India. It is particularly useful where water supply is inadequate.

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Cherrapunji was famous for receiving volume of rainfall in the world, and it still is, but experience acute water shortage as a result of extensive deforestation and due to non conservation of water from different resources. Free flow of water along the slopes of hills has caused heavy erosion of top soil. There are now many stretches devoid of trees and greenery. People have to walk long distances to collect water. If rainwater harvesting had been used, things would have been different.

II. STUDY AREA

College of Engineering, Teerthanker Mahaveer University, is located in the Moradabad, a small town in the western part of the state of the Uttar Pradesh, in northern India. The geographical area of the Moradabad is 70 sq. Km. The city is situated in western U P between 28^0 21' to $28^0$16´ Latitude North and 78^0 4´ to 79^0 Longitude East. It has an average elevation of 186 meters. The total population of the city is 27, 61,620 out of which males are 14, 94,220 and females are 12, 67,400. It lies within the great Gangetic plain, and is demarcated into three subdivisions with an elevation slightly greater than the plain below, and is traversed by numerous steams descending from the Himalayas [1] and [2]. There is great demand of water in college of engineering mainly for laboratories used in Civil Engineering, Mechanical Engineering, Chemical Engineering, Chemistry, Physics etc., for use in cleaning the building floors, labs as well as classes, for use in horticulture purpose also, for sprinkling the water in dry land of C.O.E especially in summer season for preventing the soil dust particle in air etc.

The reasons for collecting and using rainwater for domestic use are plentiful and varied. The increased need for water results in lower groundwater tables and depleted reservoirs. Many piped water supply systems fail. The use of rainwater is a useful alternative to provide continuous flow of water for the students and Laboratories.

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III. OBJECTIVES

This project is carried out to cater the need of the College of Engineering, Teerthanker Mahaveer University. This project will not only be helpful to fulfil the need of water supply to our college but also to provide water to faculty residing in the Campus.

The increased need for water may result in lowering the groundwater table and depleted reservoirs. Hence the use of rainwater will be a useful alternative to provide continuous water supply for our students and laboratories.

The water stored from the rainwater will also be of good quality i. e. free from impurities which might be there in groundwater of Moradabad as it is having large number of brass industries & e-waste.

Keeping in mind the (i) increasing water demands, (ii) quality of water supply, (iii) variations in water availability and (iii) advantages of collection and storage of rainwater near the place of use etc, it was planned to design the rain water harvesting system for the College of Engineering.

IV. PROPOSED METHODOLOGY

A) *Environment Considerations:* Environment feasibility depends on the amount and patterns of rainfall in the area, the duration of dry periods and the availability of other water sources. The rainfall pattern over the year plays a key role in

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determining whether RWH can compete with other water supply systems. Tropical climates with short (one to four months) dry season and multiple high intensity rainstorms provide the most suitable conditions for water harvesting. In addition, rainwater harvesting may also be valuable in wet tropical climates (e.g. Bangladesh), where the water quality of surface water may vary greatly throughout the year [1].

As a general rule, rainfall should be over 50mm/month for at least half a year of 300 mm/year (unless other sources are extremely scarce) to make RWH environmentally feasible [1].

B) Technical Aspects: The construction of a RWH system is determined by several technical factors as [3]:

a) Use of impermeable roofing material such as iron sheets, tiles, asbestos- cement.
b) Availability of an area of at least 1 m^2 near each house for constructing a storage tank.
c) Water consumption rate (number users and types of uses) and storage capacity required.
d) Availability of other water sources, either groundwater or surface water that can be used when stored rainwater runs out.
e) Availability of labour with technical building skill in or nearby the community.
f) Availability of required, suitable local construction material and labour.

*C) Water consumption and water management :*Water consumption for the college of Engineering, Teerthanker Mahaveer University is given in Table I.

TABLE I
WATER CONSUMPTION IN COLLEGE OF ENGINEERING, TMU

Use	Consumption in litre/ day
Drinking	3.00
Washing of laboratory utensils and machines	0.50
Flushing of water closets	5.00
For file purpose	1.50
Total	10.00

Compiled from various sources [1] Total amount of rain water harvested = Rainfall (mm) x Area of catchment x Runoff coefficient harvestment system

D) Design a rainwater harvesting system: Three main steps to be followed in designing a RWH system as [4] and [5]

a) Determine the total amount of required and available rainwater
b) Design of catchment area
c) Design of delivery system
d) Design of storage reservoir

a) Total amount of required and available rainwater: To estimate water demand the following equation can be used

Demand= Water Use x Household Members x 365 days

The water demand of COE if the average water use per person is 10 litres per day and the Institute has 2200 family members , then Demand = 10 litres x 2200 member x 365 days= 8000000 litre per year.

Rainwater data of Moradabad for last five years is shown in Table II

TABLE II
RAINFALL DATA OF MORADABAD []

Year	Jan		Feb		March		April		May		June	
	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP
2008					0.0	-100	0.0	-100	13.4	-16	365.2	358
2009	0.0	-100	10.8	-47	4.0	-71	39.6	529	5.7	-64	13.3	-83
2010	0.2	-99	13.0	-35	1.3	-99	0.0	-100	45.7	187	18.7	-77

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2011	2.1	-91	22.4	3	6.2	-52	5.9	26	43.4	175	193.6	113
2012	19.3	-14	1.4	-94	3.0	-77	6.4	36	1.1	-93	4.2	-95

Year	**July**		**August**		**September**		**October**		**November**		**December**	
	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP	R/F:	DEP
2008	173.1	-44	315.6	4	58.5	-63	2.0	-96	7.4	118	0.0	-100
2009	146.5	-53	195.9	-35	171.2	8	103.5	117	4.6	35	0.0	-100
2010	555.1	81	450.9	49	436.1	176	0.5	-99	0.2	-94	8.7	-2
2011	242.7	-17	518.6	65	134.3	-14	0.6	-99	0.0	-100	0.0	-100
2012	190.4	-35	288.6	-8	137.2	-12	0.0	-100	0.2	-94	3.7	-58

Source : CGWB,Moradabad [1] & [6]

So the average rainfall for Moradabad taken from above table = 80 mm
So we consider the average rain fall for Moradabad 100 mm considering for Future
Calculating potential rainwater supply by estimating run-off (S) = R x A x Cr
Where S= Mean annual rainwater supply (m^3)
R= Mean annual rainfall (m)
A= Catchment area (m^2)
Cr= Run-off coefficient
S= 0.1m/year x 4810.425 m^2 x 0.8 = 380.83 m^3/year = 1186/day
Runoff Coefficient for traditional roofing materials is 0.6-0.9 , considering as an average value 0.8

b) *Design of catchment area:* From the Drawing of Terrace Floor, we have calculated the total roof top area of College of Engineering (COE) = 51725 sq ft = 4801.425 m^2
c) *Design of storage reservoir* [4] and [5]
Capacity
Free Board =200 mm
Depth of top ring beam = 600 mm
Inner diameter tank at the ring beam = 12000 mm
Thickness of vertical wall at top= 100 mm
Thickness of vertical wall at the bottom = 300 mm
Thickness of 1:4:8 P.C.C base course =100 mm
Let the height of vertical wall be h meter.
Therefore, $\frac{1}{2}\left[(\pi/4)18^2+(\pi/4)\times(18-0.04)^2\right]=500\ \text{mm}$

h= 2.00
Roof Slab
It is economical to provide a dome shaped roof.
Thickness of dome = 100 mm
Rise of dome = 3500 mm
Radius of dome, R = (h/2) + (D^2/8h)
Radius of dome, R = (3.5/2) + (18^2/8x3.5)
Radius of dome, R = 13.32 m
Dead load of dome = 0.10 x 25 = 2.5 KN/m^2
Live load of dome = 1.5 KN/m^2
Total = 4 KN/m^2
Inclination of dome near the wall,
tan θ = (D/2)/(R-h)
tan θ = (18/2)/(13.32-3.5)
tanθ = 0.916

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θ = 42.50°
Cos θ= 0.737
The entire dome is in hoop compression since θ= 42.50°<51.48°
Meridional thrust = wR / (1+cosθ)
Meridional thrust = (4 x 13.32)/ (1+0.737)
Meridional thrust = 30.67 KN/m

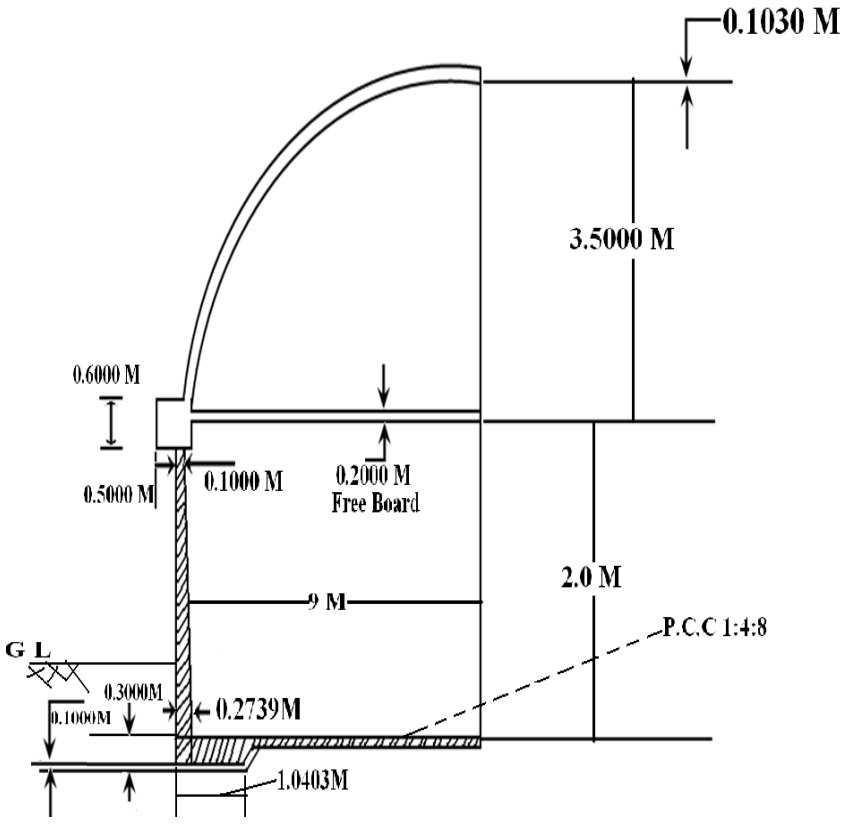
Compressive stress σ_c = (30.67 x 1000)/(1000 x 100)

Compressive stress σ_c = 0.3067 Mpa or N/mm^2

Compressive stress σ_c = <5 or N/mm^2 Hence OK

Provide 0.35% minimum steel in both directions
= [(0.35/100) x {(100/2) x 1000}]
= 175 mm^2/m
Provide 8 mm bar @ 200 mm c/c both ways.
A_t=50 x (1000/200)
A_t=250 mm^2
A_t=>240 mm^2 Hence OK

Provide a ventilator of 900mm diameter at the middle of the dome. Provide a ring beam of 150 x 150 along with 4 - 8 mm hoop bars. Also, provide 8 mm ties @ 300 mm c/c. Similarly, provide a manhole of 600 x 600 mm ^{2} near the walls.



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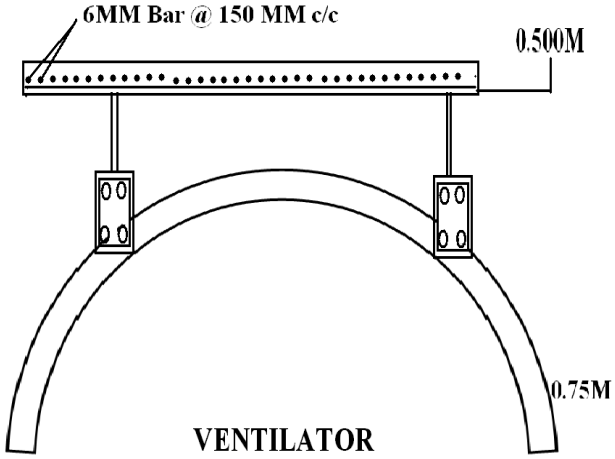

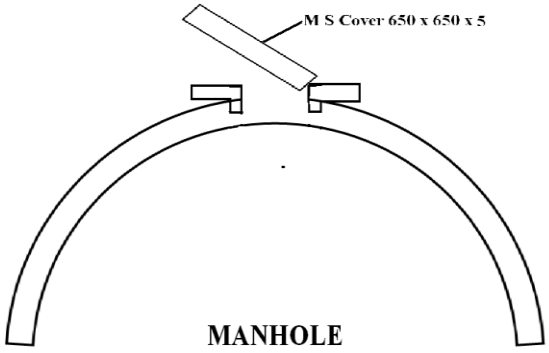

Clear cover to the bottom reinforcement in the base slab should be 40 mm elsewhere it should be 25 mm

Fig.1 Detailed Drawing Plan & Elevation of Rain Water harvesting Tank **[7]**

TABLE III
ESTIMATION OF CIRCULAR R.C.C WATER TANK [8]

S No	*Description of items*	*No*	*L (m)*	*B (m)*	*H (m)*	*Quantity (m^3)*	*Remark*
1.	Excavation of tank up-to one meter depth	1	260.15		01	260.15	$\pi/4 \times (18+0.2)^2$
2.	P.C.C slab (1:4:8)	1	260.15		0.10	26	$\pi/4 \times (18+0.2)^2$
3.	R.C.C slab (1:1.5:3)	1	32.65			32.65	$(\pi/4 \times 18.2^2 - \pi/4 \times 17^2) \times 0.3 + \pi/4 \times 17^2 \times 0.1$
4.	R.C.C vertical wall (1:1.5:3)	1	19.22			19.23	$0.10+0.30/2 \times (2-0.3) \times 2 \pi \times 9$
5.	Ring beam R.C.C (1:1.5:3) volume (600 x 600)	1	10.86			10.86	$\pi/4 \times (10.2)^2 - \pi/4 \times (9)^2 \times 0.6$
6.	R.C.C dome volume (1:1.5:3)	1	8.17			8.17	$\pi/4 \times (10.2)^2 \times 0.10$

TABLE IV
TOTAL QUANTITY OF MATERIAL USED IN WATER TANK

Description of item	*Total quantity in m^3*	*Rate [] Cost /m^3*	*Total coast (Rs)*

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Excavated Earth	260.15	75.00	19511.25
R.C.C (1:1.5:3)	70.91	6800.00	422188.00
P.C.C (1:4:8)	26	4000.00	104000.00
Total cost			545699.00

TABLE V
BAR BENDING SCHEDULE (BBS) FOR CIRCULAR SEMI UNDERGROUND WATER TANK

S No.	Description/item	Dia (mm)	Length (m)	No. of bars	Total length (m)	Weight (kg/m)	Total weight (kg)
1. a)	Dome reinforcement per meter 250 mm^2, hence dome radius for minimum area is 20.4 x 250 = 5100 mm in circular reinforcement 200 mm c/c	8	30.60	101	3090.60	0.315	973.54
b)	Dome reinforcement per meter 250 mm^2, hence dome radius for minimum area is 20.4 x 250 = 5100 mm in transverse reinforcement, 200 mm c/c	8	10.2	283	2883.00 (Average)	0.315	908.14
2. a)	Ring beam circular bars, 300 mm c/c	16	Interior =56.55 Middle =58.43 Exterior =6.32 Total	323	169.65 116.86 180.47 467.47	1.58	738.60
b)	Ring beam strips 300 mm c/c	8	(0.6-0.15) x 2=2.28	196	447.00	0.315	140.8
3. a)	Horizontal reinforcement Inner face for circular bar, 150 mm c/c	12	55.92 (average)	7	372.80	0.89	331.8
b)	Vertical reinforcement inner Vertical bars, 150 mm c/c	12	1	227	227	0.89	202.03
c)	Horizontal reinforcement outer face, 150 m	12	56	12	672	0.89	598.08
d)	Vertical reinforcement outer Vertical bars up to full length, 150 mm c/c	12	17	227	385.9	0.89	343.45
4.a)	Circular reinforcement for base slab	8	25.23	64	1608.32	0.315	506.62
b)	Transverse reinforcement for base slab	8	9	283	2547	0.315	802.3

TABLE VI
TOTAL WEIGHT OF REINFORCEMENT USED IN WATER TANK

Dia of Bar	Total weight (Kg)	Weight (ton)	Cost/ton []	Total cost (Rs)
8 mm	3331.4	3.3314		
12 mm	1475.36	1.4753		
16 mm	738.60	0.738		
Total		4.8805	58000	283069.00

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TABLE VII
ESTIMATION OF PVC PIPES

S. No	Description	L (m)	Total (m)	Cost/rm (Rs) []	Total cost (Rs)	Remark
1.	PVC Pipes					
a)	Horizontal length (25 mm dia)	155.74	155.74	142	22115	13.71 (height) x 14 (no. of pipe
b)	Vertical length (25 mm dia)	192.20	192.20	142	27292	line) = 192.20
	Total cost				49407	

TABLE VIII
ESTIMATION OF FORMWORK

S. no	Description	No	L	B	H	Area (m^2)	Cost (Rs)
1.	Outside wall upto 0.70 m		114.33		0.70	80.04	
	Inside wall up to 0.70 m		111.8		0.70	78.28	
2.	Ring Beam						
	a) side		116		0.30	35	225.48 /m^2
	b) Top & Bottom	2	114.9		0.30	86.44	
3.	Dome		$\pi/4 \times 10.2^2$			81.74	
	Total					361.5	81511.02

The total cost of the project is Rs. Nine lac fifty nine thousand six hundred eighty six as shown in table IX.

TABLE IX
TOTAL ESTIMATION COST [8]

S. No	Description	Amount (Rs)
1.	Estimation of cement, fine & coarse aggregate	545699.00
2.	Estimation of reinforcement	283069.00
3.	Estimation of PVC pipes	49407.00
4.	Estimation of form work	81511.02
	Grand Total	959686.02

V. CONCLUSION

On the basis of water requirement of the college, groundwater conditions of the area and rainwater data, it is proposed to develop rainwater harvesting system for catering the need for water for the College of Engineering. It will not only maintain the water level of the groundwater of the region but also save our water resources and power consumption for future use.

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REFERENCES

[1] (2012) Website, [Online] Available: www.google.com
[2] (2013) Website, [Online] Available: www.wikipedia.com
[3] S. K. Garg, *Water Supply Engineering*, Khanna Publications, Delhi,1998

ISSN: 2319-8753

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 3, Issue 8, August 2014

[4] Raju N. Krishna, *Reinforced Concrete Design*, New Age Publishers, 2003
[5] A. K. Jain, *R.C.C Design and Detailing*, Nem Chand & Brothers, Roorkee, 2002
[6] (2009) CGWB, *District Brochure of Moradabad District*, Central Ground water Board
[7] M. Chakraborty, *Civil Engineering Drawing*, Bhakti Vedanta Book Trust, 1999
[8] (2013) Schedule of Rates, PWD, Northern Circle

BIOGRAPHY

Dr S Rehan Ali, working as Associate Professor & Head, Department of Civil Engineering, Teerthanker Mahaveer University since last five years, completed graduation to PhD from AMU, Aligarh, India. He has been awarded JRF & SRF during PhD and having about 18 years of rich experience of research, teaching, and industry. During this period, worked in several organizations, viz., National Institute of Science, Technology and Development Studies (CSIR), New Delhi as Project Scientist, Co-ordinates Solution Pvt Ltd, Saket, Delhi as General Manager (Technical), Aligarh Muslim University as Research Associate, Guest Faculty & Assistant Professor, School of Planning & Architecture, New Delhi as Guest Lecture & presently in TMU as Associate Professor & Head. He has worked in 5 projects as project Scientist, 2 as GM (Technical) and one as Research Associate. He has attended 8 training programmes and 9 international, 8 national conferences/Seminars etc in India & abroad. He has 24 publications to his credit. Presently life member of 5 reputed scientific/ institutional societies (ISTE, IIT Delhi; ISCA, Kolkata; INCA, Survey of India, Hyderabad; ISRS, IIRS, DehraDun; SAAEG, Bhopal) and reviewer of two reputed international Journals. Three scholars are working under his supervision. His field of interest includes Remote Sensing, GIS, Engineering Geology and Environmental Engineering.