RAIN WATER HARVESTING – A CASE STUDY IN DR.AIT CAMPUS

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ABSTRACT- *In this project we have analyzed different systems of rain water harvesting (RWH) techniques adoptable to silver jubilee building.*

Here, we collect rain water from the roof top of the block, collect it, channel it to the storage tank designed. The tank is basically of underground rectangular shape.

We calculate water demand of the institute in one year and the designed tank is for peak discharge from rainfall which is most certainly in the monsoon season and precisely around the month of September and October.

Design of rectangular tank with reinforcement details and as well cost and estimation is calculated.

The collected water can be used for various purposes of the institute like cleaning, flushing etc.

INTRODUCTION

Water is one of the supreme valuable resources found on Earth. It is important for all aspects of life and ecological systems and also plays an important role in food production, human health, economic development. Due to industrialization, urbanization and over growing population, water is being consumed at a larger rate than ever and is constantly contaminated with sewage, chemical waste, oils, heavy metals, agricultural waste and other synthetic products. Both surface water and ground water are overexploited and resulting in deterioration of water quality and scarcity. The aim of this study is to conserve the rainwater and thus taking a closer step towards nature conservation. In this study, the rain water harvesting systems are analyzed as an alternative source of water at the campus of Dr. Ambedkar Institute of Technology (Dr. AIT), Bengaluru in the state of Karnataka, India.

LITRATURE REVIEW

The objective of this study is to conserve the rainwater i.e., by the technique of rain water harvesting and use it for other institutional purposes. This study deals with Rain water harvesting in a campus of Dr. Ambedkar institute of technology i.e., Silver jubilee building.

A brief review on methods of RWH and tank design has been included. Exchange of views about conserving rainwater and its purposes us entitled in the study. A work done by Bhupender Singh of PIET and Sandeep Kumar of NIT Kurukshetra in their paper "Rain water harvesting of PIET campus", they have discussed about the rainwater harvesting technique and tank design construction.

Journal by J R Julius, Dr. R. Angeline on Rainwater Harvesting (RWH) - A review.

And also, books by the govt. Of Karnataka,

Amruthavarshini: A guide for rainwater harvesting rainwater harvesting techniques to augment ground water, central ground water board has been referred to.

RAIN WATER HARVESTING

Rainwater harvesting is a technology used for collecting and storing rain water from roof tops, the land surface or rock catchment using simple techniques such as jars and pots as well as more complex techniques such as under ground check dams. Rainwater harvesting is the accumulation and deposition of rain water for reuse on-site, rather than allowing it runoff.

METHODS OF RAIN WATER HARVESTING

1. Roof top harvesting
2. Runoff harvesting

ROOF TOP HARVESTING

This method includes the catchment area as the roof top in rural and urban area. This includes roof top of houses, flats, factories and offices.

RUNOFF HARVESTING

Here the runoff water is collected. Gardens, driveways, landscapes, open fields, parks, roads, pavements and other open areas of the environment can be used to harvest the rainwater runoff. Using the method, it is possible to collect water from a larger area. This is particularly advantageous in areas of low rainfall.

COMPONENTS OF ROOF TOP HARVESTING SYSTEM

• Catchment area

• Transportation

• First flush

• Storage system

• Delivery system

• Filtration system

CATCHMENT AREA-The surface that receives rainfall directly is the catchment of rainwater harvesting system. It may be terrace, courtyard or paved or unpaved open ground.

TRANSPORTATION-Rainwater from rooftop should be carried through down take water pipes or drains to storage/harvesting system. Water pipes should be UV resistant (ISI HDPE/PVC pipes) and of required capacity.

FIRST FLUSH-First flush is a device used to flush off the water received in first shower. The first shower of rains needs to be flushed off to avoid contaminating storable or rechargeable water by the probable containments of the atmosphere and the catchment roof. It will also help in cleaning of slit and other material deposited on roof during dry season. Provisions of first rain separator should be made at outlet of each drain pipe.

DELIVERY SYSTEM-It is a system that delivers water for uses. There are use of pumps to take out water from tank and deliver for many purposes. Water is delivered by pipes.

FILTRATION SYSTEM-Filters are used for treatment of water to effectively remove turbidity, colour and microorganisms. After first flashing of rainfall, water should pass through filters. There are different types of filters in practice, but basic function is to purify water.

PROCESS OF ROOF TOP RAINWATER HARVESTING

• COLLECTION

• CHANNELING

• FILTRATION

• STORAGE

COLLECTION

Roofs can be broadly categorized into two types-flat roofs and sloping roofs. Flat roofs normally with RCC have water proofing on the surface as a surface finish. This top surface is provided with the slope towards down water pipes. For efficient collection and effective usage, slope on the roof need to be given towards the storage device placed for rainwater harvesting. This will minimize pipe length to the storage system. Sloping of roofs either with RCC, Mangalore tiles, asbestos sheets or steel sheets lead the water to the lower edge of roof. For rainwater harvesting, a gutter made out of sheet metal or PVC has to be installed at the lower edge to collect and channel water to the down water pipes. Roofs are of broadly two categories flat roofs and sloping roofs. Flat roofs, made with reinforced cement concrete normally have waterproofing course as surface finish. The waterproof course is done with small slope towards the down take pipes. Usual practice is to use lime surhki. In recent times rich cement mortar is used. Weather proof tiles are also laid on cement mortar. These types of roofs are ideal for rooftop rainwater harvesting.

CHANNELING

Down water pipes made out of PVC, HDPE or cement pipes can be used for transporting rainwater collected from roofs to the filtration system before storing. The size of the down take pipe where is depending on the roof area, which is connected to the down pipe.

FILTRATION

Rainwater collected on the roof is very pure and clean. However, there are many substances, which get mixed up with this pure water on the roof (leaves, bird droppings, dust etc.). These contaminants need to be filter before the rain water is stored. There are many filtration systems.

a. Sand bed filter

b. Popup filter

c. First flush lock and sand bed filter

STORAGE

Storage of harvested rainwater is possible at various levels. Combination of any of the above methods also can be used. In the first two methods, roof water is allowed to flow by gravity for secondary purposes like gardening, vehicle washing, floor cleaning etc. in the other methods water may have to be taken out manually or by using small fractional horsepower electric pump. The storage structures may vary from permanent masonry tanks, ferro cement tanks to plastic or metal tanks. The capacity of storage device can be decided by considering parameters such as roof area, water usage and space availability. [1]

STUDY AREA AND DATA INTERPRETATION

Fig. 1: Study Area

The campus of this institution is situated at Nagarbhaavi, Bengaluru. It is surrounded by residential area. Only a certain block of this institute has been considered for the analysis. The total strength of people in the block including students and staff is roughly around 1000. Thus, with its present strength and also with expansion, campus should also increase its facilities and maintenance requirements. Water, being the most basic need of all for primary and secondary use meets high demand of water by humans and is indispensable part of life.

Therefore, in this situation Rain Water Harvesting can be considered as a best solution for water scarcity in the campus.

DETAILS OF BUILDING

• Location: A213 Dr. Ambedkar Institute of Technology, Second Stage, Nagarbhaavi, Bengaluru, Karnataka-560056, India

• Latitude:12.964045837368584 degrees

• Longitude: 77.50653728842735 degrees

• Roof size: 740 square meters

• Roof type: Flat

• Runoff coefficient: 0.7

• Institutional water demand: 20 lpcd

• Water demand:20000 lpcd [3]

Table 1: Rainfall Data of Year 2010-2019 (All Values in mm)

Months	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	Avg
Jan	0.00	0.00	0.80	0.30	0.00	0.70	4.40	0.00	0.00	3.00	0.92
Feb	0.00	18.50	0.00	1.20	0.00	0.00	0.10	0.00	20.00	5.00	4.48
Mar	16.50	1.00	0.20	1.60	20.00	55.60	7.50	19.00	27.00	21.00	16.94
Apr	74.50	70.00	11.70	51.90	9.70	144.50	8.10	32.00	114.00	28.00	54.44
May	84.10	125.50	75.30	152.20	73.90	176.10	112.10	212.00	169.00	71.00	125.12
Jun	60.50	43.20	18.50	127.00	103.60	124.90	144.00	25.00	68.00	34.00	74.87
Jul	111.90	100.90	85.20	120.40	109.00	74.40	189.00	45.00	54.00	106.00	99.58
Aug	148.10	129.80	136.80	82.50	119.30	86.50	36.00	187.00	90.00	144.00	132.00
Sep	60.50	101.70	50.00	258.10	226.20	195.90	52.00	443.00	166.00	192.00	174.54
Oct	87.20	169.50	57.50	83.60	279.00	126.20	29.00	213.00	72.00	311.00	142.80
Nov	115.00	47.40	129.00	52.10	37.70	234.30	6.00	11.00	21.00	15.00	66.85
Dec	2.20	6.90	15.70	4.10	1.80	4.30	62.00	12.00	3.00	9.00	12.10
Total	760.40	974.40	580.7	935.1	980.20	1223.40	650.00	1198.00	753.00	939.00	899.42

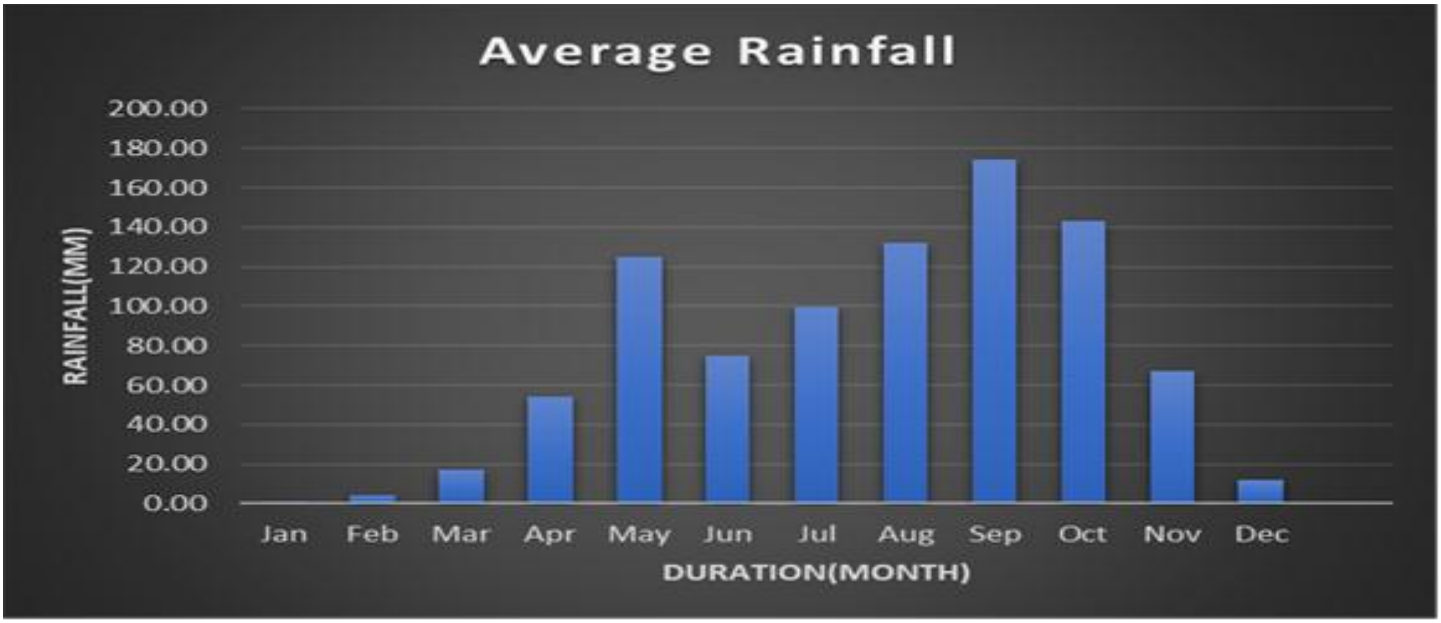


Fig. 2: Average Rainfall for each month for 2010-2019 (All data in mm)

WATER AVAILIBILITY

A flat roof has a runoff coefficient of 0.7, which means that 70% of the rain can be harvested. Based on this runoff coefficient and a roof area of 740 square meters a volume of 1191 liters (2.3 mm x 740 m2 x 0.7) of water can be collected in the driest month (January) and 93706 liters (180.9 mm x 30 m2 x 0.7) in the wettest month (September).

The total yearly amount of water that can be collected from the roof is 438500 liters (438m3) in an average year.

WATER DEMAND

The water demand is 20000.0 liters per day, which equals to about 600000 liters per month. The total water demand is 7300000 liters (7300 m3) per year.

The amount of water that can be collected from the roof (465m3) is less than the water demand (7300 m3). Only a part of the water demand can be fulfilled using a rainwater harvesting system.

DESIGN CALCULATIONS

(In reference to the highest rainfall recorded in Bengaluru in a day)

Area = 739.41 m2

Discharge, Q = C I A

= 0.7 × 185.5 × 10-3 m/day × 739.41 m2

Therefore, Q = 96.012 m3 / day

VOLUME = Q × T (Taking Time = 1day)

VOLUME = 96012.38 liters

Approximate Volume = 100000 liters

Therefore, the tank must be designed for given capacity.

REQUIRED STORAGE

The total amount of water that can be collected from this roof, 465600 liters, is not enough to fulfil the total yearly water demand of 7300000 liters.

However, it might still be worthwhile to construct a rainwater harvesting system. With a storage reservoir of 100000 liters a rainwater harvesting system.

The storage reservoir will be full in September and then slowly drain until it is (almost) empty at the end of April.

Therefore, to meet the certain water demand in the dry and wet years and based on calculations, a tank of capacity 100000 liters is to be constructed in the campus around the SILVER JUBILEE BUILDING and to be used to the best of it.

An RCC tank is suggested to be constructed underground in a suitable area so the land above can be beneficial for other purposes.

DESIGN OF UNDERGROUND TANK

Volume of water=150m^3

Depth of water= 3m

Free board=150mm

Total height of tank= 3.15m

Area of the base=150/3= 50m^2

Dimension of the tank 10m*3m*5m

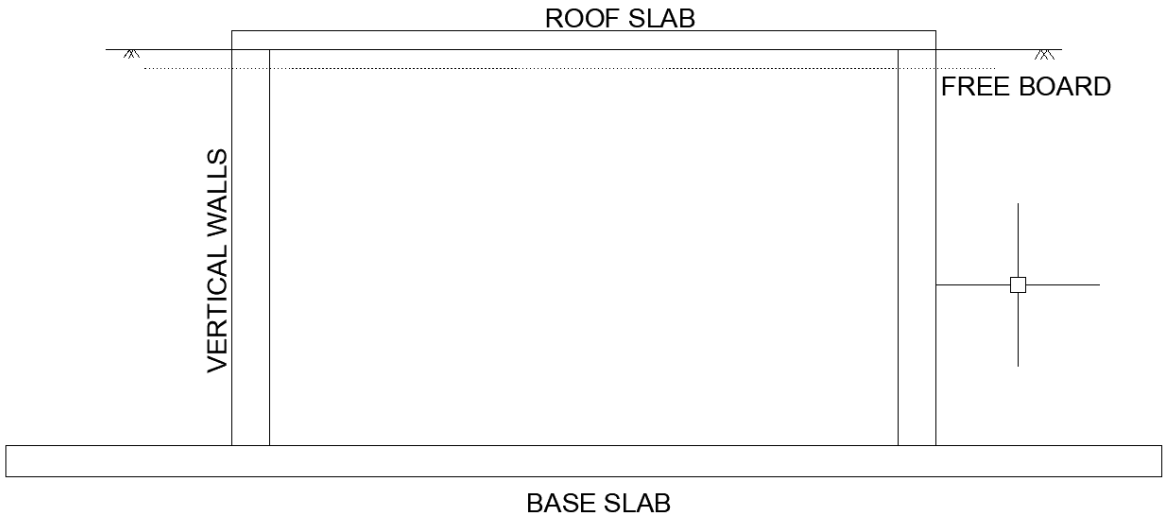
Angle of repose of wet soil=10^o

Angle of repose of dry soil=30^o

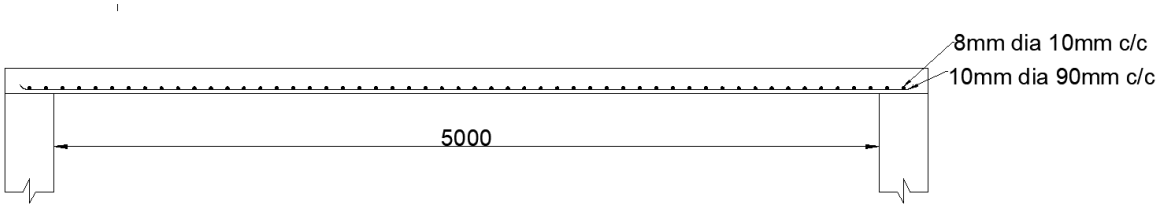
Unit weight of soil=16kn/m^3

M-25 concrete, Fe-415 steel bars

Unit weight of water=9.814km/m^3 or 9810N/m^3



Design of roof slab



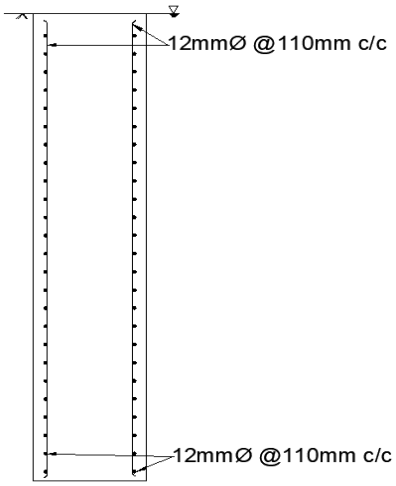
Wall thickness=300mm

Roof slab thickness=150mm

10mmϕ, @90mm c/c spacing for main bars

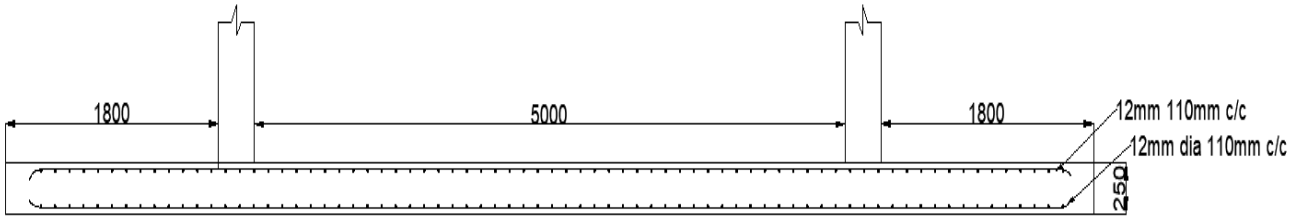
8mmϕ, @100mm c/c spacing for distribution bars

Design of vertical wall



12mmϕ, @110mm c/c spacing on both walls for main and distribution bars

Base slab



Thickness of base slab=250mm

Weight of roof slab=21km/m

Total load per meter run=68.25km

Weight of base slab=57.5kN

Weight of soil projection=181.44kN

12mmϕ,110mm c/c spacing for both main and distribution bars

COST AND ESTIMATION

Sl. No	Description	no		L	B	D	Qty	Unit	Rate	Amount
1	**Earthwork excavation for foundation o**f building, water supply ,sanitary lines and electrical conduits either in pits or in trenches 1.5m and above in width, in hard soil not exceeding 1.5 m. in depth including dressing the bottom and sides of pits and trenches, stacking the excavated soil clear from edges of excavation with lead upto 50 m. after breaking of clods complete as per specifications									
	Sump	1.00	1.00	14.50	9.50	3.55	489.01			
							489.01	**cum**	**449.00**	**2,19,566.61**

2	Providing and laying in position plain cement concrete of nominal mix M7.5 with OPC cement @ 180kgs, with 40mm and down size graded granite metal coarse aggregates @ 0.85cum and fine aggregates @ 0.57cum machine mixed, machine mixed, concrete laid in layers not exceeding 15cms, thick, well compacted, in foundation and plinth, including cost of all materials, labours, HOM of machinery, curing complete as per specifications									
	PCC for Sump	1.00	1.00	14.50	9.50	0.15	20.66			
							20.66	**cum**	**5,102.00**	**1,05,420.08**
3	Providing and laying in position reinforced cement concrete of Design mix M20 with OPC cement @ 320kgs, with 20mm and down size graded granite metal coarse aggregates @0.69cum and fine aggregates @ 0.460 cum, with super plasticisers @ 3 litres confirming to is 9103-1999 reafirmed-2008, machine mixed, concrete laid in layers not exceeding 15 cms thick, vibrated for all works in **foundation for footings, pedastals, retaining walls, return walls, walls (any thickness) including attached pilasters, columns, pillars, posts, struts, buttresses, bed blocks, anchor blocks & plinths etc.,** including cost of all materials, labour, HOM of machinery, curing, complete but excluding cost of reinforcement as per specifications.									
	Base Slab	1.00	1.00	14.20	9.20	0.25	32.66			
	RCC walls	2.00	1.00	10.60	0.30	3.15	20.03			
	RCC walls	2.00	1.00	5.00	0.30	3.15	9.45			
	Roof Slab	1.00	1.00	10.60	5.60	0.15	8.90			

		(1.00)	1.00	0.45	0.45	0.15	(0.03)			
							71.02	**cum**	**5,659.00**	**4,01,888.74**
4	Providing and removing centering, shuttering, strutting, propping etc and removal of form work for foundation, footings, bases of column for mass concrete including cost of all materials, labours as per specifications									
	PCC for Sump	2.00	2.00	14.50		0.15	8.70			
		2.00	2.00	9.50		0.15	5.70			
	Base Slab	2.00	2.00	14.20		0.25	14.20			
		2.00	2.00	9.20		0.25	9.20			
	RCC walls	2.00	2.00	10.60		3.15	133.56			
	RCC walls	2.00	2.00	5.00		3.15	63.00			
							234.36	**Sqm**	**258.00**	**60,464.88**

5	Providing and removing centering, shuttering, strutting, propping etc and removal of form work for flat surface such as suspended floors, roofs landing and etc....thickness upto 200mm, including cost of all materials , labours as per specifications.									
	Roof Slab	1.00	1.00	10.00	5.00		50.00			
	sides	2.00	2.00	32.40		0.15	19.44			
							69.44	**Sqm**	**400.00**	**27,776.00**
6	Filling available earth in sides of foundations up to plinth in layers not exceeding 20cms in depth, compacting each deposited layer by ramming after watering with lead up to 1.5m including cost of all labour complete as per specifications									
	Total excavation qty						489.01			

	Total PCC 1:4:8 qty						(20.66)			
	Total footing qty						(71.02)			
	sump	(1.00)	1.00	10.00	5.00	3.15	(157.50)			
							239.83	**cum**	**201.00**	**48,206.31**
7	Providing TMT steel reinforcement for RCC work including straightening ,cutting, bending, hooking, placing in position, lapping and / or welding wherever required, tying with binding wire and anchoring to the adjoining members wherever necessary complete as per design (laps and wastage shall not be measured and paid) cost of materials, labour, HOM of machinery complete as per specifications						**10.44**	**ton**	**70,966.00**	**7,40,579.89**
8	Providing 15mm thick cement plaster in single coat with cement mortar 1:4, to brick masonry including rounding off corners wherever required smooth rendering, : Providing and removing scaffolding, including cost of materials, labour, curing complete as per specifications.									
	base	1.00	1.00	10.00	5.00		50.00			
	roof	1.00	1.00	10.00	5.00		50.00			
	walls (10+5)*2=30	1.00	1.00	30.00		3.15	94.50			
							194.50	**sqmt**	**221.00**	**42,984.50**
9	Steps ladder for access of under ground sump for easy to access and cleaning									
		11.00	1.00				11.00			
							11.00	**Nos**	**525.00**	**5,775.00**
									Total	**16,52,662.01**
									Gst 12%	**1,98,319.44**
									Grand total	**18,50,981.45**

STEEL:

Sl no	Item Of Work	No		Length in Mt	Dia of Bar	Co-effi	Total Wt	Unit	8MM	10 MM	12 MM	16 MM	20 MM M
1	**For Base Slab**												
	Main bars top	1.00	130.00	9.25	**12.00**	1.58	1899.95				1899.95		
	Main bars bottom	1.00	130.00	9.25	**12.00**	1.58	1899.95				1899.95		
	Dist bars top	1.00	86.00	14.25	**12.00**	1.58	1936.29				1936.29		
	Dist bars Bottom	1.00	86.00	14.25	**12.00**	1.58	1936.29				1936.29		
2	**For RCC Walls**												
	Vertical main bars	1.00	49.00	3.70	**12.00**	1.58	286.45				286.45		
		1.00	49.00	3.70	**12.00**	1.58	286.45				286.45		
		1.00	23.00	3.70	**12.00**	1.58	134.46				134.46		
		1.00	23.00	3.70	**12.00**	1.58	134.46				134.46		
	Horizontal Dist bars	1.00	30.00	16.50	**12.00**	1.58	782.10				782.10		
3	**For Roof Slab**												
	Main bar	1.00	118.00	5.55	**10.00**	0.62	406.04				406.04		
	Dist bars	1.00	56.00	10.55	**8.00**	0.40	236.32		236.32				
							9938.76	**kg**	**236.32**	**0.00**	**9702.44**	**0.00**	**0.00**
									8MM	**10 MM**	**12MM**	**16MM**	**20 MM**
							9938.76						
	Wastage 5%						496.94						
	Total						**10435.70**	**Kg**					
							10.44	**ton**					

CONCLUSIONS:

- This project deals with all aspects of eradicating the water scarcity problem in Dr. AIT campus by implementing ancient old technique Rain Water Harvesting. The rain water collected from the roof is of sufficient quantity and thus, for this quantity the underground water tank capacity has been calculated for which the design can be made.
- RCC tank is constructed underground in suitable area, so that the land about the above can be beneficial for other purposes. The tank of capacity 100000 litres is to be constructed in the campus around Silver Jubilee Building.

- Hence, it is finally concluded that adopting the Rain Water Harvesting in the campus of Dr. AIT will be the best approach towards harvesting rainwater and decrease the over dependence on the ground water.

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