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Implementation of Rain Water Harvesting in Aditya Engineering College: Design and Estimation

A. Pavan Bharath [a]***, K. Santhosh Kumar*** [b]***, S. Durga Prasad*** [c]

[a,b,c] Aditya Engineering College, Surampalem, 533437 India

A B S T R A C T

The project report presents the details on planning, Analyse , design and estimation of rain water harvesting for the college building. The project is prepared with reference to standard codes (IS 15797:2008, IS 1893) by employing various task specific software (Microsoft excel and Microsoft word). It has been observed that each year a increase wastage of water occurs due to improper usage of pure water for secondary purpose like (sweeping of floor, washing of cars, water used for gardening purpose, etc) in daily life. In order to avoid this wastage of water by adopting rain water harvesting system in a household by using proper design procedures and standard codes for designing this system. In order to achieve this first we have to collect data from the where the structure needs to be designed. After collecting the data we have to prepare plan for the entire system by using software (Microsoft word). By this data we design a harvesting tank by using the data collected from various sources . After designing tank estimation and costing has to be completed for the designed tank . After that most economical design is to be adopted for the college building . By this we can reduce the wastage of water . It is anticipated that the data presented in this report will have wide application and usage .

Keywords: Design, Estimation, Rate Analysis.

1. INTRODUCTION

Rapid urbanization has lead to concentrated population density in many regions which has resulted in surface water scarcity as well as uneven drying of ground water. This has resulted in drought and drying up of river beds in the regions where industrial and domestic consumption of water is high. In order to reduce the risk of scarcity of water to the future population, rain water collection and storm water harvesting from runoff would be an effective way. The best way for rainwater harvesting is to recharge the ground water and also, if rain water collected in natural ponds or artificial tanks is unused, the same can be used to charge the natural aquifer thus boosting the ground water level. The technique by which the rain water is collected from rooftop catchments is termed as roof top rain harvesting. In order to cater the domestic needs, harvested rain water can be stored in sub-surface ground water reservoir by using artificial recharge techniques by storing in tanks.

2. LITERATURE SURVEY

Deepak Khareetal (2004) have reviewed the impact assessment of RWH on ground water quality at Indore and Dewas, India. The impact assessment of roof top improve the quality and quantity of Ground Water. The roof top rainwater was used to put into the ground using sand filter as pretreatment system. This lead to a reduction in the concentration of pollutants in ground water which indicated the effectiveness of increased recharge of aquifer by roof top rain water. He observes that in certain areas, the amount of total and faecal coliform were observed high in harvested tube well water than normal tube well water. The reason of this increases was poor cleanliness of roof top and poor efficiency of filter for bacterial removal. The author concludes that quality mounting of rainwater harvesting is an essential prerequisite before using it for ground water recharge.

Venkateswara Rao (1996) in his article has reviewed the importance of artificial recharge of rainfall water for Hyderabad city water supply. Rainfall water from the roof tops of the buildings recharged through specially designed recharge pits in order to augment the ground water resource in the city. This Water meets almost 80% of domestic water requirements, storm runoff from the public places like roads, parks play grounds etc., is recharged through naturally existing tank within the city by not allowing municipal sewage and industrial effluents in these tanks. He finally suggests that, wherever natural tanks are not existing, community recharge pits are to be constructed at hydro geologically suitable location.

Singh and Thapaliyal (1991) assessed the impact of watershed programme on rain fed agriculture in Jhansi district of Uttar Pradesh and indicated that the underground water table in the area showed a significant increase, the average annual increase in the water table being 3.7 meters. A shift in the area from pulses to cereals and from cereals to pulses was observed in Rabi and Kharif seasons, respectively.

Venkatesh and Jose (2007) conducted a rainfall study on the coastal and its adjoining areas in Karnataka State. The statistical analyses conducted included cluster analysis and analysis of variance. The study revealed that there exist three distinct zones of rainfall regimes in the study area, namely, Coastal zone, Transition zone and Malanad zone. It is observed that, the maximum rainfall occurs on the windward side ahead of the geographical peak. Further, mean monthly rainfall distribution over the zones has been depicted to enable agricultural planning in the study area

Muralidharan (2007) precipitation is the principal source of replenishment of moisture in the soil through the infiltration process and subsequent recharge to the groundwater through deeper percolation. The amount of infiltrated moisture that will eventually reach the water table is accounted as the natural groundwater recharge. In this study an attempt on correlating the rainfall amount and subsequent rise in water level yielded an exponential relation indicating that daily rainfall exceeding 40 mm/day results in significant rise in water level..

Nirmala (2003) reported that the farmer perception and constraints analysis under impact study of watershed development programme on socio-economic dimensions in Ranga Reddy district of Andhra Pradesh and found that technologies were beneficial in the form of increased income (58.33%), increased moisture (51.66%) and increased productivity (48.33%) along with increased employment generation. Reduced soil erosion integrated ground water recharge etc. were other benefits of technology as perceived by the farmers. Further she observed that the major reasons for non-adoption of structures in non-watershed area were lack of capital (51.6%) technical know-how (46.60%), size of holding (45%) followed by problems of irrigation, inadequate input availability non-availability of labour, inadequate extension services and poor quality of land etc.

Naik (2000) reported the major reasons for non-adoption of water harvesting structures and grade stabilization structures in the Kanakanala and Indawar Hullalli watersheds in Northern Dry Zone of Karnataka that non availability of credit and high interest rates were severe problems (69% each) followed by long gestation period (68%), high hiring charges of improved implements (65%) and small holdings (61%) etc. in the non-watershed area.

3. METHODS OF RAINWATER HARVESTING

There are primarily two prevalent methods of rainwater harvesting that are used in most of the areas

Surface Run-off Rainwater Harvesting: The rainwater that flows off in the urban areas can be collected and stored to recharge the groundwater level or the aquifer bed, instead of letting the water flow into the drains.

Rooftop Rainwater Harvesting: In rooftop harvesting the rainwater is directly collected from the roof of the buildings and transported either into a tank or an artificial aquifer. Through this method the harvested water can be used for daily use purposes (including drinking and cooking, only after purifying the water at a basic level) and for recharging the aquifers and help restore the groundwater levels.

4. METHODOLOGY OF RAIN WATER HARVESTING SYSTEM

Determination of catchment area

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Estimation of water harvesting potential

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Calculation of discharge

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Estimation of water demand

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Selection of catchment area based on demand

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Calculation of diameter of rain water pipes and discharge pipes

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Design of recharge well

5. BENIFITS OF RAINWATER HARVESTING SYSTEM

- Storing rainwater helps in recharging the aquifers.
- It helps in preventing urban flooding due to excess rain.
- The stored water can be used for irrigation practices in farming region.
- The water can be used for daily use and help in reducing water bills in the towns and cities.
- Is a helpful way to tackle the scarcity of water in arid and dry regions.

- It helps in restoring the groundwater level.

Table 1 - Average Rain fall in surampalem

MONTH	DAY	NIGHT	RAIN DAY
January	28 ºC	20 ºC	0
February	31 ºC	21 ºC	0
March	34 ºC	24 ºC	1
April	36 ºC	26 ºC	2
May	37 ºC	29 ºC	3
June	34 ºC	28 ºC	10
July	31 ºC	26 ºC	15
August	31 ºC	26 ºC	14
September	31 ºC	26 ºC	16
October	31 ºC	25 ºC	10
November	29 ºC	23 ºC	5
December	28 ºC	21ºC	1

6. DESIGN OF RAINWATER HARVESTING SYSTEM FOR BILL GATES BHAVAN

STEP – 1

Area of the Bill Gates Bhavan = $2895.82m^2$

Area of the half of the Bhavan = $1447.91m^2$

Coefficient of Runoff = 0.70

Average rainfall for Surampalem = 99mm

STEP– 2

Volume of Rain water harvesting calculation = Area of the building x Run off x Average rain fall

= 1447.91 x 0.70 x 99mm

$=100.3401 \times 10^{3}\, m^{3}$

$=100.34\ m^3$

STEP – 3

As per safety factor take 20% extra = 100.34+100.34(20/100)

$= 120.408m^3$

STEP – 4

Assume 2.5m as the depth of water tank V = L x B x H

B = (L/2)

= L x (L/2) x 2.5m

$120.405 = (L^2/2) \times 2.5$

L = 9.81 m

B = (9.81/2)

= 4.91 m

Size of the tank = 9.81 x 4.91 x 2.5 m

$= 120.41m^3$

If tank in circular shape $V = (\pi/4) \times D^2 \times H$

$100.34 = (\pi/4) \times D^2 \times 2.5$

D = 9.22m

Dia of the Tank = 9.22 m

RAINWATER HARVESTING SYSTEM FOR BILL GATES BHAVAN

DESIGN OF TWO WAY SLAB FOR BILL GATES BHAVAN RAIN WATER HARVESTINGTANK :

Dimensions of the slab = 10.41m x 5.51m.

Choose Fe415 grade of steel and M20 grade of concrete.

STEP – 1 Depth of slabs

As per Is 456:200 Modification factor is1.4 .

l/d = 20 x M.F

l/d = 20 x 1.4 = 28

d = l /28 = 5510/28 = 196.78mm

choose 200mm as the overall depth of the slab .

Effective depth of slab = 200 -15 -10/2 =180 mm.

Choose 10mm dia of bars.

STEP – 2 Loads

Self weight of the slab W1 = 0.2 x1 x 25= 5 KN/m.

Floor finish as W2 = 1 KN/m^2 = 1 KN/m

Total load on slab W = 6 KN/m

Factor load Wu= 6 x 1.5 = 9 KN/m.

STEP – 3 Design of Bending moment

Ly/Lx = 1.88

$M_x = d_x w_x l_X^2$

$M_y = d_y w_x l_y^2$

d_x = 1.75 x 1.88 x 2.0

0.113 x x? x 0.118

d_x = 0.113+((0.118 - 0.113)/(2.0 – 1.75)) (0.88 – 1.75).

d_x = 0.116

4.8 = 6 to 8

d_y = 1.75 x 1.88 x 2.0

0.037 x ? X 0.029

d_y = 0.037 +((0.037 – 0.029)/(1.75 – 2.0))(1.88 – 1.75)

d_y = 0.03284 .

STEP – 4

Bending moment in ‘ x ‘ direction

M_x = 0.116 x 9 x 5.51^2

M_x = 31.69 KN . m

bending moment of ‘y’ direction

M_y = 0.03284 x 9 x 5.51^2

M_y = 8.973 KN . m

STEP– 5 Depth required

$m_u = 0.138\ f_{ck}\ bd^2$

$d = \sqrt{((m_u)/(0.138\ f_{ck}\ b))}$

$= \sqrt{((31.69 \times 10^6/(0.138 \times 20 \times 1000))}$

d = 107.15 mm

107.15 < 200 mm

STEP – 6 Area of steel reinforcement in ‘ x ‘direction

$m_u = 0.87\ f_y\ A_{st}\ d\ (1 – ((A_{st} \times d\ )/(f_{ck}\ bd^2))$

$m_u = 0.87 \times 415 \times A_{st} \times 150\ (1 – ((415 \times A_{st})/(20 \times 1000 \times 150^2))$

$m_u = 54157.5 \times A_{st}\ (1 – ((415 \times A_{st})/(20 \times 1000 \times 150^2))$

31.69 x 10 6 = - 0.0499 x A_{st} 2 + 54157.5 x A_{st}

$0.02809 \times A_{st}^2 – 54157.5\ A_{st} + 31.69 \times 10^6 = 0$

A_{st} = 586.94 mm^2

Minimum reinforcement = 0.12 % of gross area

= (0.12 / 100) x 1000 x 200 =240 mm^2

A_{st} min < A_{st} provide

Hence choose 100 mm dia of bars

Area of single bar = (π/4) x 10^2 =78.54 mm^2

Spacing of bars = (78.54 / 585.46) x 1000 = 134.15 mm

Choosing @ 130 mm c/c as the spacing .

STEP – 7 Area of steel reinforcement in ‘y’ direction

d = 200 – 10 =190 mm

$m_y = 0.87 \times f_y \times A_{st}\ \ d\ (1 – ((f_y\ A_{st})/(f_{ck}\ bd^2))$

$= 0.87 \times 415 \times A_{st} \times 140\ (1 – (415 \times A_{st}\ )/(20 \times 1000 \times 190^2))$

$8.978 \times 10^6 = 50547\ A_{st}\ (\ 1 –((415 \times A_{st}\ )/(20 \times 1000 \times 140^2))$

$0.0535\ A_{st}^2 – 50547\ A_{st} + 8.973 \times 10^6 = 0$

A_{st} = 177.55 mm^2

minimum reinforcement = (0.12/100) x 1000 x 190

A_{st} min = 228 mm^2

A_{st} min > A_{st} provide

choose A_{st} = 228 mm^2

choose 8 mm dia of bars

Area of the single bar = $(\pi/4)$ x $^{\gamma 2}$ = 50.26 mm^2

Spacing of bars = (50.26/ 228) x 1000= 220.43m

choose spacing of bars as 200 mm@ 8mm

STEP – 8 Check for shear

Maximum shear = (1/2) x wlx

= (1/2) x 9 x 5.51

=24.795 KN

Nominal shear stress = (τ_v) = (24.795 x 10^3)/(1000 x 200)= 0.1653 N/mm^2

= 0.124 N/mm^2

Percentage of steel = (Ast /bd) x 100

= (585.46/(1000 x200)) x100

= 0.293 %

Table no -19

τ_c value for 0.25% 0.5%

0.36% 0.48%

For 0.39%

= 0.36 + ((0.48 – 0.36)/(0.5 -0.25))x (0.293 – 0.25)

τ_c = 0.38N/mm 2

$\tau_c > \tau_v$Hence no need for shear reinforcement .

STEP - 9 Check for deflection

Percentage of steel = 0.29%

Modification factor k = 1.4

Modified ration = 1.4 x 20 = 28.

actual (l/d) = (5510/200) = 27.55

hence safe against deflection

TWO WAY SLAB FOR BILL GATES BHAVAN

Bar bending schedule:

a) length of main straight bars

= length of short span + (2x bearings)–(2x end covers)

= 4.91 +(2 x300)-(2 x 20)

= 5470 mm

No of bars = (9810 + (2x230)-(2x 20)) / (130 x 2)+1

= 40.346 =41 No's

b) length of main cranked bars

= length of short span + (2xcrank allowance)

=5470 + (2 x0.414(200 – (2x15)-10))

=5602.48mm

No of bars = 41-1 = 40 No's

c) length of main straight bars along longer span

= clear span in longer direction+ (2 x bearings) – (2 x end covers)

= 9810 + (2 x 230) – (2 x 20)

= 10.230 m

= (5470/200x2)+1

= 150675 = 16 no's

d) Length of main cranked along longer span

=10230 +(2x0.414(200-(2x15)-8))

= 10.364m

= 16-1 = 15No's

e) Anchor bars to supported main cranked bars length of anchor bars = length of main bars along the longer

=10.364m

3+3=6

f) Anchor bar to supported main cranked bars

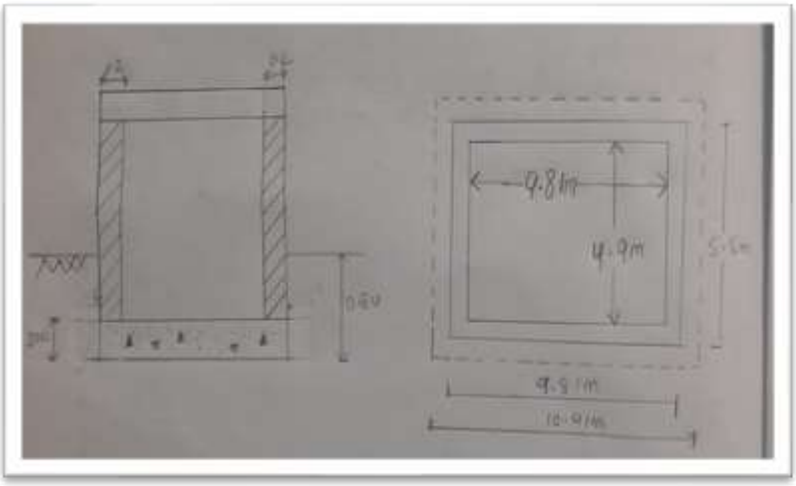
length of anchor bars = length of main bar along shorter span direction

=5.470m

3+3 =6

S/N0	**BAR**	**SHAPE**	**DIA (mm)**	**No's**	**LENGTH (m)**	**TOTAL LENGTH (m)**	**WEIGHT (Kg/m)**	**TOTAL LENGTH (Kg/m)**
1	A	Length of main straight bars	10mm	41	5.47	224.2	0.62	139.05
2	B	Length of main cranked bars	10mm	40	5.602	224.08	0.62	138.93

3	C	Length of straight main bars along longer span	8mm	16	10.23	163.68	0.39	63.84
4	D	Length of straight cranked along longer span	8mm	15	10.304	154.56	0.39	60.28
5	E	Anchor bar to supported main cranked bars	8mm	6	10.23	61.38	0.39	23.94
6	F	Anchor bar to supported main cranked bars	8mm	6	5.47	32.82	0.39	12.80
								438.84 kg/m



HARVESTING TANK

ESTIMATION FOR HARVESTING TANK:

Size of the tank = 9.81 x 4.91 x 2.56m

Particulars	**No's**	**Length**	**Breadth**	**Height**	**Total quantity**
Earth Excavation	1	10.41	5.51	0.8	40.89m^3
C.C.Bed	1	10.41	5.51	0.3	17.18m^3
Brick masonry required L = 2(10.41 + 30.64 + 4 x 0.3) = 31.84	1	31.84	0.3	2.5	23.88
No of bricks	1		23.88/(0.2x0.1x0.1x)		11940No's
Roof slab	1	10.4	5.51	0.2	11.47
Plastering Inside 2(10.41+4.94)=29.44 Outside 2(10.41+5.5)=31.82 For floor	 1 1 1	 29.44 31.82 9.81	 - - 4.91	 2.5 2.5 -	 73.6m^2 79.55m^2 48.16m 127.7 m^2

RATE ANALYSIS:

Rate Analysis for c.c. bed (1:3:6):

1+3+6 = 1/10 x 1.54 = 0.154 m^3

For 10 m 3 of work

For cement = 1.54 m^3

For sand = 3/10 x 1.54 x 10 = 4.62 m^3

For aggregate = 6/10 x 1.54 = 9.24 m^3

Material Rate

Material	**Quantity**	**Rate**	**Total Rate**
Cement	1.54	390	18330
Sand	4.62	600	2772
Aggregate	9.24	700	6468
			Total Rate = 27570

Labour Rate

Labours	**No's**	**Rate**	**Total Rate**
Head mason	½	800	400
Mason	1(1/2)	700	1050
Mazdoor	12	600	7200
Coolie	12	500	6000
Bhisti	2	400	800
T and P	L.S	500	500
			Total rate = 15950

Total amount = 29418 + 15950 = 45368/-

Add 1.5% for water change = (1.5/100) x 45368 = 68050/-

Add 2% for super vision = (2/100) x 45368 = 907.36/-

Add 2% for conveyance placing & unloading + (2/100) x 45368 = 907.36/-

Add 10% for contractor profit = (10/100) x 45368= 4536.8 /-

Total amount for 10 m^3 of work = 45368 + 680.50 + 907.36 + 907.36 + 4536.8 = 52400.02

For 1 m^3 of work = 52400.02/10 = 5240.02/-

for 17.18 m^3 of work = 5240.002 x 17. 18 = 90023.23 /-

Brick Masonry (1:6):

No of bricks required for 1 m^3 of wall = 500 no's

For 10m^3 = 5000 no 's

Quantity of cement = (1/ 7) x x0.33 = 0.047 x 10 = 0.47m^3

Sand = (6/7) x 0.33 =2.83 m^3

Material

No's	**Material**	**Quantity**	**Rate**	**Total Rate**
1	Cement	0.47	390	5850
2	Sand	2.83	600	1698
3	Bricks	5000	10	50000
				Total rate = 57548

Labour

Labour	**No's**	**Rate**	**Total rate**
Head mason	½	800	400
Mason	1(1/2)	700	1050
Mazdoor	12	600	7200
Coolie	12	500	6000
Bhisti	2	400	800
T and P	L.S	500	500
			Total rate = 15950

Total amount = 57548 + 15950 = 73498 /-

Add 1.5 % for water charge = (1.5/100) x 73498 = 1102.47 /-

Add 2% for supervision = (2/100) x 73498 = 1469.96 /-

Add 2 % for conveyance placing & unloading = (2/100) x 73498 = 1469.96/-

Add 10% for contract profit = (10/100) x 73498 = 7349.8 /-

Total amount = 7349.8 + 1102.47 + 73498 + 1469.96 + 1469.96 = 84890.19

For 10 m^3 of work = 84890.19

For 1 m^3 of work = 84890.19 / 10 = 8489.019

For 23.88 m^3 of work cost required is = 8489.019 x 23.88 = 202717.77 /-

Plastering of (1:4) :

Thickness of the plastering = 15mm = 0.015m

Take for 100sq.m

Volume of the plastering = Area of plastering x thickness + 10% extra for even surface

= 100 x 0.015 x 0.01 x 100 x 0.015 +1.5 =1.65 m^3

Dry volume of plastering = 1.22 x 1.65 = 2.01 m^3

Material

cement =(1/5) x 2.01 = 0.402 m^3

sand = (4/5) x 2.01 = 1.608 m^3

Material	**Quantity**	**Rate**	**Total rate**
Cement	12 bags	390	4680
sand	1.608	600	965
			Total rate = 5645

Labour

Labour	**No's**	**Rate**	**Total rate**
Head mason	¾	800	600
Mason	10	700	7000
Mazdoor	12	600	7200
Coolie	20	500	10000
Bhisti	4	400	1600
T and P	L.S	500	500
			Total rate = 26900

Total amount = 5645 + 26900 = 32545/-\

Add 1.5 % for water charge = 32545 x (1.5 /100) = 488.175/-

Add 2% for supervision = 32545 x(2/100) = 650.9/-

Add 2% for conveyance placing & unloading =32545 x (2/100) = 650.9/-

Add 10% for contractor profit = (10/100)x32545=3254.5/-

for 100m^3 of work = 32545 + 488.175 + 650.9 + 650.9 + 3254.5 = 37589.47/-

For 1 m^3 of work = 37589.47/100 = 375.89/-

For 201.32 m^2 = 201.32 x 375.89 = 756741.17/-

R.C.C Slab of (1:2:4) :

Cement = (1/1+2+4)x15.2 = 2.17m3

Sand = (2/1+2+4)x 15.2 = 4.34 m3

Aggregate = (4/1+2+4) x 15.2 =8.68 m3

Steel Required for the work = 438.841kg

Add 10% for wastage = 438.84 +(10/100)x438.84 = 482.72kg

Binding wires required = 1.5 kg

Material

Material	Quantity	Rate	Total rate
Cement	62bags	390	24180
Sand	4.34	600	2604
Aggregates	8.68	700	6076
Steel	482.72	64	31377
Binding wire	1.5	64	96
			Total rate = 55463

Labours

Labour	No's	Rate	Total rate
Head mason	½	800	400
Mason	3	700	2100
Mazdoor	12	600	7200
Coolie	20	500	10000
Bhisti	4	400	1600
Sundries	L.S	500	500
			Total rate = 21800

Bending , Cracking and Binding Steel bars in Position:

Labour	No's	Rate	Total Rate
Black smith	8	1500	12000
Mazdoor	8	600	4800
Sundries	L.S	300	300
			Total Rate = 17100

Total amount = 64333 + 21800 + 17100 +15800 = 119033/-

Add 1.5% for water charge = 119033 x (1.5/100) = 1786 /-

Add 2% for supervision =(2/100) x 119033 = 2381/-

Add 2% for conveyance = (2/1000 x 119033 = 2381 /-

Add 10% for contractor charge =(10/100) x 119033 = 11903.3/-

Total cost = 119033 + 1786 + 11903.3 + 2381 + 2381 = 137484/-

Earth work excavation for the building:

Volume of the Earth work = 40.89m3

Per meter cube = its charge = 200 – 300 m3

Then = 40.39 x 300 = 12267/-

For machinary if takes = 5000/day

Cost for excavation = 17267/-

PLUMBING:

PIPE DIA	LENGTH (FEET)	QUANTITY	PRICE	TOTAL PRICE
40mm	47.57	4.7	200	940
L-BEND	-	5	55	575
Pipe joints	-	5	55	575
Plumbing	-	1	1000	1000

Labour	-	2	500	1000
				Total cost = 4090

TOTAL COST FOR THE CONSTRUCTION:

COST REQUIRED FOR C.C BED =90023/-

COST REQUIRED FOR BRICK MASONARY=202717/-

COST REQUIRED FOR PLASTERING = 75674/-

COST REQUIRED FOR SLAB =137484/-

COST REQUIRED FOR EARTH WORK EXCAVATION =17267/-

COST REQUIRED FOR PLUMBING = 4090/-

COST REQURIED FOR THE ENTIRE BUILDING=527255/-

7. CONCLUSION

This study evaluated the feasibility of rain water harvesting in a locality of ADITYA ENGINEERING COLLEGE , suramplem where there is need of water for the purpose of gardening , laboratories and washrooms. It has found that amount of harvested rainwater. Could be that is collected in the harvested tank and the excess water that is filled in the tank is connected to the soak pit for increasing ground water table level in campus.

By this project we get the clear idea about the cross section of tank and its shape. Material that are used for the construction and its entire cost .

Rain water harvesting becomes more benefits and sustainable when it is properly designed . This project leads to decrease the water usage in the college In future the water resources that are available now may arise by adopting this system we reduce this scarcity.

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