ENGINEERING AND TECHNOLOGY IN INDIA
Volume 3 | Issue (1) | April, 2012 | 52-54

RESEARCH ARTICLE

Study on cost analysis of rooftop rainwater harvesting in residential premises

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ABSTRACT : An investigation was carried out to study the cost analysis of rooftop rainwater harvesting in Tamil Nadu Agricultural University, Campus. Coimbatore. The cost analysis revealed that among all individual residential blocks, all hostel buildings and buildings in different combinations, all hostel combinations was found to be more feasible for installation of rooftop rainwater harvesting structure with a benefit cost ratio of 2.82 and pay back period of 1.32 years. For individual residential blocks and all residential blocks combination, the all residential blocks combination was found to be more feasible for installation of rooftop rainwater harvesting structure with a benefit cost ratio of 2.27 and pay back period of 1.78 years. Hence, these combinations are more suitable than any other building combinations for rooftop rainwater harvesting systems. All hostel buildings combination and all residential blocks combination buildings can generate 34,48,464 and 40,92,611 litres of water per annum, respectively. Due to rooftop rainwater harvesting a sum of Rs. 1,03,454 and Rs. 1,22,778 per annum would be saved from all hostels and all residential blocks combination which otherwise could be incurred from transporting water from tanker to these buildings combinations and a computer program 'C programs' were developed for water budget calculation and design of rooftop rainwater harvesting structure for residential and hostel buildings

Key words : Rainwater harvesting, Rooftop rainwater harvesting, Cost analysis

How to cite this Article : Rajakumar, R.H., Natarajan, P., Shivanand, H.K. and Madhusudhan, M.S. (2012). Study on cost analysis of rooftop rainwater harvesting in residential premises. *Engg. & Tech. in India,* **3**(1&2) : 52-54.

Article Chronicle : Received : *08.02.2012;* **Revised :** *21.02.2012;* **Accepted :** *12.03.2012*

INTRODUCTION

Water is an essential and vital component of our life. Every living cell is water dependent and water sustained. All human activities are predicted upon the availability of water. Water is omnipresent; its existence is a fundamental assumption. Water is considered to be a free commodity-a substance to be taken, used and disposed-without a thought that it is becoming valuable. Water shortage is the gift of 20th century to the 21st century, which incidentally is also the beginning of the new millennium. Horrible predictions are being made regarding the water problems being faced by the mankind during the next 50 years. The global water crisis will reach unprecedented levels in the years ahead with growing per capita scarcity of water in many parts of the developing world. Water resources are steadily declining because of population growth and climate change. Water supplies are falling while the demand is dramatically growing at an unsustainable rate (Gopinath, 2000).

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EXPERIMENTAL PROCEDURE

Study was conducted to study the cost analysis of rooftop rainwater harvesting system in residential premises based on rainfall analysis, at Tamil Nadu Agricultural University, Campus in Coimbatore.

Experimental site:

For designing roof top rainwater harvesting structures, residential buildings 'B' C' and 'D' type, P.G. Hostel, P.P.C. Hostel and Tamizhagam Hostel were selected and the area was located in the southern side of the TNAU campus. The TNAU campus was located at latitude of 11° N, longitude of 77 °E and altitude of 426.72 m (above MSL). The average annual rainfall

of TNAU campus was 677.8 mm (35 years average).

Description of the study area:

To provide rainwater harvesting structures some houses of 'B', 'C' and 'D' type residential blocks. P.G., P.P.C and Tamizagam hostels were selected. The residential blocks were located just beside of P.G hostel building. All these buildings have same structural framework which is in the form of gabled type, provided with Mangalore tiled roof with a slope of 35° and the P.G hostel was a three storied building with flat terrace roof surface. The water to this hostel is being supplied from a circular overhead tank which is situated at the backside of the P.P.C hostel. The water is being pumped from a tube well located at the backside of the Tamizhagam hostel. The P.P.C hostel was consisted of a two storied building, which has a flat terrace roof but Tamizhagam hostel was consisted of a three storied building, which has flat terrace roof. The description of buildings are given in Table A.

Table A : Particulars of persons and roof areas of the buildings in different blocks in TNAU Campus, Coimbatore

Sr. No.	Blocks	Buildings	No. of persons	Total roof area m^2
1.	I	Quarters: B 6-7	10	397
2.	II	Quarters: B 8-9	12	397
3.	III	Quarters: B 10-11	10	397
4.	IV	Quarters: C 8-13	24	856
5.	V	Quarters: C 14-19	25	856
6.	VI	Quarters: C 40-45	24	856
7.	VII	Quarters: C 46-51	28	856
8.	VIII	Quarters: D 1-8	22	812
9.	IX	Quarters: D 17-24	21	812
10.	X	Quarters: D 25-32	20	812
11.	XI	P.G Hostel	162	1,532
12.	XII	P.P.C Hostel	98	1,138
13.	XIII	Tamizhagam Hostel	261	3,272
14.	XIV	All Hostels	521	5942
15.	XV	All residential	194	7051
16.	XVI	All Hostels and all residential	715	12993

Cost benefit analysis:

The total initial cost incurred in the installation process of the rooftop rainwater harvesting for individual buildings, combination of all hostel buildings, combination of all residential buildings and combination of all hostel with residential buildings were calculated and the expected life of all structures were taken as 25 years. The total savings after the installation of these systems were also calculated per year. To examine the economic feasibility of investment in rooftop rainwater harvesting the pay back period, benefit cost ratio and net present worth methods were used.

Pay back period:

The pay back period was the length of time required to recover the initial cash outlay of the project and it is calculated as

Pay back period= Initial cash outlay or investment / Constant annual cash inflow

According to this pay back criterion, the shorter the pay back period, the more desirable the project would be.

Benefit-cost ratio:

This ratio is calculated by dividing present worth of the discounted benefit to the present worth of the discounted cost

$$\text{BC ratio} = \frac{\sum_{t=1}^{n} Bt\,(1+i)^{-t}}{\sum_{t=1}^{n} Ct\,(1+i)^{-t}}$$

where,

Bt = benefit in t^{th} year

Ct = cost in t^{th} year

i = discount rate.

Net present worth:

This is the present worth incremental net benefit or incremental cash flow stream and it was calculated as

$$NPW = \sum_{t=1}^{n} Bt\,(1+i)^{-t} - \sum_{t=1}^{n} Ct\,(1+i)^{-t}$$

Water budgeting studies:

For the water budgeting analysis, the individual buildings of P.G hostel, P.P.C hostel, Tamizhagam hostel and residential blocks of 'B' 'C' 'D' type were selected and the weekly demand and supplies for these buildings were arrived at during the study period.

Therefore, the C programs were developed for water budget calculation and design of rooftop rainwater harvesting structure for residential and hostel buildings

EXPERIMENTAL FINDINGS AND ANALYSIS

The results of the present study as well as relevant discussion have been summarized under following heads:

Cost analysis:

The total quantity of different materials required and total costs for the installation of the structure for individual buildings B block, C block, D block, P.G hostel, P.P.C hostel and Tamizhagam hostel the total investment required were Rs. 16,513, Rs. 28,205, Rs. 28,581, Rs. 37,014, Rs 32,545 and Rs. 61,095, respectively. For combination of all hostels, all residential blocks and all hostels with all residential blocks, the investment required were Rs. 1,03,731, Rs. 1,53,009 and Rs. 2,30,695.5,

Table 1 : Pay back period, BC ratio and net present worth for different buildings

Sr. No.	Building	Pay back period	BC ratio	Net present worth (Rs)	Investment (Rs)	Benefit from RTRWH (Rs)
1.	B 6-7	5.59	1.18	8424.88	16513	6917
2.	B 8-9	5.59	1.18	8424.88	16513	6917
3.	B 10-11	5.59	1.18	8424.88	16513	6917
4.	C 8-13	3.47	1.49	38636.59	28205	14906
5.	C 14-19	3.47	1.49	38636.59	28205	14906
6.	C 40-45	3.47	1.49	38636.59	28205	14906
7.	C 46-51	3.47	1.49	38636.59	28205	14906
8.	D 1-8	3.45	1.55	39383.23	28581	14134
9.	D 17-24	3.45	1.55	39383.23	28581	14134
10.	D 25-32	3.45	1.55	39383.23	28581	14134
11.	P.G	2.08	2.04	106512.6	37014	26677
12.	P.P.C	2.71	1.72	65036.1	32545	19808
13.	Tamizhagam	1.44	2.64	277262.7	61095	56969
14.	All hostels	1.32	2.82	523532.2	103731	103454
15.	All residential	1.78	2.27	538334	153009	122778
16.	All hostels and all residential	1.35	2.77	1134139	230695.5	226232

respectively.

Benefit cost ratio:

From the Table 1. It was observed that the benefit cost ratios for the individual residents in B blocks, C blocks and D blocks were 1.18, 1.49 and 1.55 respectively and for individual hostel buildings, P.G, P.P.C and Tamizhagam hostels, the ratios were 2.04, 1.72 and 2.64, respectively. For different combination of buildings such as all hostels, all residential and combination of all residential with all hostels the ratios were 2.82, 2.27 and 2.77, respectively. It was observed that the benefit cost ratio was higher in case of combination of all hostel building compared to individual buildigs.

It was found that as the benefit cost ratio increased the pay back period decreased. The pay back periods for B blocks, C blocks and D blocks were 5.59, 3.47 and 3.45 years, respectively and for hostels P.G, P.P.C and Tamizhagam the periods were 2.08, 2.71 and 1.44 years, respectively. For different combination of buildings such as all hostels, all residential blocks and combining all residential blocks with all hostels the periods were obtained as 1.32, 1.78 and 1.35 years, respectively. In case of individual buildings the pay back period was less for Tamizhagam hostel as compared with all other individual buildings because of more roof area and it was also observed that the pay back period was less for all hostel combination as compared to all buildings in combination.

The total investment verses pay back period graph was plotted which is shown in Fig. 1 and it was observed that as the investment increased the pay back period decreased (Table 3).

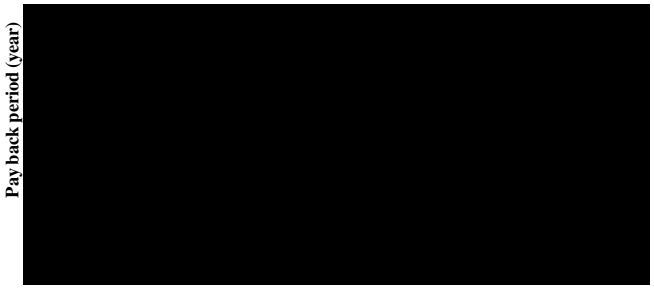

Fig. 1 : Pay back period for different investments

Development of C programs:

It is felt that calculation of different specifications for rooftop water harvesting system is laborious. It will be convenient to estimate the specifications, if we develop computer program. Therefore, the C programs were developed for water budget calculation and design of rooftop rainwater harvesting structure for residential and hostel buildings. Gould (1996 and 2000) has made some investigations on rain water utilization.

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