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Life Cycle Cost Analysis- A Decision Making Tool for Implementation of Green Infrastructure Projects

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***Abstract*— The sustainable infrastructure is the need of the next generations. There is no definite tool to give exact streamlined decision for the feasibility of the any project. Day by day, the depletion of environment due to construction activities is increasing. A solution to these crises is the construction of green structures which have minimal impact on the environment. In this process of shifting from conventional to green structures, the initial investment cost of the project may tend to rise higher, however, the entire structure gives huge returns over a period of 10-15 years due to which this shift can prove to be beneficial. The purpose of this paper is to highlight the role of life cycle cost (LCC) analysis in the feasibility study of construction projects and in deciding on the proposals of infrastructure projects. A study was made on the cash flows during the construction and further the expected returns were calculated. The results obtained, highlight that the factors like construction techniques, materials, etc. influence the cost of a green building. Therefore, after a thorough study of costs incurred and the future benefits and further the analysis of life cycle cost, we can state the feasibility of a green infrastructure project. Thus providing an alternative approach as to how to achieve long term minimum value of total costs from strategic point of view.**

Keywords— Huge returns, cash flows, feasibility, strategic point of view.

I. INTRODUCTION

At the time of taking financial decision in construction projects decision maker tends to think in the short term. In large construction projects more importance is given to initial costs, with less attention to future cost. In order to improve long term decision making life cycle cost analysis is important. Purpose of life cycle cost analysis is to determine cost of project for any number of years. Life cycle cost analysis (LCCA) method consider initial cost, operation cost, energy cost, maintenance cost, repair cost and residual value to estimate cost effectively. LCCA highlights the opportunity for overall saving in the life of building that can be achieved by investing in more cost efficient solutions initially. LCCA provide future impact of decision which has been taken at the initial stage. Cost saving can be achieved by comparing alternative options. Lowest life cycle cost alternative will be the best alternative. Comparative study of various methods of LCCA shows that NPV method is more appropriate. Categorization of various costs related to construction, operation and maintenance of building are called terminologies. Following are the terminologies used while calculating LCC of a building:

1. Initial cost: Initial cost includes land acquisition cost, design cost and construction cost.
2. Operation Cost: Operational cost includes cost required for annual building utilities and services excluding maintenance and repair cost involved in the operations of facility.
3. Maintenance cost: Maintenance cost includes cost required for the maintenance of water pump, maintenance of passenger lift, annual roof inspection etc.
4. Repair costs: Repair cost includes cost required to extend the building life without replacing the system entirely
5. Replacement costs: Replacement Cost required for replacement of entire component.
6. Residual Value: Residual value is the value of the building at the end of the study period or at the life cycle period.
7. Energy costs: Energy cost includes expenses for energy and other utilities.

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II. LITERATURE REVIEW

Weerasinghe, et. al Thanuja Ramachandra and Niraj Thurairajah's paper states that, the green building investors continue to focus on minimizing construction cost and fail to appreciate the impact on life cycle economic performances. The construction cost of green buildings tends to be higher than traditional buildings, with comparatively lower operation and maintenance costs. Therefore, this study assesses the life cycle cost of green certified industrial manufacturing building and that of a conventional building to establish the impact of sustainable features on life cycle cost. The quantitative data on construction, running and end of life cycle costs of the selected green and conventional buildings were collected and analyzed using Net Present Value. The analysis shows that the construction cost of green industrial manufacturing building is about 28% higher than that of a conventional building. However, operation, maintenance and end of life cycle costs are in the range of 35 to 41%, 26 to 30% and 6 to 18% respectively lower than that of conventional building. The study found that the life cycle cost of green building is 24 to 28% less compared to conventional building. It is expected that the outcome of this research would contribute to the organizational learning of green built environment and thereby uplift the use of sustainable construction in Sri Lanka. Marketa Spickova, Renata Myskova's paper states that costs optimization is further developed not only by the pure economic theory but more with practical management. In the context of the economic crisis 2008 and the previous crises we do observe the pressure on the sophisticated cost optimization into the important strategic costs tools like Activity Based Costing, Target Costing, Life Cycle Costing. We use these methods for optimal costs management, observation, and the costs minimization. This article has described how to choose the most efficient project based on NPV. The main attention was focused on this most widely used method which is supporting the decision making. However, the authors are going to research the similar on sequences of other methods for economic evaluation and investment decision making. In general, we say that the using of mentioned methods is very helpful in practice. But there is a small paradox, because of the companies have not used them often and regularly. It is caused by a few existing limitations for instance the complexity of information and the difficulties of data collecting.

III. METHODOLOGY

Although the concept of green buildings is gradually gaining popularity in India, it has still not become an integral part of the construction industry. One of the key reasons is the general apprehension of the building industry that green buildings are not viable from a business perspective. The capital cost involved in a green building is the biggest obstacle in allowing large-scale adoption of the concept by the construction industry. To address the issue, we conducted a study to assess the economic feasibility of incorporating energy-efficient design features in buildings with reference to improvement in their energy performance. The results are arrived by calculating a cost-benefit analysis of a building in Pune. Primary data (including information on general details of the building, the envelope system, lighting system, electrical system and water consumption) was collected. Future streams of costs arising from owning, operating, and maintaining, as well as the benefits arising from energy savings, were also evaluated. To conduct a comparative analysis of life cycle cost of green building with that of a conventional building, a benchmark (referred to as conventional case) was established. Financial tools such as payback period, life cycle cost and savings-to-investment ratio were used to assess the economic viability of additional investments made towards improving their energy performance.

Proposed building specification:
No. of flats- 6
No. of floors- 3
No. of occupants- 24

A. Calculations for Energy consumption in Conventional building:

Items	Wattage	Nos.	Approx.Working hours per day	Energy consumption (wh/day)
Incandescent lamps	60	36	8	17280

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Fluorescent tubes in Flats	40	21	8	6720
Fluorescent tubes in common area	40	3	12	4440
Fan	70	21	10	14700
Computers	100-200	6	3	2700
Refrigerators	225-500	6	20	43500
T.V.	210-400	6	5	9150
Microwave	800-1000	6	1	5400
Heater/ Geyser	1000 - 1500	9	1	11250
Mixer	150-450	6	0.5	900
Iron	40-60	6	0.5	150
Washing Machine	600-800	6	2	8400
Radio	50-200	6	1	750
DVD	80-85	6	2	990
AC	1200	6	8	57600
Total				183930

Monthly consumption = 5701.83 kWh

Total electricity bill in Rs:
Fixed charge = 10 Rs × 21 rooms = Rs. 210
Energy charge = 5701.83 × 3.6 = Rs. 20526.588
Meter charge = 20 × 21 = Rs.420

Total electricity bill = 210+ 23104.548+ 240= Rs.20976.588

B. Calculations for Energy consumption in Green building:

Table No. 2

Items	Wattage	Nos.	Approx.Working hours per day	Energy consumption (wh/day)
Incandescent lamps	15	36	8	4320
Fluorescent tubes in Flats	35	21	8	5880
Fluorescent tubes in common area	35	3	12	1260
Fan	60	21	10	12600
Computers	100-200	6	3	2700
Refrigerators	225-500	6	20	43500
T.V.	210-400	6	5	9150
Microwave	800-1000	6	1	5400
Heater/ Geyser	1000-1500	9	1	11250
Mixer	150-450	6	0.5	900
Iron	40	6	0.5	120
Washing Machine	600-800	6	2	8400
Radio	50-200	6	1	750
DVD	80-85	6	2	990
Total				107220

Monthly consumption=3323.82kWh
Total electricity bill in Rs:
Fixed charge = 10 Rs × 21 room = Rs. 210

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Energy charge = 3323.82 × 3.6 = 11965.752
Meter charge = 20 × 21 = Rs.420

Total electricity bill = 210+ 11965.752+ 240= Rs.12415.752

Total cost saving = 20976.588-12415.752= Rs. 8560/-

i. Installation of Solar panels:
Solar panels are provided to meet 100% demand for energy.
4 solar units of 5kW each are required to meet the requirement of the building considered.
Cost of one solar unit= Rs.6,00,000
Total cost= 600000 x 4 = 24,00,000

ii. Use of Passive architecture:
This method ensures natural ventilation and thus cuts down the need for AC and lighting.

C. Calculations for Water Consumption:
Per capita consumption= 150 litres/day
Occupants= 6*4= 24
Monthly consumption= 24 x 150 x 30 = 108000 litres
Car wash = 6 x 6000 = 36000 litres
Gardening=120 litres x 25 m2= 3000 litres
Total requirement= 108000 + 36000 + 3000 = 1,47,000 litres

i. Installation of Natural Water treatment plant:
Recycled water= 0.8*108000= 86400 litres (Used for flushing, car wash and gardening)
Cost of Water as per PMC regulations = Rs. 5 per 1000 litres
Water saving= 86400 x 5 = Rs.432/ month

D. Using Lime bricks instead of conventional bricks:
Approx. bricks required = 125000 nos.
Total cost of conventional bricks= Rs. 7/ unit x 125000 = Rs.875000/-
Total cost of lime bricks= Rs. 4/ unit x 125000 = Rs.500000/-
Total cost saving = Rs. 375000/-

Evaluation criteria:
Duration considered= 25 years

Table no. 3

Type of cost		Type of Building	
		Conventional	Green
Initial investment	Cost of Construction	1,00,00,000/-	96,25,000/-
	Solar panels	--	24,00,000/-
Yearly Energy		251719.056/-	14400/-
Yearly Water		8820/-	3636/-
Maintenance		72000/-	82000/-

Table no. 4

Year	Conventional	Green
0	10000000	12025000
1	10260539.06	12125036
2	10593078.11	12225072
3	10925617.17	12325108
4	11258156.22	12425144
5	11590695.28	12525180
6	11923234.33	12625216
7	12255773.39	12725252
8	12588312.44	12825288
9	12920851.5	12925324
10	13253390.55	13025360
11	13585929.61	13125396
12	13918468.66	13225432
13	14251007.72	13325468
14	14583546.77	13425504
15	14916085.83	13525540
16	15248624.88	13625576
17	15581163.94	13725612
18	15913702.99	13825648
19	16246242.05	13925684
20	16578781.1	14025720
21	16911320.16	14125756
22	17243859.21	14225792
23	17576398.27	14325828
24	17908937.32	14425864
25	18241476.38	14525900

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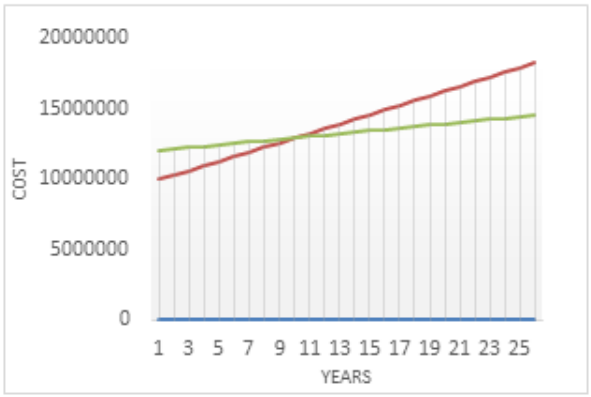
Graph No. 1



Results for Green building:
Net benefit value= Rs. 3715573.38 (20% savings)
Savings to investment ratio= 0.308 (which is zero for proposed conventional building)
Life cycle cost= Rs. 1,45,25,900/-

IV. CONCLUSION

From the above analysis and evaluation, we found out that the life cycle cost of the green building is Rs. 1,45,25,900and that of conventional building is Rs. 1,82,41,476.38, which is 125% greater than the Green building. It was also observed that the breakeven point of the green building is obtained in 9.5 years. The results prove that investing in green buildings is a profitable venture. Strategies that are integrated in the building and services design, and energy-efficient equipments installed to improve the energy performance of buildings, contribute towards the high initial investment as compared to conventional buildings. The graph no. 1 illustrates that, though the initial costs are high, the returns are significant in the long run. Getting to an equilibrium between the level of energy efficiency and life cycle costs serves as a challenge for the decision making process. Using LCC analysis as a decision support for investors in the early building design stages continues to resolve many difficulties and helps the investors to rely upon the green buildings than the conventional buildings. The decision makers and project managers, can analyze this breakeven point and optimize the investments and can plan the structures strategically giving excellent benefits in all sectors of construction industry.

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