# Analysis of Life Cycle Cost

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***Abstract-*** Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs of the project incurred over its life period are considered to be potentially important to design decision. LCCA is particularly suitable for the evaluation of building design alternatives that satisfy a required level of building performance, but that may have different initial investment costs; different operating, maintenance, and repair costs. However, LCCA can be applied to any investment decision in which higher initial costs are traded for reduced future cost obligations. Paper develops the methodology for the life cycle cost analysis for residential building. From this study we found out that the energy efficiency approach can significantly reduce the building lifecycle cost. Thus LCCA provides a better assessment of the long-term cost effectiveness of a project.

***Keywords-*** *assessment, building, cost, efficiency, energy*

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## I. INTRODUCTION

Life Cycle Costing (LCC) is defined in ISO 15686-5 as an "economic assessment considering all agreed projected significant and relevant cost flows over a period of analysis expressed in monetary value. The projected costs are those needed to achieve defined levels of performance, including reliability, safety and availability" (ISO, 2008).

Life Cycle Costs Analysis (LCCA) is an economic assessment of an item over its lifespan, expressed in terms of equivalent costs, using baselines identical to those used for the initial costs. A LCCA is used to compare various options by identifying and assessing economic impacts over the life of each option (Dell'Isola and Kirk, 1995).

One of the most basic concepts of economical decision making is that the value of the amount of money to be received in the future depends on the time of receipt or disbursement of the cash. That is to say that money in hand today is value more than money that is expected to be earned in the future. This concept to be valid needs a positive rate of interest that can invest the funds. Life Cycle Costing (LCC) was originally designed for investment purposes in the U.S. Department of Defence. The importance of LCC for the U.S. Department of Defence was shown by the fact that the operational costs regarding to weapon systems, where 75% of the total life cycle costs. Life cycle cost optimization can be carried out through the detail design by different disciplines. Those discipline could be structural design optimization, mechanical (HVAC design, elevator design etc), electrical design and architectural design (building envelope) design. The present dissertation report focuses on the architectural aspect of the life cycle cost optimization of the building.

Residential buildings of RCC framework are built to last for four to five decades or more. Over such a long lifetime, a building utilizes a range of resources and energy intensive processes. Annual cooling, heating and lighting energy and the maintenance have a significant ongoing economic cost. And therefore judging the building economics on the basis of its initial cost is not an economically good option. The life cycle thinking helps to find out the solutions in building designs which will help to reduce future costs of the building with keeping in mind the time value of money. This study investigates the influence of building energy consumption and building life cycle economy on the selection of building envelope materials with different thermal properties. For that, the case study building and chosen alternative envelope designs are modelled using Revit architect 2014 software, and then is run for energy simulation in Autodesk green building studio to find out its annual energy consumption and there economy is checked by using the net present value method .

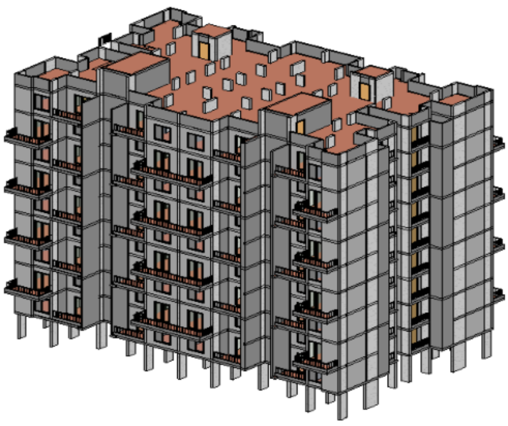


Fig.1 Building model in Revit architect

The NPV is the sum of the discounted future cash flows, both costs and benefits. NPV is a standard measure in LCC analyses, used to determine and compare the cost effectiveness of proposed options. It can be applied across the full range of construction investments, covering whole investment programmes, systems, components and operating and maintenance models. The costs and revenues/benefits to be included in each analysis are defined according to its objectives. For example, revenues from surplus energy generation are typically included in a LCC analysis of alternative sustainability options (Langdon, D. 2007).

## II. METHODOLOGY

The methodology includes study of real life construction project of residential building as base project for this research. The base project refers to a multi storied residential building located in Pune, India. The building location map is shown in figure 4.1. Pune is located at the Coordinates of 18°32'' North latitude 73°51''East longitude on the west Maharashtra.

The rooms are the basis for energy analytical spaces, for these spaces the energy consumption will be calculated by the software. After this the building type is assigned to the multifamily building. Location is defined as Pune, India. Revits internet mapping system automatically then loads the Pune weather data file which will be used for the energy simulation. The weather data file contains the annual weather data which include the hourly 1) Dry bulb temperature, 2) Wet bulb temperature, 3) Humidity, 4) Direct and diffused solar heat intensity. The single day solar path is as shown in figure 2 and annual solar path is shown in figure 3. After this the building operating schedule is defined to the 24/7 facility. After doing above settings, we run the energy simulation, in the first step software produces energy analytical model as shown in figure 2, which is then exported to the cloud based energy simulation software Green Building Studio, which yields the final results that is, the building energy consumption.

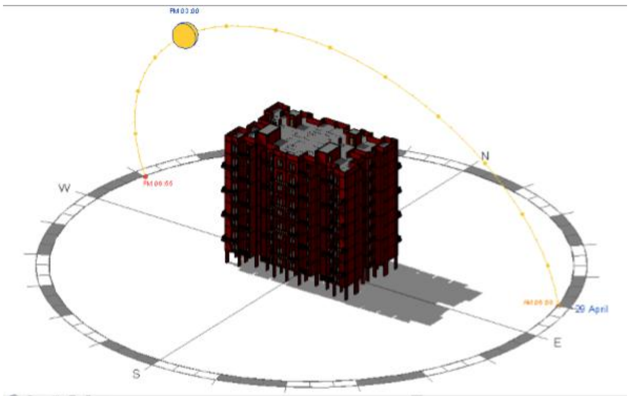



Fig.2 Sun path of single day

Once the annual energy consumption is obtained from the energy simulation, the cost of annual energy use is calculated by multiplying the annual energy units by the unit cost of electricity, this unit cost of electricity is obtained from the regional energy cost data (www.mahadiscom.com). Then the energy cost for the life period of 50 years is calculated by net present value method for the base case and each of the modification/alteration cases.

First the life cycle cost for each of the elements is calculated using net present value method. Then by subtracting life cycle cost of modification per square feet for each of element from the base case gives cost of modification per square feet. Multiplying it by its total area gives the total cost of modification for that system.

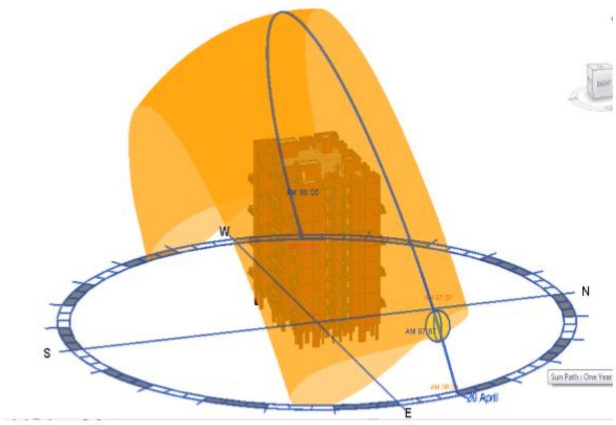



Fig.3 Sun path over the period of one year

Net savings over the base case is the savings in life cycle cost. To obtain it we first get the savings in energy cost over the base case, it is calculated by subtracting the life cycle energy cost of each of the study case from the base case, and then from this savings over the base case, the total cost of systems alteration/modification is subtracted. This value of net savings is the proof of the optimality of the design decision.

Risk assessment is carried out by using the method of sensitivity analysis, it is useful as the economic parameters like interest rates and inflation rates that are used for the future calculation has tendency to get varied with time due to market uncertainty. Also life period for which building will be used may also get varied. And therefore in present project the parameters viz., inflation rates, interest rates and the life period of building are varied one at a time by keeping other parameters constant. The variation in the values is achieved by reducing first by 10% and then by 20 % and after this increasing by 10% and then 20% of the base case, and thus the range of 40% variation is achieved. By varying these parameters one at a time the life cycle energy cost for each of the case is calculated. Savings in energy cost over the base case is obtained and then, net savings are found out by subtracting the extra cost of modification (by taking variations in economic parameters into consideration) from the energy cost savings.

The present building is designed for a ground floor and nine floors above ground floor. The ground floor is used as common parking space. Each floor has eight homes. Six homes of three rooms and two homes of four rooms. There are two lifts and two staircases. It is a RCC frame work, walls filled with cement bricks and windows of single pane clear glass.

Fig. 4 Energy analytical surfaces

## III. RESULTS & ANAYSIS

After modelling in Revit 2014, the building is simulated with the help of cloud based building energy software Green Building Studio to provide a wide variety of energy use data. The results of simulation are as follow. Figure 5 gives the annual solar energy consumption, the energy consumption by HVAC and lighting only is considered for further calculations, the energy consumption of misc equipments is not considered. The costs of energy given by Revit are not used instead the local energy costs are used for the energy calculations. Figure 6 & figure 7 gives the cooling and heating load for the building and also of individual building system, these acts as a basis for the selection of the system to be modified.

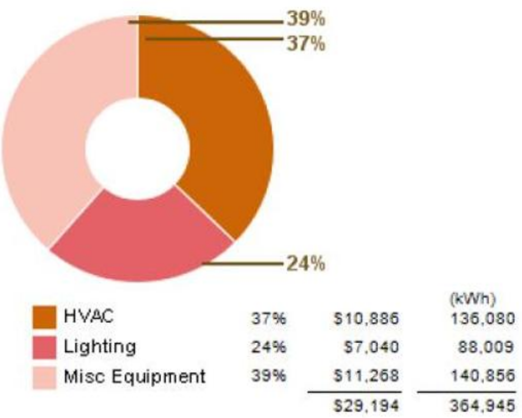



Fig.5 Energy Use: Electricity

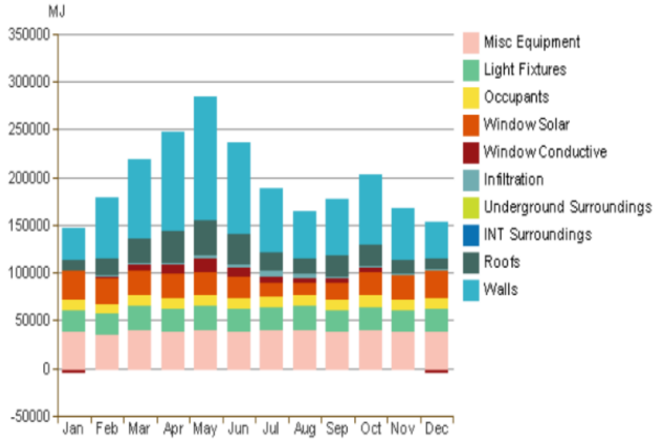



Fig.6 Monthly cooling loads

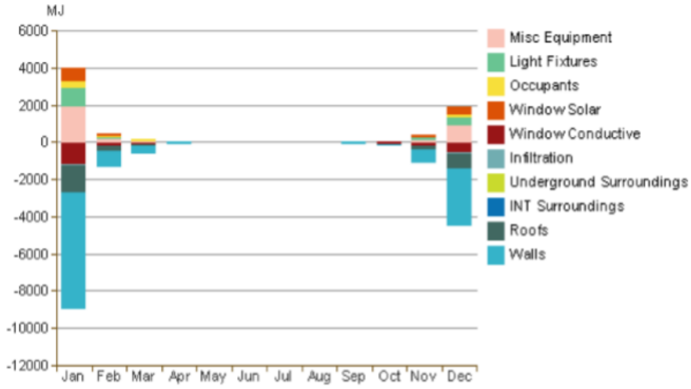
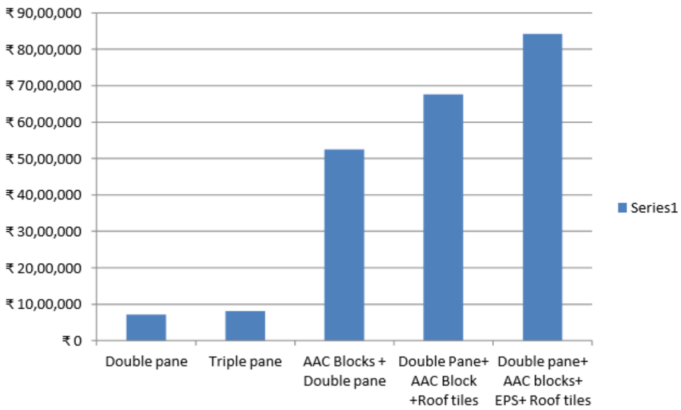



Fig. 7 Monthly heating loads




Graph 1.Savings in energy cost over base case

Table 1.Net savings over the base case

| Cases | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Net savings over base case | - | Rs. 0.29 M | -Rs. 0.136 M | Rs. 4.55 M | Rs. 5.56 M | Rs. 6.20 M |

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Table 2.Life cycle energy cost & saving over base case

| Cases | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| NPV of energy life cycle cost (n=50) | Rs. 59.864 M | Rs. 59.149 M | Rs. 59.054 M | Rs. 54.612 M | Rs. 53.101 M | Rs. 51.44 M |
| Savings over the base case | - | Rs. 0.715 M | Rs. 0.81 M | Rs. 5.253 M | Rs. 6.764 M | Rs. 8.44 M |

Case 6 has the highest LCC saving for all life periods rates. Triple pane that is case two has negative values of LCC savings for all life periods. LCC savings increases with increase in life period. At lower life periods, net savings difference between case 5 and case 6 get decreased. The pattern of variation of LCC savings for double and triple pane windows is not linear.

## IV. CONCLUSION

From the present study we found out that the energy efficiency approach can significantly reduce the building lifecycle cost. Simple modifications and alterations in the building system can help to reduce building energy consumption, without affecting the aesthetics and objectives it has to serve. Except alteration by triple pane window, all other alterations and modifications have shown positive net LCC saving. The highest potential of energy saving is found out by alteration in wall system, with simply changing it with AAC blocks. Building materials thermal properties and its cost should be carefully studied while taking any design decision regarding building systems. From sensitivity analysis we found out that, for all variations in economic parameters, case 6 has the highest energy saving potential. The pattern of variation of LCC savings with variation in economic parameter may not be linear.

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