LIFE COST CYCLE ANALYSIS

[1]Prashant V Suryawanshi,[2] P D Aher
[1]ME Student,[2]Asst. Professor,
[1]ME Civil Engineering NDMVP Nashik, India.
[1] Civil Engineering NDMVP Nashik, India.

Abstract : Life cycle cost (LCC) is an important technique for evaluating the total cost of ownership between mutually exclusive alternatives. Life-cycle cost analysis (LCCA) is an economic method of project evaluation in which all costs arising from owning, operating, maintaining, and ultimately disposing of a project are considered to be potentially important to that decision. LCCA is particularly suitable for the evaluation of building design alternatives that satisfy a required level of building performance (including occupant comfort, safety, adherence to building codes and engineering standards, system reliability, and even aesthetic considerations), but that may have different initial investment costs; different operating, maintenance, and repair (OM&R) costs (including energy and water usage); and possibly different lives. However, LCCA can be applied to any capital investment decision in which higher initial costs are traded for reduced future cost obligations. LCCA provides a significantly better assessment of the long-term cost effectiveness of a project than alternative economic methods that focus only on first costs or on operating-related costs in the short run.

I. INTRODUCTION

There are different terms used in the literature today like, “cost in use”, “life cycle costs” (LCC), “whole life costing” (WLC) and “whole life appraisal” (WLA). Where (Flanagan and Jewell, 2005) defined that the terminology has changed over the years from “cost in use” to “life cycle costing” and further to “whole life costing”. They defined the new term “whole life appraisal” which is globally used today and which contains consideration of the cost benefits and performance of the facility/ asset over its lifetime.

The draft of the ISO Standard 15686-5 (ISO, 2005) instead makes a difference between the expressions WLC and LCC. Their contention is that WLC is equivalent to LCC plus external cost. Even there it is admitted that sometimes all terms are used interchangeably, but the ISO Standard does try to interpret those terms more narrowly. The Standard states that LCC should be used to describe a limited analysis of a few components where instead “life cycle costing” should be understand as the cost calculations themselves and WLC should seen as a broader term, which covers a wide range of analysis. The Norwegian Standard 3454 (Ns, 2000) defined LCC as including both original costs and cost incurred throughout the whole functional lifetime including demolition.

According to the design selection of good construction materials that can lower or eliminate replacement or repair during future maintenance and operation will help in lowering overall costs. Owners of buildings and designers often recognize that thereare possibilities of trade-offs between initial costs and recurring costs. They are also aware that the decision about the building design, construction, maintenance and operation can be made in principle so that the building performs well over a specified period of time with minimum total costs.

1.1 OBJECTIVES OF PROJECT:

1. To study in detail concept of life cost analysis in building.
2. To analyze life cycle cost of building by actual case study of old building and interpolating using Net Present value method to determine LCC of new building.
3. To provide necessary suggestions energy efficient options to reduce the LCC of New building.
4. Results and recommendations based on above study.

II. METHODOLOGY:

2.1 Life Cycle Cost analysis (LCCA) is defined as an estimation of the monetary costs of the funding, design, construction, operation, maintenance and repair, component replacement and sometimes demolition of a building. It may be applied to new designs or to existing structures, in the latter case enabling residual life and value to be estimated. LCCA relies on predicting when elements of the building and its services will deteriorate to a condition where intervention is needed, and what the discounted cost of each intervention will be.

Life Cycle Cost using Net Present Value method

$$LCCNPV = Ct / (1 + r)t \quad (1)$$

Where, Ct – Cost in the year t

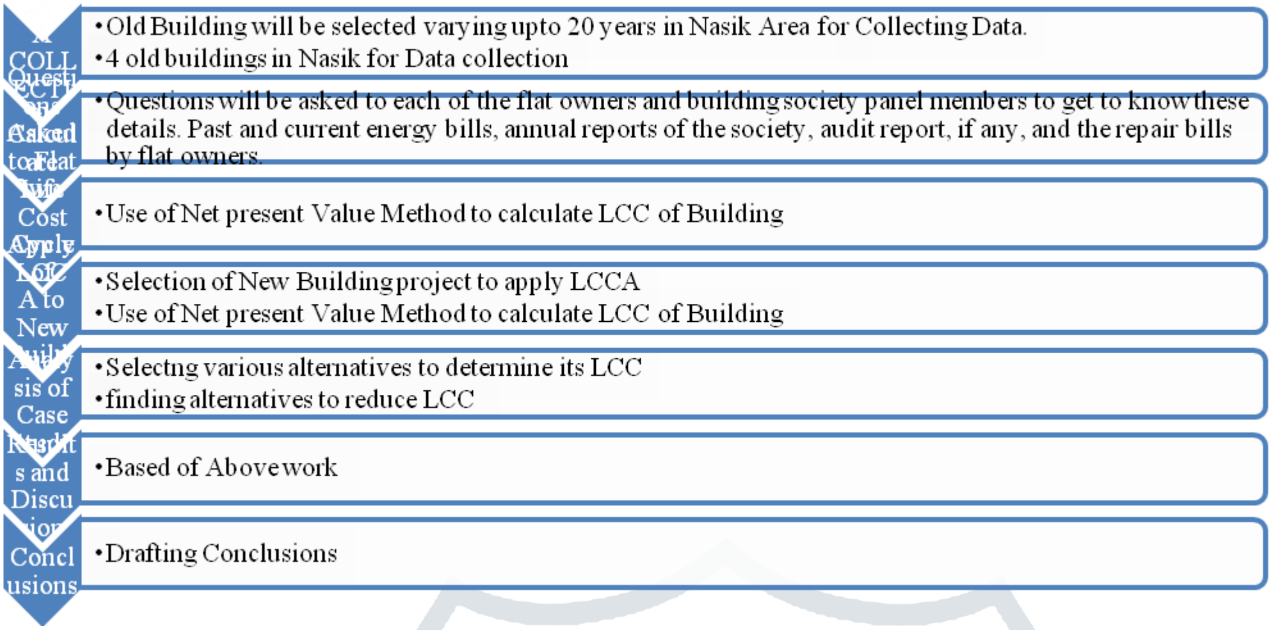
r – discount rate is calculated as follows

$$(1 + r) = (1 + \text{interest rate}) / (1+ \text{inflation rate}) \quad (2)$$

LCCA for OLD Building

Old Building will be selected varying upto 20 years in Nasik Area,

Questions will be asked to each of the flat owners and building society panel members to get to know these details. Past and current energy bills, annual reports of the society, audit report, if any, and the repair bills by flat owners.



Flow of Methodology

2.2 Net Present Value

The net present value (NPV) "is the difference between the present value of all cash inflows and outflows of a project". The NPV technique not only allows the selection of a single project based on the NPV but also a selection of the most economical choice of the project from a list of more than one alternative projects.

Net present value can be calculated using the Equation

$$NPV = \frac{A_0}{(1+i)^0} + \frac{A_1}{(1+i)^1} + \frac{A_2}{(1+i)^2} \dots \dots \dots + \frac{A_n}{(1+i)^n}$$

$$= \sum_{n=o}^{N} \frac{An}{(1+i)^n}, \qquad = \sum_{n=o}^{N} An(P/F, i, n)$$

Where:

NPV is a stream of cash flows over the life of the project,

An is net cash flow at the end of period "n",

i is the discount rate,

n is service life of the project.

A positive NPV means it promises a return greater than the required rate of return, so the project makes a profit. Therefore, if the NPV of a prospective project is positive, it should be accepted. A negative NPV means it promises a return less than the required rate of return, the project should probably be rejected, as the following decision rules:

If NPV greater than 0, accept the investment.

If NPV equal 0, remain indifferent.

If NPV less than 0, reject the investment.

III. THEORETICAL CONTENTS:

3.1 Concept Of Value Management

The purpose of applying value management is achieving best value for project or process by identifying those functions required to achieve the value objectives and to provide those functions at lowest cost (total life cost or resource use), consistent with the required quality and performance; saving time, money and energy; simplifying methods and procedures; removing unnecessary expenditure.

3.2 Comparisons of Value Engineering & Value Management

Table 3.1 Showing Comparison of Value Management and Value Engineering

	Value Management	**Value Management**
Definition	Value Management "is an organized work for best value and cost of project without ignoring the optimal performance levels. It is an inspired way of team working to accomplish clients and stakeholder's needs"	Value Engineering "is a management technique using a systematic approach to achieve the functional balance between cost, and performance of a product"
Objective	to maximize functional value of a project	To achieve the necessary functions for minimum cost of project
Subjects for discussion	Project proposal	existing design Existing design
Timing of application	From the concept to occupancy of the project	During design and construction stage
Value improving approach	It integrates client's subjective and objective value criteria	It generally assumes that value can be improved by reducing cost
Best solution	It decides on the best solution based on client's value system	The best solution, usually, is the most economical

3.3 Value Management Techniques

3.3.1. Function Analysis Method

Functional Analysis (FA) is a specific technique or methodology used to establish objectives and to eliminate uncertainty. Functional analysis is a powerful technique in the identification of the key functional requirements of a project. However, the techniques for diagramming or other forms of representation lie within the skills and experience of the value manager.

3.3.2. Function Analysis System Technique (FAST)

The technique is described as having aprimary function representing client need and four supporting functions representing client wants, namely: ensuring comfort, ensure dependability, satisfy user and attract user and gives a well explanation of the relations of function and cost (Miles, 1989).

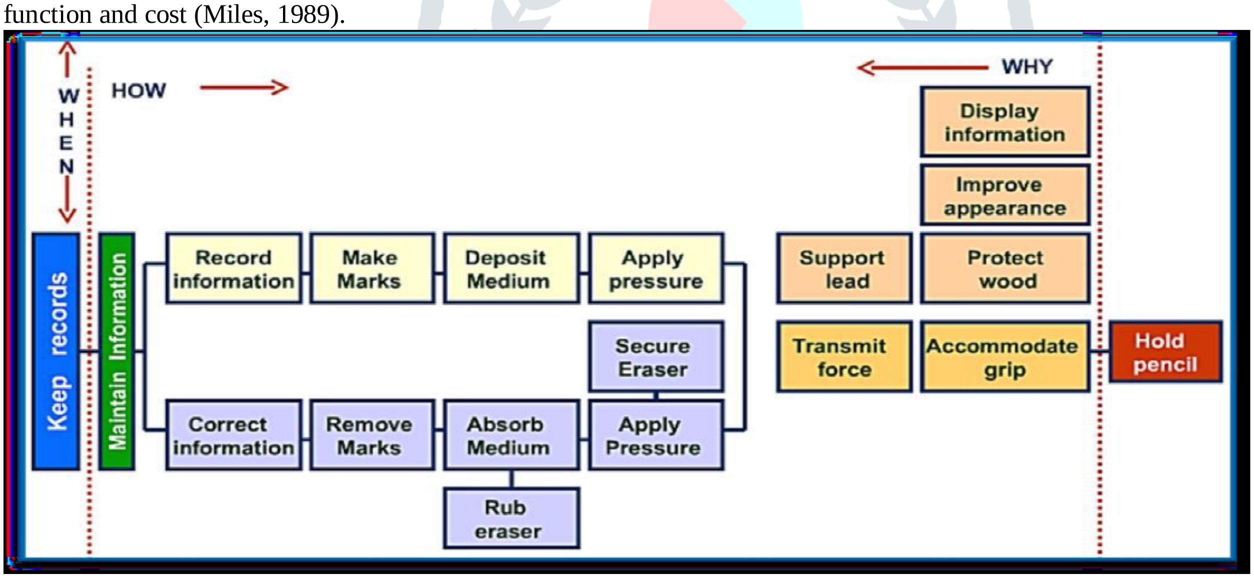


Figure3.1- FAST diagram for a pencil

FAST diagrams help to:
1. Define and understand customer needs and requirements.
2. Promote discussion and team interaction.
3. Establish boundaries for the scope of the problem.
4. Support the process of generating creative alternative solutions (Crow, 2002).

Many important points are associated with life cycle costing, some of which include:

- The main goal of life cycle costing is to get the maximum income (profit) from limited resources.
- The management plays a key role in making life cycle costing a worth for the effort.
- In general risk management is the heart of life cycle costing.
- The availability of good data is very important for good life cycle cost estimates.
- The life cycle cost model must contain all program-related costs.
- There is a sure need for both the product manufacturer and the user to organize successfully to control life cycle cost.

- There is a definite need to perform trade-offs among life cycle cost, design tocost, and performance throughout the life of the program.
- Some surprises may still occur, even when the estimator is very competent.
- Life cycle costing is gaining importance as a method for performing design optimization, making strategic decisions, conducting detailed trade-off studies, etc.
- A highly knowledgeable and experienced cost analyst may compensate for various database-related difficulties.

IV. DATA COLLECTION AND ANALYSIS

4.1 Data Collection

Case study is conducted in Two Parts, initially old buildings are considered to collect the data required for case study then data is useand apply Net Present value Technique and find the present value and its worth in investing.

4.2 Case Studies:

Selecting 4 old buildings in Nasik of age 15 to 30 years.Asking questions to occupants about Past and current energy bills, annual reports of the society, audit report, if any, and the repair bills by flat owners were referred to.

General details of Buildings selected are tabulated as shown below:

Particulars	Building 1	Building 2	Building 3	Building 4
Name of Building	NachiketaAppt	ChaitanyaSco.	Susangat Society	Shreya Appt.
Address	Nashik, Maharashtra	Nashik, Maharashtra	Nashik, Maharashtra	Nashik, Maharashtra
Number of Floors	4	3	2	3
Year of Construction	2000	2002	2000	2000
Age of Building	16	14	16	16
Number of Flats	16	9	14	10
Respondents	7	5	8	5

Summary Table of Responses after collecting data is tabulated below:

Sr. NO.	Building Name		OPERATION AND MAINTENANCE FACTORS					
		Age of Building	Waterproofing	Colouring	Electrical Operations	Plumbing/Drainage	Repairing	Water Bills
		Years	Non Annual (in Rs.)	Non Annual (in Rs.)	Annual (inRs.)	Non Annual (inRs.)	Annual (inRs.)	Annual (inRs.)
1	NachiketaAppt	16	20000	100000	20000	19000	17000	14000
2	ChaitanyaSco.	14	17000	65000	14000	18000	19000	15000
3	Susangat Society	16	19000	90000	29000	17000	18000	16000
4	Shreya Appt.	16	23000	150000	10000	20000	100000	15000

LIFE COST CYCLE ANALYSIS APPLIED TO NEW BUILDING

Data collected from old building as tabulated above is utilized to Determine life cost cycle analysis of new building, regarding this formulation is done in spreadsheet and basic data sheet and result sheet is given showing the present value with and without actual cost both of respective sheet are as shown below:

LIFE CYCLE COST ANALYSIS			
DATA FOR PROJECT.		Proposed Construction at Nashik	
	CONSTRUCTION YEAR	2017	
	ECONOMIC LIFE	50	Years
	INFLATION RATE	8.0%	%
CAPITAL INVESTMENT			
	CAPITAL	INR 2,000,000	
ANNUAL OPERATING COSTS AND CONSUMPTION			
	WATER PROFFING	INR 10,000	
	COLOURING	INR 5,000	
	PROPANE	INR 500	
	ELECTRICAL	INR 1,200	
	PLUMBING	INR 200	
	MAINTENANCE	INR 201	
	MAINTENANCE	INR 1,000	

Fig 4.1 showing spreadsheet for basic data for proposed building

In figure above as indicated proposed year of construction is 2017 having economic life 50 years. Interest Rate in India is reported by the Reserve Bank of India. Interest Rate in India averaged 6.60 Percent from 2000 until 2013, reaching an all-time high of 14.50 Percent in August of 2000 and a record low of 4.25 Percent in April of 2009. In India, interest rate decisions are taken by the Reserve Bank of India's Central Board of Directors. The official interest rate is the benchmark repurchase rate, hence Inflation rate of 8 percent is obtained from average inflation status of India by its growth rate, and it may vary depending on some adverse or active prevailing conditions. Inflation rate of 8 percent hence is average rate of incremental inflation.

Annual operation and maintenance cost is obtained from study of old buildings which is applied to new proposed building in same region in same area.

Electrical cost is per user per flat similar is for flat maintenance and building maintenance. Amenities for old buildings are almost negligible keeping low rates of annual maintenance. Purpose is to determine minimum possible life cycle cost for preparedness purpose and as per the requirement necessary charges may be added to find more accurate life cycle cost of Building.

						INFLATION		8%	
						CAPITAL		2000000	
No. of Years	YEAR	WATER PROFFING	COLOURING	ELECTRICAL	PLUMBING	MAINTENANCE	TOTAL COST	PRESENT VALUE without Initial Cost	PRESENT VALUE with Initial Cost
0	2017	0	0	1210	0	0	1210	INR 1,210.00	INR 2,001,210.00
1	2018	0	0	1225	0	1000	2225	INR 2,060.19	INR 2,002,060.19
2	2019	0	0	1230	0	1100	2330	INR 1,997.60	INR 2,001,997.60
3	2020	0	0	1235	0	1200	2435	INR 1,932.98	INR 2,001,932.98
4	2021	0	0	1240	0	1300	2540	INR 1,866.98	INR 2,001,866.98
5	2022	0	0	1245	0	1400	2645	INR 1,800.14	INR 2,001,800.14
6	2023	0	0	1250	0	1500	2750	INR 1,732.97	INR 2,001,732.97
7	2024	0	0	1255	0	1600	2855	INR 1,665.87	INR 2,001,665.87
8	2025	0	100000	1260	0	1700	102960	INR 55,626.08	INR 2,055,626.08

Fig 4.2 showing present vale with Initial cost

As in figure 3 of screenshot ofspreadsheet it shows electricity charges are annual while water proofing charges added twice as lumpsum amount of rupess one lakh twice in the life period od building and similar approach for plumbing as history suggessted from old buildings in same area. Hence electrical and regular maintenance being annual charges while all other are non recurring charges. Also to be noted that maintenance charges are not added in first year as general practice of all new buildings.

						INFLATION		8%	
						CAPITAL		2000000	
No. of Years	YEAR	WATER PROFFING	COLOURING	ELECTRICAL	PLUMBING	MAINTENANCE	TOTAL COST	PRESENT VALUE without Initial Cost	PRESENT VALUE with Initial Cost
44	2061	0	0	1440	0	5300	6740	INR 228.04	INR 2,000,228.04
45	2062	0	0	1445	0	5400	6845	INR 214.44	INR 2,000,214.44
46	2063	0	0	1450	0	5500	6950	INR 201.60	INR 2,000,201.60
47	2064	0	0	1455	0	5600	7055	INR 189.49	INR 2,000,189.49
48	2065	0	0	1460	0	5700	7160	INR 178.06	INR 2,000,178.06
49	2066	0	0	1465	0	5800	7265	INR 167.29	INR 2,000,167.29
50	2066	0	0	1470	0	5900	7370	INR 157.14	INR 2,000,157.14
							3091085	INR 350,252.36	INR 102,350,252.36

Figure 4.3 showing final LCCA at the end of 50 years

Figure above indicates final value of building at end of 50 years total cost is Rs. 3091085/- and that of total building without initial value and inflation is Rs.350252/- as show in figure above. Present value seems to be quiet high on the reason of increasing rate of inflation every year. It is to be noted that this is the cost for do nothing approach, applying no additional skills to reduce the life cycle cost.

V. CONCLUSION

Life Cycle Cost Analysis (LCCA) as applied to the Operation and maintenance costs of a building their impact of the decision made at initial stage. The studies old structures in same locality and obtaining the operational cost of building which when applied to the new building gives systematic and more probable cost of proposed building which may be helpful in investment purpose or even in determining individual financial prospect as build is one of the most costly investment in the life.

LCCA when optimized and integrated approach to of conventional and non conventional energy is properly utilized can be helpful to saving of as much as 25 to 30 percent in entire life span of building.

The study in this report hence will be on specific analysis of LCA, which not only suggest energy efficient economical aspects but also enable the user or investor to determine the flexibility to invest or preparedness for future cost of building.

REFERENCES

1. G. Verbeeck and H. Hens, "Life cycle inventory of buildings: A contribution analysis," Building and Environment, vol. 45, pp. 964-967, 2010.
2. L. Gustavsson and A. Joelsson, "Life cycle primary energy analysis of residential buildings," Energy and Buildings, vol. 42, pp. 210-220, Feb 2010.
3. J. Nassen, F. Hedenus, S. Karlsson, and J. Holmberg, "Concrete vs. wood in buildings - An energy system approach," Building and Environment, vol. 51, pp. 361-369, May 2012.
4. P. Ihm and M. Krarti, "Design optimization of energy efficient residential buildings in Tunisia," Building and Environment, vol. 58, pp. 81-90, 2012
5. N. Mithraratne and B. Vale, "Life cycle analysis model for New Zealand houses," Building and Environment, vol. 39, pp. 483-492, 2004.
6. S. R. Mahajan, S. V. Pataskar, N. S. Jain, "Life Cycle Cost Analysis Of A Multi Storied Residential Building", vol-2, issue-8, Aug 2014.
7. VaishaliAmbe, Dr.SavitaMaru, "Life Cycle Cost Assessment of Multistorey Steel Concrete Composite Building" , International Journal of Emerging Technology and Advanced Engineering, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 5, Issue 1, January 2015.
8. MohamadMonkizKhasreen , Phillip F.G. Banfill ,and Gillian F. Menzies, "Life-Cycle Assessment and the Environmental Impact of Buildings: A Review" , sustainability Journal ISSN 2071-1050, pp 675-700.
9. Cristina Tanasa, CristianSabau, Dan Stoian,DanielDan,ValeriuStoian, "Study on the life cycle cost of energy efficient residential buildings" , Advances in Environmental Technology and Biotechnology, ISBN: 978-960-474-384-1 , pp 173-179.

10. European Parliament, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (recast),Bruxelles.
11. Ashworth, A. (2004). "Cost Studies of Building". England: Pearson Prentice Hall
12. Bull, J. W. (2003). " Life Cycle Costing for Construction". UK: Taylor & Francis Group.
13. Kirk, S. J., &Dell'Isola, A. J. (1995). "Life Cycle Costing for Design Professionals". US: McGraw-Hill,Inc. Kishk, M., Pollock, R., & Al-hajj, A. (2003). "Whole life costing in construction". UK: RICS Foundation.
14. Kishk, M., Pollock, R., & Al-hajj, A. (2003). "Whole life costing in construction". UK: RICS Foundation.
15. Park, C. S. (2004). "Fundamentals of Engineering Economics". USA: Pearson Education, Inc.
16. Revelle, C. S., Whitlatch, E., &Wright , J. (2003). "Civil And Environmental System Engineering". USA: Pearson Prentice Hall.
17. Jonas Wennström, September 2014. “Life Cycle Costing in Road Planning and Management : A Case Study on Collision- free Roads”. Sweden.