ENGINEERING ECONOMICS AND LIFE CYCLE COST ANALYSIS

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Abstract

Life-cycle cost analysis (LCCA) is anevaluating tool to valuate the total financial/resource requirements for total ownership of a building. LCCA is effective when project options that fulfill the same task demands, having different initial costs and operational costs, needs to be examined in order to undertake the option that optimizes financial requirements.

Building-related expenses can be furthercategorized into the following:

- *Initial Costs*
- *Operation, Maintenance, and Repair Costs*
- *Replacement Costs*
- *Residual Values*
- *Finance Charges*
- *Non-Monetary Costs*

This article mainly focuses on the Maintenance and Repair cost analysis; giving probable trends for next 25 years for various elements using DSR, WPI and CPI. These trends are only applicable for the whole of Mumbai.

Keyordsw: *Life Cycle Cost, Maintenance and Repair cost.*

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1. LIFE CYCLE COST ANALYSIS

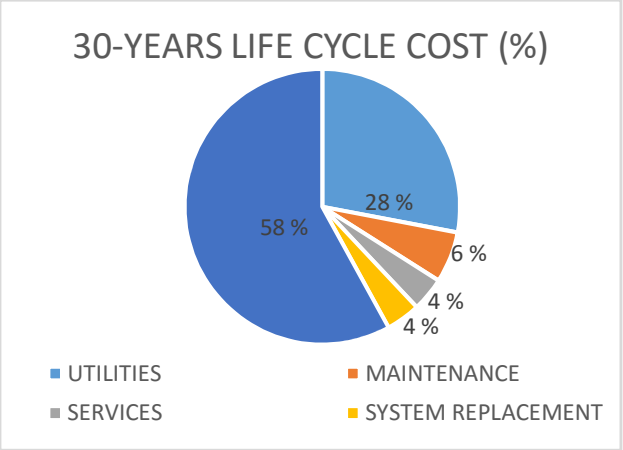
.Life Cycle Cost Analysis is a method of estimating the economic performance of a building over its life period. It is also known as "whole cost accounting" or "total cost of ownership," LCCA balances the intial stage investment with life period costs including owning cost and operating cost of that particular building.

LCCA is calculated on the premises that different building design alternatives can accomplish the same functions with the same amount of efficiency. These options having different initial costs, operational costs, maintenance and repair costs and may also differ in life cycle periods. Considering a particular alternative, LCCA forecasts the total cost of building, including initial construction cost, operation and maintenance cost, for a particular life of the building, cited as "study period".

Life cycle cost analysis helps in maintaining a balance between the initial cost of any alternative process adopted and long term cost saving of that alternative process. LCCA also helps in narrowing the most cost effective alternative and also calculates the "payback" period of the increased cost. To estimate life cycle cost for allapplicable alternatives is not feasible, and therefore the guiding principle for LCCA considers the one which affects the long-term expenses.

1.1Importance of LCCA

[1].As the **CHART-1** below depicts 30 year cost analysis of a building's life, including its construction costs, its maintenance costs, operation costs, and utility costs.



CHART–1:30-YEAR ANALYSIS

Since it is evident that for a 30-year period, maintenance cost accounts nearly 6% of the total cost, the Maintenance and Repair cost analysis will be the prime focus of this article.

2. MAINTENANCE AND REPAIR

Building repairs and maintenance mainly consists ofconserving proper state of a building, its functions and utilities in routine use.

The types of building repair and maintenance are:

- Day to day repairs service facilities
- Annual repairs
- Special repairs
- Additions and alterations
- Preventive maintenance

3. RESEARCH METHODOLOGY

The maintenance and repair costs are found for various elements that are subjected to maintenance and repairs. The cost of these elements are gathered from the DISTRICT SCHEDULE OF RATES OF MUMBAI AND SUBURBAN AREA over the last 15 years ie. from year 2001. SinceDISTRICT SCHEDULE OF RATES OF MUMBAI AND SUBURBAN AREA is used, these trnds are only applicable to Mumbai district. These rates are consideredas the basis for the projected cost over the next 25 years ie. till year 2040. Basic rates for cistern fittings and labour wages have been collected from the WHOLESALE PRICE INDEX and CONSUMER PRICE INDEX respectively corresponding forecast is developed. Forecasts are developed with the help of trendlines characterized by specific curve equations thereby giving projected rates.

4. ELEMENTS CONSIDERED FOR MAINTENANCE

Next 25 years of cost projections for following maintenance elements have been determined:-

1. INTERNAL PLASTERING
2. EXTERNAL PLASTERING
3. INTERNAL OIL PAINTING
4. CISTERN FITTINGS
5. DEDO TILING
6. FLOORING

The main reason behind selecting these elements lies in the fact that these maintenance and repair parameters are the most common and most widely subjected in reference to maintenance and repair works.

4.1 Internal Plastering

DESCRIPTION: The analysis considers internal plastering being undertaken in single coat, having 12 mm thickness. The plaster is prepared in cement to water ratio 1:5. Cost of neeru finish has been neglected in this analysis. The cost of scaffolding required and curing provided has been considered.

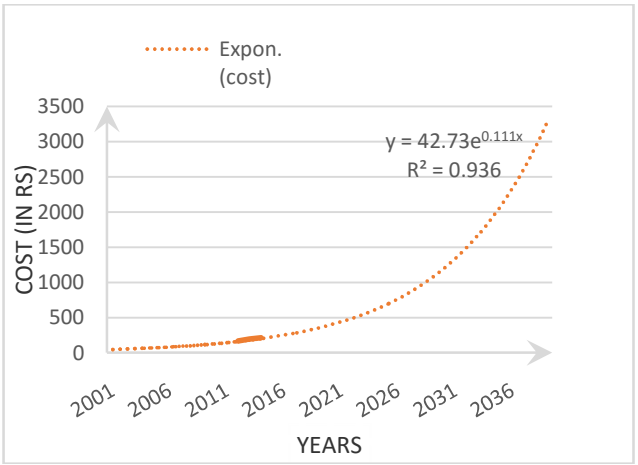


Chart 2: Cost Projections For Internal Plastering

Table 1: Cost Projections For Internal Plastering

YEARS	PROJECTED COST(Rs/Sqm)	YEARS	PROJECTED COST(Rs/Sqm)
2016	263.5237	2029	1030.573
2017	292.6699	2030	1144.556
2018	325.0397	2031	1271.146
2019	360.9897	2032	1411.737
2020	400.9158	2033	1567.878
2021	445.2579	2034	1741.288
2022	494.5042	2035	1933.878
2023	549.1973	2036	2147.768
2024	609.9395	2037	2385.315
2025	677.3999	2038	2649.135
2026	752.3216	2039	2942.135
2027	835.5297	2040	3267.54
2028	927.9408		

4.2 External Plastering

DESCRIPTION: Rough cast cement plaster is considered for external plastering. The plastering is provided in two coats to concrete, stone or brickmasonary. The analysis also includes preparing the base and watering the surface. The base coat is 12 to 15 mmthick, prepared in cement to water ratio of 1:4. The analysis also considers water proofing of the surface using water proofing compound at the rate of 1 kg per 50 kg of cement. Rough cast treatment provided is 12 mm thick and in proportion 1:1.5:3 (cement : sand : coarse aggregate). The cost of scaffolding required and curing provided for 14 days has been considered.

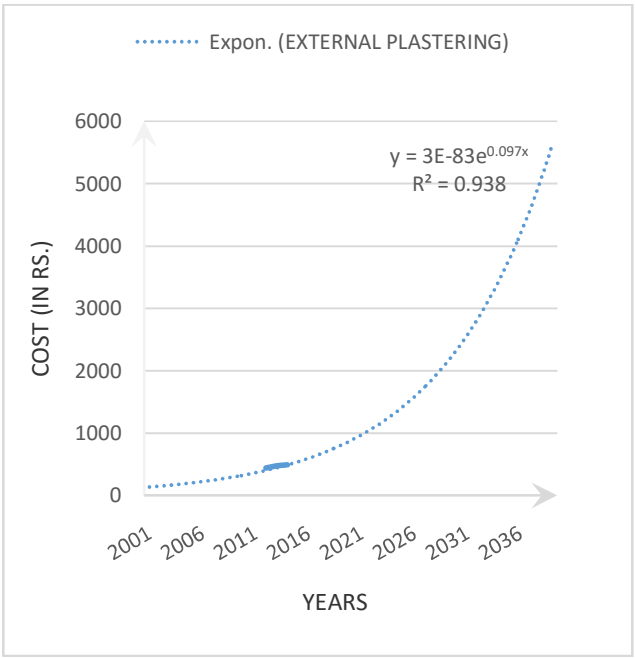


Chart 3: Cost Projections For External Plastering

Table 2: Cost Projections For External Plastering

YEAR	PROJECTED COST(Rs/Sqm)	YEAR	PROJECTED COST(Rs/Sqm)
2016	595.1564	2029	2008.143
2017	653.5202	2030	2205.071
2018	717.6076	2031	2421.311
2019	787.9796	2032	2658.756
2020	865.2527	2033	2919.487
2021	950.1035	2034	3205.785
2022	1043.275	2035	3520.16
2023	1145.584	2036	3865.364
2024	1257.925	2037	4244.42
2025	1381.283	2038	4660.648
2026	1516.739	2039	5117.694
2027	1665.477	2040	5619.559
2028	1828.802		

4.3 Internal Oil Painting

DESCRIPTION: Appling of an oil paint coat of required colour and of required shade to the building and workshop's plastered surface has been considered. Required scaffolding, surface preparation and cleaning is included.

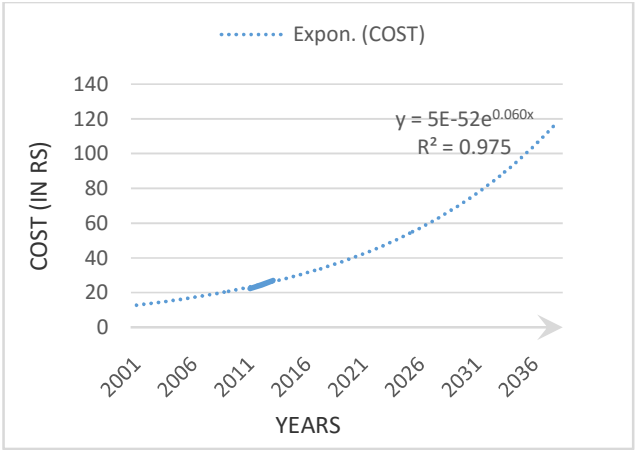


Chart 4: Cost Projection For Internal Oil Painting

Table 3: Cost Projection For Internal Oil Painting

YEARS	PROJECTED COST(Rs/Sqm)	YEARS	PROJECTED COST(Rs/Sqm)
2016	30.75552	2029	63.50921
2017	32.51975	2030	67.15229
2018	34.38518	2031	71.00435
2019	36.35762	2032	75.07738
2020	38.4432	2033	79.38405
2021	40.64842	2034	83.93776
2022	42.98014	2035	88.75268
2023	45.44561	2036	93.84381
2024	48.05251	2037	99.22697
2025	50.80895	2038	104.9189
2026	53.7235	2039	110.9374
2027	56.80525	2040	117.3011
2028	60.06377		

4.4 Cistern Fittings With Labour Wages

4.4.1 Cistern Fittings

DESCRIPTION: Under cistern fittings only considerations regarding the regular taps that are used are made. Taps ranging from kitchen taps to toilet and bathroom taps and basin taps are considered here. The cost considered are average cost of taps in household. The base costs are gathered from the WHOLESALE PRICE INDEX.

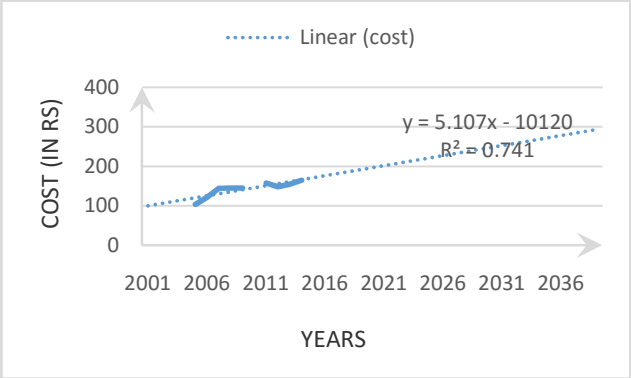


Chart 5: Cost Projection For Cistern Fittings

Table 4: Cost Projection For Cistern Fittings

YEARS	PROJECTED COST(Rs/unt)	YEARS	PROJECTED COST(Rs/unt)
2016	175.0323	2029	242.0623
2017	180.1885	2030	247.2185
2018	185.3446	2031	252.3746
2019	190.5008	2032	257.5308
2020	195.6569	2033	262.6869
2021	200.8131	2034	267.8431
2022	205.9692	2035	272.9992
2023	211.1254	2036	278.1554
2024	216.2815	2037	283.3115
2025	221.4377	2038	288.4677
2026	226.5938	2039	293.6238
2027	231.75	2040	298.78
2028	236.9062		

4.4.2 Labour Requirement For Fittings

DESCRIPTION: Skilled labour is considered for the fitting of taps. Since time requirement for the fixation of tap is nominal, generally unskilled labour wages are considered here. Since the base wages of the unskilled labour is collected from the CONSUMER PRICE INDEX references.

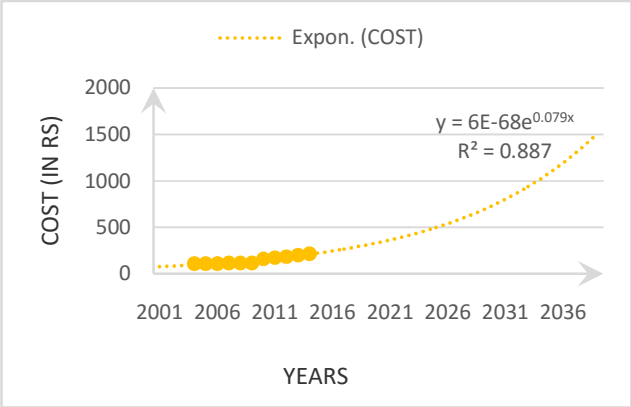


Chart 6: Cost Projection For Labour Wages

TABLE 5:COST PROJECTION FOR LABOUR WAGES

YEARS	PROJECTED COST(Rs/Hr)	YEARS	PROJECTED COST(Rs/Hr)
2016	252.9275	2029	727.1442
2017	274.331	2030	788.6773
2018	297.5457	2031	855.4176
2019	322.7249	2032	927.8056
2020	350.0349	2033	1006.319
2021	379.6559	2034	1091.477
2022	411.7835	2035	1183.841
2023	446.6298	2036	1284.021
2024	484.425	2037	1392.679
2025	525.4185	2038	1510.532
2026	569.8809	2039	1638.357
2027	618.106	2040	1777
2028	670.412		

4.5 DADO TILING

DESCRIPTION:The analysis consists of providing and fixing plain ceramic tiles of size 300 mm X 200 mm. The plaster used is cement mortar ratio of 1:4. The forecast includes filling of joints with neat cement flurry or cement paste. The cost also includes curing and cleaning after dado tiling is done.

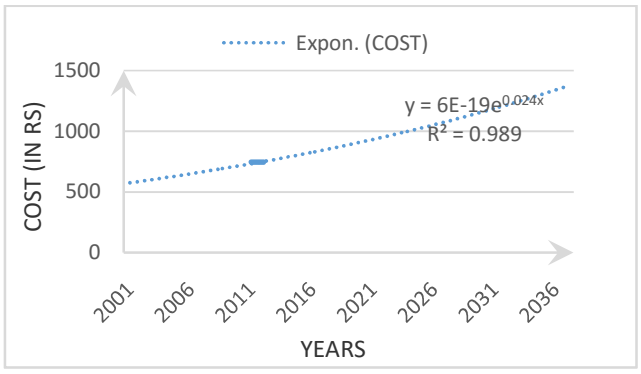


Chart 7: Cost Projection For Dado Tiling

Table 6: Cost Projection For Dado Tiling

YEARS	PROJECTED COST(Rs/Sqm)	YEARS	PROJECTED COST(Rs/Sqm)
2016	813.9379	2029	1079.762
2017	831.8262	2030	1103.492
2018	850.1075	2031	1127.744
2019	868.7907	2032	1152.529
2020	887.8844	2033	1177.859
2021	907.3978	2034	1203.745
2022	927.34	2035	1230.2
2023	947.7205	2036	1257.237
2024	968.5489	2037	1284.867
2025	989.8351	2038	1313.105
2026	1011.589	2039	1341.964
2027	1033.821	2040	1371.457
2028	1056.542		

4.6 FLOORING

DESCRIPTION: The analysis consists of providing and laying of marble mosaic that is 10 mm thick. This flooring is made of marble chips of white orany other colour. These chips are preferably of 6 mm size. Coloured cement is more suitable for flooring. It also includes an under layer of cement concrete 1:2:4.Providing aluminium strips for panels, leveling, compacting, curing, polishing, rubbing and cleaning are considered in the analysis.

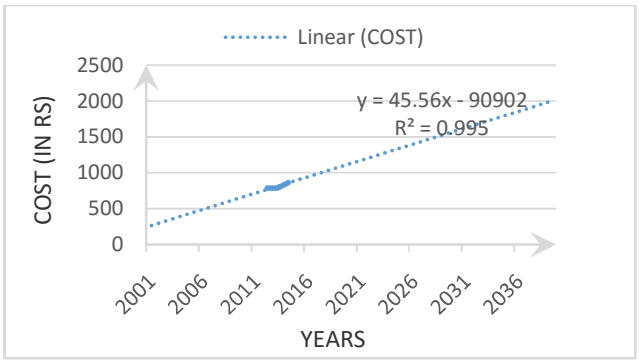


Chart 8: Cost Projection For Flooring

Table 7: Cost Projection For Flooring

YEARS	PROJECTED COST(Rs/Sqm)	YEARS	PROJECTED COST(Rs/Sqm)
2016	989.7752	2029	1584.853
2017	1035.55	2030	1630.628
2018	1081.326	2031	1676.403
2019	1127.101	2032	1722.178
2020	1172.876	2033	1767.954
2021	1218.651	2034	1813.729
2022	1264.426	2035	1859.504
2023	1310.202	2036	1905.279
2024	1355.977	2037	1951.054
2025	1401.752	2038	1996.83
2026	1447.527	2039	2042.605
2027	1493.302	2040	2088.38
2028	1539.078		

5. CONCLUSIONS

Thus based on the trendlines of different activies/ process it can be conferred that the maintenance and repair costs are bound to increase as the time passes. Some tend to increase linearly while some tend to increase exponentially. These graphs will help the financial controllers and economy managers to predict the cost of specific repair and maintenance work in the future years. These predictions will assist to plan and manage the finances according to the requirement.

ACKNOWLEDGEMENT

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REFERENCES

1. Fuller, Sieglinde. "Whole Building Design Guide–Life Cycle Cost Analysis (LCCA)." (2004). https://www.wbdg.org/resources/lcca.php
2. GUIDELINES FOR LIFE CYCLE COST ANALYSIS https://lbre.stanford.edu/sites/all/lbre-shared/files/docs_public/LCCA121405.pdf
3. Sayed, ShaguftaSajidMumtaaz, and Priyadarshi H. Sawant. "Life-cycle cost and financial analysis of energy components in mass housing projects–A case project in sub-urban India." International Journal of Sustainable Built Environment 4.2 (2015): 202-221.
4. Mumtaaz Sayed, ShaguftaSajid, and Priyadarshi H. Sawant. "Financial Feasibility Analysis of Water Conservation Components in Mass Housing Projects: Suburban Indian Case Review." Journal of Architectural Engineering (2016): 04016001.

BIOGRAPHIES

Dhruv J. Desai, Presently studing in the final year civil engineering at M.H.SabooSiddikcollege of engineering (Mumbai University). He has also presented preliminary report on "ENGINEERING ECONOMICS AND LIFE CYCLE COST ANALYSIS" at the college level. He is a construction management aspirant at Masters level. He is presently also working in research areas of costing and tendering.

Tejas H. Jain, He is pursuing Bachelors Degree in Civil Engineering from SabooSiddik College of Engineering. He has keen interest in research and he wishes to make contributions to the society by becoming a great engineer. He has presented papers in International journals and International conferences. He has done internship with different construction companies.

Atul Dwivedi, Student of be civil in M.H.Saboosiddik College of Engineering. He is interested in pursuing career in project management. Also a Masters aspirant in the field of construction management, he has given competitive exams for higher studies.

Anjum D. Attar, She has completed diploma in civil engineering from VJTI and currently pursuing bachelors in civil engineering from the M.H.SABOO SIDDIK COLLEGE OF ENGINEERING. Being a civil engineer, author want to bring in the best of advancements in the field of civil engineering that will benefit the mankind and the human race because "being a civil engineer is being a creator"