

Life Cycle Cost Analysis in Flat Buildings (Case Study of Polresta Bukittinggi Flat Construction Project)

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Received 17th April 2024; Revision 22th May 2024; Accepted 29th June 2024

ABSTRACT

The housing crisis in various cities in Indonesia has become an increasingly urgent issue. Rapid population growth and urbanization are major factors contributing to this crisis. One proposed solution is the development of high-rise building projects as a more practical and space-saving housing solution. However, in the context of high-rise construction, economic planning is crucial to ensure project sustainability. This research utilizes a quantitative method with secondary data collection. Life Cycle Cost (LCC) analysis is employed to control project costs from the initial stage to project completion, including construction, operational, maintenance, and demolition costs. The analysis results indicate that initial construction costs, operational costs, maintenance costs, and demolition costs all need to be considered in project planning. Maintenance and upkeep costs are crucial aspects in ensuring the building's sustainability throughout its economic life. By considering all these factors, the total life cycle cost of the construction of Rusun Polresta Bukittinggi during its operational period of 50 years amounts to Rp 32,064,519,750.22. The Annual Equivalent (AE) analysis shows an average annual cost of is Rp. 6,287,507,789.17.

Keywords: *High-rise Building; Life Cycle Cost; Maintenance Cost; Economic Analysis.*

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INTRODUCTION

The housing crisis in many Indonesian cities has become an increasingly pressing issue. With rapid population growth and urbanization, urbanization in a city can be attributed to various factors, and one of them is the economic aspect. In the context of economic factors, rural people tend to migrate to cities with the intention of finding work and earning a more substantial income [1]. Along with this increase in population, the demand for land also increases. The availability of decent and affordable housing in big cities is becoming increasingly difficult, this crisis includes problems such as high property prices, the inability of most people to own a home, and the high demand for housing. So the government must find appropriate and sustainable solutions that are indispensable to overcome this housing crisis problem to create more practical and sustainable housing, such as the procurement of practical and land-saving flats development projects.

A project can be defined as the combined result of various resources, gathered in a temporary organizational setting to achieve a specific goal [2]. While the construction in question is an activity of construction of a structure consisting of walls and roofs that are upright. Flats are construction projects that involve a fairly complex design with structural calculations that must be precise. During the construction process, it is important to consider aspects of building

safety and building quality by doing good planning. Good construction project planning should cover various aspects, including technical, non-technical, and economic aspects. Technical aspects involve a deep understanding of the project design, including the selection of appropriate materials, efficient construction methods, and the fulfillment of good safety and quality standards. Non-technical aspects include factors such as project management, licensing, and environmental and social aspects.

Economic considerations include establishing a realistic budget to achieve the development project and planning costs smoothly and effectively throughout the project cycle. This includes taking into account the initial construction costs, maintenance costs, operational costs, and demolition costs. The economic aspect of project planning also plans project management so that the construction project runs according to the structure that has been prepared. Project management includes a whole series of activities for planning, implementing, controlling, and coordinating a project from the initial stage to the completion of the project, with the aim of ensuring that the project runs on schedule, the budget that has been set, and achieves the desired quality standards [3].

The economic aspect must also consider maintenance costs during the economic life of the building. In making decisions for building maintenance, usually only consider initial costs without taking into account long-term costs or costs until the economic life of the building. For example, in the research of Cho, Choi, & Ryu (2018) who compared the Life Cycle Cost of several different types of insulation materials used in building maintenance [4]. To accurately assess economic feasibility, this study used Life Cycle Cost analysis. It was found that although some materials had lower initial costs, the long-term maintenance and replacement costs outweighed the savings. So, when considering these economic aspects, it is necessary to evaluate the cost using the Life Cycle Cost (LCC) method. LCC is an economic approach used to evaluate all costs incurred throughout the life cycle of a project. This method considers all costs that arise from the construction, operation, maintenance, and disposal stages of project components. These overall costs become a key factor that is very important in project-related decision-making [5].

In construction projects, LCC can help in determining whether choosing a particular material or method that is more expensive in initial cost but is more durable and requires lower maintenance costs, will be more beneficial in the long run than choosing an option that is cheaper but has high maintenance costs. The costs included in the LCC concept include planning and construction costs, which are often referred to as initial costs. In addition, it includes operational costs, routine maintenance and repair costs, often referred to as maintenance costs. In addition, LCC also takes into account demolition costs, which are often referred to as demolition costs. By considering all these aspects, LCC provides a comprehensive picture of the total costs associated with the life cycle of a project. Thus, life cycle costing (LCC) analysis is the cost control of a construction project, starting from the initial cost to the ongoing cost of the project as these costs will impact the operational cost of the economic life of the building which is important to make the building function properly and economically. Therefore, LCC analysis is needed in Rusun Polresta Bukittinggi to plan the budget efficiently, make the right financial decisions, know the cost of building maintenance and building maintenance, and know the cost of dismantling the building. In addition, this research will provide the final result in the form of the life cycle cost of the Polresta Bukittinggi Flat until the economic life of the building.

From the above, the selection of materials in construction planning is often based only on consideration of the general needs of the material, without considering its durability aspects. In addition, the complexity of designing, building and maintaining flats requires the use of the Life Cycle Cost (LCC) method in evaluating construction project costs. Thus, the objectives of this study are to determine the total initial cost and maintenance cost of architectural components of flats until the building reaches its economic life, to determine the cost required to maintain architectural components in Polresta Bukittinggi flats, and to determine which architectural elements require the highest maintenance costs in the construction of flats.

METHODS

This research uses quantitative methods using secondary data collected. Secondary data can be obtained from literature, reports, libraries, documentation, or previous research reports, and is the data used to support this research. Where in this study, this secondary data consists of project technical drawings, RAB, and also the AHSP of Polresta Bukittinggi Flat Project, which was taken from the implementing contractor. The object of this research is the Polresta Bukittinggi Flat construction project which is located at the Bhayangkara Polresta Bukittinggi Service Housing located at Jl. Sudirman No. 12 Tarok Dipo, Kec. Guguk Panjang, Bukittinggi City West Sumatra. The analysis used is Life Cycle Cost Analysis for the development of occupancy cost at Bukittinggi Police Station. The method used in calculating life cycle cost refers to a series of theories found in various literature and references, thus providing a comprehensive framework for this research. To ensure the accuracy and consistency of the data, the calculation process is performed using the Microsoft Excel application. The stages of the research carried out are illustrated in the following flowchart.

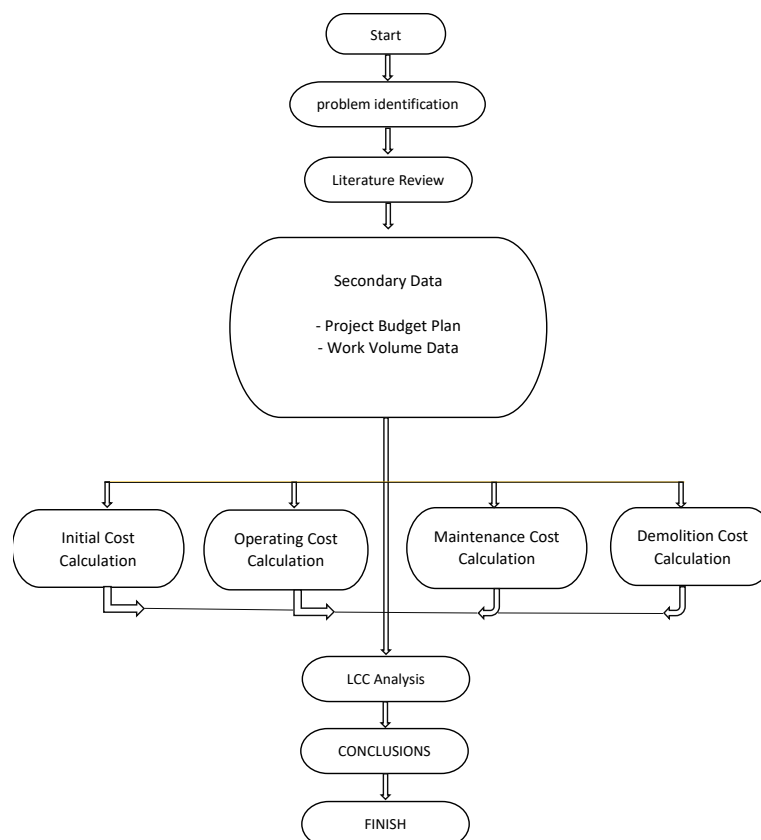


Figure 1: Research Phases

RESULTS AND DISCUSSION

A. Life Cycle Cost Analysis

Life Cycle Cost Plan is a method that can be used to control the initial and future costs of a building project. This method is used to analyze the economic value of a building by considering the cost of operating the building over its life cycle. Life cycle cost analysis is used in this study to identify all costs involved in a building project and to determine the amount of costs incurred from the design stage to the specified economic life of the building. This method helps project owners to make better and more efficient decisions in managing project costs.

1. Initial Costs

Initial cost is the cost that includes the cost of project preparation, supervision, and construction, is an important component in life cycle cost analysis that requires careful calculation and effective cost management.

a. Construction Cost

The Bukittinggi Polresta Flat consists of 3 floors with a land area of 1427.95 m² and which includes construction costs worth Rp. 23,090,538,304.00.

b. Preparation and Supervision Costs

Preparation costs include the cost of planning the construction of the Polresta Bukittinggi Flat project. The following is a detailed table:

Table 1: Preparation and Supervision Costs

No	Cost Description	Cost
1.	Planning	Rp. 1,959,000,000.00
3.	Supervision	Rp. 972,180,000.00
3.	Construction	Rp. 23,090,538,304.00
Total		Rp. 26,021,718,304.00

2. Operating Costs

Operating costs are all the expenses required by a flat to carry out all the necessary activities to ensure that it operates smoothly and efficiently. It covers various aspects, such as the cost of waste management, lighting, and various other services required for residents to enjoy a safe, comfortable, and well-functioning environment. Operating costs consist of:

a. Flat Water Demand

The Polresta Bukittinggi flat, which consists of 42 units and consists of 3 floors, is inhabited by a maximum of 4 people per unit (UU No.20 Tahun 2011) [6], with an average water demand of 144 liters per day (Ditjen Cipta Karya, 2005) [7]. Rusun Polresta Bukittinggi uses boreholes to meet the water needs of residents. As a result, because it uses a clean water pump, operational costs are charged to electricity costs. Where the total usage in a day is 24,198.06 L. Meanwhile, the total usage in 30 days is 725,941.91 L.

b. General Electricity Demand

1) Electricity needs for building complementary facilities

The amount of electricity demand is calculated based on the analysis of detailed building drawings to meet the needs of shared electricity for lighting public infrastructure in the Polresta Bukittinggi flat building. Calculation of the basic electricity tariff using Permen ESDM No.8 of 2023 [8] states that the tariff group for small household purposes with a power of 1,300 VA is charged a tariff of Rp. 1,444. Where the total use of electricity as a complementary facility in a

day is 18,552 watts or 18.55 kWh. As for usage in 30 days, 556,560 watts or 556.56 kWh.

2) Pump electricity demand

The electricity demand for water pumps is calculated based on an analysis of the water needs of the Polresta Bukittinggi flat and the duration of use of the available pumps. If it is known that the total joint electricity demand per year is 9,992 kWh, then the total joint costs incurred by the Polresta Bukittinggi flat to meet electricity & water needs in a year are:

$$\begin{aligned} \text{Total} &= \text{Total Power} \times \text{Electricity Tariff} \\ \text{Total} &= 9.992 \times \text{Rp. 1,444} \\ \text{Total} &= \text{Rp. 14,428,679 / year} \end{aligned}$$

3) Flat waste disposal fee

The garbage fee of Rp. 5,000 per unit is taken from the average garbage fee in the city of Bukittinggi. This fee is used to clean and manage waste within the Polresta Bukittinggi Flat complex. The fee usually covers waste transportation, waste management and processing, and maintenance of waste management facilities such as landfills. By paying these fees, residents can ensure that their living environment is kept clean and sanitary. The total waste fee for the flat in 1 year is Rp. 2,520,000.

After performing the calculations and the annual operating costs have been obtained. A summary of the operating costs can be found in the following table:

Table 2: Total Operating Cost of Flats

No.	Operating Costs	Total Cost
1.	Electricity and water needs	Rp. 14,428,679.04
2.	Flat waste fee	Rp. 2,520,000.00
Total		Rp. 16,948,679.04

3. Maintenance and Upkeep Costs

a. Maintenance Costs

The maintenance costs incurred are the total maintenance costs for each building component. Peraturan Nomor 22/PRT/M/2018 Menteri Pekerjaan Umum dan Perumahan Rakyat Republik Indonesia [9] on the Construction of State Buildings stipulates that maintenance costs should not exceed 2% (two per hundred) of the highest standard price per square meter (m²) in the current year.

Building area: 1020,12 m²

Price per m²: Rp. 5,500,000.00

Maintenance cost: 2% x 1020.12 m² x Rp. 5,500,000.00 = Rp. 112,213,200

Having done this, we can find the annual cost of maintaining the flats, which is Rp 112,213,200. It is important to adjust this value to the value in the base year, which is 2023.

Annual Value (A): Rp. 112,213,200

Discount Rate (d): 5.56%

$$P = A \left[\frac{(1+i)^n - 1}{i(1+i)^n} \right]$$

$$= \text{Rp } 112,213,200 \left[\frac{(1+0.055)^{50}-1}{0.055(1+0.055)^{50}} \right]$$

$$= \text{Rp } 112,213,200 (16.931)$$

$$= \text{Rp } 1,899,881,689.20$$

After getting the present value, the next step is to find the future value of the annual maintenance cost of the flat. Thus, we can project the cost value into the future to find out the estimated total maintenance cost of the Polresta Bukittinggi Flat during the economic life of the building.

Annual Value (A): Rp. 112,213,200

Discount Rate (d): 5.56%

$$F = A \left[\frac{(1+i)^n-1}{i} \right]$$

$$= \text{Rp } 112,213,200 \left[\frac{(1+0.055)^{50}-1}{0.055} \right]$$

$$= \text{Rp } 112,213,200 (246.217)$$

$$= \text{Rp } 27,628,797,464.40$$

b. Upkeep Costs

Polresta Bukittinggi's upkeep costs focus only on the architectural component. The calculation of maintenance costs is done for the period of the economic life of the building, which is 50 years. During this period, maintenance is carried out on several components. After the calculation, a recapitulation of the cost of maintenance of the flat with a present value of Rp. 2,033,254,547.33 and a future value of Rp. 42,154,359,458.57 was obtained. After getting a recapitulation of the maintenance cost of Polresta Bukittinggi Flats, then from the recapitulation of the maintenance cost, a chart is made as shown below:

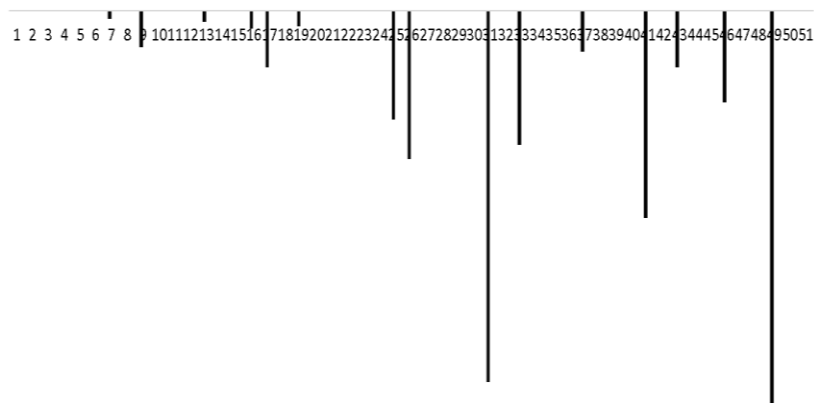


Figure 2: Upkeep Cost Of Flats

The following is a summary of the calculation of the maintenance and upkeep costs for the Polresta Bukittinggi Flat during the 50-year period of use of the building.

Table 3: Recapitulation of the maintenance and upkeep costs

No.	Cost Description	Present Value	Future Value
1	Maintenance Cost	Rp.1,899,881,689.20	Rp.27,628,797,464.40
2	Maintenance Cost	Rp.2,035,213,754.72	Rp. 42,154,359,458.57
	Roof	Rp.85,152,634.15	Rp. 2,188,572,712.51
	Architectural	Rp. 1,671,923,581.87	Rp. 33,486,422,374.37
	Utilities	Rp. 278,137,538.69	Rp. 6,479,364,371.68
	Total	Rp. 5,834,977,133.12	Rp. 97,411,954,387.37

4. Demolition Cost

Demolition costs are incurred when a building has reached the end of its planned or economic useful life of 50 years. It is assumed that the building will be demolished when it reaches its planned life. Therefore, the cost that will be incurred is a future value, so the value is converted to present value. According to Sundquist & Karoumi (2008) [10] in LCC Tools and Life Cycle Cost Methodology, the estimated cost of demolition is 10% of the total investment value of the building.

Initial cost = Rp26,021,718,304.00

Demolition Cost = 10% x Rp26,021,718,304.00 = Rp2,602,171,830.40

Demolition costs over economic life of 50 years is Rp 2,602,171,830.40, which is future value and is converted to present value as follows:

Future value = Rp2,602,171,830.40

Discount rate (d) = 5.56%

Present Value (P) = $F \left[\frac{1}{(1+i)^n} \right]$

$$P = \text{Rp}2,602,171,830.40 \left[\frac{1}{(1+5.56\%)^{50}} \right]$$

$$P = \text{Rp} 173,926,955.02$$

If the residual value is assumed to be 2%-3% of the total initial cost of the building, it is obtained as follows:

Initial cost = Rp 26,021,718,304.00

Residual value = 3% x Rp26,021,718,304.00 = Rp520,434,366.08

The residual value of the flat is Rp 520,434,366.08 in future value, so it is converted to present value:

Future value = Rp 520,434,366.08

Discount rate (d) = 5.56%.

Present Value (P) = $F \left[\frac{1}{(1+i)^n} \right]$

$$P = \text{Rp} 520,434,366.08 \left[\frac{1}{(1+5.56\%)^{50}} \right]$$

$$P = \text{Rp} 34,785,391.00$$

5. Total Life Cycle Cost

The next step is to calculate the life cycle cost of the Polresta Bukittinggi Flat after obtaining all the costs required for the life cycle cost calculation, including initial cost, operating cost, maintenance and repair cost, and demolition cost.

Table 4: Life Cycle Cost of Polresta Bukittinggi Flats

No.	TYPE OF WORK	Present Value	Future Value
1	Initial Cost	Rp. 26,021,718,304.00	Rp.389,318,506,382.26
2	Operational Costs	Rp. 16,948,679.04	Rp. 286,958,084.83
3	Maintenance and Upkeep Costs	Rp. 5,834,977,133.12	Rp. 97,411,954,387.37
4	Demolition Cost	Rp. 173,926,955.02	Rp. 2,602,171,830.40
Total LCC		Rp.32,064,519,750.22	Rp. 489,619,590,684.86

6. Annual Equivalent (AE) Calculations

The next step is to calculate the life cycle cost of the Polresta Bukittinggi Flat after obtaining all the costs required for the life cycle cost calculation, including initial cost, operating cost, maintenance and repair cost, and demolition cost.

The AE method is an even distribution of cash flows over the life of the investment. The Equivalent Uniform Annual Benefit (EUAB), which represents the average annual income, is calculated from this even distribution of cash. In the same way, the equalization of the cash payments leads to the determination of the Equivalent Uniform Annual Cost (EUAC). The difference between the EUAB and the EUAC is referred to as the AE (Giatman, 2011) [11]. In this case, the data used is the cash payout (costs) in the life cycle of the flat building during the economic life of the building. With the average inflation of Bukittinggi City of 3%, then to find the Annual Equivalent is with the following formula:

$$EUAC = \sum_{t=0}^n Cc_t(FBA)$$

EUAC = Ekvivalen Uniform Annual of Cost

Cc = cashflow cost

FBA = annual interest factor

The estimated average annual cost of the Polresta Bukittinggi Flat building is IDR 10,685,684,556.78 based on the data obtained.

CONCLUSION

Based on the analysis presented, it can be concluded that the answers to the problem formulation and objectives of this final project. The results of the analysis of the construction of the Polresta Bukittinggi Flat lead to the following conclusions:

1. The life cycle cost of Polresta Bukittinggi Flat, which occurs from the beginning to the economic life of the building, which is for 50 years, is Rp. 32,064,519,750.22, including initial cost or construction cost of Rp. 26,021,718,304.00 operating cost of Rp. 16,948,679. 04 maintenance and upkeep costs of Rp. 5,834,977,133.12 demolition costs of Rp. 173,926,955.02 and the highest maintenance cost of the architectural component is repainting the walls every 8 years at Rp. 3,067,752,240.00 during the economic life of the building, namely 50 years.
2. The Annual Equivalent Value of Polresta Bukittinggi Flat Building during the economic life of the building according to Indonesian National Standard (SNI) 1726-2019, which is for 50 years, taking into account the initial cost, is Rp. 10,685,684,556.78. For the annual equivalent

of operating cost, maintenance and upkeep cost is Rp. 6,287,507,789.17 (future value) or Rp. 571,042,652.02 (present value).

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