SELECTION OF FLOOR COVERING MATERIALS USING LIFE CYCLE COST ANALYSIS ON THE X APARTMENT DEVELOPMENT PROJECT SOUTH TANGERANG

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ABSTRACT

Developing an area can be started with infrastructure development. One example of such infrastructure is an apartment with a function as a means of residence and economic development in the area around the apartment. The South Tangerang X Apartment development project is one of the objects studied in this research. This study aims to select alternative materials for floor work based on the building cycle using life cycle cost (LCC) analysis with such a large project value. The research method used is Pareto diagram analysis to select the work to be analyzed. The LCC analysis uses a present worth analysis method with a gate-to-gate phase. This study indicates that the LCC analysis on Apartment Project X South Tangerang found the results on alternative KR1B HT floor work, namely alternative 2 of IDR. 1,437,912,015 on the KR1A HT flooring; the chosen alternative is alternative 2 of IDR. 989,177,787 on the chosen alternative KR4 HT floor work, namely alternative 2 of IDR. 1,510,914,248, and for the KR5A marble floor, the chosen alternative is alternative 2 of IDR. 617,202,771. The result of the LCC generated savings of IDR. 2,364,054,553.

Keywords: *Apartment, Life Cycle Cost, Present Worth Analysis.*

1. INTRODUCTION

The uneven development that occurs in cities and villages causes a process of urbanization in society. The urbanization process certainly has an impact on the cities visited. According to Nur'aidawati and Nurmasari, The impact on the ongoing population growth in cities can be caused by the arrival of the urban market [1]. South Tangerang is one of the cities hampered by the impact of urbanization. South Tangerang is a satellite city of Jakarta, one of the destinations for urbanites. According to BPS data, Significant population growth occurred from 2017 to 2019. There were 1,644,899 inhabitants in 2017, 1,696,309 people in 2018 and 1,744,906 people in 2019. [2].

The rapid population growth in the South Tangerang area has resulted in problems; namely, the availability of land for housing is increasingly limited. Therefore, the construction of apartments is a solution to overcome the limited land for housing. Apartments are built vertically, producing higher occupancy than housing built horizontally.

The construction of apartment buildings has an essential role in people's lives in an area. Apart from having a function as a residence, apartments can also be an economic driver for the surrounding community. After completion of construction, the apartment is expected to be able to execute its functions according to the age of the investment plan and the building. Environmental factors around the building and the use of inappropriate materials cause a decrease in building performance, increasing the age of a building.

When the apartment is operational, it is usually found that routine maintenance is often carried out. The frequency of replacement and repair will be carried out more frequently

during the life of the building and investment due to the selection of materials that are not optimal during the construction period. This results in high maintenance costs, which impact the investment costs that the developer has incurred. According to Kamagi et al., one method that can be used to analyze the economic value by considering the lifetime operational costs is using the LCC method. This method helps make decisions based on the monetary value of the building, which feels the location, technical planning of the building, construction, operation of the building, up to the demolition, followed by the replacement of components or systems during the lifetime of the building [3].

LCC analysis, according to Berawi, is carried out to develop and display the total ownership cost per building system, functional area, and subsystem. LCC modelling will identify areas that have high cycle costs. Furthermore, there will be material or system replacement from work with high cycle costs [4].

The LCC applied in the South Tangerang X Apartment development project is the answer to the needs of the urban community that need housing. The construction value of this project is IDR. 223,525,000,000, and architectural work is the work with the highest cost of IDR. 65,035,149,007; therefore, there needs to be an effort to make the development cost-efficient and the cycle cost of the work efficient.

According to Alien, Budiman, and Iskandar, in a journal entitled Comparative Study of LCC in Apartment Buildings, the comparison of life cycle costs of energy resulted in savings of 14.43% from the selection of mechanical and electrical equipment and savings during building operations of 10.20% obtained from the life cycle cost method [5].

In the research conducted by Adi, Nugroho, and Suprayitno, it was found that the total expenditure was IDR during the eight years of the building period. 483,649,711,849 with the percentage of LCC cost structure, namely initial costs of 43.94% and operational and maintenance costs of 16.57%. Replacing and adding lamps with more efficient ones as a redesign will save IDR costs. 28,072,536,738 [6]. Therefore, this study aims to analyze and substitute the floor covering work materials analyzed using the life cycle cost method, calculate the savings that occur, and choose materials with efficient cycle costs.

2. RESEARCH METHODS

Research using quantitative methods is a type of research that uses statistical procedures and quantification or other measurements in producing findings [7]. Quantitative analysis aims to obtain data describing objects, events, or project conditions [8]. The quantitative method has been used in this research.

The data needed in this study are primary and secondary. Interview with one of the architectural practitioners to obtain primary data required for research. Meanwhile, secondary data used in this study are pieces of literature that discuss LCC, shop drawings, budget plans, technical specifications, implementation methods, and lists of prices for materials and wages in Banten.

The present worth analysis (PWA) approach uses the LCC calculation technique. The phrase used in the LCC process is the construction or building construction phase up to the building investment period of 15 years. PWA is the difference between the equivalent expenditures and the equivalent income of an investment cash flow based on the selected interest rate [9]. The following formula is for this study's PWA.

PWA = Maintenance Fee per Year x Value P/A (1)

The P/A value is obtained from the compound interest using the interest rate value (i) and the length of the investment period (n).

3. RESULTS AND DISCUSSION

Based on the Budget Plan data, it was found that the architectural work that had the highest cost item was Rp. 65,035,149,007. For this reason, architectural work would be the main focus (**Table 1**).

Table 1. Jobs Cost Recapitulation

No	Job Description	Cost
1.	Preparatory Work	IDR. 26,323,793,210
2.	Structure Work	IDR. 52,602,933,767
3.	Architectural Work	IDR. 65,035,149,007
4.	MEP Work	IDR. 53,042,693,986
5.	Provisional Sum Work	IDR. 6,200,000,000
	Total	IDR. 203,204,569,971

After knowing that architectural work had the highest cost of all the work, the next thing was to describe the work in architectural work based on construction costs from the work that had the most increased cost to the job with the lowest cost. (**Table 2**)

Table 2. Architectural Works Cost Recapitulation

No.	Job Description	Weight	Cost
1.	Door and Windows Frame Works	24.60%	IDR. 16,001,384,340
2.	Masonry Works	21.13%	IDR. 13,740,513,334
3.	Façade Works	17.65%	IDR. 11,475,868,628
4.	Floor Works	11.82%	IDR. 7,689,136,390
5.	Ceiling Works	8.31%	IDR. 5,402,917,666
6.	Sanitair Works	5.73%	IDR. 3,724,486,095
7.	External Works	4.98%	IDR. 3,238,479,191
8.	Roof Works	2.40%	IDR. 1,560,222,072
9.	Miscellaneous Works	2.29%	IDR. 1,487,282,275
10.	Stairs and Ramp Works	1.10%	IDR. 714,859,015
	Total	100%	IDR. 65,035,149,007

The calculation results above indicate that the floor work would be selected for further analysis because it had the potential to have relatively high operational costs. The floor covering work would be analyzed using a Pareto to determine which work items would be analyzed for further life cycle costs. The following are the results of the Pareto diagram for Floor Covering Works (**Figure 1**).

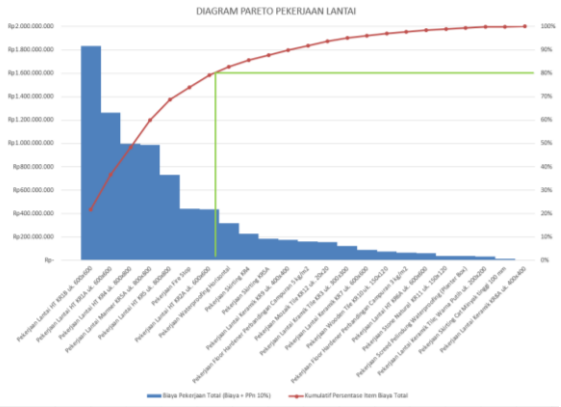

Figure 1. Pareto Chart of Work Floor

The Perto diagram shows the results of the floor works were HT KR1B floor work (area < 1 room) size 600x600, HT KR1A floor work (area > 1 room) size 600x600, HT KR4 floor work (unit corridor area) 800x800, and floor work KR5A marble (commercial space) size 800x800.

3.1 Breakdown Cost Structure

The cost variables considered in this phase were initial, building and development, annually recurring, operational, and maintenance costs, and the final costs were non-recurring.

The investment period of this building was approximately 15 years, and the average deposit interest rate in the following table (**Table 3**)

Table 3. Deposit Interest Rate

No	Bank	Interest Rate (%)
1	BCA	2.00%
2	CIMB Niaga	2.75%
3	Mandiri	2.60%
4	BNI	2.75%
5	BRI	2.85%
6	BTN	2.80%
	Total	15.75%
	Average	2.625%

Next, the interest rate would be calculated using the formula:

i = *safe risk* + *risk* (2)

When,

Safe Risk = average deposit interest rate

Risk = comparison to safe rate (½ *safe rate*)

So, i = 6,825 + ($\frac{1}{2}$ x 6,825) = 10,24 = 10%

3.1.1 Initial Cost

Initial costs in life cycle cost analysis include construction costs at the time of construction. The floor work construction costs are as follows **in Table 4**.

The alternative material for each work was arranged based on the functional value of the material, which remains the same as the initial alternative but could reduce the construction cost of the initial design. In **Table 4**, alternative 1 is the initial design, and alternative two is the suggested from the interview process.

The HT KR1B floor work, HT KR1A floor work, and HT KR4 floor work used the initial design with the type of material, namely Homogenous Tile, and based on interviews with architectural practitioners, alternatively, alternatively suggestions utilizing the kind of ceramic tile material. Ceramic tile material was recommended because, in addition to being inexpensive, ceramic tile was a floor covering material that could be easily cleaned.

While the KR5A Marble floor work had the material in the initial design, namely marble, based on the interviews, it was recommended that alternative materials use the homogeneous tile type. The homogeneous tile was recommended because it was more affordable than marble, the material also gave a luxurious impression and was easy to install and clean.

Table 4. Floor Works Building Cost

Design	Material	Total Cost (IDR)
Floor Work Type HT KR1B		
A1	*Homogenous Tile* 60x60	1,667,006,430
A2	*Ceramic Tile* Putih 40x40	1,320,464,609
Floor Work Type HT KR1A		
A1	*Homogenous Tile* 60x60	1,146,777,907
A2	*Ceramic Tile* Putih 40x40	908,382,603
Floor Work Type HT KR4		
A1	*Homogenous Tile* 80x80	905,119,154
A2	*Ceramic Tile* 60x60	468,613,856
Marble Floor Work Type KR5A		
A1	Marmer 80x80	899,207,564
A2	*Homogenous Tile* 60x80	199,234,091

Explanation :
A1 = Alternative 1
A2 = Alternative 2

3.1.2 Annual Recurring Cost

Annual recurring costs in life cycle cost analysis include operational and maintenance costs. There were no operational costs for the KR1A HT floor work because the building owner's responsibility was to clean the wall tiles. Operational costs on the HTKR4 floor work come from cleaning services with an acquisition of 90,000,000/year or equivalent to IDR 1,000,620,000 with a workload referring to the Decree of the Minister of PAN Number Kep/75/M.PAN/7/2004 and the use of the full-time equivalent method with an area of 3,033.17 m2 and the KR5A marble floor work also had operational costs, namely the cost of cleaning services. The calculation was the same as the KR4 HT work with an area of 691.38 m2, resulting in IDR. 36,000,000/year and changed to present worth to IDR. 400,248,000.

Furthermore, maintenance costs on floor work refer to PUPR Ministerial Regulation Number 24 of 2008 concerning Guidelines for Building Maintenance and Maintenance, if any, would be multiplied by a coefficient of 0.8 [10].

On the KR5A marble floor work using the initial material design, maintenance was carried out using the PUPR Ministerial Decree No. 24 of 2008. Where for marble maintenance, it was polished every three months. As for other jobs not regulated in the PUPR Ministerial Regulation Number 24 of 2008, using a multiplication coefficient of 0.8. For the results of calculating maintenance costs on floor work in 1 year and present worth for 15 years in **Table 5**.

Table 5. Jobs Maintenance Cost

Design	One Year Fee (IDR)	*Present Worth* (IDR)
Floor Work Type HT KR1B		
A1	13,336,051	148,270,220
A2	10,563,717	117,447,406
Floor Work Type HT KR1A		
A1	9,174,223	101,999,014
A2	7,267,061	80,795,184
Floor Work Type HT KR4		
A1	7,240,953	80,504,915
A2	3,748,911	41,680,392
Marble Floor Work Typr KR5A		
A1	151,268,372	1,681,801,760
A2	1,593,873	17,720,680

Explanation :
A1 = Alternative 1
A2 = Alternative 2

3.1.3 Nonrecurring Cost

Non-recurring life cycle cost analysis includes repair and replacement costs and salvage value. From the Pareto diagram of wall work results, the work items included from 20% are light brick wall work, plasterwork, and KR2B homogeneous tile work.

Repair and replacement costs on floor work were not required because there was no need for repairs and material changes during the life of the building investment. The results of an interview with an architectural practitioner yielded information regarding the durability of ceramic tiles (18 years), homogeneous tiles (20 years), and marble tiles (40 years).

There was no salvage value on the floor work because, during the investment period, there was no repair and replacement of materials, resulting in the residual value of the previous material.

3.2 Alternative Determination

Comparing the value between the initial design and the alternative method aims to determine the alternative chosen in the floor work by considering construction costs, development costs, operational costs, maintenance costs, repair and replacement costs, and salvage costs.

HT KR1B flooring, KR1A HT flooring, and KR5A HT had the same material type in the initial design and alternative materials. The initial design used homogeneous tile, while the alternative used ceramic tile. Construction costs are shown in **Table 4**, and maintenance costs are in **Table 5**. There were no costs for development because there were no costs incurred for redesign, material testing, and modelling. In contrast, operational costs do not exist in HT KR1B and floor work. KR1A HT floor because each user bears cleaning costs. The KR5A HT work had operational costs, namely the cleaning costs of IDR. 90,000,000/year and changed to present worth to IDR. 1,000,620,000. Furthermore, the cost of repair and replacement does not exist because, based on interviews with architectural practitioners for ceramic tile type materials, namely 18 years and homogeneous tile types for 20 years, no replacement and repairs were required during the investment period. Meanwhile, the salvage value does not exist because no replacement activity raises the residual value of the previous material.

While the KR5A marble floor work had the type of material in the initial design, namely marble and, in the alternative, homogeneous tile, construction costs in **Table 4**, maintenance costs are shown in **Table 5**. There were no costs for development because there were no costs incurred for redesign, material testing, and model making. In contrast, the operational costs on this KR5A marble floor work were equal to IDR. 36,000,000/year and changed to present worth to IDR. 400,248,000. Furthermore, the repair and replacement cost did not exist because based on interviews with architectural practitioners for marble type material, which is 40 years, and homogeneous tile type material for 20 years, no replacement and repair has been required during the investment period. Meanwhile, the salvage value did not exist because no replacement activity raised the residual value of the previous material.

After obtaining the value of the life cycle cost of each alternative, it will be compared, and the alternative with a bit of life cycle cost is chosen. The comparison of each alternative's life cycle cost values can be seen in **Table 6** to **Table 10**.

Table 6. Comparison of LCC Values for HT KR1B Floor Works

Present Value Cost Components	A1 (IDR)	A2 (IDR)
X1	1,667,006,430	1,320,464,609
X2	0	0
X3	0	0
X4	148,270,220	117,447,406
X5	0	0
X6	0	0
Total	1,815,276,650	1,437,912,015

Table 7. Comparison of LCC Values for HT KR1A Floor Works

Present Value Cost Components	A1 (IDR)	A2 (IDR)
X1	1,146,777,907	908,382,603
X2	0	0
X3	0	0
X4	101,999,014	90,795,184
X5	0	0
X6	0	0
Total	1,248,776,921	989,177,787

Table 8. Comparison of LCC Values for HT KR4 Floor Works

Present Value Cost Components	A1 (IDR)	A2 (IDR)
X1	905,119,154	468,613,856
X2	0	0
X3	1,000,620,000	1,000,620,000
X4	80,504,915	41,680,392
X5	0	0
X6	0	0
Total	1,986,244,069	1,510,914,248

Table 9. Comparison of LCC Value for Marble KR5A Floor Works

Present Value Cost Components	A1 (IDR)	A2 (IDR)
X1	899,207,564	199,234,091
X2	0	0
X3	400,248,000	400,248,000
X4	1,681,801,760	17,720,680
X5	0	0
X6	0	0
Total	2,981,257,324	617,202,771

Explanation :
X1 = Construction Cost
X2 = Development Cost
X3 = Operating Cost
X4 = Maintenance Cost
X5 = Repair and Replacement Cost
X6 = Residual Value
A1 = Alternative 1
A2 = Alternative 2

From the above calculations, the results obtained on floor work were the smallest life cycle cost value. There was HT KR1B floor work has alternative 2, KR1A HT floor work has in alternative 2, KR4 HT floor work has in alternative 2, KR5A marble floor work has alternative 2.

4. CONCLUSION

Life cycle cost analysis uses the present worth analysis technique. The technique calculates building costs, development costs, operational costs, maintenance costs, repair, and replacement costs, and the residual value on the selected alternative KR1B HT floor work, namely alternative 2 (ceramic tiles) from Rp. 1,437,912,015 on floor KR1A HT, the chosen alternative is alternative 2 (ceramic tile) of IDR. 989,177,787 on the chosen alternative KR4 HT floor work, namely in alternative 2 (ceramic tile) of IDR. 1,510,914,248, and for the KR5A marble floor, the chosen alternative is alternative 2 (homogenous tile) of IDR. 617,202,771. The result of the LCC generated savings of IDR. 2,364,054,553.

This study has limitations that are important for future researchers to do. Future research can examine the life cycle costs of all work, especially jobs that require energy during building operations, so the cost of energy use can be calculated during the building cycle. Furthermore, the life cycle cost phase can be calculated starting from the construction phase to the design age of the building. Where this research only takes floor work.

5. REFERENCES

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