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Life Cycle Cost Estimation that Considers Building Maintenance and Salvage Value in the Construction of Graha Cahaya Kusuma Building

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***Abstract**: A growing company will try to increase its profitability by increasing the productivity of its company. Building an office as a supporting facility is one way to increase productivity. However, most building owners or managers do not consider other cost factors that will arise, namely, the lack of knowledge about life cycle costs. Life cycle costs are calculations of all costs related to assets throughout their service life and costs arising from investment decisions. The data analysis methods carried out in the life cycle cost Graha Cahaya Kusuma Building include initial cost analysis, operational cost analysis, maintenance cost analysis, replacement cost analysis, salvage value analysis, and the Net Present Value (NPV) method. Of life cycle cost for 20 years, the initial cost is Rp 73.585.806.250 or 7,64% of the total, maintenance cost is Rp 15.142.186.691 or 1,57% of the total cost, material replacement cost is Rp 5.283.947.105 or 0,55% of the total, operational cost is Rp 858.474.984.124 or 89,11% of the total and makes operational cost the largest cost in this cycle, and salvage value is Rp 10.934.850.809 or 1,14%. This research is expected to provide an overview of the costs incurred by building owners.*

Kata Kunci:
Gedung, Pemeliharaan, NPV, Operasional, Nilai Sisa

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***Abstrak**: Perusahaan yang sedang berkembang akan berusaha meningkatkan profitabilitas dengan cara meningkatkan produktivitas perusahaannya. Membangun kantor sebagai fasilitas penunjang merupakan salah satu cara untuk meningkatkan produktivitas. Akan tetapi, sebagian besar pemilik atau pengelola gedung kurang mempertimbangkan faktor biaya lain yang akan timbul, yaitu kurangnya pengetahuan tentang biaya siklus hidup. Biaya siklus hidup merupakan perhitungan semua biaya yang berkaitan dengan aset sepanjang masa pakainya dan biaya yang timbul akibat keputusan investasi. Metode analisis data yang dilakukan pada biaya siklus hidup Gedung Graha Cahaya Kusuma meliputi analisis biaya awal, analisis biaya operasional, analisis biaya perawatan, analisis biaya penggantian, analisis nilai sisa, dan metode Net Present Value (NPV). Dari biaya siklus hidup selama 20 tahun, biaya awal sebesar Rp 73.585.806.250 atau 7,64% dari total, biaya perawatan sebesar Rp 15.142.186.691 atau 1,57% dari total, biaya penggantian material sebesar Rp 5.283.947.105 atau 0,55% dari total, biaya operasional sebesar Rp 858.474.984.124 atau 89,11% dari total dan menjadikan biaya operasional sebagai biaya terbesar dalam siklus ini, dan nilai sisa sebesar Rp 10.934.850.809 atau 1,14%. Penelitian ini diharapkan dapat memberikan gambaran tentang biaya apa saja yang dikeluarkan oleh kepada pemilik Gedung.*

INTRODUCTION

Surabaya is one of the largest cities in Indonesia and is included in the metropolitan city category (Rachmawati et al., 2015). The growth of metropolitan areas will followed by the growth of infrastructure and facilities supporting the economy (Anas et al., 2017). The construction of office buildings is one way to support a company's economic activities (Sakinah et al., 2021). Graha Cahaya Kusuma Building is an office building that will be built to support company productivity. The building is the owner's responsibility as long as the building is standing or during the economic life of the building. However, the majority of building owners or managers do not consider other factors, such as maintenance costs and building operational costs (Krisnanda, 2020).

According to Aisyah et al., (2019), there are several factors that influence the lack of consideration, namely, the building owner has not been able to provide detailed information about the condition of the building so maintenance planning cannot be prepared, the type of maintenance for each category is not consistent so the same damage has the potential to occur, and there are no building maintenance standards that can be applied.

According to (Krisnanda, 2020), The reason why building managers are less likely to consider other costs that will arise is the lack of knowledge about life cycle costs. Life cycle costs are calculations of all costs related to assets throughout their service life and costs that arise from investment decisions (Sawant et al., 2018). Life cycle cost assessment can be considered as part of an economic feasibility study, which proves the economic success of real estate, as well as resource efficiency (Kovacic & Zoller, 2015).

Cost identification is very important because it has a very large influence on the total costs incurred during the entire life cycle cost (Zabielski & Zabiels, 2018). Life cycle cost is the calculation of construction costs, operational costs, and component replacement costs during the planned life cycle period (Kaming & Marliansyah, 2016). According to (Krisnanda, 2020), Life cycle cost is the calculation of all costs in a cycle, such as initial costs, operational costs, maintenance, and replacement costs. Life cycle cost, according to (Puhessti, 2021), is the calculation of initial costs, maintenance costs, and operational costs. Based on the literature, life cycle costs can be calculated based on the initial construction costs, operational costs, maintenance costs, and operational costs during the life cycle of the plan.

The majorities of life cycle cost calculations do not consider maintenance costs and salvage value in their cycle calculations. Building maintenance is needed by a company office so that office facilities and infrastructure are optimal to facilitate employees in carrying out their duties and responsibilities so that administrative and operational activities run smoothly (‘Aisy et al., 2024). The residual value of a building is an estimate of the expected market value at the end of the study period in order to obtain a comprehensive picture of the total cost of owning an asset throughout its life cycle (Heralova, 2017).

Life cycle cost estimation in this study calculated based on the Net Present Value (NPV) method, salvage value analysis, and life cycle cost analysis. The hope is that this study can help the management of the GCK Building in calculating the estimated costs incurred during the 20-year life cycle cost period.

METHOD

This article research is based on a case study on the construction project of the Graha Cahaya Kusuma Building, Surabaya. The GCK building has 7 floors and is built on an area of 1996,23 m^2. The GCK Building construction project is scheduled to be completed in 2025. The research methods used to obtain data are interviews with the contractor and the supervising consultant, field observations, and other data obtained through literature review, data processing, and data analysis. The data obtained are in the form of shop drawing data and project construction costs. The data analysis methods that will be carried out in the life cycle cost include initial cost analysis, operational cost analysis, maintenance cost analysis, replacement cost analysis, salvage value, and the Net Present Value (NPV) method.

Initial costs are costs incurred from the preliminary survey stage to project completion (Damanik, 2024). Initial costs include land costs, planning costs, construction costs, and supervision costs. Operating costs are costs that include employee salaries, electricity costs, water costs, and internet costs.

Net Present Value is useful for comparing the value of money at different times (Saadatian et al., 2021) (Spickova & Myskova, 2015). The following is the formula for calculating Net Present Value (NPV) (Spickova & Myskova, 2015).

$$\text{NPV} = \sum_{t=0}^{T} \frac{C_t}{(1+r)^n} \quad (1)$$

T is life cycle duration, C_t is all relevant costs in period t, r is discount rate, t is monitored period (years), and n is year.

Salvage value is the estimated value of an asset after depreciation, depending on its value at the end of its useful life (Alfalah et al., 2024). The following is the formula for calculating salvage value (Damanik, 2024).

$$\text{Depreciation Percentage} = \left(\frac{100\%}{\text{life cycle cost cycle}}\right) \times 2 \quad (2)$$

$$\text{Salvage value} = \text{initial cost} \times \text{depreciaton percentage factor} \quad (3)$$

The depreciation factor can be obtained from compound interest table

Life cycle cost is all expenses in the use of an object (Schwartz et al., 2016). he following is the formula for calculating life cycle cost (Heralova, 2017).

$$\text{LCC} = \text{C} + \text{O} + \text{M} + \text{R} - \text{S} \quad (4)$$

C is initial cost, O is operational cost, M is maintenance cost, R is replacement cost, and S is salvage value. The analysis and calculations in this study were carried out with the help of Microsoft Excel.

RESULTS AND DISCUSSION

Initial costs in this study include the cost of land, cost of construction, cost of planning, and cost of supervising. The land cost is obtained based on the land price per m^2 in the Tenggilis Mejoyo area, which is set at Rp 9.187.000 and multiplied by the land area of the building, which is 1996,23 m^2. The construction costs for building construction were obtained from the results of interviews with the project team, namely Rp 52.000.000.000. This study using a rule according to Peraturan Gubernur Jawa Timur Nomor 26 Tahun 2023 Tentang Standar Biaya Umum (Pergub, 2023) it was stated that the building with construction costs from Rp 50 Milyar – Rp 100 Milyar has a project planning cost of 3,64% of the construction cost. And the cost of supervision in this study according to Gubernur Jawa Timur Nomor 26 Tahun 2023 regarding Standar Biaya Umum (Pergub, 2023) it was stated that the building with construction costs from Rp 50 Milyar – Rp 100 Milyar has a project supervision fee of 2,60% of the construction cost. The results of the recapitulation of the initial cost calculations for building construction are presented in Table 1. And Figure 1.

Table 1. Initial Cost Recapitulation

Category	Volume	Unit Price (Rp)	Total (Rp)
Cost of Land	1996,23 m^2	9.187.500	18.341.006.250
Cost of Construction		52.000.000.000	52.000.000.000
Cost of Planning	3,64%	52.000.000.000	1.892.800.000
Cost of Supervising	2,60%	52.000.000.000	1.352.000.000

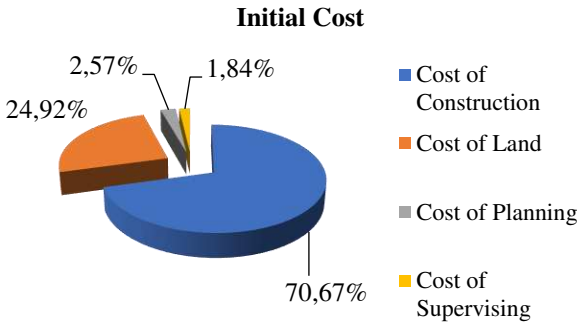

Figure 1. Initial Cost Percentage

The operational cost in this study included employee salaries, the cost of electricity, the cost of water, and the cost of internet. The employee salaries are counted based on the shop drawing, the building is estimated to be occupied by 513 staff. The nominal employee salary is obtained from a survey on several job seeker sites. Employee salaries in Table 2 are assumed to increase every 5 years and then adjusted for the discount rate of 7,77% per year. And the total is Rp 43.248.000.000. Employee salaries are further described in Table 2.

Table 2. Employee Salary

Category	Volume	Unit Price (Rp)	Total (Rp)
Founder	2	540.000.000	1.080.000.000
Managing Director	1	540.000.000	540.000.000
Director of Business Development	1	540.000.000	540.000.000
Chief Marketing Officer	1	540.000.000	540.000.000
Director	1	480.000.000	480.000.000
Accounting Director	1	216.000.000	216.000.000
General Manager	1	180.000.000	180.000.000
Manager	12	120.000.000	1.440.000.000
Senior Staff	240	96.000.000	23.040.000.000
Junior Staff	240	60.000.000	14.400.000.000
Receptionist	1	57.600.000	57.600.000
Secretary	3	72.000.000	216.000.000
Security	3	57.600.000	172.800.000
Cleaning Service	6	57.600.000	345.600.000
Total	513		43.248.000.000

The cost of electricity is counted according to data from Kementerian ESDM, electricity needs per person/capita, namely 1285 kWh or 1285 kVA. 1285 kVA falls into the category of electricity types I-1/TM, which costs Rp1.114,74/kWh. So, the electricity costs required are:
Electricity needs in one year,

$= 1285\ kWh \times 513\ orang$

$= 659.205\ kWh$

Electricity costs required in one year,

$= 659.205\ kWh \times Rp1{,}114{,}74$

$= Rp\ 734.842.182$

Water requirement per individual in one day is 60 liters according to *Peraturan Menteri Pekerjaan Umum nomor* 14/PRT/M/2010 (PU, 2010). With a building capacity of 513 people, the water requirement in one month is 923.400 liters or 923,4 m^3. According to PDAM Surabaya, the *Graha Cahaya Kusuma Building* category is another business in the medium scale and large-

scale category with a tariff code of 3.4. Because the use of water in this building is>20 m^3 in one month, then the water rate per m^3 is Rp 12.500. So, the water cost requirements are:
Water cost requirements in one month,

$= 923{,}4\ m^3 \times Rp12.500$

$= Rp\ 11.542.500$

Water cost requirements in one year,

$= Rp\ 11.542.500 \times 12$

$= Rp\ 138.510.000$

Internet costs are obtained from the estimated use of 5 floors as an office, with internet rates obtained by estimating using the internet network provider Biznet. Internet prices for *Paket Usaha* with a capacity of 100 Mbps in one month are Rp1.000.000. So, the total internet cost in a year is Rp 60.000.000. The results of the recapitulation of operational cost calculations for 20 years of the life cycle cost period on buildings with a discount rate percentage of 7,7%, referring to bank interest, are presented in Table 3 and Figure 2.

Table 3. Recapitulation of Operational Cost Analysis

Category	Total (Rp)
Employee Salary	849.824.354.488
Electricity Bill	6.810.770.553
Water Bill	1.283.758.408
Internet Bill	556.100.675

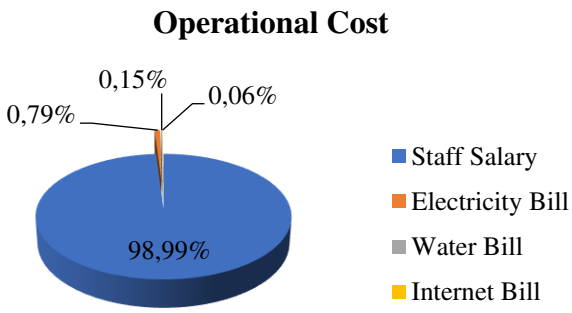

Figure 2. Operational Cost Percentage

The building maintenance cost estimate is based on Peraturan Menteri Keuangan Nomor 49 Tahun 2023 regarding Standar Biaya Masukan 2024 (Permenkeu, 2024), which is Rp 196.000 and multiplied by the area of the building to be built. Details of the maintenance cost analysis are outlined in Table 4.

Table 4. Recapitulation of Maintenance Cost Analysis

Floor Level	Volume (m^2)	Unit Price (Rp)	Total (Rp)
Level Ground	1996,26	196.000	391.266.960
Level Upper Ground	1122,55	196.000	220.019.800
Level 1	1064,09	196.000	208.561.640
Level 2	1038,01	196.000	203.448.980
Level 3	1038,19	196.000	203.485.240
Level 4	1038,19	196.000	203.485.240
Level 5	1038,19	196.000	203.485.240
Total	8335,48	196.000	1.633.753.100
Total Cost for 20 years LCC			15.142.186.691

Replacement costs are obtained by calculating the service life of the component. To find the service life of a component, interviews were conducted with the project employee. The life service of the materials from each category is used as the return period of each material, which means the materials are replaced every time the life serviced ended (Kaming & Marliansyah, 2016). There are estimated material replacement cost in the beginning of the cycle in Table 5 and Figure 3.

Table 5. Replacement Cost Analysis

Category	Total (Rp)
Structural	2.139.011.000
Architectural	12.845.552.190
Mechanical	1.157.115.450
Electrical	3.352.666.000

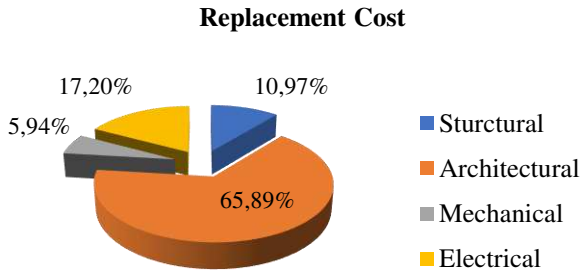

Figure 3. Material Replacement Cost Percentage

The construction project of the Graha Cahaya Kusuma Building will last until 2025, so the calculation of replacement costs will start from 2026 with n=2 until 2045. The calculation of life cycle cost on material replacement cost is calculated using the net present value method to obtain the total NPV value of Rp 5.283.947.105. Details of material replacement costs per cycle are described in Table 6.

Table 6. Details of Material Replacement Costs per Cycle

Year	Net Present Value (Rp)
Year 5	31.401.886
Year 8	1.424.856.074
Year 10	53.732.749
Year 15	801.451.394
Year 16	783.047.190
Year 20	2.189.457.812
Total	5.283.947.105

Salvage value is obtained by calculating the initial cost and depreciation percentage factor, the factor is obtained from the compound interest table and the percentage is obtained from the calculation. The calculation of depreciation percentage is as follows:

$$\text{Depreciation Percentage} = \left(\frac{100\%}{\text{life cycle cost cycle}}\right) \times 2$$

$$= \left(\frac{100\%}{20}\right) \times 2$$

$$= 10\%$$

After obtaining the depreciation percentage, the next step is to calculate the salvage value as follows:

$$\text{Salvage value} = \text{initial cost} \times \text{depreciaton percentage factor}$$

$= \text{Rp } 73.585.806.250 \times 0{,}1486$
$= Rp\ 10.934.850.809$

The estimated life cycle cost for 20 years can be calculated after the required costs are obtained. The life cycle cost value for the Graha Cahaya Kusuma Building project is obtained at Rp 941.552.073.361. In the calculation of life cycle cost for 20 years, the initial cost is Rp 73.585.806.250 or 7,64% of the total, maintenance cost is Rp 15.142.186.691 or 1,57% of the total cost, material replacement cost is Rp 5.283.947.105 or 0,55% of the total, operational cost is Rp 858.474.984.124 or 89,11% of the total and makes operational cost the largest cost in this cycle, and salvage value is Rp 10.934.850.809 or 1,14%.

Operational costs at the Graha Cahaya Kusuma Building incur the largest life cycle cost of 91,09% with the largest percentage of employee salaries. Operational costs are the largest costs because they will be incurred by the company every year and will be used to support building operations for the next 20 years. Meanwhile, material replacememnt costs actually incur the smallest costs in a 20-year cycle with a percentage of 0,38%. The recapitulation results of the building's life cycle cost over 20 years are shown in Table 7 and Figure 4.

Table 7. Recapitulation of Life Cycle Cost Analysis

Costs Category	Total (Rp)
Initial Cost	73.585.806.250
Operational Cost	858.474.984.124
Maintenance Cost	15.142.186.691
Replacement Cost	5.283.947.105
Salvage Value	10.934.850.809

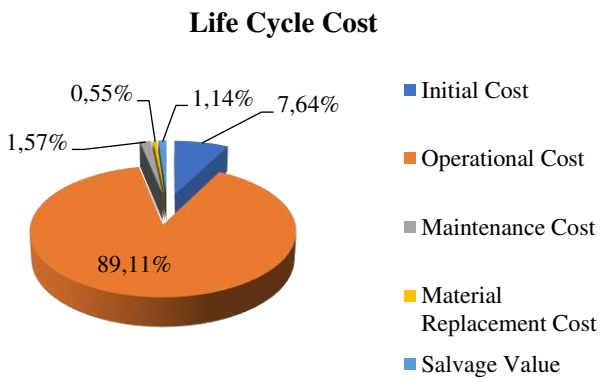

Figure 4. Life Cycle Cost Percentage

CONCLUSION

This study shows that life cycle cost analysis plays an important role in helping Graha Cahaya Kusuma Building managers to calculate the estimated costs that will be incurred during the building's 20-year service life. By using this approach, managers can obtain a clear picture of the total costs that include construction, operation, maintenance, component replacement, and salvage value. This information is very useful for planning budgets effectively and ensuring the sustainability of building operations in the long term. In addition, the results of this study can be a reference in making strategic decisions, such as determining maintenance priorities or replacing components that most affect costs. With measurable and structured calculations, managers can minimize the risk of unexpected expenses and ensure efficient use of resources. Overall, this study

provides an important contribution in supporting more effective and sustainability-oriented GCK Building management.

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