



Analysis of the Impact on Maintenance Cost for School Building Using Eco-Friendly Wall

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Abstract: The selection of wall materials is critical factor influencing long- term building. This study aims to analyze the impact of using eco-friendly wall materials on building costs using the Life Cycle Cost (LCC) approach. The research compares Eco Hollow Block (EHB), which utilizes recycled multilayer plastic waste, with conventional red brick as a comparison material. The study was conducted on Sekolah Dasar Negeri (SDN) 002 buildings in Palembang. The LCC analysis includes initial construction cost, maintenance cost, and replacement cost during a 50-year building service life. The results indicate that the initial construction cost of EHB walls is higher than conventional brick. Furthermore, the total Life Cycle Cost of EHB is also higher due to its shorter service life, which requires periodic replacement within the analysis period. However, the use of EHB provides significant environmental benefits through plastic waste utilization and supports sustainable construction practices.

Keywords: Life Cycle Cost, Eco Hollow Block, Plastic Waste Reduction, Building Cost, School Building.

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1. Introduction

The global building stock is rapidly expanding, making sustainability in existing buildings urgent. Existing buildings have a direct impact on environmental, economic, and social outcomes. Most policies and innovations in the construction sector tend focus on environmental factors (R. Isaksson & Rosvall, 2020). In Indonesia, PP number 16/2021 establishes a 2% annual depreciation rate for permanent buildings and mandates systematic maintenance to ensure safety, health, comfort, accessibility, and compliance with environmental standards (Permen PU No. 24/2008). Sustainable maintenance increases efficiency and safety (Lin et al., 2018).

The use of environmentally friendly materials is one of the key strategies to achieve building sustainability. These materials come from renewable resources, have low carbon emissions, and promote energy efficiency (A. Isaksson & Linderoth, 2018). Previous studies have shown that alternative wall systems, such as B-panels, can outperform conventional brick in terms of by reducing maintenance costs by up to 14% (Selawati, 2019). One

example of such innovation is the Eco Hollow Block (EHB), developed by Rebricks, which incorporates approximately 2.2 kg of recycled multilayer plastic waste per unit. This material meets technical standards, with compressive strength of more than 45 kg/cm² (SNI 03-0349-1989), and has passed fire-resistance and safety tests, making it suitable for non-structural wall applications.

Plastic waste has become a major global concern due to its persistence in the environment and its harmful impacts. Improper disposal methods, such as open burning, release hazardous particulates that contribute to climate change and pose serious risks to human health, including hormonal disruption and neurological disorders (Kumar et al., 2020; Ogundairo et al., 2021; Leslie et al., 2022). In building construction, wall systems occupy a large portion of the structure and significantly influence thermal comfort, acoustic performance, and maintenance requirements. Therefore, the selection of appropriate wall materials plays a crucial role in determining long-term building performance (Krstić et al., 2021; Weerasinghe et al., 2021).

Yasinta et al. (2020) conducted a literature review of 14 articles



from reputable journals discussing on methods for analyzing the cost implications of green building implementation. The results of the review indicate that Life Cycle Cost Analysis (LCCA) is the most commonly used method in such studies. LCCA provides a comprehensive framework for evaluating building costs. It covers costs across the building lifecycle: initial, operational, maintenance, and replacement (Rosita et al., 2023). Previous studies have applied LCC to assess long-term economic performance in various types of buildings (Selawati, 2019; Petra & Narindri, 2019; Rosita et al., 2023). However, most of these studies focus on conventional materials and non-educational buildings, while limited research has examined the application of LCC to environmentally friendly materials in school buildings. Therefore, this study examines the use of eco-hollow blocks on maintenance costs at SDN 002 Palembang by identifying the main cost categories and applying the Life Cycle Cost method. The analysis includes recent green school initiatives and the national school rehabilitation program, and the findings provide local evidence for a sustainable, cost-effective alternative to school infrastructure.

2. Method

2.1. Research Objectives

This study aims to:

1. Assess the cost efficiency of eco-friendly wall materials. Focus on eco-hollow block (EHB), which is made from recycled multilayer plastic, in comparison with conventional red bricks (RB), the standard fired clay building units; and
2. Analyse initial, maintenance, and replacement costs for each material with an analysis of life cycle costs.

In conclusion, this study aims to assess the long-term cost-effectiveness of eco-friendly materials in school buildings by integrating economic and environmental factors, thereby supporting sustainable material selection and reducing plastic waste.

2.2. Literature Review

Building Maintenance

Buildings are physical assets designed to support various functions: including residential, commercial, socio-cultural, and special purposes. They are classified by complexity, permanence, and risk level (PP Number 16/2021). To maintain their functionality and structural integrity throughout their service life, buildings require systematic maintenance and repair. Maintenance activities aim to preserve building components, while repair activities restore or replace damaged elements (Permen PU Number 24/2008). Most buildings are designed to last about 50 years. Annual depreciation rates range from 2% to 10%, depending on classification.

Building deterioration is classified into minor, moderate, and severe levels, which determine the appropriate intervention strategies, such as rehabilitation or renovation (Permen PU Number 24/2008). Maintenance activities include structural components, architectural elements, and building service systems. In wall construction, maintenance activities typically involve masonry work, plastering, skim coating, and surface finishing, with deterioration ranging from hairline cracks to partial or total failure (SE DJCK Number 47/2020). Preventive maintenance, including repainting, is typically performed every two to three years. In

educational facilities, maintenance is further categorised into minor and major interventions, conducted at 5 to 20 year intervals, respectively (Permendiknas Number 24/2007).

Life Cycle Cost Analysis

Life cycle cost analysis (LCCA) is a method to assess the total cost of a building over its entire life cycle. This includes planning, construction, operation, maintenance, and demolition (Ashworth, 1994; Fuller & Petersen, 1995; Barringer & Weber, 1996). This method is particularly suitable for construction projects because it considers long-term economic performance rather than focusing solely on initial costs (Selawati, 2019). LCCA typically classifies costs into three main components: initial cost, maintenance cost, and replacement cost (Kirk & Dell'Isolla, 1995). The initial cost encompasses construction expenses, especially those related to wall construction, including materials and labour. Maintenance costs represent recurring expenditures influenced by maintenance frequency and inflation, while replacement costs occur when a component's service life is shorter than the building's design life.

The LCC calculation is based on the time value of money, which accounts for changes in monetary value due to inflation and interest rates. All cost flows are converted into equivalent values using Future Value (FV) and Present Value (PV) methods.

The future value is calculated as follows:

$$F = P (1 + i)^n \dots\dots\dots (1)$$

The present value is calculated as follows:

$$P = F \frac{1}{(1+i)^n} \dots\dots\dots (2)$$

Where: P = present value, F = Future Value, i = interest/inflation rate, n = number of period

The life cycle cost formulation is expressed as follows:

$$LCC = IC + \sum PV(MC) + \sum PV(RC) \dots\dots\dots (3)$$

Where: IC = Initial Cost, PV(MC) = Present value maintenance cost, PV(RC) = Present value replacement cost

This framework allows LCC to assess cost distribution across a building's life. Maintenance and replacement costs often exceed initial construction costs, highlighting their importance in evaluating a building system's long-term economic performance and sustainability (Petra & Narindri., 2021; Yasinta dkk., 2020).

2.3. Object and Data Source

The research objects consist of selected public elementary school buildings located in Palembang. This study utilizes secondary data, including:

1. Bill of Quantities (BOQ) for building maintenance;
2. As-built drawings (ABD);
3. Price and technical specifications of Eco Hollow Block obtained from PT Rebricks Indonesia; and
4. Supporting data, such as inflation and interest rates, obtained from The Bank Indonesia

The BOQ and ABD were obtained from Satuan Kerja Prasarana Strategis Kementerian PUPR. The ABD quantified wall areas. Price data were used to estimate the costs of eco-friendly material.

2.4. Analysis Method

This study adopts a quantitative approach using comparative and analytical methods. The comparative method is used to evaluate cost efficiency between materials, while the analytical method is applied to examine each cost component in detail.

The analysis procedure consists of the following steps:

1. Calculation of wall areas, based on ABD, to determine total wall quantities;
2. Development a unit price analysis (UPA) to calculate the cost of EHB material and labour per square meter, in accordance with Permen PUPR Number .1/2022
3. Estimating the BOQ for each material. Wall construction consists of masonry work, plastering, skim coating, and painting works for all alternatives.
4. Life cycle cost analysis (LCCA) over a 50-year periode, consisting of the following stages:
 - a. Identification of cost components: initial cost, maintenance cost and replacement cost;

The initial cost considered in this study comprises construction expenses for wall construction, including both materials and labour. According to SE DJCK Number. 47/2020, wall construction items encompass wall masonry, plastering, skim coating, and painting. These components are incorporated into the initial cost calculation for each material type, specifically EHB and RB.

- b. Determination of service life for replacement cost and maintenance frequency based on regulatory standards and material characteristics;

This study examines maintenance costs for painting work. The building requires repainting every 5 years. Therefore, both RB walls and EHB walls are repainted every 5 years over a 50-year design life. Figure 1(a) shows the maintenance cost for EHB walls. Although repainting occurs every 5 years, EHB material replacement occurs at years 20 and 40, so there are no maintenance costs during those years. Figure 1(b) shows the cash flow of maintenance cost for RB walls.

Figures 1(a) and 1(b) present the cash flow diagrams for two wall materials over a 50-year analysis period, where downward arrows represent cost outflows. The initial cost (P) occurs at year 0, while maintenance costs (F₅, F₁₀, etc.) are incurred every five years. The key difference lies in the cost frequency, where EHB requires fewer maintenance costs than RB because material replacement at years 20 and 40 eliminates the need for maintenance during those intervals.

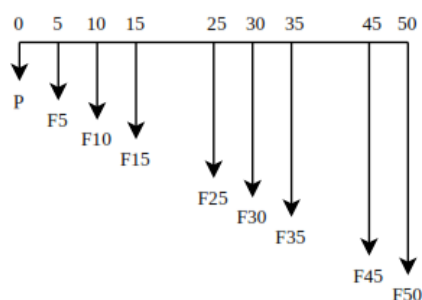


Figure 1(a). Diagram Cash Flow of Eco Hollow Block Material Maintenance Cost

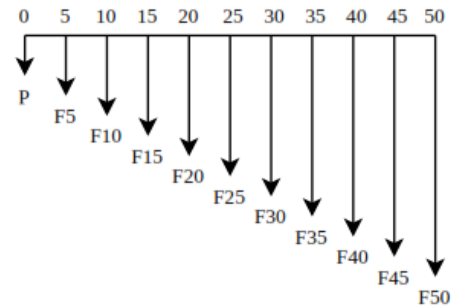


Figure 1(b). Diagram Cash Flow of Conventional Red Brick Material Maintenance Cost

The replacement cost in this study is determined by the service life of wall materials. For RB, replacement is assumed to occur every 75 years (Kirk & Dell'Isola, 1996). Consequently, within a 50-year design life, no replacement cost is included because the material lifespan exceeds the analysis period. In contrast, the EHB is assumed to have a service life of more than 20 years, based on manufacturer information (PT. Rebricks Indonesia). Therefore, wall replacement is scheduled every 20 years. The corresponding cash flow diagram is shown in Figure 2(c), with cost components comprising wall masonry, plastering, skim coating, and painting.

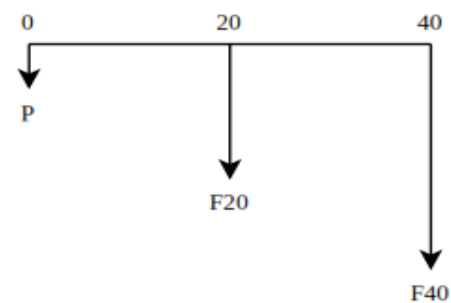


Figure 1(c). Diagram Cash Flow of Eco Hollow Block Material Replacement Cost

Figure 1(c) shows the cash flow diagram for EHB replacement costs during the analysis period. The initial cost (P) occurs at year 0. Replacement costs follow at years 20 (F₂₀) and 40 (F₄₀), reflecting the assumed service life of the material. Downward arrows indicate cash outflows at each period.

- c. Estimation of future value, considering inflation and maintenance frequency;

Periodic maintenance and replacement costs are assumed to increase with inflation. Accordingly, cost adjustments utilise an inflation rate of 4.21%, reflecting the annual average for 2022 as reported by Bank Indonesia. The resulting adjusted costs are presented as future values for both maintenance and replacement costs.

- d. Conversion into present value, using an appropriate discount rate;

The future value is converted to present value through discounting,

which adjusts for the time value of money and aligns costs to the base year. This uses a 4% discount factor, based on the 2022 annual average from Bank Indonesia data.

- e. Comparison of total LCC to evaluate the most cost-efficient material alternative.

The final stage of the analysis compares the short and long-term costs of the two wall materials to clarify their economic performance. Additionally, implementing eco-hollow blocks in the area studied reduces plastic waste.

3. Result and Discussion

3.1. Study Area

According to data from Satuan Kerja Prasarana Staregis Kementerian PUPR, a total of 28 public elementary schools were identified as priority projects in Palembang. Of these, 14 schools have undergone rehabilitation and renovation, implemented gradually based on budget availability. This study examines the highest maintenance cost during 2022–2023. Figure 2 presents the maintenance cost data for each school.

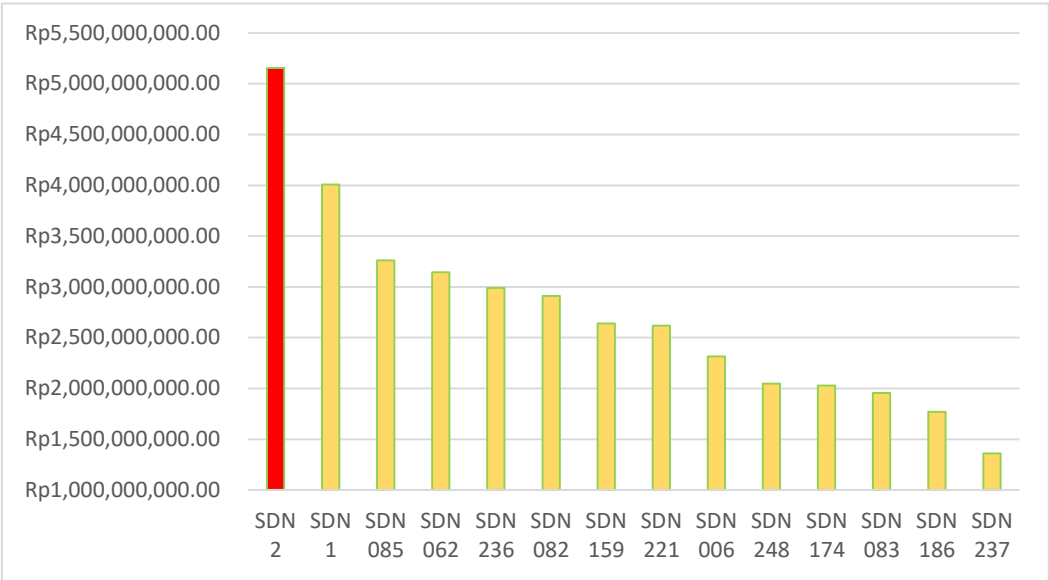


Figure 2. Comparative Maintenance Cost of Elementary Schools

Figure 2 shows that SDN 002 has the highest maintenance cost, totalling IDR5.156.067.566,82. Therefore, this study focuses on SDN 002 Palembang. The selection of SDN 002 as the case study provides a representative basis for evaluating maintenance cost

characteristics in relatively large and complex school buildings. General information of the research objects in this study summarised in Table 1.

Table 1. General Information

Name	Address	Number of Floor	Building Observed
SDN 002 Palembang	Jl. Padang Selasa Bukit Lama Kec. Ilir Barat I	2	Building A
		2	Building B
		1	Building C
		2	Building D

Table 1 informs SDN 002 1. It consists of main buildings: Building A, B, C, and D. Building A, B, and D are two-story buildings, while Building C functions as a staff residence. Due to their distinct characteristics, each building is analysed separately in this study. According to the as-built drawings, Building A and D each

have four classrooms, while Building B has two. All of these buildings are two-story structures with a ground floor and a first floor. Figures 3(a) to 3(e) present visual representations of the building elevations examined in this study.

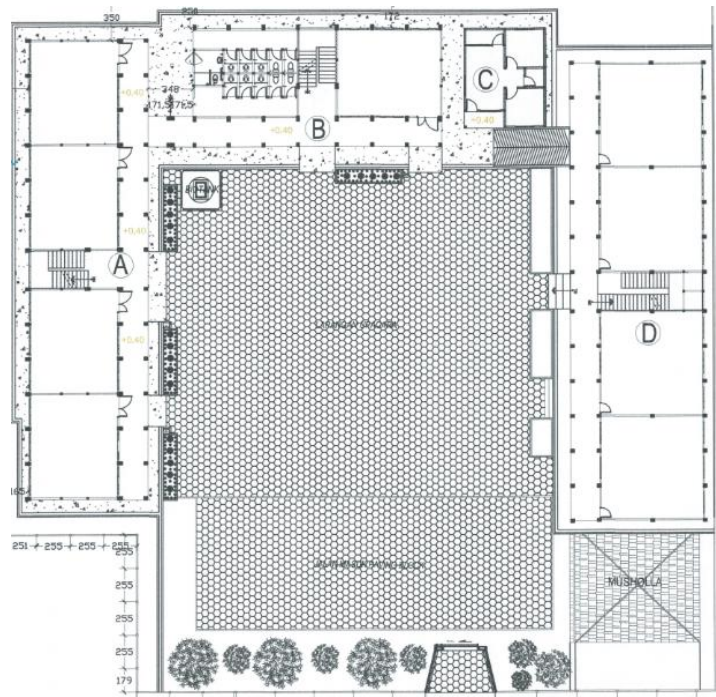


Figure 3(a) Site Plan of SDN 002 Palembang



Figure 3(b). Front View of Building A

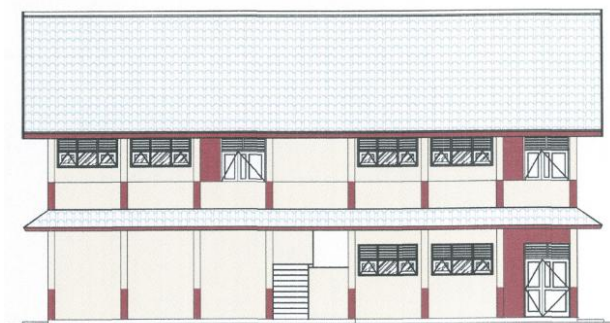


Figure 3(c). Front View of Building B



Figure 3(d). Front View of Building C



Figure 3(e). Front View of Building D

Figure 3a displays the site plan, and Figures 3b to 3e depict the front views of the main buildings at SDN 002 Palembang: Building A, B, C and D. The site plan clarifies the spatial arrangement of the buildings, while the front views illustrate their architectural forms, floor counts, and distinguishing features.

3.2. Wall Area

The net wall area was calculated by subtracting the areas of all openings, including doors, windows, and structural columns, from the gross wall area. The results are shown in Table 2.

Table 2. Total of Wall Areas		
Number	Name	Wall Area (m ²)
1	Building A	596,45
2	Building B	357,88
3	Building C	129,27
4	Building D	556,51
Total		1.679,44

Table 2 presents the wall areas for each building at SDN 002 Palembang. Building A has a wall area of 596,45 m², Building B 357,88 m², Building C 129,27 m², and Building D 556,51 m². The total wall area for all buildings is 1.679,44 m². These data provide the basis for calculating construction, maintenance, and replacement costs in the subsequent analysis.

3.3. Unit Price Analysis (UPA)

The unit price analysis (UPA) in this study is based on Permen PU Number 1/2022, with adjustments reflecting the year of construction implementation. Material coefficients for EHB wall construction were established through interviews with PT Rebricks Indonesia. The resulting AHSP parameters are methodologically comparable to those used for conventional concrete blocks, although the material compositions differ. Table 3 presents a comparison of AHSP costs for each type of work.

Table 3. Summary of Unit Price Analysis		
Type of Work	Red Brick (IDR/ m ²)	Eco Hollow Block (IDR/ m ²)
Masonry work	122.182,50	189.924,00
Plastering	62.742,90	62.742,90
Skim Coating	36.327,50	36.327,50
Painting	23.989,16	23.989,16

Table 3 presents a comparison of unit costs for wall construction using red brick and eco hollow block. The masonry work cost for eco hollow block is higher, primarily due to higher material costs and its status as an eco-friendly material. In contrast, the costs for plastering, skim coating, and painting remain consistent for both materials, as the work processes and labour requirements are comparable. These data serve as the basis for calculating the initial cost of each material.

3.4. Cost Estimate (CE)

The analysis in this study focuses on the cost calculation of wall construction using two materials: eco hollow block (EHB), a type of block made from recycled multilayer plastic materials and produced by PT Rebricks Indonesia, and conventional red brick (RB). The wall construction components analysed include masonry work, plastering, skim coating, and painting. The cost estimation is carried out using the Bill of Quantities (BoQ), calculated as the product of work volume and unit price, as expressed in the following formula:

CE = Work volume x Unit Price.....(4)

Where work volume refers to Table 2 and unit price refers to Table 3. The results obtained from this formula are presented in Table 4.

Table 4. Total Cost Estimate

Wall Construction	Eco Hollow Block (IDR)	Red Brick (IDR)
BUILDING A		
Masonry work	113.278.897,31	72.874.933,50
Plastering	74.845.164,66	74.845.164,66
Skim Coating	43.334.587,96	43.334.587,96
Painting	31.670.972,04	31.670.972,04
Total A	263.129.621,96	222.725.658,16
BUILDING B		
Masonry work	67.970.248,02	43.726.831,94
Plastering	44.909.021,24	44.909.021,24
Skim Coating	26.001.865,85	26.001.865,85
Painting	18.012.804,63	18.012.804,63
Total B	156.893.939,74	132.650.523,65
BUILDING C		
Masonry work	24.550.981,68	15.794.214,10
Plastering	16.221.223,10	16.221.223,10
Skim Coating	9.391.922,95	9.391.922,95
Painting	5.199.126,25	5.199.126,25
Total C	55.363.253,98	46.606.486,40
BUILDING D		
Masonry work	113.164.183,21	72.801.135,27
Plastering	74.769.371,23	74.769.371,23
Skim Coating	43.290.704,34	43.290.704,34
Painting	31.670.972,04	31.670.972,04
Total D	262.895.230,82	222.532.182,88
Total A+B+C+D	738.282.046,50	624.514.851,09

Table 4 shows that using EHB increases building costs by 18.22% compared to conventional RB, making it 15.41% less cost-efficient. This difference shows that, for initial costs, conventional materials are more economical than eco-friendly alternatives. EHB's higher cost results from its greater unit price and the more complex production process compared to conventional options. Additionally, EHB's limited production scale and distribution make it less cost-efficient than red brick, which remains more economical due to its broad usage and availability. Assess these findings within a comprehensive Life Cycle Cost (LCC) framework to ensure material selection considers both initial costs and long-term performance, including sustainability.

3.5. Life Cycle Cost Analysis

3.5.1. Initial Cost

The initial cost calculation for RB and EHB wall construction is determined by summing all cost components listed in Table 4. These components, masonry work, plastering, skim-coating, and painting, collectively represent the total cost required for all buildings. A summary of these costs, and thus the financial impact of each component, is provided in Table 5.

Table 5. Summary of Initial Cost

Name	Eco Hollow Block (IDR)	Red Brick (IDR)
Building A	263.129.621,96	222.725.658,16
Building B	156.893.939,74	132.650.523,65
Building C	55.363.253,98	46.606.486,40
Building D	262.895.230,82	222.532.182,88
Total	738.282.046,50	624.514.851,09

Table 5 shows that the initial cost for EHB material at SDN 002 is IDR 738,282,046.05, whereas the cost for RB material is IDR 624,514,851.09. This difference demonstrates that the initial cost of EHB is higher than that of conventional materials. These initial cost values serve as the basis for the Life Cycle Cost (LCC) analysis, which is conducted to comprehensively assess and compare the long-term economic impacts and total costs of both materials over the building's life span.

3.5.2. Maintenance Cost

Painting costs, both interior and exterior, are components of maintenance costs within the life cycle analysis. Wall maintenance is planned at five-year intervals throughout the 50-year design life.

Projected costs are assumed to increase by 4.21% per year, based on Bank Indonesia's 2022 inflation rate.

a. Maintenance Cost of Red Brick

Maintenance costs (MC) begin in year 5 of the analysis period. Figure 1(b) provides an overview of these expenses through the cash flow diagram. The total painting cost for SDN 002, which combines expenses from four building units as shown in Table 4, is IDR86.553.874,95. The cost of this painting is projected to rise in future periods at an inflation rate of 4,21% (see Equation 1) and is discounted to present value at an interest rate of 4% (see Equation 2). The result are shown in Table 6.

Table 6. Summary of Present Value Maintenance Cost Red Brick

Future Value		Present Value	
Year-	Maintenance Cost (IDR)	Year-	Maintenance Cost (IDR)
5 th	106.373.511,30	5 th	87.431.272,38
10 th	130.731.569,35	10 th	88.317.563,99
15 th	160.667.284,71	15 th	89.212.839,95
20 th	197.457.863,50	20 th	90.117.191,32
25 th	242.672.974,32	25 th	91.030.710,12
30 th	298.241.718,12	30 th	91.953.489,27
35 th	366.534.933,19	35 th	92.885.622,63
40 th	450.466.346,87	40 th	93.827.205,04
45 th	553.616.889,65	45 th	94.778.332,28
50 th	680.387.475,42	50 th	95.739.101,11
Total		915.293.328,08	

Table 6 summarises wall maintenance costs for red brick material, analysed using both Future Value (FV) and Present Value (PV) methodologies over a 50-year period. Maintenance costs calculated in FV rise from IDR106.373511,30 in year 5 to IDR680.387.475,42 in year 50. Inflation drives this progressive increase by raising nominal costs over time. Discounted to Present Value, maintenance costs remain stable, ranging from IDR87.431.272,38 to IDR95.739.101,11. This shows that inflation and the discount rate largely offset each other, leading to little variation in real terms. The total maintenance cost in PV over 50

years is IDR915.293.328,08, which represents the key finding: the economic burden identified within the Life Cycle Cost (LCC) framework.

b. Maintenance Cost of Eco Hollow Block

Maintenance costs for EHB material are calculated by applying cost values at each five-year interval over the 50-year analysis period. Replacement costs are included in years 20 and 40, reflecting the 20-year service life of the material and aligning those years with complete material replacement (see Figure 1(a)). The

initial painting cost, annual inflation rate, and interest rate were applied in the EHB maintenance cost calculation in the same way as for other materials. Specifically, the calculation involves

updating the painting cost for each maintenance interval using the inflation rate and discounting future costs to present value using the interest rate. The results for EHB are shown in Table 7.

Table 7. Summary of Present Value Maintenance Cost Eco Hollow Block

Future Value		Present Value	
Year-	Maintenance Cost (IDR)	Year	Maintenance Cost (IDR)
0 th	-	0 th	-
5 th	106.373.511,30	5 th	87.431.272,38
10 th	130.731.569,35	10 th	88.317.563,99
15 th	160.667.284,71	15 th	89.212.839,95
20 th	-	20 th	-
25 th	242.672.974,32	25 th	91.030.710,12
30 th	298.241.718,12	30 th	91.953.489,27
35 th	366.534.933,19	35 th	92.885.622,63
40 th	-	40 th	-
45 th	553.616.889,65	45 th	94.778.332,28
50 th	680.387.475,42	50 th	95.739.101,11
Total		731.348.931,72	

Table 7 summarises the maintenance costs for EHB material. In terms of FV, maintenance costs increase over time due to inflation, mirroring the trend observed in RB. The lack of maintenance activities in years 20 and 40 disrupts the cost cycle, indicating a reduced maintenance frequency. Expressed in PV, maintenance costs remain relatively stable, ranging from IDR87.431.272,38 to IDR95.739.101,11. This stability is due to discounting, which offsets inflation throughout the analysis period. The total PV MC

for EHB over a 50-year period is IDR731.348.931,72.

3.5.3. Replacement Cost

The EHB material lasts 20 years. As the building is planned for 50 years, it will need to be replaced twice, at years 20 and 40. These replacements cause cash outflows, which are included in the life-cycle cost calculation. Figure 2(c) shows the sequence of these outflows. The results are shown in Table 8.

Table 8. Summary of Present Value Replacement Cost Eco Hollow Block

Future Value		Present Value	
Year-	Replacement Cost (IDR)	Year	Replacement Cost (IDR)
0 th	-	0 th	-
20 th	1.684.264.230,12	20 th	768.676.208,58
40 th	3.842.360.802,79	40 th	800.321.660,86
50 th	-	50 th	-
Total		1.568.997.869,45	

Material replacement costs are scheduled for years 20 and 40, consistent with the expected service life. These costs will be incurred at the specified years. The FV increases due to inflation, whereas the PV indicates more controlled expenditures through discounting. The total replacement cost, expressed in present terms, is IDR1.568.997.869,45 and represents a substantial portion

of the Life Cycle Cost (LCC) analysis.

The total Life Cycle Cost (LCC) is calculated using Equation (3), which aggregates all cost components incurred over the project's duration into present-value terms as of the analysis date. The results are shown in Table 9.

Table 9. Total Life Cycle Cost

Material	Initial Cost (IDR)	Present Value of Maintenance Cost (IDR)	Present Value of Replacement Cost (IDR)	Total LCC (IDR)
Red brick	624.514.851,09	915.293.328,08	-	1.539.808.179,17
Eco Hollow Block	738.282.046,50	731.348.931,72	1.568.997.869,45	3.038.628.847,66

Table 9 presents the total Life Cycle Cost (LCC) in present value for each material, including initial, maintenance, and replacement costs. According to the analysis, red brick has a total LCC of IDR1.539.808.179,17, while the eco hollow block (EHB) has a total LCC of IDR3.038.628.847,66. Therefore, the total LCC of red brick is approximately 49.33% lower than that of EHB, clearly indicating red brick is more cost-effective over its life cycle.

3.6. Plastic Waste Reduction

Eco hollow block (EHB) material offers an alternative construction approach that promotes environmental sustainability by incorporating plastic waste. The use of EHB material per 1 m² of wall is equivalent to a reduction of plastic waste of 2,2 kg. With a total wall area of 1.679,44 m² in SDN 002 Palembang, as shown in Table 2, the estimated total reduction in plastic waste is 3.694,768 kilograms or 3,69 tons.

According to municipal waste generation data for Palembang from Sistem Informasi Pengelolaan Sampah Nasional (SIPSN), total waste generation is 1.180,25 tons per day, with plastic waste comprising 17.5% or approximately 206,54 tons per day. The use of 3,69 tons of plastic waste through the application of EHB material in the analysed buildings represents approximately 1,79% of the total daily plastic waste generated in Palembang.

The Indonesian Waste Bank reports that multilayer plastic waste sells for IDR500 per kilogram. Using this waste as raw material for Eco Hollow Block (EHB) production gives indirect benefits valued

at IDR1.847.384. This reduces initial construction costs by 1,79% and increases economic efficiency in the early construction phase. These economic benefits also increase over the building's service life. In year 20, the benefit reaches IDR1.923.438,52. It further rises to IDR2.002.624,12 in year 40. This trend shows sustained cost savings, especially through reduced replacement costs of 0,25%. Though initial costs are higher than for traditional materials, economic gains from plastic waste and long-term savings add significant value economically and sustainably.

4. Discussion

Comparative LCCA EHB dan BB

The Life Cycle Cost (LCC) analysis over 50 years shows EHB has 20,10% lower total maintenance costs (IDR731.348.931,72) than RB (IDR915.293.328,08) due to EHB's material replacement in the 20th and 40th years, which eliminates regular maintenance during those times. EHB's total LCC is IDR3.038.628.847,66, about 49,33% higher than RB's IDR1.539.808.179,17, mainly due to EHB's replacement cost of IDR1.568.997.869,45. RB incurs no replacement costs during the analysis period, leading to a lower LCC. These findings suggest that replacement cost components exert a dominant influence on total life-cycle costs. While EHB provides advantages in maintenance frequency and costs, these benefits do not sufficiently offset the considerable replacement costs within the analysed timeframe.

Table 10. Comparative Analysis of Eco Hollow Block and Red Brick Materials

Cost Component	Red Brick	Eco Hollow Block
Initial cost	624.514.851,09	738.282.046,50
Maintenance Cost	915.293.328,08	731.348.931,72
Replacement Cost	-	1.568.997.869,45
Total LCC	1.539.808.179,17	3.038.628.847,66
Indirect Benefits (waste reduction)		
Initial cost	-	(1.847.384)
replacement cost 20 th ;40 th	-	(1.923.438,52); (2.002.624,12)
Adjusted LCC	1.539.808.179,17	3.032.855.401,02
Reduce plastic waste	-	3,96 tons
Life span	>50 years	20 years

Table 10 shows that, however, the LCC analysis conducted in this study is limited to direct costs and does not comprehensively account for the indirect benefits associated with environmentally friendly materials. Specifically, adopting EHB has been shown to reduce plastic waste by approximately 3,69 tons. This reduction translates to an estimated economic value of about IDR5.773.446,64, calculated based on the cost savings from reduced waste processing. That means, including indirect benefits in the Life Cycle Cost (LCC) analysis shows that EHB can cut total life-cycle costs by 0,19%. Incorporating this economic benefit lowers the Adjusted LCC value for EHB, thereby narrowing the cost gap with RB.

Furthermore, the broader implications of utilising environmentally friendly materials warrant consideration. Widespread adoption of materials such as EHB in construction could substantially increase plastic waste reduction, decrease landfill burden, minimise environmental pollution, and support the realisation of sustainable development principles. Although these impacts have not been fully quantified in economic terms, they hold considerable strategic value over the long term. In summary, while red brick is less costly by traditional LCC measures, EHB adds value through sustainability benefits and reduced environmental impact. Thus, material selection should weigh both immediate economic and long-term environmental considerations.

Life Span Material

Previous studies indicate that the durability of a material is significantly affected by its porosity, water absorption, and mechanical properties. Materials exhibiting high porosity are more vulnerable to water ingress, which can initiate microcracking, reduce compressive strength, and accelerate degradation during environmental cycles such as wetting and drying. These factors contribute to diminished long-term performance and a reduced service life. For example, concrete blocks, which typically possess higher porosity than fired bricks, generally demonstrate lower durability and shorter service lives (Stepień et al., 2022). Similarly, EHB material, with greater porosity than RB, also exhibits reduced durability.

The durability of environmentally friendly materials, particularly those incorporating recycled components such as Eco Hollow Block (EHB), can be improved by optimising material composition, enhancing production process quality, and controlling microstructural characteristics. Reducing porosity is especially important, as a highly porous structure has been shown to directly decrease durability and increase permeability (Liu et al., 2022). Furthermore, incorporating recycled materials such as plastic into construction mixtures may reduce strength and durability due to non-homogeneity, low cohesion, and weak bonding between constituent materials (Oti et al., 2024). Consequently, optimising mix design and employing admixtures are necessary to enhance material density and bonding quality.

Environmentally friendly materials may have some durability limitations. However, optimising composition, improving production quality, and protecting materials can greatly improve their long-term performance. Durability relies not just on material choice, but also on effectively controlling design, production, and construction methods.

Plastic Waste Reduction

The implementation of eco hollow block (EHB) materials at SDN 002 Palembang demonstrates considerable potential to advance sustainable construction practices by utilising plastic waste as a raw material. A total of 3,69 tons of plastic was successfully repurposed. These results indicate that EHB serves not only as a construction material but also as an alternative to plastic waste management. The use of plastic waste in construction materials is widely recognised as an effective strategy to reduce environmental pollution, primarily because plastics are non-biodegradable and have an extremely long degradation period (Adiyanto et al., 2022). Previous studies have also demonstrated that incorporating recycled plastics into building materials can enhance resource efficiency and decrease reliance on virgin raw materials (Satria Saputra & Ramadhini, 2026).

However, relative to the total volume of plastic waste generated, the reduction achieved in this study is modest, accounting for only approximately 1.79%. This outcome aligns with research in sustainable construction, which suggests that environmental benefits at the building scale are typically incremental but can become significant when applied more broadly (Kui Hu et al., 2025). Thus, the relatively low percentage observed here reflects limitations in implementation scale rather than the effectiveness of the material.

Economically, using plastic waste as a raw material for EHB yields an indirect benefit of IDR 5,773,446.64. This finding is consistent with Life Cycle Cost (LCC) studies, which indicate that environmentally friendly materials often require higher initial investments but provide long-term economic benefits through improved resource efficiency and reduced indirect costs (Ongpeng & Umali, 2023). However, this study is limited in scope, as the analysis focuses solely on plastic waste reduction and does not include a comprehensive Life Cycle Assessment (LCA) that accounts for carbon emissions and energy consumption. Previous research has demonstrated that incorporating recycled materials in construction can significantly reduce environmental impacts, including CO₂ emissions and energy use (Darhamsyah et al., 2025).

More broadly, these findings suggest that large-scale application of EHB materials holds substantial potential. Implementing EHB in public building projects, such as schools, can serve as a strategic approach to achieving cumulative environmental and economic benefits. Policy support, including incentives for sustainable materials and the adoption of green building standards, is essential to encourage broader use of these materials.

5. Conclusion

The analysis compares the life cycle cost of eco hollow block and red brick. The discussion leads to the following conclusions:

- 5.2. The EHB has a higher LCC than Red Brick, primarily because of its higher initial cost. Maintenance costs for both materials are comparable, but EHB may incur additional replacement costs under specific conditions. Overall, RB achieves a cost efficiency of 49.33% relative to EHB.
- 5.3. The higher initial cost of EHB results in higher short-term expenses than red brick. This outcome is influenced by the properties of recycled materials, which require more complex testing, certification, and adherence to technical standards

before construction use.

- 5.4. Broader implementation of EHB in building construction can significantly reduce plastic waste generation. Key findings indicate that while EHB shows strong potential for reducing waste, its overall environmental and economic impacts warrant further evaluation. Therefore, additional research employing Life Cycle Assessment (LCA) is necessary to quantitatively assess these impacts and provide a comprehensive evaluation of the balance between economic and sustainability considerations.

In summary, the application of Eco Hollow Block as a wall material in school buildings presents distinct economic and environmental implications. Consequently, material selection should balance cost efficiency with environmental sustainability.

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