

# Implementation of Green Construction on the Use of Formwork at St. Thomas Building Construction Project

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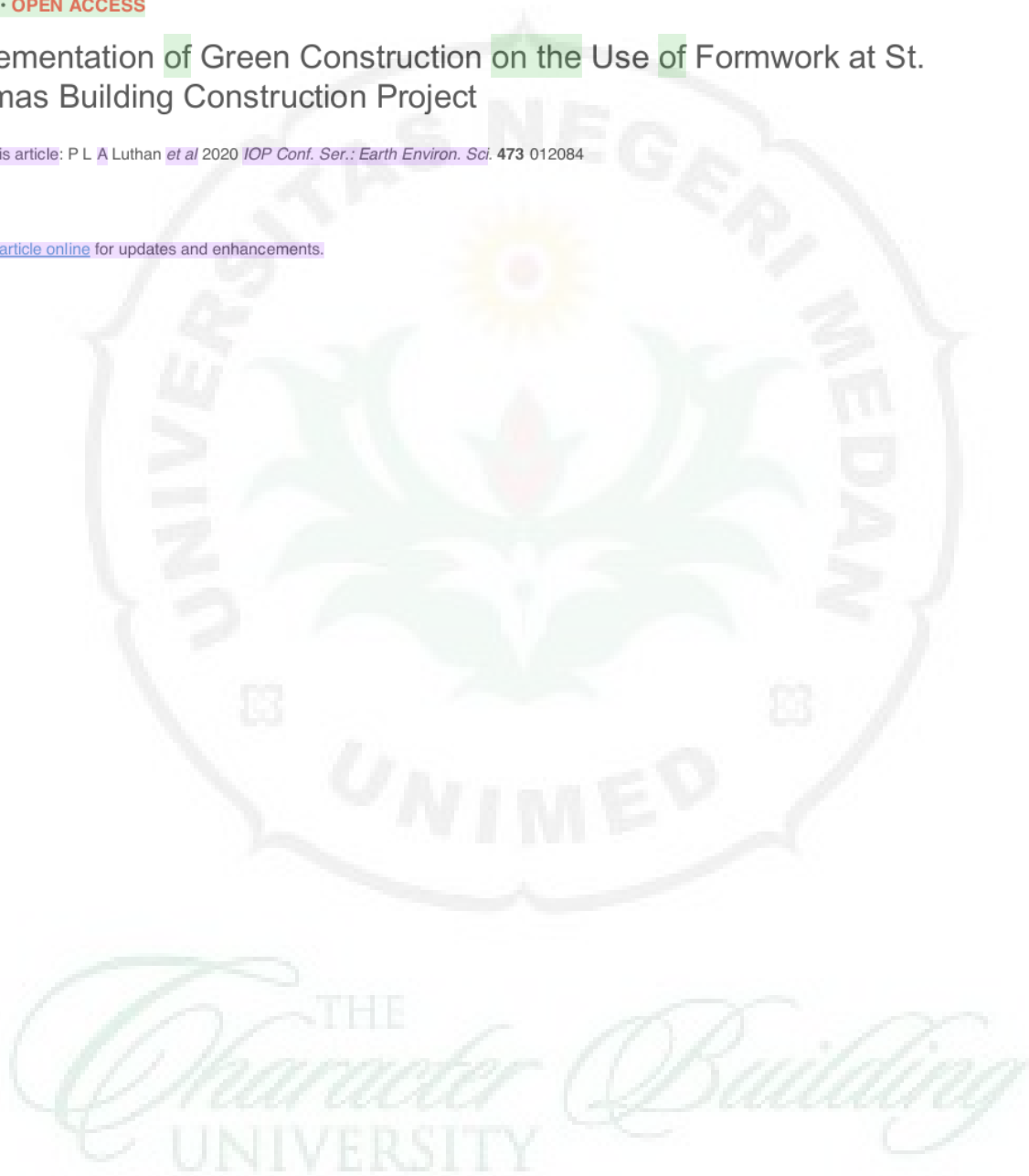
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## Implementation of Green Construction on the Use of Formwork at St. Thomas Building Construction Project

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**Abstract.** Formwork is a molding tool to get the shape of concrete to work as planned. The cost of making formwork is proportional to the cost of reinforced concrete work, so the right methods and strategies are needed to calculate the cost of formwork that can be used repeatedly. When making a bill of quantities, the cost of formwork used is adjusted to the work item, and in the calculation, the formwork that has been used in one application is no longer used for the next. But the reality in the field formwork can be used repeatedly with the right methods and strategies so that the cost for making formwork can be efficient by applying green construction strategy with the Reuse concept. This study aims to determine the methods and strategies as well as the percentage of green construction using green formwork for each building floor. The research method used is qualitative and quantitative methods. Qualitative methods are used to collect data through observation, interviews, and documentation related to the use of formwork in projects. Quantitative methods are used to calculate the cost of formwork for semi-system methods and one-floor rotation strategies. The results of the research found are the semi-system method and one-floor rotation strategy resulting in the formwork cost savings by 36.10%, and the reduced material on the application of green construction can reduce material successively by 8% for the second use, 16% for the third use, and 24% for the fourth use. This finding contributes to the list of work analysis related to formwork making.

### 1. Introduction

The building material for multi-story structures uses materials made from the cast in situ concrete mixes [1], so that the shape of the building can be shaped according to the planned shape with the help of a mold called formwork [2]. Formwork is a temporary structure that will be demolished, but the implementation must meet quality, safety, and economics [3]. According to Hurd (2005) [3] and Nemati (2007) [4], the cost of using formwork can reach more than 60% of the total cost of concrete. In the construction of the superstructure, the formwork application is a process of repetitive work on columns, beams and floor plates. Because the works are repeated and the size of the formwork used is the same, methods and strategies are needed so that the material used does not become waste so it can be reused. This concept is called green construction, [5] in the concept of green construction, the material that has been used must not end up at the disposal site, meaning that the material must be reusable, recycled, and if not, these materials disposed in an environmentally friendly way.

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Currently, in Indonesia, there are 3 types of formwork that are often used, namely conventional formwork, semi system and system [6]. Conventional formwork is formwork that is easily installed and dismantled into basic parts that can be rearranged or used again for further structural formwork. Semi system formwork is formwork designed for a particular project, the size of which is adjusted to the shape of concrete. Furthermore, the formwork system is a further development to a universal formwork, which with all the possibilities can be used in a variety of buildings. During this time, the calculation of formwork needed is calculated as a whole on work that requires formwork so that it requires a large amount of wood or Polywood material and will cause wood or Polywood waste, material that cannot be used anymore for further formwork work will produce waste [7]. Especially for large scale construction works, this will be a serious problem that can cause harm and the implementation of green construction cannot be done. For the concept of green construction can be applied, it needs a study, observation, and calculation of the amount of reduction in the cost of using formwork if it is applied using the semi system method. Conventional methods cannot be used in implementing green construction, due to the use of materials, time and high wages for labor [8]. According to [9,10] installation of formwork using the semi-system method will work more efficiently and effectively [11]. The formwork for semi-systems can be used repeatedly, and durable [10] so a strategy is needed so that the installation of formwork does not become a barrier for further work. The use of semi-formwork is used namely to realizing green construction where the materials can be used repeatedly and can be reused [12]. Rotation strategy is expected to reduce costs and time so that the project completion target is achieved using high quality and precision and the application of green construction can be realized. The installation of semi system formwork with rotation strategy is the process of using formwork repeatedly to save the cost and to apply green construction, namely the reuse of formwork material [13]. Rotational formwork installation consists of several types of work such as rotational formwork of one floor, one and a half floors, two floors and so on. One-floor rotation is formwork construction by preparing the needs of one floor and continuing to the next floor. Likewise, the rotation of one and a half floors is to prepare material requirements of one and a half floors and rotate the formwork for the next floor. The tools and materials used in the formwork installation using the rotation strategy are the same as the previous floor, the difference is to replace materials that are reduced or damaged during deconstruction.

## 2. Methodology

The research method used is qualitative and quantitative methods. Qualitative methods are used to collect data through observation, interviews, and documentation relating to the use of formwork in projects. Quantitative methods are used to calculate the cost of formwork with the semi system method and one-floor rotation strategy. Data on formwork material damage was obtained by observation and interview, while documentation was used to obtain data on unit price analysis. Furthermore, quantitative methods are used to calculate work unit analysis, which consists of 1) Preparation and checking of shop drawings, 2) Volume calculation, 3) Calculation of the total cost of formwork application, and 4) Recapitulation of each sub-item of the work.

The study design used a one-floor rotation strategy design which can be seen in figure 1, then the unit price is calculated. The results of the rotation strategy are compared with the installation of formwork without rotation.

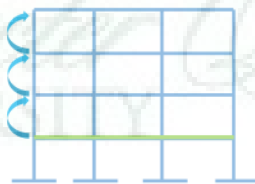



Figure 1. Formwork rotation strategy

Explanation :

 = Required Formwork

 = Rotation Direction

### 3. Result and discussion

#### 3.1. Shop drawing preparation

At this stage, drawings check is performed, based on the existing drawings, the dimensions and volumes of beam and columns can be presented in tables 1, 2 and 3:

**Table 1.** Center beam formwork volume

Beam (cm)	Beam Length (m)	Area (m <sup>2</sup> )
30x70	236	344.56
30x60	347	437.22
30x50	106	112.36
Total		894.14

**Table 2.** Side Beam formwork volume

Beam (cm)	Beam Length (m)	Area (m <sup>2</sup> )
30x70	34	53.72
30x60	37	51.06
25x30	132.05	96.39
Total		201.17

**Table 3.** Column dimensions

Column (cm)	Quantity	Area (m <sup>2</sup> )
70x70	30	325.92
70x80	14	162.96
50x50	12	93.12
Total		582

For calculation of plate, formwork needs can be calculated by subtracting the total area of the plate with the area of the beam, column, and void. In the plate work, there are voids for ladders, elevators, pipes, and cables. Based on the drawing, the overall plate size for one floor is 2,059.2 m<sup>2</sup>. From the calculation results, obtained that the area of voids on each plate is 155.65 m<sup>2</sup>.

From the data that is known, the volume of floor plate formwork is:

$$\begin{aligned} \text{Plate Formwork Area} &= \text{Gross Plate Area} - \text{Beam Area} - \text{Column Area} - \text{Void} \\ &= 2,059.2 \text{ m}^2 - 261.0125 \text{ m}^2 - 25.54 \text{ m}^2 - 155.65 \text{ m}^2 \\ &= 1,617.2875 \text{ m}^2 \end{aligned}$$

Then the total formwork needed is:

$$\begin{aligned} \text{Total formwork} &= \text{Center Beam} + \text{Side Beam} + \text{Column} + \text{Floor Plate} \\ &= 894.14 + 201.17 + 582 + 1.617.2875 \end{aligned}$$

$$= 3294.5975 \text{ m}^2$$

$$= 3294.60 \text{ m}^2$$

### 3.2. Calculation of material requirements

After calculating the dimensions of the formwork of beams, columns and floor plates, the material needs calculation is then performed. This calculation is intended to determine the number of material requirements that can be seen in table 4:

**Table 4.** The material required for one floor

Material	Vol	Unit
Multiplex 12 mm	846	Pcs
Hollow Beam	399	Pcs
Grider Beam	491	Pcs
Suri Beam	1962	Pcs
Corner steel	1962	Pcs
Mainframe dan cross brace	1576	Set
Base jack	660	Pcs
U-Head	660	Pcs
Concrete Nail	711	Kg

### 3.3. Cost Requirements analysis

3.3.1. *Formwork work costs without a rotation strategy.* To get the total cost needed, it can be calculated by multiplying the volume of needs by the unit price.

#### 1) Material Costs

The cost of materials used for the work on 1 floor formwork can be seen in table 5.

**Table 5.** Material costs for 1<sup>st</sup>-floor formwork work

Material	Vol	Unit	Cost (IDR)	Total Cost (IDR)
Multiplex 12 mm	846	Pcs	230,000	194,580,000
Hollow Beam	399	Pcs	165,000	65,835,000
Grider Beam	491	Pcs	185,000	90,835,000
Suri Beam	1962	Pcs	48,000	94,176,000
Corner steel	1962	Pcs	24,000	47,088,000
Main frame	1576	Set	48,000	75,648,000
Base jack	660	Pcs	20,000	13,200,000
U-Head	660	Pcs	20,000	13,200,000
Concrete Nail	711	Kg	15,000	10,665,000
Total				<b>605,227,000</b>

Source: Calculation results, 2019

## 2) Wages

To find out the price of wages that must be paid for 1 floor can be seen in table 6 below

**Table 6.** Analysis of labor costs for 1 m<sup>2</sup>

No	Item	Coef	Unit	Wages (IDR)	Total (IDR)
Beam Formwork Construction					
1	Foreman	0.033	P/d	150,000	450
2	Head Worker	0.033	P/d	140,000	4,620
3	Worker	0.330	P/d	120,000	39,600
4	Laborer	0.660	P/d	90,000	59,400
Beam Formwork Deconstruction					
1	Foreman	0.0133	P/d	150,000	1,995
2	Head Worker	0.0399	P/d	140,000	5,586
3	Worker	0.1997	P/d	120,000	23,964
4	Laborer	0.3993	P/d	90,000	35,937
Total Biaya Upah per m <sup>2</sup>					171,552

Source: Calculation Results, 2019

Based on table 6, the wage for one-floor formwork work is equal to:

$$\text{IDR. } 171,552 \times 3294.60 \text{ m}^2 = \text{IDR. } 565,195,219$$

## 3) Total Cost

The total cost required for beam and plate work is:

$$\text{IDR. } 605,227,000 + \text{IDR. } 565,195,219 = \text{IDR. } 1,170,422,219$$

The construction project of the St. Thomas School building is a building designed in the same shape for each floor. Because it has the same shape (dimensions), so many of the same formwork can be used for each subsequent floor. Thus, the cost needed for 4 floors is:

$$\text{IDR. } 1,170,422,219 \times 4 = \text{IDR. } 4,681,688,876$$

3.3.2. *Cost of formwork work with a rotation strategy.* Based on the results of interviews with companies and implementers in the construction project of St. Thomas Medan in formwork construction using rotation strategy, material that is often damaged is multiplex material and nails with damage percentage for each use as in table 7.

**Table 7.** Percentage of damage to formwork use

Application	Broken Percentage	Multiplex	Broken Nail Percentage
Second Application	8%		100%
Third Application	16%		100%
Fourth application	24%		100%

Source: Field Interview 2019.

In the calculation of the cost of formwork on the second floor, the multiplex that can be used for the second floor gets a reduction of 8% as seen in table 7, due to damage on the usage for the 1st floor, so that the reuse of the use of formwork material on the second floor has been reduced by 8%, namely IDR. 18,400. To recapitulate the cost calculation can be seen in table 7.

**Table 8.** Costs of second floor formwork

Material	Vol	Unit	Cost (IDR)	Total Cost (IDR)
Multiplex 12 mm	846	Pcs	18,400	15,566,400
Concrete Nail	711	Kg	15,000	10,665,000
Total Material				26,231,400

Based on the table above the cost of formwork application for the second floor is IDR.26,231,400 + IDR. 565,195,219.00 = IDR. 591,426,619.00. In the calculation of the cost of formwork in the third application can be known as the application of the second floor, the cost of the multiplex included is the cost of waste that has been reduced by 16% that is IDR. 36,800. To recapitulate the cost calculation can be seen in table 8.

**Table 9.** Third-floor formwork costs

Material	Vol	Unit	Cost (IDR)	Total Cost (IDR)
Multiplex 12 mm	846	Pcs	36,800	31,132,800
Concrete Nail	711	Kg	15,000	10,665,000
Total Material				41,797,800

Based on the table above the cost of formwork application for the third floor is equal to 41,797,800 + 565,195,219 = IDR. 606,993,019

In the calculation of the cost of formwork in the fourth application can be known as the application of formwork on the third floor, the cost of the multiplex included is the cost of waste that has been reduced by 24% that is IDR. 55,200 - For a recapitulation of cost calculations can be seen in table 9.

**Table 10.** Fourth-floor formwork costs

Material	Vol	Unit	Cost (IDR)	Total Cost (IDR)
Multiplex 12 mm	846	Pcs	55,200	46,699,200
Concrete Nail	711	Kg	15,000	10,665,000
Total Material				57,364,200

Based on the table above the cost of formwork application for the fourth floor is IDR. 57,364,200.00 + 565,195,219.00 = IDR. 622,559,419.00.-

Recapitulation of material costs and wages for fourth-floor formwork applications can be seen in table 10.

**Table 11.** Recapitulation of formwork costs

Formwork Application	Cost (IDR)
First application	1,170,422,219
Second Application	591,426,619
Third Application	606,993,019



Fourth Application	622,559,419
Total	2,991,401,276

Based on the results of the formwork application cost calculation by using new material for each floor and using a rotation strategy, the results obtained are that the cost efficiency is:

$$= \text{IDR. } 4,681,688,876 - \text{IDR. } 2,991,401,276$$

$$= \text{IDR. } 1,690,287,600$$

Thus, when compared to the calculation of formwork costs between the rotation strategy and not using the rotation strategy there is a percentage of the formwork cost efficiency of 36.10%. The results of this study, support the findings of Agustanto (2013) [14] who found that the use of semi-systems can reduce formwork costs by 48.38%. Compared with conventional methods

#### 4. Conclusion

Based on data analysis, the results and discussion can be concluded as follows. First, the rotation strategy of formwork application in the Santo Thomas School Building Construction Project in Medan is very suitable to be used, because the building floor has the same shape (dimension); Second, for the four-floor formwork application using a one floor rotation strategy, the cost-efficiency of the formwork application using the rotation strategy in the St. Thomas School Building Construction Project is 36.10%; and Third, the reduced material for the application of green construction can reduce the material respectively 8% for the second use, 16% for the third use, and 24% for the fourth use.

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