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Cost Savings Analysis the use of Alform Formwork on Beams, Columns & Floor Slab for Typical Buildings

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Abstract:- Formwork is a temporary auxiliary building construction in the form of a mold that is under the size, shape, appearance, or position planned to hold concrete as long as the concrete is poured and formed. Since it is temporary, the formwork will be removed or disassembly after the concrete reaches sufficient strength. Formworkconstruction requires consideration of the use of the method or system used to be more efficient and economical, especially for typical buildings, namely buildings that have the same shape and size between buildings and each other. The use of Aluminum Formwork on beams, columns, and floor plates. the "Triple Zig-Zag" method in typical buildings is very suitable for use since one of the advantages of this formwork is that it can be used many times and produces less waste compared to conventional formwork. This study aims to review the cost savings resulting from the use of alform formwork compared to conventional formwork, with a case study on housing development project A. This project has several types of housing with a building area of 145/105 m2, as many as 20 units. This calculation uses quantitative descriptive analysis, by calculating the need for formwork. The results of the analysis showed that using alform formwork with the "Triple Zig-Zag" method can save as much as 6 times the use, thus saving IDR. 455,983,209.32 or 69% of the original plan of column, beam, and floor platesformwork for 20 building units (IDR. 657,273,094.52).

Keywords: *Savings, Use of Alform Formwork, Typical Building*

I. INTRODUCTION

A. Background

To make savings or efficiency in construction costs, especially formwork work, careful consideration is needed, so that in its implementation it does not cause a lot of wasted material residue or waste material, and gets savings and cost advantages in the repeated use of formwork, between one building and another. Therefore, the formwork planning method must be evaluated through correct calculations and analysis, to obtain predetermined goals. In this study, it analyzes the work of columns, beams, and floor plates in typical buildings, this is because the cycle of using floor plate formwork is only disposable than the cycle of using column or wall formwork in one building, so it will cause a lot of material residue or waste material for this type of work. This study uses the alform formwork method. This project is a type of housing project, the typereviewed is the SoHo Verde type with an area of 145/105 m2, for this type it is planned in a typical form of 20 building units so that the use of formwork is relatively the same between the floors of one building and another building. In this study, the formwork of the alform model is very feasible to use, because the cost of material materials is easily affordable and efficient in use many times so that later it will get significant savings and profits without affecting the quality and quality of the concrete itself. This study aims to analyze the costs incurred in each repeated change of formwork and cost efficiency for each formwork installation on each floor and in subsequent buildings. Currently, the construction method for typical buildings commonly used is to use conventional concrete, namely by casting concrete in the structure place directly. In this study, the use of conventionalbekesting with alform formwork with the Triple Zig-Zag method will be compared with a review of the level of time efficiency and cost of implementing typical development.

B. Research Objectives

The purpose of this research was to determine the level of efficiency of implementation time and the level of cost efficiency of implementing typical building construction using the Triple Zig-Zag method using alform formwork.

II. LITERATURE REVIEW

A. Form Work

Formwork is a part of concrete structures. According to Stephens (1985), formwork is a temporary mold used to hold concrete as long as the concrete is poured and shaped according to the desired shape. Meanwhile, according to McCormac (2003) concrete formwork is a mold into which semi-liquid concrete is filled. Mold should be strong enough to hold the concrete in the desired size and shape until it hardens. Since formwork is a structure, it must be carefully and economically designed to support the load deployed using the methods needed for the design of other engineering structures. Safety is the most concerning thing in formwork because accidents with a fairly high percentage of occurrence in the construction of concrete structures are due to formwork failure. Usually, formwork failure is not caused by excessive gravitational load, although sometimes it occurs, failure is usually caused by lateral forces that cause the support rod to move. These lateral forces could have been caused by wind, the moving fixtures on the formwork in question, vibrations resulting from traffic, or by the pressure of freshly poured or vibrated concrete. Apart

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from safety, the cost is also a major consideration. The cost of formwork, which can range from one-third to two-thirds of the total cost for such concrete structures, is often higher than the cost of concrete or reinforcing steel. For ordinary concrete, formwork is considered 50% of the total cost.

In designing and building formwork there are 3 (three) main aspects (Nawy, 1997), namely:

- Quality: The formwork made must be strong in bearing the load at the time of casting, as well as the shape, size, and position must be made to adjust the building so that there are no errors at the time of implementation resulting in damage to the quality of concrete.
- Safety: In addition to the formwork made to withstand the load of concrete at the time of casting, the formwork must also be made with sufficient safety factors, to avoid a dangerous collapse for the workers and the concrete construction itself.
- Economical: The use of formwork must be carried out efficiently to minimize the time and cost of manufacture so that in the process of implementation the formwork can be used repeatedly to obtain profits for the contractor and owner (owner).

B. Aluminum Formwork (Alform)

Aluminum formwork is a formwork originating from the Korean region which has recently become trending in the construction world with its various advantages. The advantages of using Aluminum Formwork are as follows see figure 1. Advantages in the Use of Alform:

- Lightweight,
- Economically save up to 20-30 % of labor costs when compared to using conventional formwork (wood),
- The project will be classified as an environmentally friendly project, and
- Can be used many times adjustable to panel size.

However, there are also disadvantages if you use Bekesting Aluminum Formwork, including:

- Requires a fairly long initial *settingtime* because all panels in production are the same, and
- The price is expensive.

Characteristics	Formwork Type				
	Hard Held Formwork	Tunnel Formwork	Table Formwork	Traditional Formwork	Kumkang Kind Al. Formwork
No cranes or other heavy equipment required	✓				✓
Allows to pour wall, slab, beam, column and staircase in 1 single concrete pour		✓			✓
Dismantle slab panels without removing props.					✓
Can form concrete columns and beams together	✓			✓	✓
No skilled labor required	✓				✓
Suitable for single (1) or two (2) storey buildings		✓	✓	✓	✓
Suitable for high-rise buildings				✓	✓
Formwork equipment adapts to different designs					✓
Able to form all concrete elements				✓	✓
Lowest formwork to forming area ratio					✓
Respects all architectural and structural requirements of the client, without modifications.	✓			✓	✓
Self correction feature providing unmatched forming accuracy	✓				✓
Environmentally friendly - no huge debris, no messy disposals					✓

Fig. 1: Advantages in the Use of Alformkumkangkindcataloque

Fig. 2: The use of Alform formworkSoho Verde StudioAlton

C. Traditional Formwork

Traditional formwork is a formwork that is easy to install or removed into original shapes or other shapes, this is because the material consists of wooden boards, while the construction support base uses wooden beams or scaffolding supports from iron. This formwork is very easy to apply to simple building forms.

D. Half System Formwork

The half-system formwork is a part of the formwork material that has been made in such a way that follows the shape of the building to be carried out casting, the principle of this method is to be used repeatedly. This material uses steel plate material that has been set following the shape of the building, while the support material is made of steel components or wooden girders. For example Steel wall panel elements.

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E. Formwork System

The formwork system is a formwork material made in the factory, and most of the material is made of steel. This formwork is for repeated use. This means that this formwork can be used for some large-scale work. And this formwork also has suppliers who provide rentals. Example:steel panel formwork for tunnels, and formwork panels for precast concrete. According to Wigbout (1987), for simple structural work, with relatively similar (typical) structural forms, it can be concluded as follows:

- If the amount is less than 6000 m2, the most economical is the traditional method.
- If the amount is greater than 6000 m2, the most economical method is the half-system method.
- System formwork will always be the most expensive method.

F. Formwork Implementation

Implementation of Formwork,the cost of labor and equipment for the construction of formwork, and its use have the largest portion of the total cost. In various estimates, the costs of creating, erecting, and strengthening formwork are estimated at the productivity of workers. All expenditures for labor and formwork equipment are combined in 3 (three) orders of formwork work, namely making (build), installing/erecting (erect) and disassembly (strip) (Clark, 1983).

- Manufacture (*build*) The earliest formwork-making before use (prefabricated work) is a practical activity with various types of molds. The shape of the building mold depends only on the pre-fabricated initials of the formwork and further expenditures then surrounded installation and retrofitting work (Clark,1983).
- Installation (*erect*) The average productivity level of workers for the installation of formwork is sufficient to cover the installation of all forms of formwork but does not include the installation of external reinforcement systems (Clark, 1983).
- Disassembly (*strip*) Disassembly of the formwork includes removal, disassembly, cleaning, lubrication, temporary storage, and repair of the formwork after discharging so that it is ready for use for subsequent operation (Clark, 1983).

G. Formwork Requirements

In designing and building formwork there are 3 (three) main aspects (Nawy, 1997), namely:

- Quality: The formwork made must be strong in bearing the load at the time of casting, as well as the shape, size, and position must be made to adjust the building so that there are no errors at the time of implementation resulting in damage to the quality of concrete.
- Safety: In addition to the formwork made to withstand a load of concrete at the time of casting, the formwork must also be made with sufficient safety factors, to avoid a dangerous collapse for the workers and the concrete construction itself.
- Economical: The use of formwork must be carried out efficiently to minimize the time and cost of manufacture so that in the process of implementation the formwork can be used repeatedly to obtain profits for the contractor and owner.

III. METHOD OF IMPLEMENTATION

A. Use Bekesting Alform

The object of this study was carried out on building construction project A, the type of building studied was the SoHo Verde type with a building area of 145/105 m2 typical of 20 units. The steps for using Alform formwork on columns, beams, and plates are described as follows,

- Step One
  - The fabrication of the reinforcement of columns and beams is on the base floor while the milling of plate reinforcement is directly located.
  - Lift the reinforcement of columns and beams using a Tower Crane.
  - Place according to the markings of columns, beams, and floor plates.
  - Repair the reinforcement if something is damaged.
- Step Two
  - Install per formwork Aluminum formwork panel with a sequence of columns, beams, and floor slabs.
  - Strengthen it by using Pins and wedges.
  - Do it to *the desired floor-to-floor* height.
- Step Three
  - Last check of formwork and formwork firmness.
  - Checking the tension by using the plumbob and water pass.
  - Ready to be cast and assisted with vibrator tools.
- Step Four
  - Foundry elevation
  - Once installed all

B. Use of Triple Zig-Zag Method

Triple methode zig zag is a methode to use formwork with discharging cycle we can see in Figure 3. Formwork discharging cycle with Triple Zig-Zag method

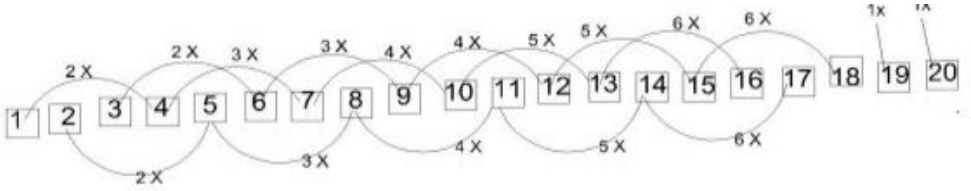

Fig. 3: Formwork discharging cycle with Triple Zig-Zag method

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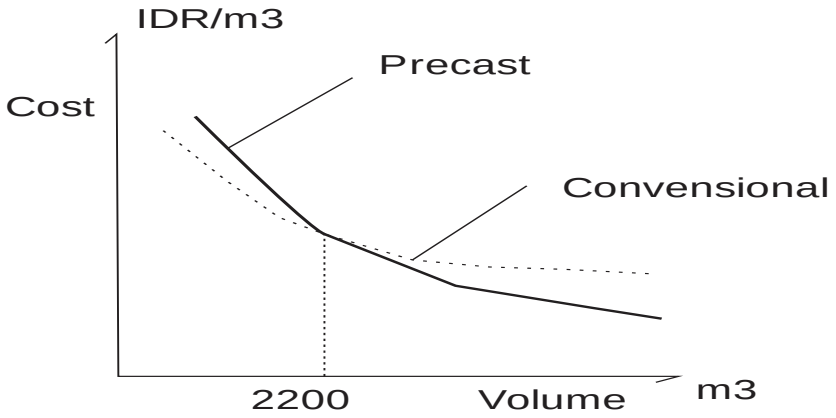

Fig. 4: Relationship Between Cost and Volume of Formwork(Kumkang kind Cataloque)

The Figure 4. Relationship Between Cost and Volume of FormworkComponents shows that the cost of implementing alfromformwork will be more efficient if the volume of work of alform components is greater ± 2200 m3 compared to conventional systems. Meanwhile, if the volume of concrete work is less than ± 2200 m3, it is recommended that it be more effective if you use conventional only. The optimization results obtained through the use of a system of precast elements are as follows:

C. Implementation Costs

- The cost of concrete is lower for economical volume and quantity. According to figure 2, the minimum limit for the use of precast system concrete to be optimal is ±2,200 m3.
- Finishing costs are lower because there is almost no re-work due to QC being carried out strictly at the time of precast element production.
- The cost of supervision can be reduced lower because most of the supervision has been carried out in the factory.

D. Implementation time

- The time it takes to complete the project work is much shorter because
- done in 2 places, namely precast casting in the factory while in the field only erection/installation
- With a short completion time, the building can be immediately utilized/operationalized earlier. Thus, economically, engineering will be obtained back periods from investments that are planted faster due to the acceleration of cash in so that it will be able to save interest costs.
- Quality of work

In general, a much better and consistent quality will be obtained. This is because production is carried out in factories so that it can be easily controlled over the results of production.

IV. RESULTS AND DISCUSSION

A. Time schedule and Project A "S" Curve

To measure the performance of the project alignment time between 2 methods, namely the use of conventional bekesting and alformformwork using the time schedule and the project "S" curve. This can be easily measured by the total difference in completion time. The time schedule and "S" curve of the project can be seen in figure 5.

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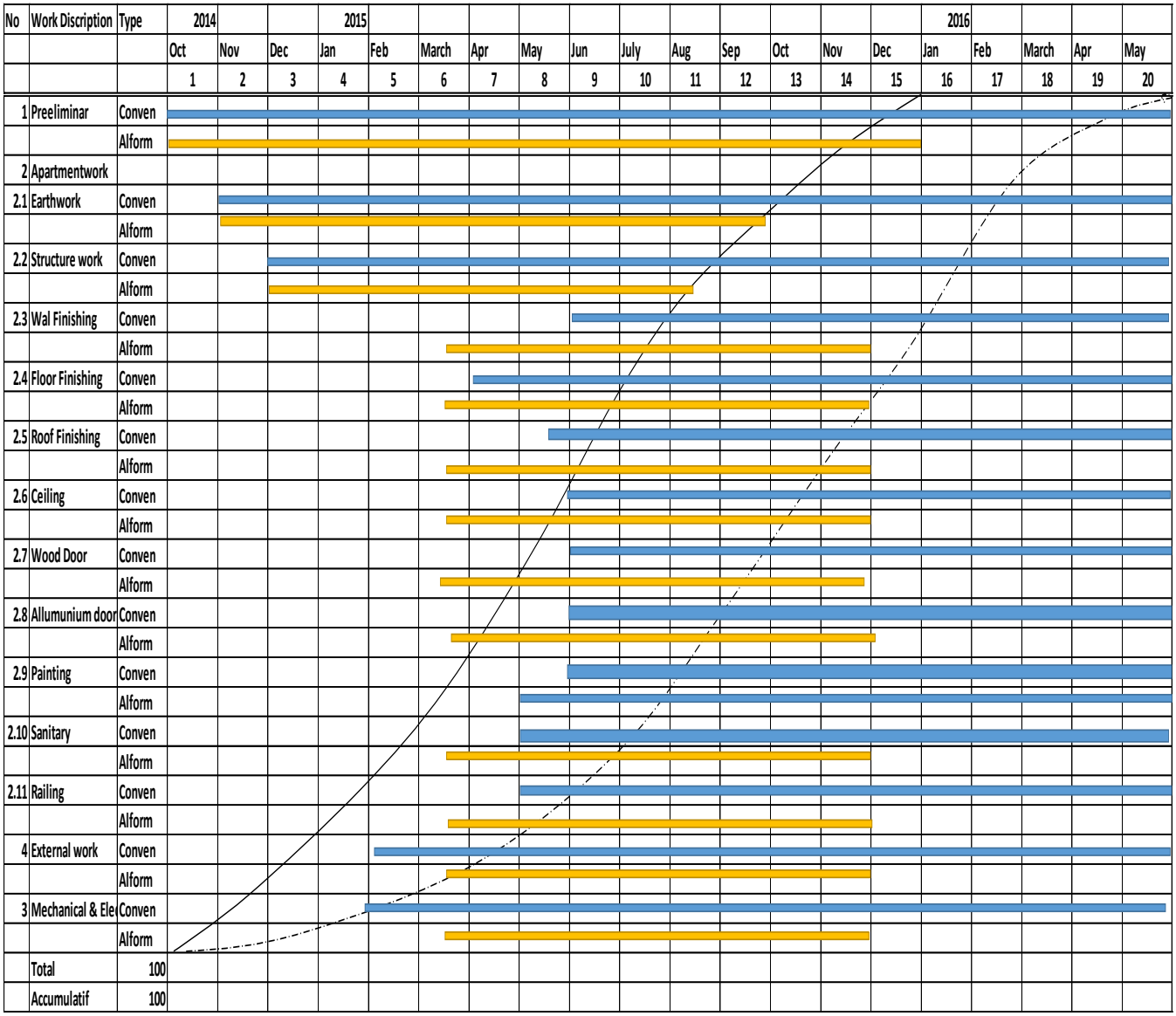

Fig. 5: Comparison of Time Schedule and Project "S" Curve

From the "S" curve and schedule above, it can be seen that with the use of alform formwork, it can reduce the completion time from 21 months to 15 months or there is a time efficiency of 28.57%. This is because the cycle per floor for alform system work can be done for 6-9 days for structural work. So that the total time required for structural work with an alform system is 7.8 months. While the implementation with the conventional system takes 14 months.

B. Cost Effective in Project A

In the Fabrication and installation of formwork the most important thing so that the formwork can be used repeatedly, namely at the time of disassembly, therefore a formwork model is needed that is easy to do at the time of disassembly, one of which is by using alform formwork.From Table 1.Coefficient formwork cost/ m² shows the price of the formwork of beams, columns, and plates of the alform model, from the calculation so that compared to conventional formworkcan save wood 4/6 on fabrication, in contrast to conventional plate formwork in general, so that the total overall cost for 1 unit type based on the existing volume is in Table 2.

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Work Discription	Unit	Volume	Unit Price / IDR	Total price/IDR
1 m2 Slab Formwork fabrication				
Formwork Wood	m3	0.048	3,200,000.00	153,600.00
Plywood 12 mm	lbr	0.365	155,000.00	56,575.00
Nail	kg	0.3	17,000.00	5,100.00
Fabrication	m2	1	35,000.00	35,000.00
Fabrication Total Cost				**250,521.00**
6 x Usage				**41,753.50**
1m2 Instalation and disasembly cost				
Formwork oil	ltr	0.5	4,500.00	2,250.00
Wood Stud	m3	0.01	3,200,000.00	32,000.00
Nail	kg	0.1	17,000.00	1,700.00
Concrete decking	bh	4	150.00	600.00
Labor cost	m2	1	35,000.00	35,000.00
Instalation and disasembly cost				**70,319.23**
				112,072.73
1m2 Formwork Instalation + 3m				
Scafolding rent	set	1	14,490.00	14,490.00
4/6 wood beam	m	0.8	25,000.00	20,000.00
Labor Cost	m2	1	15,000.00	15,000.00
Total cost				**49,490.00**

Table 1 Formwork cost / m²

Table 1: Coefficient alform formwork cost/ m²

Work Discription	Unit	Volume	Unit Price /IDR	Total price/IDR
Beam and slab Formwork Conventional at 1th Floor				
Formwork Fabrication	m2	184.36	41,753.00	7,697,583.08
Formwork Instalation and disasembly	m2	184.36	70,319.00	12,964,010.84
Steel ReinForcement	kg	3885.38	9,870.00	38,348,700.60
Concrete cast	m3	16.06	878,250.00	14,104,695.00
Slab and beam Scafolding Instalation	m2	49.49	49,490.00	2,449,260.10
Total Cost				**77,579,264.34**
Beam and rooftop Slab Conventional Formwork				
Beam and slab Fabrication	m2	108.88	41,753.00	4,546,066.64
Formwork Instalation and disassembly	m2	108.88	70,319.00	7,656,332.72
Steel Reinforcement	kg	2588.28	9,870.00	25,546,323.60
Scafolding Intalation beam amd slab	m2	82.66	49,490.00	4,090,843.40
Concrete cast	m3	8.57	878,250.00	7,526,602.50
Total Cost				**49,366,168.86**
Grand Total				126,945,433.20

Table 2: Conventional formwork

In Table 2 the total cost amount for beam, column, and slab work is Rp. 126,947,912.20. For the implementation of the use of each formwork both beam formwork, columns, and alform model plates are used for 6 times of use, the cost of formwork needs is summed up with reference and damage at the time of wasted unloading amounting to 7.5% of the total amount of formwork costs (Kwakye,1994).

In this calculation, the type of work that is carried out repeatedly between one building and the other only works, formwork, and scaffolding alone. The cycle of using formwork is in Figure 2, in Figure 2 is the master plan of the Soho Verde residential type which is a study of this research, the cycle of displacement of the use of floor formwork based on the age of the concrete floor is 21 days, after which the move is carried out in the next building, in Figure 2 it is explained that there are 3 groups of buildings that using formwork 6 times with a cycle of 21 days, namely: group 1 (buildings 1, 4, 7, 10, 13, 16), group 2 (buildings 2, 5, 8, 11, 14, 17), group 3 (buildings 3, 6, 9, 12, 15, 18) and buildings number 19 and 20 using new formwork 1 use. the calculation of the cost of formwork is described in Table 3.Calculation of the formwork cost

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No	Work Discription	Unit	Volume	Unit Price	1 st Floor	4th Floor	7th Floor	10th Floor	13 th floor	16 th Floor
I	**1 st Floor**									
1	Beam									
	Form work	m2	102.45	112,072.73	11,481,851.19	861,128.00	861,128.00	861,128.00	861,128.00	861,128.00
2	Roof Slab 2nd Floor									
	Formwork		81.91	112,072.73	9,179,877.31	688,490.00	688,490.00	688,490.00	688,490.00	688,490.00
3	Scafolding Beam And slab		90.16	49,490.00	4,462,018.40	Use 1 st Floor	Use 4th Floor	Use 7th Floor	Use 10th Floor	Use 13th Floor
II	**Roof Top**									
1	Beam									
	Form work		50.92	112,072.73	5,706,743.41	427,974.34	427,974.34	427,974.34	427,974.34	427,974.34
2	Slab Roof									
	Form work		57.96	112,072.73	6,495,735.43	487,180.27	487,180.27	487,180.27	487,180.27	487,180.27
3	Schafolding roof and slab		82.66	49,490.00	4,090,843.40	Use 1 St Floor	Use 4th Floor	Use 7th Floor	Use 10th Floor	Use 13th Floor
	Total Cost				**41,417,069.15**	**2,464,772.61**	**2,464,772.61**	**2,464,772.61**	**2,464,772.61**	**2,464,772.61**

Table 3: Calculation of the formwork cost

No	Work Discription	Unit	Volume	Unit Price	19th floor	20th floor
I	**1 st Floor**					
1	Beam	m				
	Form work	m2	102.45	112,072.76	11,481,854.26	11,481,854.26
2	Roof Slab 2nd Floor					
	Formwork		81.91	112,072.76	9,179,879.77	9,179,879.77
3	Scafolding Beam And slab		90.16	49,490.00	Use No 16	Use No.17
II	**Roof Top**					
1	Beam					
	Form work		50.92	112,072.76	5,706,744.94	5,706,744.94
2	Slab Roof					
	Form work		57.96	112,072.76	6,495,737.17	6,495,737.17
3	Schafolding roof and slab		82.66	49,490.00	Use no. 16	Use No 17
	Total Cost				**32,864,216.14**	**32,864,216.14**

Table 4: Calculation of the formwork cost 19th and 20th floor

In Table 3. It is explained that for the manufacture of new/whole formwork there are in buildings no.1, 2, 3, 19, and 20. While the other buildings use formwork repeatedly as much as 6 times with the assumption of repair costs of 7.5% of the cost of new formwork, as well as the use of scaffolding. While in Table 4 the total cost of 1 unit of formwork work is IDR. 32,863,654.73 x 5 units of new use = 164,318,273.63, and efficient 6 times the use of formwork is obtained IDR.2,464,774.10 x 15 units of new use = 36,971,611.57, while the difference between the contract cost and the cost of implementing the formwork usage is IDR. 657,273,094.52 – IDR. 201,289,885.20 = Rp. 455,983,209.32 , See Table 5 Cost Eficientcy

Beam and Formwork Beam and slab	Total Unit	Unit Price / IDR	Total / IDR
New Foormwork	5	32,863,654.73	164,318,273.65
Used formwork	15	2,464,774.10	36,971,611.50
		Total	201,289,885.15
		Contract Cost	657,273,094.52
		Cost Eficientcy	455,983,209.37

Table 5: Cost Eficiency

V. CONCLUSION

Based on the background of the research problem and the results of the cost analysis carried out, the following conclusions can be drawn:

- Using the panel model alform formwork can streamline the use of formwork up to 6 times the use, and the ease of disassembly because the formwork shape has been set to adjust the shape of the building floor plate.
- Based on the savings in the use of formwork, the profit from the contract value of formwork work is 69% of the formwork work cost Rp. 657,273,094.52.
- The project completion time can be shortened by 6 months, from 21 months to15 months(efficiency rate 28.57%). Especially at the time of execution of the work of the structurepreprint

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