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SELECTION OF METHODS OF CARRYING OUT FLOOR PLATE BEKESTING WORK WITH COST COMPARISON

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ABSTRACT

The process of developing an area can begin with infrastructure development, where one example of such infrastructure is a building that has various functions. The Surabaya City X building construction project is one of the objects that will be studied in this study. This project has an estimated value of Rp183.000.000.000.00. With a project value of that size, this study aims to choose alternative materials for floor slab formwork work. Floor plate formwork work is one type of work that results in the waste of material used for formwork. Formwork planning requires consideration of using a method or methods to make it easier and cheaper, especially for buildings that are the same shape as the previous building and are of the same size. Conventional floor plate formwork materials are wood, multiplex, and nails; alternative choices are conventional formwork, semi-system formwork, full-system formwork, and bondek plate formwork. The results of this study indicate that when initially analyzed using conventional formwork, it costs Rp6.421.406.646; when using alternative semi-system formwork, it costs Rp6.002.969.805; using full system formwork costs Rp5.530.690.993; and if using bondek plate formwork, it costs Rp6.116.119.937.

Keywords: Building; Formwork; Floor plate

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1. INTRODUCTION

Concrete is a principal construction material in building industry. It has been widely used in the constructions of residential and commercial buildings and infrastructures not only because of its excellent building properties, such as structural performance, sustainability, accessibility and low cost, but also due to its formability to achieve any shapes regardless of geometric complexity. In order toget the bestbonding strength between the hardened concrete andreinforcement requires arobustadhesive substance (Rosyidah et al., 2019). Formwork is essential for the construction of concrete structures. On one hand, it could shape concrete into the desired geometry; on the other hand, it allows fresh concrete to gradually develop strength to support structure (Li et al., 2022). Using support structures and molds to make structures out of concrete that is poured into the molds is known as formwork. Formwork comes in a wide range of varieties, typically varying depending on the needs and difficulties of the building project. Concrete is poured into molds made of wood, steel, aluminum, or prefabricated shapes, utilized as formwork. After this has had time to harden and set, it is either stripped or left in place as a feature of the building in the case of stay-in-place formwork. Formwork enables builders to cast and manufacture larger and more intricate components of a building, such as floors

and walls, which must be sturdy and support the structure (Abhiyan et al., 2014). One of the key factors affecting the effectiveness and planning of buildings is the formwork, which contributes significantly to the overall construction time and cost (Samali et al., 2018).

Formwork construction is expensive, frequently time-consuming, and difficult to plan and design for reinforced cast-in-place concrete projects. Although determining the right formwork design is time-consuming and complex, this job is typically entrusted to a field manager or engineer, who may not have the time or resources to discover all available possibilities and choose the most efficient formwork (Hyun et al., 2018) . Modern buildings use a variety of formwork materials and techniques to expedite construction. Whether a building is commercial, residential, industrial, or of any other sort, the formwork materials utilized will vary depending on the type of construction. The choice of the type of formwork is a significant effort in and of itself, and it influences the project's final cost. It is a key factor that also impacts the building's design. This essay will analyze the appropriate formwork materials for various architectural typologies (Shrivastava et al., 2020). Quality in terms of strength, durability and rigidity and it should be safe to workers and concrete structures and should possess good efficiency in operation, easy to handle and dismantle and should be economical. It should be strong enough to withstand the dead and live load. Therefore choosing a correct formwork becomes essential in construction. Incorrect selection of formwork will lead to increase in cost and time overrun in construction project (Rajeshkumar et al., 2020). The formwork cost can be significantly increased in some special projects such as tall buildings. Moreover, the completion time of a construction project depends on the progress of the activities that follow it (Golafshani & Talatahari., 2018). The cost of reinforced concrete constructions is mostly attributable to formwork techniques. The cost of reinforced concrete building projects may be greatly decreased by applying constructability concepts to the design, choice, and management of formwork systems in the preconstruction stage. Research has examined the advantages of streamlining the management of formwork, even though several studies have created tools and procedures to automate the design and selection of formwork systems (Mansuri et al., 2017).

Concrete is often poured into formworks, typically built of wood, steel, aluminum, or prefabricated forms. The same formwork used to cast larger building components, such as columns, beams, slabs, and shear walls, is also used to cast smaller construction components, such as stairs. Cost, timing, and quality considerations must be considered when choosing formwork for high-rise construction (Gaddam & Achuthan., 2020). The classic formwork technique is one of the most commonly employed systems in concrete buildings. The traditional (Traditional) formwork system usually consists of standard plywood panels tied together with timber frame over their backs with horizontal members called walling to resisting the weight and horizontal force of wet concrete (Al-Ashwal et al., 2017). Traditional formwork has the characteristics of high loss, rapid depreciation, and a low utilization rate of raw materials, resulting in a waste of resources. In addition, abandoned formwork has a great impact on the green ecological environment. Therefore, the development of formwork technology becomes an important part of promoting the progress of construction technology (Wang et al., 2022). Therefore, formwork systems have shifted from traditional formwork to permanent formwork, which can not only be removed after use but also become part of a structural member that provides structural strength to the entire system. Alternatively, because of the high strength (Li & Yin., 2021).

The use of advanced formwork techniques for construction of structures is increasing as the time progressed. Speed and efficiency are of prime importance in the present competitive market; thus, by using newly emerging formwork systems, the length of the project is decreased by using the latest methods that are reliable, durable and accelerate the building speed (Das et al., 2016).To reduce the cost, reducing the complexity of the formwork system and facilitating the placing of the structural elements are the key to success in the future. Current formwork research aims therefore towards new cost-competitive formwork systems and materials that focus on labour reduction and efficient material use (De Sutter et al., 2014). and has the potential to be reused for various concrete components or at different construction sites (Mei et al., 2023).

This research study was conducted on the X Building construction project in the city of Surabaya. This type of building project has the same form between floors to use the same formwork on each floor. The same goes for one floor of a building and another. This time the research moment compares several alternatives because

it will look for alternative slab formwork that is cheaper, easier to obtain, affordable, and effective with many uses so that it is possible to achieve significant efficiency and benefits without reducing the quality of the concrete alone. The purpose of this research is to review the rate per square meter of slab formwork for each installation.

2. METHODS

2.1 Objects and Location of The Research

The preparation of the research required data relevant to the object under study. The object of this research is the construction of Building X in the city of Surabaya. This building has nine floors plus one rooftop floor.

2.2 Data Collection Technique

Primary data are collected directly from study participants; in this situation, the research uses specified tools to collect data or information. In-depth interviews with informants were the foundation for the primary data collected in this value engineering study. The findings from the interviews provide the supporting information required in the investigation of material substitutes that may be used instead of the original components without compromising their original function.

Secondary data, which includes organized archive data, papers, reports, books, and other materials related to this research, is information discovered indirectly from publicly available research items. Shop designs, budget plans, technical specifications, implementation strategies, and pricing lists of goods and wages in East Java are examples of secondary data required for the research.

This research begins with data collection, the first of which is primary data obtained from interviews with practitioners in the field, indicating that the type of formwork most widely used in building construction is an alternative material that can be replaced without reducing its original function. While the secondary data in the study included shop drawings, floor plans, budgets, specifications, techniques, implementation methods, and price lists of materials and wages in Surabaya.

Then proceed with calculating the volume of conventional and system formwork and analyzing the unit price of the work of the two types of formwork. The volume of the formwork is calculated based on the area of the mold alone; for example, for slab molding, the volume is the area of the mold from each side of the floor plate, depending on the dimensions of the column being reviewed. After that, the work unit analysis was calculated for each square meter for each formwork alternative. The price of floor plate formwork per square meter is then determined by multiplying the volume of each work item by the unit price of comparable work for conventional formwork, semi-system formwork, full system formwork, and bonded plate formwork.

2.3 Data Analysis Method

2.3.1 Various Methods of Floor Plate Formwork

Research in the literature and firsthand accounts from building professionals. The options at this point will then be carefully examined and reviewed. An option that seeks to offer a less expensive price than the original implementation price to prevent unnecessary expenses. Currently, conventional, semi-system, full-system, and bonded plate formwork are the four forms of formwork most frequently employed in building construction in Indonesia. One of the most crucial choices at the construction level of a project is choosing the type of formwork to be utilized since it impacts prices, processing times, and building quality.

Formwork wood is a very traditional type of wood used for building houses. It is made from materials that use wood best to be strong and withhold burden during construction. It should be noted that only forest wood can be used. One up to two times only, in which way the wearer is with assemble and disassemble part structure to be done and so on, only need unpack part formwork in a manner one by one after strength concrete felt already sufficient (Pratama et al., 2017).
Superiority formwork conventional are:

- The material is easy to find.
- Cheap
- There is no need for skilled workers.

Whereas lack formwork conventional are:

- Material: wood, fast damaged If used Keep going continuously.
- The time required to assemble and disassemble formwork is not fast enough.
- Lots of waste wood and nails.
- Because the surface of the concrete was uneven, work addition plaster or exile was required.
- Shape No precision.

Semi-system formwork is the formwork material default adjusted to structure concrete of such shape, and finally, its use can be used more often and repeated if the structure is concrete alone. No experience with depreciation size Selection of semi-system formwork is on a passable construction tall repetition use formwork, mold system This is made of phenol or tego film, while scaffolding supporters are made of fabricated steel (Rahadianto et al., 2022). Tegofilm is Multiplex products coated with phenol formaldehyde film sheets on one side or two sides Tegofilm can be used repeatedly, between 5-8 times in one use. Using tegofilm gives a concrete surface a smooth and even finish because the cement sticks to the surface and is easily cleaned. Semi-system formwork is the development of conventional formwork; the improvement of quality from conventional formwork to semi-system formwork-based moment is called return formwork. This formwork has been used five times. Superiority semi-system forms are:

- Durable.
- Cheaper.

Lack of semi-system formwork is:

- requires an area for manufacturing formwork. However, moment This semi-system formwork (knockdown) is getting better and easier to order.
- More expensive than multiplex material.

The system formwork/full system method is formwork in which all materials are made of fabrication, where the fabrication is below, which means that when it is used, it is ready to use and there is no need for sawing or so on, and for this method, heavy equipment such as a tower crane is needed. System formwork, also called full system formwork, is formwork that has been further developed into a universal formwork with all its possibilities and is worn in various types of buildings. The use of system formwork is intended for repeated use. System formwork implementation is shorter compared to conventional and semi-system formwork because of the system formwork parts. This has a standard size. Funding system formwork can be expensive at first, but with a shorter assembly process and repeated use, the cost of adding materials is not too expensive (Trijeti., 2013).
The advantages of a full-system formwork are:

- Easy to assemble and disassemble.
- No heavy.

- Can be repeated.
- Good casting quality with short disassembly can be used for large concrete structures.

While the weaknesses of the formwork system are:

- The rental price is relatively expensive.
- Requires app experience.

Floor plate with the use of Bondek is one field that updates technique-related civilians with the creation of a floor plate section. Bondek, used in the floor plate process, has two uses: as formwork fixed and as reinforcement positive. One direction. Floor plate Bondek added working wiremesh for increased power from the floor plate. Bondek, or "outside steel deck," is one of the structural materials it is made of steel-shaped sheets used for floor plates.

The advantage of using bondek (floor deck) formwork is that it can function as reinforcement for floor slabs as well as formwork, thus saving reinforcement under the floor slabs. During execution, it has the advantage of not having the formwork dismantled like conventional formwork; in addition to the neat underside of the slab, it can be used as a ceiling, which is not found in the use of conventional formwork, where the bottom of the slab is not neat, so finishing activities are needed. or ceiling covering. Besides that, galvanized steel material has resistance to rust, is durable, and is safe against fire. However, the weakness of bondek formwork is that it cannot be used for cantilever formwork, the cost of steel is higher than multiplex, and it needs careful arrangement to obtain minimal material waste.

3. RESULTS AND DISCUSSION

Based on results from Plan Data Budget Cost (RAB), we obtained work Structure that have the highest cost items, that is, Rp. 71.659.316.132. For that, a job structure will become the focus. After knowing the work structure that has cost the most from all jobs The next thing is to decipher existing jobs in the work structure based on cost construction, from jobs that have the highest cost to jobs with the lowest cost.

Table 1. Recapitulation Cost Work Structure

No	Work Items	Total price (Rp.)	Weight
1	Beam	15.088.457.899	35,2%
2	Slabs	12.530.471.281	29,3%
3	column	10.228.438.679	23,9%
4	Stair	1.730.417.822	4,0%
5	Ramp	1.263.673.901	3,0%
6	PODIUM AREAS	1.058.411.997	2,5%
7	CANOPY AS 5-8/BC	698.801.116	1,6%
8	LMR Column	152.491.255	0,4%
9	MACHINE BEAM ON ROOF FLOOR	61.165.421	0,1%
	Total	42.812.32.371	100%

From the results of the data recapitulation above, it can be seen that five items cost a lot. The beam work cost Rp. 15.088.457.899 with a weight of 35%, the slab work cost Rp. 12.530.471.281 with a weight of 29%, column work costs Rp. 10.228.438.679 with a weight of 24%, stair work costs Rp. 1.730.417.822 with a weight of 4% and ramp work costs Rp. 1.263.673.901 with a weight of 3%.

In this study, we will take slab work because this work occupies number 2 as a job that incurs high costs, and slab work has several formwork alternatives often used in the construction world. With this potential, it can provide choices so that you can choose formwork, which is more economical.Determination alternative to

floor slab work done with compare price unit work floor slab formwork between design start and design alternative, which is counted as a cost per meter square.

Table 2. Price analysis unit work floor slab formwork conventional

MATERIAL	Koefesien	Unit	Unit Price	Amount
Merantih Wood (Blocks)	0,045	m3	3.900.000	175.500
Nail normal	0,400	Kg	22.000	8.800
Oil Begisting	0,200	Ltr	21.000	4.200
Plywood 9 mm, 1.20 x 2.40	0.350	Lb	221.000	77.350
Amount Material				**265.850**
For 2 X Use				**132,925**
WAGES:				
Worker	0,300	m/d	125.000	37.500
Carpenter	0,15	m/d	135.000	20.250
Head craftsman	0,015	m/d	140.000	2,100
Foreman	0,015	m/d	145.000	2.175
Amount Worker				**62.025**
EQUIPMENT:				
Scaffolding	1	Ls	40.000	40.000
Amount Equipment				**40.000**
Amount Materials + Workers + Equipment				**234.950**
rounded				**234.950**

Alternative 1 is conventional formwork. The conventional formwork still uses wood and nails as the material for making the floor plate formwork, the budget plan for the X building project uses conventional formwork to print floor plates, and the results of the unit price analysis for conventional floor plate formwork produce a fee of Rp. 234.950 for every square meter.

Table 3. Price analysis unit work Semi system floor slab formwork

MATERIAL	Coefficient	Unit	Unit Price	Amount
hollows 50.50	9,394	kg	84.000	789.096
wood rafter's 5/7	0,005	m3	2.200.000	11.000
phenol/ tego film	0,080	sheet	156.250	12.500
oil formwork	0,200	l	21.000	4.200
dynabolt	3,882	pcs	5.000	19.410
Amount Material				**836.206.00**
For 5 Use				**167.241,20**
WAGES:				
Worker	0,007	m/d	125.000	875
Carpenter	0,076	m/d	135.000	10.260
Head craftsman	0,008	m/d	140.000	1.120
Foreman	0,001	m/d	145.000	145
Amount Worker				**12.400**
EQUIPMENT:				
Scaffolding	1	Ls	40.000	40.000
Amount Equipment				**40.000**
Amount Materials + Workers + Equipment				**219.641,20**
rounded				**219.640**

In alternative 2, this semi-plate system formwork differs from the previous conventional formwork. The difference is the replacement of material from conventional formwork, which initially used wooden boards replaced with a phenol film or tego film and nails replaced with dynabolt, so that in the cost analysis of semi-plate system formwork, the floor costs Rp 219.640 for each square meter. Compared to conventional floor plate formwork, semi-system floor plate costs less money, even though the price of the manufacturing material

is quite high. Still, conventional formwork can be used five times. Because the formwork is easier to manufacture, the wages for these workers are cheaper than the wages of workers in conventional formwork.

Table 4. Price analysis unit work Full system floor plate formwork

MATERIAL	Coefficient	Unit	Unit Price	Amount
phenol/ tego film	0.08	m3	156.250	12.500
hollows 50.50	1	stick	84.000	84.000
u heads	1	set	25.000	25.000
horizontal alignment	1	set	54.500	54.500
security vertical	1	set	54.500	54.500
joint security	1	set	25.000	25.000
base jack	1	set	25.000	25.000
Amount Material				**280.500**
For 2 Use				**140.250**
WAGES:				
Worker	0,066	m/d	125.000	8.250
Carpenter	0,033	m/d	135.000	4.455
Head craftsman	0,033	m/d	140.000	4.620
Foreman	0,033	m/d	145.000	4.785
Amount Worker				**22.110**
EQUITMENT				
Scaffolding	1	Ls	40.000	40.000
Amount Equipment				**40.000**
Amount Materials + Workers + Equipment				**202.360**
rounded				**202.360**

In alternative 3, using a full formwork system, this formwork has a difference from conventional formwork and semi-system formwork; the difference is the replacement of some materials from conventional formwork and semi-system formwork, which initially used 5/7 wood beams replaced with 50.50 hollow steel, and other supporting equipment also got an update, namely using U heads, horizontal and vertical bolts, screw joints, and a jack base. Alternative 3, which uses a full system formwork, costs Rp. 202.360. Full-system formwork is cheaper than conventional and semi-system formwork because the materials are cheaper.

Table 5. Price analysis unit work Bondek Plate floor formwork

MATERIAL	Coefficient	Unit	Unit Price	Amount
beam 8/12	0,0089	m3	3.250.000	28.925
rafter's 5/7	0,0014	m3	2.200.000	3.080
Nail normal	0,2300	kg	22.000	5.060
bondek plate	1,0800	m2	120.000	129.600
Amount Material				**166.665**
WAGES:				
Worker	0,080	m/d	125.000	10.000
Carpenter	0,040	m/d	135.000	5.400
Head craftsman	0,004	m/d	140.000	560
Foreman	0,008	m/d	145.000	1.160
Amount Worker				**17,120**
EQUIPMENT:				
Scaffolding	1	Ls	40.000	40.000
Amount Equipment				**40.000**
Amount Materials + Workers + Equipment				**223.785**
rounded				**223.780**

In alternative 4, using floor plate formwork that uses bonded plates, the difference from conventional, semi-system, and fuel system floor plate formwork is the use of bonded plate material, resulting in an analysis cost of Rp. 223.780. This floor plate formwork is indeed more expensive than the semi-system formwork and full

system formwork, but the advantage of this formwork is that there is no dismantling of the bonded plate layer, the bonded plate is left attached to the floor plate, so the dismantling of this formwork is faster and neater than other formwork.

The following is a recapitulation of the calculation of the unit price analysis for floor plate formwork every square meter, starting from conventional floor plate formwork, semi-system floor plate formwork, full system floor plate formwork, and bondek floor plate formwork.

Table 6. Price analysis unit work floor slab formwork

Type Work	Total Cost	Total Savings	Percentage
Floor Plate Formwork conventional	234.950	0	0%
Semi System Floor Plate Formwork	219.640	15.310	7%
Full System Floor Plate Formwork	202.360	32.590	14%
Bondek Plate Floor Formwork	223.780	11.170	5%

Savings in slab work from conventional slab formwork, semi-system slab formwork, full system formwork, and bondek floor slab formwork result in cost and percentage savings of:

- Use Formwork Semi System Rp. 15.310 with 7%.
- Use Formwork Full System Rp. 32.590 with 14%
- Using Bondek plate, Rp. 11.170 with 5%

The entire surface area of the floor slab in building X is calculated to determine the area each formwork will cover. the total area needed for the floor plate formwork on each floor is obtained, all floors are totaled. Starting from the 1st floor to the 10th floor, the total floor plate area in building X is 27.300 square meters.

Estimated funding includes materials, wages, power work, and tools collected from the analysis results unit formwork (AHSP). Following This is a summary of the analysis cost.

Table 7. Price analysis floor slab formwork

No	Type Work	Vol	Unit Price	Total Cost
1	Conventional	27.330	234.950	6.421.406.646
2	Bondek plate	27.330	223.780	6.116.119.937
3	Semi System	27.330	219.640	6.002.969.805
4	Full System	27.330	202.360	5.530.690.993

The calculation above shows that the use of full system formwork on floor slabs produces low costs compared to the use of other formwork, namely at a price per square meter of Rp. 202.360 and the full-use floor plate formwork in building x produces a total cost of Rp. 5.530.690.993. This formwork is more economical than other forms. So based on previous research, this article will discuss the selection of the formwork slab method by comparing it in terms of cost per square meter. This study will compare four formwork floor plates, including conventional formwork, semi-system formwork, full-system formwork, and bonded plate formwork. The selection of these four alternatives is based on the results of interviews with fieldwork practitioners based on the frequent use of the four types of formwork in Indonesia, while this study previously compared conventional formwork and full system formwork. In this study, the aim was to choose a formwork implementation method to negotiate the initial cost of formwork slabs.

4. CONCLUSION

Cost Work floor slab formwork using was carried out at Rp. 6.421.406.646,11 with a price unit of Rp. 234.950/m2. Semi-system formwork was used, then the total cost would be Rp. 6.002.969.805,29 with a price unit of Rp. 219.640/m2, so the total savings obtained would be Rp. 418.436.840,83, or 7% of the price early. Using full system formwork, the total cost would be Rp. 5.530.690.993,43 with a price unit of Rp. 202.360/m2, so the total savings obtained would be Rp. 890.715.652,68, or 14% of the price. And when using bondek plate formwork, the total cost is Rp. 6.116.119.937,29 with a price unit of Rp. 223.780/m2, so the total savings obtained are in the amount of Rp. 305.286.708,82, or by 5% of the price early. So based on the cost assessment for slab formwork work that can streamline the cost of floor plate formwork work, a full system formwork work with a saving percentage of 14% from the start.

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