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ANALYSIS OF STRATEGIES AND IMPLEMENTATION METHODS FOR TIME AND COST EFFICIENCY IN MULTI-STORY BUILDING CONSTRUCTION PROJECTS

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ABSTRACT:
The construction of multi-story buildings is increasingly rapid, with difficulty in managing and implementing multi-story buildings increasingly high. The longer the duration of time required will affect the costs to complete the project. Therefore, an implementation method is needed to support and consider the costs incurred in carrying out the work. In addition, by sharpening priorities, it is hoped that project management efficiency and activities will increase. All of this is to achieve the goals of a multi-story building project that meets the client's needs. Different implementation methods in a building must be followed by exemplary project implementation and following the plan. Good technical management and implementation can reduce the risks of multi-story building construction projects and delays. It will reduce the development of project costs and will ultimately provide benefits for contractors. The method of implementing this multi-story building uses zoning and bottom-up methods. This method is expected to obtain time efficiency values. The implementation process is fast and obtains optimal costs.

Keywords: *Implementation Method, bottom-up, time, Budget Plan*

INTRODUCTION

The construction of multi-story buildings is a crucial component of a nation's developmental progress, demonstrating its proficiency in construction and other facets. Multi-story buildings contribute significantly to various aspects, including education, economy, culture, tourism, technology, and construction (Bodenhamer & Barrows, 1994).

The case study under investigation in this research pertains to a multi-story building designated for educational purposes, specifically intended to serve as a laboratory and office building for Yudharta Pasuruan University. This building is situated within the Pasuruan Regency and features a footprint measuring 25 meters in length and 25 meters in width. The project envisions the construction of 12 floors, with 5 floors designated for offices, 5 for laboratories and lectures, 1 for an auditorium, and 1 for support facilities. This building holds numerous benefits for the advancement of the campus, serving as a central hub for learning and shared lecture spaces.

The rapid proliferation of multi-story building construction projects is accompanied by increasing complexities in their management and execution (Himeur et al., 2023). Prolonged project durations can have substantial cost implications. Consequently, the adoption of effective implementation methods that consider the costs associated with project execution becomes paramount. Moreover, it is anticipated that project management efficiency and activity levels can be enhanced by refining project priorities and aligning the construction of multi-story buildings with specific project requirements.

Different construction methods are employed in multi-story buildings, and their effective execution should align with project planning (Elhegazy, 2022). Proficient technical management and execution can mitigate the risks associated with multi-story construction projects and minimize the likelihood of delays (Peterson et al., 2011). It, in turn, can result in cost savings for the project and ultimately benefit the contractors involved. This case study's selected implementation method for multi-story buildings utilizes zoning and a bottom-up approach. This method is anticipated to yield time efficiency, expeditious execution, cost optimization, and achieving quality and occupational safety and health (K3) objectives.

RESEARCH METHODS

The construction implementation method essentially involves elucidating procedures and techniques for carrying out construction work, constituting the core of all activities within the construction management system. The construction implementation method transforms all planning into a physical structure. Fundamentally, the construction implementation method entails the application of engineering concepts grounded in the interplay between the requirements outlined in tender documents (procurement documents) and the technical and economic conditions present on-site, as well as all available resources, including contractor experience.

A contractor's business revolves around the method of implementation, as what distinguishes one contractor from another lies in the disparity of implementation methods. Determining the implementation method will significantly impact the project's cost, time, quality, and occupational safety and health (K3) (Putri & Ariesyadi, 2023). The construction implementation method in project management answers the "how to." The implementation method represents a blend of art, knowledge, and experience. To determine the implementation method for a project, we should consider the following factors:

1. Cost
2. Time
3. Available technology
4. Existing land
5. Experience in similar projects.

On the other hand, project implementation strategy represents a comprehensive approach related to the execution of ideas, planning, and the execution of an activity within a specific timeframe in construction project work. Several common strategies can be employed in building construction, and in terms of their working direction, they can include conventional, bottom-up, top-down, and semi-top-down strategies.

Implementation methods can be understood as a series of construction activities with specific working procedures aimed at achieving an expected objective. The judicious use of appropriate, efficient, and safe strategies can assist in completing a project. Project implementation methods comprise a set of specific procedures and techniques that are fundamentally rooted in an engineering concept based on the interplay between the requirements outlined in tender documents, the technical and economic conditions in the field, and all available resources, thus enabling the timely, cost-effective, and high-quality achievement of set objectives.

Construction implementation methods represent construction execution activities that adhere to procedures and have been designed following established knowledge and tested standards. Formulating construction implementation methods emerges through discussions, deliberations, and referencing diverse sources. These methods are then documented in the form of working drawings, which delineate the order of work execution and serve as a comprehensive reference for each specific task during construction.

The development of implementation methods plays a crucial role in this intensive building construction (Zuo et al., 2012). Implementation methods provide insight into how this project will progress from initiation to completion, ensuring that construction is of the right quality quantity and completed within the specified timeframe (Abednego & Ogunlana, 2006). In construction work, there are instances when innovative methods are required to overcome field-related challenges, especially when facing unforeseen conditions that differ from initial assumptions.

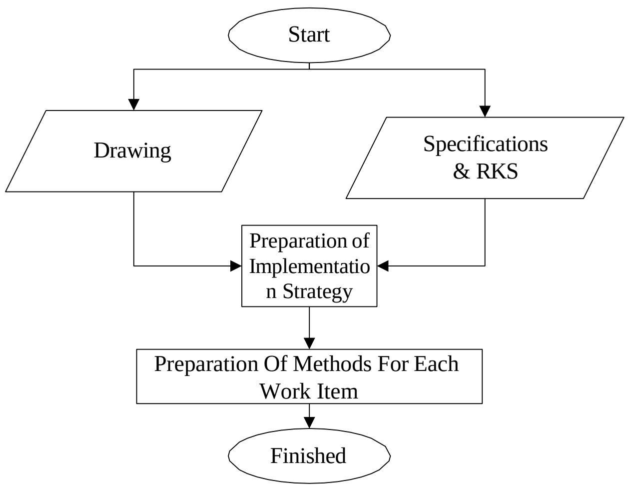


Figure 1. Flowchart for the Development of Implementation Methods
Source: Planning Results

The stages of developing project implementation strategies and methods are as follows:

1. Data collection includes plan drawings, technical specifications, and a Bill of Quantities (BOQ).
2. Formulating effective and efficient implementation strategies and methods for each task, considering environmentally friendly implementation methods following the sequence of work, taking into account the volume of the work, and creating a visualization of the work execution.

The data required to develop implementation methods consists of primary data, including field photos and secondary data. Project data includes planning drawings, Work Plans and Specifications (RKS), location maps, work area boundaries, and the Regional Spatial Plan (HSPK) for Pasuruan Regency in 2020.

After obtaining supporting data, the following steps involve data analysis and processing, which includes calculating the bill of quantity, creating a Work Breakdown Structure (WBS), and analyzing the tasks based on the chosen implementation methods. Subsequently, scheduling, cost estimation, and constructing an S-curve are undertaken.

RESULTS AND DISCUSSION

Work Breakdown Structure (WBS)

The development of a Work Breakdown Structure (WBS) aims to break down or divide each work item into smaller sub-activities, facilitating the process of project planning and control (Abednego & Ogunlana, 2006). Therefore, work items are organized and grouped, from the activities initiated at the beginning of the project to the final activities. Creating a WBS relies on project plan drawings as a reference for its development. Several major sub-tasks are considered in constructing the Integrated Laboratory Building at Yudharta University, including Preparation Work, Substructure Work, and Superstructure Work.

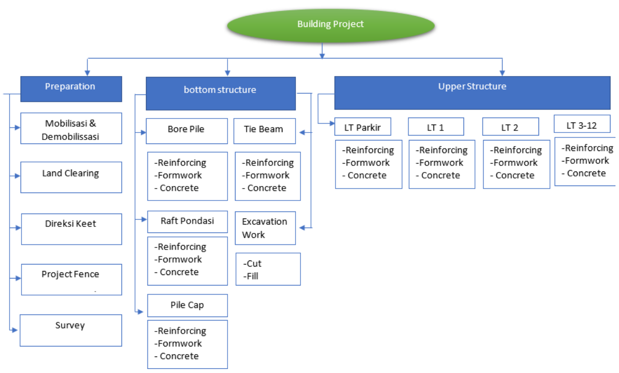


Figure 2. Work Breakdown Structure

Site Layout

Conducting a direct site inspection is essential before commencing work on construction projects of both large and small scales. This inspection is carried out to gain a comprehensive understanding of the actual field conditions, enabling the preparation of a sequence of construction activities. Consequently, the development of a site layout needs to be prepared and executed, which serves as a temporary supportive building plan until the construction process is completed.

The site layout in construction projects serves the purpose of optimizing land use, facilitating the identification of the location for each work item, and arranging the layout and supporting facilities such as project management offices, material, and equipment storage warehouses, as well as the placement of electrical facilities, bathrooms, vehicle access points, and other elements. This efficient layout ensures the smooth progression of the construction process. Given the temporary nature of these structures, selecting appropriate and cost-effective building materials is imperative to economize project expenditures. A well-designed site layout enhances work productivity regarding equipment and labor, simplifying and expediting the construction process to ensure timely completion.

Traffic Management

Traffic Management aims to organize and regulate the traffic near the project. Effective traffic management planning can impact working comfort, project cost efficiency, and the speed of various work mobilizations. Before formulating a traffic management plan, it is crucial to identify the types of vehicles expected to enter, stop at, and exit the project area. This information makes it easier to determine the road geometry pattern leading to the construction site, the width of the main project road, and the arrangement of project traffic support facilities, such as unloading areas, loading areas, parking lots, and others.

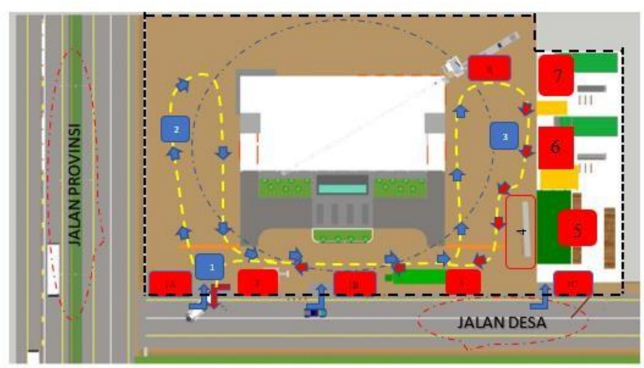


Figure 3. Traffic Management

Table 1
Description of Vehicle Traffic Management

NO	JENIS KENDARAAN	Dimensi Kendaraan		Akumulasi Lebar Satu Jalur (m)	Komulatif Lebar Kedua Jalur (m)
		Panjang (m)	Lebar (m)		
1	Tower Crane	17,298	3,000	3,000	6,500
2	*Dump Truck* 3 - 4 m^3 10 Ton	6,350	2,000		
3	Truck Trailer Suplier Besi	14,900	2,500		
4	Truck Alat Bore Pile	14,900	2,500		
5	Truck Pengangkut Excavator	14,900	2,500		
6	Truck Tangki BBM 24000 lt	8,515	2,500		
7	Truck Concrete Mixer 7 m^3	7,992	2,500		
8	Truck Concrete Pump	12,020	2,100		
9	Truck Tangki Air 24000lt	13,300	2,500		
10	Mobil Pribadi	8,210	2,100		
11	Mobil *Pick UP*	4,395	1,675		
12	Sepeda Motor	1,955	0,740		

Implementation Strategies and Methods

In this instance, the implementation strategy employed for the substructure work utilizes the bottom-up method. Meanwhile, a zoning system will be employed for the superstructure work, dividing it into two zones based on the location of the tower crane utilization.

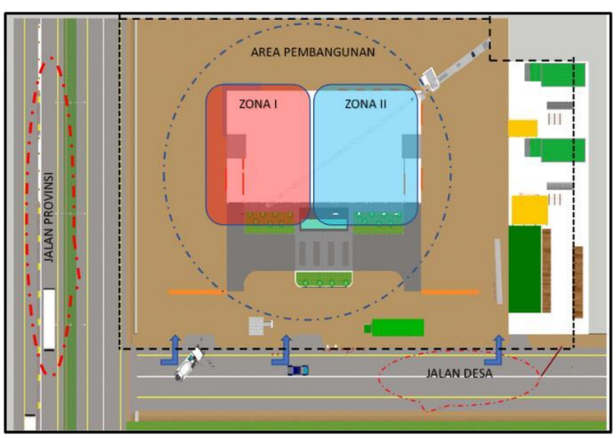


Figure 4. Division of Work Zones

This method commences with site clearance and elevation leveling, employing excavators and dozers to facilitate the clearing process. Subsequently, the next phase involves bore pile excavation, utilizing hydraulic bore machines to dig the soil at designated foundation points. While the bore pile excavation is in progress, the removed soil can be transported to a designated location. Following the bore pile excavation and soil transportation processes, the next step involves installing pile formwork, reinforcing the bore pile, and conducting the concrete pouring for the bore pile. After the pile casting process, the work progresses to pile cap construction, encompassing formwork installation, reinforcement, and concrete pouring for the pile cap.

Subsequently, in the substructure work progress, the focus shifts to the superstructure work, including floor slabs, columns, and beams. These are cast in place, with the construction sequence proceeding from the bottom to the top, culminating on the 12th floor. Scaffolding is employed to facilitate this process. For the superstructure work, the activities involving columns, beams, and floor slabs are cast in situ at their respective locations.

The bottom-up implementation strategy is planned with a cycle of equipment usage involving scaffolding that can be removed once the concrete has reached its maximum age of 7 days, allowing for progression to the next floor.

The scope of work for the Integrated Laboratory Building Construction Project includes:

1. Substructure Work

Substructure work comprises Bore Pile Work, Pile Cap Work, Raft Foundation, and Tie Beams used as components in the substructure, combined with the basement slab (Hooper, 1973). Components of the substructure work involve reinforced concrete, with conventional casting methods performed precisely on the project site (Lárusson et al., 2013).

2. Superstructure Work

The superstructure work encompasses 12 floors, consisting of Parking Levels, Floors 1-2 with a relatively consistent height of 4 meters per floor, and Floors 3-12, which also have a similar configuration with a height of 4 meters per floor (Abdulaziz et al., 2023). The building's roof is composed of concrete. Reinforced Concrete Work for the Superstructure, including columns, beams, slabs, and stairs, is executed conventionally.

In this implementation, the bottom-up method is employed. This method commences with site clearance and elevation leveling, utilizing excavators and dozers to facilitate the clearing process (Serridge & Synac, 2006). Subsequently, the next phase involves bore pile excavation, employing hydraulic bore machines to dig the soil at designated foundation points. These bore piles also serve as the building's foundation to prevent soil erosion and act as load-bearing elements for the building structure.

While the bore pile excavation is in progress, removing excavated soil can be transferred to a designated location. Soil transportation ensures uninterrupted progress in the excavation work, and the removed soil can be transported using dump trucks. Following the bore pile excavation and soil removal processes, the next step involves installing formwork for the piles, reinforcing the bore piles, and pouring concrete.

After the pile casting process, the work progresses to pile cap construction. It includes formwork installation, reinforcement, and concrete pouring for the pile cap, which aids in distributing loads evenly to the foundation. Subsequently, tie beam construction is carried out to further strengthen the building's substructure by locking the pile cap and the foundation together.

Next in the sequence, after completing the substructure work, is the superstructure work. It includes floor slab, structural column, and beam construction, which is cast in place. The construction proceeds sequentially from the bottom to the top, reaching up to the 12th floor utilizing scaffolding for support. Activities involving columns, beams, and floor slabs are cast in situ in the superstructure work.

Based on the division of work zones within the project, the following represents the planned cycle for the superstructure work, which is executed sequentially up to the rooftop.

Column Work in Zone A

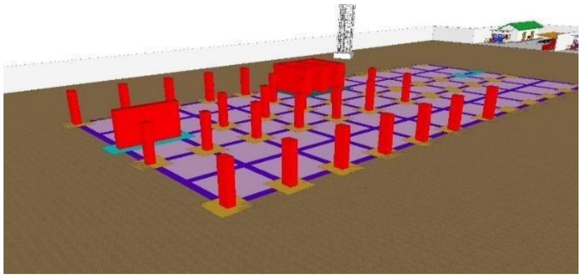


Figure 5. Column Work in Zone B, Parking Level, and Beam-Slab Work in Zone A, Floor 1

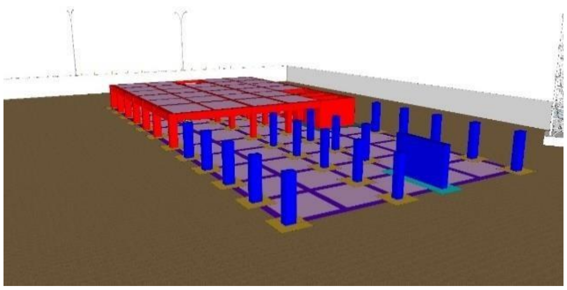


Figure 6. Beam and Slab Work in Zone B and Column Work, Floor 1 in Zone A

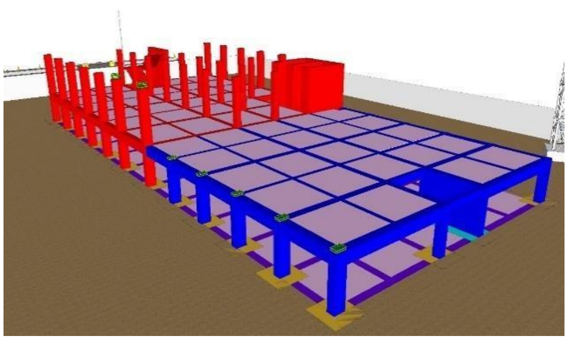


Figure 7. Beam and Slab Work, Floor 2 in Zone A, and Column Work, Floor 1 in Zone B

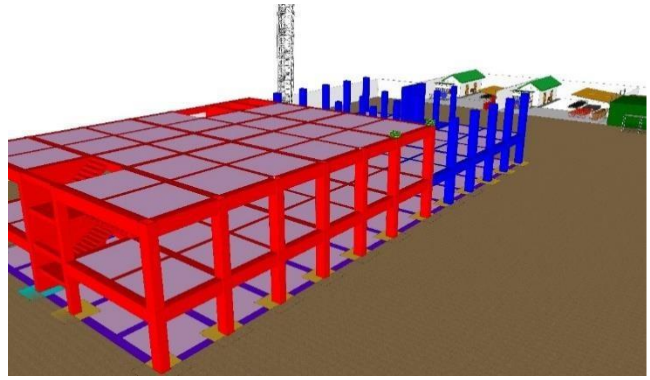


Figure 8. Column Work, Floor 2 in Zone A, and Beam-Slab Work, Floor 2 in Zone B

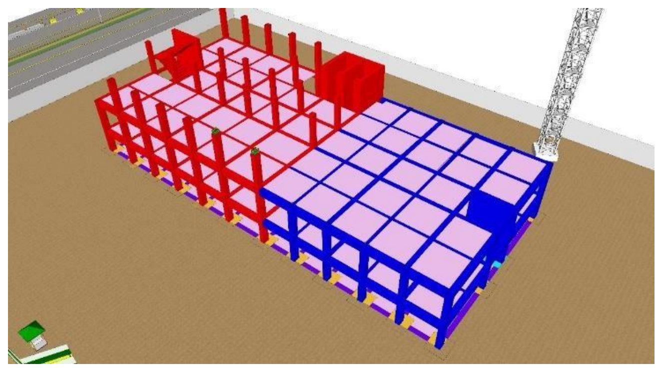


Figure 9. Beam-Slab Work, Floor 3 in Zone A, and Column Work, Floor 2 in Zone B

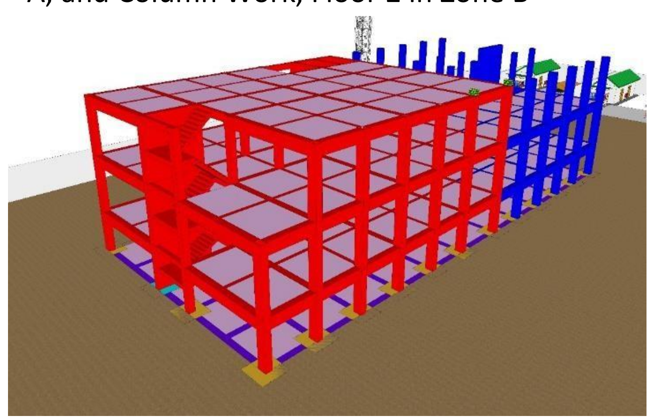


Figure 10. Work Progresses Sequentially to the Rooftop Using a Concrete Roof Deck.

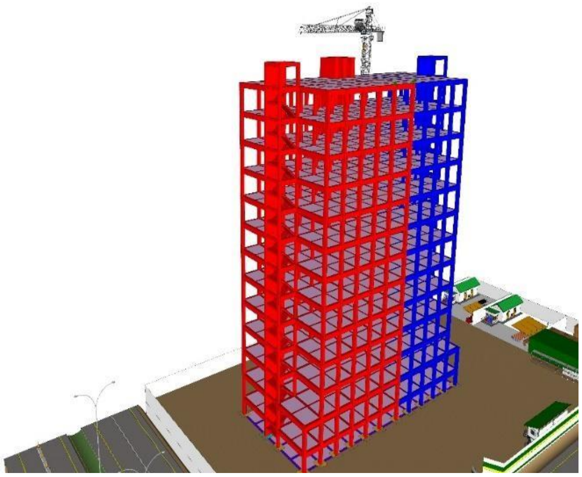


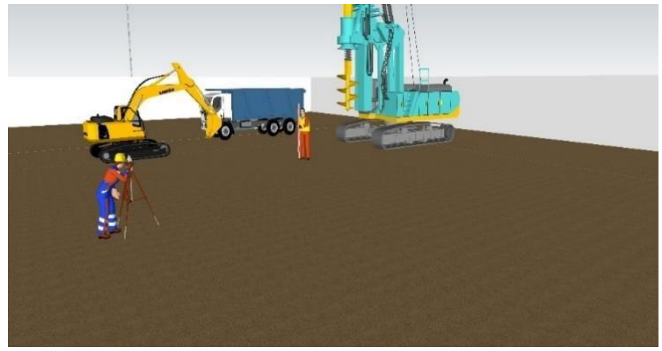
Figure 11. Work Progresses Sequentially

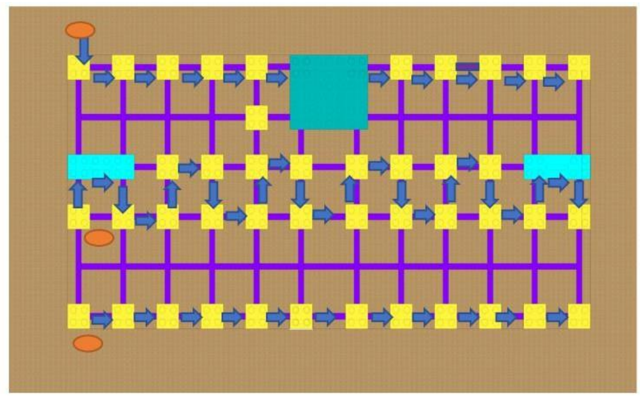
Implementation Method for Bore Pile

1. The drilling equipment is positioned in an area corresponding to the pre-determined points.
2. The drilling equipment is set up, ready for drilling, and in a safe condition.
3. The drilling process follows the planned elevation on the lower floor.
4. The vertical condition of the drilling is continuously monitored for its straightness and alignment.
5. After the drilling is completed and its straightness is checked, the next step is to install reinforcement bars in the drilled holes. Once the reinforcement process is complete, the concrete pouring process can commence.

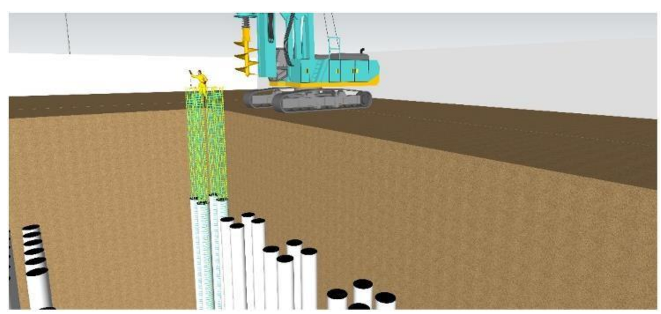
Illustration of Bore Pile Implementation Method

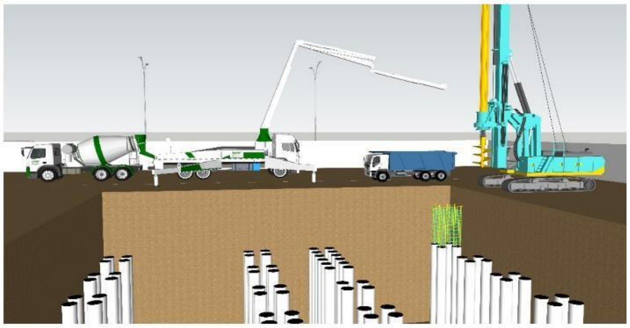
The drilling equipment is positioned in an area corresponding to the pre-determined points.





The vertical condition of the drilling is continuously monitored in terms of its plumpness and straightness.





Implementation Method for Superstructure Work

The superstructure work, comprising column, beam, floor slab, and stairway construction, is carried out sequentially up to the building's rooftop (Chau et al., 2005).

Column Work

a.) Scope of Work (Yuan et al., 2021):
- A survey of pre-determined column points
- Inspection of reinforcement fabrication and equipment
- Assembly of column reinforcement
- Formwork installation for columns
- Column casting work

b.) Implementation Method for Column Work (Vanderbeck, 2005):
- Firstly, a check is conducted on the column points to ensure their alignment.
- If the points are aligned, the next step involves inspecting the equipment and materials used during column installation.
- Once the column reinforcement materials and equipment are ready, the reinforcement is installed on the columns.
- Formwork is installed around the columns after the column reinforcement is in place.
- Following the installation of the formwork, checks are made for the squareness and plumpness of the columns.
- After all the above steps are completed, the next phase involves the casting process for the columns.

Figure 12. Site location survey

Figure 13. Reinforcement of Columns

Figure 14. Formwork Installation and Column Plumbness Check

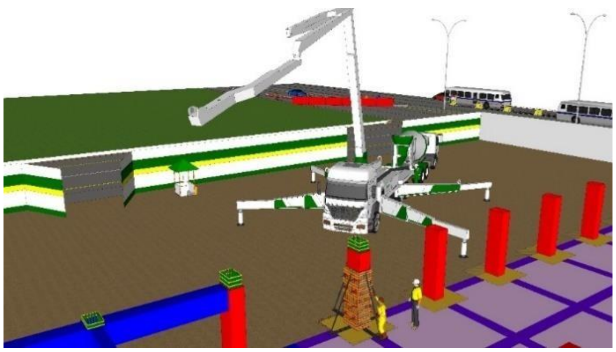


Figure 15. Column Casting

Beam and Slab Work (Zhu et al., 2020)

a.) Scope of Work (Lam et al., 2000):

- Installation of formwork and base jacks for beams and floor slabs.
- Assembly of reinforcement for beams and floor slabs.
- Casting of beams and floor slabs.

b.) Implementation Method (Miller et al., 2015)

- Following the completion of column casting work, the next phase involves beam and floor slab work.
- The subsequent step is constructing formwork for the beams and floor slabs tailored to the specified dimensions.
- After constructing the formwork, equipment, and reinforcement materials are checked and assembled for the beams and floor slabs.
- Upon completing the reinforcement assembly, the casting process for the beams and floor slabs commences.

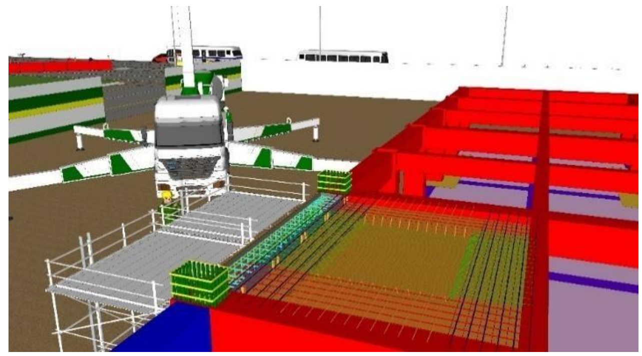


Figure 16. Reinforcement Work and Scaffolding Assembly for Beams and Floor Slabs

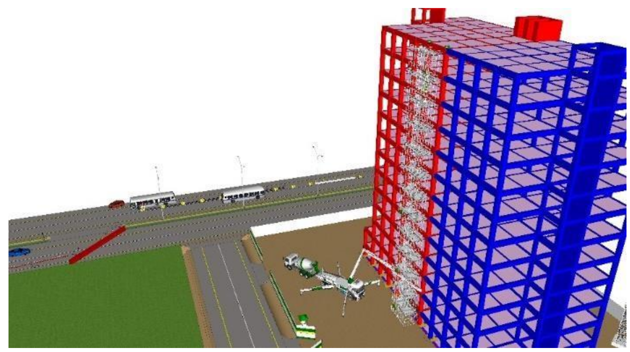


Figure 17. Superstructure Phase Up to the Building Rooftop

CONCLUSION

Based on the discussion above, the following conclusions can be drawn. The implementation strategy utilizes zoning, divided into two zones, with Zone 1 executed according to the layering method and Zone 2 employing a bottom-up strategy.The estimated duration for the execution of the Structural Work for the Construction Project of the Yudharta University Rectorate Building is **233 working days**. The Planned

Implementation Budget amounts to IDR 68,820,000,000.

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