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Research paper

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ABSTRACT

Purpose: This study aims to examine the column work implementation method, analyse productivity, calculate actual labour coefficient numbers, and identify obstacles that may hinder the implementation of formwork system work.

Methods/Design: This study uses a descriptive quantitative method. Primary data was obtained through observations and field surveys at a hospital project in Surakarta, specifically the Kasih Ibu Hospital Construction Project, by examining the actual conditions on-site. Secondary data was obtained from relevant supporting references for the research needs. The initial step of the research involved observing and analysing field data to determine work productivity values and obtain actual labour coefficient numbers using the general calculation formula, referring to an article sourced from books on planning and real cost estimates

Findings: The obtained as follows: (1) column formwork installation: 0.46 m^2/minute; (2) column pouring: 0.22 m^3/minute; (3) column formwork removal: 1.28 m^2/minute. The actual labour coefficient values [OH] obtained were: (1) Formwork installation: labour 0.009 OH, foreman 0.004 OH, operator 0.004 OH; (2) Column pouring: labour 0.018 OH, foreman 0.009 OH, operator 0.009 OH; (3) Formwork removal: labour 0.003 OH, foreman 0.0016 OH, operator 0.0016 OH. On-site obstacles include issues with formwork placement areas, lifting problems, installation difficulties, and equipment issues. With an appropriate solution approach to each challenge, it is expected that column formwork installation can be carried out more effectively and safely.

Practical implication: Obtain the productivity value of column work using the formwork system in the field and determine the actual labour coefficient. To provide an overview for stakeholders in the construction industry, such as the productivity value of column work with the formwork system, which can serve as a basis for determining the labour coefficient in the preparation of AHSP (Unit Price Analysis for Work).

INTRODUCTION

Kasih Ibu Hospital Surakarta is a type B hospital that plays an important role in providing health facilities in the city of Surakarta. Based on data obtained from solodata.surakarta.go.id in 2022, this hospital recorded high outpatient and inpatient visits, which are expected to continue to increase. To meet the need for health facilities, a new building construction project with 14 floors is being carried out, which is scheduled to be completed within 30 months, starting in October 2022.

This hospital building construction project uses reinforced concrete construction, which requires attention to concrete reinforcement, concrete mix, and formwork. Formwork work, which affects the concrete completion time, is an important factor in the efficiency of implementation time. Choosing the right type of formwork is very important, especially for high-rise buildings. One effort to speed up formwork work is to use formwork material that can be used repeatedly.

The Kasih Ibu Surakarta Hospital Construction Project has used a modern type of formwork, namely steel panel formwork, which is included in the type of system formwork or formwork system for structural column work. Formwork system is a type of formwork whose elements are produced in a factory, with most components made of steel (Zhaafira et al, 2023).

In implementing a construction project so that it can be completed and run according to plan, namely on time, right quality, right cost, effective construction methods, and work productivity are needed to measure performance in determining progress targets for a construction project. Therefore, this research aims to analyse the use of formwork system structural column work in accordance with conditions in the field and obtain a column work productivity value, which is based on obtaining the actual labour coefficient figure for formwork work.

Implementation Method

The method of implementing a construction project is the key to converting the overall plan into the physical form of the building. This construction implementation method is based on an engineering concept that focuses on the relationship between the requirements in the procurement documents, technical and economic conditions in the field, as well as the utilization of all resources, including the contractor's experience. Through the interaction and combination of these three elements, a framework of ideas and concepts for optimal methods is formed, which are then applied in the implementation of construction projects (Dipohusodo, 1995).

Column Definition

Columns are vertical compression members of the structural frame that carry the load from the beams and have a very important role in a building. If a column collapses, it can cause the floor in question to collapse completely (Dipohusodo, 1999).

Reinforced Concrete Formwork

According to Wingbout (1992) Formwork is a temporary structure used to shape fresh concrete into the desired shape before the concrete hardens and reaches sufficient strength to

stand on its own. Formwork acts as a temporary "mould" that holds the concrete and provides the necessary shape and dimensions to structural elements, such as walls, beams, and slabs.

Job Productivity

According to Adwayah (2021), the definition of productivity is a comparison between output, namely the results obtained, and input, namely all the resources used. In general, productivity can be interpreted as efficiency in producing output by utilizing available resources. The main objective is to assess the performance of an activity or work process that can be carried out efficiently and effectively in producing the desired output.

Labor Coefficient

The labour coefficient is a number that shows the amount of output or results that can be produced by one unit of labour in a certain period of time, such as hours or days. This coefficient is used to measure the efficiency and effectiveness of the workforce in completing certain tasks or jobs. In a construction context, the productivity coefficient helps determine the estimated time and amount of labour required to complete a project. The higher the productivity coefficient, the faster and more efficiently the work can be completed (Kartika et al, 2021).

METHODS/DESIGN

Types of research

This research uses quantitative methods by conducting direct observations and analysing field data to find work productivity values and obtain actual labour coefficient figures. Quantitative research is descriptive research that emphasizes analysis.

Research Location and Time

Research was conducted on one of the hospital construction projects in the city of Surakarta, namely the Kasih Ibu Surakarta Hospital Construction Project, which is located on Jl. Slamet Riyadi No. 404, Purwosari, Kec. Laweyan, Surakarta City, Central Java 57142. This research focuses on the 9th floor (+34,150), Zone 1, Zone 2, and Zone 3, with a focus on the analysis of structural column work. For more details, the location of the Kasih Ibu Hospital Construction Project in Surakarta can be seen in the image below.

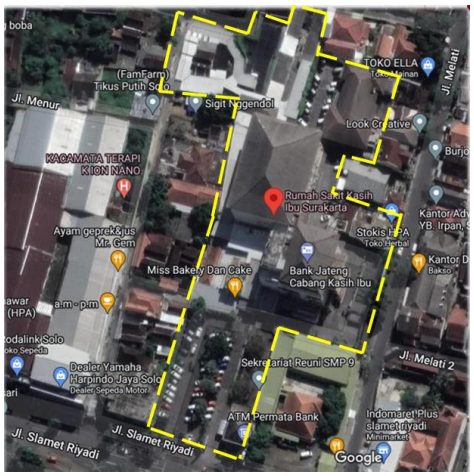

Figure 1. Research Location

The research was carried out according to project working hours, starting from 06.00-17.00 with a break time of 12.00-13.00, adjusting to the start time of the work item to be reviewed.

Research on methods for implementing structural column work focuses on steel, formwork, and casting work. Meanwhile, work productivity research is focused on formwork installation, column casting, and column formwork removal.

Data Collection

Primary data in this research was obtained by making direct observations and observations at the project location by looking at actual conditions in the field. This data is in the form of stages of work implementation methods in the field on the Kasih Ibu Surakarta Hospital Construction Project and other supporting documentation or photos. Apart from that, interviews or communication are also carried out with parties related to the issues to be discussed. Secondary data was obtained from literature studies and supporting references relevant to the research needs.

Data Analysis Techniques

Data analysis techniques for calculating the productivity of formwork installation work, casting work, and formwork removal work, formwork system column structure, using the method of cycle time or the cycle time for implementing work in the field. Then you will get a productivity value which can be the basis for determining the coefficient in preparing the Work Unit Price Analysis (AHSP). The data analysis steps are as follows:

1. Observe the implementation of work, types, codes, and sizes of steel panel formwork used in column work.
2. Counting the number of workers in the field, measuring cycle time (cycle time), carrying out formwork installation work, casting work, and formwork removal from the formwork system column.
3. Calculate the volume of work, namely the area of column formwork, casting volume.
4. Calculate the productivity value, using the formula:

$$P = \frac{\text{Output (O)}}{\text{Input (I)}} \quad \text{(1)}$$

Where:

P = Productivity (m^2/minute)
O = Output (m^2)
I = Input (minutes)

Input obtained by measuring the cycle time (cycle time) implementation of work in the field. Output obtained from the calculation results of the formwork work volume (m2) and casting volume (m3).

Calculation of formwork area volume using the formula:

Formwork volume = (Total length x height) x number of formworks (2)

Calculation of casting volume using the formula:

Casting volume = (length x width x height) x number of columns (3)

5. Recapitulation of the duration and productivity of formwork installation work.
6. Calculation of the actual labour coefficient value is based on the value of work productivity as a result of observations in the field, using the formula:

$$\text{Coefficient} = \frac{\text{Total Workforce (people)}}{\text{Productivity (days)}} \quad \text{(4)}$$

Research Flow Chart

In this research, clear flow stages are needed so that the research can be directed so that it can achieve its goals maximally and efficiently. The flow diagram of the stages of research implementation is shown in the following figure.

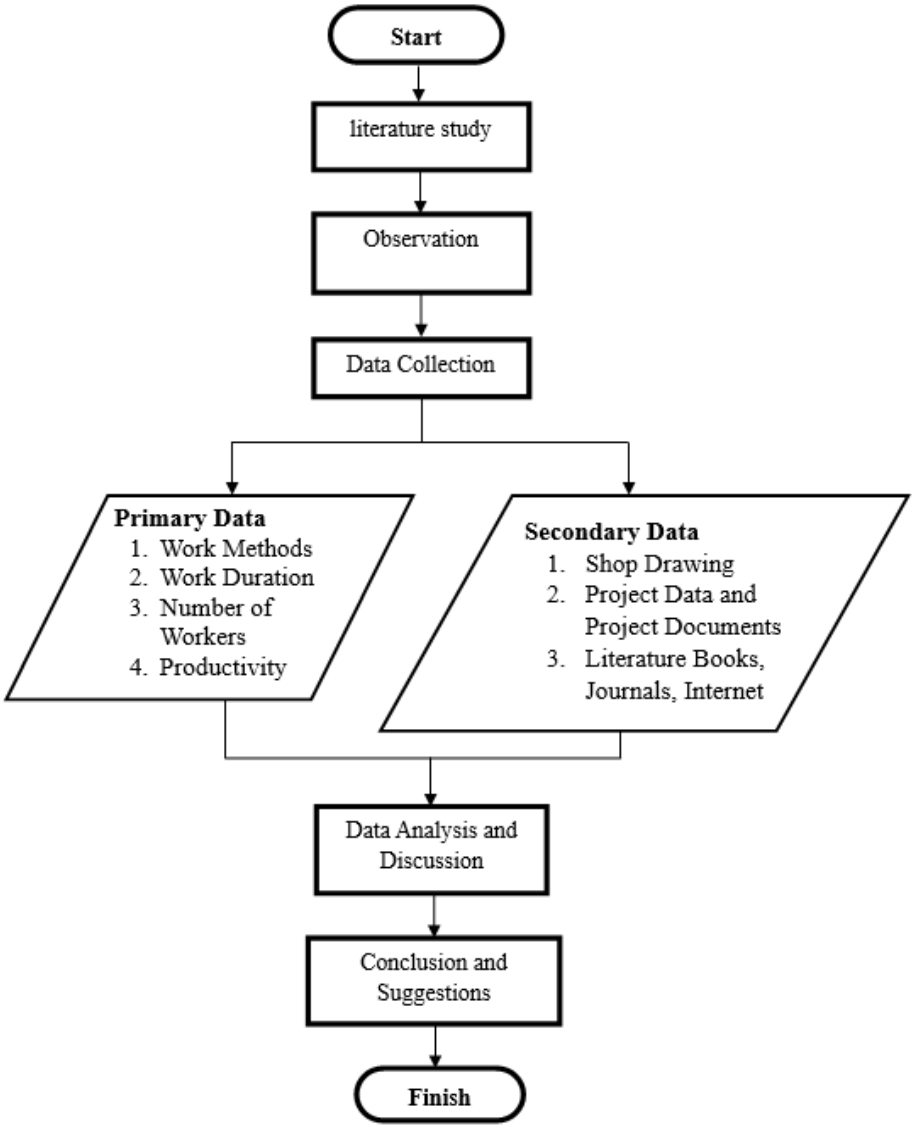

Figure 2. Research Flow Chart

FINDINGS

In the construction project of Kasih Ibu Hospital in Surakarta, the formwork for the structural columns uses a steel panel formwork system. This formwork uses a steel plate as the main material, which has been prefabricated and assembled first in a special workshop for making formwork owned by PT PBK. The assembly, fabrication, and size of the steel panel formwork are made according to the type and dimensions of the columns that have been approved in the project shop drawings.

Formwork rental price formwork system. This steel panel is quite high compared to conventional formwork, but this formwork has several advantages, including:

1. Capable of accepting much greater loads than conventional formwork because the overall components are made of steel.
2. The casting results are smooth and even.
3. Installation is easier and labour-efficient.
4. Can be used repeatedly (more than 10 times) and can even continue to be used until the frame is damaged, and if damage occurs, it can be repaired again by doing this. maintenance on workshop formwork belonging to PT PBK.

Use of a formwork system for column work is much more practical, faster, and more efficient when compared to conventional methods.

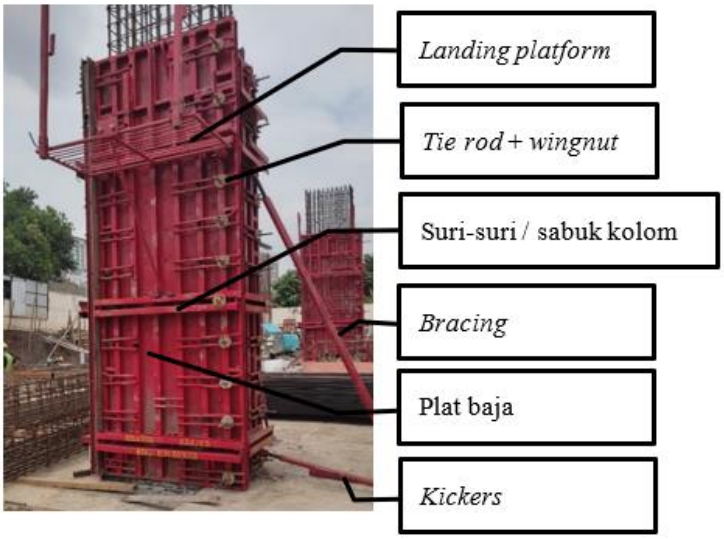

Figure 3. Formwork System Components

Determination of Employment Zones

Column work and formwork installation begin with determining the area zone or zoning. Zoning is the flow of area division on the floor plan before the construction work process is carried out to make it easier to determine targets.

In structural work on a project, especially projects in the large category or multi-storey building projects, casting work is carried out in stages, including that carried out on the Kasih Ibu Surakarta Hospital Construction Project. This is due to the availability or limitations of existing resources, including materials (formwork as a concrete moulding tool), tools (supporting the

casting process), and work time. For this reason, it is necessary to divide work zones so that existing resources and time can be used more optimally and work completion targets can be achieved.

In the Kasih Ibu Surakarta Hospital Construction Project, the Work Zone Division is divided into 3 work zones, with consideration of the zone division based on several factors, namely:

1. Land availability
2. Casting volume considerations
3. Method of work
4. Implementation schedule
5. Resource availability

The overall zone division of the project area is in the image below.

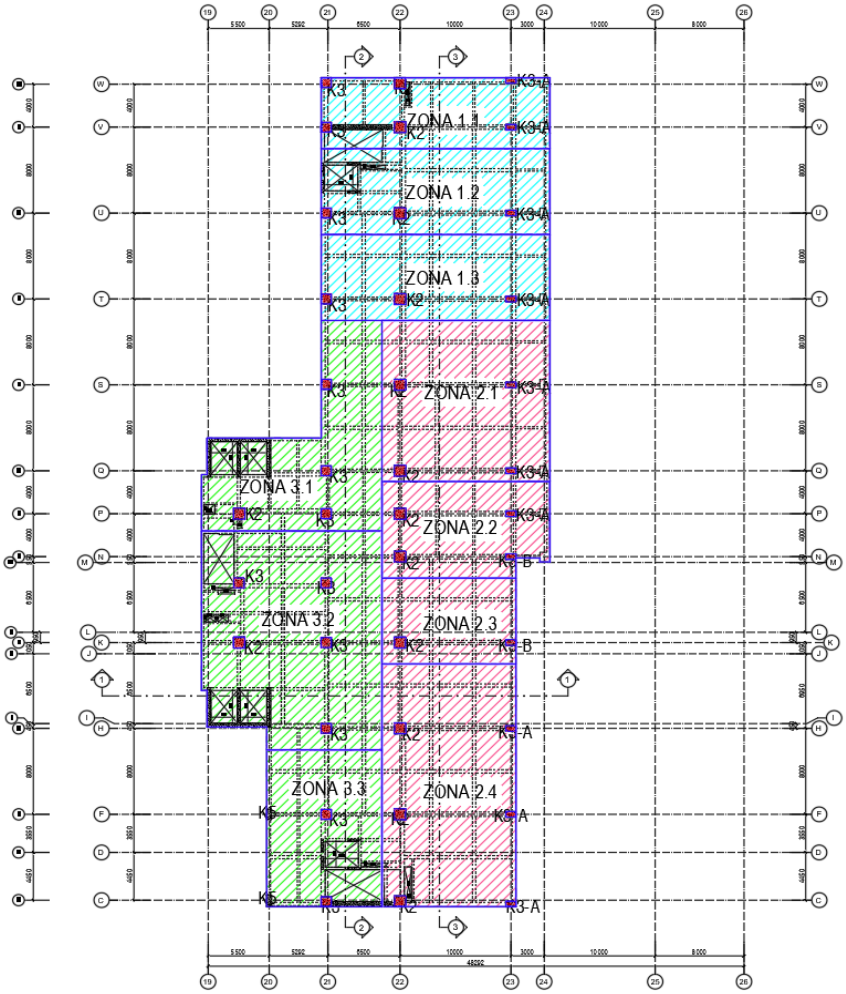

Figure 4. Division of Job Zones

Column Formwork Permutation Cycle

The permutation cycle of formwork work is the flow of material or formwork element movement within the formwork system. Columns that have been completed are moved to a specific location. Implementing formwork permutations involves careful planning. This aims to

save costs and time in the construction process while ensuring the strength and safety of the resulting concrete structure. Aspects and considerations of formwork permutation formwork system column, namely as follows:

1. Availability of formwork material
2. Deadline for formwork removal
3. Work activities
4. Transfer methods and techniques

Based on direct observations in the field, the results of the formwork permutation or movement cycle pattern were obtained from the formwork system Column work on the 9th floor of the Kasih Ibu Surakarta Hospital Construction Project, which can be seen in Figure 6.

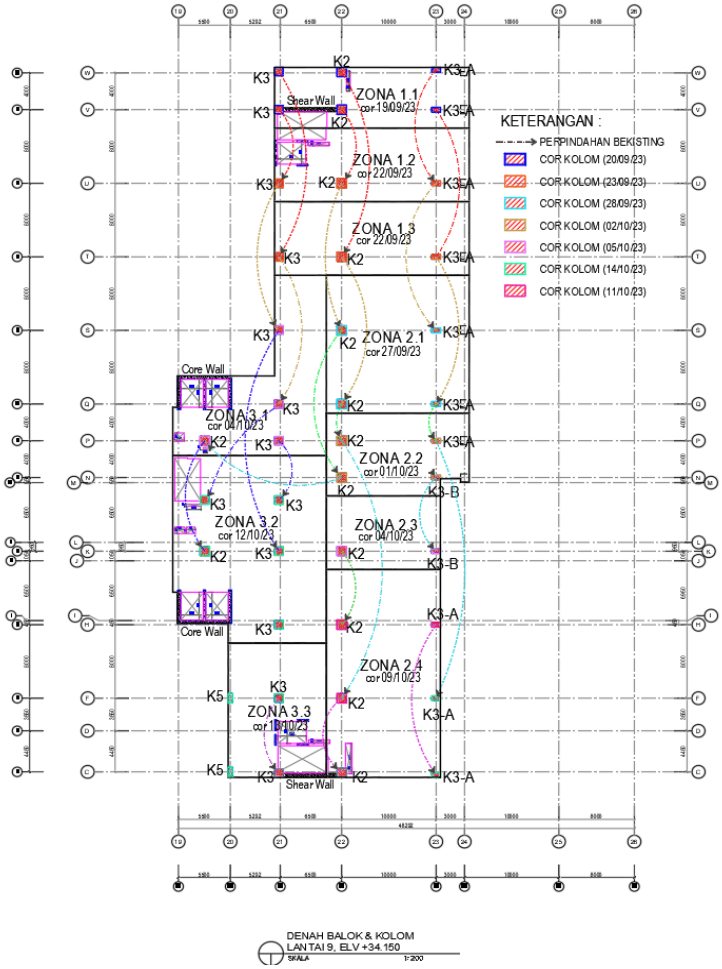

Figure 5. Formwork Permutation Cycle Pattern

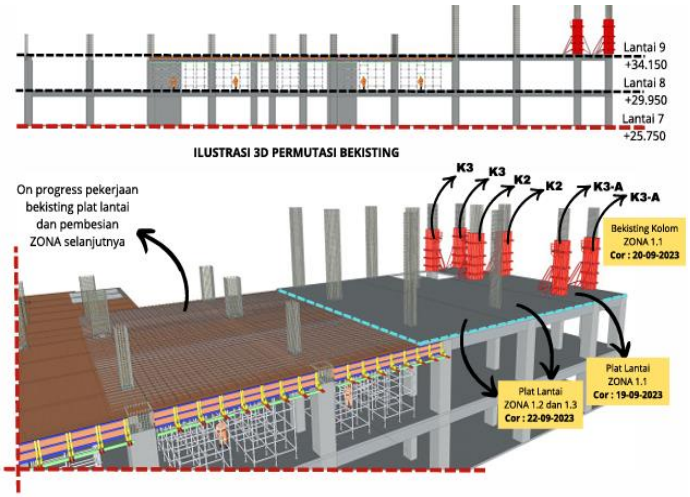

Figure 6. 3D Illustration of Zone Formwork Permutation Cycle 1.1

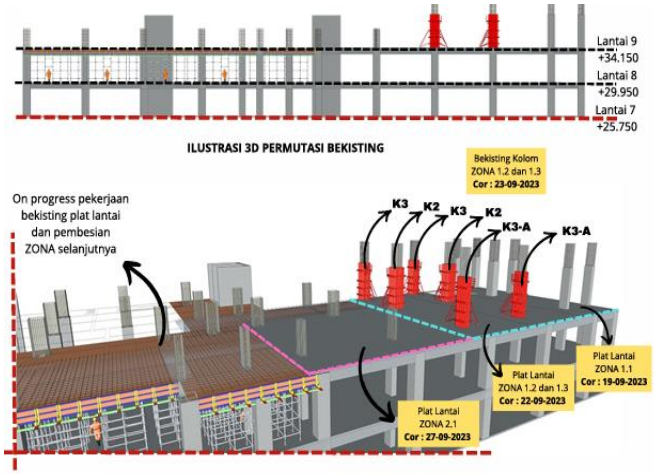

Figure 7. 3D Illustration of Zone 1.2 and 1.3 Formwork Permutation Cycle

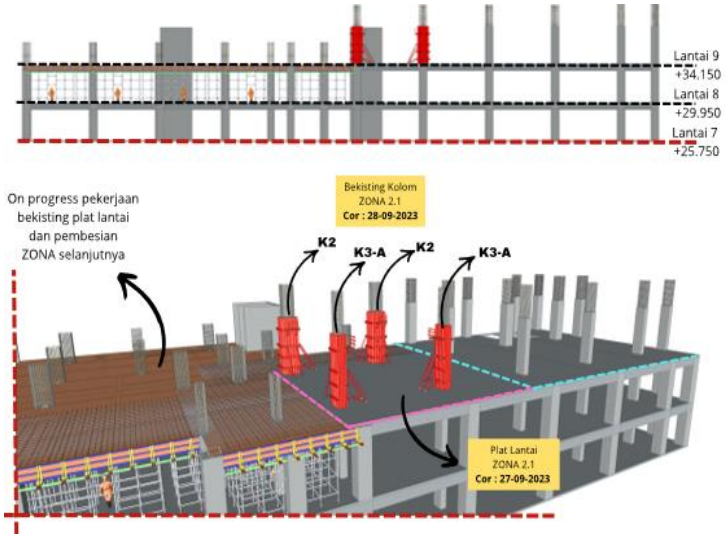

Figure 8. 3D Illustration of Zone Formwork Permutation Cycle 2.1

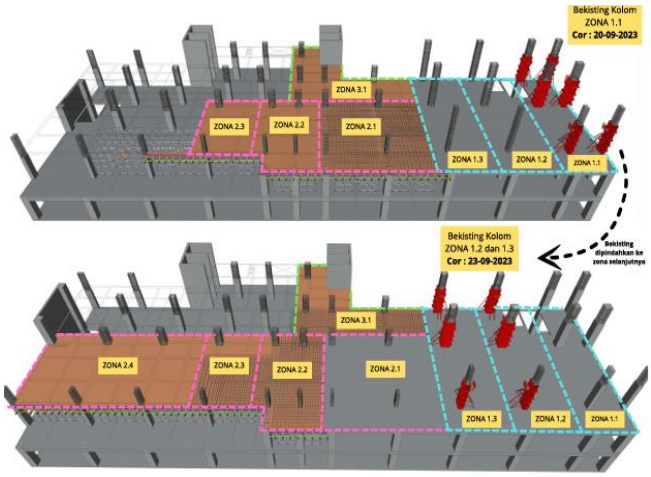

Figure 9. 3D Illustration of Formwork Removal

Column Work Productivity and Labor Coefficient

This research took samples to calculate the value of work productivity, namely in zone 1.1, zone 2.1, and zone 3.3 of the RSKI Development project.

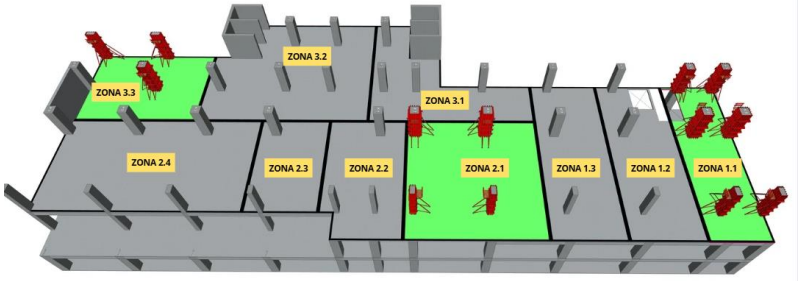

Figure 10. Location of Observed Column

1. Calculation Cycle Time Formwork Installation

   Total time cycle time from the sample work whose productivity value will be calculated, taken from the 3 work zones, a recapitulation can be obtained, which can be seen in the table below.

Table 1. Summary of Column Formwork Work Time

Date	Job Zone	Number of Columns	Job Time		
			Installation	Casting	Release
20/09/2023	1.1	6	3:24:57	1:11:10	0:56:29
28/09/2023	2.1	4	2:10:25	0:55:16	0:36:30
14/10/2023	3.3	3	1:53:20	0:29:41	0:43:08

With a description of the 3 construction method activities that are considered are as follows:

a. Formwork Installation
   1) Sling Installation, swing tower crane, and removal of formwork panels
   2) Laying and installing column formwork
   3) Wingnut and tie rod tightening
   4) Installation of kickers reinforcement by drilling

5) Installation of reinforcement using bracing/pipe push-pull
6) Checking the straightness/verticality of formwork

b. Casting
1) Equipment preparation
2) Foundry work
3) Loading waiting time truck mixer and bouquet cor
4) Work on vibrator casting

c. Formwork Removal
1) Relaxation wingnut road rod
2) Removal of kickers reinforcing iron cuttings
3) Loosen the push-pull pipe
4) Removal of formwork panels
5) Removal of formwork panels

2. Formwork Work Labor

In the Kasih Ibu Surakarta Hospital Construction Project, the number of workers required has been adjusted and formed into teams according to the type of work, so that the number of workers for formwork work and formwork system column work remains consistent.

Table 2. Column Formwork Work Labor

Manpower Column Fromwork			
No	**Manpower**	**Information**	**Amount**
1.	Technical Team	Column installation, strengthening, and dismantling team	3-4 people
		Foreman	1 person
		Workers	2 people
2.	Formwork Executor (Supervisor)	Supervisor in column formwork work	1 person
3.	Surveyor	Do marking to the appropriate column position and dimensions shop drawing, and check the verticality of the column	1 person
4.	Assistant Surveyor	Help the surveyor in surveying column formwork	1 person
5.	Column casting team	Workers in charge of carrying out column casting work	1-3 people
		Foreman	1 person
		Workers	2 people
6.	Operator / Rigger	Workers who have special skills in tying goods and operating lifting equipment, such as a crane.	1 person

3. Recapitulation of Total Time and Productivity

Table 3. Recapitulation of Column Formwork Productivity

Date	Area	Number of Columns	Information	Total Time	Productivity
20 September 2023	1.1	6	Installation	3:24:57	0.40 m^2/menit
			Casting	1:11:10	0.24 m^3/menit
			Release	0:56:29	1.47 m^2/menit
28 September 2023	2.1	4	Installation	2:10:25	0.42 m^2/menit
			Casting	0:55:16	0.19 m^3/menit
			Release	0:36:30	1.51 m^2/menit
14 Oktober 2023	3.3	3	Installation	1:53:20	0.33 m^2/menit
			Casting	0:29:41	0.23 m^3/menit
			Release	0:43:08	0.87 m^2/menit

4. Calculation of average productivity values

Next, work productivity is calculated using the calculation method, cycle time, to find the total work time column. Column work on the 9th floor of zones 1.1, 2.1, and 3.3 is a sample for observing formwork construction methods, formwork system with a total of 13 observation data. The description of the labour required for this work is 2 workers, 1 foreman, and 1 operator. The known data is the calculation of the total formwork area, the casting volume divided by the total duration, which is then converted to volume/day, then using equation (1):

$$P = \frac{\text{Volume pekerjaan (m2,m3)}}{\text{total time (minutes)}} \quad (5)$$

Table 4. Recapitulation of Average Productivity Values

Information	Average productivity (vol/min)	Average productivity (vol/hour)	Average productivity (vol/day)
Formwork Installation	0.46 m^2/menit	27.6 m^2/jam	220.8 m^2
Casting	0.22 m^3/menit	13.2 m^3/jam	105.6 m^3
Bekisiting release	1.28 m^2/menit	76.8 m^2/jam	614.4 m^2

5. Calculation of Labor Productivity Coefficient

Calculation of coefficients for labour is calculated using equation (4) by dividing the number of workers by their work productivity. During formwork installation work formwork system Productivity data obtained was 220.8 m2/day, with details of the workforce consisting of 2 workers, 1 foreman, and 1 operator. Then the worker coefficient is obtained by equation (4):

Worker Coefficient (OH) = $\frac{2}{220.8} = 0.009$ OH

Foreman Coefficient (OH) = $\frac{1}{220.8} = 0.004$ OH

Operator Coefficient (OH) = $\frac{1}{220.8} = 0.004$ OH

Table 5. Actual Labor Coefficient

Work	Coefficient (OH)		
	Workforce	Mandor	Workforce
Formwork Installation	0.009	0.004	0.004
Column Casting	0.018	0.009	0.009
Formwork Removal	0.003	0.0016	0.0016

Obstacles and Solutions

In installing column formwork, some difficulties and obstacles occur in the field, which are experienced directly by workers, which can hinder the performance of formwork installation, including:

1. Obstacles in the field
   a. There is interference from other materials
   b. The casting of the floor plate is uneven at the edge of the column area
2. Obstacles during formwork lifting work
   a. Derivation of formwork from the slings tower crane sometimes not quite right
   b. Change the queue tower crane who lack coordination so that they are distracted by other work activities.
3. Obstacles when installing formwork in edge areas
4. Formwork equipment constraints

The solution to this problem is:

1. Strict Supervision: The supervisor and the foreman must carry out periodic checks during the work process and ensure that the work in the area is safely controlled.
2. Good Communication. So that any problems can be identified and handled early.
3. Create clear and detailed schedules and work plans, including changeover times for the tower crane and the sequence of activities
4. Special Training.

PRACTICAL IMPLICATION

Obtain the productivity value of column work using the formwork system in the field and determine the actual labour coefficient. To provide an overview for stakeholders in the construction industry, such as the productivity value of column work with the formwork system, which can serve as a basis for determining the labour coefficient in the preparation of AHSP (Unit Price Analysis for Work).

For further research, the researcher can use other types of work and different types of formworks with different data collection methods. Further research can carry out an analysis of column work using formwork systems to material coefficients and AHSP calculations, with coefficients obtained from calculations based on observations of labour and materials in the field. If the work being studied has a coefficient number on SNI, a comparison can be made with regional SNI or HSPK.

ACKNOWLEDGMENT

The researcher would like to express their deepest gratitude to PT. Pulauintan Bajaperkasa Konstruksi for the support and collaboration provided during the research process for the construction project of Kasih Ibu Surakarta Hospital. It is hoped that this research can contribute positively to the development of the construction sector in Indonesia and strengthen the relationship between researchers and the industry.

DISCLOSURE STATEMENT

During the completion of this research report, permission was granted by the contractor of the Kasih Ibu Surakarta Hospital Construction Project

NOTES ON CONTRIBUTOR

The author is a final-year civil engineering student at the Vocational Faculty of Yogyakarta State University. The focus of his research is on construction implementation methods and productivity analysis of concrete formwork work on high-rise building structures.

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