

Analysis Of Heavy Equipment Productivity Tower Crane In The Construction Project Of Sultan Maulana Hasanuddin State Islamic University Building

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ABSTRACT

Building construction in Indonesia has increased rapidly; according to the BPS (Badan Central Statistics), in 2020, building construction from 2016–2019 will have 189 buildings in Jakarta. The construction includes apartments, hotels, offices, and campuses. While productivity measurements are useful as information for the company to evaluate the trends of its productivity developments over time, information from these results will later be used for reference in correcting previous shortcomings. This research aims to determine how long a tower crane's cycle time, productivity, and operating costs are. This research was carried out on the construction project of the State Islamic University of Sultan Maulana Hasanuddin Banten. The study was conducted by observing the tower crane for six days. From data collection, whether cycle time, productivity, or operating cost, the data analysis used in this study is an analysis using productiveness formulas, cycle times, and operating costs. From the analysis of the data, it can be known that the cycle time of the tower crane heavy tool on April 25, 2022, to April 30, 2022, gained an average of 0.311 hours for the average productivity of the tower crane on April 25, 2022, until April 30, 2022, which is 9662.131 kg/hour, while the operating cost of the crane tower was Rp. 574.923,57 per hour.



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1. INTRODUCTION

The construction of high-rise buildings in Indonesia has increased rapidly, recorded in BPS (Central Statistics Agency) in 2020, the construction of high-rise buildings from 2016-2019 there were 189 buildings in Jakarta, the construction includes apartments, hotels, offices, and campuses.

The construction of high-rise buildings really requires heavy equipment, heavy equipment that is commonly used serves to help and ease human work in the construction of a structure. Heavy equipment is an important factor in projects, especially large-scale projects. The purpose of using

heavy equipment here is none other than to make it easier for humans to do their work so that the expected results can be achieved more easily in an efficient time. [2]

Tower crane is one of the heavy equipment used in the construction project of Sultan Maulana Hasanuddin State Islamic University building. This heavy equipment is used as material handling equipment, from one place to another both vertically and horizontally. Tower cranes are widely used in high-rise building construction projects because they have a height that can be adjusted to the height of the building and also have a fairly wide range. Tower crane is a multi-functional tool because it can do several jobs in supporting the smooth work of high-rise building construction projects (Asiyanto, 2008). [3]

Tower Crane can work operated by operators, tower cranes work by moving goods or materials in the course of the project. In the use of tower cranes, the term tower crane productivity is known. The Big Dictionary Indonesian records productivity has meaning as the ability to produce something.

According to Kosmatka in Amalia (2017). Productivity is the ratio between activities (output) and input (input). Output in this case is interpreted as the result of the work of the tower crane, which is the amount of goods and materials that can be moved. Meanwhile, input is the time needed for the tower crane to move the goods and materials. So to calculate the productivity of tower cranes can be done by comparing between the total amount of load that the tower crane is able to move with the total amount of time it takes the tower crane to move goods or materials. Productivity is expressed in units of kg / hour (Asiyanto, 2008). [3]

In Banten itself the construction of campus buildings has been very developed, especially in the city of Serang, in the city center itself there is a lot of high potential where there are schools and colleges. At present Sultan Maulana Hasanuddin State Islamic University is building several new buildings on campus II, which is located in the Central Government Area of Banten Province, which previously had been built two buildings, namely the rectorate building and the Ushuluudin and adab faculty buildings which were built this year.

The construction of the UIN SMH Banten campus building is targeted for completion in 2022. To achieve these targets, the implementation of work must be in accordance with a predetermined schedule, the equipment used must have good productivity. Therefore, the tools used must be productive work, especially tower crane heavy equipment, because the productivity of heavy equipment here means how much work has been produced or done by a heavy equipment and will be declared productive if the results and time have been achieved from planning, so that the project work can run smoothly and on time.

As we all know that every company must want to be able to get the maximum profit or profit. Similarly, every work or project that is carried out also expects to record positive profits. One of the factors that can affect production costs is the use of the right amount of heavy equipment, namely by knowing the productivity of using the heavy equipment, [4] because it will have an impact on cost and time efficiency which in the end can contribute to obtaining profits or company profits. Also by knowing the productivity of the heavy equipment, it can be used as a benchmark or historical picture in the use of heavy equipment for work or projects in the future.

Based on this, it is necessary to conduct research on Tower Crane Heavy Equipment Productivity Analysis in the Sultan Maulana Hasanudin State Islamic University building construction project

2. METHODS

In conducting this researcher analysis, the following data are needed, namely:

- a. Primary Data Collection

Primary data collection is data obtained directly from the original source, either conducting interviews or asking original data from the project. In this study, researchers asked for data from the project contractor, site manager, and public relations. The data needed in this study are as follows types of heavy equipment tower cranes, machine life tower crane, types of work done, heavy equipment operator tower crane, how heavy equipment tower crane works, volume of work, other required data

b. Secondary Data Collection

Secondary data collection aims to obtain information and data on theories related to the subject matter obtained from literature, lecture materials, internet media, and other print media. Secondary data can be observations or field documentation. The literature that has been obtained will be used to get an overview of the theory used in this final project research so that the results obtained are scientifically scientific.

The secondary data obtained in this study are as follows; location data, field observation, working drawings, documentation or photographs of the work.

In this final project research, the case study carried out was to take observations on the existing building construction project in Serang City, namely, the Sultan Maulana Hasanuddin State Islamic University Building Construction Project located in the Central Government Area of Banten Province (KP3B). The location is shown in Figure 1. below.



Figure 1. Research Sites
Source: Google Maps, 2022

3. RESULTS AND DISCUSSION

3.1 Machine Data (Tower Crane)

In the Sultan Maulana Hasanuddin State Islamic University Building Construction project, one of the heavy equipment used is a crane. The type of crane used is Tower Crane. Where the tower crane is used to move materials used in various building construction works. These materials such as reinforcing iron, formwork, bucket concrete, etc. In this project, 1 (one) tower crane heavy equipment is used with 2 (two) operators. The tower crane used has the following specifications:

- Tool Name : Tower Crane
- Brand : Shen Yang Baoquan
- Type/Model: Topkit Tower Crane GHT6024-10
- Made : China
- Capacity : Max load 10 tons and tip load 2.4 tons

Economical Lifespan : 5 years
 Rental Price : Rp. 70.000.000
 Engine Capacity : 40.5 kW
 Hoisting Speed : 0 – 42 – 85 m/min
 Travel Speed : 0 – 58 m/min
 Slewing Speed : 0.8 rpm

3.2 Work Under Review

In this study, the work carried out during the 6-day study was column work. The columns worked on are columns A1, A2, A3, A4, A5, A6, B1, B2, B3, B4, B5, and B6. There are several types of work carried out for this column work, namely reinforcing iron installation work, formwork board installation, and casting.

The table above is the result of recapitulation for 20 working days. The data is used to calculate the productivity of the three Tower Crane. In calculating the efficiency of work time, the author uses the following equation:

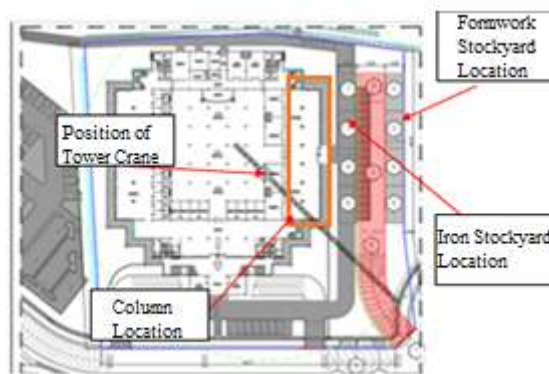


Figure 2 Map of column locations under review
 Source: Project Data, 2022



Figure 3 Columns under review
 Source: Project Data, 2022

The column used in this project is a column with a diameter of 700mm. with recurrence details as follows:

Length: 4 meters
 Main reinforcement: 16D22

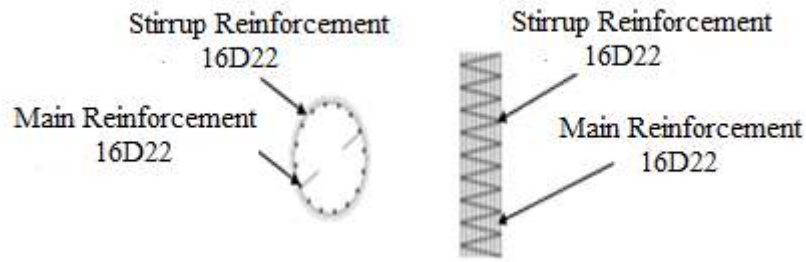


Figure 5 Details of the columns under review
Source: Project Data, 2022

From the table above, it can be seen that the lowest transportation tower crane in one transport is on reinforcing iron material of 237.28 kg. and the highest transportation in one transport is on fresh concrete material + bucket. Through direct observation in the field, [5] the results of the recapitulation of the volume value are obtained as follows:

Table 1. Result of Work Volume Recapitulation

No.	Date	Volume (kg)
1	25-Apr-22	949,1302915
2	26-Apr-22	949,1302915
3	27-Apr-22	1874,565146
4	28-Apr-22	2100
5	29-Apr-22	13141,5
6	30-Apr-22	1400
TOTAL		3402,39

3.3 Tower Crane Implementation Cycle Time Calculation

The results of the recapitulation of the daily tower crane cycle time data studied for 1 week can be seen in the following table:

Table 2 Results of Daily Cycle Time Calculation Recapitulation

No.	Date	Cycle Time (minutes)	Cycle Time (hours)
1	25-Apr-22	18,727	0,312
2	26-Apr-22	12,274	0,205
3	27-Apr-22	23,513	0,392
4	28-Apr-22	19,644	0,327
5	29-Apr-22	23,811	0,397
6	30-Apr-22	1400,000	0,234
Amount			1,864
Average			0,311

Time calculation for the installation of A2 column formwork on the 3rd floor on April 28, 2022, which is as follows:

Known:

Formwork Weight= 350 kg

Position Tc (rc)= (88.2882;93.365)

Original Position (ab)= (129.66;117.645)

Column Position (tj)= (106.281;90.3697)

a. Distance of origin to *tower crane* (D_1)

$$D_1 = \sqrt{(Y_{rc}-Y_{ab})^2 + (X_{ab}-X_{rc})^2}$$

$$= \sqrt{(93,365-117,645)^2 + (129,66-88,2882)^2}$$

$$= 47.971 \text{ m}$$

b. Destination distance to tower crane (D_2)

$$D_2 = \sqrt{(Y_{rc}-Y_{tj})^2 + (X_{tj}-X_{rc})^2}$$

$$= \sqrt{(93,365-90,3697)^2 + (106,281-88,2882)^2}$$

$$= 18,240 \text{ m}$$

c. Trolley Distance (D_h)

$$D_h = |D_2 - D_1|$$

$$= |18,240 - 47,971|$$

$$= 29.731 \text{ m}$$

d. Slewing Angle (α)

$$D_3 \text{ (turning distance)} =$$

$$= \sqrt{(Y_{tj}-Y_{ab})^2 + (X_{ab}-X_{tj})^2} = \sqrt{(90,3697 - 117,645)^2 + (129,66;106,281)^2}$$

$$= 35.924 \text{ m}$$

$$\cos \alpha = \frac{D_1^2 + D_2^2 - D_3^2}{2 \times D_1 \times D_2}$$

$$\cos \alpha = \frac{47,971^2 + 18,240^2 - 35,924^2}{2 \times 47,971 \times 35,924}$$

$$\cos \alpha = 0.768$$

$$\alpha = 39.858^\circ$$

$$a = 39.858 \times 57.2958$$

$$\alpha = 0.696 \text{ rads}$$

e. Appointment Time Calculation

1. *Hoisting* (Lifting Mechanism)

Speed (V_v)= 42 m/min

Destination Height (H_{tj})= 19.9 m

Origin height (H_{sb})= 7.822 m

Additional height (H_0)= 6 m

$$\text{Vertical Distance (dv)} = H_{TJ} - H_{SB} + H_0 = (19.9 - 7.822 + 6)$$

$$= 18.078 \text{ m}$$

$$\text{Time} = \frac{(Dv)}{\text{Vertical speed/hoisting (Vv)}}$$

$$= \frac{18,078 \text{ m}}{42 \text{ m/minute}}$$

$$= 0.430 \text{ minutes}$$

2. *Slewing* (Swivel Mechanism)

Speed (V_r)= 0.8 rpm

Angle (D_r)= 0.696 rads

$$\text{Time} = \frac{\text{Rotation distance(Dr)}}{\text{Rotation speed/Slewing (Vr)}}$$

$$= \frac{0,696 \text{ rad}}{0,8 \text{ rpm}}$$

$$= 0.870 \text{ minutes}$$

3. *Trolley* (Trolley Road Mechanism)

Horizontal Speed (V_h)

$$= 58 \text{ m/min}$$

$$\text{Trolley Distance (Dh)} = 29.731 \text{ m}$$

$$\text{Time} = \frac{\text{Horizontal Distance (Dh)}}{\text{Horizontal Speed/Trolley (Vh)}}$$

$$= \frac{29,731 \text{ m}}{58 \text{ m/minute}}$$

$$= 0.513 \text{ minutes}$$

4. *Landing* (Mechanism Downway)

$$\text{Down Speed (Vv)} = 42 \text{ m/min}$$

$$\text{Landing distance (Dv)} = 6 \text{ m}$$

$$\text{Time} = \frac{\text{Downway distance (Dh)}}{\text{Downway Speed/landing (Vh)}}$$

$$= \frac{6 \text{ m/minute}}{42 \text{ m}}$$

$$= 0.143 \text{ minutes}$$

$$\text{Total Lifting Time} = \text{Hoisting} + \text{Slewing} + \text{Trolley} + \text{Landing}$$

$$= 0.430 + 0.870 + 0.513 + 0.143$$

$$= 1.955$$

f. Return Time Calculation

1. *Hoisting* (Lifting Mechanism)

$$\text{Speed (Vv)} = 85 \text{ m/min}$$

$$\text{Hoist Distance (Dv)} = 6 \text{ m}$$

$$\text{Time} = \frac{\text{Vertical Distance (Dv)}}{\text{Vertical Speed/hoisting (Vv)}}$$

$$= \frac{6 \text{ m}}{85 \text{ m/minute}}$$

$$= 0.071 \text{ minute}$$

2. *Slewing*

$$\text{Speed (Vr)} = 0.8 \text{ rpm}$$

$$\text{Angle (Dr)} = 0.696 \text{ rads}$$

$$\text{Time} = \frac{\text{Rotation Distance (Dr)}}{\text{Rotation Speed/Slewing (Vr)}}$$

$$= \frac{0,696 \text{ rad}}{0,8 \text{ rpm}}$$

$$= 0.870 \text{ minutes}$$

3. *Trolley* (Trolley Road Mechanism)

$$\text{Speed (Vh)} = 58 \text{ m/min}$$

$$\text{Trolley Distance (Dh)} = 29.731 \text{ m}$$

$$\text{Time} = \frac{\text{Horizontal Distance (Dh)}}{\text{Horizontal Speed/Trolley (Vh)}}$$

$$= \frac{58 \text{ m/minute}}{29,731 \text{ m}}$$

$$= 0.513 \text{ minutes}$$

4. *Landing*

$$\text{Speed (Vv)} = 85 \text{ m/min}$$

$$\text{Destination Height (htj)} = 19.9 \text{ m}$$

$$\text{Height of origin (Hsb)} = 7.822 \text{ m}$$

$$\text{Addition Height (H0)} = 6 \text{ m}$$

$$\text{Vertical Distance (Dv)} = H_{TJ} - H_{SB} + H_0$$

$$= (19.9 - 7.822 + 6)$$

$$= 18.078 \text{ m}$$

$$\begin{aligned} \text{Time} &= \frac{\text{Horizontal Distancel (Dh)}}{\text{Horizontal Speed/Trolley (Vh)}} \\ &= \frac{18,078 \text{ m}}{88 \text{ m/minute}} \\ &= 0.213 \text{ minutes} \end{aligned}$$

$$\begin{aligned} \text{Total Return Time} &= \text{Hoisting} + \text{Slewing} + \text{Trolley} + \text{Landing} \\ &= 0.0706 + 0.8696 + 0.5126 + 0.2127 \\ &= 1,665 \text{ minutes} \end{aligned}$$

g. Calculation of loading and unloading time

$$\text{Unload time} = 0.75 \text{ minutes}$$

$$\text{Install time} = 0.7 \text{ minutes}$$

h. Total Cycle Time Calculation

$$\begin{aligned} \text{Cycle Time} &= \text{Load time} + \text{lift time} + \text{return time} + \text{unloading time} \\ &= 0.75 + 1.955 + 1.665 + 0.7 \\ &= 5,071 \text{ minutes} \end{aligned}$$

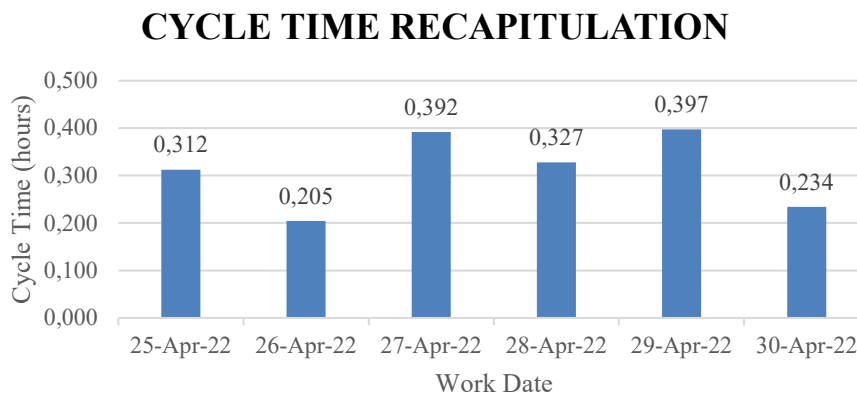


Figure 5 Cycle Time (hours) Bar Chart

3.4 Tower Crane Productivity Calculation

The productivity value of the tower crane is obtained from the comparison between the amount of cargo weight that can be transported by the tower crane with the cycle time needed by the tower crane to move the load. [6] The following is an example of the calculation of daily tower crane productivity on April 27, 2022 by tower cranes as follows:

$$\text{Daily volume} = 1874.6 \text{ kg}$$

$$\text{Number of daily cycle occupations} = 0.392 \text{ hours}$$

$$\begin{aligned} \text{Daily TC productivity} &= \frac{\text{Output}}{\text{Input}} \\ &= \frac{\text{Unit Volume}}{\text{Cycle Time}} \\ &= \frac{1874,6 \text{ kg}}{0,392 \text{ hour}} \\ &= 4783.403 \text{ kg/hours} \end{aligned}$$

Table 5 Results of Calculation Recapitulation Productivity

No.	Date	Volume (kg)	Cycle Time (hours)	Productivity (kg/hours)
1	25-Apr-22	949,130	0,312	3041,026
2	26-Apr-22	949,130	0,205	4639,800
3	27-Apr-22	1874,565	0,392	4783,403

4	28-Apr-22	2100,000	0,327	6414,057
5	29-Apr-22	13141,500	0,397	33114,166
6	30-Apr-22	1400,000	0,234	5980,337
			Amount	57972,788
			Average	9662,131

The results of the calculation of the average productivity analysis of *tower cranes* at Sultan Maulana Hasanuddin State Islamic University during the 6-day study are as follows:

$$\begin{aligned} \text{Average productivity} &= \frac{\text{Total Productivity}}{N \text{ (days)}} \\ &= \frac{57972,788}{6} \\ &= 9662.131 \text{ kg/hour} \end{aligned}$$

3.5 Tower Crane Operating cost

Total cost using *tower crane*, such as equipment rental costs; equipment operating costs; operator wage costs; mobilization and demobilization of *tower cranes*; and *erection* and *dismantle* costs. So that from the calculation of some of these aspects, the total operational costs of the tower crane are obtained as follows:

- a. Equipment Rental Cost
= IDR 291,667.00/hour.
 - b. Equipment Operating Cost
= IDR 188,000.00/hour.
 - c. Operator Wage Cost
= IDR 58,333.33/hour.
 - d. Mobilization and Demobilization of TC
= IDR 18,518.52/hour.
 - e. Erection and Dismantle Costs
= IDR 18,518.52/hour.
- Total = Rp. 574.923,57/hour.

4. CONCLUSIONS

Based on the formulation of the problem and objectives in this study on the analysis of the productivity of heavy equipment tower cranes in the construction project of Sultan Maulana Hasanuddin State Islamic University building by the contractor PT. Wika Gedung in Serang area, Central Government Area of Banten Province. Therefore, several conclusions are obtained as follows:

- a. The calculation of the heavy equipment cycle time of the tower crane on April 25, 2022 to April 30, 2022 obtained an average of 0.311 hours.
- b. The calculation of tower crane heavy equipment productivity from April 25, 2022 to April 30, 2022 obtained an average productivity of 9662,131 kg/hour
- c. The calculation of the operational costs of tower crane heavy equipment rental in the construction project of Sultan Maulana Hasanuddin State Islamic University Building amounted to Rp. 574.923,57 per hour.

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