

Productivity Analysis And Factor Affecting Climbing Tower Crane And Tied In Crane On High Rise Building

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ABSTRACT: In building the needs of building highrise required equipment to load and unload cargo tower like crane. Tower cranes are one of the most important tools used in high-rise buildings, where crane towers are used to lift the load horizontally or vertically, holding it when needed, and lowering the load to another location determined by the luffing, slewing and traveling mechanism. The use of the wrong equipment will certainly make the work productivity becomes not maximal and certainly can harm the work so that the effect is the completion of work to be late. This study calculates the productivity time of climbing tower cranes and tied cranes using time effectiveness calculation program to the work of lifting reinforced column, formwork column, formwork of floor plates and reinforced floor plates and looking for factors and variables that can affect productivity using statistical analysis methods and the result of productivity is a climbing tower crane has a better time productivity than tied to the crane of 34.22 % with a total productivity time of 27,005 kg / hour while for the total draw time of crane is 20,119 kg / hour, then the result of productivity factor analysis get 10 free variable that pass on factor analysis test, that is variable X2 (Economical age of equipment), X4 (Experienced operators operating equipment), X10 (equipment layout), X11 (selection of right type of equipment), X13 (Definite work plan), X17 (high wind speed), X18 (rainy weather conditions), X19 (unexpected heavy rain), X20 (Distance of sight) and X21 (Site conditions around the project).

KEYWORDS: climbing tower crane, tied in crane, time of productivity, productivity factors

I. INTRODUCTION

In the current development of the construction world the construction of high rise buildings has become a trend and much is happening to a developing country or in developed countries, many racing countries are making high-rise with a reason to show the equipment used to invite tourists to visit View the building the. High rise buildings become ideal inhabited by humans early on. Elevator (lift) and strong building materials. Based on some standards, it is usually called a regular Building if it has a height of 75 feet and 491 feet (23 m to 150 m). Buildings that have a height of more than 491 feet (150 m) are called skyscrapers. (source: Wikipedia). One of the tools that exist today is Tower Crane (TC). This tool as material handling equipments from one place to another either vertically or horizontally. Tower Crane is widely used because its height can be adjusted to the height of the building and also has a wide range. Procurement of this tool is done to support the ongoing work process, high-rise building construction projects with a large scale. With this tower crane, it is expected that the implementation of building construction project can be achieved more easily in a relatively short time. And for the type of tower cranes that are often used in high-rise buildings is the type of climbing tower crane and tied in crane where the type of tower crane has a difference in the location of placement and raise the height (jacking up), for climbing tower crane placed at incore building and every time adding height does not need to add sections but using a hydraulic tool, so that it can reduce the number of sections used. As for the type of tied in crane the location of the equipment is placed on the edges of the building which is anchored on the column or shear wall where each addition of tower crane height using the additional section so that the higher the building will be the more section used. The use of tower crane tools in high-rise building projects is of

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course the goal is to simplify the work and improve the progress of work, because the higher the productivity of the tool produced the progress of work will become larger, now almost all in high-rise building projects using heavy and large materials so it is a must in using tower crane tool. the determination of the use of tower crane types must also be done carefully one of them is to see the productivity of each tool because of course the two types of tower crane tool that often digunakan have different productivity time so it needs to be done study of the amount of time productivity respectively tools and see the factors and important variables that cause the productivity of the tool to the maximum, so that later can be selected type of tower crane tool that has a better productivity time.

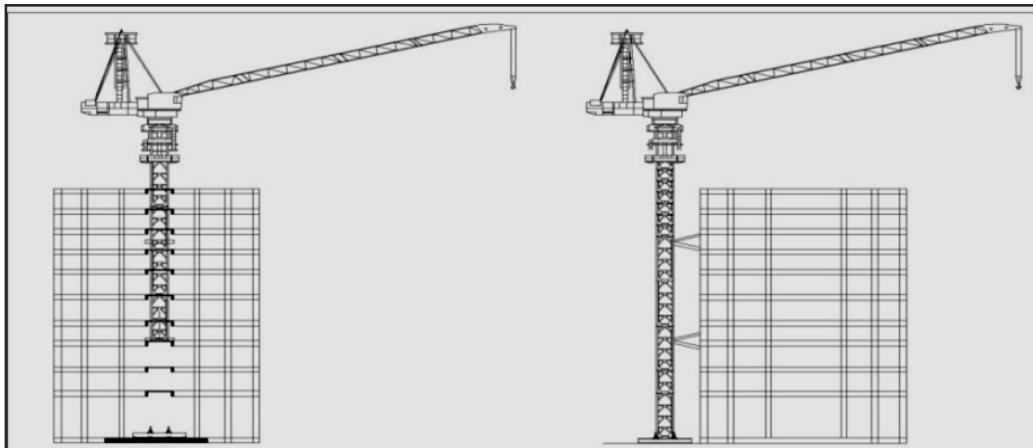


Figure 1. Type of tower crane

a.) Climbing tower crane

b.) Tied in crane

II. RESEARCH PROBLEMS

- How is the productivity time of tower crane produced by each type of tool that is climbing tower crane and tied in crane?
- How to the productivity time of tower crane equipment in high rise building work for climbing tower crane type and tied in crane?
- What are the important factors and variables that affect the productivity of tower crane tools in high rise building projects?

III. RESEARCH GAP

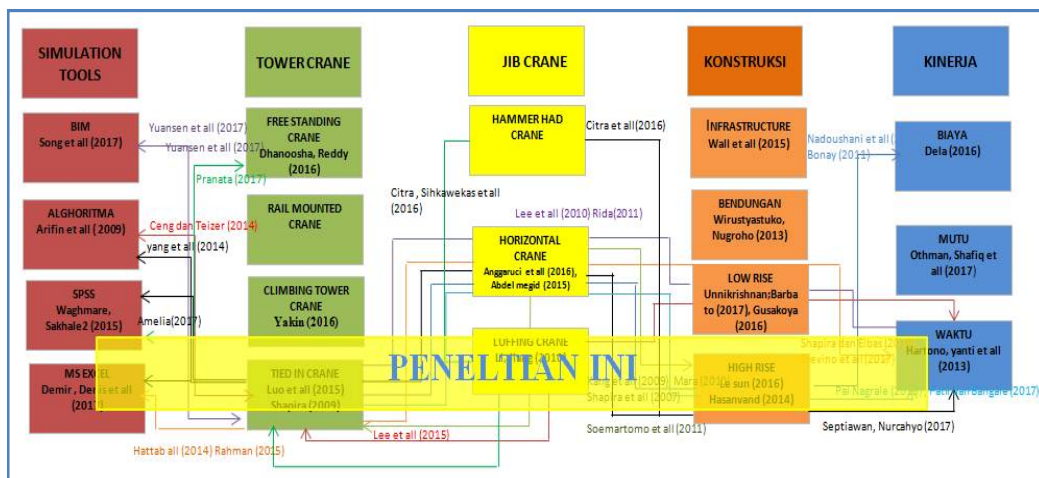


Figure 2. Research Gap

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Some of the literature that has been found is grouped by topic, among others, tower crane, jib crane type, construction type, toll simulation and performance. There is some literature that addresses more than one topic. A chart that reflects the relationship between the open themes in figure 1.2. From the research gap, it can be seen that there is no literature that addresses all the topics in one study. Therefore, this study is expected to be a bridge that can fill the gap of the themes that have been used by other researchers

IV. LITERATURE REVIEW

4.1. Tower Crane Concept

Tower Crane is a tool that has to do with the access of construction materials in a project. When further elaborated, the function is closer to the horizontal-vertical mobilization tool which greatly helps in the execution of structural work. According to Rostiyanti (2002), Tower Crane is a tool used to lift the material vertically and horizontally to a high place in limited space. Called Tower because it has a vertical frame with a standard form and plugged in a fixed placement. The main function of the tower crane is to distribute the materials and equipment required by the project in either vertical or horizontal directions. Tower crane is an electromotor equipment, which means using electricity as the driver. The power is obtained from state electricity company or generator set. Tower cranes have the function of lifting construction materials, such as concrete, steel, and generators, from bottom to top (hoisting mechanism) to the maximum height of the tower cranes. In addition to lifting from the bottom to the top, the tower crane is also capable of moving the material horizontally (trolleying) in accordance with the length of the jib (working arm) and has a slewing unit that allows the crane to rotate 360°. According Rostiyanti (2002), Type of tower crane is divided based on the way the crane stands namely:

a. Free Standing Crane

a free standing crane stands on a foundation specially prepared for the tools. If the crane must reach a large height then sometimes make the deep foundation. However, in general the use of free-standing cranes is usually used in crane is not using a belt and only use the existing foundation.

b. Rail Mounted Crane

The use of rails on a rail mounted crane makes it easy to move along those rails. But in order to keep the movement crane balanced can not be too fast. The disadvantage of this type of crane is the price of the rail is quite expensive, the rail should be placed on a flat surface so that the pole does not become oblique. Generally the tower crane is used on a large building area that allows the tool to move following the land to be done

c. Climbing Tower Crane

These cranes are used in building structures at the core or core of the building. This crane moves up along with the rising structure. Lifting of the crane is possible with a hydraulic jack. With limited land the alternative use of climbing cranes. The advantage of using this tool is that it does not require a lot of parts to increase the height because it only uses the existing high Jacking up. Does not require the storage of material parts and also does not require the mobilization of too many parts.

d. Tied In Crane

This type of crane is able to stand freely at an altitude of less than 100 meters. If a crane is required with a height of 100 meters, then the crane must be moored or anchored to the structure of the building. Its function is to withstand the horizontal force. The use of tower crane is most encountered in high-rise building project because it is very familiar with the system work. In this type of tied in crane also used pile foundation of the soil under it, after pondai bottom pole is worked then then dilanjutkan with the foundation of foundry foundation tower crane with a concrete first done iron foundation (anchored), so the foundation is stronger

4.2. Productivity

Productivity has become an activity in choosing between output and input. Thus the National Productivity Council (in Husien, 2002: 9) explains that Productivity produces the same output with the entire human resource (input). In other words, productivity has two dimensions. The first dimension is the ability that leads to reach the target with quality, quantity and time. The second is the efficiency associated with the input in accordance with the use or work performed

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4.3. Analysis of Tower Crane Cycle Time

Calculation of tower crane cycle time is obtained by summing up all activity time of the tool that is starting from load time, lifting time, unloading time and time back so that can be obtained whole cycle start up to cycle back.

1. Load Time

The load time is required in the binding process of the material. Load time is considered a fixed time because it depends on the skills of a rigger so that it can take the average time from the survey results that have been done in the field.

2. Lift time

Lift time is the time it takes to lift the material up to the destination location.

3. Unloading time

The unloading time is the time it takes to undloading he bonded material that has been fastened previously to the loading process

4. Return time

The return time is the time it takes to get back to the starting point after the unloading time is over Of the four time processes passed above then obtained calculation cycle time as follows:

$$\text{Cycle time} = \text{load time} + \text{lift time} + \text{unload time} + \text{time back} \quad (1)$$

4.4 Mileage Analysis

1. Vertical Distance (Dv)

In calculating the vertical distance to be calculated is the tujan rise plus the height for the additional distance. According Sunur et al (2007) vertical distance is the distance traveled by the hoist in the vertical direction

$$Dv = HLt + H0 \quad (2)$$

Where:

Dv = Vertical distance (m)

HLt = Destination floor elevation (m)

H0 = Height for additional distance (m)

According Sunur et al (2007) high required for the material is in accordance with the observation in the field

2. Horizontal Distance (Dh)

In the calculation of horizontal distance that needs to be calculated is the distance tower crane with the source reduced by the distance tower crane with the purpose. With previously calculated source coordinates tower crane and coordinate tower crane destination. Meanwhile, according Sunur et al (2007) horizontal distance is the distance traveled by trolley to saddle jib in the direction of horizontal arah horizontal :

$$Dh = D1 - D2 \quad (3)$$

Where:

Dh = Horizontal distance (m)

D1 = Distance tower crane with source (m)

D2 = Distance tower crane with purpose (m)

To get D1 and D2 are as follows:

$$D1 = \sqrt{(X1^2 + Y1^2)} \quad (4)$$

Where:

X1 = Coordinates of of tower crane in direction x (m)

Y1 = Coordinates of tower crane in direction y (m)

$$D2 = \sqrt{(X2^2 + Y2^2)} \quad (5)$$

Where :

X2 = Coordinate destination of tower crane direction x (m)

Y2 = Coordinate destination of tower crane direction y (m)

3. Distance Rotation (Dr)

In calculating the rotation distance (Dr) that needs to be calculated is when the tower crane activity to the point source and point of destination so as to form a rotation angle. Meanwhile, according to sunur et al (2007) rotation

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distance is the distance in the form of rotation angle formed between the tower crane, the source point, and the destination point in the slewing mechanism process

$$\cos \alpha = \frac{D1^2 + D2^2 - D3^2}{2 \times D1 \times D2} \quad (6)$$

Where :

Cos α = Rotation distance angle (rad)

$$D3 = \sqrt{(X2 - X1)^2 + (Y2 - Y1)^2} \quad (7)$$

Where :

D3 = Distance source to destination (m)

4.5. Calculation of travel time

1. Vertical time (Tv)

According Sunur et al (2007) vertical travel time is the time taken toward the vertical

$$T_v = D_v / V_v \quad (8)$$

Where :

Tv = Vertical time (minutes)

Dv = Vertical distance (m)

Vv = Speed Hoist (m / min)

2. Horizontal time (Th)

According to Sunur et al (2007) the horizontal travel time is the time taken by trolley for tower crane type saddle jib in the horizontal direction to the point of destination, whereas for tower crane type luffing is the time required for luffing mechanism or lift jib so that to the point of destination

$$T_h = D_h / V_h \quad (9)$$

Where :

Th = Horizontal time (minutes)

Dh = Horizontal mileage (m)

Vh = Speed of trolley (m / min)

3. Rotation Time (Tr)

According Sunur et al (2007) travel time rotation is the time taken to spin up to the point of destination

$$T_r = D_r / V_r \quad (10)$$

Where :

Tr = Rotation time (minutes)

Dr = Rotation distance (radian)

Vr = Swing speed (radian / min)

V. RESEARCH METHODOLOGY

In this chapter will be described on the design of research that will be used to achieve the objectives in the research, consisting of research strategy, research process, research variables, research instruments, methods of data collection techniques analysis. This research was conducted to analyze the productivity of climbing tower crane and Tied in crane and to examine what factors and important variables could influence the productivity of tower crane equipment. This analysis will be expected to result in the selection of tower cranes and the factors and variables necessary to increase work productivity.

5.1 Research Process

Based on the background and research problems, the framework of this research process is from the initial stage, literature study, analysis and discussion. Initial stages or research preparation is the first step taken to obtain information and prepare the necessary tools in research. This section consists of observing issues or research topics, problem formulation and objectives to be achieved in research.

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The literature study is derived from construction management, which may be used to determine the productivity of tower cranes. Stages of this data analysis will analyze the primary and secondary data that will continue to be used in the production of tower crane tool.

5.2. Research Respondents

Research respondent is person or agency or agency that will become source of information and answer question questionnaire. Respondents in this research are PT. Arya Kencana Semesta. Data processing was done by distributing questionnaires to 55 respondents, after the questionnaire answers were filled then collected, the authors get the data about the respondents who have experience in carrying out high-rise building project with experience above 5 years as much 96% and also has a good reputation in a construction project, has knowledge of tower cranes and has a supportive education therein.

5.3. Research Instruments

According to Arikunto (2010), the research instrument is a tool chosen and used by researchers in collecting data so that the presentation can be more systematic. Meanwhile, according to Suryabrata (2003) research instrument is a tool used to record the state and activity attributes - psychological attributes. So it can be concluded that the research instrument is used by researchers to collect data and information qualitative and quantitative about the variables being studied. The instruments used in this research are:

a. Observation sheet

The Observation Sheet is used to measure the productivity of the tower cranes during the construction work process. This observation sheet is also used as a reflection material for the next cycle.

b. Questionnaire sheet

The Questionnaire Sheet is used to determine what factors and variables are important to improve the productivity of tower crane tools in high-rise building projects. The measurement scale uses intervals with answer techniques Strongly Agree (SS) = 5, Agree (S) = 4, Less Agree (R) = 3, Disagree (TS) = 2, Strongly Disagree (STS) = 1

5.4. Productivity Analysis

To know the productivity of tower crane in the observed project is to record the loading and unloading time of the material by tower crane and calculate the total cycle time on the material removal process by the tower crane. From the data will be calculated to know the productivity of tower crane with clock unit.

$$\text{Productivity} = \text{Output} / \text{Input} \quad (11)$$

Productivity in a construction project is the work of a tools per unit of time in which the tower crane productivity unit depends on the work performed. the calculation of tower crane productivity is strongly influenced by the cycle time generated by the device where the cycle time is the time required tower crane to perform a single turn consisting of vertical movement (hoist), horizontal (trolley), and rotating (swing), where the third this main movement consists of six stages of work that is binding material, lifting, rotating, lowering and removing the material until back again to the location of the material supply (Varma, 1979). Cycle times include fixed time, and variable time. Fixed time includes time binding and removal of material depending on the type of material being removed, for each job having different fixed time such as the time to tie the reinforcement different from the time to bind the formwork. While the time dependent variable on tower crane mileage is the time of vertical travel depends on lift height, the time of the rotation depends on the rotation angle, and the horizontal time depends on the distance of the destination point of the material source.

5.5 Questionnaire Analysis

Questionnaire analysis method is a way used to analyze questionnaires that have been filled by respondents who have been determined in advance by the author. Questionnaire analysis in this research will be assisted by SPSS (Statistical Package for the Social Sciences) tool. SPSS is an application program that has a high enough statistical analysis capabilities as well as data management systems in a graphical environment using menus descriptive and simple dialog boxes so it is easy to understand how to operate

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VI. ANALYSIS AND RESULTS

6.1 Observation Method

The calculation of the results of observation is done by first knowing the object tower crane with material source and material purpose so that later known distance between them. As it is known that on the taman angrek residence apartmen project there are two types of tower cranes used in the construction process of climbing tower crane and tied in crane

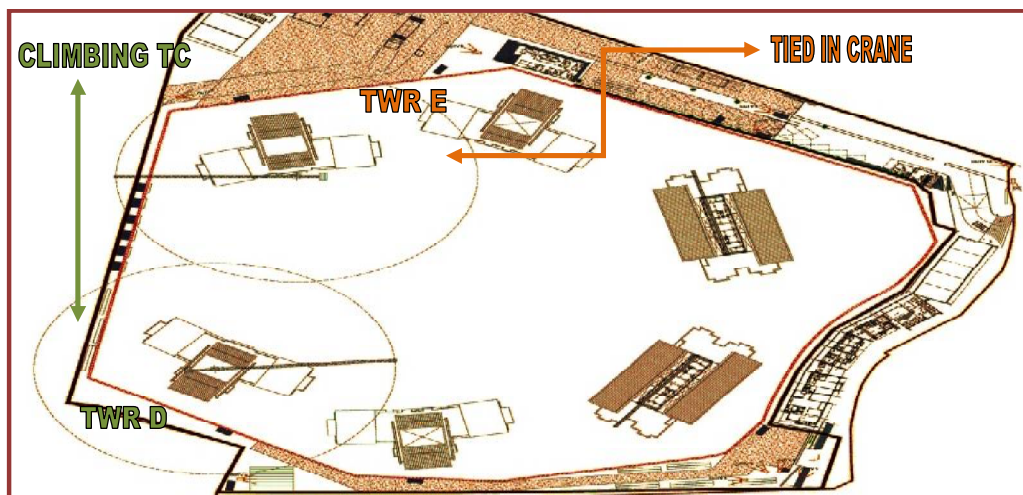


Figure 3. Placement of TC by Crane Type

Next is to observe the performance of the machine being used. This is done to determine the average performance of machines on each job. The results of the observation performance of climbing tower crane and tied in crane engines are as follows:

Table 1. Engine performance time climbing tower crane dan tied in crane

Performance	Climbing Tower Crane		Tied In Crane	
	Reinforced column and Formwork column	Formwork Plat & Reinforced Plat	Reinforced column and Formwork column	Formwork Plat & Reinforced Plat
Hoist speed is slowest	28.6	25.4	20.4	19.5
Hoist speed is fastest	38.5	35.5	28.56	26.2
Slewing speed is slowest	0.5	0.3	0.2	0.14
Slewing speed is fastest	0.7	0.5	0.4	0.3
Trolley speed is slowest	30	20	16.5	15
Trolley speed is fastest	55	48	40.5	35

After knowing the result of observation data of each machine's performance of the tool then the next step is to calculate the cycle time of each tool. From result of analysis hence obtained total time productivity is as seen in table 2 below:

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Table 2. Cycle time climbing tower crane dan tied in crane

No.	Cycle time of productivity crane			
	Work	Climbing Tower Crane	Tied In Crane	Deviation
		kg/hours	kg/ hours	kg/ hours
1.	Reinforced Column	2,546	2,025	522
2.	Formwork Column	3,395	2,464	931
3.	Floor Plate Formwork	12,423	9,162	3,262
4.	Floor Plate Reinforced	8,640	6,469	2,171
Total		27,005	20,119	6,886
Percentage		34.22%		

From the calculation of cycle time, it can be seen that climbing tower crane equipment has a better total productivity time than tied in crane, there is an increase of **34.22 %**.

4.2 Questionnaire Method

The next step is to analyze the factors and important variables that affect the increase of equipment productivity. In the early stages based on the tabulation of 22 independent variables obtained from existing literature studies then performed the following test stages

a. Validity test

Validity test is done by correlation between each question to the total score, then compared with the r table value (Pearson Product-Moment Correlation Coefficient), with level of significance value of 5%. This indicates that the tolerable error rate in this study is 5%. Thus, the confidence level in this study is 95%, while the coefficient r Pearson for the number of respondents (N) = 50, amounted to 0.279.

Based on the result of running Statistical Package for the Social Sciences on 22 variables, obtained the invalid data as much as two items as seen in Table 4:37 The invalid number is determined if the value of rxy (result of running Statistical Package for the Social Sciences) each variable less than 0.279

b. Reliability test

The reliability test is an advanced stage in the factor analysis after the validity test of the constituent variable of the factors formed. In the analysis of early stage factors have been obtained by two variable forming. Both components of these factors tested by Crombach alpha obtained from the results of reliability test.

Table 3. Reliability Coefficient

Criteria	Reliability Coefficient
Very Reliability	> 0.900
Reliability	0.700 – 0.900
Sufficient Reliability	0.400 – 0.700
Less Reliability	0.200 – 0.400
Not Reliability	< 0.200

Sumber : Sugiyono (2007)

Using Statistical Package for the Social Sciences program support, the following Table 4 is the result of the reliability test of the two component factors formed:

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Table 4. Reliability Statistics

Cronbach's Alpha	N of Items
.786	22

Based on the above table 4 the value of factor testing factor reliability alpha cronbach alpha is 0.786, which means factor is declared reliable.

c. Correlation analysis

In the correlation testing stage there are 10 variables X2, X4, X10, X11, X13, X17, X18, X19, X20 and X21 are chosen because they have correlation value $r \geq 0.4$ to the tower crane tool time performance variable, are the 10 independent variables that will be analyzed, namely the X2 variable (the average life of the tool), X4 (Experienced operators operate the tool), X10 (tool layout), X11 (selection of appropriate tool type), X13 (the existence of a clear work plan), X17 (weather conditions such as rainy season), X19 (Unexpected bushy weather), X20 (Distance of sight) and X21 (Site conditions around the project) are further analyzed by intercorrelation analysis.

d. Intercorrelation Analysis

Intercorrelation test conducted to determine the magnitude of the relationship between independent variables of the other free variables selected from the correlation test results. In contrast to correlation test, in this test the greater the number of correlation coefficients between variables, it is increasingly avoided because the greater the number of correlation coefficients, the more unstable the model formed. In the intercorrelation analysis, the independent variables that cause high correlation to other independent variables (correlation value $r \geq 0.6$) will be removed from the model until the model is obtained without independent variables that are highly correlated. Based on the results of intercorrelation analysis, it can be seen from 10 independent variables analyzed, 10 independent variables passed in intercorrelation test (have correlation value $r \leq 0.6$ to other independent variable), so at next analysis stage, 10 independent variables will be analyzed, ie variables X2, X4, X10, X11, X13, X17, X18, X19, X20 and X21.

e. Factor Analysis Test

A factor analysis test is performed to form several groups of selected independent variables from correlation and intercorrelation test results that are considered valid to explain factors affecting tower crane productivity in high rise buildings. In the analysis of this factor also, will be tested whether the determinant variable is still consistent in the factor or not.

1. KMO and Bartlett

Bartlett of Sphericity and Keizer Meyer Olkin test Measure of Sampling Adequacy (KMO) is a test instrument used to measure intercorrelation between variables and whether factor analysis can be done. Criteria data that can be analyzed factors are data showing $KMO > 0.5$ and Bartlett's test of Sphericity at significant < 0.05 (Ghozalli, 2006). The following is a table of 4.43 KMO-MSA results of factor analysis:

Table 5. KMO dan Bartlett Factor Analysis Results
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.819
Approx. Chi-Square	130.928
Bartlett's Test of Sphericity df	45
Sig.	.000

Based on table 5 above, KMO value of factor analysis is 0.819, KMO value obtained more than 0.5, this means factor analysis can be done. Furthermore, the significant value obtained from the Bartlett test is 0.000 and this value is smaller than 0.05 which means there is a significant relationship between independent variables inside and outside factors.

2. Anti Image Matrix

Anti image is used to determine whether there is a match between variables that are in 1 factor. The diagonal value of the anti Image Matrix in this study is > 0.500 , it indicates that the variable is suitable or in accordance with the structure of other variables within the factor, the following is the matrix of anti Image results of factor analysis :

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Table 6. Anti Image Matrix

Anti-image Matrices											
	X2	X4	X10	X11	X13	X17	X18	X19	X20	X21	
Anti-image Covariance	X2	,560	-,124	-,010	-,029	,043	,104	-,189	-,123	-,029	-,167
	X4	-,124	,713	-,085	-,161	,001	,010	-,042	,125	-,134	-,008
	X10	-,010	-,085	,686	-,050	-,165	-,022	-,025	-,021	-,132	-,025
	X11	-,029	-,161	-,050	,618	-,164	,079	-,086	-,122	-,009	-,051
	X13	,043	,001	-,165	-,164	,629	-,185	-,020	,030	-,073	-,010
	X17	,104	,010	-,022	,079	-,185	,635	-,053	-,102	-,055	-,185
	X18	-,189	-,042	-,025	-,086	-,020	-,053	,723	-,106	,011	,061
	X19	-,123	,125	-,021	-,122	,030	-,102	-,106	,596	-,006	-,131
	X20	-,029	-,134	-,132	-,009	-,073	-,055	,011	-,006	,668	-,106
	X21	-,167	-,008	-,025	-,051	-,010	-,185	,061	-,131	-,106	,500
	Anti-image Correlation	X2	,780 ^a	-,196	-,016	-,049	,072	,175	-,298	-,214	-,048
X4		-,196	,787 ^a	-,122	-,243	,002	,014	-,059	,192	-,195	-,014
X10		-,016	-,122	,884 ^a	-,077	-,251	-,034	-,035	-,032	-,195	-,043
X11		-,049	-,243	-,077	,840 ^a	-,263	,126	-,129	-,202	-,013	-,092
X13		,072	,002	-,251	-,263	,802 ^a	-,293	-,030	,048	-,113	-,018
X17		,175	,014	-,034	,126	-,293	,746 ^a	-,078	-,166	-,085	-,329
X18		-,298	-,059	-,035	-,129	-,030	-,078	,831 ^a	-,161	,016	,102
X19		-,214	,192	-,032	-,202	,048	-,166	-,161	,820 ^a	-,009	-,240
X20		-,048	-,195	-,195	-,013	-,113	-,085	,016	-,009	,887 ^a	-,183
X21		-,316	-,014	-,043	-,092	-,018	-,329	,102	-,240	-,183	,817 ^a

a. Measures of Sampling Adequacy(MSA)

Based on the anti Image matrix in table 6 above, the diagonal values of all anti variables > 0,500, which means all variables match or match the structure of other variables in the factor, so that no independent variables are eliminated from the model

3. Total Variance Explained

The total variance explained table describes the number of component factors that can be formed from the 10 independent variables analyzed. The following is a table of total variance explained results from the analysis of these factors:

Table 7. Total Variance Explained Factor Analysis Results

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.891	38.907	38.907	3.891	38.907	38.907
2	1.225	12.247	51.154	1.225	12.247	51.154
3	1.108	11.079	62.233	1.108	11.079	62.233
4	,786	7.864	70.096			
5	,646	6.460	76.556			
6	,619	6.191	82.747			
7	,526	5.262	88.009			
8	,475	4.745	92.755			
9	,397	3.967	96.721			
10	,328	3.279	100.000			

Extraction Method: Principal Component Analysis.

Based on table 7 above, it can be seen that the total variance explained result of factor analysis is 62.233%. This means that the factor formed by 10 independent variables is good enough to explain the productivity factor of tower crane.

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The result of factor analysis in the table shows that there are 3 components having eigenvalues more than 1 which means the independent variables further form 3 component factors

4. Components Matrix

According to Hair Et. Al (1998), each variable in factor analysis must have a strong correlation with its component factor. Each question item (variable) must have factor loading over 0.40. The following is the factor loading factor of each variable in its factors.

Table 8. Componen Matrix

Variable	Component		
	1	2	3
X2	.644	-.543	-.010
X4	.522	-.102	.641
X10	.624	.317	.259
X11	.675	-.122	.241
X13	.609	.501	.065
X17	.556	.448	-.458
X18	.546	-.470	-.020
X19	.642	-.264	-.476
X20	.647	.249	.176
X21	.742	-.003	-.316

Extraction Method: Principal Component Analysis.

a. 3 components extracted.

Based on table 8 above, the value of loading factor of each independent variable to its component > 0.4 which means the ten independent variables analyzed have a strong correlation to its components. The result of factor analysis formed 3 factor components which mean some of the variables in the components of the formed factors are no longer consistent in the factors that have been formed at the beginning of the study, although in the next analysis, this can be ignored and not analyzed further because the purpose of the next analysis is to find out the main variables in factors that affect the productivity of tower cranes in high-rise buildings. Next is an analysis of the rotated component matrix, to see the stability of the variable position

Table 9. Rotated Componen Matrix

Variable	Component		
	1	2	3
X2	.804	.249	.017
X4	.240	.783	-.152
X10	.077	.637	.381
X11	.444	.556	.148
X13	-.024	.518	.598
X17	.109	.067	.839
X18	.692	.199	.016
X19	.705	-.054	.457
X20	.163	.571	.399
X21	.530	.186	.579

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Determination of input variables which factor is determined by looking at the largest correlation value. In table 9 above has been sorted from the largest value to the smallest per factor. It can be seen that the largest correlation X2 with factor 1 is 0.804 then followed by X19 with 0.692 and X19 with 0.705 while X4 is the largest correlation with factor 2 is 0.783 and for the largest correlation with factor 3 is X17 is 0.839

So from the table above can be concluded that the member of each factor is as berikut:

Factor 1 = X2, X18,19

Factor 2 = X4, X10, X11, X11, X20

Factor 3 = X13, X17, X21

VII. CONCLUSION

Conclusion in this research are:

1. The total productivity time generated by the climbing tower crane on the removal of the column, the formwork of the column, the formwork of the plate and the work of the plate plate is 27,005 kg / hour while for the tied in crane the total productivity time is 20,119 kg /hour
2. The use of climbing tower crane with proper layout has better productivity time than tied in crane with able to increase work productivity 34.22 %
3. There are 10 independent variables that pass on the test of factor analysis, that is variable X2 (Economical age of equipment), X4 (Experienced operators operating equipment), X10 (equipment layout), X11 (selection of right type of equipment), X13 (Definite work plan), X17 (high wind speed), X18 (rainy weather conditions), X19 (unexpected heavy rain), X20 (Distance of sight) and X21 (Site conditions around the project).

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