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STUDY OF FACTORS AFFECTING PRODUCTIVITY OF POURING CONCRETE USING PORTABLE CONCRETE PUMP IN CONSTRUCTION PROJECT X

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ABSTRACT

Portable concrete pump is a tool used to pump concrete towards casting locations especially when the locations could not be reach by truck mixers. By using portable concrete pumps, concreting process can be finished quicker. This study begin with elaborating information about factors affecting the concreting process such as equipment and machinery for pumping, standard procedures for placing concrete and other requirements. The relation between productivity of portable concrete pumps and horizontal range, as well as the height of the casting location, is derived from project observation and data collection. Further calculation and analysis shows the regression equation for portable concrete pump productivity is obtained as $Y=1.0546-0.00351 X_1-0.00181X_2$ with X_1 is floor height and X_2 is horizontal range. The difference in productivity during productive time and total time that is affected by delays is 0,044 m³/min or the effect of delay time to concreting productivity is 8.7% compare to productive time.

Keywords: Portable concrete pump, productivity, horizontal range, floor height

1. Introduction

Currently, construction of buildings in Indonesia has grown rapidly along with the increase in population especially in big cities, which results in the increased need for facilities and infrastructure such as houses and high-rise buildings. Construction is an act of building facilities and infrastructures. Although, construction is commonly known as a job but in reality, construction is an activity that consists of several other different jobs, one of which is casting.

Concrete casting is the act of pouring fresh concrete into a mold of a structural element that has been fitted with reinforced bar or rebar to strengthen the concrete. Before the casting job is carried out, a work inspection must be done to ensure that the mold and rebar are installed according to plan. The casting methods for both vertical and horizontal casting generally uses tower crane and casting bucket for small volumes of concrete. For larger volumes, it is more effective to use concrete pumps.

Concrete pump is a tool specifically designed to deliver fresh concrete mixture to the formwork. For high rise buildings, the concrete casting process are highly dependent on concrete pumps. Therefore, it is required to know the productivity of portable concrete pump in order to efficiently finish a project.

At present there are several types of concrete pumps like; **long boom concrete pump** that are used for construction work with 4 floors and buildings with height of around 20 meters, **super long boom concrete pump** for concreting works in a 5 to 6 floor high building and **portable concrete pump** that can reach up to 300 m horizontal and 120 m vertical distance and for higher location a vertical pipe can be mounted to the pump up to the concreting location. In the development process it is important to consider the choice of concrete pump used according to the needs so that the concrete pump can function effectively. (https://theconstructor.org)

In this study, productivity and the factors that affecting the portable concrete pump in casting concrete will be analyzed based on data that was collected from construction site observation of slab and beam concrete works in Project X. The purpose is to understand the productivity of portable concrete pump for slab and beam concreting, whether or not height and horizontal length affecting productivity, while also finding other factors that affect the productivity of portable concrete pump.

2. Methodology

The study consisted of 3 steps as follows:

1. Literature study:

Study on types of concrete pump, productivity of portable concrete pump including factors that affecting it, and statistical correlation between productivity and the affecting factors.

2. Field study and data collection.

-Field study: comprised of doing some interview to get project information such as structural floor plan, floor height, number of floors, construction schedule, concreting zoning, and also the types of concrete pump.

- Data collection: doing on site observation during concreting phase using portable concrete pump. The data consist of floor height, horizontal distance, concreting time, including methods and other detail information during concreting work. For concrete pump productivity calculation, concreting time will be differentiate in to 3 category, that are:

(1) Effective time: time needed for pumping concrete to concreting area.

(2) Contribution time: time when concrete pump idle but the craftsmen doing other contribution work such as put on extension pipes, moving the unused pipes, cleaning the area and so on.

(3) Delay time: time when concrete pump and the craftsmen unable to cast concrete because of an external delay such as; raining, truck mixer did not come on time, clogged pipe and so on.

3. Data analysis and discussion.

In this study there are several variables used, which are:

- a. Independent variables being floor height and horizontal distance.
- b. Dependent variable being the productivity of the portable concrete pump.
- c. Control variables being concrete quality, concrete slump, specification and capacity of portable concrete pump.

Productivity of portable concrete pump and the relation between variables will be analyzed using Microsoft excel. The productivity calculation is based on productive time and total time to see how much delay time affecting productivity.

3. Literature Review

Construction process of a reinforced concrete high- rise buildings very much depend on labor and heavy equipment. The use of concrete pump has made possible for liquid concrete to be placed on a super high concrete building. Concrete pumps usually is attached to a truck or placed on a semi-trailer (for longer units).

Based on the pumping pressure, ease of working and developing technologies different concrete pumps have been developed. Type of concrete pumps that commonly used for high rise buildings is portable concrete pump, that can reach up to 300 m horizontal and 120 m vertical distance. The concrete pump can be mounted on a wide variety of available truck chassis. To be able to reach higher location, a vertical pipe can be mounted to the pump up to the concreting location. (https://brighthubengineering.com/concrete-technology/)

Process of concreting in a concrete high rise building is mostly depends on pumping equipment, so concrete pumps productivity is important aspect in completing the concreting works. According to Umar (2002:9), productivity is the ratio between results or output compared to resources used or input. In other words, productivity is two dimensional with the first dimension being effectiveness and the second being efficiency. effectiveness refers to the ability to achieve a target while efficiency refers to the quality or quantity of the output in comparison to the input. Portable concrete pump productivity can be calculated using: (Ahuja,Hira N.,1983)

Portable concrete pump productivity can be calculated using: (Anuja, Hira N., 1985)

Productivity= $\frac{volume}{time}$

To determine the effect of height and horizontal length on concrete pump's productivity, a regression analysis will be used. Regression analysis is a set of statistical processes for estimating the relationships between a dependent variable and one or more independent variables. The most common form of regression analysis is linear regression, in which a researcher finds the line that most close fits the data according to a specific mathematical criterion. The word regression that means forecast was used for the first time by **Sir Francis Galton** on the year 1877 during the time when he was researching about the height of humans, specifically between a child's height and an adult's height.

To determine the effect of height and horizontal length in concrete pump productivity, a multiple regression analysis will be done. The equation of regression for 2 predictors is : $Y = a + b_1X_1 + b_2X_2$

Information:

Y = dependent variable (productivity)

 $a, b_1, b_2 = multiple linear regression coefficient$

 X_1 , X_2 = independent variable (height, length)

Then followed with calculating the coefficient of correlation or coefficient of determination (R), to determine the level of correlation between variables.

4. Data collection and analysis

The object of this study is construction project X, consists of 2 basements, 2 Podiums, 1 Refuge dan 28 floors of living quarters, located in Tangerang City, Banten.

4.1 Concreting details

Concreting process at every level divided in to 3 zona (picture 3.1). Point A was the location of the portable concrete pump used in project X. The observation of pouring concrete was done on floors 12 until 17 with the sequence of zones A then zone B and zone C, data of concreting time for every zone was tabulated as in table 4.1.



Picture3.1 Casting zone of each floors

Table 4.1	is	example	data	sheet	of	concreting	time	in	zona	Ba	t 12	floor.
1 4010 1.1	10	onumpre	aucu	Direct	U 1	concreting	unit		Lona	D U		

	horizontal distance (m)	Floor heignt (m)	volume (m^3)	Effective time (minutes)	Contribution Time (Tc) (minutes)	Delay time (Td) (minutes)	Notes	
Zone B	72	51.975	11.0621	15.38	7.3	0	Tc: - put on suspended hose for longer distance and	
	69	51.975	10.169	14.2	2.83	0		
	66	51.975	1.318	1.8	0.56	0		
	63 60 63	51.975	3.192	4.35	4.8	0		
		51.975	2.152	2.98	1.75	0	take it off on shorter distance	
		51.975	8.37	11.5	3.68	0		
	60	51.975	1.5	2.05	0.6	0		
	60	51.975	0.864	1.2	0	0	- Td:	
	57	51.975	5.263	7.1	2.6	0	Waiting for	
	60	51.975	1.586	2.17	4.8	0	trucks	
	57	51.975	2.9	3.7	0.4	8.25		

4.2. Effect of floor height and horizontal distance

To obtain the effect of floor height and horizontal distance on concreting productivity using Anova test in SPSS, the effective time was used, the result of linear regression equation as follow: Y = 1.0546 - 0.00351 X1 - 0.00181 X2

Information :

Y = Productivity

X1 = Floor height

X2 = Horizontal distance

Regression Statistics						
Multiple R	0.789106					
R Square	0.622689					
Adjusted R Square	0.619634					
Standard Error	0.019847					
Observations	250					

 Tabel 4.2
 Summary Output

The linear regression equation above shows that as the height increases (X1 increases) and the farther the horizontal distance in (X2 increases) of the partial of the part

determination (R^2) is 0,619.

4.3 Discussion

Productivity of portable concrete pump in pouring concrete is affected by effective time, contribution time and delay time. Effective time and contribution time are durations when the concreting process is productive while delay time is the duration that reduces productivity. Productivity during productive time (effective and contributing time) and productivity for total time (effective, contribution and delay time) can be seen in table 4.3.

Floor	Volume (m ³)	Effective Time (minutes)	Contribution time (minutes)	Delay time (minutes)	Productive time (1) (minutes)	Total Time (2) (minutes)	Productivity (1) (m ³ /min)	Productivity (2) (m ³ /min)
12	186.4631	253.88	112.42	26.25	366.3	392.55	0.509	0.475
13	186.4631	256.07	110.47	52.5	366.54	419.04	0.509	0.445
14	186.4631	260.525	97.13	12.14	357.655	369.795	0.521	0.504
15	188.0351	264.616	104.036	55	368.652	423.652	0.510	0.444
16	186.4631	265.42	114.553	29	379.973	408.973	0.491	0.456
17	186.4631	267.16	111.64	44	378.8	422.8	0.492	0.441

Table 4.3 Pouring concrete productivity

The average productivity during productive time is $0.505 \text{ m}^3/\text{min}$, while the average of productivity for total concreting time is $0.460 \text{ m}^3/\text{min}$, there is $0.044 \text{ m}^3/\text{min}$ difference in productivity of productive time and total time that is affected by delay. The effect of delay time to concreting productivity is 8.7% compare to productivity on productive time. Such delays during the concreting process includes rain that caused by nature and late arrival of truck mixer and clogging hose that can be overcome by better on site management and better time arrangement.

5. Conclusion

From the result of concreting productivity analysis of the portable concrete pump in project X, it can be concluded that:

- 1. Productivity of portable concrete pump is affected by floor height and horizontal distance by the linear regression equation Y = 1.0546 0.00351 X1 0.00181 X2. This shows that as floor height and horizontal distance increase, the productivity of portable concrete pump will decrease.
- 2. To increase the productivity of pouring concrete using portable concrete pump, better time arrangement for ready mix concrete supply and better on site management during concreting time a urgently needed.

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