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Productivity of Bored Pile Foundation In Jakarta Inner City Toll Road (A Case Study)

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ABSTRACT: The construction of toll roads in cities that are densely populated especially with work areas that alongside the traffic lane, requires speed and quality accuracy in its implementation. So, it is natural for the Central Government to make Project Development of Jakarta 6 (Six) Inner-City Toll Roads their priority and categorized it as the National Strategy Project (PSN). Bored pile foundation work is the beginning of the elevated structure work and is a critical activity on this project. So, the implementation should be in timely manner with proper quality and should be able to meet the target of the planned work productivity. Through the results of this study it is known the highest productivity index is 1.60 piles per day, meanwhile for the ideal productivity index is 1.57 piles per day, with the shortest time to complete one pile of bored pile foundation is 9:35:49-10:17:16. With the results of data analysis using Relative Importance Index (RII), obtained five dominant factors that affect the productivity of bored pile foundation work, namely: different land site conditions at each construction work foundation, the presence of obstacles in land acquisition and relocation of utilities, the traffic density of vehicles at locations around the project, access in and out of projects hindered by traffic, and worker is not a permanent employee

KEYWORDS: Bored Pile Foundations, Productivity, Elevated, Relative Importance Index (RII)

I. INTRODUCTION

The Project for the Construction of 6 (six) Inner City Toll Roads, has become a National Strategic Project (PSN). The construction of this project was carried out in 3 (three) stages, with a total length of the toll road section of 71.2 km and a width of 26.3 m with a finished target of 2022. The first stage of the construction is: Semanan - Sunter - Pulo Gebang Section, with the first stage divided into 3 sections, namely section A Kelapa Gading – Pulo Gebang (9.3 km), section B Semanan – Grogol (9.5 km) and section C Grogol – Kelapa Gading (12.3 km). The plan for this toll road adopts the construction of elevated structure (flyover), with Bus Rapid Transit and with shelter on several locations integrated with other modes of transportation.

Technical recommendations and information studies show that the results of this project development can provide considerable benefits in the field of transportation, which is why the Government instructed the acceleration of the construction under the Presidential Regulation number 3 Year 2016 about Acceleration of National Strategic Projects. Because this project is one of the priorities of the Government, the completion of its construction must finish on time. This means that to achieve the target, there can't be any delays in construction, especially on foundation work which is the beginning of elevated structure works and a critical activity.

Bored pile foundation is a unique construction work because its process on each location has different difficulties and hard to predict. There are many problems found during the construction process of bored pile. So, it won't cause any problem to the work productivity, all problems must be identified, and determined a well-developed solution. In this project there are several problems found, such as: land condition, land status, work method, system management, environment, quality, safety, utilities, and human resources.

The measurement of work productivity must be done on each construction work because a wrongly determined value of productivity index will influence the performance of project. If the productivity is high then the completion of works

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will be quicker, vice versa. Delays in work will influence the cost of project (increasing it) which at the end will inflict a financial cost for the project.

Researches about productivity of bored pile using either heavy equipment or light equipment has not been done very much before. The lack of data about the value of productivity of bore pile foundation caused the duration, work target and cost of operation cannot be estimated very well. So far, the analysis of bored pile foundation work from the start of the productivity index, target, duration and cost is estimated based on the experience from previous projects or according the numbers listed on the master schedule without certainty of accuracy.

That kind of condition is not good, because early mistake in production capacity analysis will cause significant loss. That is why, to shy away from the loss because of a mistake from estimation of duration or work target, a research about bored pile foundation productivity must be taken. The research taken is to determine the capacity of productivity or an ideal productivity index and finding the factors that influence the productivity of bored pile construction. From the results of the research an accurate and realistic scheduling curve, and an effective and efficient controlling system can be made.

II. LITERATURE REVIEW

Brown (1990) [1] said that bored pile foundation is a deep foundation with the process is to bored the ground/ soil until the desired diameter and depth according to the design is achieved.

According to Sumarsono (2003) [9] productivity is a desire and effort of humanity to always improve the quality of life and life itself in all manner. According to Sedarmayanti (2001) [8], productivity is an output produced in a single unit of time for input. Productivity is a connection between input and output from a productive system. It is often easier to measure this connection/ relation as a ratio of output and input. When there are more outputs with the same number of inputs, then the productivity will increase. Likewise, if fewer inputs are used for the same number of outputs, then the productivity will also increase.

According to Sarwono (2009) [5], productivity can be defined as ratio between output and input, or ratio between the number of productions with the total number of resources used. In construction project the ratio of productivity is the value measured during construction process, which can be separated into cost, man power, materials, and tools/ utilities. Success or failure of a construction project depends on the effectivity of the use of resources. Work productivity is one of the most important targets in any company. With high work productivity and pressured production cost, company profit can be increased.

According to Schexnayder dan Mayo (2003) [7] there are to definition about productivity that connects to construction, which are: productivity on the number of works done and productivity related to the profit resulted. Sari and Fithri (2015) [2] said that the calculation of productivity index can be done by dividing the productivity period – n with output period – n, with total productivity can be calculated by dividing the output with input.

This research implements survey using likert scales, which according to Risnita (2012) [5], Likert method is a method of scaling of preference that uses response distribution as the basis for determining the scale value. Aside from that this research uses validity and reliability test using the help of IBM Statistical Package for the Social Sciences (SPSS) software and relative importance index to find the highest factor that influence productivity in bored pile foundation. Hardjomuljadi (2009) [3] said that RII is an analysis that makes quantitative relative possible, whereas the highest the rating then the influence will increase for the variable on hand.

III. RESEARCH METHODOLOGY

The research stage is a guide for analysing data in order to study and find the productivity index and influencing factors of bored pile productivity in this project.

1. Data Collecting. In this step, all relevant bored pile data is collected such as the number of bored pile done on each construction spot, the time and duration it takes to finish each bored pile, the number of vehicles and other utilities with its each time frame, and the number of human resources need to did the works.

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2. Finding the factor that influence bored pile foundation construction. To find each factor, observation was done directly on the project site. Aside from that, several interviews were taken to find other factors unseen from observation. Literature study was also taken to find the correct questions to be asked and to find several theories to support the results of observation and interviews.
3. Making those factors into variable. Meaning that every factor found are turned into variable to be analysed and turned into questions
4. Turning those variables into questionnaire. Meaning creating the questionnaire accordingly. From the variable and to make sure the recipient of each questionnaire will understand what they read so they are able to answer without any confusion.
5. Spread the questionnaire. Spreading the questionnaire to the correct people, such as the qualified worker (with enough experience and education) who worked directly inside the project and very familiar about bored pile foundation works.
6. Calculating the productivity index. Analysing data starts from here by finding the productivity index for each bored hole to find the best productivity index and productivity that can be achieved, as well as its worst
7. Analyse the work time and duration for each bored pile. From each work time and duration, it can be concluded which ones have the most efficient and effective work and duration
8. Analyse the result of questionnaire. From this it can be concluded which factors has the most influence to the productivity of bored pile works.
9. Interview and validation. The interview was done with highly prolific people with higher education standard and long experience in this field. The interview was done to validate the finding and conclusion that was taken thus far and if they have any other comments about the factor that was found and other comments that they may have about the conclusion that is taken.
10. Combine the result between the point 7 to 10. Combining all result will give a better understanding to the best and most effective and efficient bored pile works that and could happen again with the greatest factor that influence their productivity.

IV ANALYSIS AND RESULTS

Analysis 1 Index of Productivity

There are 21 unit of bored pile equipment used in this project spread around several location along the 9.3 km work areas. Below is a recap of productivity index for each area.

Table. 1 Recap of Productivity index of Bored Pile on Area Foundation 1 – 21

Number of Foundation	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Number of Bored Piles	11	11	11	13	12	11	11	11	12	11	12	12	16	12	12	16	20	16	11	11	11
Productivity Index	1.57	1.10	1.00	1.30	1.09	1.38	1.22	1.22	1.33	1.10	1.00	1.33	1.45	1.33	1.33	1.60	1.18	1.60	1.57	1.38	1.38
Average of Productivity Index																					1.31
Highest Productivity Index																					1.60
Lowest Productivity Index																					1.00

From the table 1 above, it shows that the minimum production that happened is 1 and at most is 2 bore pile by day for each equipment. With the average index of productivity is 1.31 and the highest is 1.60 with the lowest is 1.00. Therefore, it can be concluded that even though the average production is 1.31 it can still be improved to meet 1.60 of bored pile each day.

From the early conclusion above it shows that the implementation of expectation of 2 bored pile each day is inaccurate even far too high for this project. The determination of production capacity that is too high or even unrealistic will

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caused shorter duration. If those estimates are inaccurate then the scheduling will give a finish time that is far too quick, even though the time required to finish the work is till long. The effect is the cost will swell because the fund is not enough for actual production.

Analysis 2 Bored Pile Works for Each Foundation

The total work time is the time needed to complete one work point for bored pile. While the productive work duration is work time without taking into account delays due to time lags, such as waiting time, delay due to damage to the equipment, delay due to weather, delay due to traffic and so on.

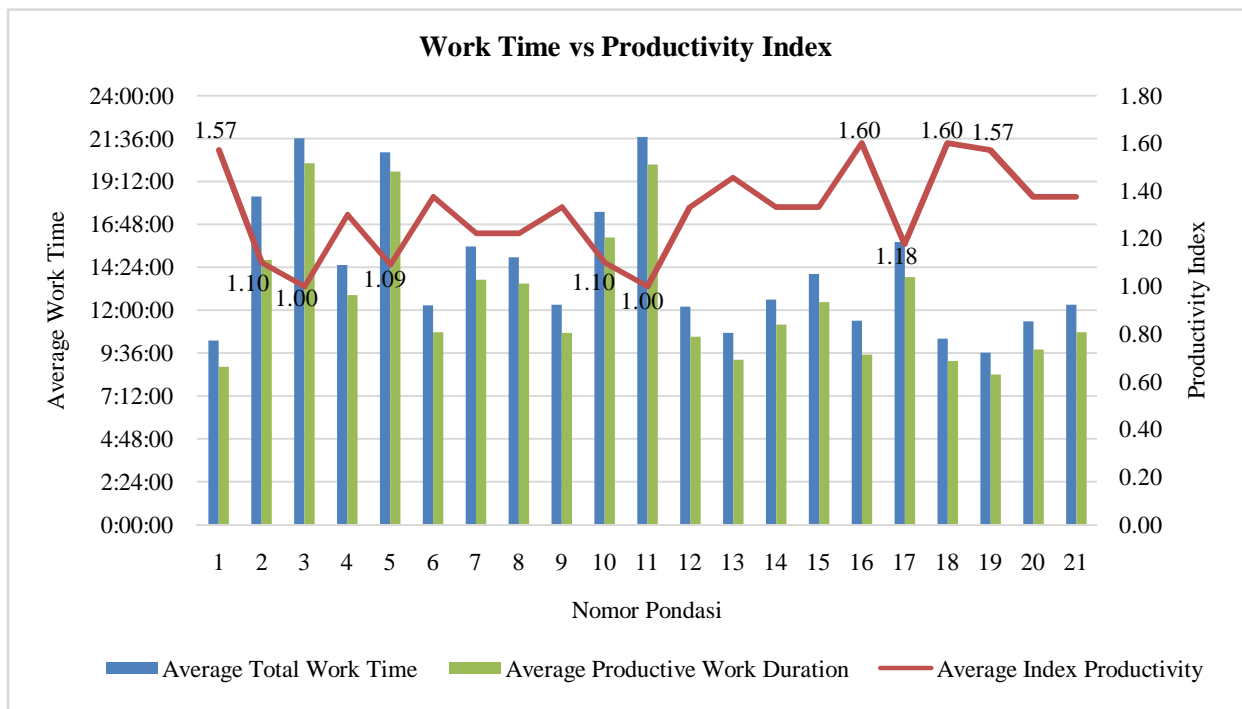


Fig. 1 Graph of Work Time Compared Against Productive Work Duration and Productivity index

From fig 1, it can be seen that: all data on the average productive work duration has a value lower than the average total work time. It also shows that the completion of bored pile work with longer time will resulted in a lower productivity index value. Likewise, the opposite is the completion of bored pile work with a shorter time, resulting in a higher productivity index.

The most extreme conditions happen on foundations 2; 3; 5; 10; 11; 17, the duration of the work is prolonged and the productivity index value is below expectations, which is between 1.00 - 1.18 bored pile per day. This is because in the foundation area there are utility lines such as PLN cables, PGN pipes and the AETRA water pipeline that must be relocated. This condition causes the work speed to be reduced because the rib drill tool is unable to freely moved. In addition, to maintain the security of existing utilities, more steel plate is needed for the foundation of the machine and the safety procedure for the project will become more complex. This situation shows that: different land conditions and utility relocation is one of the dominant factors that can hinder the productivity of bored pile work.

Foundation number 1; 4; 6; 7; 8; 9; 12; 13; 14; 15; 16; 18; 19; 20; 21 have better productivity index, with values between: 1.22 - 1.60 bored pile per day for each set of equipment. The maximum production results are in number 1, 16, 18 and 19 with the performance as shown in the table below:

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Table. 2 Maximum Production for Bored Pile Work

Num	Notes	Foundation			
		1	19	18	16
1	Average Work Time	10:17:16	9:35:49	10:24:00	11:23:38
2	Average Productive Work Duration	8:48:55	8:22:16	9:07:07	9:29:37
3	Productivity Index	1,57	1,57	1,60	1,60
4	Number of Bore Pile	11	11	16	16

The conclusion from the table 2 above shows that: the productivity index for foundation number 1; 9; 18; and 16 is almost the same. But through many considerations, the best performing works is at foundation number 1 and 19. The considerations taken are:

1. Foundation 1 and 19 have better work time than foundation 18 and 16
2. Foundation 1 is the first foundation to be worked on and it became the model for many competent individuals (consultant, planner, owner, and contractor), because the bored pile worked on that location is able to fulfil the quality, time, and safety needed for the project.

Based on bored pile data and the research, this section of analysis can be concluded with:

1. In bored pole works, the lowest productivity index is 1.00 per day and at maximum 1.60 per day.
2. Average productivity index is 1.31 point per day.
3. The best possible productivity index can be achieved in bored pile work is 1.57 point per day.
4. Average shortest work time for 1 bored pile work is 9:35:49 – 10:17:16 at foundation 1 and 19.
5. Average shortest productive work duration for 1 bored pile is 8:22:16 – 8:48:55 at foundation 1 and 19.
6. Several efforts to increase the productivity of bored pile are:
 - a. Quickly work on land providing and relocation of utilities before the bored pile equipment enter the work area.
 - b. By controlling traffic well enough so there isn't any traffic jam especially around the access gate for land dumping trucks and material supplies.
 - c. Because the majority of bored pile works is finish to start, the supplies and resources must be consistently maintained.
7. Different area condition and relocation of utility is one of the dominant factor that could slow down bored pile production

Analysis 3 Questionnaire Results

After the productivity index has been found, the research continues with analysis of factors that influence the production work of bored pile, categorized as: labour, utilities, and materials. In theory, there are many factors or variables that could influence productivity. But in this research, variables for questionnaire is selected based not only on theory, but also by actual condition that happened as bored piled foundation works is taken.

The sources of research variables include work methods, equipment, management, environment, quality and safety and human resource factors. All of these variables are collected directly by: observation, interview, and discussion with production team, with direct practice on research location and through production records.

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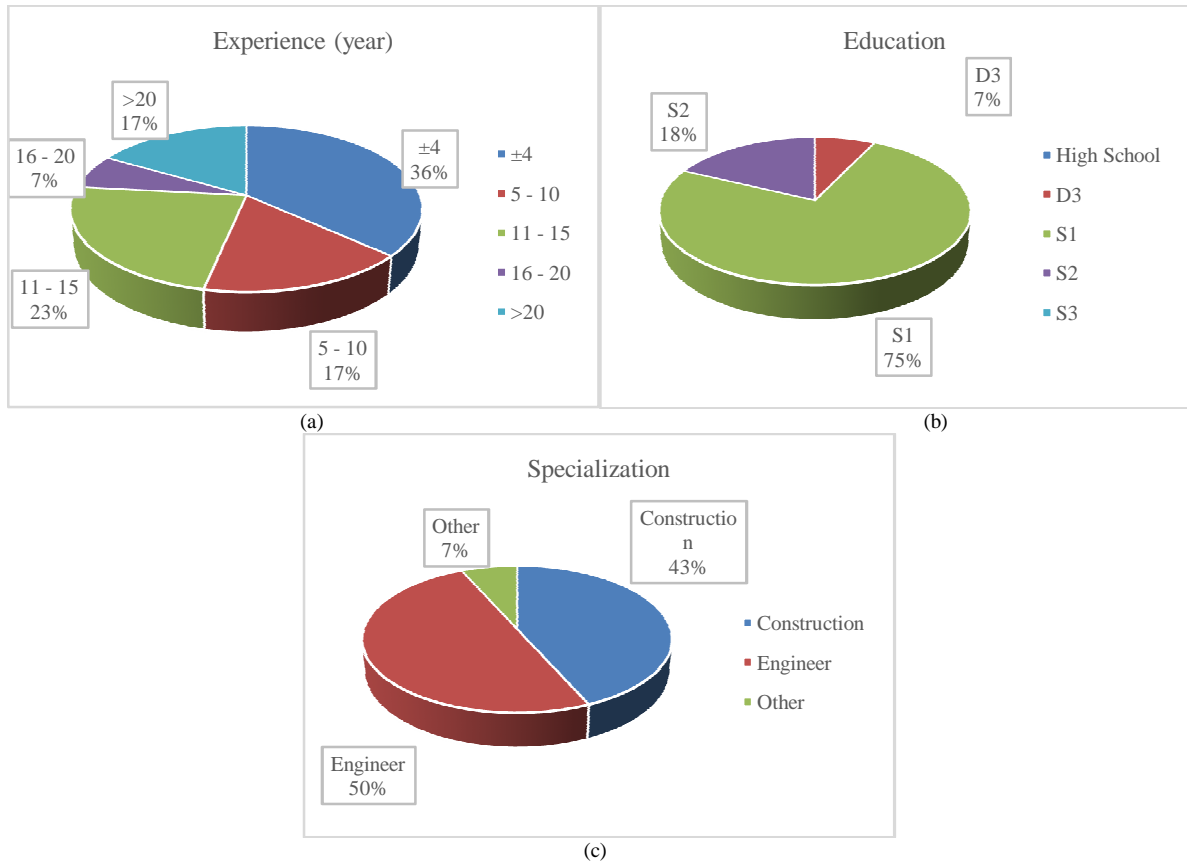


Fig. 2. (a) Respondent's Work Experience (b) Respondent's Education (c) Respondent's Work Specialization

Fig. 2 above are details about the respondents for the questionnaire, which are their experience (in years) corresponding to the field of this research, their final education at the time of this research was conducted, and their specialization inside the project which this research was based on. From the figures above, it can be seen that the respondents are peoples who contributed directly in the project, the figures also show that the respondents have enough experience, education, and specialization that is corresponding to the construction project of bored pile. Respondent's experienced varied from 4 years to more than 20 years in their respected specialization, with minimum education is D3, and with several people with higher education and expertise certification.

After the results of the questionnaire were obtained from each respondent, the results of the questionnaire need to be tested for validity and reliability before they can be analysed further. After the validity test is done, the values for the validities are above 0.306, which 0.306 is the limit of variable validity with the number of respondents as much as 30 with a significance level of 0.05, with reliability value is 0.945, based on Mahlangu and Kruger theory (2015) [4], the results can be declared as Excellent or very good. This means that this questionnaire as a measuring device is accurate so that whenever this measurement is made, it will give the same results.

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The next step is to analyse the data using RII. The analysis resulted in:

Table. 3 Results of Relative Importance Index Test

Rank	Variable	RII
1	Land condition is different for each foundation construction works	0,83
2	There are delays in land acquisition and utility relocation	0,79
3	High traffic density around the location of the project	0,78
4	In and out access into the project are blocked by traffics	0,70
5	Laborers aren't permanent employees	0,65

According to the analysis using RII method, those 5 variables on tababove are the factors that heavily influenced the productivity of bored pile foundation works.

Analysis 4 Interview Results

Based on the interview from the first interviewees who is an expert in this subject are:

1. Productivity of work achievement of the bored pile foundation has been maximized when viewed from the performance and various kinds of innovations that have been carried out by the construction people. Variations in productivity indexes from 1.00 per day to 1.60 per day are natural, because of various situations and constraints.
2. The five factors found through RII is correct. As for the order there is the possibility of disagreement, depends on the experience and conditions of the project.
3. Based on the theory and experience of the interviewees, there are several main factors that can generally affect the productivity of construction work, namely: land conditions, environmental and safety conditions, material mobilization, characteristics and status of workers and especially in bored pile foundation work on infrastructure projects within the city is the status of the land and the relocation of utilities.
4. Other additional factors such as: expertise and education, work wage system, supervision system, management system, type and age of equipment, work methods used, number of equipment, time and cycle of equipment used, can also affect productivity.

Based on the interview from the second interviewees who is an expert in this subject are:

1. Productivity of bored pile foundations in inner city toll road projects, there are two things that must be considered, namely: land preparation and complexity of utilities.
2. Because the work of the bored pile foundation is unique, the work of land investigation is mandatory because the data will show the quality of the land structure, also a documentation of how many utility lines are in the area is required. The lower the quality of the land and the more utility lines in the area, the more difficult the work will be and the higher the risk of work. This will reduce the work productivity.
3. Factors such as: land acquisition, heavy traffic, non-current mobilization of tools and materials and a narrow work area are conditions that can disrupt the performance and sequences of work.
4. To increase the productivity of the construction workforce, it can be done by increasing individual abilities, individual attitudes, management, and work organizations. For improvement in work productivity as a whole, we need to pay attention to three things, such: recognizing the main factors for increasing productivity, arranging the level of influence of these factors, measuring them and arranging the order and priority of which factors need to be improved first.
5. Regarding production capacity or bored pile productivity index that occurs in toll roads projects in the city, which are 1.00 to 1.60 per day with an average of over 1.30 per day, according to the opinion of the

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interviewees/ expert, it is good. Especially with many obstacles, such as land problems, utilities and heavy traffic.

V. CONCLUSION

The conclusion that can be said from this research is:

1. For the work of bored pile foundation, the highest productivity index is 1.60 points per day, with the lowest is 1.00 point per day, and the average is 1.31 points per day.
2. For the work of bored pile foundation, the most ideal productivity index is 1.57 points per day with average work time is 9:35:49 – 10:17:16 and productive work duration is 8:22:16 – 8:48:55.
3. There are 5 dominant factors that heavily influenced the productivity of bored pile foundation works according to the analysis using Relative Importance Index Method. Those 5 factors are:
 - a. Land condition is different for each foundation construction works
 - b. There are delays in land acquisition and utility relocation
 - c. High traffic density around the location of the project
 - d. In and out access into the project are blocked by traffics
 - e. Laborers aren't permanent employees

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