THE PRODUCTIVITY ANALYZES OF BORED PILE FONDATION IN THE MAIN BRIDGE AREA

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ABSTRACT

Productivity is an important thing that has to be known in implementing a project. The project is said successful if the contractor manages to gain maximum profit and the owner obtains satisfactory output, also it is on time to accomplish the project. One factor determining the success of a project is productivity. Specifically, the productivity in making foundation of bored pile can be increased by enhancing the resources for supporting it, including the project workers and the tools or equipment used in the project. The observed object is the Suramadu Bridge's bored pile foundation in the main bridge area, between pylon forty six and forty seven. The analyzes output of bored pile foundation making process with diameter of 2.4 meters at depth of 97.99 meters for pylon forty six and 104.99 meters for pylon forty seven. In this research, indicates productivity of the whole works at 0.76 meters/hour for pylon forty six and 0.54 meters/hour for pylon forty seven.

Keywords: Foundation, bored pile, bridge, productivity, pylon, Suramadu.

1. INTRODUCTION

Suramadu Bridge is a bridge that connects Surabaya City in Java Island and Bangkalan Town in Madura Island. The bridge, with the width at 30 meters, consists of emergency stay line, with the width at 2 x 2.25 meters, motor-vehicle lane with the width at 2 x 2 x 3.5 meters, central median with the width at 2 meters and motor way with the width at 2 x 3.05 meters and barrier concrete with the height at 1 meter as a protector. The existence of this bridge will accelerate the traffic of goods, service and people's transportation. The bridge with the length at 5.4 kilometers will be a change activator for Madura Island.

As the longest bridge in Indonesia, Suramadu Bridge also has a unique tourist interest. In the reverse of its sturdy structure, attractive architecture, high technology and a range of labels accompanying Suramadu Bridge, there are still stored other potencies. The larger chances can be quarried if it is integrated with the potencies available in both of regions, which is connected by Suramadu Bridge, namely Surabaya City as an Eastern Indonesia Regional Area service centre and Madura Island as an unprocessed area.

By seeing the fact, the bridge constructing technology becomes more developing in Indonesia, especially the Suramadu Bridge development existed in the middle of the sea, it needs the further study about the bridge constructing implementation, specifically the process of bored-pile foundation constructing striven to be able to provide benefits for the development construction doers or contractors in Indonesia. The development is implemented by Consortium of Indonesia Contractor (CIC), which is the consolidation of several contractors such as PT. Adi Karya, PT. Waskita Karya dan PT. Wijaya Karya for the causeway part of Suramadu Bridge. Whereas, in the main span part, it is constructed by Consortium of China Contractor (CCC).

Data analyzes technique are used by SPSS 12 and Microsoft Excel. The analyzes output of bored pile foundation making process with diameter of 2.4 meters at depth of 97.99 meters for pylon fourty six and 104.99 meters for pylon fourty seven in this research, indicates productivity of the whole works at 0.76 meters/hour for pylon fourty six (46) and 0.54 meters/hour for pylon fourty seven (47).

2. LITERATURE REVIEW

A project is said to be successful if the contractor succeeds to get the maximum profit and the *owner* obtains the satisfactory output or result and is on time for the completion. One determinant of the success for a project is productivity. The productivity can be increased by enhancing the supporting resources, including the project workers and the tools used in the project. In one condition, using a more productive machine with large capacity can increase the productivity and minimize the production unit cost, as well as laborers and materials cost [1].

The design change, or slowness ini supplying the materials or the tools can destruct the working rhythm. When the working rhythm is disturbed, it will get the effects that reduces the productivity and finally cause slowness. Slowness of project can be reviewed at the time of planning, implementation and also through the project final output. The slowness can also be supposed as a consequence of no fulfillment of ready schedule or planning, caused by incompatibility of the background condition and the fact [3].

Productivity has a variety of meanings, each knowledge area has divergent understandings about the productivity, based on the concept, productivity is a ratio of output produced by each input resource unit, compared to become a ratio at the time with the same or increased quality [2]. Productivity is an output per working hour or a value per working hour [4]. The contractor usually tends to connect the productivity definition with the result gained from the work because it can cause the working hour change, the number of needed laborers or the used tools.

2.1. The Foundation

The foundation is a part of building structure directly related to the soil and having the function of transferring the load gained by the structure to the soil [7]. In the other meaning, foundation is a part of building construction having the function of putting a building and accommodating the *upper structure or super structure* load to the quite sturdy soil base to support it. For the intention, the building foundation has to be considered to be able to assure the stability of building toward self-weight, surface style such as wind pressure, earthquake and local foundation degradation or average foundation degradation that exceed a certain limit may not happen. The loads working in the foundation are below: horizontal or shifted load (the load as a consequence of soil pressure force), vertical load or pressing and pulling force (for example dead load is itself building load, alive load is building residents, rain water and quake force) and moment [8].

Bore foundation is the foundation made to restrain the heavy loads in a low, medium or high storey building. The bore foundation is divided into two types according to the setting location, namely a dry type where foundation is made on land and a wet type where it is made in the sea. This foundation is created by making the boring hole with a bore. The depth of boring hole reaches the soil layer supposed to be quite hard. This hole of boring result is filled with cast-concrete with combined-steel frame. According to the width of building, in each low part of building pole, one, two, three or more bore foundations can be made that each of foundation is combined with *poer* (*pile cap*), then connected with *sloof,* another column point .

2.2. The Stage of Suramadu Bridge Bored-Pile Foundation Constructing

Suramadu Bridge with the length at 54.38 kilometers consists of three parts, namely Surabaya *Expanse Causeway* at 1457.5 meters, *Main Span* at 2162 meters and Madura *Expanse Causeway* at 1818.5 meters. In the part of *Main Span*, it consists of three parts, namely Surabaya *Expanse Approach* at 672 meters, *Main Bridge* at 818 meters and Madura *Expanse* at 672 meters. Foundation in *Causeway* is the steel pegging pile foundation with diameter of 60 centimeters and 100 centimeters, foundation in *Approach Bridge* is the *bored-pile* foundation with diameter of 1.8 meters and 2.2 meters and depth between 61 – 94 meters, foundation in *Main Bridge* is the *bored-pile* foundation with diameter of 2.4 meters and depth 97.99 meters for *pylon* 46 and 104.99 meters for *pylon* 47. The observed part is the *Main Bridge* part that consists of *pylon* 46 and *pylon* 47.

Stage1: Installing Casing, the first stage in constructing *bored pile* foundation in Suramadu Bridge is *Casing* Installing. Previously, *casing* has been made first in the place of *casing yard* assembling, Marina *shipyard*, Gresik. *Casing* foundation of *bored pile* is made of curved plate with planned diameter. After casing is formed, casing is moved to *auxiliary platform* by using ponton. In the process of bored-pile foundation constructing at *pylon* 46 [6] and *pylon* 47 [5], there are three *platforms* namely: *auxiliary platform, drilling platform* and *batching platform. Auxiliary platform* is a place for storing substances and materials to construct *bored pile* foundation located beside the place of *bored pile* foundation constructing. This platform has been made previously before the process of *casing* installing. *Drilling platform* is a place for the position of *bored pile* foundation constructing implementation, and *batching platform* is a batching plant for the process of *bored pile* foundation. Batching platform is made after drilling platform is finished. The pegging process starts from pulling of *auxiliary platform* and is moved to the pegging point by using *pile driving barge* 220 feet equipped with *crawler crane* 150 tons and a type of *diesel hammer* D80 – 100. The casing pegging activity is continued with the erection and the assembly *casing* in the type of *diesel hammer* D 80–100 with aid of *crawler crane.* The erection and the assembly in the specified position need quite long time more carefully because this pegging process is implemented in the sea. The factors of wind and wave also take an important part in the quick or slow process of this erection and assembly. If the wind blows too strongly or the wave is too high, the work will be ceased because oscillation happening to *Barge* due to the wave or the wind is too high, too dangerous for the pegging process and the default risk of pegging accuracy is high. In the erected and installed position, there is a *diesel hammer, casing* is positioned according to the *bored-pile point* with aid of 2 GPS to keep the accuracy, then continued with the pegging process using *diesel hammer*. After being right in the specified position, the *casing* installing process by using *diesel hammer* started with the strict control to minimize the error emergence. The casing pegging is done until the planned depth.

Stage 2: Drilling**,** after the casting pegging process is finished, the next work is *Drilling Platform* constructing as a place for putting the drilling tools. After *Drilling Platform* is finished to build, it is continued with *Batching Platform* constructing. *Batching Platform* is made to put *batching plant* used for the casing process. After *Drilling Platform* and *Batching Platform* are finished to build, the drilling work is immediately implemented for the sake of time efficiency. The applied drilling tools are RCD (*Reserved Circulation Drill*), absorption pipe and *auger bore* eye. *Slurry* is also used to keep wall unbroken after the result of drilling. *Slurry* for drilling generally consists of water, *clay* (or *bentonite*), dan *additive. Fresh water* is more compatibly used to prepare *slurry*. If sea water is used, salt content testing will have to be done and get agreement from the engineer. The drilling process starts from the preparation works such as place cleansing, tool installment taking about two hours. After those works, the next work is *tremie* assembling such as *tremie* pipe segments of 3 meters, continued with the drilling work by using *auger bore eye*.

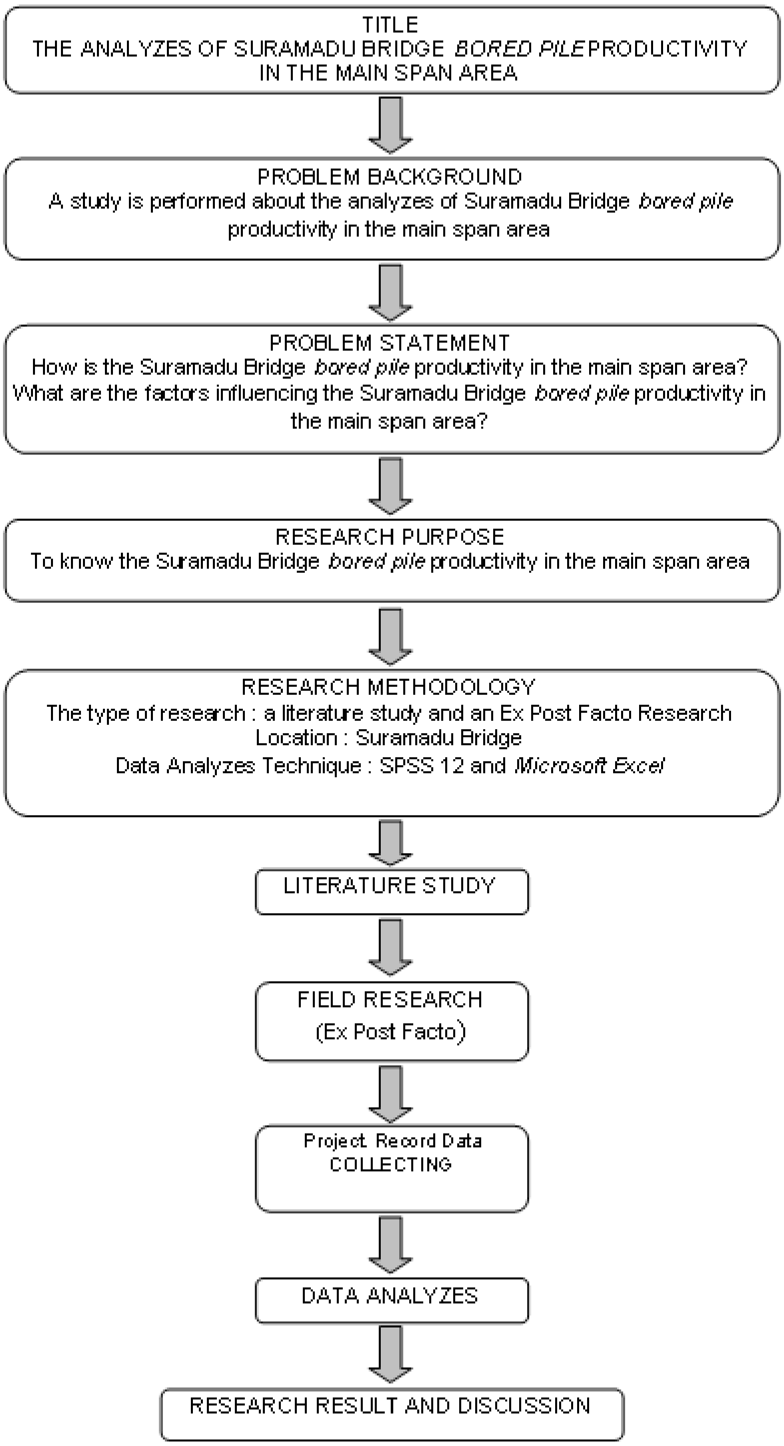
RCD works with pressure system. *Auger bore eye* keeps on turning to drill a *bored pile* hole. During drilling, the high pressure is used by employing disposal absorber pipe to take out materials of drilling result and during this, *slurry* is included to replace the existed cavity in order that walls of drilling result can’t be eroded. The drilling work is ceased each three minutes depth for disposal absorber pipe installment. After the *tremie* pipe is assembled, the drilling work is back to continue. It is done repeatedly till the specified depth. The materials of drilling result come out of a RCD tool separately, namely dry soil and muddy water. After this work is finished, hole cleansing is done from the tool and the rest of materials. In the hole, the depth testing is also performed by using pendulum.

Stage 3: Erect rebar cage, after the drilling work is finished, immediately continued with the work of framework putting, in order that erosion happening to the wall of drilling result does not make it collapsed.The framework is moved by using *crane* from *auxiliary platform* to *drilling platform*. The framework consists of nine separate segments, each segment is put one by one with aid of *crane*, after one segment gets into a *bored pile hole*. This segment is connected to another segment by using nut. Putting framework is performed slowly to minimize framework oscillation that can cause the collapse of internal wall in *bored pile* hit by the framework. Depth control is performed several times with pendulum, so the depth is still compatible with the planning.

Stage 4: Pouring, the final work of *bored pile* foundation constructing is pouring. After the framework is finished to put, continued with the pouring work. The works of drilling, putting framework, and pouring are performed in chronology without respite so that the collapse happening to the wall of drilling result does not continue. Pouring uses *self compacting concrete* with concrete quality of K-300, *water cement ratio* of 0.45 and *slump flow* value of 650-880 mili meters. Pouring uses the *tremie* method with two *concrete pump.* Implementation of pouring is performed continuously by using eight *silo*. The *tremie* hose is put till the hole base to make the drop point of concrete mixture not too high, so that segregation does not happen, then the hose is pulled to the top slowly in compliance with the increase of concrete mixture in a *bored pile hole*. This work is performed until the *bored pile hole* is fully filled with concrete mixture.

3. METHODOLOGY

RESEARCH METHODOLOGY



4. LYZES AND DISCUSSION

Suramadu Bridge is lied in Madura Straight with the total length at 5.438 kilometers. It consists of *Causeway* in Surabaya side, *Approach Bridge* in Surabaya side, *Main Bridge*, *Approach Bridge* in Madura side and *Causeway* in Madura side. *Main Bridge* of Suramadu Bridge uses the bridge structure of *cable-stayed* consisting of two *pylons* namely *pylon* forty six (diameter of *steel casing*: 2.7 meters, length of *steel casing*: 35.2 meters, depth of *drilling*: 70.17 meters) and *pylon* forty seven (diameter of *steel casing*: 2.7

meters, length of *steel casing*: 37 meters, depth of *drilling*: 88.08 meters). Each *pylon* has 56 *bored pile* and different depth of *bored pile* between 84.15 meters till 107.26 meters.

The works of Suramadu Bridge *bored pile* in the *main bridge* area consist of four kinds, among others pegging *steel casing,* drilling, putting framework and concreting. In each scope of these works, the influential factors will be analyzed later by using regression analyzes.

Based on Figure 1., the highest productivity is in the *bored pile* number 39 at 1 meter/hour, whereas the lowest productivity is in the *bored pile* number 28 at 0.42 meter/hour. it gains the average productivity of *bored pile of pylon* 46 is 0.76 meters/hour. Based on Figure 2. the highest productivity is in the *bored pile* number 13 at 0.81 meters/hour, whereas the lowest productivity is in the *bored pile* number 28 at 0.14 meter/hour. it gains the average productivity of *bored pile of pylon* 47 is 0.54 meters/hour. Figure 3. also shows that productivity of *bored pile of pylon* 46 is higher than the productivity of *bored pile of pylon* 47.

The work of Drilling Bored Pile.

The *Bored Pile* in Suramadu Bridge has the various *bored pile* depth, on average has the depth ± 78.17 meters for *pylon* 46 and ± 88.8 meters for *pylon* 47. The tools used to drill in each *pylon* are 3 drilling machine units, 1 *crawler crane* of 80 ton, 2-4 *air compressor* (*air pressure* at 0.8 Mpa, *air flow rate* at 22 m^3/min) and 4 *slurry treatment equipment* sets (capacity at 100-150 m^3/h). The used *drilling machine* is RCD (Reserve Circulation Drill) because RCD can be used in stone soil, although the usage cost is relatively expensive and the implementation is relatively slow, but it can be used till drilling of 500 meters. For *pylon* 46 *bored pile drilling*, the analyzes is performed by using the regression analyzes, then it gains equation $Y = 0.583 – 0.006 X_1 + 0.010 X_2 + 0.002 X_3$, show that the productivity of *pylon* 46 *bored pile* (Y) depends on duration (X_1), *drilling* depth (X_2) and duration of *add tremie* (X_3). For *pylon* 47-*bored pile* (Y) = $0.786 – 0.003 X_1 + 0.010 X_2$ depends on duration (X_1) and *drilling* depth (X_2). Based on Figure 3., it can be known that the average productivity of *pylon* 46-*bored pile drilling* at 0.76 meters/hour and the productivity of *pylon* 47-*bored pile drilling* at 0.54 meters/hour. Besides, the productivity of *pylon* 47-*bored pile drilling* is lower than the productivity of *pylon* 46-*bored pile drilling*.

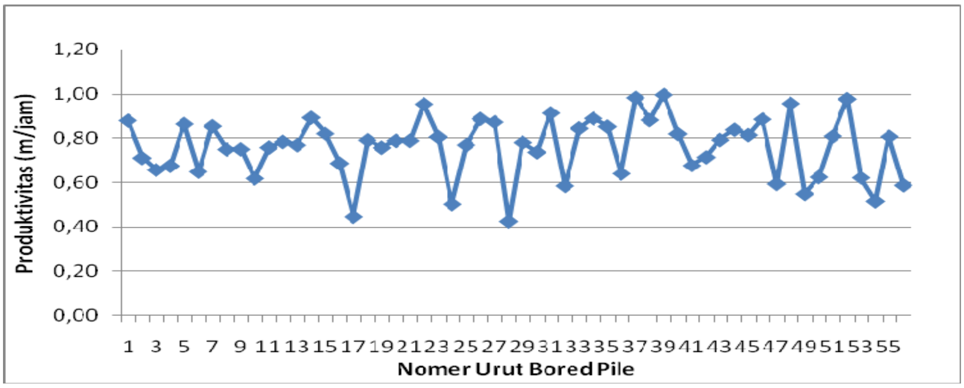


Figure 1. Productivity Based on the *Bored Pile* Chronological Numbers

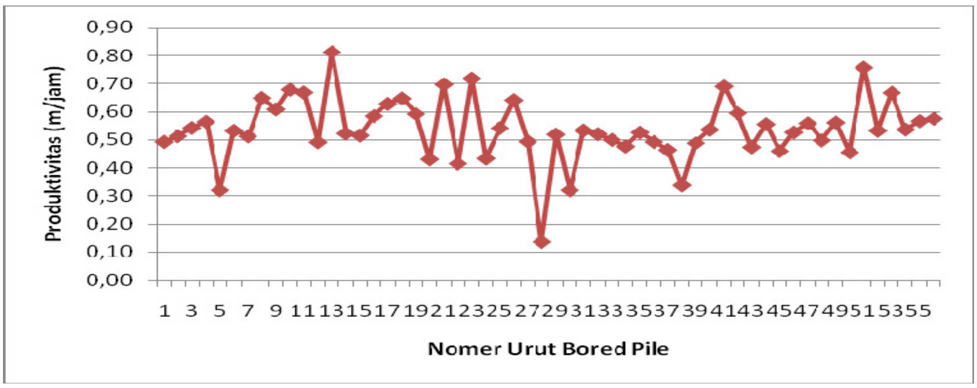


Figure 2. Productivity Based on the *Bored Pile* Chronological Numbers

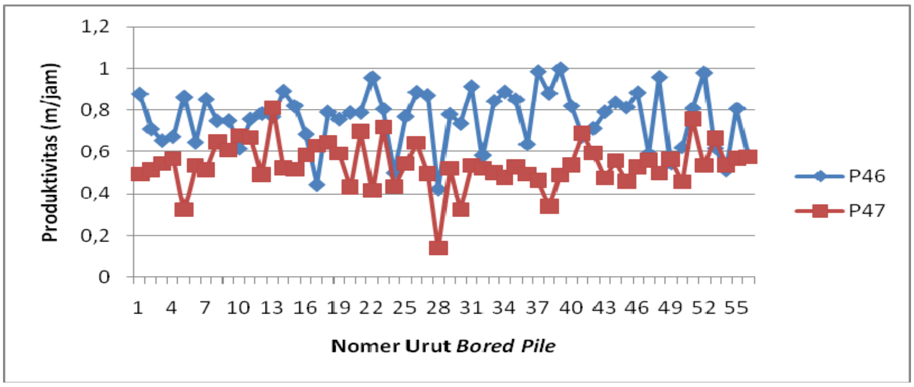


Figure 3. Comparison of *Pylon* 46 and *Pylon 47 Bored Pile* Productivity

5. CONCLUSION

From the analyzes result of *bored pile* productivity in the main bridge area of Suramadu Bridge, several conclusions that can be taken as follow:On the whole, productivity of *pylon forty six bored pile* is higher than productivity of pylon forty seven *bored pile* (Figure 3.)The existence of a soil type, *clay*, influencing the *bored pile* productivity especially in the work scope of *drilling* because *clay* retards the speed of *auger bore eye*. The observed object is the Suramadu Bridge's bored pile foundation in the main bridge area, between pylon forty six and forty seven. The analyzes output of bored pile foundation making process with diameter of 2.4 meters at depth of 97.99 meters for pylon forty six and 104.99 meters for pylon forty seven. In this research, indicates productivity of the whole works at 0.76 meters/hour for pylon forty six and 0.54 meters/hour for pylon forty seven

6. SUGGESTION

Based on the conclusion above, several advices being possibly beneficial can be revealed, namely:

The observation toward the soil of each *bored pile* needs to be added, so the kinds of soil can be known and they will be drilled later because the type of soil really influences the productivity, especially for the work of *drilling*.

This research is limited only at the time of implementation of *bored pile*. This research can be also developed by including the durations of instrument or equipment preparation, material carriage to *auxiliary platform*, *platform* setting, and others to obtain better outputs or outcomes.

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