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Methods of Piling Work on Long Span Bridges: A Review

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ABSTRACT

Building construction such as bridges, and flyovers. are constructions that need by the public. The selection of the foundation must be done carefully so that it loads above it. Pile planning is one of the solutions in choosing the right foundation. The simple, and relatively inexpensive working method makes the use of the pile method much in demand by planners in various parts of the world. Testing the bearing capacity of the pile is one of the pile work items. where this can ensure quality and quantity in the implementation of the work of this piling method.

1. Introduction

Increasingly, technological developments make people more determined to make creative innovations. Especially with the facet of development, many are competing to build infrastructure like a bridge. The bridge must have a strong building structure. The durability of a bridge does not fall from a sturdy foundation as well. One of the infrastructures in Saudi Arabia is the use of a stake or a piece of the infrastructure. Besides the security of the foundation of the stake, it is being used on the foundation of the inner foundation. the foundations of these stakes were laid out at a depth of 105 meters below the ground. One important aspect of the performance of the construction project is the saving of the safety plan and the saving of the procedure. In the matter of safety, high workplace accidents and loss of lives have resulted in negative results [1].

In the work of construction, the work of the foundation is a matter of concern. Both buildings, waterworks, and bridges. Particularly on the bridge, the foundation of these stakes would have a function of various benefits such as durability to support durable foundations. Indonesia is a country in which soil conditions are often moist. Extending the burden to relatively soft ground required the foundation of the torture stake to hold the horizontal force on a bridge. It is a lot to consider why a lot of the users of the inner foundation like the foundation of the stake and the foundation of the drill pole. Especially on the chopping of this stake other than the work on this foundation. Especially with the frequent natural disasters Indonesia has made planners more sensitive to that. Because in fact, many foundations suffer damage after natural disasters strike [2].

Jambu Sarang Bolaang is a bridge that connects Gorontalo and Manado districts. With silt soil material the pile foundation planning is expected to be a means for the community to carry out social, economic, and other activities. And planning the pile foundation on this bridge also uses a concrete pile foundation. consisting of their construction. Reinforcing the bridge structure when built on unstable ground, which is easy enough to make for efficient supervision, the stake of concrete stake also had such a lack as the supply needed heavy tools and took no time and all. However, the construction must also be considered carefully starting from the lower structure of the bridge such as pile foundations, and also the superstructure of the bridge such as abutments, girders, bridge plates, and others [3].

These are structures that relate to the ground. Planners should be able to understand what kind of foundation is good on the ground, such as when the soil is unstable, hard, and stuff. The foundation is

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defined as underground structures that carry on the burden derived from the weight of the building itself. The foundations of these stakes could be built vertically and horizontally, giving them equal drag. The safety of these stakes must also be given more careful attention so that the building is not subject to premature and substantial defects according to the standard. The foundations of a concrete execution stake could compile soil material that would prevent soil shifts and movement in a bridge. That's why many superpowers utilize the foundation of these concrete stakes in the Europe [4].

The safety factor in each foundation is something that planners must carefully consider. The purpose of this paper is too able to determine the safety factor of the piles on the sei bone cs bridge. To know the bearing capacity of the soil that affects the load on the structure above it. In constructing this pile, the foundation can reduce excavation in the soil. if it requires the excavation of land will cause a reduction in the existing land beside it, such as roads and culverts [5].

2. Literature Review

2.1 General

The piles are a deep foundation that functions as a foundation in the form of a pile located in the soil layer. And can also transfer loads originating from the construction above the construction below and towards the ground. This method can facilitate planners in building construction due to its simple implementation [6]. pile foundations must also be able to reach the limit of the factor safety supported by the load and pile foundations can also withstand axial and lateral loads to achieve an efficient structure.

The superstructure of the bridge consists of structures that have a heavy load. Therefore, a pile foundation is needed so that it can carry the load above it. Added if the soil at the base of the bridge does not have good soil carrying capacity. One important aspect that must be considered is the scour of water flowing around the foundation, this can cause disrupted safety, lack of service limits for bridge users and can also cause serious damage to the bridge [7].

2.2 Concrete Piles

Concrete pile is one of the increasing innovations in the field of construction. Many planners in parts of the world are trying to improve the latest innovations for the progress of their respective nations [8]. the erection of concrete piles has many advantages and disadvantages. Starting from the ease of installation, ease of mobility, and good enough durability, this makes the owner prefer concrete piles over other types. There are several types of concrete piles, namely:

a. Precast Prestressed Concrete Pile

A Precast prestressed concrete pile is a prestressed concrete pile that utilizing wire cables and reinforcement as the prestressing force. having the advantages, among others: the pile can be driven to a deep enough depth before the pile material can be checked, and the pile can affect the compaction of granular soil. Apart from the advantages of this pole there are also disadvantages such as a large diameter which can make it difficult during the driving process, can cause vibration disturbances, and sound which can cause damage to the surrounding buildings.

b. Cast in Place Pile

On this type of pile by way of making it first by drilling the ground and this method can also be done in 2 ways. Starting with steel pipes driven into the ground, then filled with concrete and pounded, then steel pipes driven into the ground and then filled with concrete.

c. Precast reinforced concrete pile

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Piles of reinforced concrete cast in concrete forms or references. Then after hardening, then lifted and staked because the tensile stress on the concrete is considered minor and practically considered to be zero, while the concrete's weight is significant. Therefore, reinforcement must be provided that is strong enough to withstand the bending moment. In planning precast concrete piles, it must be calculated with maximum accuracy so that the work can get optimal results.

2.3 An Important item on the piling tool

Good tool selection is significant for the productivity of a stable job [9]. Hammer, an item that is generally made of steel material that is used as a hammer to hit the pile into the ground, where the direction of the vertical blow is from above to downward. Having a large size and length, the hammer is dropped onto the pile, and then embedded in relatively dense soil. By having a heavy weight, the hammer functions to apply pressure so that it sinks into the ground perfectly. One example of this type of hammer is the drop hammer. The hammer is simple and widely used in construction activities. Having advantages such as simple operation and relatively cheap tool price. However, it is slow, and the vibration is large enough to make this drop hammer have disadvantages that are quite detrimental. The drop hammer can be seen in Figure 1.

Figure 1. Drop Hammer

The Steam engine is a specification of heavy equipment that has the characteristics of having one cylinder consisting of two diesel engines, fuel tanks, and lubricants that function as a driving hammer in single or double-acting steam hammers. Leader an item that functions as a path for the movement of the hammer in the up and down direction. Leaders are also divided into three types—namely swinging leaders or leaders that rotate in the vertical plane, hanging leaders, and fixed leaders.

2.4 Diesel Hammer

A Diesel hammer is one type of tool used for driving poles into the deep ground. This tool is often used in multi-story building foundation work projects, flyovers, and bridge efficient use making this tool a mainstay in pile foundation work. This tool can also be allocated to remote locations and is economical to use. Having an efficient tool can increase a positive trend in a job [10].This tool also does not require additional energy and its maintenance is easy and efficient.

3. Methodology

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The method used in writing this paper is using the literature review method. looking for relevant topics related to related material through international journals quoted from applications Harzing Publish or Perish, Scopus, and Google Scholar applications published in 2018 - 2022. then concludes the quotations cited from journals and books and selected to find the best of what is reference material that has been presented in this paper. the method in making this paper also uses a qualitative descriptive method by quoting the ideas of other people's thoughts and concluding them into a sentence [10] [11] [12].

4. Result and Discussion

4.1 Site Preparation

In this preparation, some things need to be considered, such as the soil condition at the piling site. It must be strong enough to support. It is feared that at the time of driving, there will be a slope or collapse. If the soil is not strong enough to support it, the pile will not be driven vertically perpendicularly. This will reduce the bearing capacity of the pile in case of slope. This can cause damage to the pile and the soil water content factor can affect the pile Field's bearing capacity [13]. Damage to the piles can cause functional defects in structures such as bridges. It can interfere with the quality of the bridge itself. Failure in construction can create a negative trend in the construction [14]. If the final head elevation is below ground level, the excavation shall occur before driving because the piling tool must be close to the location that is driven. site preparation must be reviewed immediately so that the work can run well. Good practice can increase work mobility to be smooth [13].

4.2 Pile Preparation

The Preparation of tools for piling work is adjusted to the pile type and soil at the driving location. Tools include crane service, excavator, hammer, leader, and others. It is intended that when carrying out the erection of piles, there are no obstacles. The piles can penetrate the soil at the planned depth and reach the specified bearing capacity. Soil investigations should be investigated carefully, such as measuring the stiffness of the rock mass and the nature of the defects [15].

Carry out a thorough soil investigation and soil investigation must be carried out because mistakes can occur. The better the soil is in actual conditions, the more efficiently the work can be done [16]. When ordering piles, there was a size error. This can ensure that the order of piles by following per under the actual specifications required. If an error occurs in selecting piles, this can increase the budget plan (RAB). Therefore, they must be carried out carefully and coordinated with each other.

4.3 Pile Mobilization

When the piling tool is mobilized to the piling location, the pile has met the material strength requirements and is stored near the piling location. This is to ensure the quality of the piles to make driving more efficient. Good job mobilization can improve service quality [17]. Furthermore, at the time of driving, it does not take a long time for the crane service to transport the piles from the storage location to the piling location.

The tools in the form of piles are arranged so that, like a pyramid at the bottom, there are more piles, and the top ones are fewer. It is intended that the piles do not slip and deform one another. An increase in the quantity of work must be balanced with an increase in the quality [18]. This can be dangerous for workers or something that can damage the object.

Storage is grouped into several sections according to the diameter, type, dimensions, and casting date. It is intended that the project life cycle can flow according to what was planned. When improper storage occurs, it is feared that it can reduce productivity in implementing the piling work. And also storage of

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piles can be stored in a place with a stable temperature because temperature instability can cause a decrease in the carrying capacity of piles, such as hydration heat [19].

4.4 Implementation of the Pile Method

In carrying out the installation of piles, the piles are marked on a 1-meter depth scale. This is intended to control how many meters the pile has been driven, how many connections, and so on. So, with this in terms of quality and quantity backup when there is an inspection, we have evidence. During an erection, we can see the marks we have made and can be used as documentation in the form of photographs. So that at the time when there is an inspection, we have evidence to show those concerned. It can also determine if the pile's depth is appropriately recorded.

A Cushion is a bearing that serves as a protective pile head. Pads in the form of wood, this cushion serves as a protector when driving is carried out. The cushion will be pounded with a hammer, so the pile does not crack. This cushion is needed as a cushion for the pile head.

During driving, the pile is tied to the alternating tool and pulled so that the pile enters the bottom of the hammer. The lifting point on the pile has been determined. this aims to avoid cracks in the pole. At the lifting point, the piles are generally strengthened with additional reinforcement, such as reinforcing steel, and the moment has been calculated so that the work runs smoothly. The head of the pile is attached to the hammer, then the alignment level is adjusted, and the driving can be done.

at the time of piling in progress, each segment can be documented to control the driving depth. And monitoring of piles can also be carried out on the form provided. For example, at the time of setting up, how deep the stake was, how many punches, penetration when it reached the hard ground, or what is commonly known as the final set, rebounding, and so on. It aims to be able to control the driving mechanism and calculate the actual bearing capacity that occurs directly at the piling location.

4.5 Pole Hitter Selection

The hammer selection tool must be adjusted to the type of pile, soil conditions, weight, and carrying capacity of the specified plan if the pile specification has heavyweight and complex ground conditions. It is intended that the beater, which has heavyweight, can provide a large amount of energy so that the driving can run efficiently.

The characteristic of the hammer is that it weighs at least half the total pile weight and can be affected by driving depth. Table 1 shows the ratio of the minimum hammer weight to the pile weight and pile length. The selection also depends on air pressure, pile verticality, hammer availability, etc. The recommended energy for driving is 635 kg.m for every 1m^3 weight on the concrete pile.

Table 1. The ratio of minimum hammer weight to pile length

Length (m)	Ratio
0 - 15	1
15-18	3/4
>18	2/3

4.6 Pile Bearing Capacity Test

a. Pile Dynamic Analysis Test

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The PDA test has the characteristic that the pile foundation is hit with a hammer so that a wave reaction will occur. The waves will be moved along the pile and then reflected and captured by the accelerometer sensor and strain gauge. The waves will be processed through Signal Matching analysis software to obtain dynamic and static components. With that, we can know the carrying capacity of the element. the static load test is the primary method determining the design developed on the construction structure [20].

This analysis is carried out through the case method procedure, which includes measuring velocity and force data at the time of testing and calculating dynamic variables, which aims to provide an overview of the bearing capacity of a single pile foundation. By using the case method, the integrity of the pile and joints and the efficiency derived from the transfer of hammer blows can be determined.

Equipment such as a pile driving analyzer, two strain transducers, two accelerometers, connecting cables, and a concrete drill tool is needed. The test determines the bearing capacity of a single pile foundation integrity and connection. Dynamic testing is carried out to consider the axial bearing capacity. Therefore, the instrument's installation is carried out so that the effect of bending can be lost during testing. With this, it is necessary to install the strain transducer must be installed on the neutral line and the accelerometer diametrically at the opposite location, and the position of the strain transducer line must be perpendicular to the hammer pile. The process of carrying out the PDA test can be seen in Figure 2.

Figure 2. proses of implementing (PDA) test

b. Calendaring

The calendaring method is carried out due to limitations in conducting dynamic and static tests. Due to the high cost of doing static and dynamic tests. Then it is equipped with calendaring which aims to support the carrying capacity data of the PDA test results. This calendaring method is also easy to do. The planner only needs to prepare some of the tools such as paper, markers, millimeter block paper, masking tape, and markers that are useful so that they are always in their original position.

Hiley's formula, the equation commonly used to find the calculation of the bearing capacity of the pile by the calendaring method:

$$R = \frac{2WH}{S+k} + \frac{W+N^2 P}{W+P}$$

Where:

R = limit bearing capacity (ton)

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W = hammer weight (ton)

P = Pile Weight

H = Hammer fall height

S = penetration of the pile during the last impact

K = rebounding average for the last 10 hits

N = restitution coefficient

Using this calendaring method is a method that is easy to do, but it has many functions as we can estimate the carrying capacity and then compare it with the results of the PDA test. It is estimated to be logical or not as a compliment. Because not all poles can be tested by PDA or static loading. The simplest method is this calendaring method. This makes this calendaring method mandatory for each pile driven at the driving location. An example of a calendaring result chart can be seen in Figure 3.

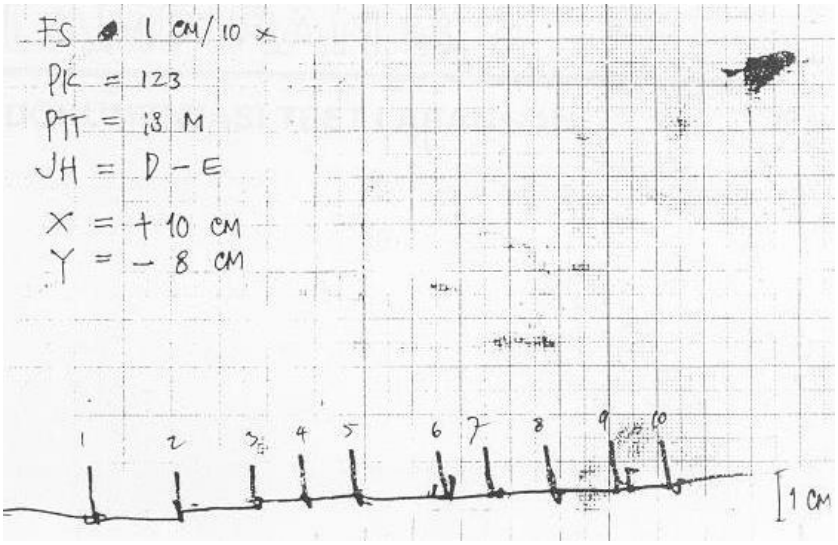

Figure 3. Calendaring test results

When the pole is hit, the chart will show an increase due to a rebound and then will decrease again. And there is a difference in the decrease between the first and second results. And this will be counted for 10 strokes, and then the total value of the decrease will be marked as the letter S (final set). Then the last set is divided by the number of strokes. The bearing capacity of the pile will be calculated using the Hiley formula.

5. Conclusion

It can be concluded in this paper that this paper discusses the working method of carrying out pile foundation work on bridges where there are various types of pile foundations, such as steel, wood, and concrete pile foundations. the selection of work items on pile foundations is also critical to implement pile work with the appropriate time, quality, and scope. There is a work method for carrying out the pile foundation, starting with land preparation, mobilizing the pile tools, carrying out the pile work, then ending with testing the pile bearing capacity, such as testing the static, dynamic, and calendaring carrying capacity.

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