Impacts Due to Foundation Piling Work

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Abstract. The foundation erection work is a job that has a high enough complexity. In making the decision of the type of pile and the method of erection, practitioners have many choices with various conditions in the field. Decision making will result in an impact during the foundation erection process. This study aims to analyze what are the impacts caused by the choice of pole type and piling method. A preliminary survey was conducted together with four experts to verify and reduce the 11 impact indicators obtained from the literature study, obtained 6 impact indicators which are quite relevant according to experts and will be used in the questionnaire survey. The questionnaire survey was conducted on 45 practitioner respondents who had carried out foundation building work. Data analysis validity and reliability tests were carried out on the questionnaire data. It was concluded that there were three main impacts that occurred due to the choice of the type of foundation pile and the piling method, namely environmental impact, economic impact, and social impact. The main impacts are broken down into six impacts including the use of fuel, ground vibration, fuel and material costs, equipment and labor costs, workplace safety, and noise.

1. Introduction

In general, building structures are divided into two main parts, namely the sub structure and the upper structure. The foundation is the structure of the lower part of the building that functions as a load support for all parts of the building structure that are above the ground level, then the foundation is part of the most stable structure [1].

In choosing the type of foundation must consider the carrying capacity of the soil and the depth of hard soil that will affect the selection of the shape of the foundation, and need to consider the burden of the structure of the upper building where the load will be supported by the foundation [2]. Cost and implementation time need to be considered in choosing the type of foundation, said the types of foundations that are very numerous so that the selection of foundation types must take into account some of the existing criteria to get the best cost and implementation time [3]. In addition to the type of foundation, the implementation method also needs to consider the constraints of the environment, in general the process of carrying out the pile foundation work has an adverse effect on human comfort or physical damage to the building around the piling location.

In general, foundation work is work that has many aspects that must be considered and has many alternative types of foundation poles and piling methods. Unique knowledge is required with strict regulations that must be followed in the selection of the type of foundation piles and piling methods so that the cost and time of implementation go into economic conditions and also avoid the impact on the environment and social [4].
Therefore, this study analyzes the impacts that occur due to the choice of the type of foundation pile and the piling method. It is hoped that this research can be used as a reference in considering the impact of foundation work.

2. Literature Review

2.1. Foundation Structure

The foundation consists of two types, namely shallow foundation and deep foundation. Shallow foundation does not require deep soil excavation, because hard soil is at a surface or not too deep and is used in simple house buildings. While deep foundations are used in hard soil layers that have a deep enough depth, generally used in high rise buildings, bridges, coastal or offshore buildings, and so on. Pile foundation is a type of deep foundation [5]. Pile foundation has two types, namely driven pile and bored pile. For a driven pile can be reclassified based on the materials used. According to the materials used, the pile can be divided into four type there are namely wood piles, concrete pile (precast), steel pile, and composite pile. For concrete pile divided into three type as follows square pile, octagonal pile, and spun pile. While for steel pile divided into 2 type there are H-beam pile and pipe steel pile [6]. A diagram of the types of piles based on the previous discussion is shown in figure 1 as follows.

![Diagram of Pile Foundation Types Foundation Piling](image)

**Figure 1.** Diagram of Pile Foundation Types Foundation Piling

2.2. Foundation Piling Method

There are various alternative piling machine in the foundation piling method, such as drop hammer, single-acting steam hammer, differential differential-acting hammer, double acting steam hammer, diesel hammer, vibratory hammer, hydraulic pile hammer and hydraulic jacking-in pile. However, some types of equipment are rarely used today to design piles, for example single-acting hammer, steam double-acting hammer, and steam differential-acting hammer are rarely used due to practical reasons and the amount of air emissions due to the large installation of a steam engine generator used. Lately, the foundation piling method that is commonly used is using a drop hammer, diesel hammer, vibratory hammer, hydraulic pile hammer and hydraulic jacking-in pile [7]. Drop hammer is a type of foundation piling machine with a method of using a hammer that is dropped from a height, then the hammer falls freely against the head of the pile. The diesel hammer is conceptually the same as the drop hammer which is free fall hammer, but the diesel hammer uses a cylinder that surrounds the pounder or piston with two diesel engines, the machine power is obtained from the weight of the piston which presses the air in the cylinder. Vibratory pile driver is a piling machine that uses vibration to penetration pile into soil layers, thereby reducing ground vibration and noise in the environment. Hydraulic pile hammer uses the same concept as a drop hammer or diesel hammer, meanwhile in the engine used to pull the pounder up using oil pressure or hydraulic. Hydraulic jacking-in pile uses a system hydraulic with a grasping and
pressing technique, so that it has a slight vibration and noise impact on the surrounding environment [8].

In choosing the foundation piling method, several factors such as environmental impact, cost and location need to be considered. Environmental effect such as noise and vibration due to the implementation of piling need to be considered. The vibration caused by the piling activity is quite problematic because it is very disturbing and can damage the existing buildings around it if the piling method is conducted in a densely populated location, therefore use a cast in place or bored pile using drilling method is the right choice [9]. Types of drilling methods for foundation installation include kelly drilling, mini cranes, full displacement drilling, and portal drilling. In general, drilling foundation that have smaller diameter than 1 meter usually using mini crane or portal drilling. The difference from the mini crane and the portal drilling is only from the height of the pole, both can use the dry or wet drill method. Kelly drilling or auger drill is a method commonly used for soil drilling. his method of transporting the soil from below to the surface using short rotary drills such as augers or cylinders. Full displacement drilling is a modification of drilling auger or kelly, this method places the cylinder on the ground and directly casts on the cylinder [10]. A diagram of the types of piling method based on the previous discussion is shown in figure 2 as follows.

![Diagram of Piling Methods](image)

**Figure 2.** Design Method Diagram

2.3. Impact of Pilling Works

The impact of pilling works will be used as a research variable in the verification process with experts in the preliminary survey. The following are the impacts of foundation erection shown in the table below.
Table 1. Impacts from Staking

| ID | Impact            | References |
|----|-------------------|------------|
| D1 | Air pollution     | [17]       |
| D2 | Water pollution   | [17]       |
| D3 | Soil pollution    | [17]       |
| D4 | Fuel usage        | [17]       |
| D5 | Ground Vibration  | [10]       |
| D6 | Fuel and material costs | [8] |
| D7 | Equipment and labour costs | [8] |
| D8 | Residual material value | [8] |
| D9 | Public health     | [14, 12]   |
| D10 | Workplace safety | [14, 12]   |
| D11 | Noise             | [14, 12]   |

2.4. Decision Making

Decision making is the process of choosing choices between alternative actions to achieve a certain goal and target. The decision-making process involves four main stages. First, the intelligence stage is to clarify the purpose of the decision by identifying the problem that occurred. Second, the design stage is to formulate a model that represents alternatives to each decision, then the model is validated with several criteria and alternatives for decisions that might be taken. Third, the optional stage which includes evaluation of criteria and alternatives and recommends solutions that are appropriate for the case problem. Fourth, the implementation phase is implementing the recommended solution [11].

3. Research Methodology

3.1. Preliminary Survey

The preliminary survey aims to verify the research indicators determined from some of the literature with the help of experts or practitioners who are experienced in foundation piling work. Data collection techniques using the help of the interview form. This verification is carried out by researchers assisted by 4 (four) experts, then verification by these experts is considered valid. The profile of the experts is shown in Table 2. Most of the experts who verified the impact of this study predominantly had experience of more than 20 years and had been involved at least 8 times on the foundation piling work.

Table 2. Profile of Respondents Expert

| No | Position       | Education | Work Experience | Project of Foundation Erection |
|----|----------------|-----------|-----------------|-------------------------------|
| 1  | Project Manager| S1        | > 20 years      | > 10 projects                 |
| 2  | Lecturer       | S2        | > 20 years      | 7-8 projects                  |
| 3  | Director       | D3        | > 20 years      | > 10 projects                 |
| 4  | Site Engineer  | S1        | 5-10 years      | > 10 projects                 |

3.2. Preliminary Survey Analysis

From a preliminary survey conducted by 4 (four) experts, the survey results were analyzed by using Mean Test. The Mean Test is to find the average score of the overall score of the respondents answers [16]. All piling impacts are sorted by test value. The cut-off score used is three (3.00) which is “quite relevant” [13], this score value is used to reduce the indicator or assess whether the indicator is valid and can be used at the questionnaire stage.
3.3. Pilot Survey
After processing the draft questionnaire, a pilot survey is needed with a sample size of 10% of the total planned sample [12]. A pilot survey was conducted to find out whether the draft questionnaire was appropriate for distribution and was understood by respondents.

3.4. Questionnaire Distribution
The questionnaire was distributed to 45 samples with the criteria of experts/practitioners who had been involved in the project doing foundation piling work in Balikpapan. Data collection techniques using a questionnaire form.

3.5. Data Collection
This study uses a cross-sectional data collection method by focusing on analyzing the large group perceptions of respondents, in this case the large group is the foundation piling practitioner in Balikpapan.

3.6. Data Analysis
After survey data has been obtained from respondents, a preliminary analysis is needed to be examined and prepared to ensure that the data to be used in the analysis meets the requirements. Preliminary analysis consists of data preparation, descriptive analysis, and non-parametric tests (Kruskal Wallis). A preliminary analysis aims to examine the characteristics of the data whether it meets the basic assumptions for conducting the analysis. Descriptive analysis aims to obtain data characteristics and perceptions of experts and practitioners about the research criteria with mean, standard deviation, and skewness and kurtosis. Skewness and kurtosis are used to find out whether the data is normally distributed or not, the data is said to be normally distributed if the Z-values skewness and Z kurtosis are between -1.96 and 1.96 [13]. Non-parametric tests (Kruskal Wallis) are used to analyze data that are not normally distributed there is an effect of the answers in the assessment of significant decision making from each of the different respondents' backgrounds. Non-parametric test used is the test Kruskal Wall is because the data tested have more than two groups and only have one factor [14].

3.7. Validity and Reliability Test
Validity test is used to determine whether the variable to be used is valid or can be used. A variable is said to be valid if it meets the requirements of R count> R table. Reliability testing uses Cronbach's alpha tools where the questionnaire can be said to be reliable if Cronbach's alpha is > 0.60 [15]. The validity and reliability tests in this study were calculated using the SPSS aids program.

4. Results and Discussion
4.1. Preliminary Survey Results
The results of the preliminary survey of the experts gave a response regarding the relevance of each indicator of the impact of staking. For the measurement of relevance, responses from experts are presented using the test mean shown in the following table.

| ID | Impact of Erection            | 1 | 2 | 3 | 4 | Mean | Conclusion |
|----|--------------------------------|---|---|---|---|------|------------|
| D4 | Fuel usage                     | 5 | 5 | 5 | 4 | 4.75 | Relevant   |
| D6 | Fuel and material costs        | 5 | 5 | 5 | 4 | 4.75 | Relevant   |
| D7 | Equipment and labour costs     | 5 | 5 | 5 | 4 | 4.75 | Relevant   |
| D10| Workplace safety               | 5 | 4 | 5 | 3 | 4.25 | Relevant   |
| D5 | Noise                          | 3 | 4 | 5 | 4 | 4   | Relevant   |
| D11| Ground Vibration               | 3 | 4 | 5 | 4 | 4   | Relevant   |
The number of piling impact scores is 70.9%. A value of 70.9% is included in the "relevant" interval category, and a score of three (3.00) is used as a cut-off [16]. There are 5 indicators that have a mean value below the cut-off value, so it is considered irrelevant as a determining indicator of decision making and is not used in questionnaire surveys.

4.2. Pilot Survey Data Results
In this study the number of respondents taken for the pilot survey was 10% of the 45 respondents is 5 samples chosen randomly from the total number of respondents [12].

Table 4. Pilot Response to Indicator Impacts

| ID | Erection Criteria                 | R1 | R2 | R3 | R4 | R5 | Mean | Conclusion |
|----|----------------------------------|----|----|----|----|----|------|------------|
| D7 | Equipment and labour costs       | 4  | 4  | 5  | 5  | 4,5| 4.6  | Relevant   |
| D5 | Ground Vibration                 | 5  | 5  | 4  | 4  | 4  | 4,4  | Relevant   |
| D10| Workplace safety                 | 4  | 5  | 4  | 4  | 5  | 4,4  | Relevant   |
| D6 | Fuel and material costs          | 4  | 4  | 4  | 4  | 5  | 4,2  | Relevant   |
| D11| Noise                            | 4  | 4  | 5  | 4  | 4  | 4,2  | Relevant   |
| D4 | Fuel usage                       | 4  | 5  | 3  | 4  | 4  | 4    | Relevant   |

Total score is 86% which is included in the "very relevant" interval category [16]. The mean value obtained from each indicator of the impact of stakes does not have a value below the cut-off value of 3.00 which means that the pilot respondents gave a high value on each indicator and have understood the contents and purpose of the questionnaire.

4.3. Questionnaire Survey Data
The number of data / samples collected from the questionnaire survey is 45 data, which is the data collected is above the minimum limit. The minimum amount of data from studies using 3 variables is 30 data [16].

Table 5. Profile of Respondents Questionnaire

| Respondents | Position | Work Experience | Total Project | Education |
|-------------|----------|-----------------|--------------|-----------|
| R1          | Engineering | <5 Year         | 1-2 Project  | Bachelor  |
| R2          | QA / QC   | <5 Year         | 1-2 Project  | Bachelor  |
| R3          | Director  | 5-10 Years      | 5-6 Project  | Magister  |
| R45         | Director  | > 20 Years      | > 10 Projects| Diploma   |
Table 6. Percentage of Respondents Background Questionnaire

| Position          | Work Experience |
|-------------------|-----------------|
| Site Engineering  | 31%             |
| Engineering       | 27%             |
| Director          | 20%             |
| Commercial        | 26%             |
| QA/QC             | 9%              |
| Estimator         | 7%              |

| Number of Projects | Education          |
|-------------------|---------------------|
| 5-6 Projects      | 24%                 |
| 7-8 Projects      | 15%                 |
| >10 Projects      | 8%                  |
| 1-2 Projects      | 21%                 |
| 3-4 Projects      | 31%                 |
| 9-10 Projects     | 5%                  |

4.4. Data Analysis
Data analysis using descriptive analysis using the IBM SPSS program. In this analysis obtained the mean value, standard deviation, and skewness and kurtosis to determine whether the data is normally distributed or not [13]. If the data are not normally distributed then it is necessary to do a non-parametric test to analyze answers between groups.

4.5. Descriptive Analysis
The mean value generated by each indicator is above 4.00 which means that all indicators can be said to be "relevant" [16]. All questionnaire respondents agreed that all indicators could be used as a decision maker for the type of foundation pile type and the piling method. Data can be said to be normally distributed if the value of Skewness and Kurtosis is between -1.96 and 1.96 [5].

Table 7. Descriptive Analysis of Questionnaire Data

| ID | Mean | Std. Deviation | Skewness | Kurtosis | Conclusion       |
|----|------|----------------|----------|----------|-----------------|
|    |      |                | Stat. (a) | Std. Error (b) | Stat. (c) | Std. Error (d) | Z (c/d) |                  |
| D4 | 4.33 | 0.56           | -0.09    | -0.25     | -0.64          | -0.93       | Distributed Normally |
| D5 | 4.16 | 0.77           | -0.91    | 0.35      | -2.57          | 1.14        | Not Distributed Normally |
| D6 | 4.38 | 0.61           | -0.43    | -1.23     | -0.60          | -0.86       | Distributed Normally |
4.6. Non-Parametric Test
This test is carried out to analyze whether there is an influence of the answers in the assessment of significant decision making from each different respondent background, in this case the position, work experience, number of projects and recent education. The test method used is Kruskal-Wallis which aims to determine the existence of significant differences between two or more criteria/groups [17]. All variables get values Asymp. Sig. greater than 0.05, except D7 on the influence of work experience. All indicators of all respondents with diverse backgrounds do not have different perceptions in assessing the impact that may occur on the decision making of the type of foundation pillar and the piling method.

4.7. Validity and Reliability Test Results
R tables are used with a value of 0.248 (N = 45). R table is used to test the validity. Because all the calculated R values are greater than the R table, it can be concluded that the 6 indicators on the piling impact used in this study are valid.

| ID  | Impact of Erection             | R Count | R Table | Conclusion   |
|-----|--------------------------------|---------|---------|--------------|
| D4  | Fuel usage                     | 0.643   | 0.248   | Valid        |
| D5  | Ground Vibration               | 0.466   | 0.248   | Valid        |
| D6  | Fuel and material costs        | 0.653   | 0.248   | Valid        |
| D7  | Equipment and labour costs     | 0.633   | 0.248   | Valid        |
| D10 | Workplace safety               | 0.524   | 0.248   | Valid        |
| D11 | Noise                          | 0.615   | 0.248   | Valid        |

In the reliability test, a cut-off with a value of 0.6 is used as a condition that the variables can be said to be reliable [15]. Cronbach alpha value obtained from variable exceeds the cut-off value, it can be concluded that the sample used in this study has a good answer or reliable consistency.

Table 9. Impact Piling Reliability Test Results

| Variable        | Cronbach Alpha | Cut Off | Conclusion |
|-----------------|----------------|---------|------------|
| Impact Piling   | 0.609          | 0.6     | Reliable   |

5. Conclusion
Based on data collected from 45 respondents to the indicators on the survey questionnaire has been verified by four experts, after Data analysis is done with valid and reliable data, so it can be concluded that there are three main impacts that occur due to the foundation piling work, namely environmental impact, economic impact, and social impact. The main impacts are broken down into six impacts including the use of fuel, ground vibration, fuel and material costs, equipment and labor costs, workplace safety, and noise.
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