International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 3, pp 132-141, March-2023

https://doi.org/10.47001/IRJIET/2023.703020

Effect of Pile Foundation Implementation on Environment, Cost of Elevated Railway Line Construction Project Between Solo Balapan-Kadipiro KM 104+700 to KM 107+000 (Phase II)

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***Abstract* - With the development of traffic flow, infrastructure development is needed to create comfort and safety in driving. In addition, the development must also be supported by good traffic management in order to reduce the traffic density of vehicles, one of which is the construction project of the Elevated Railway Line between Solo Balapan - Kadipiro KM.104+700 to KM.107+000 (Phase II). This research was taken from the Elevated Railway Development Project between Solo Balapan-Kadipiro KM+ 104+700 to 107+000 (Phase II), which is located at the Joglo Intersection in Banjarsari Village, Surakarta City. The research method used is quantitative and qualitative research methods. From the research results of pile driving work: air pollution, noise pollution, and vibration caused by the pressure of the drop hammer tool hitting the pile, from these influences, the main effect is that the vibration caused results in buildings and building structures, so that many influences interfere with human comfort. The amount of analysis of the bearing capacity of the pile: (1) The stress that occurs in the transportation of 32.67 σ 1400 kg / cm^2 and is quite safe (2) The ability of the spunpile a. to the strength of the pile material 14.50008 kg 145.50 tons, b. against the strength of the soil bearing capacity of the pile 31.20 tons, due to friction pile net load allowed pile N 41.216 - 10.016 31.2 Ptiang is quite safe Bearing capacity of group piles: a. for one pile in a group 25.18 tons (Qpg1321 kg), b. for one group pile Q 3.30 tons. Pile efficiency Eff.n 0.21 with bearing capacity of each pile 8.22 tons.**

Keywords: Cost, Environmental Impact, Friction Force, Piles, Supportability.

I. INTRODUCTION

With the development of traffic flow, infrastructure development is needed to create comfort and safety in driving. In addition, the development must also be supported by good traffic management in order to reduce the density of traffic from vehicles, one of which is the construction project of the Elevated Railway Line between Solo Balapan - Kadipiro KM.104 + 700 to KM.107 +000 (Phase II).

The Elevated Railway Line Development Project between Solo Balapan - Kadipiro KM.104+700 to KM.107+000 (Phase II) which will have an elevated track along 1.8 Km 'namely from STA. 104+700 to STA. 107+000, using a composite steel frame arch type bridge with a span of 270 m and a construction height of 40 m, which will be the longest span bridge in Indonesia that crosses over the Joglo Intersection.

The foundation is the lowest part of a structure that functions to forward the load of the structure to the supporting soil layer below. There are two types of foundations, namely shallow foundations and deep foundations. Shallow foundations are foundations that do not require deep excavation because the shallow soil layer is hard enough. While deep foundations are foundations that require deep drilling or piling because the hard soil layer is at a considerable depth, usually used for large buildings, bridges, offshore structures, and so on. The types of deep foundations are further divided into two, namely pile foundations and drill foundations.[1]

According to the book Foundation Analysis and Design Volume 2 compiled by Joseph E. Bowles in 1986 published by Erlangga on page 184 explained about the types of pile foundations, pile foundations are construction parts made of wood, concrete, and / or steel, which are used to forward (transmit) surface loads to lower surface levels in the soil mass[2]. In this project, the pile foundation used is a type of pile made of precast concrete from PT Adhi Persada Beton. The depth of the SOP foundation is designed based on the axial inner force using D600 piles, L = 15m.

The problems that will be raised include the effect of the implementation of pile driving work on the environment, the solution of these problems on the cost and time spent during

ISSN (online): 2581-3048
Volume 7, Issue 3, pp 132-141, March-2023
https://doi.org/10.47001/IRJIET/2023.703020

the work carried out, and how much is the strength and stability of the bearing capacity of the pile.

The purpose of the pile foundation research on the elevated railway construction project between Solo Balapan-Kadipiro KM 104+700 to 107+000 (Phase II), to find out what are the effects of the implementation of pile driving work on the environment, to find out the solution to the problem whether it affects the cost and time spent during the work carried out, and to determine the strength and stability of the bearing capacity of the pile.

The limitations of this problem include project financing through cost budget planning that has been planned before the project starts by compiling a RAP (Implementation Budget Plan). According to the Decree of the Minister of Environment KEP 48/MENLH/11/1996, noise is unwanted sound from business or activities in a certain level and time that can cause human health problems and environmental comfort. Regarding work safety that needs to be considered, there is a law PP no 50 of 2012 concerning the Implementation of Occupational Safety & Health Management System (SMK3)[3].

In previous research on the analysis of factors causing cost overruns in projects that have been carried out by Muhammad Nur Sahid, Ika Setyaningsih, Mochamad Solikin, and Bariq Al Salam in 2019 with the title Analysis of Factors Causing Cost Overruns by Contractors on the Solo City APBD Road Project in 2017-2018 written in the journal Proceedings of the National Symposium on Design and Industrial Application Engineering on pages 199-208, In this study discussing cost overruns in construction projects that result in losses. Construction project overruns are highly dependent on several factors both from internal and external factors of the project. Thus a high level of expertise, knowledge, and experience is needed to estimate costs ranging from project costs to managing project cash flow during the work implementation stage[4]. So it is necessary to have a management function starting from planning, implementing, and controlling, a project can be said to be successful if it is right on cost, right on quality, and right on time. Research was also conducted by Muhammad Nur Sahid, Anto Budi Listyawan, Abdul Rochman, and Rim Dzaky Haidar entitled "Analysis of Dominant Factors Causing Cost Overruns by Contractors on Wonogiri Regency Road Projects for the 2017 and 2018 APBDs written in the journal of research and the field of civil engineering studies volume 0, number 2, October 2019. [5]

1.1 Soil Investigation

According to the book Foundation Analysis and Planning I and II prepared by HaryChrystandyHardiyatmo in 2015, soil investigation is an effort to obtain information related to the characteristics of the soil that will be used as initial planning in construction. With the existence of soil data, it will make it easier to analyze the soil in the area so that at the construction implementation stage, the implementer can determine a good work method according to the soil conditions at the job site[6].

1.2 End Bearing and Friction Pile

Piles that are calculated based on End Bearing are driven into the hard soil layer, which is able to carry the load received by the pile.

To assess the resistance of hard soil layers to the tip of the pole, a method that is widely used in Indonesia, the Netherlands, and European countries is the sondir tool. With the Sondir Tool, it can determine how deep the pole should be driven and what is the bearing capacity of the hard soil layer against the tip of the pole[7].

Pole capability:

$$P_{tiang} = \sigma_{tiang} \times A_{tiang} \quad (1)$$

By:

P_{tiang} = Allowable strength of the pile (kg).

σ_{tiang} = Allowable compressive stress of pile material (kg/cm^2)

A_{tiang}= Cross-Sectional Area of the pile (cm^2)[7]

Against soil strength:

1. Temporary Load:

$$Qtiang = \frac{A_{tiang} \times p}{2} + \frac{0xlxc}{5} \quad (2)$$

2. Fixed/ Static Load:

$$Qtiang = \frac{A_{tiang} \times p}{3} + \frac{0xlxc}{5} \quad (3)$$

3. Dinamic Load:

$$Qtiang = \frac{A_{tiang} \times p}{5} + \frac{0xlxc}{8} \quad (4)$$

By:

Q_{tiang} =Pile balance bearing capacity (kg)
p =the conus value of the sondir result (kg/cm^2)
0 =Pile circumference (cm)
l =The length of the pole that is in the ground (cm)
c =Average Cleef price (kg/cm^2)[7]

1.3 Determining Individual Supportability (*Single Pile*)

Balance carrying capacity:

$$Q_t = CN_cA + 2(B + Y)1c \quad (5)$$

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Allowable bearing capacity of pile group:

$$N_c = (1 + 0{,}2\,\frac{B}{y})N_{cs} \qquad (6)$$

By:

N_c = Bearing capacity factor that can be obtained from the graph according to "Skempton"
B = Pole group width
Y = Pile group length
L = In the Pile
C = Soil shear strength *(indrained)*
N_{cs} =Nc value for circular foundation obtained from "Skempton" chart.[7]

II. METHODS

This research was taken from the Elevated Railway Construction Project between Solo Balapan-Kadipiro KM+ 104+700 to 107+000 (Phase II), which is located at Joglo Intersection in Banjarsari Village, Surakarta City. The research methods used are quantitative and qualitative research methods.

At this stage, data collection techniques are carried out by looking at several sources and previous research studies, as well as direct observation at the project site. Data can be divided into two, namely: Primary Data is data obtained by conducting direct observations at the project site; Secondary Data is data obtained by seeking scientific information directly from related contractors and other media.

2.1 Research Location

This research was conducted on the Elevated Railway Line Construction Project between Solo Balapan-Kadipiro KM.104+700 to KM.107+000 (Phase II) located at Simpang Joglo, Banjarsari District, Kartasura City, Central Java Province.

Figure1: Project Location
(Source: Google Earth)

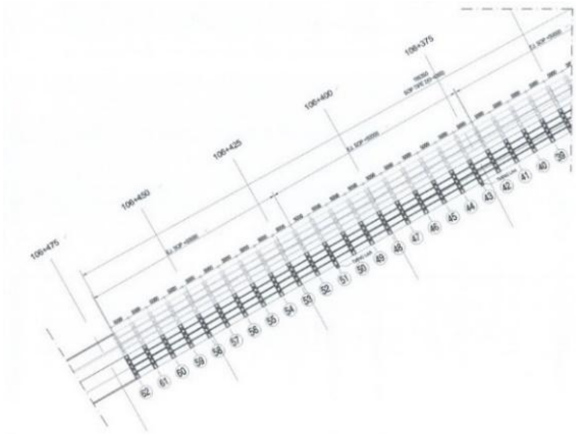

Figure 2: P62 Piling Plan (STA KM.106+475 to KM.106+375)
(Source: Shop Drawing PT Adhi Karya (Persero) Tbk)

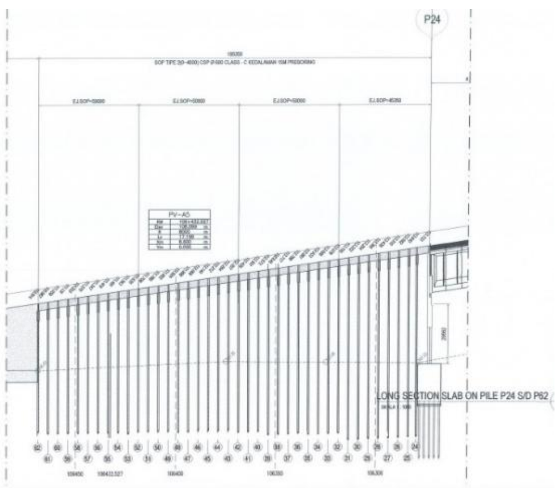

Figure 3: Long Section of Pile Foundation P62
(Source: Shop Drawing PT Adhi Karya (Persero) Tbk)

III. RESULTS AND DISCUSSIONS

After conducting research on the Elevated Railway Line construction project between Solo Balapan-Kadipiro KM 104+700 to 107+000 (Phase II). The following results and discussion have been obtained:

The following Site Plan of the P62 piling point taken is on the south side which is located at P1 STA KM 105+061 to KM.105+171:

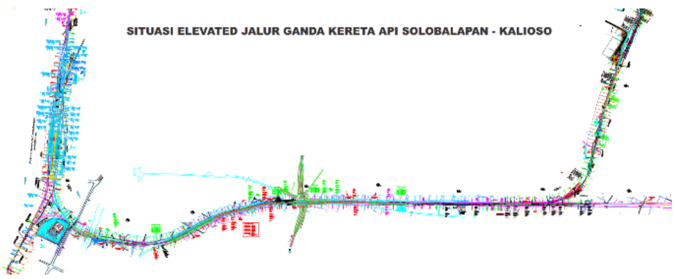

Figure 4: Elevated Situation of Solo Balapan - Kalioso Double Line Railway
(Source: PT Rayakonsult)

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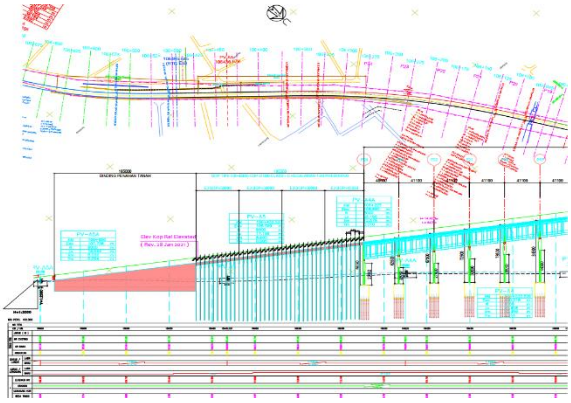

Figure 5: South Side Piling Site Plan
(Source: Data PT Rayakonsult)

3.1 Analysis of the Effect of Piling Work on the Environment

Analysis of the effect of piling on the environment on the siteplan at the point of pier 62 which is on the south side, along the railroad, namely the distance from the piling point to the settlement is ± 8 m. Based on the data search in the field experienced during the pile foundation piling work, this piling work has a major effect on the community environment of the Joglo Junction area. The influences caused during the piling work on the environment and social are as follows:

1) According to the literature study by interviewing respondents and data obtained from PT Adhi Karya, explaining the effect on the structure of the house affected by vibration such as: cracked walls, falling / shifting roof tiles, and loose / loose ceilings. Pile driving when the Drop Hammer was dropped onto the 50 m radius pile starting at a depth of 11 m experienced vibrations that were feared to affect the foundation of the house in the long run, so there were people who protested by trying to request that the piling be stopped.
2) Monitored environmental components include community attitudes and perceptions, decreased air quality, increased noise, increased vibration, the emergence of disruptions to traffic flow and traffic safety according to the monthly report of the RKL-RPL for the Construction of the Solo-Semarang Phase 1 Picture Line.[8]
3) Influence on the comfort of the surrounding community and traffic users who pass the road in the area near the piling feel afraid and worried about heavy equipment and materials if it will endanger public safety.
4) Vibration and noise impacts caused by pile driving:

To find out the impact caused and how far the effect of vibration and noise pollution or noise caused by piling work can be seen from the results as follows:

a) Vibration impact of pile driving work

Location : Jl. Kolonel Sugiyono No.61, Kadipiro, Kec. Banjarsari, Surakarta City

Coordinates: 7°32'47.69"S - 110°49'28.85"E

f (Hz)	Vibration Speed (V) (mm/s)					Category (KepmenLH 49/1996)			
	MC0		Spunpile		Enhancement	A	B	C	D
4	4.19	B	67.11	C	62.92	< 12	12 - 27	27 - 140	> 140
5	3.63	A	67.30	C	63.68	< 7,5	7,5 - 25	25 - 130	> 130
6,3	3.58	A	87.12	C	83.54	< 7	7 - 21	21 – 110	> 110
8	5.00	A	133.03	D	128.03	< 6	6 - 19	19 - 100	> 100
10	8.02	B	187.34	D	179.33	< 5,2	5,2 - 16	16 - 90	> 90
12,5	13.65	B	211.14	D	197.48	< 4,8	4,8 - 15	15 - 80	> 80
16	14.25	C	148.77	D	134.52	< 4	4 - 14	14 - 70	> 70
20	10.59	B	103.86	D	93.27	< 3,8	3,8 - 12	12 - 67	> 67
25	13.52	C	55.32	C	41.80	< 3,2	3,2 - 10	10 - 60	> 60
31,5	3.49	B	29.00	C	25.51	< 3	3 - 9	9 - 53	> 53
40	1.35	A	17.07	C	15.71	< 2	2 - 8	8 - 50	> 50
50	1.28	B	14.34	C	13.06	< 1	1 - 7	7 - 42	> 42

Figure 6: Vibration Measurement Data of Spun pile Piling South Side
(Source: RKL-RPL Construction of Solo-Semarang Phase 1 Image Line)

Category:

A: No damage
B: Likely to cause stucco cracking (cracking/detachment of stucco on load-bearing walls in special cases)
C: Likely to cause damage to structural components of load-bearing walls
D: May cause damage to load-bearing walls

The measurement results of the south side of the spunpile work can be seen that there are four measurement points with different coordinates with varying distances. The closest points to the spunpile work are at points SS1, SS2 and SS3. Vibration levels at this location in conditions without heavy equipment operating are still mostly in Category B having the possibility of causing stucco cracks (cracking / detachment of plaster on the load-bearing walls in special cases). Vibration levels with Category C are only at frequencies of 16 Hz and 25 Hz.

In the period October 10-16, 2022, spunpile work was observed at location P25 (north of the Viaduct) by PT Adhi Karya. In the monitoring period October 10 - 16, 2022 will focus on the impact of vibration on spunpile work by PT Adhi Karya, measurements were taken on October 14, 2022 with a total of 6 measurement points on the north (3 points) and south (3 points). The following is the measurement documentation of the spunpile work.

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Volume 7, Issue 3, pp 132-141, March-2023
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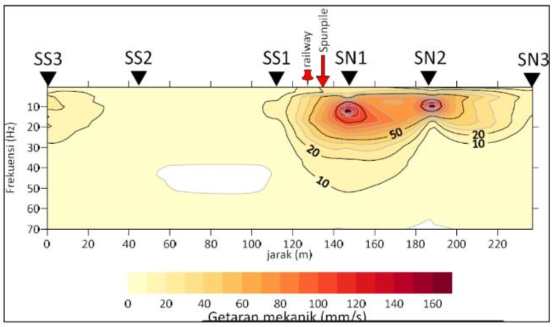

Figure 7: Modeling from measurement table data at the spunpile work site.

(Source: RPL-RKL Report)

The figure above is a modeling of tabular data that has been obtained during measurements at the Spunpile piling work site at PT Adhi Karya Persero Tbk. The data has been analyzed or compared with vibration quality standards in accordance with Kepmen LH no. 49 of 1996.[8]

Table 1: Spunpile Vibration Results on the South Side

No	Location	Category	Results
1	SS1	A,B and C	South side of Railway Street 1 A: 31.5 and 40 Hz. B: 4-6.3 Hz and 20 and 25 Hz, C: 31.4 - 50 Hz
2	SS2	A and B	South side of Railway Street 2 A : 5 and 6.3 Hz and 16-50 Hz. B : 31.5-50 Hz.
3	SS3	B and C	South side of JlKeretaApi 3 B : 31.5 and 40 Hz C : 5 - 25 Hz

a) Noise from Pile Driving Work:

Table 2: Noise level of piling work at the work site

Excecutor	Work	Date	No Activity Construction		Activity Construction		Δ Leq dB(A)
			Range L dB(A)	Leq dB(A)	Rentang L dB(A)	Leq dB(A)	
PT. WIKA – BKU KSO (JGSS 02)	Borepile	31/10/22	61,8 - 78,4	63.67	77,8-98,5	83,43	19.76
		1/11/22	62,5 - 87,5	72.65	80,2 - 114	94,74	22.09
PT. Adhi Karya (JGSS 03)	Borepile	31/10/22	63,1 - 83,2	74.38	72,5 - 99.7	84,79	10.41
		1/11/22	61,7 - 79,4	66.55	75,1 - 92,9	85,44	18.89
		2/11/22	65,1 - 75,2	68.09	74,1 - 94,7	83,67	15.58
	Spunpile	18/11/22	62,0 - 65,7	62,69	73,7 - 106,6	89,79	27.10
		19/11/22	61,5 - 88,1	71,50	73,1 - 129,0	90,12	18.62
	Borepile	23/11/22	60,4 - 94,9	73,72	74,0 - 119,0	93,13	19,41
		24/11/22	60,5 - 85,1	72,02	75,3 - 101,1	87,94	15,92
		25/11/22	60,9 - 75,1	68,96	71,3 - 126,6	92,65	23,69
		26/11/22	61,8 - 71,5	66,48	76,2 - 92,9	85,23	18,75
PT. Istana Putra Agung (JGSS 04)	Borepile	17/11/22	58,6 - 86,8	71,13	72,8 - 131,8	89,41	18.28
		18/11/22	62,3 - 80,3	67,49	75.9 - 131.9	88,91	21.42
	SSP and Land Development	21/11/22	62,3 - 86,7	67,77	72,8 - 131,8	90,20	22,43
		23/11/22	61,4 - 83,6	65,86	75.9 - 131.9	85,28	19,42
PT. Calista Perkasa Mulia (JGSS 05)	Borepile and SSP	7/11/22	60,6 - 75,0	66,78	79,2 - 87,3	81,58	14.80
		8/11/22	60,8 - 72,7	66,77	75,7 – 89,0	82,62	15.85
		9/11/22	62,0 - 73,3	68,24	80,5 - 111,1	90,14	21.9
		10/11/22	59,2 - 74,9	64,10	80,8 - 102,4	89,23	25.13
		11/11/22	60,3 - 77,4	68,93	83,5 - 96,9	88,00	19.07
		15/11/22	62,2 - 83,4	68,55	77,9 - 93,1	86,51	17.96
		24/11/22	60,6 - 70,9	68,55	77,6 - 118,4	92,62	24,07
		25/11/22	60,9 - 75,0	67,64	78,0 - 98,5	86,33	18,69

Source: Survey Results 2022 RKL-RPL

The noise level was analyzed using the Hearing Damage Risk Criteria (OSHA Criteria) with a comparison between the allowable noise duration per day and the noise level. The Hearing Damage Risk Criteria (OSHA Criteria) are presented in the following table.

Table 3: Risk of Hearing Damage Criteria (OSHA Criteria)

No	Duration of allowable noise per day (Hours)	Noise Level (dBA)
1	8	90
2	6	92
3	4	95
4	3	97
5	2	100
6	1,5	102
7	1	105
8	0,5	110

Source: Sasongko, 2000

Installation of spun pile by PT Adhi Karya Persero Tbk. Observed noise level measurements during spunpile work reached a Leq of 89.79 dB(A), based on OSHA criteria the length of accumulated work in a day is 3 hours. Observed to have a difference or delta (Δ) with before the work reached 27.10 dB (A), the significant increase was also influenced by the traffic flow on Jalan Kolonel Sugiyono. Related to the work that causes an increase in noise impact, it is necessary to socialize or notify the surrounding community [9].

3.2 Analyze the resolution of these problems on the costs incurred during the pile foundation piling work

Analysis of problem solving on costs incurred during piling work, from the effects caused by pile driving work, of course there is a solution to each of these effects agreed between the community and the contractor. But it cannot be separated from the costs incurred during the work. Overcoming the problem of Cost Overrun on the formulation of the problem, the resolution of the influence is obtained as follows:

1) In previous research, conclusions were obtained from the journal Muhammad Nur Sahid, IkaSetyaningsih, MochamadSolikin, and Joshua Jordy C with the title Study of Factors Causing Cost Overrun in Road Construction Projects with the Sukoharjo Regency APBD in 2017 and 2018 published in 2019 in the Civil Engineering journal pages 79-88 mentioning conclusions, paying more attention to the influence of inflation and escalation such as price changes, price increases, and all aspects of a project that can be influenced by inflation and escalation in order to minimize the possibility of additional costs in a project, especially road projects.[4]
2) The effect on the damaged building structure and the community asked for the piling work to be stopped, the

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ISSN (online): 2581-3048

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solution was that the consultant made a policy by making an official report on the temporary suspension of the piling work until waiting for the decision of both parties between the contractor and the affected community, with a form of compensation in the form of physical repair of building damage directly repaired by the contractor. Based on the literature study to the contractor, the replacement value of damage repair varies from Rp.100,000-, to Rp.1,500,000-, received by residents. After both parties were conducive, the consultant made an official report addressed to the contractor to carry out the re-piling work.

3) The influence on the comfort of the surrounding community is noise pollution and air pollution, these two things cannot be controlled because the impact of the piling is that the sound and air become dirty and bad, the solution to this impact is to clean up material splashes, install safety fences, watering the mobilization path, and cleaning the wheels of vehicles.
4) Influence on traffic comfort near the piling area, the solution is to socialize to the surrounding community about traffic engineering so that people prioritize their own safety. In addition, it is also important to involve K3 officers to secure and assist the piling work.
5) In research conducted by Muhammad Nur Sahid and NizaWidiana, the results obtained by using the average value (mean) of questionnaire data so that researchers get 5 specific factors causing cost overruns from cost estimation variables, project financial variables, implementation time variables as follows:
   a) Schedule delays due to weather.
   b) Occurrence of natural disasters.
   c) Poor cost control.
   d) Does not take into account unexpected cost.
   e) High interest rates on bank loans.[10]

Of course, some of the solutions have to do with additional costs so that more or less result in Cost Overrun. The larger the size of a project means the more problems that must be faced. If the problem is not handled properly, it will have an impact, one of which is cost overruns[4].

The main cost control aims to ensure that the final project cost does not exceed the implementation budget plan. A good tool used in suppressing cost overruns is by preparing a RAP (Implementation Budget Plan) that relates the quality, volume, and unit price of work that has been obtained.[11].

The contractor emphasized that there was no cost overrun, because the contractor before starting work had compiled a RAP (Implementation Budget Plan) by considering the social impact of the community in CSR (Corporate Social Responsibility).

3.3 Analysis of the Impact of Problems/Constraints on Work Implementation Time

Analysis of the impact of problems on the time of work implementation in research conducted by Muhammad Nur Sahid, Gotot Slamet Mulyono, Aziz Singgih Jati Nuryanto, and Jaji Abddurroyid entitled Evaluation of Time Control and Productivity of Work Pressure for the Implementation of the Parking Building Construction Project Using the Critical Path Method (CPM) Work Network Method in the 2020 Civil Engineering Dynamics journal on pages 71-79 explains that, Project control is a process of activities from start to finish on a project that ensures conformity between plans and work results and takes actions against deviations encountered in the field or during implementation, both regarding labor, materials, equipment, costs, management, time, and quality. In this case, what is related to the control process is controlling and evaluating[12]. carrying out their functions. The objectives of project control include:

a) So that the results of the project implementation can be in accordance with the project plan drawings and specifications that have been determined.
b) Can complete the work in accordance with the predetermined schedule.
c) Pressing the cost of implementation as efficiently as possible.
d) Be responsible and maintain the quality of work.

3.4 Pile Foundation Supportability Analysis

Can be seen in Figure 1. 12 m Bottom Pile Foundation, Figure 2. Detail of Pile Shoe Pencil, and Figure 3. Section B.

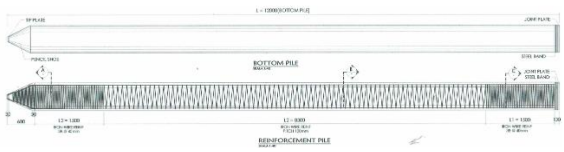

Figure 8: Bottom 12 m pile foundation
(Source: Shop Drawing)

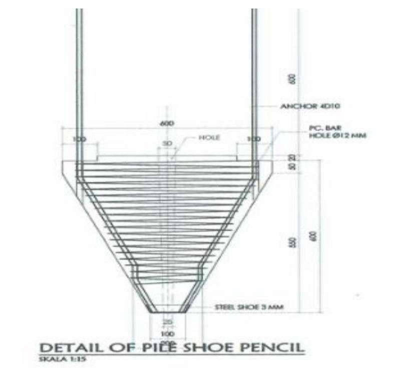

Figure 9: Detail of Pile Shoe Pencil
(Source: Shop Drawing)

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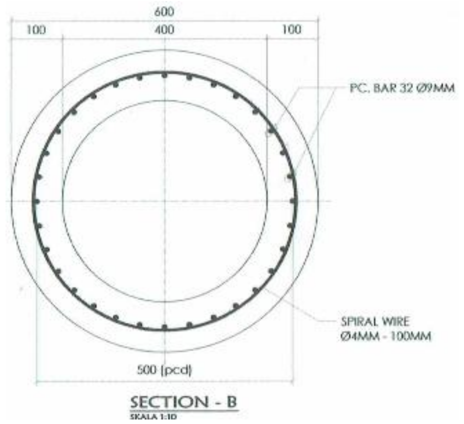

Figure 10: Section B

(Source: Shop Drawing)

The following are the materials that can be seen in the Shop Drawing Spun Pile Ø600 mm by PT Adhi Karya.

REMARK

(1) *Strength Of Concrete At Age 28 days:*
Fc' = 60 Mpa*(Cylinder Strength)*

(2) *Standard* Material:
Aggregate : SNI 8321-2016
ASTM C33/C33M-2018
Cement : SNI 2049-2015 (Type 2)
Admixture : SNI 2495-1991/ASTM C494 99
Concrete : SNI 6880-2016
PC Bar : SNI 7701:2016
Jacking Force = 75% UTS
Tensile Strength = 1420 Mpa
Section Area = 64 mm^2
Spiral WRE : SNI T-07-0053-2016/JIS G 3532
Tensile Stregth = 420 Mpa
Reinforcement : SNI 2052:2017
: Ø >10 mm : BjTS- 420B
: Ø >10 mm : BjTP-280
Joint Plate : JIS G 3101/JIS G 3192
Welding : ANSI/AWS D1.1-1990

All Measurement IN "MM"

A. ***End Bearing and Friction Pile***

I. **Single Pole Reinforcement *(Single Piles)***

a. $M_1 = \frac{1}{2} g.a^2$

$$M_1 = M_2$$

$$M_1 = M_2 = \frac{1}{2} g.a^2 = \frac{1}{2}.1440.3{,}135^2 = 7076\ kgm$$

b. $M_1 = \frac{1}{2} g.a^2$

$$M_1 = M_2 = \frac{1}{2} g.a^2 = \frac{1}{2}.1440.4{,}35^2 = 13624{,}2\ kgm$$

So, the most decisive circumstance is that (b) reinforcement is taken: PC BAR 32Ø9 mm.

Stresses that occur in transportation

$$Concrete : \sigma = \frac{M}{M_d} = \frac{13624{,}2}{22{,}527} = 60{,}40\ {}^{kg}/_{cm^2} < \sigma = 60\ {}^{kg}/_{cm^2}$$

$$Steel : \boldsymbol{\sigma} = \frac{M}{M_e} = \frac{13624{,}2}{417} = 32{,}67 < \boldsymbol{\sigma} = 1400\ {}^{kg}/_{cm^2}$$

$$< Safe\ Enough >$$

Pilw Capability

a. Against the strength of the pile material:

$$A_{tiang} = F_b + nF_e = 60 + 15.32.4{,}91 = 2416{,}8\ cm^2$$

$$P_{tiang} = \sigma_b \times A_{tiang} = 60 \times 2416{,}8 = 14.5008\ kg$$

= 145,50 tons.

b. Against soil strength:

Due to end resistance (*End Bearing*)

At a depth of 13.50 m, conus p = 26 kb/cm^2 (obtained from soil investigation data on the joglo intersection underpass, in the PT Rayakonsult soil investigation report in table 3-2 Recapitulation of N-SPT Value BH-14)[13].

Depth (m)	N-SPT Value														
	BH-01	BH-02	BH-03	BH-04	BH-05	BH-06	BH-07	BH-08	BH-09	BH-10	BH-11	BH-12	BH-13	BH-14	BH-15
1.55	5	4	4	3	4	2	5	3	81	2	3	4	6	4	12
3.55	13	13	12	3	6	5	8	10	17	10	6	9	19	5	15
5.55	33	37	30	4	13	13	10	8	9	21	16	29	35	12	26
7.55	40	30	59	9	14	18	9	14	15	16	11	19	16	15	37
9.55	48	32	52	15	27	39	11	40	62	17	26	18	17	17	46
11.55	41	29	60	47	39	63	41	38	40	78	38	35	27	18	21
13.55	61	24	26	29	36	21	51	100	100	51	100	48	63	26	20
15.55	100	50	29	49	33	29	47	26	34	37	48	100	62	29	27
17.55	84	53	44	50	25	34	100	43	56	55	78	92	66	89	42
19.55	70	43	41	49	21	43	53	53	31	34	100	100	71	58	25
21.55	58	81	45	57	61	40	24	35	86	68	40	67	46	86	46
23.55	64	41	89	46	53	58	65	68	80	48	45	70	49	55	49
25.55	88	59	56	61	50	40	100	49	66	96	53	71	74	62	100
27.55	100	100	100	67	67	87	100	62	40	58	55	50	100	63	57
29.55	100	67	100	71	89	39	64	52	53	100	90	25	80	73	84
31.55	100	61	100	62	79	53	73	100	58	82	75	52	100	55	54
33.55	100	100	44	45	100	40	58	68	84	97	65	59	100	100	100
35.55	100	65	69	40	42	52	41	90	100	67	97	87	100	100	84
37.55	100	89	100	51	25	68	53	100	70	73	54	55	100	100	85
39.55	100	66	100	38	48	77	40	100	66	68	67	100	100	100	100
41.55					51										
43.55					57										
45.55					94										
47.55					100										
49.55					93										
51.55					49										
53.55					70										
55.55					88										
57.55					68										
59.55					70										
EOB	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	30.00 m	60.00 m	60.00 m	80.00 m	60.00 m	60.00 m

Figure 11: N-SPT Value Recapitulation

(Source: PT Rayakonsult Soil Investigation Report)

$$A_{tiang} = 60 \times 60 = 3600\ cm^2$$

Bearing capacity of the pile:

$$\frac{A_{tiang} \times p}{3} = \frac{3600 \times 26}{3} = 31{,}20\ tons$$

International Research Journal of Innovations in Engineering and Technology (IRJIET)

ISSN (online): 2581-3048

Volume 7, Issue 3, pp 132-141, March-2023

https://doi.org/10.47001/IRJIET/2023.703020

Due to friction cleeff*(Friction Pile)*

The length of the pole is divided into 3 parts:

$$Bearing\ Capacity\ Of\ The\ Pile: \frac{0x1xc}{5}$$

$$\frac{160}{5}(300.0{,}45 + 400.0{,}20 + 700.0{,}14) = 10{,}016\ tons$$

So the total balance carrying capacity = 31,20 + 10,016 = 41,216 tons.

Pole self-weight:

$$0{,}60 \times 14 \times 2400 = 20160\ kg = 2{,}01\ tons$$

Allowable net load on the pole:

N = 41,216 – 10,016 = 31,2 ton <P_{tiang} **<Safe Enough>**

II. Piles Group

a) Division of stresses in the pile group. Bearing capacity of individual piles (Single Piles):
Based on the strength of the pole material:

$$A_{tiang} = F_b - F_y = 60 + 15.32.4{,}91 = 2416{,}8\ cm^2$$

Force obtained on the pole:

$$P_{tiang} = \sigma_b \times A_{tiang} = 50.2416{,}8 = 1208 = 12{,}08\ tons$$

Based on strength:

$$A_{tiang} = 60 \times 60 = 3600\ cm^2$$

The conus price at a depth of13,5 m ≈ 14 m is p= 26 kg/cm^2
Cleef amount at 13.5 m depth is c = 380 kg/cm
Pole circumference 0 = 4 x 60 = 240 cm

$$Q_{tiang} = \frac{2416{,}8.26}{3} + \frac{240.380}{5} = 39185{,}6\ kg = 39{,}18\ tons$$

Bearing Capacity of*single pile* = $Q_s.p = 39{,}18\ tons$

Bearing capacity of group piles*:*

Balance carrying capacity

$$Q_t = CN_cA + 2(B+Y)1c = 2.382\ cm^2$$

Circle foundation for “SKEMTON”

$$N_c = \left(1 + 0{,}2\frac{3{,}97}{0{,}6}\right)9 = 20{,}91$$

$$Q_t = 0{,}07.20{,}91.2{,}382 + 2(3{,}97 + 0{,}60)380 = 302179\ kg$$

With safety numbers n=5 $Q_{pg} = \frac{Q_t}{n} = \frac{302179}{3} = 100726\ kg$

For one pile in a group:

$$Q = \frac{1}{4}Q_{pg} = \frac{1}{4}.100726 = 25181{,}5\ kg = 25{,}18\ tons$$

With safety numbers n=3, Cleff=5

$$Q_{pg} = \frac{0{,}07.20{,}91.2{,}382}{3} + \frac{2(397 + 0{,}60)}{5} = 1321\ kg$$

For one pile in a group:

$$Q = \frac{1}{4}Q_{pg} = \frac{1}{4}.1321 = 330\ kg = 3{,}30\ tons$$

b) Pile Efficiency Analysis
Pile efficiency analysis according to “Los Angeles Group-action formula”:

$$Eff.\text{ɲ} = 0{,}21$$

Bearing capacity of each pile:

$$0{,}21 \times Q_{s.p} = 0{,}21 \times 39{,}18 = 8{,}22\ ton$$

IV. CONCLUSION

From the results of the research that has been obtained, the influence of pile driving work is air pollution, noise pollution, and vibration caused by the pressure of the blow from the drop hammer tool that hits the pile, from these influences the main one is the vibration caused which results in buildings and building structures, so that many influences interfere with human comfort because the work is done during the day. From the influence of the vibrations caused, there is compensation for building repairs carried out directly from the contractor with a value that varies between Rp.100,000-, to Rp.1,500,000-,.

The contractor said that there was no cost overrun and no project delay because before starting work, they had prepared a RAP by considering the social impact of the community in CSR.

The magnitude of the analysis of the bearing capacity of the pile: (1) The stresses that occur during transportation 32.67 <$\boldsymbol{\sigma}$ = 1400 kg / cm^2 and are quite safe; (2) The ability of the spunpile a. to the strength of the pile material = 14.50008 kg = 145.50 tons, b. to the strength of the soil with the bearing capacity of the pile = 31.20 tons, due to the cleff friction pile

ISSN (online): 2581-3048
Volume 7, Issue 3, pp 132-141, March-2023
https://doi.org/10.47001/IRJIET/2023.703020

with the allowable net load on the pile N = 41.216 - 10.016 = 31.2 <Ptiang and is quite safe; Bearing capacity of group piles: a. for one pile in a group = 25.18 tons (if with safety number n = 3, cleff = 5□ Qpg = 1321 kg), b. for one pile in a group Q = 3.30 tons.; Pile efficiency according to "Los Angeles Group-action formula" = Eff.n = 0.21 with bearing capacity of each pile 8.22 tons.

ACKNOWLEDGEMENT

The authors would like to express their gratitude to their supervisors for their support, help, advice and expertise during this research.

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ISSN (online): 2581-3048
Volume 7, Issue 3, pp 132-141, March-2023
https://doi.org/10.47001/IRJIET/2023.703020

Citation of this Article:

Aisyah Fidina Bella, Co. Prof. Muhammad Nur Sahid, "Effect of Pile Foundation Implementation on Environment, Cost of Elevated Railway Line Construction Project Between Solo Balapan-Kadipiro KM 104+700 to KM 107+000 (Phase II)" Published in *International Research Journal of Innovations in Engineering and Technology - IRJIET*, Volume 7, Issue 3, pp 132-141, March 2023. Article DOI https://doi.org/10.47001/IRJIET/2023.703020

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