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USING MINIPILE IN SOIL IMPROVEMENT METHODS FOR REDUCING SETTLEMENT VALUE IN HIGHWAY TOLL KERTOSONO – KEDIRI

Ardha Rahadian[1], Lalu Mulyadi[2], Lies K. Wulandari[3]

Abstract: **A highway toll project is an urgent need in this modernization era, especially in our country, which currently has a population of around 250 million people. From the population that has been increasing, In the current era the need for transportation is also growing rapidly, Therefore, a safe and comfortable transportation is needed. Relationship with the occurred of soft soil in the STA. 18 + 000 to STA. 20 + 300, the authors need to provide an analyzing way of handling the soft soil in order to meet the criteria for the settlement criteria. Meanwhile, the purpose of making analysis soft soil improvement using minipile is to find out a technical point still meets the requirements stated in the design criteria. To achieve this goal, analysis of the soft soil improvement in carrying out the analysis and calculations was taken from the results analysis of the N-SPT value and laboratory testing material from the soil investigation of the borehole. The calculation results obtained are in the soil improvement methods at the location which was originally using a minipile it can reduce settlement value < 20 mm/years, safety factor in earthquake condition > 1.10 and time schedule for implementation pilling work on site 1 month faster than the time required when using an other methods for each location that has of soft soil content, especially in the section STA. 18 + 000 to STA. 20 + 300.**

Keywords: **Cost, Efficient, Schedule, Soil Improvement Methods.**

I. INTRODUCTION

The project location for the highway toll Kertosono – Kediri is located between Nganjuk Regency and Kediri Regency, East Java - Indonesia, the highway toll stretches for 20.30 km through the two districts mentioned above. In detail, the location of the highway toll is 150 km from Surabaya as the capital city of East Java province. In the feasibility study phase, the basic design and detailed engineering designs that have been prepared by geotechnical experts related to the results of soil investigations in soft soil. Soil improvement methods Forsythe (2015), Mott MacDonald in his report entitled Feasibility Study of the Kertosono - Kediri highway toll. [1] which states that by using geotextiles to strengthen the slope stability of high embankment and soft soil replacement with materials that have better bearing capacity to reduce settlement rates. Meanwhile, Ahmad (2016) in his book entitled Basic Engineering Design of the Kertosono - Kediri Toll Road [2] which states a recommendation replacement on soft soil of a maximum of 2.00 m depth to reduce the settlement rate and to increase the bearing capacity of the foundation, suggests using a mixture of soil-cement, as well as installing a geo-membrane that is impermeable to water horizontally or vertically drain water trapped in the embankment. Provide preloading or surcharge for the pressure due to the expansion of the soft soil layer. Pramono (2019) in his book entitled Detail Engineering Design of the Kertosono - Kediri Toll Road [3] states that it provides a method of installing pre-vabricated vertical drain (PVD) to reduce settlement rates.

Related with the final report of the detailed engineering design work contract carried out by the consultant, the project owner will tender the work to the construction stage. Then the author tries to provide an alternative minipile installation to reduce the settlement rate significantly and shorten the implementation time schedule. This problem makes the subject matter for the author to assist the project owner in carrying out the analysis and calculations of the existing design.

The study to improve the soft soil foundation using the minipile, mentioned above was chosen by the author due to considerations of easier implementation and effects of handling soft soil both from a technical point of view, namely to reduce the settlement rate and the project implementation schedule that has been regulated in the service provider contract construction.

The conclusion from the results of the analysis of soil improvement on soft soil will be applied to the Kertosono - Kediri highway toll, especially at locations where there is an indication soft soil layer in accordance with the results of the soil investigation in 2019. The results of the analysis will be recommended through the results of the analysis and the calculation of the reduction settlement value and increase the safety factor. These results will be recommended to the project owner to be applied in the project site.

Not only from a technical point of view that will be recommended, but the author will also analysis the time schedule for the implementation of the work mentioned above. The author will provide the advantages and disadvantages of this method with the methods of previous researchers.

II. STUDY LITERATURE

In the feasibility study phase, basic engineering design and in the detailed engineering design phase, which is prepared by several geotechnical experts related to the results of the soil investigations they have carried out and the proposed soil improvement method.

The 20.30 km Kertosono – Kediri highway toll consists of various types of structures to support the facilities and infrastructure of this highway toll. The various types of structures, there are foundations on soft soil layer. One of the structure was found in STA. 19 + 707 is located at the abutment Box Underpass Interchange Maron plan. Soft soil according to Terzaghi (1967) is soil that has a category N-SPT value $\leq$ 4 and has a soil bearing capacity value or qu $\leq$ 25 kPa. From the soil investigation data, the value of N-SPT $\leq$ 4 was found of 6.00 m depth. Meanwhile, the embankment height in the area reaches a height of almost 8.00 m.

From the value of N-SPT 0 – 4 according to

Terzaghi, K. and Peck, R. B., Soil (1967) Mechanic in Engineering Practice, 2nd Edition, [4] as follows:

Sub Unit	N-SPT Value	Consistency Unconfined	Compressive Strength qu (kPa)
1.1	$\leq$ 4	Very Soft to Soft	$\leq$ 25
1.2	4 - 10	Medium	25 - 50
1.3	10 - 25	Stiff	50 - 100
1.4	$\geq$ 25	Stiff to Very stiff	$\geq$ 100

From the above conditions require special soil improvement handling, especially to minimize the settlement rate and increase the number of safety factors for the embankment slopes stability.

III. RESEARCH METHODS

The data used by the authors for this study were obtained from the results of geotechnical drilling and laboratory testing of undisturbed samples that had been carried out by previous researchers, namely at the stage of detailed engineering designs. The data grouping is divided into data obtained from geotechnical drilling tests, namely data on the N-SPT number in each drill hole as much as 2 points and from the results of laboratory tests that have been carried out from undisturbed soil sampling (UDS). In accordance with the standards of undisturbed soil sampling according to Bowles (1997). Foundations Analysis and Design. McGraw-Hill Book Co, Fifth Edition. Singapore. [5] and according to the National Standardization Agency (2017). Geotechnical Design and Requirements. SNI. 8460-2017. BSN. Jakarta. [6].

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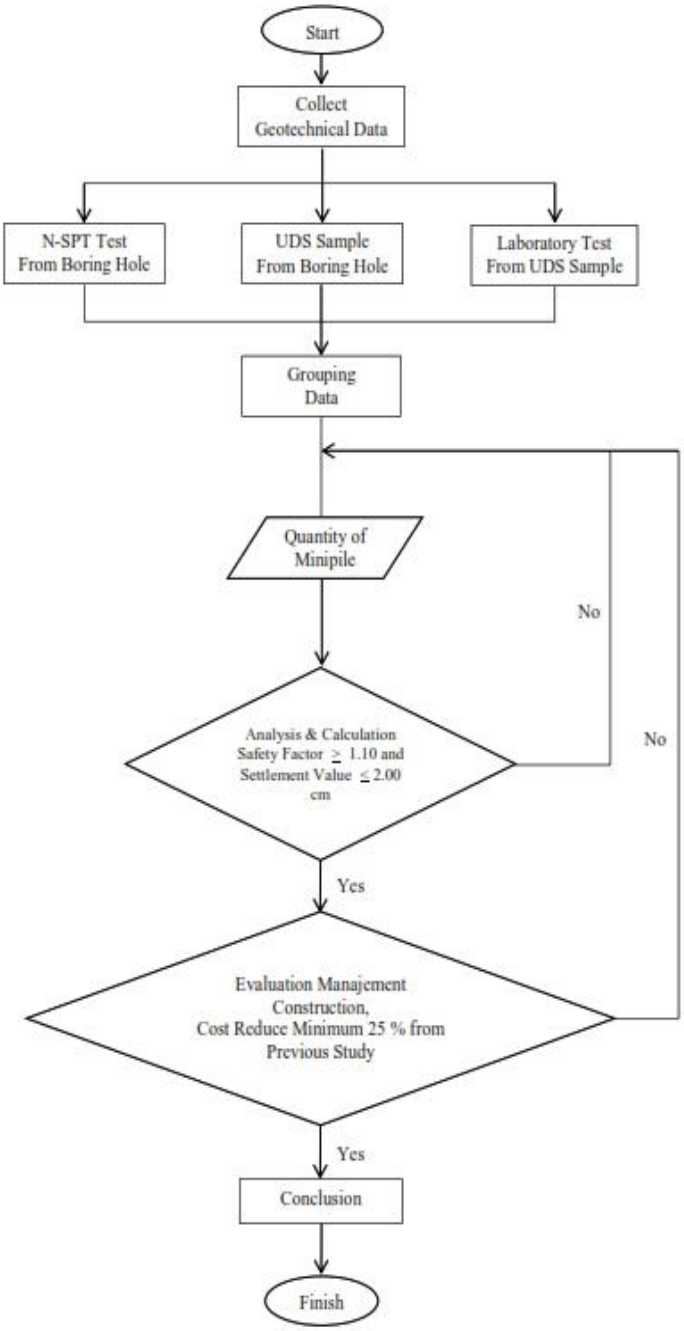
The data analysis used by the author in analyzing the data is presenting, evidence and data consisting of testing, categorizing, tabulating parameters obtained from soil investigation data and laboratory tests. The main requirements that will be analyzed in the discussion, especially on the soft soil improvement method above are as follows:

1. Analysis of settlement using minipile.
2. Analysis of the safety factor for embankment slope stability using a minipile.

Meanwhile, from the aspect of the work schedule, the author recommends the most effective and efficient method of easier project implementation schedule.

The flow chart that is focused on the study is settlement analysis and slope stability analysis after minipile installation, the analysis in a flowchart diagram as below.



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IV. ANALYSIS

1.1 Design Criteria

1.1.1 Settlement

The required settlement during the construction period is ≥ 90% (S/Stot) and the rate of settlement is ≤ 20 mm/year. The settlement that occurs during construction before the pavement is implemented (Geotechnical Guide 4 – Road Piles on Soft Soil, Center for Transportation Infrastructure Research and Development 2001). During the construction period the maximum allowable decrease is 20 mm and the first 10 years after construction is 10 cm.

Faktor Keamanan	Galian	Timbunan	
		Jalan Tol	Oprit**
Jangka pendek	1.50	1.30	1.70
Jangka panjang	1.40*	1.50	1.70
Gempa	1.10	1.10	1.10

1.1.2 Safety Factor For Slope Stability

All analysis shall be based on analysis in earthquake conditions. Because the condition of the earthquake is considered the most critical condition. According to the Research & Development Center for Kimpraswil Ministry of PUPR (2017). Map of Indonesia's Earthquake Sources and Hazards. ISBN - 978 602 5489 01 3. Jakarta. [7]. The following are design criteria that must be met when earthquake conditions occur, as shown in the table below.

1.2 Design Parameter

Design parameters are generated from the results of soil investigations and laboratory testing that have been completed by previous researchers at the detailed engineering design stage. Below is a table of design parameters used in the input software for calculating and analyzing slope stability as follows:

1.2.1 Density

No	STA	Soil Type	Sub Unit	γ kN/m3
1	STA. 18 + 000 Sampai STA. 20 + 300	Clay Very Soft to Soft	1.1	15.00
2		Clay Medium	1.2	16.00
3		Clay Stiff to Very Stiff	1.3	17.00
4		Clay Hard	1.4	18.00
5		Sand Loose	2.1	17.00
6		Sand Medium Dense	2.1	19.00
7		Sand Dense	2.3	20.00

1.2.2 Consolidation

No	STA	Soil Type	Sub Unit	Cv %	Cc %	Eo %
1	STA. 18 + 000 Sampai STA. 20 + 300	Clay Very Soft to Soft	1.1	2.890E-04	0.197	0.288
2		Clay Medium	1.2	2.860E-04	0.196	0.286
3		Clay Stiff to Very Stiff	1.3	N/A		N/A
4		Clay Hard	1.4	N/A		N/A

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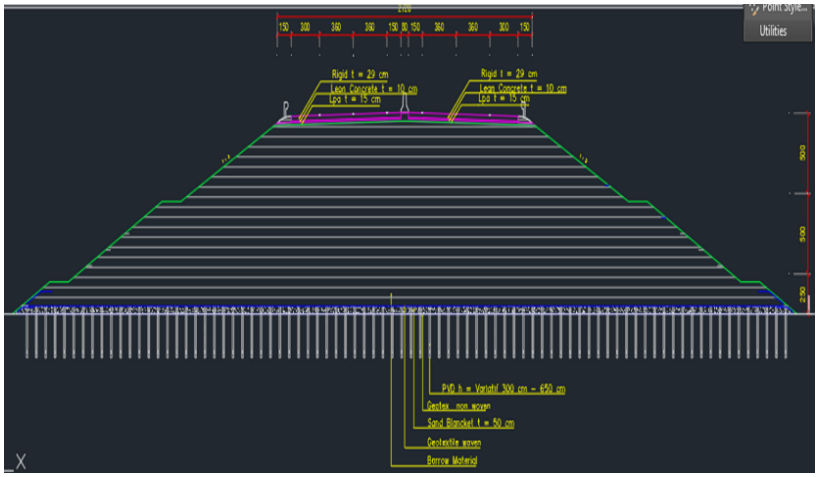
1.2.3 Shear Strength From N-SPT Value

No	STA	Soil Type	Sub Unit	Su kN/m2
1	STA. 18 + 000 Sampai STA. 20 + 300	Clay Very Soft to Soft	1.1	22.00
2		Clay Medium	1.2	50.00
3		Clay Stiff to Very Stiff	1.3	125.00
4		Clay Hard	1.4	150.00
5		Sand Loose	2.1	50.00
6		Sand Medium Dense	2.1	125.00
7		Sand Dense	2.3	170.00

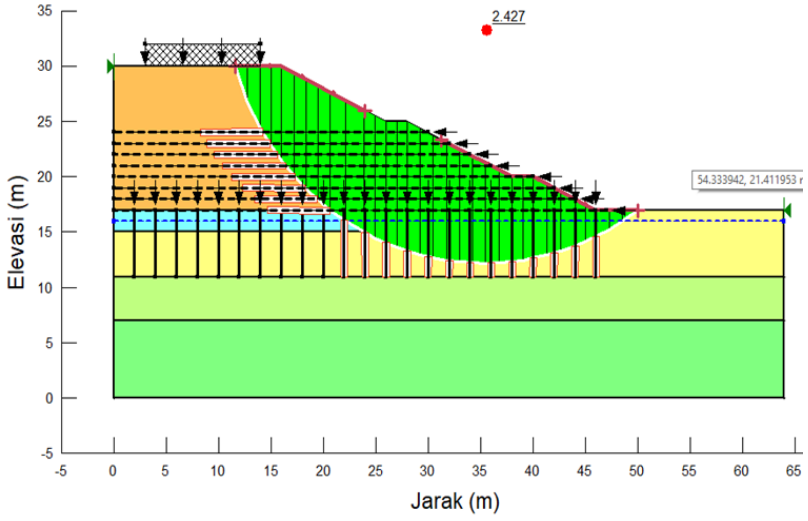
1.3 Analysis And Modelling

1.3.1 Cross Section



1.3.2 Safety Factor

a. Normal Conditions



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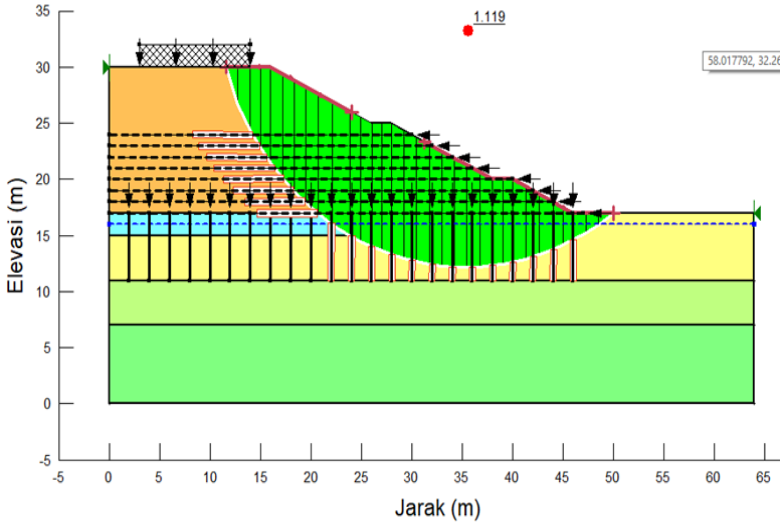
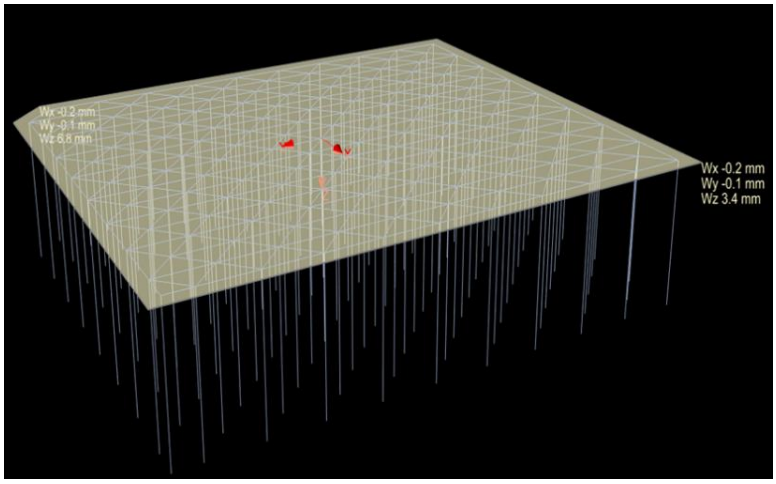
b. Earthquake Conditions

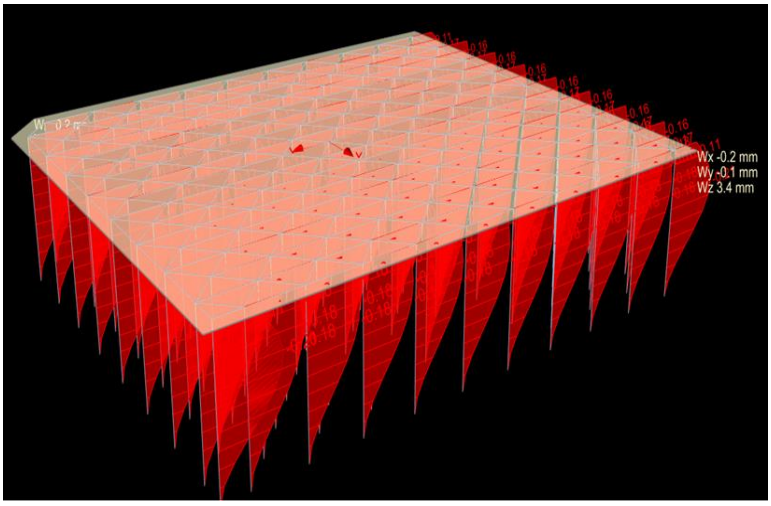


1.3.3 Settlement

a. Minipile Installation Modelling



b. Moment



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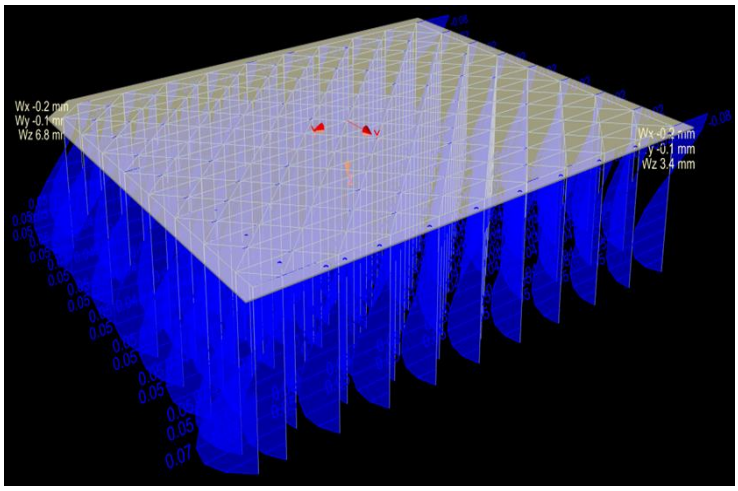
c. Shear Forces



From the three pictures above, it can be summarized that the maximum bending moment that occurs is 0.40 kN.m while the quality of the minipile is able to restraint the bending moment of 35.4 kN.m so it can be concluded that the bending moment number that occurs is still below the bending moment that it can restraint by the minipile. Meanwhile, the settlement rate that occurs is 6.8 mm or 0.68 cm, which is still smaller as required by the design criteria, which is a maximum of 2.5 cm.

From the two aspects of the analysis and calculation results, both the slope stability safety and the settlement that occurs can be recapitulated in the table below.

Jenis Analisa	Kriteria Desain	Perhitungan	Keterangan
1. Angka Keamanan Kondisi Normal	1.50	2.427	Aman
2. Angka Keamanan Kondisi Gempa	1.10	1.119	Aman
3. Settlement	25 mm	6.8 mm	Aman

From the analysis of the soft soil improvement method using a minipile, it can technically be the safety factor under normal conditions which is still above 1.50 and in the earthquake conditions it is still above 1.10. The settlement rate also still not exceed from design criteria, which is $\leq$ 25 mm. So the two technical requirements, both the settlement rate and the slope stability rate, can be concluded that can still be met by the soft soil improvement method using a minipile

1.4 Cost Analysis

From the total volume of minipile installation work along the 50 m length of the soft soil improvement area, it has a total volume of 20 unit of longitudinal direction, 17 unit of wide direction and 6.00 m depth at each point. The total volume of the minipile is 2040 m'.

The minipile installation is to reduce the settlement rate, besides that it is also to get the expected soil bearing capacity. Soft soil improvement method with minipile has been widely used. When compared to the consolidation process using other methods, the soft clay consolidation process occurs faster if other methods are installed. This shows that the process to obtain the expected settlement will be obtained quickly because the minipile is planted at a depth of hard soil at 6.00 m depth. In this study, the minipile installation pattern used is a triangular pattern with a distance of 1.50 m.

Below, in the terms of cost analysis or construction costs for the soil improvement methods using a minipile, it can be seen in the table below:

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Table Unit Price of Equipment Kediri Regency 2019

No	Nama Peralatan	Satuan	Harga Satuan (Rp)
1	Bulldozer 100-500 HP	unit/jam	686.638
2	Compressor 4000-6500 L\M	unit/jam	191.568
3	Concrete Breaker	unit/jam	743.315
4	Crane 10-15 Ton	unit/jam	620.391
5	Crane on Track 35 Ton	unit/jam	507.674
6	Crane on Track 75 - 100 Ton	unit/jam	784.314
7	Dump Truck 12 Ton	unit/jam	540.594
8	Dump Truck 3,5 Ton	unit/jam	323.175
9	Excavator 80-140 HP	unit/jam	465.606
10	Flatbed Truck 3-4 m3	unit/jam	318.963
11	Minipile Drop Hammer	unit/jam	90.250
12	Generator Set	unit/jam	73.545
13	Jack Hammer	unit/jam	52.596
14	Pile Driver + Hammer	unit/jam	221.792
15	Rock Drill Breaker	unit/jam	46.655
16	Tamper	unit/jam	55.933
17	Tandem Roller 6-8 T	unit/jam	460.978
18	Tire Roller 8-10 T	unit/jam	494.355
19	Trailer 20 Ton	unit/jam	626.036
20	Tree Wheel Roller 6-8 T	unit/jam	269.258
21	Tronton	unit/jam	539.133
22	Vibratory Roller 5-8 T	unit/jam	431.124
23	Water Pump 70-100 mm	unit/jam	55.096
24	Water Tanker 3000-4500 L	unit/jam	290.660
25	Welding Set	unit/jam	13.003
26	Wheel Loader 1,0-1,6 m3	unit/jam	504.389

Sources: HPS Kediri Regency - East Java Province 2019.

Table Unit Price of Human Resources Kediri Regency 2019

No.	Deskripsi	Satuan	Harga Satuan (Rp.)
1.	Pekerja	Jam	17.380
2.	Tukang	Jam	19.384
3.	Mandor	Jam	22.142
4.	Operator	Jam	22.568
5.	Pembantu Operator	Jam	17.182
6.	Sopir / Driver	Jam	19.857
7.	Pembantu Sopir / Driver	Jam	16.300
8.	Mekanik	Jam	22.388
9.	Pembantu Mekanik	Jam	18.379
10.	Kepala Tukang	Jam	19.867

Sources: HPS Kediri Regency - East Java Province 2019

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Table Coefficient Analysis Mobilization Work of Minipile

NO. MATA PEMBAYARAN : 10.05 (4a)
JENIS PEKERJAAN : Mob & Demob Minipile Segitiga 32 x 32 cm
SATUAN PEMBAYARAN : M1

No.	URAIAN	KODE	KOEF.	SATUAN
I.	**Asumsi**			
1.	Pekerjaan dilakukan secara mekanis			
2.	Lokasi pekerjaan : sepanjang jalan proyek			
3.	Kondisi jalan : sedang/baik			
4.	Jam kerja efektif per hari	Tk	7,0000	Jam
5.	Faktor kehilangan bahan	Fk	1,0000	-
6.	Truk trailer sekali angkat	btg	12,0000	btg
7.	Panjang	Pj	12,0000	m
II	**Urutan Kerja**			
1	Besi tulangan dibengkokan dan dipotong sesuai kebutuhan			
2	Truck mengangkut materaial kelapangan	L	117,0	km
3	Besi tulangan dipasang sesuai gambar kerja dan persilalgan diikat kawat bendrat			
III	**Pemakaian Bahan, Alat Dan Tenaga**			
1	**BAHAN**			
1.a	Minipile Beton Persegi Pretensioned, 32 x 32 cm		1,000	m1
2	**ALAT**			
2.a	Crane			
	Kapasitas	V	1,000	
	Faktor Efisiensi alat	Fa	0,830	-
	Waktu siklus			
	- memasang ikatan dan melepas	T1	2,000	Menit
	- Waktu memuat dan membongkar	T2	5,000	Menit
	- dan lain-lain (termasuk mengatur dan menggeser)	T3	3,000	Menit
		Ts1	10,000	Menit
	Kap. Prod / Jam = (V x Fa x Bj x Pj):(Ts1/60)	Q1	143,424	m1/jam
	Koef. Alat / M^2 = 1 : Q1		**0,006972**	jam
2.b	Flat Bed Truck w/ Crane 4 m3 / 4 Ton			
	Kapasitas Bak	V	144,0000	m1
	Faktor Efisiensi alat	Fa	0,8300	-
	Kecepatan rata-rata bermuatan	v1	30,0000	Km/jam
	Kecepatan rata-rata kosong	v2	35,0000	Km/jam
	Waktu siklus	Ts2		
	- Waktu Tempuh isi = (L : v1) x 60	T1	234,0000	Menit
	- Waktu tempuh kosong = (L : v2) x 60	T2	200,5714	Menit
	- Mengisi bak = (V : Q1) x Ts1 x 60	T3	120,0000	Menit
	- Tunggu + dump + berputar	T4	60,0000	Menit
		Ts2	614,5714	Menit
	Kap. Prod / Jam = (V x Fa x 60) : (FkxTs2)	Q2	11,6686	m1/jam
	Koef. Alat / M^2 = 1 : Q2		**0,0857**	

Sources: Analysis & Calculations

Table Human Resources Coefficient Analysis Mobilization Work of Minipile

NO. MATA PEMBAYARAN : 10.05 (4a)
JENIS PEKERJAAN : Mob & Demob Minipile Segitiga 32 x 32 cm
SATUAN PEMBAYARAN : M1

No.	URAIAN	KODE	KOEF.	SATUAN
3.	**TENAGA**			
	Produksi menentukan	Q	11,6686	kg/jam
	Produksi /hari = Tk x Q	Qt	81,6803	kg/hari
	Kebutuhan tenaga :			
	- Pekerja	P	10,0000	orang
	- Mandor	M	1,0000	orang
	- Tukang	O	2,0000	orang
	Koefesien tenaga/m3 :			
	- Pekerja = (Tk x P) : Qt		**0,8570**	Jam
	- Mandor = (Tk x M) : Qt		**0,0857**	Jam
	- Tukang		**0,1714**	Jam

Sources: Analysis & Calculations

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Table Coefficient Analysis Pilling Work

URAIAN ANALISA HARGA SATUAN

NO. MATA PEMBAYARAN 10.05 (4a)
JENIS PEKERJAAN Pemancangan Minipile Segitiga, 32 x 32 cm
SATUAN PEMBAYARAN M1

No.	URAIAN	KODE	KOEF.	SATUAN
I.	**Asumsi**			
1.	Pekerjaan dilakukan secara mekanis			
2.	Lokasi pekerjaan : sepanjang jalan proyek			
3.	Kondisi jalan : sedang/baik			
4.	Jam kerja efektif per hari	Tk	7,0000	Jam
5.	Faktor kehilangan bahan	Fk	1,0000	-
6.	Panjang pancang	P	6,0000	m
7.	Kedalaman pancang	Pj	6,0000	m
II	**Urutan Kerja**			
1	Besi tulangan dibengkokan dan dipotong sesuai kebutuhan			
2	Truck mengangkut materaial kelapangan	L	117,0	km
4	Besi tulangan dipasang sesuai gambar kerja dan persilalgan diikat kawat bendrat			
III	**Pemakaian Bahan, Alat Dan Tenaga**			
1	**BAHAN**			
1.a	Kawat las		2,025	kg
2	**ALAT**			
2.a	Pile Driver hammer			
	Kapasitas	V	1,000	titik
	Faktor Efisiensi alat	Fa	0,830	-
	Waktu siklus			
	- penggeseran dan penyetelan	T1	20,000	Menit
	- Pemancangan sampa final set 3 cm	T2	45,000	Menit
	- Waktu penyambungan tiang	T3	10,000	Menit
		Ts1	75,000	Menit
	Kap. Prod / Jam = (V x Fa x Pj x 60) : (Ts1)	Q1	3,984	ml/jam
	Koef. Alat / M^3 = 1 : Q1		**0,251004**	jam
2.b	Generator set			
	Kapasitas prod/jam	Q2	3,9840	ml/jam
	Koefisien alat/m3 = 1 : Q4		**0,2510**	Jam
2.c	Welding set			
	Kapasitas prod/jam	Q3	3,9840	ml/jam
	Koefisien alat/m3 = 1 : Q4		**0,2510**	Jam

Sources: Analysis & Calculations

Table Human Resources Coefficient Analysis For Pilling Work

NO. MATA PEMBAYARAN **10.05 (5b)**
JENIS PEKERJAAN **Pemancangan Minipile Segitiga, 32 x 32 cm**
SATUAN PEMBAYARAN **M1**

No.	URAIAN	KODE	KOEF.	SATUAN
3.	**TENAGA**			
	Produksi menentukan	Q1	3,9840	m'/jam
	Produksi /hari = Tk x Q1	Qt	27,8880	m'/hari
	Kebutuhan tenaga :			
	- Pekerja	P	10,0000	orang
	- Mandor	M	1,0000	orang
	- Tukang	O	2,0000	orang
	Koefesien tenaga/m3 :			
	- Pekerja = (Tk x P) : Qt		**2,5100**	Jam
	- Mandor = (Tk x M) : Qt		**0,2510**	Jam
	- Tukang		**0,5020**	Jam
IV	**HARGA DASAR SATUAN UPAH, BAHAN DAN ALAT**			
	Lihat lampiran			
V	**ANALISA HARGA SATUAN PEKERJAAN**			
	Lihat perhitungan dalam :			
	ANALISA HARGA SATUAN BAHAN DAN PEKERJAAN			
VI	**MASA PELAKSANAAN YANG DIPERLUKAN**			
	Masa pelaksanaan :			
VII	**VOLUME PEKERJAAN YANG DIPERLUKAN**			
	Volume pekerjaan :			

Sources: Analysis & Calculations

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Table Unit Price Analysis Equipment Mobilization of Equipment

NAMA MATA PEMBAYARAN	10.05 (4a)
NOMOR MATA PEMBAYARAN	Penyedian Minipile Beton Triangel 32 x 32 cm
SATUAN PENGUKURAN	M.15
HARGA SATUAN	Rp 224.254,55

NO.	URAIAN	SATUAN	VOLUME	HARGA SATUAN (Rp)	TOTAL
A	Tenaga				
L01	Pekerja Biasa	Jam	0,85700	11.340,00	9.718,37
L03	Mandor	Jam	0,08570	17.450,00	1.495,46
L02.1	Tukang	Jam	0,17140	14.070,00	2.411,60
				SUB TOTAL	13.625,43
B.	Bahan				
M471	Tiang pancang persegi 32 x 32 cm	m'	1,00000	141.000,00	141.000,00
				SUB TOTAL	141.000,00
C.	Peralatan				
E07	Crane 25 - 50 T	Jam	0,00697	507.674,00	3.539,67
E11	Flat Bed + Crane Truck 10 Ton	Jam	0,08570	533.287,00	45.702,67
				SUB TOTAL	49.242,34
D	Jumlah Harga Tenaga, Bahan Dan Peralatan (D=A+B+C)				203.867,77
E	OVERHEAD & PROFIT 10% x D				20.386,78
F	HARGA SATUAN PEKERJAAN (D + E)				224.254,55

Sources: Analysis & Calculations

Table Unit Price Analysis For Pilling Work

NAMA MATA PEMBAYARAN	10.05 (4a)
NOMOR MATA PEMBAYARAN	Pemancangan Minipile Segitiga, 32 x 32 cm
SATUAN PENGUKURAN	M1
HARGA SATUAN	Rp 92.713,00

NO.	URAIAN	SATUAN	VOLUME	HARGA SATUAN (Rp)	TOTAL
A	Tenaga				
L01	Pekerja Biasa	Jam	2,51004	11.340,00	28.463,86
L03	Mandor	Jam	0,25100	17.450,00	4.380,02
L02.1	Tukang	Jam	0,50201	14.070,00	7.063,25
				SUB TOTAL	39.907,13
B.	Bahan				
				SUB TOTAL	-
C.	Peralatan				
E53	Mini Pile Drop Hammer	Jam	0,25100	90.250,00	22.653,11
E12	Generator Set 250 Kva	Jam	0,25100	73.545,00	18.460,09
E32	Welding Set	Jam	0,25100	13.003,00	3.263,81
				SUB TOTAL	44.377,01
D	Jumlah Harga Tenaga, Bahan Dan Peralatan (D=A+B+C)				84.284,14
E	OVERHEAD & PROFIT 10% x D				8.428,41
F	HARGA SATUAN PEKERJAAN (D + E)				92.712,55

Sources: Analysis & Calculations

The table above explains that the unit price of work for minipile materials (triangel 32 x 32 x 32 cm) and piling is IDR. 646.610.640,- is the unit price of 1 m' of material and minipile erection. The price includes VAT and profit of 10% of the total price of materials and erection. The table below describes in detail the total price for for minipile installation (triangle 32 x 32 x 32 cm) for of 50 m' length with a total of 20 piece longitudinal section, 17 piece width and 6.00 m depth.

Table Recapitulations Unit Price of Installation Minipile (Triangle 32 x 32 x 32 cm).

No	*Deskripsi Pekerjaan*	*Satuan*	*Volume*	*Harga Satuan*	*Harga*
2	Minipile				
	- Mobilisasi Tiang Minipile 32 x 32 cm	m'	2040	Rp. 224.254,00	Rp. 457.478.160,00
	- Pemancangan	m'	2040	Rp. 92.712,00	Rp. 189.132.480,00
				TOTAL	*Rp. 646.610.640,00*

Sources: Analysis & Calculations.

1.5 Schedule Analysis

The overall time schedule for the construction work of the Kertosono - Kediri Toll Road takes 18 months which is planned to be auctioned in early 2023. Although the author's main goal is to improve the cost efficiency of soft soil improvement work, it cannot be separated from the issue of the most effective implementation time schedule.

From the analysis technical and cost calculations in the previous chapter, in terms of time schedule for the implementation of the soft soil improvement work using miniple, there is a difference of 1 month faster than that proposed by the previous author. This is due to the soil improvement of soft soil with minipile, in the process the piles can be directly pilling without waiting for the consolidation time. This is because the minipile is installed at hard soil with 6.00 m depth. This means that in evaluating soft soil improvement work using a minipile it takes a total of 18 months, while for soft soil improvement work using other methods such as PVD installation it will take a total of 19 months. From the foregoing, it can be concluded that the proposed time for soil improvement soft soil using minipile takes 1 month faster than what the previous author proposed, namely repairing soft soil using PVD.

From the time difference between the implementation of the soft soil improvement using minipile, it can be concluded that the use of minipile is still more effective and efficient for soil improvement soft soil in the STA. 18 +000 up to STA. 20 +300 highway toll Kertosono - Kediri.

V. CONCLUSSIONS AND RECOMMENDATIONS

Based on the analysis and calculations in the previous chapter, it was obtained a recapitulation of the safety factor of slope stability the embankment and calculation of settlement, financing plans and time schedule for work implementation. From the results of the soil improvement method of handling soft soil using a minipile, it can be recommended to the owner of the Kertosono - Kediri highway toll.

According to Dipohusodo (1996). Project Management and Construction Volume 1. Yogyakarta: Kanisius. [8]. The things that underlie the selection of the minipile are:

1. Very significant cost reduction 29.84 % from the cost of using the previous method.

2. In terms of the time schedule, minipile installation only takes 18 months, 1 month faster than the theory suggested by the previous author, which takes 19 months.

3. From the technical aspect, the long-term settlement rate is still below 25 mm, namely 6.8 mm. The number safety factor is still more than 1.10 for the most critical condition, namely analysis during an earthquake, which is 1.119.

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