

ANALISIS TIMBUNAN RINGAN MORTAR BUSA MENGGUNAKAN MESIN KONVERSI ENERGI PADA PROYEK FLY OVER

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ABSTRACT

The relatively high population growth rate as a result of the development in South Tangerang City has caused traffic jams during rush hour at the Gaplek intersection. This congestion can be minimized by constructing a Martadinata flyover without disturbing the existing transportation movements. Heap construction is often faced with several problems, including stability and reduction problems due to the weight of the pile load, due to vehicle traffic loads, and due to being above soft soil layers. This study aims to obtain the magnitude of the carrying capacity of the subgrade under light weight foam mortar, to obtain the amount of stability and reduction of light weight foam mortar to soft soil behavior. Comparative research to get a comparison between manual calculation and finite element calculation method plaxis 8.2 software. The results of the bearing capacity of the soil under lightweight foam mortar at a soil depth of 1.5 meters and 10 meters, the soil bearing capacity is 366,481 kN/m² and 376,295 kN/m². The stability results of the lightweight foam mortar pile above the soft soil layer due to the weight of the pile load of 3.52 and 12.53 due to vehicle traffic loads of 3.05 and 9.54 have met the minimum safety factor requirements for road class 1 of 1.4. The results of the reduction of light weight foam mortar are above the soft soil layer due to the weight of the embankment load of 11.91 mm/year and 12.61 mm/year, due to vehicle traffic loads of 15.25 mm/year and 20.06 mm/year. meet the criteria for road embankment reduction of 20mm/year. So it can be concluded that the foam mortar stockpile at the Martadinata Pamulang Tangerang Selatan flyover has met the requirements in the technical planning guidelines for lightweight foam mortar pile on soft soil.

Keywords: flyover, embankment, foam mortar, stability, settlement, conversion energy machine

INTRODUCTION

The relatively high rate of population growth as a result of development in South Tangerang City creates its own problems in terms of providing services needed by the community in the infrastructure sector at Simpang Gaplek, which experiences traffic jams during morning and evening rush hours until evening.

This requires improvements in transportation facilities and infrastructure services, both roads and bridges, so that this congestion can be minimized by constructing the Martadinata flyover at Simpang Gaplek without disrupting existing transportation movements.

The construction of the Martadinata flyover was used as the object of analysis for the Final Project at Simpang Gaplek Jalan Raya Martadinata, Pamulang, South Tangerang. It is necessary to pay attention to the embankment construction on the Martadinata flyover in relation to the condition of the subgrade, aimed at obtaining a soil structure that has adequate bearing strength, both subgrade and road pavement base foundations.

Embankment construction is often faced with several problems, including problems of stability and settlement due to the own weight of the road embankment, due to the load of vehicle traffic, and due to being on top of soft soil layers in subgrade conditions with low bearing capacity.

Problems in embankment construction can be overcome by using lightweight foamed embankment mortar or also known as "high grade soil" which was developed using an energy conversion machine as a technological innovation because it has several advantages and optimal use. The lightweight foam mortar material is a mixture of sand, cement, water and foam (foam agent).

The important thing in using lightweight foam mortar material as a road embankment material is that it has the characteristics of a light bulk with a fairly high strength as a subgrade, and the compressive strength can be designed according to wishes so that it is expected to reduce the occurrence of stability and settlement problems.

Based on the description explained above, the construction of embankments using light foam mortar materials on the Martadinata flyover requires research to determine the amount of soil bearing capacity, stability and settlement that occurs, so the author took the title: "Analysis of Light Foam Mortar Embankments on the Martadinata Pamulang Flyover South Tangerang".

METHODS

3.1 General Description

In processing the data, the author conducted research at Simpang Gaplek Jalan Martadinata, Pamulang, South Tangerang. Preparation is a series before starting data collection and processing. In the preparation stage, things are arranged that must be done with the aim of making the final project writing time and work more effective. This preparation stage includes activities including:

1. Site survey to get an overview of the project,
2. Determine data needs,
3. Literature study of previous research,
4. Making a proposal for the preparation of the Final Project.

3.2 Research Location

research location for the construction of the Martadinata flyover at Simpang Gaplek Jalan Martadinata, Pamulang, South Tangerang.

3.3 Types of Research Data

Writing a Final Assignment requires data that is used as a writing reference. The types of data used are:

General data is data obtained from the Martadinata Flyover construction project at Simpang Gaplek Jalan Martadinata, Pamulang, South Tangerang, namely machine drilling data, planning drawing data, laboratory data.

Secondary data is data obtained from literature related to this research and data originating from several related agencies, namely the Public Works Department of Highways, PUPR Road and Bridge Research and Development Center, Contractors and Consultants, both planners and supervisors.

3.4 Data Analysis Plan

In carrying out this research, there is a data analysis plan to determine the bearing capacity of the subgrade, stability and settlement of the pile of lightweight foam mortar material. The formula used in this data analysis is

1. Analysis of basic soil data
2. Analysis of embankment geometry data and traffic loads
3. Data analysis of lightweight foam mortar materials
4. Calculation of embankments manually and software using the finite element method using the plaxis 8.2 application
5. Discussion regarding bearing capacity, stability and settlement of embankments

RESULTS AND DISCUSSION

4.1 Soil Data

The soil data used in this final project is machine drill data (bore log) obtained from taking soil investigation test samples at 4 (four) points at the Gaplek Flyover Interchange, Martadinata. The coordinate location points for soil investigations can be seen in Table 4.1. as follows :

Table 4.1. Soil Investigation Coordinates

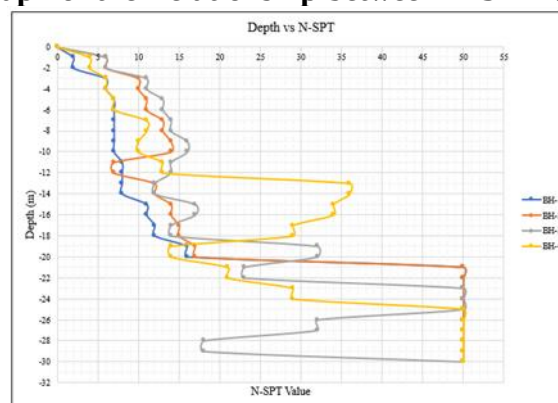
Titik Bor	X	Y	Lokasi
BH-1	0693567	09298153	STA 0+500
BH-2	0693534	09298132	STA 0+500L
BH-3	0693562	09298150	STA 0+475R
BH-4	0693562	09298082	STA 0+450L

Source: PT. Maratama Soil Laboratory

Based on the coordinate points of the soil investigation, the soil data available on the Martadinata flyover is BH-1, BH-2, BH-3, BH-4. then the next step is to combine the N-SPT results from the 4 (four) soil investigation location points.

The combined N-SPT results from the 4 (four) soil investigation location points can also be seen in the form of a graph of the relationship between N-SPT values and depth in **Figure 4.1.**

Figure 4.1. Graph of the Relationship between N-SPT Value and Depth



Source: Analysis Results

4.2 Load Data

The Martadinata Flyover is a primary road network that connects the National Activity Center (PKN) and the Regional Activity Center (PKW) so that the loads that are taken into account include: road pavement load (pavement), traffic load (qLL), and loads due to the weight of the embankment. lightweight foam mortar.

1. Road Pavement Load

Road pavement loads can be seen in Table. 4.2. as follows :

Table. 4.2 Pavement Loads

Jenis Beban	Tebal Perkerasan (cm)	Berat Volume (kN/m ³)
Perkerasan Lentur/Aspal	5	1,2
Perkerasan Lantai Beton	25	6
Aksesoris Barrier	-	7,84
Total Beban Perkerasan Jalan (pavement)		15,04

Source: Analysis Results

2. Traffic Load

The traffic load on the Martadinata flyover is 15 kN/m².

3. Loads Due to the Weight of Light Foam Mortar Filling.

Loads due to the weight of lightweight foam mortar can be seen in the table. 4.3. as follows :

Table. 4.3 Foam Mortar Backfill Load

Lokasi	Tinggi Timbunan (m)	Tinggi Perkerasan (m)	Total Tinggi Timbunan (m)	Beban Timbunan (kN/m ²)	Berat Timbunan Dan Beban Lalu Lintas (kN/m ²)
	Htimb	Hperkerasan	Htotal	q timb	q rata-rata
STA 0+300	0,5	0,36	0,86	5,16	35,2
STA 0+325	1	0,36	1,36	8,16	38,2
STA 0+350	2	0,36	2,36	14,16	44,2
STA 0+375	4	0,36	4,36	26,16	56,2
STA 0+400	5	0,36	5,36	32,16	62,2
STA 0+425	7	0,36	7,36	44,16	74,2
STA 0+450	7,5	0,36	7,86	47,16	77,2

Source: Analysis Results

4.3 Stockpile Data

In this final project, embankment data analysis will be carried out consisting of the physical material of lightweight foam mortar embankments, embankment geometry data and embankment dimensions at stationing points on the Martadinata flyover. The Martadinata Flyover has a total flyover length of 400 meters from station point STA 0+300 to STA 0+700 consisting of two sides of embankment which have a length of 150 meters. The embankment location points that will be reviewed are only on the Parung – Bogor side from station point STA 0+300 to STA 0+450. The embankment length, embankment width and embankment height use the following planning data, namely:

- Embankment width = 17.5 meters
- Heap height = 7.86 meters
- Length of embankment = 150 meters
- Longitudinal slope of embankment = 5%
- Transverse embankment slope = 3%

Stockpile data can be seen in Table. 4.4. as follows :

Table. 4.4. Heap Data STA 0+300 Up to STA 0+450

Lokasi	Tinggi Timbunan (m)	Lebar Timbunan (m)	Panjang Timbunan (m)
STA 0+300	0,86	17,5	25
STA 0+325	1,36	17,5	25
STA 0+350	2,36	17,5	25
STA 0+375	4,36	17,5	25
STA 0+400	5,36	17,5	25
STA 0+425	7,36	17,5	25
STA 0+450	7,86	17,5	0

Source: Analysis Results

Data on the filling of lightweight foam mortar material and the geometry of the lightweight foam mortar filling. The physical properties of foam mortar light embankment material can be seen in Table 4.5. below as follows:

Table. 4.5. Physical Properties of Foam Mortar Light Fill Material

Parameter Properties	Timbunan Ringan Mortar Busa		Unit
Soil unit weight above phreatic level	γ_{unsat}	6	kN/m ³
Soil unit blow phreatic level	γ_{sat}	6	kN/m ³
Poisson's ratio	ν	0.15	-
Young's modulus (constant)	E_{ref}	892600	kN/m ²

Source: Analysis Results

4.4 Heap Crisis Height

Calculation of the critical height of the embankment is carried out to determine the initial value of embankment stability. The calculation of the critical height of the embankment at the location point STA 0+300 to STA 0+450 on the Martadinata flyover was carried out on soft clay and silty clay.

$$H_c = \frac{4C_u}{\gamma}$$

$$H_c = \frac{4 \times 20}{6}$$

$$H_c = 13,33 \text{ m,}$$

$$H_c > H = 13,33 \text{ m} > 7,86 \text{ m}$$

The critical embankment height is greater than the design embankment height so it meets the requirements. If the height of the embankment exceeds the critical height, then part of the embankment must be dismantled.

4.5 Calculation of Carrying Capacity

The bearing capacity of the subgrade is needed to determine the ability of the subgrade under light embankment of foam mortar to accept the working load. Calculation of the soil bearing capacity at location points STA 0+300 to STA 0+450 on the Martadinata flyover was carried out on soft soil with the soil layers being examined being the soft clay layer and the silty clay layer under the embankment with a depth of 1.5 meters and 10 meters being considered.

$$q_{ult} = cN_c + \gamma D_f N_q + 0,5 B_w N_\gamma$$

$$q_{ult} = (40,50 \times 7,73) + (19,03 \times 1,5 \times 1,81) + (0,5 \times 17,5 \times 0,20)$$

$$q_{ult} = 313,065 + 51,666 + 1,75$$

$$q_{ult} = 366,481 \text{ kPa}$$

$$q_{ult} = 366,481 \text{ kN/m}^2$$

Table. 4.6 Amount of Ultimate Bearing Capacity Value for Each Layer of Soil Depth

Jenis Tanah	Kedalaman (m)	q_{ult} (kN/m ²)
Lempung lunak	1,5	366,481
Lempung lanau	10	376,295

Source: Analysis Results

The safety factor for soil bearing capacity to meet safety requirements, it is recommended that the safety factor against collapse due to maximum load be = 3. A safety factor of 3 is very important to overcome the uncertainty of basic soil conditions.

Depth = 1.5 meters

$$Q_{izin} = q_{ult} / FK$$

$$Q_{izin} = 366,481 / 3$$

$$Q_{izin} = 122,16 \text{ kN/m}^2$$

Table. 4.7 Amount of Permit Carrying Capacity Value for Each Layer of Soil Depth

Jenis Tanah	Kedalaman (m)	q_{izin} (kN/m ²)
Lempung lunak	1,5	122,16
Lempung lanau	10	125,43

Source: Analysis Results

4.6 Calculation of Embankment Settlement

4.6.1 Instant Drop

The instantaneous settlement calculation is carried out using the embankment settlement approach at each point at the base of the embankment with the soil depth being considered in the soft clay and silt layers, because the embankment is located on the original soil surface, then $\mu_0 = 1$,

Find the net stress from the weight of the embankment:

$$\begin{aligned} q_n &= q - (D_f \times \gamma_{sat}) \\ &= 35,2 - (0 \times 9,81) \\ &= 35,2 \text{ kN/m}^2 \end{aligned}$$

$$\begin{aligned} \mu_1 &= H/B \\ &= \frac{1,5}{17,5} \\ &= 0,03 \end{aligned}$$

so, the value $\mu_1 = 0.04$ is obtained from the correction factor curve for the foundation

depth D_f .

So, the instantaneous decrease can be calculated as follows:

$$S_i = \mu_1 \times \frac{qn \times B}{E}$$

$$S_i = 0,040 \times \frac{35,2 \times 17,5}{3000}$$

$$S_i = 0,040 \times 0,205$$

$$S_i = 0,0082 \text{ m}$$

Table. 4.8 Results of instantaneous decrease due to foam mortar embankment load and traffic load at embankment height H= 0.86 m

Kedalaman	γ_{sat}	q	E	L	B	Df	q_u	μ_1	S_i
(m)	(kN/m ³)	(kN/m ²)	(kN/m ²)	(m)	(m)	(m)	(kN/m ²)		(m)
0,5	9,81	35,2	3000	150	17,5	0	35,2	0,04	0,0082
1,5	9,81	35,2	3000	150	17,5	0	35,2	0,08	0,0164
2,5	17,65	35,2	6720	150	17,5	0	35,2	0,11	0,0101
3,5	17,65	35,2	6720	150	17,5	0	35,2	0,15	0,0138
4,5	17,65	35,2	6720	150	17,5	0	35,2	0,19	0,0174
5,5	17,65	35,2	6720	150	17,5	0	35,2	0,21	0,0193
6,5	17,65	35,2	6720	150	17,5	0	35,2	0,26	0,0238
7,5	17,65	35,2	6720	150	17,5	0	35,2	0,31	0,0284
8,5	17,65	35,2	6720	150	17,5	0	35,2	0,36	0,0330
9,5	17,65	35,2	6720	150	17,5	0	35,2	0,38	0,0348
S_i									0,2052

Source: Analysis Results

So the instantaneous decrease due to embankment load and traffic load at an embankment height of 0.86 m is 0.2052 m

4.6.2 Consolidation Decline

Before calculating subgrade subsidence, first calculate the stresses that occur in the soil. The stresses calculated are overburden stress (P_o'), which is the effective vertical soil stress, stress distribution (ΔP), which is the stress due to the load acting on the ground, and pre-consolidation stress (P_c'), which is the stress that has occurred on the ground in the past.

1. Calculation of overburden stress

Overburden stress calculations are reviewed at each depth at 1 m intervals. Calculation of stress for a depth of 1 m with an embankment height of 0.86 m.

Overburden stress (P_o'):

$$P_o' = \gamma' \times z$$

$$= (\gamma_{sat} - \gamma_w) \times z$$

$$= (9,81 - 5,41) \times 0,5$$

$$= 4,40 \times 0,5$$

$$P_o' = 2,20 \text{ kN/m}^2$$

Table. 4.9 Overburden Stress Calculation Results for embankment height H = 0.86 m

Kedalaman	z	H	γ_{sat}	γ_w	γ'	$P_{o'}$
(m)	(m)	(m)	(kN/m ³)	(kN/m ³)	(kN/m ³)	(kN/m ²)
1	0,5	0,86	9,81	5,41	4,40	2,20
2	1,5	0,86	9,81	5,41	4,40	6,59
3	2,5	0,86	17,65	6,17	11,48	28,71
4	3,5	0,86	17,65	6,17	11,48	40,19
5	4,5	0,86	17,65	6,17	11,48	51,68
6	5,5	0,86	17,65	6,17	11,48	63,16
7	6,5	0,86	17,65	6,17	11,48	74,64
8	7,5	0,86	17,65	6,17	11,48	86,13
9	8,5	0,86	17,65	6,17	11,48	97,61
10	9,5	0,86	17,65	6,17	11,48	109,09

Source: Analysis Results

So the overburden stress at the 0.5 m depth point in the soil is 2.20 kN/m².

2. Calculation of stress distribution

The stress distribution calculation is reviewed at each depth with an interval of 1 m.

$q_0 \text{ lead} = H \times \gamma_{\text{mortar}}$

$= 0.86 \times 6$

$= 5.16 \text{ kN/m}^2$

Voltage distribution (ΔP):

$\Delta P = I \times q_0 \text{ timb}$

$= 0.25 \times 5.16$

$= 1.29 \text{ kN/m}^2$

There is an increase in effective stress in the stress distribution

$2\Delta P = 2 \times 1.29$

$= 2.58 \text{ kN/m}^2$

Table. 4.10. Stress Distribution Calculation Results for embankment height H = 0.86 m

Kedalaman	z	x	y	n	m	I	$q_0 \text{ timb}$	$2\Delta P$
m	m	m	m	m	m		kN/m ²	kN/m ²
1	0,5	8,75	150	17,5	300,0	0,25	5,16	2.58
2	1,5	8,75	150	5,8	100,0	0,25	5,16	2.58
3	2,5	8,75	150	3,5	60,0	0,247	5,16	2.55
4	3,5	8,75	150	2,5	42,9	0,245	5,16	2.53
5	4,5	8,75	150	1,9	33,3	0,24	5,16	2.48
6	5,5	8,75	150	1,6	27,3	0,231	5,16	2.38
7	6,5	8,75	150	1,3	23,1	0,215	5,16	2.22
8	7,5	8,75	150	1,2	20,0	0,214	5,16	2.21
9	8,5	8,75	150	1,0	17,6	0,205	5,16	2.12
10	9,5	8,75	150	0,9	15,8	0,195	5,16	2.01

Source: Analysis Results

So, the stress distribution ΔP at the 0.5 m depth point in the soil is 2.58 kN/m².

3. Preconsolidation Stress Calculation

In general, soft soil layers in Indonesia can be considered as slightly overconsolidated (OC) soil, so that pre-consolidation stress calculations are used. Preconsolidation stress calculations were reviewed at each depth at 1 m intervals.

$$Pc' = Po' + P \text{ fluktuasi}$$

$$= 2,20 + 8$$

$$Pc' = 10,20 \text{ kN/m}^2$$

$$P1' = Po' + \Delta P$$

$$= 2,20 + 2,58$$

$$P1' = 4,78 \text{ kN/m}^2$$

$$\begin{aligned} \text{OCR} &= \frac{Pc'}{P1'} \\ &= \frac{10,20}{4,78} \end{aligned}$$

OCR = 2.13 > 1, then it is overconsolidated (OC)

In two conditions, if $P1' < Pc' = 4.78 < 10.20$, then the calculation of overconsolidated (OC) clay uses equation (2.15).

$$\begin{aligned} \Delta e &= C_r \times \log \frac{P1'}{Po'} = C_r \times \log \frac{Po' + \Delta P}{Po'} \\ &= 0,041 \times \log \frac{4,78}{2,20} \end{aligned}$$

$$\Delta e = 0, \square$$

4. Decrease Due to Total Consolidation

The calculation of the decrease due to total consolidation is as follows:

$$\begin{aligned} Sc &= \frac{\Delta e}{1 + eo} \times H \\ &= \frac{0,013827}{1 + 1,608} \times 0,86 \end{aligned}$$

$$Sc = 0,004559 \text{ m}$$

So, the magnitude of the pre-consolidation settlement at the soil depth point considered at 0.5 m is 0.004559 m

The results of calculating the decrease due to consolidation can be seen in Table 4.11. as follows:

Table. 4.11. Calculation Results of Decrease Due to Consolidation (H = 0.86)

z	Po'	ΔP	Pc'	P1'	Cc	Cr	eo	Δe	Sc
m	kN/m ²	kN/m ²	kN/m ²	kN/m ²					m
0,5	2,20	2,58	10,20	4,78	0,638	0,041	1,608	0,013827	0,004559
1,5	6,59	2,58	14,59	9,17	0,638	0,041	1,608	0,005880	0,001939
2,5	28,71	2,55	36,71	31,26	0,346	0,040	1,496	0,001478	0,000509
3,5	40,19	2,53	48,19	42,72	0,346	0,040	1,496	0,001060	0,000365
4,5	51,68	2,48	59,68	54,15	0,346	0,040	1,496	0,000813	0,000280
5,5	63,16	2,38	71,16	65,54	0,346	0,040	1,496	0,000644	0,000222
6,5	74,64	2,22	82,64	76,86	0,346	0,040	1,496	0,000509	0,000175
7,5	86,13	2,21	94,13	88,33	0,346	0,040	1,496	0,000440	0,000152
8,5	97,61	2,12	105,61	99,72	0,346	0,040	1,496	0,000372	0,000128
9,5	109,09	2,01	117,09	111,10	0,346	0,040	1,496	0,000318	0,000109
Sc									0,008439

Source: Analysis Results

4.7 Consolidation Speed

The calculation of settlement over time is predicted using Terzaghi's one-dimensional consolidation theory, so the time factor for consolidation speed can be calculated.

$$\begin{aligned}
 H_t &= 17 \text{ m} \\
 C_v &= 6,43 \\
 C_v &= 5,01 \\
 h &= h_1 + h_2 \\
 h &= 1,5 + 8,5 \\
 \Sigma h &= 10 \text{ m} \\
 \Sigma \sqrt{C_v} &= \sqrt{6,43} + \sqrt{5,01} \\
 \Sigma \left(\frac{h}{\sqrt{C_v}} \right) &= (0,591 + 3,79) \\
 &= 4,389 \\
 C_v &= \Sigma H_t / \Sigma \left(\frac{h}{\sqrt{C_v}} \right) \\
 &= (10)^2 / (4,389)^2 \\
 &= 5,191
 \end{aligned}$$

then the time factor uses the following calculation:

$$\begin{aligned}
 T_v &= \frac{C_v \times t}{H_t^2} \\
 t_{50} &= \frac{0,197 \times 17^2}{5,191} = 10,97 \text{ year} \\
 t_{90} &= \frac{0,848 \times 17^2}{5,191} = 47,22 \text{ year} \\
 T_v &= (\pi/4) \times U(50\%) \\
 &= 50,13\% \\
 T_v &= -0,933 \times \log(1 - U(90\%)) - 0,085 ; U(90\%) \\
 &= 89,97\%
 \end{aligned}$$

4.8 Calculation Analysis Results

1. Calculation of the decrease in foam mortar embankment due to the weight of the embankment:

The stot (Sc) that occurs is 0.625 m, so:

$$\begin{aligned}
 S_t(50\%) &= U(50\%) \times S_c = 50,13\% \times \\
 &\quad 0,625 \\
 &= 0,313 \text{ m} \\
 S_t(90\%) &= U(90\%) \times S_c = 89,97\% \times \\
 &\quad 0,625 \\
 &= 0,562 \text{ m}
 \end{aligned}$$

The results of all calculations for the reduction to the height of the lightweight foam mortar embankment can be seen in Table 4.12. as follows:

Table. 4.12 Calculation Results of Settlement Due to Embankment Loads

Tinggi Timbunan	Stot	50%	90%	Sisa Tinggi Timbunan
m	m	m	m	m
0,86	0,039	0,019	0,035	0,821
1,36	0,067	0,033	0,060	1,293
2,36	0,132	0,066	0,118	2,228
4,36	0,288	0,144	0,259	4,072
5,36	0,377	0,189	0,339	4,983
7,36	0,573	0,287	0,516	6,787
7,86	0,625	0,313	0,562	7,235

Source: Analysis Results

If we refer to the decline criteria, the amount of decline that occurred during the construction period on road class 1 of the Martadinata flyover embankment (>90%) was 0.562 over 47.22 years, amounting to:

$$\frac{0,562}{47,22} = 11.91 \text{ mm/year} < 20 \text{ mm/year}$$

Fulfills the requirements of kimpraswil guidelines (Pt T-10-2002-B,2000) for embankment reduction criteria. Thus, the total subsidence that occurs still meets the criteria for subsidence on soft soil.

2. Calculation of decrease in foam mortar embankment due to traffic load:

The stot (Sc) that occurs is 0.800 m, so:

$$S_t(50\%) = U(50\%) \times S_c = 50,13\% \times 0,800 = 0,401 \text{ m}$$

$$S_t(90\%) = U(90\%) \times S_c = 89,97\% \times 0,800 = 0,720 \text{ m}$$

The results of all calculations for the reduction to the height of the lightweight foam mortar embankment can be seen in Table 4.13. as follows:

Table. 4.13 Calculation Results of Reduction Due to Traffic Load

Tinggi Timbunan	Stot	50%	90%	Sisa Tinggi Timbunan
m	m	m	m	m
0,86	0,214	0,107	0,192	0,646
1,36	0,242	0,121	0,217	1,118
2,36	0,307	0,154	0,276	2,053
4,36	0,463	0,232	0,417	3,897
5,36	0,552	0,277	0,497	4,808
7,36	0,748	0,375	0,673	6,612
7,86	0,800	0,401	0,720	7,060

Source: Analysis Results

If referring to the settlement criteria, the magnitude of the decline that occurred during the construction period on road class 1 of the Martadinata flyover embankment (>90%) was 0.720 over 47.22 years, amounting to:

$$\frac{720}{47,22} = 15.25 \text{ mm/year} < 20 \text{ mm/year}$$

Fulfills the requirements of kimpraswil guidelines (Pt T-10-2002-B,2000) for embankment reduction criteria. Thus, the total subsidence that occurs still meets the criteria for subsidence on soft soil.

4.9 Embankment Stability Calculation

A stockpile is considered to be at the point of failure if the safety factor, $FK = 1$, and is in a stable condition if the FK owned is greater than one ($FK > 1$) or in other words has more strength (reserve strength).

1. Calculation of embankment stability due to the weight of the embankment load.

$$\begin{aligned} a &= 0,5 \text{ m} \\ h &= 0,5 \text{ m} \\ H &= 7,86 \text{ m} \\ W_{\text{mortar}} &= 177,12 \text{ kN} \\ W_w &= 18,63 \text{ kN} \\ \gamma_w &= 5,41 \text{ kN/m}^3 \\ S_{\text{tot}} &= 0,625 \text{ m} \\ B_w &= 17,5 \text{ m} \\ L &= 150 \text{ m} \\ O_{\text{REG}} &= 0 \text{ kN/m}^2 \\ W_w \text{ timbunan} &= 1/2 \times a \times H \times \gamma_w \\ &= 1/2 \times 0,5 \times 7,86 \times 5,41 \\ &= 10,633 \text{ kN/m} \\ FK &= \frac{W_{\text{Mortar busa}} + W_w + O_{\text{REG}}}{\frac{1}{2} \gamma_w \cdot B_w \cdot (h + S_{\text{tot}})} \\ &= \frac{177,12 + 18,63 + 0}{\frac{1}{2} \times 5,41 \times 17,5 (0,5 + 0,625)} \\ &= 3,52 > 1,4 \end{aligned}$$

Meet the requirements of construction and building guidelines (Pd-T-11-2005, 2005) embankment stability safety factors. In this way, the stability of the embankment due to the weight of the embankment load still meets the safety factor of having greater strength (reserve strength).

2. Calculation of embankment stability due to traffic loads.

$$\begin{aligned} a &= 0,5 \text{ m} \\ h &= 0,5 \text{ m} \\ H &= 7,86 \text{ m} \\ W_{\text{mortar}} &= 177,12 \text{ kN} \\ W_w &= 18,63 \text{ kN} \\ \gamma_w &= 5,41 \text{ kN/m}^3 \\ S_{\text{tot}} &= 0,800 \text{ m} \\ B_w &= 17,5 \text{ m} \\ L &= 150 \text{ m} \\ O_{\text{REG}} &= 0 \text{ kN/m}^2 \\ W_w \text{ timbunan} &= 1/2 \times a \times H \times \gamma_w \\ &= 1/2 \times 0,5 \times 7,86 \times 5,41 \\ &= 10,633 \text{ kN/m} \\ FK &= \frac{W_{\text{Mortar busa}} + W_w + O_{\text{REG}}}{\frac{1}{2} \gamma_w \cdot B_w \cdot (h + S_{\text{tot}})} \end{aligned}$$

$$= \frac{177,12 + 18,63 + 0}{\frac{1}{2} \times 5,41 \times 17,5 (0,5 + 0,800)}$$

$$= 3,05 > 1,4$$

Meet the requirements of construction and building guidelines (Pd-T-11-2005, 2005) table 2.9 embankment stability safety factors. In this way, the stability of the embankment due to traffic loads still meets the safety factor of having more strength (reserve strength).

4.10 Embankment Modeling Using Plaxis Software

Embankment modeling uses soil data by obtaining cross sections of soil layers from SPT and laboratory investigations, so that the soil parameters of each layer can be determined to determine the amount of settlement, stability and safety factors for lightweight foam mortar embankments using the Plaxis 8.2 program

Basic soil material parameters can be seen in Table 4.14. as follows :

Table 4.14. Basic Soil Material Parameters

Properties	Lapisan	Lempung	Lempung Lanauan	Lempung Kepasiran	Unit
Kedalaman	-	1.5	10	17	m
Material Model	Model	Mohr-Coloumb	Mohr-Coloumb	Mohr-Coloumb	-
Type of behaviour	Type	UnDrained	UnDrained	UnDrained	-
Soil unit weight above phreatic level	γ_{dry}	7,52	10,52	10,84	kN/m ³
Soil unit blow phreatic level	γ_{sat}	9,81	17,65	18,63	kN/m ³
Permeability in horizontal	K_x	0,00000001	0,00000001	0,00000001	m/day
Permeability in vertical direction	K_y	0,00000001	0,00000001	0,00000001	m/day
Young's modulus (constant)	E_{ref}	3000	6720	11400	kN/m ²
Poisson's ratio	ν	0,3	0,3	0,3	-
Cohesion (constant)	c_{ref}	88,36	83,75	65,61	kN/m ²
Friction angle	ϕ	20,092	21,017	37,027	°
Dilatancy angle	ψ	0	0	0	°

Source: Analysis Results

Foam mortar material parameters can be seen in Table 4.15. as follows :

Table. 4.15 Foam Mortar Backfill Material Parameters

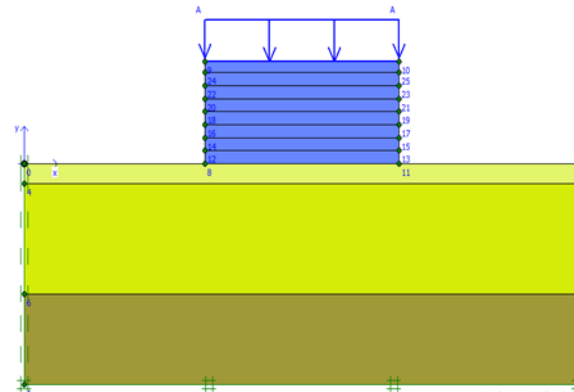
Parameter Properties		Timbunan Ringan Mortar Busa	Unit
Material Model	Model	Linear Elastic	-
Type of behaviour	Type	Non-Porous	-
Soil unit weight above phreatic level	γ_{unsat}	6	kN/m ³
Soil unit blow phreatic level	γ_{sat}	6	kN/m ³
Poisson's ratio	ν	0.15	-
Young's modulus (constant)	E_{ref}	892600	kN/m ²
Cohession (constant)	c	-	kN/m ²
Friction angle	ϕ	-	°

Source: Analysis Results

4.11 Calculation Stage Using Plaxis Software

4.11.1. Input Stage

Create a geometry model of the embankment using the Geometry Line toolbar or by inputting coordinates by typing the point on geometry line at the bottom of the window. so that a model is formed as in Figure 4.2. below as follows:



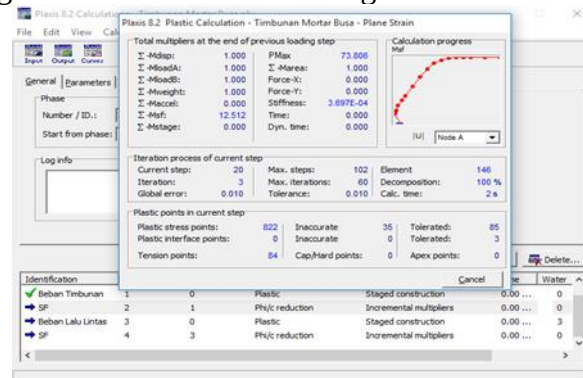
Source: Embankment Analysis With Plaxis 8.2

Figure 4.2. Foam Mortar Light Fill Model

4.11.2. Plaxis Calculations 8.2

1. Calculation Stage Consequences of Embankment Weight

Calculation Process Reviewed Due to Embankment Weight. Below, the calculation process is reviewed due to the weight of the embankment in Figure 4.3. below as follows

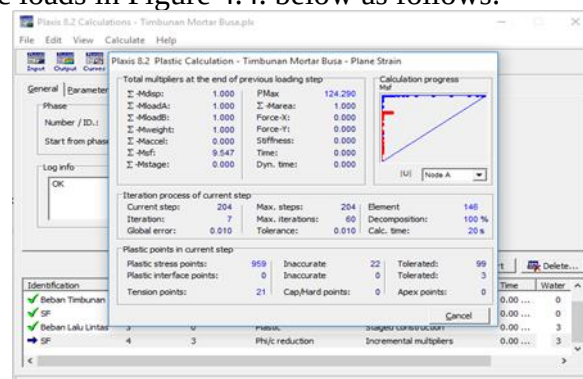


Source: Embankment Analysis With Plaxis 8.2

Figure 4.3. Calculation Process Reviewed Due to Embankment Weight

2. Traffic Load Calculation Stage

Calculation Process Reviewed Due to Traffic Loads The following calculation process is reviewed due to traffic loads in Figure 4.4. below as follows:



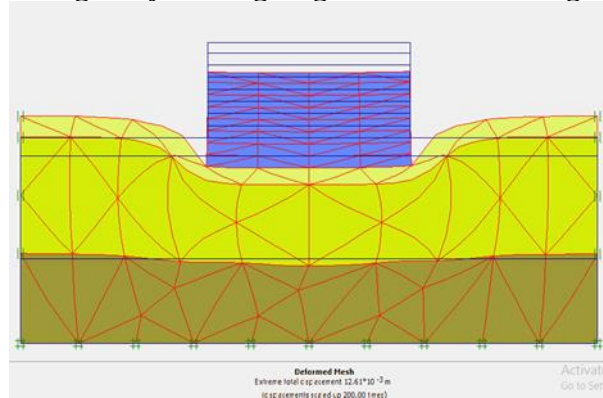
Source: Embankment Analysis With Plaxis 8.2

Figure 4.4. Calculation Process Reviewed Due to Traffic Load

4.11.3. Plaxis Output 8.2

1. Gravity Loading Stage

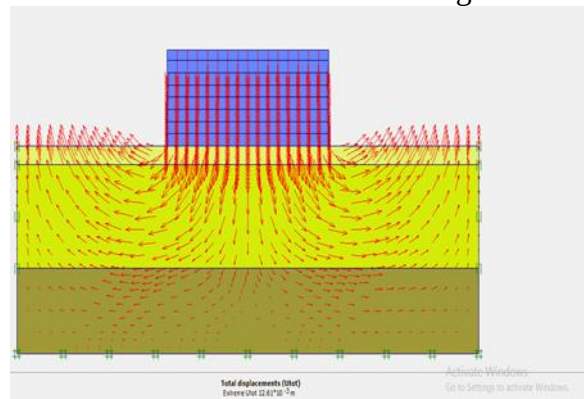
At this stage, the results show that the weight of the embankment with lightweight foam mortar material, in the lower structure of the road body, has decreased by 12.61 mm or 1.261 cm. The output results of the gravity loading stage can be seen in Figure 4.5. as follows :



Source: Embankment Analysis With Plaxis 8.2

Figure 4.5. Embankments Deformed Due to Gravity Loading

At this stage, the soil receives the weight of the lightweight material filled with foam mortar. The direction of movement and settlement due to the weight of the embankment load from the lightweight foam mortar material can be seen in Figure 4.6. as follows :

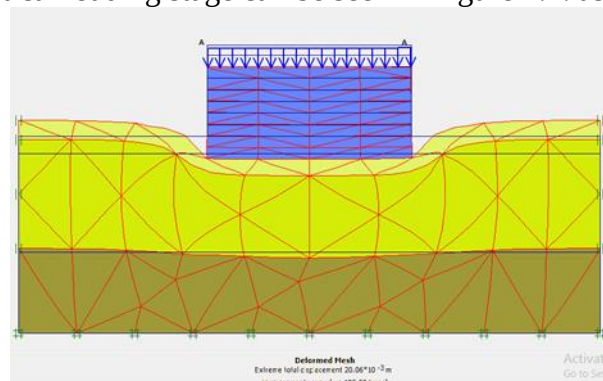


Source: Embankment Analysis With Plaxis 8.2

Figure 4.6. Direction of Ground Movement and Settlement Due to Gravity Loading

2. Vertical Loading Stage

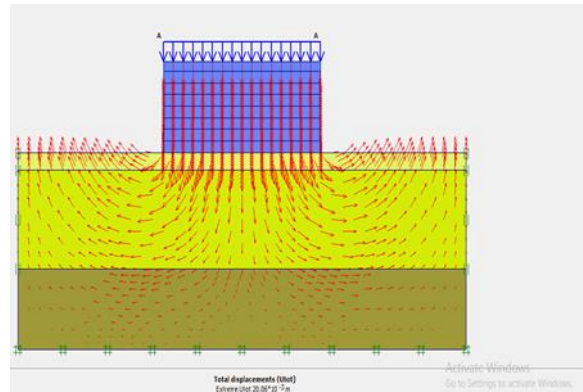
At this stage, the soil receives the load of the road pavement structure which is modeled as a uniform load (tractions). The soil experienced deformation of 20.06 mm or 2.006 cm. The output results of the vertical loading stage can be seen in Figure 4.7. as follows :



Source: Embankment Analysis With Plaxis 8.2

Figure 4.7. Embankments Deformed Due to Vertical Loading

At this stage, the soil receives the load of the road pavement structure and road traffic which are modeled as uniform loads (tractions). The direction of movement and settlement due to the load of the road pavement structure and road traffic can be seen in Figure 4.8. as follows :

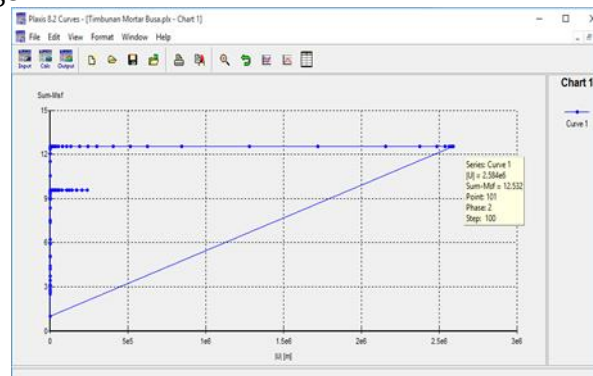


Source: Embankment Analysis With Plaxis 8.2

Figure 4.8. Direction of Ground Movement and Settlement Due to Vertical Loading

4.11.4. Plaxis Curves 8.2

1. Gravity Loading Stage

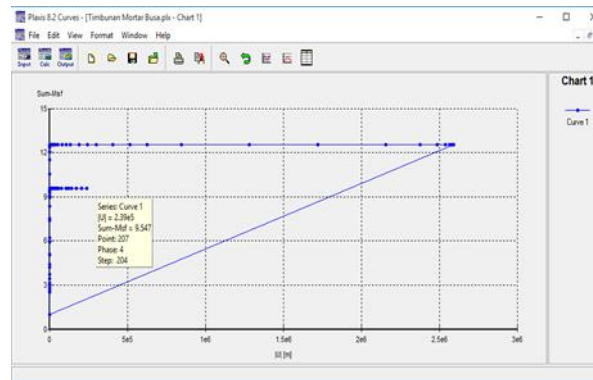


Source: Embankment Analysis With Plaxis 8.2

Figure 4.9. Safety Figures Due to Gravity Loading

From Figure 4.9. It can be seen that the SF due to gravity loading is 12.532. This figure is greater than the minimum SF for class 1 road collapse, which is 1.4. So it can be concluded that the embankment meets the required minimum safety factors.

2. Vertical Loading Stage



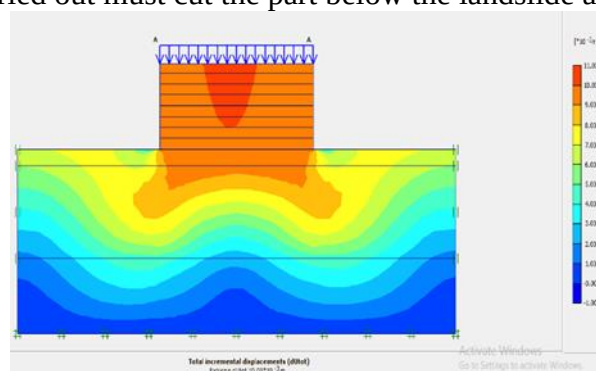
Source: Embankment Analysis With Plaxis 8.2

Figure 4.10. Safety Figures Due to Vertical Loading

From Figure 4.10. It can be seen that the SF due to vertical loading is 9.547. This figure is greater than the minimum SF for class 1 road collapse, which is 1.4. So it can be concluded that the embankment meets the required minimum safety factors.

3. Derivation Field

Knowing the area of landslides that occurred at the study location can be seen in the SF Vertical Loading output by selecting the Total Incremental Displacement toolbar as in Figure 4.11. The treatment carried out must cut the part below the landslide area



Source: Embankment Analysis With Plaxis 8.2

Figure 4.11. Total Incremental Displacement

CONCLUSIONS AND SUGGESTION

Conclusion

Based on the results of the analysis of the light embankment of foam mortar on the Martadinata Pamulang Flyover, South Tangerang, with manual calculations and using the plaxis 8.2 program, the following conclusions are drawn:

1. Based on the calculation results, the bearing capacity of the soil under the pile of lightweight foam mortar material to accept the load acting at a soil depth of 1.5 meters, the ultimate soil bearing capacity is 336.481 kN/m² and the permitted bearing capacity is 122.16 kN/m². At a soil depth of 10 meters, the ultimate soil bearing capacity is 376.295 kN/m² and the permitted bearing capacity is 125.43 kN/m².
2. Based on the results of manual stability calculations that occur in light embankments of foam mortar above the soft soil layer due to an embankment load of 3.52, a traffic load of 3.05 and the results of a plaxis calculation of 8.2 due to an embankment load of 12.53, a traffic load of 9, 54 has met the requirements for a class 1 road safety factor of 1.4. So it can be concluded that the embankment meets the required minimum safety factors.

Meanwhile, the settlement that occurred in light embankments of foam mortar was above the soft soil layer due to embankment loads of 11.91 mm/year, traffic loads of 15.25 mm/year and the results of plaxis calculations due to embankment loads of 12.61 mm/year, The traffic load of 20.06 mm/year meets the requirements for the reduction criteria of 20 mm/year in the Kimpraswil guidelines (Pt T-10-2002-B, 2002).

Suggestion

From the results of the research that has been carried out, there are several suggestions for further research, including:

1. There needs to be a comparison between earth filling and light foam mortar filling on the stability and settlement of the Martadinata Pamulang South Tangerang flyover.
2. Analysis using the Plaxis 8.2 program still has weaknesses, to get more accurate results it requires comparison with other methods or programs, such as GEOSLOPE, ROC SCIENCE, Z SOIL, SAGE CRISP, and so on.

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