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VERTICAL DEFORMATION OF LIME TREATED BASE (LTB) MODEL OF LATERITE SOIL USING NUMERICAL ANALYSIS

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ABSTRACT

This study aim to analyze and produce vertical deformation of lime treated base model of laterite soil. The samples of laterite soil were obtained from Sorowako Regency of East Luwu, South Sulawesi, Indonesia. The physical and mechanical properties of the soil are obtained from laboratory testing, according to American Standard for Testing and Materials (ASTM). The lime treated base of the laterite soil layer is modeled with the dimension of length (L) = 4 m, width (W) = 2 m, and height (H) = 1.5 m. Stabilization of laterite soil with lime was conducted with variations of lime addition of 3, 5, 7, an 10%, under the maximum density conditions of standard Proctor test results. The model of the layers consists of soil subgrade layer (1.5 m), and lime treated base layer of laterite soil (0.1 m). Furthermore, the physical model is numerically analyzed by the finite element method. The results showed that the lime treated base layer with 10% lime content reduced the vertical deformation three times less than the laterite soil without stabilization. While the vertical deformation of the lime treated base layer meets the maximum deflection (L/240) in the addition of 7-10% lime.

Key words: Vertical deformation, lime treated base, laterit soil, numerical analysis.

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1. INTRODUCTION

The reqiure of materials for base layer in certain areas is often a problem because it is difficult, expensive and limited.Therefore, the development should be done on bad soil conditions such as soft soil base, soil with large potential for shrinkage, soil from the sea, even unstable soil in case of earthquake. One method that can be used to overcome this problem is soil stabilization, in order to improve soil geotechnical properties chemically so that the soil meets certain technical requirements [1]. In addition, forthe certain areas with very limited soil conditions and even eligible soils are difficult to obtain, the alternatives to efficient of soil as road foundation layers may Developed. It is intended to reduce the type and thickness of the road foundation layer.

One of the soil that can be developed is laterite soil in Sorowako, East Luwu Regency, South Sulawesi, Indonesia. This area is limited to obtain the soil type that meets the technical requirements as base material, even must be imported from the other regions.Instead this areais dominated by laterite soils with relatively high metal content, especially iron oxide (Fe_2O_3), which is simply wasted from nickel mining[2], [3] and [4].Some previous studies include; effect of clay minerals in the laterite soil [5], mdification of lateritic soil with lime and cement [6], cement stabilization of Makassar sedimen soil in Indonesia[7], stabilization of Malyasia laterite soil with polymer solution [8], laterite soil stabilization using a mixture of charcoal and cement [9], laterite soil stabilization with corn cob ash (CCA) [10], stabilization of Malaysia laterite soil using liquid sodium silicate [11], and stabilization soil with mixing of fed gasoline [12]. This research was conducted to analyze the vertical deformation characteristic of laterite soil with lime stabilization, so that it can be used as an alternative base layer on the road.Meanwhile, the determination of base layer criteria can be done by model test or by simulation model using numerical analysis.

The analysis of vertical deformation of road base layer can be performed numerically using the finite element method. Numerical methods are techniques used to formulate mathematical problems to be solved by count operations. Mathematical modeling is needed to help solve engineering problems. Descriptions of processing stages of engineering problems that are analytically difficult to solve are then brought to mathematical models and completed mathematically, algebraically or statistically and computationally. The development of software technology today, greatly facilitate the work of construction experts, especially to solve complex problems, especially in designing work with complex field conditions as well. Various simulsion models can be made by considering all engineering aspects based on accurate and fast analysis. One of the software that will be used to analyze the lime treated base layer model made is Plaxis 2D. The soil behavior given is Mohr-Coulomb, the simplest soil behavior with two stiffness parameters ie elasticity (E') and poisson ration (υ'), and three strength parameters is cohesi (C), internal friction angle (ϕ') and dilatancy (ψ), which can generally be obtained in soil laboratory tests. The key components of Plaxis 2D operation consist of material model, material behavior, and data input.

2. MATERIALS AND METHOD

The material used in this research is laterite soil from Sorowako East Luwu Regency South Sulawesi with coordinates S 2^{o}56'21,16" and E 121^{o}36'26,54". Physical and mechanical properties of soil obtained from laboratory test according to ASTM standard. Stabilization of laterite soil using qiuck lime with CaO content = 97,8% and SiO_2content = 2,2%, with lime addition of 3, 5, 7, and 10% in maximum dry density of standard Proctor test results. The physical model is made with dimensions of length (P) = 4 m, width (W) = 2 m, and height (H) = 1.6 m. The road foundation layer consists of a subgrade layer using alluvial soil with 1.5 m thick and lime treated base layer using laterite soil with 0.1 m thick.Furthermore, the physical model is numerically analyzed using finite element method (*Plaxis 2D*).The parameters of soil for each layer are obtained from laboratory test results. Static loading is done for lime treated base with lime stabilization variations of 0, 3, 5, 7, and 10% and curing time for 28 days. The *Plaxis 2D* analysis were conducted to calculate the magnitude of the vertical deformation and maximum pressure.The physical model of lime treated basewith numerical analysis as shown in Figure 1. While input of soil parameters showed in Table 1 and Table 2.

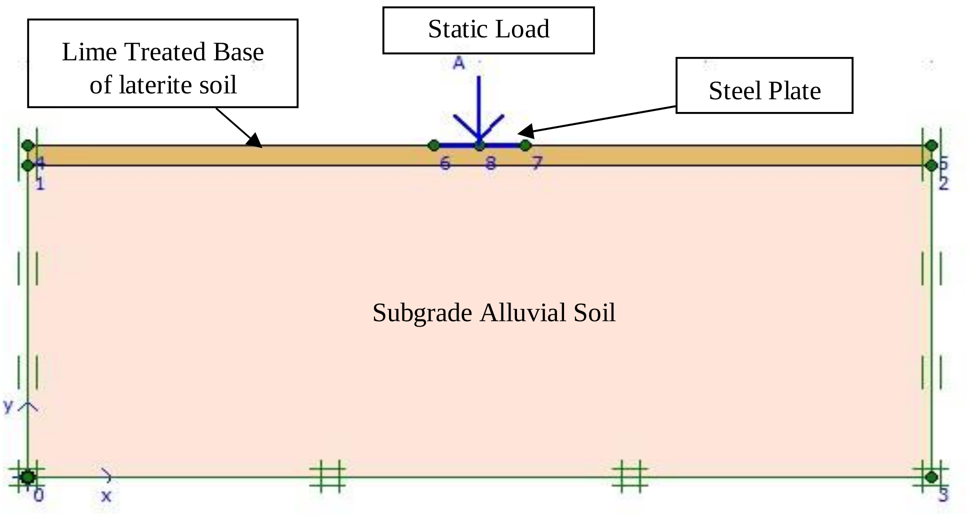


Figure 1 Problem set of lime treated base model

Table 1 Soil input parameters

No.	Layers	Soil Type	Analysis Model	Type of Analysis	Soil Parameters Input					
					γ_{unsat} (kN/m³)	γ_{sat} (kN/m³)	E (kN/m²)	υ	C (kN/m²)	θ⁰
1	Subgrade	Aluvial Soil	Mohr Coulomb	Drained	14,6	20	2400	0,3	12	13
2	Elastic Treated Base	Laterit Soil +0% lime			14,8	16,5	3000	0,3	16	22
		Laterit Soil +3% lime			15,2	18,6	3556	0,3	26	20
		Laterit Soil +5% lime			16,63	19,3	7200	0,3	29	18
		Laterit Soil +7% lime			17,4	20,5	10000	0,3	30	18
		Laterit Soil +10% lime			18,3	21,7	14667	0,3	31	16

Table 2 Parameters of steel plate

Plate Type	Type	EA (kN/m)	EI (kN/m)	d (m)	υ
Steel	Elastic	5,72E+07	2040	0,02	0,3

3. RESULT AND DISCUSSION

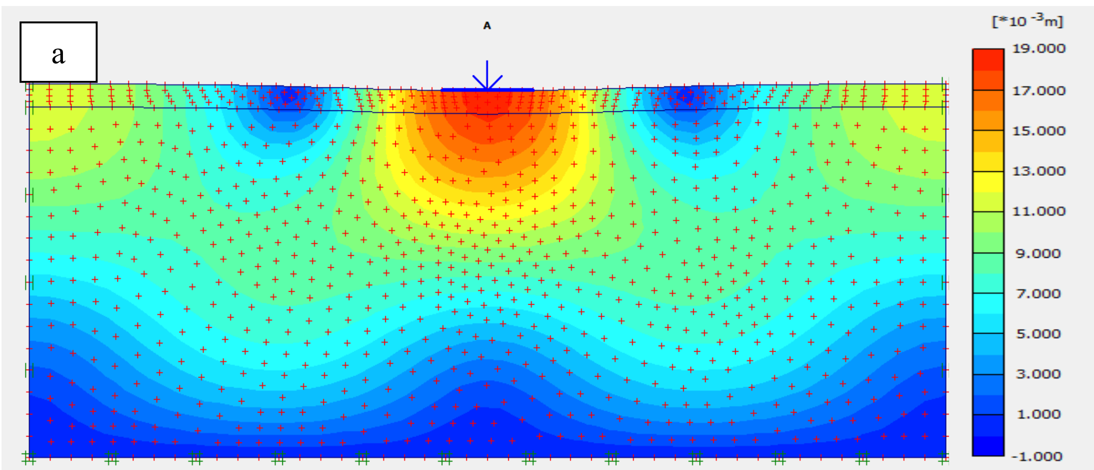
The results of physical and mechanical properties of alluvial soil and laterite soil showed in Table 3.

Table 3 Physical and mechanical properties of alluvial soil and laterite soil

No	Soil Characteristics	Unit	Alluvial Soil	Laterit Soil
1	Specific Gravity (Gs)	-	2.62	2.64
2	Water content (w)	%	34.12	24.17
3	Sieve analysis a. gravel	%	-	-
	b. sand	%	31.80	8.34
	c. Silt/clay	%	68.20	91.66
4	Atterberg limits a. Liquid limit (LL)	%	66.21	67.91

	b. Plastic limit (PL)	%	33.79	35.25
	c. Index plasticity (PI)	%	32.42	32.66
5	Standard Proctor compaction			
	a. Maximum dry density ($\gamma_{d\ maks}$)	kN/m^3	16.21	16.89
	b. Optimum moisture content (w_{opt})	%	27.34	16.53
6	Unconfined compression strength (q_u)	kN/m^2	42.34	75.61
7	California Bearing Ratio (CBR)			
	a. CBR unsoaked	%	6.52	22.80
8.	Direct shear test			
	a. Cohesion (C)	kN/m^2	14.37	14.7
	b. Internal friction angle (θ)	(^{0})	12	19
9.	Soil classification			
	USCS		CH	CH
	AASTHO		A-7-6	A-7-6

Subsequently, the result of numerical analysis using *Plaxis 2D* is shown in Figure 2 (shading model of deformation) and Figure 3 (arrows model deformation). The results of this numerical analysis are only performed for the deformation model, the maximum pressure and the magnitude of the deformation occurring due to static loading. Based on the results of numerical analysis of *Plaxis 2D* as in Figures 2 and 3 is known that soil without stabilization, the maximum pressure was 63.3 kN/m^2 and the maximum vertical deformation occurred was 17 mm, while at 35 kN/m^2 pressure, the vertical deformation of 9.3 mm. The result of 3% lime stabilization analysis, obtained maximum pressure is 76.3 kN/m^2 and the maximum vertical deformation is 15 mm. While at pressure of 35 kN/m^2, the vertical deformation is 6.56 mm. The result of analysis for 5% lime stabilization obtained maximum pressure is 73.3 kN/m^2 and maximum vertical deformation is 11 mm. While at a pressure of 35 kN/m^2, the vertical deformation of 5.4 mm occurred. The result of analysis for 7% lime, obtained maximum pressure is 83 kN/m^2 and the maximum vertical deformation occured is 13 mm. While at pressure of 35 kN/m^2, the vertical deformation of 3.59 mm occurred. The result of analysis for 10% lime stabilization, obtained maximum pressure is 85 kN/m^2 and maximum vertical deformation is 11 mm. While at pressure of 35 kN/m^2, the vertical deformation was 2.97 mm.



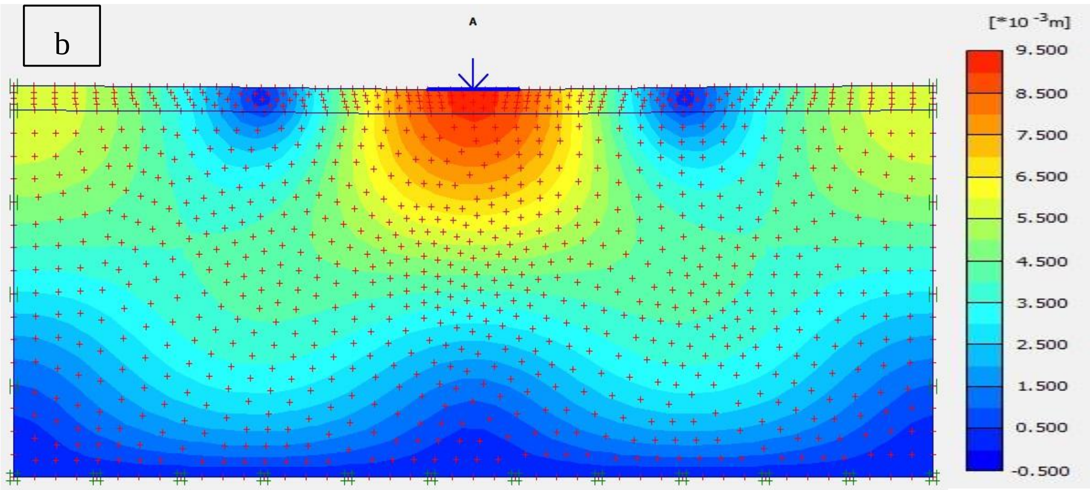


Figure 2 The results of Plaxis 2D analysis(total displacement model shadings);

a) soil without stabilization; b) soil stabilization with 10% lime content

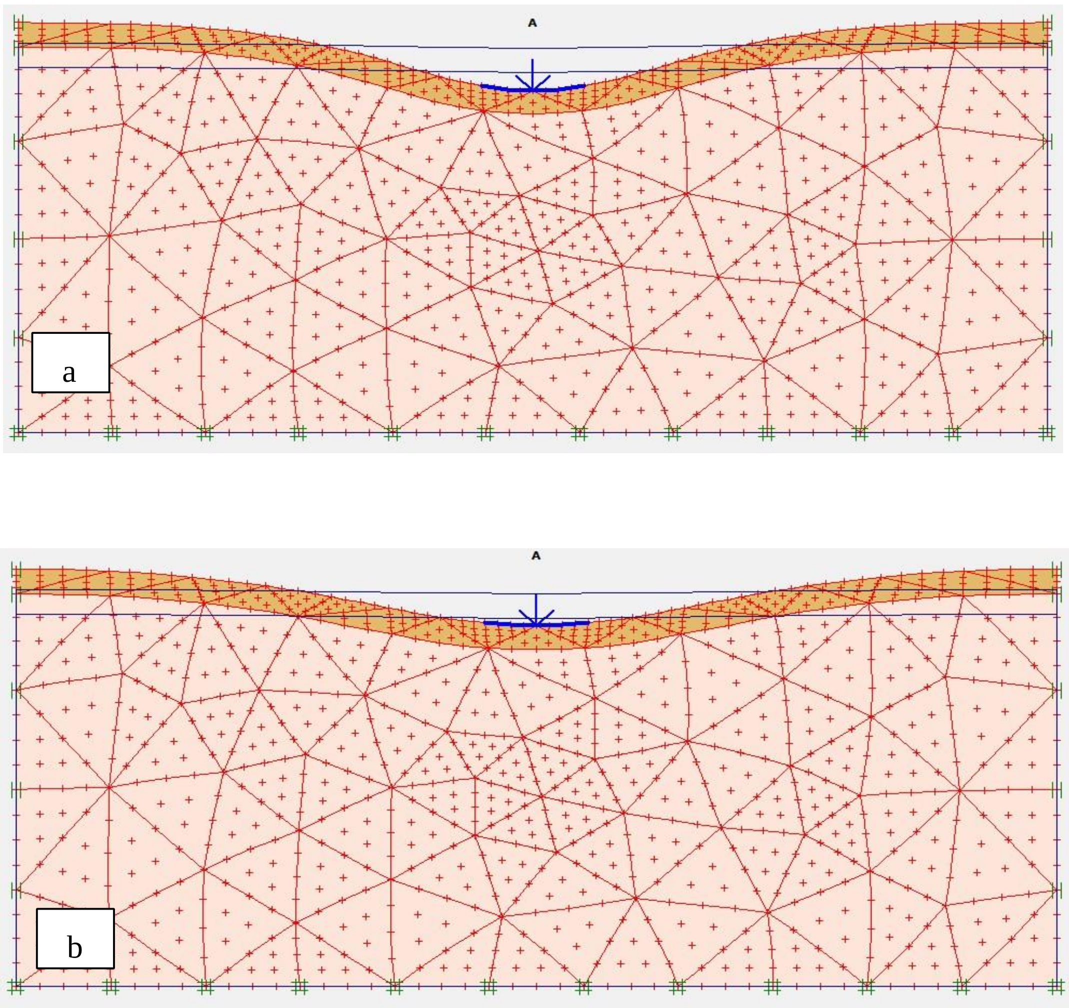


Figure 3 The results of Plaxis 2D (deformed model); a) soil without stabilization;

b) soil stabilization with 10% lime content

In addition, an increase in lime content up to 10% and curing time of 28 days, causes the vertical deformation of lime treated base layer to be smaller (three times less than soil witout stabilization). This condition due to reactions of laterite soil, lime, and water forming the cementation matrix that is hardened and fills the soil micropore, so that the soil becomes denser which causes the strength and soil bearing capacity to increase. The cemented layered matrix is calcium silicate hydrate (CSH) with the chemical formula $CaO.SiO_2.H_2O$, and calcium alumina hydrate (CAH) with the chemical formula $CaO.Al_2O_3.H_2O$ [13, 14, and 15].

4. CONCLUSION

Numerical analysis of the laterite soil LTB model has been performed. The lime stabilization on the laterite soil reaches a maximum condition of 10% with 28 days curing time. At maximum conditions, the vertical deformation decreases three times less than the soil without stabilization. Based on the results of numerical analysis (*Plaxis 2D*) on the laterite soil with lime stabilization deformation model, it is known that the LTB layer meets the maximum vertical deformation requirement of L/240 on lime addition of 7% to 10%.

REFERENCES

[1] Hardiyatmo, C.H., 2010, Soil Stabilization for Road Pavement, Gajah Mada University Press, UGM Yogyakarta.

[2] Saing Z, Samang L, T. Harianto, Patanduk J, 2016, Microstructural and Mechanical Characteristic of Potential Ferro Laterite Soil as Sub-base Material, *International Journal of Innovative Research in Advance Engineering* (IJIRAE), Issue 2 Volume 3, Pebruary 2016, pp 42-48.

[3] Zubair Saing, Lawalenna Samang, Tri Harianto, Johannes Patanduk, 2016, Strength Characteristic of Ferro Laterite Soil with Lime Stabilization as Subgrade Material, *10thInternationational Symposium on Lowland Technology*, Mangalore India, pp.228-233.

[4] Zubair Saing, Lawalenna Samang, Tri Harianto and Johannes Patanduk, Mechanical Characteristic of Ferro Laterite Soil with Cement Stabilizationas a Subgrade Material. *International Journal of Civil Engineering and Technology*,8(3), 2017, pp. 609–616.

[5] Sree Danya, Ajitha, A.R, Evangeline, Y. Sheela., 2010, Study on Amended Soil Liner Using Lateritic Soil, Indian Geotechnical Conference – 2010, GEO *trendz* December 16–18, 2010IGS Mumbai Chapter & IIT Bombay, pp 381-284.

[6] F.H.M. Portelinha, D.C. Lima, M.P.F. Fontes, C.A.B. Carvalho, 2012, Modification of a Lateritic Soil with Lime and Cement: An Economical Alternative for Flexible Pavement Layers, Soils and Rocks, São Paulo, 35(1): pp. 51-63.

[7] Yusuf H, Pallu M.H , Samang L and Tjaronge M.W, Characteristical Analysis of Unconfined Compressive Strength and CBR Laboratory on Dredging Sediment Stabilized With Portland Cement, *International Journal of Civil & Environmental Engineering*, 12(04), pp. 25-31.

[8] Marto A, Lativi N, Souhaei H, 2013, Stabilization of Laterite Soil using GKS Soil Stabilizer, *Engineering Journal of Geotechnical and Environmental*, 18, pp. 521-532.

[9] Kiran S.P, A.N Ramakrishna, Shrinivas.H.R, 2014, Stabilization of Lateritic Soil by using Sugarcane Straw Ash and Cement, *Journal of Civil Engineering Technology and Research*, 2(10), pp.615-620.

[10] Yinusa A. Jimoh , O. Ahmed Apampa, 2014, An Evaluation of the Influence of Corn Cob Ash on the Strength Parameters of Lateritic Soils, *Civil and Environmental Research*, 6(5).

[11] Nima Latifi, Amin Eisazadeh, Aminaton Marto, 2014, Strength behavior and microstructural characteristics of tropical laterite soil treated with sodium silicate-based liquid stabilizer, *Environmental Earth Science*, 72, pp. 91–98, Springer-Verlag Berlin Heidelberg.

[12] Wisley Moreira Farias, Geraldo Resende Boaventura, Éder de Souza Martins, Fabrício Bueno da Fonseca Cardoso, José Camapum de Carvalho and Edi Mendes Guimarães., 2014, Chemical and Hydraulic Behavior of a Tropical Soil Compacted Submitted to the Flow of Gasoline Hydrocarbons, *Environmental Risk Assessment of Soil Contamination, Intech*, pp. 638-655.

[13] Ken O. C., and Okoafor F.O., 2012, Geochemistry of Soil Stabilization, *Journal of Earth Science Asian Research Publishing Network*, 1(1), pp. 32-35.

[14] Jaritngam S, O. Somchainuek, and P. Taneerananon, 2014, Feasibility of Laterite-Cement Mixture as Pavement Base Course Aggregat, *International Journal of Science and Technology Transaction of Civil Engineering* Vol. 38. No. C1+, pp. 275-284

[15] Pranshoo Solanki and Musharraf Zaman (2012). Microstructural and Mineralogical Characterization of Clay Stabilized Using Calcium-Based Stabilizers, Scanning Electron Microscopy, Dr. Viacheslav Kazmiruk (Ed.), ISBN:978-953-51-0092-8, InTech.

[16] Adegoke Omotayo Olubanwo and Emmanuel Kelechi Ebo. Soil-Sheet Pile Interaction - Part II: Numerical Analysis and Simulation. *International Journal of Civil Engineering and Technology,* 6(5), 2015, pp. 113-122.