International Journal of
INTELLIGENT SYSTEMS AND APPLICATIONS IN ENGINEERING
ISSN:2147-6799 www.ijisae.org Original Research Paper

Stabilization of Expansive Soil with Lime, Fly Ash and Cement

Pratikso[1], Abdul Rochim[2], Rachmad Mudiyono[3], Adolf Situmorang[4]*

Submitted: 10/11/2022 **Accepted**: 12/02/2023

Abstract: Soil with low bearing capacity and problems such as expansive soil are found in the Grobogan Regency area. Expansive soil is soil that is easy to expand and shrink due to the influence of water. In the rainy season the soil absorbs a lot of water so that its volume increases, while in the dry season the water decreases so that the volume decreases. Expansive soils are characterized by large clay content and high soil plasticity index. The highway building which is located on this expansive land is never stable because the road surface will be bumpy, rise in the rainy season and fall in the dry season because the subgrade of the flower road shrinks due to the influence of water content. One way to reduce the swelling and shrinkage of this soil is by using the stabilization method so that it is carrying capacity increases and shrinkage swelling decreases. In this study, stabilization was carried out by adding 6% lime, 2% rice husk ash, 4, 6 and 8% cement by weight with a curing time of 7 and 14 days. From the results of the CBR test there was a significant increase where in the original soil the CBR = 4.3% increased to 37.63% with the addition of 8% cement with a curing time of 14 days. With stabilization of swelling shrinkage (swelling) of the soil is also significantly reduced where the original soil = 16.19% while with cement stabilization 8% it decreases to = 3.12%, this means that the rate of swelling and shrinkage of the soil becomes small. With an increase in the CBR value, it means that the carrying capacity of the soil also increases so that the road becomes stable and not bumpy.

Keywords: *Expansive Soil, Stabilization, Plasticity Index, CBR.*

1. Introduction

Geographically, Indonesia is located in the tropics, with conditions in the rainy season there will be high rainfall and in the dry season with hot weather there will be no rain. Changes in weather result in repeated wetting and drying cycles, so that the soil will experience changes in soil volume due to repeated changes in water content. On soils that are easy to develop shrinkage (expansive). Roads that are on land like this become bumpy and make the service decline. This land problem is not only limited to subsidence but covers a whole, such as land shrinkage and development. Therefore, the technical properties related to the subgrade must be considered so that a structure built on it can be stable against the influence of the soil. Several types of soil require special handling to be used as the basis for construction, one of which is expansive clay. It is called so because this type of soil generally has high fluctuations in swelling and shrinkage and contains minerals that have a high swelling potential when exposed to water. So that special handling is needed to overcome the problems that will arise if the building or road is located on expansive clay soil. The number of damaged road surfaces, with the level of damage in the form of roads with holes at several points. Some of the damaged road points are. In problems like this, special treatment is needed for subgrade which has soft properties. This kind of treatment is called soil stabilization, there are various kinds of soil stabilization that can be done, for example by mechanical means using compaction and chemically by mixing cement, lime, fly ash, gypsum and so on. The success of this stabilization effort depends on the type of soil, local conditions and the availability of equipment. For this research, samples were taken from 3 locations, namely Jl. Godong – Purwodadi KM.9, Jl. Penawangan – Purwodadi KM.3 and Jl. Purwodadi – Blora KM.10. Samples from 3 locations can be determined from which location is the worst condition. Stabilization is done by adding lime, rice husk ash and cement.

2. Modeling and Analysis

Collecting of Data

To analyze the existing problems, it is necessary to have field data. The data collection method was carried out from the results of soil mechanics laboratory testing. Before the test is carried out, first the sample preparation is taking 3 Soil Samples with different locations, then testing 3 Original Soil Samples and choosing one that has the characteristics of soft soil which is high in a mixture of 6% Lime, 2% Husk Ash and Cement 4, 6, 8 % with a curing time of 1 week and 2 weeks. After the

[1] *Professor, Postgraduate Program of Civil Engineering, Universitas Islam Sultan Agung (UNISSULA), Semarang, 50112, Indonesia.*
[2] *Associate Professor, Postgraduate Program of Civil Engineering, Universitas Islam Sultan Agung (UNISSULA), Semarang 50112, Indonesia.*
[3] *Associate Professor, Postgraduate Program of Civil Engineering, Universitas Islam Sultan Agung (UNISSULA), Semarang 50112, Indonesia.*
[4] *Civil Engineering, Universitas Semarang, Semarang, Indonesia.*
* *Corresponding Author: pratikso@unissula.ac.id*

sample has been prepared, the next stage is laboratory testing. Lab test. The tests carried out are soil properties test (water content), Grain size (to determine soil gradation), Atterberg limits (todetermine soil plasticity (PI, PL, LL)), Proctor (to determine soil density), CBR (to determine soil strength), Consolidation and Shrinkage limit.

Next, soil stabilization analysis was carried out with Lime, Husk Ash and Cement on Soft Soil using lab data. With the results of the analysis obtained, it is used as the basis for the design of the stabilization of Soft Soil the sample.

Processing of Data

From the data obtained from soil properties, Atterberg limits, CBR, proctor, consolidation and shrinkage limit.

Then processing is carried out to determine the strength of the soil layer which has been added to a mixture of 6% Lime, 2% fly ask and cement 4, 6, 8% so that a more economical layer model can be made.

Soil test

Preliminary testing is a test to obtain information about the physical properties and mechanical properties of the tested clay. Visually Seen the land from Jl. Godong – Purwodadi KM.9, Jl. Penawangan – Purwodadi KM.3 and Jl. Purwodadi – Blora KM.10 is clay soil. Physical and mechanical properties can be used as initial informationwhether the soil is expansive soil or not. The results of preliminary testing of clay can be shown in Table 1.

Table 1. Soil properties

No	Item	Result of Test		
		Sample 1	**Sample 2**	**Sample 3**
1	GS	2,342	2,328	2,333
2	LL	66,4	54,44	64,67
3	PL	23,65	23,28	24,35
4	PI	42,75	31,16	40,32
5	Gravel (%)	0,333	0,600	0,32
6	Sand (%)	1,961	2,290	2,02
7	Silt (%)	38,263	59,75	50,65
8	Clay (%)	59,443	37,36	47,01

The test results of 3 original soil samples are given in Table 1, indicating that the soil on Jl. Godong – Purwodadi KM.9 has the highest plasticity index (PI) value of 42.75indicating high plastic soil characteristics.

Stabilitation

From the initial test with 3 samples, it was concluded that the soil sample from Godong – Grobogan KM 9 was due to the worst condition, then stabilization was carried out with the original soil composition with the addition of material with a composition of 6% lime [8], rice husk ash 2% [9]

Cement varied 4, 6 and 8%. Then curing is carried out for 7 days and for 14 days, laboratory tests are carried out.

The laboratory tests carried out are: Atterberg limit test, Free Shear Test, Proctor Test, Consolidation Test CBR Test,and Swelling Test. The curing time was carried out for 7 days and 14 days then the test was carried out.

3. Results and Discussion

Atterberg Limits

Tests for the consistency limit of the soil at the 7-day and 14-day curing period included checking the liquid limit,plastic limit and the value of the plasticity index. The resultsof the examination will be tabled in Table 2 as follows:

Table 2. Atterberg limits

Admixture	Curing Time	Liqiud Limit (LL)	Plastic Limit (PL)	Plasitic Index (PI)
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	51.337	28.681	22.565
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	48.876	29.596	19.28
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	46.308	31.176	15.131
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	51.301	28.397	22.903
Soil + lime 6% + flay ash 2% + Cement 6%	14 day	47.838	29.28	18.558
Soil + lime 6% + flay ash 2% + Cement 8%	14 day	47.302	32.869	14.434

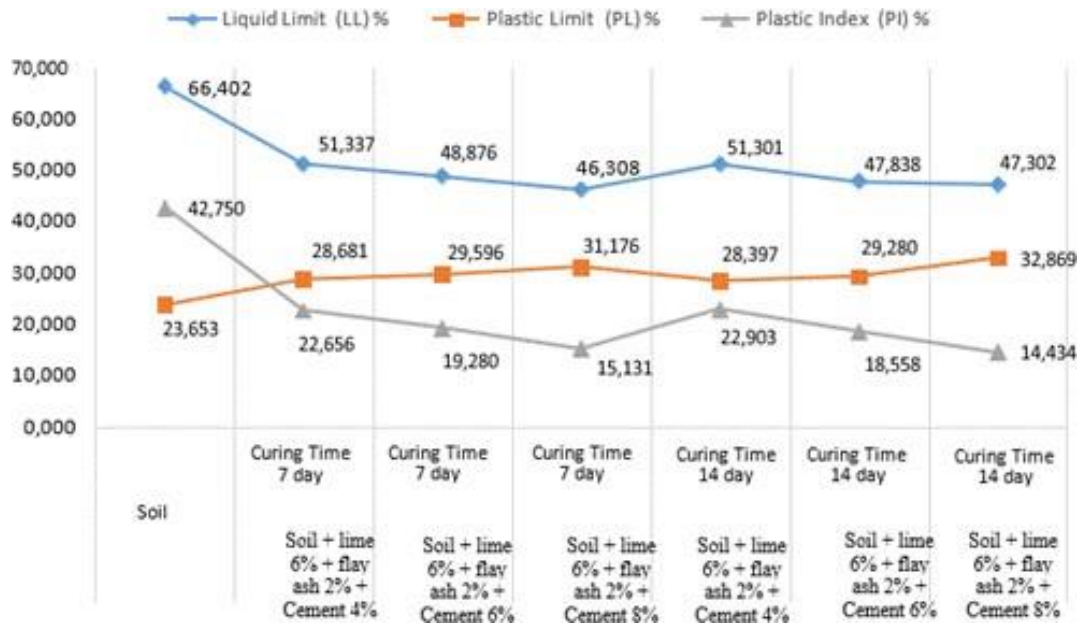

Fig. 1. Atterberg Limit Graph

From the results of the Atterberg Limit test from Table 2, shows that the more percent of cement in the Atterberg Limit test, the smaller the Plasitic Index (PI) value, which means that the soil characteristics are getting better and vice versa, the smaller the cement mixture for stabilizing material, the greater the Plasitic Index (PI), which means that the soil characteristics are not good so that the bearing capacity of the soil decreases.

The longer the curing period, the more the soil bearing capacity can be increased.

Direct Shear Test

Direct Shear test was conducted to determine the shear strength of the soil (values of c and). Cohesion (c) and Shear Angle (□) of the soil are the main factors that affect the shear strength of the soil. The results of the direct shear test can be seen in Table 3 below:

Table 3. Dierect Shear Test

Soil, Lime, flyash and cement Admixture	Curing Time	Cohesion	Angle of Internal Friction
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	0.374	25.092
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	0.378	28.339
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	0.39	29.351
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	0.354	27.262
Soil + lime 6% + flay ash 2% +Cement 6%	14 day	0.354	30.343
Soil + lime 6% + flay ash 2% +Cement 8%	14 day	0.366	30.381

Judging from the results of the direct shear test from Table 3, it can be seen that the more percent of cement inthe soil mixture, the greater the value of the Shear Angle, which means that the bearing capacity of the soil is increasing and vice versa, the smaller the percent of cement mixture, the smaller the value of the Shear Angle. The longer the curing process, the higher the shear angle value so that the bearing capacity of the soil increases.

Modified Proctor Test

This compaction test was carried out to determine the maximum dry density (γd) and optimum moisture content inthe original and stabilized soil using Lime, fly ash, Cement which is shown in Table 4 as follows

Table 4. Modified Proctor Test

Soil, Lime, flyash and cement Admixture	Curing Time	d Max	Optimum Moisture Content
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	1.31	31.8
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	1.239	38.29
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	1.24	39.4
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	1.361	29.8
Soil + lime 6% + flay ash 2% + Cement 6%	14 day	1.26	37.55
Soil + lime 6% + flay ash 2% + Cement 8%	14 day	1.216	38.52

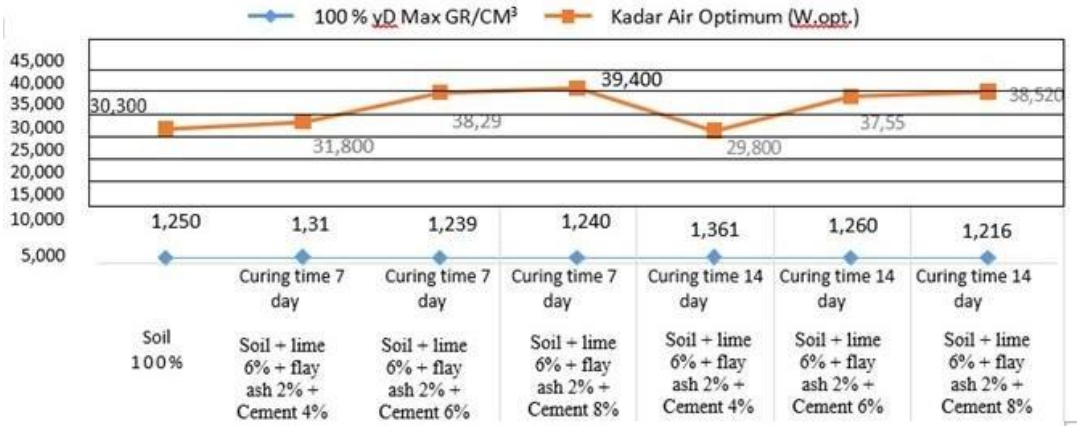

Figure 2. Modified Proctor graph

It can be seen from the results of the Modified Proctor test from Table 4.5 that the higher the percentage of cement in the soil mixture, the greater the value of d Max and Optimum Moisture Content and vice versa, the smaller the percentage of cement mixture, the smaller the value of d Max and Optimum Moisture Content.

California Bearing Ratio

The results of the CBR examination, there are 2 types of CBR Unsoaked (Without Soaking) and CBR Soaked (Immersion) can be seen in Table 5 below.

Table 5. CBR Soaked Result

Soil, Lime, flyash and cement Admixture	**Curig Time**	**95%**	**100%**
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	7.05	9.3
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	7.4	11
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	9.5	13.4
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	8.5	10.87
Soil + lime 6% + flay ash 2% + Cement 6%	14 day	8.8	12.21
Soil + lime 6% + flay ash 2% + Cement 8%	14 day	10	13.85

From the results of the Unsoaked CBR Test Table 4.6 andthe Soaked CBR test Table 5 shows that the higher the percentage of cement in the CBR test, both Unsoaked and Soaked, the greater the CBR value, which means that the bearing capacity of the soil is increasing on the contrary, the less cement mixture for stabilizing material in the CBR test.the smaller the CBR value, which indicates that the bearing capacity of the soil is decreasing. With the longer curring period, it can increase the bearing capacity of the soil.

Consolidtion test

The purpose of the consolidation test is to determine the compressibility properties of the soil and its consolidation characteristics which are a function of soil permeability. The results of the consolidation test can be seen in Table 6

Table 6. Consolidation test result

Soil, Lime, flyash and cement Admixture	Curing Time	Compression (cc)
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	0.212
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	0.225
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	0.189
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	0.216
Soil + lime 6% + flay ash 2% + Cement 6%	14 day	0.212
Soil + lime 6% + flay ash 2% + Cement 8%	14 day	0.188

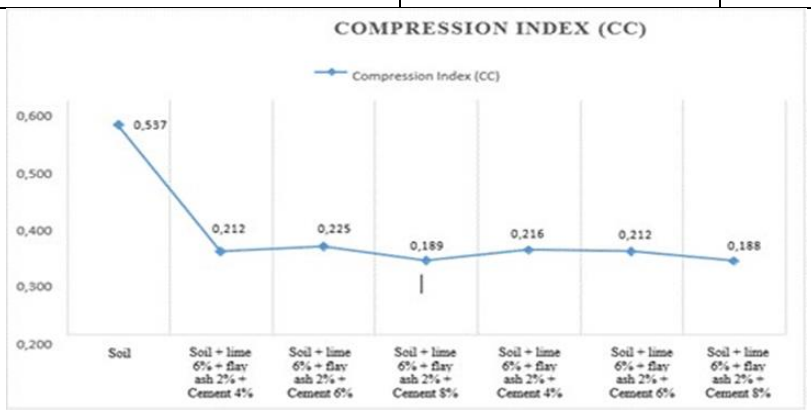

Fig. 3. Compression Index (cc) graph

From the results of the Consolidation test from Table 6 shows that the more percent of cement in the Consolidation test, the smaller the value of Compression (CC) which means that the smaller the settlement in the soil and vice versa, the less cement mixture for stabilization material, the greater the value of the compression (CC). The longer the curing period, the lower the compression value (CC).

Shrinkage Limits

The purpose of the shrinkage limit is to determine the water content of the semi-solid and solid state limits andalso determine the properties of the soil. The results can be seen in Table 6.

Table 6. Shrinkage Limits result

Soil, Lime, flyash and cement Admixture	Curing Time	Srinkage Limit
Soil + lime 6% + flay ash 2% + Cement 4%	7 day	7.145
Soil + lime 6% + flay ash 2% + Cement 6%	7 day	6.286
Soil + lime 6% + flay ash 2% + Cement 8%	7 day	3.145
Soil + lime 6% + flay ash 2% + Cement 4%	14 day	7.009
Soil + lime 6% + flay ash 2% + Cement 6%	14 day	6.079
Soil + lime 6% + flay ash 2% + Cement 8%	14 day	3.127

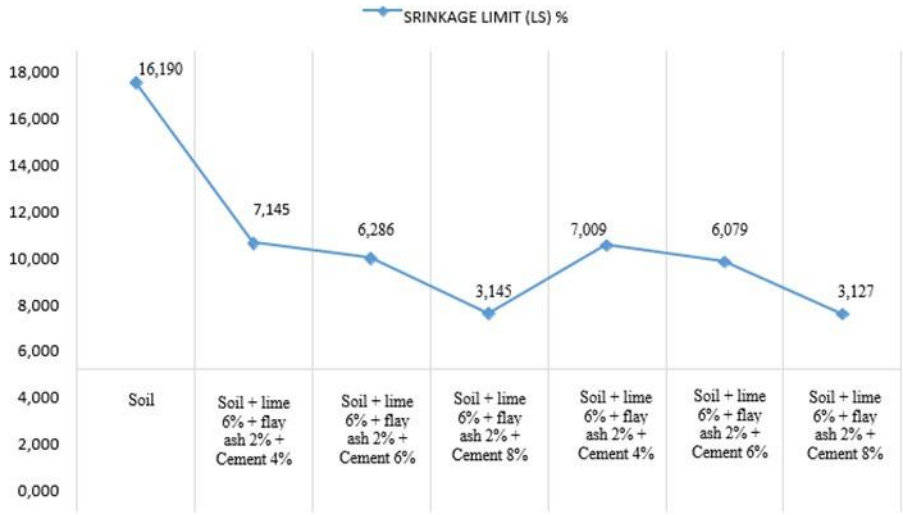

Fig. 4. Shrinkage limit graph

From the Shrinkage Limit (SL) test from Table 4.9 shows that the higher the percentage of cement in the Shrinkage Limit (SL) test, the smaller the shrinkage value, which means that the potential for shrinkage (expansion) is getting smaller on the soil and vice versa, the less cement mixture for stabilizing material. Then the value of shrinkage is getting bigger, which means that the potential for shrinkage (expansion) is getting higher. The longer the curing period, the lower the shrinkage value.

4. Conclusion

From the results of laboratory tests carried out on soil stabilized with the addition of 6% lime, 2% rice husk ash and 8% cement with Atterbeg test, Direct Shear test, Proctortest, CBR test and Swelling test resulted From the Atterberg test there was a decrease in SoilPlasticity (IP) from 42.75 to 14.43, From the direct shear test there is an increase in theshear angle in the soil (□) from 15.42 to 30.38. From the soaked CBR test there was an increase from4.3% to 37.63%. From the swelling test there was a decrease from 0.218to 0.096. The longer the curing time, the greater the value ofCBR. The amount of soaked CBR is greater when comparedto unsoaked, this is due to the curing time, soil hardening occurs due to the addition of stabilizing material. It can be seen that there is an increase in the strength of the soil so that it will increase the bearing capacity of the soil. There is also a decrease in the rate of shrinkage of the soil which means the soil is more stable so that the road above it is not bumpy anymore.

References

[1] **Bowles, J. E. 1986**, Sifat-Sifat Fisis Dan Geoteknis Tanah. (J. K. Hainim, Trans). Jakarta: Erlangga.

[2] **Das Braja M, 1988**, Mekanika Tanah (Prinsip-prinsip Rekayasa Geoteknik) Jilid I, Penerbit Erlangga. Jakarta

[3] **Terzaghi, Karl, Peck, B., Ralph, 1991**, Mekanika Tanah Dalam Praktek Rekayasa Jilid-2, Penerbit Erlangga, Jakarta.

[4] **Hardiyatmo, H. C. 2010**. Mekanika Tanah I. Edisi Ke V Gadjah Mada University Press. Yogyakarta.

[5] **ASTM D4546- 90 INTERNATIONAL, 1999**, "Standard Test Method for free swell test (free swell test)

[6] **ASTM D188 INTERNATIONAL, 1999**, "Standard Test Method for CBR (California Bearing Ratio) of Laboratory-Compacted Soils1"

[7] **Ingles, & Metcalf. (1972**). Soil Stabilization, Principles and Practice. USA

[8] **Pratikso (2006).** Pengaruh Penambahan Kapur terhadap Sifat Fisik dan Mekanis Tanah Lempung pada Subgrade di Jalan Semarang – Purwodadi. Jurnal Pondasi vol. 12 No.1 Juni 2006.

[9] **Ariyani N, Wahyuni PD (2007).** Perbaikan Tanah Lempung dari Grobogan Purwodadi dengan Campuran Semen dan Abu Sekam Padi. Majalah Ilmiah UKRIM Edisi 1/th XII/2007

[10] **Chen, F. H., 1975, 1988.** Foundation of Expansive Soils.

[11] New York: American Elsevier Science Publication.

[12] **Hidayat R (2014).** Stabilisasi Tanah Lempung dengan Menggunakan Campuran Aspal (Bitumen) terhadap Nilai CBR Subgrade Jalan. Diploma thesis, Universitas Andalas.

[13] **Hardiyatmo, H. C., 2014.** Tanah Ekspansif. Gajahmada Univercity Press Yogyakarta