CIVED Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

Mechanical Properties of Expansive Soil Stabilized by Sand

Tri Kurnia Rahayu.J[1*], Andi Herius[2], Dhevi Mulyanda[3], Nita Anggraini[4], Akifah Nadiareta[5], Anisah Qanitah Rashifah[6]
[1,2,3,4,5,6] Civil engineering, Politeknik Negeri Sriwijaya, Indonesia
[*]Corresponding author, e-mail: tri.kurnia.rahayu@polsri.ac.id

Received 20th August 2023; Revision 5th September 2023; Accepted 26th September 2023

ABSTRACT

Expansive clay soils have swelling and shrinkage properties and somehow reduce the mechanical properties required for soils to be used in civil engineering works. One method to improve the soil is by mechanical stabilization, namely mixing expansive clay soil with sand material. The sand material used in this research varied by 7.5%, 15%, and 22.5% of the total dry weight of expansive clay. The results shows that changes in mechanical properties were observed from the compaction test and California Bearing Ratio (CBR) both for soaked or unsoaked test. Based on these variations, in the compaction test, the addition of sand variations increases the maximum dry unit weight value and generally reduces the optimum water content value. The same results were also seen in the soaked and unsoaked CBR tests. In the swelling potential test, the addition of sand material succeeded in reducing the swelling value in expansive clay soils.

Keywords: *Soil Stabilization, Expansive clay, Sand, Soil Compaction, California Bearing Ratio (CBR)*

INTRODUCTION

Expansive clay soil is one of the problematic soils that cause problems in geotechnical engineering. Expansive clay soil has the potential to expand and contract greatly due to the reaction between the clay mineral content and changes in water content. The abundance of clay minerals, particularly the negatively charged mineral montmorillonite, has an impact on these characteristics [1]. Therefore, soil stabilization is required to lessen the swelling and shrinkage characteristics of expansive clay soils in order to raise the soil's bearing capacity.

In the discipline of geotechnical engineering, at least there are two main categories of expansive clay stabilization techniques; chemical stabilization and mechanical stabilization. Chemical stabilization is the process of introducing chemicals from substances including fly ash, silica fume, limestone, marble, cement ash, and even bacteria [2]. Contrarily, mechanical stabilization, which can take the form of soil mixing, subgrade removal, compaction, or fortifying the soil with geogrid or geotextile, is done without altering the chemical properties of clay soil [3].

Prior research has demonstrated an improvement in the mechanical qualities of clay soil that has been stabilized by sand material mixing. Sand is utilized because it has a low water content, which reduces the plasticity properties of clay soil by up to 50% and raises the maximum dry density value by up to 11% of the original soil when 10%, 20%, and 30% of

Journal of Civil Engineering and Vocational Education

EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

sand are added to it [4]. In addition, the CBR value can be raised by between 15% and 30% by mixing quartz sand and clay [5]. Therefore, more research must be done on the changes in mechanical properties caused by the stabilizing of expanding clay soil using sand material. Compaction tests, CBR values, and swelling potential will all reveal the alterations in mechanical qualities in concern.

MATERIALS AND METHODS

The soil material used in this research is clay soil from the Kapal Betung (Kayu Agung – Palembang – Betung) Toll Road construction project STA 64+800 KM 20, Banyuasin Regency. To calculate the plasticity index value, the Atterberg limits test is conducted. In this test, the plasticity index value is equal to 47.35% which means the soil belonged to the expansive soil. After that, sieve analysis test classified the soil as CH soil in the USCS soil classification.

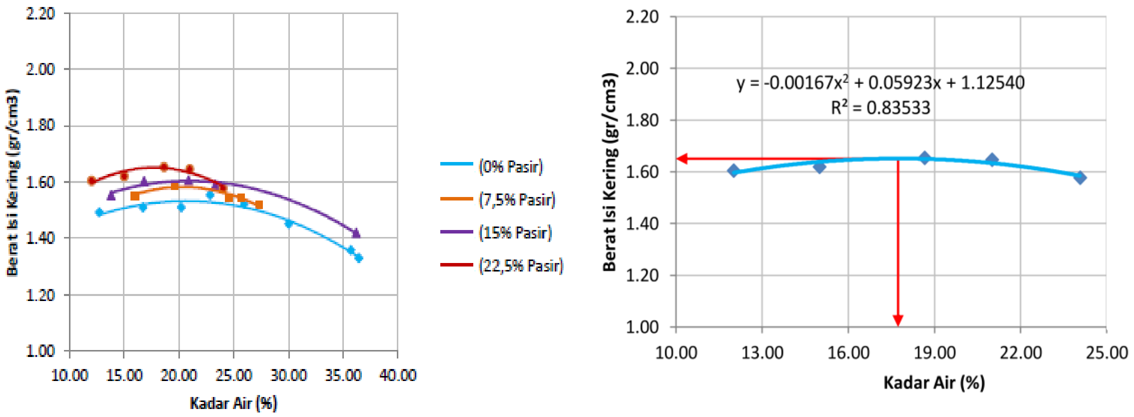
The sand utilized in this study was adopted in the Muara Enim Regency's Tanjung Raja area. This sand soil was also tested for sieve analysis and the sand soil was included in zone 2 sand gradation or rather coarse sand. In this study, varying amounts of sand material were used, including 0%, 7.5%, 15%, and 22.5%.

Additionally, conventional proctor compaction (SNI 1742: 2008) and unsoaked and soaked CBR (SNI 03-1744-1989) tests were utilized to quantify the mechanical impact of adding sand to expansive clay. Following the soaking CBR test, the swelling potential test was conducted. All testing was done at the State Polytechnic of Sriwijaya [6].

RESULTS AND DISCUSSION

Soil Compaction Testing

In this work, standard compaction tests and CBR were utilized to examine the mechanical properties of the soil. The goal of standard compaction testing is to establish the maximum density (w_{opt}) and maximum density (γ_{dmaks}) obtained from the compaction curve. Five samples of each type of sand mixture were tested to determine the compaction curve. In Figure 1 (a) there are four compaction curves for each type of sand mixture. As can be observed, adding different amounts of sand raises the expansive clay soil's dry unit weight value [7] with the largest curve coming from different sand addition amounts reaching 22.5%.



(a) (b)

Figure 1: Compaction curve showing (a) all variations (b) variations due to the addition of 22.5% sand.

CIVED Journal of Civil Engineering and Vocational Education
EISSN: 2622-6774
Vol 10 No.3 September 2023
http://cived.ppj.unp.ac.id/index.php/CIVED

The peak point of each compaction curve in Figure 1 (a) is then observed from its second order polynomial equation. The maximum dry unit weight and the optimum water content are represented by the peak x and y points of the curve, respectively. For example, the second order polynomial equation for variations in 22.5% of sand addition is shown in Figure 1 (b). The highest peak point is produced by the first level differential of this second order polynomial equation, which has a maximum density of 1.65 gr/cm^3 and an optimum water content value of 17.73%.

Table 1 summarizes the optimum water content and maximum dry unit weight for each type of sand mixing in expansive clay soil. According to this data, the addition of 22.5% sand from expansive clay soil can improve the maximum bulk weight from 1.53 gr/cm^3 to 1.65 gr/cm^3, while decreasing the optimum water content value from 20.61% to 17.73% or by 2.88%.

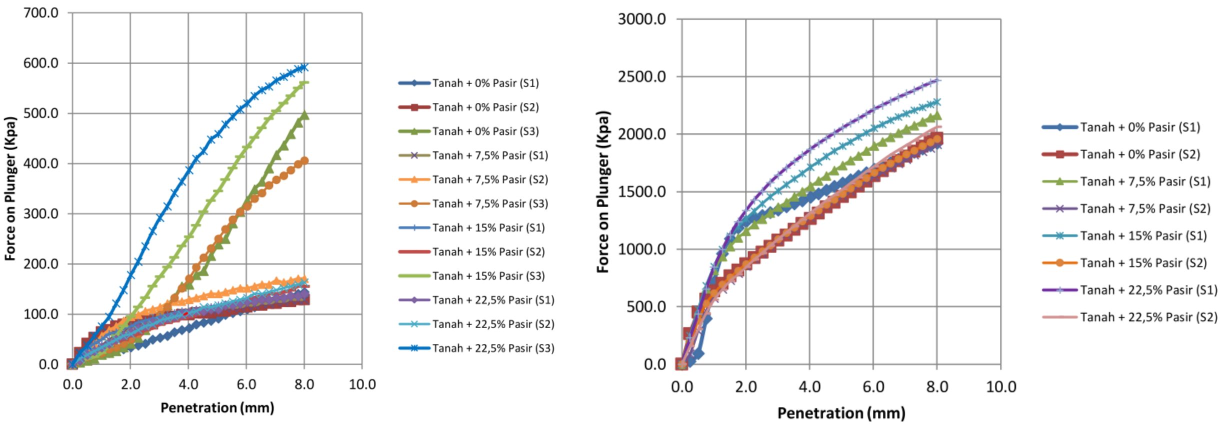
Table 1: Maximum dry unit weight and optimum water content for a sand and expansive clay mixture

Sample variation	w_{opt} **(%)**	γ_{dmaks} **(gr/cm3)**
Expansive clay soil + 0% sand (control sample)	20.61	1.53
Expansive clay soil + 7.5% sand	20.39	1.58
Expansive clay soil + 15% sand	20.97	1.60
Expansive clay soil + 22,5% sand	17.73	1.65

In contrast to other variations which give a decreasing trend in optimum water content, the variation with the addition of 15% sand, as presented from the Table 1, gives an increase in water content as high as 1.75% from control sample (20,61%) or equal to 20.97%. The maximum dry unit weight values that result, however, show the same trend: value increases as the percentage of sand increases.

California Bearing Ratio (CBR) Testing, Section

CBR test is carried out to obtain the value of the soil's bearing capacity in its maximum solid state. This test is carried out as one of the requirements for determining the thickness of the base and sub-base layers in road work. The thickness of the base and sub-base layers will be lessened if the CBR value in the base soil is high. In this study, two CBR testing techniques were used: soaked and unsoaked. **Error! Reference source not found.** displays the findings o f CBR load penetration in this research.



(a) (b)

Figure 2: CBR load penetration curve (a) soaked (b) unsoaked

According to Table 2, the CBR test findings in this study demonstrate that adding sand has an influence on raising the CBR value both for the soaked and unsoaked condition on expansive clay soil. For example, the unsoaked and soaked CBR value on Expansive clay soil + 22,5% sand sample are 17.62% and 2.23%, slightly increased from the control sample.

Table 2: CBR value from different sample variation

Sample variation	CBR (%)	
	Unsoaked	Soaked
Expansive clay soil + 0% sand (control sample)	15,56	1,49
Expansive clay soil + 7.5% sand	15,81	1,72
Expansive clay soil + 15% sand	17,14	1,90
Expansive clay soil + 22,5% sand	17,62	2,23

Swelling Potential Test

The swelling potential test is carried out after the soaked CBR test, which aims to see changes in the volume of expansive clay soil subjected to change in the surrounding water content. The results of the swelling potential test can be seen in Table 3.

Table 3: Swelling potential test for different sample

Sample variation	Swelling Potential (mm)
Expansive clay soil + 0% sand (control sample)	10,20
Expansive clay soil + 7.5% sand	9,70
Expansive clay soil + 15% sand	8,31
Expansive clay soil + 22,5% sand	7,40

It can be inferred from the swelling potential test findings in Table 3 that the swelling value tends to decrease with increasing sand mixture variation. According to Table 3, the lowest swelling value was belong to the Expansive clay soil + 22,5% sand mixture variation, namely 7.40 mm and the highest value obtained was 10.20 mm for control sample.

CONCLUSION

The compaction test demonstrates that the inclusion of variations in sand raises the value of the maximum dry unit weight while, generally lowering the value of the ideal soil water content. The maximum dry unit weight value for the control sample clay soil (0% sand mixture variation) is 1.53 gr/cm^3. The addition of sand material at 7.5%, 15%, and 22.5% produces a maximum dry unit weight value of 1.58 gr/cm^3; 1.60 gr/cm^3; and 1.65 gr/cm^3 or an increase of 3.27%; 4.57%; and 7.84%. Additionally, the addition of 7.5% and 22.5% of sand increased the ideal water content value from 20.61% to 20.39%, and decreased the ideal water content value from 20.61% to 17.73%. Conversely, the addition of 15% sand mixture increases the optimum water content value by 1.74% or equal to 20.97%

With regards to CBR values, sand material used to stabilize expansive clay soil show rise in proportion to the sand material's composition. A result of 5.56% CBR value was found in the unsoaked CBR test for original clay soil/control sample. Unsoaked CBR values were achieved at 15.81%, 17.14%, and 17.62%, by changing in sand material proportion of 7.5%, 15%, and 22.5% respectively. Meanwhile, in soaked CBR, control sample for soaked CBR value was obtained at 1.49%. CBR values increased by 15.44%, 27.52%, and 49.66% as a result of the addition of sand material variations of 7.5%, 15%, and 22.5%, respectively.

Lastly, the addition of sand as a stabilizing material can reduce the swelling value in expansive clay soil. The original soil had a swelling value of 10.20 mm. The swelling value can be decreased by 9.70 mm, 8.31 mm, and 7.40 mm, respectively, with the addition of sand material variations of 7.5%, 15%, and 22.5%.

REFERENCE

[1] A. Gunarso, R. Nuprayogi, W. Partono, and B. Pardoyo, "Stabilisasi Tanah Lempung Ekspansif dengan Campuran Larutan NaOH 7,5 %," *J. Karya Tek. Sipil*, vol. 6, no. 2, pp. 238–245, 2017, doi: 10.47178/dynamicsaint.v5i2.1098.

[2] A. M. Indriani, G. Utomo, and M. R. Syahputra, "Pengaruh Siklus Basah Kering terhadap Perilaku Mekanik Tanah Lempung Stabilisasi Biosementasi dengan Bakteri Bacillus Subtilis," vol. 10, no. 2, pp. 416–427, 2023.

[3] U. Zada *et al.*, "Recent advances in expansive soil stabilization using admixtures: current challenges and opportunities," *Case Stud. Constr. Mater.*, vol. 18, no. November 2022, p. e01985, 2023, doi: 10.1016/j.cscm.2023.e01985.

[4] A. A. Chandra, "Modifikasi Sifat Plastisitas Tanah Lempung Dengan Penambahan Pasir," pp. 437–449.

[5] M. R. A. Simanjuntak, K. Lubis, and N. M. Rangkuti, "Stabilization of Clay Lands with Coastal Sand Mixes on CBR Value," *J. Civ. Eng. Build. Transp.*, vol. 1, no. September, pp. 96–104, 2017.

[6] A. Nadiareta and A. Q. Rashifah, "Stabilisasi Tanah Lempung Lunak Ekspansif Menggunakan Material Pasir Terhadap Nilai CBR," 2022. [Online]. Available: http://eprints.polsri.ac.id/13862/

[7] Habiburrahman and N. Gofar, "Pengaruh Penambahan Pasir Terhadap Sifat Pemadatan Tanah Lempung," *Bina Darma Conf. Eng. Sci.*, pp. 438–450, 2015.