ISSN (*Online*) 2620-7222
ISSN (*Print*) 2503-2399

Available online at
https://jurnalteknik.unisla.ac.id/index.php/CVL

https://doi.org/10.30736/cvl.v2i2

The shear Strength of Clay Stabilized with Palm Bunch Ash and Cement

Teguh Waluyo[1], Muthia Anggraini[2*], Lusi Dwi Putri[3]
[1,2*,3] Fakultas Teknik, Universitas Lancang Kuning.
Email : [1] teguhwaluyo961@gmail.com [2*] muthia@unilak.ac.id [3]lusidwiputri@unilak.ac.id

A R T I C L E I N F O

Sejarah Artikel :
Article entry : 09-16-2023
Article revised : 09-21-2023
Article received : 09-29-2023

Kata Kunci:
Clay, Cohesion, Shear Strength, Soil Stabilization.

IEEE Style in citing this article:
T. Waluyo, M. Anggraini and L. D. Putri, "Shear Strength of Clay Stabilized With Palm Bunch Ash and Cement," CIVILA, vol. 8, no. 2, pp. 215-222, 2023.

A B S T R A C T

Roads with soft subgrade have low bearing capacity. The result is non-uniform soil settlement. One way to overcome this is with soil stabilization. Stabilization of clay soil is done chemically with palm bunch ash and cement. The purpose of this study was to determine the bearing capacity of soil for the shear strength value of clay soil with variations in mixing 5%, 10%, 15%, 20% oil palm bunch ash, and 10% cement with a 7-day curing period, and then the samples were tested using a direct shear test tool SNI 3420: 2016. The results showed that in the addition of a mixture of oil palm bunch ash and cement with levels of 5%, 10%, 15%, 20%, and 10% cement, the cohesion value increased at a percentage of 20% oil palm bunch ash and 10% cement, namely 0.5448 kg/cm2 compared to the cohesion value in the original soil of 0.0081 kg/cm2, an increase of 98.51%, and a shear angle value of 53.12° while the value of the original soil shear angle was 16.93°. This research concludes that the shear strength value of clay soil stabilized with oil palm bunch ash and cement increases.

1. Introduction

Subgrade can be defined as the lowest layer of soil to support the construction load above it. Subgrade road conditions with soft soil (clay) cause problems in this type of soil because clay soil has a low bearing capacity, and water greatly affects its physical and mechanical behavior. The impact is uneven subsidence in soil conditions with low bearing capacity [1]. Soft soils such as clays have a Plasticity Index (PI) value of >17%, classified as high plasticity clays [2].

Clay soils are characterized by low bearing capacity, and high shrinkage properties, resulting in this condition affecting the subgrade [3]. Clay soil properties are high moisture content, high compressibility, and low permeability [4]. In overcoming the problem of clay soil there are several ways, namely by soil stabilization. Soil stabilization is a process to improve soil properties and can increase the carrying capacity of the soil [5].

One of the parameters used for clay stabilization is the direct shear test. Therefore, research needs to be conducted on the effect of palm bunch ash and cement addition on the shear strength of clay soil. This research can increase the shear strength value of the soil [6]. Bowles (1997) concluded that clay soil in UU condition has a shear angle of 0^0 , while in CU condition the shear angle can range from 3 - 20^0 , due to the type of cohesion and soft soil, chemical stabilization is carried out to increase the bearing capacity of the soil [7].

Stabilization of clay soil with ash and cement is one of the ways to increase the shear strength of the soil. The combination of these stabilization materials is intended to cover the shortcomings of cement that can bind and harden when it reacts with water [8]. Palm bunch ash is a pozzolanic material that does not bind like cement. material that does not bind like cement [9]. Variations used for the stabilization material mixture are 5%, 10%, 15%, 20%, palm bunch ash and 10% cement.

Burning oil palm empty fruit bunches in ash have a high potassium content of 30-40% as K_2O. The ash of oil palm bunches was found to have a composition of 30-40% K_2O, 7% P_2O_5, 9% CaO, and 3% MgO [6]. Palm Oil Fuel Ash (POFA) or palm bunch ash is a waste produced by the palm oil industry palm oil industry [10]. Ash from burning palm bunches is the main additive additive used for soil stabilization and mixes soil [1]. Cement is the result of burning limestone, silica sand, iron sand, and clay. Cement has chemical elements of 60-65% lime (CaO), 17-25% silica (SiO_2), 3-8% aluminum (Al_2O_3), 0.5-6% iron (Fe_2O_3), 0.5-4% magnesia (MgO), 1-2% sulfur (SO_3), 0.5-1% soda/potash (Na_2+K_2O) [11].

Previous studies that examined the stabilization of clay soil are [12] with a mixture of 7.5% palm bunch ash and 5%, 7.5%, and 10% cement. Research [13], examines the addition of coconut shell charcoal coconut shell charcoal and tras on soil shear strength. Research [14], with a mixture of 5% of oil palm ash and 5%, 7.5%, and 10% cement. Research [15], Research on stabilization of loamy soil with the addition of coconut fiber in direct shear test. Research [16], on the effect of clay content on soil shear strength using direct shear test. The difference from previous research is the variation of stabilizers and stabilizer materials used.

2. Research Method

The research method is laboratory testing and the research location is in the Civil Engineering laboratory of Universitas Lancang Kuning. Clay soil samples were taken at Jalan Badak, Tenayan Raya Subdistrict, Pekanbaru. Samples were taken in disturbed soil and undisturbed soil. The disturbed soil was taken by digging using a plow and then cleaned of garbage, then put into sacks. The soil was then dried in the sun until dry. Then the soil was sieved using a no.4.75 sieve. The undisturbed soil was taken by using a handbore. Fresh fruit bunches that have been processed remain as waste and then burned after being extracted into palm bunch ash. The cement used is PCC (Portland Composite Cement) type from PT Semen Padang, in each test, 10% cement is used. The parameter used to increase the bearing capacity of the soil is shear strength, the shear strength of the soil can be determined by Direct Shear testing, to determine the cohesion value (c) and shear angle (º) of the soil.

Source: Google Earth, 2023

Figure 1. Research Location

3.1 Description and Technical

1. Population and Samples
   The clay soil was taken from Badak Street, Tenayan Raya District, Pekanbaru. The soil samples used are disturbed soil and undisturbed soil samples. The disturbed soil was taken by digging using a plow and then cleaned from garbage, and then put into sacks. The soil was dried in the sun until dry, then the soil was sieved with a no.4.75 sieve. While undisturbed soil is taken by using handbore. The method used is SNI 3420:2016 for the shear strength test. The shear strength of the soil is the resistance force carried out by the grains of soil against pressure or pull. Based on this understanding, if the land experiencing the burden will be detained [17] :
   a. Soil cohesion depends on the density and type of soil, but is independent of the normal stress acting on the shear plane.
   b. Friction between large soil grains is directly proportional to the normal stress in the shear plane
2. Sampling Techniques
   The soil samples used are disturbed soil and undisturbed soil samples. The disturbed soil was taken by digging using a plow and then cleaned from garbage, and then put into sacks. The soil was dried in the sun until dry, then the soil was sieved with a no.4.75 sieve. While undisturbed soil is taken by using handbore. Fresh fruit bunches that have been processed are left as waste and burned after being extracted into palm bunch ash, with variations of 5%, 10%, 15%, and 20%, palm bunch ash. The cement used in the test is PCC (Portland Composite Cement) type from PT Semen Padang, in each test, 10% cement is used.
3. Definition of Variable Operations
   Soil physical and mechanical properties testing aims to determine soil characteristics in the form of water content tests, liquid limit tests, plastic limit tests, specific gravity tests, and compaction tests.
4. Instrument Analysis Tool
   The physical properties of the soil are the original state of the soil the land whose value will later be used for determining the type of soil. Soil properties index test to determine soil characteristics in the form of water content test, liquid limit test, plastic limit test, specific gravity test, and compaction test. The parameters used to increase the bearing capacity of the soil are shear strength, shear strength of the soil can be known by direct shear testing, to determine the cohesion value (c) and shear angle (φ) of the soil.
5. Data Analysis Techniques
   The research methodology in this study is based on a laboratory approach, namely by conducting tests to obtain data. The collected data is then processed by performing calculations using the formula from the data from the tests carried out in the laboratory with the following provisions:
   a. For testing the specific gravity of the standard SNI 1964 – 2008
      The specific gravity of soil is the ratio between the density of soil grains and the density of distilled water at a temperature and the same volume [18].
   b. For testing the water content using the SNI 1965-2008 standard
      Is the ratio between the weight of water (Ww) with a solid grain weight (Wd) whose value is expressed in percent. The value of this water content affects the behavior of the soil, especially during development [19].
   c. To test the sieve analysis using the standard SNI 3423-2008
      The size of the soil particles differs from one soil type to another depending on the type of soil. Getting the value of the grain size of the soil is done by testing the sieve analysis [20].
   d. For the shear strength testing using the standard SNI 3420:2016
      Shear resistance commonly referred to as shear strength in the soil is very important to know for soil stability. The shear strength that occurs in a soil mass is the internal

resistance of the soil per unit area to failure or displacement that occurs along the shear plane in the soil [21].

e. For soil compaction testing using the standard SNI 1742-2008
Soil compaction in the laboratory is intended to determine the optimum moisture content and maximum dry density. This maximum moisture content and density can be used to determine the conditions that must be achieved in soil compaction work in the field [22].

4. Result and Discussion

4.1 Soil Classification Test

After testing the original soil moisture content, the following results were obtained:

Table 1. Moisture Content Testing

Pycnometer Number		1	2	3
Weight of Cup	(W_1) gr	11,36	11,00	11,27
Cup Weight + Wet Soil	(W_2) gr	76,15	63,67	77,63
Weight of Dish + Dry Soil	(W_3) gr	60,53	50,22	61,86
Water Weight/Mass	(gr)	15,62	13,45	15,77
Dry Soil Weight/Mass	(gr)	49,17	39,22	50,59
Water Content	(%)	31,77	34,29	31,17
Average Water Content	(%)		32,41	

Source: Data analysis (2023)

From Table 1, The initial soil moisture content value obtained at 32.41% indicates that in a specific soil sample or particular experiment, the initial moisture content of the soil was measured to be 32.41%. Soil moisture content refers to the amount of water present in a soil sample relative to its total weight or volume. In this context, the figure 32.41% signifies that approximately 32.41% of the total weight or volume of the soil sample consists of water. This information is of significance in various fields such as agriculture, environmental science, and engineering as it aids in understanding the soil's water content, which can have significant implications for plant growth, land use, construction, and other applications.

Table 2. Specific Gravity Test Result

Pycnometer / Measuring Flask Number	1	2	3
Weight of Dish	168,7	167,4	166,7
Weight of Dish + Dry Soil	219,2	217,3	217,1
Dry Weight of Soil (Ws)	50	50	50
Temperature T ºC (ºC)	28,00	28,00	28,00
Relative Water Density Relationship (Table)	0,9962652	0,9962652	0,9962652
Weight of Flask + Water (At T ºC) W1 (gr)	698,5	694,3	695,4
Weight of Flask + Water + Soil (At Temperature T ºC) W2 (gr)	729,9	725,3	726,8
Soil Contents (cm^3)	19,070	18,900	19,000
Specific gravity (Gs)	2,627	2,621	2,633
Average Specific gravity (average Gs)		2,627	

Source: Data analysis (2023)

From Table 2, the results of the soil specific gravity test conducted yielded an average soil specific gravity value of 2.627. This indicates that the original soil used in this study falls into the category of organic loam soil. This conclusion is drawn because the soil's specific gravity value falls within the range of 2.58 to 2.65, as specified in the table. Therefore, this result provides important information about the type of soil used in the research, which can have implications for understanding the soil's properties and its relevance within the context of the study [17].

Table 3. Atterberg Limits Test Results

	Liquid Limit (LL)			Plasticity Limit (PL)		
Many strokes	17	25	39	17	25	39
Cup number	1	2	3	1	2	3
Weight of cup (gr)	11,23	10,26	11,13	11,35	10,56	11,12
Weight of cup + wet soil (g)	42,75	40,89	42,23	16,35	15,56	16,12
Weight of cup + dry soil (gr)	31,49	30,24	31,90	15,23	14,52	15,20
Water weight (gr)	11,26	10,65	10,33	1,12	1,04	0,92
Dry soil weight (gr)	20,26	19,98	20,77	3,88	3,96	4,08
Water content (%)	55,58	53,30	49,74	28,87	26,26	22,55
Average moisture content (%)		52,87			25,89	
Plasticity index (%)			26,98			

Source: Data analysis (2023)

Based on the test results of the original soil Zetterberg limits, the liquid limit value is 52.87% and the plastic limit is 25.89% and the plasticity index value is 26.98%. From the plasticity index data, it can be seen in Table 2.3 that this soil is a high plasticity clay of>17% (Hardiyatmo, H. C., 2019).

Table 4. Compaction Test Results

Material	Optimum Water Content (%)	Dry Density (g/cm^3)
Clay	19%	1,44

Source: data analysis (2023)

The compaction test graph can be seen in Figure 2.

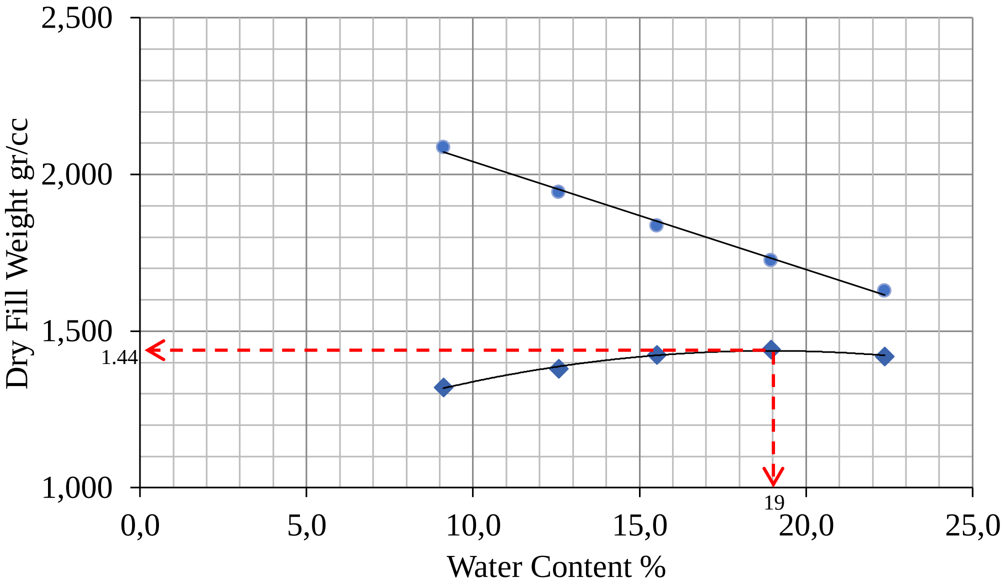

Figure 2. Graph of compaction testing results

From the results of the compaction test, sample 1 was taken at the highest point of dry weight on the y-axis, then the moisture content on the x-axis, after which it was connected to obtain a dry weight of 1.44 gr/cc and the optimum moisture content was 19.00%.

4.2 Shear Strength Test

Soil shear strength testing using a shear tester, conducted in the laboratory. The results of shear testing of clay soil stabilized with palm bunch ash and cement are:

Table 5. Shear Strength Test Results

No	Ash Content Palm Bunches (%)	Cement (%)	Cohesion (kg/cm^2)	Shear Angle (°)
1	0	0	0,0081	16,93
2	5	10	0,1374	41,95
3	10	10	0,4526	43,56
4	15	10	0,5044	46,69
5	20	10	0,5448	53,12

Source: Data analysis (2023)

Based on table 5. The results of the shear strength test with the addition of oil palm bunch ash and cement can increase the shear strength value of the soil. This is because palm bunch ash contains potassium (K) which can raise the pH of the soil and improve the physical, chemical, and biological properties of the soil. Meanwhile, cement contains calcium (Ca) which can harden and quickly react with water. The combination of palm bunch ash can reduce the shortcomings of cement that easily binds and hardens when exposed to water (Anggraini, M. dan Saleh, A., 2022). The highest value of shear strength is in the variation of 20% ATKS and 10% cement with a shear angle of 53.12° and cohesion of 0.5448.

5. Conclusions and Suggestions

5.1 Conclusion

From the results of this study, it can be concluded that the maximum increase in the variation of 20% ATKS and 10% cement produces a cohesion value of 0.5448 kg/cm2 while the original soil cohesion value is 0.0081 kg/cm2. The maximum increase in the variation of 20% ATKS and 10% cement produces a shear angle value of.

5.2 Suggestions

The suggestions from the results of the clay stabilization research using palm bunch ash and cement on shear strength values are as follows:

1. Further research for different mixing variants is expected.
2. Other tests need to be carried out using other variations of mixed materials such as combinations with fly ash, lime, and other stabilizers: Fly ash, lime, and other stabilizers.

References

[1] D. Panggabean, W. Winayati, and M. Anggraini, "Stabilisasi Tanah Lempung Menggunakan Abu Tandan Kelapa Sawit dan Semen Untuk Meningkatan Nilai CBR," *J. Tek. Sipil*, vol. 10, no. 1, 2021.

[2] M. Anggraini, V. T. Haris, and A. Saleh, "Stabilisasi Tanah Lempung Dengan Abu Tandan Sawit dan Semen Terhadap Tingkat Kepadatan Tanah," *J. RACIC*, vol. 7, no. 1, pp. 44–54, 2022, [Online]. Available: https://scholar.archive.org/work/324a7gurbrcsfcdect7odt2mzq/access/wayback/http://jurnal.univrab.ac.id/index.php/racic/article/download/1423/897.

[3] I. Ardiansah, Z. Zainuri, and M. Anggraini, “Experimental Study of Addition of Plastic Waste (PET) to the Shear Strength of Clay Soil,” *Civilla J. Tek. Sipil Univ. Islam Lamongan*, vol. 7, no. 2, p. 161, 2022, doi: 10.30736/cvl.v7i2.891.

[4] L. Yang, W. Xu, and K. Li, “Analysis of the Embankment Settlement on Soft Soil Subgrade with a Cement Mixed Pile,” *Adv. Civ. Eng.*, vol. 2021, 2021.

[5] M. Sari, F. Lubis, and M. Anggraini, “Stabilisasi Tanah Gambut Dengan Kapur Terhadap Nilai California Bearing Ratio (CBR),” *J. Tek. Sipil UTU*, vol. 7, no. 2, pp. 136–145, 2021.

[6] P. Ningrum, Husnah, and Husni Mubarak, “Pengaruh Penambahan Abu Tandan Sawit pada Tanah Lempung berdasarkan Nilai Kuat Geser,” *Aptek*, vol. 14, no. 1, pp. 46–52, 2022, doi: 10.30606/aptek.v14i1.1104.

[7] A. J. Susilo, G. S. Sentosa, I. Sumarli, and A. Prihatiningsih, “Karakteristik Parameter Kekuatan Tanah Yang Dipadatkan Dengan Uji Triaksial Metode UU,” *J. Muara Sains, Teknol. Kedokt. dan Ilmu Kesehat.*, vol. 2, no. 2, p. 572, 2018.

[8] M. Miswar, S. Syaifuddin, and N. Amani, “Stabilisasi Tanah Lempung Menggunakan Semen Dan Kapur Untuk Meningkatkan Daya Dukung Cbr Tanah,” *Portal J. Tek. Sipil*, vol. 9, no. 2, pp. 1–13, 2018, doi: 10.30811/portal.v9i2.615.

[9] J. Sarifah and B. Pasaribu, “Pengaruh Penggunaan Abu Cangkang Kelapa Sawit Guna Meningkatkan Stabilitas Tanah Lempung,” *Bul. Utama Tek.*, vol. 13, no. 1, pp. 55–61, 2017.

[10] A. W. Otunyo and C. C. Chukuigwe, “Investigation Of The Impact Of Palm Bunch Ash On The Stabilization Of Poor Lateritic Soil,” *Niger. J. Technol.*, vol. 37, no. 3, p. 600, 2018, doi: 10.4314/njt.v37i3.6.

[11] Maryati and Y. Apriyanti, “ANALISIS PERBANDINGAN PENGGUNAAN LIMBAH GYPSUM DENGAN SEMEN SEBAGAI BAHAN STABILISASI TANAH,” vol. 4, 2016.

[12] M. Anggraini and A. Saleh, “Kuat Geser Tanah Lempung Dengan Abu Tandan Sawit dan Semen,” *J. SAINSTEK*, vol. 10, no. 1, pp. 24–31, 2022.

[13] A. N. E. Naseriman, O. B. A. Sompie, and A. Sarajar, “Pengujian Kuat Geser Pada Stabilisasi Tanah Lempung Dengan Campuran Arang Tempurung Kelapa Dan Tras Ditinjau Dari Waktu Pemeraman,” *J. Sipil Statik*, vol. 8, no. 5, pp. 779–788, 2020.

[14] A. Muthia and S. Alfian, “Compressive Strength Value Of Clay Soil Stabilization With Palm Oil Fuel and Cement,” in *IOP Conference Series: Earth and Environmental Science*, 2021, vol. 737, no. 1, pp. 1–6, doi: 10.1088/1755-1315/737/1/012038.

[15] G. Y. Setiawan, M. I. Yani, and O. Hendri, “Stabilisasi Tanah Lempung Dengan Penambahan Serabut Kelapa Pada Pengujian Kuat Geser Langsung (Direct Shear Test),” *Info-Teknik*, vol. 22, no. 1, p. 31, 2021.

[16] D. P. Pratama and N. Gofar, “Pengaruh Kandungan Lempung Terhadap Kuat Geser Tanah Menggunakan Uji Geser Langsung,” *Bina Darma Conf. …*, no. 200, pp. 961–971, 2021, [Online]. Available: https://conference.binadarma.ac.id/index.php/BDCES/article/view/2993%0Ahttps://conference.binadarma.ac.id/index.php/BDCES/article/download/2993/1236.

[17] H. C. Hardiyatmo, *Mekanika Tanah 1*, Edisi-5. Yogyakarta: Gadjah Mada Unibersity Press, 2010.

[18] BSN, “Cara Uji Berat Jenis Tanah,” in *Sni 1964:2008*, 2008, pp. 1–14.

[19] BSN, “Cara Uji Penentuan Kadar Air untuk Tanah dan Batuan di Laboratorium,” in *Sni 1965:2008*, 2008, pp. 1–16.

[20] SNI 3423:2008, “Cara Uji Analisis Ukuran Butir Tanah,” in *Sni 3423:2000808*, 2008, pp. 1–27.

[21] Badan Standardisasi Nasional, “Metode Uji Kuat Geser Langsung Tanah Tidak Terkonsolidasi dan Tidak Terdrainase,” in *SNI 3420:2016*, 2016, pp. 1–19.

[22] BSN, “Cara Uji Kepadatan Ringan untuk Tanah,” in *Sni 1742:2008*, 2008, pp. 1–20.

[23] C. H. Hardiyatmo, *Mekanika Tanah 1*. Yogyakarta: Gadjah Mada University Press, 2019.