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Stabilization of Fibrous Peat Soils with Addition Palm Shell Ash Waste

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ABSTRACT

South Sumatra Province has a peat area of 1.4 million Ha. The distribution of peat soil in Ogan Ilir is 23,687.91 Ha. Peat soil has a low bearing capacity. This research aims to explain the effect of stabilization on peat soil characteristics. Peat soil samples were taken using the Block Sampling method. The research locations are Parit Village and Lorok Village, Ogan Ilir Regency. Peat soil needs better properties and is unsuitable for foundation soil for civil construction. To overcome this, one method of soil improvement is required, namely the chemical stabilization method: changing the chemical properties of the soil by adding a mixture. The mixture used is palm shell ash waste with variations of 0%, 10%, 15%, 20%, 25%. Soil properties (physical and chemical), SEM, EDS, PTS, and CBR tests were carried out to determine the effect of this mixture. Soil properties test results: water content (□) in Parit Village 226.39%, and Lorok Village 252.39%. The fibre content (FC) test results for Parit Village were 25.18% and for Lorok Village 28.01%. Peat soil is classified as fibrous peat soil. The CBR value for Parit Village was 4.60%, and Lorok Village was 4.16%. The results of the immersion CBR test showed that Parit Village had a curing period of 7 days, a variation of 5%, namely 4.68%. Look Village obtained the most outstanding results: a curing period of 14 days, a variation of 25%, and 4.76%. The CBR value obtained in this study is 3%-5% (average) when used for subgrade strength with compaction conditions depending on the road category.

Introduction

The distribution of peatlands in South Sumatra reached 1,968,243.75 Ha. The distribution is explained in Figure 1 which includes: Banyuasin (574,683.42 Ha), Muara Enim (23,687.91 Ha), Muratara (45,896.31 Ha), Musi Banyuasin (379,874.78 Ha), Musi Rawas (26,147.49 Ha), Ogan Ilir (23,687.91 Ha), Ogan Komering Ilir (863,704.81 Ha),

and Pali (30,561.13 Ha) (Wahyudi, Anugerah, & Arif, 2021). Peatland is a soil that contains a large amount of organic matter (Andriani, Yuliet, & Fernandez, 2012). Peatland is categorized as soft soil, which means the soil could be in better condition and is problematic if construction is built on it. Peat soil has many disadvantages; for example, having high moisture content, low carrying capacity on peat soil, and high compressibility are the main problems for construction development. Explains the analysis of soil support data. Analysis of shear strength and flow/seepage based on (Hardiyatmo, 2007). To increase strength and improve the carrying capacity of peatlands, efforts must be made to stabilize the soil.

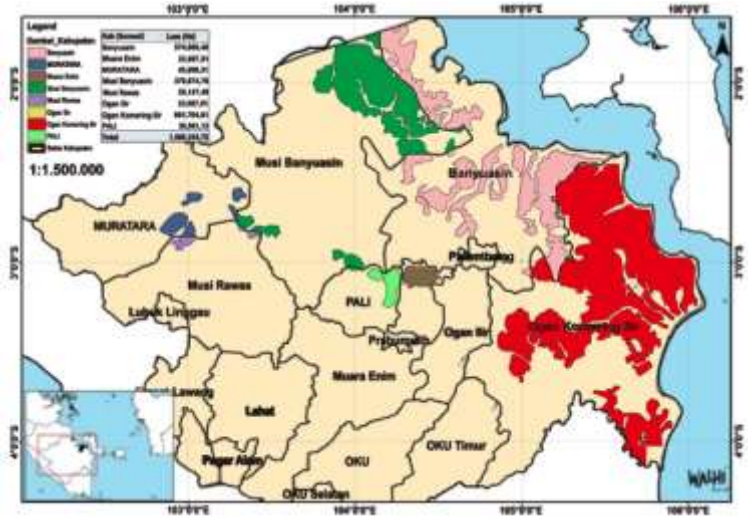


Figure 1 Peatland distribution in South Sumatra

Stabilization is an effort to improve the properties of the original soil so that the problematic soil has parameters suitable for use in construction development. Yusof et al. (2023) researched stabilizing 3%, 6%, 9%, and 12% coconut shell charcoal ash and 10% fly ash on peat soil. Stabilization of lime (10%) and Matos (4%, 6%, 8%) on peatlands (Prabowo, 2018). (Gazali & Kurniawan, 2023) researched stabilizing 4%, 6%, 8%, 10%, and 12% lime palm shell ash in soft clay soils. (Waluyo, Anggraini, & and Putri, 2023) examined the stabilization process of clay soil with a mixture of 5%, 10%, 15%, 20% palm ash and 10% cement. Stabilization of clay soil with a mixture of 20% palm oil fuel ash (Toyeb, Hakam, & Andriani, 2023). Stabilization of oil palm empty bunch fibers on soft soils (Arifin, Arfiandoyo, Salsabila, & Ridha, 2023). Research by (Susanti, Endriani, & Thamrin, 2022) regarding the analysis of stabilization of palm shell ash and cement on clay soils with a mixture of 0%, 6%, 12%, 18%, 24%, and 30%. Sanderab et al. (2021) conducted a stabilization test of palm shell ash (0%, 3%, 6%, 9%, 12%, and 15%) on clay soils. Meanwhile, the research of Sitorus and Husny (2020) tested the stabilization process of palm shell ash on clay soils with variations of 0%, 4%, 8%, 12%, 16%, and 20%. As well as the effect of coconut shell ash stabilization (0.4%-0.8%) on soft soils (Prasanna & Kumar, 2017).

Based on the description above, this research uses a mixture of palm shell ash waste to stabilize peat soil. Palm shell ash waste is waste from palm oil processing that has

been burned in an incineration furnace with a temperature of 700oC – 800oC. Palm shell ash waste has pozzolanic properties because it contains silica and alumina, which can form cement materials beneficial for soil stability. After all, they can increase the binding power between soil particles.

Tests must obtain comparable parameter values to determine the effect of adding palm shell ash waste on peat soil. The tests carried out are Standard Soil Compaction (PTS) testing, CBR (California Bearing Ratio), Soaked (Immersion) testing, and SEM-EDS tests. Scanning Electron Microscope (SEM) is used to observe the orientation of fibers on fibrous peat soils. Energy Dispersive X-ray spectroscopy (EDS) is used to analyze peat soil samples' elements or chemical characterization.

Method

This research started with literature studies and field surveys. A literature study is a stage of collecting materials and information related to research used as a reference in carrying out this research. The material is obtained from various sources such as scientific writings, books, diktat, the internet, journals, or previous research. The field study sampled native peatland from Indralaya, Ogan Ilir Regency, South Sumatra Province. The research locations in this area are in Parit Village and Lorok Village, North Inderalaya District, Ogan Ilir Regency, South Sumatra Province (Figure 2). The soil taken is disturbed soil and undisturbed soil. Undisturbed soil was taken using the Block Sampling method (ASTM D7015-04) by excavating to a depth of ±1 m.

(a) Desa Parit (b) Desa Lorok

Figure 2 Research location

Laboratory work (physical, chemical, and mechanical properties) is done at the Laboratory of Soil Mechanics, Department of Civil Engineering and Planning, Faculty of Engineering, Sriwijaya University, in Indralaya. Soil samples for stabilization materials start with drying, pounding, and filtering soil samples. For palm shell ash waste, preparation begins by drying the material using an oven at a temperature of 110°C for 2 hours and then filtering it using a No.200 sieve. Then, the palm shell ash waste is prepared for the original soil mixture according to the variations used (0%, 5%, 10%, 15%, 20%, and 25%). The soil mixture material, namely palm oil shell ash waste, is produced from factory waste taken from PT. Tirta Fresindo Jaya.

The number of samples for each soil property test was six samples. These tests include testing moisture content (SNI 1965-2008), specific gravity (ASTM D854-02), ash content and organic content (ASTM D2974-00), fiber content (ASTM D1997-91), and acidity degree (pH) (ASTM D2976-71). Soils included in the classification of fibrous peat soils (fibrous peat) are then continued for soil mechanical testing. Mechanical testing of peat soil is carried out to determine the structural properties of soil masses when given force/pressure. Mechanical testing on peat soils includes Standard Soil Compaction (PTS) testing (SNI 1742-2008), CBR Soaked testing (SNI-1744-2012), and SEM and EDS testing.

The test pieces in this study were made with various variations of mixture between peat soil and oil palm shell ash waste additives. Mixing this test piece is adding additives in the form of palm oil shell ash waste with a predetermined percentage of the dry soil weight and then adding water. The moisture content value is obtained by calculating the optimum level in the Standard Soil Compaction (PTS) test. Table 1 describes the specimens for mechanical properties testing in 18 samples, with each variation tested from 3 samples. Testing of mechanical properties of fibrous peat soils (CBR). Research materials and equipment can be seen in Figure 3.


Palm Shell Ash Waste


Tanah Gambut


NO AND EDS


CBR Soaked

Figure 3 Research materials and equipment

Table 1
Sample specimen

No.	Types of Variations	Number of Test Pieces	Code
1.	Native Fibrous Peatlands	3	AC00
2.	Peatland + 5% Palm Shell Ash Waste	3	AC5
3.	Peatland + 10% Palm Shell Ash Waste	3	AC10
4.	Peatland + 15% Palm Shell Ash Waste	3	AC15
5.	Peatland + 20% Palm Shell Ash Waste	3	AC20
6.	Peatland + 25% Palm Shell Ash Waste	3	AC25
	Total Test Specimens	**18**	

Results and Discussion

Results of Testing Soil Properties of Native Soil

Testing soil properties on soil is testing the characteristics of native soil in peat soil. The data from the test results of the physical properties of the original soil can be seen in Table 2. The results obtained from the peat soil moisture content test (□) in Parit Village were 226.39%, and the soil moisture content test in Lorok Village was 252.39%. Furthermore, the specific gravity test (Gs) of peat soil results showed that Parit Village obtained a particular value of gravity of 0.91. Meanwhile, in Lorok Village, a specific gravity (Gs) value of 0.89 was obtained. Furthermore, the results of the fiber content (FC) test. The average soil fiber content testing value was 25.18% in Parit Village and 28.01% in Lorok Village. Organic content (OC) of Parit Village with a value of 69.32%. Meanwhile, Lorok Village obtained an organic content value of 74.41%. Furthermore, the ash content (AC) test results in Parit Village obtained an ash content value of 83.57%. Meanwhile, Lorok Village obtained an ash content value of 19.46%. The Acidity Degree (pH) test results, Parit Village, were obtained at 4.32, while Lorok Village was 3.57.

Table 2
Results of testing the physical properties of native soil

Desa Parit			Look Village		
Testing	**Symbol**	**Result**	**Testing**	**Symbol**	**Result**
Up Air	*ω* (%)	226,39	Up Air	*ω* (%)	252,39
Specific Gravity	Gs	0,91	Specific Gravity	Gs	0,89
Fiber Content	HR (%)	25,17	Fiber Content	HR (%)	28,01
Organic Up	OC (%)	69,32	Organic Up	OC (%)	74,41

Up to Abu	AM (%)	83,57	Up to Abu	AM (%)	19,46
Degree of Acidity	pH	4,31	Degree of Acidity	pH	3,57

Results of Standard Soil Compaction Testing (PTS) of Native Soil

Table 3 shows the Standard Soil Compaction (PTS) test results. This test obtains the optimum dry fill density values and the maximum moisture content. The test results obtained from Parit Village connected the ωopt value of 23.80% with the result of the γdmax value of 0.90 gr/cm3, and the test results obtained from Lorok Village connected the ωopt value of 18.33% with the result of γdmax value of 0.91 gr/cm3. The test was obtained to determine the optimum moisture content for the next CBR test.

CBR Test Results of the Original Soil Immersion Laboratory

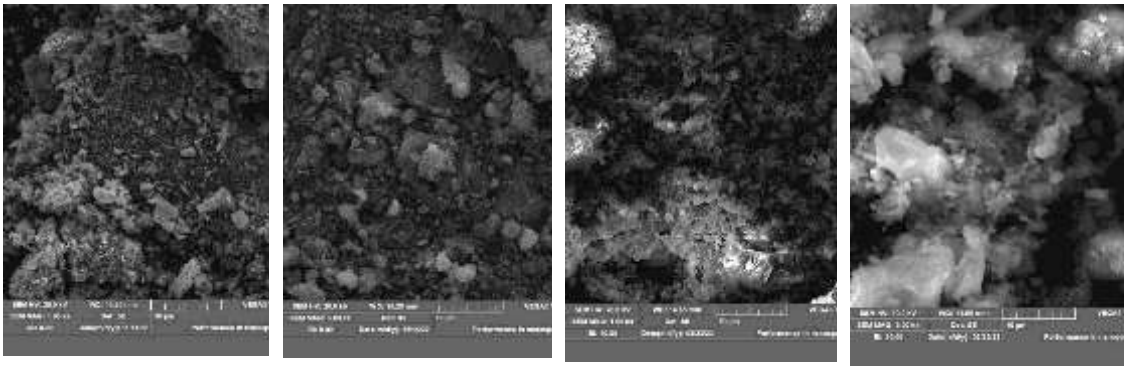
The results of the CBR value obtained at 0.1-inch penetration in Parit Village of 3.27% and 0.2 inches worth 4.60% are shown in Figure 5. produced a maximum value of 0.1 inches of penetration result with a development percentage value of 1% in the CBR test, and the load of 0.1 inches of penetration result of the CBR test resulted in 101.17 lbs, while a penetration load of 0.2 inches produced 207.07 kg. The results of the CBR value obtained at 0.1 inches penetration in Lorok Village of 3.15% and 0.2 inches worth 4.16% show that Figure 6. produced a maximum value of 0.1 inches of penetration result with a development percentage value of 1% in the CBR test and a load of 0.1 inches of penetration result of the CBR test produced 94.48 lbs. A penetration load of 0.2 inches of the CBR test produced 186.99 kg.

Table 3
Standard Soil Compaction (PTS) test results

Desa Parit			Look Village		
Testing	**Symbol**	**Result**	**Testing**	**Symbol**	**Result**
Up-to-air optimum	ωopt (%)	23,80	Up-to-air optimum	ωopt (%)	18,33
Maximum dry fill density	γdmax (gr/cm3)	0,90	Maximum dry fill density	γdmax (gr/cm3)	0,91
Immersion CBR value	(%)	3,2	Immersion CBR value	(%)	3,15
Development percentage	(%)	1	Development percentage	(%)	1

SEM (Scanning Electron Microscope) Test Results of Native Soil

The results of SEM (Scanning Electron Microscope) tests for the original soil of Parit Village and Lorok Village can be seen in Figure 4 and Figure 5. In the SEM test carried out at the Palembang Police Forensic Laboratory, the results for the original soil were magnified by 1000x, 5000x, and 10000x. For the magnification of 10000x, the cavities of the original peatland are more evident than the magnification of 1000x and 5000x.



1000x 5000x 1000x 5000x

10000x 10000x

Desa Parit **Desa Lorok**

Figure 4 SEM results of original peatland

EDX (Energy X-ray Spectroscopy) Test Results of Native Soil

EDX (Energy X-ray Spectroscopy) testing for the native peat of Parit Village and Lorok Village can be seen in Figure 7 and Table 4. The results of the EDX content for the original peatland of Parit Village show the highest elemental values in barium and the lowest in carbon. Similar to the EDX content results for the original soil of Lorok Village, the highest element value is found in the element Barium and the lowest in the element Carbon.

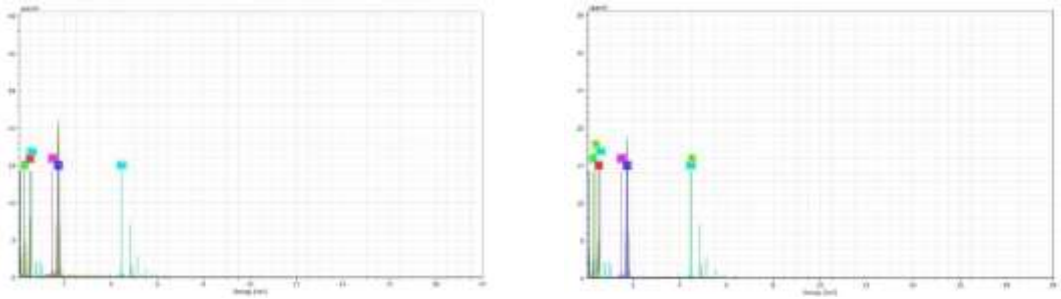


Figure 5 Graph of EDX results for native peatlands

Table 4

EDX content for native peatlands

Desa Parit			Look Village		
Element	**At. No**	**Net**	**Element**	**At. No**	**Net**
oxygen	8	25200	oxygen	8	23564
Carbon	6	16935	Carbon	6	12161

Silicon	14	107993	Silicon	14	115198
Barium	56	2231	Barium	56	6966
Aluminium	13	2128	Aluminium	13	3017
Iron	26	588	Iron	26	970
Sulfur	16	599	Sulfur	16	615
Calcium	20	191	Calcium	20	193
Titanium	22	1477	Sodium	11	38
Potassium	19	199	Magnesium	12	42
			Potassium	19	40

Results of Testing Mechanical Properties of Mixed Soil

Mechanical testing of soils with mixed soils consists of Standard Soil Compaction testing and California Bearing Ratio (CBR) testing. The CBR test used is CBR of soaking soil (Soaked).

Results of Standard Soil Compaction Test with Mixture

A PTS test carried out the percentage variation in the addition of palm shell ash waste to soil. Both values are used for the California Bearing Ratio (CBR) test. The conditions that occur when conducting this test are used as a standard for the density of each test piece to test the development potential of the soil. The results of this test show the values of Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) in Table 5. Figure 6 explains the graph of the variation of the palm shell ash mixture to the OMC value and Figure 7 to the MDD value. The maximum moisture content (OMC) value (ωop) for AC00 variation from Parit Village was 23.08%, and Lorok Village was 18.33%. As well as the optimum dry fill moisture content (MDD) (γdmax) value for AC00 variation from Parit Village of 0.89 gr/cm3 and Lorok Village of 0.91gr/cm3.

Table 5
OMC and MDD results with mixed variations

Desa Parit			**Look Village**		
Variations	Up to Air Maximum (OMC) (ωopt, %)	Up to the Air Work Kering Optimum (MDD) (γdmax, gr/cm3)	Variations	Up to Air Maximum (OMC) (ωopt, %)	Up to the Air Work Kering Optimum (MDD) (γdmax, gr/cm3)
AC00	23,80	0,89	AC00	18,33	0,91
AC5	22,10	0,73	AC5	36,10	0,65
AC10	16,17	0,75	AC10	28,30	0,65
AC15	18,05	0,76	AC15	28,00	0,60
AC20	15,10	0,77	AC20	16,50	0,65
AC25	16,10	0,70	AC25	18,20	0,65

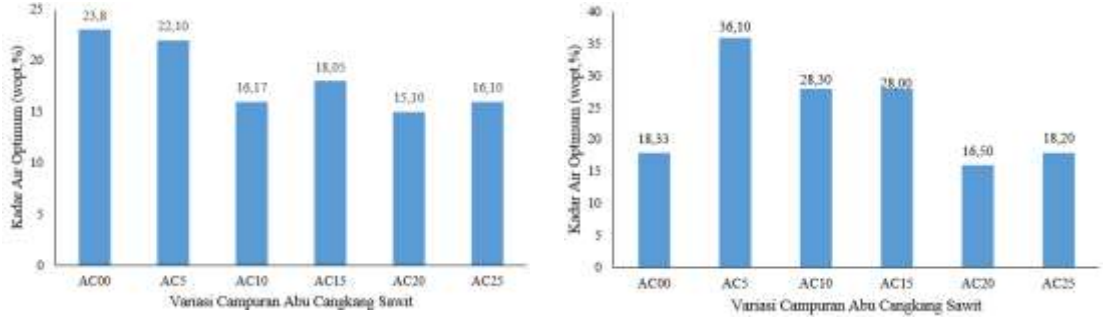


Figure 6 Graph of variation of palm shell ash mixture on OMC value

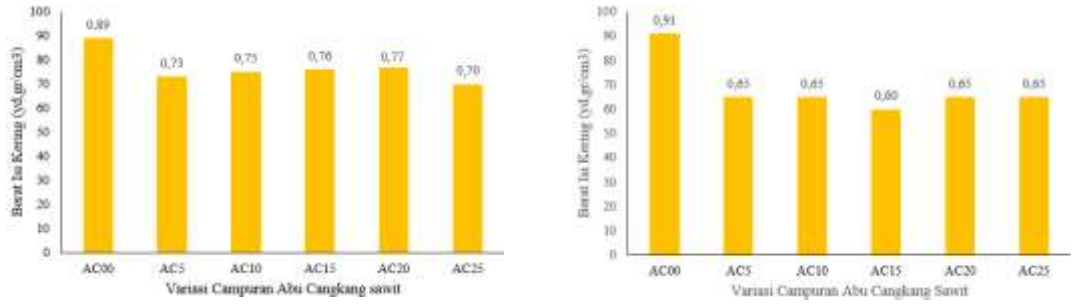


Figure 7 Graph of variation of palm shell ash mixture to MDD value

Results of CBR Test of Immersion with Mixture

The CBR test with a mixture of palm shell ash waste has five variations, namely 5%, 10%, 15%, 20%, and 25% of the original soil weight. Each mixture has a curing period of 0, 7, and 14 days. The recapitulation of the results of the CBR test of immersion with a mixture of palm oil shell ash waste is shown in Table 6. In Table 6, it is stated that the CBR value of trench village immersion based on the corrected penetration value of 0.1 and 0.2 inches is obtained; the highest penetration value is 0.2 inches. The CBR value of soil immersion after mixing palm shell ash experienced a relatively significant increase from the original soil, which was 4.60%. The CBR value in the 25% variation increased during the 0-day curing period, increased again during the 7-day curing period, and decreased again during the 14-day curing period.

Judging from the results of the CBR value of the soak, the maximum value was 4.68% at a variation of 5% and a curing period of 7 days. Meanwhile, the CBR value of Lorok Village immersion based on the corrected penetration value of 0.1 and 0.2 inches was obtained; the highest penetration value was 0.2 inches. The CBR value of soil immersion after mixing palm shell ash experienced a relatively significant increase from the original soil, which was 4.16%. The CBR value in the 25% variation decreased during the 0-day curing period, decreased during the 7-day curing period, and increased again during the 14-day curing period. Judging from the results of the CBR value of soaking, the maximum value was 4.76% at a variation of 25% and a curing period of 14 days.

Based on the CBR test of immersion with the curing period, it was obtained that the longer the curing period, it was influenced by the increase in the CBR value of the immersion. The increase in CBR value is caused by ions from palm oil shell ash binding together into peat soil particles. Judging from the 0-day curing period, Parit Village obtained the most significant result, 4.66% in the 5% variation. For the 14-day curing period, the most considerable yield was found in the 5% variation, 4.65%. The most important result was obtained during the 7-day curing period when the variation was 5%,

which was 4.68%. Meanwhile, judging from the 0-day curing period, Lorok Village obtained the most significant result, 4.7% in the 10% variation. For the 7-day curing period, the most considerable yield was found in the 25% variation, 4.68%. The most significant result was obtained during the 14-day curing period when the variation was 25%, which was 4.76%.

Table 6
Results of CBR value of soaking with a mixture of palm shell ash waste

Desa Parit				**Look Village**			
Mixed Variations	Treatment Period (days)	CBR Value Rendaman (%)		Mixed Variations	Treatment Period (days)	CBR Value Rendaman (%)	
		1 (inch)	2 (inches)			1 (inch)	2 (inches)
AS00	-	3,37	4,60	AS00	-	3,15	4,16
AS5	0	3,37	4,66	AS5	0	3,03	4,15
	7	3,35	**4,68**		7	3,07	4,16
	14	3,36	4,65		14	3,11	4,17
AS10	0	3,21	4,58	AS10	0	3,48	4,70
	7	2,72	4,15		7	2,76	4,01
	14	2,62	3,86		14	3,07	4,26
AS15	0	3,24	4,61	AS15	0	3,37	4,51
	7	2,68	4,10		7	3,07	4,09
	14	3,21	4,51		14	3,02	4,17
AS20	0	3,29	4,59	AS20	0	3,41	4,41
	7	2,59	3,62		7	3,27	4,47
	14	3,49	4,58		14	2,78	3,57
AS25	0	3,25	4,47	**AS25**	0	3,56	4,69
	7	3,35	4,49		7	3,57	4,68
	14	3,20	4,44		**14**	3,61	**4,76**

The value of the Parit Village CBR test development results is described in the form of a curing period, according to Figure 8. Meanwhile, the results of the development of the CBR test in Lorok Village are described in the form of a curring period, according to Figure 9. The development value based on the CBR test of soaking accompanied by the addition of palm shell ash waste shows that if the percentage of variation of palm shell ash increases, the development tends to decrease. The curing period also affects the development outcome factor. The longer the curing period, the less development will be. It is known that the results of the development of Parit Village decreased by 0% to 25% for each variation during the entire curing period. The smallest percentage of development occurred at 20% variation; when the curing period was 14 days, it was 0.24%. The most significant percentage of development happened in the 0% variation of 1.93% because the tests carried out did not use mixed materials but native soil.

The development results in adding the mixture were the most significant variation of 5% when the treatment period of 0 days was 1.44% and seven days was 1.37%, while the treatment period of 14 days was obtained by 1.30%. Meanwhile, the development results of Lorok Village decreased by 0% to 25% for each variation during the entire

curing period. The smallest percentage of development occurred at 25% variation; when the curing period was 14 days, it was 0.27%. The most significant percentage of development happened in the 0% variation of 1.96% because the tests carried out did not use mixed materials but native soil. The development result in adding the mixture was the most significant variation of 15% when the treatment period of 14 days was 1.61%.

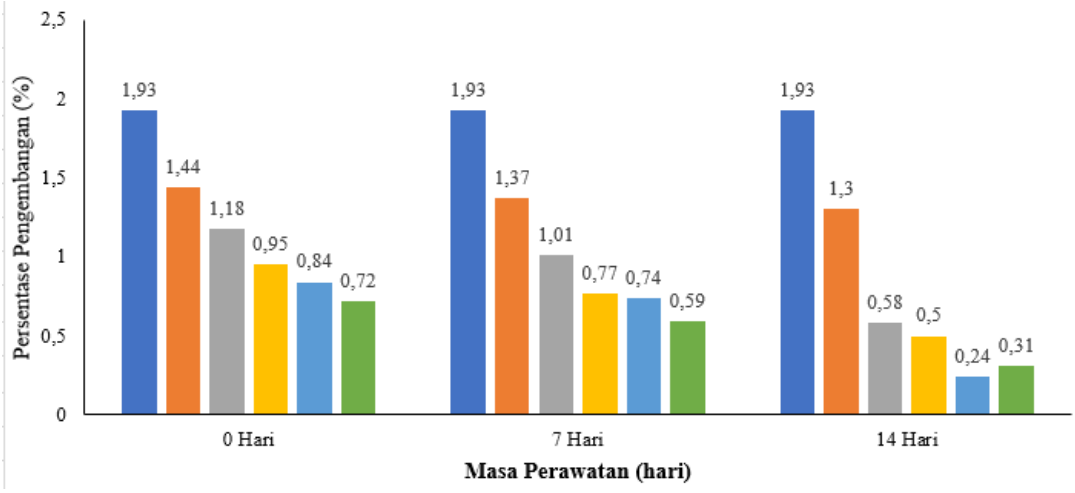


Figure 8 Results of CBR development of Parit Village Immersion

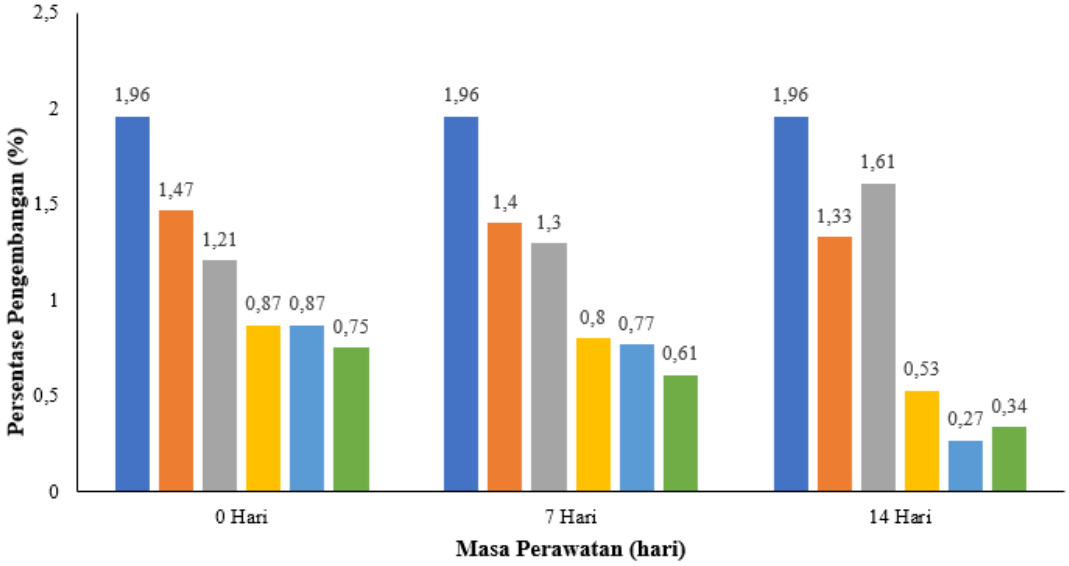


Figure 9 Results of CBR development in Lorok Village

Furthermore, the percentage change in the CBR value is calculated. The changes that occurred in the CBR value of the immersion aimed to determine the comparison between the changes in the CBR test results of the immersion and the CBR value of the original soil. The result of the change is expressed in the form of percent (%). The results of the shift between the CBR value of the soaking using a mixture of oil palm shell ash waste and the original soil are shown in Figures 10 (Parit Village) and 11 (Lorok Village).

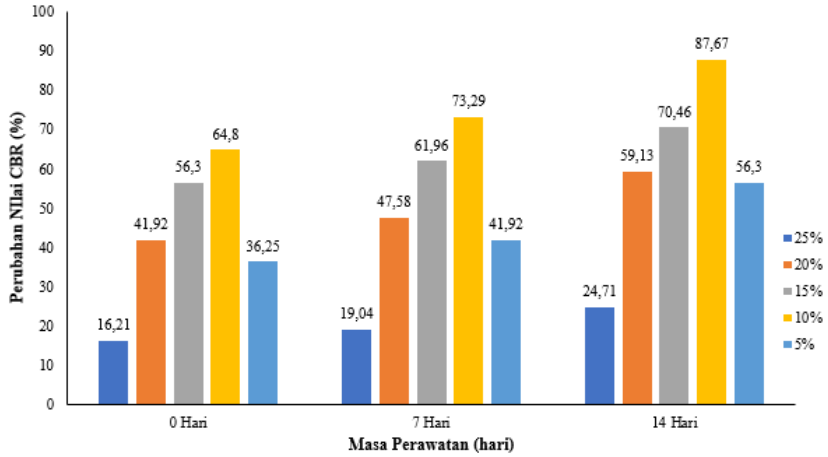


Figure 10 Percentage Change in CBR Value of Mixed Immersion in Paris Village

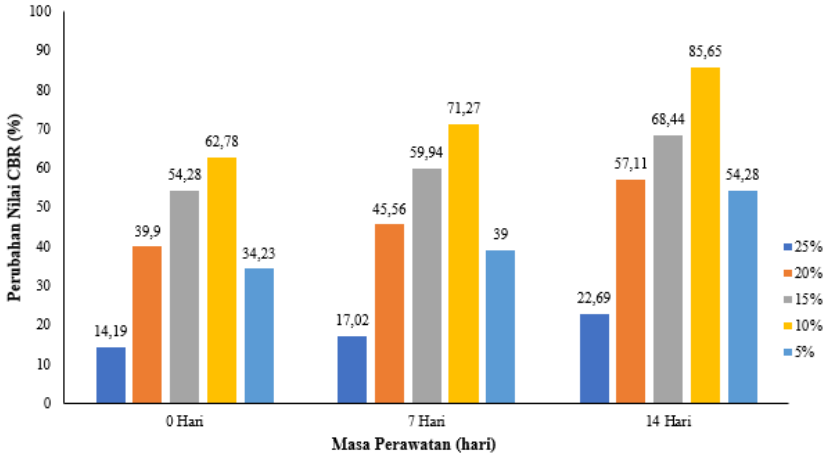


Figure 11 Percentage Change in CBR value of mixed immersion in Lorok Village

The results of the percentage change in the CBR value for Parit Village were obtained as a result of the shift between the CBR value of soaking using a mixture of oil palm shell ash waste and native soil increased in the percentage variation of 5% to 20% with a curing period of 0.7 and 14 days. The maximum change value from the 14-day curing period is shown in the percentage variation of 10%, which is 87.67%. In comparison, the lowest CBR change value is found in the variation of 5% every 0-day curing period, which is 16.21%. The results of the percentage change in the CBR value for Lorok Village were obtained as a result of the shift between the CBR value of the immersion using a mixture of palm shell ash and native soil increased in the percentage variation of 5% to 20% with a curing period of 0.7, and 14 days. The maximum change result value from the 14-day curing period is shown at the 10% variation percentage of 85.65%. In comparison, the lowest CBR change value is found in the 5% variation every 0-day curing period, which is 14.19%.

The results of the research of Ridwansyah et al. (2018): expansive soil stabilization in Glagaagung village, Banyuwangi Regency, with the addition of sand in variations of 15%, 20%, 25%, 30%, and 35%. The results of the test of the land development rate were

1.15%. If there is a lot of sand mixture, the percentage of expansive soil development will decrease. This is seen at a variation of 35% sand; the growth rate is 0.214%. The results of expansive soil stabilization in Banyuwangi Regency with Ca(OH)2 lime, variations of 4%, 6%, 8%, 10%, 12%, and 24-hour curing time, namely: the percent development of 1.15% was reduced to 0.064% with a lime variation of 4%, and 0% at the variation of 6% to 12% (Carisa et al., 2019).

Peatlands are stabilized by adding coconut shell coal ash (CSCA), varying between 3%, 6%, 9%, and 12%, and a fly ash constant of 10%. Samples treated were preserved for 0, 7, 14, and 28 days. The results of the unconfined compression strength test (UCS), which were treated after 0, 7, 14, and 28 days, were 25,388 kPa, 29,253 kPa, 36,611 kPa, and 39,953 kPa, respectively. All UCS are capped at 12% CSCA (Yusof et al., 2023). (Waluyo et al., 2023) stabilized clay soil with 5%, 10%, 15%, 20% oil palm bunch ash (ATJS), and 10% cement. The maximum increase in ATKS variation of 20% and cement 10% increases the shear angle value. This study concluded that the shear strength value of clay was stable with an increasing percentage of variation in oil palm bunch ash and cement.

In this study, the maximum result of the CBR test of soaking in Parit Village with a curing period of 7 days was at a variation of 5%, which is 4.68%. For Lorok Village, the most significant result was obtained: a 14-day curing period, a 25% variation of 4.76%. The CBR value obtained in this study is 3%-5% (normal) if used for subgrade strength with compaction conditions depending on the road category.

Conclusion

The conclusions obtained from this study are described as follows: The results of soil properties testing on native peatland are the moisture content (□) of Parit Village of 226.39% and Lorok Village of 252.39%. The specific gravity (Gs) result of Parit Village was 0.91, and Lorok Village was 0.89. Furthermore, the fiber content (FC) test results in Parit Village were 25.18% and Lorok Village 28.01%. Organic content (OC) of Parit Village with a value of 69.32%. Meanwhile, Lorok Village obtained an organic content value of 74.41%. Furthermore, the ash content (AC) test results in Parit Village obtained an ash content value of 83.57%. Meanwhile, Lorok Village obtained an ash content value of 19.46%. The Acidity Degree (pH) test results showed that Parit Village obtained 4.32, while Lorok Village obtained 3.57. From the results of soil properties on the original peatland from 2 locations, peatland is classified as fibrous peatland. The results of the Standard Soil Compaction (PTS) test of Parit Village, the ωopt value was 23.80%, and the γdmax value was 0.90 gr/cm3. And from Lorok Village, the ωopt value was 18.33%, along with a γdmax value of 0.91 gr/cm3. The results of the CBR value obtained at 0.1inch penetration in Parit Village were 3.27% and 0.2 inches worth 4.60%. The results of the CBR value obtained at 0.1inch penetration in Lorok Village were 3.15%, and 0.2 inches were worth 4.16%.

The results of the CBR test of the immersion with the curing period were obtained, and the longer the curing period, the higher the increased CBR value of the immersion. The increase in CBR value is influenced by ions from palm shell ash waste binding together into fibrous peat soil particles. Parit Village obtained the most significant result, 4.66%, in the variation of 5% of the 0-day curing period. For the 14-day curing period, the most considerable yield was found in the 5% variation, 4.65%. The most important result was obtained during the 7-day curing period when the variation was 5%, which was 4.68%. Meanwhile, judging from the 0-day curing period, Lorok Village obtained the most significant result, 4.7% in the 10% variation. The most considerable yield for the 7-day curing period is found in the 25% variation, 4.68%. The most significant result was obtained during the 14-day curing period when the variation was 25%, which was 4.76%. The CBR value obtained in this study is 3%-5% (normal) if used for subgrade strength with compaction conditions depending on the road category. The results of the percentage change in the CBR value for Parit Village were obtained with the maximum change value from the 14-day curing period at the percentage variation of 10%, which was 87.67%. In comparison, the lowest CBR change value was found in the 5% variation every 0-day curing period, which was 16.21%. As for Lorok Village, the result of the maximum change from the 14-day curing period was shown at the percentage variation of 10%, which was 85.65%, while the lowest CBR change value was found in the variation of 5% every 0-day curing period, which was 14.19%.

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