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Subgrade Stabilization With Powder Clamshells As An Alternative Lime Substitute

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ABSTRACT

Soft soil stabilization studies in Indonesia often use lime to reduce soil plasticity, increase strength and endurance, reduce water absorption and swelling caused by water. Lime is not only found in limestone (limestone mine) but also in clam shells. Therefore this study will use Blood Clamshell powder (Anadara Granosa) as a substitute for lime for soil stabilization. The research method was started by preparing mashed shellfish shell material and taking soil samples in the ULM Banjarmasin campus area. Soil samples were taken to the Banjarbaru ULM Soil Mechanics Laboratory. Tests of Index Properties, Atterberg Limit, Standard Proctor, Unconfined Compression Test (UCT), and California Bearing Rasio (CBR) were carried out. For CBR and UCT testing using a variation of a mixture of 0%, 2%, 4%, 6%, and 8% shellfish powder against the dry weight of the soil.

The results of the examination of chemical content in soil samples showed that there were 60.5% silica (SiO_2) and 18% alumina ($Al2O_3$) while shellfish powder had lime/calcium oxide (CaO) content of 87.47% where the three components were the main ingredients conditions for cementation reactions when exposed to water (Rudianto, 2013). For compaction experiments, each addition of shellfish powder increases the maximum dry volume weight. While the water content decreases as the percentage of shellfish powder increases. This indicates that water reacts to the compounds contained in the mixed sample. In the Unsoaked CBR test with a 7 day curing period the mixed samples experienced an increase with the increase in the number of shellfish powder but not so large, namely the largest increase of 5.8% CBR. Whereas for Unsoaked CBR with a 14 day curing period the biggest increase in the percentage mixture sample is 8%, which is 7.7% CBR. In CBR Soaked testing, an increase in CBR value did occur with the increase in the number of shellfish powder but not so significant. For samples with a 7-day curing period, the largest CBR value occurred in a mixed sample of 8%, namely 2.9% CBR. Whereas in the sample with a 14 day curing period the biggest increase occurred in the 8% mixed sample, which was 3.6% CBR. For UCT testing, Soaked and Unsoaked are also performed. In the sample, UCT Soaked the increase in stress value is not very visible. Samples with a 7-day curing period from 0% to 8% mixture only increase from 0.09 kg / cm2 to 0.19 kg / cm2. While samples with a 14-day curing period from 0% to 8% of the mixture also increased from 0.09 kg / cm2 to 0.19 kg / cm2. In the Unsoaked sample UCT, the increase in stress value is quite visible. Samples with a 7-day curing period have the highest increase in the 8% mixed sample, which is 1.46 kg / cm2. While the sample with a 14-day curing period was the largest increase in the mixed sample of 8% ie 1.64 kg / cm2. This shows that the curing period of the Unsoaked sample has an effect on the value of stress (qu), whereas the UCT Soaked sample has no effect.

KEYWORDS: *stabilization, clay, clamshells, alternative substitute for lime, subgrade.*

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I. PRELIMINARY

Soft soil stabilization studies in Indonesia often use lime as a mixing material. The addition of lime can reduce soil plasticity, increase strength and endurance, reduce water absorption and development (swelling) caused by water. This increase occurs due to chemical processes that change the structure of the soil by means of the formation of larger aggregates of grain (flocculation), and this is very beneficial for a construction (Harnaeni, 2012). Lime is not only found in limestone (limestone mine) but also in other sources such as shellfish. Therefore this study will use Blood Clamshell powder (Anadara Granosa) as a substitute for lime for stabilizing clay soil.

In order for the soil stabilization research with shells to run well, it is necessary to have suitable soil as a medium for stabilization. Soft clay (selected low CBR value) was chosen in Banjarmasin because clay has a high silica content where the chemical stabilization process requires the main element in the form of silica (SiO_2) + lime (CaO) + H_2O water (Rudianto, 2013).

With the use of Blood Clamshell waste in soft soil stabilization, it is expected to increase soft soil stability, be environmentally friendly, reduce excessive mining, and be more economical than using ordinary lime. The dried clamblood waste can be seen in Figure 1.1.

Figure 1. Blood ClamShell

II. LITERATURE REVIEW

Soil stabilization is the mixing of soil with certain materials to improve soil engineering properties, such as supporting capacity, compressibility, permeability, ease of work, development potential and sensitivity to changes in water content, it can be done by the easiest treatment. In the construction of road pavements, soil stabilization is defined as the improvement of existing local road material, by mechanical stabilization or by adding an additive to the soil. Stabilization improves subgrade capacity, thereby reducing the thickness of the pavement component. Chemical stabilization using additive additives or often called chemical stabilization aims to improve the technical properties of the soil, by mixing soil using added ingredients with a mixture of mixtures depending on the quality of the desired mixture (Hardiyatmo, 2002).

Soil compaction is a process by which air and soil pores are removed in one mechanical way. Mechanical means used to compact the soil in the field are usually used by means of grinding, while in the laboratory methods are used for hitting (Wesley, 1977). Soil compaction is the clearest and simple way to improve the stability and strength of the carrying capacity of the land (Dunn, 1992).

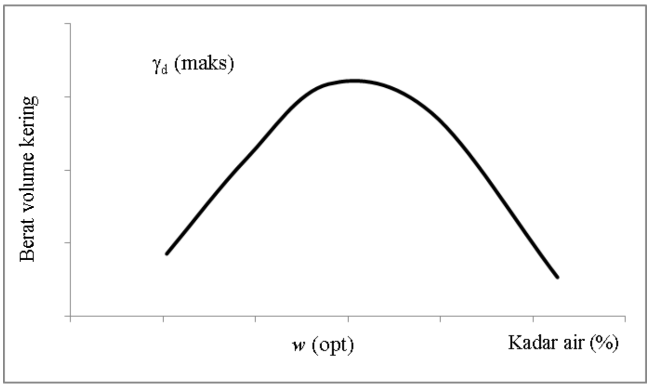

Figure 2. The relationship between moisture content and dry weight of soil volume (Hardiyatmo, 2002)

This experiment was carried out by compacting the soil in a mold with a volume of 1/30 ft3 using a compactor hammer weighing 5.5 lb (2.5 kg) and falling height 12 in (30.48 cm). The mold is filled with soil consisting of three layers, each layer is compressed 25 times with the condition that the soil used must pass filter No.4. Determination of optimal water content to determine the optimal water content in the soil, compaction testing is carried out, the test is carried out by compacting wet soil samples (at controlled water content) in a mold with a certain number of layers. Each layer is compacted by a number of collisions determined by pounders with a certain mass and falling height. If we know the weight of wet soil in the mold whose volume is known then the weight of the wet content can be known.

CBR value is the value obtained from subgrade samples in the construction of new roads which are original land, excavated land or piles which have been compacted to reach a 95% density to the maximum. This CBR is called the CBR point plan and because it is prepared in a laboratory it is also called a laboratory CBR

Table 1. Baseline CBR Value (Das, 1993)

CBR Value	CBR of Subgrade
>50%	Very good
20 – 50%	Good
7 – 20%	Medium
3 – 7%	Bad
0 – 3%	Very bad

The Unconfined Compression Test is a method carried out in the laboratory to calculate the compressive strength of the soil. This free compressive strength test measures how strongly the soil receives the compressive strength given until the free cylindrical soil sample is separated from its granules (broken) and also measures the strain of the soil due to pressure. This compressive strength test is carried out on native soil and also on soil that has been mixed.

III. RESEARCH METHODS

The sequence of the research that will be carried out is preparing the materials that will be used in the research, namely soft clay which has been dried and has passed the sieve no.10 and no.40. Prepare dried and mashed shellfish powder and pass filter No. 200. Mixing clay test material with clamshell powder with a percentage of 0%, 2%, 4% 6%, and 8% to the dry weight of the soil. Compaction tests were carried out on each variation to obtain optimum water content (Wopt). After obtaining the optimum water content in each variation, use the water content to make several samples in each variation with the number of collisions 10 times, 25 times, and 56 times for the CBR Soaked (marinade) and CBR Unsoaked (without marinade). CBR Soaked and Unsoaked CBR samples will be treated/treated for 7 days and 14 days before being tested to see the difference in CBR values with time. Making UCT samples in each variation. This sample makes uses the remaining mixture from making CBR samples to be uniform. The mixed soil printed on the UCT mold has the same volume weight on the maximum volume weight (γ_{wet}) of the mixed soil printed on the standard compaction mold. Microscopic tests will be carried out on variation samples with the highest CBR results. Analyzing data from research results than drawing conclusions.

Table 2. Plan for Sample Quantity for Each Mixed Variation

		Number of sample variations				
Percentage		0%	2%	4%	6%	8%
CBR Soaked	7 days	3	3	3	3	3
	14 days		3	3	3	3
CBR Unsoaked	7 days	3	3	3	3	3
	14 days		3	3	3	3
UCT Soaked	7 days	3	3	3	3	3
	14 days		3	3	3	3
UCT Unoaked	7 days	3	3	3	3	3
	14 days		3	3	3	3
Total number of test samples				108		

IV. RESULTS AND DISCUSSION

Examination of the Chemical Content of Banjarmasin Clay

The chemical components contained in Banjarmasin clay can be seen in table 3 as follows:

Table 3. Chemical Components of Banjarmasin Clay Soil

Component	Content (%)
Silica / silicon dioxide (SiO_2)	60,5
Aluminum / alumina (Al_2O_3)	18
Calcium calcium / calcium oxide (CaO)	3,68
Titanium / titania (TiO_2)	2,67
Chromium (Cr_2O_3)	0,11
Manganese oxide (MnO)	0,08
Iron (Fe_2O_3)	12,2

Copper (CuO)	0,087
Potassium (K_2O)	2,52
Vanadium (V_2O_5)	0,15
Ytterbium / ytterbium (Yb_2O_3)	0,02
Nitrogen (NiO)	0,042
Zinc (ZnO)	0,092
Rhenium (Re_2O_7)	0,07

Characteristics of Shellfish Powder

In the preparation process, the shells are dried first by burning on fire 2 to 3 minutes so that the shells are easily destroyed. The process can be seen in Figure 3 as follows:

Figure 3. The process of burning shellfish

The chemical components contained in shellfish powder can be seen in table 4 as follows:

Table 4. Chemical Components of Shellfish Shell Powder

Component	Content (%)
Silica / silicon dioxide (SiO_2)	4,9
Sulfur (SO_3)	0,37
Calcium calcium / calcium oxide (CaO)	87,47
Titanium / titania (TiO_2)	0,1
Chromium (Cr_2O_3)	0,13
Manganese oxide (MnO)	0,63
Iron (Fe_2O_3)	5,13
Copper (CuO)	0,036
Strontium (SrO)	0,57
Europium (Eu_2O_3)	0,2
Ytterbium / ytterbium (Yb_2O_3)	0,44

Compaction

In an effort to find the maximum density in each percent mixture found different results because the optimum water content obtained also varies. Data can be seen in table 5 and the picture as follows:

Table 5. Compaction Test Results

Mixed Variations	Max Dry Dry Weight	Optimum Water Content
0%	1,21 gr/cm^3	35%
2%	1,21 gr/cm^3	35%
4%	1,25 gr/cm^3	32%
6%	1,28 gr/cm^3	29%
8%	1,33 gr/cm^3	25%

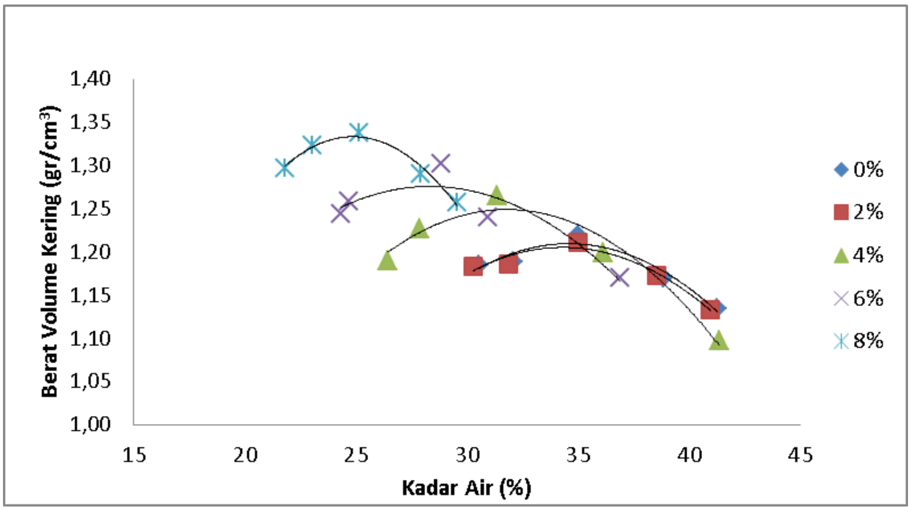

Figure 4. Relationship of Water Content and Mixed Percentage Dry Volume Weight

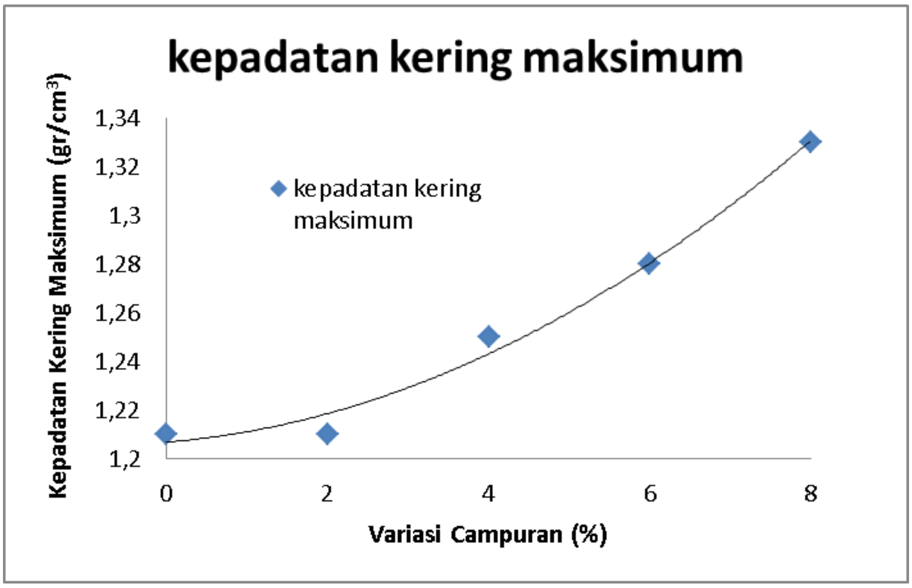

Figure 5. Relationship of Maximum Dry Density with Mixed Variations

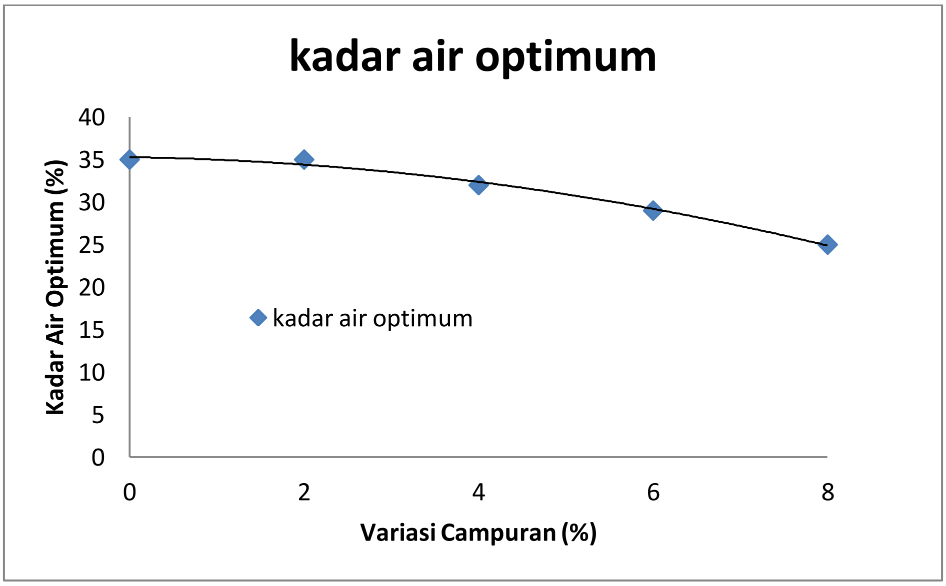

Figure 6. Relationship of Optimum Water Content with Mixed Variations

From the data above, it can be seen that every percentage increase in shellfish powder results in an increase in maximum dry volume weight. The greatest increase in dry volume weight occurs in the 8% mixture. In figure 6 the water content decreases as the percentage of shellfish powder increases. This indicates that water reacts to the compounds contained in the mixed sample.

California Bearing Ratio (CBR)

In the CBR sample testing several methods were applied, namely, the Unsoaked CBR test which was bred for 7 days and 14 days to see the difference in time. Likewise, the CBR Soaked (4-day soaked) test was also brooded for 7 days and 14 days. The CBR samples for variations of 0% mixture were not ripened because there was no mixture of clamshell powder in the sample. The results of the CBR test are described as follows:

Table 6. CBR Samples Test Results Mixed 0%

Testing	CBR Value (%)
CBR Unsoaked	2,7
CBR Soaked	1,3

Table 7. Test Results for Mixed CBR Samples 2%

Testing	CBR Value (%)
CBR Unsoaked curing 7 days	3,3
CBR Unsoaked curing 14 days	3,4
CBR Soaked curing 7 days	1,2
CBR Soaked curing 14 days	1,5

Table 8. Test Results for Mixed CBR Samples 4%

Testing	CBR Value (%)
CBR Unsoaked curing 7 days	3,7
CBR Unsoaked curing 14 days	4
CBR Soaked curing 7 days	2,3
CBR Soaked curing 14 days	2,7

Table 9. Test Results for Mixed CBR Samples 6%

Testing	CBR Value (%)
CBR Unsoaked curing 7 days	4,3
CBR Unsoaked curing 14 days	5,8
CBR Soaked curing 7 days	2,3
CBR Soaked curing 14 days	2,9

Table 10. 8% Mixed CBR Sample Test Results

Testing	CBR Value (%)
CBR Unsoaked curing 7 days	5,8
CBR Unsoaked curing 14 days	7,7
CBR Soaked curing 7 days	2,9
CBR Soaked curing 14 days	3,6

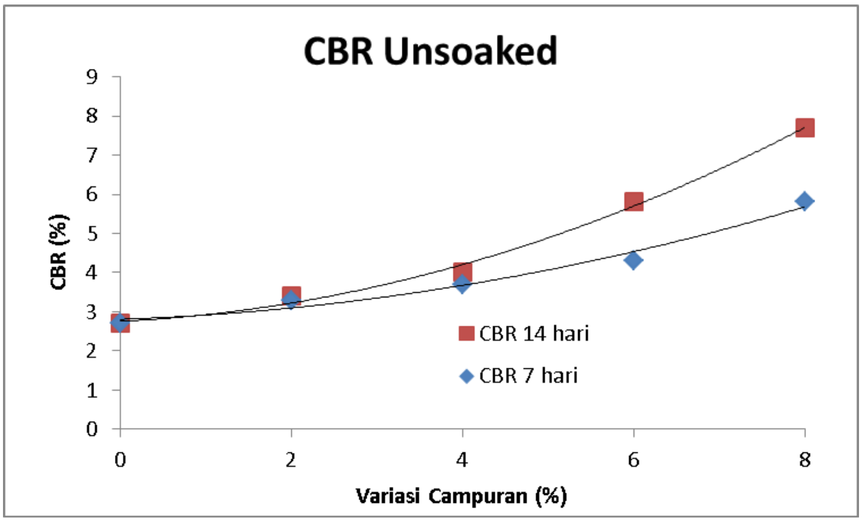

Figure 7. Relationship of CBR Value with CBR Unsoaked Mixed Variations

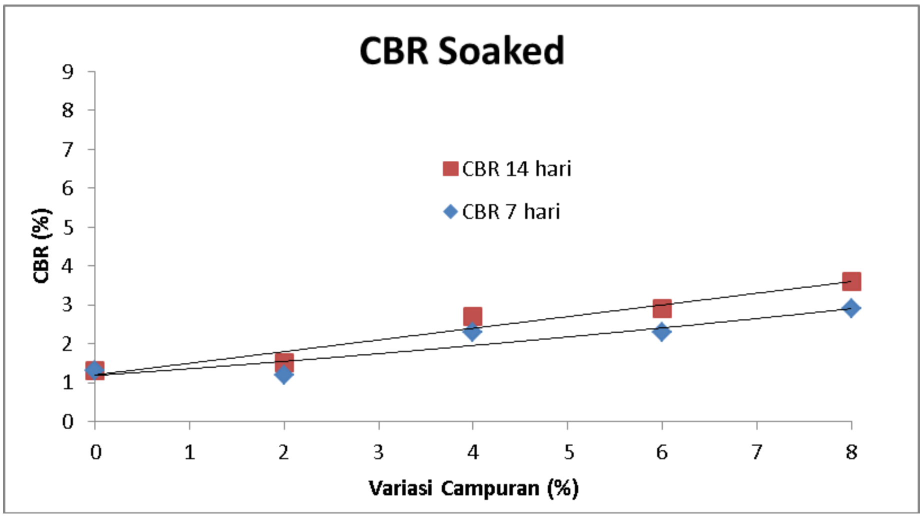

Figure 8. Relationship of CBR Value with CBR Soaked Mixed Variations

From the data above, there are differences in CBR values with different curing times. In the Unsoaked CBR test, mixed samples of 2%, 4%, 6% and 8% with 14 days curing were seen to increase by 0.1, 0.3, 1.5 and 1.9 CBR from mixtures which were incubated for 7 days. The largest CBR value occurred in a mixed sample of 8%, namely 7.7% CBR. Whereas in the CBR Soaked test, a mixture of 2%, 4%, 6% and 8% with 14 days curing was seen to increase by 0.3, 0.4, 0.6 and 0.7 CBR from the mixture which was brooded for 7 days. The largest CBR value occurred in a mixed sample of 8%, namely 3.6% CBR. Thus it can be concluded that the longer the curing period, the higher the CBR value. Likewise with the amount of shellfish powder mixture, the more the mixture the more the CBR value increases.

Unconfined Compression Test (UCT)

In testing UCT samples, samples were made by homogenizing or equalizing the weight of the UCT volume with the maximum volume weight obtained from the compaction test of each variation mixture. Samples made (disrupted) were blamed for 7 days and 14 days to see the difference in time. UCT samples were also immersed to compare the results with no soaking. The UCT samples for variations of 0% mixture were not ripened because there was no mixture of clamshell powder in the sample. The results of the UCT test are described as follows:

Table 11. Test Results for 0% Mixed UCT Samples

Testing	Stress Value qu (kg/cm^2)			Strain Value (%)		
UCT Unsoaked	0,98	0,95	1,01	5,5	6,2	5,8
the average		0,98			5,83	
UCT Soaked	0,09	0,09	0,09	2	3,1	2,5
the average		0,09			2,53	

Table 12. UCT 2% Test Results

Testing	Stress Value qu (kg/cm^2)			Strain Value (%)		
UCT Unsoaked 7 days	0,98	1,01	1,031	5,8	6,5	6,2
the average		1,01			6,17	
UCT Unsoaked 14 days	1,05	1,05	1,09	5,8	6,2	5,8
the average		1,06			5,93	
UCT Soaked 7 days	0,09	0,11	0,11	2,1	2,9	2,5

the average		0,11			2,5	
UCT Soaked 14 days	0,11	0,09	0,09	3,3	2,5	2,9
the average		0,10			2,9	

Table 13. Test Results for Mixed UCT Samples 4%

Testing	Stress Value qu (kg/cm^2)			Strain Value (%)		
UCT Unsoaked 7 days	1,12	1,15	1,17	6	6,6	6,6
the average		1,15			6,40	
UCT Unsoaked 14 days	1,46	1,42	1,42	5,3	5,3	5,4
the average		1,43			5,33	
UCT Soaked 7 days	0,09	0,11	0,11	2,5	2,9	2,5
the average		0,11			2,63	
UCT Soaked 14 days	0,13	0,13	0,15	2,9	2,9	3,3
the average		0,14			3,03	

Table 14. Test Results for Mixed UCT Samples 6%

Testing	Stress Value qu (kg/cm^2)			Strain Value (%)		
UCT Unsoaked 7 days	1,20	1,19	1,16	5,8	6,2	5,8
the average		1,18			5,93	
UCT Unsoaked 14 days	1,46	1,42	1,47	5,4	5,8	5,8
the average		1,45			5,67	
UCT Soaked 7 days	0,13	0,15	0,15	2,9	3,7	3,3
the average		0,14			3,30	
UCT Soaked 14 days	0,13	0,17	0,17	3,3	4,2	3,7
the average		0,15			3,73	

Table 15. Test Results for Mixed UCT Samples 8%

Testing	Stress Value qu (kg/cm^2)			Strain Value (%)		
UCT Unsoaked 7 days	1,49	1,46	1,44	5,8	5,9	6,4
the average		1,46			6,03	
UCT Unsoaked 14 days	1,70	1,64	1,61	6,3	5	5,4

the average		1,65			5,57	
UCT Soaked 7 days	0,17	0,19	0,20	3,3	3,7	4,2
the average		0,19			3,73	
UCT Soaked 14 days	0,17	0,20	0,21	3,7	3,7	2,9
the average		0,19			3,43	

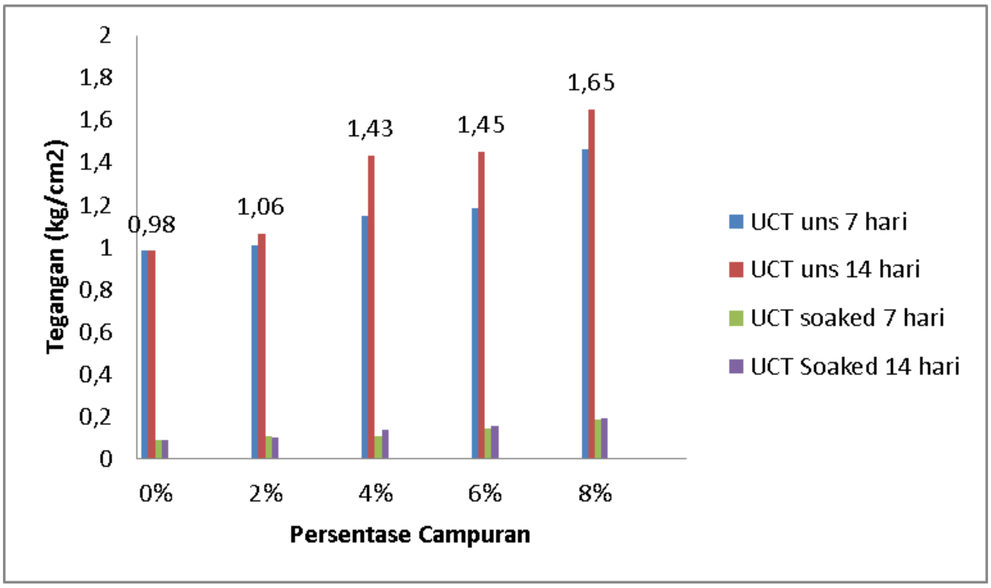

Figure 9. The relationship between Mixed Stress and the Percentage

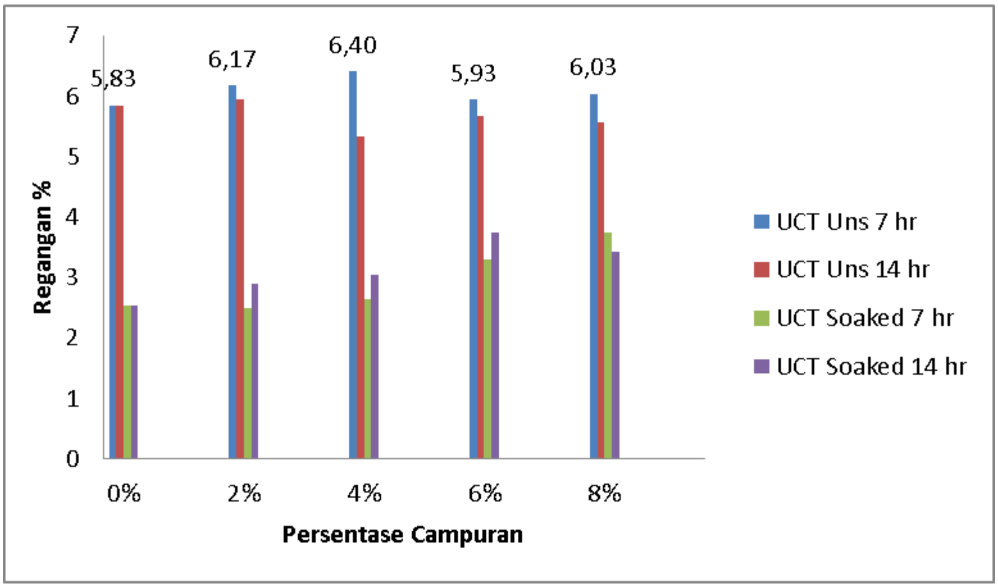

Figure 10. Relationship of Strain and Mixed Percentage

From the picture above, it can be seen that UCT Unsoaked samples with a 7 day curing period, the highest stress reach 1.46 kg / cm2. Whereas in the sample with a 14-day curing period the highest value reached 1.65 kg / cm2. This eliminates the longer curing period, the greater the stress obtained in the Unsoaked sample. For the UCT Soaked sample stress with a 7 day curing period, the highest value reaches 0.19 kg / cm2. Whereas in the sample with 14 days of curing period the highest value also reached 0.19 kg / cm2. It can be concluded that the curing period has little or no effect on the Soaked sample. Whereas for strain values in the UCT Unsoaked and Soaked samples, the values for each percentage did not undergo major changes.

V. CONCLUSION

From the results of the research and discussion conducted, it can be concluded that a number of things include:

1. From the chemical examination of soil samples and shellfish powder there are 60.5% Silica (SiO_2) and 18% Alumina (Al_2O_3) from the soil and 87.47% Cretaceous (CaO) from clamshells which are the components main which will react chemically at room temperature to form Calcium Alumina Hydrate (CAH) compounds which have properties such as cement (Rudianto, 2013)
2. From the results of the compaction test, there is an increase in the maximum dry volume weight for each percentage increase in the shellfish powder. An increase of 0.12 gr / cm3 from a mixed sample of 0% to 8% with the highest value of 1.33 gr / cm3 in a mixed sample of 8%. While the optimum water content decreased by 10% from the sample mixture of 0% to 8% with the lowest value of 25% in the mixed sample of 8%.
3. The CBR test results show the influence of the CBR value on the percentage of the mixture (0%, 2%, 4%, 6%, 8%) and the period of sample marinade (7 days and 14 days). Unsoaked CBR testing with 14 days curing was seen to increase by 0.1, 0.3, 1.5 and 1.9 CBR from mixtures which were incubated for 7 days. The largest CBR value occurred in a mixed sample of 8%, namely 7.7% CBR. Whereas the CBR Soaked test with 14 days curing was seen to increase by 0.3, 0.4, 0.6 and 0.7 CBR from the mixture which was brooded for 7 days. The largest CBR value occurred in a mixed sample of 8%, namely 3.6% CBR. Thus it can be concluded that the longer the curing period, the higher the CBR value. Likewise with the amount of shellfish powder mixture, the more the mixture the more the CBR value increases. The biggest increase in CBR value is 7.7% which can achieve moderate land quality based on subgrade classification.
4. The results of the UCT test show the effect of the value of the stress on the percentage of the mixture (0%, 2%, 4%, 6%, 8%) and the period of sample marinade (7 days and 14 days). In the UCT Unsoaked sample with a 7 day curing period, the highest stress value reached 1.46 kg / cm2. Whereas in the sample with a 14-day curing period the highest value reached 1.65 kg / cm2. This eliminates the longer curing period, the greater the stress obtained in the Unsoaked sample. For the UCT Soaked sample stress with a 7 day curing period, the highest value reaches 0.19 kg / cm2. Whereas in the sample with 14 days of curing period the highest value also reached 0.19 kg / cm2. This indicates that the period of impact only had little or no effect on the Soaked sample. Whereas for the strain values in the UCT Unsoaked and Soaked samples, the values in each percentage did not experience such a large and irregular change. In the sample 7-day marinade, the smallest strain change occurred in the sample mixture of 0% by 5.83% and the largest strain in the mixture sample of 4% is 6.40%. Whereas the smallest 14-day stretching period occurred in mixed samples of 5.33% and the largest strain in mixed samples was 2%, 5.93%.
5. The need for clamshell powder for stabilization of clay so as to achieve a minimum requirement of 6% CBR as subgrade (based on SPESIFIKASI UMUM 2010 Rev. 3 Divisi 3 Pekerjaan Tanah) then a mixture of clamshell powder is needed 6.3% of the dry weight of the soil.

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