



Effect of sea sand addition on liquid limit, plasticity index, and cbr of clay soil

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ARTICLE INFO	ABSTRACT
<p>Article history: Received Mar 18, 2025 Revised Apr 15, 2025 Accepted May 28, 2025</p>	<p>Soil is a composition of grains resulting from weathering of massive rock masses, where the size of each grain can be as large as gravel, sand, silt, clay and uncemented intergranular boxes including organic materials. Laboratory testing includes liquid limit tests, plastic limits, and plasticity index, soil specific gravity, compaction and laboratory CBR to determine soil strength. The method used in this study is the Experimental method, which is a method carried out by conducting experimental activities to obtain data. Based on the results of the research test using clay soil and sea sand, the CBR value with 100% clay soil and 0% sea sand was 5.41% with soil classification A-7-6, 85% clay soil and 15% sea sand obtained a CBR value of 8.82% with soil classification A-4 and 70% clay soil with 30% sea sand obtained a value of 10.55% with soil classification A-2-6. The better CBR value and soil classification are in 70% clay soil and 30% sea sand.</p>
<p>Keywords: Classification land; CBR; Clay Soil.</p>	<p><i>This is an open access article under the CC BY- NC license.</i></p>



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1. INTRODUCTION

Soft clay soil is a type of soil that has low bearing capacity and high compressibility, where soft clay soil is soil that has high clay mineral content and water content with low soil shear strength (Sakr *et al.*, 2021) . Soil as a material consisting of solid mineral grains that are not cemented (Rezaeian *et al.*, 2019) and from organic matter that has decayed accompanied by gas and liquid that fills the empty space between solid particles (Haghshenas & Gerlich, 2018) .

Clay soil is a soil that is microscopic to submicroscopic in size that comes from the weathering of chemical elements that make up rocks, clay soil is very hard when dry and is plastic at moderate water content (Sir *et al.*, 2019) . At higher water content, clay is sticky (cohesive) and very soft (Zen & Hellyward, 2024) .

Sand is a non-cohesive soil (Patakiewicz & Zabielska-Adamska, 2017) . Non-cohesive soil does not have a boundary line between plastic and plastic states (Dewi *et al.*, 2022) , because this type of soil is not plastic for all water content values. (Hutabarat *et al.*, 2021) . Non-cohesive soil with a fairly high water content can act as a thick liquid (Zhang *et al.*, 2024) .

Soil shear strength is the internal resistance of the soil to a unit area against collapse or hardening along the shear plane in the soil in question (Febrina & Agustina, 2021) .

Sandy soil is soil with large particles (Hura & Gulo, 2024) . This soil is formed from igneous rocks and sedimentary rocks that have large and coarse grains or what is often called gravel (Kusuma, 2019) .

In a study conducted by Oktaviana *et al.*, (2021), regarding the addition of a mixture of bagasse ash, portland cement, and fly ash to the shear strength and bearing capacity of the soil with a curing time of 1 and 7 days. Where the curing time greatly affects the shear strength and bearing capacity of the soil, the longer the curing time, the higher the shear strength and bearing capacity of the soil. AMANIA *et al.*, (2022) studied the effect of adding zircon sand, wood ash and fly ash to clay soil on the bearing capacity and shear strength of the soil. With a mixture variation of 5%, 10% and 15% and a soaking time of 3 and 7 days. The results of the tests carried out were that the increase in the shear strength and bearing capacity of clay soil was influenced by the addition of zircon sand, wood ash and fly ash. In a study conducted by Verdiyanti, et al (2022) on clay soil in Mempawah district, it was concluded that the greater the liquid limit (LL) and plasticity index (IP) values, the smaller the cohesion value of the clay soil (Verdiyanti *et al.*, 2022) . Research Method The soil sample used was clay soil found in the area (Anggraini & Saleh, 2020) .

2. RESEARCH METHOD

The research approach is a design of how the research will be carried out. The design is used to get answers to the formulated research questions. The type of research used for this researcher is quantitative research or explanatory research, namely research that analyzes the relationship between research variables and hypotheses that must be proven (Patonah *et al.*, 2023) .

This research was conducted at PT Rapi Arjasa Jl. Megawati Binjai The implementation of this research was certainly carried out consistently and systematically based on the initial time of the research proposal until the completion of the research. The following is a schedule of research that has been carried out.

According to Sugiyono (2020:128) in Lenaini (2021), the sampling technique is technique taking sample for determine sample to be used in research, there is a number of sampling techniques used. From the definition on researcher can conclude that sampling technique or technique taking sample This is a process and a way taking sample to be researched, where the purpose for get sample (sampling object).

In the research This method taking sample to be studied in the laboratory determined based on the provisions of SNI 03-6899-2002 are: with method $\sqrt[3]{}$ (area test sample taken). For taking sample taken from area Orahili Ulunoyon Subdistrict Ulunoyo regency South Nias. Research This conducted in the PT RAPI ARJASA laboratory .

In accordance with the test parameters, then there is a number of tools and materials needed prepared for support smoothness of the testing process. For type liquid limit testing, tools used covering bowl, stem stirrer (spatula), bottle, scales, and oven. While for plastic limit testing, tools used such as cup, oven, pan, spatula, glass plate, and scales. Apart from tools, materials are used in testing this is also very important. The main ingredients used is land, which was taken in accordance with sample testing and prepared as much as 75 kg. In addition, clean water that has been distilled is also used, especially in testing certain as in liquid limit testing.

Data analysis techniques are the process of studying and processing data to identify patterns, relationships, and information important contained in it. The goal is for get understanding yes more in about the data being analyzed and retrieved decision based on information found.

3. RESULTS AND DISCUSSIONS

3.1. Testing of Basic Materials

Based on the provisions of SNI 03-6889-2002, soil sample collection for testing in the field is carried out using the formula:

$$\sqrt[3]{}$$
 (area example of the test taken) (1)

Therefore, the samples prepared for testing at PT. Rapi Arjasa are approximately 120 kg of clay and 60 kg of sea sand.

3.2. Test results for clay soil (100%) and sea sand (0%)

Atterberg Limit Test (ATT)

The Atterberg Limit test aims to determine the ability of a soil material to show plastic limits, liquid limits, and plasticity index values, so that it can be declared suitable as fill soil material in road

construction. This test refers to the 2018 General Specifications Revision 2 and is carried out based on the provisions of the required Indonesian National Standard (SNI).

The steps in the Atterberg Limit test procedure consist of two parts, namely the liquid limit and plastic limit tests, as follows:

1. Liquid Limit Testing Steps
(Referring to SNI 1967:2008)
 - a. Preparing soil test sample materials.
 - b. Dry the test sample in an oven at $110 \pm 5^\circ\text{C}$ for 24 hours.
 - c. Prepare a test sample of 300 grams, then pound it until the soil clumps are destroyed and become homogeneous.
 - d. Carry out screening using sieve No. 40 (0.425 mm).
 - e. Take 100 grams of test sample that passes sieve No. 40, then add water little by little, starting with an initial addition of around 15–20 ml, until the soil is evenly mixed (homogeneous).
 - f. The mixed soil is put into a brass bowl, then rotated until two points of soil meet.
 - g. Conducting water content sampling on each sample, namely two samples with a number of blows of more than 25 and two samples with a number of blows of less than 25. Weighing is carried out on the weight of the empty cup, as well as the weight of the cup and the wet test sample.
 - h. The samples were dried in an oven at $110 \pm 5^\circ\text{C}$ for 24 hours.
 - i. After drying, reweighing is carried out to obtain the dry weight.
 - j. All test results are recorded and analyzed using a graph of the relationship between the number of blows and water content to determine the liquid limit.
2. Plastic Limit Testing Steps
(Referring to SNI 1966:2008)
 - a. Take 300 grams of soil test sample and sieve it using sieve No. 40 (0.425 mm).
 - b. Add water to the soil slowly until it is evenly mixed and forms moist soil.
 - c. The moist soil is formed into a ball.
 - d. Some of the soil that has been formed into a ball is then rolled on a glass plate to form a worm-like roll with a diameter of ± 3 mm, and observed until cracks appear.
 - e. Take a test sample that already shows cracks, then weigh the empty cup first, then put the test sample into the cup and weigh it again to get the weight of the cup + wet test sample.
 - f. Repeat the process until two test samples are obtained.
 - g. Place the test sample in an oven at $110 \pm 5^\circ\text{C}$ for 24 hours.
 - h. Once dry, weigh the cup + dry soil again.
 - i. Analysis of test results to determine the plastic limit and plasticity index.

Table 1. Results of Atterberg Limit Consistency Test on Clay (100%) and Sea Sand (0%)

Many punches	Liquid Limit (LL)		Plastic Limit	
	P1	C3	S4	
Cup Number	P1	C3	S4	
Sample Mass Wet + Cup (grams)	26.88	28.65	28.25	
Mass of Dry Sample + Cups (grams)	22.23	24.98	24.65	
Mass of Water (grams)	4.65	3.67	3.60	
Mass of Cup (grams)	12.99	15.01	14.91	
Sample Mass (grams)	9.24	9.97	9.74	
Water content (%)	50.32	36.81	36.96	36.89

Information:

Liquid limit : 49.82

Plastic Limit : 36.89

Plasticity Index : 12.94

Soil Classification : A-7-6 Clay Soil

Table 2. Results of Atterberg Limit Consistency Test with Clay (85%) and Sea Sand (15%)

Blow Blow	Liquid limit (LL)		Plastic Limit	
	R2	W	B1	
Cup Number	R2	W	B1	
Sample Mass Wet + Cup (grams)	25.02	29.00	28.20	
Mass of Dry Sample + Cups (grams)	21.90	25.90	25.24	

Water Mass	3.12	3.10	2.96
Mass of Cup (grams)	13.88	16.02	15.77
Sample Mass (grams)	8.02	9.88	9.47
Water content (%)	38.90	31.38	31.26

Information:

Liquid Limit : 38.90

Plastic Limit : 31.32

Plasticity Index : 7.59

Land Classification : A-4 Soil

Table 3. Results of Atterberg Limit Consistency Test with Clay (70%) and Sea Sand (30%)

Many Punches	Liquid Limit (L.L)		Plastic Limit	
	U.C.	XN		
Cup Number	26.00		P5	
Sample Mass Wet + Cup (grams)	27.89	29.00	28.76	
Mass of Dry Sample + Cups (grams)	24.34	26.25	25.96	
Mass of Water (grams)	3.55	2.75	2.80	
Mass of Cup (grams)	14.67	15.34	14.90	
Sample Mass (grams)	9.67	10.91	11.06	
Water content (%)	36.71	25.21	25.32	25.26

4. CONCLUSION

From the results of the study conducted through soil parameter testing, which includes soil grain size analysis test, liquid limit test, plastic limit test, specific gravity test, light soil compaction test, and laboratory CBR test, soil parameter data were obtained based on variations in the mixture between clay and sea sand, namely in the composition of 100% clay soil with 0% sea sand, 85% clay soil and 15% sea sand, and 70% clay soil with 30% sea sand. The results showed that the more sea sand was used, the smaller the value of the material passing through sieve No. 200, while the more dominant use of clay soil caused the value of the material passing through sieve No. 200 to increase. In addition, the gradual addition of the percentage of sea sand also resulted in a smaller liquid limit value of the soil, thereby improving the consistency of soil behavior. The plastic limit value also tended to decrease with increasing percentage of sea sand, which indicated that the lowest water content also decreased and the soil could be compacted in a different optimum water content range.

Furthermore, the soil specific gravity value shows a tendency to improve with increasing percentage of sea sand, because the larger grain size contributes to increasing the ratio between the mass weight of the soil and the volume of water. The addition of sea sand also has an impact on increasing the density value, where soil with a mixture of 30% sea sand has the highest density value compared to other mixtures. Along with that, the optimum water content value decreases with increasing sea sand, indicating a decrease in the ability of the soil to absorb water. The CBR test results show that the CBR value increases as the percentage of sea sand in the mixture increases.

Soil classification is determined based on the results of grain size analysis, plastic limit, liquid limit, and plasticity index. Based on this, soil with a composition of 100% clay and 0% sea sand is classified into soil group A-7-6 (clayey soil), while a mixture of 85% clay and 15% sea sand is included in group A-4 (silty soil). Meanwhile, a mixture of 70% clay and 30% sea sand is classified as soil group A-2-6, namely sand and gravel that have silty and clayey properties. Based on the results of this study, it can be concluded that the addition of sea sand to the soil mixture will cause changes in the density value, physical properties, and soil classification. The best soil mixture composition based on the CBR value test and soil classification was obtained in a mixture of 70% clay and 30% sea sand.

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