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Stabilization of the Shear Strength of Clay Soil with Limestone Powder

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Abstract-Soil is base and the most widely material used for civil engineering and structural engineering construction. However, not all kind of soils can be used for the construction. For a soil having low a shear strength such as a soft soil, it needs to stabilize. Stabilization methods that commonly used are by compaction or chemical stabilization. With the objective to study the shear strength of clay soil, this research performed an experimental study by adding variation of limestone powder to clay soil. The clay sample is from Nganjuk city, East Java that is classified as a montmorillonite clay with Gs number is 2,698; liquid limit 62,6 %; plasticity index 19,07% , and the qu number is 1 Kg/cm^2. The percentages of the limestone powder were in 5%,10%,15%,and 20%. The pure clay and modified clay were tested using Unconfined Compression Test (UCT). The result showed that with the addition of 20% limestone powder may decrease the Gs number to be 2,351; liquid limit 54,2%; and plasticity index 7,81 %; however the qu number increased with the addition 5-15% limestone powder but it decreased with 20%.

***Keywords*:** clay soil, soil stabilization, limestone, shear strength, unconfined compression test

1. Background

Soil is the main material in every engineering construction. It is just because, soil is the material that spreading load from the construction to the sub base or base course. So, in every construction need the strong soil that can hold any load there.

Soil that used in this research is clay soil. Clay soil has low strength number,that can give harm for construction that build on it. It can easily give friction and movement,because of that unstable soil.

Soil stabilization really need to do in unstable soil. Like , clay soil, and any kind of soil that has the low strength. This stabilization itself really need to make this clay soil to be stable and ready to build a construction on it.

Soil stabilization method that commonly used are by compaction stabilization method and chemical stabilization method. Stabilization that used in this research is chemical method. By adding limestone powder in clay soil.

This research focused on compressive strength and shear strength. And by adding limestone powder it can increase that strength by decreasing the plasticity of the clay soil.

2. Formulation of the Problem

In this research we intend to compare the shear strength and compressive strength number of real clay soil and clay soil with limestone addition. By find out the result, we also know the effectiveness of limestone itself.

3. Research Purpose

1. To find out the result of specific gravity value (Gs) of the real clay soil and clay soil with limestone addition.
2. To find out the result of liquid limit (LL), index plastic (IP), plasticity index (IP) value of the real clay soil,and clay soil with limestone addition.

3. To find out the value of shear strength of the real clay soil,and clay soil with limestone addition.
4. To find out the value of compressive strength of the real clay soil,and clay soil with limestone addition.

4. Limits of Problem

1. The clay soil that used in this research is from Nganjuk city,East Java.
2. The limestone powder that used in this research is from Nganjuk city, East Java
3. Do this research in Clay Laboratory of Sultan Agung Islamic University,to find the properties index and engineering index value.

5. Basic Theory

Soil Stabilization

Stabilization is the permanent physical and chemical alteration of soils and aggregates to enhance their engineering properties thus improving the load bearing capacity of a sub-grade or sub-base to support pavements and foundations. There are different methods used. The first is dewatering, the second is compaction and the third is by mixing additives to the soil. The last method is the most effective of all the methods, in terms of the ease of application, time consumption and cost. The process of soil stabilization can be mechanical or chemical depending on the properties that need to be enhanced for the construction at hand. Fly ash, cement kiln, Portland cement and lime are some of the common bonding agents that are mixed into the target soil to change its gradation and engineering properties.

Limestone Powder

Limestone is a sedimentary rock composed primarily of calcium carbonate ($CaCO_3$) in the form of the mineral calcite. It most commonly forms in clear, warm, shallow marine waters. It is usually an organic sedimentary rock that forms from the accumulation of shell, coral, algal, and fecal debris. It can also be a chemical sedimentary rock formed by the precipitation of calcium carbonate from lake or ocean water.

Most limestones form in shallow, calm, warm marine waters. That type of environment is where organisms capable of forming calcium carbonate shells and skeletons can easily extract the needed ingredients from ocean water. When these animals die, their shell and skeletal debris accumulate as a sediment that might be lithified into limestone. Their waste products can also contribute to the sediment mass. Limestones formed from this type of sediment are biological sedimentary rocks. Their biological origin is often revealed in the rock by the presence of fossils.

Some limestones can form by direct precipitation of calcium carbonate from marine or fresh water. Limestones formed this way are chemical sedimentary rocks. They are thought to be less abundant than biological limestones.

The direct shear test is one of the oldest strength tests for soils. In this laboratory, a direct shear device will be used to determine the shear strength of a cohesiononless soil (i.e. angle of internal friction (f)). From the plot of the shear stress versus the horizontal displacement, the maximum shear stress is obtained for a specific vertical confining stress. After the experiment is run several times for various vertical-confining stresses, a plot of the maxi mum shear stresses versus the vertical (normal) confining stresses for each of the tests is produced. From the plot, a straight-line approximation of the Mohr-Coulomb failure envelope curve can be drawn, f may be determined, and, for cohesiononless soils (c = 0), the shear strength can be computed from the following equation: s = s tanf.

Atterberg

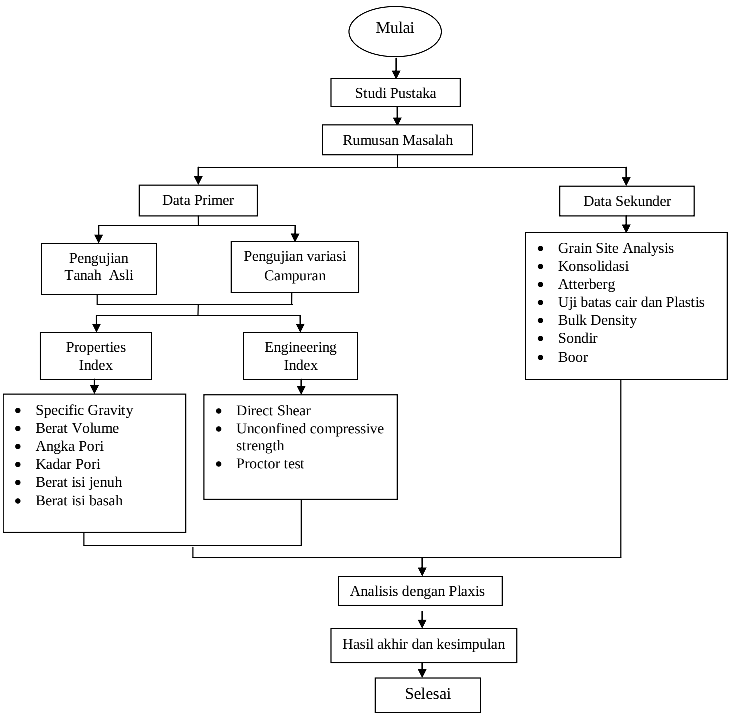
The Atterberg limits are a basic measure of the critical water contents of a fine-grained soil: its shrinkage limit, plastic limit, and liquid limit. As a dry, clayey soil takes on increasing amounts of water, it undergoes distinct changes in behavior and consistency.

1. Liquid Limit
   The water content at which the soil has such a small shear strength that it flows to close a groove of standard width when jarred in a specified manner. The Liquid Limit, also known as the upper plastic limit, is the water content at which soil changes from the liquid state to a plastic state.
2. Plastic Limit
   The water content at which the soil begins to crumble when rolled into threads of specified size. The Plastic Limit, also known as the lower plastic limit, is the water content at which a soil changes from the plastic state to a semisolid state. Plastic Limit (PL or wP) - the water content, in percent, of a soil at the boundary between the plastic and semi-solid states.
3. Shrinkage Limit
   The moisture content at which the soil change from a semi solid state to a solid state.
4. Plasticity Index (PI)
   The range of consistency with in which the soil exhibit plastic properties

Specific Grafity

Specific gravity is the ratio of the density of a substance to the density of a reference substance; equivalently, it is the ratio of the mass of a substance to the mass of a reference substance for the same given volume.

6. Research Methode



7. Review

The Real Soil Classification

Table 1. Gs value of real clay soil

Description	Value
Spesific Gravity (Gs)	2.698

Table 2. Category of clay soil

Category	Gs Value
Kaolinite	2,6
Illite	2,8
Montmorillonite	2,65-2,8

There are some criteria that can describe specific kind of soil from Nganjuk city

Tabel 3. Kind of soil depends on plastic index (PI) by (ASTM D-1883)

Deskripsi	Hasil
Liquid Limit (LL)	62,60 %
Plastic Limit (PL)	43,53 %
Index Plasticity (IP)	19,07 %

Tabel 4. The relation between IP and swelling potential (Chen, 1998)

Index Plastcity (IP)	Swelling Potential
>35	Very High
22-55	High
10-35	Medium
1-15	Low

Tabel 5. The relation between swelling potential and IP by Atteberg Menurut Raman, 1967

Swelling Potential	Indeks Plasticity
Low	< 12
Medium	12 – 23
High	23-32
Very High	>32

From some classification above, can conclude that this soil is expansive clay soil with medium

IP (ASTM D-424)	Swelling Degree	Percentage (ASTM D-1883)
0-10	Not Expansive	2 atau kurang
10-20	Expansive	2 – 4
>20	High Expansive	>4

swelling factor. It caused the PI value of this soil is, PI =19,07 %

A. Specific Grafity Value

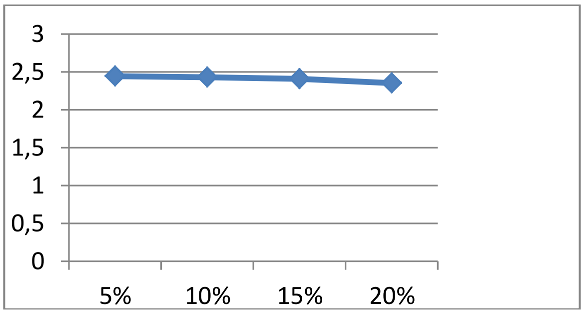


Chart 1. Specific grafity value chart

Table 6. Specific Grafity Value Table

Sample	**Gs Value**
TA	2,698
5%	2,445
10%	2,432
15%	2,408
20%	2,351

From the result above,Gs value from the real clay soil until clay soil that added with 20% limestone is decreasing. It means that the limestone powder works great on it.

B. Atterberg Value

Table 7. Value Of Atterberg Limits Test Result

Sample Code	**Liquid Limit (LL) (%)**	**Plastis Limit (PL) (%)**	**Index Plasticity (IP) (%)**
TA	62,6	43,53	19,07
5%	60	43,7	16,3
10%	57,8	46,27	11,53
15%	55	45,5	9,5
20%	54,2	46,39	7,81

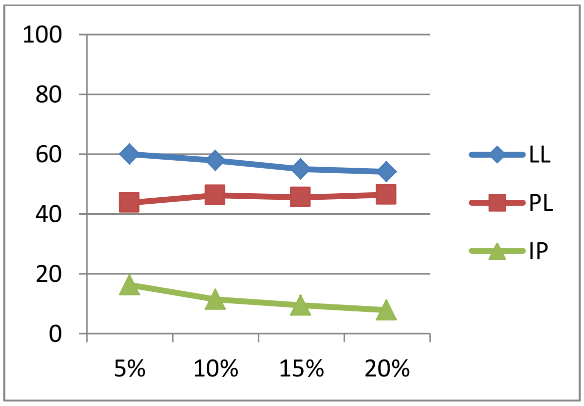


Chart 2. Atterberg Limit Value Chart

From the result above the limestone powder affecting in increasing the liquid limit number and index plasticity, and decreasing the plastic limit number. It means the limestone powder works on decreasing the water consistence in soil.

C. Direct Shear Value

Table 8. Direct Shear Value

Sample	**Kohesi** (c)
TA	0,08
TA+5%	0,12
TA+10%	0,155
TA+15%	0,26
TA+20%	0,44

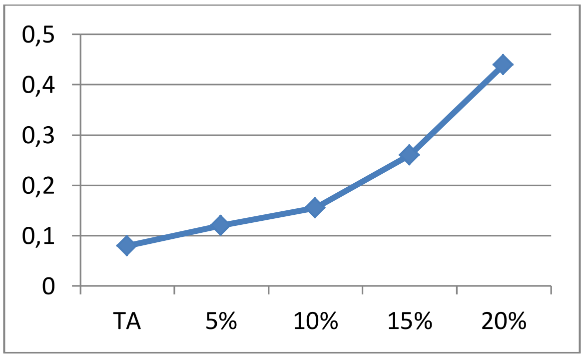


Chart 3. Direct Shear Test Value Chart

From the result above,the limestone powder increasing the value of the cohesion (c). It's just because the $CaCO_3$ from the limestone mixed perfectly with the soil and water during the research.

D. Compressive Shear Value

Table 10. The Value Of Qu

Sample	**Qu** (Kg/cm^2)
TA	1
TA+5%	1
TA+10%	2,4
TA+15%	2,5
TA+20%	1,52

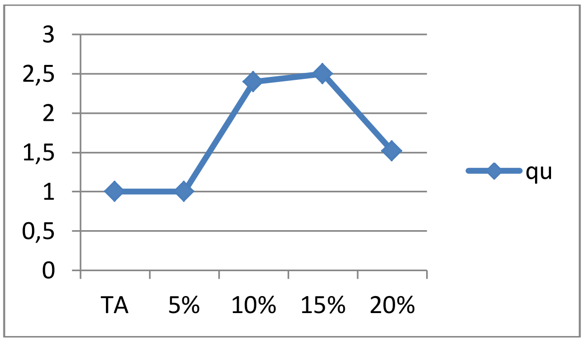


Chart 4. Qu Value Chart

From the result above, the qu value through up and down. It is because of relation and coherency between CaCO , H_2O , and O_2 not going well during the research.

8. Conclution

From the resulrtt of the research that been done , it can be conclude as :

1. In real clay soil gravity index,the Gs value is 2,698. And after adding some limestone powder in the clay with the percentage 5%,10%,15% and 20% ,it decreased the Gs value to be 2,351
2. The real clay soil has plasticity index = 19,07% and based on (*PI*) (ASTM D - 1883) it categorized by expansive clay soil with medium swelling factor. and the whe the limestone powder add on it with percentage 5%,10%,15%,and 20% it decrease the PI value into 7,81%. It can conclude that limestone powder is work at doing the stabilization.
3. For direct shear and compressive shear of the soil,the cohesion (c) value number of real clay soil is 0,08 and cohesion (c) value of clay soil with 20% limestone addition is 0,44. For qu value it through up and down value due the problem of the $CaCO_3$ reaction.

9. Suggestion

1. To know the specific mineral of the clay soil, there's should be any mineralogy test in another research.
2. From atterberg test it just give the liquid limit ,plastic index, and index plasticity but it doesn't give the swelling potential of the clay. We suggest to do shrinkage test in the next research.
3. And in the next research should do with more percentage, with limit range such (1%,3%,5%,7%...........) to know more specific about the value.

Reference

http://rustonpaving.com/stabilization.aspx
https://globalroadtechnology.com/definition-soil-stabilization-2/
http://geology.com/rocks/limestone.shtml
http://geology.com/articles/expansive-soil.shtml
Chen, F.H. (1988). Foundations on Expansive Soils, Elsevier Scientific Publishing Company, Amsterdam.
Engineering Properties of Soils Based on Laboratory Testing Prof. Krishna Reddy, UIC http://cemmlab.webhost.uic.edu/Experiment%2012-Direct%20Shear.pdf
https://en.wikipedia.org/wiki/Atterberg_limits
http://www.aboutcivil.org/atterberg-limits.html
https://en.wikipedia.org/wiki/Specific_gravity