

Compression strength testing model on clay soil stabilization using variations of cement composition

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Abstract. The title of this study is "Compression Strength Testing Model on Clay Soil Stabilization Using Variations of Cement Composition". The focus of this test is the addition of different compositions of cement and clay. Composition of this test is 100% soil + 0% cement, 70% soil + 30% cement, 50% soil + 50% cement and 30% soil + 70% cement. The next stage of drying is done for 0 days, 5 days, 10 days, 15 days and 20 days. The test is performed by unconfined compression test machine for each sample dried within the time specified above. The cement used is Portland composite cement type (Portland Cement Composite / PCC). The conclusion is obtained from the results of tests that have been done that the soil composition of 100% + 0% cement land indicates if the longer drained the value of the compressive strength will decrease. However, in the other composition 70% of soil + 30% cement, 50% soil + 50% cement and 30% soil + 70% cement show that the longer drying is done for each composition the relationship between strain and stress shows an increase along with the duration of drying done. However, if analyzed for the largest compressive strength value of this test was found in the 50% + 50% cement sample showing the largest compressive strength (q_u) compared with the other samples.

1. Introduction

Development of infrastructure and other supporting facilities, both roads, office buildings, supermarkets and all objects of the results of other construction activities are inseparable from the influence of the ability of the land in sustaining the continuity of all activities that occur in every product of construction. As a result of channeling the load from the upper structure to the structure below it is then passed to a layer of soil that is able to withstand the amount of load. Therefore, there needs to be sufficient of the carrying capacity of certain soils to carry the burden on them. So, the problem of whether or not stable land becomes something important to study.

A very clear example of the stabilization problem we can see is the problem that occurred in the world-famous building of the Tower of Pisa in Italy. The height of this building is 55.86 meters in the low ground area whereas 56.70 m in the higher ground area. The width of the inter-column of this building is 4.09 m at the bottom and 2.48 meters at the top. The weight of this building is about 14500 tons and has approximately 296 steps.



2. Literature study

2.1. Soil and clay soil

In general engineering terms, soil is defined as the set of minerals, organic materials and loose deposits, located above bedrock. The soil is defined as a material comprising granular solids unsaturated between each other from decayed organic materials (solid particles) with liquids and gases that fill the spaces empty between the solid particles [1].

Clays and clay minerals are soils that have certain mineral particles that "produce plastic properties on the soil when mixed with water". Soil particles smaller than 2 microns ($= 2\mu$), or <5 microns according to other classification systems, are referred to as clay-sized particles rather than clay. Particles of clay minerals are generally colloidal ($<1\mu$) and size 2μ is the upper (largest) limit of clay mineral particle size.

To determine the type of clay is not enough just seen from the size of the grain alone but please note the minerals contained therein. ASTM D-653 provides a limitation that the physical size of the clay is particles measuring between 0.002 mm to 0.005 mm.

The properties of clay are as follows:

- Fine grain size, less than 0.002 mm
- Low permeability
- Increased high capillary water
- Very cohesive
- High shrinkage rate
- The consolidation process is slow.

Here are the results of research on the chemical elements contained in the clay soil ever researched in Chemical Laboratory FMIPA USU, 2011:

Table 1. Compound of clay (%).

Chemical compounds	Clay (%)
Silica dioxide (SiO_2)	75,40
Calcium Oxide (CaO)	0,70
Magnesium Oxide (MgO)	0,71
Iron (III) Oxide (Fe_2O_3)	0,01
Aluminum Carbonate (Al_2O_3)	14,10

2.2. Cement

Cement is a material that has adhesive and cohesive properties as an adhesive that binds mineral fragments into a compact unity. Cement is classified into 2 (two) types, namely hydraulic cement and non-hydraulic cement. Hydraulic cement is a hardening binder if it reacts with water and produces a waterproof product. Examples are portland cement (OPC, PCC), white cement and so on, while non-hydraulic cement is a cement that is not stable in water.

Ordinary Portland Cement (OPC) is a Portland Cement used for all kinds of construction when no special properties are required, such as resistance to sulfate, hydration heat, and so on. Cement PCC (Portland Composite Cement) is a derivative of OPC cement with the same raw material as OPC raw material but on PCC cement type added additive besides gypsum there are other additives added which are not available on OPC cement: Lime stone, Fly Ash and Trass.

2.3. Unconfined compression test

In soil material, the parameters that need to be considered is the shear strength of the soil. Knowledge of shear strength is needed to solve problems related to soil stabilization. One of the tests used to determine the soil shear strength parameter is the free compressive strength test. What is meant by Unconfined Compression Strength Test is the magnitude of the broad axial load at the time the specimen is collapsed or when the axial strain reaches 20%.

Unconfined Compression Test is a special test of Unconsolidated-Undrained Triaxial. The loading conditions are the same as those in the triaxial test, except that the cell pressure is zero ($\sigma_3 = 0$). The schematic drawing of this loading principle can be seen in the figure below

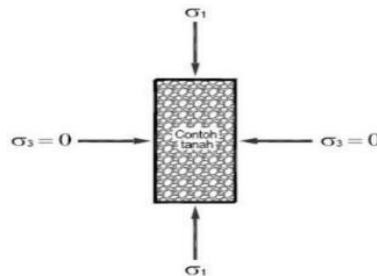


Figure 1. The principle of loading of the Unconsolidated-Undrained triaxial test.

Free compressive strength experiments (Unconfined Compression Test) in the laboratory were carried out on the ground samples in their original or remolded state. The axial pressure occurring on the ground can be written in the following equation:

$$\sigma = \frac{P}{A}$$

with:

P = work load (unit force, N)

A = area of cross section (unit area, mm²)

As for the soil shear strength can be written in the following equation:

$$c_u = \frac{\sigma_1 + \sigma_3}{2} = \frac{\sigma_1}{2} = \frac{q_u}{2}$$

Information:

Cu = undrained shear strength

$\sigma_3 = 0$

qu = unconfined compressive strength (ultimate strength).

2.4. Soil stabilization

Soil stabilization is the mixing of soil with certain substances, in order to improve soil properties, or it may be, soil stabilization is an attempt to change or improve the technical properties of the soil in order to meet certain technical requirements [2].

Soil stabilization can also be defined as an attempt to improve the carrying capacity (quality) of bad soil and increase the carrying capacity (quality) of land that has been classified as good. The objective of soil stabilization is to increase the carrying capacity of the soil in load resistance and to improve soil stability.

Stability may consist of one of the following measures [3]:

- increase the soil density.
- adding inactive material thus enhancing cohesion or shear resistance.
- Adding material to cause chemical and physical changes from soil material.
- lower water table (dewatering) and replace bad soil.
- Soil stabilization efforts can be done by compacting, mixing with other soils, and adding chemical mixers.

Commonly used stabilizers are cement, lime, rice husk ash, palm oil ash, bagasse ash, fly ash, bitumen and other ingredients.

- The advantages of stabilization by using additional materials (admixtures) are as follows:
- Increases soil strength.
- Reduce deformation.
- Maintains volume stability.
- Reduces permeability.
- Increases durability.

2.5. *Cement stabilization*

Adding cement to both the clay and into the sand soil would increase the maximum density of the soil by approximately 10% [4]. However, if applied to the silt soil, the density actually decreases. According to him, cement lowered the cohesive soil plasticity index caused by the increase in plastic limit and the decrease of its liquid limit.

Cement is increasingly being used as a soil stabilization material especially for subgrade. Soil strength will increase with increasing curing time. The grained soil and low plastic soil clays are more precisely stabilized with cement [5]. Experience has shown that the calcium found in clay soil is more easily stabilized with cement, on the contrary the sodium and hydrogen found in expansive clay soil is more precisely stabilized with lime.

3. **Testing method**

This test, soil sampling is done in the field and then stabilized the soil using chemical mixer in the form of cement. The initial stage is done by mixing the test ground with various levels of cement into the mold and compacted. After the solid soil mixture is removed from the mold and then dried on the condition of the room in accordance with the specified drying time. The next step is one of the test of mechanical characteristic that is free press test, the sample that has been made in the cylinder form is tested using UCS machine that is for the original soil sample (without mixture) and the soil has been mixed with cement by 30%, 50% and 70% of the soil dry weight in the soil conditions taken (0 days) or dried for 5 days, 10 days, 15 days and 20 days (cement variations i.e. 100% soil and 0% cement, 30% soil and 70% cement, 50% soil and 50% cement and 70% soil and 30% cement). Examples of test or soil samples prepared in this test are as many as 20 pieces, i.e. for soils with no mixture of cement (original soil) and soil with cement mixtures of three different levels and each sample is taken when the soil is taken (0 days) and when the age of drying of soil samples reaches 5 days, 10 days, 15 days and 20 days.

3.1. Conceptual frameworks

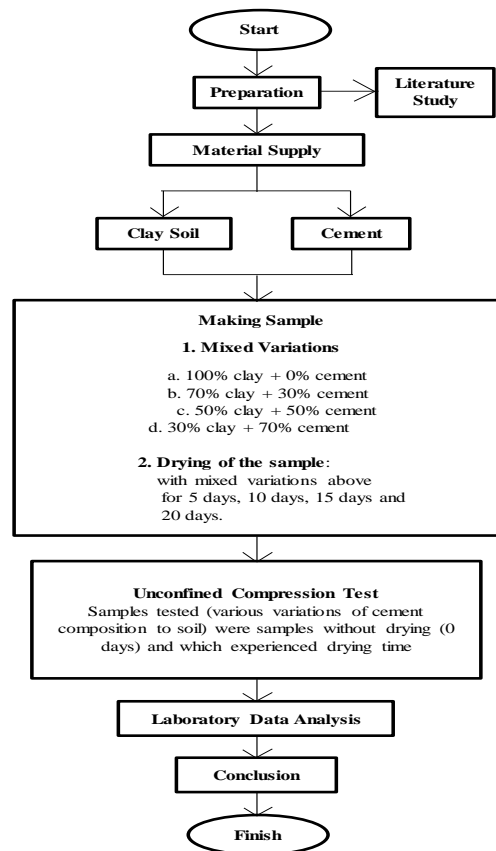


Figure 2. Test's flowchart.

4. Result and discussion

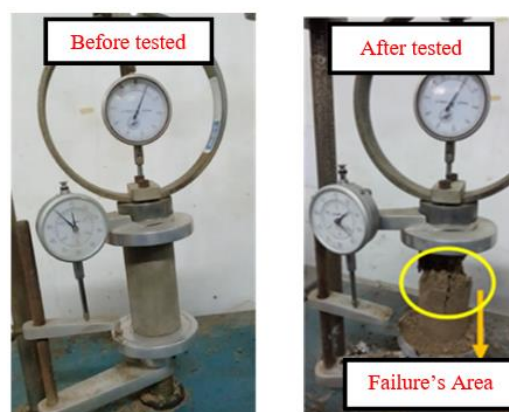


Figure 3. Sample's conditions before and after being tested.

The following analysis of data on the relationship between strain-clay soil stress mixed with certain cement variations then carried out drying with a predetermined time:

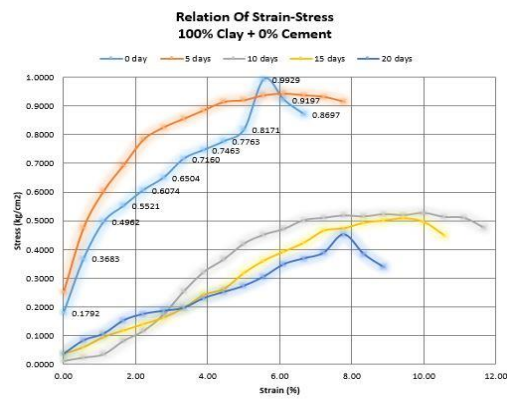


Figure 4. Relation of strain – stress, 100% soil + 0% cement to drying duration.

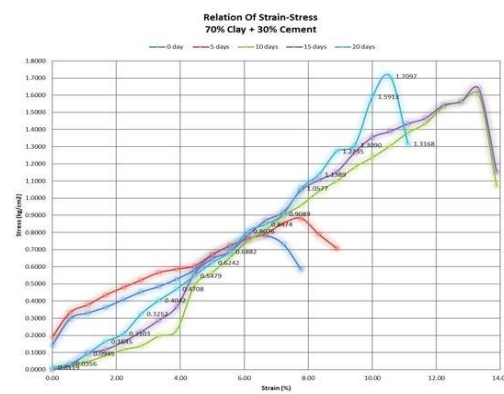


Figure 5. Relation of strain – stress, 70% soil + 30% cement to drying duration.

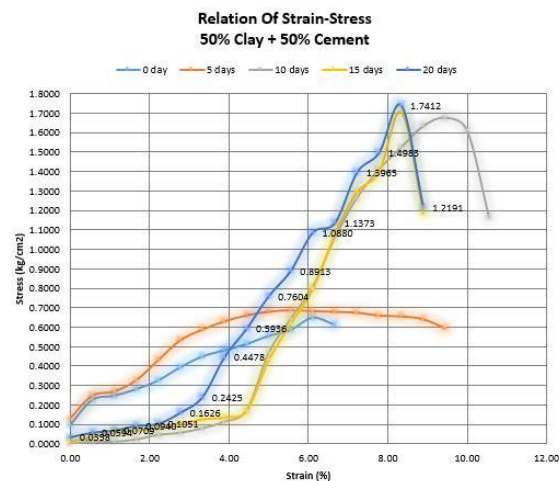


Figure 6. Relation of strain – stress, 50% soil + 50% cement to drying duration.

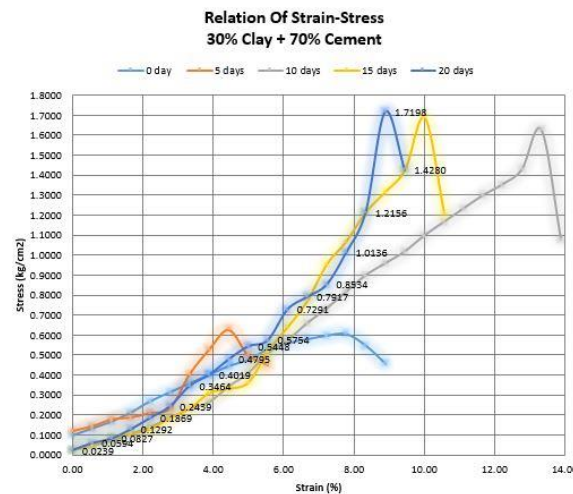


Figure 7. Relation of strain – stress, 30% soil + 70% cement to drying duration.

In addition to the above relationship graphs, an analysis is also made of the relationship between the drying duration and the ultimate stress of cement mixed soil with different composition:

5. Conclusions

The conclusion of the graph of the relationship between strain – ultimate stress on the duration of a particular drying:

- For a sample variation of 100% soil + 0% cement: it is found that if the sample length is dried then gradually the compressive strength will decrease and it is found that on day 0 the drying time shows the largest compressive strength (q_u) of 0.9929 kg / cm².
- For a sample variation of 70% soil + 30% cement: it is found that if the sample length is dried it will gradually increase its compressive strength and found that on the 20th day the drying time shows the largest compressive strength (q_u) of 1, 7097 kg / cm².
- For sample variation 50% of soil + 50% cement: it is found that if the sample length is dried then gradually the compressive strength will increase and it is found that on the 20th day the drying time shows the largest compressive strength (q_u) which is 1, 7412 kg / cm².
- For a sample variation of 30% soil + 70% cement: it is found that if the sample length is dried it will gradually increase its compressive strength and find that on the 20th day the drying time shows the largest compressive strength (q_u) of 1, 7198 kg / cm².

The conclusion of the analysis of the graph of the relationship between the drying duration with the ultimate stress that occurs is obtained:

"In the 50% sample soil + 50% cement showed the largest compressive strength value (q_u) when compared to the other samples. Tests using clay soil and cement mixed with each variation of different composition on the chart illustrated pattern that shows that the longer drying time of the sample is done then there will be a significant increase to the value of compressive strength of the sample. But this looks different from the sample on 100% soil + 0% cement, where seen along with the length of drying time is done then the value of the compressive strength will decrease. "

References

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