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COMPARATIVE ANALYSIS OF PORTLAND AND WHITE CEMENT IMPACT ON UNCONFINED COMPRESSIVE STRENGTH OF SOIL

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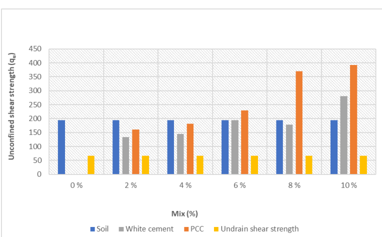
Graphical abstract



Abstract

Soil improvement plays a vital role in any engineering project, as the entire load from the superstructure is transmitted on the underlaying soil. Weaker soil increases foundation dimension, which is costly and soft soil generally causes difficulties on construction sites when it has low strength and low stiffness. Hence, in order to reduce cost and achieving better structural stability, soil must be stabilized with a mixture in order to achieve larger load carrying capacity. When soils fail to meet the geotechnical requirements, stabilizing the soil using cement is an essential process in geotechnical practice. Clay soil was stabilized in this study using white cement and regular Portland cement. White cement and Portland cement were collected and mixed with clay soil in amounts of 2%, 4%, 6%, 8%, and 10%. Soil tests such as grain size distribution, specific gravity test, unconfined compressive test, soil tests were performed on samples. The report includes field sampling, laboratory testing and engineering analysis and evaluation. From the result of unconfined compressive strength test, it is found that the addition of 6%, 8%, 10% of Portland cement and 10% of white cement increases the shear strength of the clay soil.

Keywords: Soft soil, OPC, White cement, Cement stabilization, Superstructure.

1.0 INTRODUCTION

In-depth research has been done on the stabilization of expansive soils utilizing a variety of additives, including lime, cement, industrial waste, calcium chloride, phosphoric acid, fly ash, and potassium nitrate (Mittal, 2013). The stabilization of soils with cement is an engineering technique generally used when the underlying soil has low bearing capacity. The cementitious linkages that form between the soil particles and the calcium silicate and aluminate hydration products are what cause cement stabilization to occur (Croft, 1967). One of the most essential building materials is cement, which acts as a binding agent and sets and hardens to cling to other building materials like stones, bricks, and tiles. Portland cement is a type of hydraulic cement created by crushing a limestone and clay mixture in a kiln (Kowalski et al., 2007, Deboucha et al., 2008, Sattynda, 2013). The only distinction between white and grey Portland cement is the color and fineness. The cement's color is a result of both the raw ingredients used and the manufacturing process. One of the most crucial strength metrics of cement-stabilized soils, unconfined compressive strength (UCS), has attracted a lot of attention in the literature (Bui Truong et al., 2020). Their findings demonstrated that the UCS of soil-cement compositions varies on the kind of soil, the water-to-cement ratio, the type of cement, and the amount of binder resulting in the increase of the strength. In a different study, white cement and regular Portland cement were used to stabilize clay soil. The clay soil was gathered and blended with regular Portland cement and white cement in various proportions, including 3%, 6%, 9%, 12%, and 15%. The results showed that adding 15% cement to both white cement and regular Portland cement increased shear strength on clay soil (Hossain et al., 2020). The application of cement enhances the unconfined compressive strength in relation to the curing period (Imran et al. 2007). According to the findings, samples cured for 14 days exhibited higher unconfined compressive strength than samples treated for 7 days (Sadek et al.2008). According to Nelson and Miller (1992), adding cement to clay soil decreases the liquid limit, plasticity index, and swelling potential while increasing the shrinkage limit and shear properties. Another study showed that the plasticity index first increased in the samples treated with 3% cement, 3% lime, 3% lime, and 3% Sarooj. But as more were added, the plasticity index gradually shrank. The samples treated with lime and cement mixtures, on the other hand, showed an initial reduction at 3% lime+3% cement and 5% lime+3% cement, followed by a general increase at higher additions (Al-Rawas et al., 2005). Akbulut et al. (2007) researched clayey soil alteration utilizing scrap tire rubber and synthetic fibers. The result demonstrated that the unreinforced and reinforced samples were tested for strength and dynamic qualities using unconfined compression, shear box, and resonant frequency tests and these waste fibers improve clayey soils' strength and dynamic activity. Brooks (2009) explored soil stabilization with fly ash and rice husk ash. According to the findings of this investigation, the failure stress and strains increased by 106% and 50%, respectively, when the fly ash concentration was increased from 0 to 25%. When the rice husk ash (RHA) content was increased from 0 to 12%, Unconfined Compressive Stress increased by 97%, while California Bearing Ratio (CBR) improved by 47%. Understanding the behavior of soils both before and after treatment is necessary for the stabilization of soils with various additives for engineering applications. The purpose of the study is to ascertain the geotechnical characteristics of the soil samples using various tests (grain moisture, grain size analysis, specific gravity, and Atterberg limit) as well as to ascertain the ultimate compressive strength of the soil samples mixed with various ratios of Portland cement and white cement.

2.0 METHODOLOGY

This research method was conducted by following three steps:

2.1 Location of the Site

The plot where the soil sample was taken was located at 161, Road 06, Block J, Bashundhara R/A, Dhaka. Figure 1 shows that the location of soil collection.

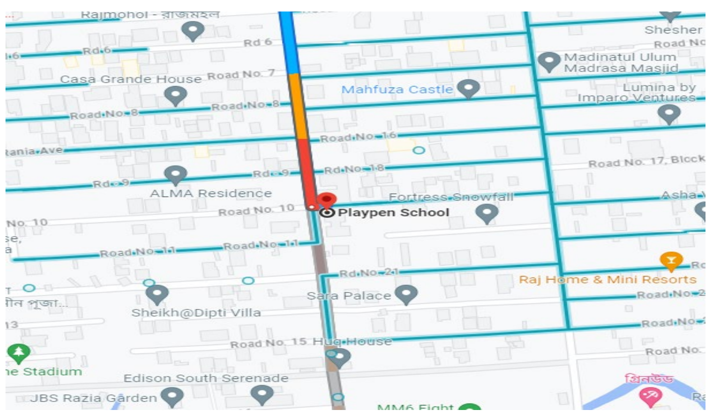


Figure 1 Location of the site

2.2 Sample Preparation in Laboratory

Following the collection of the soil sample, the laboratory's closest store was used to acquire White and Ordinary Portland cement. The soil sample was combined with regular Portland cement and white cement at 2%, 4%, 6%, 8%, and 10% ratios with the presence of a little amount of water after the grain size analysis test (sieve analysis and hydrometer) confirmed it was a clay soil. The molds were 4 inches tall and 1.5 inches deep. After that, it was left in the sun for one day to dry. After one day, the plastic mold was taken off, and the natural soil and all of the cement-mixed soil underwent an unconfined compression strength test. Figure 2 shows the prepared samples. The soil sample is unquestionably ready for mixing cement when the ground-up soil or natural soil passes through the #200 sieve. Table 1 shows that the tests that were conducted for natural and modified soil sample.

Figure 2 Sample preparation in laboratory

Table 1 The tests that were conducted for both natural and modified soil samples according to ASTM D2166-00 (2000) and ASTM D 2166 -06, (2010)

Name of the test	No. of test conducted
Determination of Moisture content	1
Grain size analysis test (Sieve analysis)	1
Determination of specific gravity of soil	3
Grain size analysis test (Hydrometer)	1
Atterberg Limit Test	1
Unconfined Compressive Strength Strength test	22

3.0 LABORATORY TEST RESULTS AND DISCUSSIONS

According to the results of the Unconfined Compressive Strength Test, the strength somewhat increased with the addition of white cement and conventional cement. However, it was discovered that the cement mixing with the sample in the cases of regular Portland cement (2% & 4%) and white cement (2%, 4%, and 8%) exhibited a low value due to a lack of cement and soil bonding.

However, for mixing level of 6%, 8%, and 10%, the enhanced soil compressive strength is 3.1%, 7.7%, and 13.7%, respectively. Similar to white cement, compressive strength values for 6% and 10% admixture were higher than mother soil. Table 2 and Figure 3 show the unconfined compressive strengths for several soil samples combined with two different types of admixtures (Portland and White Cement).

Table 2 Unconfined Compressive Strength (q_u) and Cohesion (c) values for different samples

Percentage of mixing	Portland cement		White cement	
%	q_u (kPa)	c (kPa)	q_u (kPa)	c (kPa)
0	194	97	194	97
2	161	81	133	67
4	181	90	145	73
6	230	115	195	98
8	370	185	179	90
10	392	196	281	141

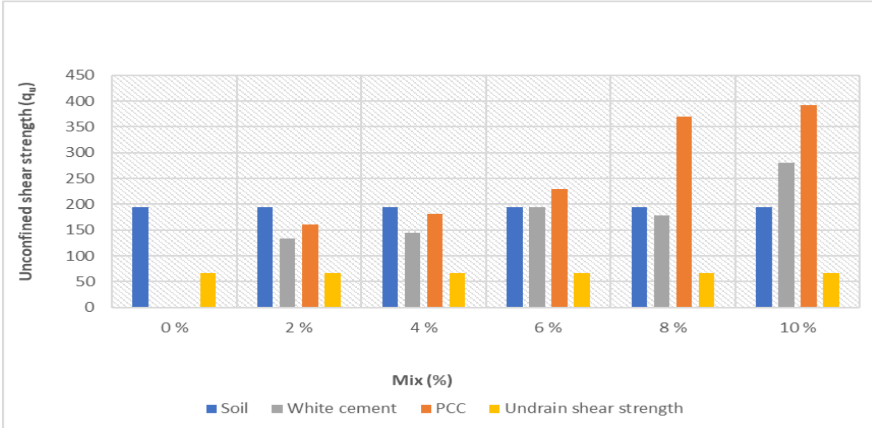


Figure 3 Data summary of unconfined compressive strength.

4.0 CONCLUSION

Soil stabilization with cement is an interesting field of experimental research by laboratory tests. In this way, it is useful to develop a quick and economical methodology based on a minimum set of geotechnical tests on cement-soil moistures for soil stabilization. After completing the required analysis, we got the analysis data mentioned below:

1. The compressive strength of the collected natural soil is 194 kPa obtained from the unconfined compression test. Compressive strength has increased with the increase of cement mixing.
2. The compressive strength of soil samples with Portland cement mixture at 2%, 4%, 6%, 8% and 10% were found to be 161 kPa, 181 kPa, 230 kPa, 370 kPa, and 392 kPa. Similarly, the compressive strength of soil sample with white cement mixture at 2%, 4%, 6%, 8% and 10% were found to be 133 Kpa, 145 Kpa, 195 Kpa, 179 Kpa, and 281 Kpa respectively.
3. The maximum compressive strength has been obtained using 10% mixing for both Portland cement and white cement. In case of Portland cement, it is 28.31% higher than that of white cement mixture.

5.0 RECOMMENDATION FOR FURTHER STUDY

This study concludes that the addition of local readily available industrial materials (various types of Portland cement and white cement) with clay soil can have economic results and useful applications in Bangladesh due to their low cost and availability. According to the test results from Portland cement, better results are obtained than another stabilizer. To obtain more accurate results, different test methods and acceptance criteria are required for each stabilizer, with the performance efficiency of different types of cement as soil stabilizing agents. A unified testing program is required to demonstrate. To secure the objective of this study, more test data were required which was not possible due to time constraints. As recommended here, this topic needs more future work.

1. The California Bearing Ratio (CBR) test can be conducted in order to conduct further research on this area.
2. These tests should be carried out with different stabilizing agent concentrations.
3. Similar tests can be conducted and results should be compared using other stabilizers such as small pieces of facemask, glass breeds, coarse and fine aggregates, lime, ceramic powder and stone dust and so on.
4. Since the triaxial test is recognized to produce relevant shear strength parameters, conducting this test is advised in future research.
5. In order to obtain more reliable results, samples from several locations should be used.

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