International Journal of Trend in Scientific Research and Development (IJTSRD)
Volume 3 Issue 5, August 2019 Available Online: www.ijtsrd.com e-ISSN: 2456 – 6470

Experiential Investigation on the Stabilization of Dispersive Soil with Lime

Soe Soe War[1], Nyein Nyein Thant[2]

[1]Lecturer, [2]Associate Professor

[1,2]Department of Civil Engineering, Technological University, Mandalay, Myanmar

How to cite this paper: Soe Soe War | Nyein Nyein Thant "Experiential Investigation on the Stabilization of Dispersive Soil with Lime" Published in International Journal of Trend in Scientific Research and Development (ijtsrd), ISSN: 2456-6470, Volume-3 | Issue-5, August 2019, pp.1376-1380, **https://doi.org/10.31142/ijtsrd26658**

IJTSRD26658

Copyright © 2019 by author(s) and International Journal of Trend in Scientific Research and Development Journal. This is an Open Access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0) (http://creativecommons.org/licenses/by/4.0)

ABSTRACT

The soils that are highly susceptible to erosion and containing high percentage of exchangeable sodium ions are called Dispersive Soils. In appearance, dispersive clays are like normal clays that are stable and somewhat resistant to erosion, but in reality they can be highly erosive and subject to severe damage or failure. Using dispersive clay soils in hydraulic structures, embankment dams, or other structures such as roadway, embankments can cause serious engineering problems if these soils are not stabilized and used appropriately. This problem is worldwide, and structural failures attributed to dispersive soils have occurred in many countries. This paper presents the stabilization of dispersive soil with lime. The soil sample is taken from Mandalay. Grain size distribution, Atterberg's limit test, compaction test, unconfined compressive strength (UCS) test and triaxial test are carried out to obtain the properties of soil. Type of studied soil classified by unified classification system is lean clay with sand. Crumb test is performed to know the dispersion degree of study soil. According to crumb test, the study soil is highly dispersive clay soil. Lime is used as stabilizing agent. The amount of lime used is 2%, 3% and 4% by dry weight of soil. The studied soil is mixed various contents of lime, and then crumb test is performed. At dispersive soil mixed with 4% of lime, there is no dispersion characteristic in soil. For stabilization of studied soil, 4% of lime is selected to investigate the improvement of strength in treated soil. The treated soil is performed compaction test, unconfined compression strength (UCS) test and triaxial test. Unconfined compression strength of treated soil at 4% lime is increased as 1.12 times that of natural soil. The shear strength of treated soil increases about 2 times than that of natural soil. The cohesion value of treated soil increases about 1.12 times and the angle of internal friction increases about 1.23 times than that of natural soil. Finally, it is concluded from this study that the lime treated soil is more resistant to erosion and the treated soil is more resistant to shear stress and lateral pressure.

KEYWORDS: *Dispersive Soil, Stabilization, Lime, sodium ion.*

I. INTRODUCTION

Dispersion occurs in soils when the repulsive forces between clay particles exceed the attractive forces, thus bringing about deflocculation, so that in the presence of relatively pure water the particles repel each other to form colloidal suspensions. In non-dispersive soil, there is a definite threshold velocity below which flowing water causes no erosion. The individual particles cling to each other and are only removed by water flowing with a certain erosive energy. By contrast, there is no threshold velocity for dispersive soil; the colloidal clay particles go into suspension even in quiet water and therefore are highly susceptible to erosion and piping. Dispersive soils contain a higher content of dissolved sodium (up to 12%) in their pore water than ordinary soils and the pH value generally ranges between 6 and 8. These soils occur in semi-arid regions; for example, many areas of central Myanmar and the presence of the dispersive soil always causes serious piping, failures of the earth dams and earth retaining structures.

In the presence of dispersive soil, piping is due to a deflocculation process where water travels through a concentrated leakage channel, such as a crack (even a very small crack), from its source. The erosion of the walls of the leakage channel then occurs along the entire length at the same time. Unlike erosion in cohesionless soils, erosion in dispersive clay is not a result of seepage through the pores of a clay mass. The dispersive soils cannot be differentiated from non-dispersive soils by routine soil mechanics testing, for example, they cannot be identified by their plasticity or activity. Although a number of special tests have been used to recognize dispersive soils, no single test can be relied on completely to identify them. These tests can be divided into physical and chemical tests.

To avoid serious problems caused by dispersive soils and uneconomical replacement of dispersive soil bank sources with non-dispersive bank sources, it has become necessary to make such soils suitable for construction. In order to do that, soil stabilizing is very effective and suitable. This study focuses on the investigation of the dispersive soils and chemical stabilization by using additive hydrated lime.

II. Objectives of the Study

The objectives of the study are stated as follows;

1. To study the engineering properties of dispersive soil.
2. To analyze the dispersive soil of the proposed area by performing necessary tests.
3. To perform the stabilization of dispersive soil with selected lime percentage.
4. To study the improvement of physical properties and mechanical properties of treated soil.

III. Properties Of Dispersive Soil

A. Grain-Size Analysis

Soils are generally characterized as gravel, sand, silt or clay depending upon the predominant sizes of particles within the soil. In determination of grain-size distribution of the soil, sieve analysis is carried out for particles greater than 0.075 mm and hydrometer analysis is used for particles smaller than 0.075 mm. In hydrometer analysis, ASTM 152H hydrometer and 50 grams of soil passing No.200 sieve (0.075 mm opening) are used. Figure.1 shows particle –size distribution curve for study soil.

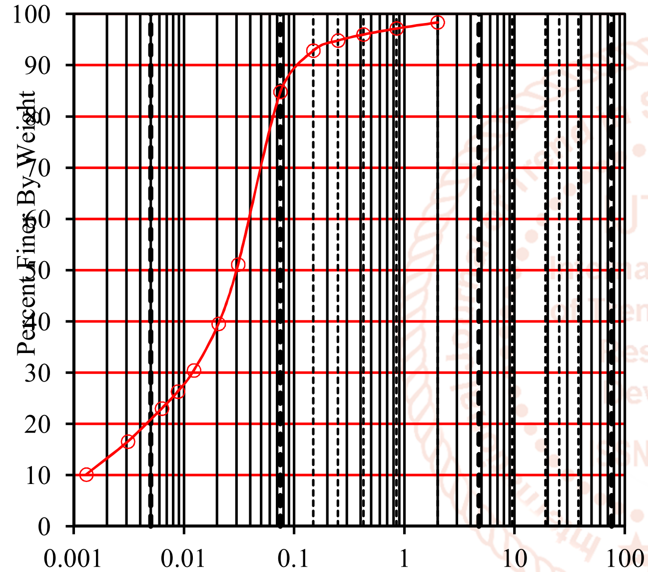

Figure. 1 Particle size distribution curve

B. Atterberg Limit Tests

The state of the soil depends on the amount of water present in the soil. The water content levels at which the soil change from one state to the other are the Atterberg limits. They are the liquid limit (LL), plastic limit (PL).

Liquid Limit (LL)

During the drying process, the initially liquid state reaches a consistency at which the soil ceases to behave as a liquid and begins to exhibit the behaviour of plastic. The water content at this state is called the liquid limit (LL).

Plastic Limit (PL)

As the drying process continues, the plastic state reaches a consistency at which the soil ceases to behave as a plastic and begins to break apart and crumbed when rolled by hand into cylinders 3.22 mm in diameter. The water content at this state is called the plastic limit (PL).

Plasticity Index

The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both the liquid and plastic limits are moisture contents.

Plasticity Index = Liquid Limit – Plastic Limit

$$PI = LL - PL$$

Table1.Consistency Limits of Studied Soils

Consistency Limits	Sample Soil's Results
Liquid Limit, L.L (%)	50.3
Plastic Limit, P.L (%)	19.7
Plasticity Index, P.I (%)	30.6

C. Compaction Test

Compaction is one kind of densification that is realized by rearrangement of soil particles without outflow of water. It is realized by application of mechanic energy. It does not involve fluid flow, but with moisture changing altering. Test result for study soils is shown in Figure 2.

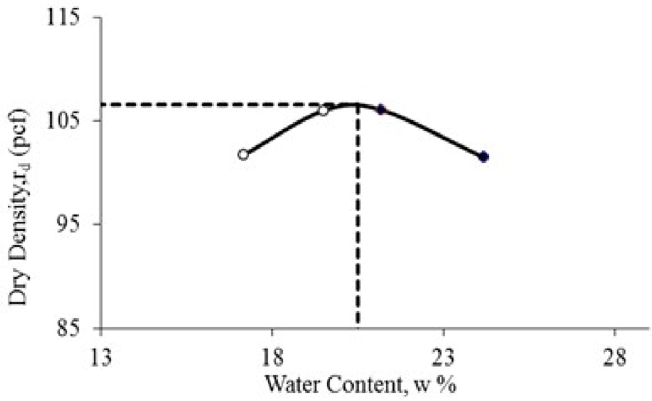

Figure2. Moisture Content and Maximum Dry Unit Weight Curve

The curve shown in Figure 2 represents the relationship of moisture content and dry unit weight. The optimum moisture content is 20.5% and the maximum dry unit weight is 106.6 lb/ft^3.

D. Unconfined Compression Strength (UCS) Test

The Unconfined Compression Strength test is used to obtain an estimation of the undrained shear strength of cohesive soil. In this test, a cylindrical specimen of the soil is loaded axially without any lateral confinement to the specimen at a sufficiently high rate. The unconfined compression Strength test result of study soil is 1.15 kg/cm^2.

E. The Crumb Test

The crumb test is the simplest of the tests used for detecting dispersive clays. Crumb tests are often performed during an investigation to supplement laboratory information on samples collected. To perform the crumb test in the lab, a cubical specimen of sides of approximately 15 mm is placed in 250 millilitres (ml) of distilled water. Once placed in water, the soil is monitored after two minutes, one hour, and six hours and classified based on the tendency of the colloidal particles to deflocculate and go into suspension. Observations are made at each time interval and the soil is classified into four grades;

Grade 1 – No colloidal cloud develops. Even though the crumb may slake and particles spread away from the original clod because of this slaking activity, no trace of a colloidal cloud is observed in the water is called Non-dispersive.

Grade 2 – A colloidal cloud is observable, but only immediately surrounding the original clod. The cloud has not spread any appreciable distance from the crumb is called Intermediate.

Grade 3 – A colloidal cloud emanates an appreciable distance from the crumb. However, the cloud does not cover the bottom of the glass, and it does not meet on the opposite side of the glass bottom from the crumb is called Dispersive.

Grade 4 – The colloidal cloud spreads completely around the circumference of the glass. The cloud may not completely obscure the bottom of the glass, but the cloud does completely cover the circumference of the glass. In extreme cases, the entire bottom of the glass is covered by the colloidal cloud is called Highly Dispersive (Bureau of Reclamation, 1991).

A dispersive soil may sometimes give a nondispersive reaction in the crumb test. However, if the crumb test indicates dispersion, the soil is probably dispersive.

Table2. Crumb Test Results for Studied Soils

Medium	Crumb Condition	Time	Grade
Distilled Water	Remoulded	2 minutes	1
		1 hour	4
		6 hours	4

From above Table, sample has grade-4, so the studied soil is highly dispersive.

F. Triaxial Shear Test Results

The triaxial shear test is one of the most reliable methods available for determining shear strength parameters. Triaxial shear tests are carried out to calculate the shear strength of the soil.

Figure 3 shows Mohr's circle of soil sample. From this figure, cohesion of studied soil is 0.95 kg/cm² and the angle of internal friction is 13°.

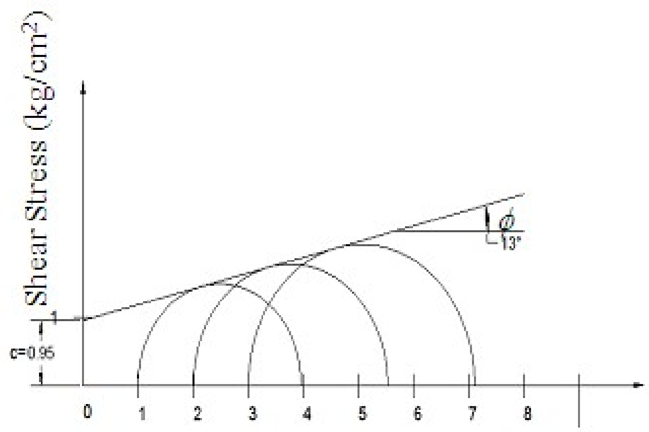

Figure3. Mohr's Circles of Sample Soil

IV. EXPERIMENTAL INVESTIGATION ON STABILIZES WITH LIME

The natural soil treated with lime is carried out through crumb test. In crumb test, a cube of moulded soil approximately 15 mm is placed in a beaker containing 250 mL of distilled water. Visual determinations of dispersion grade are made and recorded at two minutes, one hour and six hours. The Table 3 shows grade description for crumb test.

Table3. Crumb Test Results of Studied Soil Treated with Lime

Lime content	Grade		
	2 minutes	1 hour	6 hours
0%	1	4	4
2%	1	1	1
3%	1	1	1
4%	1	1	1

According to above table, after addition of 2% of lime, it is converted to non- dispersive soil although slaking of the sample occurred. When adding 3% of lime, the sample also converted to non-dispersive and the occurrence of slaking is less than that of 2% of lime. At 4% of lime, also derisory slaking appeared compared to 2% of lime but there is no dispersion characteristic. According to the crumb test, 4% of lime is suitable for stabilizing of highly dispersive soil.

A. Consistency Limit

Liquid limit and plastic limit of soils mixed with selected 4% lime is tested. Attreberg's limits test results of treated soils are shown in Table 4.

Table4. Atterberg's Limit Tests Results of Treated Soil

Stabilizer content	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index
Natural Soil	50.3	19.7	30.6
Soil treated with 4% of lime	47.4	24.7	22.7

Addition of 4% lime to dispersive soils alters the plasticity of the soils. It is observed that there is an increase in plastic limit, both liquid limit and plasticity index are decreased fairly.

B. Compaction test

Compaction increases the density of the soil, which generally leads to increase in the strength and stiffness characteristics of the soil, to increase in the stability of slopes and embankments. Therefore, compaction test is performed with 4% lime content. Compaction test is carried out to determine the optimum moisture content which gives the maximum dry density of stabilized soils. The relationship between dry density and moisture content for treated soil is shown in Figure 4.

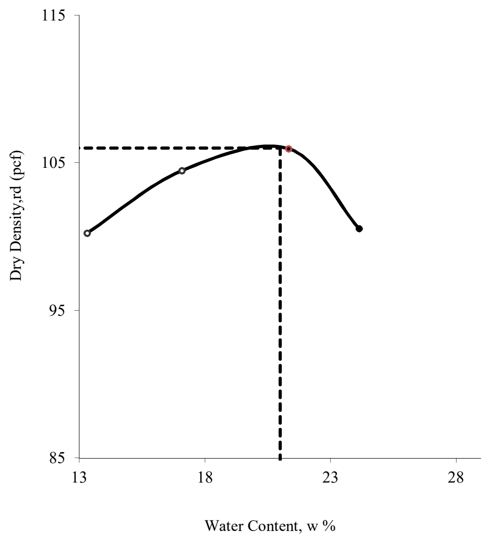

Figure4. Moisture Content and Maximum Dry Unit Weight Curve

The curve shown in Figure 4 represents the relationship of moisture content and dry unit weight. The optimum moisture content is 21.0% and the maximum dry unit weight is 106.0 lb/ft^3.

Comparison for compaction test rsults of natural soil and treated soil are compared in Table 5.

Table5. Compaction Test Results of Natural Soil and Treated Soil

Soil Type	O.M.C (%)	M.D.D (pcf)
Natural Soil	20.5	106.6
4% Lime Treated Soil	21	106

In compaction test, it is observed that addition of 4 % lime to the natural soil, did not affect significantly on optimum moisture content and maximum dry density of natural soil.

C. Unconfined Compression Strength Test (UCS) Results for Treated Soil

In unconfined compression strength test, addition of 4% lime is carried out because it is the optimum stabilizer content according to physical dispersion test. Unconfined compression strength of treated soil with 4% lime at OMC is 2.57 kg/cm^2.

Table 6 shows the comparison of unconfined compression strength between natural soil and treated soil with 4% lime at OMC. It can be found that the unconfined compression strength is increased in 4% lime treated soil.

Table6. Unconfined compression strength of Natural Soil and Treated Soil

Soil Type	q_u (kg/cm^2)
Natural Soil	1.29
4% Lime Treated Soil	2.57

D. Trixial Shear Test Result For Treated Soil

Figure 5 shows Mohr's circle of soil sample. From this figure, cohesion of studied soil is 1.36 kg/cm^2 and the angle of internal friction is 16°.

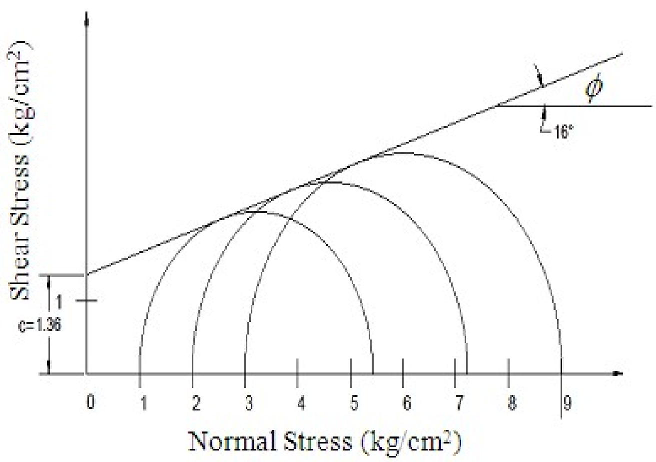

Figure5. Mohr's Circles of 4% Lime Treated Soil

Table7. Results of Shear Strength on Natural Soil and Treated Soil with 4% Lime

Lime Content (%)	Natural	4% Lime Treated Soil
c (kg/cm^2)	93.16	133.37
ϕ (degree)	13	16
θ (degree)	51.5	53
σ_f (lb/ft^2)	210.56	524.09
τ_f (lb/ft^2)	141.77	283.65

From comparison results, the shear strength increases twice after treated with 4% lime. The cohesion of treated soil with 4% lime increases about 1.12 times than that of natural soil.

V. CONCLUSIONS

Stabilization of soil is widely accepted as an effective means of improving soil properties and pavement system performance. In this study, soil sample is taken from selected area of Mandalay city. To identify the soil sample is dispersive clay soil or not, physical test such as crumb test is performed. This study deals with stabilization of dispersive soil using lime as stabilizing agent.

After performing crumb test, the selected soil sample is Grade-4 (highly dispersive). Therefore, the selected soil sample is needed to stabilize. At first, lime percentages (2%, 3%, and 4%) are selected to stabilize the natural soil.

In crumb test, after addition of 4% of lime, this soil is converted to nondispersive soil. Therefore, 4% of lime is the most suitable percentage among chosen percentages for stabilizing of studied soil.

Based on the results of Unified Soil Classification System, the selected sample is in CH group which is inorganic clay of high plasticity and the sample is Lean clay with sand.

According to specific gravity test, the selected soil sample is silty sand. From consistency limits, selected soil sample is high plasticity soil. After 4% of lime is added, the treated soil is still the high plasticity soil although consistency limits are altered. In compaction test, it is observed that addition of 4 % lime to the natural soil did not affect significantly on optimum moisture content and maximum dry density of natural soil. From the results of Triaxial test, internal friction angle of selected sample increased from 13° to 16° after addition of 4% lime.

In UCS test, the consistency of selected sample is very stiff, although the unconfined compressive strength of treated soil with 4% lime is greater than that of natural soil. In strength consideration, unconfined compression strength of the sample soil treated with 4% of lime is increased 1.12 times when compared to the natural soil. And also, the value of cohesion increases about 1.12 times and the shear strength at failure increases about 2 times than that of natural soil.

REFERENCES

[1] [18Lin] Lin Nay Chi Aung: Study on Stabilization of Dispersive Soil, M.E. Thesis, Department of Civil Engineering, MTU (2018).

[2] [13Amr] Amrita Maharaj: The Evaulation of Test Protocols for Dispersive Soil Identification in Southern Africa, Master of Science, Department of Geology, University of Pretoria, (2013).

[3] [09Ume] Umesha T.S, Dinesh S.V, and Sivapullaiah P.V: Control of Dispersivity of Soil Using Lime and Cement, International Journal of Geology, (3)1, (2009).

[4] [09Har] Hardie M: Dispersive Soils and their Management, Technical Reference Manual, Department of Primary Industries and Water, Tasmania, (2009).

[5] [06Yun] Yun Zhou, Ph.D., P.E.: Soil and Foundation, Manual, 1(1), (2006).

[6] [06Rob] Robert W. Day: Foundation Engineering Handbook, (2006).

[7] [03Mur] Murthy V.N.S.: Principles and Practices of Soil Mechanics and Foundation Engineering, Geotechnical Engineering, Marcel Dekker, Inc, New York, (2003).

[8] [98Bra] Braja M. Das: Principle of Geotechnical Engineering, Fourth Edition, Boston, U.S.A, PWS Publishing Company, (1998).

[9] [85Elg] Elges, H F W K: Dispersive Soils, Civil Engineer in South Afria: (1985), 347-353.

[10] [77She] Sherard, J. L., and R. S. Decker: Dispersive Clays, Related Piping, and Erosion in Geotechnical Projects, American Society for Testing and Materials, Philadelphia, (1977).

[11] [58Don] Donald W Taylor: Fundamental of Soil Mechanics, Tenth Printing (1958).

International Journal of Trend in Scientific Research and Development
IJTSRD
International Journal of Trend in Scientific Research and Development
ISSN: 2456-6470