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Improving the Compaction Effect of Expansive Soil Using Lime and Quarry Dust

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Abstract

Soil Stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. So it is very important to stabilize the expansive soil. In our project stabilization of expansive soil is done using quarry dust and lime mixes. The combined effect of these two materials are expected to show better results on compaction characteristics, unconfined compressive strength, California bearing ratio (CBR) when it is used along with expansive soil. As quarry dust and lime are the cheapest and easily available material it mixes will increase the characteristics of soil. Here we have planned to conduct several testing methods such as specific gravity, sieve analysis, atterberg limits, UCC, proctor compaction in order to improve the strength of soil at different proportions of lime and quarry dust mixes. Then the results and graphs of various mixes are compared to see their effects in soil stabilization.

Keywords: *Quarry Dust, California bearing ratio (CBR), Soil Stabilization*

INTRODUCTION

For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work. From the beginning of construction work, the necessity of enhancing soil properties has come to the light. Ancient civilizations of the Chinese, Romans and Incas utilized various methods to improve soil strength etc., some of these methods were so effective that their buildings and roads still exist.

In India, the modern era of soil stabilization began in early 1970's with a general shortage of petroleum and aggregates; it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost-effective method for soil improvement.

Geotechnical Engineers will design the foundations and other structures on the soil only after investigating the type of soil, its characteristics and its extent. If the soil is good at shallow depth below the ground surface, shallow foundation such as footings and rafts are generally preferred which are considered to be most economical. However if the soil just below the ground surface is of not good but a strong stratum exists at a greater depth, deep foundations such as piles, wells and caissons are preferred. Deep foundations are quite expensive and are of cost effective only for the structures which are to be supported are quite heavy and huge. Sometimes the soil conditions are very poor even at greater depth and it is not even practical to construct deep foundation. In such cases various soil stabilization methods and reinforcement techniques are adopted. The main objective is to improve the characteristics of soil at site and make it capable to carry more loads and also to increase its shear strength and to decrease its compressibility.

Soil stabilization is the process of altering some soil properties by different methods, mechanical chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of the soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

2. LITERATURE WORKS

The combined effects of two industrial wastes fly ash and quarry dust on, compaction characteristics, unconfined compressive strength, California bearing ratio (CBR), shear strength parameters and swelling pressure of an expansive soil[1].

Lime generally improves the performance of soils. The influence of lime stabilization on these soils was evaluated through determination of geotechnical properties such as liquid limit, plastic limit, swell, compressive strength etc. For the soil having less silica content lime can be used effectively for stabilization[2].

Clayey soil can be stabilized by the addition of small percentages, by weight of lime thereby enhancing many of the engineering properties of the soil. The soil used in the study is clay from thonnakal in Trivandrum district. The lime solution with different concentrations was added to the soil samples for stabilization. From the test results it was found that the unconfined compressive strength increases[3].

Four soils samples were used in this study to show shrinkage variability within a soil group with the addition of lime and fly ash. It was found that both lime and fly ash reduced the linear shrinkage, however, the addition of lime reduced the linear shrinkage to a greater degree than the same percentage of fly ash[4].

This study deals with durability characteristics and unconfined compressive strength of clayey soil stabilized with lime.

The tests comprises of unconfined compressive strength for samples stabilized with the optimum lime percentage. The results indicated that, the lime improves the unconfined compressive strength of clayey soil[5].

The combined effects of two industrial wastes fly ash and quarry dust on compaction characteristics, unconfined compressive strength, California bearing ratio (CBR), shear strength parameters and swelling pressure of an expansive soil have been discussed in this paper. The effect of molding water content on CBR of fly ash-quarry dust stabilized expansive soil and the economy of fly ash-quarry dust stabilization have also been discussed[6].

The availability of build able land is fast drifting away each day due to scarcity lands with good natural bearing capacity. This leads to construction of buildings on poor soils which eventually lead to structural foundation failures. It has become very imperative to improve soils or the quality of grounds by the adoption of suitable improvement methods depending on the materials available. However during soil or ground improvement, cost effectiveness is one of the major factors considered cardinal. Consequent upon this, there is a paramount need to adopt the use of admixtures during cement/soil improvement or stabilization. This necessitated the review on a very important admixture in geotechnical engineering and in cement stabilization of soils during pavement construction[7].

The use of laterite stabilized with cement using quarry dust as additive for use as base course material was investigated. The laterite soil used was an A-2-6 and GP soil using AASHTO and USCS classification, obtained from Ikpayongo. It was stabilized with 2-10% cement and 10-50% quarry dust by weight of dry soil. Soil samples were subjected to General classification test. Using the West African Standard (WAS) compaction energy, samples were also subjected to California Bearing Ratio (CBR) test, Unconfined Compressive Strength (UCS) test, and the Durability test to ascertain the reliability of the strength tests. Results showed that Liquid Limit, plastic Limit, Plasticity Index, and maximum dry density (MDD) decreases with increase quarry dust content, in all the cement proportions used. Unconfined Compressive strength increased with quarry dust content, for all the cement proportions regardless of curing age[8].

The effect of lime on some geotechnical properties of an expansive soil stabilized with optimum percentage of quarry dust has been described in this paper. The lime added were 2 to 7 % at an increment of 1%. Atterberg's limit, compaction, consolidated undrained triaxial compression, and durability tests were conducted on these mixes. The effect of 7 and 28 days of curing were also studied on shear strength. It was concluded that addition of lime had increased the plastic limit, shrinkage limit, cohesion ,angle of internal friction, optimum moisture content ,decreased the liquid limit, plasticity index, maximum dry density of the soil- quarry dust mixes ,made the soil-quarry dust mixes durable .Curing had positive effects on shear parameters[9].

Compaction properties California bearing ratio, shear strength parameters, compression index, swelling pressure and durability of an expansive soil stabilized with rice husk ash and lime sludge have been discussed in this paper[10].

3. EXPERIMENTAL INVESTIGATIONS

a) Specific Gravity

Specific gravity is defined as the ratio of the unit weight of soil solids to unit weight of water. The specific gravity is needed for various calculations purpose in soil mechanics, e.g. void ratio, density and unit weight.

Dry the pycnometer and weigh it with its cap. Take about 200 gm of dry soil passing through 425 μ sieve into the pycnometer and weigh again. Fill the pycnometer with water completely. Thoroughly dry the pycnometer from outside and weigh it. Clean the pycnometer by washing thoroughly. Fill the pycnometer completely with water up to its top with cap screw on. Weigh the pycnometer after drying it on the outside thoroughly. Figure 1 shows the pycnometer and Table 1 presents the values.

Figure 1 Pycnometer

Table 1 Specific gravity

Sample No	W_1 in gms	W_2 in gms	W_3 in gms	W_4 in gms	Specific Gravity
1	0.640	0.840	1.660	1.530	2.86
2	0.640	0.840	1.650	1.530	2.5
3	0.640	0.840	1.660	1.530	2.86

b) Compaction test

Compaction is the process of densification of soil mass by reducing air voids under dynamic loading. This test is conducted in order to find out the optimum moisture content and maximum dry density of the soil. Take about 3 kg of the soil. Add water to it to bring its moisture Content. Clean, dry and grease the mould and base plate. Weigh the mould With base plate. Fit the collar. Compact the wet soil in three equal layers by the rammer with 25 evenly distributed blows in each layer.

Remove the collar trim off the soil flush with the top of the mould. Clean the outside of the mould and weigh the mould with soil and base plate. Repeat the above procedure by increasing the water content until the weight of mould with soil decrease. Calculate the dry density and moisture content Plot the moisture content on X – axis. Draw a smooth curve passing through the points , which is known as compaction curve.

Figure 2 Cylindrical mould with rammer

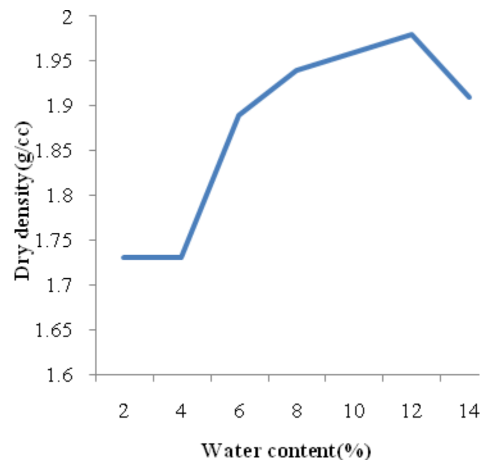

Figure 3 Water content Vs Dry density

Table 2 Standard Proctor Compaction test

S.No	Water Content (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight of soil	Dry unit weight
1	2	6150	1770	1.77	1.73
2	4	6180	1800	1.80	1.73
3	6	6390	2010	2.01	1.89
4	8	6480	2100	2.10	1.94
5	10	6540	2160	2.16	1.96
6	12	6600	2220	2.22	1.98
7	14	6560	2180	2.18	1.91

Find out the point of maximum dry density and corresponding water content from the compaction curve. Figure 2 shows the cylindrical mould which is used for the process of compaction and Figure 3 represents its relation. Table 2 gives the values of compaction. The optimum moisture content is of 12% and the maximum dry density is of 1.98 g/cm^3.

3. RESULTS COMPACTION FOR DIFFERENT MIXES

Figure 4, 5, 6, 7 and 8 represents the water vs dry density values for different mixes and Table 3, 4, 5, 6 and 7 gives the readings of different mixes.

a) Lime 5%, Quarry Dust 10%

Table 3 Standard Proctor Compaction test

S.No	Water Content, (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight of soil	Dry unit weight
1	2	6140	1760	1.77	1.74
2	4	6180	1800	1.81	1.74
3	6	6400	2020	2.03	1.92
4	8	6440	2060	2.07	1.92
5	10	6490	2110	2.12	1.93
6	12	6360	1980	1.99	1.78

The optimum moisture content is 10% and maximum dry density is 1.93g/cm^3.

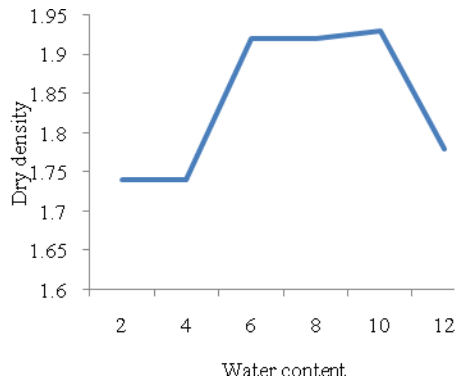

Figure 4 Water content Vs Dry density

b) Lime 10%, Quarry Dust 20%

Table 4 Standard proctor compaction test

S.no	Water Content, (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight Of soil	Dry unit weight
1	2	6090	1710	1.72	1.69
2	4	6220	1840	1.85	1.78
3	6	6390	2010	2.02	1.91
4	8	6490	2110	2.12	1.96
5	10	6430	2050	2.06	1.87

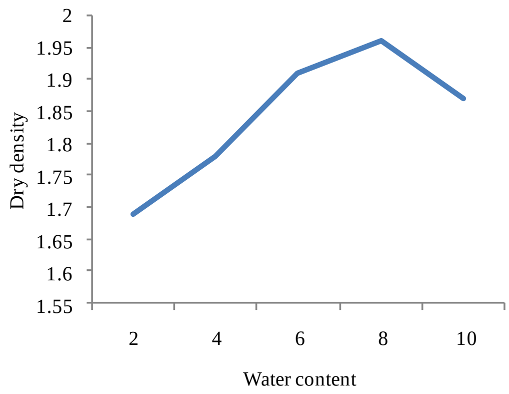

Figure 5 Water Content Vs Dry Density

The optimum moisture content is 8% and maximum dry density is 1.96g/cm^3.

c) Lime 15%, Quarry Dust 30%

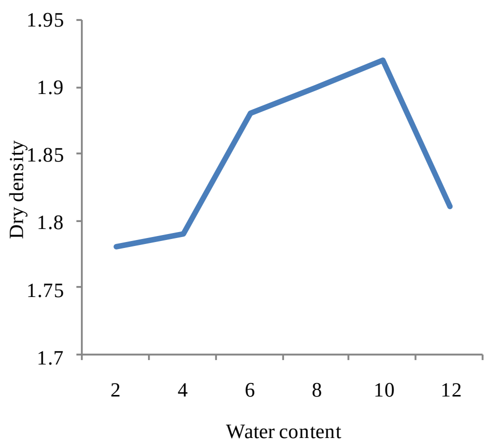

Figure 6 Water Content Vs Dry Density

Table 5 Standard Proctor Compaction test

S.No	Water Content, (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight Of soil	Dry unit weight
1	2	6190	1810	1.82	1.78
2	4	6230	1850	1.86	1.79
3	6	6370	1990	1.99	1.88
4	8	6430	2050	2.06	1.90
5	10	6490	2110	2.12	1.92
6	12	6400	2020	2.03	1.81

The optimum moisture content is 10% and maximum dry density is 1.92g/cm^3.

d) Lime 20%, Quarry Dust 40%

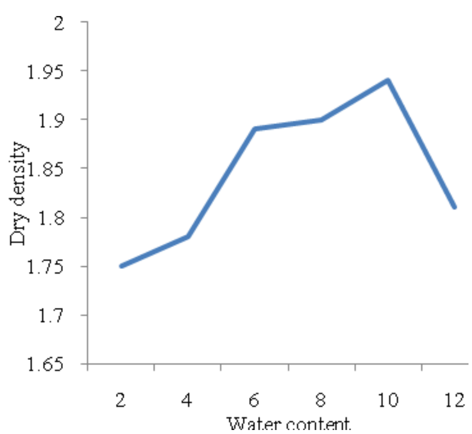

Figure 7 Water Content Vs Dry Density

Table 6 Standard Proctor Compaction test

S.No	Water Content, (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight Of soil	Dry unit weight
1	2	6160	1780	1.79	1.75
2	4	6220	1840	1.85	1.78
3	6	6370	1990	2	1.89
4	8	6420	2040	2.05	1.90
5	10	6500	2120	2.13	1.94
6	12	6400	2020	2.03	1.81

The optimum moisture content is 10% and maximum dry density is 1.94g/cm^3.

e) Lime 25%, Quarry Dust 50%

Table 7 Standard Proctor Compaction test

S.No	Water Content, (%)	Weight of Mould with Compacted Soil(gm)	Weight of Compacted Soil(gm)	Unit weight Of soil	Dry unit weight
1	2	6200	1820	1.83	1.79
2	4	6270	1890	1.90	1.83
3	6	6390	2010	2.02	1.91
4	8	6440	2060	2.07	1.92
5	10	6490	2110	2.12	1.93
6	12	6420	2040	2.05	1.83

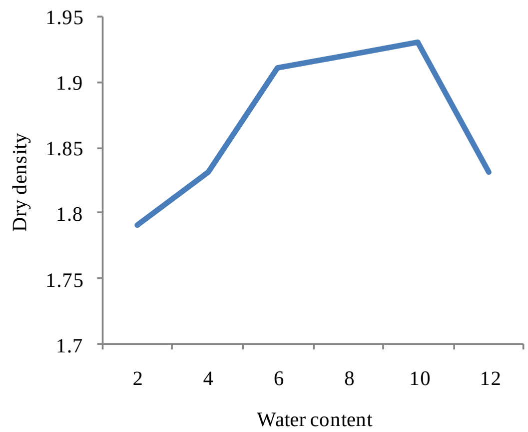

Figure 8 Water Content Vs Dry Density

The optimum moisture content is 10% and maximum dry density is 1.93g/cm^3.

4. CONCLUSION

The study after conducting several experiments revealed the following significances in using quarry dust and lime as a stabilizing agent . The addition of quarry dust and lime mixes to expansive soil increases the unconfined compressive strength value more than that byordinary methods .The soil stabilization with quarry dust and lime mixes improves the strength behaviour of clayey soil .It can potentially reduce ground improvement costs by adopting this method of stabilization.

The strength of expansive soil is improved by 10% lime and 20% quarry dust mix found to be best among all mix ratios.

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