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Soil Stabilization by using Industrial Waste Material as a Stabilizer

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Abstract : Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization is to increase the bearing capacity of the clay soil, it's resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable clay soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of clay soil so that it can successfully sustain the load of the superstructure especially in case of clay soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil. This paper deals with the complete analysis of the improvement of clay soil properties and its stabilization using industrial waste sand and lime. The experimentation is carried out keeping 20% of lime as constant and industrial waste sand 10%, 20%and 30%. Disposal of these waste materials is essential as these are causing hazardous effects on the environment. With the same intention literature review is undertaken on utilization of solid waste materials for the stabilization of soils and their performance is discussed.
Keywords : Clay Soil, Industrial waste sand, Quarry dust, Stabilization.

1.0 Introduction

Marginal soils, including loose sands, soft clays, and organics are not adequate materials for construction projects. These marginal soils do not possess valuable physical properties for construction applications. The usually methods for remediation of this weak subgrade such as remove the soil and change to the new one is typically expensive [1,2].

Waste materials such as industrial waste sand, bottom sand offer a cheaper method for stabilizing marginal soils. As an added benefit, utilizing waste materials in soil stabilization applications keeps these materials from being dumped into Landfills, thereby saving already depleting landfill space. Included in this report is an extensive investigation into the current state of research on waste and recycled materials in construction applications[3]. Changes in the engineering properties of soils. as a result of adding these waste materials were studied and recommendations on implementing these effects into construction applications are offered.

2. Objective of This Study

The major objectives of the project are:

1. To explore the possibility of using waste sand in construction programme.

2. To study the effect of lime and waste sand on proctor's density and OMC of clayey soil.
3. To study the effect of lime and waste sand on the consistency limits of clayey soil.
4. To study the changes in CBR of soil by the addition of lime and waste sand.
5. To study the effect of curing period on the properties of clayey soil

3.0 Literature Review

Vishnu.T.C and Shree Lakshmi(2016)

Many researches have been carried out on soil with RHA and CSA separately, and the following results were obtained. Coconut shell ash on lateritic soil showed that, till 1-4% of CSA the properties were observed to be increasing and decreasing after 4%.With the combination of RHA and cement with soil, 10% RHA and 6% cement showed good results.

When RHA and fly ash were used on expansive soils, 10-20% of RHA and 25% of fly ash were recommended.

AMU.O.O (2005)

amu.o.o studied the effect of egg shell powder on the stabilizing potentila of lime on an expansive clay soil.He conducted series of test to determine the optimalpeecentage of lime – egg shell powder combination.The optimal quantity of lime was gradully replaced with suitable amount of egg shell powder .Result indicated that the lime stabilization at 7% is better than thecombination of 4% egg shell powder + 3% lime [3].

4.0 Materials Used

4.1 Clay soil

The soil used in this study was collected from area Agri culture university, Coimbatore. The sample was thoroughly oven dried, weighed and stored in sacks at room temperature. The general property of the soil was thoroughly studied in the laboratory. The soil was tested for liquid limit, plastic limit optimum moisture content, maximum dry density, permeability etc.

Figure4.1 Clay soil

4.2. Industrial waste sand (IWS)

Industrial waste sand is high quality silica sand with uniform physical characteristics. It is a byproduct of the ferrous and nonferrous metal casting industry, where sand has been used for centuries as a moulding material because of its unique engineering properties. In modern foundry practice, sand is typically recycled and reused through many Production cycles. Industry estimates are that approximately 100 million tons of sand are used in production annually. Of that, four (4) to seven (7) million tons are discarded annually and are available to be recycled into other products and industries.

Figure 4.2 Industrial waste sand

4.3. Lime

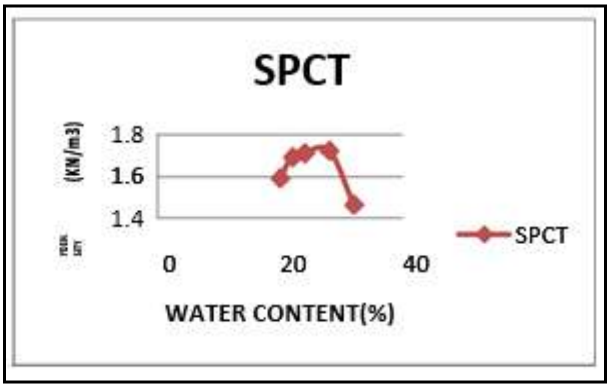
Lime is a calcium-containing inorganic material in which carbonates, oxides and hydroxides predominate. Strictly speaking, lime is calcium oxide or calcium hydroxide. The word "lime" originates with its earliest use as building mortar and has the sense of "sticking or adhering." These materials are still used in large quantities as building and engineering materials (including limestone products, concrete and mortar) and as chemical feedstock‟s, and sugar refining, among other uses. The rocks and minerals from which these materials are derived, typically limestone or chalk, are composed primarily of calcium carbonate. They may be cut, crushed or pulverized and chemically altered. "Burning" (calcinations) converts them into the highly caustic material quicklime (calcium oxide, CaO) and, through subsequent addition of water, into the less caustic (but still strongly alkaline) slaked lime or hydrated lime (calcium hydroxide, Ca(OH)2), the process of which is called slaking of lime.

Figure 4.3 Lime

5.Properties of Clay Soil

Table 5.1 Properties of clay soil

Sl.No.	**Properties of the Clay soil**	
1	Specific gravity	2.63
2	Liquid limit	18
3	Shrinkage limit	25.25
4	Plastic limit	22.22
5	Standard Procter compaction test	$16.78 kg/m^3$
6	Unconfined Compressive strength	$2.43x10^{-3} N/mm^2$
7	Relative density	55.435%



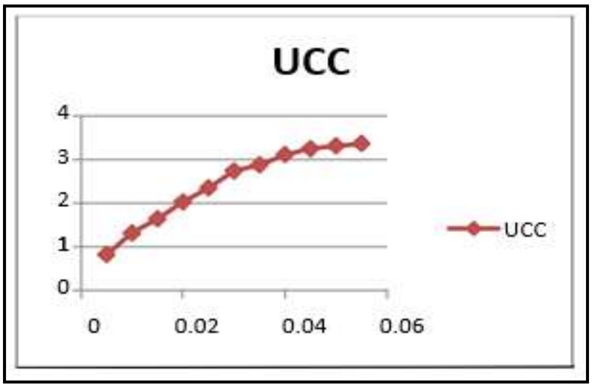


Figure 5.1 SCPT for Normal clay soil

Figure 5.2 UCC for Normal clay soil

6.0 Experimental Work

In this project The project have conducted various experiment to find the stabilization of the sub base using the Industrial waste and lime the various test conducted to find the stabilization of the sub base based on the ASTM

Procedure are listed below:

6.1 Liquid Limit (ASTM D 4318 – 05)
6.2 Plastic Limit (ASTM D 4318 – 10e)
6.3 Sieve Analysis (ASTM D 6913)
6.4 Specific Gravity (ASTM D 6473)
6.5 Standard Proctor Compaction Test (ASTM D 1557)
6.6 Unconfined Compressive Strength (ASTM D 2166)
6.7 California Bearing Ratio Test (ASTM D 1883)

6.1 Liquid Limit:

Liquid limit is defined as the moisture content at which soil begins to behave as a liquid material and begins to flow. The importance of the liquid limit test is to classify soils. Different soils have varying liquid limits. Also, once must use the plastic limit to determine it's plasticity index.

6.2 Plastic Limit

Plastic limit is defined as the project moisture content and expressed as a percentage of the project of the oven dried soil at which the soil can be rolled into the threads one-eighth inch in a diameter without the soil breaking into pieces. This is also the moisture content of a solid at which a soil changes from a plastic state to a semisolid state.

6.3 Sieve Analysis:

A sieve analysis is a practice or procedure used assesses the particle size distribution of a granular material.

6.4 Specific Gravity:

Specific gravity is defined as the ration of the unit. The specific gravity is needed for various calculation purposes in soil mechanics, e.g. void ratio, density.

6.5 Standard Proctor 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.

6.6 Unconfined Compressive Strength:

The unconfined compression test is used to measure the shearing resistance of cohesive soils which may be undisturbed or remolded specimens. An axial load is applied using either strain-control or stress-control condition. The unconfined compressive strength is defined as the maximum unit stress obtained within the first 20% strain.

6.7 California Bearing Ratio Test:

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road subgrades and base courses. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard crushed rock material. The CBR rating was developed for measuring the load-bearing capacity of soils used for building roads.

6.8 Experimental Setup

The experimental program consisted of by varying the percentage of lime powder and industrial waste sand to the soil and studied the compaction characteristics and Unconfined compressive strength of soil. The industrial waste sand was varied between 10, 20,30and 40%and lime powder as constant 20% by weight of soil.

Index Properties	**Lime**
Specific Gravity (G)	2.5 Kg/m3
Liquid Limit (WL)	25 %
Plastic Limit (WP)	25 %
Shrinkage Limit (WS)	6 %
Sieve Analysis- Coefficient of curvature (Cc)	0.53

7.0 Results and Discussions

From the experiments conducted with optimum percentage of IWS and varying percentage of Lime and the obtained results were shown below.

The unconfined compression test is used to measure the shearing resistance of cohesive soils which may be undisturbed or remolded specimens. An axial load is applied using either strain-control or stress-control condition. The unconfined compressive strength is defined as the maximum unit stress obtained within the first 20% strain.

7.1 Atterbergs limits

Experiment	**10%**	**20%**	**30%**
Liquid limit test	36%	33/50%	32%
Plastic limit	50%	33.33%	25%
Shrinkage limit	26%	26.50%	24

7.2 Compaction Characteristics

By addition of lime powder and industrial waste sand to the soil, the maximum dry density and optimum moisture content was found by Proctor compaction test as per IS 2720.

7.2 Standard proctor compaction test

This test is conducted in order to find out the optimum moisture content and maximum dry density of the soil.

Table 7.2 Influence of IWS and LP on optimum moisture content and max.dry density

LIME POWDER (%)	INDUSTRIAL WASTE SAND(%)	OMC (%)	MDD (G/CC)
20	10	26	1.683
20	20	28	1.722
20	30	30	1.745
20	40	28	1.721

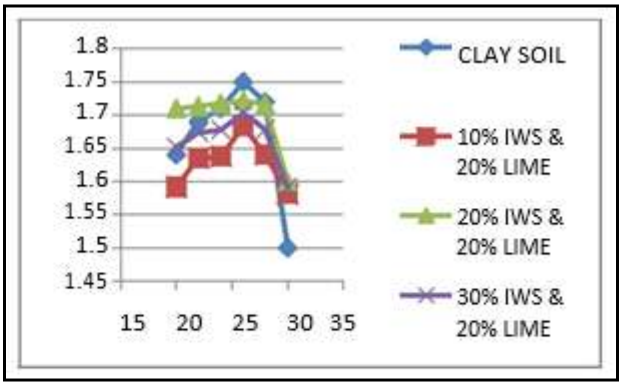


Figure 7.1 Comparative Graph for SCPT

7.3Unconfined compressive strength

Table 7.3 Unconfined compressive strength

LIME POWDER (%)	INDUSTRIAL WASTE SAND(%)	STRESS N/mm^2
20	10	8.47x10^{-3}
20	20	9.48x10^{-3}
20	30	8.41x10^{-3}

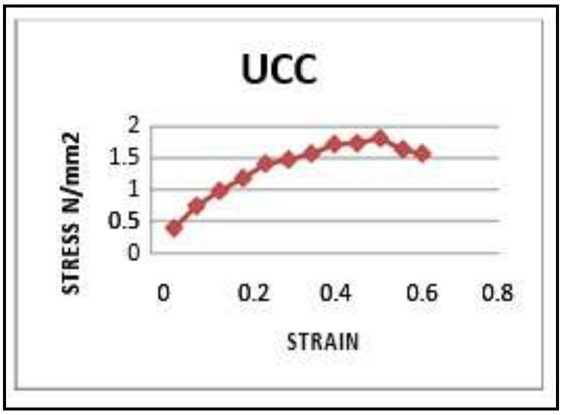


Figure 7.3.1 UCC for 20% Lime powder and 10% IWS

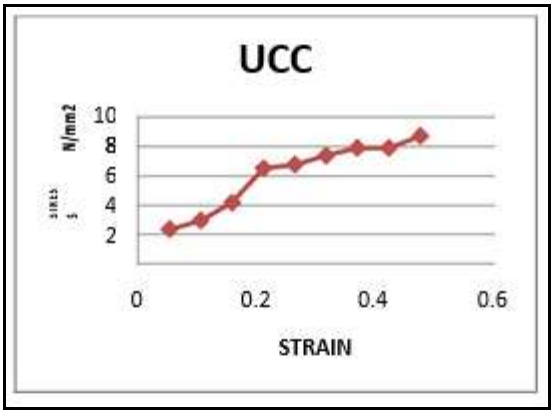


Figure 7.3.2 UCC for 20% Lime powder and 20% IWS

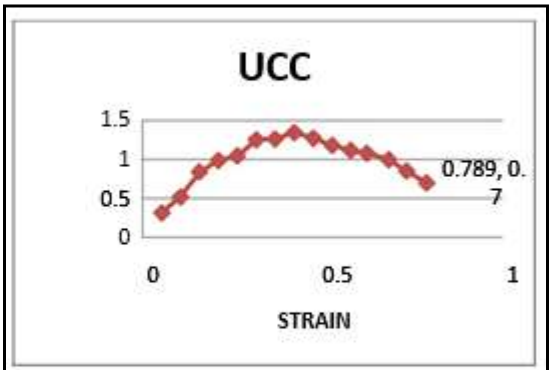


Figure 7.3.3 UCC for 20% Lime powder and 30% IWS

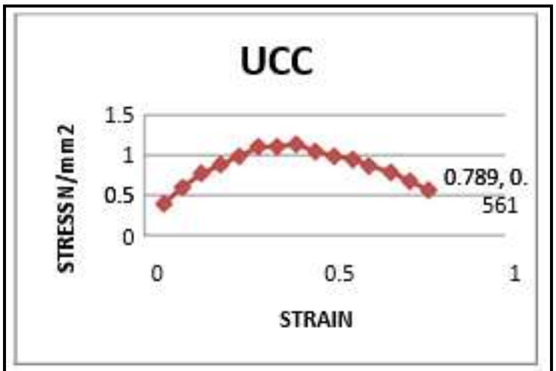


Figure 7.3.4 UCC for 20% Lime powder and 40% IWS

7.4 California Bearing Ratio

Table 7.4 California Bearing Ratio

The CBR rating was developed for measuring the load-bearing capacity of soils used for building loads.

LIME POWDER (%)	INDUSTRIAL WASTE SAND (%)	CBR (%)
20	10	9.59
20	20	21.48
20	30	33.37
20	40	38.81
20	50	28.45

8.0 Conclusion

From the study it is observed that there is an appreciable improvement in the optimum moisture content and maximum dry density for the soil treated with industrial waste. In terms of material cost, the use of less costly Admixtures can reduce the required amount of industrial waste. Soils had the greatest improvement with all soils becoming non plastic with the addition of sufficient amounts of industrial waste. The study after conducting several experiments revealed the following significances in using lime and industrial waste as a stabilizing agent. The addition of lime and industrial waste mixes to sub base increases the unconfined compressive strength value more than that by ordinary methods. The sub base stabilization with lime and industrial waste mixes improves the strength behavior of sub base. It can potentially reduce ground improvement costs by adopting this method of stabilization.

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