Improvement of Bearing Capacity of BC Soil Using Stone Column With and Without Encasement of Geosynthetics

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Abstract—**In B C Soil, laboratory model footing experiments on, single stone columns with and without encasing of geosynthetics of various grades have been conducted. The dia and longitude of stone column are varied during the experiments to determine the impact of encasing and the performance of single column arrangements. Small model footing test is carried out on both unblended and blended black cotton soil in a steel cylindrical tank with a dia of 250 mm and a height of 300 mm. Tests that aren't fortified are done first, and then tests that are reinforced with quarry dust column encasement are done. The number encased columns for embedded depths is one of the study's parameters.The study assessed the behaviour of columns made of enclosed, unreinforced quarry dust. The test findings are evaluated in terms of the load improvement ratio and the settlement reduction factors (SRF) at two levels of settlement are explored due to the demand for serviceability in actual foundation application. Adding columns of quarry dust can significantly increase the black cotton soil's ability to hold loads while reducing settling, according to test data. The load improvement ratio and settling reduction factor of the reinforced black cotton soil are investigated. Properties are observed, including how a certain sort of column behaves and how black cotton encasing improves the column's strength characteristics.**

Key Words: Bearing Capacity, BC Soil, Geosynthesis, Stone Column.

1. Introduction

Particularly in urban regions, there is a dearth of land for the expansion of commerce, industry, transportation, etc. This required the usage of land, whose layers are weak. The usage of marginal sites with subpar engineering features is now required due to the ever-increasing demand for land. For construction on soft soils, the application of stone columns has shown to be a practical and affordable ground improvement approach. Typically, the stone columns are made to support vertical loads from the constructions. The modification of project earth structures or foundation soils for improved performance under operating loading circumstances is known as ground improvement.Ground improvement methods are being employed more frequently for new projects in order to make use of sites with bad subsurface conditions and to design and construct necessary projects despite poor subsurface conditions that would previously have made the project technically or economically impracticable. The spectrum of soils that can be enhanced by vibratory techniques is expanded by vibro-replacement. To do this, the ground is penetrated with either dry or wet top feed vibrators. Aggregates are then used to replace the removed soil, exerting pressure on the surrounding soil and increasing its ability to support loads.

1.1 Principle of stone column:

The fundamental purpose of a stone column is to generate a composite material by replacing loose material with compacted stone and densifying and decreasing the compressibility of the surrounding ground. The capacity of stone columns relies on the amount of soil stiffening obtained in the surrounding region as well as on the internal friction of the columns since stone columns will bend under applied load. The stone columns will serve as drainage pathways in fine soils to accelerate consolidation and show that the water that is drained can disperse. The construction of stone or sand columns can be utilised to enhance soft soil using a variety of excavation, replacement, and compaction techniques.

2. Objective:

When working on a project that has challenging foundation conditions, engineering ground improvement becomes necessary. The following is the study's primary goal:

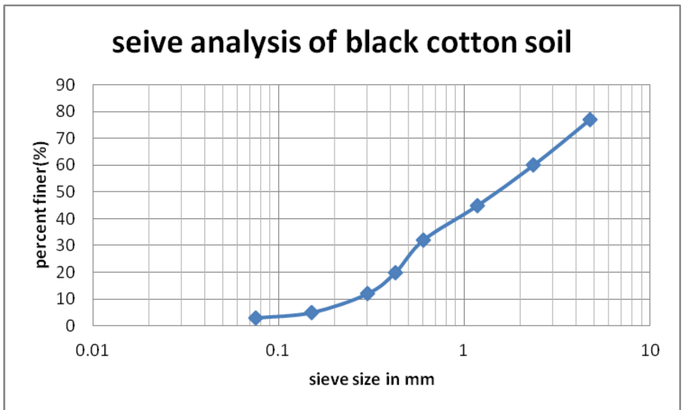
1. To investigate how a column of quarry dust wrapped in geosynthetics might enhance the strength properties of black cotton soil.
2. To investigate the single geosynthetic-encased quarry dust columns' ability to support loads.
3. To compare reinforced and unreinforced ground and forecast the element that reduces settlement.
4. Because soil has no natural tensile strength and is good in compression, this creates a vulnerability that must be addressed by the use of reinforcement and research into the features of the strengthened soil.

3. Materials:

3.1 Black cotton soil

The rural parts of Chitradurga are where the black cotton soil is gathered. By using open excavation, a soil sample was taken from a depth of one meter below the normal ground level, keeping the top layer of soil untouched. The qualities of the black cotton soil are outlined in table after the soil has been oven dried and used.

Fig 4.1: Black cotton soil in site



Graph 4.1:BC Soil Sieve Graph

Table 4.1:BC Soil Properties

A. BC Soil Index Properties

Moisture Content	21.66%
Sp. Gravity (G)	2.44
W_L	63.29%
Wp	26.41%
Ip	36.88%

According to Index properties, the soil classification belongs to the CH group, which contains inorganic clay with a high compressibility.

B. Engg. Properties of soil

Optimum Moisture	19%
Maximum Dry Density	15.00 KN/m^3
UCS	0.03 KN/m^2

4.2Quarry Dust:

Quarry dust generated from this industry is wasted. The quarry dusts are sieved until they produce a fine aggregate that resembles sand. For experimental work, quarry dust that has been sieved through to 2.36mm is used.

Figure 4.3: Quarry dust

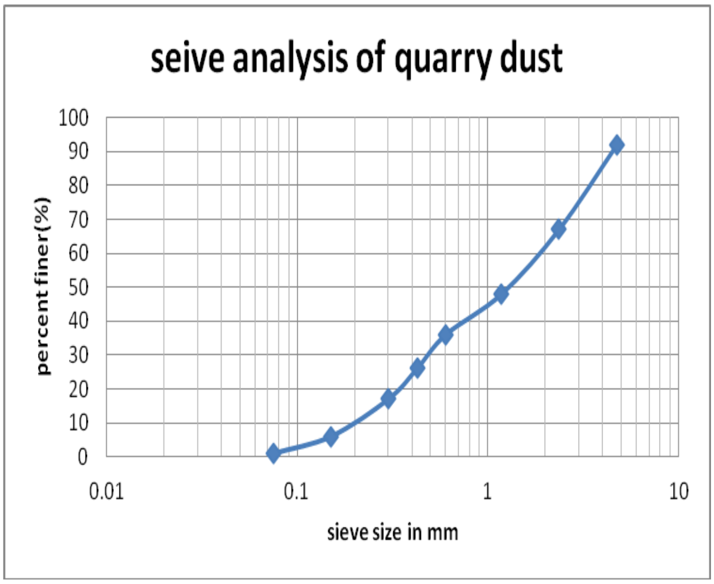


Chart 4.2: Sieve analysis of quarry dust

Table 4.2. Properties of quarry dust

Sp Gravity	2.53
Cu	10.00
Cc	0.650

4.3Geo grid

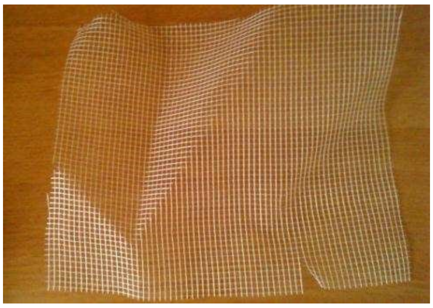


Figure 4.3: Geogrids

Table 4.3: Geogrids Properties

Mass	45	g/m^2
Size of Mesh	2.5*2.5	mm
Content of Coating	18	%
Tensile strength	400(MD)	N/cm

4.4. Fly ash:

In order to increase soil strength, fly ash is utilised as a soil stabiliser. Many projects have employed fly ash successfully to enhance the soil's strength properties. Fly ash can be used to stabilise bases or subgrades, backfill to lessen lateral earth pressures, embankments to enhance slope stability, and more.

Fig.4.4: Fly Ash

5. Methodology

- For the model footing test, different lengths of geosynthetic-covered quarry dust columns are utilised for various D/B ratios, where "D" stands for the diameter of the test tank and "B" stands for the diameter of the circular model footing. The model footing test is carried out on individual columns of quarry dust coated in geosynthetics at embedded, floating, and intermediate depths, and the results are shown for columns with various diameters.
- For a settlement of 20 mm, both enclosed columns and single configurations of quarry dust columns wrapped in geosynthetics are analysed using model footing experiments to assess the load settlement characteristics of black cotton soil.
- Based on the results of the experiment, conclusions are drawn for D/B ratios of 1, 2, and 3, as well as for different durations. Quarry dust column arrangement design.

5.1 Preparation of black cotton soil deposit:

To lessen any friction between the soil and the tank wall, oil is applied to the tank wall. To maintain the MDD, the necessary amount of soil is combined with the ideal amount of water, and using the rainfall approach, the properly mixed soil is added to the tank in three layers.

A.

5.2. TestingProcedure:

- The model test tank is a circular steel test tank with a height of 250mm and a diameter of 250mm. In order to lessen the boundary effects, the tank's side walls were made smooth by covering them with a lubricating lubricant.
- To attain its maturation stage, the black cotton soil that is needed for labour is stored for 24 hours.
- Using the rainfall technique, fill the test tank in 5 levels with the weight of the soil sample that is needed to achieve the lowest density as determined by the results of the compaction test. The sample's vacant spots are eliminated with a tamping rod.
- Throughout the process, the soil sample is put into the test tank while preserving its density.

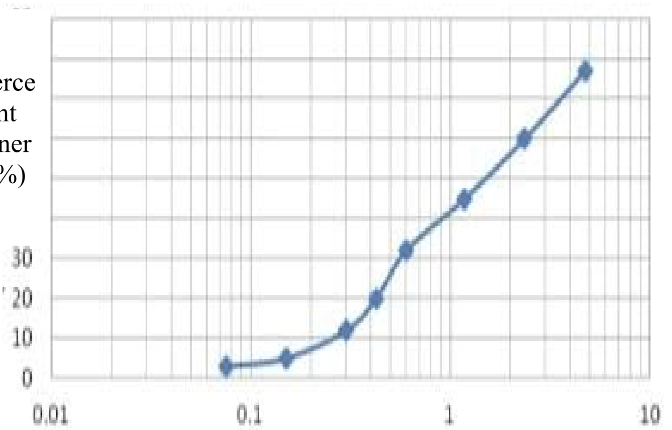
- Without affecting the soil's density in the tank, a hole with a variable diameter is made in the center.
- In the test tank, a cylindrical hole covered in geosynthetics forms.
- Then, using a paper cone as a funnel, the quarry dust is poured into the various-sized holes.
- The 75mm-diameter circular model footing is precisely positioned on top of the quarry dust column.
- To avoid eccentric loading, the footing was carefully placed in the centre of the loading jack. The load transmitted to the footing is measured using a calibrated proving ring. Deliveries of the load were made in discrete, steady strain-rate steps. Up until the footing settling stabilises, each load increment is kept constant.
- Dial gauges are anchored to the ground, and they are used to measure deformations (Dg1). For a settlement level of 20 mm, the load improvement ratio and settlement reduction factor are computed.
- The aforementioned process is repeated for columns of quarry dust with varying diameter arrangements.

6. RESULTS AND DISSCUSSIONS

6.1.Blackcotton soil:

Sieve analysis of black cotton soil

Percent finer (%)



Sieve size in mm

Graph 6.1:Propertiesofblackcottonsoil

Table 6.1: (A) Indexpropertiesofsoil

Moisture Content	21.66%
Sp. Gravity (G)	2.44
W_L	63.29%
Wp	26.41%
Ip	36.88%
Shrinkage	22.49%
FSI	84%

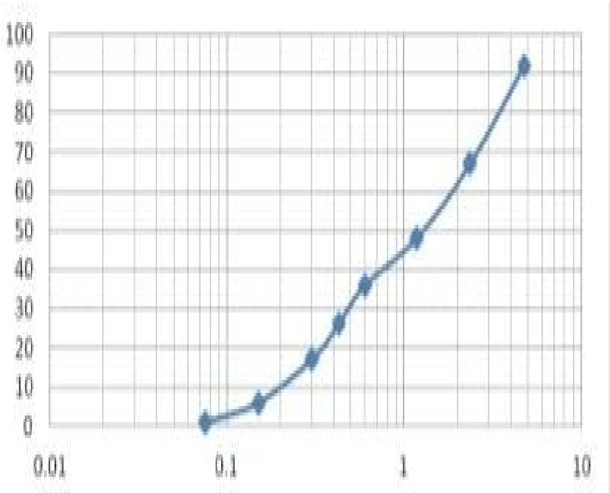
(B) Engineering properties of soil

MDD	1.89 g/cc
OMC	17%
UCS	26.24 kg/cm^2
CBR	4.5 %

6.2. Quarry dust

Sieve analysis of quarry dust

Percent finer (%)



Sieve size in mm

Graph 6.2:Quarry Dust Sieve analysis

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Table 6.2: Properties of quarrydust

G	2.53
Cu	10.00
Cc	0.650

Final Result

Table 6.3:Longitude and Dia of tank usedforproject

Length(mm)	Diameter(mm)
300	30
150	30

Table 6.4: Properties of various combinations to UCS

Quarrydust(%)	Qu(N/mm^2)	cu(N/mm^2)
5	0.039	0.020
10	0.053	0.026
15	0.060	0.030

Table 6.5: Percentage of quarry dust used

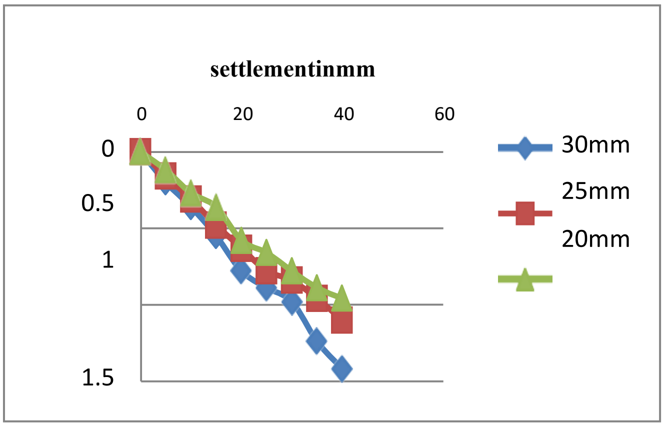
Quarrydust	C(N/mm^2)	Ødegree
5	0.0032	15
10	0.0044	12
15	0.006	18

6.9. Settlement Analysis:

The settlement conditions should be met by a suitable foundation system. The primary goal of the ground improvement technique reduces the settlement factor since a week ground treated with a quarry dust column settles less than a week ground that has not been treated. The relation = SO-Sr) /SO can be used to derive the settlement reduction factor. Where So is the difference in unreinforced soil settlement measured in millimeters. And Sr is the difference in reinforced soil settlement in millimeters from unreinforced soil.

Table 6.6: settlement analysis

Lengthi mm	Dia mm	Failure in KN		Contribution	Improvement Of strength %
		without	with		
300	30	1.42	1.93	0.51	35.87
150	30	1.32	1.79	0.47	35.84



Graph 6.3: Settlement analysis graph

7. CONCLUSION

The following conclusions are drawn from the debates above:

- In comparison to 5% and 10%, it was shown that 15% composition of stone dust provides the greatest strength. According to the current study, black cotton soil was encased in geosynthetics, and a column of quarry dust displayed higher cohesiveness with 0.006N/mm^2.
- Encased stone columns with all 300mm and 150mm lengths and a 30mm diameter have improved bearing capacities. It was found that a 30mm diameter by 300mm length had a high bearing capacity.
- Geogrid encasement increases bearing capacity of stone column, which delivers Improvement in strength up to 35.87% because bulging behavior of stone column lowers. • Smaller diameter stone

columns have lower bearing capacity than larger diameter stone columns.

- When a stone column is covered in geosynthetic, settling is greatly reduced.
- The footing was positioned precisely in the centre of the loading jack to prevent eccentric loading. Using a calibrated proving ring, the load transmitted to the footing is measured. Small, continuous load increments at predetermined strain rates were used. Each load increment remains constant during the footing settlement stabilisation process.

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