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Improving the Performance of Stone Column Embedded in Black-Cotton Soil by Reinforcing it with Geogrid

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Abstract - *To investigate how lateral reinforced stone columns increased the load bearing capacity and settling behaviour of soft soils. The black cotton soil is fortified using stone columns in this study, which are reinforced with geogrid and geogrid discs within the column. The tests were carried out on a plain clay bed, a plain stone column, and a stone column with geogrid and geogrid discs, with three geogrid discs covering the middle portion of the column length. The results of the different tests show that the spacing of the reinforcement has an impact on the stone column's ultimate load. By supplying a stone column, the soil settlement has been minimised, and it has been further reduced by strengthening it with geogrid.*

Key Words: **Stone Column, Black Cotton Soil, Geogrid, Geogrid disc, Reinforcement, Ultimate Load, Settlement.**

1.INTRODUCTION

Soil deposits exist in nature in various manners producing there by a multiple varieties of possible combinations which in turn affect the properties of the soil and also the different methods of making it beneficial (purposeful).

The black-cotton soil, which covers almost 24% of the country and may be found up to a depth of 3.7 metres on average, is a major soil deposit in various parts of India.. The black-cotton soil is very productive and good for agriculture, but it is typically regarded as unsuitable for the construction of massive civil engineering projects due to its low bearing capacity, low shear strength, low stability, and substantial seasonal expansion and shrinkage in volume.

1.1 Properties of black-cotton soil

The black-cotton soil is black in colour because it is generated by the weathering of rocks (lava rocks) and contains high levels of iron(Fe), magnesium(Mg), and aluminium(Al). They hold moisture which makes it sticky when it is wet and cracks appears when it is dry.

- Rich in magnesium, potash and calcium carbonates.
- Poor in nitrogen and phosphorous.
- Highly fertile and clayey texture.
- Comparatively lesser fertile on the high lying areasthan on low lying areas.
- Highly attractive to moisture, tenacious when wetand develops cracks when dry.
- Higher carbon exchange capacity with lowerorganic matter content.
- Highly suitable for agricultural use.
- Black-Cotton soil includes 50% clay and may hold water for an extended period of time.

1.2 Construction Activities on Black-Cotton Soil

There are various methods to carry out the construction activities on the black cotton soil.

1.2.1 Soil stabilization

It's a technique for fusing soil particles together to improve the soil's engineering properties. Soil stabilisation can be accomplished in a number of ways.:

1. Lime stabilization
2. Bitumen stabilization
3. Cement stabilization
4. Electrical stabilization
5. Mechanical stabilization
6. Stabilization using Stone column

1.3 Stone-Column

Granular piles are another name for stone columns. These are widely utilised as ground reinforcing and supporting materials. Bridges, buildings, and other flexible structures are among the many types of structures available. The stone column consists of crushed stone pillars placed in the various layers with or without reinforcement depending upon the requirements and soil available. Even if the pile foundation meets design standards, the -ve drag force and extended length of the pile may necessitate additional costs. The constriction formed by the surrounding soil increases the load-bearing capacity.

1.4 Modes of failures in stone-column

When stone columns are erected in a clay bed, there is a potential that the stone column will fail after the load is aplied.

1. General-Shear Failure
2. Local-Shear Failure
3. Punching-Shear Failure
4. Failure by Sliding

2. OBJECTIVES OF THE STUDY

- Inserting a stone-column into black-cotton soil to assess its load-bearing capacity.
- To determine the load variations using the stone column reinforced with Geo-grid.
- To investigate the variation in soil load carrying capacity by reinforcing the middle portion of the stone column where bulging failure occurs.
- To assess the settlement behaviour of black cotton soil using Geo-grid reinforced stone-columns.
- To compare the results of stone column with and without reinforcement of Geo-grids.

3. METHODOLOGY

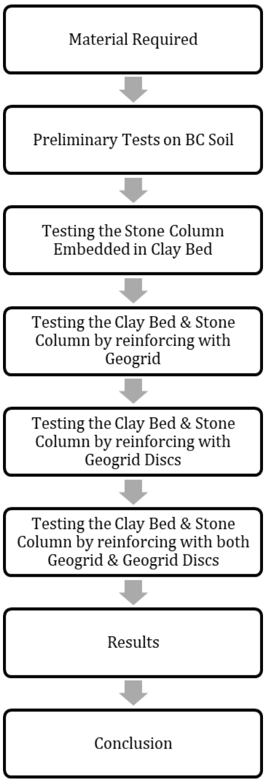

Fig-3.1: Flow Chart for Methodology

The above process was followed for the execution of this research work.

3.1 Materials Used

1. Black-cotton Soil: It was utilised since it was readily available.
2. Coarse Aggregate: Crushed coarse aggregate with a size range of 4.75 mm to 10 mm is considered.
3. Geo-grid: STRATAGRID (SG200) is used for the reinforcement of stone column which was collected from Strata Geosystems. Pvt .Ltd .Mumbai.

Fig-3.1.1: Geogrid

3.2 Preparation of Clay-Bed

In this test, the air dried and powdered clay sample was mixed with the proper amount of water (35 percent). Adding distilled water to the clay powder and thoroughly mixing it will result in a homogenous paste. The prepared paste is hand-filled into the tank in 0.50 cm thick layers to the appropriate thickness, ensuringthat no air gaps remain in soil. Cover the compressed soil with damp for one day (24 hours). To accomplish moisture equalisation, use a gunny cloth.

Fig-3.2.1: Clay Bed

The tank utilised in this study has a 20-cm diameterand a 30-cm height. Before filling the tank with soil, athin coating of grease was applied to the inside surface of the tank wall to decrease friction between the soil and the tank wall.

3.3 Construction of Stone-Column.

The clay bed is made in the same manner as before. Following the preparation of the clay-bed in tank, a tube (or pipe) with a diameter just greater than or equal to that of the stone column being prepared is greased on both sides and gently placed into the clay bed.

Then a revolving auger with a diameter somewhat smaller than that of the casing pipe is placed into the pipe and the clay is expelled, leaving a hole in the clay-bed.

Fig-3.3.1: Clay Bed with Stone Column

The stone-column was then prepared in stages, with each 50mm depth being prepared by compacting stone aggregate in the hole created and concurrently removing the casing pipe. After each layer was compacted, the pipe was carefully lifted to a height where there must be a 5mm gap between the surface of the stone aggregate and the bottom of the pipe. Each layer was crushed using a 900gm tamping rod and 10 blows at a height of 10cm. The loading is completed after that.

3.4 Testing of stone-column

Following the construction of the stone column, the weight was transferred to a 12 mm thick circular footing with a diameter twice that of the stone column, resulting in a 25% area replacement ratio. To guarantee an undrained state, models were exposed to strain-controlled compression loading in a standard loading frame at a settlement rate of 0.25 mm/min up to a maximum footing settlement of 20mm.

Fig-3.4.1: Testing on Stone Column

3.5 Test on Clay-Bed with Stone-Column Reinforced with Geogrid

A geogrid of the desired diameter and height is created. The clay bed is prepared once more, and the geogrid is introduced into the pipe before inserting the stone, creating a reinforced stone column, which is then loaded into the loading machine, yielding the following result.

Fig-3.5.1: Stone column reinforced with geogrid

3.6 Test on Clay-Bed with Stone-Column Reinforced by Circular Geogrid-Discs

The circular geogrid discs are prepared whose diameter is same as of stone column. the clay bed is again prepared and also the geogrid discs are placed in it before inserting the stones within the column.

From the previous papers it was suggested that stone column reinforced with three circular geogrid discs such that 1 disc of geogrid was placed after very 4.85cm i.e., after every compacted stone layer. And the test procedure remains same, the results was noted.

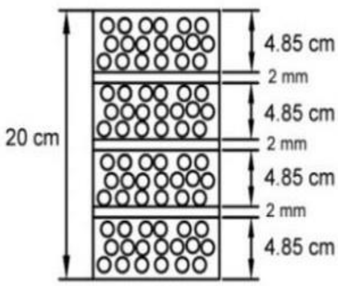

Fig-3.6.1: Stone Column Reinforced with Circular Geogrid Discs

3.7 Test on Clay-Bed with Stone-Column Reinforced with Geogrid and also with Circular Geogrid Discs

The geogrid is first placed round the pipe then the stones are inserted in it in 5 layers and before insertingeach layer, the geogrid discs is placed so that it gives good horizontal and vertical reinforcement. Three geogrid discs are used here. The test procedure remains identical and the results are calculated.

Fig-3.7.1: Stone Column Reinforced with Geogrid and also with Circular Discs

4. RESULTS AND CALCULATIONS

Table-1: Preliminary Tests on soil

Sl. No.	Test	Results
1	Grain size distribution	Cu = 2.67
2	Water content by pycnometer	w=25%
3	Specific gravity by density bottle method	G=2.53
4	Liquid limit test by Casagrande's method	w_L=67.3%
5	Plastic limit	w_p=31.79%
6	Unconfined compression test	UCS=3.216 kg/cm^2
7	Standard proctor test	MDD=1.5 gm/cc OMC=24.36%

Test 1: Loading on clay bed

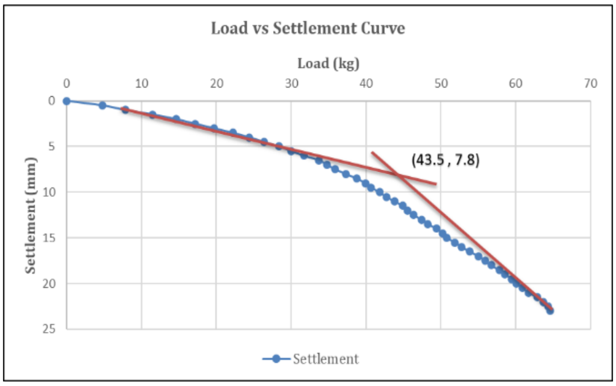

Chart-1: Graph showing load v/s settlement response of clay soil

The final load bearing capacity was determined by drawing a double tangent to the load settlement curve (shown in figure).

Table-2: Results of the above test

Content	Settlement(mm)	Load (kg)
Clayey soil	7.8	43.5

Test 2: Loading on clay-bed and stone-column

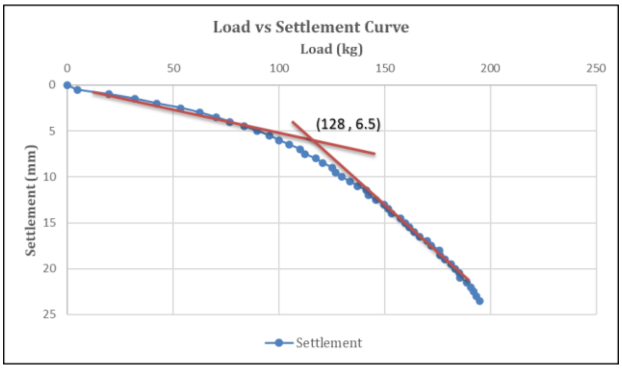

Chart-2: Load v/s Settlement response of clay-bed withstone-column

The final load bearing capacity was determined by drawing a double tangent to the load settlement curve (shown in figure).

Table-3: Results of the above test

Content	Settlement(mm)	Load (kg)
clay bed with stone column	6.5	128

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Test 3: Clay-bed and stone-column reinforced with geogrid

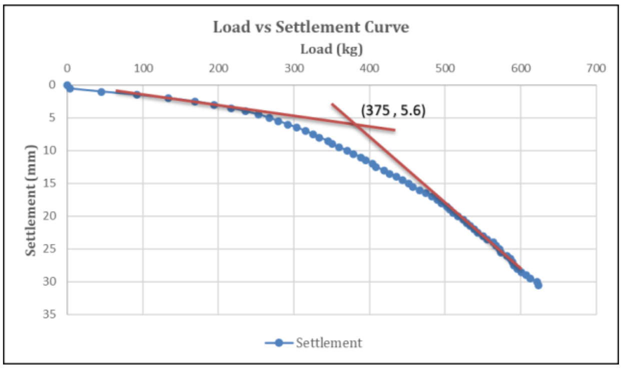


Chart-3: Load v/s Settlement response of clay-bed and stone-column reinforced with geogrid

The final load bearing capacity was determined by drawing a double tangent to the load settlement curve (shown in figure).

Table-4: Results of the above test

Content	Settlement(mm)	Load (kg)
clay bed with circular reinforced stone column	5.6	375

Test 4: Values of Clay-bed and reinforced stone-column with 3 geogrid-discs

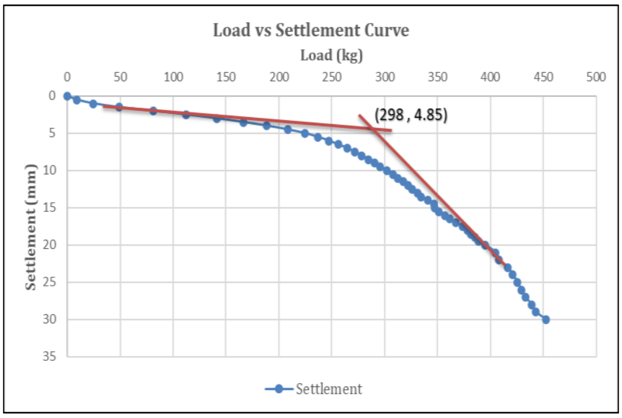


Chart-4: Load v/s Settlement response of clay-bed and reinforced stone-column with 3 geogrid disc

The final load bearing capacity was determined by drawing a double tangent to the load settlement curve (shown in figure).

Table-5: Results of the above test

Content	Settlement (mm)	Load (kg)
Clay bed with reinforced stone column with 3 geogrid discs.	4.85	298

Test 5: Clay-bed and stone-column reinforcedwith geogrid and also with circular-geogrid discs

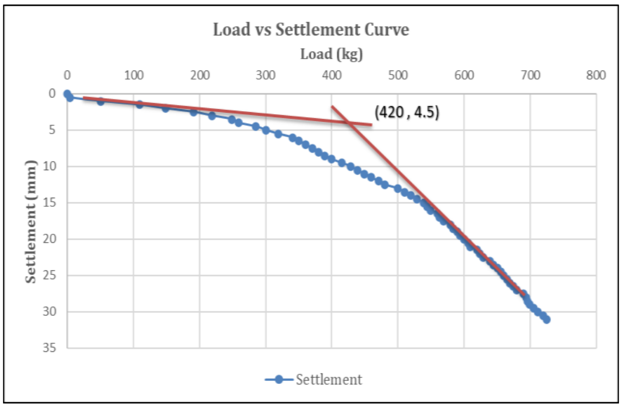


Chart-5: Load v/s Settlement response of clay-bed andstone-column reinforced with geogrid and also with circular-geogrid discs

The final load bearing capacity was determined by drawing a double tangent to the load settlement curve (shown in figure).

Table-6: Results of the above test

Content	Settlement(mm)	Load (kg)
Clay-bed and stone- column reinforced with geogrid and also with circular geogrid discs.	4.5	420

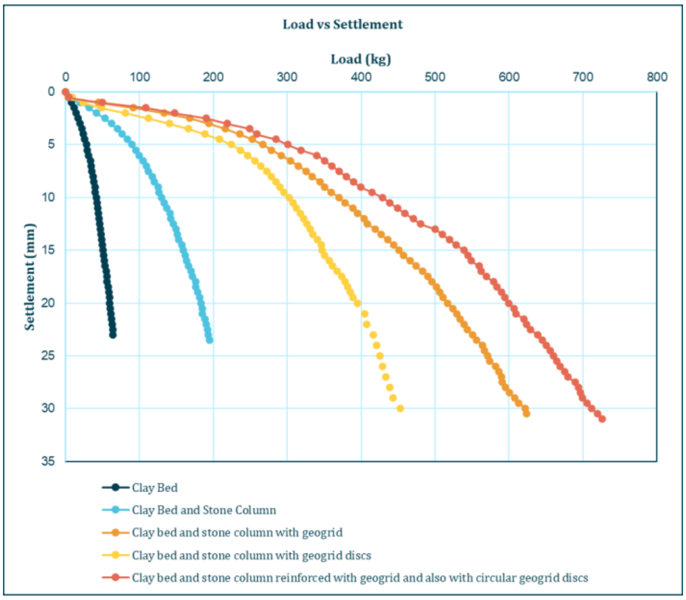


Chart-6: Load v/s settlement response for different geogrid arrangements

Table-7: Final Results

Test-condition	Ultimate load (in kg)	Settlement (in mm)
Clay-bed	43.5	7.8
Clay-bed with stone-column	128	6.5
Clay-bed and stone-column reinforced with geogrid	375	5.6
Clay-bed and stone-column reinforced with 3 geogrid discsin middle portion	298	4.85
Clay-bed and stone-column reinforced with geogrid and also with circular-geogrid discs.	420	4.5

5. CONCLUSIONS

1. By densifying the soil, the addition of a stone-column enhances the load bearing capacity ofsoil by around three times.
2. The maximal load of a stone column reinforced with encapsulated geogrid was 2.92 times that ofa stone column without reinforcement.
3. In comparison to a stone column without geogrid discs (3 discs), the maximal load of the stone-column reinforced with geogrid discs increases by 2.33 times.
4. When a stone column is reinforced with both geogrid and a circular geogrid disc, the ultimateload increases by 3.3 times when compared to a stone-column alone.
5. When compared to a clay-bed alone, the ultimate load of the stone column reinforced with encapsulated geogrid was enhanced by 8.62 times.
6. When compared to the clay-bed alone, the maximum load of the stone-column reinforced with geogrid discs (3 discs) increases by 6.85 times.
7. When compared to a clay-bed alone, the maximum load of a stone column reinforced with both geogrid and circular geogrid disc increases by ten times.
8. The soil settling was decreased from 8.3 mm to 6.5 mm by putting the stone-column alone in the soil.
9. When the stone column was encased within geogrid, the soil settlement at the ultimate load was reduced from 6.5mm to 5.6mm.
10. The insertion of three geogrid discs in the stone-column lowered the maximum settlement of soil from 6.5mm to 4.85mm.
11. By using both geogrid and circular-geogrid discs to strengthen the stone-column, soil settlement at the ultimate load was reduced from 6.5mm to4.5mm.

REFERENCES

[1] Samuel Thanaraj. M, Freeda Christy. C, Brema. J. (2019). Analysis on the performance of stone columns with different materials in soil stabilization. International journal of Engineering and Advanced Technology (IJEAT), Volume-8, Issue-3S, February 2019.

[2] Ahmed Naseem A. K and Patil K. A. (2018). Application of geo reinforced stone column technique for soft clay soil ground improvement. Electronic Journal of Geotechnical Engineering (EJGE), pp 417-428, (23.01),2018.

[3] S. Siva Gowri Prasad and P. V. V. Satyanarayana. (2016). Improvement of soft soil performance using stone columns improved with circular geogrid discs. Indian Journal of Science and Technology (IJST), Vol 9(30), August 2016.

[4] S. Siva Gowri Prasad and P. V. V. Satyanarayana. (2016). Improvement of soft soil performance using stone columns improved with circular geogrid discs. Indian Journal of Science and Technology (IJST), Vol 9(30), August 2016.

[5] Manita Das and A. K. Dey. (2015). Behaviour of geotextile reinforced stone columns. 50th Indian Geotechnical Conference, College of Engineering, Pune,19 December 2015.

[6] Ali Falsafi and M. R. Motahari. (2015). Improving the bearing capacity of footing on soft soil using stone columns. Current World Environment, Vol 10 (Special issue 1), 1037-1042, April 2015.

[7] Pradip Das and Dr. Sujit Kumar Pal. et. (2013). A study on the behaviour of stone column in local soft and loose layered soil. Indian Journal of Science and Technology,Vol 18, Bund. I, 2013.

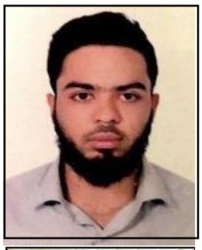
[8] Tandel Y. K, Solanki C. H, Desai A. K. (2012). Reinforced granular column for deep soil stabilization. International Journal of Civil Engineering and Structural Engineering,Vol-2, No 3, 2012.

[9] M. R. Dheerendra, Nayak. S, Shivashankar. R, Majeed J. A. (2010). Load settlement behaviour of stone column with circumferential nails. Indian Geotechnical Conference IGS Mumbai Chapter & IIT Bombay, 18 December 2010.

[10] Rudrabir Ghanti and Abhijeet Kashliwal. (2008). Ground improvement techniques- With a focused study on stone columns. Dura Build Care Pvt. Ltd. An ISO Company, 9001: 2008.

[11] J. A. Black, V. Sivakumar, M. R. Madhav, G. A. Hamill. (2007). Reinforced stone column in weak deposits: Laboratory model study. Journal of Geotechnical and Geo-environmental Engineering, 1090-0241, September 2007.

BIOGRAPHIES



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