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Experimental Investigation on Comparative Study on Bearing Capacity of Stone Column Replaced with Ceramic Waste and Geogrid Encasement

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Abstract: *Stone columns are most efficient ground improvement technique for treating problematic soil. Stone columns could increase the bearing capacity of soft soil, reduce settlement, increase rate of consolidation, and mitigate liquefaction potential. Stone columns have been widely employed to improve the load settlement characteristics of soft soil. The load carrying capacity, load settlement relationships can be easily monitored with the help of PLAXIS 3D software with some laboteric analysis. In laboratory part we add ceramic dust with the soil sample, find the optimum value and check the bearing capacity improvement. This research is based on a computational analysis by creating a finite element model of stone columns using PLAXIS 3D. A certain range of parameters for example spacing, diameter and angle of friction of stone columns are considered. Here the stone column material is replaced with ceramic waste and settlement of stone column and ceramic column is compared. Based on the load settlement evaluation, ceramic column is found to be more effective.*

Keywords: Plaxis3D, Consolidation, stone column, Ceramic column

I. INTRODUCTION

The stone column is one of the best-suited techniques to improve soil conditions. Stone columns are an efficient ground improvement technique for treating problematic soils. Stone columns have been widely employed to improve the load settlement characteristics of soft soil. Using stone columns is an efficient method to increase the bearing capacity of soft soils. Using stone columns is a useful, cost effective, and environmentally friendly method for resolving low bearing capacity and large-scale settlement of soft soil. Construction and demolition waste is generated whenever any construction/demolition activity takes place. It generates large amounts of waste, such as ceramic tile demolition waste. Here we use the demolishing waste in stone column. The present study aims to replace the material of stone column with ceramic waste. The present study also aims to utilize the demolishing waste in a sustainable and effective way. By implementing this technique, we try to reduce the material cost of stone column. Try to suggest best stone column grouping for reducing the settlement issue.

II. AREA OF STUDY

The soil used in this study collected from PUNCHAKARI region in Thiruvananthapuram. Classification of soil as per BIS is CL which is clay with low compressibility. The laboratory experiments were conducted in Geotechnical laboratory of St. Thomas institute of science and technology which is located near kattayikonam, Thiruvananthapuram.

III. MATERIALS USED

3.1 Soil

Locally available clayey soil sample (figure 1) is collected from punchakari region in Thiruvananthapuram. The raw soil is enriched with water and bio content. The soil shows high weight which indicates the water content in soil. It has a blackish colour which also indicates the accumulation of biodegradable particles and presence of organic matter.

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Sometime the soil is not meet the engineering requirement, so we use soil stabilization, we improve the soil properties with the help of stone column.Various properties of soil given in Table1.

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Fig1: Virgin soil sample collected from Punchakari

TABLE I properties of soil

Experiment conducted	Test result	inference
Water content	66.43%	
Specific gravity	2.116g/cc	Organic soil
UCC	0.691kg/cm²	Medium strength
Hydrometer analysis	• percentage of silt=75.5% • percentage of clay=21% • percentage of sand=3.5%	Soil is silty clay (CM)
Liquid Limit	64%	≥50, the soil is silt and clay
Plastic Limit	53.3%	
Plasticity index	10.5	Silty clay
Proctor compaction	• Dry density • Water content	1.362g/cc 26.16%

Ceramic powder

construction and demolishing waste are used to replace the stone column material. Ceramic waste powder (CWP), produced during the process of polishing ceramic tiles. They withstand chemical erosion that occurs in other materials subjected to acidic or caustic environments. The ceramic sample was collected from quarry region Kollam.

Fig2:Ceramic dust

PLAXIS 3D software

PLAXIS 3D includes the most essential functionality to perform everyday deformation and safety analysis for soil and rock. This comprehensive software for the design and analysis of soils, rocks, and associated structures makes it easy to model in full 3D. Easily generate and scale construction sequences for excavations.

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IV. EXPERIMENTAL METHODS

4.1 Proctor Compaction

Compaction test was done by adding different percentages of ceramic waste powder to the soil. Here adding 5,10,15,20 percentages of ceramic in a maximum strength attaining percentage of ceramic in soil, the maximum dry density value of virgin soil is 1.362 g/cc and optimum moisture content is 26.16, while adding the ceramic powder the dry density value goes increasing. and OMC goes decreasing up to a limit, we can see that its 10% ceramic. So that in optimum condition the OMC and MDD are 1.462 and 23.6 respectively.

4.2 Unconfined compressive strength test

Add 5,10,15,20% of ceramic powder in plain soil and try to find out the optimum percentage. From the test results we can see that the strength of soil ample is increasing and after 10%, the shear strength and unconfined compressive strength goes decreasing. The maximum strength values are 0.887 and 0.443kg/cm².

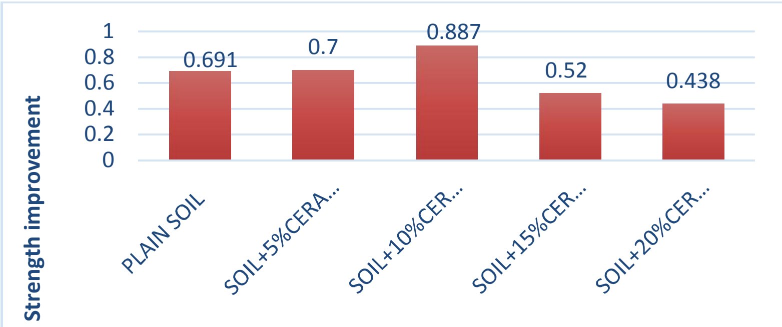

Fig 3: UCC comparison by adding ceramic waste powder

4.3 Numerical analysis by PLAXIS 3D

Initially a basic model is created by applying basic values of soil, stone column, ceramic powder etc. For analyse anything in a software like plaxis 3D we need a model by assigning all the values. We gave the input values from compaction and UCC test result, such as C=0.34, E=1000, $\emptyset = 46, \gamma, \gamma d$values are 13.35&13.83respectively for soil&C=1, E=7500, γ, γd=18,18 &$\emptyset = 35$for stone column. Then create single stone column,4,9 grouped stone columns with different ceramic fractions5%,10%,15%,20% and give different loading conditions 25,50,100,150 kN respectively. Then we can see that 10%ceramic added stone column has less settlement value in each group, then we analyse the 10%ceramic added (optimum) single,4grouped,9 grouped ceramic columns. From the analysis part we can see that 9 grouped stone column is better when compared to single and 4 grouped ceramic columns. In the case of 4 grouped ceramic column suddenlyshows settlement problem in 100,150 kN loading so we gave geogrid encasement of high axial stiffness to rectify the settlement issue.

TABLE 2:10% Ceramic added columns without geogrid TABLE 3:10%Ceramic added columnswith geogrid

Load	10%SCC	10%4GCC	10%9GCC
25	0.1284	0.06073	0.017
50	0.1402	0.09647	0.028
100	0.1511	0.2148	0.053
150	0.1527	0.3046	0.081

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V. CONCLUSION

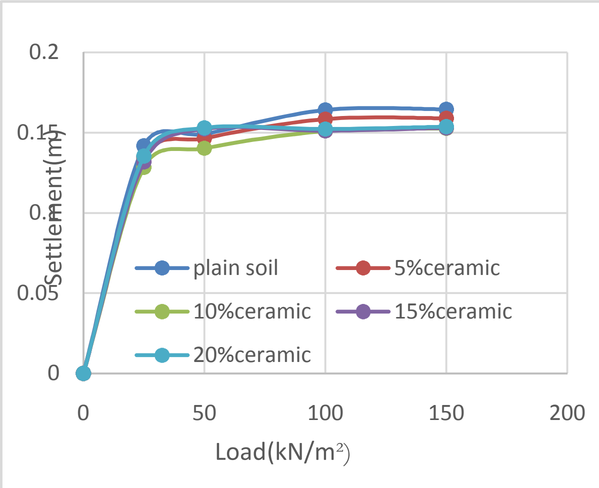

Fig 4: Load settlement improvement curve of ceramic added single stone column

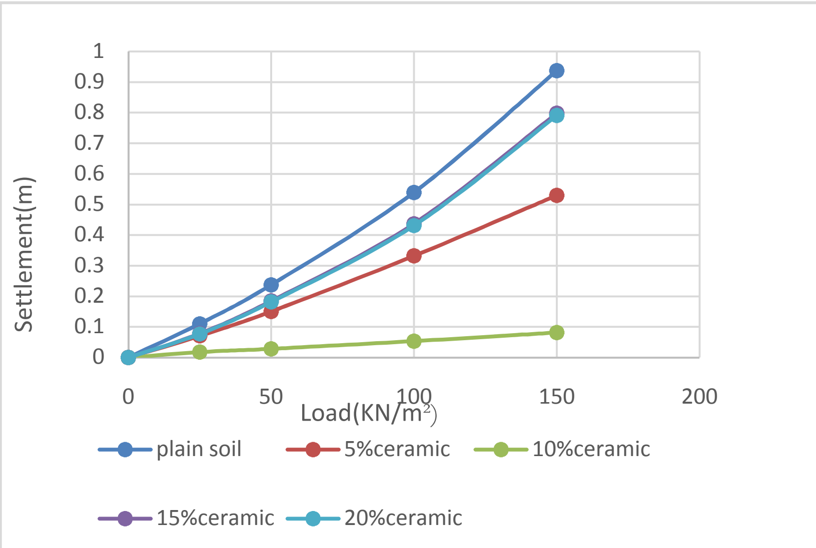

Fig 6: Load settlement improvement curve ceramic added 9 grouped stone columns

Load	10%SCC	10%4GCC	10%9GCC
25	0.1284	0.0458	0.017
50	0.1402	0.07097	0.028
100	0.1511	0.1396	0.053
150	0.1527	0.1417	0.081

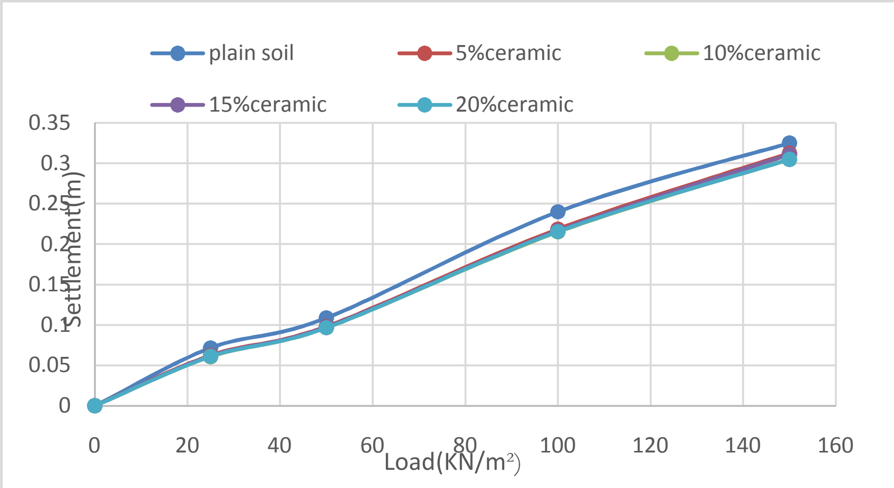

Fig 5: Load settlement improvement curve of ceramic added 4 grouped stone columns

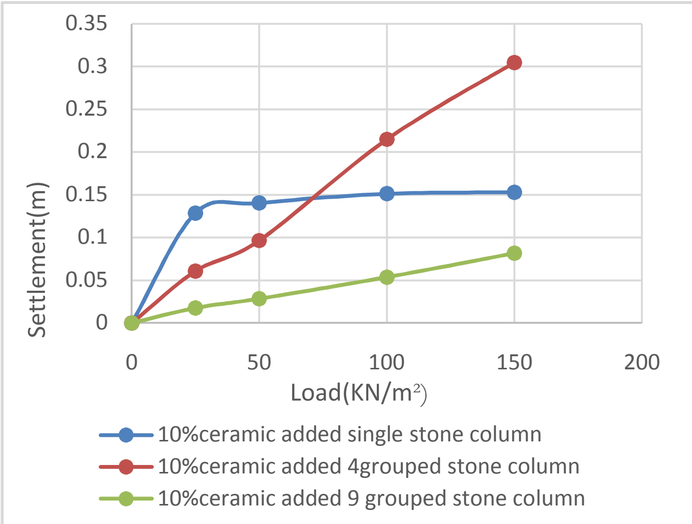

Fig 7: Load settlement curve of 10%ceramic added single,4grouped, 9 grouped stone columns

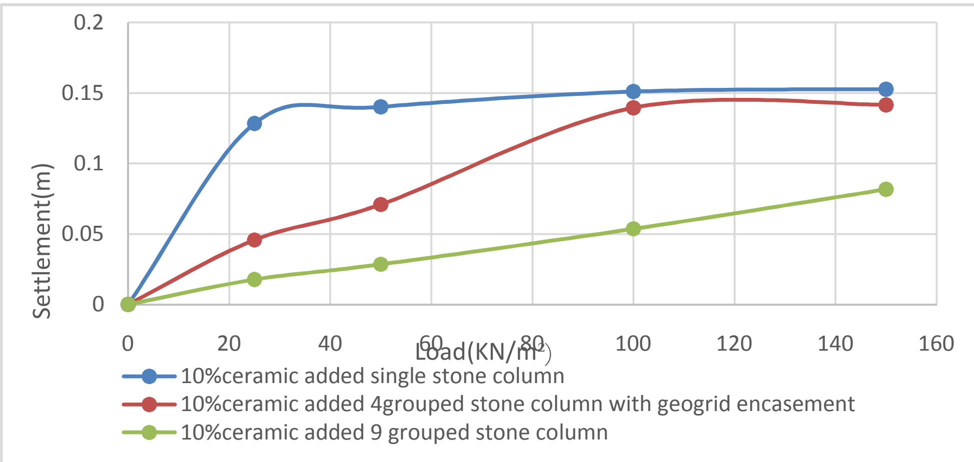

Fig 8: Load settlement curve of 10% ceramic added single,4 grouped, 9 grouped stone columns with geogrid encasement

The following conclusions are obtained from the present study

1. Ceramic dust is a kind of construction and demolishing waste which is suitable of increasing the bearing capacity of soil in a sustainable way.
2. It observed that when the ceramic dust is added to stone column the settlement values reduce.
3. 9 grouped stone column shows less settlement value when compared to ceramic added single stone column,4 group stone column.
4. 4 grouped stone column settlement can be improved by applying geogrid encasement of axial stiffness 2000N/m.

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