Experimental Study on Stone Column using Concrete Waste in Black Cotton Soil

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***Abstract*— The aim of this work is to demonstrate the stone column L/D ratio which delivers maximun load carrying capacity in black cotton soil .Generally the black cotton soil contains montmorillonite mineral which makes it expansive soil because the percentage of clay is more compared to other soil and settlement in this soil is more and hence bearing capacity is low. To overcome this behaviour of soil we are using stone column technique in which instead of using stone aggregate we are using concrete waste which makes it economical.Also soil stabilization in the areas where water table is high in that case other stabilization methods are not useful then stone column is usefull. Refering to various research paper we came to know that the stone column technique is trustable and also reduce settlement upto 30% to 60% also load carrying capacity increased significantly hence soil bearing capacity get increased.Triaxial loading frame test is carried out to determine the load settlement behaviour of floating stone column prepared in cylindrical tank with varying diameter and length.**

Keywords*— Concrete waste, Triaxial loading frame, Stone column, Load carrying capacity, etc

I. INTRODUCTION

India is developing fast and infrastructure development is imperative. There is a need of expand the construction activities also in the area with poor subsoil condition. Uses of land in such weak strata challenges geotechnical engineer by the presence of various problematic soil with different engineering characteristic. Pile foundation can be use for big project but for small project alternate technique is required for ground improvement.Vibrocompaction, vaccum consolidation, soil nailing are some of the recent technique to improve soil. But in soft soil, stone column is extensively used to increase bearing capacity and reduce settlement for poor ground. Stone column can be end bearing or floating. If hard strata is unavailable for placing of stone column then floating column are used. Stone column technique is widely used to support oil tanks, low rise building, highway facilities, bridge abutment etc. So it is necessary to find out the the cost effective and environment friendly material for stone column. Instead of using stone aggregate as material. We can use alternate material such as concrete waste, quarry waste, maganese slag etc. these material are not only cost effective but also important in point of view of environment. The improvement of a soft soil by stone columns is due to three factors. The first one is inclusion of a *stiffer* column material (such as crushed stones, gravel, and others) in the soft soil. The second factor is the *densification* of the surrounding soft soil during the installation of stone column. The third factor is that it acts as *vertical drains*.Stone column ground improvement technique is highly useful when ground water level is high.

II. LITERATURE REVIEW

Several experimental studies have been proposed to predict the effect of stone column in soil:

Hugus and withers (1974) They carried out series of model test in normally consolidated clay in triaxial test and the test results indicate that the ultimate capacity of stone column was govern by the primarly maximum radial reaction of the soil against the bulging and the extend of vertical movement in stone column was limited to about 4 times the diameter [1].

Ambily (2004), He conducted an experimental and theoretical evolution of stone column in soft clay the result is obtained when column area alone is conducted. The failure by bulging of Column with maximum of 0.5 to 1 times the column diameter below the top and load settlement behaviour when entire area is loaded [2].

Ayothraman (2009**),** He conducted experimental studies using shredded tyre chips as stone column material. They found the mix proportion of 20%T+80%S,60%T+40%S and 40%S+60%T have load carrying capacity of stone columnwith only stone aggregates. Also combinations of aggregate and chip gives higher load carrying carrying capacity of stone column [3].

Murugesan (2010), He conducted experimental study on stone column & he used sand and stone aggregate as stone column materials. He used static load test for stone column.He observed the load carrying capacity of stone column . Load settlement curve were obtained from laboratory test in encased with non woven geotextile.And it is observed that there is improvement in load carrying capacity and reduction in settlement. [4].

Tandel (2010), He conducted the experiment to compare the performances of an ordinar stone column and reinforced stone colum. By reinforcement using geosynthetic, sand column and the lateral bulging is minimized and the load carrying capacity of stone column can be increased and they also found the elastic modulus of the geosynthetic reinforcement play an important load carrying capacity of reinforced column due to confining pressures [5].

Shahidul (2010), He conducted the experimental studies on stone column. He uses cement,calcium chloride and sand as astone column materials. He use static load test and obtained the result as pre mixed settlement is 13.6mm and post mixed with auger is 17.2mm [6].

Kalantari and Abbas (2012), They made a review on soil stabilization using stone column. The use of stone column in soft clay has been found to provide moderate increases in load carrying capacity accompained by significant reduction in settlement and freely drained material, consolidation settlement in acclerated and post construction settlement is minimized [7].

Ali (2012), He performed the model test on different depth of stone column by varrying size of aggregate in stone column. He obtained the result as load carrying capacity of stone column is improved and there is reduction in settlement [8].

Kumar (2016), He conducted the experimental study on stone columns with quarry solid,coir and lime as the materials used in stone column. He carried static load test and observed the l/s ratio is optimum at 3.5 and bearing capacity is increased by 75% [9].

Harish C (2016), He conducted experiment in cylindrical test tank of 200mm dia and height of 300mm.The experiment is conducted by triaxial loading frame. The loadsettlement response is plotted with varying reinforcement depths (0.25L, 0.5L, 0.75L). The maximum load carrying capacities of reinforced stone column with reinforcement depths of 0.25L, 0.5L, 0.75L and L are 612.0N, 663.2N, 704.0N and 742.4N respectively and the corresponding settlements is 25mm. The load carrying capacity and stiffness are increased by using lateral reinforcement of column using geo-textile circular discs.Hence stone column with geotextile is very much effective [10].

Baruah and Sahu (2016), They performed the model of stone column in clay bed with different size of aggregate and varying depth with or without encasement. The test performed is plate load test and result of the test are as increment in load bearing capacity of clay bed and reduction in settlement [11].

Mohapatra (2017), He analysed three dimensional numerical analysis of geosynthetic encased granular column carried out on a model with varying diameter as 50mm and 100mm with load increment of 15, 20, 45 and 75kPa and result of geosynthetic encasement were mobilized in both vertical and circumferential dimension [12].

Cegiz and Guler (2018), They evoluted and compared the conventional and geosynthesis wrapped stone column in seismic action placed in large shaking table test.water resistent strain gauge are used to measured strain through the experiment [13].

Ghazavia and Ehsani (2018), They presented some large body laboratory tests on horizontally reinforced stone columns with diameters of 60, 80, and 100mm and groups of stone columns with 60mm diameter. Results show that the bearing capacity of stone columns increases by using horizontally reinforcing layers. Also, they reduce lateral bulging of stone columns by their frictional and interlocking effects with stone column aggregates. Finally, numerical analyses were carried out to study main affecting parameters on the bearing capacity of HRSCs [14].

Hamidi and Lajevardi (2018), They conducted some laboratory tests on conducted on different stone columns to investigate the effects of using a gravel mattress, steel fibre reinforcement, geotextile encasement and also varying gravel particle distributions and shapes on the load-carrying capacity of columns. By considering the project conditions and the

Fig 1 Dry sieved soil sample


Fig 2 Mixing of soil sample at OMC

Fig 3 Concrete waste

Fig 4 Stone column casting

Fig 5 Stone column testing setup

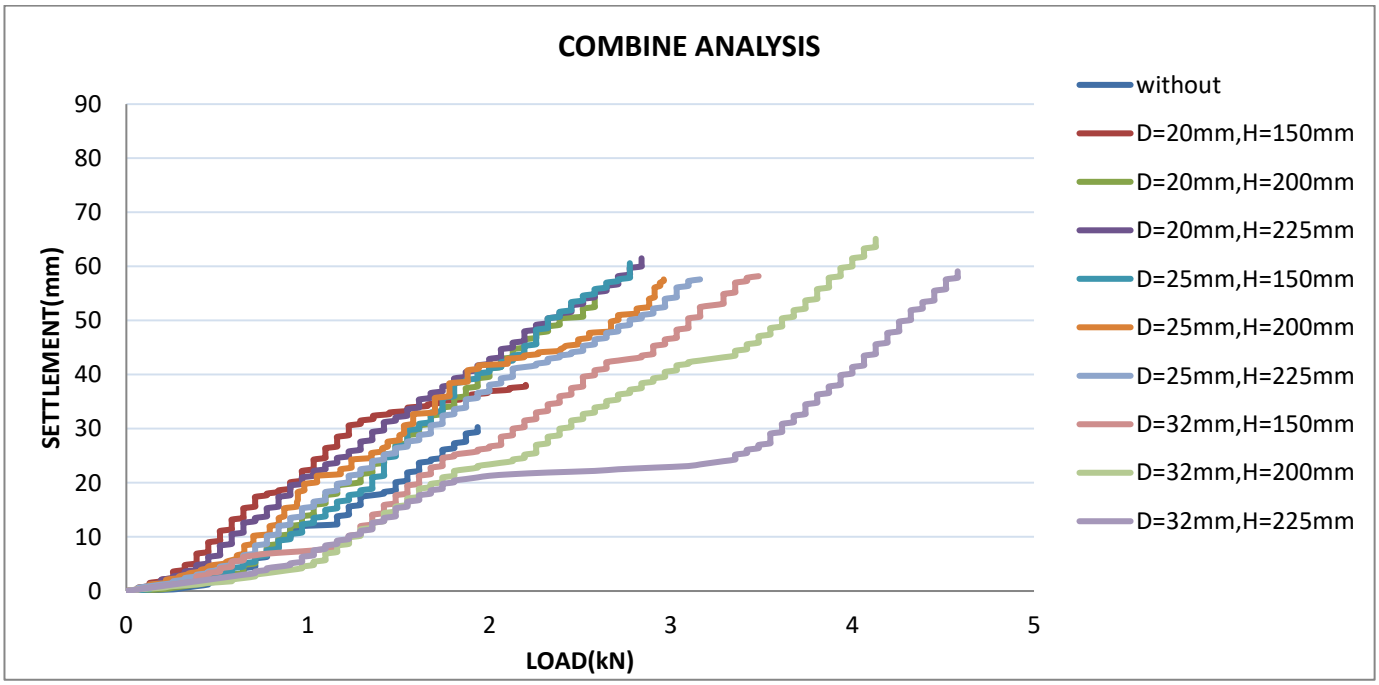

Fig 6 Result Graph

amount of load carrying capacity that was needed for each project Some additional tests were also conducted on columns covered by an ordinary gravel mattress reinforced by geotextile. In addition, stone columns with diameters of 63 and 92 mm were tested with a length-to-diameter ratio of 5 [15].

Mohsen and Haddad (2019), They taken a single stone column with three types of materials, including recycled crushed brick (CB), recycled crushed concrete (CC) and gravel as natural aggregates was modelled. The results of the recycled aggregate index tests demonstrated a poorer performance of these materials compared to the natural aggregate. Despite this, the bearing capacity of the clay bed reinforced with the floating column, which was filled with CB or CC, was approximately five times the bearing capacity of the unreinforced clay bed. Moreover, the loading results showed that the floating stone columns constructed of a type of aggregate delivered a better performance in comparison with the columns constructed of a combination of several types of recycled aggregates together or a combination of natural and recycled aggregates [16].

SUMMARY:

The stone column ground improvement technique is very effective to improve load carrying capacity also in added that it is also cost effective if we use different recyclable materials & geotextile membranes.The experiment can be performed on single or group of stone column by stone column testing machine or by triaxial loading frame with respective size of mould.

III MATERIAL AND METHODOLOGY

The study was conducted on black cotton soil. Soil was brought from marathwada region of maharashtra (Latur district).concrete waste were collected from Naigaon which is in Vasai Tehsil. Initial properties of soil and aggregate were tested.here concrete waste is used as stone column material and with the help of triaxial loaing frame the load settlement behaviour of stone column prepared in cylindrical tank is determined.

1. Collecting soil sample.
2. Finding Basic properties of soil.
3. Test to be performed on soil: Density test , Atterberg limit test , Water content , standard procter test , swell test,particle size distribution(hydrometer
4. Test to be performed on concrete waste: Grading and water absorption test.
5. Ploting load vs Settlement curves for soil using concrete waste.
6. Find the optimum L/D ratio for which stone column can carry maximum load and minimum settlement.

A. Materials used

Initial properties of soil and concrete waste are tested and concrete waste of size 10mm is used. The initial properties of black cotton soil is given in table I.The soil & aggregates testing is done in geotechnical lab as per recommendations of IS code.

TABLE I. INITIAL PROPERTIES OF SOIL

Properties	***Result***
Specific gravity	2.4
Liquid limit	76.90%
Plastic limit	32.58%
Plasticity index	44.32%
Optimum moisture content	27.19%
Maximum dry density	1.5g/cc
Percentage of clay	65.40%
Unconfined compressive strength	15.4kPa
Cohesion	7.7kPa

TABLE II INITIAL PROPERTIES OF CONCRETE WASTE

Properties of concrete waste	***Value obtained***
Water absorption	3.6%

B. Preparation of soil bed

In order to study load settlement behaviour of stone column.triaxial load test were conducted on circular tank of size 150 mm diameter with 300 mm height. the stone column of diameter 20, 25 & 32mm with changing the length of stone column with each diameter and placed at the centre of the bed. The different length of stone column are 225, 200, 150mm.the column were design as floating column for the test. The load is applied through 8mm thick MS plate.

Before the preparation of the soil bed oil was applied to the side wall of the tank in order to avoid the friction. The centre of the tank was clearly marked for floating column, after placing the first layer of soil bed then PVC pipe was placed at the centre. Then surrounding part of soil was filled at OMC to obtain max dry density.soil was filled in the tank in 50mm thick layer to desired height and compacted using a tamping rod of 12mm diameter.such that no air voids are left in the soil. The concrete waste is used as a column material.the concrete waste is filled in the pipe in three different layer by compacting with 12 mm diameter rod. After compaction of each layer the pipe is lifted gently.after construction of stone column,load was applied to the stone column with triaxial loading frame till the failure. Then with the help of load settlement behviour the bearing capacity of soil can be determined.

IV.CONCLUSION

1) The treated soil with stone column can carry more load than untreated soil.

2) It has been observed from the load–settlement characteristics that the introduction of stone columns has significantly increased the load carrying capacity of black cotton soil.

3) As we increase diameter there is significant improvement in load carrying capacity improvement as **11.4% to 115%** , by keeping same length. On the other hand if we increase length there is significant improvement in load carrying capacity improvement by **10% to 100%** for same size of diameter.

4) Stone column improves the load carrying capacity and reduce settlement behaviour of soft soil.

5) A portion of stone in the column can be replaced partially or fully by concrete waste without affecting the strength of the improved ground

6) Stone column of **D=32mm, H=225mm** increased load carrying capacity by **2.36** times as compared to **virgin** soil sample. On the other hand the settlement is also reduced significantly.

7) The effective L/D ratio is lies between **6.25 to 7.03**.

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