Experimental Evaluation of Effect of Length of Stone Column on Load Carrying Capacity of Cohesive Soil

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Abstract*: Stone column technique is widely used to improve load bearing capacity and to reduce settlement in case of soft clayey soil and loose silty soil. Stone column helps to improve the properties of soil by densifying, reinforcing the soil forming stiff fused soil mass. More over stone column provides good drainage path and diminishes the excess pore pressure. This paper discuss the effect of length of stone column on the performance of stone column through a lab study.

***Keywords*: Stone Column, laboratory model, Cohesive Soil, Load settlement curve**

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I. INTRODUCTION

Every so often we come across the deep seated soft cohesive soil during the construction of various structures. These soil deposits are not suitable for the construction of foundations. In this situation various ground improvement techniques are employed from point of view of economy and safety. Stone columns are one of the method of ground improvement having a tested record of practice. They are ideally suited for improving soft clays and silts and also for loose silty sands. It reduces the damage due to excessive pore pressure, by providing drainage bath and increasing stiffness of soil layer. The stone column are generally used in construction of foundation for highways, railways, storage tanks, bridge abutments etc. Seemingly, the concept was first applied in France in 1830 to improve a native soil. However, this method has been used widely in Europe for ground improvement since the late 1950's.

Numerous researchers have worked on stone columns. These works primarily focus on assessment of load carrying capacity and settlement analysis of soft ground reinforced with stone columns. All these works are either numerical or analytical Studies, theoretical studies, model tests or Prototype/ Field tests

The failure of stone columns was more noticeable in the upper portion of the stone column and the depth of bulging was observed to be approximately four times the diameter of the column as suggested by Hughes and Withers (1974). Some author suggested that L/D ratio of 4.5 required to develop the full limiting axial stress. (Mitra and Cahttopadhyay -1999). McKelvey et al. (2004), testified from their experimental study that L/D ratio of minimum 6 is required to grow the full limiting axial stress on the column. The present study deal with experimental evaluation of effect of stone column and its length on load carrying behavior of cohesive soil which is locally called as Black Cotton (BC) soil.

II. LABORATORY MODEL

A metallic cylindrical mould of diameter 400mm and length 600mm is prepared to cast and test the stone column with different length. An auger of diameter 100mm and length of 350mm is fabricated to prepare the stone column of required length in the mould as shown in figure 1.

(a) Cylindrical Mould (b) Auger

Figure 1: Lab model for stone column

III. MATERIAL AND TESTING

The soil used in this test is Black Cotton soil (BC soil) collected from nearby place in Aurangabad city. Black cotton soil (BC soil) is a highly clayey soil. The Black Cotton soil has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in colour.

The soil used for experimentation is having liquid limit of 58.42% and PI of 22. The aggregate used to cast stone column are having size between 2mm to 10mm.

Stone column is prepared by taking required quantity of soil and mixed with optimum moisture content. Thoroughly mixed paste is filled in the tank in 3 layers each giving uniform compaction to achieve a uniform dry density of 1.465g/cm^3. Care was taken to ensure that no significant air voids are formed in the test bed.

The column is constructed by boring method. A 100 mm outer diameter auger is used to create a bore of required length. Gravels of size 2 – 10mm are filled in 3 layers into considered length and each giving uniform compaction to each layer. A sand layer of 30 mm height is placed over the prepared stone column and clay bed as shown in figure 2. To load the stone column loading plate of 150 mm diameter is placed exactly at the center of the stone column to distribute the load evenly on column.

Figure 2: Installing stone column in the soil

After preparing the stone column, the load deformation behavior of the column is studied by loading it in loading frame at a strain rate of 1.25mm/minute. In present study the diameter of the stone column is kept constant by varying its length.

The table 1 shows the variation of length of stone column constructed in black cotton soil with a constant diameter. Also with each variable length and constant diameter the load settlement behavior of the soil is found out by load test.

Table 1: Trial length of stone column

Sr. No.	**Length of stone column (mm)**	**Diameter of stone column (mm)**	**L/D ratio**
1	00	00	00
2	135	100	1.35
3	180	100	1.80
4	225	100	2.25
5	270	100	2.70

Iv. Results and Discussion

The load settlement curve obtained for the soil without stone column is shown in figure 3. From the study it is observed that soil take load of 1400N before it get flatten. The load bearing characteristic improves with stone column with L/D ratio of 1.35 and the maximum load taken is around 1600 N before it fails. The load settlement curve for soil with stone column with L/D ratio of 1.35 is represented in figure 4. The failure load is increasing with increase in length of stone column up to L/D ratio of 2.25 there after it reduces. The load settlement curve for L/D ratio of 1.8, 2.25 and 2.70 are shown in figure 5, 6 and 7. A comparative plot for soil without stone column and with stone column of various L/D ratio is shown in figure 8.

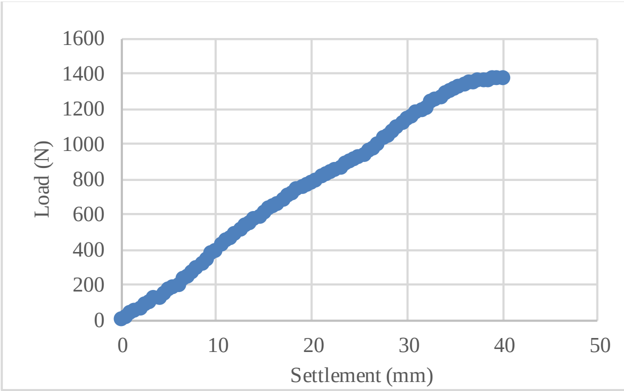

Figure 3: Load settlement curve without stone column

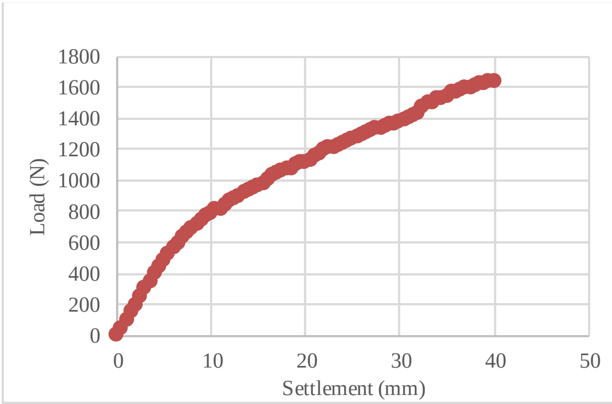

Figure 4: Load settlement curve stone column 135mm length

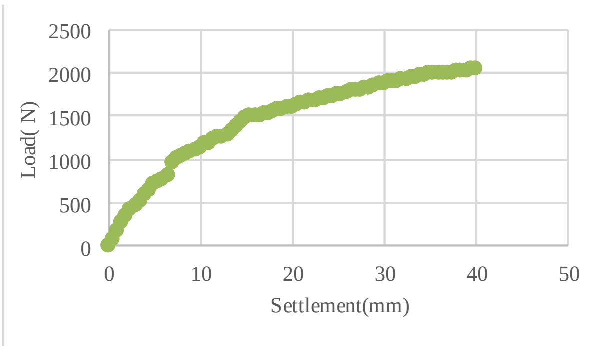

Figure 5: Load settlement curve stone column 180mm length

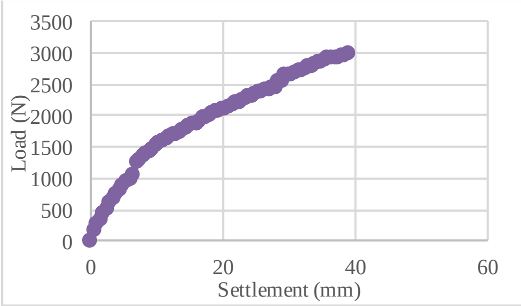

Figure 6: Load settlement curve stone column 225mm length

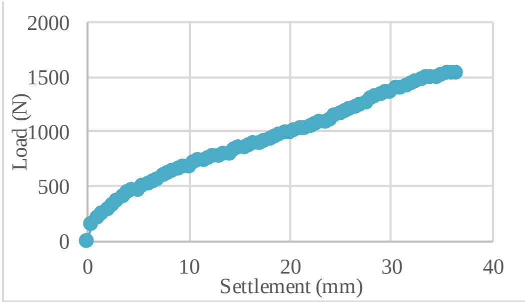

Figure 7: Load settlement curve stone column 270mm length

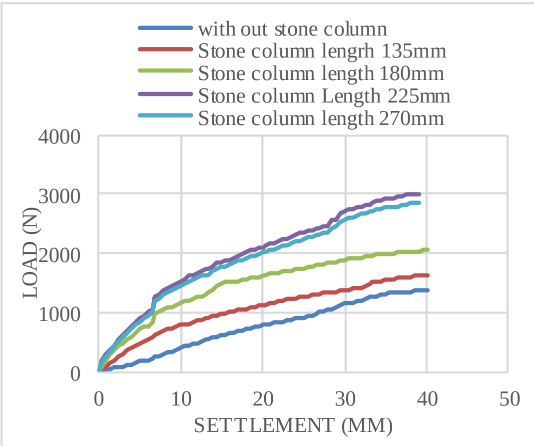

Figure 8: Load settlement curve comparison for different length of stone column

The study suggest that the increase in L/D ratio have significant impact on load carrying capacity of stone column up to L/d ratio of 2.5. Increase in L/D ratio beyond this optimum ratio have no significant improvement in capacity of stone column as demonstrated in figure 9.

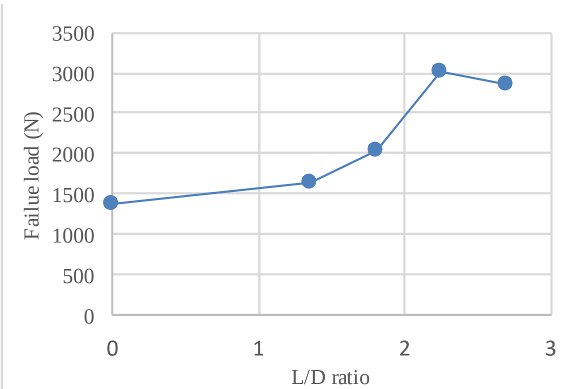

Figure 9: Failure load at different L/D ratio

v. Conclusions

Based on the experimental study it is clear that stone column is effective in increasing bearing capacity BC soil. It is also observed that improvement in load carrying capacity is increasing with increase in length up to a critical length beyond which increase in length do not have significant effect on soil stiffness. This critical length is important from point view of economy and efficiency of stone column.

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