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# EXPERIMENTAL STUDY ON GROUND IMPROVEMENT WITH STONE COLUMNS

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## ABSTRACT
Ground improvement is an important requirement in today's construction industry as land reclamation is becoming increasingly popular. Stone column method is one of the efficient and economical method and it is one of the soil stabilizing method that is used to increase the bearing capacity and decrease the settlement of soft soils. In this research paper the bearing capacity, settlement of stone columns and encased stone columns were analysed using a scaled model. Gunny bags are used as geo textile for stone column encasement. The results shown significant improvement in bearing capacity of soil using stone column, the efficiency of stone column is increased when encased with geotextile.

**Keywords:** Ground improvement, stone columns, bearing capacity, geo textile.

## INTRODUCTION
In the early times before the advancement in the geotechnical engineering, the only chance for the foundation engineers was to design the foundation matching to the sub soil conditions at the provided site. But now a days due to the improvement in geotechnical techniques and with the help of latest technology it is possible for us to modify the weak foundation soil to the strength and compressibility characteristics to suit the foundation of our choice.
"The process in which in-situ soils are improved for the support of the foundations in known as ground improvement".
The problems of soft soil in most parts of the world have been one of the major challenges for geotechnical engineers. Stone columns are created by replacing poor soil with sand or a combination of sand and crushed stones to construct a vertically resistant system. The use of the stone columns is useful, cost-effective and environment-friendly method for resolving such issues. The changes made through this process are permanent and are not effected with the passage of time or due to change in the weathering condition. The main objective of these processes is to increase the density and shear strength parameters and to decrease the compressibility, permeability and the settlement, which makes the soil more water resistant, durable and stable.

### 1.2 Need for Ground improvement
Ground improvement techniques are mainly used where the mechanical properties of the soil are not adequate. Mainly at the sites which have organic soils, peaty soils, collapsible soils, soils havin swelling and shrinkage properties etc. ground improvement is carried out to:

- Prevent excessive settlements of the surface of the reclamation area when structures like buildings, roads and other foundations are loaded on it.
- Improve shear strength of fill and subsoil to ensure sufficient bearing capacity of the foundations and /or sufficient stability of the slopes.
- Increase the density of the fill mass and/or subsoil to prevent liquefaction, and improve soil permeability in order to increase drainage capacity.

### 1.3 Benefits of Ground improvement

The feasibility of a land reclamation project often depends on the availability of a sufficient amount of good quality fill, within a reasonable distance of the site. If such fill is not accessible, improvement of the existing ground can offer a cost-effective solution to improve non-compliant material. Sometimes quality control after construction reveals that certain parts of the reclamation area are inadequate. In that case, these poor quality areas can be repaired at a lesser cost than removing and replacing the inferior soil with higher quality material. Generally speaking, ground improvement is very flexible and feasible as it can be carried out at any location and at any time after construction is completed. The role of stone columns in improving the bearing capacity of has been investigated by several researchers [1-11].

Early studies regarding stone column were published by researchers such as GREENWOOD [1]; HUGHES et al [2] ,MCKENNA et al [3] and Alarifi Hamzh [5] . In their researches, they reported the positive performance of the stone column in increasing bearing capacity and reducing settlement. VAN IMPE [4] discussed using geosynthetic to increase bearing capacity of stone columns for the first time. Samuel Thanaraj [6] used different materials like marbles, pebbles and concrete for stone column and observed increased bearing capacity.

Sharad kumar soni [7] and M. MONISHA [8] performed the settlement analysis of stone columns and observed decreased settlement when soil is improved with stone columns.

Lateral confining pressure increased using geotextile around stone columns. Geotextile prevents granular materials of stone column from sinking into the soft soil and as a result, bearing capacity increases significantly. The concept of encasing granular columns with geosynthetics to increase their capacity has been acknowledged by numerous researchers [9–12]. MURUGESAN et al [10] explored the bearing capacity improvement of the stone column by geosynthetic rings using numerical analysis with finite element method. Their analysis showed that cylindrical reinforcement around the stone column increases its bearing capacity and rigidity and reduces bulging in compare to ordinary stone column.

## OBJECTIVES

The objectives of this study are:

1. To perform settlement and bearing capacity analysis on soil, soil with stone columns, soil with encased stone columns.
2. To determine the percentage decrease in settlement in soil with stone columns and encased stone columns.
3. To determine the percentage increase in bearing capacity of soil with stone columns and encased stone columns.

## MODELLING AND TEST PROCEDURE

Settlement and load bearing capacity analysis of soil, soil with stone columns and soil with encased stone columns are carried out using a scaled model of rectangular box filled with soil. Pipes filled with coarse aggregates is used as stone columns and gunny bags are used as geosynthetic material in case of encased columns.

### 3.1 Settlement Analysis

One third of the box is filled with soil and tamped for 25 times all over the surface and the remaining portion aslo filled in same way. The surface is levelled and a plate load is placed on the soil such that concentrated load is distributed uniformly on soil. A load of 1kg is applied and allowed to settle for 2 minutes and corresponding settlement is noted. The load increased upto 5kg (2kg, 3g, 4kg, 5kg) and corresponding settlements are noted.

Three columns are made with the help of pipe filled with coarse aggregate of 6.3 to 10mm. these columns are placed in soil such a way they form a triangle over which place load is placed. In the similar manner as above the settlement corresponding to loads are noted.

In the similar manner another 3 columns are prepared using coarse aggregates are filed in gunny bags to act like a encased stone columns. As above two cases settlements are noted for corresponding load. A graph is plotted to observe the variation of settlement in all three cases.

Figure 1: Setup

Figure 2: Geosynthetic stone column

### 3.2 Bearing Capacity Analysis

A wooden box is taken which can fit the loading machine and soil is filled in the box same as settlement analysis. The soil is levelled and placed on the loading frame of apparatus. A plate load is applied on the center on which plunger is placed. The dial guage is adjusted in such a way that is in contact with plate load. Load is applied at a rate of 1.25mm/min and load is recorded at regular intervals of settlement.
In the similar manner loads are recorded for stone columns and encased stone columns.

Figure 3: Setup

## RESULTS AND DISCUSSIONS

### Settlement

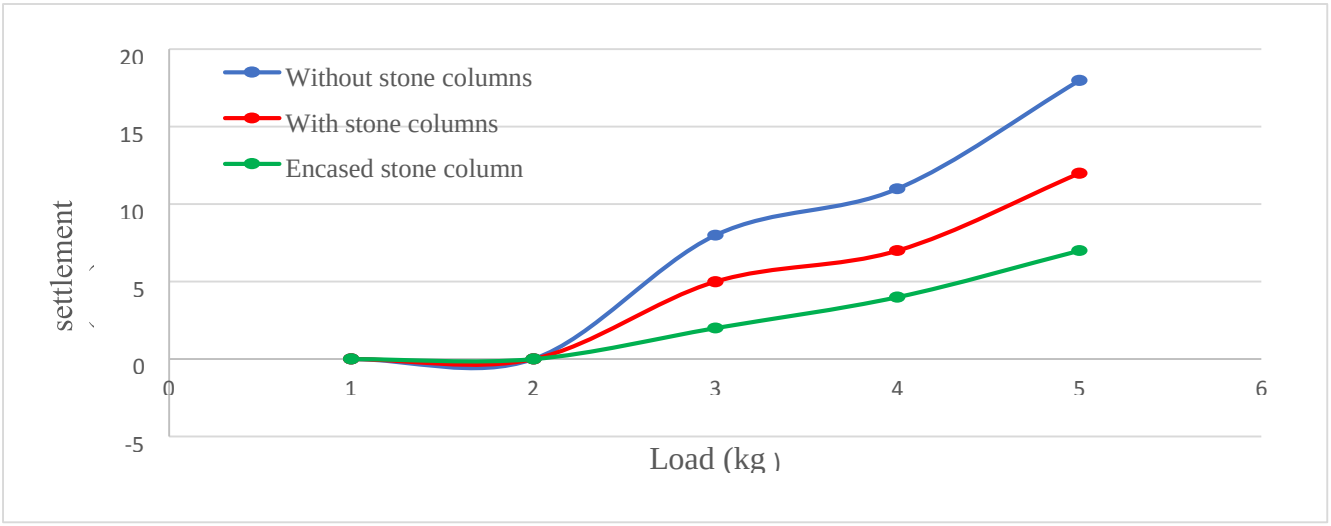


Figure 4: Graph of settlement analysis

Figure 4 shows the graph of settelement analysis of soil without stone columns, soil wih stone columns, and soil with encased stone columns. It is observed that for same loading the settlement in soil is decreased when stone columns are used as soil improvement and there is further decrease in settlement when Encased stone columns are used.

### 4.2 Bearing capacity analysis

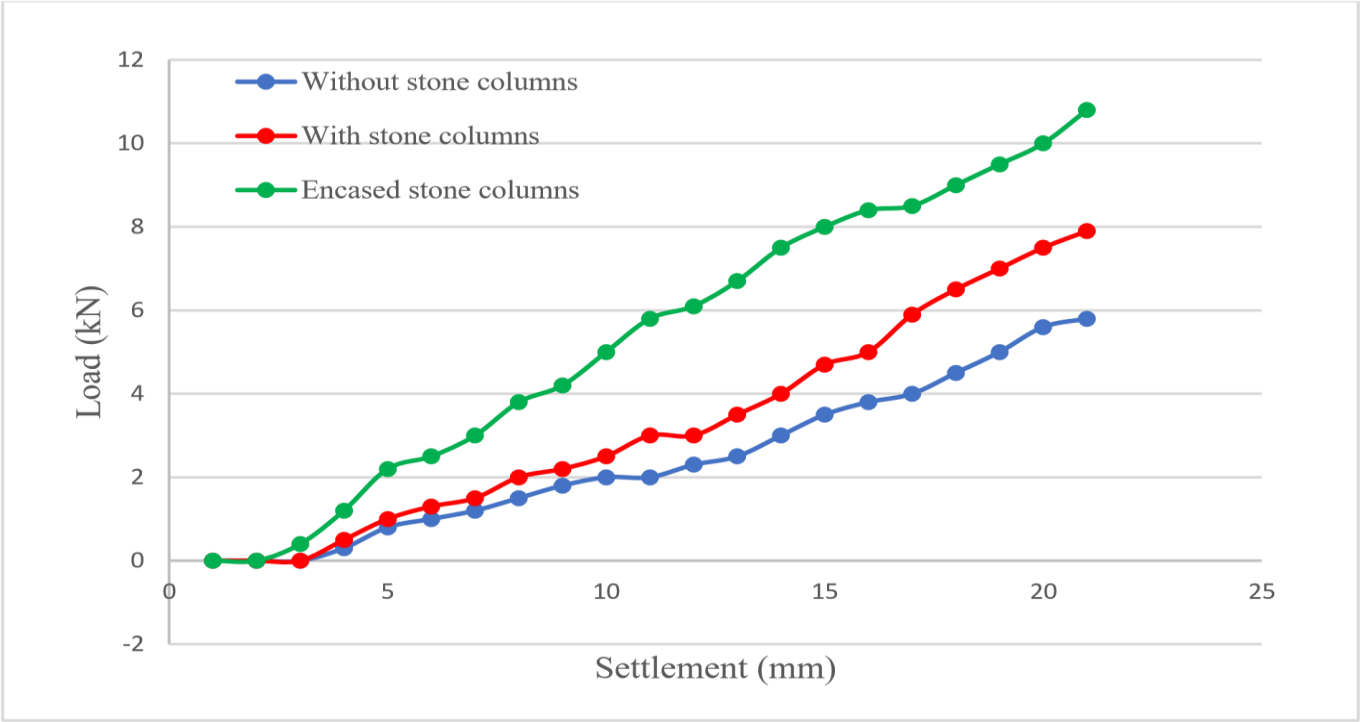


Figure 5: Graph of bearing capacity analysis

From figure 5 shows the graph of bearing capacity analysis soil without stone columns, with stone columns, and with encased stone columns and it is observed that the load bearing capacity of soil is increased when soil is improved with stone columns and when encased stone columns are used there is further increment in load bearing capacity of soil. This is due densification of soil.

## CONCLUSIONS

Settlement and bearing capacity analysis are performed on soil without stone columns, with stone columns and with encased stone columns.

- It is observed that settlement is decreased and bearing capacity is increased when stonecolumns are used.
- From the experimental results it isconcluded that settlement is decreased by 33.33% and bearing capacity is increaased by 36.21% when stone columns are used.
- It is concluded that when encased stone columns are used the settlement is decreased by 61.11% and bearing capacity is increased by 86.21%.

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