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In situ soil stabilization using stone columns as ground improvement technique

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Abstract - Stone column ground stabilization involves adding columns filled with stone into the ground to a depth of at least 4m below the ground surface. Compacted gravel layer can then be put over the top of the columns, ready for the construction of new house foundations. This method is quick to construct and can be done at any time of the year. Stone columns are widely used to improve the bearing capacity of soil and reduce the settlement of structures which are built on them. It increases the strength and decreases the compressibility of soft, loose fine graded soils, accelerating consolidation effect and reducing the liquefaction potential of soil. These columns consist of either compacted gravel or crushed stone arranged by a dynamic vibrator. This article shows its installation methods, design and its failure modes. Key words : stone column, bearing capacity, settlement, stabilization, soft soil

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1.INTRODUCTION

There's number of technique available to improve ground conditions such as stone columns, jet grouting, compaction grouting, short pile, dynamic compaction, lime stabilization, micropiles, soil nailing etc. But before using any of these techniques, it is important to know the ground improvement in detail. In simple words ground improvement can be defined as "the process of enhancing the quality of soil." It mainly refers to the improvement of soil in layers but also in some cases it refers to the improvement of rocky layers. These are tools used by the geotechnical engineer for "fixing" the problems of poor ground, when a poor quality soil exists at the project site (Ghanti & Kashliwal, 2008).

Soft clay deposits are widely located in many coastal areas and they have poor strength, compressibility. Stone columns consist of granular fills, compacted in long cylindrical holes is used as a technique for enhancing the strength and consolidation behaviours in soft clays. The load carrying capacity of a stone column is attributed to frictional properties of the fill mass, cohesion and frictional properties of surrounding soil, flexibility characteristics of the foundation transmitting stresses to the improved ground and the magnitude of lateral earth pressures developed in the surrounding soil mass and acting on the sides of the column resulting from interaction between various elements in the system. Stone columns basically makes its axial capacity from the passive earth pressure developed as a result of the bulging effect and increased resistance to deformation under imposed surcharge load. The theory of load transfer, estimation of ultimate bearing capacity and prediction of settlement of stone columns was first proposed by several researchers (Malarvizhi, 2004).

The next factor is densification of the surrounding soft soil during the installation. The third factor is the acting as vertical drains.

2. Application of stone columns: ew application on field are:

- These stone columns act as vertical drains, speeding up the consolidation process.
- It replaces the weak soil by a stiffer material and increases compaction of soil during the process of installation hence enhancing the unit weight.
- Stone columns also mitigate the liquefaction potential and damage by increasing negative pore pressure by providing drainage path, thereby increasing the effective stress.

3. Advantages: Stone columns are ideally suited for structures, because:

- To reduce both total and differential settlements.
- Reduction of liquefaction potential of cohesionless soil.
- To enhance the bearing capacity of a site to make it possible to use shallow foundation on the soil.
- To increase the stiffness.
- Improving the drainage conditions and environment control.
- controlling the deformation and accelerate consolidation

4. Limitations: when these columns are used in sensitive clays

- Increase in the settlement of the bed due to the absence of the lateral restraint.
- Clay particles get clogged around the column thereby reducing radial drainage. To overcome this, they are encased with geosynthetic material

5. Installation of stone columns: They are installed using either top- or bottom-feed systems, either with or without using jetted water. Top-feed method is used when a stable hole can be formed using vibratory probe. With the dry method, probe is inserted into the ground and it penetrates to the target depth under the action of its own weight and compressed air jetting (Taube and Herridge, 2002).

Most extensively used techniques for installation of stone columns are:

Vibro-Replacement (Wet, Top Feed Method) and Vibro-Displacement (Dry, Top and Bottom Feed Method)

Construction of these columns is generally carried out using either of these two techniques. In the displacement one, in situ soil is displaced laterally through a vibratory probe using compressed air. This installation method is significant where ground water level is low and in situ soil is firm. This method is shown in the Figure 1 and Figure 2.

In the replacement method, in situ soil is replaced by stone columns in a regular pattern where the holes are constructed using a vibratory probe by water jetting. This method is shown in the Fig. 3 (Lee and Pande, 1998).

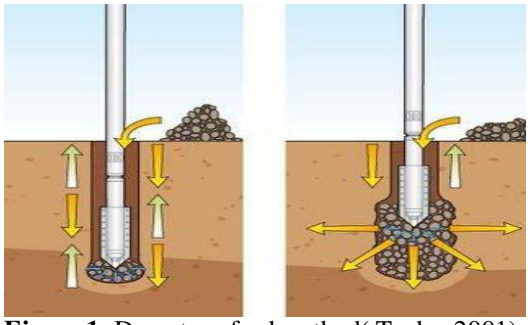

Figure 1: Dry – top- feed method(Taube, 2001)

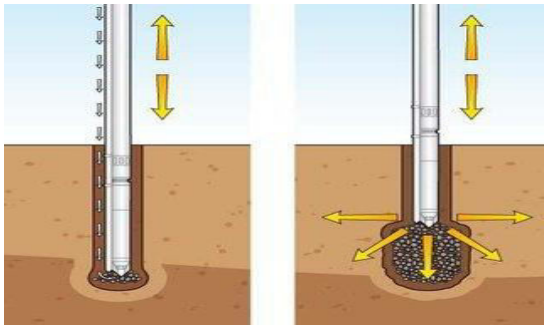

Figure 2: Dry – Bottom- feed method (Taube, 2001)

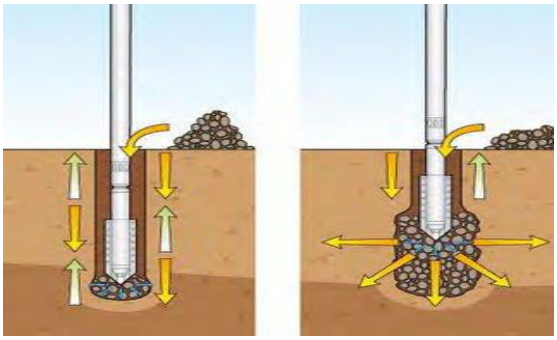

Figure 3:Wet - top - feed method process

Failure modes of stone columns: Single column can be built upon a firm stratum under a soft soil as a floating column with tip of column being embedded within the layer of soft soil. To make the most optimum use of these columns, we should understand its failure mechanisms.

Basic Failure Modes of Stone Columns are:

- General shear failure.
- Local shear failure.
- Bulging failure.
- Failure by sliding.

it is believed that if the length of column exceeds 2-3 times the diameter of column, then bulging takes place. Failure of Stone Columns depends upon the following factors:

- Type of Stone Column (End-bearing or Free Floating).
- Type of Loading on columns.

6. CONCLUSIONS

Stone columns successfully been used to support isolated footings, large raft foundations and embankment. Apart from their use in soft clays has been found to provide moderate increases in load carrying capacity accompanied by significant reduction in settlement. Granular fill accompanied with good drainage accelerates consolidation settlement and post construction settlement is minimized. Stone columns may have particular application in soft soils such as Normally consolidated clay.

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Deep interest in geosynthetics and reinforced soil structures.