Chapter 1

INTRODUCTION

Construction on soft soils have presented severe challenges to geotechnical engineering. Amongst the various ground improvement techniques, soil reinforcement has always been a preferred choice. Vast areas covered with thick layers of fills or with layers of soft clay deposits are not suitable for the construction of a foundation. With the increasing size of urban areas and industrial zones it is necessary to consider the possibilities of realizing foundations on these areas. Ground improvement techniques are normally preferred for economic considerations. Out of several techniques available, stone columns belong among the most preferable and are also widely used. This ground improvement technique has been successfully used to increase bearing capacity and reduce the settlement of constructions such as storage tanks, earthen embankments, raft foundations etc. Their main advantage lies in improving the soil properties below a structure (raft and depth) and following the reduction of an irregular settlement. In spite of the wide use of stone columns and their development in construction methods, present design methods are empirical and only limited information about designing stone columns are available in technical codes. Installation of stone columns or granular piles as reinforcement in soft or clayey soil has acclaimed wide acceptance as it creates a composite system of overall lower compressibility and higher shear strength compared to original ground. The column drain rapidly removes the excess pore water pressure generated upon application of load and act as strong and stiff elements to carry higher shear stresses at reduced settlements, thereby improving the strength and deformability properties of weak ground. Stone columns subjected to compressive loads experience failure modes such as bulging, general shear failure and punching failure. However the most common failure modes for stone columns in very soft soils is bulging due lack of required lateral confining pressure. In these situations, to provide the required lateral confining pressure and to increase the bearing capacity, stone columns can be reinforced. The effectiveness of this technique is largely influenced by various parameters such as column length, column diameter, reinforcement modulus, reinforcement length, strength of column and the surrounding soil. Most types of ground improvement are intended to work with the existing ground whereas rigid inclusions (piles) are intended to bypass the ground to some extent. While stone columns will transmit some load to the soil by shear stresses (along the column-soil interface) and end bearing (at the column base), the predominant load transfer mechanism (unless the column is very short) is lateral bulging into the surrounding soil. The passive resistance of the surrounding soil dictates the column performance under load. Generally the column bulging will be greatest close to the top of the column where the overburden pressures are highest.

There is considerable interest in the applicability of stone columns to cohesive and organic soils. The following checklist are useful for contemplating a Stone Column ground improvement solution: Organic soils are characterised by high moisture content, plasticity index and compressibility and as a general rule, the higher the organic content, the more difficult it is to arrest settlement in these soils. Most organic silts and clays may be successfully treated. Reinforcement installed around the column's perimeter have also been used to confine columns through weaker strata. Hence the reinforcement technique is adopted for soft clayey soil. The plasticity index (Ip) of a soil reflects the potential for volume change; swelling and shrinkage which will be controlled by adding stone columns. High plasticity soils can still be improved by stone columns in certain circumstances.

Careful examination of the loading in the case of short columns (i.e. less L/d), bulging took place over the entire length of the columns and they punched into the clay beneath their bases. The long column (greater L/d) deformed significantly in the upper region whereas the bottom portion remained undeformed. This suggests that there was little or no load transfer to the base in longer columns, with failure arising from bulging or shear.

1.1. DIFFERENT FAILURE MODES OF STONE COLUMN:

Single stone column can be built upon a firm stratum under a soft soil by end bearing capability or as a floating column with tip of column embedded within the soft soil layer. However end bearing columns are more in practice. To make the most optimum application of stone columns, we must understand the various failure mechanisms it can undergo. Four Basic Failure Modes of Stone Columns are:

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