Strength Improvement in the Soil Using Waste Materials

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Abstract - *In construction industry ground improvement is an important factor, the stone column technique is one of the effective methods used for improving the soil parameters like consolidation and reduce the settlement. In this study, quarry waste which is a waste material from the quarry industry are used in constructing the column to improve the bearing capacity of the soil. The results obtained from model test are compared with aggregate as column. The geotextile uses this study, the ultimate load increasing and reduce the settlement. The stone column fully replaced by waste materials like quarry waste and the result compared by aggregate using columns. In this study conducted by the model test arrangement. The natural materials like aggregate using in stone column is a comparative study of the waste material like quarry waste used in column. The aggregate result similar to the quarry waste. Then the quarry waste used for the columns in ground improvement.*

Key Words: **column, quarry waste, aggregate**

1.INTRODUCTION

The rapid growth of population and infrastructure developments in construction industry has been very dynamic. Then the stone column techniques are the most effective method for improving the soil parameters like bearing capacity. Stone drainage by improving strength and deformation properties of the soft soil. The commonly used material in stone column construction is crushed stone aggregate. Stone column is used in weak deposits to increase the load carrying capacity and reduce settlement of structural foundations. Stone column generally depends upon circumferential confinement provided by native soil or the weak peat deposits over the several deposits below the ground deposits. The loss or poor ground surface conditions are responsible for the failure under foundations so it is very important for ground surface that it should be treated by different ways so as to obtain the better result and helps to improve the better ground surface conditions. In general, the improvement of soft clay using stone columns is due to the following points:

1. The implication of a stiffer column material (such as stone, gravel, etc.) in soft clay.

2. The densification of surrounding soft soil during the installation of the stone column.

3. The stone column and gravel column will be as drains and accelerate the drainage of water and accelerate consolidation process of soft clay.

2. LITERATURE REVIEW

The literature reviews are listed below:

- **Alexiew D et.al. (2005)** conducted experiment is cylindrical test tank. The maximum load carrying capacities of stone column with depths of 0.25L, 0.5L are 612.0N, 663.2N respectively and corresponding settlement is 25mm. The load carrying capacity and stiffness are increased by using lateral reinforcement of column using geo-textile circular 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.

- **Jamal M et.al. (2014)** is carried out by the uses to stone column technique is conducted in soft soil. In this technique always used for isolated footing, large foundation and embankment. Granular and drained materials are consolidation settlement can be primarily minimized. Being granular and freely drained material, consolidation settlement is accelerated and post construction settlement is minimized. Stone columns may have particular application in soft soils such as N.C clay, silt and peat, they are generally inserted on volume displacement basis excavating a hole with specified diameter and desired depth.

- **Golakiya H D** & **Lad M D (2015)** is carried out by the uses of highway construction. Reinforced earth walls have been supported on cohesive soils having shear strengths as 200 to 400 psf. For these very soft soils, wall settlement has been on the order of 1 to 2 ft. Important applications of stone columns also exist for landslide stabilization and liquefaction problems involving bridge foundation and embankment support during earthquakes. The support of a Reinforced earth retaining wall or abutment on stone columns gives a very flexible, compatible type construction, capable of withstanding relatively large movements.

- **Hassan M I H et.al. (2017)** is carried out by the physical and mechanical properties of clay brick. The percentage of quarry dust waste as a second raw material was 10% for obtained the best results in physical and mechanical properties. The results show the decrease in the compressive strength of fired clay brick when the percentage of the waste increased. Furthermore, the density was in the standard range (1879.2 kg/m3). As the bricks become more porous it will result to lightweight brick. The increase of the waste also will produce high suction brick because the IRS test shows it more than 1.5 kg/m2.min. All the physical and mechanical properties were complied with the BS 3921:1985 standard.

- **Dr. Rao H C & Prakash K S (2017)** is carried out by observed that the strength characteristics of quarry dust is same as sand. The specific gravity of all the crusher samples is lies in between 2 to 2.7 which fulfill the sand requirement. The sieve analysis is carried out for the collected quarry dust crusher sample and sand which possess the sand zone. From the experimental study it is concluded that the quarry dust can be used as a substitute for sand. It is identified that 40% replacement of sand by quarry dust give good result in strength than normal concrete for M20 and M30 grade. The results possess that 40% replacement of sand by the quarry dust induced higher compressive strength and the workability of concrete decreases as replacement increases. Thus, the environmental effects and waste can be significantly reduced.

- **Castro J (2017)** is carried out by a single stone column with three types of materials, including recycled crushed brick (CB), recycled crushed concrete (CC) and gravel as natural aggregates was modeled. 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.

- **Nazir R & Zukri A (2018)** is carried out by the partial replacement of compressible soil with more competent and promising materials such as stone aggregate, sand, and other granular materials, presents several benefits in the construction of stone columns. It also acts as reinforcing materials that increase the overall strength and stiffness of soft soils. Until now, a number of researches have been accomplished pertaining to stone column behaviour and performance with various materials used as column fillers. Most of the alternative materials used as stone column fillers or backfill materials can be produced from waste and recycled materials. These materials have been established based on experiments, numerical analysis and physical modelling as conducted in a laboratory. Therefore, the findings need to be further verified in a full-scale environment, to develop design guidelines, specifications and QA testing, prior to implementing any of these replacement materials to be conventionally utilized as stone column fillers. If this is fulfilled, then these materials could offer excellent and sustainable solutions by utilizing potential wastes effectively while reducing demands for primary aggregates. These alternative materials for stone column fillers offer high efficiency apart from being economical, as the materials are cheap, easily available and environmentally friendly.

3. OBJECTIVES

The objectives of this project are listed below:

- To study the settlement in soil using number of stone columns (1, 2) using stones placed at equal intervals encased without geotextile.

- To study the settlement in soil using number of stone columns (1, 2) using stones placed at equal intervals encased with geotextile.

- To determine the settlement in soil using of number of quarry waste columns (1, 2) using quarry waste placed at equal intervals encased without geotextile.

- To determine the settlement in soil using of number of quarry waste columns (1, 2) using quarry waste placed at equal intervals encased with geotextile.

4. SCOPE

The scopes of this project are listed below:

- The number of stone columns varying to investigate this study. For example, 7, 8 etc. columns are used this study.

- The spacing of the stone column varying to this study.

- The pattern of the columns placed in different wise for this study.

5. MATERIAL COLLECTION

5.1 SOIL

The soil found in the Neyyatinkara, Thiruvananthapuram region from the depth up to 1.5 m in soil level. The liquid limit is 39.50% and the plasticity index is 1.61 %. According to Indian Standard Soil Classification System (ISSCS) based on particle size distribution and the plasticity characteristics of the soil, it is classified as the Organic Silt (MH). The table 1 shows properties of soil. The figure 1 shows the plasticity chart.

Table-1: Properties of soil

Moisture Content (%)	31.00
Liquid limit (%)	39.50
Plastic Limit (%)	37.89
Plasticity Index (%)	1.61
Specific Gravity	1.89

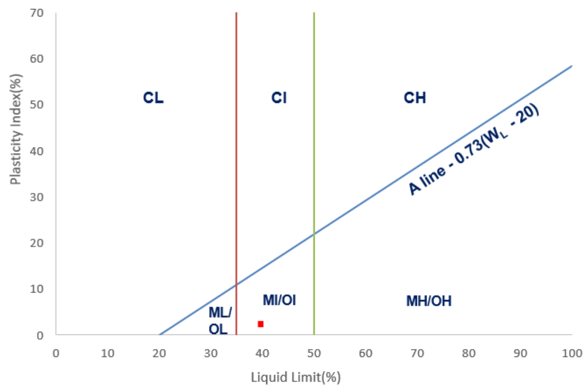

Chart-1: Plasticity Chart

5.2 AGGREGATE

The aggregate was collected from quarry industry. The Stone column is generally constructed with the help of crushed aggregates, gravels, recycled aggregates and different sizes of aggregates such as 20mm to 70mm size of aggregates used in the formation of the stone column. The table 2 shows the properties of aggregate.

Table-2: Properties of aggregate

Properties	Value
Bulk specific gravity	2.61
Water absorption (percentage of dry weight)	0.33
Finess Modulus	7.25
Unit weight (kg/m^3)	1653.4

5.3 QUARRY WASTE

The quarry waste is the byproduct of quarry industry. Quarry waste consist of overburden, rock, or processed material, which has no economic value and is stored temporarily or permanently at the extraction site. The table 3 shows the properties of quarry waste.

Table-3: Properties of quarry waste

Properties	Value
Specific gravity	2.57
Water absorption	0.30
Finess Modulus	2.80
Surface texture	Rough

5.4 GEOTEXTILE

The geotextile are those fabrics used in geotechnical applications, such as road and railway embankments, earth dikes and coastal protection structures, designed to perform one or more basic functions such as filtration, drainage, separation of soil layers, reinforcement or stabilization.

6. RESULTS AND DISCUSSION

In this part, first data of loading the column made of different materials compared. Then, the outputs of the loaded columns, constructed of both natural and waste materials, are evaluated and compared together.

6.1 Ultimate load

In this study mainly focused on two materials ultimate load. The two materials ultimate load as given below.

6.1.1 Ultimate load from aggregate as column

The below table 4 shows the ultimate load on aggregate using with and without geotextile. In this study, the ultimate load for with geotextile is higher than that of without geotextile. The below figure 2 shows the ultimate load on without geotextile. The figure 3 shows the ultimate load on with geotextile. Using geotextile, the ultimate load increasing and settlement rate reduced.

Table-4: Ultimate load on Aggregate

No of columns		Ultimate Load (kN)	
		1	2
Aggregate	Without geotextile	3.1	3.2
	With geotextile	3.6	3.5

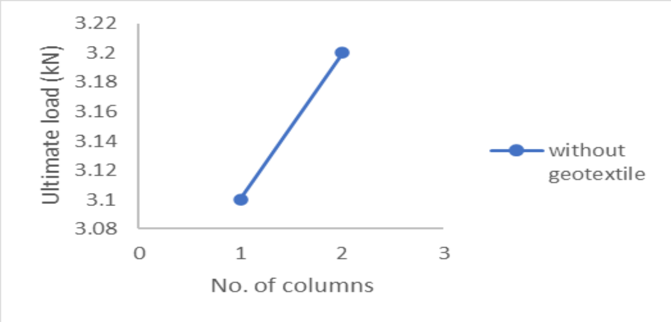

Chart-2: Ultimate load on without geotextile

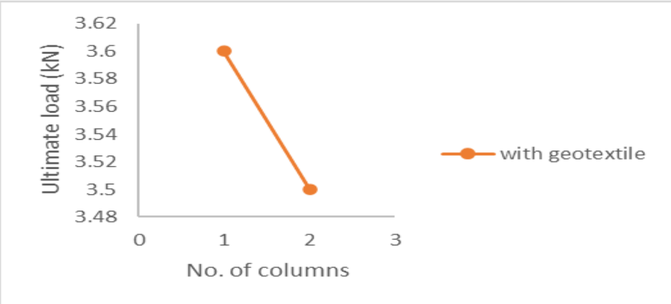

Chart-3: Ultimate load on with geotextile

6.1.2 Ultimate load from quarry waste as column

The below table 5 shows the ultimate load on quarry waste using with and without geotextile. The figure 4 shows the ultimate load on without geotextile. And the figure 5 shows the ultimate load on with geotextile.

Table -5: Ultimate load on Quarry waste

No of columns		Ultimate Load (kN)	
		1	2
Quarry waste	Without geotextile	3.0	3.1
	With geotextile	3.5	3.5

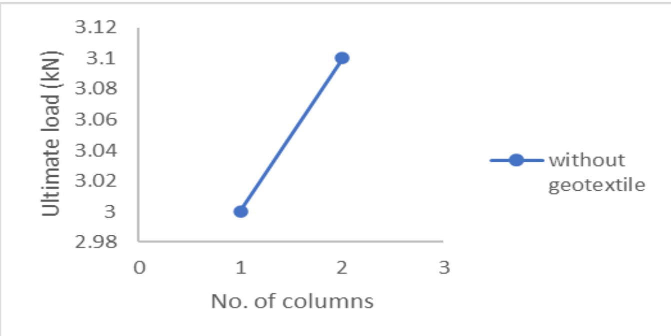

Chart-4: Ultimate load on without geotextile

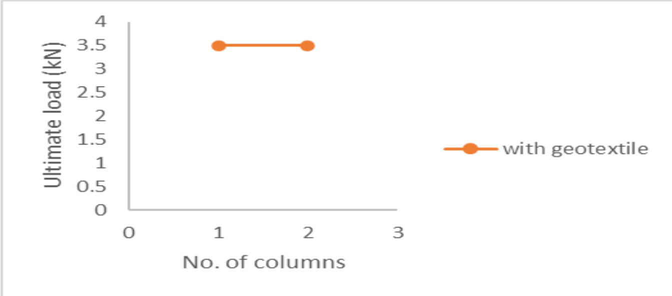

Chart-5: Ultimate load on with geotextile

6.2 Settlement

In this study, mainly focused on two materials like aggregate and quarry waste.

6.2.1 Settlement from aggregate as column

The table 6 shows the settlement on aggregate using with and without geotextile. The figure 6 shows the settlement without geotextile. The figure 7 shows the settlement with geotextile.

Table-6: Settlement on Aggregate

No of columns		Settlement (mm)	
		1	2
Aggregate	Without geotextile	0.30	0.29
	With geotextile	0.29	0.20

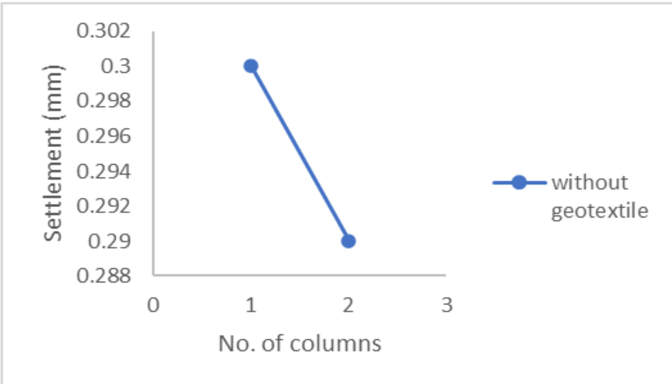

Chart-6: Settlement on without geotextile

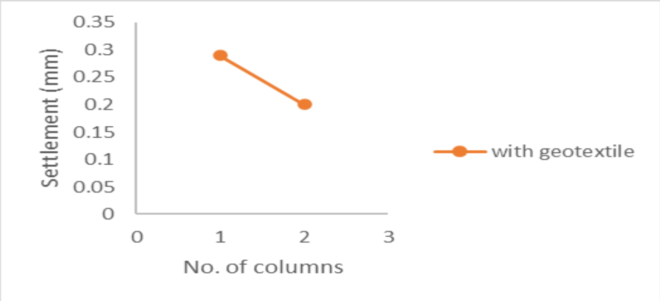

Chart-7: Settlement on with geotextile

6.2.2 Settlement from quarry waste as column

The table 7 shows the settlement on aggregate using with and without geotextile. The figure 8 shows the settlement without geotextile. The figure 9 shows the settlement with geotextile.

Table-7: Settlement on Aggregate

No of columns		Settlement (mm)	
		1	2
Quarry waste	Without geotextile	0.29	0.19
	With geotextile	0.29	0.14

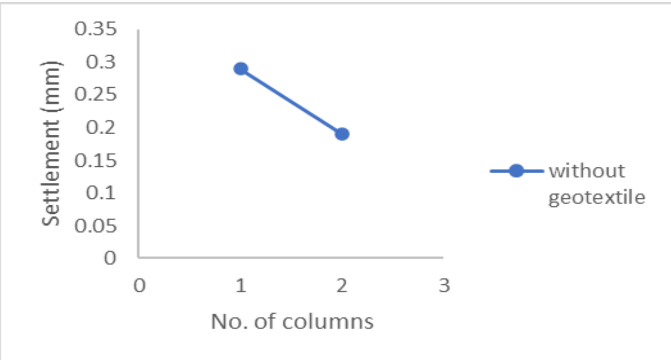

Chart-8: Settlement on without geotextile

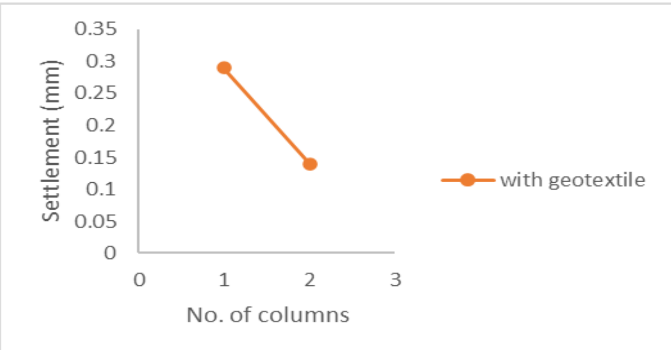

Chart-9: Settlement on with geotextile

In ultimate load and settlement graphs clearly known the number of columns increasing the corresponding load increases and the corresponding settlement rate reeduces. The columns used for the soil strength can be increases. The geotextile used in the columns, the strength increases with respect to the without geotextile. The geotextile used, the strength improvement in soil ane no bulging effect.

7. CONCLUSIONS

This chapter deals with the conclusion derived from the obtained results and discussion from this study. The soil improvement study for using stone column techniques as replacement of stones in various material like quarry waste. These materials using in soil to determine the settlement by test. And the results were obtained and the compared along these materials. The settlement rate was also compared in every case. It is expected that with the use of waste material like quarry waste in replacement in column to improve the soil strength and to reduce the settlement rate.

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