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Ground improvement by stone column of soft silty soil bed

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***Abstract** — Stone columns are extensively used to improve the bearing capacity of poor ground and reduce the settlement of structures built on them. A stone column is one of the soil stabilization methods that is used to increase strength, decrease the compressibility of soft and loose fine graded soils, accelerate a consolidation effect and reduce the liquefaction potential of soils. They are mainly used for stabilization soft soil such as soft clays, silts and silty-sands. It may be possible to limit settlement and increase the strength of foundation. During an earthquake, stone columns can also act as a gravel drain column to release pore water pressure and the liquefaction potential of a ground can be reduced.*

coarse aggregate, quarry dust. The test was performed in laboratory to understand geotechnical engineering properties. The Atterberg limit, Specific gravity, Standard compaction test, Unconfined compressive strength, model plate load test, were performed on very soft silty soil. The optimum moisture content of the soil bed is 26 percent which is higher than its liquid limit.

Keywords Stone column, Standard proctor test, UCS test, Encapsulation, aggregates

I. INTRODUCTION

Stone column enhances the shearing strength of soft silty soil bed. The main purpose is to increase the bearing capacity of weak ground and reduce the settlement of foundation. it also helps in reducing the liquefaction potential of soils. There are a number of methods available to improve ground conditions such as stone columns, jet grouting, compaction grouting, short pile, dynamic compaction, lime stabilization etc. Before using any of these methods, it is required to know the local ground conditions in detail. Even though processes are costly and time consuming, they must be done in order to choose a most suitable and appropriate ground improvement method to mitigate the undesirable consequences both under static and dynamic conditions.

One of the techniques extensively used in soft silty soils is vibro replacement, which consists of replacing some of the soft soil with crushed rock or gravel to form an array of stone columns beneath the foundation. The use of conventional stone columns in soft soil deposits was found to benefit foundations in many respects.

II. OBJECTIVE OF STUDY

- Ratio of aggregate and quarry dust for good strength,
- Increased strength to improve stability of soft soil bed,
- Reduced deformation due to compressibility of the soft soil bed,
- Reduced susceptibility to liquefaction.

III. LITERATURE REVIEW

In present literature study, stone column is used to release pore water pressure and to improve the liquefaction potential of a ground.

❖ Improvement of soft soils using Geogrid encased stone columns
Joel Gniel 1, Abdelmalek Bouazza* (June 2009)

- This paper discusses the results of a series of small-scale model column tests that were undertaken to investigate the behaviour of Geogrid encased columns. The tests focused on studying the effect of varying the length of encasement and investigating whether a column that was partially encased with Geogrid would behave similarly to a fully-encased column. In addition, isolated column behaviour was compared to group column behaviour.

- The constrained conditions provided by unit-cell loading provided additional lateral confinement to the encased columns, preventing radial column failure and enabling encasement mesh to be loaded to tensile capacity. Isolated columns failed by radial expansion below the level of encasement.
- For group columns, increasing the length of encasement acted to increase column stiffness and steadily reduce vertical strain. Fully-encased columns reduced vertical strain by about 80% when compared to clay behaviour alone.
- For isolated columns, increasing the length of encasement acted to increase column capacity, although the strain at failure remained quite consistent. A large increase in capacity was observed for the fully-encased column.
- Significant radial column bulging occurred directly below the base of the encasement. For partially encased group columns this bulging occurred along the full-length of the non-encased section. For partially encased isolated columns, this bulging was confined to a length of about 2 column diameters.

❖ Ground Improvement Using Stone Column
K. S. BEENA (2010)
Cochin University of Science and Technology, Cochin, Kerala, INDIA

- Many methods for ground modification and improvement are available around the world now, including dewatering, compaction, preloading with and without vertical drains, grouting, deep mixing, deep densification and soil reinforcement are among those. Many of these techniques, such as dewatering, compaction, preloading and grouting, have been used for many years.
- The author has highlighted the importance of using stone column for improving the liquefaction resistance of cohesion less soil bed using quarry dust.

➢ Effect of Quarry dust

- The stone chip in the stone column is replaced by quarry dust with varying proportion in order to reduction the cost of the stone column. The percentage of quarry dust varies as 30 %, 50% 70%, 100%. The pressure settlement behavior for column

Conclusions

Encasing the stone column with geotextile result in an increase in load carrying capacity and reduction in settlement when compared to that with the case without geotextile.

• A portion of stone in the column can be replaced by quarry dust without affecting the strength of the improved ground.

• The replacement of 30% (by weight) of stones by quarry dust can be possible without affecting the strength and performance of the system.

• Further studies in this direction have to be conducted so as to get more understanding of the system specially in the context of liquefaction.

III. MATERIAL CHARACTERIZATION

For this experiment the soil is used silty soil which is available at nearer to sea or river or water level. collected sample has been air dried and pulverized. The pulverized sample was sieved through 75 microns for easy mixing and quicker hydration. the property of silty soil, quarry dust, stone aggregate, Geogrid and Geojute.

Table 1. Properties of Soil.

PROPERTY	VALUE
Specific gravity	2.4
Liquid limit	24.74
Plastic limit	0
Clay content %	12.769
Silt content %	62.60
MDD (gm/cc)	1.4
OMC %	26

Table 2. Properties of quarry dust and stone.

PROPERTY	QUARRY DUST	STONE	STONE
Effective size (mm)	2	10	20
Density gm/cc	1.949	1.65	1.56
Cohesion (kg/cm^2)	0.15	-	-
E modulus of elasticity N/mm^2	147.84	102.56	76.22
Uniformity coefficient	0.53	3.1	7.4

IV. EXPERIMENTAL DETAIL

Air dried and pulverized soil sample was mixed with 26% of water. Initially the soil was thoroughly mixed with the water and kept covered for 24 hours in order to achieve uniform consistency. After 24 hours of hydration, the soil was mixed and kneaded well and checked for moisture content. Loss of water, if any due to evaporation was compensated by adding water before forming the bed. Thoroughly mixed clay is filled in the tank in layers of 200 mm thickness and the weight of clay was adjusted so as to achieve a uniform wet density of 1.4 gm/cc. the total height of the soil bed was 600 mm

- Stone column installation:

The center of the square tank was properly marked and a PVC pipe of required diameter was place of the center at the tank and soil bed was formed. The pipe was filled with 10mm, 20mm and 2mm (quarry dust) size of aggregate and stone column was prepare by pulling the pipe.
The pipe was placed at the Centre of the soil bed having single stone column of diameter 50mm respectively and load was applied. The curves were recorded with load – settlement.

- Experimental setup for load test:

The test was conducted on a single column of diameter 50 mm for property of stone and quarry dust on standard loading frame.

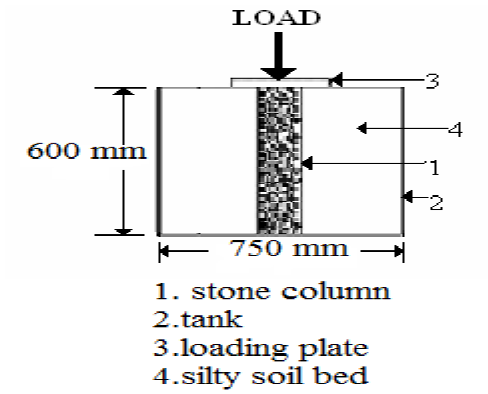

Fig 1. Sketch of set up of test

Size of plate: 100mm* 100mm*120mm
Size of stone column: D= 50 mm
H= 300mm

Fig 2. Pic of the Test set up

V. RESULTS AND DISCUSSION

I. *Effect of stone column (diameter 50mm) with 10 mm 20 mm and 2 mm size of aggregate.*

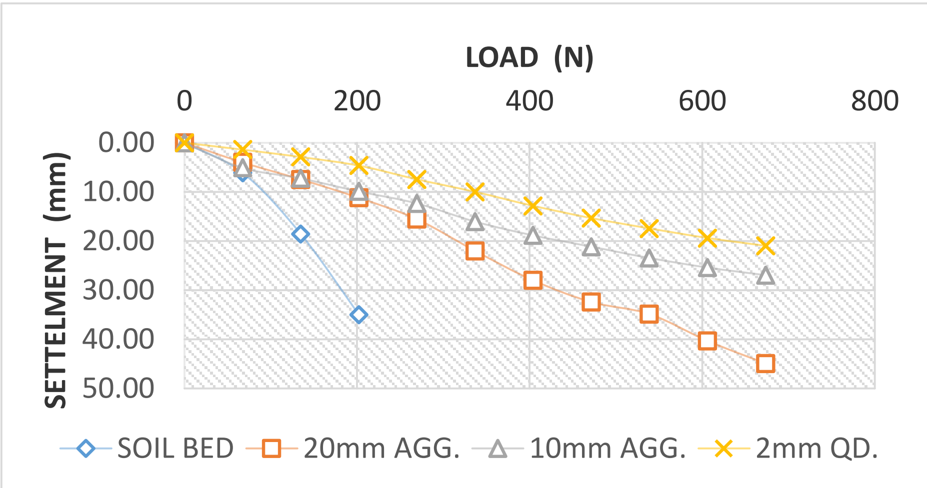

Fig 3

II. *Effect of stone column (diameter 50mm) with ratio various % of aggregate and quarry dust.*

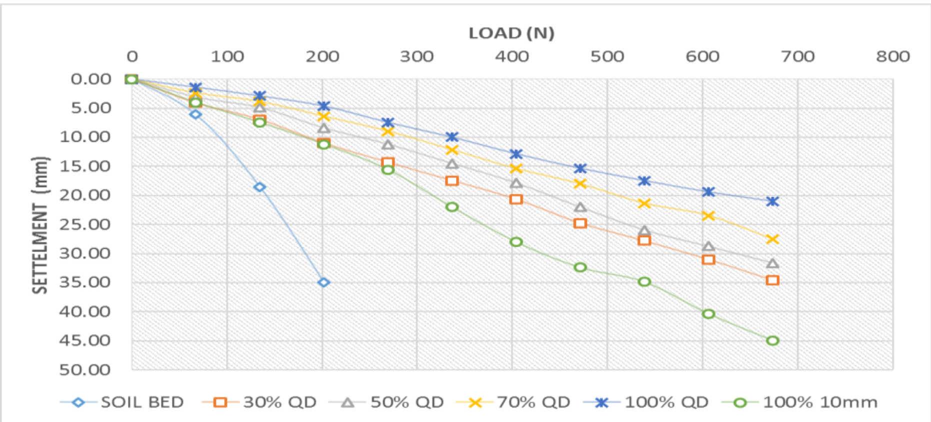

Fig 4

III. Effect of stone column (diameter 50mm) with ratio various % of aggregate and quarry dust.

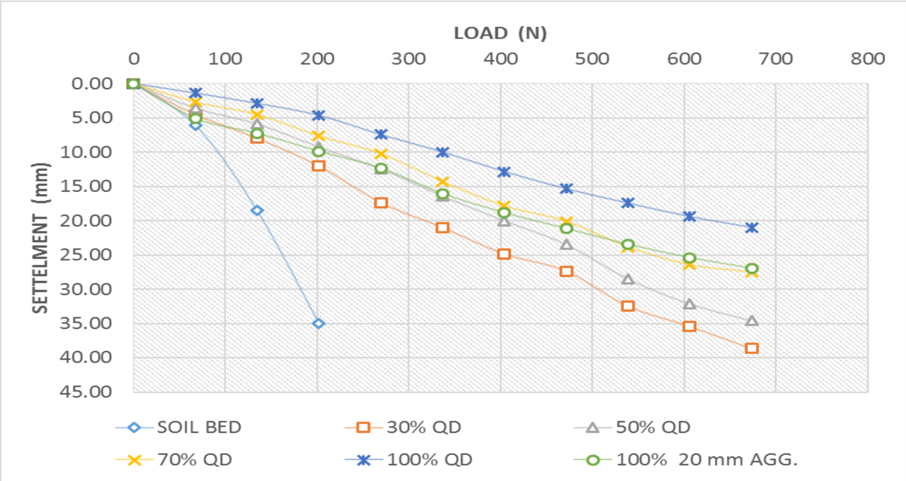

Fig 5

It is observed from above results that

- The load carrying capacity of quarry dust is more as compare to the 20 mm size and 10 mm size of aggregate at various settlement.
- It is the found that the load carrying capacity of quarry dust stone column given highest value compared to the rest.

Table 3. Results for Various Proportions of Quarry dust and different size of stone in stone column

PROPERTY OF STONE COLUMN	AT 10 mm SETTLEMENT LOAD N	AT 20 mm SETTLEMENT LOAD N	ULTIMATE LOAD CAPACITY N/mm^2
Soil bed	90	135	135
Stone column (10mm)	200	435	315
Stone column (20mm)	175	330	290
Quarry dust (2mm)	325	615	335
30% QD with 10mm	185	390	250
50% QD with 10mm	170	325	285
70% QD with 10mm	150	300	300
30% QD with 20mm	210	425	220
50% QD with 20mm	235	450	245
70% QD with 20mm	255	485	260

IV. CONCLUSIONS

The use of stone column is an acceptable technique for poor ground condition. The cost of construction mainly depends on the cost of stone used for filling the stone column. Here an alternative is thought of, to replace partially, the stones filling the column by lower cost material. The following observations could be made from this study.

- Stone column improves the bearing capacity and reduce the settlement behavior of poor ground.
- The increment in the load bearing capacity is due to fill of void by quarry dust. But there is a very small difference in the ultimate load capacity.
- To fill the different size ratio material of stone column is more effective as compare to the single size material.
- Further studies in this direction have to be taken up so as to get more understanding of the system specially in the context of liquefaction.

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