IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

IMPROVEMENT OF ENGINEERING PROPERTIES OF SOFT COHESIVE SOIL USING GROUTED TECHNIQUE

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Abstract: Grouting have been used effectively in many application of ground improvement to increase the bearing capacity and reduces the settlement, particularly in strengthening the foundation.The main purpose of this study is to examine the effectiveness of using cement grout to improve the bearing capacity and settlement reduction on soft clay. For this purpose, the grouting is conducted by varying water cement ratio and pressure .The index and engineering properties of both untreated and treated soil is studied. Laboratory load test is carried out on model footing of dimension 7.5cm x 7.5 cm x 1.0 cm resting on soft clay before and after the grouting process.

The load versus settlement behavior of both cases were compared and the results obtained from the load-settlement analysis indicate that maximum load bearing capacity of footing on cement grouted clay increased to about 6.5 times and the settlement of footing reduced to 2.7 times when compared to that of untreated soft clay.

Index Terms - Expansive soil, cement grout, footing, bearing capacity, settlement reduction

S 1.INTRODUCTION

Soil stabilization has become one of the useful solutions to treat the soft soils to achieve the required engineering properties and specification so that structures can be placed safely without undergoing large settlements. The use of admixture such as lime, cement, oils and bitumen is one of oldest and most widespread method for improving soil. Bearing capacity improvement and settlement control of soft clay with cement grout reinforcements under footing have been widely used. These cement grout reinforcement techniques were used to prevent the foundation failure under different circumstances. In previous studies, soil is reinforcements are used to improve the properties of soft clay. the ability of strengthening the soil by different reinforced elements in the vertical form was investigated.Morever the possibility of using different vertical reinforcement in the form of geogird and bamboo sticks was reported and studied .

Grouting techniques in the vertical form are widely used and considered as a rigid reinforcing element. Grouting have been used effectively in many application of ground improvement to increase the bearing capacity and reduces the settlement, particularly in strengthening the foundation. In this study, soft clay is grouted with cement slurry and the improvement in bearing capacity and reduction in settlement was observed.. Investigation of the Engineeering properties of cement grout in soft cohesive soil and developed shear strength was studied.

The main objective of this paper to analyze the technique of using cement grout on inserted column on required spacing surrounded by model footing to increase bearing capacity ,mitigate the settlement and control the horizontal movement below the footing soil system.

2. MATERIAL AND METHODOLOGY

2.1Materials

The Soil used in these study is black cotton soil Representative soil sample is collected behind GCT Guest House, GCT Campus. The locations are 11.01780 N and 76.9380 E. The clay sample was collected below 1.5m depth and care was taken to avoid loss of moisture before testing The physical and engineering properties of Black Cotton soil are determined as per the relevant IS codes and presented in table-1 & 2. and cement grout is made up of suspension grout of cement(ordinary Portland cement) and water. The physical properties of the cement are summarized in Table 3 .

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Table 1 Physical Properties of Black cotton soil

S.No	Properties of Clay	Value
1	Grain Size Distribution (%) Gravel (> 4.75mm) Sand (4.75-0.0 75mm) Silt (<0.075mm) Clay (<0.002mm)	 0% 28% 56% 16%
2	Atterberg's limits Liquid Limit (%) Plastic Limit (%) Plasticity Index (%)	 53% 28%
3	IS-Classification (Clay of High Compressibility)	CH
4	Specific Gravity	2.63
5	Free Swell Index (%) (Very high)	73%

Table 2.Engineering properties of soil

S.No	Properties of Clay	Value
1	Compaction Properties Optimum Moisture Content (%) Maximum Dry Density (kN/m^3)	 23% 1.65g/cc
2	Unconfined Compressive strength (qu)	67 kN/m^2
3	Cohesive strength	34 kN/m^2

Table3. Physical properties of cement

S.NO	Properties	Results
1	Initial setting time(min)	165
2	Final setting time(min)	220
3	Fineness(cm^2/g)	3140
4	Avg.strength after three days(kg/cm^3)	230
5	Avg.strength after seven days(kg/cm^3)	310

3.TESTING PROCEDURE

3.1 Preparation of foundation medium

The air dried and pulverized clay sample of required quantity passing through 4.75mm IS sieve was taken and mixed with required quantity of water to achieve the required consistency. Initially the soil was thoroughly mixed with the water and filled in the model tank in 5 layers the number of blows required for each layer was calculated with the help of relationship between compaction energy volume of sample height of hammer height of fall number of layers. The dense condition is achieved by compaction using hammer weights about 4.5kg and height of fall 45cm.PVC pipe inserted with spacing of 5cm.The grouting mixture inserted in PVC pipe using water cement ratio of 0.6 with pressure 80kPa.and cured for 3 days to achieve its strength.

3.2 Grouting mix properties

The water cement mixes are prepared considering ratio between clay and cement injected by the ratio of 1:25 . This Ratio was taken from this various experimental mixes which provides acceptable grouting viscosity and strength. In order to prepare the grout mix, the subsequent steps to be followed:

1. The weight of clay required for injection should be determined according to its volume, and hence the required weight of clay equal to (W x d x 0.6 x γ_{clay})
2. The weight of cement is determined according to zone of clay to be injected as before by ratio 1:25.
3. The optimum water cement ratio is determined. The designed amount of water is added to the cement to form the grout mix.
4. The designed amount of water is added to the cement to form the grout mix.

A tested sample was prepared by casting the grout mix on clay sample at a given density in PVS cylinder(38 mm diameter and 76 mm height) and model steel box (35 x 35 x 45cm) They were cured for 3 days until the mix hardens ; subsequently ,the hardened grouts the chosen water cement ratio has low bleeding and a viscosity permitting the grout to penetrate into clay .

3.3 Model Footing and Tank

The soil bin in steel box of side dimension 35cm and 35 cm and 45 cm depth. Experimental work on shallow foundation to limit the number of variables involved.The footing model was made up steel box section 7.5cm x 7.5 cm x 1.0 cm

3.4 Number of blows

The number of blows required for each layer is calculated with the help of relationship between compaction energy, volume of sample, weight of the hammer, height of fall, number of layers. With respect to above calculation, the number of blows was found to be blows using 2.6kg weight of hammer for each layer. The foundation medium was prepared by placing the prepared sample in three equal layers with compaction as calculated.

4. EXPERIMENTAL SETUP

4.1 Vertical loading test setup

The vertical load was applied to the model raft by means of 50 ton capacity compression testing Machine. The load frame consists of proving ring of 50kN capacity with 0.0606kN accuracy was used to record applied load. The settlement was measured using a linear variable displacement transducers (LVDT) having 0.01 sensitivity.The test is proceed until the pile achieves its ultimate axial capacity for the corresponding failure load.

Figure 1 Vertical loading arrangement

5. RESULTS AND DISCUSSION

5.1 The Load settlement relationship

Loading tests were carried out in accordance with testing program.Load – displacement relationship for each test is plotted and then gathered as shown. The ultimate bearing capacity of the footing soil system of each test was obtained from the load displacement curves. From these figures it can be seen that the presence of the cement grout improves the bearing capacity of the footing soil system. As the relative depth of grouted inclusion increases, the footing load Capacity increases,the footing load capacity increases. Also, it is noticed that the load settlement curves are improved with the increases of various pressure. which increases the stability of soil under the footing are shown in the figure

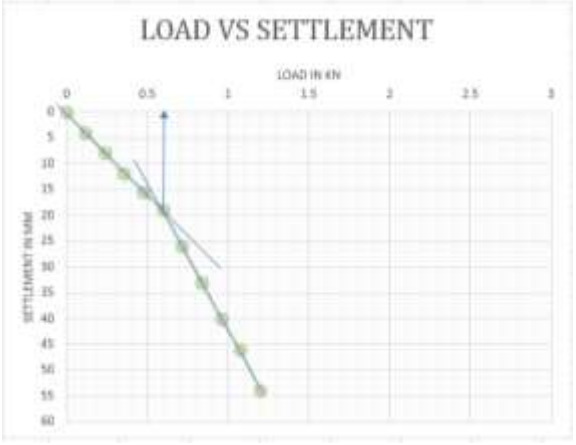

Figure 2 Load settlement graph for model footing Resting on soft clay without cement grout

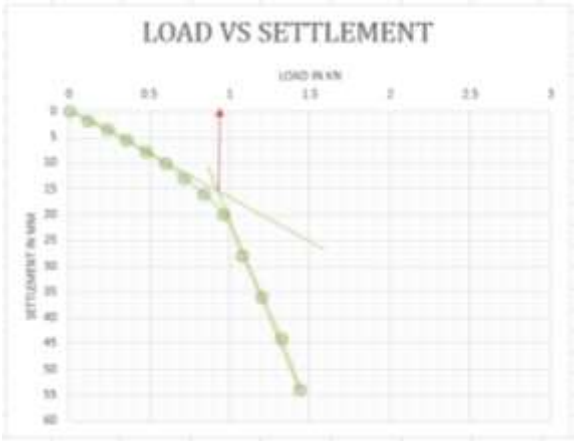

Figure 3 Load settlement graph for model footing Resting on soft clay with cement grout of 40kPa

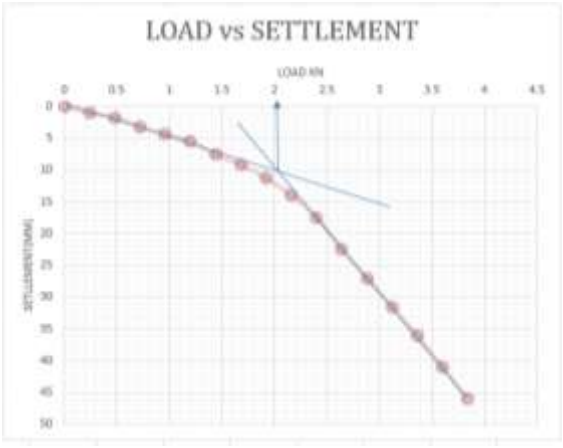

Figure 4 Load settlement graph for model footing Resting on soft clay with cement grout of 80kPa

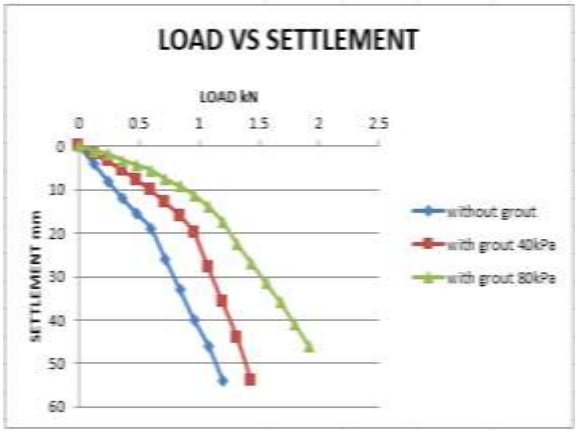

Figure 5 Comparison graph for without and with cement grout

The ultimate Load carrying capacity of model footing resting on soft clay without cement grout was determined from the figure 2 is found to be 0.52kN and failure load for 40mm is 0.8kN.And the model footing resting on soft clay with cement grout considering pressure of 40kPa was determined from the figure 3 is found to be 0.85kNand failure load for 40mm is 1.75kN.And the model footing resting on soft clay with cement grout considering pressure of 80kPa was determined from the figure 3. is found to be 2.2kN and failure load for 40mm is 3.5 kN. Below graph explains Load- settlement for the model footing with cement grout resting on soft clay considering Pressure of 40kPa and 80 kPa.Ultimate load carrying capacity is found pressure of 40kPa and 80kPa is 0.85kNand 2.2kN respectively and Failure load for 40mm is pressure of 40kPa and 80 kPa is 1.75kN and 3.5kN. . From the figure 5 the ultimate load carrying capacity of model footing on soft clay with cement grout considering pressure of 40kPa and 80 kPa increases 1.6 and 5times of without cement grout and the settlement of model footing on soft clay with cement grout considering pressure of 40kPa and 80kPa decreases 2.5 and 6 times of without cement grout.

Table 4 Ultimate Load Carrying Capacity of without and with cement grout

S.No	Samples	Ultimate Bearing capacity (kN)	Failure Load(kN)
1	Without grout	0.52	0.8
2	With grout at 40kPa	0.85	1.75
3	With grout at 80 kPa	2.2	3.5

6.CONCLUSION

The current study was undertaken to investigate the improvement of load carrying capacity of foundation and reduction is settlement by using grouted technique. For this purpose, experiments were conducted in model strip footing with and without grout in the foundation medium. From this experimental results the following conclusion were made.

1. The ultimate load carrying capacity of soft clay without cement grout was found to be 0.52kN and load at the permissible settlement of 40mm is 0.8kN.
2. The ultimate load carrying capacity of model footing on Soft clay with cement grout considering pressure of 40kPa and 80kPa is 0.85kN and 2.2kN respectively, and load at the permissible settlement of 40mm for soft clay with cement grout at 40kPa and 80kPa is 1.75kN and 3.5kN respectively.
3. Load carrying capacity of model footing resting on soft clay with cement grout was found nearly 5 times then that of ungrouted soft clay. Similarly, the settlement of model footing on soft clay with cement grout showed reduction in settlement of about 6 times than that of the ungrouted soft clay.
4. Better improvement in the performance of footing can be obtained when soft clay is stabilized with cement grout. The reason of improvement by the addition of cement is due to high cation exchange capacity could lead to the binding that would participate in formation of cementing material plays a major role clay stabilization.
5. Hence, from the experimental study of load-settlement behaviour there is an overall improvement in the load carrying capacity and a significant reduction in the settlement of soft clay .

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