IMPROVEMENT OF BEARING CAPACITY OF SANDY SOIL BY GROUTING

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ABSTRACT—*The structures constructed in the coastal belt requires deep foundation due to the existence of week soil which has poor Engineering properties. The soil profile about 3 to 4 meters deep, in these areas is mostly loose sand which are then underlain by clayey soil. The structures constructed here suffer excessive settlement. In this paper the bearing capacity of soil is improved in order to reduce settlement and this done by grouting. Ordinary Portland cement is used. It was found that shear strength of the grouted sand increases with the increase in cement quantity also it is found from results that 4%cement grout is effective as compared to 2% and 6% of grout.*

Index Terms—Enter Cement, Grouting, Ground Improvement, Sandy soil.

1. INTRODUCTION

THE term ground improvement basically refers to the improvement to the Engineering properties of soil which are not present in its natural state. Ground improvement refers to the increase in shear strength, decrease in permeability, and decrease in compressibility. A number of techniques have been developed so far to improve the ground conditions. [1]

One method is to excavate the week soil and then replace it with soil having the desired properties but this method is used only at a depth of 3m and water table must be below 3m, otherwise it will be uneconomical to excavate large amount of soil and replace it. [2]

Selection of ground improvement techniques basically depends upon a number of factors like the soil condition, type of structures, time available for the project completion, material and equipment's availability, degree of compaction and also the transportation facility. [9]

Many of the foundation problems can be effectively solved by compaction, which will cause reduction in total settlement. But compaction of soil depends upon the vertical effective stress and gradation of soil etc. That is well graded soil compact more than poorly graded soil. [3] Dynamic compaction gives best results up to depth of 10 to 20m.The relative density of Sandy soil properties cannot be increased by compaction or by vibration, the best method is grouting. Grouting is mostly used in foundations of the structures. It is also used in seepage control in dams, rocks, cutoff walls and tunnels. The technique of grouting is to fill the voids between the medium by a grouting material in order, to improve the Engineering properties. [4]

Grout is basically a liquid solution or suspension that is injected into the soil under pressure in order to fill up the voids present between the soil particles and to bind them together. Grouts are available in two forms one is the suspension grout. Which is basically small sized particles suspended in a liquid example is cement grout and bentonite grout both are made in water mostly cement grout is used with a mixing ratio of 10:1 or 2:1 and the other is solution grout, which consists of a variety of chemicals like sodium silicate acryl amide, lingo sulphonates, amino plasts and many more. Cement grout has a number of advantages it not only fills the voids but also sets with time, reduces the permeability and binds the soil particles. [5]

The grout properties are; stability, permanence, grout ability, toxicity and setting time. Following are some the grouting methods; permeation grouting, compaction grouting, hydro-fracture grouting and jet

grouting. [6]

II. METHADOLOGY

A. Material

The proper selection of grouting material is very important and depends upon the purpose of grouting and the type of granular material. Here in this study sand is used as a granular material and cement is used as a grouting material. [5]

1) Sand

In this project sand is used as a granular material, which is collected from Sardaryab, Charsadda, which is a part of Kabul River. The grain size distribution is shown as below.

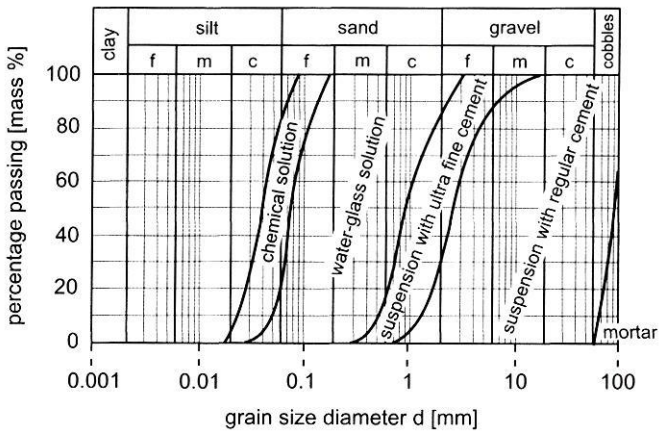

Figure 2:Grain size distribution curve of sand

2) Sand Cone replacement test

Sand cone replacement test is conducted in order to find the insitu density of sand. Suitable site selected. Sample is collected from the top surface and at a depth of about 3ft and 6ft.The moist unit weight of sand was found to be 1030.211 kg/m^3. While the dry unit weight was calculated as 944.543 kg/m^3.

3) Specific Gravity

Pycnometer is used to determine the specific gravity of sand, and the results are shown in the following table

Specimen number	
Pycnometer bottle number	1
W_P = Mass of empty, clean pycnometer (grams)	17.7 g
W_{PS} = Mass of empty pycnometer + dry soil (grams)	20.20 g
W_B = Mass of pycnometer + dry soil + water (grams)	69.70 g
W_A = Mass of pycnometer + water (grams)	68.0 g
Specific Gravity (G_S)	3.125

Figure 3: Specific gravity of sand

4)Cement

The ordinary Portland cement of grade43 is used for preparing the cement grout. In order to avoid any changes in the properties of the cement, it is stored in air tight bins. And for further precaution, once a

was opened it should be used within ten days.
The physical properties of cement were calculated.

5) Fineness
The fineness of cement was determined using dry sieving. From the results it was found that percent fineness is 91%.

6) Standard consistency
This test is performed to find out the right amount of water required to make a paste of standard consistency and from the test results it was calculated as 28%.

B. Tests on grouting material

Following test were performed on the grouting material to find its properties.

1) Shear strength test
The test was performed direct shear box test.

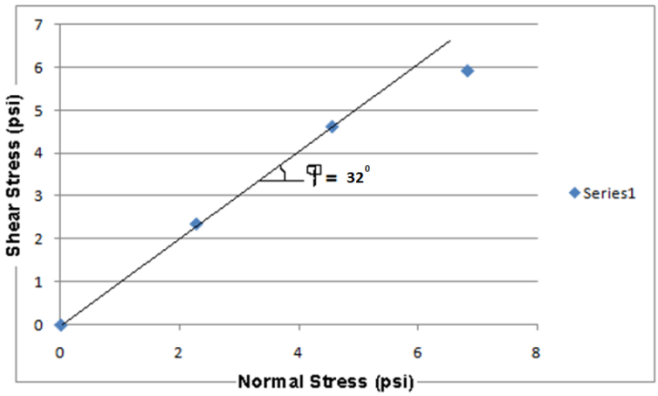

Figure 4: Graph b/w Shear stress and Normal stress

2) Permeability
Permeability is the property of porous material which permits the seepage of water through the void. Stiff clay is least permeable and gravel is highly permeable. In the present study constant head test is used to find the permeability. And from the test the hydraulic conductivity, k = 1.52 * 10-3 cm/sec was calculated.

C. Plate load tests

The efficiency of the grouting process was also verified through load tests conducted on ungrouted / grouted sand beds.The initial tests for the assessment of improvement in load carrying capacity through densification were conducted by filling the sand at the desired densities in small tanks of size 30cmx30cmx30cm.

Figure 5: Sand in mold

1) Without grouting

The sample is placed in the mold in its loosest form. Then the sample is placed in universal testing machine. Load is applied by 6in circular plate.

Figure 6: Sample in universal testing machine

The sand is compressed and the load settlement curve is obtained on the computer. The load settlement curve is shown below:

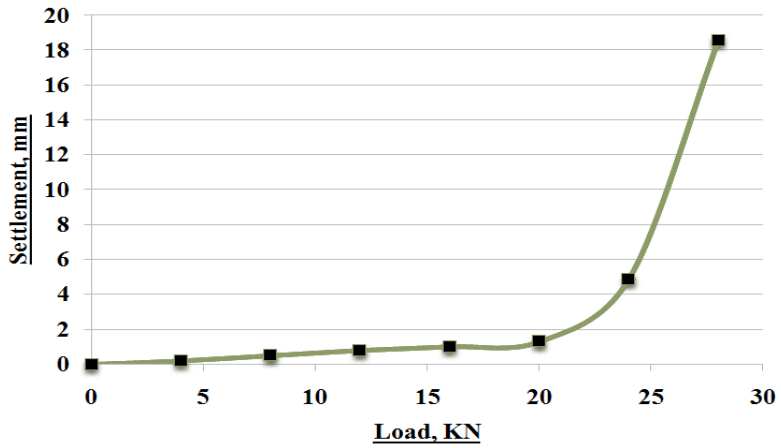

Figure 7: Load settlement curve

2) With grouting

Plate load test are conducted for various ratio of grout starting from 10:1 to 4:1 water-cement ratio.

3) Grout ratio 10:1 to 4:1

The grout is prepared by water cement ratio by weight. And grout is injected using four PVC pipes having 20mm diameter with perforation of 3mm diameter in the surface of pipe. The perforations are 36 in number. In order to make grout more effective the bottom of PVC is made plugged so that the grout can easily be dispersed. The grout is agitated well and then poured in order to reduce the chances of segregation. The grouted sample was kept under moist condition for a curing period of 3 days and 7 days.

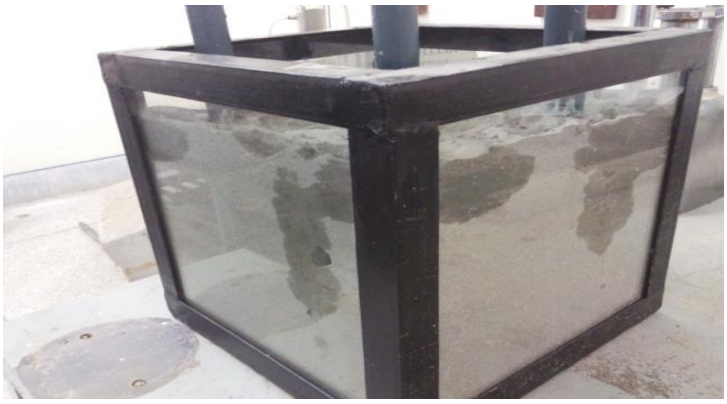
Figure 8:Permeation of grout occur

After 3 days curing the plate load test is performed on it. The following load settlement curves are obtained.

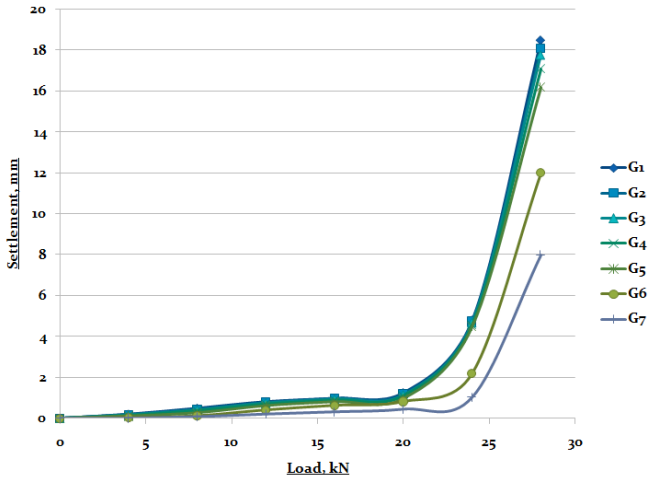

Figure 9: Combined load settlement curve

III. Conclusions

The following are the conclusions drawn from plate load test:

1. The ultimate load decreases as the grout ratio increases.
2. As the cement content increases the angle of internal friction and cohesion also increases also with curing.
3. In medium and coarse sand about 4%of cement grout is effective as compared to 2& and 6%.
4. The medium sand grouted with 4% cement grout, strength behavior is much highest than at loosest form.
5. The shear strength of sandy soil increases with the increase in cement content.
6. Compressive strength of grouted material also increases with the increase in the cement content and curing.
7. Moreover, the permeability reduces with the increase in cement content and it is more effective when used along with clay.
8. As compared to lime the effect of cement along with clay is more pronounced for the reduction in permeability.

This research proves that grouting is an effective way of improving the foundations of structures constructed on loose sandy soil.

IV. Recommendations

It is recommended from the study that permeability should also be tested at a water cement ratio of 2.0 and 3.0. Using ultra fine cement with different ratios of water cement to check its applicability in coarse and fine to medium sand collected from local geological formations for enhancing the application of permeation technique in local construction industry.

Some other factors like the dimension of the box should be based on the flow measurement, the effect of additives on the stability of cement grout and the effect of degree of saturation of soil should also be included in future research work.

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