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Improvement of sandy soil by low pressure grouting using cement grout

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ABSTRACT

Permeation grouting is a simple method of ground improvisation technique which helps to stabilize the loose soil stratum. Permeation grouting is a process of filling the pores in the soil with the cement slurry and improves the engineering properties of the soil. The shear strength parameters in the loose and medium dense state of the soil are investigated by plate load test on the grouted soil sample by determining the correlation between load and displacement on the grouted medium. Cement grout with different ratio of 10:1 (Water: Cement), 8:1, 6:1, 4:1 are injected into the soil with the low pressure without disturbing the soil. Grouting experiment is performed with the 60 ml syringe with a pressure gauge fixed in the bottom in the tank size of 20 cm x 20 cm x 20 cm sandy soil. The strength properties of the grouted soil after 3 and 7 days of curing are determined by the plate load test using 5cm x 5cm plate. It can be revealed that the increase in water cement ratio shows an increment in load carrying capacity of the sandy soil. From this study it is proved that permeation grouting can be an effective method for increasing the strength of the grouted soil sample and the reducing the permeability of the grouted soil sample in loose and medium dense state.

KEY WORDS: Improvement, Grouting, Cement.

1. INTRODUCTION

The ground improvement of the soil sample is a technique to modify the engineering properties of the soil that can be carried out at a site. Permeation grouting is also a process of low pressure grouting which helps to effluent the cement slurry in the soil with less pressure. Low pressure grouting is a process of injecting the cement slurry into the voids, cavity of the soil in order to improve the properties of the soil, especially to reduce the permeability in the sample. It reduces the permeability of formations under the water retaining structures, control the erosion of soil, increase the strength of materials below foundation of heavy structures and or reduce the deformability of the material in the foundation, fill the voids between rock and tunnel linings, form cut off walls, fill voids for rehabilitation etc.

Bezuijen (2007), stated that the injecting process of the grouting will leads to the reduction in the permeability of the soil and forms a thick bonding so that it reduce the bleeding in the sample. Tahia Awad (2005), concluded that the measured ultimate bond capacity of grouted is linearly increases with the surcharge pressure. The measured ultimate bond capacity of grouted anchor increases as the grout curing time increases.The peak strain of cement-bentonite grouted anchor model decreases as the grout curing time, grout viscosity, and surcharge pressure increase.

2. MATERIALS

The medium dense (coarse sand) sand is collected by sieving the regular sand by the sieve size 4.25 and 1.18. Preliminary test of the coarse sand, cement and bentonite is done. The grouting is performed in the tank of 20 cm x 20 cm x 20 cm with the 60 ml syringe with a pressure gauge fixed in the bottom, the stability test done by plate load test in Triaxial Loading frame after 3days and 7 days of curing.

Table.1.Properties of sand

Properties of sand	
Properties of Sand	**Values**
D60	0.52
D30	0.4
D10	0.3
C_C	2
C_U	1.38
OMC	15%
e_{max}	0.719
e_{min}	0.49
e_{avg}	0.6
Specific Gravity "G"	2.59
Classification	SP

Grain size distribution is a process which is used to state the soil by sieve analysis to perform test on the soil, it's used to distinguish them by non-organic or organic granular material including sands, rock, clays, granites, fled spars coal soil a wide range of manufactured powder grain and seeds down to a minimum size.

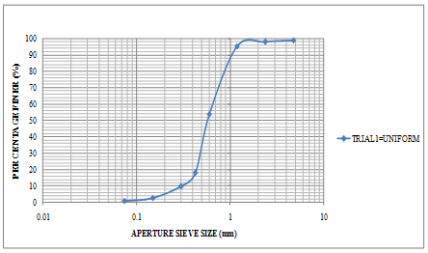

Figure.1. Grain size distribution curve

The soil sample is separated into various fractions by sieving through sieves; the weight of soil retained on each sieve is recorded. The moisture content of soil if above 5% it is to be measured and recorded. At the base around pan, called the receiver. The results of this test one and two used to describe. As shown in the figure 1. Table 2 shows the property of the cement which is been used in this study.

Table.2. Property of cement

Property	Characteristic Value
Normal consistency of cement	33%
Initial setting time cement	30 minutes
Fineness of the cement	3%
Specific gravity of cement	3.15

Viscosity is used to measure the resistance of a fluid which is being deformed by either shear or tensile stress. The term viscosity (and for fluids only), is "thickness" or "internal friction". Thus, water is "thin", having a lower viscosity, while honey is "thick", having a higher viscosity. Put simply, the less viscous the fluid is, the greater its ease of movement (fluidity).

Table.3. Marsh Funnel Viscosity

Ratio	Marsh Value in Sec
4:1	31.23
6:1	30.78
8:1	30.14
10:1	29.45

The marsh funnel is a simple device which is used for measuring viscosity by time and it is termed as a known volume of liquid to flow from a cone through a short tube. It is standardized process to find specific gravity of cement. The time in seconds is recorded as a measure of the viscosity.

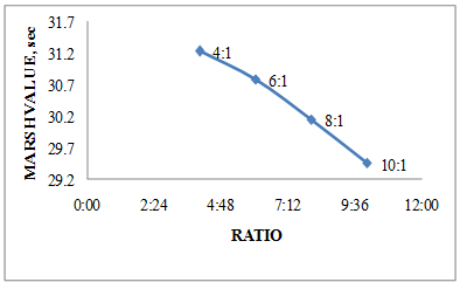

Figure.2. Graphical representation of grout ratio and viscosity Pressure Measuring Device

Predetermined quantity of cement without admixtures was taken and thoroughly mixed with a definite amount of water. The slurry was thoroughly mixed for 10 minutes. The grouting setup consists of an injecting cylinder, air compressor, grouting nozzle and pressure gauge. The grouting nozzle was kept in position (at 5cm above bottom level of the tank) and the sand bed was prepared in a tank size of 20 cm x 20 cm x 20 cm at the loose and medium dense state should be grout at a pressure 0.5 kg/cm^2 (unit weight of 11.68 kg (loose state) and 16.36 kg (medium dense state) at a void ratio of 0.6). The grouting nozzle was raised during the grouting operation at regular intervals in order to get uniform flow of grout over the entire thickness of the sand bed. The grouted samples were kept for curing under moist condition.

Figure.3.Injecting Grout solution in Tank

Methodology: The efficiency of the grouting process is verified through plate load tests were done with the grouted and ungrouted soil sample. The initial tests for improvement in load carrying capacity through densification were conducted by filling the sand at the desired densities in small tanks of size 24cm x 19cm x 21cm.

Figure.4. Triaxial Loading Frame Test

Fig 4 shows the load frame test is applied for our samples such that it is used to check its compressive strength. It can be calculated by the data logger by taking the values of load and displacement by calculating it to draw the graph.

3. RESULT AND DISCUSSION

Plate Load Test on Loose State and Medium Dense State before Grouting: The load- displacement curves of fine grained sand compacted at same unit weight without grouting on the soil beds. The plot represents the ultimate stress at the loose state (unit weight 11.68 kg) and medium dense (unit weight 16.36 kg). Here also the ultimate stress is not well defined, but at higher units it is easily identifiable by distinct peak at failure.

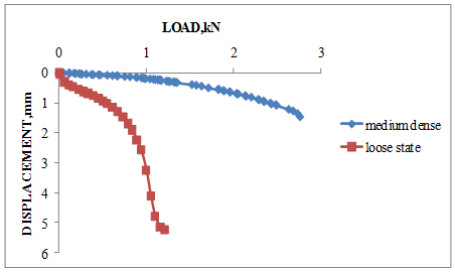

Figure.6. Load- Settlement Curve of Loose and Medium Dense State before Grouting

According to the figure 7 the water cement ratio differ to the load bearing capacity of the soil of loose state of 3 days.According to 10:1,8:1,6:1,4:1 the load bearing capacity of the soil is (3.5 kn ,1.5 kN, 5.5kN,5.5 kN.Since 6:1 and 4:1 withstands more loads compare to others.

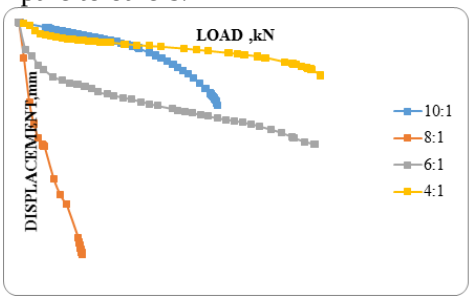

Figure.7. Load-Settlement Comparative Curve of Loose State 3 Days

The figure 8 shows the graphical representation of load settlement curve in the loose state of the soil stratumwith different the water cement ratio from 10:1 to 4:1 after grouting from a curing period of 7 days from the grouting the load bearing capacity of the soil is (6.5 kn ,7 kn, 6 kn,10 kn for the respective water cement ratio). Therefore when comparing with all the ratios the load bearing capacity is increased in the ratio of 6:1

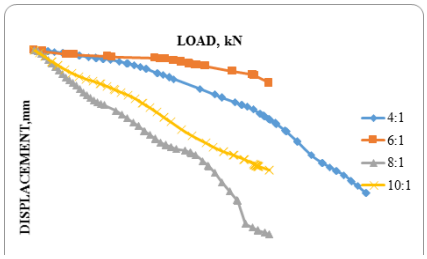

Figure.8. Load – Settlement Curve of Loose State 7days

According to the figure 9 the water cement ratio differ to the load bearing capacity of the soil at medium dense state of 3 days.According to 10:1,8:1,6:1,4:1 the load bearing capacity of the soil is (8 kn ,10 kn, 10.23 kn,12 kn).Since 8:1,6:1,4:1 and withstands more loads compare to others.

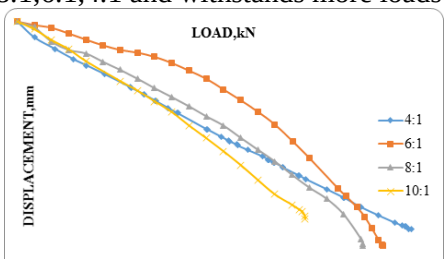

Figure.9.Load – Settlement Curve on Medium Dense State 3 Days

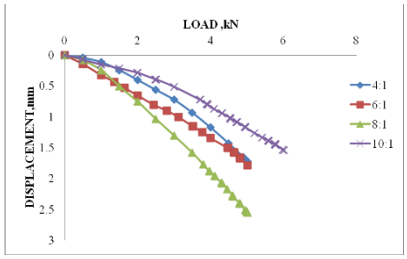

Figure.10. Load – Settlement Curve on Medium Dense State 7 Days

According to the figure 10 the water cement ratio differ to the load bearing capacity of the soil at medium dense state of 7 days.According to 10:1,8:1,6:1,4:1 the load bearing capacity of the soil is (6 kn ,10 kn, 10.23 kn,12 kn).Since 8:1,6:1,4:1 and withstands more loads compare to others.

4. CONCLUSION

The results of a series of load tests conducted on the grouted sand beds gave the following conclusion. A comparison in the strength behaviour between medium dense sand and loose sand when grouted with the water cement ratios shows that the strength of the grouted loose and medium dense sand is much higher and its exhibits a brittle type failure to load of 14 kn. A comparison in the strength behaviour between dense and loose state ,from our study by increasing the curing period i.e. 7 days it can withstand 75% of load bearing capacity and for 3 days it can withstand 45% of load bearing capacity For loose sand , a minimum cement content is required for the grouting to be effective. This may be due to the increased pore space available in the case of loose and medium dense state. In the case of loose sand, the load carrying capacity (twice the strength compared to the sand bed grouted without admixtures).

This can be attributed to the increased lateral flow of the grout when admixtures are used along with cement in grouting medium dense state. A comparison in strength of the medium sand beds grouted with cement (grout pumped through grout pump) with that of the uniformly mixed sand beds (ideal condition) stress the need for developing more appropriate grouting tools and methods for making the grouted process more efficient so that the foundation design can be made more economical.

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