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Improvement of Bearing Capacity of Sandy Soil by Grouting

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Abstract: **The constructional activities in the coastal areas often demand deep foundations because of the poor engineering properties and the related problems arising from weak soil at shallow depths. The very low bearing capacity of the foundation bed causes shear failure and excessive settlements. Further, the high water table and limited depth of the top sandy layer in these areas restrict the depth of foundation thereby further reducing the safe bearing capacity. Grouting, which has several applications in the field of civil engineering, was once considered as a mysterious operation. The effectiveness of grouting requires a lot of understanding, skill, meticulous attention and an intuitive perception Grout is injected under pressure into the material to be grouted until it fills the desired volume of material around the hole or until the maximum specified pressure is attained and a specific minimum grout flow is reached. the strength improvement of loose sandy soils through cement grouting 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 possible solutions to the foundation problems by improving the properties of soil at shallow depths by using sodium silicate. 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.**

Keywords - **Grouting Sand; Cement; Shear Strength Improvement; Sodium Silicate;**

I. 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

Soil stabilization, with cement grouts injected under pressure, has come into widespread use in construction. At present the method of grouting is highly prevalent in a number of branches of structural engineering; and in foundation engineering for the reinforcement of existing foundations beneath buildings and structures as well for strengthening the soils in their beds. The penetrability of soils, which can be characterized by the permeability and the dispersivity of the cement - water suspension, which can be characterized by its grain size distribution; serve as criteria for defining the possibility of the impregnation of a soil by cement grout.

Pressure grouting substantially alters the strength, modulus, failure strain, and mode of failure of sand. It would be both practical and useful to estimate the properties of the grouted sand from the constituent properties that will lead to proper selection of grouts. The compressive behavior of grouted sand will depend on the cohesive behavior of the grout, the groutsand adhesion (bonding), and the properties of the sand. The physical or chemical interaction, or both, of two materials at their interface is known as adhesion or bonding. The strength and type of this bond plays an important, though poorly understood, role in the mechanical behavior of chemically grouted geo-materials Cement grouting by impregnation in granular media is a widely used technique in civil engineering, applied in order to improve the mechanical characteristics of soils. The idea consists in incorporating a pressurized cement grout in the pore space of the soil. The setting of cement grout in the pore space increases both the strength and stiffness. Grouting is mainly responsible for the gain in cohesion by the material and only marginally affects the friction angle. The cohesion linearly varies with cement content, the magnitude of the cohesion gained by grouting and also the friction angle is a slightly increasing function of cement content. The increase in angle of friction is negligible with respect to cohesion The Mohr Coulomb cohesion varies between 0.1 and 0.5 MPa depending on the cement content of the grout and the relative density of the soil and increases in proportion with the cement to water ratio.

Limitations

The existing standard laboratory methods for the determination of consistency limits, though in general use, still are not highly rational. They have various limitations and by which variations in test results are quite possible in the case of different trials. Fully rational methods have yet to be developed to define these limits especially in the case of liquid limit and plastic limit. Due to lack of time for conducting the tests, the project is not highly rational.

II. LITERATURE REVIEW

[1] Gopalsamy.p1, Sakthivel.m2, Arun.k (2017) the very low bearing capacity of the foundation bed causes shear failure and excessive settlements. Further, the high water table and limited depth of the top sandy layer in these areas restrict the depth of foundation thereby further reducing the safe bearing capacity. Based on this experimental investigation made on sandy and grouted soil was concluded as, it can be seen that grouted soil has good liquid limit, plastic limit, compaction and bearing ratio are high when compared to ordinary sandy soil.

[2] Santhosh Kumar. T. (2016) The constructional activities in the coastal areas often demand deep foundations because of the poor engineering properties and the related problems arising from weak soil at shallow depths.the very low bearing capacity of the foundation bed causes shear failure and excessive settlements. The shear strength of the loose sandy soil steadily increases with increase in cement content and also with curing period. The rate of increase in shear strength is very high at higher percentages of cement than at lower percentage. The stress strain response exhibits a linear relationship prior to the peak value for all cement. Contents and the peak stress decreases with increase in water content.

[3] K. VenkatRaman1 , P. Dayakar1 , K.V.B. Raju(2016) 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 mediumThe results of a series of load tests conducted on the grouted sand beds gave the following conclusion. A comparison in the strength behavior 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.

III. EXPERIMENTAL SET UP

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. The density at loosest state was13.1 kN/m3 and at densest state, it was 16.2 kN/m3. Improvement in shear strength of the soil can be obtained by improving both the c and Ø values. Grouting which alters the pore structure and enhances the bonding and interlocking between particles can give considerable improvement in c as well as Ø values. To place the grout within the pores of the granular medium, two methods were adopted. In the first method, the grout was deposited within the pores by hand mixing in order to get a uniform grouted bed. In the second, previously prepared sand beds were grouted with grouting material using a grout pump similar to the grouting operations in the field. In the first case, samples were obtained by thoroughly mixing soil and grouting material with hand. Sand sample of medium size range was taken in a tray. The predetermined percentage of cement by weight of sand was added to the sand and thoroughly mixed using a trowel. 10% or 20% of water by the combined weight of sand and cement was added to the sand cement mixture to get a uniform mix so that the viscosity of the cement grout will be within the pump able limits ie, a Marsh funnel viscosity of 30-60 seconds. The mix was filled in the split mould of size 60mm x 60mm x 25mm (for conducting direct shear tests), in layers with uniform density, after hand impregnation of samples; it was kept under wet condition for 28 days for curing.

Fig.1.Grout tank

MATERIALS USED:

River sand was used in the present study and was graded into fine (75 µm- 425 µm), medium (425 µm- 2 mm) and coarse (2mm- 4.75mm) fractions as per the ASTM and BIS classifications. The dry density of sand was kept at 14.5 kN/m3 . The cement used for the study was 43 grade Ordinary Portland Cement, the properties of which are given in table1. For improving the properties of cement grouts, certain additives are sometimes used. Various admixtures such as sodium silicate

(accelerator), tartaric acid (retarder), and aluminum sulphate (antibleeder) were used in the present study. T

Sandy Soil

Sand is fairly coarse and loose so water is able to drain through it easily. While this is good for drainage, it is not good for growing plants because sandy soil will not hold water or nutrients.

Tap water:

Ordinary drinking water available in the construction laboratory was used for casting all specimens of this investigation. Water helps in dispersing the cement even, so that every particle of the aggregate is coated with it and brought into ultimate contact with the ingredients. It reads chemically with cement and brings about setting and hardening of cement. It lubricates the mix and compact property. Potable water, free from impurities such as oil, alkalis, acids, salts, sugar and organic materials were used. The quality of water was found to satisfy the requirement.

Sodium Silicate:

Sodium silicate is stable in neutral and alkaline solutions. In acidic solutions, the silicate ion reacts with hydrogen ions to form silica acid, which when heated and roasted forms silica gel, a hard, glassy substance.

Fig.2.Sodium Silicate.

Grouting is made to soil by using injection model, which will be applied pressurized by hand pressure only.

Table1. Properties of the Cement

Property	Characteristicvalue
Standard consistency	28 %
Initial setting time	131 minutes
Final setting time	287 minutes
Blaine's sp. Surface	298500 mm2
Sp. gravity	3.14
Compressive strength	35.1 N / mm2

Grouting operations:

To the grout with in the pores Of the granular medium two procures were adopted in the first method the grout material was deposited with in the pores by hand mixing in the second method previously prepared sand beds were grouted with different materials by using a grout pump to simulate the grouting operations in the fieldThe grouting materials like cement, lime with and without admixtures were hand mixed uniformly with the sand for the preparation of test specimens.

The efficiency of the grouting process is verified through plate load tests were done with the grouted and ungrouped 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

Table Sand Properties.

Specific Gravity	2.7
Void Ratio	0.65
Dry Unit Weight	16 kN/m^3
Relative Density	40%

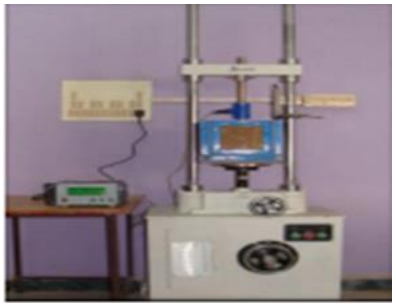

Figure.4. Triaxial Loading Frame Test

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.

IV. PLASTIC LIMIT OF A SOIL SPECIMEN

The plastic limit of a soil is the water content of the soil below which it ceases to be plastic. It begins to crumble when rolled into threads of 3mm diameter. Earlier studies have indicated that the relative density of loose sandy soils can be substantially improved by different methods, and among these, vibration techniques are reported to be the most effective. The values of safe bearing capacity computed from the results of direct shear tests conducted on samples of medium sand compacted at different relative's densities are given in table 3. It can be seen that the maximum safe bearing capacity achieved by maximum compaction in the laboratory is only 90.3 kN/m2, which may not be sufficient in case of foundations for multistoried buildings. Further, these methods will be quite expensive in the field. Hence, studies were initiated to see whether grouting with cement could be a simpler and economical alternative to this.

Table.Plastic limit of a soil specimen

Description	Sandy soil	Grouted soil
Container Number	1	2
Weight of Container + Wet Soil	0.040	0.042
Weight of Container + Dry Soil	0.028	0.030
Weight of Water	0.012	0.012

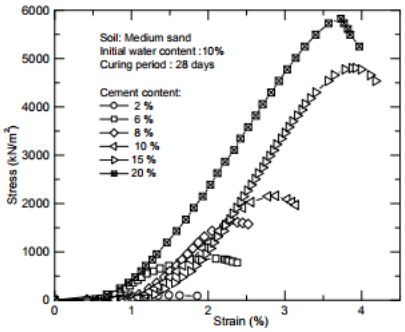

Fig :Stress Strain curves for treated medium sand for different initial water contents.

Table Stress Strain curves for treated medium sand used for different initial materials

Admixture	Chemical	Optimum dosage % cement wt
Accelerator	Sodium scilicate	0.5-3
Antibleeder	Aluminium sulphate	Up to 20%

The effect of percentage of aluminum sulphate (used as ant bleeder) on shear strength of cement grouted medium sand specimens cured The results of tests on specimens cured indicated a marginal reduction in shear strength compared to the original value. But as the curing period increases the shear strength is found to increase with increase in percentage of this salt with a slight reduction noticed at around 2 % of this salt content. Results of load tests conducted on medium sand filled in tanks at the loosest density and grouted with cement content of 4 % using the grouting set up, are given as Fig.10. It can be seen from the figure that the ultimate stress at the loosest state (corresponding to a dry unit weight of 13.1 kN/m3) is only 22.7 kN/m2. Maximum compaction yielded a unit weight of 16.2 kN/m3 and the corresponding ultimate stress was 367 kN/m2. The ultimate load corresponding to 4% cement grout was 611 kN/m2, which is around 27 times the ultimate stress at the loosest state.

V. CONCLUSIONS

Based on this experimental investigation made on sandy and grouted soil was concluded as, it can be seen that grouted soil has good liquid limit, plastic limit, compaction and bearing ratio are high when compared to ordinary sandy soil. The cost of sodium silicate is low when compared to other grouting materials; it has property to rise the normal properties of soil in effective mannerThe effect of accelerator (sodium silicate) is to reduce the strength slightly, but while considering the other benefits such as improvement in properties like viscosity, stability and the early setting of the grout, this reduction in strength is within the tolerable limits. One has to be very careful in the use of tartaric acid (retarder) with cement grout. The results indicate a sharp decrease in shear strength value when the cement content is less than 0.15 %. The shear strength is found to increase with increases in percentage of aluminum sulphate (ant bleeder), eventhough there is a slight reduction at lower percentage of this salt. Hence use of admixtures like sodium silicate, tartaric acid, and aluminum sulphate with cement do not adversely affect the strength of the grouted medium.

VI. REFERENCES

[1] Gopalsamy.p1, Sakthivel.m2, Arun.k (2017). study-on improvement of bearing capacity of soil by grouting" International Research Journal of Engineering and Technology. ISSN: 2395 -0056Volume: 04 Issue: 02

[2] K. VenkatRaman1, P. Dayakar1, K.V.B. Raju (2016) Improvement of sandy soil by low pressure grouting using cement grout Journal of Chemical and Pharmaceutical Sciences. ISSN: 0974-2115. Volume 9 Issue 2

[3] Santhosh Kumar. T. G1(2016); Benny Mathews Abraham Bearing Capacity Improvement of Loose Sandy Foundation Soils through Grouting International Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 1, Issue 3, pp.1026-1033.

[4] Gopalakrishnan K, PremJeya Kumar M, SundeepAanand J, Udayakumar R, (2013), Analysis of static and dynamic load on hydrostatic bearing with variable viscosity and pressure, Indian Journal of Science and Technology, 6 (6), 4783-4788.

[5] Jeyanthi Rebecca L, Susithra G, Sharmila S, Das MP, Isolation and screening of chitinase producing Serratia marcescens from soil, Journal of Chemical and Pharmaceutical Research, 5 (2), 2013, 192-195.

