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STUDY ON IMPROVEMENT OF BEARING CAPACITY OF SOIL BY GROUTING

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Abstract - *The constructional activities in some particular 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. This paper discusses grouting as one of the possible solutions to the foundation problems by improving the properties of soil at shallow depths by using sodium silicate.*

Key Words ***Grouting, Sodium silicate, Shear strength, Bearing capacity, Settlement.***

1. INTRODUCTION

The construction of structures on weak ground often requires the soil to be improved in order to ensure the safety and the stability of surrounding buildings. Soil is one of the most important engineering materials. Determination of soil conditions is the most important first phase of work for every type of civil engineering facility. The knowledge of soil is necessary for the designing of foundation, pavement, underground structures, embankments, earth retaining structures, dams etc. As a result, various parameters like bearing capacity, stress distribution in the soil beneath the loading area, the probable settlement of the foundation, effect of ground water and effect of vibrations etc are needed for the design of foundation. The thickness of pavement and its component parts depends upon the characteristics of the subsoil, which should be determined before design is made. The index properties such as density, plasticity characteristics and specific gravity, particle size distribution and gradation of the soil, permeability, consolidation and compaction characteristics and shear strength parameters under various drainage conditions needs to be determined for the construction of earth dams. In this region with a wide range of soil and hence the property of soil varies within short distances. A majority of the land area were being used for cultivation of crops. Soil in the residential area is not preloaded. The variation in the type of the soil through is not very marked. The performance of the soil in the designs cited above depends upon the characteristics of the soil. Hence, the testing of soil with relation to the determination of its physical properties and the evaluation of effects of certain other factors such as seepage conditions etc forms the most essential part of the development of soil engineering. The knowledge of theoretical soil mechanics, assuming the soil to be an ideal elastic isotropic and homogeneous material helps in predicting the behavior of the soil in the field. Ground improvement in granular soils can be achieved by different methods such as vibro-flotation, compaction piles, compaction with explosives, excavation and replacement, well point system, reinforced earth, grouting etc. The selection of the most suitable method depends on a variety of factors, such as: soil conditions, required degree of the compaction, type of structures to be supported, maximum depth of compaction, as well as site-specific considerations such as sensitivity of adjacent structures or installations, available time for completion of the project, competence of the contractor, availability of equipments and materials etc. Soil compaction can offer effective solutions for many foundation problems, and is especially useful for reducing total settlements in sands. However, efficient use of soil compaction methods requires that the geotechnical engineer understands all factors that influence the compaction process. The poor quality soils, especially their low bearing capacity, make it necessary to improve their properties by stabilization. The compaction of soils is intrinsically dependent upon the vertical effective stress, the type and gradation of soil, etc.

1.1 Objectives

The main objectives are

- Study the different properties of soil.
- Conducting detailed laboratory tests to determine the properties of soil.
- Increasing depth of soil foundation.
- Compacting and confining the soil.
- Replacing the poor soil.
- Stabilizing the soil with chemicals (sodium silicate).
- Reducing the settlement of soil.

- Improving bearing capacity and shear strength of soil.

1.2 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

2. EXPERIMENTAL SET UP

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**. 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 Sand sample of medium size range was taken in a tray. Here the grout used here are sodium silicate solution which was poured into the grout chamber. In order to reduce the chances of segregation of the grout, an agitator was provided inside the grout chamber. Grout was pumped under a uniform hand pressure into the prepared sand bed. 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 sand bed.

Fig.1.Grout tank

3. MATERIALS USED

The following are some of the materials used in this experiment for analyzing are

1. Sandy soil
2. Tap water
3. Sodium silicate
4. Grouting injection

3.1. 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.

3.2. 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 if IS456-2000.

3.3. 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

3.4. Grouting injection

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

4. RESULT AND DISCUSSIONS

4.1. 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

Table.1.Plastic limit of a soil specimen

Sl.No	Description	Sandy soil	Grouted soil
1	Container Number	1	2
2	Weight of Container + Wet Soil	0.040	0.042
3	Weight of Container + Dry Soil	0.028	0.030
4	Weight of Water (2)-(3)	0.012	0.012
5	Weight of Container	0.011	0.011
6	Weight of Dry Soil (3)-(5)	0.017	0.019
7	Moisture Content	0.706	0.684
8	Moisture Content in Percentage	70.58 %	68.4%

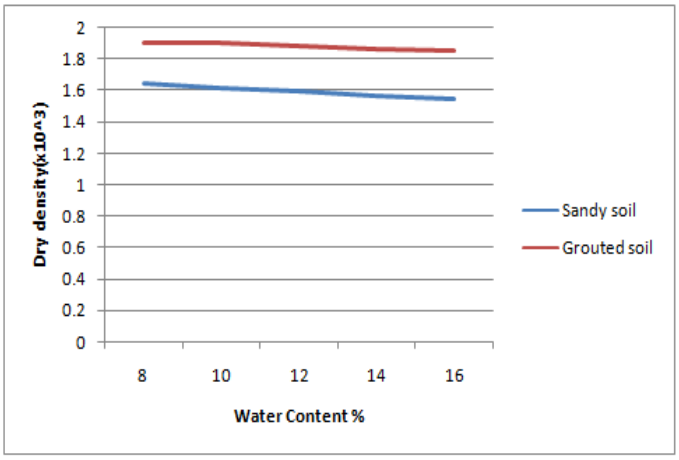
4.2. Proctor compaction test

Compaction is the process of densification of soil by reducing air voids. The degree of compaction of a given soil is measured in terms of its dry density. The dry density is maximum at the optimum water content. A curve is drawn between the water content and the dry density to obtain the maximum dry density and the optimum water content.

Fig.3. Proctor compaction mould

Table.2. Proctor compaction test values

S.No	Water Content in Dry Soil		Dry Density	
			Sandy soil	Grouted soil
1	8	200	$1.65x10^3$	$1.90x10^3$
2	10	250	$1.62x10^3$	$1.90x10^3$
3	12	300	$1.60x10^3$	$1.88x10^3$
4	14	350	$1.57x10^3$	$1.86x10^3$
5	16	400	$1.55x10^3$	$1.85x10^3$



Graph.1. Proctor compaction test values

4.3. Liquid limit of soil

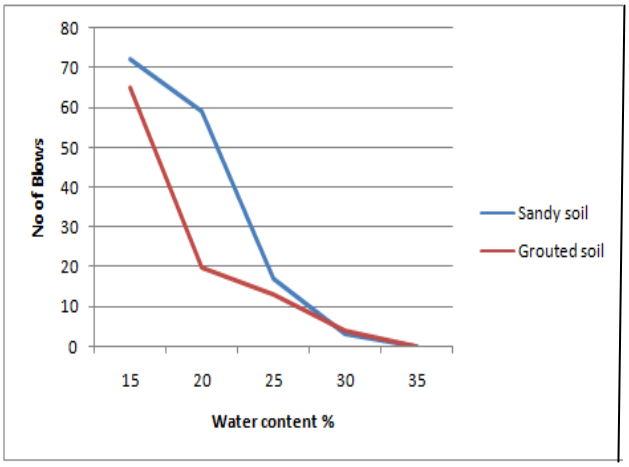
This test is done to determine the liquid limit of soil as per IS: 2720 (Part 5) – 1985. The liquid limit of fine-grained soil is the water content at which soil behaves practically like a liquid, but has small shear strength

Table.3.Liquid limit of a sandy soil specimen

Sl.No	Water Content		No. of Blows
	%	ml	
1	15	15	72
2	20	20	59
3	25	25	17
4	30	30	3
5	35	35	0

Table.4.Liquid limit of a grouted soil specimen

Sl.No	Water Content		No. of Blows
	%	ml	
1	15	18	65
2	20	29	20
3	25	30	13
4	30	36	4
5	35	42	0



Graph.2 Liquid limit of Sandy and Grouted soil

4.4. CALIFORNIA BEARING RATIO TEST

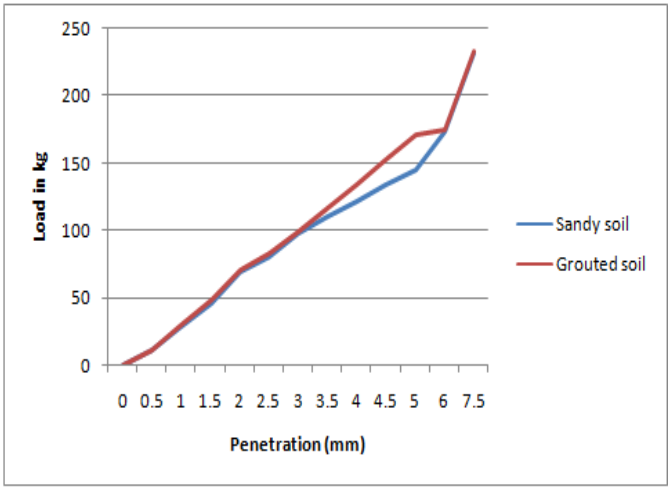
The California Bearing Ratio Test (CBR Test) is a penetration test developed by California State Highway Department (U.S.A.) for evaluating the bearing capacity of sub grade soil for design of flexible pavement. Tests are carried out on natural or compacted soils in water soaked or un-soaked conditions and the results so obtained are compared with the curves of standard test to have an idea of the soil strength of the sub grade soil.

Table.5. California bearing ratio test value

S.No	Dial Reading	Proving Ring Reading	Penetration (mm)	Sandy soil (Load in kg)	Grout soil (Load in kg)
1	0	0	0	0	0
2	50	1	0.5	11.6	11.5
3	100	2.5	1	29	29.2
4	150	4	1.5	46	48.2
5	200	6	2	69.6	70.4
6	250	7	2.5	81.2	82.3
7	300	8.5	3	98.6	99.5
8	350	9.5	3.5	110.2	115.7
9	400	10.5	4	121.8	133.5
10	450	11.5	4.5	133.4	152.4
11	500	12.5	5	145	170.9
12	600	15	6	174	174.3
13	750	20	7.5	232	232.4

Thus in the result California Bearing Ratio(CBR)of a soil is the water content of the soil below which it ceases to be tested. The value of CBR for grouted soil is obtained high.

Fig.4. California bearing ratio test



Graph.3. California bearing ratio test value

4. 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 manner.

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