IMPROVING SBC OF SANDY SOIL BY CEMENT GROUTING TECHNIQUE

SYED SADATH ALI[1], SYED MOHAMMED SALI[2], SYED MOHAMMED SAMAN[3], SYED MOHAMMED RAABI[4], UMMER AZZAM[5]

[1]*Assistant Professor, Dept. of Civil Engineering, Anjuman Institute of Technology and Management, Karnataka, India*
[2]*UG Student, Dept. of Civil Engineering, Anjuman Institute of Technology and Management, Karnataka, India*
[3]*UG Student, Dept. of Civil Engineering, Anjuman Institute of Technology and Management, Karnataka, India*
[4]*UG Student, Dept. of Civil Engineering, Anjuman Institute of Technology and Management, Karnataka, India*
[5]*UG Student, Dept. of Civil Engineering, Anjuman Institute of Technology and Management, Karnataka, India*

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Abstract - *Ground improvement refers to any procedure undertaken to increase the shear strength, decrease the permeability and compressibility, or otherwise render the physical properties of soil more suitable for projected engineering use. A large number of methods have been developed for ground improvement from ground surface to depths of 20 m or more by in-situ treatment. The improvement may be accomplished by drainage, compaction, preloading, reinforcement, grouting, electrical, chemical or thermal methods. Among the various soil stabilization procedures, the most suitable one is selected depending upon the type of soil available, time, cost involved etc. Grouting is quite a familiar technique in the field of civil engineering, especially in foundation engineering. The technology of grouting finds applications in almost all the fields of foundation engineering such as seepage control in rock and soil under dams, advancing tunnels, cut off walls etc. The primary purpose of grouting is to fill the voids of the formation material by replacing the existing fluids with the grout and thereby improving the engineering properties of the medium especially reducing the permeability.*

Key Words: Grouting, Sandy soil, Shear test, Cement, Compression test.

1. INTRODUCTION

The terms ground improvement and ground modification refer to the improvement in or modification to the engineering properties of soil that are carried out at a site where the soil in its natural state does not possess properties that are adequate for the proposed Civil Engineering activity. Excavating the poor soil and replacing it with soil having desired properties is normally economical only when soil has to be treated down to a depth of 3 m and the water table is below 3 m. If the water table is high lowering of water table prior to excavation has to be carried out by dewatering techniques, which are expensive. Vibro-compaction is used to increase the density of loose sand. This technique is not useful for soils having greater than 20 percent fines.

Grouting is quite a familiar technique in the field of civil engineering, especially in foundation engineering. The technology of grouting finds applications in almost all the fields of foundation engineering such as seepage control in rock and soil under dams, advancing tunnels, cut off walls etc. The primary purpose of grouting is to fill the voids of the formation material by replacing the existing fluids with the grout and thereby improving the engineering properties of the medium especially reducing the permeability.

Grouting is effective in both sand and silt deposits. Grouts are liquid suspensions or solutions that are injected into the soil mass to improve its behaviour. Such liquids can permeate into the void space of the soil and bind the soil particles together. For medium sands or coarser materials, the grout used most often is a slurry of water and cement. This slurry however, cannot enter into the void space of fine sand and silts for which chemical grouts are used.

Grouts can be broadly classified as suspension grouts and solution grouts. Suspension grouts consist of small-size solid particles dispersed in a liquid medium. These include cement grouts, that is, slurry of cement in water; soil-cement grouts consisting of a slurry of soil and cement in water; and bentonite grouts comprising a slurry of bentonite in water. Cement grouts are the most widely used and usually have water and cement in the ratio ranging from 10:1 to 2:1.

2. MATERIALS AND METHODS

The selection of proper grouting materials depends upon the type of granular medium and the purpose of grouting. Cement, bentonite, clay and lime are the grouting materials normally used for grouting a granular medium. In the present study sand was used as the grouting medium and cement was used as the grouting materials.

To place the grout within the pores of the granular medium, two procedures were adopted. In the first method, the grout material which is cement was deposited within the pores by hand mixing. In the second method, previously prepared sand beds were grouted with different grouting materials by using a grout pump to simulate the grouting operations in the field. The preparations by first method is used for our project and Grouting with cement is elaborated:

A unit weight of 13.11 kN/m^3 for sand was chosen for the preparation of samples. This was selected by considering the fact that it can be achieved relatively easily with very good reproducibility and by considering the difficulty experienced in preparing the samples at unit weights corresponding to the loosest state. The required amount of sand of medium size range was taken in a tray. The predetermined quantity of cement i.e. 2, 4, 6, 8% was then added to the sand and thoroughly mixed with a trowel. Water was (10% and 20% by weight of sand + cement) sprinkled over the cement sand mixture and thoroughly mixed with a trowel.

This was filled in split moulds of size 60 mm x 60 mm x 25 mm in two layers to obtain specimens for direct shear tests and also size 70 mm x 70 mm x 70 mm, to obtain specimens for compressive strength tests. These specimens were kept at room temperature for 24 hrs, then taken out from the moulds and kept for curing for periods of 7 and 28 days.

Fig -1: Grouted specimen for direct shear test

Table -1: Physical properties of cement

Sl no.	Properties	Characteristic value
1	Normal consistency	27%
2	Initial setting time	80 min.
3	Final setting time	210 min.
4	Specific gravity	3

5	Compressive strength 1. 7 days 2. 28 days	34.2 N/mm2 42.6 N/mm2

Chart 1 shows the particle size distribution. From IS 383-1970 table no.4 the fine aggregate is seen to be confirming to grading zone II. The fineness modulus was found to be 2.9 and is classified as medium sand as its fineness modulus is within the limit of medium sand i.e. (2.6 – 2.9).

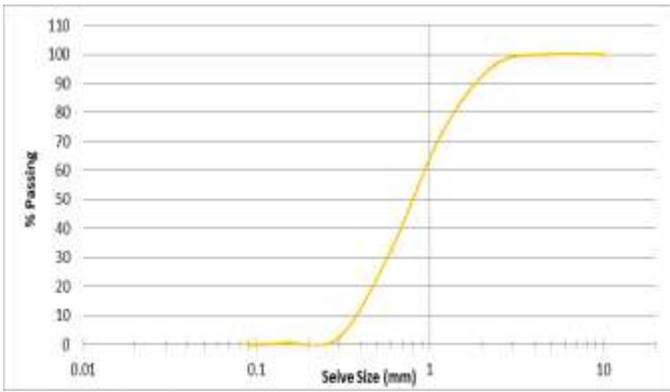

Chart -1: Particle size distribution

The characteristic of sand is given in the table below;

Table -1: Characteristic of sand

SAND	Unit weight (kN/m^3)	Ø (degree)	SBC (kN/m^3)
At loosest/natural state	13.11	18	46.38
At densest state	14.2	23	89.69

3. RESULTS AND DISCUSSION

3.1 Direct shear strength test

Direct shear tests were conducted in moulds of size 60 x 60 x 25 mm to determine the shear strength of the grouted soil samples. To place the grout within the pores of the granular medium, first method was adopted. In the first method, the grout was deposited within the pores by mixing the sand with the required quantity of the grout material (cement) and soil specimens were prepared in the moulds at desired unit weights of 13.11 kN/m^3 and kept for curing under humid conditions as explained in section 3.2. The results of direct shear strength test, which were conducted on 60x 60 x 60 mm of laboratory-cured specimen are presented in Tables below for different percentage of cement content and initial water content respectively for 7 and 28 days.

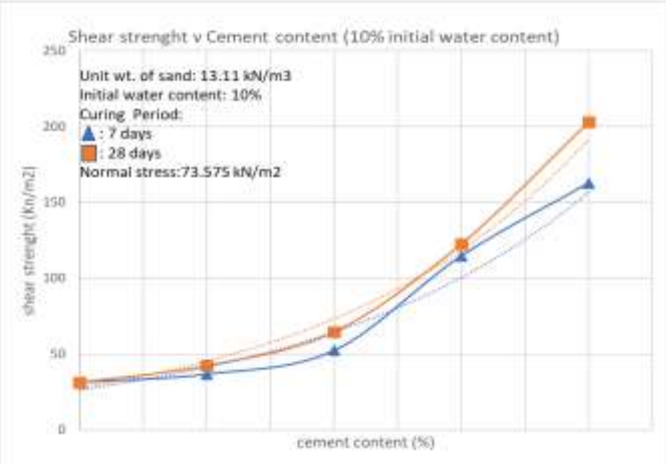

Chart -2: Shear strength v cement content with 10% IWC

The variation in the shear strength Ʈ with cement content (varying from 2 to 8 % by weight of dry sand) at an initial water content of 10 % is shown in chart -2. As expected, the value of shear strength steadily increases with increase in cement content. In the case of 2 % cement content, the increase in shear strength is only 17.35 % (after 7days of curing) and 35.33 % (after 28days of curing) when compared with the shear strength of sand without addition of any cement. The percentage increase in shear strength at 4, 6 & 8 % of cement contents after the 7 days of curing is 50.21%, 199.33%, and 153.7% respectively, whereas the percentage increase is 71 %, 186.12 % & 256.9 % in case of specimens cured for a period of 28 days. The results are as expected –i.e. Ʈ Value increases with increase in the curing period

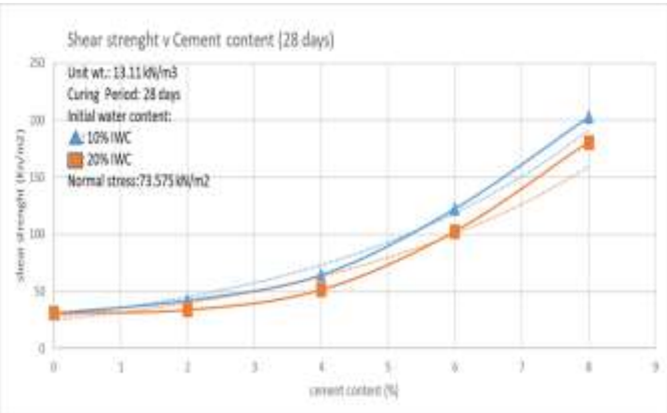

Chart -3: Shear strength v cement content with 28D curing period

The variation in shear strength with cement content at initial water contents of 10 and 20 % after 28 days of curing are shown in chart-3 respectively. At constant cement content, a marginal decrease in shear strength is seen with increase in initial water content.

3.2 Compression strength test

Determination of shear strength through direct shear test is a time-consuming process and also requires at least three to four specimens. Further, at higher cement content, it is very difficult to conduct the tests till the failure of the specimens with the normal test set up. But determination of compressive strength in such cases is very easy and can be done very accurately. Thus, this test was conducted to determine the load carrying capacity of grouted specimen. The gradation and type of sand influenced the compressive properties of grouted sand. The compressive properties strength increased with the increase of the coefficient of uniformity of the sand (better gradation) and with the increase of the particle's angularity. The results of compression strength test, which were conducted on 70x 70 x70 mm of laboratory-cured specimen are presented in Tables below for different percentage of cement content and initial water content respectively for 7 and 28 days.

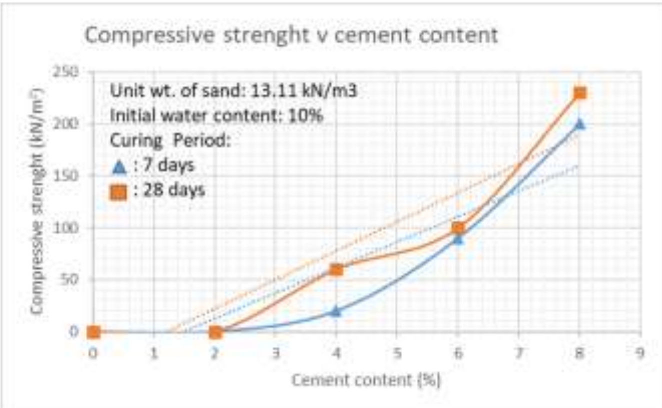

Chart -4: Compression test v cement content with 10% IWC

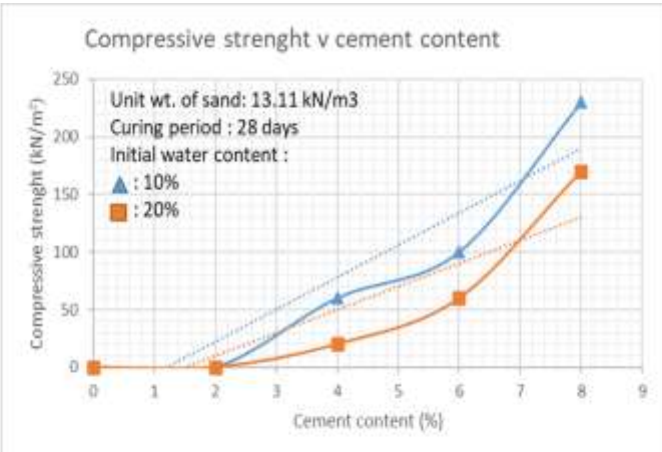

Chart -5: Compression test v cement content with 28D curing period

Chart-4 shows the variation in compressive strength with cement content in the case of specimens prepared at an initial water content of 10%. As one would expect, the compressive strength goes on increasing with increase in percentage of cement content. The compressive strength of the grouted sand also increases with the curing period.

The effect of the initial water content on the compressive strength of the grouted soil samples is shown in chart-5. It can be seen that the compressive strength decreases with increase in initial water content.

4. CONCLUSIONS

- The shear strength of the loose sandy soil steadily increases with increase in cement content and also with curing period, for the sand fractions.
- The rate of increase in shear strength is very high at higher percentages of cement than at lower percentages for the sand fractions.
- The influence of the increased initial water content of the grout decreases the shear strength of the grouted sand and the effect is more pronounced at higher cement contents.
- Compressive strength goes on increasing with increase in percentage of cement content and curing period.
- Also, as in the case of shear strength, the compressive strength also decreases with increase in initial water content.

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