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Comparative Study Of Bearing Capacity Of Soils Using Grouting Technique

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Abstract

It refers to injecting a pumpable material into soil to alter its characteristics. This grouting technique can be used to improve the engineering properties of soil such as compaction characteristics, shear strength characteristics. Slurry is pumped till a particular value of pressure is achieved. In our study, soil samples were collected from Channapatna and Bidadi (Karnataka, India) and basic tests such as sieve analysis, compaction characteristics, shear strength parameters, Atterberg limits were conducted. The bearing capacity of soil samples was determined from test results. Field conditions were simulated in laboratory by injecting cement and fly ash slurry using a pumping device and pressure was checked for different soil samples for different slurry ratios in a wooden box. Volume of pressure bulbs were measured on 1st, 5th and 10th day. The results show that bearing capacity had increased notably.

Keywords: *Injection grouting, Pressure bulbs, Bearing capacity, cement slurry*

Introduction

Injection grouting is one of the ground improvement techniques that involve injection of slurry at particular pressure at given location, either single or multiple systems, into soil to enhance geotechnical properties. Grouting is widely used and its usage varies depending on project. Grout that is injected into soil through holes or pipes at particular location lead to formation of bulbs. Some of the types are jet grouting, compaction grouting, injection grouting. Low pressure grouting is one in which cement slurry is injected into voids so that permeability is reduced in the grouted sample. This grouting method has number of applications in civil engineering; for the strengthening of existing foundations and soils in their beds in the foundation engineering. The permeability of the cement-water suspension, which can be characterized by its distribution of grain size defines the possibility of the injecting grout into soil.

Injection grouting alters the soil properties. Estimation of grouted soil properties is useful in selection of grouting technique.

Grouting technique had been empirical till recently, where heave was observed on surface aftr gout was injected into soil.

During pressure grouting, characteristics of bulb created below the surface are unknown, though the process is efficient and safe. Uncertainties are predominant due to the empirical nature of the procedure. Cracking of ground under great pressure may also occur. Since grout propagates in uncontrolled manner, damage to structures surrounding injected area may occur, thus provides necessity to study of grout propagation in the soil during grouting.

In this paper, grout patterns and characteristics of grout are studies and bulbs are analyzed at various grout pressure levels from identical soil samples in the lab.

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Grout properties and soil properties influence the bulb shape and soil fracturing. In this study, different grout w/c ratios (0.5 and 1) of cement fly ash slurry and different pressure levels are considered for laboratory tests.

Helal.M. et al. (1992) [4] investigated that water cement ratio of the grout and the sedimentation behavior of the suspended particles influences pore structure of a soil. Cement grout was used in the study. They concluded that there is a preferred distribution of the cement particles in pore space.

Chang,M., et al.(2016) [2] conducted experiment and found that the engineering properties of soil can be improved by introducing cohesive agents into the ground by soil grouting technique. Field mapping and laboratory tests of grouted soils were carried out. A numerical simulation of the grouting process was also performed.

Azadi Reza M et al.(2017) [1] showed that injection of grout is needed for strengthening the ground in order to prevent seepage or other failure after soil is excavated using permeation grouting technique and found that in order to achieve best results grout quality should be given importance. Various factors such as injection pressure and soil particle size influence grouting operations.

Experimental set up

Soil was filled in wooden tanks of size **60cmx60cmx60cm**. Ordinary potable water was used for conduction of experiments. Water helps in equal dispersion of cement, so that each particle will be coated and brought into full contact with the ingredients. Injection model was used in order to carry on grouting process, hand pressure was used to inject grout into the soil. Cement and fly ash slurry was used as injection agent.

Figure 1: Grouting apparatus and wooden box

Methods

Soil samples were obtained from Bidadi and Channapatna, Karnataka. Various tests were conducted to determine index properties and engineering properties of soil. Bearing capacities was determined analytically for grouted samples.

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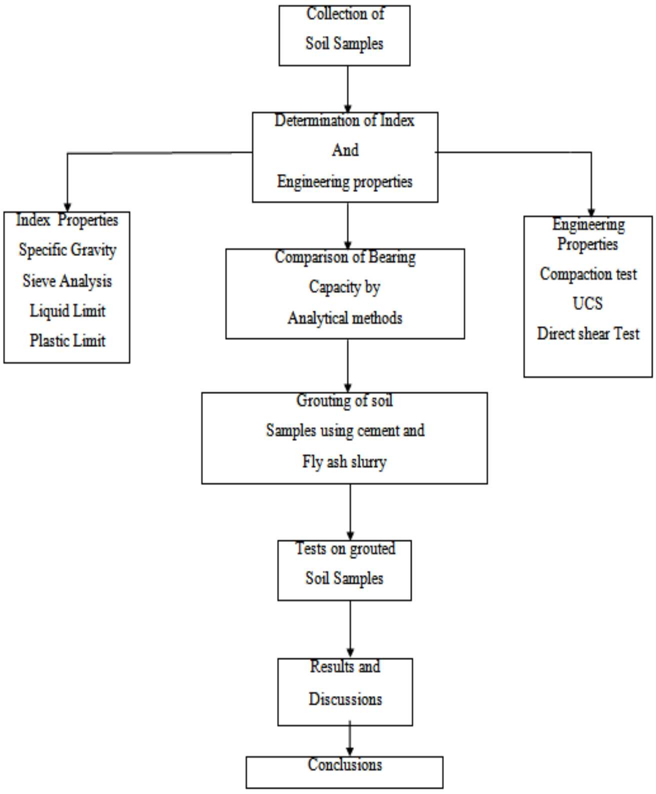

Figure 2: Methodology

Figure 3: Pressure bulb

Results

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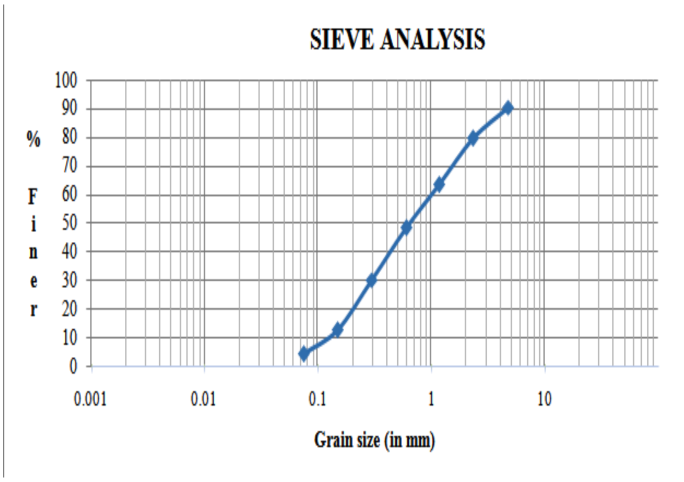

Figure 4: Gradation curve of Bidadi soil

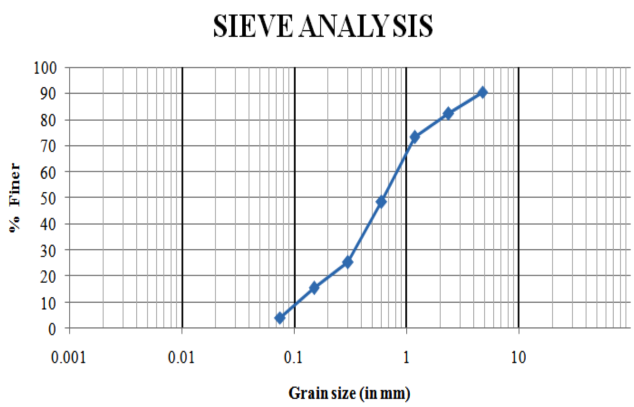

Figure 5: Gradation curve of Channapatna soil

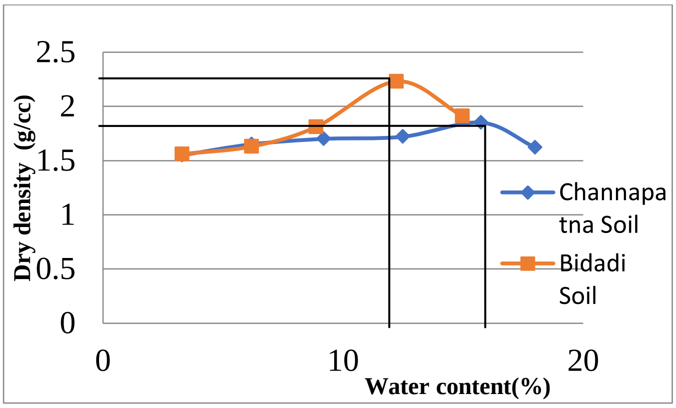

Figure 6: Compaction curve

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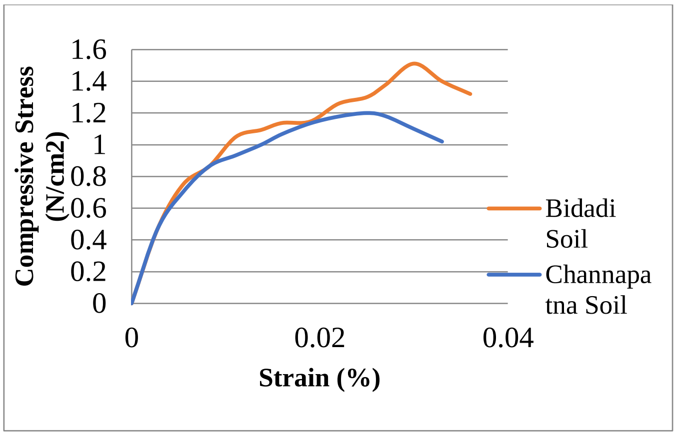

Figure 7: UCS test result (before grouting)

Table 1: Overall test results before grouting

Description	Bidadi soil	Channapatna soil
Liquid limit (%)	42.50	40.00
Plastic limit (%)	21.50	20.15
Plasticity Index (%)	21	19.85
OMC (%)	13.50	15.00
MDD (g/cc)	2.20	1.83
UCS (kN/m2)	15.33	12.05
C (kN/m2)	30	25
ϕ (°)	15	12
Bearing Capacity (kN/m2)	175	130

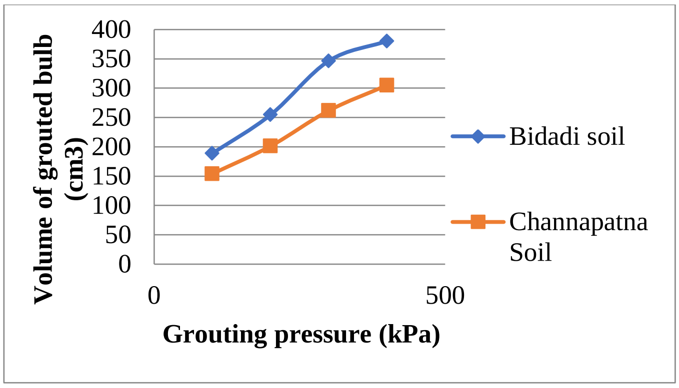

Figure 8: Graph of volume of grouted bulb v/s grouting pressure

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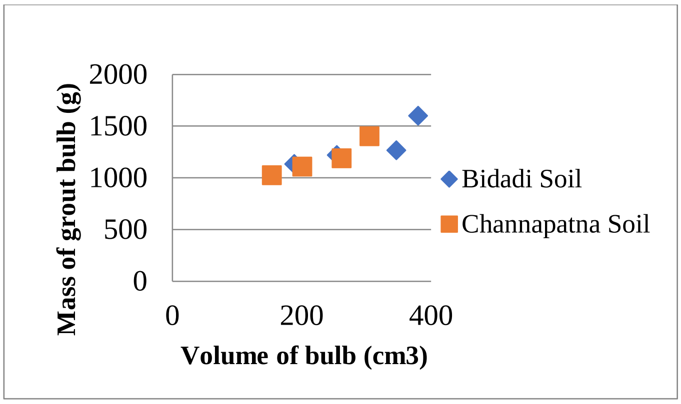

Figure 9: Graph of mass of grouted bulb v/s volume of bulb

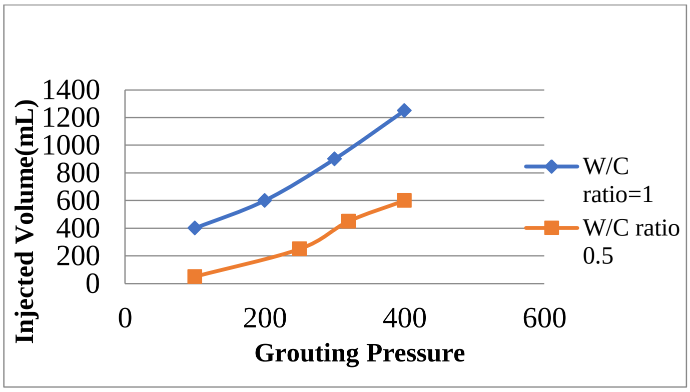

Figure 10: Graph of Injected volume v/s grouting pressure of Bidadi soil

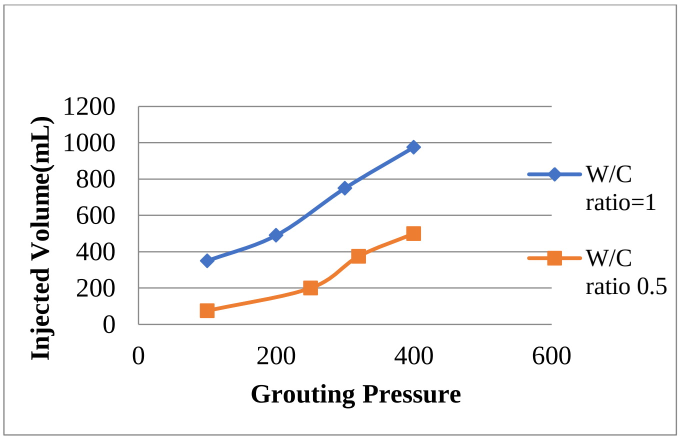

Figure 11: Graph of Injected volume v/s grouting pressure of Channapatna soil

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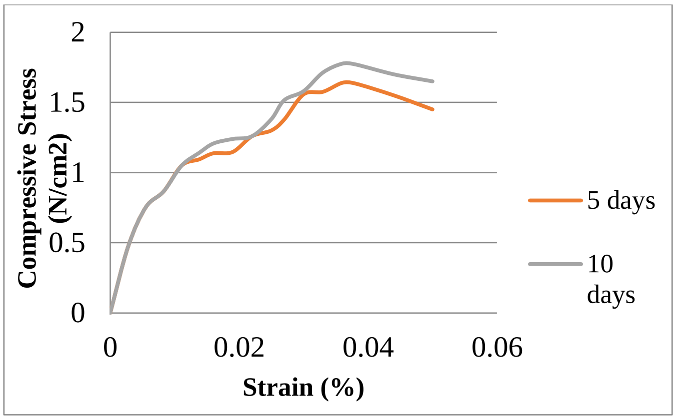

Figure 12: UCS test result of Channapatna soil (after grouting)

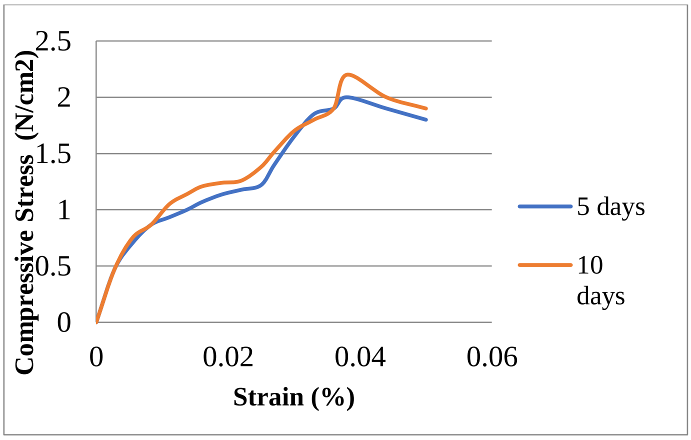

Figure 13: UCS test result of Bidadi soil (after grouting)

Table 2: Overall test results after grouting

Description	Bidadi soil	Channapatna soil
Liquid limit (%)	40.00	38.75
Plastic limit (%)	20.00	19.50
Plasticity Index (%)	20.00	19.25
UCS values of 10 days test, (kN/m2)	22.0	17.5
C (kN/m2)	40	34
ϕ (°)	13.5	10
Bearing Capacity (kN/m2)	200	170

Discussions

Bearing capacity of soils were calculated using Terzaghi's Bearing Capacity equation –

$$Qu = cN_c + \gamma DN_q + 0.5\gamma BN_\gamma$$
$$Qa = Qu/\text{Factor of safety}$$

Values of Bearing capacity factors N_c, N_q and N_γ were taken from Terzaghi's table based on ϕ values obtained from the tests. Factor of safety of 3.0 was adopted for calculations.

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Bearing capacity of Bidadi and Channapatna soil were found to be 175kN/m^2 and 130kN/m^2. After grouting, bearing capacities value has increased to 200kN/m^2 for Bidadi soil and 170kN/m^2 for Channapatna soil. Shear strength of grouted soil is greater than ordinary soil. Volume of grouted bulb of Bidadi soil is higher than that of Channapatna soil.
UCS tests on grouted samples were conducted after 5days and 10days curing. From above test results, we observe that UCS value increases with increase in passage of time.

Conclusions

Based on the above test results, we can conclude that grouting improves the bearing capacity of soil. Grouted soil has good shear strength, lower LL value. UCS values of grouted soils are higher than ordinary soil. Cost of cement is economical and easily available when compared to other grouting materials, also cement and fly ash slurry grouting has proved to be efficient technique to improve bearing capacity of soil.

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