A Study on the Engineering Behaviour of Grouted Alluvial Soil

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Abstract

Alluvial soils are widespread in the northern plains and river valleys. It covers about 40% of the total area of the country. These soils are mainly derived from the debris brought down from the Himalayas.

In the Peninsular region, they are found in deltas of the east coast and in the river valleys. Alluvial Soil is also called as Alluvium.

Alluvium (derived from Latin word alluvius) is loose clay, silt, sand or gravel that has been deposited by running water in a stream bed, on a floodplain, in an alluvial fan or beach, or in similar settings. Alluvium is also sometimes called alluvial deposit. Alluvium is typically geologically young and is not consolidated into solid rock. Sediments deposited underwater, in sea, lakes, or ponds, are not described as alluvium.

This type of soil profile is very common in areas of Jammu & Kashmir, especially in Akhnoor Area of Jammu district. 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.

The present investigation was aimed at obtaining solutions for problems like this. The improvement in relative density and thereby the load carrying capacity of loose sandy soils of different gradations through different methods such as vibration technique was studied. The low values of bearing capacity estimated even after densification compared to the requirement in the case of foundations for multi-storey buildings or structures of highways/roadways prompted to try grouting as one of the possible solutions.

Grouting is quite a familiar term in foundation engineering, the primary purpose of which is to fill the voids of the formation material by replacing the existing fluids/air with the grout and thereby improving the engineering properties of the medium. The most commonly used grout material i.e. - ordinary Portland cement - has many advantages such as high strength, high durability, environmentally free and of low cost. Two methods were adopted to place the grout within the pores of the sand medium. They

are: (1) by hand mixing the grout uniformly with the soil, and (2) by mixing the filter media with the soil.

The effect of cement grouts on the shear strength and the shear strength parameters of loose sandy soils were investigated. The effect of the common admixtures used along with cement grouts (accelerators, retarders, fluidiser, antibleeders, etc.) on the shear strength of the grouted medium was also studied.

A grouting setup was developed in the laboratory for grouting the sand beds prepared in mould or will choose a particular site of NH144A Jammu to Akhnoor ongoing work. The lateral flow of the grout and thereby the efficiency of grouting was assessed by three methods (1) from the cross section area of the grouted mass measured at different depths, (2) by determining the cement content at different radial distances at different depths, and (3) by conducting load tests on the grouted sand beds.

The effectiveness of grouting in reducing the permeability of granular medium was also studied. Constant head permeability tests were carried out on the sand medium treated with different materials such as cement, bentonite, lime, locally available clay and different combinations of the above materials.

The results of the various investigations conclusively proved that grouting can be used as an effective method for improving the strength characteristics significantly and reducing the permeability of loose sandy soils.

Chapter 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.

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.

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% 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

(Nonveiller, 1989). 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.

Properties of a grout are described in terms of five parameters: groutability, stability, setting time, permanence and toxicity. Grouting methods for soils are classified as permeation grouting, compaction grouting, hydrofracture grouting and jet grouting. Cement grout not only fills the voids and reduces permeability but also sets with time and binds the soil grains together. As a consequence, the strength of Soil mass increases and its compressibility decreases. Sometimes cement in a grout is replaced by clay to reduce the cost. When the objective of grouting is only to reduce permeability, bentonite grouts can be used (Lovely, 1998). However, the permanence of such grouts under high hydraulic gradients is questionable and often cement is added to the bentonite to improve its permanence.

Even though grouting has found several applications in the practice of civil engineering, available studies on grouts and grouting have been very limited. Even today, the grouting operations are based on thumb rules and existing practices rather than rational design principles or well defined procedures substantiated by research data (Shroff and Shah, 1992). In the present investigation on the engineering properties of grouted medium including methods to improve the same which can be effectively used in foundation soils for increasing the bearing capacity and in dam grouting or cut off walls for reducing the seepage to a minimum**.**

Chapter 2

2.1. Introduction

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. Even though grouting was started 200 years ago, it was treated for a long time, as an art which eluded scientific investigation and improvement (Nonveiller, 1989). Its performance was for some time, more or less a privilege and a well protected secret of a few specialist companies. The curious image of grouting is changing slowly, as research and development broaden our knowledge in this area.

Grouting is a procedure by means of which grout is injected into voids, fissures, crevices or cavities in soil or rock formation in order to improve their properties, specifically to reduce permeability, to improve strength or to reduce the deformability of formations. Grouting has a wide application in

modern civil engineering. It reduce 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.

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. From injected watery suspensions, injected water is squeezed out in the pores and the compacted mass of the injected compound fills the fissures and voids.

2.2. Scope of the work

The constructional activities in the northern part of our country often demand deep foundations because of the poor engineering properties and the related problems arising from weak soil at shallow depths. The soil profile in coastal area often consists of very loose fine sandy soil extending to a depth of 3 to 4 m from ground level underlain by clayey soils of medium consistency. The very low shearing resistance of the foundation bed causes local as well as punching shear failure. Hence the structures built on these soils may suffer from excessive settlements. This type of soil profile is very common in areas of the Jammu & Kashmir, especially in Jammu district. 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. Strengthening of these loose sandy Review of Literature 35 soils at shallow depths through economical techniques such as grouting could be a possible solution for these foundation problems. Even though grouting has found several applications in the practice of civil engineering; studies on grouts and grouting have been very limited. Grouting often has to serve the primary purpose of filling the voids or replacing the existing fluids in voids by the grout with a view to improve the engineering properties of the grouted medium. Cement grouting is the most important and the most widely used method in the construction industries for reducing the mass permeability and increasing the strength of formations and also we grout filter media instead of cement. They develop the strength and become impermeable when the cement hydrates and cures into a system of interlocking crystals. Even today the grouting operations are based on thumb rules and existing practices rather than design principles and well defined procedures substantiated by research data. Hence a systematic study on the behavior of cement grouted or filter media grouted alluvial soils will be of immense help to the engineering community.

2.3. Objectives of the Present Study

The objectives of the present investigation are

1. To study the improvement in load carrying capacity of different fractions of loose sandy beds.
2. To investigate the effect of cement grouts on the shear strength of loose sandy soils.
3. To study how the commonly used admixtures affect the strength of the cement grouted soils.
4. To arrive at a useful correlation between the shear strength and compressive strength of grouted sand.
5. To develop a grouting setup for conducting model studies in the laboratory.
6. To assess the grouting efficiency through various methods such as measurement of cross section dimensions of the grouted mass, determination of cement contents at different points and by conducting load tests on the grouted sand beds.
7. To study the effectiveness of grouting in reducing the permeability of granular medium.

2.4. Conclusion

There has been rapid development in the field of the engineering of civil requiring the selection site from the considerations other than soil quality alone. This results in the need to make use of sites with very low bearing capacity/strength also, such as alluvial soils. This investigation examine the scope of the improving granular soils of low strength with cement grouting. Results on systematic studies carried out on strength of cement grouted sand medium from the view point of bearing capacity are scanty. Based on the experimental investigations and test results, the following conclusions are made.

- The load carrying capacity of the sand medium depends not only the density but also on the gradation and the load carrying capacity of finer fractions, is always higher compared to the coarser fractions irrespective of the density. This can be the attributed to the increased contact area b/w the particles, in the case of finer fractions.
- The rate of increase in shear strength is very high at higher percentages of cement than at lower percentages in the case of all the sand fractions.
- The shear strength of the loose sandy soil increases with increase in lime content and curing period, but this increase is negligible compared to the tremendous increase in shear strength when cement is used as the grout material.
- 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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