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Soil Improvement Techniques

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Abstract—*Soil in its natural state is not always fully suitable for supporting the structures at the construction site. Due to the instant growth in the population, speedy urbanization and the development of infrastructures (like buildings, highways, railways and other structures) to a great extent, in the past recent years it shows the reduction in the accessibility of good quality of soil. The main aim to this paper is to improve the soil by increasing its bearing capacity and by reducing the expected settlement. The paper gives an overview of different soil improvement techniques which are commonly used at present to improve the bearing capacity and to reduce settlement of soil to a considerable extent. The soil improvement techniques which are available at present are soil replacement, stone column, grouting, vibro-compaction, dynamic compaction, chemical stabilization, soil reinforcement and thermal methods of soil improvement. Reinforcing of soil is one of the method among all the soil improvement techniques which is used to improve the stability of soil, increase the bearing capacity and decreases the settlements and lateral deformations of soil by using material likes fibers of steel, glass, aluminium, nylon and various polymers in the form of strips, grids or geosynthetics. Depending on the composition and structure the geosynthetics can be permeable or impermeable in nature. On the basis of the requirement and the site condition a recently developed technique Geocell reinforcement can also be used in the area of soil reinforcement.*

Keywords*: Soil improvement, Geosynthetics, Vibro-compaction, Soil replacement, Dynamic compacton, Soil reinforcement.*

1. INTRODUCTION

The growth of the economical, social, cultural and industrial of any country extremely depends on its transportation system. Transportation by highways and railways is only mode which provides the maximum service to one and all. In the past recent years, as the result of development of infrastructures like highways, railways, buildings and other structures has resulted in the shortage of the good quality of land for the construction projects. Therefore, for construction the engineers are constrained to use inferior and weak soil. Now a day, for various construction projects the soil improvement techniques plays an important and essential task. Soil improvement techniques are used to increase the strength of the soil, to reduce compressibility and to enhance the performances of the soil under the applied loading. Due to the unique behaviour of high swelling and shrinkage action the expansive and collapsible soils are the biggest challenges to the engineers. There are some problems for the construction of foundation over the soft soils, sanitary landfills, organic soils and karst deposits. To overcome such type of problems it is good to replace and bypass such type of soil strata by using suitable design of foundation and if it is not possible we can use the soil improvement techniques which are the best solution for such type of construction project site. In this paper we study on the various modern soil improvement techniques and their applications.

Soil improvement techniques is divided into four categories:

1. Soil improvement without admixture.
2. Soil improvement with admixtures or inclusions.
3. Soil improvement using stabilization with additives and grounting methods.
4. Soil improvement using thermal methods.

2. LITERATURE REVIEW

Abdel Salam [4] and Abdel Fatah [7] made investigation on the soft clayey soil experimentally on the effect of using different types and thickness of replacement layer on increasing the bearing capacity and reducing the consolidation settlement. They concluded that, the vertical settlement decreases with the increase in replacement layer thickness.

Sneha P. Hirkane, N.G. Gore, P.J. Salunke (ISSN: 2319-9598, Volume-2, Issue-2, January 2014): Soil improvement techniques are frequently used to improve the properties of sub soil like bearing capacity, shear strength, settlement characteristics, drainage etc. Soil improvement technique has a wide range of application from coarse grained soil to fine grained soil. A suitable technique which is economical should be adopted depending on the loading condition and the nature of the soil. This paper gives an overview on the concept and theory of soil improvement techniques and its applications.

3. SOIL IMPROVEMENT WITHOUT ADMIXTURES

3.1. Soil Replacement

Soil improvement technique is one of the simplest and the oldest method to improve the bearing conditions of the soil. For the improvement of the foundation condition poor soil must be replaced with the more competent materials like sand, gravel or crushed stone. Some of the soil when used as a replacement layer is more difficult to compact than others. Under the shallow foundation the replacement of soil is use to reduce the consolidation settlement and to increase the bearing capacity of soil.

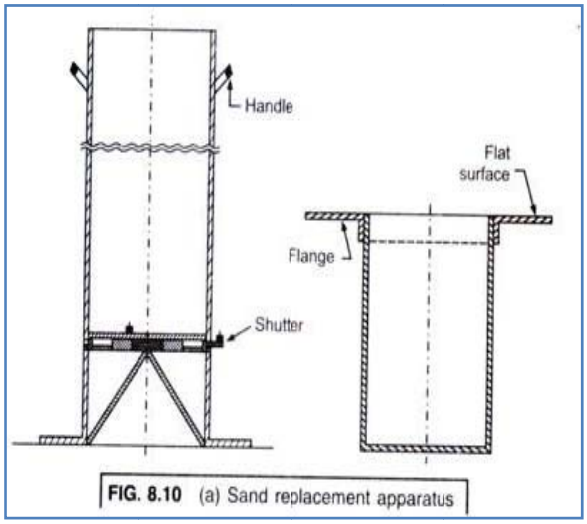

Fig. 1: Soil Replacement

3.2. Vertical Drains

Vertical drains is a special technique in which under the surcharge loading drains are installed to accelerate the drainage of relatively impervious soil and thus to speed up the consolidation. Drains provide a smaller path for the flow of the water from the soil to get away through it.

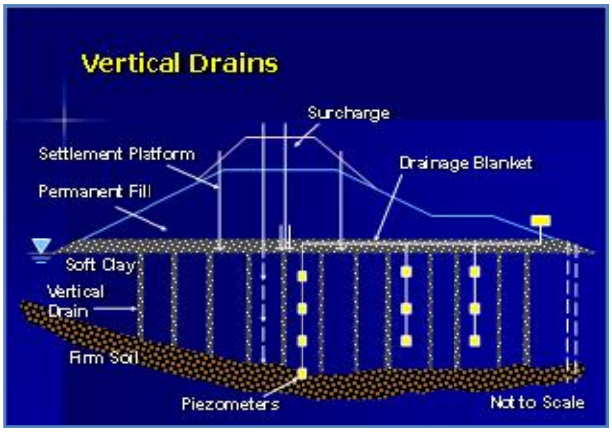

Fig. 2: Vertical Drains

There are commonly two types of vertical drains

1. Sand Drains.
2. Prefabricated Vertical Drains.

3.2.1. Sand Drains

Sand drains are constructed by drilling the holes in the soil through the clay layer by using rotary drilling, by driving down hollow mandrels or by continuous flight auger.

Application

1. Normally used with pre-loading in conjunction.
2. Sand drains are installed without surcharge loading to relieve excess hydrostatic pressure.

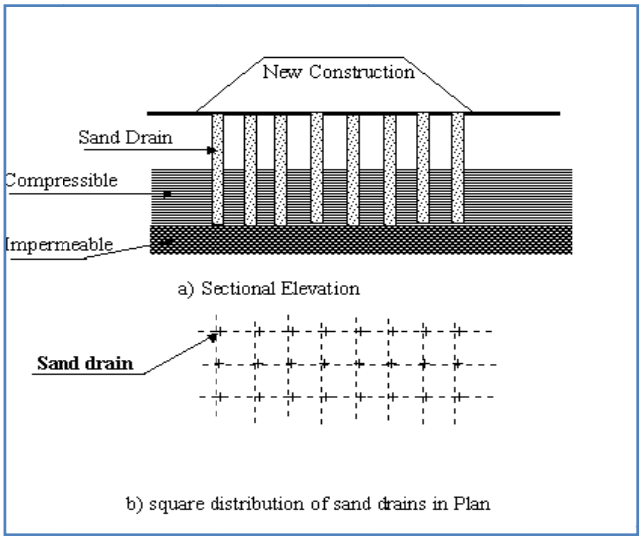

Fig. 3: Sand Drains

3.2.2. Prefabricated Vertical Drains

Prefabricated vertical drains are also called as “Wick Drains”. Prefabricated vertical drains are flexible, durable and inexpensive. As compare to the sand drains it is more advantageous and do not need drilling. It is use to decrease the process time of surcharge and to accelerate settlement.

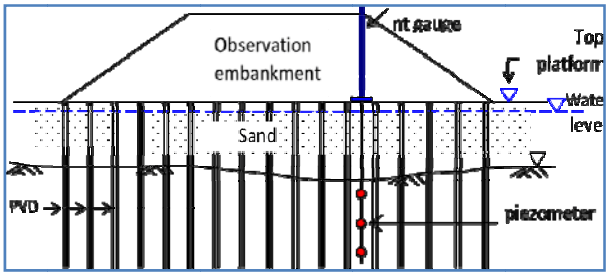

Fig. 4: Prefabricated Vertical Drains

4. SOIL IMPROVEMENT WITH ADMIXTURES OR INCLUSION

It is also called as “in-situ densification” because at the construction site it helps in densifying existence of the natural soil.

4.1. Stone Columns

Stone columns are used for the improvement of shear strength, to decrease the excessive settlement and to speed up the consolidation in the cohesive soils by shortening horizontal drainage paths for pore water flow.

Because of its granular nature which provides the additional shear strength to the surrounding soils stone columns are more preferable than sand drains.

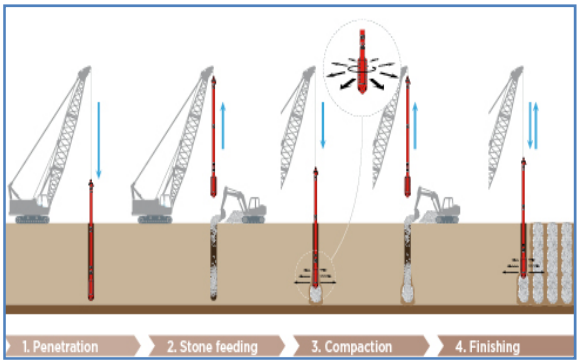

Fig. 5: Stone Columns

Application

1. Used to increase density in loose sand deposits.
2. Used to reduce the settlement of foundation.
3. To improve the bearing capacity of the soil.
4. In slope stabilization.

5. SOIL IMPROVEMENT USING STABILIZATION WITH ADDITIVES AND GROUTING METHODS

Soil stabilization technique is mostly used method to improve the strength of soil and to reduce its compressibility by bonding the soil particles together.

5.1. Chemical Stabilization

Soil stabilization can be attained by crumbling the natural soil, mixing it in a chemical additive and methodically compacting the mixture. To achieve the desired effect the soil stabilization depends on the chemical reactions between the natural soil and the additive (like lime, cement, fly ash or combinations of them).

The main aim of stabilizing soil is to improve the soil performance, to accelerate settlement, to increase the strength, durability and to decrease the compressibility of the soil.

There are three types of chemical stabilization

1. Cement Stabilization
2. Lime Stabilization
3. Fly ash Stabilization

5.2. Grouting

For soil improvement in underground and foundation construction grouting technique is commonly used.

Grout mix are classified as follows

1. Mortar and pastes such as cement to fill in holes or open cracks.
2. Suspensions such as ultra-fine cement to seal and strengthen sand and joints.
3. Solutions such as water glass (silicate).
4. Emulsions such as chemical grout.

Grout mixes depends on the soil nature and the soil gradation. Grouting are further classified as follows

1. Penetration grouting
2. Displacement grouting
3. Compaction grouting
4. Grouting of Voids
5. Jet grouting

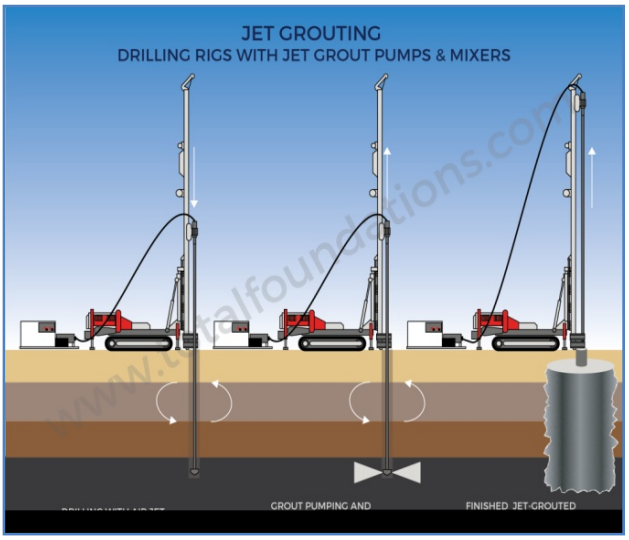

Fig. 6: Jet Grouting

6. SOIL IMPROVEMENT USING THERMAL METHOD

Heating or freezing of a soil causes the change in its properties. Due to its high cost the use of this method is limited even it appears to be very effective.

6.1. Soil Freezing

To convert in situ pore water in to ice by the refrigeration we use soil freezing. This ice will then act as a cement or glue, for bonding together the adjacent particles of soil or blocks of rock to increase their combined strength and make them as a impervious structure.

There are following considerations of soil freezing

1. Thermal analysis
2. Thermal properties of ground
3. Energy requirements
4. Freezing rates
5. Coolant/refrigerant distribution system analysis

Application

1. In the temporary underpinning.
2. Soil stabilization.
3. In providing temporary support for an excavation.
4. In preventing the excavated area from the groundwater flow.

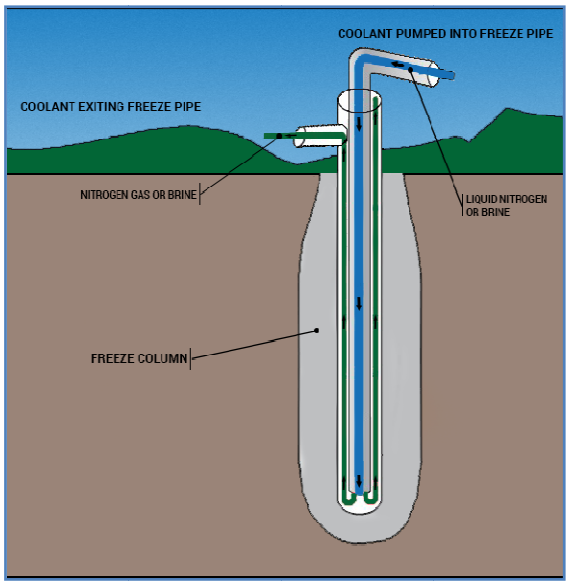

Fig. 7: Soil Freezing

7. CONCLUSION

In this paper we concluded that the soil improvement techniques are cost effective and viable solution for those soils which are weak in strength and suitable treatments are done in order to make them beneficial for construction. In the past years, the use of various techniques have been tested for various projects like highways, ports, railways, dams, industrial structures and other infrastructure facilities. All the techniques mentioned in this paper of soil stabilization have been used world-wide for different types of soils like silts, clays, loose sand and weak rocks.

8. ACKNOWLEDGEMENT

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