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A Study on Advances in Ground Improvement Techniques

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Abstract

In a construction project, there are numerous foundation problems that are encountered during the execution phase. Soil in its natural form, at a construction site, is not always suitable to completely bear heavy structural loads. For such situations, the soil needs to be improved to enhance its bearing capacity and decrease the expected settlement. There are certain techniques for ground improvement which are often used to improve sub-soil properties in terms of their bearing capacity, shear strength, settlement characteristics, drainage, etc. These techniques have a wide range of applicability from coarse grained soils to fine grained soils. Depending upon the loading conditions and nature of soil, a suitable technique which is also economical needs to be adopted. This paper gives the overview and concept of recent major ground improvement techniques and discusses their practical applications.

Key words,
Ground improvement, soil nailing, vibrofloatation, jet grouting, pre compression

1. Introduction

Ground improvement, is the modification of soil in foundation so as to provide better efficiency under design and/or operational loading conditions at the construction site. Ground improvement changes soil characteristics there by permitting different types of construction operations. These characteristics may be shear strength, swelling and shrinkage characteristics and bearing capacity. There is an increasing use of these techniques in the construction industry where the soils are having poor subsurface conditions. The ground improvement has been of great concern since early times. Different technologies started to develop since 17th century AD. Today, use of modern methods have made soil improvement relatively easier for the expects in the construction industry. In this paper, some of the major recent and convectional technologies are discussed with their applications in the field and their advantages and disadvantages.

2. Methods of Ground Improvement

There are numerous techniques for soil stabilization. These methods mainly depend on the nature of strata and the purpose of improvement. Techniques for soil stabilization can be broadly classified as

1. Soil improvement using additives
2. Soil improvement using mechanical methods
3. Soil improvement without using admixtures
4. Soil improvement using thermal methods
5. Other methods

3. Soil Improvement Using Additives

Certain additives such as lime bitumen, fly ash and cement etc. are added onto the soil at site to improve its characteristics. These may be classified as following.

3.1 Soil Improvement Using Chemicals

Some of the chemicals like lime, fly ash and cement are used as additives for soil improvement.

3.1.1 Lime Stabilization

This technique came into picture more than half a century ago. Lime can be used to treat soils in order to improve their workability and load bearing characteristics in a no. of situations. Quicklime delays the reaction time with soil by about 1.25 times the time taken by slaked lime

3.1.2 Fly Ash Stabilization

Fly ash, being a waste product from the thermal power plants is generally used in a variety of operations. Around 15% of the fly ash is utilized in the

Manufacturing of bricks and cement and the remaining is stored as slurries in lagoons. Hence despite having lesser cementitious properties than in lime and cement, the abundance of fly ash has made it an increasingly popular alternative during recent years. The fly ash is used potentially as a subgrade stabilizer and in land reclamation.

4. Soil Improvement Using Mechanical Methods

In this method soil is being densified using rollers and vibrators by applying a compressive force on the given soil. These techniques are further classified below.

4.1 Stone Column

Though this technique was first used in France in 1830s, the wide range of use of this technique spread especially in Europe since 1950s. In this method, the columns consist of compacted gravel or crushed stone arranged by a vibrator. Stone column technique decreases the compressibility of the soft and loose fine graded soils leading to increase in strength, accelerates consolidation effect and reduce the liquefaction potential of soils. Stone columns are more preferable than sand drains because of their granular nature which provides additional shear strength to the surrounding soils. They are mainly used for stabilization of soft soils such as soft clays, silts and silty-sands.

4.2 Vibro Floatation

Vibro-compaction, sometimes referred to as Vibro-floation, is the rearrangement of soil particles into a denser configuration by the use of powerful depth vibration. Particles of granular soil can achieve the effective depth of surface compactor and vibratory roller is limited to a few meters below ground level and the larger depths can be reached by deep compaction methods using depth vibrators.

4.3 Micro Piles

Micro piles are deep foundation elements constructed using high-strength, small-diameter steel casing and/or threaded bar. Micro piles were first used in Italy in the early 1950s for underpinning of those monuments and historic buildings that were getting damaged with time. Micro-piles have a small diameter (up to 300mm), and have a high load bearing capacity (up to 5000 KN in compression). They can be installed through virtually any ground condition, obstruction and foundation at any inclination and ensure minimum vibration or other damage to foundation and subsoil.

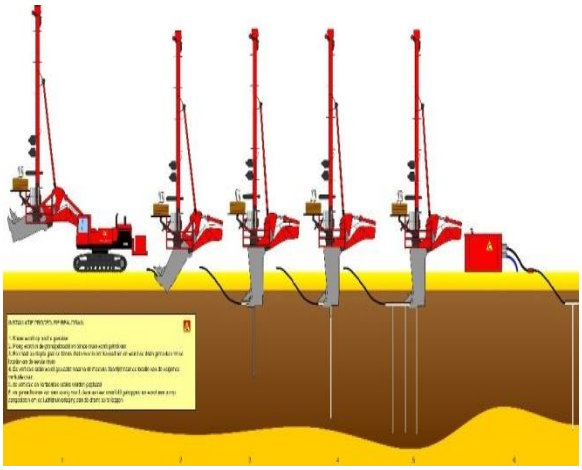
5 Soil Improvement without Using Admixtures

Some methods do not require use of any admixtures for soil stabilization. Some of these techniques are described below.

5.1 Soil Replacement

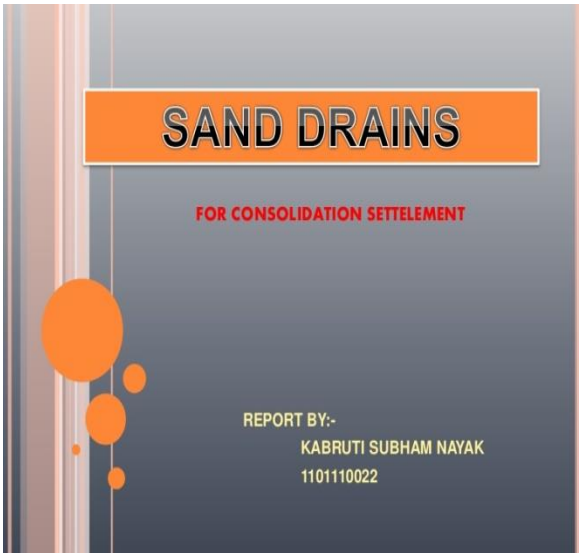
Where the soil is soft and of limited depth and thickness, removal of unsuitable material and replacement with well compacted suitable fill may be carried out. The removal and replacement required to be carried where the naturally occurring soils were found to be a low shear strength and high moisture content. Subsurface drainage may have to be introduced in most of these areas.

5.2 Vertical Drains

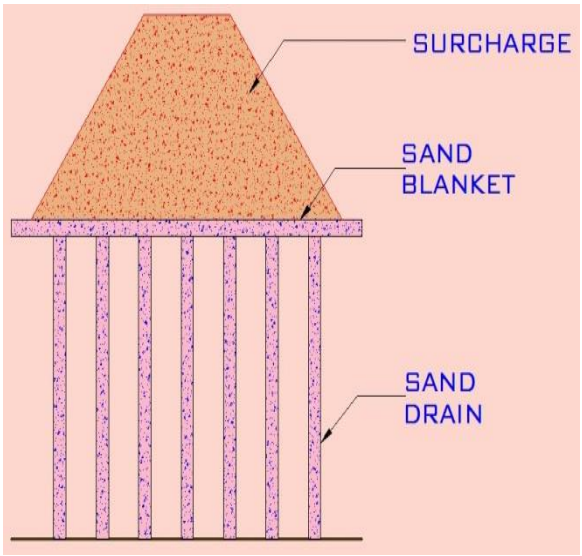


Vertical drains are used for speeding up the consolidation and thus increasing the shear strength and bearing capacity of the fine grained soils, as they provide a shorter distance for water to travel through the permeable vertical drains out of soil.

5.2.1SandDrains

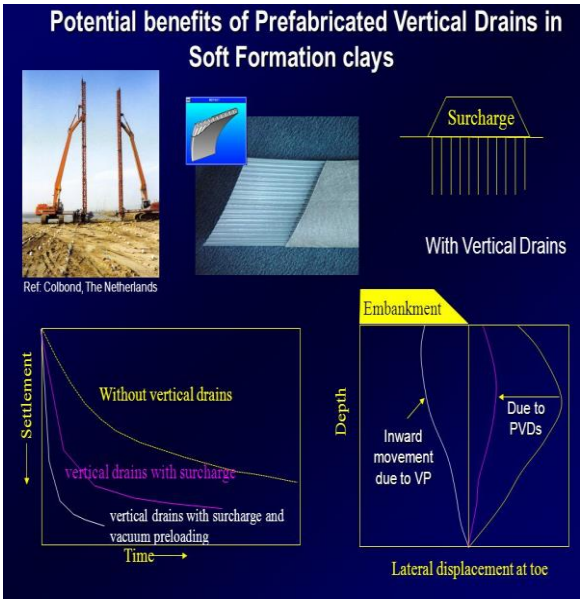


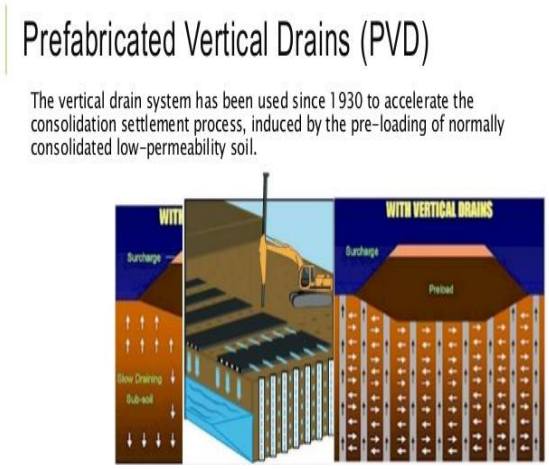
These are the vertical drains in which holes are drilled using rotary drilling and the hole is filled with sand which is highly permeable.



5.2.2 Pre-Fabricated Drains

Prefabricated vertical drains also known as wick drains consist of channeled synthetics core wrapped in geotextile fabric. They are flexible, durable, and inexpensive and have an advantage over sand drains is that they don't need drilling. The installation of prefabricated vertical drains is done by a mandrel and it is a displacement installation.





6. Soil Improvement Using Thermal Methods

By applying thermal treatment on soil its strength related properties can be influenced. There are two methods of thermal treatment; soil heating and soil freezing. These methods seem to be effective but its use is limited because of its high cost.

6.1 Soil Heating

The increase in temperature of especially fine soil can cause significant increase in its strength, by reducing electric repulsion between the grains and also flow of

Pour water takes place due to thermal gradient and a reduction in moisture content because of increasing evaporation rate.

6.2 Soil Freezing

Lowering the temperature of soil causes its pore water or moisture to freeze down and thus increase in volume of water and this acts as a cementing agent between the soil particles thereby increasing the shear strength of soil and decreasing its permeability. A refrigeration plant is used to maintain the coolant's temperature. Soil contaminated with radioactive elements that leaked from Japan's Fukushima Daiichi nuclear power plant was contained through ground freezing.

7. Conclusion:

The recent development in of ground improvement techniques which are widely used in the field of geotechnical engineering and will play a major role in the field and earthwork construction projects of many types in the years. As described many technologies are now available, some that are very old and some that are still developing and emerging, How to best incorporate sustainability considerations in ground improvement method selection and implementation giving consideration to embodied energy, carbon emissions, and life cycle costs.

1. Development of practical, economical and environmentally safe biogeochemical methods for soil stabilization and liquefaction risk mitigation.

2. Development of databases for variability of soil and material parameters required in the design of ground improvement

3. Development of improved and more reliable methods for evaluating the long term durability of soils mixed with binder.

4. Understanding creep mechanisms in soils and interaction of creep with semi-rigid inclusions. The sub discipline of ground improvement will continue its development and importance as a critical component of successful geotechnical engineering and construction.

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