Trends in Ground Improvement Techniques

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Abstract

Improvement of soft ground deposit s near the coastal areas, delta and black cotton soil areas of the country has been the challenge for infrastructural development. Rapid urban and industrial growth demands more land for further development. In order to meet this demand reclamation and utilization of unsuitable and environmentally affected lands have been taken up. These useless lands for construction have been converted to useful ones by adopting one or more ground improvement techniques. A wide range of techniques have been employed for the load settlement response of weak soil deposits. The field of ground improvement technique is rapidly expanding. It requires lots of investigation and monitoring some of the field problems related to compaction characteristics and feasibility of construction material.

Keyword- Compaction, Consolidation, Ground Improvement, Liquefaction, Settlement

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I. INTRODUCTION

In India, in some circumstances steel pipes, coated wooden piles are used as cost-effective Options in improving the bearing capacity of foundation or restrict Displacements to tolerable levels and similar uses in stabilization of slopes, strengthening of foundations are common. H.R. Sreekantiah (1993) presented a case study of ground improvement by using Vibrofloation method. In that investigation, a case history has been presented pertaining to the adoption of Vibrofloation technique, for compacting a very loosely filled up granular soil in the area around the Mangalore Chemicals and Fertilizers Company Limited, Mangalore, India, situated on the West Coast of India. Sridharan and Murthy (1993) described a Case study in which a ten-storeyed building, originally in a precarious condition due To differential settlement, was restored to safety using micro piles. . In this paper various ground improvement methods have been selected to provide soil strength improvement, mitigation of total settlements, reduce the construction cost as well as to shorten the construction time.
Types of ground improvement technique

A. Vibro-Compaction

Vibro-compaction, sometimes referred to as Vibrofloation, is the rearrangement of soil particles into a denser configuration by the use of powerful depth vibration. Vibrocompaction is a ground improvement process for densifying loose sands to create stable foundation soils. The principle behind vibrocompaction is simple. The combined action of vibration and water saturation by jetting rearranges loose sand grains into a more compact state. Vibrocompaction is performed with specially-designed vibrating probes. Both horizontal and vertical modes of vibration have been used in the past. The vibrators used by TerraSystems consist of torpedo-shaped probes 12 to 16 inches in diameter which vibrates at frequencies typically in the range of 30 to 50 Hz. The probe is first inserted into the ground by both jetting and vibration. After the probe reaches the required depth of compaction, granular material, usually sand, is added from the ground surface to fill the void space created by the vibrator. A compacted radial zone of granular material is created.

B. Vacuum Consolidation

Vacuum Consolidation is an effective means for improvement of saturated soft soils. The soil site is covered with an airtight membrane and vacuum is created underneath it by using dual venture and vacuum pump. The technology can provide an equivalent pre-loading of about 4.5m high conventional surcharge fill. Vacuum-assisted consolidation preloads the soil by reducing the pore pressure while maintaining a constant total stress.

C. Preloading

Preloading has been used for many years without change in the method or application to improve soil properties. Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time. The pore water dissipation reduces the total volume causing settlement. Surcharging is an economical method for ground improvement. However, the consolidation of the soils is time dependent, delaying construction projects making it a non-feasible alternative.

D. Heating

Heating or vitrification breaks the soil particle down to form a crystalline or glass product. It uses electrical current to heat the soil and modify the physical characteristics of the soil. Heating soils permanently alters the properties of the soil. Depending on the soil, temperatures can range between 300 and 1000 degree Celsius. The impact on adjacent structures and utilities should be considered when heating is used. .

E. Ground Freezing

Ground freezing is the use of refrigeration to convert in-situ pore water to ice. The ice then acts as a cement or glue, bonding together adjacent particles of soil or blocks of rock to increase their combined strength and make them impervious. The ground freezing considerations are Thermal analysis, Refrigeration system geometry,Thermal properties of soil and rock, freezing rates, Energy requirements, Coolant/ refrigerant distribution system analysis.

F. Vibro-Replacement Stone Columns

Vibro-Replacement extends the range of soils that can be improved by vibratory techniques to include cohesive soils. Reinforcement of the soil with compacted granular columns or "stone columns" is accomplished by the top-feed method. The important Vibro-replacement stone columns are Ground conditions, Relative density, Degree of saturation, Permeation.

G. Soil Nailing

The fundamental concept of soil nailing consists of reinforcing the ground by passive inclusions, closely spaced, to create in-situ soil and restrain its displacements. The basic design consists of transferring the resisting tensile forces generated in the inclusions into the ground through the friction mobilized at the interfaces.

H. Micro Piles

Micro-piles are small diameter piles (up to 300 mm), with the capability of sustaining high loads (compressive loads of over 5000 KN).The drilling equipment and methods allows micro – piles to be drilled through virtually every ground conditions, natural and artificial, with minimal vibration, disturbances and noise, at any angle below horizontal. The equipment can be further adapted to operate in locations with low headroom and severely restricted access.

I. General Grouting

Grouting is the injection of pumpable materials into a soil or rock formation to change the physical characteristics of the formation. Grouting selection considerations are Site specific requirement, Soil type, Soil groutability, Porosity. Grouting can be prevented by Collapse of granular soils, Settlement under adjacent foundations, Utilities damage, Day lighting. Grouting can provide increased soil strength and rigidity, reduced ground movement, Predictable degree of improvement.

The ground can be improved by adapting certain ground improvement techniques.

- Vibro-compaction increases the density of the soil by using powerful depth vibrators.
- Vacuum consolidation is used for improving soft soils by using a vacuum pump.
- Preloading method is used to remove pore water over time.
- Heating is used to form a crystalline or glass product by electric current.
- Ground freezing converts pore water to ice to increase their combined strength and make them impervious.
- Vibro replacement stone columns improve the bearing capacity of soil whereas Vibro displacement method displaces the soil.
- Electro osmosis makes water flow through fine grained soils. Electro kinetic stabilization is the application of electro osmosis. Reinforced soil steel is used for retaining structures, sloping walls, dams etc….
- Seismic loading is suited for construction in seismically active regions. Mechanically stabilized earth structures create a reinforced soil mass. The geo methods like Geosynthesis, Geogrid etc…. are can be used.
- Soil nailing increases the shear strength of the in-situ soil and restrains its displacement.
- Micro pile gives the structural support and used for repair/replacement of existing foundations.
- Grouting is injection of pump able materials to increase its rigidity. The jet grouting is quite advanced in speed as well as techniques.

J. Design Steps

1) Identify underground construction problem.
2) Establish objectives of grouting program.
3) Perform special geotechnical study.
4) Develop initial grouting program.
5) Compare with other solutions.
6) Refine design and prepare specifications.

II. CONCLUSION

The choice to adopt particular method of ground improvement basically depends upon the type of soil to be improved, extent of soil and cost involved. The suitability and limitation of various ground improvement methods are summarized below:

- For sandy soil, silty sand, sand gravel mixtures, Vibro-compaction, explosive compaction, cement stabilization, penetration grouting methods are generally used. Most of these methods can stabilize the soil up to 10 to 30 meter depth. The choice of the particular method depends upon the site condition and relative cost involved.
- For clayey soil, silt clay mixtures stone column technique can be used to improve the soil characteristics. The soil replacement technique may also be used for shallow depths. The use of admixture like lime is very popularly used for clays and black cotton soil.
- Some methods are suitable for most type of soils. They include sand and gravel compaction pile, deep soil mixing, soil replacement, admixture stabilization and Jet grouting (except high plastic clay).
- The cost of explosive compaction, stone column, Vibro-compaction, permeation grouting, replacement is low to moderate however the relative cost of chemical grouting, jet grouting, deep soil mixing is high to very high. However the cost to adopt a particular method depends upon site conditions, soil characteristics, location of the site, sub surface condition, depth of treatment, liquefaction vulnerability and many other factors.

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