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Review on Various Techniques to Improve Bearing Capacity of Soil

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Abstract

Due to the fresh land unavailability for the construction of infrastructure in present time, there are several techniques for the land reclamations. The main idea is to get a higher density of soil at site which finally gives the higher value of the shear strength and bearing capacity. The density can be increase by many techniques. Some of them required removal the water where the soil have a higher amount of the water content because high amount of water in the voids leads to lower shear strength and load carrying capacity. Creating the load bearing column which can drain water form low permeable soil and bear the load of superstructure on the weak soil (stone column,).And there are some other methods which glue the soil solids together and enhance its specific properties using geo materials (grouting, soil nailing).

Keywords: *Bearing Capacity, Compaction, Soil Mechanics, Settlement.*

INTRODUCTION

Bearing capacity is the strength of soil to support the loads applied to the ground. The bearing capacity of soil structure system is the maximum average contact pressure between the foundation and the soil, which should not produce shear failure or excessive settlement in the soil.

Since the population is increasing rapidly land availability for the structures are reducing now we have sites having poor soil for development of any civil engineering

structure. These sites soil have very less amount of bearing capacity so for the structure to sustain on the ground we required to increase the foundation area. An alternative method is also possible improve the soil at the site‘. So it is required to know about the methods to improve the soil‘s bearing capacity.

There are several techniques to improve the bearing capacity of the soil. Before going towards the methods of improvement we must know the causes that can affect the bearing capacity because the idea of improving the soil is directly related to these factors.

1. Some sites have high water table level and since we know that when soil goes into the submersed condition the bearing capacity is reduced by half amount. So if we are able to reduce the water table i.e. decrease the water content in the soil we can get an enhanced bearing capacity for that soil structure system.

The technique associated with this concept is very old method as by pumping the water out from the soil. Some techniques involve putting load on the soil which creates a head that allows water to come out. Some sites have very low permeability which does not allow the water to flow out easily we can introduce the sand drains which allow it to remove water rapidly.

2. The next problem is associated with the density of the soil. If we can achieve more mass into the same volume the density is enhanced hence the bearing capacity also improved. The technique associated with this concept to introduce a load by which particles of the soil mass can come closer to each other. Some time the friction between the soil solids creates the problem which can be eliminated by using a specific amount of water.

TECHNIQUES TO IMPROVE THE BEARING CAPACITY OF SOIL

There are so many various techniques for improving bearing capacity of soils. These are

1. Grouting
2. Soil nailing
3. Stone columns
4. Dynamic compaction
5. Preloading
6. Prefabricated vertical drains
7. Geosynthetics.

1. GROUTING

Grouting is an earth construction material used to embed rebar in masonry walls and fill voids, and seal joints. Grout's are applied as a thick liquid and hardens over time, much like mortar. Grouting is the process to inject grout into the ground. Materials used for grouting are Cement and water etc.

There are many techniques of grout mainly known as Compensation grouting, Jet Grouting, Compaction Grouting, Chemical grouting, Cement grouting.

Compensation grouting is the process of injecting grout that can compensate for stress relief and associated ground settlement.

Jet grouting is the process of grout injection that cuts and mixes the soil to be treated with cement or cementitious grout.

Compaction grouting is also known as Low Mobility Grouting. Compaction Grouting is a grouting technique that densifies reinforces fine grained soils and loose granular soils and stabilizes subsurface voids, by the staged injection of low-slump, low mobility aggregate grout.

Chemical grouting is a ground treatment method for soils with low viscosity grout.

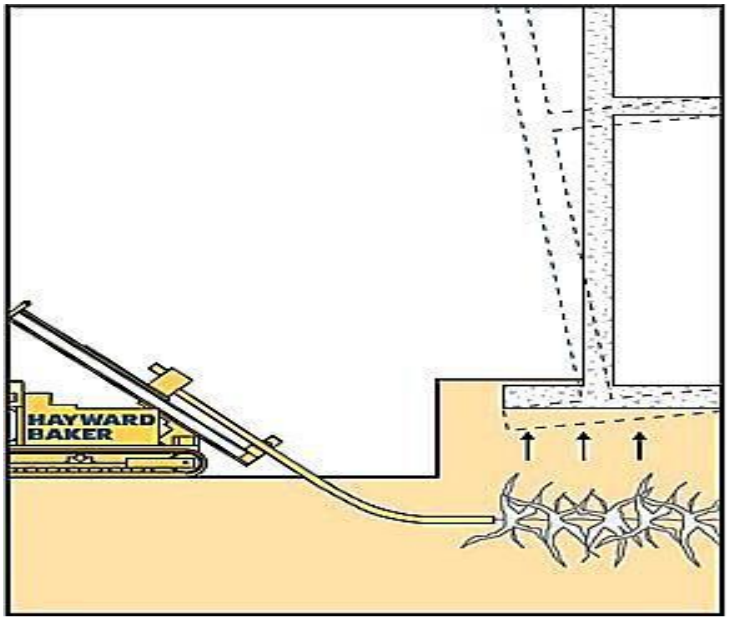

Fig. 1: Grouting

Cement grouting is also known as high mobility grouting. It is a grouting technique that fills pores in voids in rock or granular soil with flowable particulate grouts.

2. SOIL NAILING

Soil nailing is one of the earth retention technique using grouted tension-resisting steel elements that can be used for permanent or temporary support. The walls are generally constructed from the top down. In soil nailing 3 to 6 feet of earth is excavated from the top of the planned excavation. Near-horizontal holes are drilled into the exposed face at typically 3 to 6 feet centers.

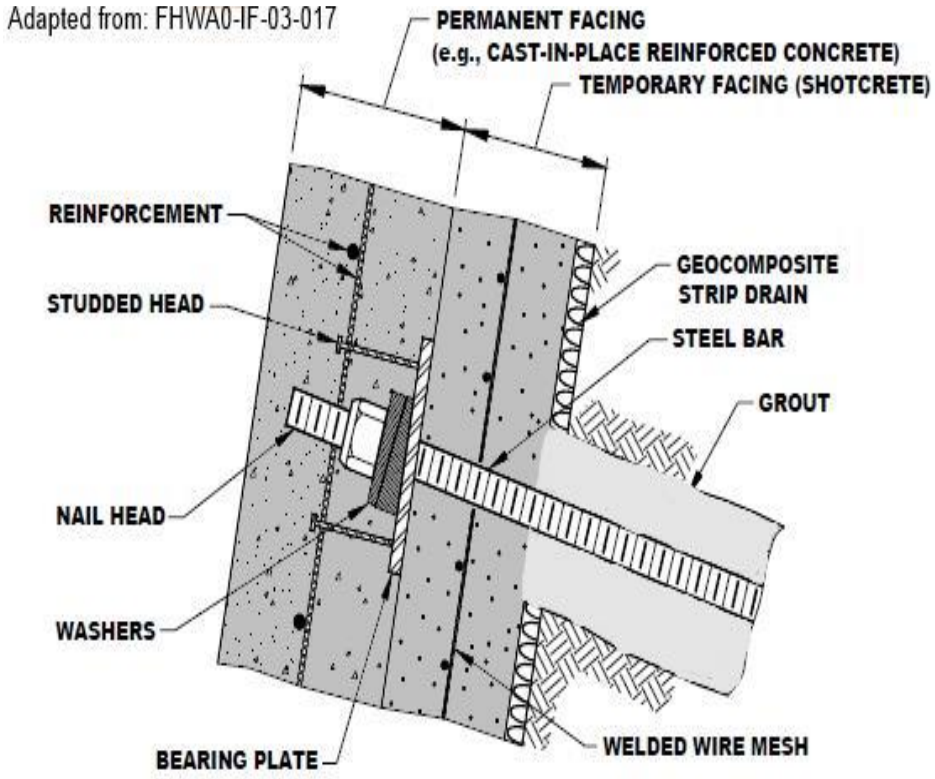

Fig. 2: Soil Nailing

COMPONENTS OF SOIL NAIL

The various components of a soil nail

Steel Bar- Steel bar is the main component of soil nail system. Steel bar acts as a tension member. It may be solid with necessary required strength.

Centralizers- Centralizer is fixed with steel bar so that nail can be placed centrally in drill hole.

Grout- Grout is used to fill the space between ground and installed nails.

Nail Head- Nail Head works as a reaction pad for generation of tensile force in the nails and it also prevent local failure between the nails.

Hex Nut, Washer and Bearing Plate- It provides support to the exposed surface of soil nail. After this the permanent facing should be installed over temporary facing.

Temporary and Permanent Facing- Permanent Facing provide support to the exposed surface of the soil nail and acts as bearing surface for bearing plate. And then permanent facing is installed over temporary facing.

Drainage System- A prefabricated synthetic drainage is placed vertically to the excavation face to prevent any seepage against the excavation face.

Type of Soil Nailing- Driven nails, Grouted nails, Jet grouted nails, Launched nails.

Materials used for Soil Nailing- Steel reinforcements, Shot Crete/gunite, Grout mix.

3. STONE COLUMNS

A stone column is a ground improvement technique that improves the load bearing capacity of the soil. The stone column is made up of crushed coarse aggregates of various sizes. The ratio in which the stones of different sizes will be mixed is decided by design criteria.

Stone columns are ideally suited for improving soft silts and clays and loose silty sands. Stone columns under suitable conditions will:

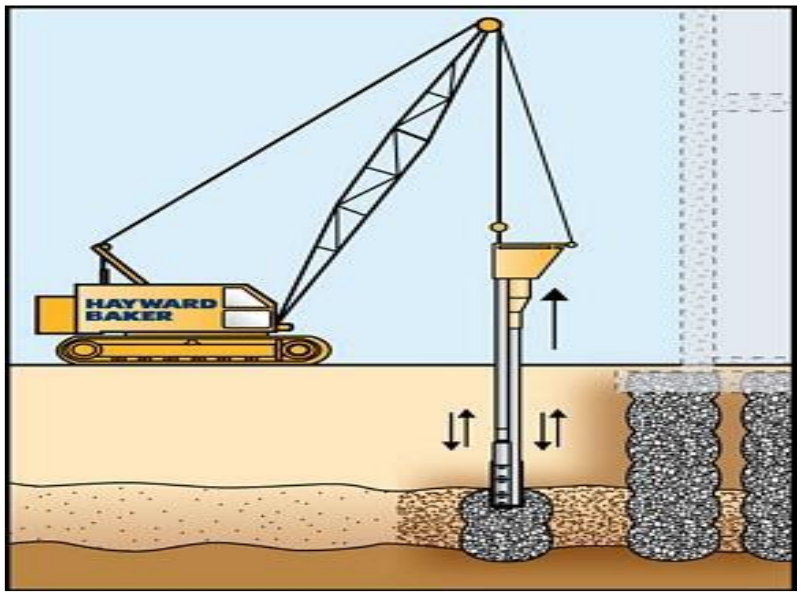

Fig. 3: Stone Columns

1. Increase a soil's bearing capacity and shear resistance
2. Reduce settlements
3. Increase the time-rate of consolidation
4. Reduce liquefaction potential.

4. DYNAMIC COMPACTION

Dynamic compaction is the ground improvement technique by using weights dropped from a height that results in the application of high energy to the in-situ soil resulting in improvement of the soil.

Typically, the weight from height dropped ranges from 11 to 39.6 kips and is dropped from heights of 30 to 100 feet.

Advantages

1) Increases soil density and collapses voids
2) Increases the bearing capacity of granular soils
3) Reduces the volume of landfills
4) Reduces the potential of soil liquefaction and seismic settlement
5) Reduces post-construction settlements

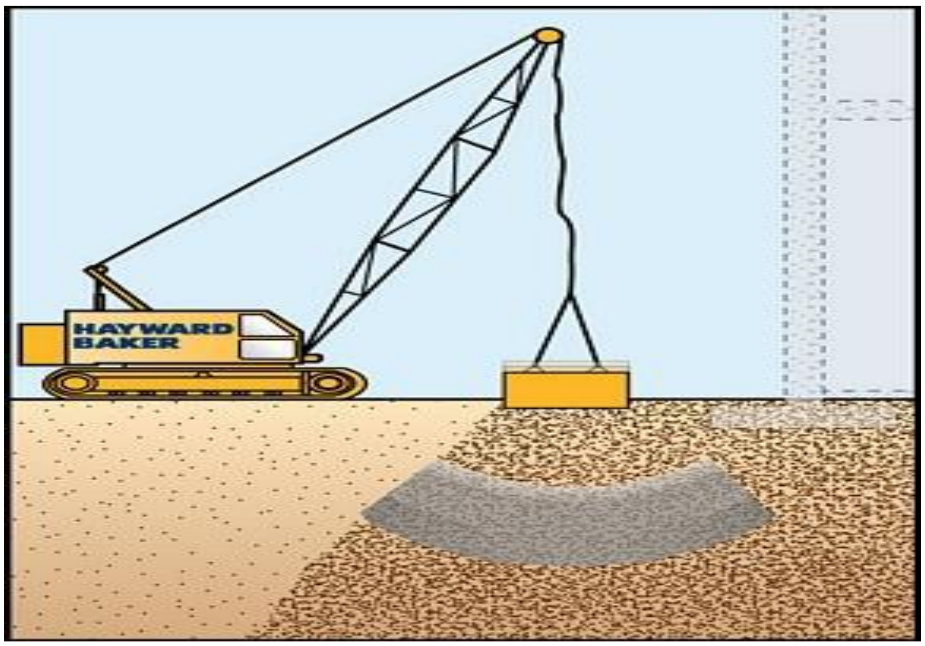

Fig. 4: Dynamic Compaction

Application

Treatment for industrial warehouses, port and airport platforms, road and railways embankments, heavy storage, tanks.

5. PRELOADING

- In this method we place a surcharge fill on top of the soil that requires consolidation.
- Once sufficient consolidation has done, the fill can be removed form site and construction takes place.
- The surcharge fills are typically 10-25 feet thick and produces settlement round about 1 to 3 feet.
- This method is most effective in clay soil.

Advantages

1. Requires only conventional earthmoving equipment
2. Any grading contractor can perform the work
3. Long track record of success

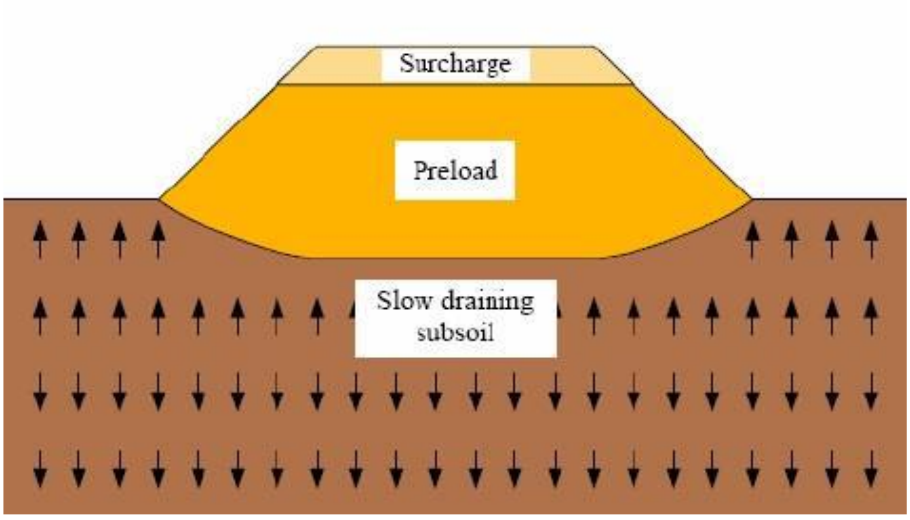

Fig. 5: Preloading

Disadvantages

1. Surcharge fill must extend horizontally at least 10 m beyond the perimeter of the planned construction, which is generally not possible at confined sites.

2. Transport of large quantities of soil required.

3. Surcharge must remain in place for months or a year that delays the construction.

6. PREFABRICATED VERTICAL DRAINS

Prefabricated vertical drain is defined as any prefabricated product consisting of a synthetic filter jacket that surrounds a plastic core because of their shape. These are also known as band or wick drains. After being they are manufactured in rolls of 200-300 m they are inserted into ground to required depths using special drain stitcher rigs. Generally, installation takes place up to full depth of compressible soils.

The prefabricated band drains are used for accelerating the consolidation of marine deposits or soft soils.

Components of Pvds

There are two components of pre-fabricated vertical drains.

1. ***Core-*** It is also called drain body which is a unique, corrugated, and flexible and made of polypropylene that is specifically

designed for providing high discharge capacity, high tensile and compressive strength.

2. ***Filter Jacket*** **–** It is strong non-woven, thermically bonded polypropylene fabric wrapped around the core. The fabric has random texture with high tensile strength, high permeability and effective filtering properties.

Application of Pvds

1. Airport Runways
2. Golf Courses
3. Dredge Consolidation
4. Mine Tailings Consolidation
5. Tailing Ponds
6. Wetland Development
7. Building Foundations
8. Retaining Walls
9. Parking Lots
10. Landfills

Advantages

(1) Minimum disturbance to the soil layers during installation.

(2) High water discharge capacity.

(3) High compressive strength core prevents the collapse of the flow path.

(4) Fast and easy installation.

(5) Deep installation exceeding 40 m in depth.

(6) High installation speed 1500 m/hr.

(7) Close spacing is possible.

7. GEOSYNTHETICS

Geosynthetics is defined as planar products manufactured from polymeric material, which are used with soil, rock, or other geotechnical engineering material to form an integral part of a manmade project, structure, or system. Geosynthetics are widely used for many geotechnical, environmental, and hydraulic applications related to groundwater quality and control. One of the most common examples is the use of geotextile filters in trench drains.

Types of Geosynthetics

1. Geotextiles
2. Geonets
3. Geogrids
4. Geocomposites
5. Geomembranes
6. Geocell.

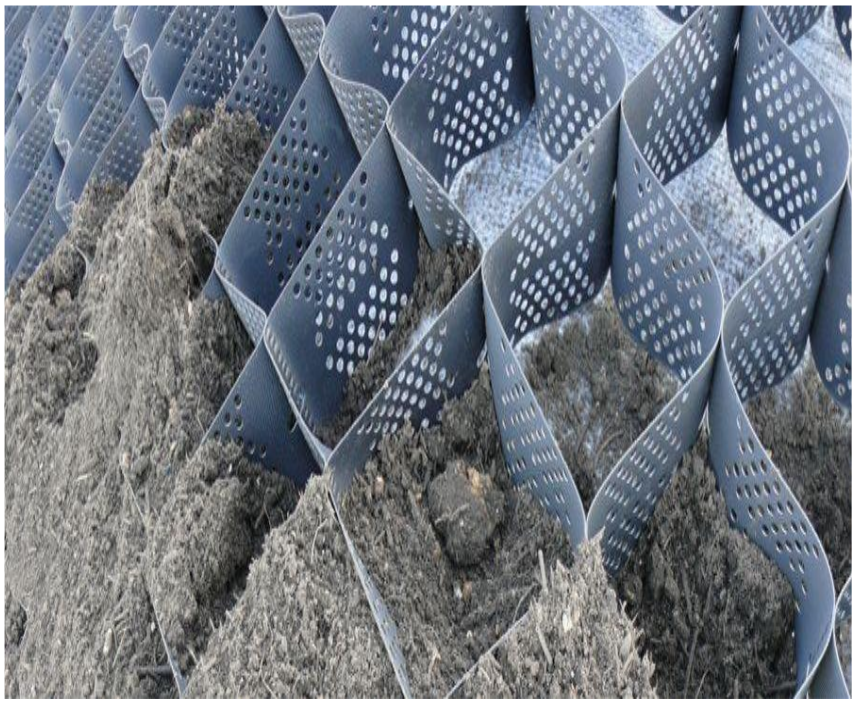

Fig. 6: Geosynthetics

Fig. 7: Geotextiles

GEOTEXTILES

Almost all geotextiles available are manufactured from either polyester or polypropylene. Polypropylene is lighter than water,strong and very durable. Polypropylene filaments and staple fibers are used to manufacture woven yarns and nonwoven geotextiles. High tenacity polyester fibers and yarns are also used for manufacturing geotextiles. Polyester has excellent strength and creep properties. It isalso compatible with most common soil environments.

GEONETS

Geonets are made of stacked, criss-cross polymer strands which provide in-plane drainage. Nearly all geonets are made from polyethylene.

1. Geonets are also planar products.

2. Consists of ribs in two directions.

3. Apertures are of diamond shape.

4. Ribs in the two directions are at different planes.

5. Thickness of geonets is larger than that of geogrids.

6. Geonets are also referred to as geospacers.

Fig. 8: Geonets

GEOGRIDS

Geogrids are single or multi-layer materials that are made byextruding and stretching high-density polyethylene or polypropylene. It canalso be manufactured by weaving or knitting and coating high tenacity polyester yarns. Resulting grid structure possesses large openings that aids in enhancing interaction with the soil or aggregate.

See Figure 9.

Functions of Geosynthetics

1. Separation
2. Drainage
3. Filtration
4. Reinforcement

Polymers used in Geosynthetics

1. Polypropylene
2. Polyethylene
3. Polyester
4. Polyamide
5. Polystyrene
6. Poly Vinyl Chloride

Advantages of Geosynthetics

1. Cheaper in product cost, transport and installation.
2. Space Savings.
3. Easy Material Deployment.
4. Increased safety factor.
5. Less Environmentally Sensitive.

Fig. 9: Geogrids

Application of Geosynthetics

1) In Roads and Pavements- Subgrade separation and Stabilization, base reinforcement, overlay stress absorption and for reinforcement.

2) In Subsurface Drainage- Subgrade dewatering, Road base drainage, Structure drainage.

3) In Reinforced Soil Systems- Embankments for soft foundations, Reinforced Steepened slopes, Reinforced soil walls.

4) In Seepage control systems- Structure water proofing, Environmental Protection.

CONCLUSION

In this study we have seen many techniques. These techniques can be applied depending on the type of improvement requires, economy of stabilization. As the grouting techniques applied on fractured rocks and loose soil. By the pressure this is injected into the soil/rock and it holds together the masses. Soil nailing is applied where the tension is required in the soil in other word we can say that where we required to retain soil or rock mass, which have a sliding tendency.

Stone columns are used where the bearing of soil is needed to be improved. Dynamic compaction is done to improve the bearing capacity, to reduce the volume of the land fill, reduce the liquefaction potential and settlement. Preloading is mostly suitable for clayey soil where the water content in the soil needs to be reduce. The geosynthatics is an advance material which can be used to enhance the specific properties of the soil. The freezing technique is also important but in those areas where the temperature is low.

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