2020

Ground Improvement Technique Final Paper

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14429

QUESTION NO.1

Part (A)

<u>How do we improve soil through excavation and replacement? How & which properties of soil are modified through additives, name a few additives with their functions?</u>

Answer:

The Need for Engineered Ground Improvement:

As more and more land become subject to urban or industrial development, good construction sites and borrow areas are difficult to find and the soil improvement alternatives becomes the best option, technically and economically. Where a project encounters difficult foundation conditions, possible alternative solutions are:

1. Avoid the site. Relocate a planned highway or development site.
2. Design the planned structure accordingly. Some of the many possible approaches are to: - Use a raft foundation supported by piles, - Design a very stiff structure which is not damaged by settlement, - Or choose a very flexible construction which accommodates differential movement or allows for compensation.
3. Remove and replace unsuitable soils. Removing organic topsoil, which is soft, compressible, and volumetrically unstable. This is a standard precaution in road or foundation construction.
4. Attempt to modify the existing ground

Vibro-flotation

Vibro-flotation involves the use of a vibrating probe that can penetrate granular soil to depths of over 100 feet. The vibrations of the probe cause the grain structure to collapse thereby densifying the soil surrounding the probe. To treat an area of potentially liquefiable soil, the vibro-flot is raised and lowered in a grid pattern. Vibro Replacement (right, HB) is a combination of vibroflotation with a gravel backfill resulting in stone columns, which not only increases the amount of densification, but provides a degree of reinforcement and a potentially effective means of drainage.

Dynamic Compaction

Densification by dynamic compaction is performed by dropping a heavy weight of steel or concrete in a grid pattern from heights of 30 to 100 ft. It provides an economical way of improving soil for mitigation of liquefaction hazards. Local liquefaction can be initiated beneath the drop point making it easier for the sand grains to densify. When the excess porewater pressure from the dynamic loading dissipates, additional densification occurs. As illustrated in the photograph, however, the process is somewhat invasive; the surface of the soil may require shallow compaction with possible addition of granular fill following dynamic compaction.

Stone Columns

As described above, stone columns are columns of gravel constructed in the ground. Stone columns can be constructed by the vibroflotation method. They can also be installed in other ways, for example, with help of a steel casing and a drop hammer as in the Franki Method. In this approach the steel casing is driven in to the soil and gravel is filled in from the top and tamped with a drop hammer as the steel casing is successively withdrawn.

Compaction Piles

Installing compaction piles is a very effective way of improving soil. Compaction piles are usually made of prestressed concrete or timber. Installation of compaction piles both densifies and reinforces the soil. The piles are generally installed in a grid pattern and are generally driven to depth of up to 60 ft.

Compaction Grouting

Compaction grouting is a technique whereby a slow-flowing water/sand/cement mix is injected under pressure into a granular soil. The grout forms a bulb that displaces and hence densifies, the surrounding soil (right, HB). Compaction grouting is a good option if the foundation of an existing building requires improvement, since it is possible to inject the grout from the side or at an inclined angle to reach beneath the building.

Drainage techniques

Liquefaction hazards can be reduced by increasing the drainage ability of the soil. If the porewater within the soil can drain freely, the build-up of excess pore water pressure will be reduced. Drainage techniques include installation of drains of gravel, sand or synthetic materials. Synthetic wick drains can be installed at various angles, in contrast to gravel or sand drains that are usually installed vertically. Drainage techniques are often used in combination with other types of soil improvement techniques for more effective liquefaction hazard reduction.

For information on other soil improvement techniques, see these links to related web sites.

Verification of Improvement

A number of methods can be used to verify the effectiveness of soil improvement. In-situ techniques are popular because of the limitations of many laboratory techniques. Usually, in-situ test are performed to evaluate the liquefaction potential of a soil deposit before the improvement was attempted. With the knowledge of the existing ground characteristics, one can then specify a necessary level of improvement in terms of insitu test parameters. Performing in-situ tests after improvement has been completed allows one to decide if the degree of improvement was satisfactory. In some cases, the extent of the improvement is not reflected in in-situ test results until sometime after the improvement has been completed

Soil modification through soil additives

Soil Stabilization using Lime

Slaked lime is very effective in treating heavy plastic clayey soils. Lime may be used alone or in combination with cement, bitumen or fly ash. Sandy soils can also be stabilized with these combinations. Lime has been mainly used for stabilizing the road bases and the subgrade.

Lime changes the nature of the adsorbed layer and provides pozzolanic action. Plasticity index of highly plastic soils are reduced by the addition of lime with soil. There is an increase in the optimum water content and a decrease in the maximum compacted density and he strength and durability of soil increases.

Normally 2 to 8% of lime may be required for coarse grained soils and 5 to 8% of lime may be required for plastic soils. The amount of fly ash as admixture may vary from 8 to 20% of the weight of the soil.

Soil Stabilization with Bitumen

Asphalts and tars are bituminous materials which are used for stabilization of soil, generally for pavement construction. Bituminous materials when added to a soil, it imparts both cohesion and reduced water absorption. Depending upon the above actions and the nature of soils, bitumen stabilization is classified in following four types:

- Sand bitumen stabilization
- Soil Bitumen stabilization
- Water proofed mechanical stabilization, and
- Oiled earth.

Chemical Stabilization of Soil

Calcium chloride being hygroscopic and deliquescent is used as a water retentive additive in mechanically stabilized soil bases and surfacing. The vapor pressure gets lowered, surface tension increases and rate of evaporation decreases. The freezing point of pure water gets lowered and it results in prevention or reduction of frost heave.

The depressing the electric double layer, the salt reduces the water pick up and thus the loss of strength of fine-grained soils. Calcium chloride acts as a soil flocculent and facilitates compaction.

Frequent application of calcium chloride may be necessary to make up for the loss of chemical by leaching action. For the salt to be effective, the relative humidity of the atmosphere should be above 30%.

Sodium chloride is the other chemical that can be used for this purpose with a stabilizing action similar to that of calcium chloride.

Sodium silicate is yet another chemical used for this purpose in combination with other chemicals such as calcium chloride, polymers, chrome lignin, alkyl chlorosilanes, siliconites, amines and quarternary ammonium salts, sodium hexametaphosphate, phosphoric acid combined with a wetting agent.

Part (B)

What are the various dewatering techniques which are generally used for ground improvement discuss?

Well points.

In Well point, wells are drilled around the excavation area with submersible pumps installed in the well shaft.

Deep wells.

In Deep well, one or several individual wells are drilled, and submersible pumps are placed in each shaft.

Bypass dewatering.

Flood control.

Tunneling dewatering.

QUESTION NO.02

Part (a)

<u>What do you understand about soil nailing? Under what condition the soil nailing is preferable?</u>

Soil Nailing is a technique to reinforce and strengthen ground adjacent to an excavation by installing closely spaced steel bars called “nails”, as construction proceeds from top down.

It is an effective and economical method of constructing retaining wall for excavation support, support of hill cuts, bridge abutments and high ways.

The nails are subjected to tension compression, shear and bending moments

Critical excavation depth of soil is about 1-2 m high vertical or nearly vertical cut.

All soil nails within a cross section are located above groundwater table.

Favorable Soils

- Stiff to hard fine-grained soils, dense to very dense granular soils with some apparent cohesion, weathered rock with no weakness planes and glacial soils etc.
- Stabilization of railroad and highway cut slopes
- Excavation retaining structures in urban areas for high-rise building and underground facilities.
- Existing concrete or masonry structures such as failing retaining walls and bridge abutments.
- Tunnel portals in steep and unstable stratified slopes
- construction and retrofitting of bridge abutments.
- Stabilizing steep cuttings to maximize development space.

Part (b)

Discuss the characteristics of a grout where and why grouting is required? What is compaction grouting, discuss the advantages and disadvantages of grouting?

Answer.

CHARACTERISTICS OF GROUTING:

Bleeding.

It is a phenomenon in which water is squeezed out from pores between cement particles into the ground. This process is similar to water drainage in soil consolidation. Bleeding has some consequences such as reducing the mobility and pumpability of the grout. Lambardi stated that a grout is considered stable when the final bleeding is less than 5% after 120 min. Tan et al. (2005) investigated the effects of bentonite, fly ash, and silica fume on the bleeding using Taguchi approach and found the silica fume as the most efficient additive among the above additives for bleeding reduction.

Setting time.

It defines the effective radius for the mobility of grout, and the ease of grouting operation. Depending on the individual conditions, either rapid or delayed setting may be desired. Rapid setting time is often desirable when injection is under water table (into moving or even not moving water), so that the grout will set before being excessively diluted or washed away. Conversely, where injection is to be made through a very long delivery system, extension of the setting time may be required. Likewise, where large linear void spaces require filling, delay of the initial set is usually desirable until filling is complete (Warner, 2004).

Strength:

It is a fundamental significance in the strengthening of rock or soil to enable it to withstand greater loads. It is highly crucial for strengthening of soils in slope stability and vertical trenches as well. In some grouting projects, however, especially those in connection with water control, strength is not of much importance.

Viscosity:

This characteristic refers to a fluid's resistance to flow, which is the result of internal molecular friction. The flow properties of a grout can be evaluated by the time in which a certain volume of grout is flowed out of a standard funnel. The pumpability of a grout mixture is primarily defined by its viscosity. Of course, based on the fact that there is a wide range of grout mixture with proper viscosity to pump, the in-range viscosity can easily be obtained.

Where Grout is required?

Grout is a dense fluid that is used to fill gaps or used as reinforcement in existing structures.

Grouts are used in a variety of applications such as;

repair of cracks, water

stopping in submerged structures such as canals, tunnels, etc., fill seams between tiles, and for stabilizing soil.

WHY?

Grout is used as a filler for the joints between tiles once the tile you are installing has been set.it helps keep dirt and debris from getting in between and under your tile. It adds rigidity and strength to the tile installation

Compaction Grouting

Compaction grouting involves the injection of a low slump, mortar grout to densify loose, granular soils and stabilise subsurface voids or sinkholes.

Common Uses

- Suitable for rubble fills, poorly placed fills, loosened or collapsible soils, soluble rocks and liquefiable soils
- Often selected for treatment beneath existing structures because the columns do not require structural connection to the foundations

- Decrease or correct settlement
- Increase bearing capacity
- Stabilise sinkholes or reduce sinkhole potential

Process

An injection pipe is inserted, typically to maximum treatment depth, and the grout then injected as the pipe is slowly removed in lifts, creating a column of overlapping grout bulbs. The expansion of the grout bulbs displaces surrounding soils and the grouting increases the density, friction angle, and stiffness of surrounding granular soils.

You can increase effectiveness by sequencing the compaction grouting from primary to secondary to tertiary locations. In all soils, the high modulus grout column reinforces the treatment zone.

ADVANTAGES:

- Often more economic than conventional approaches such as removal and replacement, or piling
- Can be done where access is difficult and in limited space

Advantages of Grouting

- This can be done on almost any ground condition
- It does not induce vibration and can be controlled to avoid structural damage
- Improvement in-ground structures can be measured
- Very useful for limited space and low headroom applications
- Used for slab jacking that lifts or levels the deformed foundation
- It can be installed adjacent to existing walls

Disadvantages of Grouting:

- The one main disadvantage of this technique is that it is a bit messy and may require cleanup. However, when you work with Engineered Solutions, this is never an issue, as our team strives to leave your property looking as it did when we arrived, only with sturdier ground soils underneath.

- Grouting adjacent to unsupported slopes may be ineffective.
- Not suitable in decomposable materials
- Danger of filling underground pipes with grout.
- Effectiveness questionable in saturated clays compaction permeation

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QUESTION NO.3

Part (a)

Answer:

Ground improvement is carried out to:

improve shear strength of the fill and subsoil to ensure sufficient bearing capacity of the foundations and/or sufficient stability of the slopes; increase the density of the fill mass and/or subsoil to prevent liquefaction;

- prevent excessive settlements of the surface of the reclamation area when structures like buildings, roads and other foundations are loaded on it;
- improve shear strength of the fill and subsoil to ensure sufficient bearing capacity of the foundations and/or sufficient stability of the slopes;
- increase the density of the fill mass and/or subsoil to prevent liquefaction; and
- improve soil permeability in order to increase drainage capacity.

Part (b)

Geotechnical problems of expensive soil

Soils are composed of a variety of materials, most of which do not expand in the presence of moisture. However, a number of clay minerals are expansive. These include: smectite, bentonite, montmorillonite, beidellite, vermiculite, attapulgite, nontronite, and chlorite.

Expansive soils contain minerals such as smectite clays that are capable of absorbing water. When they absorb water, they increase in volume. The more water they absorb, the more their volume increases. Expansions of ten percent or more are not uncommon. This change in volume can exert enough force on a building or other structure to cause damage.

Cracked foundations, floors, and basement walls are typical types of damage done by swelling soils. Damage to the upper floors of the building can occur when motion in the structure is significant.

Expansive soils will also shrink when they dry out. This shrinkage can remove support from buildings or other structures and result in damaging subsidence. Fissures in the soil can also develop. These fissures can facilitate the deep penetration of water when moist conditions or runoff occurs. This cycle of shrinkage and swelling places repetitive stress on structures, and damage worsens over time.

QUESTION NO.4

Part (a)

Answer.

Stone column

It acts as vertical drains and thus speeding up the process of consolidation, replaces the soft soil by a stronger material and initial compaction of soil during the process of installation thereby increasing the unit weight.

Stone columns is a technique for improving the soil strength and decreasing the compressibility. It is used in both cohesive and non-cohesive soils. This method can improvise the by reinforcement, densification and drainage functions.

Out of many methods used out there for increasing the soft clay, stone column is most suitable one. This technique is economical and makes the construction faster if the soils are having less safe bearing capacity. In this technique we place vertical columns of the coarse aggregate which is more compacted in nature through the soil which is meant to be improvised.

Requirements:

Knowledge of Geotechnical engineering.

Knowledge of Concrete Technology.

Test the parameters for the soil

Project Implementation:

1. Loose soils are found on the ground and are tested for the soil characteristics tests.
2. Test like plate load test or CPT are performed.
3. The stone columns are introduced into the loose soil.
4. Same tests are again performed on the improvised soil.
5. Compare and make a report of the difference between the soil before and after the improvisation of the soil.

Advantages:

- This method can be used in improving the slopes.
- Post settlements are not observed in this method as the stone are every granular.
- Reduction of foundation settlements.
- Increase in resistance to soil liquefaction
- This method can also resist lateral loads.

- Construction is very simple and effective.

Blasting

Blasting is the use of buried explosives to cause the densification of loose cohesion less ground. The principal is that the blasting of explosives in a predetermined pattern causes liquefaction, followed by the expulsion of pore water and subsequent densification of the ground. Blast densification is being utilized for more than 80 years to densify loose, saturated sand deposits.

The aim of this ground-improvement technique is to densify and improve the engineering characteristics of loose sand deposits and thus prevent or minimize the effects of liquefaction during an earthquake. The liquefaction of loose, saturated sands due to seismically induced ground motions continues to be the major source of damage to facilities and loss of human lives after severe earthquake events.

Procedure of the blasting for ground improvement

- Series of boreholes are drilled and Pipe of 7.5 to 10 cm is driven to the required depth
- The detonator and the dynamic sticks are both enclosed in a water proof bundle and is lowered through casings
- Casing is withdrawn and a wad of paper or wood is placed against the charge of Explosive (To protect it from misfire)
- Boreholes are backfilled with sand to obtain full force of blast
- The charge is fired in definite pattern

Part (b)

lime stabilization is one of the techniques which is in use for stabilizing black cotton soil from the past few decades. Use of lime reduces the high plasticity of black cotton and makes it workable. Also reaction between lime and soil makes the soil-lime mixture more strength resistant for the past few decades, researchers had tried to stabilize black cotton soil using lime for improving its shrinkage and swelling characteristics. But these days, the cost of lime has increased resulting in increase in need for alternative and cost effective waste materials such as fly ash and rice husk ash. Brick powder, one among the alternative materials, is a fine powdered waste that contains higher proportions of silica and is found near brick kilns in rural areas.

Introduction

Black cotton soils are boon to agriculture but are proved to be serious threat to construction founded on it. These soils have the property of high swelling due to imbibing of water in monsoon and shrinkage due to evaporation of water in summer seasons. This swelling and shrinkage nature is attributed to the presence of mineral montmorillonite. Because of this high swelling and shrinkage nature, the structures constructed on these soils experience cracks, making it unsuitable for foundation. Hence there is a need for improving black cotton soil to suite as foundation material.

lime stabilization of black cotton soil

stabilization is found to be the best technique for reducing the swelling and shrinkage nature of black cotton soil

Black cotton soil is mixed with lime in varying proportions of 2%, 4%, and 6%. The lime-mixed soil is then cured for a duration of 3 days. The mixture is then oven-dried for 24 hours.

Proportioning of brick powder and lime stabilized black cotton soil:

Addition of 4% lime to black cotton soil for stabilization did not yield the required value of CBR of 20% for subbase (Clause 401, Morth). Hence the lime-stabilized black cotton soil is mixed with brick powder, as it is rich in silica, in various proportions to obtain the optimum mixture suitable for use as subbase material. Also use of brick powder reduces the cost, as it is freely available at brick kilns. Lime-stabilized black cotton soil (LS) and brick powder (BP) are mixed in various proportions viz. 80% LS + 20% BP, 60% LS + 40% BP, 40% LS + 60% BP, and 20% LS + 80% BP. Maximum dry density and optimum moisture content of each proportion are determine by carrying out the IS light compaction test.