Question No. 1

(Part A)

Improvement of Soil through Excavation & Replacement:

Soils are used to support engineering structures. Few soils are used in their natural state while some may be excavated, processed and compacted in order to serve their purpose or replaced with suitable soils transported from suitable quarries. Blending and mixing heterogeneous soils to produce more homogenous soils. They may be mixed the soil during excavation by using equipment such as a power shovel or a deep-cutting belt loader to excavate through several layers in one operation. When such material is placed on a fill, it may be subjected to further blending by several passes with a disk harrow for pulverization.

Which properties of soils are modified through additives?

(1) Swell
(2) Shrinkage

When the volume of earth increases because of losing, this increase is defined as swell. It is expressed as a percent of the original undisturbed volume. If the earth removed from a hole having a volume of 1 Cu Yd. is found to have a loose volume of 1.25 Cu Yd. The gain in volume is 0.25 Cu yards or 25 percent when earth is placed in a fill and compacted under modern construction methods, it will usually have a smaller volume than in its original condition. This reduction in volume is the result of an increase in the density. This reduction in volume is defined as shrinkage.

Which additives are used?

(1) **Lime:** The plasticity index of soil with high clay content can be reduced by incorporating hydrated lime into the soil using a disk harrow or other stabilizing equipment such as the pulverize. The explanation for

this soil improvement lies in a Base Exchange reaction occurring between the lime and clay particles, which cause the clay to agglomerate and become more granular and porous. After compaction a cementing reaction occurs between the lime and free silica and alumina in the clay, resulting in a substantial improvement in the strength and stability of the soil.

(2) **Asphalt:** such as Mc-3 or Rc-3 are mixed with granular soils, in amounts of 5 to 7 percent of the volume of soil. To produce more stable soil. The moisture content of the soil must be low at the time the asphalt is added, also the volatile oils must be allow to evaporate from the bitumen before finishing and rolling the material. Soil treated in this manner may be used as finished surface for low traffic density secondary roads or as base courses for high-type pavement.

(3) **Cement:** This method is economical and convenient where the soil is clay or silt and native deposits of gravel or rock are scarce. The ratio of cement to soil is from 5 to 7 percent by weight.

(Part B)

What is Dewatering: Dewatering is a process in which groundwater contained within the site’s soil is extracted, ensuring a stable foundation

Dewatering Techniques:

1. Open dewatering

2. Well Point Dewatering

3. Deep Well Dewatering

4. General Sump Pumping

1. Open Dewatering: It enable one to lower the groundwater table adequately in cohesive and low permeable soils. Water is pumped off directly from sumps (ditches) along the toes of the slopes of the excavation works. The suction hose with strainer is merely placed in the sump and the collected water is primed and discharged. This makes the open dewatering system easy to install and simple to operate. The open dewatering system utilizes:

1. Self-Priming

2. Vacuum assisted centrifugal pumps

2. Well Point Dewatering: Well point dewatering systems enable one to lower the groundwater table adequately for deep and large construction sites. It has proven to be a very flexible system. The water from high permeable soils is pumped from well points, installed along the trench of the site. The well points are jetted and spaced to obtain an efficient drawdown against lowest capacity. The well point with integral strainer are jointed to transparent flexible hoses, which are connected by quick release couplers to the ring main header pipeline.

3. Deep Well Dewatering: Deep well dewatering systems enable one to lower the groundwater table to a considerable depth. A submersible pump is installed at the bottom of the well, of which the casing generally has a minimum diameter of 150 mm. The discharge pipes from the submersible pumps

of a number of adjacent wells are connected to a common delivery main. The water is raised from the well by a multi-staged pump

4. General Sump Pumping: Sump Pumps are used in applications where excess water must be pumped away from a particular area. They generally sit in a basin or sump that collects this excess water. This classification includes bilge and ballast pumps, centrifugal pumps, cantilever pumps, sewage pump pumps, submersible sump pumps and utility pumps, among others

Question No. 2

(Part A)

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.

Preferable Soil Conditions for Nailing:

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.

Unpreferable Soil Conditions for Nailing

Dry, poorly graded cohesion less soils, soils with cobbles and boulders, soft to very soft fine grained soils, organic soils.

(Part B)

Grout is a construction material used to embed rebar in masonry walls, connect sections of pre-cast concrete, fill voids, and seal joints (like those between tiles). Grout is generally composed of a mixture of water, cement, sand, often colour tint, and sometimes fine gravel (if it is being used to fill the cores of cement blocks). It is applied as a thick liquid and hardens over time, much like mortar. Initially, its application confines mainly in void filling, water stopping and consolidation. Nowadays, it extends to alleviate settlement of ground caused by basement and tunnel excavation works, to strengthen ground so that it can be used as a structural member or retaining structure in solving geotechnical problems

Characteristics of Grouting, where & why is required : Grouting is the process to inject grout into the ground. Hence, the volume of the ground ready to accept grout is the primary consideration before any other considerations. **Compaction grouting**: Involves injecting a very stiff homogeneous **grout** mix under relatively high-pressures and at low injection rates to subsurface locations in pre-designed patterns in order to displace and compact soils.

Advantages & Disadvantages:

It is a very effective, affordable, and practical soil stabilization technique, and many satisfied clients throughout the region have been pleased with the success of this method when installed by Engineered Solutions. The one main **disadvantage** of this technique is that it is a bit messy and may require clean-up.

Question No. 3

(Part A)

Causes of Ground Improvement Techniques:

Following are the causes of utilization of Ground Improvement Techniques:

1. Mechanical properties are not adequate
2. Swelling and shrinkage
3. Collapsible soils
4. Soft soils
5. Organic soils and peat soils
6. Sands and gravel deposits
7. Foundations on dumps and sanitary landfills
8. Handling dredged material
9. Handling hazardous materials in contact with soils

Why Ground Improvement Techniques are employed:

(1) To increase the bearing capacity of soil
(2) To control deformations and accelerate consolidation of soil
(3) To provide lateral stability
(4) To form seepage cut-off and environmental control
(5) To increase resistance to liquefaction

(Part B)

Because of the Expansive soil **swelling** and shrinking of **soils** may cause which may create the following **problems** in structures or construction projects:

1. Structural damage to lightweight structures such as sidewalks and driveways
2. Lifting of buildings
3. Damage to basements, and building settlement
4. Cracks in walls and ceilings.

Methods such as removing it completely and replacing it with fill dirt, pre-wetting and pre-**swelling** the **soil** and injecting or mixing of lime or other solutions into existing **soils**. These methods of trying to minimize the swell potential of the clay are costly, destructive, and disruptive to the environment. Expansive Soil Can Cause Foundation Problems. Expansive spoil is distinguished by the presence of swelling clay minerals that can absorb a significant amount of water molecules. When expansive soils obtain moisture, they expand or swell up.

Likewise, when expansive soils lose moisture, they begin to shrink. Since foundation walls are designed to support loads from above rather than lateral (sideways) bearings, expanding soil can cause foundation problems. Hence, when rain or improperly channelled water enters too quickly and oversaturates your backfill soil, that excess water will exert immense pressure against your foundation walls. This is known as hydrostatic pressure. The Problem with Hydrostatic Pressure Water is heavy! And it can build up underneath the floor, pushing upwards against your foundation. This is known as hydrostatic pressure and will enter the home through any weak point it can find. When that pressure bearing down becomes greater than you're below ground basement or crawl space walls can handle, the affected walls will begin to crack, bow, and push inwards. As pressure continues to build over time, what starts as a hairline crack will worsen and can eventually result in extreme wall failure, typically in the form of buckling, shearing, or even complete collapse. In addition to hydrostatic pressure caused from heavy or steady rains, factors such as expansive clay (which all homes in Georgia reside on) and water thawing too quickly after a winter freeze can also create too much stress on basement walls, causing them to crack, bow, and deteriorate.

Question No. 4

(Part A)

Stone column ground improvement involves adding vertical columns of stone into the ground to a depth of at least 4m below the ground surface. A layer of compacted gravel can then be put over the top of the columns, ready for the construction of engineering structure foundations. The stone column method is quick to construct and can be done at any time of the year.

How do stone columns improve the ground?

Stone columns help to limit the amount and consequences of future liquefaction by Densifying the soil through vibration and introducing stone into the soil. Reinforcing the soil creating a stiff composite soil mass. By achieving this, the non-liquefying soil crust is thickened and stiffened to reduce the likelihood of undulations, tilt and uneven ground surface subsidence from liquefaction of the underlying soil layers, therefore reducing damage to the house foundations. In addition, stone columns may sometimes provide the soil with an increased drainage path to help reduce excess pore water pressure that can lead to liquefaction, so the columns can reduce the consequences of liquefaction when this occurs.

How Blasting improve the ground?

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 densities 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.

How Blasting Done to Stabilize the Soil:

1. Series of boreholes are drilled and Pipe of 7.5 to 10 cm is driven to the required depth

2. The detonator and the dynamic sticks are both enclosed in a water proof bundle and is lowered through casings.

3. Casing is withdrawn and a wad of paper or wood is placed against the charge of Explosive (To protect it from misfire)

4. Boreholes are backfilled with sand to obtain full force of blast

5. The charge is fired in definite pattern

Blasting is more effective in loose sands that contain less than 20% silt and less than 5% clay. In case of partial saturated soil, the capillary action obstructs the densification tendency by preventing soil particles to come close. So this method is not useful for partial saturated soils. When deeper deposits are in question, the blasting is done in stages. Repeated shots are more effective than a single larger one.

(Part B)

In rainy season **black cotton soil** absorbs water heavily which results into swelling and softening of **soil**. In addition to this it also loses its strength and becomes easily compressible. Black cotton soil causes many problems to structures constructed on it. About 20% of the soil found in India is expansive in nature. Black cotton soil has tendency to heave during wet condition. In summer season reduction in water content it shrinks and produces cracks. Thus as a result of this roads on black cotton soil suffer from early failures in pavement with heavy traffic excessive unevenness, ruts, waves and corrugations are formed.

It is proposed to study causes of structures failure on black cotton soil. Typical behaviour of these soils under different climatic conditions has made the construction and maintenance of structures not only expensive but also difficult.

How to Improve ground having black cotton soil :

The usage of industrial waste in stabilization of soil becomes economical and it is easily available. There is a need to focus on improving properties of black cotton soils using cost effective materials like treating with industrial wastes those having cementations properties. Industrial wastes like rice husk ash (RHA), Foundry sand (FS) and Bagasse ash (BA) are used to improve geotechnical properties of a black cotton soil. Lime is also used for stabilization of black cotton soil mixed with soil.