Ire National University

Final Term Exam Paper

Subject: Ground Improvement Technique

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Q1:

Party A:

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?

Answer:

Soil excavation: 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.

SOIL REPLACEMENT: Soil replacement is one of the oldest and simplest methods which improve the bearing soil conditions. The foundation condition can be improved by replacing poor soil (eg. organic soils and medium or soft clay) with more competent materials such as sand, gravel or crushed stone as well, nearly any soil can be used in fills. However, some soils are more difficult to compact than others when used as a replacement layer.

Soil improvement using stabilization with additives methods. Soil stabilization method is widely used to improve soil strength and decrease its compressibility through bonding the soil particles together. Additives or grout are mixed with soil to bring about the stabilizing action required.

1. **Chemical Stabilization**: Soil stabilization can be achieved by pulverizing the natural soil, mixing in a chemical additive, and thoroughly compacting the mixture. Under this category, soil stabilization depends mainly on chemical reactions between the additive (such as lime, cement, fly ash or combinations of them) and the natural soil to achieve the desired effect [16]. The main purposes of stabilizing soil are to improve the performance of the soil, accelerate settlement, increase the strength, the durability and reduce the compressibility of the soil [17]. 4.1.1. Cement stabilization Cement is the oldest binding agent since the invention of soil stabilization technology in 1960's. It is commonly used to stabilize wide range of soils, provided sufficient quantity is added. As clay content increase, soils become more difficult to pulverize and work, and larger quantities of cement must be added to harden them. Cement reaction is not dependent on soil minerals, and the key role is its reaction with water that may be available in any soil.
   This can be the reason why cement is used to stabilize a wide range of soils.In this technique, cement is mixed with water and soils by special equipment in site.
   Physical and chemical reactions within cement and soil are happened. Setting of cement will enclose soil as glue, but it will not change the structure of soil. The soil is hardened as cemented soil. Hardening process can be affected by physical and chemical properties of soil, water-cement ratio, curing temperature and the degree of compaction.

On the other hand, the nature of soil treated, the type of cement utilized, the placement and cure conditions adopted affect determining the correct proportion of soil – cement.

2. **Lime stabilization** Lime provides an economical way of clayey soil stabilization. Selection of the suitable lime concentration for clay stabilization is based on achieving a target pH value. Stabilization can be ineffective if the concentration of admixture is not adequate to ensure strength and durability.it is usually in the range from 5 to 10% Lime can be mixed with the soil either in plant or in site or lime slurry can be injected in to the soil The improvements in soil properties are attributed to the soil-lime reactions (cation exchange and flocculation – agglomeration). In these reactions, monovalent cations associated with clay are generally replaced by divalent ions. Flocculation – agglomeration produces changes in clay texture and clay particles become larger there by improving soil strength.
3. **Fly-Ash stabilization** of soils with coal fly ash is an increasingly popular alternative nowadays. Fly ash is a product of coal fired electric power generation Asphalt-soil stabilization 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. Facilities; it has little cementitious properties compared to lime and cement.

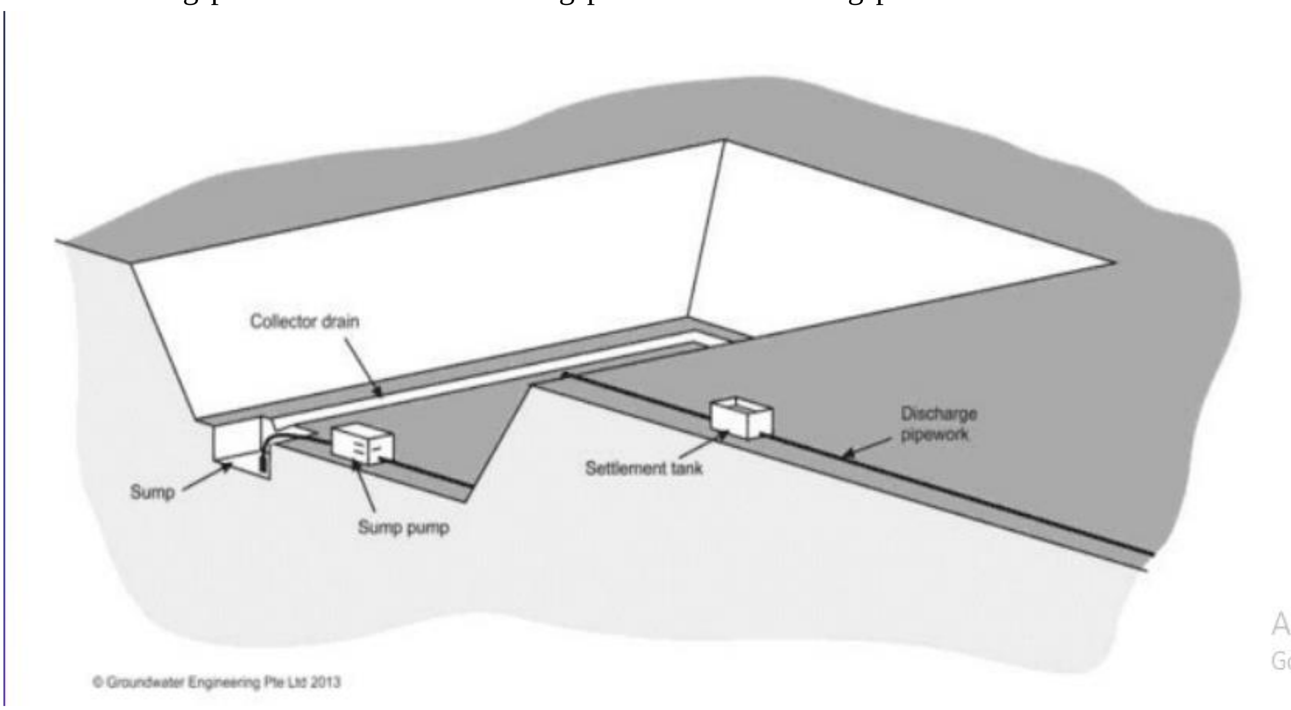
Part B:

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

Answer:

1. **Dewatering** is to lower an existing groundwater table by open pumping (sumps, trenches, and pumps), a well system (well points or deep wells), and the electro osmosis method. The most common purpose for dewatering is for construction excavations.
2. Dewatering for construction excavations is mostly temporary. There are structures and highways constructed with permanent dewatering systems, but they are far less than temporary or construction dewatering systems. Permanent dewatering systems require continuous operation without interruption; therefore, they should be conservatively designed and maintained.
3. Dewatering or construction dewatering are terms used to describe the action of removing groundwater or surface water from a construction site. Normally dewatering process is done by pumping or evaporation and is usually done before excavation for footings or to lower water table that might be causing problems during excavations.

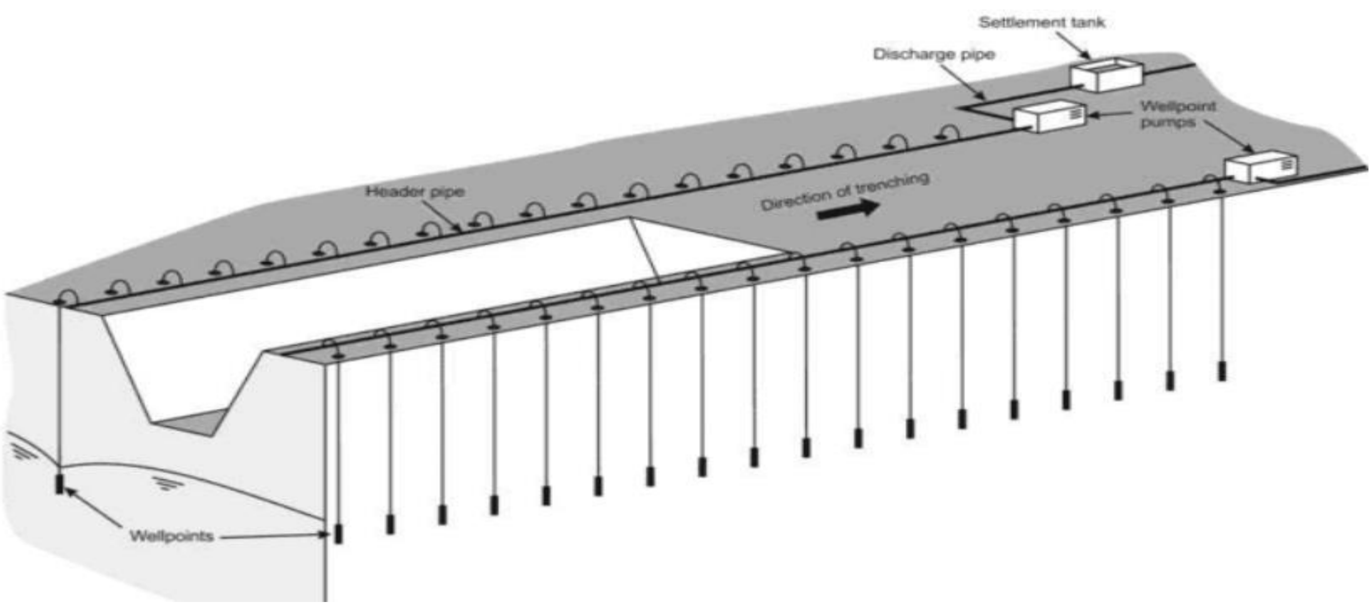
4. Dewatering can also be known as the process of removing water from soil by wet classification. What is the need for drainage and dewatering?
5. **.Sumps and sump pumping:**
6. Sumps and sump pumping: A sump is merely a hole in the ground from which water is being pumped for the purpose of removing water from the adjoining area They are used with ditches leading to them in large excavations. Up to maximum of 8m below pump installation level; for greater depths a submersible pump is required. Shallow slopes may be required for unsupported excavations in silts and fine sands. Gravels and coarse sands are more suitable. Fines may be easily removed from ground and soils containing large percent of fines are not suitable.
7. If there are existing foundations in the vicinity pumping may cause settlement of these foundations. Subsidence of adjacent ground and sloughing of the lower part of a slope (sloped pits) may occur. The sump should be preferably lined with a filter material which has grain size gradations in compatible with the filter rules. For prolonged pumping the sump should be prepared by first driving sheeting around the sump area for the full depth of the sump and installing a cage inside the sump made of wire mesh with internal strutting or a perforating pipe filling the filter material in the space outside the cage and at the bottom of the cage and withdrawing the sheeting. Two simple sumping details are shown in Figures 2 and 3. Visit : Civildatas.blogspot.in Visit : Civildatas.blogspot.in Civildatas.blogspot.in



8. **OPEN SUMPS AND DICTHES:** The essential feature of this method is a sump below the ground level of the excavation at one or more corners or sides.. a small ditch is cut around the bottom of the excavation , falling towards the sump. It is the most widely used and economical of all methods of ground water lowering. This method is also more appropriate in situations where boulders or other massive

obstructions are met with the ground. There is also a disadvantage that the groundwater flows towards the excavation with a high head or a steep slope and hence there is a risk of collapse of the sides.

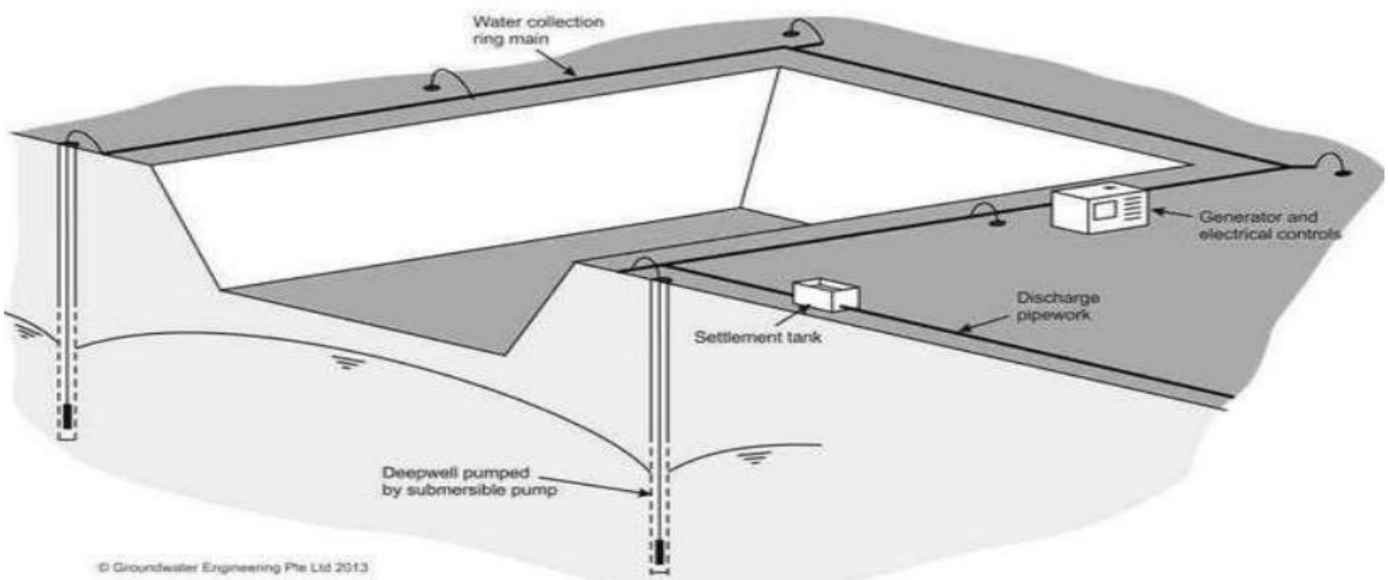
9.
10. **WellPoint systems** A wellpoint is 5.0-7.5 cm diameter metal or plastic pipe 60 cm – 120 cm long which is perforated and covered with a screen. The lower end of the pipe has a driving head with water holes for jetting Well points are connected to 5.0-7.5 cm diameter pipes known as riser pipes and are inserted into the ground by driving or jetting. The upper ends of the riser pipes lead to a header pipe which, in turn, connected to a pump.
11. The ground water is drawn by the pump into the well points through the header pipe and discharged The well points are usually installed with 0.75m – 3m spacing 1). This type of dewatering system is effective in soils constituted primarily of sand fraction or other soil containing seams of such materials.
12. In gravels spacing required may be too close and impracticable. In clays it is also not used because it is too slow. In silts and silt – clay mixtures the use of well points are aided by upper (0.60m – 0.90m long) compacted clay seals and sand-filtered boreholes (20cm – 60cm diameter). Upper clay seals help to maintain higher suction (vacuum) pressures and sand filters increase the amount of
13. • A line or ring of small diameter shallow wells (called wellpoints) installed at close



spacing (1 to 3 m centres) around the excavation. • Commonly used for dewatering of pipeline trenches • Can be a very flexible and effective method of dewatering in sands or sands and gravels • Drawdown limited to 5 or 6 m below level of pump due to suction lift limits • Individual wellpoints may need to be carefully adjusted (“trimming”).

14. Deep Wells:

Wells are drilled at wide spacing (10 to 60 m between wells) to form a ring around the outside of the excavation • An electric submersible pump is installed in each well. Drawdown limited only by well depth and soil stratification • Effective in a wide range of ground conditions, sands, gravels, fissured rocks



Q2:

Party A:

What do you understand about soil nailing? Under what condition the soil nailing is preferable?

Answer:

Soil Nailing:

Soil nails are a cost effective method for long or short term stabilization of steep existing or proposed slopes. The stability of the slope is increased with the installation of steel or glass fiber threaded soil nails placed into pre-bored holes or simultaneous drilling and installation techniques. The end results along with the correct drainage significantly reduce the chances of a landslide or other ground movements.

Whether it's for roadway cut excavations, slope stabilization or retaining wall support, soil nails are a versatile and practical form of earth retention used to prevent horizontal movement. Aarsleff Ground Engineering proves time and time again that Soil nailing is a proven technique for the construction of new steep cuts or the strengthening of an existing slopes, In certain conditions, soil nails offers a viable alternative from the viewpoint of technical feasibility, construction costs, and construction duration when compared to ground anchor walls, which is another popular top-to-bottom retaining system. Soil nail walls are particularly well suited to excavation applications for ground conditions that require vertical or near-vertical cuts and have been shown to be particularly well suited for the following temporary or permanent applications:

- Roadway cut excavations.
- Road widening under an existing bridge end.
- Repair and reconstruction of existing retaining structures.
- Temporary or permanent excavations in an urban environment.

Soil nails are usually much shorter than tieback anchors, and generally have no structural (vertical) wall member (e.g., soldier pile or structural wall) for reaction.

Soil nails generally comprise metallic or polymeric members installed in the ground to provide tension and bending resistances to reinforce the soil mass for stabilization of natural or existing slopes. Installation can be either grouted in prebored holes or by insertion using a displacement technique with either static push or dynamic forces (vibration, percussion, and/or rotation). Soil nails are installed either horizontally or at various degrees from the horizontal, depending on the slope geometry. Horizontal nails develop significant tension resistance, whereas nails perpendicular to a failure plane develop significant bending resistance.

Soil nail advantages

Soil nail walls exhibit numerous advantages when compared to ground anchors and alternative top-down construction techniques. Some of these advantages are described below:

- Less disruptive to traffic and causes less environmental impact compared to other construction methods.
- Provide a less congested workplace, particularly when compared to braced excavations.
- There is no need to embed any structural element below the bottom of excavation as with soldier beams used in ground anchor walls.
- Soil nail installation is relatively rapid and uses typically less construction materials than ground anchor walls.
- Nail location, inclination, and lengths can be adjusted easily when obstructions (cobbles or boulders, piles or underground utilities) are encountered. On the other hand, the horizontal position of ground anchors is more difficult to modify almost making field adjustments costly.
- Soil nailing is advantageous at sites with remote access because smaller equipment is generally needed.
- Soil nail walls are relatively flexible and can accommodate relatively large total and differential settlements.
- Measured total deflections of soil nail walls are usually within tolerable limits.
- Soil nail walls have performed well during seismic events owing to overall system flexibility.
- Soil nail walls are more economical than conventional concrete gravity walls when conventional soil nailing construction procedures are used.

Soil nail walls are typically equivalent in cost or more cost-effective than ground anchor walls when conventional soil nailing construction procedures are used.

The preferable Conditions for Soil Nails:

According to a report done for the Federal Highway Administration, soil nailing is most favorable (and cost-effective) under the following slope conditions:

- Preferably, all soil nails will be implemented above the groundwater table.
- Should any nails need to be below the water table, the conditions can still be favorable so long as the ground water doesn’t cause a problem with the bond strength of the grout, the excavation face, or the life of the nails, themselves.
- In ideal conditions, the slope receiving the soil nails can stay standing without support for 24-48 hours at a 3-6 foot vertical cut.

In addition, certain ground types are preferable for **soil nailing**. Slopes which are comprised of other types of soils require different methods of slope stabilization.

The following are the most favorable ground types for soil nailing:

- Glacial soils
- Weathered rock (provided there are no problematic weakness planes)
- Stiff to hard cohesive soils

- Dense to very dense granular soils (preferably with a level of cohesion)

Part B:

Characteristics of Grouting

- Non-corrosive
- Not flammable, non-toxic
- Shrinkage compensated
- Process and its Specification
- Substrate preparation
- Able Adjustable Fixture
- Very good flow characteristics
- Excellent Bond to Concrete
- No segment or bleeding
- High final strengths
- Easy to use (ready to mix powder)
- Easy to mix, only add water
- Initial expansion by gas generation
- Impact and vibration resistant

What is Compaction Grouting?

Compaction Grouting is a very specialized grouting technique designed to stabilize or densify the existing weak soils. This is accomplished by drilling/driving injection casing to the predetermined grout zone depth and injecting a low-slump, low-mobility soil/cement grout from the bottom of the grout zone up in designed stages. Each stage creates a grout bulb displacing the existing soils in all directions thus densifying the grout zone.

Compaction grouting can solve soil density problems. In this technique, a stiff mortar-like mixture is pumped into the soil. Rather than flowing through the soil, it forms an expanding bulb, displacing the soil while forcing out air and water. The resulting denser soil has a higher load-bearing capacity, thus stopping or preventing settlement. It can also be used to lift settled structures

How Does Installation Process Work

It is typically carried out over a predefined grid pattern in a sequenced operation. The casing is driven or drilled on a design depth at each location, and the mixture is typically carried out in stages of 1 to 3 feet until refusal met. The spacing and steps of the grid pattern will determine by the depth of the grout zone, the overload of the grout zone, the types of soil and the pre-grow blow counts from the soil boring. The volume can be determined by an increase in the amount of the ground usually from 5% to 20% range.

Compaction Grouting Utilization

It is used to improve bearing capacity of soils for new construction or adding load to existing structures. It is also used for densifying soils and lifting settled structures, stabilizing underground formations for pipes, improve bearing capacity of soils, and manage sites with sinkhole activity.

The following can use compaction grouting subsurface conditions.

- Sinking or settling formations
- Sinkholes
- Weak soils
- inadequately compact fills

Advantages of Compaction Grouting

It can manage the settlement of foundations on existing homes; stabilize subsoils that are defined to be weak before starting construction on a new home or structure, and lifting existing foundations that have settled.

Here are some advantages of Compaction Grouting:

- Rapid installation
- No spoil generation
- Can be accomplished in restricted access situations
- Structural foundation connections not required
- Low mobility grout rheology allows for precisely controlled placement

- To increase bearing capacity
- To arrest or reduce foundation settlements
- Mitigation of liquefaction potential
- Sinkhole remediation
- Stabilization of karstic formations

Compaction Grouting Limitations

- Not suitable for soils with deficient permeability (i.e. clays)
- Zone where limited overburden above the grout zone results in heaving. Usually, a minimum of 5 feet of overburden is required.

Disadvantages

Truth be told, there are few disadvantages associated with compaction grouting. 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 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.

If you are interested in the compaction grouting services that we offer to commercial customers in the Chattanooga, TN, area, contact Engineered Solutions today for more information.

Placement Sequence of Compaction Grouting Technique

- Because every site is different, it is impossible to standardize compaction grouting probe spacing, placement procedures and sequences. Many factors including soil types, site conditions, and the results of soil tests influence the probe spacing, volumes, pumping pressures, and injection rates and sequence needed to correct the soil deficiencies. The mixture can be injected from the “bottom up” or “top down,” depending on the desired result. Grouting from the top down is more expensive because of the additional time required to drill through previously placed grout stages. However, top-downs typically work best for improving the ground at depths of 3 to 15 feet and when incremental releveling of a structure is required. Bottom-up placement is faster (due to continuous pumping) and, therefore, cheaper. It works very well to stabilize structures that require very little, if any, re-leveling. But it doesn’t compact soils less than 15 feet deep as well as top-downs. The two systems can be combined. Say a structure with a shallow foundation has settled and the soil is very soft to depths greater than 15 feet. In those areas where the structure requires re-leveling, do bottom ups from bedrock up to about 10 feet below the structural element. Then do top-downs until you encounter the bottom-up grout. With this sequence, the bottom-ups provide a stabilized base for the topdowns to push against. The topdowns can then lift the structure in increments. This system works well because in some cases if the bottom is not stabilized first, the top-down stages will add weight to the site and induce further settlement. Probes are typically spaced on 8- foot centers along foundation structural elements. However, the actual spacing should be calculated based on the spanning capabilities of the structure's foundation system. When the total soil volume is stabilized beneath an entire building footprint, a triangular grid on 8-foot spacings often works best.

When a grout casing has been drilled or driven to its appropriate depth, It is pumped at that location until:

(1) a predetermined grout volume has been pumped,

(2) a predetermined pumping pressure has been reached, or

(3) Undesired ground or structural movement is occurring.

In most cases, the grout casing is then moved up, and pumping is resumed. Stage lengths may vary from site to site, but most work is pumped in 1-foot vertical increments

Advantages of Grouting Include:

• 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

• Can be used to control seepage, groundwater flow, and hazardous waste materials Process and its types

Q3:

Party A:

What are the causes for which ground improvement techniquies are under taken?

Answer:

Causes for which Ground Improvement Techniques:

When difficult ground conditions are encountered there are a number of alternatives that can be employed to achieve project objectives. These alternatives include:

(1) Bypassing the poor ground through relocation of the project to a more suitable site or through the use of a deep foundation;

(2) Removing and replacing the unsuitable soils;

(3) Designing the planned structure to accommodate the poor/marginal ground; or

(4) modifying (improving) the existing soils, either in-place or by removal, treatment and replacement of the existing soils; Through a wide-variety of modern ground improvement and geoconstruction technologies, marginal sites and unsuitable in-situ soils can be improved to meet demanding project requirements, making the latter alternative an economically preferred solution in many cases. In essence, the modern builder has the option to “fix” the poor ground conditions and to make them suitable for the project’s needs.

The final selection often depends on geotechnical condition, loading condition, performance requirement, and cost. Option (a) is preferred and also more economic when the load on the foundation is low and competent geo material exists near the ground surface. Option (e) is more suitable for high foundation loads on problematic geo materials with high-performance requirements, which is often most expensive. Options (b), (c), and (d) are more suitable for intermediate conditions and requirements between option (a) and option (e). There are also four options for earth retaining structures as shown in Figure 1.2: (a) unreinforced cut-and-fill slopes, (b) unreinforced cut-and-fill earth walls, (c) reinforced cut-and-fill slopes, and (d) reinforced cut-and-fill

As more engineering structures are built, it becomes increasingly difficult to find a site with suitable soil properties. The properties at many sites must be improved by the use of some form of soil improvement methods, such as: static or dynamic compaction, reinforcement, drainage or by the use of admixtures. Thus, it is important for the soil engineers to know the different soil improvement methods; the degree to which soil properties may be improved; and the costs and benefits involved. In this way, the soil engineer can gain knowledge in order to design ground improvement projects as well as to advise the client regarding value engineering to save cost and obtain maximum benefits for the specific project.

The following are some of the methods used as ground improvement techniques: Surface Compaction, Deep Compaction, Preloading, Vertical Drains, Stone Columns, Vacuum Drainage, Mechanically Stabilized Earth (Reinforced Earth), Granular Piles, Micropiles, Lime Stabilization, Cement Stabilization, Chemical Stabilization, Grouting, Geotextiles, Lightweight Embankment Materials.

Ground improvement is carried out to:

- 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.

Ground improvement is carried out for various objectives: to improve bearing capacity and reduce settlement of soft ground, prevent earthquake liquefaction, control groundwater, stabilize excavation bottom, prevent deformation of surrounding ground, or clean up contaminated ground. Based on improvement objectives and ground and site conditions, the most suitable method is selected from 3 different technologies: Mechanical Soil Mixing, Grouting, and Jet Grouting.

- MECHANICAL SOIL MIXING
- SHALLOW SOIL MIXING
- JET GROUTING
- GROUTING

1.MECHANICAL SOIL MIXING

The auger and mixing paddles attached to the rod drill the ground and mechanically mix in-situsoil with cementitious materials to produce homogenous solidified columns of well-defined dimension and strength. Raito Kogyo provides a full range of soil mixing techniques including deep soil mixing, shallow soil mixing, dry jet mixing, hybrid soil mixing combined with jet grouting. Equipment to be used is ranging from a large pile driving rigs to ones as small as a backhoe.

2.SHALLOW SOIL MIXING

Shallow Soil Mixing is one variety of Mechanical Soil Mixing technology. As the name indicates, it improves the soft ground shallowly. The compact mixing equipment, attached to a standard 0.7m3 to 1.0 m3 excavator, can improve the soft ground to the depth of up to 7 m. This technique is applied to improve the foundation soil and prevent settlement of road, embankment, and building as well as to solidify and stabilize the contaminated soil.

3.JET GROUTING

Jet Grouting is a technique of mixing in-situ soil with the energy of high-pressure jet of slurry. A small-diameter rod drills down to the improvement bottom. Then the rod, while being withdrawn, jets the cement-base slurry and air to produce an improved column. Jet Grouting enables improvement closely contacted to or, in some cases, encompassing existing underground structures without causing damage to them.

4.GROUTING

Grouting is a technique to inject various types of grout into the ground at a deliberately controlled pressure and flow rate. The grout is based on cement, silicate, or other materials, selected to suit particular ground conditions and improvement objectives. The grout fills in voids and cracks of the ground and permeates into soil pores to produce a solidified soil-grout mass. The grouting is often applied to improve the ground underneath existing structures such as large oil tanks, railroad tracks and others. Directional drilling technique is often employed for drilling boreholes to circumvent underground obstructions to reach the target improvement zone.

Part B:

Identify various geotechnical problem of expansive soil?

Answer:

• Where large seasonal changes in soil moisture are responsible for swelling, construction should be scheduled during or immediately after a prolonged rainy period. This will ensure less potential volume change in the future.

• The patterns of wetting and drying on the site largely affect the construction consequences in expansive soils. Changes like the fluctuation of the groundwater table, unusual rains and ponding of water near foundations, changes in humidity, or unusual drought may accelerate the swelling and shrinkage of soils. Moreover, plumbing leaks, site drainage, and irrigation practices can cause differences in moisture volume influencing the behavior of expansive soils. Planting trees near buildings constructed in areas of expansive soils may cause damage to the structure because of the evapotranspiration loss causing shrinkage of soil. Plants that require more water should be avoided.

Care should be taken not to allow moisture content variation near the construction site due to the reasons mentioned previously.

• During summer, light watering of the ground near the building twice or thrice a week may be helpful. However, heavy watering should be avoided, as this could saturate the foundations.

• Impervious blankets, provision for rain gutters, and surface grading can be provided around the foundations to prevent infiltration of surface water. French drains (trench filled with gravel with a perforated pipe at the bottom and connected to a discharge point) and cut-off walls (a vertical barrier preventing soil moisture travelling horizontally) may be provided to prevent the ill effects of swelling soils.

• For foundations on fill materials containing plastic fines and susceptible to swelling, fill should be placed at a moisture content above Optimum Moisture Content (OMC) with a density no higher than that required for strength and rigidity. This is because excessive compaction results in greater swelling.

• Stabilization of the foundation soils and backfill materials with lime and other agents can be done to minimize the swelling potential of soils. High-sulphate soils do not respond well to lime or other calcium-based agents. However, such soils can be treated with silica fume, amorphous silica, fly ash, different types of cation exchange products, enzyme acids, emulsions, polymers, etc.

• For concrete floor slabs placed directly on potentially expansive clays, expansion joints should be provided to allow the floor to move freely away from the structural frame. Similarly, grade beams should contain sufficient steel reinforcement to resist the horizontal and vertical thrust of swelling soils. If possible, compressible joint filler or open blocks or boxes beneath grade beams can be provided to minimize swelling pressures. In some cases, placing the structure on a pile system raised above the surface can help to minimize the swelling effect. Because, this would allow normal air circulation and evaporation below the structure and if drainage is properly designed, it will cause minimal disturbance to the water content of swell-susceptible strata.

• For light structures, the division of the structure into units that can move independently of each other can be a practical solution. Differential heave between units causes no stress to the structure and only minor repair work may be sufficient.

Post construction solutions to problems caused by expansive soil that may affect structures mainly include the drill-hole lime and pressure-injected lime methods. In addition, drainage improvement and membrane placement may be used to minimize the swelling effects. Excavation and replacement, electro-osmosis, mud jacking, and pavement overlays in the case of highways may also be used. However, their effectiveness is poor, since these methods give only localized or temporary solutions or involve large site activities.

Q4:

How stone columns and blasting help soil to stabilize and gain bearing capacity?

Ans4, A:

The principle of stone column is to replace loose material by compacted stone, together with densification and reduction in compressibility of the surrounding ground to form a composite material. Because the stone columns will deform under applied load, the capacity of the columns depends on the degree of stiffening achieved in the Surrounding soil as well as on the internal friction of the columns. Stone columns 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. Blasting is most effective in loose sands that contain less than 20% silt and less than 5% clay. Although blasting is quite economical, it is Limited by several considerations, as it produces strong vibrations that may damage nearby structures or produce significant ground movements. Weak soil, which has very low shear strength and high compressibility to support structures require Strengthening to be capable of carrying loads from structures. Stone columns are ideally suited for structures, because:

∗ To reduction of total and differential settlements.

∗ To reduction of liquefaction potential of cohesion less soil.

∗ To increase the bearing capacity of a site to make it possible to use shallow foundation on the soil.

∗ To increase the stiffness.

∗ To improve the drainage conditions and environment control.

∗ To control the deformation and accelerate consolidation.

Q4, B:

Which types of ground improvement would be used in black cotton soil and why?

Ans4, B:

Black cotton soil is a highly clayey soil. They are found in many parts of the world, such kind of soil generally consists of active clay minerals. Geotechnical engineers face various problems while designing foundation, because the black cotton soil possess poor bearing capacity and excessive settlement. To overcome those problems researches concentrated on soil improvement techniques by adding fibers. The main objective of our project is to investigate the use of pili (human hair) and lime in geotechnical applications and to evaluate the effects of pili and lime with black cotton soil. The various percentages of pili (0.5%, 1%, 1.5%, 2%) and lime (3%, 6%, 9%, 12%) are mixed with black cotton soil to enhance the ground improvement. This project includes testing and comparison of Atterberg's limit, Standard Proctor Compaction, Unconfined compressive strength by curing of normal black cotton soil with stabilized black cotton soil and determining optimum dosage of lime and pili to be added to soil. 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.

Characterization of Black Cotton Soil

Black cotton soil used in the study is procured from Bhimavaram area of Andhra Pradesh, India. Extensive laboratory work is carried out to characterize the black cotton soil. The plasticity index is calculated by determining Atterberg's limits. Compaction characteristics are determined by conducting IS light compaction test and strength characteristics by conducting California bearing ratio (CBR) test.

Ground improvement techniques that are used in Black Cotton Soil:

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.

These are the important techniques that improve the capacity of Black Cotton Soil:

1. It was concluded that stone dust and lime gives maximum strength at 15% composition when compared to 5% and 10%.
2. In the present study indicated that geosynthetics encased black cotton soil,lime and stone dust column of PE1302EF has shown better cohesion with 0.006N/mm2.
3. Improvement of bearing capacity is observed in encased stone column in all 300mm, 225mm and 150mm lengths and in 30mm, 25mm and 20mm diameter and for 40mm,35mm and 30mm settlement. It is observed that the bearing capacity of 30mm diameter 300mm length and for 40mm settlement is higher.
4. The smaller diameter of the stone column has lower bearing capacity than larger diameter stone column.
5. Geogrid encasement increases bearing capacity of stone column in which it gives Improvement in strength up to 57.23% because bulging behavior of stone column decreases.

6. Geotextile of higher strength in which PE1302EF increases bearing capacity of stone column it gives improvement of strength up to 67.32%.
7. There is considerable reduction in settlement when the stone column encased with geosynthetic.