Name:- Nizam Ud Din
Reg. No. :- 15367
Paper :- Final Term
Program: MS
Subject: GROUND IMPROVEMENT TECHNIQUES (MS)

Q.NO(01) 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?

ANSWAR:-

I):-Soil Replacement

Where the soil is soft and of limited depth and thickness, removal of unsuitable material and replacement with well compacted suitable fill may be carried out. The removal and replacement required to be carried where the naturally occurring soils were found to be of a low shear strength and high moisture content. This method is one of the oldest and most convenient methods to enhance the strength of the soil hardpan. The advantage of this method is that it requires only conventional land transfer equipment, can be perform by any contractor, and also records the long-term success. To apply the use of heavy machinery in the paddy field, the force of the hardpan layer should be more than 0.3Mpa and suitable soil must be choose to ensure that the replacement soil will not affect the crop.

ii);- ? How & which properties of soil are modified through additives, name a few additives with their functions?

Answer:-

In engineering practice, various stabilizing admixtures are used to improve the soils properties. Many properties of soil can be modified through additives like liquid limit, plastic limit, shear strength, Maximum dry density, Optimum moisture content, cohesion Angle of friction, CBR value etc

Following are some additives with their functions:

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. 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

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.

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% [17] [2]. Lime can be mixed with the soil either in plant or in site or lime slurry can be injected in to the soil [2] 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. [20]

Fly-Ash stabilization

Stabilization of soils with coal fly ash is an increasingly popular alternative nowadays. Fly ash is a product of coal fired electric power generation facilities; it has little cementitious properties compared to lime and cement Most of the fly ashes belong to secondary binders; these binders cannot produce the desired effect on their own. [16]. Therefore, the use of fly ash to stabilize clay must usually be in concert with lime or cement. For example," type F" fly ash is ineffective as stabilizer without the addition of lime as a source of calcium. [21] Fly-Ash and cement have significant environmental impacts associated with its production in terms of high energy consumption and CO2 emissions.

Q.NO(01) B :- What are the various dewatering techniques which are generally used for ground improvement discuss brief?

Answer:-

Methods of Dewatering

Ground water can be controlled by adopting one or more types of dewatering systems appropriate to the size and characteristics of the soil. The different types of methods involved in dewatering are:

- Open sumps and ditches
- Well point systems
- Deep well drainage
- Vacuum Dewatering Systems
- Electro Osmosis

Open sumps and ditches:-

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.

Well point systems: -

Well points are small well screens of sizes 50 to 80 mm in diameter and 0.3 to 1m length. Well points are either with braces or stainless steel screens and are made with either closed ends or self-jetting types. spacing of the well points depends on the permeability of the soil and on the availability of the time to affect the drawdown. In fine to coarse sands a spacing of 0.75 to 1m is satisfactory. A spacing of 1.5 m may be necessary in silty sands of fairly low permeability. In highly permeable coarse gravels they may be as close as 0.3m. A serious limiting of well point system is the suction lift. A lowering of about 6m below pump level is generally possible beyond which excessive air shall be drawn into the system through joint in the pipes, valves etc., resulting in loss of efficiency. If the ground is consistently mainly of large gravel, stiff clay or soil containing cobbles or boulders it is not possible to install all points. For dewatering deeper excavations, the well points must be installed in two or more stages. There is no limit to the depth of drawdown in this way, but the overall width of excavation at ground level becomes very large. On the other hand, it is possible to avoid multi-well point stages by excavating don to water level before installing the pump and header. When well points are used in braced excavations, they are placed closed to the toes of the sheet piles. This is done in order to ensure lowering the water level between the sheet pile rows. Well points are provided in conjunction with the sheet piles under the following

conditions. To prevent quick condition of the bottom when the sheet piles are of limited penetration. To eliminate hydrostatic pressure on the back of a sheet pile coffer dam, thus allowing higher bracing to be used.

Deep Well Drainage: -

Deep well drainage system consists of deep wells and submersible or turbine pumps which can be installed outside the zone of construction operations and the water table lowered to the desire level. Deep wells are usually spaced from 8-80 meters depending upon the level to which water table must be lowered, permeability of the sand stratum, source of seepage and amount of submergence available. Deep well system is suitable for lowering the ground water table where the soil formation is pervious with depth; the excavation extends through or is underlain by coarse-grained soils. This method is also suitable when a great depth of water-lowering is required or where a head due to artesian pressure has to be lowered in permeable strata at a considerable depth below the excavation level. Deep wells may be combined with the well point system on certain field conditions for lowering the ground water tables.

Vacuum Dewatering Systems:-

Gravity methods, such as well points and deep wells are not much effective in the fine-grained soils with permeability in the range of 0.1 –10 x 10 -3 mm/s. Such soils can be dewatered satisfactorily by applying a vacuum to the piping system. A vacuum dewatering system requires that the well-point screens, and rise a pipe be surrounded with filter sand extending to within a few meters of the ground surface. This method is most suitable in layered or stratified soils with coefficient of permeability of the range 0.11 - 0 x 10 -4 cm/s.

Dewatering by electro osmosis:-

When an external electro motive force is applied across a solid liquid interface the movable diffuse double layer is displaced tangentially with respect to the fixed layer . this is electro osmosis. As the surface of fine grained soil particles causes negative charge, the positive ions in solution are attracted towards the soil particles and concentrate near the surfaces. Upon application of the electro motive force between two electrodes in a soil medium the positive ions adjacent to the soil particles and the water molecules attached to the ions are attracted to the cathode and are repelled by the anode. The free water in the interior of the void spaces is carried along to the cathode by viscous flow. By making the cathode a well, water can be collected in the well and then pumped out.

Q.NO(02) A :- What do you understand about soil nailing? Under what condition the soil nailing is preferable?

Answer: -

Soil nailing is a construction remedial measure to treat unstable natural soil slopes or as a construction technique that allows the safe over-steepening of new or existing soil slopes. The technique involves the insertion of relatively slender reinforcing elements into the slope often general purpose reinforcing bars (rebar) although proprietary solid or hollow-system bars are also available. Solid bars are usually installed into pre-drilled holes and then grouted into place using a separate grout line, whereas hollow bars may be drilled and grouted simultaneously by the use of a sacrificial drill bit and by pumping grout down the hollow bar as drilling progresses. Kinetic methods of firing relatively short bars into soil slopes have also been developed. Bars installed using drilling techniques are usually fully grouted and installed at a slight downward inclination with bars installed at regularly spaced points across the slope face. A rigid facing (often pneumatically applied concrete, otherwise known as shotcrete) or isolated soil nail head plates may be used at the surface. Alternatively, a flexible reinforcing mesh may be held against the soil face beneath the head plates. Rabbit proof wire mesh and environmental erosion control fabrics and may be used in conjunction with flexible mesh facing where environmental conditions dictate. Soil nail components may also be used to stabilize retaining walls or existing fill slopes. this is normally undertaken as a remedial measure.

ii):- Following are the conditions where soil nailing is preferable.

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.
- 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.

Soil nailing is typically used to stabilize existing slopes or excavations where top-to-bottom construction is advantageous compared to other retaining wall systems. For certain conditions, soil nailing 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 in 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 nailing has proven economically attractive and technically feasible when:

1: The soil in which the excavation is constructed is able to stand unsupported in a 1- to 2-m (3- to 6-ft) high vertical or nearly vertical cut for one to two days.

2: All soil nails within a cross section are located above the groundwater table

3: If soil nails are below the groundwater table, and the groundwater does not adversely affect the face of the excavation, the bond strength of the interface between the grout and the surrounding ground, or the long-term integrity of the soil nails (e.g., the chemical characteristics of the ground do not promote corrosion).

Q.NO(02) 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:-

Grouting:-

Grouting in civil engineering refers to the injection of pumpable materials into a soil or rock formation to change its physical characteristics. It is one of the ways ground water can be controlled during civil engineering works. Grouting technology has become a common ground improvement method used frequently for underground and foundation constructions. The process of grouting consists of filling pores or cavities in soil or rock with a liquid form material to decrease the permeability and improve the shear strength by increasing the cohesion when it is set. Cement base grout mixes are commonly used for gravely layers or fissure rock treatment. But the suspension grain size may be too big to penetrate sand or silty-sand layers. In this case, chemical or organic grout mixes are also used. In recent years, the availability of ultrafine grout mixes has extended the performance of hydraulic base grout for soil treatment.

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

Compaction Grouting

Compaction grouting is typically performed in loose or weak soils to mitigate settlements and is also used for sinkhole remediation. Compaction grouting involves the injection of a very stiff, mortar like, cementitious grout into soil to densify or compact the soil under high pressure. When injected, the grout will not permeate the surrounding soils, but instead form "grout bulbs" that laterally displace the soil. By repeating the process in adjacent holes the soil between the holes is densified through the lateral displacement.

Advantages of Grouting: -

In compaction grouting, a grout mixture is injected into the ground at the elevation of the substandard soil, where it then densifies and sturdies the soil. Here are some of the key advantages of this ground-shoring method:

- Compaction grouting causes minimal disruption to the landscape, surrounding soils, and nearby structures.
- This technique can be utilized for projects that have limited access and require more delicate installations.
- It is cost-effective and easy to install compared to some other soil stabilization and ground-shoring methods.
- Engineered Solutions has used this versatile technique on a variety of projects, and it has successfully strengthened ground soils in each instance
- 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 measure
- 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: -

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.

Q.NO (03) A:- What are the causes for which ground improvement techniquies are under taken?

ANSWAR: - following are the causes for which ground improvement techniquies are under taken:-

- Mechanical properties are not adequate
- Swelling and shrinkage
- Collapsible soils
- Soft soils
- Organic soils and peaty soils
- Sands and gravelly deposits.
- Foundations on dumps and sanitary landfills
- Handling dredged materials
- Handling hazardous materials in contact with soils
- Use of old mine pits.

Q.NO (03) B:- Identify various geotechnical problem of expansive soil?

Expansive soil is defined as partially saturated plastic soil that exhibits high volume change when its environmental conditions are altered from dry to wet. The degree of expansion depends on whether the soil mass contains active day minerals or not. The most common active clay minerals are smectite, sometimes chlorite and vermiculite, and a mixed-layer of smectite and other clay minerals. These soils, which lie above the water table, undergo shrinkage on drying and swelling on wetting. Numerous reports of expansive soil problems and related damages have been documented in different countries

Expansive soils, which have high contents of absorptive clay, can really put the squeeze on concrete foundation walls. These soils swell when they get wet, with increases in volume of 10% or more. That's enough pressure to crack concrete foundation walls and floor slabs and even cause foundation movement, resulting in damage to the upper floors of a home or building. To make matters worse, expansive soils also shrink when they dry out. This cycle of shrinkage and swelling puts repeated stress on concrete foundations and can create fissures in the soil that allow water runoff to seep through to basement walls.

Q.NO (04) A:- How stone columns and blasting help soil to stabilize and gain bearing capacity?

Answer: -

There are a number of methods available to improve ground conditions such as stone columns, jet grouting, compaction grouting, short pile, dynamic compaction, lime stabilization etc. Before using any of these methods, it is required to know the ground improvement in detail.

In simple words-ground improvement can be defined as “the process of enhancing the quality of soil.”
Ground improvement mainly refers to the improvement of soil layers but in some cases it also refers to the improvement of rock layers.

Stone columns is also known as 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. Granular piles including stone columns are used as a ground improvement method. These compression elements introduced into the ground, although they cannot resist tensile stresses, possess high compressive strength and stiffness. Thus such columnar inclusions carry a substantially greater proportion of applied loads with significantly smaller deformation compared to the in-situ soft clay. Stone columns not only serve the primary functions of reinforcement and drainage but also enhance the bearing capacity and reduce settlement of the composite ground. Also, as a consequence of the installation processes, the lateral stresses in the original ground conditions around the inclusions tend to be higher than its values at rest. Construction of stone columns in soft clay under an embankment is a common economical ground improvement method when shear strength increase, settlement reduction and acceleration of consolidation are needed above the vertical stresses, which remain approximately constant. The stone column derives its axial capacity from the passive earth pressure developed due to the bulging effect of the column and increased resistance to lateral deformation under superimposed surcharge load,

By Blasting :-

Blasting is the ground modification technique whereby the energy released from setting off explosives in subsoil inducing artificial earthquake effects, which compact the soil layers. The efficiency of EC predominantly depends on the soil profile, grain size distribution, initial status, and the intensity of energy applied to the soil. Depending on the importance and load level of a structure, ground improvement may be a viable alternative to expensive foundations in conditions involving weak and problematic soil deposits.

Q.no (04) b:- which types of ground improvement would be used in black cotton soil and why?

Answer: -

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.

(1) Lime stabilization of black cotton soil under study improved the strength characteristics of the soil, but not to the extent of suitability as subbase material.
(2) Mixing 20% brick powder and 80% lime-stabilized black cotton soil improved the maximum dry density and decreased the optimum moisture content in comparison to 4% lime stabilized soil.
(3) 80% lime-stabilized black cotton soil and 20% brick powder mixture resulted in increase in the soaked CBR value by about 135%, when compared to 4% lime-stabilized soil, making it satisfactory for use as subbase material.
(4) Use of brick powder reduces the content of lime which in turn reduces the cost of project as brick powder is freely available. Also, use of brick powder reduces the problem of waste disposal.

These soils are characterized by their highly swelling and shrinkage properties. In dry conditions these soils have high strength which is almost completely lost when they come in contact with water. These soils are having high degree of expansion which creates a lot of problems during the execution of work and after completion of it. Hence, the stabilization of such soil is prime importance. Attempts have been made to stabilize these soils by using different materials such as lime, cement, asphalt etc. Industrial wastes such as fly ash, furnace slag can also be used for this purpose. In order to improve the engineering and index properties of soil, the experiments have been conducted with industrial wastes of steel foundry called as furnace slag plus black cotton soil. The results show that 20% addition of slag to black cotton soil is the optimum proportion to improve almost all properties of soil. For 20% addition of slag, the CBR increase from 3–6%. The pavement design and cost analysis of such slag stabilized soil shows reduction in the cost of construction of pavement by 10.58% as compared to pavement construction by only black cotton soil as subgrade.

THANKS

ASSIGNMENT NO:- 01

Name :- Nizam Ud Din

Reg No. :- 15367

Subject:- Ground Improvement Techniques

Question # 01 :- Write Geotechnical report on any civil Engineering project located near to your area.

Geotechnical report of GGDC Barawal District Dir Upper (which is under construction in my supervision).

Our purpose was simple & conventional soil investigation & laboratory tests on soil of site for construction of GGDC Barawal District Dir Upper KPK. These tests are common soil tests, normally conducted before any Civil engineering project. Before designing any structure the soil of the area must be tested for its basic properties. However the local departments have already investigated the sites & have complete specifications. Some standard guideline is required before starting any project or research work. The researcher follows these standards & completes their research in the light of these standards. Civil engineering & specially soil mechanics is very vast subject. Million of researchers are engaged in research work & new ideas are developing day by day. The guideline & standards are provided by different agencies. These standards are based on research work. The guidelines used in our research are:

ASTM: American standards of testing materials
AASHTO American association of state highway & transportation officials
IS soil classification (IS: 1498-1970)
USCS Unified soil classification system

These are some standards on the basis of which we carried out our work & classified our soil sample. The standard references are given with each experiment.

Summary

The laboratory tests were performed for the determination of engineering properties of soil of site for construction of GGDC Barawal District Dir Upper Kpk. For this purpose the soil sample was collected form " site " &brought to our department lab " material testing lab" C&W Department Phase 05 Hayatabad Peshawar. The sample was protected from sun light & air so that its moisture content did not disturbed. Some of the sample was placed in open air for air drying, some was oven dried & some was placed in polythene bags as undisturbed sample. After collecting sample, laboratory work began in material testing lab. The moisture content test was performed directly on undisturbed sample and found to be 5.56%. Specific gravity was found 2.66. Wet unit weight was about 16.35 KN/m^3 and dry unit weight was 15.48 KN/m^3. Direct shear test was performed to find shear strength parameters, internal angle of friction for direct shear test was 33.24^0 and cohesion was 0. To find coefficient of

permeability, Constant head test was conducted and coefficient of permeability was found about 0.0391 cm/sec. and natural voids ratio was calculated to be 0.68. Sieve analysis test was also performed and the sand was poorly graded, by analysis of the unit weights, voids ratios in different state, the density index was found to be 0.42, which is in medium state of compactness. Using same data friction for short pile was found out for two cases i-e for hollow pipe and for one end plugged pipe. After the completion of these tests, the data was plotted on graphs& tables in excel sheets.

S. no	Test description	Result
1	On site moisture content	5.56%
2	Specific gravity	2.66
3	Dry Unit weight in natural state	15.48 KN/m^3
4	Wet unit weight in natural state	16.35 KN/m^3
5	Dry unit weight in loosest state	13.64 KN/m^3
6	Wet unit weight in loosest state	14.40 KN/m^3
7	Dry unit weight in densest state	19.16 KN/m^3
8	Wet unit weight in densest state	20.06 KN/m^3
9	Voids ratio in natural state	0.68
10	Voids ratio in loosest state	0.91
11	Voids ratio in densest state	0.36
12	Density Index	0.42
13	Sieve analysis	Poorly Graded
14	Co-efficient of permeability	0.0391
15	Internal friction angle (direct shear test)	33.24^0
17	Skin friction of a hollow pipe (critical conditions)	16.79KN
18	Skin friction and end bearing of one end plugged pipe(critical condition)	8.61 KN
19	Skin friction of a hollow pipe (normal Condition)	42.41 KN
20	Skin friction and end bearing of one end plugged pipe (Normal condition)	21.67 KN

- **Question # 02 :- Write brief note that what you have learnt from this subject ground improvement Techniques.**

  Answer : - after studying this subject , I learned a lot about Mechanical Modification ,Deep Compaction Techniques vibro compaction, Dynamic Tamping and Compaction piles, Hydraulic Modification, traditional dewatering methods and their choice, Design of dewatering system, electro-osmosis, electro kinetic dewatering. Filtration, Drainage and seepage control with geosynthetics, preloading the vertical drains. Physical and Chemical Modification- Modification by admixtures, shotcreting and Guniting Technology, Modification at depth by grouting, crack grouting and compaction grouting. Jet grouting, Thermal modification, Ground freezing. Modification reinforcement by inclusions and confinement with strip, and grid reinforced Soil reinforcement, soil. In-situ ground reinforcement, and ground anchors, rock bolting and soil nailing, Vacuum Preloading for Soil Improvement and much more about soil investigation and ground improvement techniques.

Thanks