Ground improvement Techniques

Final Assignment/Quiz

Summer Semester 2020
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Subject: Ground improvement techniques

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Semester: Summer

Ans#1: Part:1: How do we improve soil through excavation and replacment

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.

The use of replacement soil under shallow foundation can reduce consolidation settlement and increase soil bearing capacity. It has some advantages over other techniques and deep foundation as it is more economical and requires less delay to construction. Despite of soil replacement's advantages, the determination of the replacement soil thickness is based on experience which in many cases is questionable stated that the region of high stress in a shallow foundation is only 1 to 1.5 its breadth and this part can be replaced by selected good soil. investigated the effect of using different types and thickness of replacement layer on increasing bearing capacity and reducing consolidation settlement of soft clayey soil experimentally and concluded that, with increasing replacement layer thickness the vertical settlement decreased.

Properties of soil:

Swell and 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 Yd., 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

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. [20] 4.1.3.
3. **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 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.
4.

Part#b: DEWATERING:

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.

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.

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.

Dewatering can also be known as the process of removing water from soil by wet classification. What is the need for drainage and dewatering?

To provide suitable working surface of the bottom of the excavation. To stabilize the banks of the excavation thus avoiding the hazards of slides and sloughing. To prevent disturbance of the soil at the bottom of excavation caused by boils or piping. Such disturbances may reduce the bearing power of the soil. Lowering the water table can also be utilized to increase the effective weight of the soil and consolidate the soil layers. Reducing lateral loads on sheeting and bracing is another way of use. 3. What are the various methods of dewatering? Surface water control like ditches, training walls, embankments.

Simple methods of diverting surface water, open excavations. Simple pumping equipment. Gravity drainage.Relatively impermeable soils. Open excavations especially on sloping sites. Simple pumping equipment. Sump pumping Wellpoint systems with suction pumps. Shallow (bored) wells with pumps. Deep (bored) wells with pumps. Eductor system 8. Drainage galleries. Removal of large quantities of water for dam abutments, cutoffs, landslides etc. Large quantities of water can be drained into gallery (small diameter tunnel) and disposed of by conventional large – scale pumps. 9. Electro-osmosis. Used in low permeability soils (silts, silty clays, some peats) when no other method is suitable. Direct current electricity is applied from anodes (steel rods) to cathodes (well-points, i.e. small diameter filter wells)

Dewatering Techniques:

• Sump Pumping

• Wellpoints

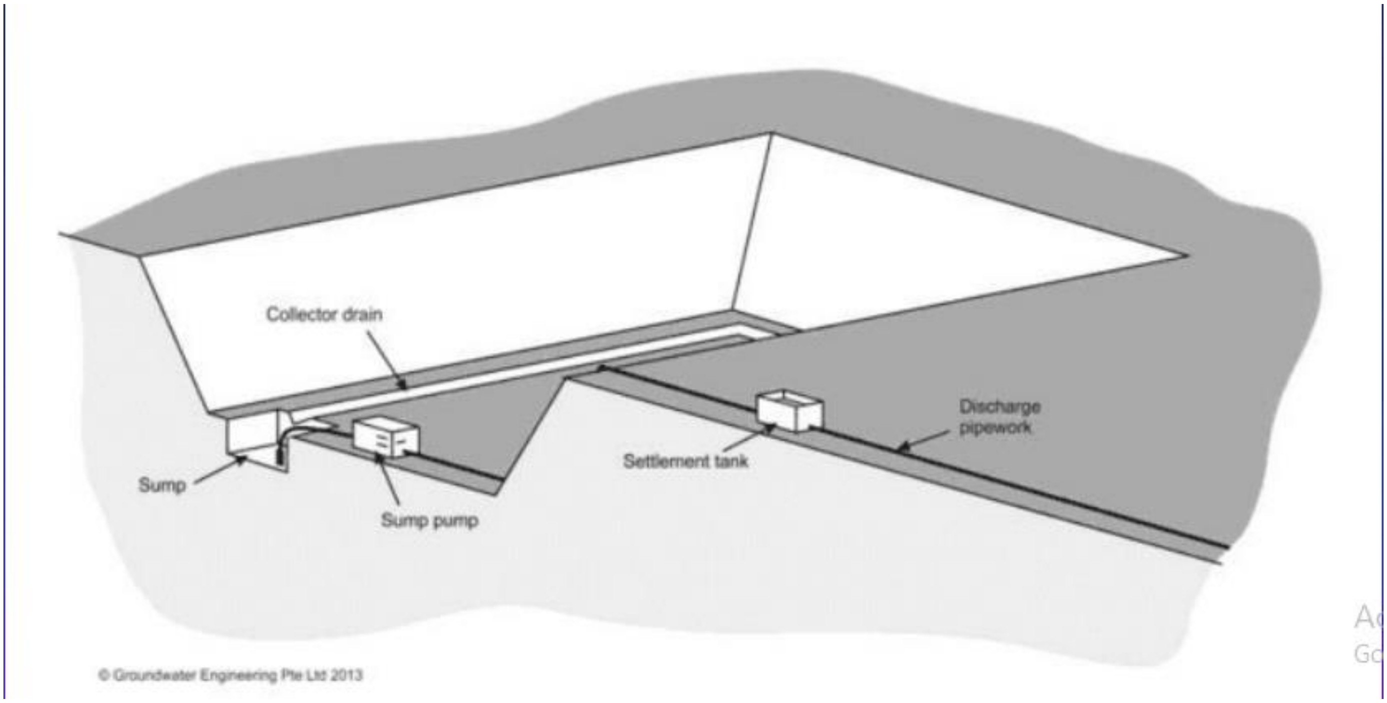
• Deepwells

• Ejector wells

.Sumps and sump pumping:

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.

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



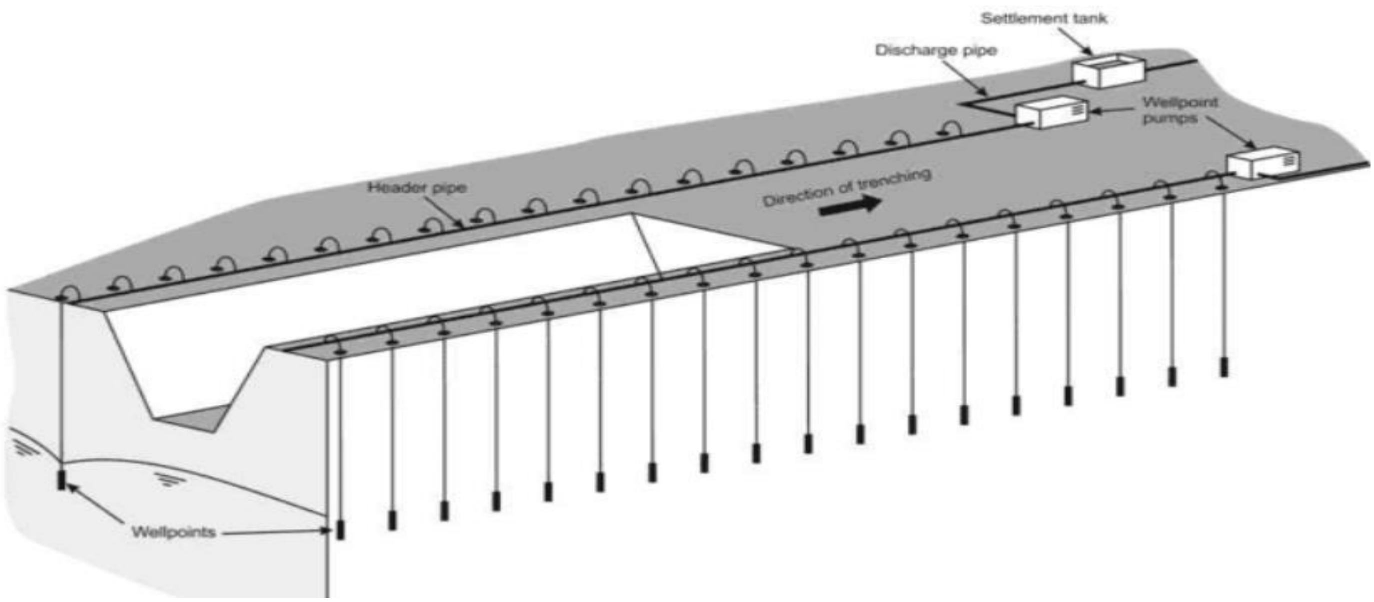
OPEN SUMPS AND DICTHES: The essential feature of this method is a sump below the ground level of the excavation at one or more corners or sides.. a small ditch is cut around the bottom of the excavation , falling towards the sump. It is the most widely used and economical of all methods of ground water 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.

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.

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.

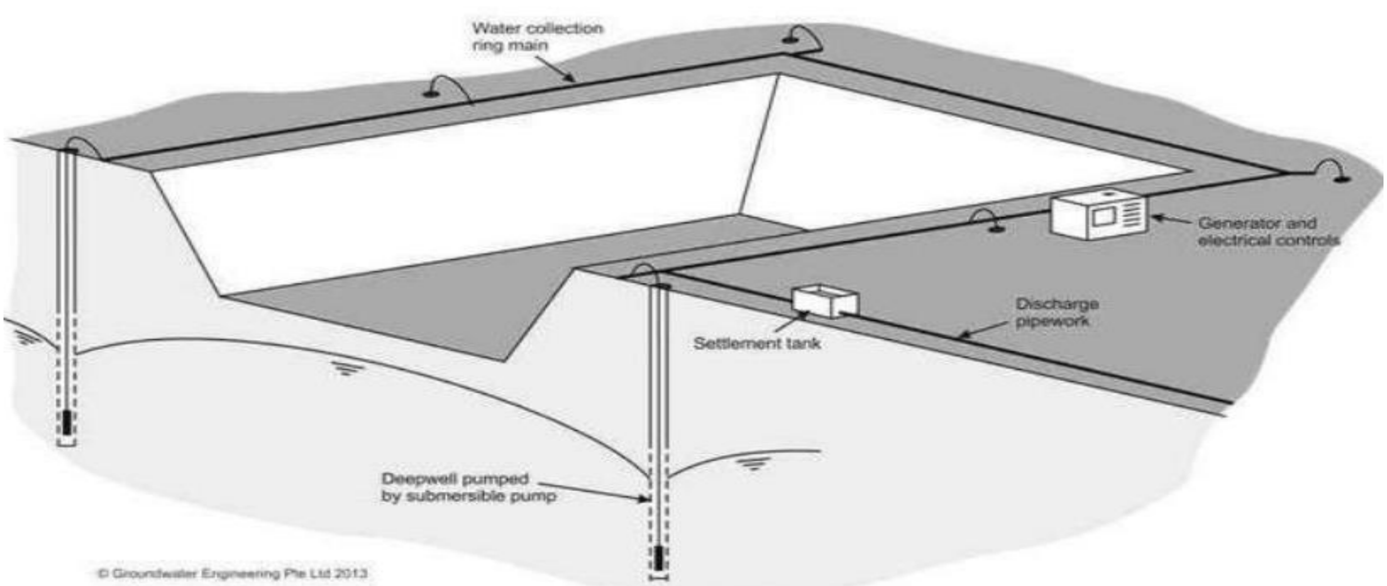
In gravels spacing required may be too close and impracticable. In clays it is also not used because it is too slow. In silts and silt – clay mixtures the use of well points are aided by upper (0.60m – 0.90m long) compacted clay seals and sand-filtered boreholes (20cm – 60cm diameter). Upper clay seals help to maintain higher suction (vacuum) pressures and sand filters increase the amount of

• 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").



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



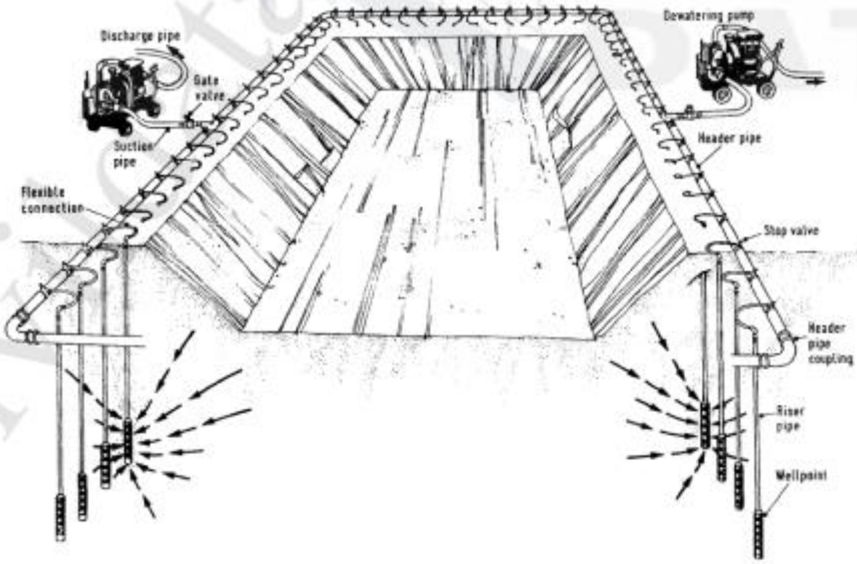


Figure 9.5 Wellpoint dewatering system components

Educator Wells:

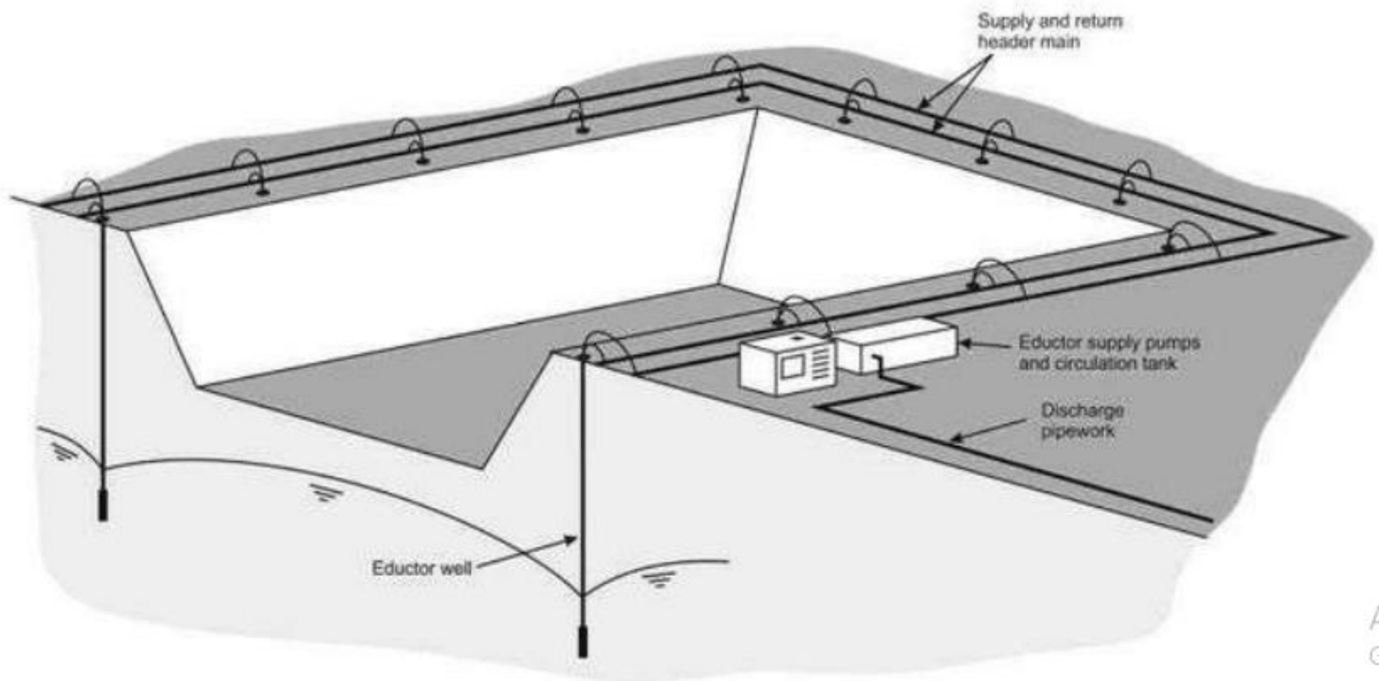
Effective in stabilising fine soils (silts, silty sands) by reducing pore water pressures

• Wells are drilled around or alongside the excavation

• Suitable when well yields are low. Flow capacity 30 to 50 litres/min per well

• Drawdown generally limited to 25 to 30 m below pump level

• Vacuum of 0.95 Bar can be generated in the well, making this very effective in low permeability soils



Some of the less dewatering techniques are below.

Some of the Less commonly used dewatering techniques

• Horizontal wellpoints

• Relief wells • Artificial recharge

• Groundwater remediation

End Of Question1#a part b

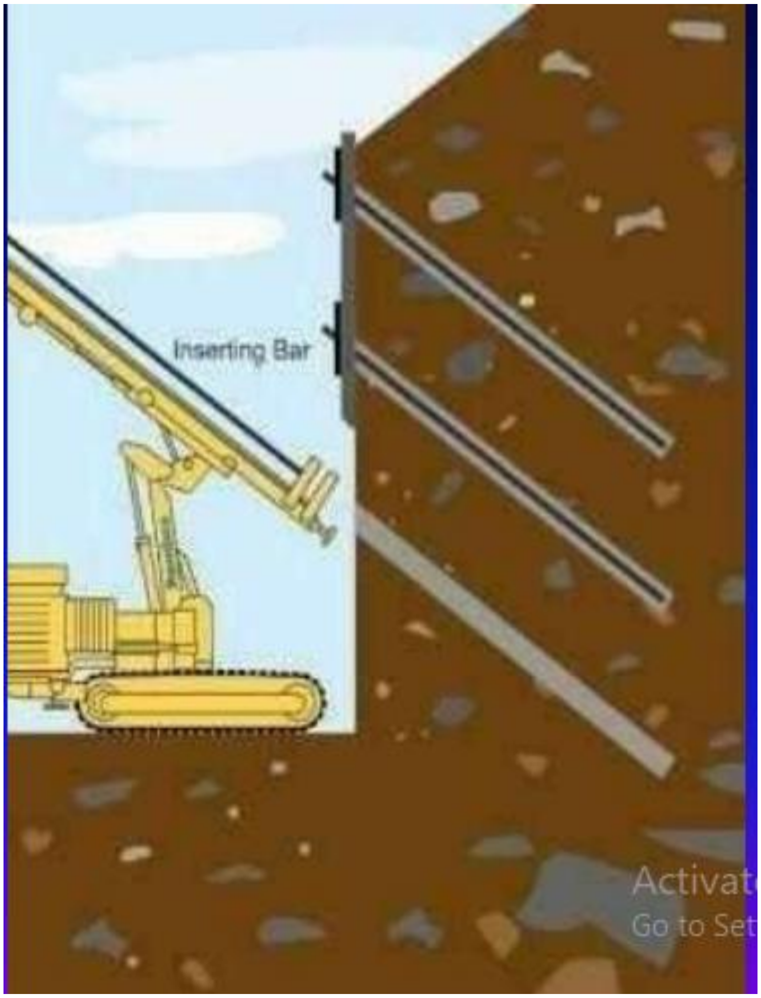
Ans#2 part1:

SOIL NAILING: Soil nailing is a technique to install closely spaced, passive structural inclusions to stabilize existing unstable ground due to the change of geotechnical conditions by nature and/or human activities. Common natural causes are precipitation and/or erosion, while the common human activity is partial removal of the ground for project needs.

The basic procedure for installing a soil nail consists of drilling a hole in the ground, placing a steel bar in the hole, and grouting the hole. Soil nails can be installed on existing or cut slopes and walls during excavation. shows a typical cross section of soil nailing, which includes multiple soil nails, temporary and/or permanent facing, and drainage system.

There are different types of nails in practice, which include

- Grouted nails
- Self-drilling nails
- Jet grouted nails
- Helical nails
- Driven nails
- Shoot-in nails



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

Suitability: Soil nailing is suitable for vertical or near vertical excavations in both soils and weathered rocks. It is also suitable for stabilizing steep unstable terrain of soils or weathered rocks.

The favorable geo materials for soil nailing installation include

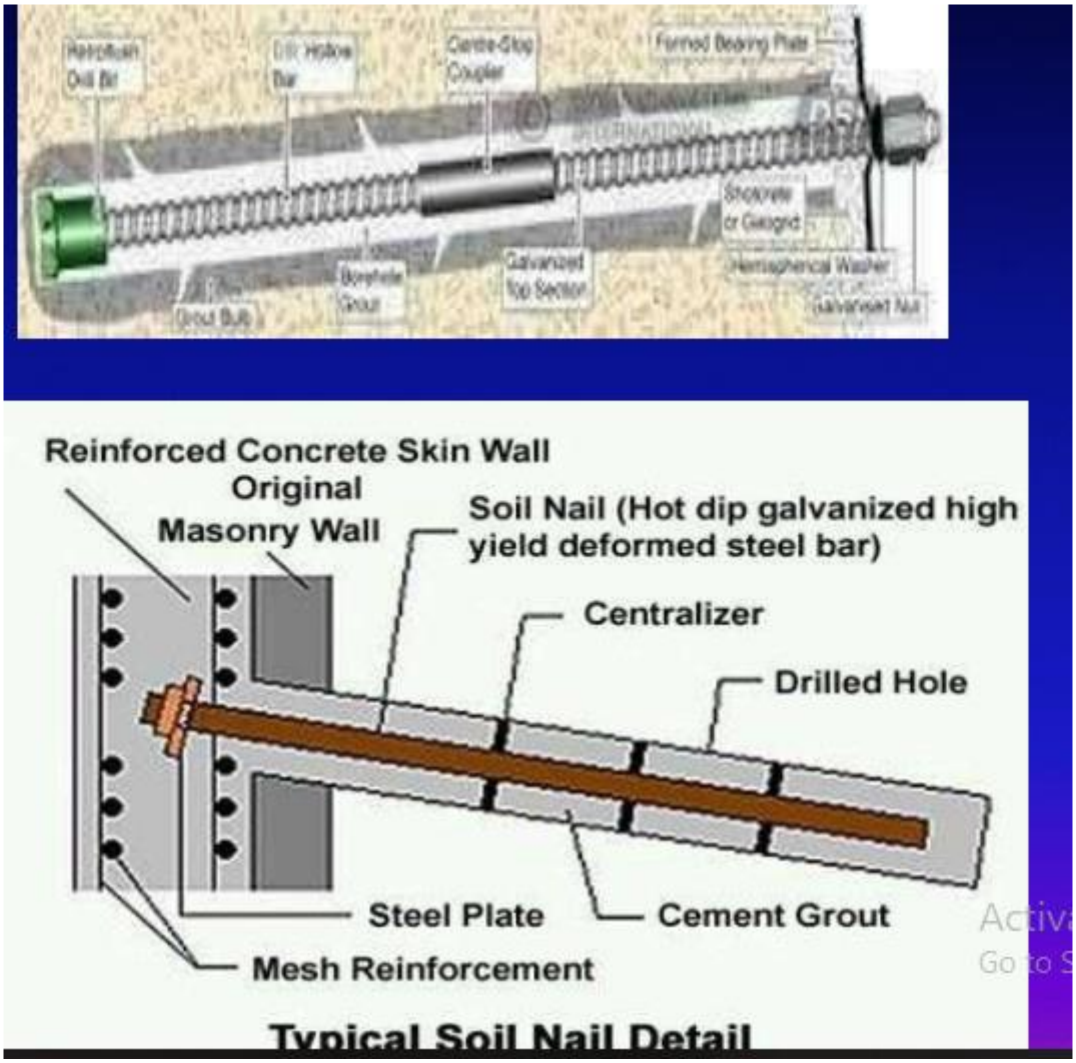
• Stiff to hard fine-grained soils

• Dense to very dense granular soils with some apparent cohesion

• Weathered rock with no weak plane

• Glacial soils

• Ground that can stand unsupported on a vertical or sloped cut of 1–2 m for 1–2 two days.



The unfavorable geo material conditions for soil nailing are

• Dry, poorly graded cohesion less soils

• Soils with high groundwater

• Soils with large boulders or cobbles

• Soft to very soft fine-grained soils

• Organic soils

• Highly corrosive soil (e.g., cinder or slag) or groundwater

• Weathered

Q#2partb:

Characteristics of Grouting:

Grout is a construction material used to embed rebars 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 color 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.

Different types of Grouting

i. Compaction grouting
ii. ii. Compensation grouting
iii. iii. Jet grouting Compaction Grouting .

Compaction grouting: is a single-stage grouting with high strength mortar to the ground to create a grout-bulb at the end of drill pipe.

Grouting Mechanism ν

- A stiff grout with a very low slump is injected under relatively high pressure through pipes or casings into soil. The grout exiting the bottom of the pipe forms a bulb-shaped mass that increases in volume.
- Displacement of the soil is produced by the weight of the overburden pushing back against the expanding grout bulb. Thus it densifies the soft, loose, or disturbed soil surrounding the mass. ν It can also be used to alleviate settlement problem during the excavation of tunnel or deep basement as the hardened bulb-shaped grout will induce an increase in the soil volume strain to the soil strata and cause heaving of ground at the ground surface.
- When applying the compaction grouting process usually a stiff to plastic grout is injected into the soil under pressure.
- It expands in the soil as a relatively homogeneous mass and at the same time is forming almost ball-shaped grout bulbs.
- The soil surrounding the grouted area is displaced and at the same time compacted.
- • Compared to other grouting techniques, the grout material neither penetrates into the pores of the in-situ soil (as is the case with the classical injection) nor are local cracks formed • During the compaction grouting process pressure and grout quantity as well as possible deformations at ground surface, respectively at structures are monitored.

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

- 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 potentia

The basic principles of compaction grouting are (1) to improve bearing capacity and density of soil by injecting stiff mortar to form a bulb around the injection pipe and (2) to displace and compact weak soil by the formation of the bulb. In addition, the mortar should be a coherent mass not to enter pores or fractures. The mechanism of compaction grouting is similar to that of vibro-compaction with backfill because both methods achieve the densification of the soils by displacing soils with foreign materials.

Application of Grouting (why and where:

1. Producing mass concrete structures and piles

2. Fixing ground anchors for sheet pile walls, concrete pile walls, retaining walls tunnels etc

3. Repairing a ground underneath a formation or cracks

4. Defects on building masonry or pavement

5. Fixing the tendons in prestressed post tensioned concrete

6. Filling the void between the lining and rock face in tunnel works

7. Seepage control in soil

8. Soil stabilization and solidification

9. Vibration control

Advantages: Grouting has the following advantages as compared with alternate technologies

: • No need for removal and replacement

• Effective for underpinning and protecting existing structures

• Easy to access and operate within constrained space

• Low mobilization cost

Disadvatges:

• Quantity of grout is hard to estimate

. • Effectiveness of some applications cannot be predicted

. • Area of improvement is sometimes uncertain

. • Grouting may cause ground movement and distresses to existing structures.

• Certain chemical grouts may contain toxicity and have adverse impact to groundwater and underground environment.

• Specialty contractors are required for the operation.

End Of Question#2 part a and b and c

Ans#3Part#a

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 geo construction 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.

A variety of terms are used to describe this “fixing the ground”: ‘soil improvement’, ‘ground improvement’, ‘ground treatment’, or ‘ground modification’.

Charles (2002) notes that the process of altering the ground is ground treatment, while the purpose of the process is ground improvement, and the result of the process is ground modification. For better or worse the treatment has modified the ground’s support conditions.

When superstructures are to be built on ground, there are five foundation options

(a) bearing on natural ground,

(b) bearing on replaced ground,

(c) bearing on compacted/consolidated ground, and

(d) bearing on composite ground, and

(e) bearing on piles to deeper stratum.

Options (b), (c), and (d) involve ground improvement methods.

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.

Below are some of the reasons

- 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

Ans#3Part#2 :

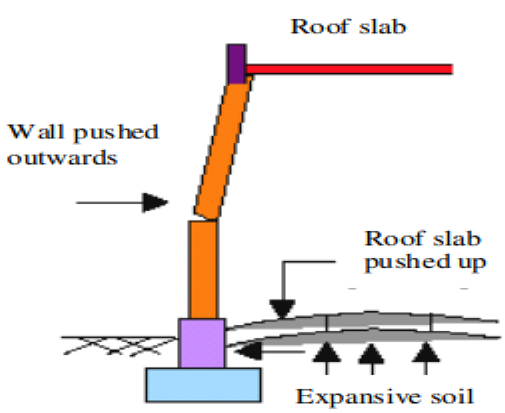
PROBLEMS ASSOCIATED WITH EXPANSIVE SOILS:

Expansive soil is an expensive material. Expansive soils occurring above water table undergo volumetric changes with changes in water content .Increase in moisture content causes the following effects:

1. Expansive soils expand and contract due to change in moisture content of the soil, causing structural Problems through differential movement of the structure resulting in severe damage to the foundations, buildings, roads, retaining walls, canal linings etc.

   The amount by which the ground can swell and/or shrink is determined by the water content in the near-surface zone. However, it may be noted that swelling and shrinkage are not fully reversible processes, and the effects of

   high shrink–swell potential can cause severe damage to various structures constructed on or in these expansive soils.



2. A second effect of expansive soils is the additional horizontal pressure applied to foundation walls in basements and crawl spaces. Increased water content in the soils adjacent to the foundation wall will cause the soils to expand and increase the lateral pressure on the foundation wall. If the foundation wall does not have sufficient strength, minor cracking, bowing or movement of the wall may occur. Serious structural damage or failure of the wall may also occur.

3. A third effect associated with claystone (a type of expansive soils) is the movement of soils on unstable slopes. Expansive claystone soils found as a layer under a more rigid top layer of soils, become unstable as the moisture content increases, allowing the claystone and top layers of the soil to move. If the soil is located on a slope, the top layer of soil can creep. Consequently, a house with an inadequate foundation built on unstable slopes can be subjected to creeping of the structure down slope or to failure of the structures in a landslide.

Ans#4 part1:Stone column.

STONE COLUMNS

Introduction Stone Columns: In contrast with vibro-compaction, which is undertaken solely to compact granular soils, stone columns may be installed in granular or cohesive soils. Vibrated stone columns are relatively stiff with respect to the surrounding ground. Stone columns may be provided in areas where subsoil consists of more than about 5 m thick soft cohesive soil and where stability and stringent considerations cannot be satisfied with conventional removal / replacement of soft material. Stone columns enable the embankment to be constructed to its full height continuously without requiring stage construction. The Technique A cylindrical vertical hole is made and gravel backfill is placed into the hole in increments and compacted by a suitable device which simultaneously displaces the the material radially.

The vibro flot is allowed to sink into the ground due to its own weight, assisted by water or air as a flushing medium, upto the required depth. The soil surrounding the vibro flot is disturbed or remoulded and the softened material can be removed by jetting fluid. By this process a borehole of larger diameter is formed once the vibroflot is withdrawn. The borehole is backfilled with gravel of 12 to 75 mm.

Stone columns: are typically used to address the following conditions:

1. Stone columns can be used to improve the stability of a slope by creating discrete zones of high shear strength within a low shear strength soil mass and thereby increase the average resistance to movement along any potential failure surface.

2. Stone columns can enhance the performance of a low bearing capacity soil layer by transferring most of a heavy surface load to a deeper, stronger layer. Further bearing capacity improvement can be accomplished by densification of the in-situ soils through the use of vibro-displacement methods.

3. Stone columns can be used to reduce the amounts of total and differential settlement that a new embankment would experience if placed over a low strength soil.

4. Stone columns will provide a conduit for the flow of ground water under excess pore pressure, thus decreasing the time for settlement to occur below a new embankment.

Also, the use of stone columns can further decrease the time required for placement of a large fill by allowing construction to proceed immediately instead of waiting for settlement to stabilize after placement of a temporary surcharge.

5. Stone columns are used to mitigate the potential for liquefaction induced by a seismic event through densification of loose, in-situ sandy soils and by providing pore pressure relief zones which have a far greater hydraulic conductivity than the in-situ sands. The installation of stone columns can also improve the cyclic resistance ratio of the soil mass.

BLASTING:

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.

It is often necessary to densify loose granular soils to achieve acceptable foundation performance of structures, particularly in areas of seismic activity where it is necessary to reduce soil liquefaction and seismic deformation potential.

Compaction in granular soils is achieved by vibration, typically either by insertion of a large vibrating poker into the ground (vibro-compaction) or by frequent drops of a large mass from a great height (deep dynamic compaction).

Increases in building code design accelerations for structures in potential seismic areas and the resulting increase in the requirement for densification has led to investigation of the potential for use of explosive compaction (EC) as an economic alternative to the more traditional techniques.

The Technique

• A certain amount of explosive charge is buried at a certain depth of a cohesionless soil required to be compacted and is then detonated.

• A pipe of 7.5 to 10 cm is driven to the required depth in a soil stratum. The sticks of dynamite and an electric detonator are wrapped in the water proof bundles and lowered through the casing.

• The casing is withdrawn and a wad of paper of wood is placed against the charge of explosives to protect it from misfire.

• The whole is backfilled with sand in order to obtain the full force of the blast.

• The elctrical circuit is closed to fire the charge. A series of holes are thus made ready.

• Each hole is detonated in succesion and the resulting large diameter holes formed by lateral displacement are backfilled.

• The surface settlements are measured by taking levels or from screw plates embedded at a certain depth below the ground surface. Once an area of ground has been treated and pore pressures have largely dissipated, repeated applications ("passes") of shaking caused by controlled blast sequences causes

Ans#4 part2:

Black Cotton 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

Over the past few decades, stabilization is found to be the best technique for reducing the swelling and shrinkage nature of black cotton soil.

Various researchers had tried stabilizing black cotton soil using lime, cement, fly ash, rich husk ash, etc. Of these, 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 .But in recent days, the cost of lime has increased. This resulted in increase of cost of lime stabilization of soil [2]. Also in the present study, an attempt is made in stabilizing the black cotton soil with lime which turned out to be unsuitable as subbase material. Hence the need for alternative and cost-effective materials has aroused.

Black Cotton Soil
Is a clay or soil that is prone to large volume changes (swelling and shrinking) that are directly related tochanges in water content. Soils with a high content of expansive minerals can form deep cracks in drierseasons or years; such soils are called vertisols. Soils with smectite clay minerals, including montmorillonite and bentonite, have the most dramatic shrink-swell capacity.

Stablization 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. The results of various tests carried out on black cotton soil mixed with varying percentages of lime are tabulated in Table 3.

Engineering property	2% lime	4% lime	6% lime
Plasticity characteristics			
(a) Liquid limit (%)	64.4	NP	NP
(b) Plastic limit (%)	34.0	NP	NP
(c) Plasticity index (%)	30.4	NP	NP
Differential free swell (DFS) index (%)	90	60	40
IS light compaction			
Maximum dry density (g/cc)	1.37	1.51	1.34
Optimum moisture content (%)	28	25	32
Soaked CBR (%)	7.59	8.52	0.62

From Tables , it can be observed that the plasticity index of the soil under study had decreased from 45.4% for 0% lime to 30.4% for 2% lime and thereafter the soil had become non plastic (NP) with increase in the lime content.

The differential free swell index of the black cotton had decreased from 100% to 40% with increase in the lime content from 0% to 6Compaction characteristics of lime-stabilized soil are determined by conducting the IS light compaction test. Figure 2 shows the variation of maximum dry density with varying percentages of lime added to black cotton soil. It can be observed that the maximum dry density of the black cotton soil increased from 0% lime content to 4% lime and thereafter it decreased.

End of question 4 part 1 and 2

End of question 3 part 1 and 2