GROUND IMPROVEMENT TECHNIQUES

(Subject code: PCI7J002)

Module I

1. What are different types of engineering problems with soils?
2. What are the problems with expansive soils?
3. What are the problems with collapsible soils?
4. What are the problems with soft and sensitive soils?
5. How do slope stability problems occur?
6. What are the problems due to liquefaction due to earthquakes?
7. What are the strategies for ground improvement?
8. What are different methods of ground improvement?
9. What are different methods that are applicable to different types of soils
10. How are different ground improvement techniques classified?
11. What are the factors affecting the selection of ground improvement techniques?
12. What are the objectives of ground improvement techniques?
13. What are the emerging trends?
14. What are different methods of modification of soils?
15. What are the differences among ground reinforcement, ground improvement and ground treatment?
16. What are the factors affecting the selection of ground improvement?
17. How does assessment of engineering properties of native soils help in arriving at the choice of ground improvement?
18. Why does the expansive soil treatment with lime does not work in the presence of sulphates?
19. How does reusability of certain products help in general terms in the reduction of carbon footprint?
20. How does recycling of plastics help in ground improvement
21. What are the typical engineering properties that need to be improved and give suitable examples.
22. What are the benefits of ground improvement?
23. Name different types of ground reinforcement techniques.

24. What are the emerging trends? Explain how i) a dump yard can be stabilized ii) how waste materials can be reused. iii) how geosynthetics help in geotechnical construction. iv) what are the uses of biotechnical stabilization.

25. What are the catalysts and accelerators of better use of ground improvement techniques?

26. List the problems associated with expansive soils?

27. What are the mechanisms of improvement when soil is mixed with lime?

28. What are the factors compiling the characteristics of lime treated clay?

29. Comment on the drying-wetting test results on lime-treated expansive soils.

30. How is lime added to the soil in the field?

31. How are lime columns helpful?

32. How are lime columns installed?

Module II

1. What are the purposes of dewatering?

2. What are the common methods of dewatering?

3. What are the well point systems?

4. Discuss the applicability of dewatering systems in different soils?

5. What are the different applications of dewatering?

6. What are the most important design input parameters for dewatering?

7. Write short notes on different types of tests that need to be conducted for evaluation of permeability?

8. What are the difference between fixed wall permeameter and flexible wall permeameter test?

9. Evaluate discharge from an aquifer in the case of a) single well b) multiwells.

10. What are the uses of electro-kinetic stabilization?

11. What is electro-osmosis?

12. What are the factors influencing electro-osmosis?

13. What are the electrode reaches and how does it help in the electro-osmotic process?

14. Describe the case-study conducted in U.K.?

15. Explain the results obtained in the above case study?

16. What are the electro-kinetic geosynthetics? What are the applications?

17. Describe a case study on electro-kinetic geosynthetic technology?

18. What are the properties on which temperature control methods depend on?
19. Define thermal conductivity of soil?
20. Define heat capacity of the soil?
21. Define heat of fusion?
22. Define heat of vaporization?
23. What are the methods of heating the soil in-situ?
24. What is ground freezing?
25. What are the principles of ground freezing?
26. What are the application areas?
27. How does liquid nitrogen vapor freezing technique?
28. What are the various types of chemical grouting?
29. Comment on the penetrability of various grouting?
30. What are the characteristics of chemical grouts?
31. Discuss the case study in the construction of street tunnel?
32. What are the rheological considerations in grouting?
33. Discuss how the water pressure testing is done and explain various pattern of flow rate/pressure diagrams.
34. What are geotechnical considerations for use of compaction grouting?
35. What are the various steps in compaction grouting?
36. What are the applications of compaction grouting?
37. What are the advantages of compaction grouting?
38. Explain the case study of Mc Clellan pump station?
39. What is jet grouting? What are different systems of jet grouting?
40. What is compaction grouting?
41. What are the advantages of jet grouting?
42. What is chemical grouting?

Module III

1. What are the advantages of compaction?
2. What are the strategies for good compaction process?

3. How do you do laboratory compaction?
4. What is the difference between standard compaction and modified compaction?
5. What are the fundamental processes in the compaction?
6. How the line of optimums is obtained?
7. What are the various equipment used for shallow compaction? What are their characteristics?
8. What are the typical ranges of pressure induced in clays and sands due to compaction?
9. What are the requirements t of compaction control tests?
10. What are compaction control procedures?
11. What are different types of specifications?
12. What are different types of tests that are conducted for compactioncontrol?
13. What are non-destructive methods in compaction control?
14. What are different methods of compaction control?
15. How are statistics and probability useful in compaction control?
16. What are the methods of improving soil at deeper strata?
17. What are the principles and procedures in dynamic compaction?
18. For which types of soils, dynamic compaction is preferable?
19. What are different types of dynamic compaction methods?
20. How do you evaluate dynamic compaction method?
21. How do you evaluate ground vibrations due to dynamic compaction?
22. Specify tolerable limits for peak particle velocity and how do you do monitoring?
23. Discuss a design approach to dynamic compaction
24. How do you verify that the area is compacted as per requirement using suitable field testing? Give examples in relation to improvement of liquefaction resistance in a loose sandy deposit?
25. What are Vibro-compaction methods?
26. How does grain size distribution help in deciding about compatibility?
27. What are the applications of stone columns?
28. What are the factors that influence stone –column foundation response?
29. What are the principles of stone column design?
30. Explain IS method of stone column design?

31. What are the salient points of Preibe's method?

32. What are aggregate piers and what is the difference between stone columns and aggregate piers?

33. What is the principle of preloading?

34. Explain the design of PVDs for soft ground improvement?

35. What are the advances of PVDs over sand drain?

36. What is a trial embankment?

37. Explain the installation of PVDs.

38. What the different layout patterns in sand drains?

Module IV

1.What are the applications of ground treatment with cement?

2. What are the factors that influence strength and stiffness improvement of cement treated soils

3. What are the chemical reactions that take place and explain their effects.

4. How is a soil treatment project using cement is executed?

5. Discuss the experimental results obtained from the studies of Bergado et al (1996).

6. Write short notes on deep mixing methods?

7. How are the procedures adopted for deep mixing in the field?

8. What are the various types of geosynthetic materials.

9. What are the different functions of geosynthetics.

10. What are geogrid, geofoam, GCL and geopipe. Give application for each product.

11. How are RE walls useful?

12. What are the typical application of geosynthetics in geoenvironmental Engineering.

13. What are the typical applications of geosynthetics in transportation engineering?

14.What are different types of polymers?

15. What are typical properties of polymers.

16. How geosynthetics are produced in factory.

17. What are externally stabilized and internally stabilized retaining systems.

18. What are the concepts of reinforced soil?
19. What are the technical and economic benefits of reinforced soil.
20. Explain the effect of reinforcement orientation.
21. What is strain compatibility of reinforced soil?
22. How do you identify polymers used in geosynthetics.
23. What are the geometric properties of geosynthetics.
24. What are the mechanical properties of geosynthetics.
25. What are different types of creep tests on geosynthetics?
26. Why creep properties are important
27. How are impact and abrasion tests conducted?
28. What are hydraulic properties of geosynthetics?
29. What are the durability properties of geosynthetics. How they are measured?
30. List the factors that influence the performance of reinforced soil characteristics.
31. How do the reinforcement form, distribution affect reinforced soil structure performance.
32. How do soil type and state influence the reinforced soil structure performance.
33. What are the different construction factors that affect the performance of reinforced soil.
34. What are the modes of failure of reinforced soil foundations.
35. What are the steps required to evaluate tensile failure of the reinforced soil foundation.
36. What are the steps required to evaluate pullout failure of the reinforced soil foundation.
37. How is bond resistance of geogrids helpful in reinforced soil beds.
38. What are the various mechanisms by which the bearing capacity of a soil can be improved using geosynthetics.
39. What are different types of retaining walls.
40. Write short notes on design approaches for RE walls.
41. Explain the difference between tie back wedge method and coherent gravity method.
42. How do you evaluate tensile failure of reinforcement?
43. How do you evaluate pull-out failure of reinforcement?
44. What are the differences between segmental wall and panel wall constructions.
45. Explain the uses of geocells in embankment.

46. Explain the concept of geocell reinforcement.

47. Explain the construction of embankment on soft soil using a) geosynthetics b) geocells.

QUESTION WITH ANSWERS

Ground Improvement Techniques ((Subject code: PCI7J002)

PART - A (short type questions of 2 / 5marks)

1. What are the major problematic soils?

1. Collapsible soils
2. Liquefiable soils
3. Waste materials
4. Expansive and shrinkage
5. Marshy and soft soils
6. Karst deposits

2 . What is expansive soil? Give one example.

Expansive soils are soils that expand when water is added and shrink when they dry out. This continuouschange in soil volume can cause the structures built on this soil to move unevenly and cracks are developed

Ex. Deccan plateau and in some parts of Andhra Pradesh, liquid limit is highest water content in the range of about 100 percent and the shrinkagelimit could be as low as 10 percent.

3. What is a collapsible soil?

These collapsible soils are nothing but the soils, which have a tendency to collapse upon loading. Many of the reasons such as, the stable or unstable meta structure or capillary structures nullification are some of the reasons for this collapsible nature of the soil. Suppose the soil is partly saturated and when it comes in contactwith water, the moment there is a contact with water all the capillary structures are destroyed. Because of this,there is a volume change; it is in fact a reduction in volume and that leads to collapse.

4. What are the difficulties faced with soft clay?

When the soft soil is so poor, it is very difficult to construct anything, because the bearing capacity is verylow, shear strength is low, consolidation settlements are going to be very high and permeability is very low.

These are all very peculiar. So, this needs to be improved.

5. Name the various soil deposits found in India.

a. Black cotton soil
b. Laterites and murmurs
c. Alluvial soil
d. Desert soil
e. Boulder soil

6. Name any four ground improvement techniques.

1.Compaction Pile

2.Blasting

3. Pre-Compression
4. Stone Column
5.Vibrofloatation

6. Grouting
7. Electro Osmosis
8.Thermal Treatment

7. What is the need for improving the ground?

- Reclamation of unusable land
- Betterment of soil properties for improved performance
- Cost effective design of foundations.

8. Briefly write the role played by ground improvement in foundation engineering.

- Improves bearing capacity.
- Reduces foundation settlements.
- Enables construction on granular fills.
- Provides temporary underpinning.
- Provides excavation support.
- Reduction of foundation dimensions
- Construction of shallow foundations
- Enables dry working conditions for foundation excavations.

9. Define ground improvement.

Ground improvement technique is the process of improving the geo-technical characteristics ofsoil used in construction. The soil at a construction site is not always totally suitable for supporting structures such as buildings, bridges, highways and dams. For example, In granular soils, in-situ soil may be very loose and indicate large elastic settlement. Under these conditions, soil needs to be dandified toincrease its unit weight and shear strength.

10. What is compaction? When is it adopted?

The compaction is process of increasing density of soil by means of suitable compaction device . It is predominantly adopted for cohesive soils and also however cohesion less soil can be also compacted by asuitable device.

11. What is dewatering? What are the various methods of dewatering?

Dewatering is the process of continuous removal of water to lower the groundwater table to the required depth.Different methods of dewatering are

1. Sumps and ditches
2. Well point system

3. Deep well system
4. Vacuum dewatering 5. Electro-osmotic dewatering

12. When is pre-loading adopted as a ground improvement technique?

Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time. The pore water dissipation reduces the total volume causing settlementSurcharging is an economical method for ground improvement.

13. **What is advantage of using vertical drains along with pre-loading?**

The main applications of this method are in areas of transportation, highway Embankments, housing projects, hazardous waste remediation and in reducing negative skin friction on pile foundations. Vertical drains are nowadays primarily constructed with prefabricated vertical drains.

14. How are heating and freezing used to improve ground?

Heating soils permanently alters the properties of the soil. Depending on the soil, temperatures can range between 300 and 1,000° C.The expected property changes are increase in shear strength and modulus of elasticityIts application areas include immobilization of contaminant and soil stabilization

Freezing

Ground freezing is the use of refrigeration to convert in situ pore water to ice.The ice then acts as a cement or glue, bonding together adjacent particles of soil or blocks of rock to increase their combined strength and make them impervious.

Freezing is mainly adopted for

- Temporary underpinning
- Support for excavation
- Slope stabilization
- Contaminant containment
- To prevent ground water from entering excavation

15. What is a lime column?

Lime column is the process in which soft clays and silts are mixed with dry unslaked lime to form a column of treated soil.This process uses a mixing tool that combines the lime with in-situ material during treatment.

16. What is vibro-compaction? In which soils is it adopted?

Vibrio-Compaction, sometimes referred to as Vibro-flotation, is the rearrangement of soil particles intoa denser configuration by the use of powerful depth vibrators. It is mainly adopted to reduce settlements, reduce liquefaction hazard and permit construction on granular fills.

It can be adopted in sands and silty sands with excellent to good results. Its applicability is poor in silts and cannot be adopted for clays.

17. What are the various methods of grouting?

- Suspension
- grouts Solution
- Grouts
  Colloidal
  solution grouts

Part –B (long type questions)

1. Explain in detail the role of ground improvement in foundation engineering.

Role of GIT in Foundation Engg. is as given below.

- Improves bearing capacity.
- Reduces foundation settlements.
- Enables construction on granular fills.
- Provides temporary underpinning.
- Provides excavation support.
- Reduction of foundation dimensions.
- Construction of shallow foundations.
- Enables dry working conditions for foundation excavations.

2. What are the various geotechnical problems faced with black cotton soil, laterite soil andalluvial soil deposits?

Geotechnical Problems in Soils

• Soil is a material which exhibits a very wide range of characteristics that, it led a whole branch of study to understand it better

• In this endeavour, man has encountered a wide variety of soils posing problems to his developmental activities

• Not all soils are problematic from engineering point of view.

• Different soils exhibit different levels of difficulty in their handling.

i. **Black cotton soil**

- This is well known group of soils characterized by dark grey to black colour with high clay content.

- They are neutral to slightly alkaline in reaction.
- Major black soils are found in Maharashtra, Madhya Pradesh, Gujarat and Tamilnadu

• **Problems with black cotton soil**
- The major problem with black cotton soil is its expansive nature due to presence of montmorillonite clay mineral.
- Its surface is hard in summer, and becomes slushy in rain and loses its strength substantially.
- This swell and shrink nature results in movements leading to heaving of lightly loaded structures and road pavements

• **Laterite Soil**
- The upper horizons of laterite soils are rich in oxides of iron and alluminium
- The texture is light with free drainage structure.
- Clay is predominant and lime is deficient and contain more humus and are well drained.
- They are distributed in summits of hills of Deccan Karnataka, Kerala, Madhya Pradesh, Ghat regions of Orissa, Andhra Pradesh, Maharashtra and also in West Bengal,Tamilnadu and Assam.

• **Problems with Laterite soils**
- Porous in nature
- Medium to high permeability
- Stability problems
- Difficulty in assessment of lateral stresses
- Wide ranging characteristics

• **Alluvial Deposits**

The soils are sandy loam to clay loam with light grey color to dark colour,structure is loose and are very fertile

- These soils are distributed in Indo-Genetic plains, Brahmaputra valley and almost all states of Northand South India

• Problems with alluvial soils Loose deposits with good water holding capacity

3. Write in brief about

(a) Compaction

Compaction is the process of increasing the density of the soil by means of suitable compaction deviceThis method is predominantly adopted for cohesive soils

However, cohesionless soils can also be

compacted(densification)

(b) Vibro-Compaction

- Vibro-Compaction, sometimes referred to as Vibroflotation, is the rearrangement of soil particlesinto a denser configuration by the use of powerful depth vibrators
- It is mainly adopted to reduce settlements, reduce liquefaction hazard and permit construction ongranular fills
- It can be adopted in sands and silty sands with excellent to
- good resultsIts applicability is poor in silts and cannot be adopted for clays

(c) Pre-loading

Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time.

- The pore water dissipation reduces the total volume causing settlement.
- Surcharging is an economical method for ground improvement.
- The various soils that can be treated using this method include,
    - Organic silt
    - Varved silts and clays
    - Soft clays
    - Dredged material

The main applications of this method are reduction of post construction settlement, reduction of secondarycompression, densification and improvement of bearing capacity.

(d) Pre-loading with vertical drains.

Vertical drains shorten the drainage path for the purpose of reducingthe consolidation time

- The drains increase the rate at which excess pore water pressure is dissipated during consolidationof compressible soils.
- Vertical drains are used to densify soft compressible soils in conjunction with preloadingThe main applications of this method are in areas of transportation, highway embankments, housing projects, hazardous Waste remediation and in reducing negative skin friction on pile foundations
- Vertical drains are nowadays primarily constructed with prefabricated vertical drains.

4. Write short notes on

(a) Dewatering

Dewatering is the process of continuous removal of water to lower the ground water table to the required depth. Different methods of dewatering are,

- Sumps and ditches
- Well point system
- Deep well system
- Vacuum dewatering
- Electro-osmotic dewatering

(b) Heating

I. Heating or vitrification breaks the soil particles down to form a crystalline or glass product.

II. It uses electrical current to heat the soil and modify the physical characteristics of the soil.

III. Heating soils permanently alters the properties of the soil. Depending on the soil, temperatures can range between 300 and 1,000° C

- The expected property changes are increase in shear strength and modulus of elasticity
- Its application areas include immobilization of contaminant and soil stabilization.

(c) Freezing

- Ground freezing is the use of refrigeration to convert in situ pore water to ice.
- The ice then acts as a cement or glue, bonding together adjacent particles of soil or blocks of rock toincrease their combined strength and make them impervious.
- Freezing is mainly adopted for
  - temporary underpinning
  - support for excavation
  - slope stability
  - contaminant containment
  - to prevent ground water from entering excavation area

(d) Lime columns

- Lime column is the process in which soft clays and silts are mixed with dryun slaked lime to form a column of treated soil.

- This process uses a mixing tool that combines the lime with in-situ material during treatment.

- The main applications of lime columns are in improvement of fills,embankments and deep trenches.

5. What are the factors influencing the selection of ground improvement techniques?

Selection of GIT

Selection of Ground Improvement Technique depends on the following factors

- Soil type
- Area and depth of treatment required.
- Type of structure and load distribution
- Soil properties
- Permissible total and differential settlement
- Material availability
- Availability of skill and equipment
- Environmental considerations
- Local experience and preference
- Economics

Ground Improvement	Type of Soil
Compaction	Wide range of geomaterial
Smooth wheeled roller	Paving mixtures
Sheep foot roller	Clay and silty clays
Grid roller	Coarse grained soils
Pneumatic rollers	Low cohesive soils like clayey, sands and sandy clays and cohesionless soils like gravels, sands andsilty
Vibratory rollers	Coarse grained soils
Dynamic compaction	Best in cohesionless but other types of soils also can be compacted
Sumps and ditches	Clean gravels and coarse sands
Well point system	Most effective in sands, sandy gravels to fine sands
Deep well system	Gravels to silty fine sands and water bearing rocks
Vacuum dewatering	Fine grained soils with k in the range 0.1 to 0.01mm/s
Electro-osmotic	Silts, silty clays, soft clays, dewatering and peat
Preloading andOrganic silt vertical drains	silts and clays, Soft clays,Dredged material
Lime Columns	Effective in clayey soils and expansive clays, soft and loose inorganic fills

Heating	Fine grained soils, Especially for partially saturated clays, silts and loessial soils
Freezing	Wide range of soil types like sands, cohesionless silts and clays
Vibro-compaction	Effective in sands and silty sands, poor applicability in silts and cannot be adopted in clays
Stone columns -	Granular and cohesive
Vibro-displacement soils	Cannot be adopted for thick peats, very soft clays, recently filled cohesive soils,collapsible fills and hard ground
Blasting	Loose cohesionless soils, Saturated clean sandy soils. Partly saturated sands and siltsAfter flooding
Chemical stabilization	Different soils can be Stabilization treated by Different varieties of chemicals and resins
Grouting	Most grouts are suitable for gravels to silts. Compaction grouting can be adopted for partially saturated cohesive soils
Geosynthetics	All soils
Earth reinforcement	All soils

6. Explain in brief the various methods of ground improvement.

Methods of Ground Improvement

- Compaction
- Drainage and Dewatering
- Pre-loading
- Pre-loading with Vertical Drains
- Lime Columns
- Heating
- Freezing

- Vibro-compaction
- Stone Columns
    i. Vibro-displacement
    ii. Vibro-replacement
- Electro-kinetic Method
- Blasting
- Chemical Stabilization
- Grouting
- Geosynthetics
- Soil Reinforcement

Compaction

Compaction is the process of increasing the density of the soil by means of suitable compaction device.This method is predominantly adopted for cohesive soils.However, cohesionless soils can also be compacted(densification)

- **Drainage and Dewatering**

Dewatering is the process of continuous removal of water to lower the groundwater table to the required depth.
Different methods of dewatering are:

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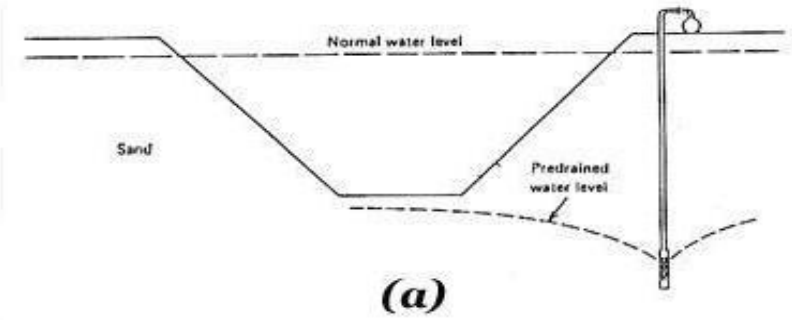

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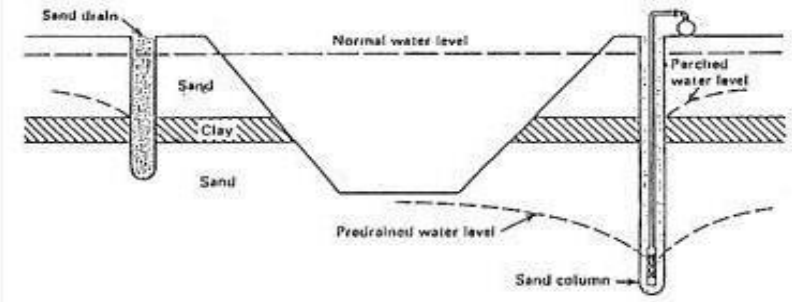

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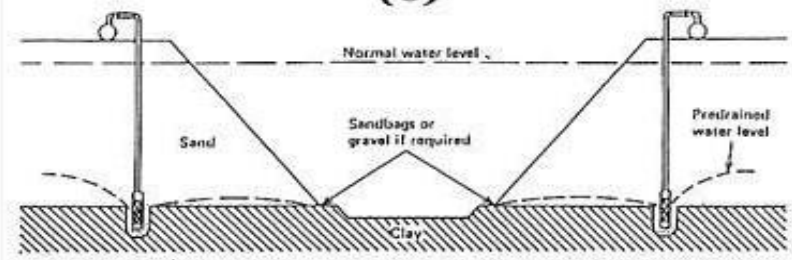

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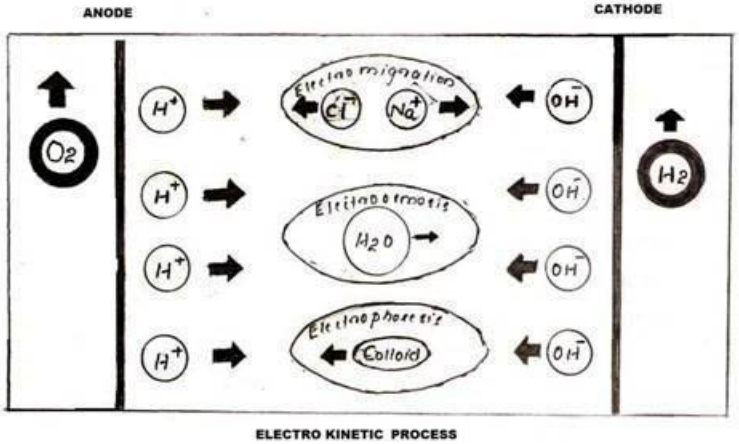


ELECTRO KINETIC PROCESS

• **Pre-loading**

Preloading or pre-compression is the process of placing additional vertical stress on a compressible soil to remove pore water over time.The pore water dissipation reduces the total volume causing settlement.Surcharging is an economical method for ground improvement. The various soils that can be treated using this method include:

- Organic silt
- Varved silts and clays
- Soft clays
- Dredged material

The main objectives of this method are reduction of post construction settlement, reduction of secondary compression, densification and improvement of bearing capacity.

Preloading With Vertical Drains

Vertical drains shorten the drainage path for the purpose of reducingthe consolidation time

- The drains increase the rate at which excess pore water pressure is dissipated during consolidationof compressible soils.
- Vertical drains are used to densify soft compressible soils in conjunction with preloading. The main applications of this method are in areas of transportation, highway embankments, housing projects, hazardous Waste remediation and in reducing negative skin friction on pile foundations.
- Vertical drains are nowadays primarily constructed with prefabricated vertical drains.

Lime Columns

- Lime column is the process in which soft clays and silts are mixed with dryunslaked lime to form a column of treated soil
- This process uses a mixing tool that combines the lime with in-situ material during treatment
- The main applications of lime columns are in improvement of fills,embankments and deep trenches.

• **Heating**

- Heating or vitrification breaks the soil particles down to form a crystalline or glass product
- It uses electrical current to heat the soil and modify the physical characteristics of the soil
- Heating soils permanently alters the properties of the soil
- Depending on the soil, temperatures can range between 300 and 1,000° C
- The expected property changes are increase in shear strength and modulus of elasticityIts
- application areas include immobilization of contaminant and soil stabilization

• **Freezing**

- Ground freezing is the use of refrigeration to convert in situ pore water to ice
- The ice then acts as a cement or glue, bonding together adjacent particles of soil or blocks of rockto increase their combined strength and make them impervious
- Freezing is mainly adopted for:
    - temporary underpinning
    - support for excavation
    - slope stabilization
    - contaminant containment
    - to prevent ground water from entering excavation area.

• **Vibro-compaction**

- Vibro-Compaction, sometimes referred to as Vibroflotation, is the rearrangement of soil particlesinto a denser configuration by the use of powerful depth vibrators
- It is mainly adopted to reduce settlements, reduce liquefaction hazard and permit construction ongranular fills
- It can be adopted in sands and silty sands with excellent to
- good resultsIts applicability is poor in silts and cannot be adopted for clays

• **Stone columns**

Vibro-displacement

The Vibro Rig displaces the soil by vibrating a mandrel into the ground to the required depth or refusal, whichever is achieved first.The mandrel is withdrawn and the subsequent void filled with a clean stone. The mandrel is then re-introduced to the in-filled void and taken down close tothe base of the previously formed void, displacing the stone laterally into the surrounding soil. The process is repeated with subsequent filling and compaction of the stone to form a vertical stone column, with close interlocking into the surrounding soils.

This method provides the ground with the ability of increased load bearing characteristics.

Stone columns - Vibro-replacement

Vibro-Replacement technique is a method by which stone columns are formed by replacement of poor soils using stones and forming columns. With Vibro-Replacement Stone Columns, columns of dense, crushed stone are designed to increase bearing capacity, reduce settlement, aid densification and mitigate the potential for liquefaction, and improve shear resistance

Electrokinetic method

- Electro-kinetic soil stabilization is the application of electro-osmosis to draw stabilizing chemicals through soil
- Electro-Osmosis is the process of using a cathode and an anode to create a direct current electrical field and making water flow through fine-grained soil.
- The water is removed from the cathode side and is not replaced, consolidating the soil.
- The process has been applied to liquefiable sands where grout cannot pass to stabilize the soil.
- The soils that can be treated by this method are sands and dredgings.

Blasting

- Blasting is the process of detonating small charges within loose cohesionless soils for the purpose of densification.
- Due to blasting there is immediate and long term settlement.
- But already dense zones may loosen due to blasting.

Chemical Stabilization

- Chemical stabilisation is the process of bonding the soil particles with a cementing agent, the primary additive being the chemical that binds the soil by a chemical reaction with or within the soil.

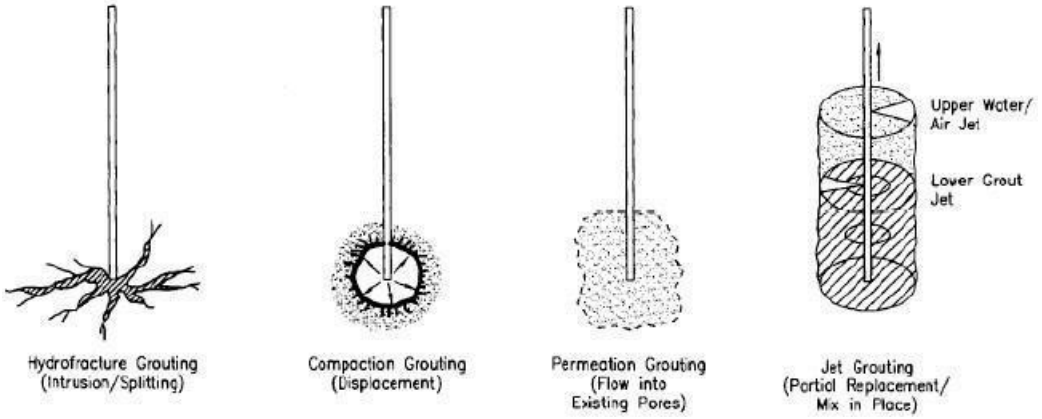
- The primary additives generally used are lime, salts, lignins and polymers.

Grouting

Grouting is the process of ground improvement attained by injection of a fluid like material that is capable of forming a gel and binding the soil particles.

Grouting can be permeation grouting, compaction grouting or hydraulic fracturing. Permeation grouting involves the free flow of grout into the soil voids with minimal effect. Compaction grouts remain intact as a mass on grouting and exert pressure on the soil. Hydraulic fracturing process causes fracture of rocks due to the intense pressure of grouting and flows into the fractures. Grout materials may be cement based grouts or solution grouts or suspension grouts, the latter two being chemical based

Continued…



• **Geosynthetics**

They are artificial fabrics used in conjunction with soil for any construction project.

They are primarily two types:

• Geomembranes – impermeable

• Geotextile – permeable

The different types available based on applications are geospacers, geogrids, geowebs, geosynthetic clay liners, geomats, geofoam and geocomposites.

- They can be used for applications like separation, reinforcement, drainage, filtration and barriers

Soil reinforcement

- It is provision of reinforcement to soil to increase its strength.
- Reinforcements can be steel bars, steel sheets, steel flats, geogrids, geotextiles etc