

QUESTION WITH ANSWERS

DEPARTMENT: CIVIL -IV

SEMESTER:VII

SUB.CODE/ NAME: CE 2033 / Ground Improvement Techniques

UNIT 1- INTRODUCTION

PART - A (2 marks)

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 continuous change in soil volume can because homes built on this soil to move unevenly and crack.

Ex. Deccan plateau and in some parts of Andhra Pradesh

Minimum volume like liquid limit is highest water content in the range of about 100 percent and the shrinkage limit could be as low as 10 percent.

4. 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 contact with 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.

5. 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 very low, 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.

7. Name the various soil deposits found in India.

1. Black cotton soil
2. Laterites and murmurs
3. Alluvial soil
4. Desert soil
5. Boulder soil

8. Name any four ground improvement techniques. (AUC MAY/JUNE 2013)

1. Compaction Pile
2. Blasting
3. Pre-Compression
4. Stone Column
5. Vibrofloatation
6. Grouting
7. Electro Osmosis
8. Thermal Treatment

9. What is the need for improving the ground? (AUC MAY/JUNE 2013)

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

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

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

11. Define ground improvement. (AUC NOV /DEC 2012)

Ground improvement technique is the process of improving the geo-technical characteristics of soil 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 to increase its unit weight and shear strength.

12. What is compaction? When is it adopted?

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

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

14. 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 settlement

Surcharging is an economical method for ground improvement

15. 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

16. 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 elasticity

Its 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

17. 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.

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

Vibro-Compaction, sometimes referred to as Vibroflotation, is the rearrangement of soil particles into a 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

19. What is stone column? What are the methods of installing a stone column?

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 to the base of the previously formed void, displacing the stone laterally into the surrounding soil

20. What are the various methods of grouting?

- Suspension grouts
- Solution Grouts
- Colloidal solution grouts

Part –B

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

Role of GIT in Foundation Engg.

- 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 and alluvial soil deposits? (AUC NOV /DEC 2012) (AUC MAY/JUNE 2013)

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
- **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 aluminium
- 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 North and 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 device This 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 particles into a 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

(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 secondary compression, densification and improvement of bearing capacity

(d) Pre-loading with vertical drains.

Vertical drains shorten the drainage path for the purpose of reducing

The consolidation time

- The drains increase the rate at which excess pore water pressure is dissipated during consolidation of 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

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

- 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 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 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 area

(d) Lime columns

- 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
- 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?

(AUC MAY/JUNE 2013)(AUC NOV /DEC 2010)

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	
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 and silty sands
Vibratory rollers	Coarse grained soils
Dynamic compaction	Best in cohesionless butn 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 0.01 mm/s
Electro-osmotic	Silts, silty clays, soft clays Dewateringb and peat
Preloading and Organic silt vertical drains	Varved silts and clays Soft clays Dredged material
Lime Columns	Effective in clayey soils and expansive clays, soft and loose inorganic fills
	Fine grained soilsEspecially For partially saturated clays, silts and

Heating	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 silts After 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. (AUC NOV /DEC 2012)

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

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This method is predominantly adopted for cohesive soils

However, cohesionless soils can also be compacted

(densification)

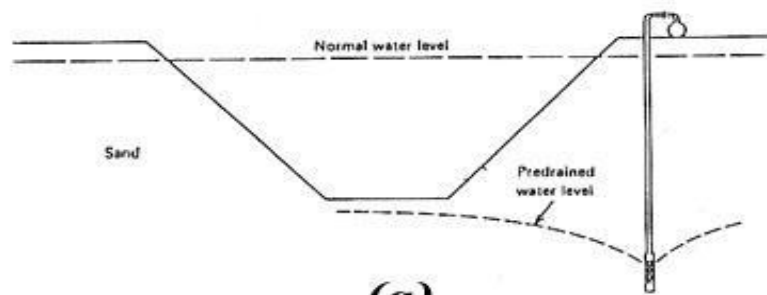
• Drainage and Dewatering

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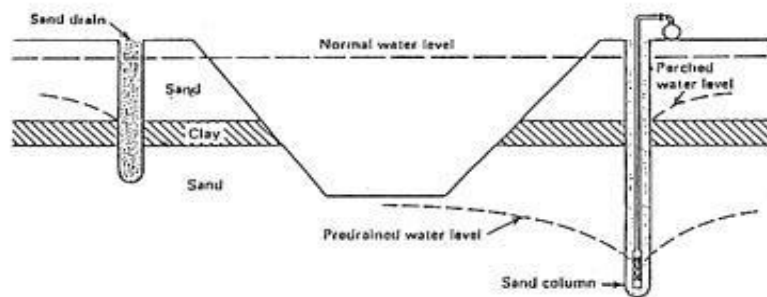
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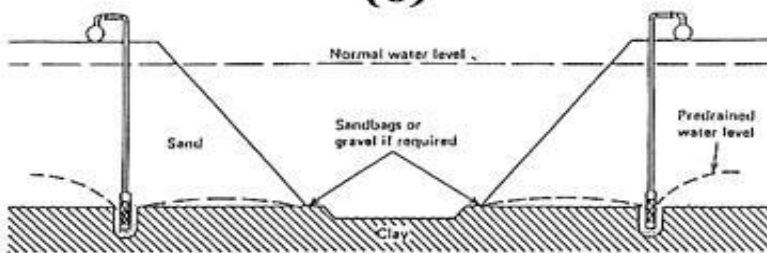
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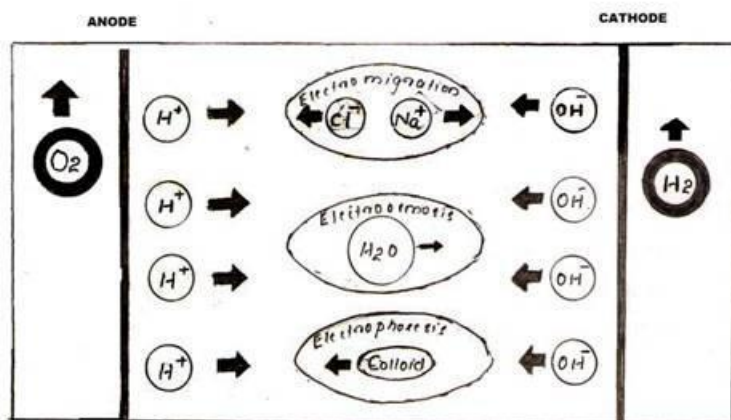
(a)



(b)



(c)



ELECTRO KINETIC PROCESS

• **Pre-loading**

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

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stabilization

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• Stone columns

- Vibro-displacement
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- 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 to the 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

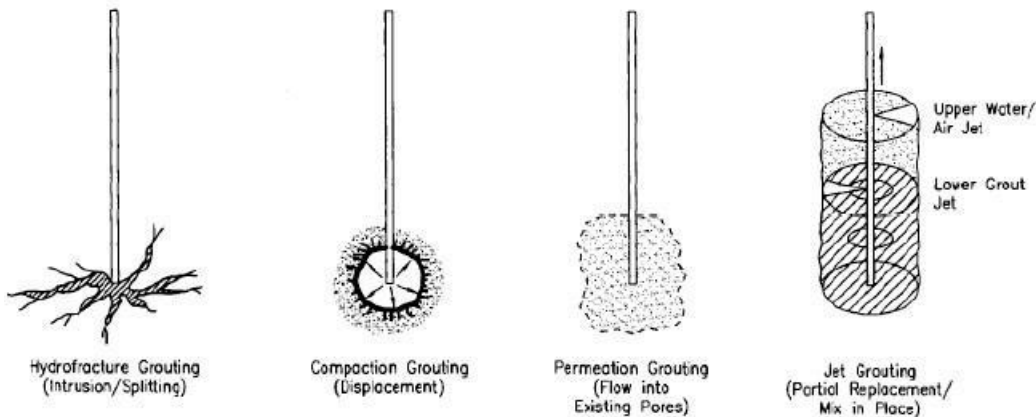
pressure of grouting and flows into the

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, geowebbs, geosynthetic clay liners, geomats, geof foam 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.

