MODULE 3

Refer text book of Dr. P Purushothama raj and R.hausman

CHEMICAL STABILIZATION

SOIL STABILIZATION

- Soil Stabilization :is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundation.

  BENEFITS:

  - Higher resistance values
  - Reduction in plasticity
  - Lower permeability
  - Reduction of pavement thickness

CHEMICAL STABILIZATION

- It is a type of soil stabilization.
- Chemical stabilization :consists of bonding the soil particles with a cementing agent(primary additive is the chemical) that is produced by a chemical reaction within the soil to improve strength and durability . the reaction does not necessarily include the soil particles, although the bonding does involve intermolecular force of the soil.
- Chemical stabilization can be done with:

1. cement
2. granular admixture

1.cement

- It is the most commonly used additive for soil stabilization.
- By adding cement to soil it will react with the siliceous soil ,to cement the particle together.
- Cement and soil blended material is referred to as soil-cement.
- In a soil –cement more of coarse grained particles are cemented and the proportion of fine grained soil cementation is small.
- Physical properties of soil cement depends on the nature of soil treated , the type and amount of cement utilized the placement and conditions adopted.
- Application are in the bases of roads and air fields

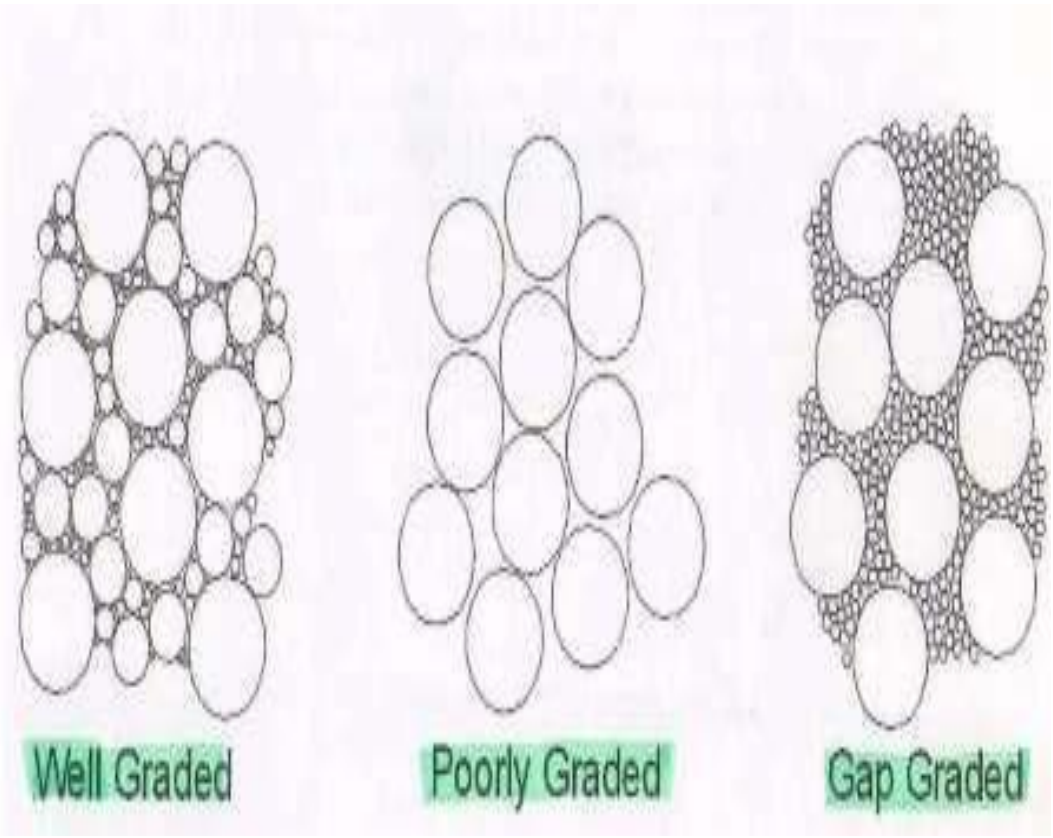
Process of cementing

- Excavation and spreading of cement to the required thickness
- Mixing –to desired depth
- Sealing the material by passing smooth rollers
- Allowing period –for the reactions to complete
- Compacting
- Curing for 7 days

2.GRANULAR ADMIXTURE

- Mixing granular materials improves the density and cohesiveness of the soil.
- Strength of the course grained soil depends upon their density and particle size distribution.

Based on soil gradation



- Well graded soil-soil containing particles of wide range of sizes.
- Poorly graded soil-soil doesn't have all sizes of particles uniformly sized.
- Gap graded soil-soil that have excess or deficiency of certain particle size.

Continued...

- If an area contain poorly graded soil ,mixing materials from different location may bring an improvement in the grain size distribution and thus in density .

thus selected materials can be imported and mixed with the on site soil to gain higher strength and lower compressibility .

3.Chemical stabilization by Lime

SOIL STABILISATION

SOIL STABILIZATION

- The improvement process under the situation when the influence zone is limited to less than 1m (roads etc.) is called **surface stabilization.**

- Geo-Technical process of improving the engineering properties of the soil (density, shear strength, C&O factors are improved while compressibility, settlement and permeability reduced) and making it more stable and durable is called **ground improvement.**

- Stabilising a soil implies the modification of the properties of a soil – water – air system in order to obtain lasting properties, which are compatible with a particular application. The parameters involved are:

- Properties of the soil to be stabilised
- Planned improvements
- Project economies
- Construction techniques
- Maintenance of the project
- **OBJECTIVES**
- Reducing the volume of voids = reducing the porosity.
- Filling the voids that cannot be eliminated = reducing the permeability.
- Increasing the bonding between grains = increasing the mechanical strength.
- **PROCEDURES**
- Mechanical – by compaction to reduce the porosity and increase the compressibility.
- Physical – by acting on its texture (e.g. the controlled mixing of different grain fractions).
- Chemical – by adding other materials or chemicals to modify its properties.

LIME STABILIZATION

There are basically five types of lime:

- High Calcium, quick lime (CaO)
- Hydrated, high calcium lime [$Ca(OH)_2$]
- Dolomite lime (CaO+MgO)
- Normal, hydrated dolomitic lime [$Ca(OH)_2$+MgO]
- Pressure, hydrated dolomitic lime [$Ca(OH)_2$+$Mg(OH)_2$]

—The quick lime is more effective than the hydrated lime, but the latter is more safe and convenient to handle. Generally, hydrated-lime is used. It is also known as slaked lime.

—The higher the magnesium content of the lime, the less is the affinity for water and the less is the heat generated during mixing.

—The amount of lime required varies between 2 to 10% of the soil.

Lime Stabilization

Lime stabilization is done by adding lime to soil. It is useful for the stabilization of clayey soil.

- When lime reacts with soil there is exchange of cations in the absorbed water layer and a decrease in the plasticity of the soil occurs.
- The resulting material is more friable than the original clay, and is, therefore more suitable as sub-grade.

Types of Lime

Lime is produced by burning of lime stone in kilns. The quality of lime obtained depends upon the parent material and the production process.

Lime Stabilization

The following amount may be used as a rough guide:

1. 2 to 5% for clay gravel material having less than 50% of silt-clay fraction
2. 5 to 10% for soils with more than 50% of silt clay fraction
3. About 10% for heavy clays used as bases and sub-bases
4. For soils having particle size intermediate between (1) and (2) above, the quantity of lime required is between 3 to 7%.

—Lime stabilization is not effective for sandy soils.

Lime Stabilization Cont.

Construction Method— Construction methods used in lime stabilization are similar to those used in cement stabilization. However, the following points should be carefully noted.

- The reaction in the case of lime is slow, there is no maximum time limit between the addition of lime to the soil and the completion of compaction.
- Lime may be added in the form of slurry instead of dry powder.
- A rest period of 1 to 4 days is generally required after spreading lime over a heavy clay before final mixing is done.
- The soil-lime is compacted to the required maximum dry density.
- After compaction, the surface is kept moist for 7 days and then covered with a suitable wearing coat.

Lime Stabilization___Cont.

Chemical & Physical Changes in Lime Stabilization

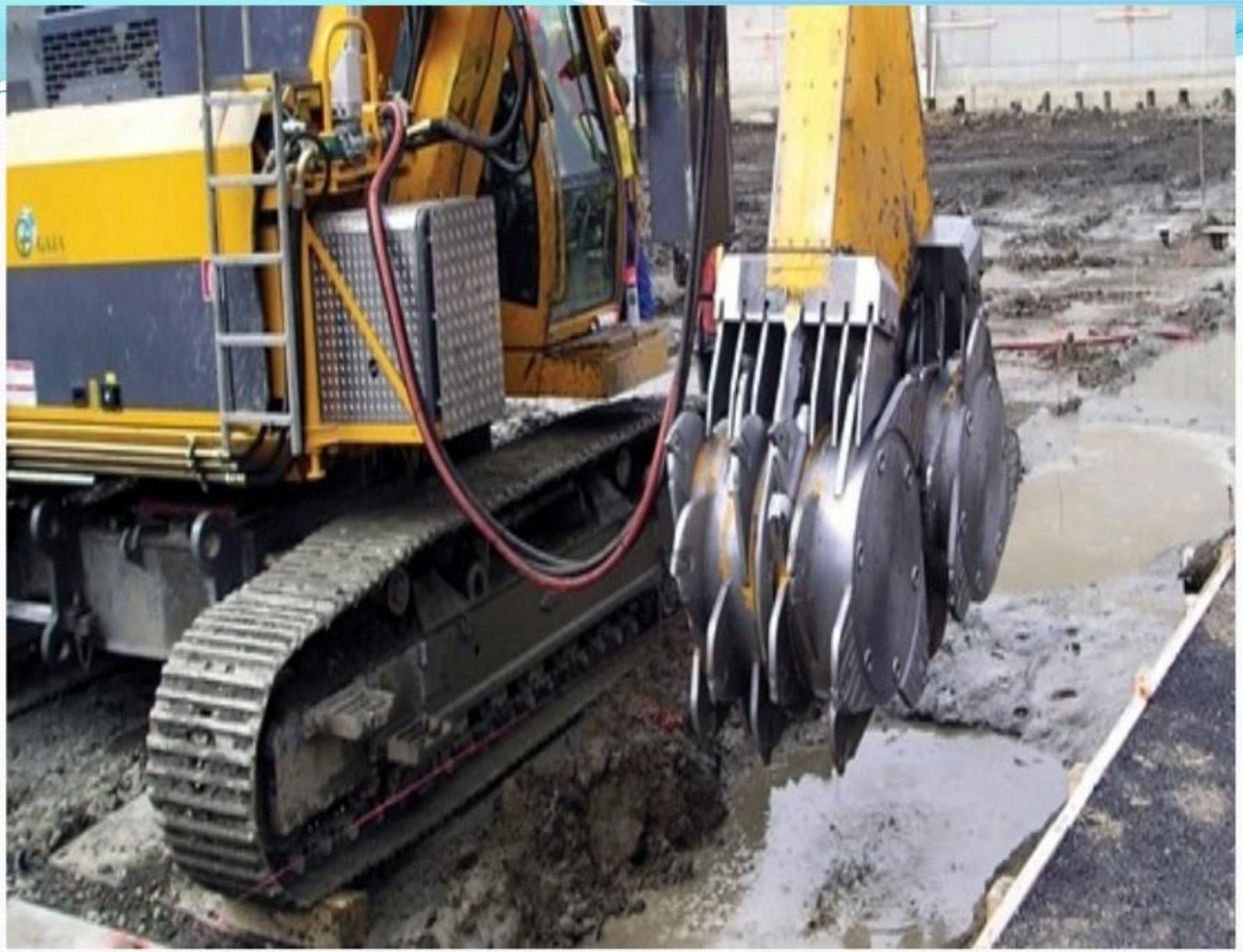
- Lime reacts with wet soil and alters the nature of absorbed layer as calcium ions replace the sodium or hydrogen ions, the double layer is depressed due to increase in cation concentration but sometimes expand due to high PH value of lime.
- Lime reacts chemically with silica and alumina in soils and forms natural cement composed of calcium-alumino-silicate.
- In Lime stabilization, liquid limit decreases, plastic limit increases, plasticity index decreases. Soil becomes more friable and workable. The strength of the soil is improved. Unconfined compressive strength is increased up to 60% and the modulus of elasticity of soil increases.
- Lime causes decrease in tendency of attraction of water.

Lime Stabilization Cont.

- Soil resistance to water absorption, capillary rise and volume changes on wetting or drying is increased.
- Lime stabilized bases and sub-bases form a water resistant barrier which stops penetration of rain water.
- Optimum water content is increased and maximum dry unit weight is decreased.
- In swampy areas where water content is above the optimum, it helps in drying of the soil.

Fly ash is a pozzolanic material, i.e. it reacts with lime and is therefore almost always used in combination with lime in soils that have little or no plastic fines. It has often been found desirable to use a small amount of portland cement with lime and fly ash for added strength. This combination of lime-cement-flyash (LCF) has been used successfully in base course stabilization. Asphalt or bituminous materials both are used for waterproofing and for strength gain. Generally, soils suitable for asphalt stabilization are the silty sandy and granular materials since it is desired to thoroughly coat all the soil particles.


Before Lime
After Lime

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4.CALCIUM CHLORIDE

CHEMICAL STABILIZATION

- Chemical stabilization consists of bonding the soil particles with a cementing agent(the primary additive is a chemical)that is produced by a chemical reaction within the soil.

  CALCIUM CHLORIDE

- Calcium chloride act as a soil stabilizer in some or other way.
- Calcium chloride has been used in recent years as additive in the construction of granular stabilized road wearing and base courses.

- The effect of salt on soil is from,

i. Causing colloidal reaction, and

ii. Altering the charecteristics of soil

- Although calcium chloride act as soil flocculants,they are not as effective as other chemicals such as ferric chloride.
- Most of the beneficial action of this salt in soil are mainly due to the changes salt makes in the charecteristics of the water in the soil pores.
- These changes reduce the loss of moisture from the soil and are explained bythe fact that salts are deliquescent and hydroscopic and lower the vapour pressure of water.

- Thus the performance of salt stabilized soil depends on the amount of ground water movement.
- Salt addition shows a slight increase of maximum compacted density and a slight reduction in the optimum moulding water content.

5. CHEMICAL STABILIZATION BY FLY ASH

- There are two types of fly ash:

i. Class C fly ash

ii. Class F fly ash

- Class C and class F products blends can be used in numerous geotechnical applications common with highway construction.It is used to ,

❖ Enhances strenght properties.

❖ Stabilize embankments

❖ To control shrink swell properties of expansive soil

❖ Drying agent to reduse soil moisture contents to permit compaction.

- Class C fly ash can be used as a stand-alone material whereas class F can be used in Soil stabilization applications with the addition of a cementitious agent(Lime,Lime kiln dust...).
- The self cementitious behaviour of fly ashes is determined by ASTM D 5239.
- The primary reason fly ash is used in chemical stabilization is to improve the compressive and shearing strength of soil.
- The compressive strength of fly ash soil depend on:

i. In place soil properties
ii. Delay time
iii. Moisture content and fly ash addition ratio.

6. CHEMICAL STABILIZATION BY BITUMEN

A black viscous mixture of hydrocarbons obtained naturally or as a residue from petroleum distillation. It is used for road surfacing and roofing

PRODUCTION OF BITUMEN

Petroleum **Bitumen**, normally called "**Bitumen**" or "Asphalt" is **produced** by refining crude oil. Used as a binder in road-building products, it is a very viscous, black or dark brown material. ... This process is called **bitumen production** by straight run vacuum distillation.

BITUMEN IN ROAD CONSTRUCTION

Bitumen gain certain unique properties that are inbuilt in it during its manufacture . It is used as raw material in flexible road construction & bitumen as a mix . Serves certain advavantages ,that promote to use bitumen widely used in road construction

TYPES OF BITUMEN

- Paving grade bitumen
- Cutback bitumen
- Bitumen emulsions
- Modified bitumen
- Polymer modified bitumen
- Multi grade bitumen
- Industrial bitumen

Factors influencing bitumen Aging

1.Oxidation

2. Loss of volatiles

3. Steric or physical hardening

4. Exudative hardening

…. Time, Heat, Oxygen, Sunlight

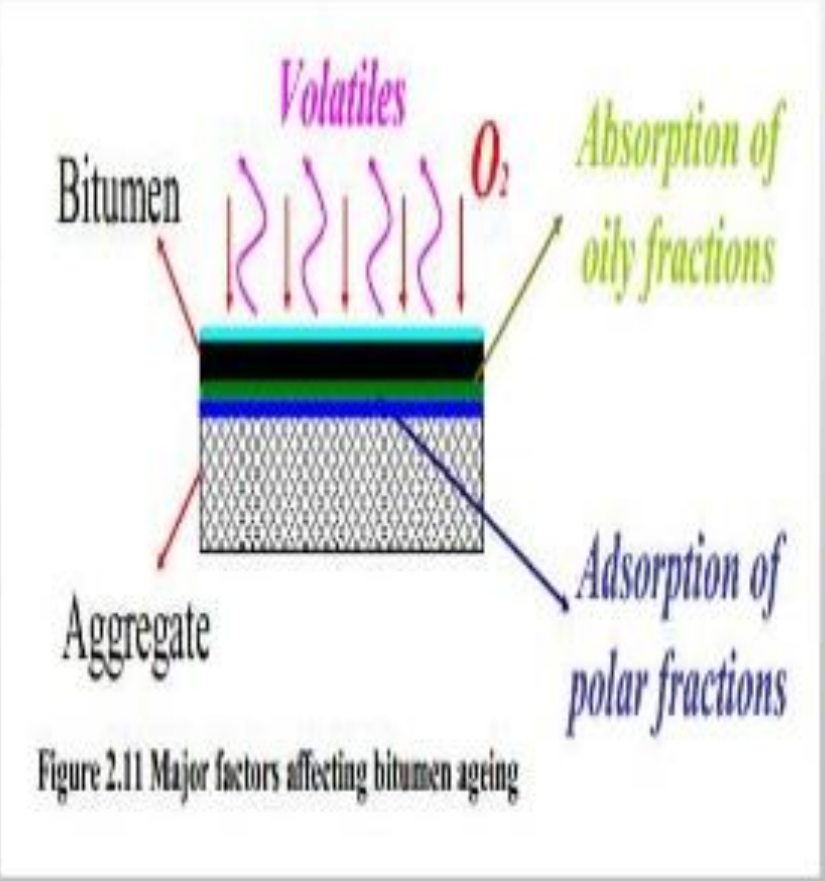


Figure 2.11 Major factors affecting bitumen ageing

7. OTHER ADMIXTURES-LIGNIN

Lignin is one of the most abundant natural polymers (next to cellulose and hemi cellulose) present in plant material. The chemical structure known today does reflect the structure for **bitumen** and therefore it could be used as an alternative for **bitumen** in applications like roofing or **asphalt**.

8 Polymer modified bitumen

- Polymer modified bitumen material bring benefits in terms of better and longer lasting roads and saving in total road life costing.

- The main polymer used to modify bitumen are:
  1. Natural rubber
  2. Styrene-butadiene-styrene(SBS)
  3. Ethylene-vinyl acetate (EVA)

CONSTRUCTION METHODS

INTRODUCTION

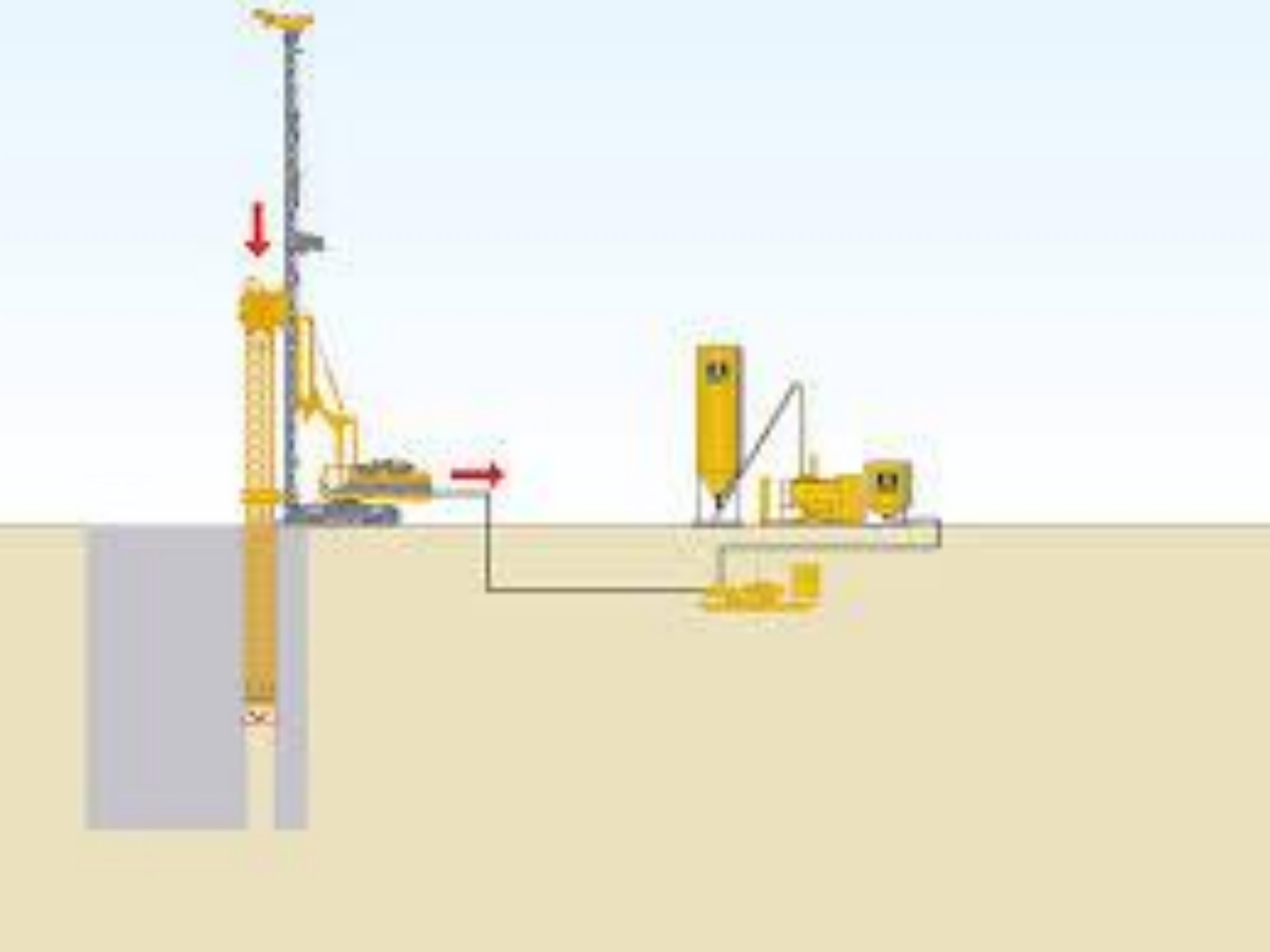
- Construction methods are the procedures and techniques that are used during the building process.
- Materials readily available in the area generally dictate the construction materials used (e.g. brick versus stone, versus timber).

TYPES OF CONSTRUCTION METHODS

- Mix in place method
- Travelling plant method
- Stationary plant method

MIX IN PLACE METHOD

- Soils loosened using machines.
- Water added after loosening.
- Apply stabilizers in the forms of sprays or powder.
- Mix the soil well.
- Compaction done using rammers, vibrators, or rollers.
- Thereafter curing is done.



ADVANTAGES

- Simple, cheap and easy operation.
- The number of machines required can be adjusted to the size of work.
- Compaction can be done at same time.
- In wet climate, evaporation loss is advantageous.

DISADVANTAGE

- Uniform thickness cannot be maintained.
- Difficult to maintain required moisture content for required depth.
- Difficult to maintain uniform mixing.
- Heavy rain can spoil the work.
- In dry climate ,evaporation loss is disadvantageous.

TRAVELLING PLANT METHOD

- Done in two way:

  1.soil in the treatment area is taken to the factory and there it is mixed with the stabilizer and it is then taken back to the area, then compacted.

  2.stabilising agent is applied first and then loosening and mixing is done.

ADVANTAGE

- More accurate proportioning of added water can be attained.
- Uniform mixing is possible.
- Mixing time was reduced.
- Uniform subgrade is obtained.
- Depth of treatment is controlled.
- Gives the highest output for the given expenses.

DISADVANTAGE

- Initial cost is high.
- Required to run the plant continuously at full capacity.
- A minor breakdown in equipment will effect the whole process.

STATIONARY PLANT METHOD

- Soil is taken from the site and transport to the plant of mixing.
- Two types of mixers are used:

    1.continuous mixers

    2.batch mixers

ADVANTAGE

- Accurate proportioning.
- Easy control of depth of treatment.
- Concrete mixer can be used.
- Small lose of water while transporting and mixing.

DISADVANTAGE

- Very expensive.
- Must be compacted as delivered but not as complete section.

PREVIOUS YEAR QUESTIONS

- What do you understand about flyash stabilization? (ktu 18)
- Explain how the eng properties are changed by the calcium chloride? (ktu 18)
- Explain briefly soil bitumen stabilization? (ktu 18)
- Give applications of soil-lime columns.
- Explain the factors affecting soil-cement stabilization. (calicut 18)
- Write a short note on lignin and bitumen as a chemical stabilizer
- Explain in detail about the construction steps involved in chemical stabilization?
- What is chemical stabilization?
- Explain the characteristics of cement as a chemical stabilizer