UNIT 4: MODIFICATION BY ADMIXTURES

Dr. Supia Khatun
Assistant Professor
Civil Engineering Department
Aliah University

Principle

- Stabilization of soil cement consists of adding Portland cement to a pulverized soil, and permitting the mixture to harden by hydration of the cement.

Factor Affecting The Properties Of Soil-cement

- The **factors which effect** the physical properties of soil-cement include soil type, quantity of cement, degree of mixing, time of curing and dry density of the compacted mixture.

Soil-cement Reaction Effect

- 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.

- Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water.
- The cementing action is believed to be the result of chemical reaction of cement with the silicious soil during hydration.
- The binding action of individual particles through cement may be possible only in coarse-grained soils.
- In fine-grained soils (i.e. cohesive soils) only some of the particles can be expected to have cement bonds, and the rest will be bonded through natural cohesion.
- The strength of soil cement increases with an increase in the amount of cement added to a soil. The ordinary Portland cement is generally used for stabilization.

Soil Types And Cement Content

- Almost every inorganic soils capable of pulverization can be successfully stabilized with cement, although the cement requirement will increase with the increase in the specific surface of soil.
- Well graded granular soils with 10-35% fines (LL<40%, PI<20%) give best results and require lesser amount of cement.

- The amount of cement required, expressed as a percentage by weight of dry soil, generally varies between 5 to 10%.
- Finer soil require more cement.
- The actual amount required is determined experimentally by performing compressive strength and durability test.
- The amount of cement giving a compressive strength of 25 to 30 kg/cm^2 should normally prove satisfactory.
- The approximate amount needed for different types of soil is as under.

Type of soil	**Amount of cement (%)**
Gravels	5 to 12
Sands	7 to 12
Silt s	12 to 15
Clays	12 to 20

Principle

The major strength gain of lime treated clay is mainly due to three reactions, namely: dehydration of soil, ion exchange, and pozzolanic reaction.

(i) Hydration: A large amount of **heat** is released when **quicklime** (CaO) is mixed with clay. This is due to the hydration of quicklime with the pore water of the soil. The increase in temperature so high that the pore **water starts to boil**. An immediate reduction of natural water contents occurs when quicklime is mixed with cohesive soil, as water is consumed in the hydration process.

$$CaO + H_2O \longrightarrow Ca(OH)_2 + HEAT \quad (280 \ Cal/gm \ of \ CaO)$$

(quicklime)

The **calcium hydroxide**, Ca(OH)$_2$, from the hydration of quicklime or when using calcium hydroxide as the stabilizer, dissociates (separated) in the water, increas**ing the electrolyte concentration and the pH of the water, and dissolving the Sio$_2$ and Al$_2$O$_3$** form the clay particles.

$$Ca(OH)_2 \longrightarrow Ca^{++} + 2(OH)^-$$

Hydrated lime

This processes will result in ion exc**hange, flocculation, and pozzolanic reactions.**

(ii) Ion exchange and Flocculation:

When lime is mixed with clay, sodium and other **cations adsorbed to the clay mineral surfaces are exchanged with calcium**.

This results in the dissociation of the lime into Ca^{++} (or Mg^{++}) and $(OH)^{-}$ which **modifies the electrical surface forces of the clay minerals.**

So, lime causes the clay to coagulate, **aggregate** or flocculate. Which turn in **reduction of plasticity of the soil**.

$$Ca^{++} + \text{Clay} \longrightarrow Ca^{++} \text{ exchanged with monovalent ions } (K^{+}, Na^{+})$$

(iii) Pozzolanic Reaction: The shear strength of the stabilized soil gradually increase with time mainly due to **pozzolanic reactions**.

Calcium hydroxide in the soil water **reacts with the silicates** and **aluminates** in the **clay** to form cementing materials or binders, consisting of **calcium silicates** and/or **aluminate hydrates**.

The dissolved Ca++ ions reacts with the dissolved SiO_2 and Al_2O_3 form the clay particle's surface and from **hydrated gels**.

$$Ca^{++} + 2(OH)^{-} + SiO_2 \longrightarrow CSH$$

$$Ca^{++} + 2(OH)^{-} + Al_2O_3 \longrightarrow CAH$$

The **gel of calcium silicates (and/or aluminate hydrates) cements the soil particles** in a manner similar to the effect provide by the hydration of Portland cement, but the **lime stabilization process is much slower reaction** which requires considerably longer time than the hydration of cement.

Treated soil properties

The physical changes produced by lime treatment of clay soils can be summarized as follows:

(a) The **plasticity index** decreases about **3 times**, **plastic limit increases, liquid limit decreases.**

(b) The **shrink** and **swell** decrease.

(c) Soil can be **pulverized** and **worked** easily.

(d) **Unconfined compressive strength**, **CBR** and **bearing capacity** increases.

(e) Increase optimum moisture content (**OMC**) and reduce maximum dry density (**MDD**).

Suitability and applications

- Lime treatment is specially suitable for **clays**.
- Lime may be used as a stabilizer for soils in the **sub-base courses** of pavements, under concrete **foundation**, on **embankment** slopes and canal **lining**.
- Quicklime treatment has been used for drying of soils by the heat of hydration. **Quicklime** is suitable for stabilization of **extremely soft clay**.
- Hydrated lime with high percentage of calcium oxide is better for stabilization.

Amount of Lime

The amount of lime required may be judged based on the unconfined compressive strength or the CBR test criteris.

2 to 8% of the soil weight for plastic soils (i.e. clay).

5 to 8% of the soil weight for coarse grain soils.

BITUMINOUS STABILIZATION

Asphalts and tars are the bituminous materials which are used for stabilization of soil, generally for pavement construction. These materials are normally too viscous to be used directly with soil. The fluidity of asphalts is increase by either heating, emulsifying or by cut-back process.

Principle

The bituminous materials when added to a soil impart cohesion or binding action and reduced water absorption.

Classification

Depending upon the actions and the nature of soils, bitumen stabilization is classified under the following four types:

(i) Sand bitumen

This term refers to bitumen stabilized cohesionless soil. The primary function of bitumen is to bind the soil particles. In sandy soils, bitumen required is about 4 to 10% by weight of dry soil.

(ii) Soil (clay) bitumen

It refers to bitumen stabilized cohesive soil. The main function of bitumen is to reserve the natural cohesive strength by water-proofing the soil or reducing the water absorption.

Bitumen requirement commonly range from 4 to 7% of the dry weight of the cohesive soil.

(iii) Oiled earth

Slow and medium curing road oils are spread on the ground surface to make it water and abrasion resistant.

The oil penetrate a short depth into the soil without involving any mechanical mixing.

ENGINEERING PROPERTIES FO TREATED SOIL

The various engineering properties of treated soil are:

(1) Unconfined compression test

- The unconfined compressive strength varies according to the type of stabilizer added and increase with increase in the percentage added and the dry density rise.
- The unconfined compressive strength varies according to the curing temperature and increase with age.
- Increase in the strength varies according to the type of parent material.
- The failure strain fall within a range from 0.5% to 2% regardless of the type of the parent material.

(2) Tri-axial compression tests

- The stress-strain relationship tends to be similar regardless of the parent material.
- The shear strength properties of treated soil increases.

(3) Cyclic strength behaviour

- Cyclic strength can be increased by adding the stabilizer.

(4) Dynamic deformation

- The shear modulus after treatment varies with the percentage of stabilizer added and becomes approximately 2 to 6 times of what it is before treatment.

(5) Coefficient of permeability

- The coefficient of permeability of treated soil is about one order lower than that of untreated soil.

SOIL STABILIZATION USING INDUSTRIAL WASTE

- More production equals more waste, more waste creates environmental concerns of toxic threat.

- An economical viable solution to this problem should include utilization of waste materials for new products which in turn minimize the heavy burden on the nation’s landfills.

- Use of waste materials saves natural resources, saves energy, reduces solid waste, reduces air and water pollutants and reduces greenhouse gases.

❖ Nowadays, various industrial waste materials are used for soil stabilization.

1) Fly ash
2) Slag (steel slag, copper slag, blast furnace slag, etc.)
3) Rubber tire scrap
4) Cement kiln dust
5) Stone dust

(1) Fly ash

- Fly ash (FA) is an industrial waste being generated from thermal power plants and it is available in fine dust form.

- Flyash is the finely divided residue that results from the combustion of pulverized coal.

- Pozzolans are siliceous or siliceous and aluminous materials, which in a finely divided form and in the presence of water, react with calcium hydroxide at ordinary temperature to produce cementitious compounds.

- Flyash is typically finer than Portland cement and lime. Flyash consists of silt-sized particles which are generally spherical, typically ranging in size between 10 & 100 µm. Fineness is one of the important properties contributing to pozzolanic reactivity of flyash. Flyash consists primarily of oxides of silicon, aluminum, iron and calcium. Magnesium, potassium, sodium, titanium and sometimes sulfur are also present to a lesser degree.

- Flyash used as mineral admixture are classified as either class C or class F based on its chemical composition.
-
- Class C ashes are generally obtained from sub-bituminous coals and consist primarily of calcium alumino-sulfate glass as well as quartz, tricalcium aluminates and free lime (CaO).

- Class C ashes contain more than 20% CaO.
- Class F ashes are typically derived from bituminous coal and consist primarily of an alumino-silicate glass, with quartz, and magnetite also present.
- Class F has less than 10% CaO.
- Flyash color can be light to dark grey depending upon its chemical and composition. FA with high lime concentration has light color.

The End !!!!