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Microstructure Study and Plasticity Characteristics of Clay

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Abstract - *The life of any structure is purely dependent on the foundation which forms basic and fundamental unit of any structure. The efficiency of foundation is highly based of the soil behavior as the total load applied to the foundation is directly transmitted to soil. The soil in various locations has variety of property thanks to the environmental and geological condition. The rapid development in construction field created a demand for building structures in various challenging conditions. These requirement gives rise to the need for study in altering the behavior of soil to enhance the strength of the soil. The study is using calcium and phosphate based stabilizer to alter the properties of clay soil like plasticity, liquid limit, shear strength and optimum moisture content. The microstructure study of both conventional and stabilized soil is done to identify bonding nature and composition of the samples. The microstructure study is done through Scanning Electron Microscope (SEM) which identifies bonding nature and X ray – diffraction which identifies the composition of the soil tested. This study paves way for the ideas to overcome the challenges in construction of structures over soil layer which has minimal shear strength. The type of foundation can be chosen based on the altered behavior of stabilized soil.*

Key Words: *Soil behavior, Calcium and phosphate based stabilizer, Microstructure study, SEM, X ray-diffraction*

1 INTRODUCTION

Soil is an accumulation or deposit of earth material, derived naturally from disintegration of rocks or decay of vegetation, that can be excavated readily with power equipment in the field or disintegrated by gentle mechanical means in the laboratory. The supporting soil beneath pavement and its special under courses is called sub grade. Clay sub-grades in particular may provide inadequate support, particularly when saturated. Soil stabilization a general term for any physical, chemical, biological, or combined method of changing a natural soil to meet an engineering purpose. Improvements include increasing the weight bearing capabilities, tensile strength, and overall performance of in-situ sub soils, sands, and other waste materials in order to strengthen road surfaces. Industrial development in India has necessitated construction of infrastructure facility such as highways, airports, seaports and residential, commercial buildings. There is a need to select a good soil conditions for proper safety consideration of all these projects. Such soils exhibit extreme stages of minerals that are capable of absorbing water. They undergo severe consistency from very hard to very soft when saturated. Expansive soils contain volume changes corresponding to changes in moisture content. They swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water. Because of their alternate swelling and shrinkage, they result in detrimental cracking of lightly loaded civil engineering structures such as foundations ,walls, pavements, airports, side - walks, canal beds and linings. Due to these reasons expansive soils are generally poor material for construction. So to improve the engineering properties of soil, stabilization or reinforcement is done. For many years, engineers have used traditional additives such as lime, cement and cement kiln dust etc. to improve the qualities of readily available local soils. The stabilization of expansive soils with cement and lime is well documented. Cement stabilization nowadays is less appreciated because of the increasing cost of cement and environmental concerns related to its production. India being the second largest producer of cement has a very heavy impact on CO_2 emission. One can imagine from the fact that approximately one tone of CO_2 is produced during the production of one tone of cement. On the other hand, lime also contributes CO_2 to the world climate during its production. The cost of these additives has also increased in recent years. In recent years an increasing amount of research has been devoted to finding chemical treatments capable of stabilizing soil so as to render it a more suitable engineering material. Of particular interest has been the chemical solidification of soil to increase its load-bearing capacity. One of the more promising new chemical treatments for soil solidification is phosphoric acid, which was first reported by Lyons.W and Michaels

2 PROPOSED SYSTEM

2.1 Soil Structure

The arrangement and organization of primary and secondary particles in a soil mass is known as soil structure. Soil structure controls the amount of water and air present in soil. Different soil contains different soil structure and each structure gives us the properties of particular soil. India being the second largest producer of cement has a very heavy impact on CO_2 emission. One can imagine from the fact that approximately one tone of CO_2 is produced during the production of one tone of cement. On the other hand, lime also contributes CO_2 to the world

climate during its production. The cost of these additives has also increased in recent years.

2.2 Types of Soil Structure

There are six different types of soil structure and they are,

1. Single grained structure
2. Honey comb structure
3. Flocculated structure
4. Dispersed structure

2.2.1 Single Grained Soil Structure

Single grained structure are present in cohesion less soil likes gravel and sand. The drains of cohesion less soil have less surface force and more gravitational force. So, when we pour some amount of sand or gravel on the ground, the grains will settle using gravitational force rather than surface force. Generally the particles are not spherical in nature, but we can say the void ratio of single grained soil is between0.35 to 0.90.

2.2.2 Honey Comb Soil Structure

These soil contains the particle of size 0.02mm to 0.002mm which are generally fine sands or silts. When this type of soil is allowed to settle in ground, the particles will attract each other and join one with other and forms the bridge of particles. A large void is also formed between bridges which makes the soil very loose in nature.

2.2.3 Flocculated Soil Structure

Flocculated soil structure is present in clay particles which contains large surface area. These are charged particles which having positive charge on the edges and negative charge on the face of the particles. There is net attractive force between the particles attracted towards negatively charged face which results the formation of flocculated structure. Clay present in the marine area is the best example of the flocculated structure.

Because of edge to face orientation void ratio is high in this type soil and water contains also optimum but they are light in weight. The compressibility is very low for this type of soil.

2.2.4 Dispersed Soil Structure

Dispersed soil structure are also occurs in clay particles when the clay is remolded. Remolding reduce the shear strength of the soil which reduce the net attractive force between the particle. This type of soil is highly compressible and highly permeable. The loss of strength due to remolding is slowly achieved by time. The process of regaining its strength is known as thixotropy.

2.2 Consequences of Contamination of Soil

All types of contamination have direct or indirect effects on the various properties of soil, due to the interaction between inorganic or organic pollutants present in the contaminants or generate from contaminants due to the imposed environment condition. Interaction between soil and pollutants change soil behavior and also can lead to particles or total immobilization of pollutants. Effective grain size of particles, index particles, specific gravity parameters, hydraulic conductivity, compaction characteristics, and consolidation and shear strength parameters of soil are modified or affected due to the above interaction.

Modification of various soil properties can lead to several geotechnical engineering problem such as landslides, ground subsidence, settlement, erosion, progressive failures, and structural stability of sub structure, corrosion and durability of foundation problems. Due to the above, it because necessary and study the mechanisms controlling the behavior of soil and the effect of soil-pollutant interaction on various engineering properties of soil.

2.3 Soil Stabilization

Soil stabilization is a method of improving soil properties by blending and mixing other materials. Soil stabilization is the process improving shear strength parameters of soil. It is used to reduce compressibility and permeability of soil mass in the earth. Soil stabilization involves the use of stabilizing agent in the weak soil to improve its geotechnical properties. The method of soil stabilization which includes the,

1. Mechanical stabilization
2. Stabilization by using different admixtures

2.4 Calcium

Lime is a calcium-containing inorganic mineral in which carbonates, oxides and hydroxides predominates. In the strict sense of the term, lime is calcium oxide or calcium hydroxide. It is also the name of natural mineral CaO which occurs as the product of coal seam fires and in altered lime stone xenoliths in volcanic ejecta. The word lime originates with its earliest use as building mortar and the sense of sticking and adhering.

Calcium is the form of quick lime (calcium oxide CaO), hydrated lime (calcium hydroxide $Ca(OH)_2$) , or lime slurry can also be used as treat soils. Dolomite lime can perform well in stabilization, although the magnesium fraction react slowly then the calcium fraction.

2.5 Stabilization by Calcium

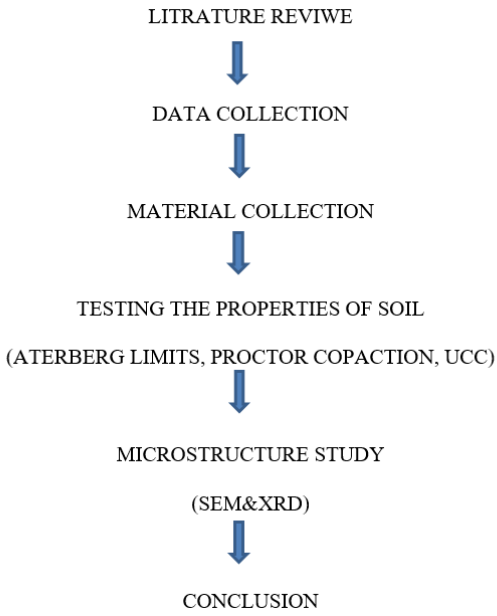
Soil stabilization can be explained by the soil properties by chemical and physical means in order to enhance the

engineering quality of the soil, the main objective of soil stabilization is to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long term performance of any construction projects is mainly depends on the soundness of the underlying solids. Unstable soils can create the significant problems in pavements or structure, therefore soil stabilization is necessary to improve the stability of the soil so it is successfully sustain the stability of the soil which are highly active,. Also it saves the millions of money and lot of time when compared to the method of mixing and cutting the unstable soil. This paper deals with the complete analysis of the improvement of soil properties and its stabilizing using calcium.

2.6 Stabilization by Phosphate

This paper describe an investigation concerning the use of phosphate to solidify soil, thus rendering the soil more suitable for certain engineering uses. The treatments reported involve the use of rock phosphate, sulfuric acid, phosphoric acid and salts of iron. The results given in the terms of unconfined compressive strength of immersed treated soil samples, reveal the importance of material balance to achieving optimum solidification with these treatments. However, phosphate minerals naturally accumulate some heavy metals that may cause additional contamination of the environment if used improperly. Nine commercial available phosphate minerals were evaluated for remediation of contaminated soil based on solubility, concentration of metal/metalloids impurities and leach ability of impurity metal/metalloids. The phosphate material consists of three groups: processed (fertilizers), mined rock (rock phosphates from different formations) and biogenic (ground fish bone). Processed and mined rock phosphates contained relatively high total combining biogenic and mined phosphate it is possible to obtain a wide range of phosphate release rates, permitting rapid immobilization of contaminants while concentration of As, Co, Cr and Cu but did not exceed the RCRA toxicity characteristics leaching producer (TCLP) limits. Biogenic apatite contained much lower metal concentration than processed and mined rock phosphate and was appreciably more soluble.

2.7 Methodology



3 RESULT DISCUSSION

3.1 Liquid Limit

We conducted the liquid limit test to the soil of Calcium and sodium bentonite clay. 300g soil taken after sieve the 425micron is sieve. The water added with soil to various percentage. The No blows will be taken and plot graph between the No blows and water content in % for adding Ca to both soil (1%, 3%,5%).

The liquid limit will be decreased while adding the calcium amount increase. Which can shows the graph.

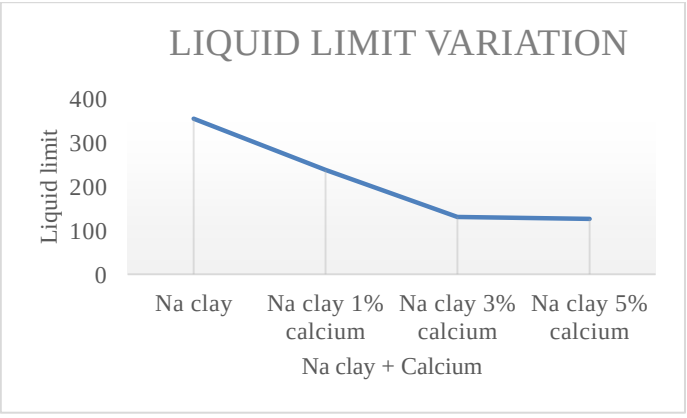


Chart -1: liquid limit variation of Na clay

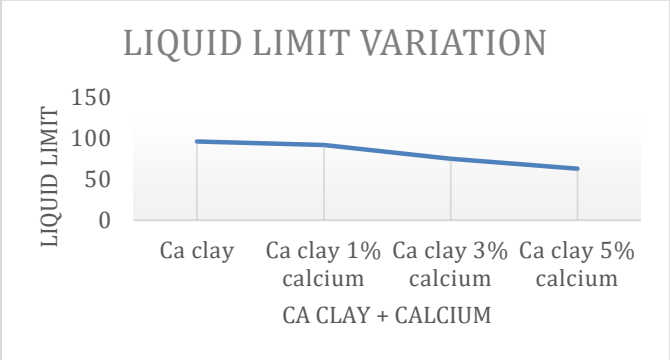


Chart -2: liquid limit variation of Ca clay

3.2 Unconfined Compression Test

The soil taken about 300 gm and water added to 12-13% of its own weight. The soil is placed 3 layer of mold. Each layer compacted by 25 blows. After fill first layer that will groove by the knife because of to create the bond between the layers. The mold placed the Ucc test machine the load can be note each 0.2mm deformation of soil, While Ca and Na clay adding calcium and phosphate ton soil is same procedure. The result can shows below. The shear strength will be decrease and suddenly increase adding the calcium to the Na clay soil. The calcium added to the Ca clay the high shear strength attain in calcium 1% residues. And further added calcium residues to the calcium bentonite soil that can contaminate so the shear strength will be decrease. We adding the phosphate to the high shear strength attain soil calcium residues added soil that will decrease the shear strength so it indicate the further contamination take place.so the paper describe the phosphate addition to soil loss the strength.

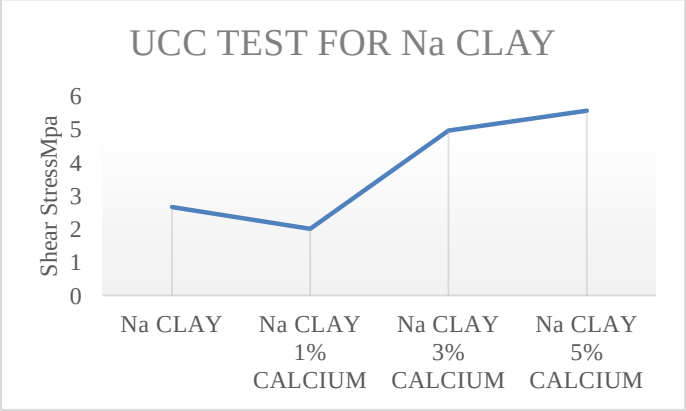


Chart -3: Stress strain relation of Na clay

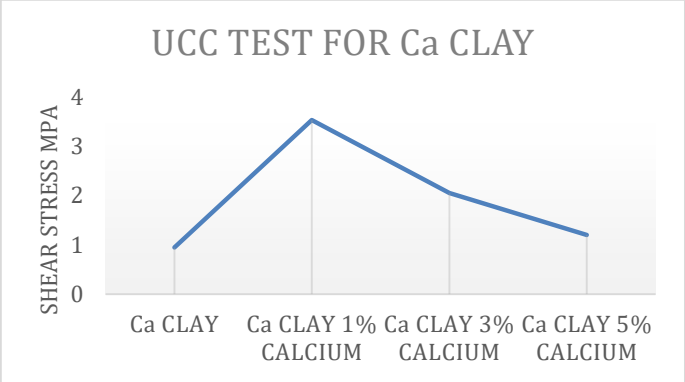


Chart -4: Stress strain relation of Ca clay

3.3 XRD Test Analysis

XRD analysis is the process of identify the mineral composition of soil. From the XRD analysis, the behavioral changes in the pure ca-clay and Na-clay are examined by adding different proportions of calcium and phosphate residues (1% , 3% and 5%), by addition of calcium & phosphate residues at different proportions. Sample pellet of size 1cm×1cm is taken under low vacuum of various 20 ranges. In the beginning, it is found that major account of size and component of ca, mg, al, and Na are present in the samples. By increasing the further range of 20 the presence of minor amount of components such as Al_20_3, Fe_20_3, silicon and oxygen are also found. By adding 1% of calcium of its own weight to the sample pellets, results in the formation of minor amount of calcium silicate hydrates by the combination of ca, free silicon and oxygen with water. Similarly addition of 3% of calcium results in the formation of major amount of calcium silicate hydrate. The resultant component calcium silicate hydrate will increase the bonding strength, meanwhile addition of 5% of calcium to the sample results in the formation of sodium silicate hydrate. The result will be shown below.

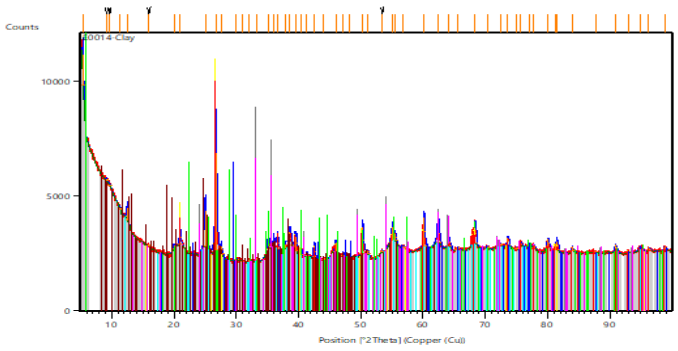


Chart -5: XRD graph of Ca clay

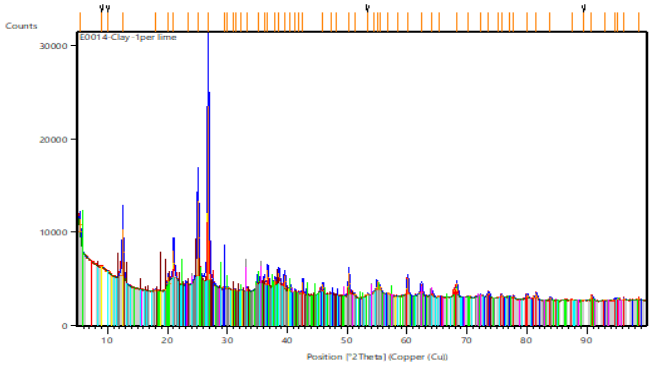


Chart -6: XRD graph of Ca clay with 1% calcium

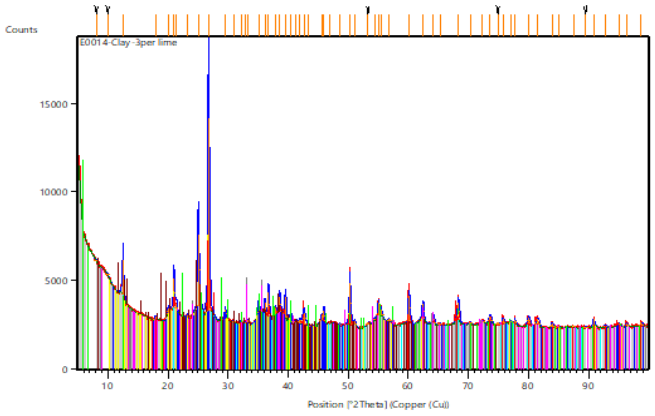


Chart -7: XRD graph of Ca clay with 1% calcium

4. CONCLUSION

Thus, we conclude that addition of calcium and clay soil decrease the plasticity of the contaminated ground and it increases the unconfined compression strength. Addition of phosphate sludge on clay which decreases the shear strength. This study it is observed that when the lime is added to sodium bentonite and calcium bentonite clay soils, its plasticity decreased. When the lime is added to clay soil its unconfined compression strength is increased. Based on the performance lime can be used to increase the basic index properties of the clay soil. The optimum quantity of lime for Na clay is 5% and 1% for Ca clay. The addition of phosphate in clay soil increases the plasticity and it decreases with increasing the quantity of phosphate. The low shear strength soil has the free calcium to the soil. The unbounded free calcium obtained from SEM analysis. The high shear strength soil having plate bonded togather.so the concern amount of calcium to soil will improve the shear strength.

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