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STUDY ON STABILIZATION OF CLAYEY SOIL BY USING CALCIUM CARBIDE RESIDUE AND FLY ASH

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ABSTRACT

The available clayey soil or the cohesive soil often possess such properties which do not fulfill the engineering requirements of all such activities. Due to which improvement in soil properties are required by a technique known as Soil Stabilization. It is a process to treat asoil to maintain or improve the performance of soil as a construction material. Stabilization can increase the shear strength of a soil and or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soil stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub-soils are not suitable for construction. stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process is accomplished using a wide variety of additives, including lime, fly-ash, calcium carbide and port land cement. Other material byproducts used in stabilization include fly ash and calcium carbide residue.

Keywords: Soil Stabilization, Calcium-Carbide-Residue, Fly Ash, Engineering Properties.

I. INTRODUCTION

In this present era where urbanization is at its peak and rapid construction of bridges, roads, buildings etc. is going on to meet the needs and demands of the growing population, it becomes one of the most important task of knowing the important soil strength parameters so as to start the construction. It often happens that the desired properties necessary for such engineering constructions are not found but in order for the construction to be done, soil strength parameters are often modified in positive manner. This technique of alteration of soils to enhance their physical properties is known as stabilization.

Soil is the basic foundation for any civil engineering structures. It is required to bear the loads without failure. In some places, soil may be weak which cannot resist the oncoming loads. In such cases, soil stabilization is needed. Numerous methods are available in the literature for soil stabilization. But sometimes, some of the methods like chemical stabilization, lime stabilization etc. adversely affects the chemical composition of the soil

The Highway Research Board (HRB) classification of the soil strata is done using suitable sampling technique such as core cutter method. To determine the characteristics like grading by sieve analysis, atterbergs limits i.e. liquid limit using cone penetration method and casa grande method, plastic limit by rolling the sample to 3mm diameter thread, shrinkage limit using shrinkage apparatus, optimum moisture Content and maximum dry density using standard proctor test and also california bearing ratio by conducting CBR test.

In this project, different proportions of fly ash and calcium carbide residue has been mixed with the available clayey soil and the modified strength are to be compared with the Standard results. Initially the physical properties of clay have been found by conducting wet sieve analysis, liquid limit, plastic limit, then for the purpose of determining the shear strength of virgin soil, unconfined compressive strength test, triaxial test has been conducted.

Principles of Soil Stabilization:

i. Evaluating the soil properties of the area under consideration.

ii. Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.

iii. Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

II. REVIEW OF LITERATURE

Tastan E. et al. (2011) have reported that blending fly a shin to soft organic soils increases their unconfined compressive strength and resilient modulus. It is possible to increase the unconfined compressive strength of organic soils with an addition of fly ash, but the amount of advancement depends on soil type and fly ash characteristics. Stabilization is adversely affected by soil organic content. Soil with more organic matter will have less strength, indicating that soil with more fly ash will have less strength.

Sabat A. et al. (2013) have analyzed the mutual effects of two industrial wastes namely, fly ash and quarry dust on several properties such as compaction characteristics, shear strength parameters, UCS, California bearing ratio (CBR), and swelling pressure of expansive soil. The highest value for UCS is achieved concerning 45% fly ash-quarry dust mixture. The UCS value further decreases with an increment in its percentage. As the percentage of fly ash-quarry dust mixes increases, the MDD increases and the OMC decreases.

Horpibulsuk S. et al. (2013) have analyzed the improvement in the strength of stabilized CCR and FA clay.

A very high $Ca(OH)_2$ content of 76.7% is found in CCR. A soil that contains a high percentage of natural pozzolanic material can be improved by using it alone. They also mentioned that if the natural pozzolanic material is completely absorbed by the input CCR, CCR and FA can be used together for higher strength requirements.

Kampala A. et al. (2013) have focused their study to have a basic idea about the engineering properties of stabilized CCR soil in its recycled form. Scanning electron microscopic(SEM) images manifest that the recycled form of stabilized CCR soil grains is bigger than the CCR and clay particles. The reason for this is the attached pozzolanic products with there cycled stabilized CCR soil. The large grains of the recycled CCR stabilized clay reduces linear shrinkage and free swell ratio. Since the hard pozzolanic products resist compaction, the recycled CCR stabilized clay has a lower unit weight compared to the CCR stabilized clay for the same amount of compaction energy and CCR content.

Vichan S. et al. (2013) have conducted experimental work to investigate the effects of blending CCR and biomass ash (BA) which acts as a stabilizing chemical additive, and leads to a pozzolanic reaction. Their research work suggests that calcium hydroxide $Ca(OH)_2$ was formed when CCR dissolves in water. Pozzolanic products were obtained by dissolving the amorphous Si from BA in a higher pH solution (pH=12.6). It has also been observed that the combined effects of CCR and BA on clay strength development were observed when the binder content reached 30% of the dry soil weight.

Raut J. et al. (2014) have tried to examine the property enhancement of expansive soil by varying the percentage of fly ash and murrum. With an increase in the percentage of fly ash and murrum, the MDD and unconfined compressive strength is found to be increasing till a certain limit and thereafter their value decreases. They have reported that the optimal combination for property enhancement of clay is attained by mixing 5% of fly ash and 7.5 % of murrum with it.

Jiang N. et al. (2015) have compared the stabilized quicklime soil by conducting a multi-scale laboratory investigation focusing on the several properties viz., mechanical, physical and also microstructural of stabilized CCR clayey soils. It was observed that within the initial 28d, stabilized CCR soil has significantly lower pore volume as compared to stabilized quicklime soil. However, this difference in pore volume is almost negligible at 120d. A converse correlation was noticed between the stabilized soil and a larger volume of pore in the soil. At the initial stage, the vital contributor to the rapid and complete development of flocculation and agglomeration of soil particles are high pH value, significant specific area and fine size particle of CCR soil when compared to quicklime.

Du Y. et al. (2016) worked on finding the mechanical properties of CCR stabilized soft clayey soil which is utilized as a subgrade course material for the highways. In an adjacent field section, Quicklime was used as a control binder to compare its performance with CCR.

Latifi N. et al. (2018) have focused their study to examine CCR practicability to stabilize clay. Natural pozzolanic materials in clay can react with CCR following pozzolanic reactions. Tests indicated that a significant improvement in compressibility and strength has been observed utilizing CCR. The highest strength improvements in UCS tests wereobtained with CCR dosages of 9% and 12% for bentonite and kaolin, respectively.

After 28 and 90 days of curing, the UCSof the 9% added CCR tested bentonite increased by 4.7 and 6.8 times those of untreated soil respectively. Upon curing CCR-stabilized kaolin for 28 and 90 days, the UCS improvedby 3.8 and 5.8 times, respectively.

Noolu V. et al. (2018) have observed that the use of CCR and fly ash has enhanced the index properties namely compaction characteristics and Atterberg limits to a great extent. It has also been noticed that up to 8% CCR addition, the strength properties like California bearing ratio and unconfined compressive strength increase significantly. There is a decreasing tendency for LL and PI when the CCR stabilized black cotton soil is provided with fly ash.

Jafer H et al. (2018) have successfully figured out the impact of palm oil fuel ash (POFA) pozzolanic reactivity on the soft soil engineering properties, stabilized with high calcium fly ash (HCFA). According to UCS and Atterberg limits the HCFA and POFA combination leads to higher compressive strength and lower plasticity index (PI) compared to the HCFA-based treated soil alone.

Murmu A. et al. (2018) have performed certain experiments by differing the content of fly ash in the range of 5% to 20% and handing the samples at a considerably least concentrated 5M NaOH solution. A laboratory test was conducted to determine the California bearing ratio, unconfined compressive strength, resilience modulus, and California bearing ratio of stabilized samples. The addition of fly ash from 0% to 20% has slightly decreased the liquid limit and increased the plastic limit.

Ayodele F. et al. (2022) have tried to find out the influence of binary blends of Rice Husk Ash (RHA) and Calcium Carbide Residue (CCR) on lateritic soil engineering properties. A noticeable improvement in soil consistency was noted. At different dosages of optimum CCR: RHA, the California Bearing Ratio improved for soil strength up to 6%. Overall, the stabilized soil strength as measured by UCS improved as additives were added. These additives improve the soil's ability to resist erosion. As the additive content of the soil increased, its plasticity decreased.

III. AIMS AND OBJECTIVES

1. To determine the effect of stabilization in engineering properties and index properties of clayey soil of an appropriate manner.
2. To determine the improvement of soil properties such as the optimum moisture content (OMC) and maximum dry density (MDD).
3. To analyses the combined as well as individual effects of the various proportion of fly ash (FA) and calcium carbide residue (CCR) to compare the improvement of soil properties.

IV. MATERIALS USED

Clay soil: It is one of the most important types of soil. These are finely grained particles of size less than 0.002 mm. These are cohesion plastic soils. Clayey soils are very important in geotechnical engineering because of their complex behavior. They generally have high plastic Index (PI>30%), Liquid limit (LL>50%). The source of clayey soil used in the project is clayey soil.

Fly Ash: it is one of the residues formed in combustion, and consists of the fine particles that rise with the flue gases. It is also known as flue-ash. Fly ash is captured from the chimneys of coal-fired power plants. It mainly consists of SiO_2 and Al_2O_3due to which it is pozzolanic in nature. The mineralogical composition, fine particle size and amorphous character of fly ash shows that it is generally pozzolanic and in some cases self cementitious. compression test as per IS 2720 (part 10) was performed on the samples after 7, 14 and 28 days of curing. All specimens were prepared at the same density and water content by means of proctor's compaction to control the effect of density and moisture on the strength.

Calcium carbide residue: (CCR) is a by-product of the acetylene production process that mainly contains calcium hydroxide, $Ca(OH)_2$. The study of soil stabilization with a mixture of CCR and pozzolanic materials is an engineering, economic, and environmental challenge for geotechnical engineers and researchers. Understanding the mechanism controlling strength development in blended CCR-stabilized clay is necessary for estimating the optimal (CCR: FA) ratio for different binder contents. The study of soil stabilization with a mixture of (CCR) and pozzolanic materials is an engineering, economic, and environmental challenge for geotechnical engineers and researchers. This paper investigates the possibility of solely utilizing (CCR) with fly ash to stabilize problematic weak clayey soils. The unconfined compressive strength was used as a practical indicator to investigate strength development. Fly ash is one of the most plentiful industrial waste products. It is a solid waste product created by the combustion of coal. Its appearance is generally that of light to dark grey powder. It is the by-product of acetylene gas production process, and is in slurry form that mostly has calcium hydroxide (Ca (OH) 2) along with CaCO3, SiO2, and other metal oxides. Acetylene gas factories and (PVC) chemical Plants produce (CCR) in huge quantities and cause hazards to the environment due to their alkalinity. It has high calcium content. With the increase in (CCR) content, the maximum dry density decreases and optimum moisture Content increases.

V. METHODOLOGY

The experimental study can be divided into two parts. In the first part, the effect of calcium carbide residue (CCR) on clayey soil is to be studied. Variation in atterberg limits, (UCS) values, and (CBR) of clayey soil, when mixed with different percentages (by dry weight) of calcium carbide residue (CCR), shall be studied. An optimum percentage of (CCR) is to be obtained based on the results obtained from the first part. In the next part of experiment that is second part, improvement in the properties of calcium carbide residue (CCR) stabilized clayey soil with the further addition of fly Ash (FA) is to be studied. In this part of experiment, the optimum percentage of calcium carbide residue (CCR) (from the first part) added to the clayey soil, and the variation of its properties with different fly ash (FA) percentages shall be studied.

To determine this, there are various tests that can be tested by adding different proportions of calcium carbide residue (CCR) and fly ash (FA).

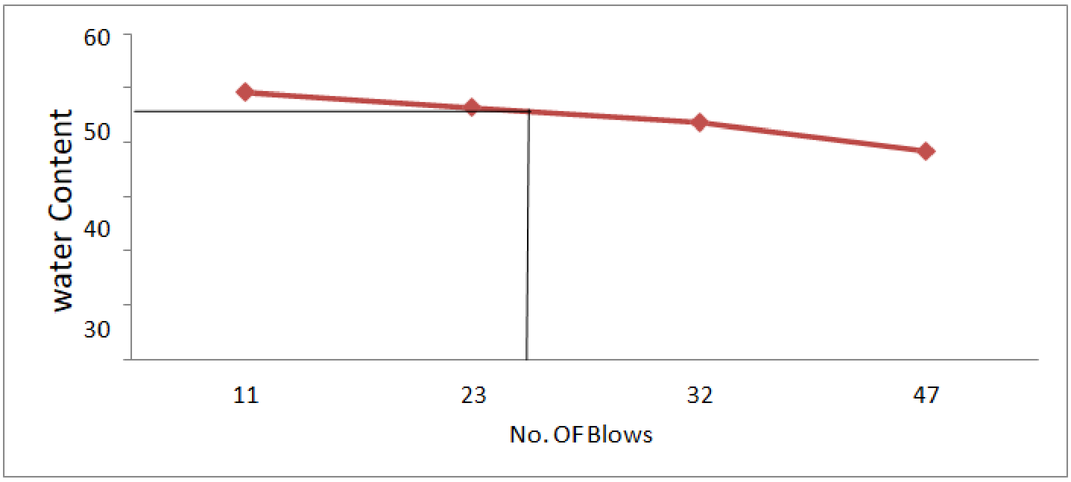
a) Atterberg's limit test
b) Compaction test
c) Unconfined compressive strength test (UCS)
d) California bearing ratio test (CBR)
i. Unsoaked condition
ii. Soaked condition

PURPOSE OF PRESENT STUDY

While increasing the overall strength of the soil by the method of compaction of soil and soil's permeability shall be reduced.as a result the strength comes out to be more by stabilizing the soil, the stabilization process ensures the soil's stability. This results in strong soil with improved the bearing capacity of the weak soil also enhanced the shear strength of the soil,

VI. RESULTS AND DISCUSSION

Liquid Limit



Liquid limit

W_L=Water Content at 25 Blows = 45.64 %

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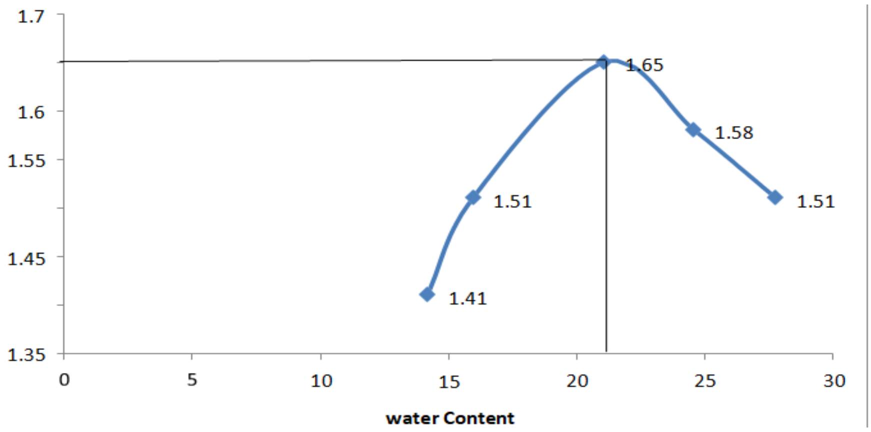
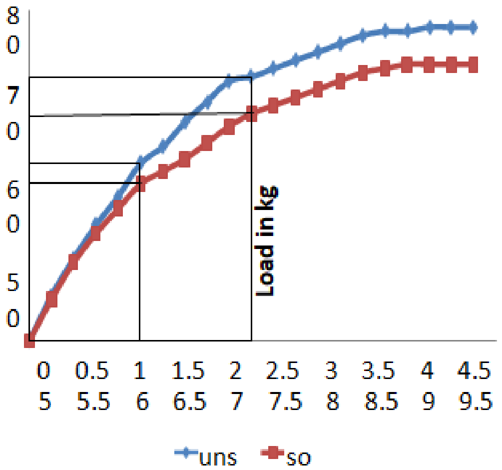
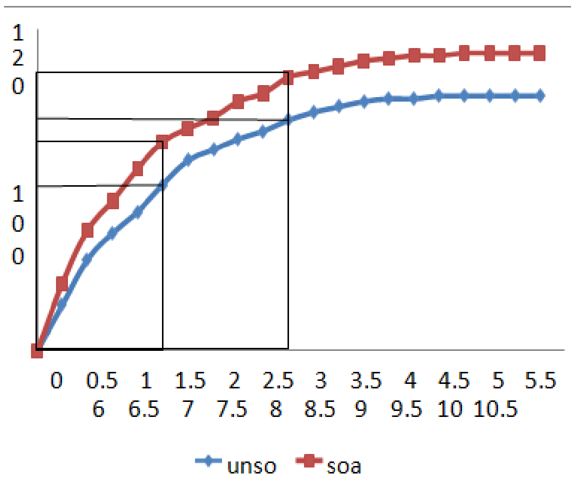
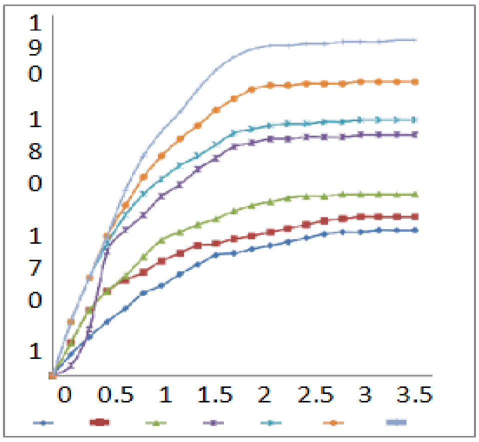


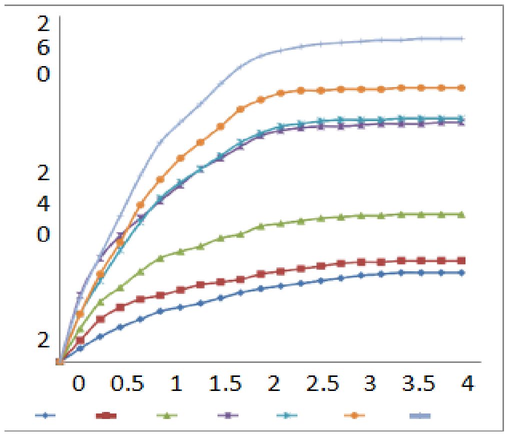
Dry density vs water content graph

CBR TEST RESULTS









VII. CONCLUSION

With respect to this study, the following conclusion can be derived

1. With addition of 5% (FA) by weight of soil , the (CBR) values in unsoaked condition increased from 3.14 % to 3.94 % and in soaked condition from 2.77 % to 3.65.
2. With addition of (CCR) in small amounts , there is a significant increase in the (CBR) values as compared to the (FA) and also the soaked (CBR) is greater than the unsoaked (CBR) on account of curing.
3. When 5% (CCR) by weight of soil was mixed with the soil as per the optimum moisture of the soil the (CBR) values in unsoaked condition was found to increase to 4.53% from 3.14
4. Further with addition of 5% (CCR) and (FA) cement by weight of soil, the unsoaked (CBR) values increased from the 3.14 % to 6.57% leading to 109.23% increase and from 2.77% to 8.83% in soaked situation leading to

218.77 % increase . This also suggests an increase of 109.54 % in unsoaked and soaked condition.

5. With further (FA) to 10 % and (CCR) being restricted to 5 % by weight of soil, the unsoaked (CBR) values increased form 3.14% to 6.93% and the soaked (CBR) from 2.77% to 8.98 % with repsect to the (CBR) values of the virgin soil . Hence this suggests an increase of 120.70% in unsoaked condition and an increase of 221.30% in soaked condition with difference of 101.2% between them.

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