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# A REVIEW STUDY ON THE SOIL STABLIZATION WITH CEMENT AND LIME

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**Abstract:** Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objective of the 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 project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures. Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which is highly active. Clayey soil which is also major type of expansive soil has a very weird property of swelling and shrinking in presence and absence of water or moisture. The best way to stabilize such type of soil is to disturb the soil sample by physically adding an additive. The additive added should be cheap, effective, and environmental friendly and easily available in large quantity. In this paper the brief of studies is made on researches by various authors.

**Keywords:** Soil Stabilization, properties of soil, Cement and Lime

## 1.0 INTRODUCTION

In developing country like India due to the remarkable development in road infrastructure, Soil stabilization has become the major issue in construction activity. Stabilization is an unavoidable for the purpose of highway and runway construction, stabilization denotes improvement in both strength and durability which are related to performance. Stabilization is a method of processing available materials for the production of low-cost road design and construction, the emphasis is definitely placed upon the effective utilization of waste by products like ground granulated blast furnace slag GGBS and fly ash, with a view to decreasing the construction cost. In the present investigation is to evaluate the compaction and unconfined compressive strength of stabilized clayey soil using fine ground granulated blast furnace slag (GGBS) and fly ash. Characterization of clayey soil is to be carried out for grain distribution and soil classification. A series of compaction test are to be carried out using mini compaction mould for different combination of soil along with fine ground granulated blast furnace slag (GGBS) and fly ash mixtures. For stabilization of clayey soil, the unconfined compressive strength and CBR test will be conducted in accordance with the standard procedures for different combinations of soil and additives. Soil stabilization is any process which improves the physical properties of soil, such as increasing shear strength, bearing capacity etc. which can be done by use of controlled compaction or addition of suitable admixtures like cement, lime and waste materials like fly ash, GGBS, rice husk etc. The cost of introducing these additives has also increased in recent years which opened the door widely for the development of other kinds of soil additives such as plastics, bamboo etc. This new technique of soil stabilization can be effectively used to meet the challenges of society, to reduce the quantities of waste, producing useful material from non-useful waste materials. Around 110 million tonnes of fly ash get accumulated every year at the thermal power stations in India. Internationally fly ash is considered as a byproduct which can be used for many applications. Fly Ash Mission was initiated in 1994 to promote gainful and environment friendly utilization of the material. One of the areas identified for its bulk utilization was in construction of roads and embankments.

## 1.1 INDUSTRIAL WASTE MATERIALS

There has been a great deal of concern about land pollution since the onset of industrialization.

The attention is mainly because of incidents of contamination, the scarcity of usable land and increased general concern about the effect of industrial activity on the environment.

Till recently land disposal has been the only option available for the solid residues, which may be concentrated with toxic contaminants. Use of the waste materials is big option in finding solution to this problem. On the other hand these solid wastes may have potential for reuse. Bulk utilization of industrial solid waste is very important. One such potential application is for infrastructure development works in civil engineering. For example stabilisation of problematic soils using waste can achieve great deal of economy and environmental safety. Among all the wastes, the wastes which are produced in large amounts in India are the Fly ash and the GGBS and are associated with the disposal and environmental problem. Thus the two major solid wastes considered are:

1. Fly Ash and
2. Granulated Blast Furnace Slag

 

3. Recron Fibre
4. Polypropylene

### 1.2 COMPONENTS OF STABILIZATION

Soil stabilization involves the use of stabilizing agents (binder materials) in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementitious materials).

### 1.2.1 SOILS

Most of stabilization has to be undertaken in soft soils (silty, clayey peat or organic soils) in order to achieve desirable engineering properties. Fine-grained granular materials are the easiest to stabilize due to their large surface area in relation to their particle diameter. A clay soil compared to others has a large surface area due to flat and elongated particle shapes. On the other hand, silty materials can be sensitive to small change in moisture and, therefore, may prove difficult during stabilization. Peat soils and organic soils are rich in water content of up to about 2000%, high porosity and high organic content. The consistency of peat soil can vary from muddy to fibrous, and in most cases, the deposit is shallow, but in worst cases, it can extend to several meters below the surface. Organic soils have high exchange capacity; it can hinder the hydration process by retaining the calcium ions liberated during the hydration of calcium silicate and calcium aluminate in the cement to satisfy the exchange capacity. In such soils, successful stabilization has to depend on the proper selection of binder and amount of binder added.

### 1.2.2 STABILIZING AGENTS

These are hydraulic (primary binders) or non-hydraulic (secondary binders) materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementitious composite materials. The commonly used binders are:

- cement
- lime
- fly ash
- Blast furnace slag

**Cement**

Cement is the oldest binding agent since the invention of soil stabilization technology in 1960's. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required. 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. Numerous types of cement are available in the market; these are ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually the choice of cement depends on type of soil to be treated and desired final strength.
Hydration process is a process under which cement reaction takes place. The process starts when cement is mixed with water and other components for a desired application resulting into hardening phenomena. The hardening (setting) of cement will enclose soil as glue, but it will not change the structure of soil .The hydration reaction is slow proceeding from the surface of the cement grains and the centre of the grains may remain unhydrated. Cement hydration is a complex process with a complex series of unknown chemical reactions. However, this process can be affected by

- presence of foreign matters or impurities
- water-cement ratio
- curing temperature
- presence of additives
- Specific surface of the mixture.

Depending on factor(s) involved, the ultimate effect on setting and gain in strength of cement stabilized soil may vary. Therefore, this should be taken into account during mix design in order to achieve the desired strength. Calcium silicates, $C_3S$ and $C_2S$ are the two main cementitious properties of ordinary Portland cement responsible for strength development. Calcium hydroxide is another hydration product of Portland cement that further reacts with pozzolanic materials available in stabilized soil to produce further cementitious material. Normally the amount of cement used is small but sufficient to improve the engineering properties of the soil and further improved cation exchange of clay.

**Lime**

Lime provides an economical way of soil stabilization. Lime modification describes an increase in strength brought by cation exchange capacity rather than cementing effect brought by pozzolanic reaction. In soil modification, as clay particles flocculates, transforms natural plate like clays particles into needle like interlocking metalline structures. Clay soils turn drier and less susceptible to water content changes. Lime stabilization may refer to pozzolanic reaction in which pozzolana materials reacts with lime in presence of water to produce cementitious compounds. The effect can be brought by either quicklime, $CaO$ or hydrated lime, $Ca(OH)_2$. Slurry lime also can be used in dry soils conditions where water may be required to achieve effective compaction. Quicklime is the most commonly used lime; the followings are the advantages of quicklime over hydrated lime.

- higher available free lime content per unit mass
- denser than hydrated lime (less storage space is required) and less dust
- Generates heat which accelerates strength gain and large reduction in moisture content according to the reaction equation below.
  $CaO + H_2O = Ca(OH)_2 + \text{Heat (65 KJ/mol)}$

**Fly–Ash**

Fly ash is a byproduct of coal fired electric power generation facilities; it has little cementitious properties compared to lime and cement. Most of the fly ashes belong to secondary binders; these binders cannot produce the desired effect on their own. However, in the presence of a small amount of activator, it can react chemically to form cementitious compound that contributes to improved strength of soft soil. Fly ashes are readily available, cheaper and environmental friendly. There are two main classes of fly ashes; class C and class F .Class C fly ashes are produced from burning sub bituminous coal; it has high cementing properties because of high content of free CaO. Class C from lignite has the highest CaO (above 30%) resulting in self-cementing characteristics (FM 5-410). Class F fly ashes are produced by burning anthracite and bituminous coal; it has low self-cementing properties due to limited amount of free CaO available for flocculation of clay minerals and thus require addition of activators such as lime or cement. The reduction of swell potential achieved in fly ashes treated soil relates to mechanical bonding rather than ionic exchange with clay minerals. However, soil fly ash stabilization has the following limitations:

- Soil to be stabilized shall have less moisture content; therefore, dewatering may be required.
- Soil-fly ash mixture cured below zero and then soaked in water are highly susceptible to slaking and strength loss
- Sulfur contents can form expansive minerals in soil-fly ash mixture, which reduces the long term strength and durability.
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**Blast Furnace Slags**

These are the by-product in pig iron production. The chemical compositions are similar to that of cement. It is however, not cementitious compound by itself, but it possesses latent hydraulic properties which upon addition of lime or alkaline material the hydraulic properties can develop .Depending on cooling system, - Air-cooled slag .Hot slag after leaving the blast furnace may be slowly cooled in open air, resulting into crystallized slag which can be crushed and used as aggregate. Under certain conditions, steam produced during cooling of hot slag may give rise to expanded slag.

**Pozzolanas**

Pozzolanas are siliceous and aluminous materials, which in itself possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperature to form compounds possessing cementitious properties (ASTM 595). Clay minerals such as kaolinite, montmorillonite, mica and illite are pozzolanic in nature. Artificial pozzolanas such as ashes are products obtained by heat treatment of natural materials containing pozzolanas such as clays, shales and certain silicious rocks. Plants when burnt, silica taken from soils as nutrients remains behind in the ashes contributing to pozzolanic element. Rice husk ash and rice straw and bagasse are rich in silica and make an excellent pozzolana.

## 2.0 LITERATURE REVIEW ON STABLIZATION

**Priyanka M Shaka et al** studied on Laboratory investigation on Black cotton soils and Red soil stabilized using Enzyme. The most important aspect in any project is its durability and economic criteria. Recently many bio enzymes have come into existence and these were used in many constructions works. The areas of Bagalkot are covered with Black cotton soil and few areas with Red soil which have less bearing capacity. The present paper describes a study carried out for improving of geotechnical properties of soils. The collected soil samples were treated with the commercially available Enzyme and were cured for 7, 14 and 21days. The results of Consistency limits, Compaction test, Free swell index (FSI), Unconfined Compressive Strength (UCS and California Bearing Ratio (CBR) of untreated soils are presented in this paper. The engineering properties obtained for different mix proportions of soil and curing period were studied. The Free swell index (FSI) and the soaked CBR tests were conducted for the stabilized soil at different curing period.

**Prof. Guruprasad Jadhav et al** studied on experimental investigation of bio-enzyme stabilized expansive soil. In this study a laboratory experiments are conducted to evaluate the effects of Bio-enzymes (TerraZyme) with different dosages and curing time on the Atterberg’s limit, compaction, unconfined compression (UCS) and durability for black cotton soil.

**Faisal Ali et.al** focuses on this research is on the improvement of engineering properties of three natural residual soils and mixed with different proportions of liquid chemical. Series of laboratory test on engineering properties, such as unconfined compressive strength (UCS), consistency limits, moisture-density relationship (compaction) was undertaken to evaluate the effectiveness and performances of this chemical as soil stabilizing agent. The results show that addition of the liquid stabilizer can reduce plasticity and shrinkage by eliminating re-absorption of water molecules; It reduces optimum moisture content by ionizing and exchanging the water molecules on the surface of the clay platelets; It increases maximum dry density by neutralizing and orderly re arranging the clay platelets and increases the compressive strength by increasing the inter particles bonding.

**C. Venkata Subramanian et.al** Three different soils with four different dosages for 2 and 4 weeks of period after application of enzyme on its strength parameters were studied. It is inferred from the results that addition of bio enzyme significantly improve UCC values of selected samples. These soil-stabilizing enzymes catalyze the reactions between the clay and the organic cat-ions and accelerate the cat-ionic exchange without becoming part of the end product.

**Peng et al.** Conducted unconfined compression tests on three soils; fine-grained, silty loam and coarse grained textures named as Soil I, Soil II and Soil III respectively. Three soils were stabilized with quicklime and an enzyme (Perma-zyme). The samples were cured up-to 60 days in two different conditions; air dry and in sealed container. In air-dry curing the samples were allowed to dry at room temperature where as in sealed container the moisture was preserved in the samples during the curing time. The enzyme was found more effective in air-dry curing for Soil I and Soil II than quicklime where as it was not effective for Soil III in air-dry curing and for three soils in sealed curing too. In sealed containers, the quicklime was found more effective than the enzyme as the water in the specimens was not allowed to evaporate which promoted the further hydration of quicklime.

**Shukla.M et al** Made experiments on an expansive soil treated with an organic, non-toxic, ecofriendly bio-enzyme stabilizer in order to assess its suitability in reducing the swelling in expansive soils. The experimental results indicate that the bio enzyme stabilizer used in the present investigation is effective and the swelling of an expansive soil reduces on wet side of OMC.

**M B Mgangira et al** Thus the aim of this paper is to present laboratory results on the effect of enzyme based liquid chemicals as soil stabilizer. 1 soil had plasticity index of 35 and the other had PI of 7. Tests –Atterberg’s limits Standard proctor and unconfined compressive strength. Treatment with enzyme based products to lead a slight decrease in PI of both soil. Enzyme based chemical treatment of two soils using the two products showed a mixed effect on the UCS. No consistence significant improvement in the UCS could be attributed to treatment.

**A.U. Ravishankar et.al** conducted a comprehensive study of the TerraZyme soil stabilizer product with abundantly available lateritic soil in Dakshina Kannada and Udupi districts does not satisfy the requirements (Liquid Limit ≤25% and Plasticity Index ≤6 %) to be used as a base course material in pavements. In order to improve its properties the soil is blended with sand at different proportions unless until it satisfies the Atterberg’s Limits for sub-base course. The effect of enzyme on soil and blended soil in terms of Unconfined Compressive Strength (UCC), and permeability are studied.

**H.N. Ramesh et al** studied the performance of coated coir fibers on the compressive strength behaviour of reinforced soil. Research work did comparison between coated coir with kerosene and uncoated coir. Both fibers were in 100% in submerged condition. Both coated and uncoated fibers were used to reinforce the black cotton soil. 0.5% of uncoated coir found optimum for compaction and compressive strength. Further it was observed that 0.5% of kerosene coated coir fiber increases unconfined compressive strength by 55% compared to uncoated to coir fiber in black cotton soil at 60 days curing. Kerosene and Bitumen coated coir fibers are better substitute for reducing water absorption of soil fibers.

**R.R. Singh et al** studied improvement of local subgrade soil for road construction by the use of coconut coir fibers. 0 to 1% White coir fibers were used for the investigation having diameter 0.5mm and length 3 to 5cm. Sample were tested in both soaked and unsoaked condition. Results showed that Unsoaked and soaked CBR values increases from 8.72% to 13.55% and 4.75 to 9.22% respectively. Unconfined compressive strength ranges between 2.75kg/cm2 to 6.33kg/cm2 with an addition of white coir.

**Arpansenet al.st** studied Soil stabilization using waste fiber materials This study investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained were compared for the two samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach.

**Rakesh Kumar Dutta et al** conducted laboratory tests on slay with inclusion of treated coir fibers (15mm length)with dry , sodium hydroxide, and Carbon tetrachloride. Results showed that unconfined compressive strength was highest with carbon tetra chloride treatment. The coir fiber content was varied from 0.4% to 1.6%. The clay with treated coir fibers can be used for making bricks for houses in rural India. Although above mentioned fibers are successfully used in different types of soils to improve the engineering properties we can use polyester fibers to improve the engineering properties of black cotton soil. Polyester fibers are commonly used to increase the strength of concrete so we can use the polyester fibers in black cotton soil to observe the changed properties of it. Polyester or polypropylene fibers are not commonly used in soil to improneit‟s properties.

**Prof. S.Ayyapan, Ms.K.Hemalatha, Prof. M. Sundaram** carried out series of laboratory unconfined compression strength tests and California bearing ratio tests. Polypropylene fibers with different fiber length (6mm, 12mmand 24 mm) were used as reinforcement. Soil -fly ash specimens were compacted at maximum dry density with low percentage of reinforcement (0 to 1.50 % of weight).Four primary conclusions were obtained from this investigation. First, inclusion of randomly distributed fibers significantly improved the unconfined compressive strength of soil fly ash mixtures. Second, increase in fiber length reduced the contribution to peak compressive strength while increased the contribution to strain energy absorption capacity in all soil flyash mixtures. Third, an optimum dosage rate of fibers was identified as 1.00 % by dry weight of soil- fly ash, for all soil flyash mixtures. Fourth, a maximum performance was achieved with fiber length of 12mm as reinforcement of soil fly ash specimens.

## CONCLUSION

After reviewing the various researches following conclusions were drawn:

- Results of analysis reveal lime clay mixed with cemented soil influences the shear and unconfined compressive strength of the soil specimen.
- It is observed that replacement of soil with cement is more effective than the lime.
- Hence it is proved that clayey soil increases its strength if stabilized with certain additives and it can be successfully used in construction field.
- It can be concluded that the by the decrease in plasticity index and increase in dry density improves the bearing capacity of clayey soil.
- As the amount of lime and cement are increased in tested (treated) soil samples, the value of plastic limits tends to increase.

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