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A Review Study on Additives used Lime and Fly ash for Weak Soil Stabilization

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ABSTRACT
The volumetric unstable soils are already declared as weak engineering soils on account of their behavior of Swell-Shrink which is in view to presence of certain minerals in the soil such as Montmorillonite. Such soils are known as expansive soil. Nowadays, these types of soil properties are a typical issue in engineering projects. This review paper presents the research ideas on soil stabilization with lime and fly ash. Soil stabilization performed the use of technique to adding as a binder to the soil in order to improve the engineering behavior of soil. Researches were employed while adding the additives leads to improve in workability and mechanical behavior of soil after stabilization. Lime and fly ash as nearest natural and industrial resources were used for chemical stabilization. These additives could improve the mechanical properties of soil such as shear strength, swelling, plasticity index and compressibility. The obtained results were indicated that, for improving in soil properties the combination of lime and fly ash might be more effective than use of only lime or fly ash.

Keywords - Fly ash, Lime, Swell, Shrink, Stabilization and Montmorillonite.

INTRODUCTION

The phenomenon of movement of mass of soil (Settlement of soil) downward or outward, under the action of earth's gravity rock slide called landslide which is one of the geologic natural hazards. Landslide is happened by some typical reasons such as heavy prolonged rainfall, earthquakes, rapid snow melting, volcanic activity, and human activities. The various studies were detected that, landslide disaster was occurred because of the inappropriate soil properties such as high plasticity, low workability and poor mechanical properties. Many countries such as United States, Canada, Italy, China, Thailand, **India**, and Brazil suffer continuing landslide fatalities.430 people dead, over 1000 still missing, 958 injured, and 600,000 affected. Damage to 435,000 houses, over 300 government offices including hospitals, 550 schools, 139 temples. Heavy damage also on Bridges, Irrigation projects, Mines and Roads. 300,000 hectare of farmland destroyed and 137,000 animals dead. Total loss estimated at US dollars 122 million. In spite of the huge amount of damage, the extent of loss caused by landslides is far from understood. The Landslide and flooding event, in January 2011, in Serrana mountain region of the State of Rio de Janeiro, Brazil, led to worst-ever natural disaster in Brazil. A series of flash floods and landslide claimed 895 lives and grave damage to the urban and rural infrastructures.

Another common problem of construction projects in many countries such as USA, **India** and some European countries is constructing roads/civil structure on the soft and inadequate soil. The expansive approach for solving this type problem is, replace this soft sub grade soil with stronger materials. In order to progress the properties of inefficient land several construction methods such as displacement, replacement, stage loading and surface, reinforcement, pile supported embankment, light weight fill raft, deep in situ-chemical stabilization were implemented.

In this context, soil stabilization is applied as effective technique/method .Some researchers have indicated the variety in result of soil stabilization; nevertheless, the given results about the effect of chemical stabilization with lime and fly ash, on soil properties will be investigate in this review paper.

MONTEMORILLONITE, THE TROUBLESOME MINERAL:

Clay is a conglomerate of silicate minerals. Key elements in clay are Silica, Aluminum and oxygen disposed in particular configuration of either triangular pyramid or octave pyramid arranged in a certain way. In tetrahedral structure one silicon atom is surrounded by four oxygen atoms at the tips of a triangular pyramid and a tetrahedral sheet is a combination of tetrahedral units while in octave pyramid structure there are six hydroxyl ions at the tips of the octave pyramid which surround Aluminum or magnesium or other metallic atom (which in the case of Montmorillonite is aluminum). In clays tetrahedral and octahedral units are attached to each other in sheet structures giving rise to tetrahedral and octahedral sheets which are disposed in definite peculiar and unique way giving rise to clay minerals depending upon the disposition of sheets.

STABILIZATION

This type of stabilization such as chemical stabilization introduced the use of technique using different additives to the soil in order to improve the performance of proposed soil such as mechanical and chemical properties of soil. Some studies are reported that, different materials such as cement, lime, fly ash, silica fume, and rice husk ash have been used for chemical stabilization of soft soils.

Chemical stabilization is considered as a cost effective, eco friendly and efficient method for expansive soil treatment. It is also well known that stabilizing soil with local natural, industrial resources particularly lime and fly ash has a significant effect on improving the soil properties. In soil stabilization with lime and fly ash, additives combined by specific moisture content, then apply for improving the soil properties in large engineering projects. Investigator experiments on the physical and chemical reaction of stabilized soil revealed that, lime, fly ash, and mixture of lime-fly ash have short-term and long-term effect on the characteristic of soil.

The short-term effect is flocculation and agglomeration soil particles on the surface of soil by ion exchanges, which lead to improve the workability and reduction in shrinking, plasticity and swell properties of soil. On the other hand, Improvement in compaction properties of soils is the result of long-term effect of chemical stabilization.

Hence, these obtained result of soil stabilization with lime and fly ash as an appropriate additive in a variety of geotechnical constructions will be explored in the following step.

Lime

M.R.Thompson (1970) examined the ability of lime stabilized materials to resist the detrimental effects of moisture and freeze-thaw cycling over time has been evaluated in several ways, in both the laboratory (soaking in conjunction with strength/stiffness tests, cyclic freeze-thaw tests) and the field. The results of these evaluations have often shown only slight detrimental effect of environment on the levels of strength/stiffness produced by the addition of lime.

Locat et al. (1990) performed experiment on in organic clayey soil sample on varying the lime percentage from 1- 10% and sample had water content 122-650%. To achieve maximum compression strength, the curing period for this work are 100 days which is a long period and not applicable for area of dense traffic flow during re-construction of roads. The percentage of lime is little high which is not economical.

D.L. Little (2000) also performed an evaluation of the structural properties of lime-stabilized soil and aggregate. Lime is used extensively to change the engineering properties of fine-grained soil and the fine grained fractions of more granular soil. It is most effective in treating plastic clay capable of holding

large amount of water.

Nilo et al. (2009) says that the addition of lime is an attractive technique when the engineering work requires improvement of the local soil. The use of lime with soil finds an application in the construction of pavement base layers, in slope protection of earth dams, and as a support layer for shallow foundations. He achieves the value of maximum compression strength at 11% lime which is much higher. Usually soil is stable with 7-9% of lime, but 11% of lime is high in quantity and it is not economical for engineering projects.

Khelifa et al. (2011) shows that the combination of lime natural pozzolana 10% (lime and 4% natural pozzolanic) increases the maximum dry density for grey soil and decreases for red soil. This combination is not suitable for all types of soil, so it is not used in every part of the country, due to this if it is not applicable than it is neither useful nor economical.

Kavak and Baykal (2012) study that the stage of lime soil stabilization that long-term strength is achieved when lime is added to reactive soil to generate this long-term strength gain. This study investigates the use of micro-fabric for long-term cured lime-stabilized silty and clay soil. The combination of lime and fabrics is costly than lime alone. The soil treatment with lime is also economical than this combination.

Chee-Ming Chan (2016) studied that stabilization of soil using cement and lime the overall strength of solidified soil increases with water-cement ratio and prolonged curing. The maximum strength was recorded at 2.5 times between 3 and 56 days of rest period. The 56 days of rest period is not possible for dense traffic areas so use of lime for stabilization and we can achieve the maximum strength between 6-8 days which is suitable and applicable from 56 days

In comparison with un-stabilized soil, lime treatment not only forms a remarkable increases in optimum moisture content, but also the results indicated the decrease in maximum dry density after lime stabilization.

In investigation on the stabilized specimens with lime were detected a shear failure mode such as failure in brittle materials ,nevertheless, more studies Established about the effective role of lime for progressing in the strength characteristic of soils.

Scholars revealed that, reduction in plasticity index was caused by increase the amount of lime in the chemical stabilization. In some cases, the obtained results reported the multiplied reduction in plasticity index of pure soil after lime treatments. In addition, plasticity index of soil has directly associated with swelling pressure and swell potential of soil. Therefore, swell pressure reduction was the direct result of decrease in the plasticity index of stabilized soil.

Fly ash

Cokca Erdal (2001): Effect of Fly Ash on expansive soil was studied by Erdal Cokca; FLY ASH consists of often hollow spheres of silicon, aluminum and iron oxides and unoxidized carbon. There are two major classes of Fly Ash, class C and class F.
Fly Ash Geopolymeric Binder: Geopolymerisation or alkaline activation of acuminate materials is alternative to cement **(Hardjito and Rangan, 2005).**

The reduction is as high as 80% based on the activating solution; dissolved solids of Na2O and SiO2 content **(Duxson et al., 2007).**

Alkaline-activated materials showed better performance since durability and stability can be increased, improvement from mechanical aspect compared to cement and also improved bond between the soil particles and binder **(Torgal et al., 2012; Villa et al., 2010).**

In geotechnical applications, alkaline activation (Geopolymeric binder) of fly ash was tested for soil improvement since waste material was obtained as binder in most of other Geopolymeric applications **(Cristelo et al., 2012).**

In strength development of alkaline activated systems, sodium hydroxide concentration plays a very important role **(Cristelo et al., 2012).**

Alkaline activation generally was a reaction concerning alumina-silicate materials and alkali or earth substances' alkali. At a molecular level to natural rocks, materials formed from reactions between silica, alumina and alkali cat ions were very alike in term of stiffness, durability and strength **(Cristelo et al., 2012)**

Sodium hydroxide concentration significantly influenced the strength development **(Criestelo et al., 2012; Cristelo et al., 2013).**

Due to the reduction of CO2 emissions from the activation of ashes and/or slag's with the absence of high temperature in calcinations step compared to cement production **(Cristelo et al., 2013).**

Bhuvaneshwari. S. and Gandhi .S.R.: A study was carried out by S.Bhuvaneshwari and S.R. Gandhi on the effect of engineering properties of expansive soil through an experimental programme. Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity.

The obtained results indicated that incorporation of fly ash with soil particles resulted in significantly improvement in strength property of soil. Therefore, the bearing capacity of fly ash treated soil might be effectively developed due toimprovement the shear strength, and cohesion of soil.
Lime is one of the excellent soil stabilizing materials for highly active soil which undergo through frequent swelling and shrinkage.

AIM AND OBJECTIVE

This study of research is aimed to know the effective proportion of lime and fly ash which is suitable for stabilization of soil used in any civil structure. An extensive laboratory testing program was conducted to determine suitability of the above recycled stabilizers for stabilization of common problematic soil. The main objectives of this work are:

- To study the effect of lime and fly ash on optimum moisture-content (OMC) of the soil.
- To study the strength and stabilization of soil using different percentages of lime and fly ash.
- To study the unconfined compression strength (UCS) of soil used in any civil structure on replacing with different percentages of lime and fly ash.

SUMMARY

Testing to determine different parameters as:
1. Compaction test is performed to determine the strength of soil treated with different percentage of lime & fly ash.
2. Optimum moisture content (OMC) and maximum dry density (MDD) values are determined for the different percentage of lime & fly ash mixed with silty sand.
3. Unconfined compressive strength (UCS) tests are conducted. A total of 24 samples are tested.

The aim of the tests is to check the desirable percentage of lime & fly ash which gives maximum strength to the sub-grade soil for stabilization.

Lime acts immediately and improves various property of soil such as carrying capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, increase in CBR value and subsequent increase in the in the compression resistance with the increase in time.

Use of lime as stabilizing agent in conjunction is technically and financially feasible as it increases both the strength and durability parameters of soil. Furthermore it is an environment friendly.
In order to modify the different properties of Expansive soil were employed few methods. Chemical stabilization asa common technique was adopted by addition of some additives such as lime, fly ash to

the expansive soil.

Investigation on the compressibility of soil revealed that, fly ash could improve the optimum moisture content and decrease the maximum dry density of soils. Although lime treatment method was known as an effective method for compaction properties of soil, in some cases lime had not sufficient effect on soil.

Moreover, about the efficiency of lime and fly ash treatment on strength characteristic of soils, has not been achieved the same result. In general utilization of fly ash led to improve the soil strength. Although, some scholars observed a shear failure mode in lime stabilized soil, lime stabilization was applied as a successful method for increasing the strength of soil.

It seems still there are some major questions about the appropriate amount of lime and fly ash, and applicable combination of the additive in soil stabilization, which are, needs to be taken more into account. It can be clearly seen from the previous studies, most of researches were carried out on fine-grained soil. Therefore, in order to obtain a more comprehensive result need to be taken more researches on the different kind of soil such as coarse- grained soil.

Some researchers studies about the effect of combination of lime and fly ash on soil. The investigations revealed that, might be the effectively of stabilization increased by the utilization of mixture of lime and fly ash. In this field, the workability and strength behavior of soft soils, and freezing–thawing (durability) were notably improved in comparison with fly ash stabilization or lime treatment alone.

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