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A Review on The Lime and Fly ash Application in Soil Stabilization

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***Abstract*—**Nowadays, inefficient properties of soils are a critical issue in engineering projects. In some cases, improve the characteristic of unsuitable soils is a fundamental step for making construction. This review paper presents the results of research on soil stabilization with lime and fly ash. Soil stabilization performed the use of technique to adding a binder to the soil in order to improve the engineering performance of soil. Researches were illustrated that adding the additives leads to progress in workability and mechanical behaviour of soil after stabilization. Lime and fly ash as local natural and industrial resources were applied for chemical stabilization. These additives could improve the mechanical properties of soil such as strength, swelling, plasticity index and compressibility. The obtained results were indicated that, for progressing 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, Stabilization.

I. Introduction

The phenomenon of downward or outward movement mass of soil, rock under the influence of earth's gravity called landslide which is one of the key geologic and costliest natural hazards [4]. Landslide is triggered by some key causes such as powerful or prolonged rainfall, earthquakes, rapid snow melting, volcanic activity, and human activities. The various studies were detected that, landslide disaster was happened because of the inappropriate soil properties such as high plasticity, poor workability and low mechanical properties [4], [17] .Many countries such as United States, Canada, Italy, China, Thailand, India, and Brazil suffer continuing landslide fatalities [4], [6].

Researchers [4] have reported that, the catastrophic landslide in Thailand caused to kill 373 people plus $280 million financial in November 1988 and 136 people with $5 million property damage cost in August 2001.

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 [3].

Another common problem of construction projects in many countries such as USA [18], India [5], and some European countries [1], [17], [19] is constructing roads on the soft and inadequate soil [15], [18]. The costly approach for solving this problem is, replace the soft subgrade soil with stronger materials [5], [18].

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 [7], [12], [18].

In this context, soil stabilization is applied as effective technique .Some scholars have indicated the variety 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.

II. Stabilization

Chemical stabilization introduced the use of technique to add a binder to the soil in order to improve the geotechnical performance of land such as mechanical and chemical characteristics of soil [1] - [2], [12]. Some studies are reported that, different additives such as cement, lime, fly ash, silica fume, and rice husk ash have been used for chemical stabilization of soft soils.

Chemical stabilization is applied as a cost effective, environmental friendly and efficient method for soil treatment [1]. It is also well known that stabilizing soil with local natural, industrial resources particularly lime [1], [7], [9], [17], and fly ash [2], [10], [12], [20] 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 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, development of compaction properties of soils is the result of long-term effect of chemical stabilization [7] – [9], [11], [13].

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Hence, the 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.

III. MAIN PREVIOUS STUDY IN THE LITERATURE REVIEW

A. Lime

One of the most frequently used chemical stabilization method is lime stabilization, which was found a well-established technique for developing plastic properties and strength of cohesive soil. Investigation on lime indicated that, improve the soil resistance was one of the most noticeable benefit of lime stabilization. Due to the cations exchange, flocculation agglomeration, lime carbonation and pozzolanic reaction soil particles stick to each other and make larger particles [7], [9].

Some surveys have been reported that, lime had no efficient effect on compaction parameters; however, in comparison to other binder lime create a quick and extensive chemical reaction with soil particles. Changing the characteristics of soil as result of chemical interaction lead to progress in the soil properties, such as compaction and strength characteristics of soil [1], [7], [9]. In comparison with un-stabilized soil, lime treatment not only form a remarkable increases in optimum moisture content, but also the results indicated the decrease in maximum dry density after lime stabilization [1], [7], [8], [12], [13].

In investigation on the stabilized specimens with lime were detected a shear failure mode such as failure in brittle materials [8], [11], nevertheless, more studies [7] – [9], [17], [20] established about the effective role of lime for progressing in the strength characteristic of soils. Based on several reports, the reaction between soil and lime particles called pozzolonic reactions, which causes to increase the soil strength [9].

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 [1], [7] – [9].

B. Fly ash

In recent years, the potential for applying natural resource and industrial mineral in soil stabilization has been explored. In this field, fly ash has been used as an additive in chemical stabilization. Fly ash is divided into class C and class F fly ash based on the type of coal burned [2], [10], [18]. Regarding to low unit weight and compressibility [21], pozzolanic reactivity characteristic [17], [21], cost-effective, and energy saving benefit [19] fly ash has found one of most plentiful and flexible waste materials that extensively applied for progressed properties of soft soil in geotechnical engineering constructions [5], [7], [21].

Some studies [2], [15] have argued about the effect of fly ash on soil plasticity index. It can be observed that, fly ash treatment could lead to decrease the plasticity index as a result of increase in liquid values. Subsequently, reduce the soil plasticity related with lessen the degree of damaging sulphate-heave and potential for swelling. On the other hand, the results of the other studies revealed that, applying only fly ash might be insufficient for developing the properties of highly plastic soil [12] – [13], [15].

Several researches regarding investigation on compaction characteristic of soil [2], [13], [18], [19] have established that, adding fly ash to soils changed the range of porosity and void ratio of soils. Through the soil stabilization, soil particles can attract more amount of water. This interaction directly leads to an increase in optimum moisture content and a decrease in maximum dry density.

Furthermore, many studies [7], [10], [15] – [16] reported about the effectively of fly ash in the strength of soil. 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 to improvement the shear strength, and cohesion of soil.

The experiment results reported that, the small amount of coefficient of secondary compression in fly ash treated specimens. This advantage can reduce the possibility of settlement due to secondary consolidation of structures [20].

On the other hand, some scholars 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 behaviour of soft soils, and freezing–thawing (durability) were notably improved [7], [13], [21] in comparison with fly ash stabilization or lime treatment alone.

IV. SUMMARY

In order to modify the inadequate properties of soft soil were implemented several methods. Chemical stabilization as a common technique was applied by addition of some additives such as lime, fly ash to the soil.

The numerous studies were established about the effect of lime and fly ash on soil properties; however, the obtained results were extremely different about the efficiency and affectivity of stabilization with lime and fly ash.

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.

In spite of insufficiency of fly ash treatment for decreasing the plasticity index of highly plastic soil, in the other cases fly ash stabilization were effective in the reduction of plasticity index of soil as well as applying lime stabilization method for inadequate soil.

On the other hand, 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.

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