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Influence of Flyash on the Strength Behaviour of Lime and Cement Treated Red Soil

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Abstract

For an effective disposal of fly ash avoiding environmental pollution, it is necessary to utilize it on a continuous basis for some beneficial purposes. Its bulk utilization is feasible through civil engineering applications. This study reports on the testing carried out on solidification/stabilization (S/S) for disposal of heavy Metal sludge wastes. S/S has emerged as an efficient method for the treatment of industrial sludge contaminated with potentially toxic heavy metal ions. The work investigated the feasibility and effectiveness of the fly ash along with soils like red earth and black cotton soil on S/S of the industrial chromium bearing sludge obtained from the industry. As fly ash as admixture with or without the small additives of lime and cement Unconfined compressive (UCC) strength moulds were prepared these moulds were cured in a polythene bags. The UCC strength tests were carried out at the end of 0, 7, 30 and 60 days of curing. The UCC tests in which fly ash lime and cement are increased reveals that as the lime and cement percentage increases the strength increases. Compressive strengths of cement stabilized moulds were higher than the lime stabilized moulds. The rate of improvement of strength is rapid for the seventh day. The UCC tests revealed that as percentage of sludge increases the corresponding compressive strength decreases. A laboratory testing program was designed to investigate the strength properties of expansive and non expansive soil blended with a class F fly ash, lime and cement. Fly ash was mixed in increasing proportions up to 90% by mass of the soil. Cement content was varied up to 2% of the combined mass of fly ash and soil. The test

line-up included classification tests, compaction tests and unconfined compression tests. Curing periods up to 60 days were used. The test results indicate that the addition of fly ash plays an important role in the development of strength of the two soil types. A little addition of cement even at 1% to the soil-fly ash mixes significantly increases the unconfined compressive strength. The main focus of the present investigation was to stabilize the chromium sludge obtained from industry in order to develop a solid matrix that produces the stable and sustainable end products. In the current investigation UCC tests were carried out for different proportion of soil, fly ash with and without addition of cement and lime in small percentage and sludge mixtures. Characteristic unconfined compressive strengths were carried out using UCC machine to assess the strength of stabilized moulds for the different curing periods.

1. Introduction

Electricity has become an integral part of the day-to-day life of modern society, at the same time the large quantities of fly ash are being produced from major thermal power plants. Increasing demand for electrical power by the rapidly growing industrial as well as agricultural sectors of India has led to the setting up of a number of coal-based thermal power stations. The major four countries namely, China, India, Poland, and United states, produce more than 270 million tons of fly ash every year. The disposal of fly ash has serious impact on environmental aspect. The fly ash poses multiple environment problems besides occupying large areas of land for its storage and disposal. Wherever large volumes of earthen materials are used in civil engineering, applications of fly ash can emerge. Several investigators have reported the influence of the addition of fly ash on index properties of soils and they have reported that the effect of fly ash is mainly due to the pozzolanic reactivity. The effect of lime and cement on unconfined compressive strength (UCS) of soil-fly ash mixtures have shown increase in compressive strength which was attributed due to pozzolanic reactions after curing period of 60 days.

An attempt has been made in this work to improve the physical and strength property of non expansive soil- red earth. The present paper describes the effect of pozzolanic fly ash along with cement and lime on the strength behavior and improvement in physical properties of red earth soil.

2. Materials

Naturally occurring red soil collected from Bangalore University premises has got unconfined compressive strength of 450 kpa and maximum dry density of 15.6 kN/m^3. The chemical property reveals that red earth has 60.4% silica and 6.9% calcium oxide.

Raichur Fly Ash (RFA) is non plastic with specific gravity of 2.02. Chemical analysis reveals that the soluble silica and free lime content in fly ash are very less.

Ordinary Portland cement is collected from authorized supplier. Chemically pure hydrated lime is procured commercially.

3. Methods of Testing

3.1 Compaction

According to IS 10074-1982 compaction was done for soil and trial mixes chosen to immediate mixing using proctors apparatus and the value of maximum dry density and corresponding optimum moisture content inferred from compaction curves. As per IS 2720 part VII compaction test is carried out for the soil alone and soil mixed with additives.

1. UNCONFINED COMPRESSIVE STRENGTH:
2. *SPECIMEN PREPARATION:*

The samples were prepared by static compaction method to achieve maximum dry density at optimum moisture content. The mould consists of steel device with an internal diameter of 38mm and height 76 mm. The volume of steel tube was calculated as equal to the volume f the sample, knowing the volume and the density required, the weight of the sample of trial mixes whose combination percentages were chosen are determined and the water corresponding to the optimum moisture content was added. This was transferred to the steel tubing device. It was then compressed by rotating or pistons simultaneously from both the ends, which resulted in a sample of 38 mm diameter and 76 mm long.

3.2 Curing

These identical samples were prepared for their maximum dry density at optimum water content based on compaction curves obtained. The sample for various curing periods of testing that is immediate, 7, 14, 28 and 60 days testing. All the samples prepared were labeled according to the trial combination chosen. Samples were cured in desiccators and covered with moist cloth to maintain 100% humidity and to prevent loss of any moisture from the samples. All the samples intended for immediate testing were tested immediately.

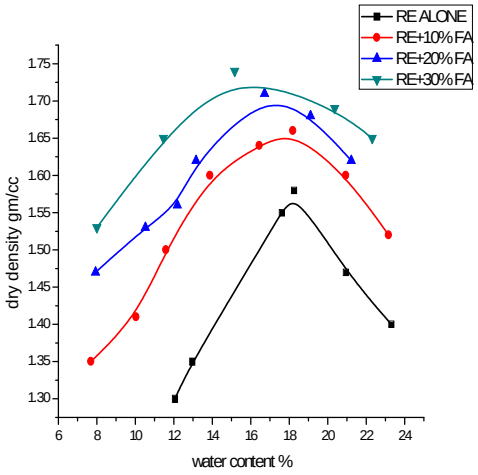
3.3 Test Procedure

The test was conducted using unconfined compression test apparatus at a strain rate of 1.2 mm/min. the specimen to be tested was placed centrally in between the lower and upper platform of the testing machine. The proving ring readings were noted for each 50 divisions on a deformation dial gauge. The loading was continued until three or more consecutive reading of the load dial showed a decreasing or a constant load or a strain of 20% has been reached.

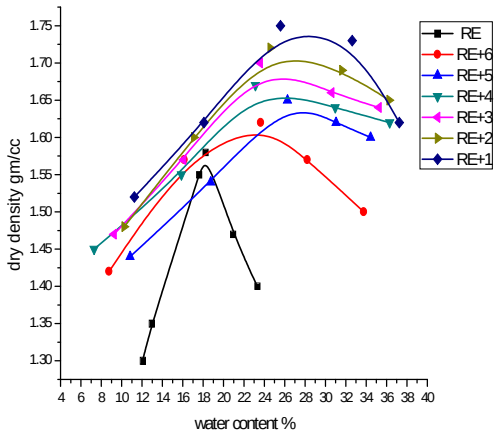
4. Results and Discussions

4.1 Effect of fly ash and other additives on proctors maximum dry density of soil

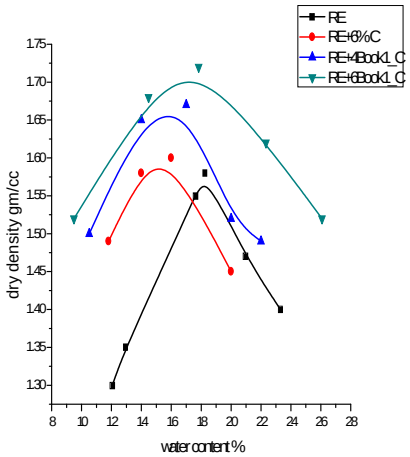
Figure 1, 2 & 3 shows the compaction values of soil and ash mixture. For every addition of ash (10% every time) the maximum dry density goes on decreasing. The maximum dry density of red earth with 10% fly ash was 17 kN/m^3 and got reduced to 16.4kN/m^3 for red earth mixed with 30% fly ash. The decrease in maximum dry density is due to the domination of low specific gravity of fly ash. Further the soil gradation may be adversely affected the dry density at higher content of ash in the mixture. However above factors decreases the water holding capacity of the mixture and hence optimum moisture content decreases continuously with every increment of ash.



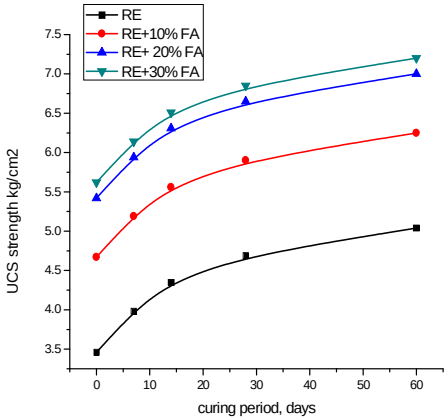
Effect of fly ash on density of soil (fig1)



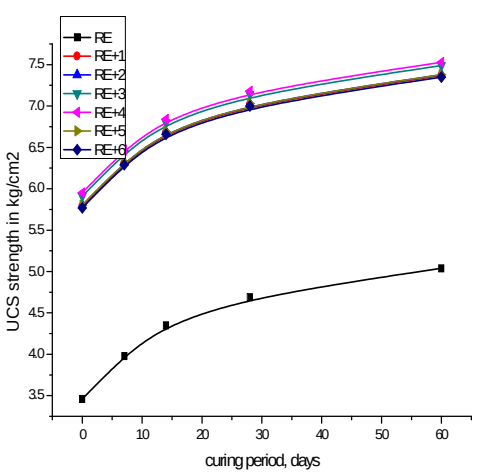
Effect of lime on red earth mixed with 30% ash



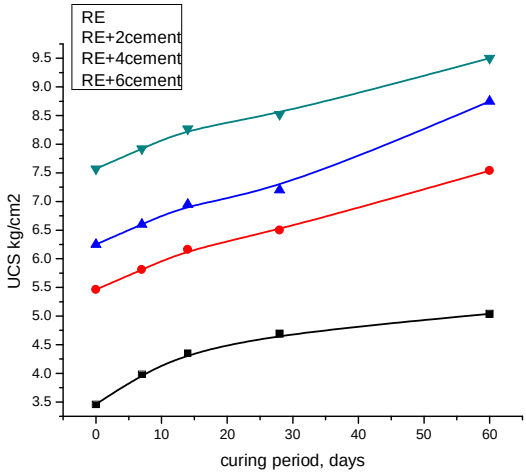
Effect of cement on red earth mixed with 30% ash



Variation of UCS on red earth with ash



Variation of UCS on red earth with ash on increasing % of lime content



Variation of UCS on red earth with ash on increasing % of cement content

4.2 Effect of ashes and other additives on unconfined compressive strength of soils

The effect of addition of ash on unconfined compressive strength of soil samples compacted to their respective maximum dry density at corresponding moisture content has been examined. Figure 4, 5 & 6 shows the unconfined compressive strength of soil and ash mixtures for all combinations cured for 60 days. The combination of RE+RFA mixtures has shown good strength. This has reached 700 kpa for addition of 30% fly ash after 60 days curing from as low as 350 kpa of red earth alone. The effect of effect of pozzolanic reaction dominates strength gain at lower curing periods.

4.3 Effect of strength by secondary additive on 60 days cured samples

To observe the possibility of further improvement of strength of 60 days cured sample, addition of cement and lime for RFA has been considered. The chemical analysis reveals the RFA has less reactive silica and free lime, which are responsible for early impart of strength to mixtures.

The cement treated RFA+ RE soil mixtures have reached upto 900 kpa for 30% ash and 6% cement cured for 60 days. The lime treated soil mixtures have shown the strength reaching upto 700 kpa for 30% ash and 6% lime cured for 60 days. The figure 3 shows the effect of cement on strength behavior of soil and figure 4 shows the effect of lime on strength behavior of soil after curing samples upto 60 days.

5. Conclusions

This paper presented the effect of curing time on the unconfined compressive strength of soil stabilized with combination of lime and cement with fly ash. On the basis of test result from the stabilized soil mixtures the following conclusions can be drawn.

- On addition of any ash decreases the diffused double layer thickness of mixture and hence water holding capacity of soil mixtures decreases.
- On addition of any ash the gradation of mixture is adversely affected which leads in reduction of dry density for higher content of ash.
- Fly ash can be used as a good stabilizer along with secondary additives.
- Cement and lime imparts considerable strength in soil.

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