STABILIZATION OF EXPANSIVE SOIL USING ALKALI ACTIVATED FLYASH

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ABSTRACT

Soil is a peculiar material. Some waste materials such Fly Ash, rice husk ash, pond ash may use to make the soil to be stable. Addition of such materials will increase the physical as well as chemical properties of the soil. Some expecting properties to be improved are CBR value, shear strength, liquidity index, plasticity index, unconfined compressive strength and bearing capacity etc. The objective of this study was to evaluate the effect of Fly Ash derived from combustion of sub-bituminous coal at electric power plants in stabilization of soft fine-grained red soils. California bearing ratio (CBR) and other strength property tests were conducted on soil. The soil is in range of plasticity, with plasticity indices ranging between 25 and 30. Tests were conducted on soils and soil–Fly Ash mixtures prepared at optimum water content of 9% .Addition of Fly Ash resulted in appreciable increases in the CBR of the soil. For water contents 9% wet of optimum, CBRs of the soils are found in varying percentage such that 3,5,6and 9.We will found optimum CBR value of the soil is 6%.Increment of CBR value is used to reduce the thickness of the pavement. And increasing the bearing capacity of soil.

Expansive soils, popularly known as highly problematic soils. In India more than 1/3rd of soils are expansive soils. These are highly challenging soils in the construction of structures like buildings, dams, pavements etc. The alternate Swelling and Shrinkage they undergo due to seasonal moisture changes result in distress of structure founded in/on such soils. The settlements under foundations of the expansive soils, there by decreases and the environment pollution can be reduced by utilizing the waste from power plant. From the investigation the properties of expansive are improved with increase in number of days of curing with fly ash

Keywords: *Expansive soils, California bearing ratio, peculiar material.*

INTRODUCTION

Expansive soils also known as swelling soils or shrink-swell soils are the terms applied to those soils, which have a tendency to swell and shrink with the variation in moisture content. As a result of which significant distress in the soil occurs, causing severe damage to the overlying structure. During monsoon"s, these soils imbibe water, swell, become soft and their capacity to bear water is reduced, while in drier seasons, these soils shrinks and become harder due to evaporation of water. These types of soils are generally found in arid and semiarid regions of the world and are considered as a potential natural hazard, which if not treated well can cause extensive damages to not only to the structures built upon them but also can cause loss of human life. Soils containing the clay minerals montomorillonite generally exhibit these properties. The annual cost of damage to the civil engineering structures caused by these soils are estimated to be ₤ 150 million in the U.K., $ 1,000 million in the U.S. and many billions of dollars worldwide.

Expansive soils also called as Black soils or Black cotton soils and Regur soils are mainly found over the Deccan lava tract (Deccan Trap) including Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent. Black cotton soils are also found in river valley of Tapi, Krishna, Godavari and Narmada. In the north western part of Deccan Plateau and in the upper parts of Krishna and Godavari, the depth of black soil is very large. Basically these soils are residual soils left at the place of their formation after chemical decomposition of the rocks such as basalt and trap. Also these type of soils are formed due to the weathering of igneous rocks and the cooling of lava after a volcanic eruption. These soils are rich in lime, iron, magnesia and alumina but lack in the phosphorus, nitrogen and organic matter. Their colour varies from black to chestnut brown, and basically consists of high percentage of clay sized particles. On an average, 20% of the total land area of our country is covered with expansive soils. Because of their moisture retentiveness, these soils are suitable for dry farming and are suitable for growing cottons, cereals, rice, wheat, jowar, oilseeds, citrus fruits and vegetables, tobacco and sugarcane.

During the last few decades damage due to swelling action has been clearly observed in the semiarid regions in the form of cracking and breakup of pavements, roadways, building foundations, slab-on-grade members, channel and reservoir linings, irrigation systems, water lines, and sewer lines.

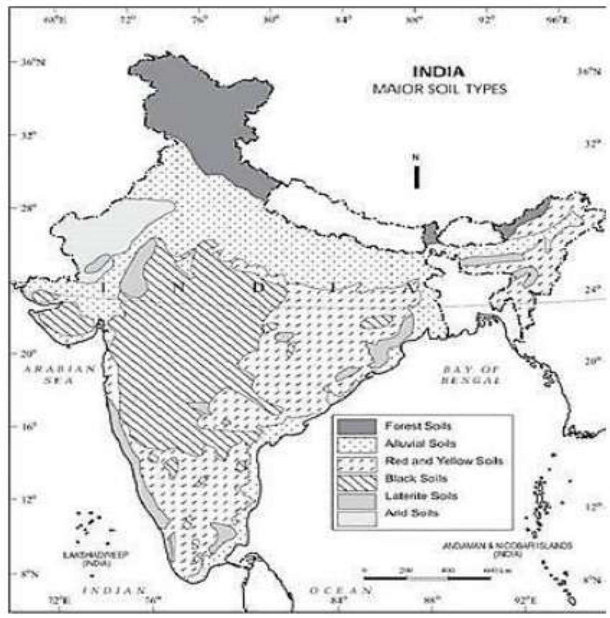
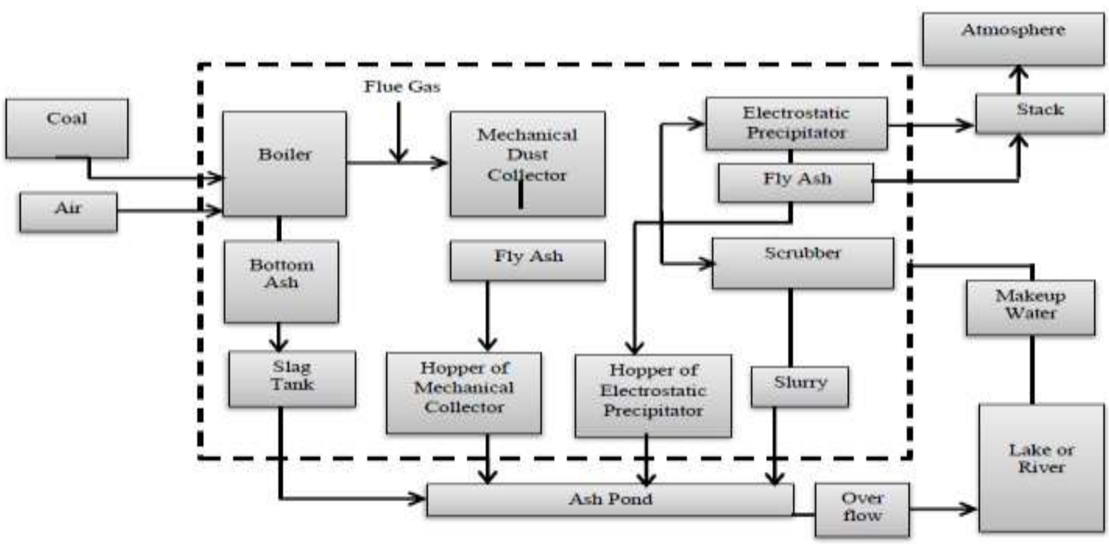


Figure 1.1 Major Soil Types in India



Schematic view of a typical coal based thermal power plant

LITERATURE REVIEW

Sharma *et al*. (1992) studied stabilization of expansive soil using mixture of fly ash, gypsum and blast furnace slag. They found that fly ash, gypsum and blast furnace slag in the proportion of 6: 12: 18 decreased the swelling pressure of the soil from 248 kN/m2 to 17 kN/m2 and increased the unconfined compressive strength by 300%. Srivastava *et al*. (1997) studied the change in micro structure and fabric of expansive soil due to addition of fly ash and lime sludge from SEM photograph and found changes in micro structure and fabric when 16% fly ash and 16% lime sludge were added to expansive soil. Srivastava *et al*. (1999) have also described the results of experiments carried out to study the consolidation and swelling behaviour of expansive soil stabilized with lime sludge and fly ash and the best tabilizing effect was obtained with 16% of fly ash and 16% of lime sludge. Cokca (2001) used up to 25% of Class-C fly ash (18.98 % of CaO) and the treated specimens were cured for 7 days and 28 days. The swelling pressure is found to decrease by 75% after days curing and 79% with 28 days curing at 20% addition of fly ash. Pandian *et al*. (2001) had made an effort to stabilize expansive soil with a class –F Fly ash and found that the fly ash could be an effective additive (about 20%) to improve the CBR of Black cotton soil (about 200%) significantly.

Peethamparan and Jain (2008) studied four CKD with different chemical and physical characteristics in stabilizing Na-Montmorillonite Clay. All CKDs considerably decreased the plasticity index, thereby improving the workability of the clay, while they also considerably increased the initial pH value of clay, providing a favourable environment for further chemical pozzolanic reaction. The addition of CKDs and subsequent compaction substantially increased the UCS and the stiffness of the clay, thus improving its structural properties. The extent of improvement of the clay characteristics was found to be a function of the chemical composition of the particular CKD, specifically its free lime content. It was also found that the length of curing period after compaction had a major role in the stabilization process

MATERIALS AND METHODOLOGY

Expansive Soil:-

In the present investigation, expansive black cotton soil was procured from a site having coordinates as N 21° 12'' 34.03" and S 79° 09'' 29.09", Khairi, Kanli road, Nagpur, Maharashtra. The black cotton soil was collected by method of disturbed sampling after removing the top soil at 500 mm depth and transported in sacks to the laboratory. Little amount of the sample was sealed in polythene bag for determining its natural moisture content. The soil was air dried, pulverized and sieved with 4.75 mm Indian as required for laboratory test. The various geotechnical properties are shown in Table.

Photographic image showing test setup of UCS

Geotechnical Properties of Expansive soil

SL.NO	PROPERTIES	CONFIRMING TO IS CODE	VALUE
1	Coefficient of uniformity (Cu)	IS 2720 : Part 4 : 1985	2.43
2	Coefficient of curvature (Cc)	IS 2720 : Part 4 : 1985	0.51
3	Specific gravity (G)	IS 2720 : Part 3 : Sec 1 : 1980	2.64
4	Maximum dry density (MDD)	IS 2720 : Part VII : 1980	1.55 gm/cc
5	Optimum moisture content (OMC)	IS 2720 : Part VII : 1980	23.31%
6	Natural moisture content	IS 2720 : Part 2 : 1973	7.11%
7	Free swell index	IS 2720 : Part XL : 1977	100%
8	Liquid limit	IS 2720 : Part 5 : 1985	72%
9	Plastic limit	IS 2720 : Part 5 : 1985	21%
10	Swelling pressure	IS 2720 : Part XLI : 1977	6 kg/cm^2
11	Classification	IS 1498	CH

Methodology Adopted:-

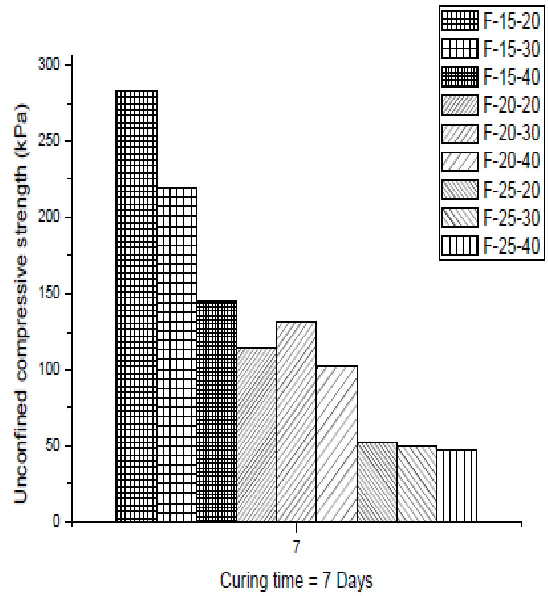
To evaluate the effect of the ash/soil ratio (by dry mass) on mechanical strength, three different fly ash percentages, regarding the total solids (soil + ash) weight, were used: 20, 30 and 40 %, corresponding to ash/soil ratios of 0.25, 0.43 and 0.67, with activator/total solids ratios of 0.15, 0.2 and 0.25. The details of the experimental specimens are shown in Table. The soil and the ash were previously homogenised before the activator was added to the mixture. After mixing for 3 min, the samples were cast into 50-mm moulds by tapping the moulds on the lab counter, which were then left in a sealed container. Since the behaviour of the mixtures was that of a viscous fluid, no density control was used during the preparation of the samples. However, when removed from the moulds, every sample was weighted, and an average unit weight of 20 kN/m3 was obtained, regardless of the fly ash percentage in the mixture. The 15 molal mixtures showed a very high viscosity which made the preparation and handling process more difficult than with the remaining concentrations, to a point where this factor should be considered when designing future studies and/or applications. This effect is related to the SiO2 : Na2O mass ratio of the silicate + hydroxide solution which, for the 15 molal activator, is approximately 1, making the metasilicate solution very unstable and favouring crystallisation. This SiO2 : Na2O mass ratio was, in the original silicate solution, approximately 2, but the addition of the hydroxide solution reduced it significantly, especially in the 15 molal mixtures. After 48 h, the samples were removed from the moulds and wrapped in cling film and left at ambient temperature and humidity conditions (50–60 % RH and 32-35º C). Immediately before testing, at the ages of 3, 7 and 28 days, the samples were trimmed to 100 mm long and tested for unconfined compressive strength (UCS) on an Aimil hydraulic testing machine. Every single result obtained was the average of 3 tested samples. The details of the alkaline activator mixed soil specimens are shown in Table.

Photographic image of Samples wrapped in cling film.

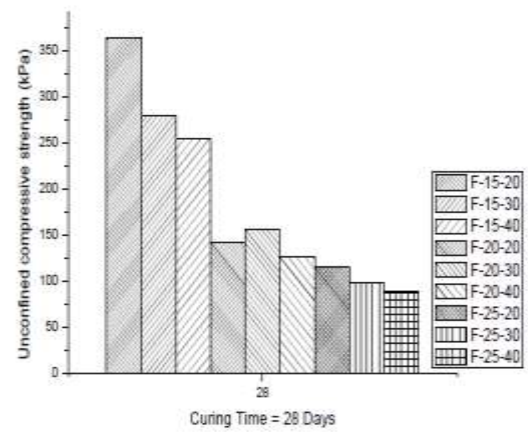
RESULTS ON STABILIZATION OF EXPANSIVE SOILS WITH FLY ASH

This paper presents the results of stabilization of expansive black cotton soil, with fly ash.

The increase in strength criteria is ascertained by conducting unconfined compression test on samples, at 3, 7 and 28 days curing. The samples, casted were of 50 mm diameter and 100 mm height, thereby ensuring L/D ratio as 2. These samples contains fly ash in 20, 30 and 40% by weight of dry mass and water to total solid ratio is varied from 15, 20 and 25%. All the samples were covered with cling film, after casting and are kept in a air tight container for 48 hours. After 48 h, the samples were removed from the moulds and wrapped in cling film and left at ambient temperature and humidity conditions (50–60 % RH and 32-35º C). Immediately before testing, at the ages of 3, 7 and 28 days, the samples were trimmed to 100 mm long and tested for unconfined compressive strength (UCS) on an Aimil hydraulic testing machine at constant strain rate of 1.2 mm/min. Every single result obtained was the average of 3 tested samples.

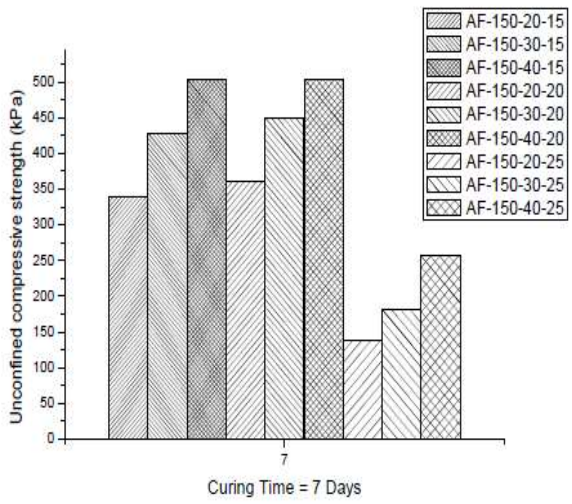


Bar chart showing the UCS results of Fly ash Samples after 7 days of curing

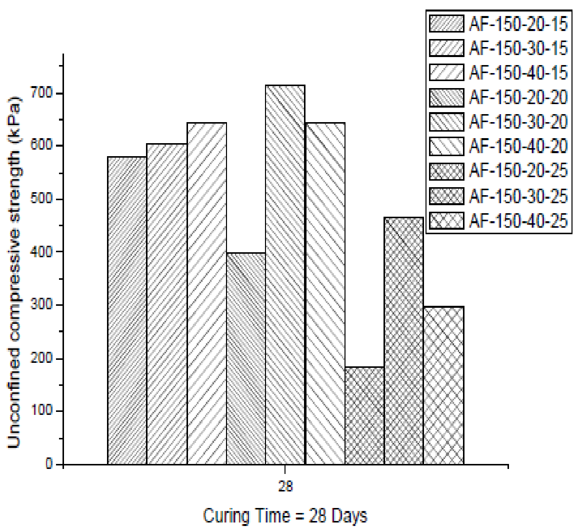


Bar chart showing the UCS results of Fly ash Samples after 28 days of curing

RESULTS ON STABILIZATION OF EXPANSIVE SOILS WITH ACTIVATED FLY ASH



UCS results of 15 molal sample (7 Days curing)



UCS results of 15 molal sample (28 Days curing).

CONCLUSIONS

Based on the obtained results and discussion thereof following conclusions can be made.

- The unconfined compressive strength soil is found to vary with concentration of chemical in the activated fly ash and curing period.
- 10 molal samples are giving better 3 and 7 days strengths than 12.5 and 15 molalbsamples, which make it economical as compared to 12.5 and 15 molal samples.
- Long term strength is more in case of 12.5 molal samples.
- Maximum 3 day strength attained by activated sample is 392.7 kPa, which is 3.25btimes more than that attained by fly ash treated samples.
- Maximum 7 day strength attained by activated sample is 546.88 kPa, which is 2 timesnmore than that attained by fly ash treated samples.
- Maximum 28 day strength attained by activated sample is 977.09 kPa, which is 2.7 times more than that attained by fly ash treated samples.
- There is a strong dependency between the activator/ash ratio and mechanical strength. Results showed that it is advantageous to reduce this ratio since it has a positive effect on strength results, which has also a positive effect on final cost.
- Lowering the viscosity of the grout mixtures to similar values to that of cement grout can have a negative effect on final strength, since it demands an increase in the activator/ash ratio. Therefore, it is recommended that a compromise is made between an optimum viscosity level and the lowest activator/ash ratio possible, whenever the viscosity is a key issue for a particular application.
- Alkali-activated fly ash can be used effectively as a chemical stabiliser for stabilizing expansive soils.

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