GEO-ENGINEERING PROPERTIES OF SEDIMENTED FLYASH BED STABILIZED BY CHEMICAL COLUMNS

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ABSTRACT: Ash ponds cover up enormous stretches of valuable land and accounts environmental problem. Adaptation of appropriate in-place stabilization technique may bring about enhancement in the geotechnical properties of the ash deposit as a whole, transforming it into a worthy construction site. In this present experimental program, large-scale laboratory model test tank of diameter 105 cm with 120 cm height has been filled with ash slurry at 70% water content with a centrally installed chemical column of sodium hydroxide (1% of NaOH by dry weight of the ash in the bed) having a diameter of 20cm. Undisturbed samples were collected from different radial distances of 15cm, 25cm, 35cm and 45 cm after curing periods of 7, 30, 60 and 90 days and the in-situ water content, dry density, unconfined compressive strength and hydraulic conductivity were measured. This method has been found more efficient in increasing the unconfined compressive strength and reducing hydraulic conductivity of the ash deposits in addition to altering other geotechnical parameters like in-situ water content and dry density. A substantial increment in strength was noticed up to a radial distance of 2D (where D is the diameter of the chemical column) from the center of the column.

KEYWORDS: flyash, chemical column, unconfined compressive strength, hydraulic conductivity.

1 INTRODUCTION: The exponential increase in the generation of fly ash in India has been reached up to 170 million tons per every year posturing serious disposal problems and environmental issues. It is calculated that, in India, about 20,000 hectares of valuable land is covered with abandoned ash ponds. These ash deposits possess very low density, high compressibility, and poor bearing capacity, and are generally considered inappropriate for any construction activity. However, it may be feasible to use some suitable in-situ stabilization techniques to enhance the geotechnical properties of the ash deposits as a whole converting it to a construction worthy site.

In-situ chemical stabilization is a promising method of stabilization to improve the geotechnical parameters of soft compressible ground. Available literature is very scarce. Here are few literatures on in-situ chemical stabilization technique. Rajasekaran and Rao (1997) conducted laboratory tests on stabilization of marine clay by lime column technique. It is reported that a significant enhancement of engineering properties occurred due to migration of lime from lime injection zone. Hua and van Deventer (2002) observed significant increases in compressive strength when NaOH and KOH mixed together with flyash, kaolinite, and albite. It is also observed that when a calcined source material (i.e. fly ash) is added it not only improved the compressive strength, but also a substantial reduction in reaction time. Granizo et al. (2002) observed that the alkali activation of metakaolin (MK) by injecting calcium hydroxide $Ca(OH)_2$ to the raw MK produces a different reaction structure and C-S-H gel form. Kamarudin et al. (2011) studied the early age strength gain for kaolin at day-1 and day-2 of curing. It is noticed that when NaOH concentration increases from 8M to 12M the strength increases but the strength drops at 14M of solution due to higher concentration.

Several efforts have been made to enhance the geo-engineering properties of fly ash by mixing lime and chemicals through mechanical mixing method. Joshi et al. 1975; Usmen and Bowders 1990; Malhotra 1994; Ghosh and Subbarao 2001 and 2006 have studied various geo-engineering properties of fly ash mixed with different chemicals. However, mechanically excavating and mixing is cumbersome and expensive. The lime column technique is suitable as an alternative approach but it gives later age strength and very slow migration of lime. Therefore an attempt has been made to improve the geoengineering properties of sedimented ash deposits by in-place chemical stabilization technique. It may improve the geo-engineering properties of ash deposits at a early age of curing such that the massive ash pond sites become construction worthy site.

2 MATERIALS

2.1 Fly Ash and Alkali

The fly ash used in this experimental work was brought from Adhunik Metaliks Ltd. Rourkela. Its gradation and chemical composition are given in Figure 1 and Table1 respectively. Sodium hydroxide (NaOH) pellets having 99% purity was used in this test programme.

3 EXPERIMENTAL PROGRAM

3.1 Preparation of Model Test Tank

In the present study, a large circular galvanized iron test tank is used having diameter 105 cm and 120 cm height open at the top shown in Fig. 2. In order to prepare sedimented fly ash bed, approximately 1 ton of fly ash sample was used and the quantity of water essential for flow able fly ash slurry is determined from step-by-step water addition. The optimum moisture content without bleeding of water from the fly ash was based on eye judgment, and it was found to be 70%. Before placing slurry in the test tank, a steel casing with GI mesh of small aperture will be placed exactly at the center of test tank. The test tank is covered with polythene sheets, and the ash will be allowed to remain in place for an initial sedimentation period of 30 days to facilitate sedimentation and consolidation under self-weight.

3.2 Installation of Chemical Column

At the completion of initial sedimentation period of 30 days, the NaOH of 1% by dry weight of flyash was mixed thoroughly and poured into the perforated GI mesh having 20 cm diameter. Thus, a column of NaOH was neatly installed at the center of the ash bed. The samples were collected at different radial distances 15cm, 25 cm, 35cm, and 45cm from the centre of the chemical column after 7 days, 30 days, 60 days and 90 days of curing.

3.3 Details of Test Program

After specified curing period samples were subjected to following laboratory tests in addition to finding out the in-situ density and moisture contents.

3.3.1 Unconfined Compressive Strength Test

Undisturbed samples of 50mm diameter and 100mm height were collected by introducing thin wall samples in the test tank at specified locations at the end of each curing period. The tests were conducted according to IS: 2720 (Part-10) 1991 and the average value of three samples are reported.

3.3.2 Hydraulic Conductivity Test

Undisturbed specimens collected from different locations after specified curing periods were subjected to falling head test according to IS: 2720(Part-17) - 1987.

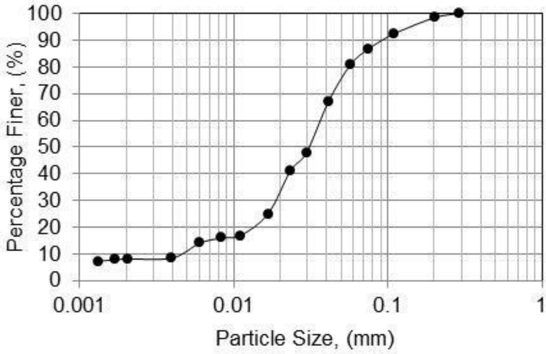
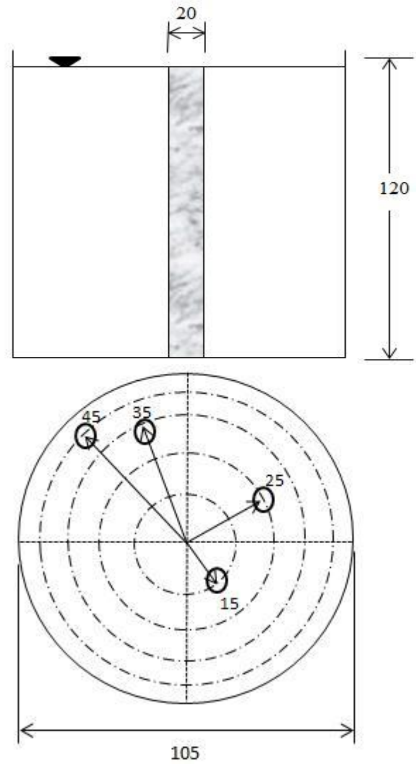


Fig. 1 Gradation Curve of Flyash

Table 1 Chemical Composition of Fly Ash

Constituents	Percentage	Constituents	Percentage
SiO_2	59.2	MgO	1.3
Al_2O_3	17.9	SO_4	1.2
Fe_2O_3	9.5	Unburnt Carbon	7.0
CaO	3.2	Others	0.7



All dimensions are in cm

Fig. 2 Details of Model Test Tank Showing All Sampling Locations

4 RESULTS AND DISCUSSION

4.1 In-situ Water Content and Dry Density

The in-situ water content and dry density at different radial distance and curing period are shown in Fig. 3, Fig. 4, Fig. 5, and Fig. 6. It is observed that due to continuous migration of chemicals from the column and formation and deposition of hydration products the dry density continuously increases whereas the in-situ m/c decreases. These changes are more prominent up to a radial distance of 2D (where D is the diameter of the chemical column).

4.2 Unconfined Compressive Strength

The unconfined compressive strength determined at radial distances of 15, 25, 35, and 45cm after 7, 30, 60 and 90 days of curing are shown in Fig. 7 and Fig. 8. A significant increment in strength is observed up to a curing period of 60 days thereafter no appreciable increase in strength is noticed. These changes are more prominent up to a radial distance of 2D beyond this no substantial increase in strength is noticed. This is because of distribution of migrated chemicals over a larger area as the radial distance increases.

4.3 Hydraulic Conductivity

The hydraulic conductivity of sedimented ash deposits collected from radial distances of 15, 25, 35, and 45cm after 7, 30, 60 and 90 days of curing are determined and these are presented in Fig. 9 and Fig. 10. It is observed that at a given curing period the hydraulic conductivity is the minimum at locations closer to the column and the same increases with increase in the radial distance. Further as expected the hydraulic conductivity at a given location decreases with the increase in curing period. This is due to the reaction of NaOH with flyash and formation alumina-silicate gel which reduces the capillary voids. This in turn reduces the hydraulic conductivity.

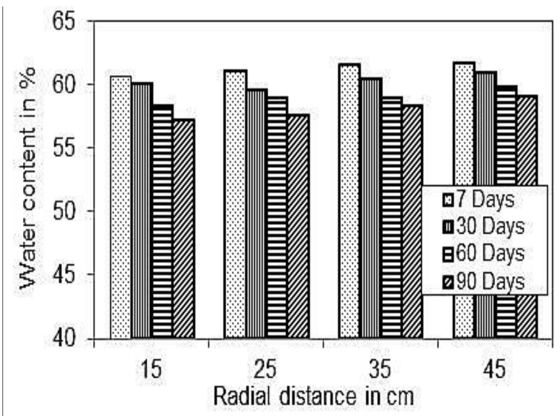


Fig. 3 Variation in In-situ Water Content at Different Radial Distances

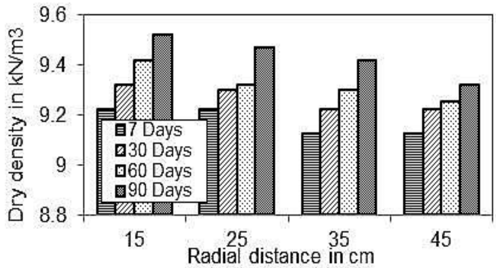


Fig. 4 Variation in In-situ Dry Density at Different Radial Distances

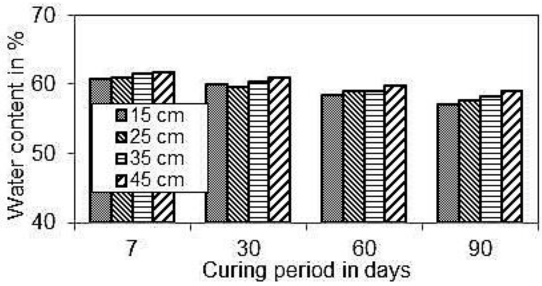


Fig. 5 Variation in In-situ Water Content at Different Curing Periods

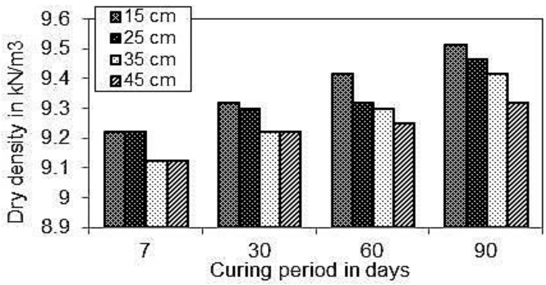


Fig. 6 Variation in In-situ Dry Density at Different Curing Period

5 SUMMARY AND CONCLUSIONS

Chemical stabilization of sedimented ash deposits by mechanical mixing is cumbersome and expensive; emphasis has been done in the application of the in-place chemical column technique for stabilization of sedimented flyash deposits.

It is observed that at a given location the in-situ dry density increases whereas the in-situ moisture content and permeability value is found to decrease with curing period. A substantial increment in strength is observed up to a radial distance of 2D from the center of the column. No substantial increase in strength is noticed after a curing period of 60 days. This technique is found effective in increasing the unconfined compressive strength and reducing hydraulic conductivity of the ash deposits in addition to altering other geotechnical parameters like in-situ water content and dry density.

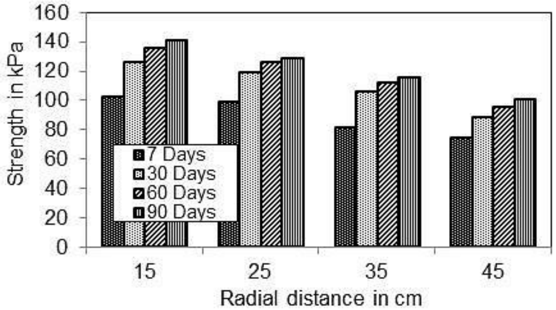


Fig. 7 Compressive Strength Variation in Radial Direction

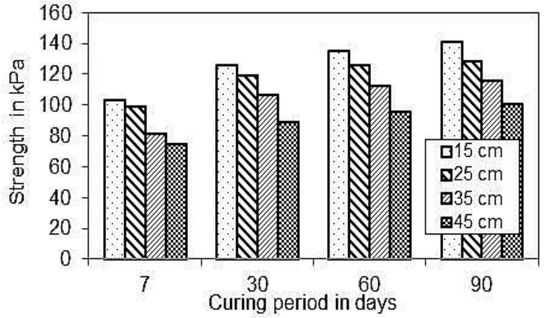


Fig. 8 Compressive Strength Variation at Different Curing Periods

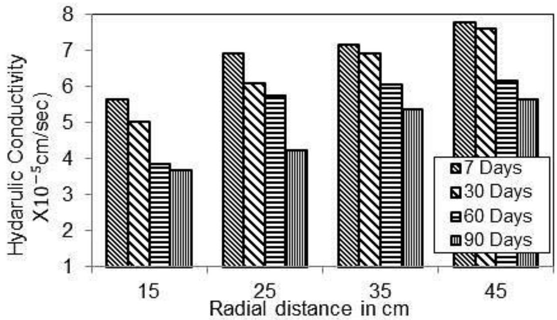


Fig. 9 Variation of Coefficient of Permeability Value with Radial Distance

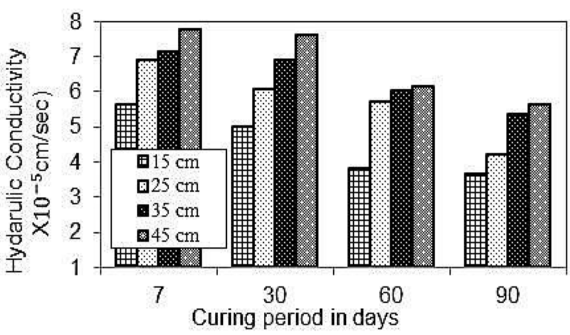


Fig. 10 Variation of Coefficient of Permeability Value with Curing Period

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