STABLIZATION OF EXPANSIVE SOIL USING ALKALI ACTIVATED FLY ASH

Khalid Shafi Paddar[1], Dr. Sachit Vardhan[2]

M.Tech Research Scholar (Geotechnical Engineering)[1], Associate Professor[2]
Department of Civil Engineering
CT University Ludhaina, Punjab.

***Abstract*: In India nearly 51.8 million hectares of land are covered with expansive soil. Because of cohesiveness the property of expansive soil is hard in dry state and soft in wet state. Stabilization of soil is one of the most important aspects in construction industry, which is widely used in foundation and road pavement construction. Materials formed using reactions between silica and alumina and alkali cations such as sodium or potassium are very similar, at a molecular level, with natural rocks. At higher levels the alkali activated materials shows improved mechanical character than cement. The activated fly ash at different alkali concentrations and potassium hydroxide and fly ash ratio also tested. The different geotechnical properties like Atterberg's limits, compaction and strength behavior of stabilized soil were tested. It is observed that with the addition of alkali activated fly ash there is a considerable improvement in geotechnical properties expansive soils.**

***Keywords*: Expansive soil. Alkali activated fly ash. Unconfined compressive strength (UCS) . Rheological properties.**

Introduction

Expansive soils also known as swelling soils or shrink-swelling soils are the terms for those soils which tend to swell and shrink with moisture content variations. As a result of which there is considerable distress in the soil, which causes serious damage to the soil Upper structure. During the monsoon, these soils absorb water, swell, become smooth and fluffy The capacity to carry water is less, as these soils shrink and become drier in seasons Hardier with water evaporation. These soil types are generally found in arid and semi-arid soils Arid areas of the planet are considered as a possible natural disaster unless treated Okay, not only the structures built on them can cause significant damage, but also This causes loss of life. Soils which generally contain clay minerals montomorillonite show off those lands. The annual damage costs to the civil engineering structures In the United Kingdom, these soils are estimated at $150 million, in the United States at $1,000 million and in the United States. Hundreds of billions of dollars the world over. Expansive soils also known as Black soils or Black Cotton soils and Regur soils are Dropping on the Deccan Lava Tract like Maharashtra, Madhya Pradesh,Gujarat, Andhra Pradesh and the Indian sub-continent, in several parts of Odisha. Schwarz Cotton soils are also present in the Tapi, Krishna, Godavari, and Narmada river valleys. In the Frame The north-west part of the Deccan Plateau and the upper part of Krishna and Godavari.The depth of the black soil is massive. These soils are basically residual soils left at the place of Its formation following chemical rock decomposition, such as basalt and pit. So these too The soil type is formed by the weathering of the igneous rocks and the cooling of the lava after a Volcanic rash. Such soils, however, are rich in lime, iron, magnesia and alumina. Phosphorus, organic matter, and nitrogen. Their colour ranges from black to brown chestnut and is generally strong Particles sized to clay. On average, 20 per cent of our country's total land area is occupied by Spread soils. Owing to their preservation of moisture these soils are ideal for drying Agriculture and suitable for growing cotton, cereals, rice , wheat, jowar, oilseeds and citrus fruit And the fruits, cigars and tobacco Damage due to swelling activity has been clearly observed over the last few decades Semiarid areas, in the form of pavements cracking and breaking, highways, building Foundations, slab-on-grade materials, canal and tank linings, irrigation systems, water Lines, and line sewing.

Fly ash is waste material, extracted from a coal fired furnace's flue gases. They are very similar to the volcanic ashes used as hydraulic cements. Back in ancient times, These volcanic ashes have been considered one of the best pozzolans used up to now, in this world. The demand for electricity now has a day due to rapid urbanization and industrialisation It has resulted in the development of several thermal power plants.These thermal power plants use coal to generate electricity, and after burning the coal Some mineral residue left is called Fly ashes. These ashes are picked from the fly Plant static electro precipitator (ESPs Secure disposal and control of fly ash are the two major problems that affect the Made of fly ash. The waste created from the industries generally possesses Quite complex features which are very unsafe, so safe and protected Effectively dispose of such waste, so that it does not disturb the atmosphere and does not disrupt the system Natural and human life causes any catastrophe. Pre-treatment should be provided Until disposal and storage of such industrial waste; otherwise it will cause Pollution to the climate.) The fly ashes are generally micro-sized particles consisting essentially of alumina, silica and iron. And iron. Generally speaking, these particles are spherical in size which makes them easy to flow and Mix, to make an acceptable mixture. The fly ash has both amorphous and crystalline character Minerals. Its composition varies according to the character of the burned coal and is essentially A fine silt which is not plastic. Currently fly ash production is far beyond its utilization. Fly ash also serves as a possible waste liner material. Lime and bentonite combined, Ash from fly can also be used as a barrier material.

Literature Review

Stabilization is one of the way in which the expansive soil are managed to suit them Building: Building. Stabilizer variety can be split into three classes (Petry 2002):

(a) Modern stabilizers (lime, cement, etc.)

(b) Fly ash, quarry mud, by-product stabilizers,

(c) Non-traditional stabilizers (sulfonated oils, potassium compounds, Polymers, Enzymes, ammonium chlorides, etc.). Deletion of significant quantities of Industrial by products as fillings at disposal sites adjacent to industries does not only require large quantities Space but also cause a lot of problems with the geo-environment. Different attempts are being made Organizations and researchers have the best places to use them in bulk. Expansion stabilisation Soil is one way to make good use of these. Much of the analysis work that is performed by Earlier investigators have been listed below.

Srivastava et al. (1997) studied the change in micro-structure and expansive soil fabric due to add fly ash and lime sludge from SEM photograph and microphone changes find Structure and cloth were applied to vast soil by applying 16 per cent fly ash and 16 per cent lime sludge.

Srivastava et al. (1999) also summarized the findings of experiments conducted to research the Consolidation and swelling of expansive, lime-sludge and fly-ash soil and with 16 percent of fly ash and 16 percent of lime sludge, the best stabilising effect was achieved.

Cokca. (2001) used as much as 25% of Class-C fly ash (18.98% of CaO) and the treated specimens we were healed for seven days and 28 days. After 7 days, the swelling pressure decreases by 75 per cent Healing days and 79 percent with 28 days of healing at 20 percent adding fly ash.

Pandian et al. (2001) endeavored to stabilize vast soil with a class – Fly ash And found that fly ash could be an effective additive (approximately 20 percent) for improving the CBR Significantly black cotton soil (about 200 per cent).

Turker and Cokca. (2004) used fly ash class C and Class F along with sand for Expansive soil stabilisation. Class C fly ash was more powerful and free than expected Swell with cure time decreased. The best performance with soil, Class C was observed Fly ash and sand as 75%, 15% and 10% after 28 days of healing, respectively.

Baytar (2005) used fly ash and desulpho- to study the stabilisation of expansive soils Gypsum produced by 0 to 30 per cent from thermal power plants. Varying lime percentage The vast soil-fly ash-desulphogypsum mixture was applied to 8 per cent). The specimens were treated Healed for 7 days, and 28 days. Swelling percentage dropped and swelling rate increased with Rising percentage of stabilisers. Curing resulted in additional decrease in swelling percentage And the swelling was decreased by 25 per cent fly ash and 30 per cent desulphogypsum additions Comparable percentage to lime stabilisation rate.

Sabat et al. (2005) said fly ash-marble powder could boost engineering Expansive surface properties and optimum soil proportion: fly ash: marble powder 65:20:15 See below.

Wagh (2006) used separately and in combination fly ash, rock flour and lime The proportion of black cotton soil from Nagpur Plateau, India stabilized. Whether adding rock-flour or Fly ash or both together to the black cotton soil to some extent improve the CBR and the shearing angle Despite decreased cohesion the resistance increased. But besides rock-flour and fly ash when Lime is mixed with black cotton soil CBR value increases significantly with both cohesion increase And immune to friction.

Phani Kumar and Sharma (2007) explored the effect of fly ash on a highly plastic swelling Another non-expansive high plasticity clay is expansive clay and compressible. Swelling Potential and swelling strain, if the sample weight is constant dry unit (Mixture), decreased by almost 50 per cent, compression index and secondary coefficient Consolidation of both the clays decreased by 40% at 20% fly ash content.

Kumar et al. (2007) studied the impact of inclusions of polyester fibers and lime stabilisation on Geotechnical properties of fly ash-expanding mixtures of soil. Lime and ash from flight were added 1–10 percent and 1–20 percent to abundant soil, respectively. The experiments with Optimum fly ash and chalk content (15 percent fly ash and 8 percent chalk) based on Added compaction, non-confined compression and split tensile strength with 0, 0.5, 1.0, 1.5, and 2 percent by weight of plain and crimped polyester fibres. Soil-fly ash-limestone MDD. The mixtures decreased with fly ash and lime content increased. Fibers of polyester (0.5–2.0 per cent) the fly ash-soil-lime-fibre mixtures had no major impact on MDD and OMC. All the same, through the addition of fibres, unconfined compressive strength and split tensile strength improved.

Buhler et al. (2007) researched the stabilisation of vast lime and Class C fly soils Ash. Linear shrinkage reduction was better with lime stabilisation compared with the same percentage of fly ash in class C.

Methodology

The soil was collected by the method of disturbed sample and placed into sacks to the laboratory after removing the top soil at 500 mm depth. Some amount of soil is sealed and placed into polythene bag for determining the moisture content. The soil is air dried, pulverized and sieved with 4.75 mm sieve. The soil is passed through this sieve and is used for laboratory tests. The geotechnical characterization of soil sample as per ASTM standards as shown in Table 1. The Coefficient of uniformity (CU) of the soil is 2.43, Coefficient of curvature (CC) is0.51, Specific gravity is 2.64, maximum dry density is 15.19 KN/m³, optimum moisture content is 23.31% and natural moisture content is 7.11%, natural moisture content is 7.11%, Free swell index 100%, liquid limit is 72%, plastic limit is 21% , Swelling pressure is 6kg/cm² As per the ASTM the soil is classified as clay.

The sodium silicate was originally in powder form and having molecular weight of 284.20 gm/mole, and specific gravity of 1.5. While the sodium hydroxide was originally in flake form with a molecular weight of 40gm/mole, and specific gravity of 2.13 at 20ºC and purity of 95-99%.1 mole of sodium silicate solution was prepared by adding the 284.20 gm of sodium silicate powder to 1 litre of distilled water. Sodium hydroxide of different concentrations of 10, 12.5 and 15 molal were prepaid before testing. In the present study the ratio of sodium silicate to sodium hydroxide solution by mass was kept as 2 as per Hardijito and rangan(2005), Criado et al. (2007) and villa et al. (2010) as a guide line.

Three different fly ash percentages regarding the total solids (soil + fly ash) weight, were used 20, 30 and 40% corresponding to ash/soil ratios of 0.25, 0.43, and 0.67 moreover to study the effect of activator on the gain in mechanical strength, the activator/total solids ratios are kept as 0.15, 0.2 and 0.25, respectively with each percentage of fly ash mixed with the soils.

The marshal funnel viscometer is used to calculate the viscosity of both cement and alkali activated grouts .by using this we can measure the time taken for a known volume of liquid to flow from the base to the bottom end of the inverted funnel.

Results

Results of stabilizing expansive black cotton soil, with fly ash triggered with alkali. The improvement in strength requirement is determined by performing unconfined sample compression tests at 3, 7 and 28 days of healing. The casted samples were 50 mm in diameter and 100 mm in height, thus ensuring an L/D ratio as 2. Such samples contain fly ash by weight of dry mass and operation in 20, 30 and 40 per cent of The dry mass and overall solid activator ratio ranges between 15%, 20% and 25%. Upon casting all the samples is coated with cling film and are held for 48 hours in an airtight container. The samples were removed from the moulds after 48 h and covered in cling film and left at ambient temperature and humidity (50–60 percent RH and 32–35°C). At 3, 7 and 28 days The samples were trimmed to 100 mm in length and tested on an Aimil hydraulic measuring system for unconfined compressive strength (UCS) at a constant strain rate of 1.2 mm / min. Every single result that was obtained was an average of 3 samples tested.

Table 4A.1 UCS results of AF-100-20-15, AF-100-30-15, AF-100-40-15

Curing time (Days)	Unconfined compressive strength (kPa)		
	AF-100-20-15	AF-100-30-15	AF-100-40-15
3	195.43	175.91	140.54
7	253.30	179.25	131.45
28	436.66	195.29	128.92

Table 4 A.2. UCS results of all 10 molal sample

Curing time (Days)	Unconfined compressive strength (kPa)								
	AF-100-20-15	AF-100-30-15	AF-100-40-15	AF-100-20-20	AF-100-30-20	AF-100-40-20	AF-100-20-25	AF-100-30-25	AF-100-40-24
3	195.43	175.91	140.54	311.32	392.5	322.81	103.93	94.74	85.47
7	253.30	179.25	131.45	350.44	462.54	546.33	130.12	146.95	112.06
28	436.66	195.29	128.92	407.76	580.26	810.1	238.71	215.73	232.76

Table 4A.3 UCS results of all 12.5 molal sample

Curing time (Days)	Unconfined compressive strength (kPa)								
	AF-125-20-15	AF-125-30-15	AF-125-40-15	AF-125-20-20	AF-125-30-20	AF-125-40-20	AF-125-20-25	AF-125-30-25	AF-125-40-25
3	114.52	158.84	187.01	307.25	196.43	287.12	128.43	114.21	113.65
7	220.1	152.21	250.23	230.65	293.89	419.32	154.65	179.56	192.34
28	364.37	221.59	399.45	548.87	590.74	977.76	317.44	555.32	852.34

Table 4A.4. UCS results of all 15 molal sample

Curing time (Days)	Unconfined compressive strength (kPa)								
	AF-150-20-15	AF-150-30-15	AF-150-40-15	AF-150-20-20	AF-150-30-20	AF-150-40-20	AF-150-20-25	AF-150-30-25	AF-150-40-25
3	288.34	247.43	160.45	207.32	239.39	171.31	111.34	98.73	75.43
7	339.5	428.83	503.58	361.86	450.43	503.48	138.52	181.69	256.55
28	579.45	603.23	643.26	396.53	715.42	643.56	182.35	465.54	296.5

The variation of strength obtained for 15 molal activator content and 20, 30 and 40% fly ash content mixed soil samples, after 3, 7 and 28 days curing periods is shown in Table 4A.4.

Conclusions:

Based on the results obtained, the following conclusions can be made.

- The unconfined compressive strength of soil is found to vary with concentration of chemical in the activated fly ash and curing period. The 10 molal samples give better strengths of 3 and 7 days than 12.5 and 15 molal samples, making it cost-effective compared with 12.5 and 15 molal samples. In the case of 12.5 molal samples the long-term reliability is greater.
- The overall 3 day intensity of the disabled sample is 392.7 kPa, which is 3.25 times greater than that of the samples treated with fly ash.
- The average intensity of 7 days obtained by the disabled sample is 546.88 kPa, which is 2 times greater than that reached by the samples
- The average 28 day intensity of the disabled sample is 977.09 KPa, which is 2.7 times greater than that of the samples treated with fly ash.
- The activator / ash ratio and the mechanical strength are strongly dependent.
- Results showed that rising this ratio is beneficial because it has a positive effect on intensity outcomes, which also has a positive effect on final cost.
- Reducing the viscosity of the grout mixtures to values close to that of cement grout can have a negative impact on the final strength because it involves an increase in the activator / ash ratio. It is therefore recommended that a compromise be made between an optimal degree of viscosity and the lowest possible activator / ash ratio, if the viscosity is a key problem for a specific application.
- Alkali-activated fly ash can be used as a chemical stabilizer to maintain vast soils effectively.

Refrences

[1] Chen, F. H. (1975). *Foundations on expansive soils*, Elsevier Science, Amsterdam, The Netherlands.

[2] Chew, S. H., Kamaruzzaman, A. H. M. and Lee, F. H. (2004), Physicochemical and Engineering Behavior of Cement Treated Clays, *Jl of Geotech.andGeoenv. Engineering, ASCE,* 130 (7), 696–706.

[3] Chindaprasirt P, Chareerat T, Hatanaka S, Cao T (2011) Highstrength geopolymer using fine high-calcium fly ash. J Mater Civ Eng 23(3):264

[4] Chindaprasirt P, Jaturapitakkul C, Chalee W, Rattanasak U (2009) Comparative study on the characteristics of fly ash and bottom ash geopolymers. Waste Manag (New York, NY) 29 (2):539–543.

[5] Cokca, E. (2001). Use of class C fly ash for the stabilization of an expansive soil. *Jl. Of Geotech.andGeoenv. Engineering, ASCE*, 127 (**7**), 568–573.

[6] Criado M, Fernández-Jiménez A, De la Torre AG, Aranda MAG, Palomo A. An XRD study of the effect of the SiO_2/Na_2O ratio on the alkali activation of fly ash. Cem Concr Res 2007;37:671–9.

[7] Croce P, Flora A. Analysis of single-fluid jet grouting. In: Raison CA, editor Ground and soil improvement. Thomas Telford; 2004. p. 177–86.

[8] Desai, I. D. and Oza, B. N. (1997). Influence of anhydrous calcium chloride on shear strength of clays. *Symp. on Expansive Soils*, Vol. 1, 17–25.

[9] Edil, T. B., Berthoueux, P. M. and Vesperman, K. D. (1987). Fly ash as a potential waste liner. *Proc., Geotechnical Practice for Waste Disposal*, R. D. Woods, ed., ASCE, New York, 447–461.

[10] Escalante-Garcia JI, Espinoza-Perez LJ, Gorokhovsky A, Gomez-Zamorano LY. Coarse blast furnace slag as a cementitious material, comparative study as a partial replacement of Portland cement and as an alkali activated cement. Construct Build Mater 2009; 23: 2511–7.

[11] Essler R, Yoshida H. Jet grouting. In: Moseley MP, Kirsch K, editors. Ground Improvement. Spon Press; 2004. p. 160–96.

[12] Gourly, C.S. Newill, D. and Schreiner, H. D. (1993). Expansive soils: TRL"s research strategy. *Proc., 1st Int. Symp. on Engineering Characteristics of Arid Soils*.

[13] Hardjito D, Rangan BV. Development and properties of low-calcium fly ash based geopolymer concrete – research report GC 1. Perth; 2005.

[14] Holtz, W. G. and Gibbs, H. J. (1956). "Engineering properties of expansive clays." *Trans. Am. Soc. Civ. Eng.*, Vol 121**,** 641–677.

[15] Locat, J., Berube, M. A. and Choyuette, M. (1990), Laboratory Investigations on the Lime Stabilization of Sensitive Clay: Shear Strength Development, *Canadian Geotechnical Journal*, 27, 294–304.

[16] Palomo, A., Grutzeck, M.W. and Blanco M.T. (1999), Alkali-activated fly ashes A cement for the future, *Jl. of Cement and Concrete Research, Elsevier Science Ltd.*, 29, 1323-1329.

[17] Phani Kumar, B. R., Naga Reddayya, S. and Sharma, R. S. (2001). Volume change behavior of fly ash-treated expansive soils. *Proc., 2nd Int. Conf. on Civil Engineering*, Indian Inst. of Science, Bangalore, India, Vol. 2, 689–695.

[18] Rollings, M. P. and Rollings, R. S. (1996). *Geotechnical materials in construction*, McGraw–Hill, New York.

[19] Romagnoli M, Leonelli C, Kamse E, Lassinantti Gualtieri M. Rheology of geopolymer by DOE approach. Constr Build Mater 2012;36:251–8.

[20] Sridharan.A. Pandian, N. S. and Rajasekhar, C. (1996). Geotechnical characterization of pond ash. *Proc., Conf. on Ash Ponds and Ash Disposal Systems*, Indian Inst. of Technology, New Delhi, India, 97–110.

[21] Villa C, Pecina ET, Torres R, Gómez L. Geopolymer synthesis using alkaline activation of natural zeolite. Constr Build Mater 2010:24:2084–90.

[22] Winnefeld F, Leemann A, Lucuk M, Svoboda P, Neuroth M. Assessment of phase formation in alkali activated low and high calcium fly ashes in building materials. Constr Build Mater 2010;24:1086–93.