STABILIZATION OF EXPANSIVE SOIL USING FLYASH AND LIME

B Indrani Parimala[1],B Ganesh[2],Dr. R Chitra[3],Shahidnoor[4]
[1]M.tech Student, Roll no-14961D1901, Lenora College of Engineerng, Rampachodavaram
[2]Asst. Professor of Civil Engg, Lenora College of Engineering, Rampachodavaram
[3]Group head (Soil, Rockfill & Geosynthetics), CSMRS, New Delhi
[4]Scientist C, CSMRS, New Delhi

Abstract

Historical changes are evidence for occurring in the world from Egyptian pyramids to the today's world twin tower, for any change in structural development depends on deep study of soil existing by civil engineers.Expansive soil which is one among the problematic soils is a term used for any soil that has a high potential for shrinking or swelling due to any change of moisture content.

Understanding this expansive soil and adopting the appropriate remedial measures to modify the soil or to reduce its detrimental effects if expansive soils are identified in a project. The motive of this project is to improve the properties of the expansive soil and to study the effectiveness of the additives on the expansive soil geotechnical characteristics. In this research work the findings of laboratory test performed at CSMRS for stabilization of problematic soil in Subarnarekha main canal are presented. Two additives were elected Flyash from Parichha thermal power station and hydrated lime and mixed with the soil in various percentages. The results highlights that the expansive soil becomes effective mixed with fly ash along lime.

Keywords: Expansive soil, swelling characteristics, stabilization, fly ash, hydrated lime, MDD, OMC, UCC

1. INTRODUCTION

The soil is considered as a complex material, even when dates back to prehistoric time every engineer try to make use of the soil as construction material for various purposes. In the eve of soil improvement conferences have given a big boost to the soil engineers to perform reams of research in order to improve the soil characteristics and develop stable skyscrapers Deformation due to the expansive soil is significantly greater than elastic deformations and these cannot be predicted by the classical elastic and plastic theory. Movement is usually in an uneven pattern developed by expansive soil with magnitude to cause extensive damage to the structures resting on them. The detrimental effects can be reduced, once identified the type of soil as expansive using requisite tests before the construction stage. The expansive nature of soil is most obvious near the ground surface where the profile is subjected to seasonal, environmental changes. Most of expansive soil exist with properties like low bearing capacity, low shear strength and high compressibility, low permeability and unfit for using it as construction material for embankments etc.

Fly ash: Fly ash is a fairly divided residue which results from the combustion of ground or powdered bituminous coal or sub- bituminous coal like lignite and transported by the flue gases of boiler fired by pulverized coal or lignite.

Chemical properties of fly ash include chemical composition, pH values, lime reactivity, and Cation exchange capacity. In general the chemical composition of the fly ash constitutes silicon dioxide, aluminium oxide, ferric oxide calcium oxide, magnesium oxide, composition compounds differ with sources of production of fly-ash. The

uranium concentration of the fly ash ranges from 63.4 to 79.2 ppm.

Hydrated Lime: It is a colourless crystal or white powder and is obtained when calcium oxide (called *lime* or *quicklime*) is mixed, or "slaked" with water. It is large enough that it will partially dissolve and release hydroxyl anions (OH^-) in solution according to the following reaction:

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2\ OH^-$$

Laboratory Identification

Laboratory identification tests for expansive soils includes grain size analysis, Atterberg's limit, swelling pressure, free swell index, light compaction, permeability test,unconfined compression test, one dimensional consolidation etc.are performed in the laboratory as per IS specifications

2. LITERATURE REVIEW

Erdal Cokca (2001) studied the effect of flyash on expansive soil. He carried out investigations using soma fly ash and Tuncbilek fly-ash andadded it to expansive soil at 0-25%. Specimens with flyash were cured for 7days and 28 days after which they were subjected to odeometer, free swell tests. And his experimental findings confirmed that the plasticity index, activity and swelling potential of the samples decreased with increasing percent stabilizer and curing time and the optimum content of flyash in decreasing the swell potential was found to be 20%. The changes in the physical properties and swelling potential is a result of additional silt size particles to some extent and due to chemical reactions that cause immediate flocculation of clay particles and the time dependent pozzolanic and self-hardening properties of flyash and he concluded that both high calcium and low calcium class C fly ashes can be recommended as effective stabilizing agents for improvement of expansive soils.

Pandian (2002) studied the effect of two types of fly ashes Raichur fly ash (class F) and Neyveli fly ash (class C) on the CBR characteristics of the black cotton soil. The fly ash content was increased from 0 to 100%. The addition of fly ash to black cotton soil increased the CBR of the mix up to the first optimum level. Further addition of fly ash beyond the optimum level caused a decrease up to 60% and then up to the second level there was an increase. In Neyveli fly ash there was an increase of strength with the increase in the fly ash content, here there will be additional pozzolanic reaction forming cementitious compounds resulting in good binding between black cotton soil and fly ash particles.

Monica Malhotra, Sanjeev Naval (2013) has conducted an experimental study on stabilization of expansive soils using low cost materials with lime and fly ash. This study resulted in it change of the expansive soil texture takes place. When lime & fly ash are mixed with the expansive soil, the plastic limit increases by mixing lime and liquid limit decreases by mixing fly ash, which decreases plasticity index and by adding lime and fly ash, it lead to increase in the different properties and Atterberg's limits.

3. METHODOLOGY

Materials used

Expansive soil: Expansive soil sample is taken from Subarnarekha main canal basin. The soil was air dried and pulverized manually. Natural soil has the swelling and shrinkage properties in the present of moisture. This expansive soil is yellow and light grey in colour. Basic properties of the natural untreated expansive soil used in experiment work are presented in table 3.1.

Table. 3.1 Properties of Expansive soil

S.no	Properties	Values
1	Clay content	87.9 %
2	Silt content	3.9
3	Fine sand	4.8
4	Medium sand	3.4
5	Classification of soil	CH
6	Liquid limit	69.2 %
7	Plastic limit	25.3 %
8	Plasticity Index	43.9 %
9	Shrinkage limit	10.1
10	Specific gravity	2.55
11	Free swell index	67%
12	MDD	1.78 g/cc
13	OMC	12.4 %
14	UCS	1.52 kg/cm²
15	Swelling Pressure	1.70 kg/cm²

Fly ash:The flyash sample collected from Parichha thermal power station. It resembles a pozzolanic substance which although not cement itself contains constituents which when

combines with the lime forms a material having cementing properties. The chemical and engineering properties of fly ash are presented in table 3.2

Table.3.2: Engineering properties of Fly ash

S.no	Properties	Values
1	Loss of Ignition	1.75
2	Silica (SiO_2)	56.12
3	Mixed Oxide (R_2O_2)	28.02
4	Total Chloride	0.035
5	Calcium Oxide (CaO)	10.54
6	Magnesium Oxide	1.19
7	Na (as Na_2)	0.23
8	K (as Na_2)	0.46
9	Classification of Fly ash	C
10	Silt content	53.58%
11	Fine sand	43.16%
12	Medium sand	3.26
13	Liquid limit	64.8 %
14	Specific gravity	2.06
15	MDD	1.12 g/cc
16	OMC	29 %

Hydrated Lime: It is taken from Rajahmundry, Andhra Pradesh. *Method applied for mixing:* Two sets of expansive soil samples were taken and one was mixed with only fly ash and other with hydrated lime (5%) and fly ash in different percentage proportions. Details of percentage mix are given in table.3.4

Table.3.4: Percentage of Mixes taken

S. No	Mix	5%	10 %	15%	20 %	25%
1	By weight (g)	200	400	600	800	1000
2	By Volume (cc)	208	417	625	833	1042

The fly ash, lime & expansive soil are mixed on dry weight basis in desired proportions. The various tests mechanical analysis, liquid limit, plastic limit, compaction, UCC, permeability, differential free swell index, swelling pressure, and one dimensional consolidation test were performed in laboratory as per IS code standards.

Mechanical analysis: The grain size analysis were performed on expansive soil and soil-additive mixes according to IS 2720 part-4, 1985.

Atterberg's limit: The liquid limit (wl) and plastic limit (wp) and shrinkage limit tests were performed on expansive soil and soil-additive mixes according to IS 2720 part-5, 1985 and IS 2720 part-6, 1972.

Compaction characteristics: The compaction tests to obtain the moisture-densityrelationship of the soil-additive mixtures were conducted according toIS 2720 part-7, 1980.

Unconfined compression strength: The shear strength of the expansive soil and the soil-additive mixes were obtained by the unconfined compression tests performed according to IS.2720 part-10, 1991.

Swelling characteristics: the swelling pressure of the expansive soil and soil-mixes were obtained by performing the consolidometer test according to IS 2720 part-41, 1977.

4. RESULTS AND DISCUSSIONS

Liquid limit

Liquid limit values of the samples declined with percentage enhancement of fly ash along with 5% lime as constant. With 5% of fly ash diminished the liquid limit of the expansive soil by 17.7 % and further reduction continued with the increasing percentage of fly ash. The maximum fly ash added (25%) resulting in 35.5% reduction in liquid limit of expansive soil.

Plastic Limit

Plastic limit of the fly ash added samples lowered narrowly with percentage rise of fly ash. 25% of fly ash resulted themaximum decrement of 23% in the plastic limit of expansive soil.With the 5% lime combined with 5% fly ash, there was a maximum gain of 45% in the plastic limit of the expansive soil and thengradual reduction appeared with raising percentage fly ash. The minimum incrementwas 25% occurred with 5% lime+ 20 % fly ash.

Plasticity index

The plasticity index of the expansive soil decreased on increase in fly ash content. The maximum amount of the fly ash reduced the plasticity index of the expansive soil by 42.4%.

Addition of 5% lime resulted in a sudden fall of plasticity of the soil sample by 79.7%. This is the maximum reduction obtained with 5% lime + 25% fly ash. Hence lime was found as most effective stabilizer, helps to decrease the plasticity.

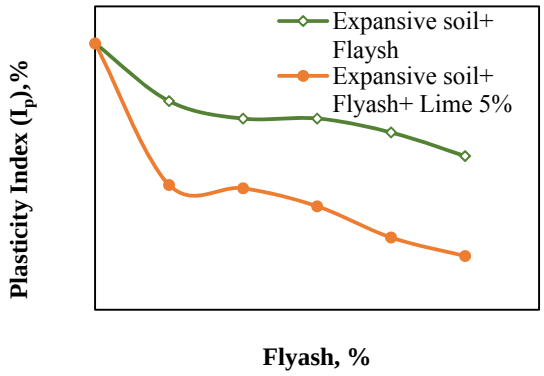

Figure.4.5:
Plasticity index of the soil mixtures.

Compaction Parameters Addition of additives resulted in the minor decremental values of MDD at little bit raise in the OMC with percentage raise of fly ash.From the compaction curves, it can be analysed that the soil with the combination of fly ash showed a consistent decrease in the maximum dry density (MDD) of ES and increase in optimum moisture content (OMC) with ascending percentage of fly ash. And with 5% lime alteration, MDD of soil has diminished narrowly at consistent increment in the OMC. The fly ash of low specific gravity used and the increased resistance offered by the relatively coarser particles present in the fly ash resulted in lowering of MDD. The OMC variation with increasing fly ash content is shown in figure.4.6. The MDD variation with increasing fly ash content is shown in figure 4.7.

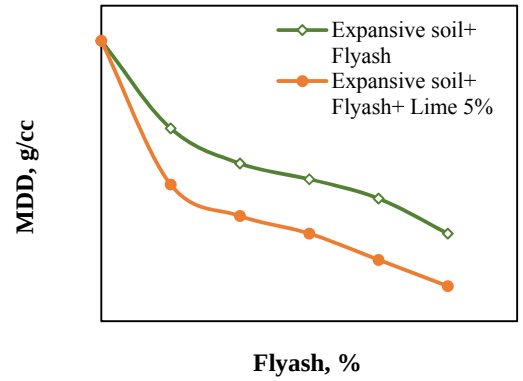

Figure.4.7: MDD of blended soil sample.

Unconfined compressive characteristics

With 5% of fly ash, the UCC value has enhanced by 9.5% and further increment occurred with more percentage of fly ash added. With 25% of fly ash the UCC was raised by 92%. When the lime was combined with fly ash, UCC value increased by 16% on 5% of lime and fly ash. The maximum UCC of the expansive soil gained by 55%. It is evident from the test performed that the utilization of fly ash and in combination of fly ash and lime, the shear strength can be modified. Hence, stability is achieved.

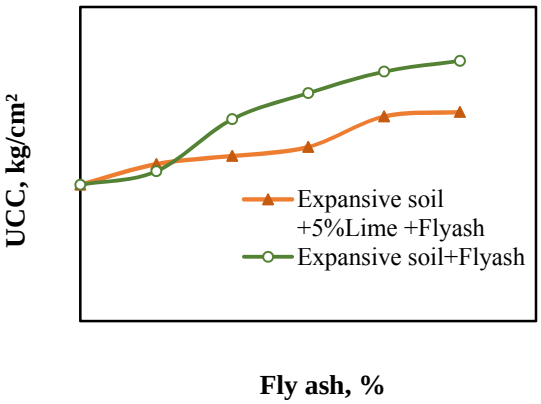

Figure.4.8: The UCC values of blended soil samples.

Swelling Characteristics 5% fly ash degraded the swelling pressure of the ES by 45.9%. In other words, declination continued as per the percentage raise of fly ash.On adding maximum percent i.e. 25% fly ash, the swelling pressure reduced by 92% and the swelling pressure got eliminated when soil-fly ash mixed samples combined with 5% lime. The variation of the swelling pressure values for soil- additive mixtures are shown in figure.4.9.

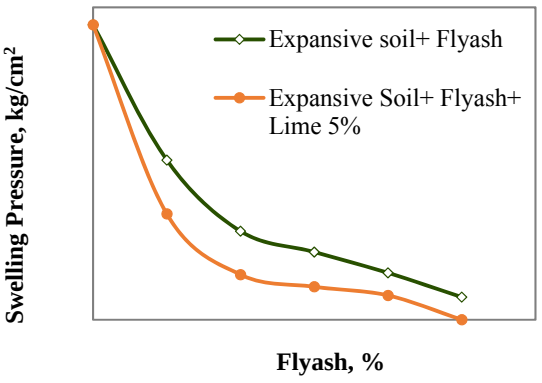

Figure.4.9: Swelling Pressure of the blended soil samples.

The tests results of varying % fly ash and lime with expansive soil is shown in table 4.1

S.No	Type of soil	Liquid Limit, %	Plastic Limit, %	Plasticity Index, %	Swelling pressure, kg/cm^2	Compaction Characteristics		UCC, kg/cm^2
						MDD, g/cc	OMC,%	
1	Expansive soil + 5 % fly ash	56.9	22.5	34.4	0.92	1.71	13.1	1.67
2	Expansive soil + 10% fly ash	52.6	21	31.6	0.51	1.69	14.0	2.25
3	Expansive soil + 15% fly ash	52.2	20.7	31.5	0.39	1.68	14.7	2.54
4	Expansive soil + 20% fly ash	49	19.8	29.2	0.27	1.67	15.0	2.78
5	Expansive soil + 25% fly ash	44.6	19.3	25.3	0.13	1.65	14.5	2.90
6	Expansive soil + 5% Lime + 5% fly ash	57.3	36.7	20.6	0.61	1.68	15.6	1.75
7	Expansive soil + 5% Lime + 10% fly ash	55.9	35.9	20	0.26	1.66	16.7	1.84
8	Expansive soil + 5% Lime + 15% fly ash	51.2	34.2	17	0.19	1.65	16.8	1.94
9	Expansive soil + 5% Lime + 20% fly ash	43.6	31.7	11.9	0.14	1.64	16.8	2.28
10	Expansive soil + 5% Lime + 25% fly ash	42.9	34	8.9	0.00	1.62	16.6	2.34

CONCLUSION

The conclusion drawn from the present investigation is Liquid limit of expansive soil decreases with increasing % fly ash. Also, Liquid limit of expansive soil decreases with constant percent of lime along with increasing % fly ash as well.

Plastic limit of expansive soil decreased with increase percentage of fly ash. But the plastic limit first increased with addition of 5% Lime

and then decreased with increasing percentage of fly ash. Hence the plasticity index for both soil-fly ash and soil-lime and fly ash mixes decreased gradually.

Compaction characteristics of expansive soil also affected by varying % of fly ash, i.e. OMC of expansive soil increase with increasing % fly ash and MDD decrease with increase of fly ash. Likewise Compaction characteristics of expansive soil also affected by constant % of lime along with varying % of fly ash, i.e. OMC of expansive soil increase with constant % lime and MDD decreased with constant % of lime.

UCC value of expansive soil also increased with increasing % fly ash. UCC value of expansive soil

also increases with (5%lime + increasing % of fly ash).It can be concluded that the waste material such as fly ash can be used effectively in the civil engineering construction but it is become more effective with lime if lime will be added in more than 5%.

The swelling pressure decreases with the increase in fly ash percent. And with the lime addition to soil-fly ash samples, swelling pressure was eliminated completely.

REFERENCES

[1] Erdal Cokca (2001). "Use Of Class C Flyash For The Stabilization Of An Expansive Soil" Journal Of Geotechnical And Geo Environmental. Engineering Vol. 127, July, 2001, 568–573.

[2] Hayder A. Hasan AL (2012). "Effect of Fly Ash on Geotechnical Properties of Expansive soil" *Journal of Engineering and Development*, Vol. 16, No.2, June 2012 ISSN 1813- 7822

[3] IS 2720 part-5, (1985): "Methods of Tests for Soils, Determination of Liquid and Plastic Limit" *Bureau of Indian Standards*, New Delhi, (reaffirmed 2006)

[4] IS 2720 part-7, (1980): "Methods of Tests for Soils, Determination of Water Content-Dry Density Relation Using Light Compaction" *Bureau of Indian Standards*, New Delhi, (reaffirmed 2011)

[5] IS.2720 part-10, (1991): "Methods of Tests for Soil, Determination of Unconfined Compressive strength." *Bureau of Indian Standards*, New Delhi, (reaffirmed 2006)

[6] IS 2720 part-41, (1977): "Methods of Tests for Soils, Measurement of Swelling Pressure of Soils" *Bureau of Indian Standards*, New Delhi, (reaffirmed 2002).

[7] Monica Malhotra, Sanjeev Naval (2013) "Stabilization of Expansive Soils Using Low Cost Materials with Lime and Fly Ash." *International Journal of Engineering and Innovative Technology (IJEIT)* Volume 2, Issue 11, May 2013.

[8] Pandian, N.S., Krishna, K.C. & Leelavathamma B.(2002). "Effect of Flyash on the CBR Behaviour of Soils" *Indian Geotechnical Conference, Allahabad,* Vol1, 2002, 183-186.

[9] Prof.J.M. Raut, Dr. S.P.Bajad, Dr. S.R.Khadeshwar3, (2014) "Stabilization of Expansive Soils Using Flyash and Murrum."*International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization)* Vol. 3, Issue 7, July 2014