

A Study on Expansive Behaviour of Blackcotton Soil & Its Stabilization using Fly Ash

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ABSTRACT: Nearly 51.8 million hectares of land area in India are covered with Expansive soil (mainly Black Cotton soil). The property of these expansive soils, in general, is that they are very hard when in dry state, but they lose all of their strength when in wet state. In light of this property of expansive soils, these soils pose problems worldwide that serve as challenge to overcome for the Geotechnical engineers. One of the most important aspects for construction purposes is soil stabilization, which is used widely in foundation and road pavement constructions; this is because such a stabilization regime improves engineering properties of the soil, such as volume stability, strength and durability. In this process, removal or replacing of the problematic soil is done, replacement is done by a better quality material, or the soil is treated with an additive. In the present study, using fly ash obtained from Sesa Sterlite, Jharsuguda, Odisha, stabilization of black cotton soil obtained from Nagpur is attempted. With various proportions of this additive i.e. 10%, 20%, 30%, 40% & 50%, expansive soils are stabilized. Owing to the fact that fly ash possesses no plastic property, plasticity index (P.I.) of clay-fly ash mixes show a decrease in value with increasing fly ash content. In conclusion, addition of fly ash results in decrease in plasticity of the expansive soil, and increase in workability by changing its grain size and colloidal reaction. Tested under both soaked and un-soaked conditions, the CBR values of clay with fly ash mixes were observed. Analysis of the formerly found result exposes the potential of fly ash as an additive that could be used for improving the engineering properties of expansive soils.

KEYWORDS: Black cotton & Fly Ash.

I. INTRODUCTION

1.1 OVERVIEW

With the increasing of population and reduction of available land more and more construction of buildings and other civil engineering structure have to be carried out on weak of soft soil. Owing to such soil of poor shear strength and high swelling and high shrinkage, a great diversity of ground improvement techniques such as soil stabilization and reinforcement is employed to improve mechanical behaviour of soil, thereby enhancing the reliability of construction.

The construction of foundation of most engineering structure requires that adequate information about the engineering properties of the soil and sub-soil condition of the area are known. This is necessary for the engineering planning, design and construction of such foundations to be based on sound geotechnical parameters. This is a more important especially in the design and construction of highways, where there is need for a good and sound knowledge of the geotechnical and engineering properties for sound engineering decisions to be taken. Such geotechnical parameters include the strength, the maximum dry density (MDD), the number of fines (clay and silts) as well as the compaction performance.

Soil stabilization is the improvement of strength or bearing capacity of soil by controlled compaction, proportioning or addition of suitable admixtures or stabilizers. Stabilization

can increase the shear strength of soil and control the shrink or swell properties of a soil, thus improving the load bearing capacity of a sub grade to support pavements and foundation.

Stabilization can be utilized on roadways, parking areas, site development projects, airports and many other situations where sub grade material are not qualified for construction.

Stabilization can be used to treat a wide range of sub-grade materials, varying from expansive clays to granular materials. This process is found using additives like fly ash, rice husk, lime, Portland cement etc.

1.2 BLACK COTTON SOIL

Expansive soils, which are also called as swell-shrink soil, have the tendency to shrink and swell with variation in moisture content. As a result of this variation in the soil, significant distress occurs in the soil, which is subsequently followed by damage to the overlying structures. During periods of greater moisture, like monsoons, these soils imbibe the water, and swell; subsequently, they become soft and their water holding capacity diminishes. As opposed to this, in drier seasons, like summers, these soils lose the moisture held in them due to evaporation, resulting in their becoming harder. Generally found in semi-arid and arid regions of the globe, these of soils are regarded as potential natural hazard - if not treated, these can cause extensive damage to the structures built upon them, as well causing loss in human life. Soils whose composition includes presence of montmorillonite, in general, display these kinds of properties. Tallied in billions of dollars annually worldwide, these soils have caused extensive damage to civil engineering structures.

Also called as Black Cotton soils or Regur soils, expansive soils in the Indian subcontinent are mainly found over the Deccan trap (Deccan lava tract), which includes Maharashtra, Andhra Pradesh, Gujarat, Madhya Pradesh, and some scattered places in Odisha. These soils are also found in the river valley of Narmada, Tapi, Godavari and Krishna. The depth of black cotton soil is very large in the upper parts of Godavari and Krishna, and the north-western part of Deccan Plateau. Basically, after the chemical decomposition of rocks such as basalt by various decomposing agents, these are the residual soils left behind at the place of such an event. Cooling of volcanic eruption (lava) and weathering another kind of rock igneous rocks are also processes of formation of these types of soils. Rich in lime, alumina, magnesia, and iron, these soils lack in nitrogen, phosphorus and organic content.



Fig. 1: - black cotton soil

1.3 Fly Ash

A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. One of the chief usages of volcanic ashes in the ancient ages were the use of it as hydraulic cements, and fly ash bears close resemblance to these volcanic ashes. These ashes were believed to be one of the best pozzolans (binding agent) used in and around the globe.

The demand of power supply has exponentially heightened these days due to increasing urbanization and industrialization phenomena. Subsequently, this growth has resulted in the increase in number of powers supplying thermal power plants that use coal as a burning fuel to produce electricity. The mineral residue that is left behind after the burning of coal is the fly ash. The Electro Static Precipitator (ESP) of the power plants collect these fly ashes.



FLY ASH
HSN Code - 26219000

Fig.: - fly ash

II. LITERATURE REVIEW

1. **Sharma *et al.* (1992)**, using mixtures of fly ash, blast furnace slag and gypsum, studied stabilization. He found that when fly ash, gypsum and blast furnace slag are used in proportions of 6:12:18, the swelling pressure decreases from 248 KN/m² to 17 KN/m², whereas an increase by 300% was observed in case of unconfined compressive strength.
2. **Srivastava *et al.* (1997)** studied the microscopic changes in the fabric and micro-structure of the expansive soil due to the addition of lime sludge and fly ash using SEM photography. He found that there were changes in the micro-structure and fabric of the expansive soil when 16% lime sludge and 16% fly ash were both added. Srivastava *et al.* (1999) have also stated that the best stabilizing effect of the swelling and consolidation behaviour in an expansive soil mixed with fly ash and lime sludge was obtained when 16% lime sludge and 16% fly ash were added.
3. **Cokca (2001)** found out that swelling pressure decreased by 75% after 7-day curing, and 79% after 28 day curing when soil specimens were treated with 25% Class C Fly ash (18.98% of CaO).
4. **Pandian *et al.* (2001)** made an effort towards stabilization of expansive soil by using Class F Fly ash. He found that fly ash can make for an effective additive when he saw that with 20% fly ash content, the CBR value of Black cotton soil improved (about 200%) significantly.
5. **Turker *et al.* (2004)** employed sand along with Class C & Class F fly ash for stabilization of expansive soil. Without any contradiction of belief, Class C fly ash was more effective in stabilization, and decrease in free swell with curing period was observed. The percentage content of soil, Class C fly ash and sand that gave the best result was 75%, 15% and 10% respectively.
6. **Satyanarayana *et al.* (2004)** aimed to study the mutual effect of addition of lime and fly ash on the engineering properties of the expansive soil. He found out that 70%, 26% and 4% were the optimum percent mixture of the ingredients for the construction of roads and embankments.
7. **Phani Kumar *et al.* (2004)** saw that the hydraulic conductivity, swelling properties and plasticity of expansive soil-fly ash mixture decreased, whereas the strength and dry unit weight increased with the increase of fly ash content in the mix. For a given water content, the resistance to penetration also increased with the increase in fly ash content.

III. MATERIAL & METHODOLOGY

3.1 OVERVIEW

In this chapter of the thesis the theoretical description of the test performed on both the soil sample and their procedures are discussed thoroughly.

3.2 TEST TO BE PERFORMED ON THE SOIL

1. Determination of specific gravity, water content and grain size distribution.
2. Determination of Atterberg limit: -
 - Liquid limit determination
 - Plastic limit determination

3. Standard proctor compaction test.
4. Unconfined compression strength test.
5. California bearing ratio.

3.3 TEST PROCEDURES

3.3.1. DETERMINATION OF SPECIFIC GRAVITY, WATER CONTENT AND GRAIN SIZE DISTRIBUTION.

A. SPECIFIC GRAVITY

Objective - Determination of specific gravity of soil solids by pycnometer method.

Equipment & Apparatus -

- Pycnometer
- Sieve(4.75mm)
- Vacuum pump
- Oven
- Weighing balance
- Glass rod

Preparation Sample:

after receiving the soil sample, it is dried in oven at a temperature of 105°C to 115 for a period of two to 24 hours.

B. WATER CONTENT

A pycnometer is a glass jar of about 1 litre capacity, fitted with a brass conical cap by means of a screw type cover, the cap has a small hole of about 6mm diameter at its apex.

The water content (w) of the sample is obtained as

$$W = (M_2/M_3 - M_1/M_4)(G-1/G) \times 100$$

Equipment's -

- Pycnometer
- Weighing balance with an accuracy of 1.0g
- Glass rod

C. SIEVE ANALYSIS

Purpose:

The test is performed to determine the percentage of different grain size contained within a soil. The botanical or sieve analysis is performed to determine the distribution of the coarse; large particles and the hydrometer method is used to determine the distribution of the finer pealed

Equipment: Balance, set of sieves, cleaning brush, sieve shaker, mixture (blender), 152H Hydrometer, sedimentation, control cylinder, thermometer, tanker, timing device

3.3.2 DETERMINATION OF ATTERBERG LIMITS.

3.3.2.1. DETERMINATION OF LIQUID LIMIT

Objective

For determination of the liquid limit of soil using Casagrande apparatus.

Equipment and Apparatus -

- Over
- Balance (0.01g accuracy)
- Sieve (425 micron)
- Casagrande's Apparatus



Fig.3.3 – Casagrande's Apparatus

Preparation sample -

After receiving the soil sample, it is dried in air or oven. If clods are there in soil sample, then it is broken with the help of wooden mallet. The soil passing 425-micron sieve is used in this test.

3.3.2. DETERMINATION OF PLASTIC LIMIT

Objective: -

For determination of the plastic limit of soil.

Equipment and apparatus

- Oven
- Balancing (0.01g accuracy)
- Sieve (425 micron)
- Flat glass surface for rolling

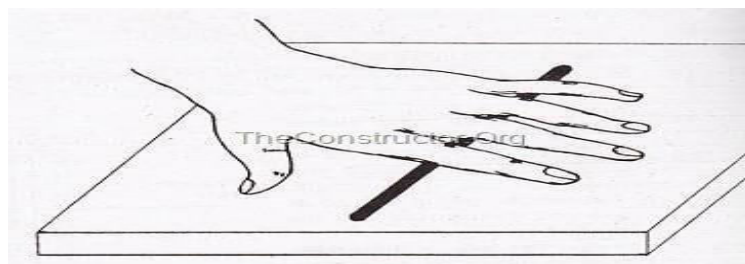


Fig. 3.4 Method of plastic limit- threads formation

Preparation sample:

After receiving the soil sample, it is dried in air or oven. If clods are there in soil sample, then in broken with the help of wooden mallet. The soil passing 425-micron sieve is used in this test.

3.3.3 STANDARD PROCTOR TEST

Objective

For determination of the relation between the water content and the dry density of soils using light compaction.

Equipment and apparatus

- Cylindrical mould & accessories[volume=1000cm³]
- Rammer [2.6kg]
- sieves[19mm]
- Mixing tray

- Trowel
- Graduated cylinder [500ml] capacity

Preparation sample

Obtain a sufficient quantity (10kg) of air-dried soil and pulverize it. Take about 5 kg of soil passing through 19mm sieve in a mixing tray.



4Fig. 3.3 Standard proctor test

3.3.4 CALIFORNIA BEARING RATIO TEST

Objective:

Determination of CBR of soil either in undisturbed or remoulded condition

Equipment & apparatus

- Compression machine
- Sampling tube
- Proving ring, dial gauge, timber
- Vernier calliper, balance

Preparation samples the test may be performed, (a) On undisturbed soil specimen, (b) On remoulded soil specimen.

IV. RESULTS & DISCUSSIONS:

4.1 OVERVIEW

This chapter deals with all the results and discussion obtained through proposed method and solution methodology. A satisfactorily experimental setup has been made and through discussion have been also spelt out.

4.1 RESULTS AND CONCLUSION

Summary of results:

Table 4.18 summary of results of expansive soil properties:

Properties of soil	Results
Water Content	0.8
Specific Gravity	2.67
Liquid Limit	63.2%
Plastic Limit	32.18%

Table 4.19 Comparison of results on soil properties with and without fly-ash

Test conducted	Value on plain soil	Soil with fly ash content				
		10%	20%	30%	40%	50%
OMC	22.65	22.13	22.56	24.71	23.57	24.81
MDD	1.57	1.58	1.57	1.67	1.68	1.71
CBR (at 2.5mm)	5.75%	10.4	14.93	9.35	7.37	10.05

From the result of the test performed, the following conclusion can be drawn: -

According to the data and results acquired from the experimental work on soil stability investigation with different percentages of fly ash i.e. (0%,5%,10%,20%,30%), the following conclusion can be drawn in the aspect of strength properties due to application of fly ash as a stabilizing agent for the natural black cotton soil.

From the above data, the maximum dry densities are found to be 1.794 g/cc for 0%, 1.796 g/cc for 5%, 1.801 g/cc for 20%, 1.807 g/cc of 30% fly ash. Based on the results from the compaction test, it can be stated that with increase in percentage of fly ash the compaction parameter i.e.

MDD (maximum dry density) is increased up to 1.812g/cc at 20% fly ash content and then decreases. Other compaction parameter i.e. OMC (optimum moisture content) is found out to be 12.1% at 20% fly ash content. So, it is concluded that for effective soil stabilization at 20% fly ash gives better result.

- Based on the results from the compaction test, it can be stated that at 20% fly ash content the compaction parameter i.e.MDD (maximum dry density) is found out to be maximum and is equals to 1.812gm/cc. Other compaction parameter i.e.OMC (optimum moisture content) is found out to be minimum (11.5 %) at 30% fly ash content.
- Based on CBR test results, it is observed that addition of fly ash as stabilizing agent for clayey soils produces significant increase in CBR value. It is concluded that, with increase in fly ash the CBR values are also increased considerably and is found to be maximum 4.2 for 30 % fly ash.
- From the above discussion, it is inferred that addition of fly ash to the black cotton soil there is appreciable impact on the compaction parameters and bearing capacity of soil. It is also inferred that, expensive methods for stabilization of soils such as with cement, gypsum etc. can be supplanted together with fly ash as an alternative method to improve the weak black cotton soil properties. Fly ash can be used for stabilization of pavement sub grade, embankment and other fields of civil engineering according to the requirements for black cotton soils.
- The maximum dry density (MDD) value of the black cotton soil initially decreased with the addition of fly ash then; it showed increment with increasing fly ash content in the soil fly ash mixture. The mixture value of MDD was observed for a mixture of soil and 30% of fly ash content by weight. The MDD values consistently decreased thereafter.

REFERENCES

1. O. C. McDowell, "Stabilization with lime, lime-fly ash, and other lime reactive materials", High Res Board Vol 231, pp. 60-61, 1959.
2. T. S. Nagaraj, and N. Miura. "Soil Clay Behaviour, Analysis and Assessment", Brook Field, Rotterdam: AA. Belkema, 2001.
3. Chemical and Mechanical Stabilization of Subgrades and Flexible Pavement Sections", July 1998. TTN Tenser Technical Note BR 10, 1998.
4. A. Kezdi, "Stabilized Earth Roads". Amsterdam: Elsevier Scientific Publishing Company, 1979.
5. U. S. Army, U. S. Navy, and U. S. AirForce, "Soil Stabilization for Pavements", In University Press of the Pacific. Honolulu, Hawaii, 2005.

6. Mc Dowell, C. (1959). "Stabilization of Soils with Lime Lime-fly ash and other Lime reactive minerals", HRB, Bulletin No.231
7. Ramana Murthy, V. (1998). "Study on swell pressure and method of controlling swell of expansive soil", PhD. Thesis, Kalkatiya university, REC, Warangal.
8. Ramana Sastry, M.V.B. (1989). "Strengthening Subgrades of Roads in Deltaic Areas of Andhra Pradesh", Proc of IGC-89, Visakhapatnam, India Vol.1, pp 181-184.
9. M. Jayakumar and Lau Chee Sing, "Experimental studies on treated sub base soil with fly ash and cement for sustainable design Reconditions", International Journal of engineering and applied Sciences.
10. VenkaraMuthyalu, K. Ramu and G.V.R. Prasada Raju Expansive Soil" International Journal of Advances in Engineering& Technology, Jan 2012.
11. Chen, F.H. (1975) Foundations on Expansive Soils, Elsevier Scientific Pub.Co. Amsterdam.Adeniji, F.A. Conference on Arid zone Ideology Hydrology And water resources, Maduguri pp.331-348.
12. Brajesh Mishra," A Study on Engineering Behaviour of Black cotton soil and its stabilization by use of fly ash.
13. Radhakrishnan, G., Kumar, M.A., and Raju, G.V.R.P., "Swelling Properties of Expansive Soils Treated Fly ash", American Journal of Engineering Research. Vol. 3, Issue 4, pp. 245-250, 2014.



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