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Stabilization of Expansive Soil using Plastic Fiber and Fly Ash

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ABSTRACT

Rapid improvements in the engineering world have influenced the lifestyle of human beings to a great extent. But the day to day activities of mankind are augmenting risks to the environment in the same proportion. Plastic wastes have become one of the major problems for the world. The harmful gas which is being produced by them leads to tremendous health related problems. So, effective engineering implementation of this has become one of the challenging jobs for engineers. In recent years, researchers from various fields have attempted to solve environmental problems caused by the production of non-biodegradable wastes like plastic. Using a geotechnical viewpoint, this paper proposes a partial solution to a major item which piles up in the wastages i.e. Plastic. Soil Stabilization is the alteration of soils to enhance their physical properties. Soil is very important in civil engineering constructions. The poor engineering properties of the local soils may present many difficulties for construction and therefore need to improve their engineering properties. In civil engineering, soil stabilization is a technique to refine and improve the engineering properties of soils such as mechanical strength, permeability, compressibility, durability and plasticity. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. In this research paper we study the impact of plastic fibre & fly ash to improve the strength of expansive soil.

Keywords-Stabilization, Fly Ash , Plastic Fibre, Bearing Capacity, Permeability, Compressibility

1. INTRODUCTION

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 Koradi Thermal Plant, Nagpur, 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 is stabilized. Owing to the fact that fly ash possess 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.The process of soil stabilization collectively refers to various techniques of modification changing the physical and/or mechanical properties of soil for a specification application and in order to improve its strength, durability, or other qualities through alterations in texture and plasticity of the soil.Generally Soil is a peculiar material. The Fly Ash use to make the soil to be stable. It can increase the physical and chemical properties of the soil. Some expecting properties to be improved are liquidity index, plasticity index, unconfined compressive strength and specific gravity etc. For any type of structure, the foundation is very important and it has to be strong to support the entire structure. In order for the strong foundation the soil around it plays a very critical role.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 type 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 kind 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.

2. OBJECTIVES

- To check the ambit of reducing expansiveness and improving bearing capacity value by adding additives.
- Also to establish the usage of Fly Ash as an additive, thereby helping utilize it which otherwise always lays as fine waste product from thermal power plants.
- Using plastic fiber like polypropylene fiber is waste of plastic material which can help to improve bearing capacity of soil.
- To provide an alternative solution for the disposal of waste material.
- To improve certain undesirable properties of soil, such as excessive swelling or shrinkage, high plasticity using waste material.

3. LITERATURE REVIEW

Sharma et al. (1992), [1] 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.**Srivastava et al. (1997), [2]** 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. 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).**Pandian et al. (2001),[3]** 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.**Turker et al. (2004), [4]** 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.**Satyanarayana et al. (2004), [5]**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.**Phani Kumar et al. (2004), [6]** 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.

Sabat et al. (2005), [7] studied the stabilization of expansive soil using fly ash-marble powder mixture. He concluded that the optimum proportions of soil, fly ash, and marble powder in the mixture in percentage by weight to give the best result were 65%, 20% and 15% respectively.**Rajesh et al. (2006), [8]** talked about experimental investigation of clay beds stabilized with fly ash-lime segments and fly ash segments. An observation of swelling in clay beds of 100 mm thickness strengthened with 30 mm diameter fly ash-lime and fly ash segments. There was a considerable decrease in heave in both fly ash-lime and fly ash columns. However, lime-fly ash mixture generated better results.

4. MATERIALS AND METHODOLOGY

4.1 Materials

4.1.1 Expansive soil

As a part of this investigation, the expansive black cotton soil was acquired from the site Khairi, Nagpur, Maharashtra. The black cotton soil thus obtained was carried to the laboratory in sacks. A small amount of soil was taken, sieved through 4.75 mm sieve, weighed, and air-dried before weighing again to determine the natural moisture content of the same.

The various geotechnical properties of the procured soil are as follows:

Table 4.1: Geotechnical properties of expansive soil

Properties	**Code referred**	**Value**
Specific Gravity	IS 2720 (Part 3/Sec 1) - 1980	2.44
Maximum Dry Density (MDD)	IS 2720 (Part 7) - 1980	1.52 gm/cc
Optimum Moisture Content (OMC)	IS 2720 (Part 7) - 1980	22.65%
Natural Moisture Content	IS 2720 (Part 2) - 1973	7.28%
Free Swell Index	IS 2720 (Part 40) - 1977	105%
Liquid Limit	IS 2720 (Part 5) - 1985	65%
Plastic Limit	IS 2720 (Part 5) - 1985	37.08%
Shrinkage Limit	IS 2720 (Part 6) -: 1972	17.37%

4.1.2 Fly ash

A waste material extracted from the gases emanating from coal fired furnaces, generally of a thermal power plant, is called fly ash. 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. Essentially consisting of alumina, silica and iron, fly ashes are micro-sized particles. Fly ash particles are generally spherical in size, and this property makes it easy for them to blend and flow, to make a suitable concoction. Both amorphous and crystalline nature of minerals are the content of fly ash generated. Its content varies with the change in nature of the coal used for the burning process, but it basically is a non-plastic silt. For the purpose of investigations in this study, fly ash was obtained from Koradi Thermal Plant, Nagpur. To separate out the vegetation and foreign material, this fly ash was screen through a 2 mm sieve. The samples were dried in the oven for about 24 hours before further usage.

4.1.3Polypropylene Plastic Fiber (PPF)

It is a mixture of plastic fiber collected from used chairs and bottles. Fiber strips which passes through 10mm sieve is used in this investigation.

Table 4.2: Mechanical properties of polypropylene Fiber

Behaviour Parameters	values
Fiber Type	single
Unit weight	0.91 g/cm3
Average Size	10mm
Tensile strength	350MPa
Modulus of elasticity	1800 N/mm2
Density	0.92 g/cm3
Burning point	590˚ c
Fusion point	165
Resistance to acidic and alkali actions	Very good

4.2 Methodology Adopted

[A] Expansive Soil with Fly Ash

To evaluate the effect of fly ash as a stabilizing additive in expansive soils, series of tests, where the content of fly ash in the expansive soil was varied in values of 10% to 50% (multiples of 10) by weight of the total quantity taken.

The Indian Standard codes were followed during the conduction of the following experiments:

- Standard proctor test – IS : 2720 (Part 7) - 1980

[B] Expansive Soil with Plastic Fibre

Following steps are carried out while mixing the fiber to the soil-

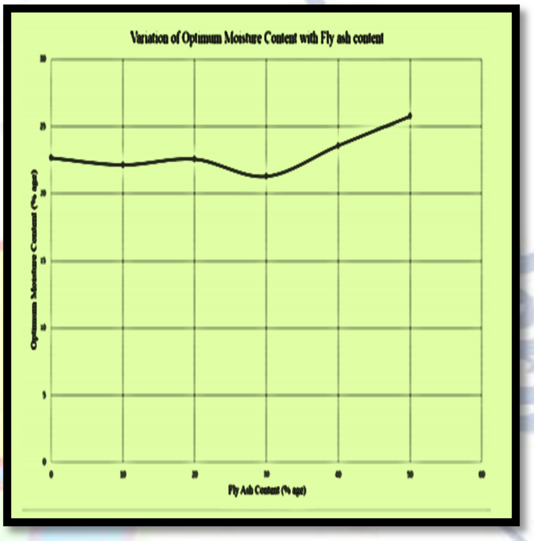
All the soil samples are compacted at their respective maximum dry density (MDD) and optimum moisture content (OMC), corresponding to the standard proctor compaction tests

- Content of fiber in the soils is herein decided by the following equation:

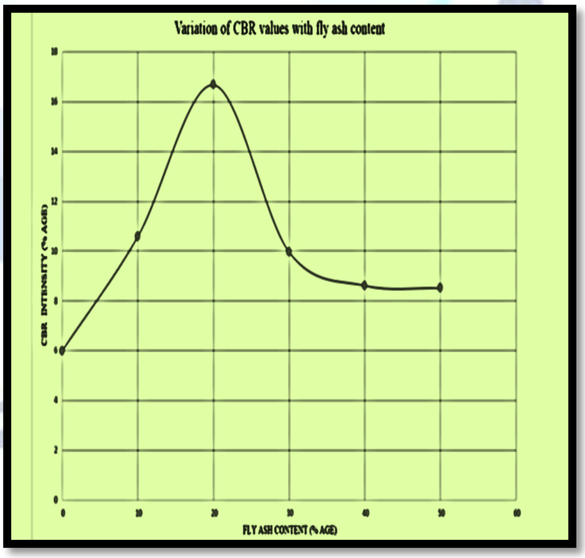
Pf = Wf/W

Where, Pf= ratio of fiber content Wf = weight of the fiber
W = weight of the air-dried soil

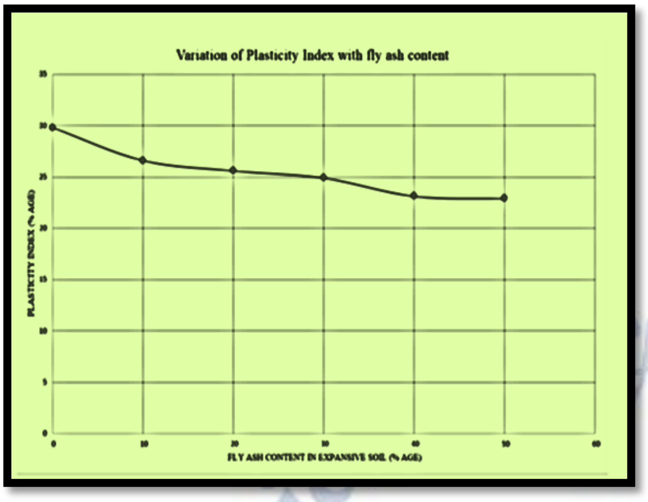
- The different values adopted in the present study for the percentage of fiber reinforcement are 0, 0.05, 0.15, and 0.25.
- In the preparation of samples, if fiber is not used then, the air-dried soil was mixed with an amount of water that depends on the OMC of the soil.
- If fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.



(Fig.4.1: Variation of OMC values with different fly ash content in expansive soil)



(Fig.4.2 :Variation of Un-soaked CBR values of expansive soil with varying fly ash content)



(Fig.4.3 Variation of plasticity index values of expansive soil with varying fly ash content)

5. CONCLUSION

Due to the increment of the polypropylene fiber in different types of soil, it plays a important role in increasing the shear strength of the soil. Overall its can be said that fiber reinforced soil using polypropylene fiber can be considered for the improvement in the deep foundation and the soil properties specially in the engineering projects on loose soils or weak soils and it can be used as a substitute to deep foundation by reducing the cost as well as energy. 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 maximum value of MDD was observed for a mixture of soil and 30% of fly ash content by weight. The MDD values consistently decreased thereafter. Fly ash as an additive decreases the swelling, and increases the strength of the black cotton soil

Scope for future study

Fly ash along with another additive like lime, murrum, cement, and other such materials can be used together, and may be varied in quantity to obtain the best possible stabilizing mixture

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Conflict of interest statement

Authors declare that they do not have any conflict of interest.

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