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EFFECT OF FLY ASH AND COIR WASTE ON GEOTECHNICAL PROPERTIES OF EXPANSIVE SOIL

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Abstract - *Expansive soils possess undesirable properties like excessive variation in volume with change in water content, formation of extensive crack upon shrinkage, low compressive strength at higher water content etc. This experimental study is conducted on black cotton soil mixed with varying percentage of fly ash and coir waste. The objectives of the present study focuses on analyzing properties of soil stabilized with fly ash and coir waste such as Atterberg Limits, Compaction Curve (O.M.C. and M.D.D.), Shrinkage Limit, unconfined compression test. To achieve this goal a study was conducted in two phases. In the first phase, the physical properties of soil such as moisture content, specific gravity, Atterberg limits, maximum dry density (MDD), optimum moisture content (OMC),unconfined compressive strength (UCS) values were determined. In the second phase, various tests were performed on the soil with varying percentages of Fly Ash at 5%,10%, 15%, 20%, 25%,30% fly ash and Coir waste at 2.5%, 5% by dry weight of the soil. It was observed that the MDD and UCS characteristics of soil increased with increase in fly ash percentage up to 20% and then decreased on further addition of fly ash in a soil sample. 2.5% and 5% coir was added to 20% fly ash and soil mix. The maximum values of dry density and UCS were obtained at 20% fly ash and 2.5% coir waste mixed soil.*

Key Words: Expansive soil, Fly Ash, coir waste, Atterberg limits, OMC, MDD, UCS etc.

1. INTRODUCTION

Civil engineering constructions over expansive soil are difficult in several cases due to low bearing capacity. Expansive soils are perceived by differential settlement, low shear strength and high compressibility. Improving the load bearing capacity of soil is absolutely necessary in the case of high rise buildings constructed over such soils. To tackle these problems of expansive soil, various techniques have been adopted like soil stabilization by mechanical and chemical means, use of admixtures and reinforcement etc. The heightening expense of materials and absence of accessible assets have inspired Geotechnical engineers to explore advanced substitute. This study deals with the stabilization of locally available expansive soil in the region of Jabalpur, Madhya Pradesh with varying percentages of fly ash and coir waste to determine the optimum percentage of fly ash and coir required to suitably strengthen the soil. Combustion of pulverized coal annually produces some millions tons of fly ash as a by-product of thermal power stations and the disposal of this by-product has become an important global concern. Coconut coir is an important commercial product obtained from husk of coconut. The main advantages of using these two by-products in improving the strength of sub grade are that they are locally available and are one of the most economical combinations of materials that could be used for stabilization purposes. Also it would serve the environmental purpose of tackling the issue of disposal of industrial by-products such as fly ash and coir by using them as stabilizing materials in expansive soils.

2. MATERIALS USED

2.1 Expansive soil

The soil used was locally available expansive soil which was collected from Jabalpur, Madhya Pradesh. The properties of the soil determined by various experiments have been enumerated below in the table as:

Table -1: Basic properties of soil

S. No.	Properties	Values
1.	Liquid Limit (LL)	51.65%
2.	Plastic Limit (PL)	31.04%
3.	Plasticity Index (PI)	20.61%
4.	Specific Gravity	2.45
5.	Differential Free Swell (DFS)	45%
6.	Optimum Moisture Content (OMC)	16.0%
7.	Maximum Dry Density (MDD)	1.54g/cc
8.	California Bearing Ratio (CBR)	2.96%
9.	Unconfined compression strength (UCS)	0.129Mpa
10.	Soil classification	CH

2.2 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 collects these fly ashes. Essentially consisting of alumina, silica and iron, fly ashes are micro-sized particles. By itself, fly ash has little

cementitious value, however, this changes in presence of moisture, with which it reacts chemically, and forms cementitious compounds. These compounds attributes to the improvement of compressibility and strength characteristics of a soil. The fly ash used in this study was purchased from the local markets of Jabalpur, Madhya Pradesh.

Table -2: Basic properties of fly ash

S. No.	Properties	Values
1.	Colour	Light grey
2.	Specific Gravity	2.30
3.	Plasticity Index (PI)	Non-plastic
4.	Classification	Type C

2.3 Coir waste

Coir or coconut Fibre belongs to the group of hard structural fibres. It is an important commercial product obtained from the husk of coconut. In industries manufacturing mattresses, ropes etc. shorter mattress fibres are separated from the long bristle fibres which are in turn a waste in the coir fibre industry. So this coir fibre waste can be used in stabilization of soil and thus it can be effectively disposed-off. The inclusion of fibres had a significant influence on the engineering behaviour of soil-coir mixtures. The coir used in this study was obtained from various temples in Jabalpur, Madhya Pradesh.

3. EXPERIMENTAL WORK

3.1 Preparation of Sample

Different samples were prepared with the mixture of dry soil and addition of 0%, 5%, 10%, 15%, 20%, 25% and 30% of fly ash on the basis of weight of the soil respectively. In order to get homogeneous mix, proper care was taken while mixing the samples. The UCS value of different samples containing different percentage of fly ash was found out. From which Optimum fly ash percentage was determined. Coir waste was added of different proportion (2.5% and 5%) to the sample having optimum fly ash content and variation of UCS was evaluated.

3.2 Standard proctor test

The standard proctor test was performed as per IS 2720 (Part VII) 1980. The compaction tests were done on soil and fly ash blends. The weighted oven dried soil was taken and various percentages of fly ash and coir waste were added with dry soil. The appropriate quantity of water was added with soil, fly ash and coir waste mixture and the wet specimen was compacted in mould in three layers utilizing standard proctor rammer of 2.6kg. The MDD and OMC for various samples were determined from this test

3.3 Unconfined Compression Test

The mixture of soil-fly ash and coir waste was compacted in a cylindrical mould to obtain standard proctor's MDD. Then the sample was extracted from the mould for the further test. The extracted samples were prepared with inclusion of soil with (0%, 5%, 10%, 15%, 20%, 25% and 30%) fly ash and soil with optimal percentage of fly ash and (2.5%, 5%) coir fiber. The experiments were regulated at a consistent strain rate of 0.125mm per min according to Indian Standard 2720 (part 10) 1991. Three samples were examined for each variable proportion. The UCS value was calculated from the Stress-Strain curve.

4. RESULTS AND DISCUSSIONS

According to experimental program, numerous tests were executed on soil with various percentages of fly ash and coir waste. The effects of fly ash and coir fiber inclusion on UCS values were considered. The outcomes are presented below

Table -3: OMC, MDD and UCS values for soil samples containing varying percentages of fly ash and coir waste

S. No	Soil + Fly Ash + Coir	MDD (gm/cc)	OMC (%)	UCS (kpa)
1.	soil + 0% fly ash + 0% coir	1.54	16.00	130
2.	soil + 5% fly ash + 0% coir	1.59	18.52	310
3.	soil + 10% fly ash + 0% coir	1.63	20.10	320
4.	soil + 15% fly ash + 0% coir	1.64	21.00	370
5.	soil + 20% fly ash + 0% coir	1.69	21.50	510
6.	soil + 25% fly ash + 0% coir	1.62	21.62	350
7.	soil + 30% fly ash + 0% coir	1.58	19.30	250
8.	soil + 20% fly ash + 2.5% coir	1.75	16.21	650
9.	soil + 20% fly ash + 5% coir	1.67	18.75	610

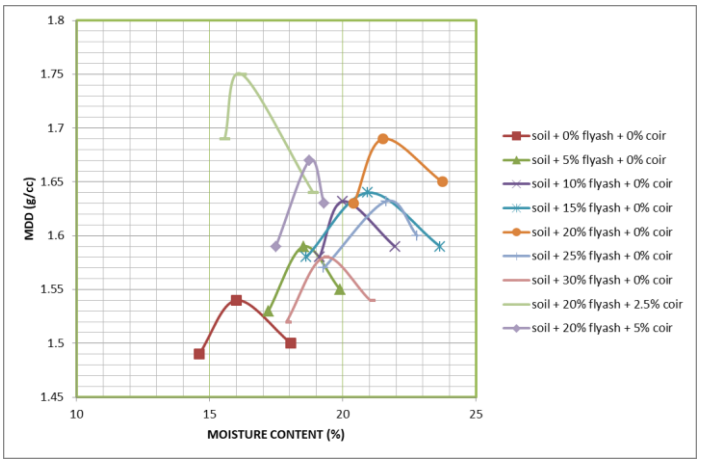

Figure -1: MDD and OMC values for soil samples containing varying percentages of fly ash and coir

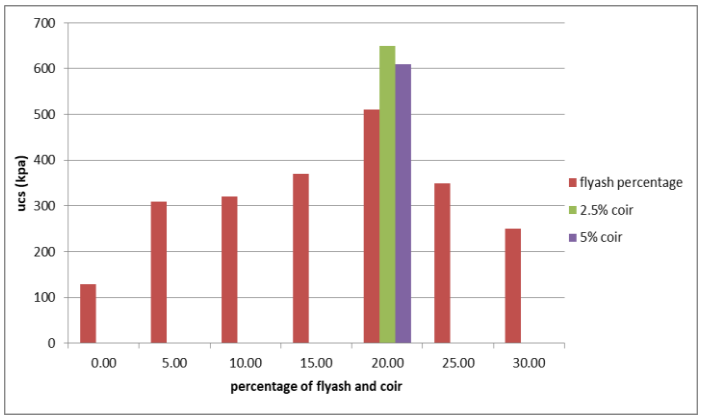

Figure -2: UCS values for soil samples containing varying percentages of fly ash and coir waste

4.1 Standard Proctor Test

It is observed in Table -3 and Figure -1 that with the inclusion of fly ash, the MDD increased up to 20% fly ash addition and then decreased. On inclusion of 20% fly ash with soil, the optimum value of MDD was obtained. On addition of coir waste(2.5%, 5%) to this optimum percentage of fly ash it was observed that the MDD increased for the sample containing 2.5% coir waste and 20% fly ash while it decreased for the sample containing 5% coir waste and 20% fly ash. The maximum value of MDD was obtained for a soil sample containing 20% fly ash and 2.5% coir waste by dry weight of the soil sample.

4.2 Unconfined Compression Test

The experimental outcomes of experiments are given in Table -3 and Figure-2. The outcomes reveal that the UCS value of soil constantly increased upon inclusion of fly ash up to 20% fly ash by dry weight of the soil sample and finally decreased with inclusion of higher percentages of fly ash. Two different percentages of Coir waste (2.5% and 5%) were added to this optimum dose of fly ash and soil. The UCS values increased with addition of 2.5% coir waste and 20% fly ash while decreased with the addition of 5% coir waste and optimum dose of fly ash. The maximum value of UCS was obtained for a soil sample containing 20% fly ash and 2.5% coir fiber by dry weight of the soil sample.

5. CONCLUSION

For the stabilization of expansive soil, the optimum quantity of fly ash and coir waste was found to be 20% and 2.5% respectively by dry weight soil respectively. The two materials were mixed in the above proportion in the black cotton soil. The maximum dry density increased from 1.54 g/cc for plain soil to 1.75 g/cc for soil stabilized with a combination of 20% fly ash and 2.5% coir waste. The unconfined compressive strength increased from 130 KPa for plain soil to 650 KPa for soil stabilized with a combination of 20% fly ash and 2.5% coir waste.

6. FUTURE SCOPE

1. Further studies can be done on the characteristics of soil stabilized with coir upon degradation of coir with time.

2. The fly ash can be replaced by lime, stone dust, sand, cement.

3. Coir waste could be replaced by other fibers or geotextiles as per availability and economy such as jute (natural fibers) or polypropylene, shredded rubber tire (artificial fibers), geotextile or geo-synthetic. From the above materials, mixes of different proportions or combinations can be made for improving the properties of soil which may be used for construction of embankment or soil sub grade in highways.

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