ORIGINAL RESEARCH PAPER

Engineering

STABILIZATION OF BLACK COTTON SOIL USING FLY ASH

KEY WORDS: Black Cotton Soil, Fly ash, Road Pavement

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ABSTRACT

This paper deals with the technique to stabilize the Black Cotton soil (B.C) for the construction of road using fly ash. Construction of road in a black cotton soil is a challenging task in the civil engineering field. Excessive heaves associated with swelling of expansive soil can cause considerable distress to lightweight civil engineering structures. When the B.C. soil comes in contact with the moisture, it shows considerable volumetric changes. Due to this type of phenomenon, many problems associated regarding maintenance and economic life of the highway and roadway. An attempt is made here to find out solution by using fly ash, which is a by-product of thermal power station. Fly ash becomes a main concern of worry because of its disposal problems and hazardous nature. Use of fly ash in an expansive soil gives economical and ecological solution for stabilization of sub grade of road embankment. So it is a case of **"Churning waste into wealth and turning ash into cash"**. Investigation says that fly ash is a good stabilizing agent for the construction of road in the black cotton soil.

1.0 INTRODUCTION

The Black Cotton (B.C) soil is expansive in nature and posses high swelling and shrinkage properties. The B.C. soil is hard so long as it is dry but looses its stability almost completely when it becomes wet. When again it becomes dry it shows lots of cracks on its surface. Expansive soil undergoes extensive volumetric change when subjected to fluctuating moisture. Considerable damage has taken place over the years to canals, roads, buildings and other existing structure, constructed on or with the use of black cotton soil. The present thrust is on the construction of road on the expansive soil. Due to shrinkage properties of this soil, top surface settled excessively and shows failure. The pavements constructed in black cotton soil areas are found to suffer from early failure. In flexible pavements with heavy traffic excessive unevenness, ruts, waves and corrugations are formed almost after every monsoon season, resulting in heavy cost of maintenance every year. An attempt is here made to eliminate such problems by adopting proper soil stabilization technique. The term soil stabilization is used to indicate any treatment or process on soil to improve its strength or bearing power by reducing its susceptibility to the adverse influences of water and traffic. Soil stabilization of black cotton soil is done with fly ash. Fly ash is having good cementing and pozzolanic properties. Use of fly ash in road construction on the black cotton soil is an excellent technique of utilization of industrial waste and stabilizing this high expansive black cotton soil.

2.0 LITERATURE REVIEW

Udayashankar D.Hakari, S.C.Puranik [5] investigated the stabilisation of black cotton soils using fly ash and they concluded that the geotechnical properties of Hubballi-Dharwad black cotton soils can be favourably changed using the Dandeli fly ash and an optimum quantity between 30- 40% can yield the best possible results. Karthik.S et al.,[1] investigated the soil stabilization by using fly ash. They concluded that the borrowed red soil has bearing capacity of 10 kg/mm^2. The stabilized red soil with 6 percentage of fly ash achieves bearing capacity of 35kg/mm^2. The CBR value of borrowed red soil is 3.1 and of stabilized soil is 4.82. Pravin Patel and Dr. H. K. Mahiyar[3] conducted an experimental study of black cotton soil, stabilized with Rice Husk Ash, Fly Ash and Lime. They concluded that CBR value of black cotton soil is maximum with combination of Lime (8%), Fly ash (20%) and RHA (20%). Swelling pressure is minimum at 20% of RHA. Pallavi et al.,[2] studied the stabilization of black cotton soil using fly ash and nylon fibre. The effect of fly ash and Nylon fibres on certain properties of soil such as Liquid Limit, Plastic Limit, Plasticity Index, Dry density, OMC, CBR (Soaked) of clayey soil had been studied. They have Studied the effect of varying percentage of fly ash (10%, 20%, 30%,40%) and varying percentage of nylon fibre (0.25, 0.50, 0.75, 1, 1.25, 1.50) at varying aspect ratios (20,40,60,80) on properties of black cotton soil and also studied the combined effect of varying percentage of optimum quantity of fly ash and optimum quantity of nylon fibre at various aspect ratio on properties of black cotton soil. Results from various test determine that the optimum quantity of fly ash and nylon fibre are 20 % and 0.75 % (at aspect ratio of 40) respectively for achieving maximum soaked CBR. Shubham Maheshwari and S.S.Goliya[4] analyzed the stabilization of black cotton soil for pavement using fly ash and lime. They concluded that the addition of 25% of fly ash with 4% lime, the liquid limit and plasticity index reduced by 22.58% and 70.21% whereas increase in plastic limit by 20.26%. There is increase in CBR value with normal 4 days soaking is 55.44% more than the plain soil.

3.0 PROPERTIES OF THE MATERIALS

3.1 Properties of the black cotton soil

The black cotton soil is one of the major soil groups in India, For this Experimental work, it was brought from the Coimbatore district. It contains montmorillonite clay mineral that has high expansive characteristics. It is under classification of CH. Its Specific gravity is 2.65, Silt and Clay content is 99%, Liquid limit is 65%, Plastic limit is 40%, Plasticity index is 25% and free swell index is 65%. Its optimum moisture content is 24% and maximum dry density is 13.24KN/m^3

3.2 Properties of the fly ash

Fly ash is a finely divided residue that results from the combustion of the pulverize coal and is transported from the combustion chamber by exhausted gases. Fly ash is generally spherical, typically resting in a size from 10 to 100 micron. Fly ash used in this work is Class-F fly ash. This fly ash was brought from the thermal power plant Neyveli, which is Class - F. Its chemical composition is SiO_2 – 55%, Al_2O_3 – 26%, Fe_2O_3 – 7%, CaO – 9%, MgO – 2% and SO_3 – 1%.

4.0 EXPERIMENTAL INVESTIGATION

The purpose of the experimental work is to find out effects of fly ash on various engineering properties of the black cotton soil, on which the road is going to be constructed. In this experimental

work, soil is mixed with the different proportion of fly ash like 0, 8, 10, 12, 14, 20, 30 and 40% of fly ash by dry unit weight of the soil and it is named as SF0, SF8, SF10, SF12, SF14, SF20, SF30 and SF40. Various mixes were prepared and tested the liquid limit, plastic limit, plasticity index, swelling pressure swelling index and California Bearing Ratio (CBR) value. The test results are shown in Table 4.1.

Table 4.1Test results of soil sample with fly ash

Sample	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Swelling Index (%)	Swelling Pressure (Kg/Cm^2)	C.B.R. value
SF0	65.00	30.30	34.70	65.00	0.685	3.95
SF8	58.35	24.70	34.65	40.90	0.520	5.50
SF10	54.80	23.10	31.70	36.36	0.480	5.90
SF12	52.00	21.80	30.20	32.83	0.430	6.20
SF14	50.00	21.30	28.70	30.43	0.398	6.30
SF20	47.50	20.10	27.40	27.36	0.365	6.20
SF30	43.00	19.80	23.20	20.26	0.325	6.00
SF40	41.00	17.80	24.00	22.23	0.290	5.95

5.0 ANALYSIS AND DISCUSSION OF TEST RESULTS

- Effects on Atterburg's Limit: The results mentioned in Table 4.1indicate that liquid limit, plastic limit, and plasticity index decreases considerably while increasing the fly ash content. Constant decrease in liquid limit, plastic limit and plasticity index is observed up to 30% fly ash addition. Addition of 30% of fly ash causes reduction in liquid limit up to 34 % as compare to initial value. Same type of reduction can be seen in plastic limit and plasticity index. Plastic limit is decreased up to 24 % by adding 10% fly ash while addition of 40% fly ash can reduce plastic limit up to 42% as compare to initial value. Plasticity index also decrease as increase in fly ash content. Addition of 10% fly ash cause reduction of 9% as compare to initial value and 30% addition give reduction in plasticity index up to34%.
- Effects on swelling properties: Table 4.1 clearly indicating that the swelling pressure and swelling index decrease considerably as there is increase in fly ash content. Swelling index was 65% but it was reduced up to 20.26% by adding 30% fly ash, which shows reduction of 70% than initial value. Swell pressure is also reduced up to 53% while adding 30% fly ash.
- Effects on California Bearing Ratio: The effect of fly ash in addition to black cotton soil with different percentages on CBR at the respective maximum proctor's dry density is tested and the result is shown in Table 4.1. It is to be found that addition of fly ash content increase the CBR value. Initially the black cotton soil has a very poor CBR value of 3.95, which is improved up to 6.30 by adding 14% fly ash and up to 6.00 by adding 30 % fly ash. The increase in strength in terms of CBR may be due to two factors, viz., the change in gradation and plasticity and pozzolanic reaction between the soil and fly ash.
- Fly ash reduces the potential of black cotton soil to undergo volumetric expansion by a physical cementing mechanism. Fly ash control shrink swell by cementing the soil grain together, much like a Portland cement bonds aggregate together to make a concrete. By bonding the soil grain together, soil particles movements are restricted. Fly ash provides adequately array of divalent and trivalent cat ions (Ca^{+2}, Al^{+3}, Fe^{+3}, etc.) under ionized conditions that can promote fluctuation of dispersed clay particles. Thus black cotton soil can be potentially stabilized by cat ions exchange using fly ash.

CONCLUSION

1. Addition of fly ash reduces liquid limit, plastic limit, plasticity index and swelling characteristics of the soil. Hence fly ash improves most of the engineering properties of the black cotton soil as expansive soil tends to become non expansive in nature.
2. Fly ash improves the CBR value of the black cotton soil. This improved value of CBR gives reduction in thickness of pavement which ultimately results in a cost saving.
3. Fly ash is a hazardous industrial waste, which can be effectively utilized in road construction.

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