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Behavior of Black Cotton Soil Stablized With Fly Ash

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Abstract
This project mainly includes the stabilization of black cotton soil with the admixtures fly ash. It is very important to know the behavior of black cotton soil and its problems so that construction could be done efficiently. This research paper examine the behavior of black cotton soil stabilized with different proportion 15%, 20% and 25% of fly ash added to the black cotton soil. The admixtures used in this project are easily available and are economical beneficial. The various tests on black cotton soil with addition of fly ash are performed after developing the samples. The main aim of this research was to find the optimum percentage of mixing fly ash with the black cotton soil. The results obtained from the experiments are compared to the black cotton soil with the admixture fly ash. The results are obtained in terms of liquid limit, plastic limit, shrinkage limit, plastic index, maximum dry density and optimum moisture content.
Keywords: *Black cotton soil, stabilization techniques, fly ash stabilization, hydration of fly ash*.

1. Introduction

Black cotton soils are widely distributed in central India. Where they cover an area of 5, 00,000
Square kilo meters. Black cotton region extends over the states of Andhra Pradesh, Madhya Pradesh, Gujarat, Karnataka, Tamilnadu, Maharashtra & districts of Deccan. It covers about 15 to 20% of the total area of the country. These soils are dark in color due to the presence of iron and magnesium minerals delivered from basalt. In India black cotton soils have a high percentage of clay minerals and iron oxide, some calcium carbonate and a low organic content they are predominantly rich in montomonarliteic clays of high Base Exchange capacity which generally ranges from 50 to 70 milli equivalents/100 grams.

Black cotton soil sub grade is problematic to high way engineer mainly because of its high swelling and shrinkage properties. It is very hard when dry, but loses its stability completely when wet. On drying it splits into cracks of about 15 cm wide and about 3 meters depth. The points for consideration are therefore as follows

- High swelling and shrinkage characteristics during drying and wetting processes resulting in vertical and horizontal moment of soil mass.
- Low bearing capacity (when wet)
- Differential swelling and shrinkage characteristics due to differential moisture content. In the sub grade soil across the road length provided with an impervious surfacing. Because of the above undesirable properties the black cotton soil are generally regarded unsuitable for engineering constructions. Hence to improve the properties of these soils for foundations and construction, the stabilization is generally resorted to.

The most commonly used stabilizers are lime, cement, natural pozzolanas, volcanic ash and combination of these. Besides these water retaining agents, modifiers and resins etc, are also added to assist in the construction and to regulate the strength increase during curing. The problems created by black cotton soils made the engineers to take up the challenge and study

the soil thoroughly. Investigators and research works are taken up throughout the world to understand the behavior and predict satisfactorily the solutions to these problems. Studies on expansive soils by various research workers are mostly directed towards understanding the nature and development of swelling pressure. However to understand the behavior of this soil thoroughly shear strength characteristics are also to be given due importance.

According to Erdal Cocka that has concluded that based on the test results it can be concluded that the expansive soil can be successfully stabilized by fly ashes. According to Gandhi N.S.V.V.S.J., Kumar B.R Phani and Kumar J.V. P that has concluded that when expansive soils are treated with fly ash the engineering properties like shear strength, compressibility are increased. According to Nramesh H., Mohan S. and Siva Pullaiah P.V.S. has concluded that based on the test data test results the fly ash properties are improved more when lime is added additionally. According to Pandian N.S. (I.I.Sc- Bangalore) and Krishna K.C. has concluded that the test results shoes that adding fly ash to the black cotton soil is not only helps to improve the engineering properties, but also helps in the utilization of fly ash, which can reduce the disposal and pollution problems.

1.1 Different stabilization techniques for soil

Natural soil is both a complex and variable material. Yet because of its universal availability and its low cost it offers great opportunities for skillful use as an engineering material. The various types of stabilization techniques are:

- Mechanical stabilization
- Cement stabilization
- Lime stabilization
- Bitumen stabilization
- Chemical stabilization
- Thermal stabilization
- Electrical stabilization
- Stabilization by grouting
- Stabilization By geotextiles and fabrics

1.2 Fly ash stabilization

Erdal cokca used fly ash as a stabilizer along with lime in 1998.in his research works lime is added to black cotton soils at 0 to 8% to establish base line values. Next fly ash is at 0 to 25% range. The soaking period is considered at 7 days age for his experiments. Fly ash is defined as the material extracted from the flue gases of a furnace fired with coal. Fly ash consists of often hollow spheres of silicon aluminum, iron oxide and UN oxidized carbon. Thus expansive soils can be potentially stabilized effectively by cation exchange using fly ash. Addition of 20% fly ash can decreased the selling potential considerably. There is slight decrease in swelling from 20 to 25 % fly ash addition .therefore the optimum fly ash content is near 20% only. The plasticity index, activity, cbr, UCS, and swelling pressure etc. gave satisfactory results when black cotton soils are treated with fly ash. Thus fly ash is a good stabilizer now a day.

1.3 Hydration of fly ash

Formation of cementitious material by the reaction of free lime (CaO) with the pozzolans (AlO3, SiO2, Fe2O3) in the presence of water is known as hydration. The hydrated calcium silicate gel or calcium aluminates gel (cementitious material) can bind inert material together. For class C fly ash, the calcium oxide (lime) of the fly ash can react with the siliceous and aluminous materials (pozzolans) of the fly ash itself. Since the lime content of class F fly ash is relatively low, addition of lime is necessary for hydration reaction with the pozzolans of the fly ash. For lime stabilization of soils, pozzolanic reactions depend on the siliceous and aluminous materials provided by the soil. Hydration of tricalcium aluminates in

the ash provides one of the primary cementitious products in many ashes. The rapid rate at which hydration of the tricalcium aluminate occurs results in the rapid set of these materials, and is the reason why delays in compaction result in lower strengths of the stabilized materials. The hydration chemistry of fly ash is very complex in nature. So the stabilization application must be based on the physical properties of the ash treated stabilized soil and cannot be predicted based on the chemical composition of the fly ash.

2. MATERIALS

2.1 Black cotton soil

The black cotton soil properties before mixing of any additives and individual admixture properties like specific gravity, grain size analysis and consistency limits etc. are also found out at this stage. They are reported below.

- Liquid limit……..40 to 100%
- Plasticity index……15 to 55%
- Shrinkage limit…….7 to 12 %
- Sand content ……...10 to 20 %
- Silt content……..15 to 45 %
- Clay content……30 to 70 %
- Swelling…… …..10 to 20 %
- O.M.C…… ….20 to 30 %
- Standard proctor density (gr./cc)……1.3 to 1.7

2.2 Properties of fly ash

Fly ash is the finely divided mineral residue resulting from the combustion of ground or powdered coal in electric generating plant. Fly ash consists of inorganic matter present in the coal that has been fused during coal combustion. This material is solidified while suspended in the exhaust gases and is collected from the exhaust gases by electrostatic precipitators. Since the particles solidify while suspended in the exhaust gases, fly ash particles are generally spherical in shape. Fly ash particles those are collected in electrostatic precipitators are usually silt size (0.074 - 0.005 mm**).**

Colour	**Dark gray**
Specific gravity	2.74
Liquid limit	27%
Plastic limit	Non plastic
Maximum dry density	1.1g/cc
Optimum moisture content	32%
Swelling pressure	0.124kg/cm2

Chemical Composition of fly ash

Constituents	**Fly Ash (%)**
SiO2	54 – 58
Al2O3	28 - 32
Fe2O3	4 – 8
CaO	1 – 2
Na2O	0.5 - 1.2
MgO	0.5 – 2

K2O	0.4 – 1.5
Loss of ignition	0.2 – 1.5
PH	7.7 – 8.3

3. METHODOLOGY

3.1 Preparation of samples

After deciding the methodology and soaking/maturity period etc., the soil samples are prepared by the following step-by-step procedure.

1. Black cotton soil (4.75 passing & 425 microns passing), Fly ash are first of all weighed according to the proportion specified and quantity requirements for testing.
2. Dry mixing is done in a tray.
3. The O.M.C. water is added to the dry mixture, which is already prepared, and once again mix it thoroughly
4. The samples are placed in a polythene bag and put it in a container. The top surface is covered with wet cloth.
5. Then the sample is kept for soaking/ Maturity.

3.2 Testing of prepared samples

After 7 –days soaking/Maturity is completed then prepared samples are allowed for the testing according to the standard procedure given in code. And also the various admixtures properties (like specific gravity, grain size analysis and consistency limits etc.) are also found out previously. The various tests conducted are as follows:

1. Liquid limit test
2. Plastic limit test
3. Plasticity index
4. Shrinkage limit test
5. Maximum dry density test
6. O.M.C. test

4. RESULTS AND DISCUSSION

4.1 Black cotton soil result

The results obtained from the experimental analysis are shown in table.

PROPERTY	BLACK COTTON SOIL
Liquid limit	53
Plastic limit	22
Plasticity index	9.10
Shrinkage limit	28
Maximum dry density	1.52
O.M.C.	22

4.2 Black cotton soil +Fly ash

PROPERTY	85% B. C. + 15% F. A.
Liquid limit	51
Plastic limit	24
Plasticity index	10.75
Shrinkage limit	25
Maximum dry density	1.45
O.M.C.	24

PROPERTY	85% B. C.

	+ **20% F. A.**
Liquid limit	43
Plastic limit	27
Plasticity index	11.95
Shrinkage limit	18
Maximum dry density	1.42
O.M.C.	25

PROPERTY	**85% B. C. + 25% F. A.**
Liquid limit	50
Plastic limit	25
Plasticity index	10.15
Shrinkage limit	24
Maximum dry density	1.39
O.M.C.	27

4.3 Comparison of results of various samples

PROPERTY	**BLACK COTTON SOIL**	**85% B. C. + 15% F. A.**	**85% B. C. + 20% F. A.**	**85% B. C. + 25% F. A.**
Liquid limit	53	51	43	50
Plastic limit	22	24	27	25
Plasticity index	9.10	10.75	11.95	10.15
Shrinkage limit	28	25	18	24
Maximum dry density	1.52	1.45	1.42	1.39
O.M.C.	22	24	25	27

In the above table the values represents the increases or decreases over the original black cotton soil property result. Analysis of test data in all the cases of black cotton sail + fly ash, the 80% B.C. soil + 20% F.A. set gives optimized results than other two sets nearly 85% B.C. soil + 15% F.A. set & 75% B.C. soil + 25% F.A. set. By observing the above results when 80% B.C. soil + 20% F.A. are kept constant the most optimum results are obtained.

5. CONCLUSION

From the literature it appears that a number of stabilizers are available like lime, cement lime and cement combinations etc.

- Through this experimentation it is concluded that the byproduct fly ash is also good stabilizing compound.

- The optimum proportions for combination of black cotton soil + by product are 80% black cotton soil + 20% fly ash.
- When the percentage of fly ash increased then the liquid limit increased and plastic limit decreased
- With the addition of fly ash greater than 20%, the plasticity index of the soil is also decreased.
- With the addition of fly ash greater than 20%, the optimum moisture content of the black cotton soil is increased while the maximum dry density of soil decreased.

REFERENCES

1. CHANDRASEKHAR B.P., PRASADA RAO G.V.R , RAMANA MURTHY V. and. KRISHNA P.H. (1999) "Relative performance of lime and calcium chloride on properties of expansive soils for pavement sub grades" journal of I.G.C. pp-279-282
2. ERDAL COKCA (july-2001) "Use of class C fly ashes for the stabilization of expansive soil" journal of Geotechnical and geo environmental engineering, pp- 568-573.
3. GANDHI N.S.V.V.S.J., KUMAR B.R PHANI and KUMAR J.V. P (2001) "Some engineering characteristics of fly ash-treated expansive soils" journal of I.G.C. pp-157-161.
4. LYCHCO Y.M., PEVZNER, BELENKY, ILYINA and ZAGOVORA (1997) "Use of by product in foundation engineering" journal of I.G.C. pp-12-15.
5. NRAMESH H., MOHAN S. and SIVA PULLAIAH P.V.S. (1998) "Geotechnical properties of Maddunur fly ash with lime" journal of I.G.C. pp-247-249.
6. PANDIAN N.S. and KRISHNA K.C (2002) "Engineering properties of black cotton soils-fly mixes" journal of I.G.C. pp.175-178
7. PANDIAN N.S. , KRISHNA K.C. and Bb. Leelavatamma (2002) "Effect of fly ash on the C.B.R. behavior of soils" journal of I.G.C. pp.183-186.
8. PANDIAN N.S., SRIDHARAN A. and SRINIVAS S. (1998) "Use of fly ash to improve the C.B.R. of soils" journal of I.G.C. pp-261-264.
9. RAMAKRISHNAN A.K., NATARAJAN K. and CHANDRAN R. K. (2001) "Stabilization of Annamalai Nagar clay with lime-fly ash" journal of I.G.C. pp-251- 254.
10. SHENBAGA and GAYATRI V. (sept-oct.-2003) "Factor influencing the strength of cement, fly ash base courses" journal of transportation engineering ASCE. pp. 538- 547.
11. SIKDAR P.K. and GURUVITTAL U.K. (2004): "Economics of using fly ash in road construction" journal of Indian High ways. pp. 37-45
12. SONICS T., CHIRISTOULAS and KOLIYAS (1998) "Soil improvement with coal ash in road construction" journal of I.G.C. pp-961-964.
13. UPPAL H.L and. CHADDA L.R (july-2001) "Some problems of road construction in black cotton soils and remedial measures" journal of Geo technical and geo environmental engineering, pp-577-585.