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Stabilisation of Black Cotton Soil Using Admixtures

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Abstract*-Stabilization of Black Cotton Soil (BC soil) is studied by using Lime and Fly ash. BC soils are highly clayey soils (Montmorillonite clay mineral). The moisture changes in BC soils, compressibility and plasticity nature can be greatly improved with the addition of Lime and Fly ash. This paper includes the evaluation of soil properties like Optimum moisture content, dry density, and strength parameter (California Bearing ratio value). Different quantities of Lime and Fly ash (% by weight) are added to the BC soil and the experiments conducted on these soil mixes. The result shows that the use of Lime and Fly ash increases the California Bearing Ratio values i.e. the strength of soil to a great extent.

Keywords: **Stabilization, Black Cotton Soil, California Bearing Ratio, Lime and Fly Ash.**

I. INTRODUCTION

Soil is defined as sediments or other accumulation of mineral particles produced by the physical or chemical disintegration of rocks plus the air, water, organic matter and other substances that may be included. Soil is typically a non homogeneous, porous, earthen material whose engineering behavior is influenced by changes on moisture content and density. Based on the origin, soil can be broadly classified as organic and inorganic. Organic soils are mixture derived from growth and decay of plant life and also accumulation of skeleton or shell of small organism. Inorganic soils are derived from the mechanical or chemical weathering of rocks. Inorganic soil that is still located at the place where it was formed is referred to residual soil. If the soil has been moved to another location by gravity, water or wind, it is referred to as transported soil. Black cotton soils are highly clay soil grayish to blackish in color. They contain montmorillonite clay mineral which has high expensive characteristics. BC soils have low shrinkage limit and high optimum moisture content. It is highly sensitive to moisture changes, compressible subgrade material. Hence the subgrade and its undesirable characteristics to be modified using a suitable stabilization technique. Stabilization involves the methods used for modifying the properties of a soil to improve its engineering performance. In the construction pf road and airfield prevents the main objective of stabilization is to increase the strength or stability of soil and to reduce the construction cost by making best use of the locally available materials. Lime has been widely used either as a modifier for clayey soil or as a binder. When clayey soils with high plasticity are treated with lime, the plasticity index is decreased and soil becomes friable and easy to be pulverized, having less affinity with water. Lime also imports some binding action. In developing countries like India the biggest handicap is to provide a complete network of road system in the limited finances available to build road by conventional method. Therefore there is a need to go for suitable method of low cost road construction, followed by a process of stage development of the roads, to meet the growing needs of road traffic. thus apart from affecting economy in the initial construction cost of lower layers of the pavement such as sub-base course it should be possible to upgrade the low cost roads to higher specification at a later date without involving appreciable wastage, utilizing the principle of pavement construction in stages. The construction cost can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the sub-base course. If the stability of local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization technique. Stabilization of course-grained soils having little or no fines can often be accomplished by the use of LF combination. Lime and Fly ash in combination can often be used successfully in stabilizing granular materials. LF stabilization is often appropriate for base and sub-base course materials. The water content of the fly ash stabilized soil mixture affects the strength. The maximum strength realized in soil-fly ash mixtures generally occurs at moisture contents below optimum moisture content for density. For silt and clay soils the optimum moisture content for strength is generally four to eight percent below optimum for maximum density. For granular soils are the optimum moisture content for maximum strength is generally one to three percent below optimum moisture for density. Therefore, it is crucial that moisture content be controlled during construction. Moisture content is usually measured using a nuclear density measurement device. Fly-ash reduces the potential of a plastic soil to undergo volumetric expansion by a physical cementing mechanism, which cannot be evaluated by the plasticity index. Fly ash controls shrink-swell by cementing the soil grading together much like a Portland cement bonds aggregates together to make concrete. By bonding the soil grains together, soil particle movements are restricted. Fly ash is a pozzolan. It has been successfully used with granular and fine grained materials to improve soil characteristics, providing adequate support for pavements and improving working conditions where undesirable soils are encountered. Fly ash and other ash such as bottom ash and boiler ash have been widely used in application with source. The factors that most readily influence the quality and reactivity of fly ashes are the source of the coal, the degree of pulverization of coal, the efficiency of the burning operation and the collection and storage method of the ash.

II.OBJECTIVE OF STUDY:

- To study Black Cotton Soil.
- To study the admixtures like lime and Fly ash.
- To study the behavior of strength gain in BC soil using process of lime - Fly ash stabilization.

III.METHODOLOGY:

The purpose of soil classification is to arrange various types of soils into groups according to their engineering or agricultural properties and various other characteristics. Soil possessing similar characteristics can be placed in the same group. Soil survey and soil classification are carried out by several agencies for different purposes. For example the agricultural departments undertake soil investigations from the point of view of the suitability or otherwise of the soil for crops and its fertility. However from engineering point of view the classification may be done with the objective of finding the suitability of the soil for construction of dams, higher ways or foundations etc. For example engineering purposes soils may be classified by the following systems.

1) Particle size classification
2) Textural classification
3) Highway Research Board (HRB) classification
4) United soil classification and IS classification system.

The division of A-7 group on the basis of the demarcation line ($I_{p=}W_L$-30) into A-7-5 and A-7-6 sub-groups does not appear to divide the Indian Black Cotton soil into two distinct groups having maximum value of the group index as 20 only. Based on investigations carried out at the Central Road Research Laboratory, New Delhi (1953), a classification of black cotton soil into narrow sub-groups has been suggested extending the maximum value of group index from 20 to 50.

Table 1: Component with Range

Chemical components	Range
Silicon dioxide	45-60%
Aluminum oxide	21-29%
Iron oxide	5-18%
Sulphur trioxide	About 0.4%
Manganese oxide	0.2-3%
Calcium oxide	0.5-6%

Table 2: Component with Range with Percentage

Constituent	High Calcium Range %	Dolomitic range
CaO	92.25-98.00	55.50-57.50
MgO	0.30-2.50	37.60-40.80
SiO_2	0.20-1.50	0.10-1.50
Fe_2O_3	0.10-0.40	0.05-0.40
Al_2O_3	0.10-0.50	0.05-0.50
H_2O	0.10-0.90	0.10-1.90
CO_2	0.40-1.50	0.4-1.50
Specific Gravity	3.20-3.4	3.2-3.4
Specific Heat	442 J/Kg	448 J/Kg

Accordingly the factors for the calculation of groups index have the following maximum values a=65, b=65, c=45 and d=34. Compaction means pressing the soil particles close to each other by mechanical methods. Air during compaction is expelled from the void space in the soil mass and, therefore, the mass density is increased. Compaction increases the shear strength of the soil, and permeability of soil. To assess the amount of compaction and the water content required in the field, compaction tests are done on the same soil in the laboratory. The tests provide a relationship between the water content and the dry density. The water content at which the maximum dry density is attained is obtained from the relationships provided by the tests. Poctor (1993) used a standard mould of 4 inches internal diameter and an effective height of 4.6 inches, with a capacity of 1/30 cubic foot. The mould had a detachable base plate and a removable collar of 2 inches height at its top. The soil was compacted in the mould in 3 equal layers; each layer was given 25 blows of 5.5 pounds rammer falling through a height of 12 inches. A curve was obtained between the dry density and the water content. IS: 2720(Part VII) recommends essentially the same specification as in Standard Proctor test, with some minor modifications and metrification. The mould recommended is of 100 mm diameter, 127.3mm height and 1000ml capacity. The rammer recommended is of 2.6 kg mass with a free drop of 310mm and a face diameter of 50mm. The soil is compacted in three layers. The mould is fixed to a detachable base plate. The collar is of 60mm height. If the percentage of soil retained on 4.75mm sieve is more than 20%, a larger mould of internal diameter 150mm, effective height of 127.3mm and capacity 2250ml is recommended.

Procedure:-About 3 kg of air-dried, pulverized soil passing 4.75mm sieve is taken. Water added to the soil to bring its water content to about 4% if the soil is coarse-grained and to about 8% if it is fine-grained. The water content should be much less than the expected optimum water content. The soil is mixed thoroughly and covered with a wet cloth and left for maturing for about 15 to 30 min. The mould is cleaned, dried and greased lightly. The mass of empty mould with the base plate, but without collar, is taken. The color is then fitted to the mould. The mould is cleaned, dried and greased. The mass of the empty mould with the base plate, but without collar, is taken .the collar is then fitted to the mould. The mould is placed on a solid baseand filled with fully matured soil to about one-third its height. The soil is compacted by the 25 blows of the rammer, with a free fall of 310mm. (the number of blows required for the bigger mould of 2250ml capacity is 56 instead of 25). The blows are evenly distributed over the surface. The soil surface is scratched with a spatula before the second layer is placed. The mould is filled to about two-third height with the soil and compacted again by 25 blows. Likewise, the third layer is placed and compacted. The third layer should project above the top of the mould into the collarby not more than 6mm. the collar is rotated to break the bond between the soil in the mould and that in collar. The collar is then removed, and the soil is trimmed off flush with the top of the mould. The mass of the mould, base plate and the compacted soil is taken, and thus the mass of the compacted soil is determined. The bulk density of the soil is computed from the mass of the compacted soil and the volume of the mould. Representative soil samples are taken from the bottom, middle and top of the mould for determining the water content. The dry density is computed from the bulk density and the water content.

Bulk mass density=M/V gm/ml Where M=mass of compacted soil (gm.), V=volume of the mould (ml). Dry density, P_d= p/1+w where, w is the water content.

CBR Test Procedure:

The soil removed from the mould is broken with hand. More water is added to the soil so as to increase the water content by 2 to 3%. It is thoroughly mixed and allowed to mature. The test is repeated and the dry density and the water content are determined. Normally 3 specimens each of about 7 kg must be compacted so that their compacted densities range from 95% to 100% generally with 10, 30 and 65 blows. Weigh of empty mould. Add water to the first specimen (compact it in five layer by giving 10 blows per layer). After compaction, remove the collar and level the surface. Take sample for determination of moisture content. Take weight of mould and compacted specimen. Place the mould in the soaking tank for four days (ignore this step in case of unsoaked CBR**.** Take other samples and apply different blows and repeat the whole process. After four days, measure the swell reading and find %age swell. Remove the mould from the tank and allow water to drain. Then place the specimen under the penetration piston and place surcharge load of 10lb. Apply the load and note the penetration load values. Draw the graphs between the penetration (in) and penetration load (in) and find the value of CBR**.** Draw the graph between the %age CBR and Dry Density, and find CBR at required degree of compaction. This is a penetration test developed by the California Division of Highways, as a method for evaluating the stability of soil sub grade and other flexible pavement materials. The Indian Road Congress has recommended a CBR design chart for tentative use in India. Different curves A, B, C, D, E, F and G have been given based on the volume of commercial vehicles. In order to design a pavement by CBR method, first the soaked CBR value of the soil sub grade is evaluated. Then the appropriate design curve is chosen by taking the design wheel load or by taking the anticipated traffic into consideration. Thus the total thickness of flexible pavement needed to cover the sub grade; such that it may be used as sub-base course then the thickness of construction over this material could be obtained from the design chart knowing the CBR value of the sub-base. Thickness of the sub-base course is the total thickness minus the thickness over the sub-base.

IV. RESULTS AND DISCUSSION:

Table 1: Result Analysis 1

Parameters	Liquid limit	Plastic limit	Plasticity index	Maximum dry Density (gm./cc)	Optimum Moisture Content (%)	CBR
Values	45.01	20.36	24.36	1.64	18	8

Table 2: Result Analysis 2

Parameters	Liquid limit	Plastic limit	Plasticity index	Maximum dry Density (gm./cc)	Optimum Moisture Content (%)	CBR
Values	45	31.9	13.1	1.53	22	24

Table 3: Result Analysis 3

Parameters	Liquid limit	Plastic limit	Plasticity index	Maximum dry Density (gm./cc)	Optimum Moisture Content (%)	CBR
Values	38.2	32.13	6.07	1.58	17	46

V. CONCLUSION

It can be concluded that the thickness of pavement decreases by 66% as the CBR value goes on increasing. The improved CBR value is due to addition of Lime and Fly ash as admixtures to the BC soil. It also reduces the hydraulic conductivity of BC soil. There will be no need of drainage layer after treatment of BC soil as sub grade with lime and fly ash. In combination, the admixtures are beneficial for lower plasticity and higher silt content soils. In terms of material cost, the use of less costly fly ash can reduce the required amount of lime.

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