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A Study on Techniques Used for Stabilization of Black Cotton Soil

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ABSTRACT: Soil stabilization involves adding certain additives or materials to the soil to improve its Engineering properties. The design foundation on black cotton soil (expansive soil) has always been a difficult task for the engineers. Soil proportion changes depending upon their constituents, i.e. water content, density, bulk density, angle of friction, shear strength etc. The properties of black cotton soil can be modified by stabilizing the soil can be modified by stabilizing the soil with the use of additives or by mechanical means. Stabilization can enhance the soil's strength, reduce its susceptibility to erosion, improve its drainage properties, and mitigate potential issues related to swelling or shrinkage. Soil modification plays a significant role in achieving the desired soil properties for construction purposes. Soil modification involves altering or improving the properties of the soil to make it more suitable for construction work. Various techniques and methods are employed to modify soil, depending on its specific characteristics and the requirements of the project.

KEYWORDS: Black Cotton Soil, Stabilization, Mechanical Methods, Chemical Methods

I. INTRODUCTION

Due to changes in moisture, black cotton soils are prone to unfavorable volume changes. These are the residual deposits of lava or rockfalls, which mainly occupy arid and semi-arid areas and a large part of the world. The soil plays an important role in the development of civil engineering structures and hence for the type of foundation to use for the same. The presence of montmorillonite is the main reason for the effective water content of the soil and the shrinkage and expansion behavior of the soil. Black cotton soil is not suitable for the construction work on account of its volumetric changes. It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell; when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place, so the stabilization is being done for the Stabilization of black cotton soil has been done. The most common types of soil stabilization are without admixtures and with admixtures. It also classified as surface stabilization and subsurface stabilization.

II. CHARACTERISTICS OF BLACK COTTON SOIL

Black cotton soils are generally reddish brown to black in color and occur from 0.5m to 10m deep and have high compressibility. Black cotton soil are made of varying properties of clay minerals like Montmorillonite, Illite and Kaolinite, chemicals like iron oxide and calcium carbonate (in the form of kankars), and organic matter like humus. Montmorillonite is the predominant mineral of Black cotton soils. The swelling and shrinkage behavior of black cotton soil originate mainly from this mineral are hydrous silicates of aluminum and magnesium .They are made of sheets of silica (tetrahedral) and alumina (octahedral) stacked on above the other forming sheet like of flaky particle.

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Sr. No.	Property	Range
1.	pH Value	>7(Alkaline)
2.	Organic Content	0.4 to 204 %
3.	CaCO ₃	5 to 15 %
4.	SiO ₂	50 to 55 %
5.	SiO ₂ , Al ₂ O ₃	3 to 5 %
6.	Montmorillonite Mineral	30 to 50 %

Montmorillonite has a three-sheeted structure with expanding lattices. The structure carries negative charge, due to isomorphic substitution of some aluminum ions by magnesium ions and minerals becomes chemically active.

The generally observed characteristics of black cotton soils are recorded in table below –

Table 1: Characteristics of Black Cotton Soils

Sr. No.	Property	Value	Sr. No.	Property	Value
1.	Dry Density (γ_d)	1300 to 1800 kg/m ³	8.	Specific Gravity (G)	2.60 to 2.75
2.	Fines (<75 μ)	70 to 100%	9.	Proctor Density	1350 to 1600 kg/m ³
3.	2 μ Fraction	20 to 60 %	10.	Max. Dry Density O.M.C.	20 to 35 %.
4.	Liquid Limit (L.L.)	40 to 120%	11.	Free Swell Index	40 to 180%
5.	Plastic Limit (P.L.)	20 to 60%	12.	Swelling Pressure	50 to 800 kN/m ²
6.	Activity	0.8 to 18%	13.	C.B.R. (Soaked)	1.2 to 4.0
7.	Soil Classification	CH or MH	14.	Compression Index	0.2 to 0.5

Table 2: Chemical composition of black cotton soil

SOIL STABILIZATION

Various methods to improve its engineering properties-

Classified into two groups:

1. without admixtures.

- Taking advantage of inherent shear strength of soil.
- Examples are: (1) Compaction (2) Drainage

2. with admixtures

(1) Soil Mixing - (a) Surface soil mixing (b) Deep soil Mixing

(2) Soil-Lime stabilization

(3) Soil-Cement stabilization

(4) Bitumen (asphalt) - soil stabilization

(5) Chemical stabilization-(a) Calcium chloride. (b) Sodium chloride(c) Sodium silicate

It also classified as surface stabilization and subsurface stabilization.

MECHANICAL STABILIZATION OF SOIL

The mechanical Soil Stabilization Method is the method of improving soil properties by changing its gradation. In mechanical of soil stabilization methods includes compaction and densification of soil matter by application of mechanical energy using various sorts of rollers, rammers, vibration techniques, and sometimes blasting. The stability

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of the soil generally depends on the inherent properties of the soil material. In this method, two or more natural soils are mixed together which is superior to any of its components. Mechanical stabilization of soils is done by mixing or blending soils of two or more gradations to obtain a material meeting the required specification. There are three main mechanical soil stabilization methods; these are Compaction, Preloading, and Replacement.

Compaction of Soil is commonly used method in the construction and convenient method. This method is mainly used for granular soils that do not have adequate engineering strength parameters. The methods used to compact the soil are Vibration, Impact, Kneading, and Pressure. The compaction of the soil is measured by means of the increase in density. To achieve better compaction, the moisture content of the soil is maintained at the optimum level.

PHYSICAL STABILIZATION OF SOIL

Physical soil stabilization techniques are not common when compared to mechanical soil stabilization methods. The mechanical methods are not required very high skill whereas physical soil stabilization techniques required sophisticated technologies and technical knowledge. Stabilization of soils such as silt, clayey peat, peat, organic soils, etc. is done. The most commonly used materials that can be used for ground improvement are Cement Lime, Fly-Ash, Blast Furnace Slab, Pozzolans, Bitumen, and Polymer. All these materials are mixed with the soil and stiffness or the strength of the soil is enhanced. Mainly there are two types of chemical stabilization of soil, these are Surface Mixing and Deep Mixing. Surface Mixing is relatively easy method this can be done from the shallower depth to deeper level. The mixing of the stabilization material is done with the soil using a machine. Removal of the soils which are highly organic and or highly compressible other silts such as peat could be done before the mixing. Deep mixing method involves depths greater than 1.5m generally. This method can be used to stabilize the solid for larger depths. Weak soil types such as clay, peat, or organic soils will be mixed with stabilizer injected into the soil by mechanical means. Mainly there are two approaches in the deep mixing method. Wet mixing will be mixed with slurry binding (cement, lime, fly ash, etc.). This method is greatly applicable for soils having a moisture content of less than 60%. Higher the moisture level, the lesser will be the effectiveness of mixing. Dry mixing is mixed with the dry binder. This type of mixing is applicable for soils having higher moisture content such as above 60%. Since the dry binder is inserted to mix with the soil, it mixes properly with the presence of moisture.

III. CONCLUSION

When the black cotton soil comes in contact of water, it causes structure damage and also creates many problems. The replacement of finer particle of black cotton soil with coarser particle of materials used alters the gradation of it and the composite acts as a well graded material. Further the additions of these materials i.e. fly ash, lime, cement; bituminous etc. stabilized black cotton soil improved the various geotechnical properties of black cotton soil. Also, the final composite allows its application in many construction fields beneficially and also leads to a safe and effective disposal technique of waste materials. By using these different soil stabilizing techniques, soil properties can be increased which will be beneficial for construction.

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