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A Review on Stabilization of Black Cotton Soil Using RBI Grade 81, Lime, Rice Husk Ash and Foundry Sand

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Abstract: India has demonstrated its potential to break through world's economy in past decade. The growing rate of the nation is continuously increased. Road transport contributes of 4.8 percentage in India's GDP. As per the results of economic liberalization, the demand of an adequate and well-coordinated road transport system is drastically increased. Around 20% part in India is covered with black cotton soil which shows high rate of shrinkage and swelling because of change in moisture content. To overcome this troublesome, stabilization of soil by using various stabilizer is carried out. Stabilization is the process of bringing the soil in suitable condition which can be used for engineering purposes. Stabilization is carried out by mechanical method or by using some chemical admixtures. In this paper, we studied the stabilization of black cotton soil by using stabilizer such as RBI Grade 81, Rice Husk Ash, Foundry sand, Lime and also the factors affecting the effectiveness of the stabilization.

Keywords: Soil Stabilization, Black Cotton Soil, RBI Grade 81, Rice Husk Ash, Foundry Sand, Lime.

I. INTRODUCTION

India is an agricultural country. An agriculture play an important role in economic development of country and hence overall economic development of country begins with gross root development. For overall development of the Nation, development should start with rural areas. Among all modes of transport, Roads are the most convenient mode of transportation for men, goods, services, etc. with door to door service facility. Hence it is essential to develop the roads in rural areas. In India 20% area is covered with black cotton soil. Deccan plateau prominent relief feature of Maharashtra is bordered by Western Ghats (Sahyadri). Construction of any structure essentially tries to meet the demand of required material easily accessible and in economic cost. In rural areas black cotton soil is predominantly found as a crust or base which imparts enormous problems due to its characteristics even during and after construction. Soil used in sub grade layer is core material on which entire stability of structure or pavement is dependent. In case of black cotton soil due to extremely low bearing capacity of sub grade when it is wet and extensive swelling during wetting condition affect the stability and durability of road pavement as a whole. In order to improve or overcome all the problems associated with characteristics of black cotton soil so that it can be used as a sub grade material, various soil stabilization techniques are implemented. Soil stabilization is precautionary process apply on the soil using additive material to overcome the drawbacks, improve engineering properties and make soil suitable for road construction. ⁽¹⁾

A. Black Cotton Soil

In India, Black cotton soil is one of the major deposits predominantly found in Maharashtra, Karnataka, Gujarat, and Madhya Pradesh. Black cotton soil is formed from cooling and weathering of lava after volcanic eruption. The origin of the black cotton soil is from volcanic rock that is found in deccan plateau. Black cotton soil is generally rich in montmorillonite and beidellite group of clay minerals.

Black cotton soil is greatly sensitive to seasonal moisture variations and responsible for significant distress to the structures which are constructed over these soils. Black cotton soil perceives the properties of swelling and shrinkage which varies from place to place and depends on weathering condition. The change in the volume of soil is about 200-300% when soil at its liquid limit. Self ploughing property of the soil causes wide cracks.

The primary composition of the soil are iron, lime, calcium, potassium, aluminium, magnesium and its lacking in nitrogen, phosphorous, organic matter. Earth is used as a core material in subgrade layer for construction of road pavement. Though black cotton soil available in plenty amount cannot be used in subgrade layer due to its enormous critical characteristic. Civil Engineering Structures especially pavements in these areas suffer from premature failures.

B. RBI Grade 81

Road Building International Grade 81 (RBI Grade 81) is a odourless powder consists of number of naturally occurring material. It enhances properties of material over wide range. This stabilization method is effective for silty and clayey soil which is affected with low geo-mechanical qualities. Black cotton soil is stabilized with RBI Grade 81 by using different proportion. RBI Grade 81 is environment friendly material which has many advantages over various chemical stabilizers. ^{(6), (8)}

TABLE I
Physical Properties of RBI Grade 81

Sr. No.	Physical properties	Description
1	pH	12.59 (saturated paste)
2	Odour	Odourless
3	Solubility	Insoluble in water
4	Freezing Point	None, Solid
5	Specific Gravity	2.5
6	Self life	12 month (Dry Storage)
7	Flammability	Non-flammable
8	Bulk Density	700 kg/m ³
9	Storage	Dry Storage

TABLE II
Chemical Properties of RBI Grade 81

Sr.No.	Chemical Constituents	Percentage %
1.	Calcium	52-56
2.	Silicon	15-19
3.	Sulphur	9-11
4.	Aluminium	5-7
5.	Water	1-3
6.	Magnesium	0-1
7.	Fibres (polypropylene)	0-1
8.	Additives	0-4
9.	Manganese, potassium, Copper, zinc	0.1-0.3

II. SOIL STABILIZATION

Soil stabilization is a process of physical, chemical or biological changes in the soil mass by blending and mixing the material with soil to improve the strength and bearing capacity of the soil. In soil stabilization, the engineering properties such as CBR value and UCS value are improved and even control on moisture content present in the soil, reduces liquid limit and plastic limit of soil, increase bearing capacity and durability of the pavement. Soil stabilization also prevents from the excessive or uneven settlement of pavement. ⁽⁷⁾

A. Soil Stabilization Method

There are two methods of soil stabilization in-situ stabilization and ex-situ stabilization. In in-situ stabilization, the stabilizing agents are applied on the surface without extracting or ploughing the bulk mass of the soil. Deep mixing, dry mixing, wet mixing are the methods of in-situ stabilization.

In ex-situ stabilization, soil is dislodged and moved to other place for modification. Stabilization techniques are mechanical stabilization and stabilization using different types of admixtures. Mechanical stabilization is based on the principle of compaction. Soil is densified by using mechanical energy on surface such as roller, compaction equipment, etc. stabilization done using admixture changes the proportion of soil by adding some materials. ⁽⁷⁾

III. LITERATURE REVIEW

In 2018, Gagan V. S., Likhita G. R., Megha S., Pruthviraj T. N., Dr. B. Shivakumara, Manasa H. G.⁽¹⁾ conducted a research on soil stabilization on black cotton soil using RBI-grade 81. As per the research and analysis this paper represents that, RBI Grade 81 (road building international grade 81) is a chemical stabilizer predominantly used in stabilization of subgrade soil and various layers in pavement. RBI Grade 81 admixture is mixed with varying proportion of 0% - 6%. Liquid limit of black cotton soil is continuously decrease with increase proportion of RBI Grade 81. Liquid limit at RBI 0% is 50% and at RBI 6% is 33.3%. Plastic limit of black cotton soil is continuously increase with increase proportion of RBI Grade 81. Plastic limit at RBI 0% is 55% and at RBI 6% is 75%. Maximum dry density of black cotton soil is slightly increase 1.776 kg/m^3 - 1.808 kg/m^3 with increasing proportion of 0% - 6% RBI Grade 81. Optimum moisture content of black cotton soil increases upto proportion of 2% of RBI Grade 81 after that OMC decreases with increasing in the proportion of RBI Grade 81. California bearing ratio value is proportional to the percentage of RBI Grade 81. CBR value at 0% RBI Grade 81 is 7.136% and at RBI Grade 81 6% is 28.22%. Construction time can be reduced upto 40% by using RBI Grade 81.

In 2018, Prof. P Vandana Rao, Prof. G Sudheer Kumar and Prof. G Prasanna Kumar⁽²⁾ conducted a research on stabilization of black cotton soil using rice husk ash. As per the research and analysis this paper represents that, Husk is a by-product in rice milling industries. It is used as a fuel in rice mills which contains 75% of volatile matter and 25% converted to ash known as rice husk ash RHA. RHA contains 85-90% amorphous silica, 10-15% iron oxide. In a manner conforming to experiments on black cotton soil MDD is decrease with increasing dose of RHA, OMC increases with RHA contains, UCS value and CBR value is increase up to RHA contains is 10% after that it decrease. The optimum dose of RHA is 10%.

In 2016, Gaus Makandar⁽³⁾ conducted a research on stabilization of black cotton soil using waste foundry sand and lime. As per the research and analysis, this paper represents that the pozzolanic properties of the waste foundry dust and lime can be utilized in the construction industry. In metal casting industry, metal foundries require large quantity of sand. This sand is recycle and reused many times but after that, this sand is removed as a waste foundry sand. It contains more than 80% of high quality silica, 5-10% of bentonite clay, 2-5% of water and sea coal less than 5%. As per the estimate, around 100 million tons foundry sand produced annually.

When WFS and hydrated lime added to black cotton soil, it reacts with clay particles and converted into strong cementitious matrix. CBR increases with constant percentage of WFS and increasing percentage of lime. Combination of WFS and lime is beneficial for control on OMC of the soil. Liquid limit is decrease and increase in dry strength of black cotton soil. WFS and lime is a good compound for stabilization and improving engineering properties of black cotton soil.

In 2010, Prof. Nadgounda K. A. & Prof. Hedge R. A.⁽⁴⁾ conducted a research on the effect of lime stabilization on properties of black cotton soil. As per the research and analysis this paper represents that, Lime is predominantly use for stabilized clay, improve workability, increase strength, increase volume stability and increase OMC which helps in dealing with wet soil. Two methods of lime stabilization are surface stabilization and deep stabilization. In surface stabilization, mechanical mixing of lime with black cotton soil is done. In deep stabilization, lime column, lime pile or lime injection is done below the surface. Usually, lime content varies from 2.5% to 7.5%. In a manner conforming to experiments on black cotton soil liquid limit decreases with increasing dose of lime, plastic limit decrease upto 4% of lime after that again start increasing, Free swell index decreases with increasing dose of lime, CBR value decreases up to 3.5% then again increase with lime dose. As per compaction curve, lime dose not affect much on MDD but it controls moisture. The optimum lime content ranges from 3.5% to 4.5%.

IV. FACTORS AFFECTING THE EFFECTIVE STABILIZATION

A. Temperature

At construction site, temperature is vary continuously. Temperature is highly sensitive for the pozzolanic reaction between soil particles and binders. Reaction rate decreases at low temperature and increases at high temperature. In cold weather, strength of the stabilized soil is relatively less. Hence warm weather is favourable for stabilization of soil.⁽⁵⁾

B. Moisture content

Stabilization of soil using cementitious admixture such as cement, lime, RBI Grade 81, etc., hydration reaction takes place. The heat is liberated during this reaction. For that there must be adequate water to control heat of hydration. This requirement of water is fulfilled by natural water present in soil known as moisture content. Moisture content is essential for gaining the strength of stabilized soil.⁽⁵⁾

C. Compaction

Compaction is essential for densifying the bond between soil particles. Some times chemical admixtures are also use in composition with soil mass. To ensure the strong bond between soil particles and admixture compaction is necessary. Compaction reduces the pore space from the soil, density of soil is increase and improve the strength of the stabilized soil. It helps to reduce in permeability of the subgrade and increase durability of the road pavement.⁽⁵⁾

D. Organic Matter

Organic matter present in the soil is react with the chemical admixture which are used in the soil for stabilization. This result pH reduction of the soil. Hence it is essential to determine the percentage of organic matter present in the soil. According to the quantity of organic matter present, the stabilization method is designed and implemented.⁽⁵⁾

V. CONCLUSION

India has endowed with great physical diversity. India covers 20% of area with black cotton soil. Deccan plateau prominent relief feature of Maharashtra is bordered by Western Ghats (Sahyadri) in west. Deccan trap basalt covers 95% area of Maharashtra. Deccan trap basalt evolved due to volcanic eruptions undergoes erosion. Due to weathering action basalt rock undergoes degradation and erosion of rock, which finally result in formation of black cotton soil. Construction of any structure essentially tries to meet the demand of required material easily accessible and in economic cost. Earth is used as a core material in subgrade layer for construction of road pavement. Though black cotton soil available in plenty amount cannot be used in subgrade layer due to its enormous critical characteristics. Hence black cotton soil needs to be improved using soil stabilization techniques before it is used in subgrade. RBI Grade 81 is an effective stabilizer which increases strength, reduces permeability, increases durability and controls moisture content of the soil. It also reduces overall thickness of the pavement, construction cost and time of road project. Lime stabilizer improves strength, workability and volume stability of the soil. Its controls on moisture content effectively. Rice husk ash is byproduct of the rice mills containing high amount of amorphous silica and iron oxide used to increase density and strength of the soil. Foundry sand is a waste product in metal foundry industry having large amount of high quality silica used to increase strength and control on moisture content. It forms a good stabilizer compound when it mix with lime. Precautions must be taken related to temperature, moisture content, compaction and organic matter during the process of stabilization. The entire above stabilizer are effective and economical in improving engineering characteristics of black cotton soil.

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