

Investigations on Soil Characteristics Improvement by using Lime and RBI Grade 81

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Abstract— In India approximately 52.6 million hectares of the land region are covered with black cotton soils. The Black cotton soils are hard when dry; however lose its quality totally when in wet condition. Different techniques are adjusted to enhance the building qualities of far reaching soils. The dangerous soils are either evacuated by great and better quality material or treated utilizing added substance. The present theory shows the properties of black cotton soils. In this study, black cotton soil was stabilized using RBI Grade-81 and lime. For better performance of the structure built on such soils need to be improved. The poor engineering properties of soil have forced engineers to improve the properties of soil by various stabilizing techniques. There is a need to look towards alternative materials or methods. Soil stabilization using RBI grade-81 is one such technique which can be used to improve the Geotechnical properties of soil very effectively. RBI Grade-81 (Road Building International Grade-81) and lime is a natural and chemical soil stabilizer which can stabilize a wide range of soils in a very efficient, eco-friendly and least-cost manner. In this study, the effectiveness of the stabilizer RBI Grade-81 to stabilize the black cotton soil is investigated through laboratory experiments. RBI Grade-81 and lime has been used as soil stabilizer in this study. Various Laboratory tests were performed to study the effect of RBI Grade-81 on the soil. Experimental results showed that RBI Grade-81 and lime decreased the MDD and increased the OMC. It also reduces the Plasticity and swelling characteristics of soil. From the test results it was also observed that with the increasing dosage of RBI and with increasing curing periods, it effectively improved the CBR values of soil.

Keywords: Black cotton soil, RBI Grade-81, CBR value

I. INTRODUCTION

A. Background of the Study

India has the population of 125 million (approximate) over the area of 32, 87,240 sq. km needed vast network of structures and roads. The land available for construction is less because of increasing urbanization. Recently various polymer stabilizers have emerged and are being used for soil stabilization.

RBI G81 value is inversely proportional to thickness of the pavement layer. If the subgrade is stronger, the higher is the CBR value, so lesser thickness is required and vice-versa. It is a natural soil stabilizer. It is a unique and innovative product that was developed for the stabilization of a wide spectrum of soils in an efficient, least-cost manner. RBI Grade-81 is an environmental friendly, inorganic, hydration activated powder-based stabilizer that dramatically improves the soil properties. The properties of RBI Grade-81 encouraging engineers to prefer it over other stabilizer.

B. Soil Stabilization

Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. In its broadest senses, stabilization includes compaction, pre consolidation, drainage and many other processes. Soil stabilization is used to reduce to the permeability and compressibility of the soil mass in earth structure and to increase its shear strength. However, the main use of stabilization is to improve the natural soil for the construction of highways and make an area trafficable within a short period of time for military and other emergency purposes. Soil Stabilization can be defined as any physical, chemical, biological or a combined method of changing the available natural soil in order to meet the engineering properties & fulfill the necessity.

C. RBI Grade 81 Stabilization

RBI Grade-81 was developed by the South African army 20 years ago. It has since undergone extensive technological advancement to provide the complete road solution.

Serial no	Physical properties	RBI Grade 81
1	Odour	Odourless
2	Ph.	12.5
3	Freezing point	None
4	Flammability	Non-flammable
5	Shelf life	1 year
6	Storage	Dry storage
7	Bulk Density	700 Kg/m ³
8	Appearance	Greyish powder
9	Specific Gravity	2.5
10	Solubility	In water 0.2pts/100pts
11	Storage	Store in dry place avoiding contact of moisture

Table 1.2: Physical Properties of RBI G81

Serial no	Chemical Properties	% By mass
1	Calcium	52 – 56%
2	Silicon	15 – 19%
3	Sulphur	9 – 11%
4	Aluminum	5 – 7%
5	Iron	0 – 2%
6	Magnesium	0 – 1%
7	Manganese, Potassium, Copper, Zinc	0.1 – 0.3%
8	Water	1 – 3%
9	Fibers	0 – 1%
10	Additives	0 – 4%

Table 1.3: Chemical Property of RBI G81

II. METHODOLOGY

A. General

This chapter presents the details of the experimental work carried out using black cotton soil, lime and CBR Grade 81. Black cotton soils are highly clayed soils, which have very low strength and bearing capacity and highly unstable. These soils cannot be used for any construction work or for construction of any structure over it. An attempt is made in this study to improve the strength by stabilizing the soil with lime and CBR Grade 81. The matter is discussed under the following heads:

- 1) Materials used
- 2) Laboratory tests program

1) Material Used

The materials used in the investigation consist of:

- 1) Expansive soil
- 2) CBR Grade 81
- 3) Lime
 - a) Expansive soil

Black cotton soil is a type of expansive soil and covers very large area of world, mostly found in the arid and semi-arid region. In India it covers about 20% of land area and includes approximately the entire Deccan Plateau, Maharashtra, Karnataka, Andhra Pradesh and part of Gujarat and Madhya Pradesh. It exhibit low bearing capacity and high volume change due to the presence of montmorillonite clay mineral. Because of the poor engineering properties and high swell-shrink characteristics, the design of structures on black cotton soil has been a cause of concern for various construction agencies.

B. Use of RBI Grade-81 Stabilizer

RBI Grade-81 (Road Building International Grade-81) is a natural and chemical soil stabilizer. It is a unique and innovative product that was developed for the stabilization of a wide spectrum of soils (shown in Table-1.1) in an efficient, least-cost manner. It has ability to react with a wide range of soil types and under different soil conditions. Clay, silt, sand and gravel based soils can all be stabilized with a single product, eliminates the requirement of multiple stabilizers for a given project. RBI Grade-81 is an odourless beige powder, which is insoluble in water, non UV degradable and chemically stable. It forms dust free surface. It is durable, permanent and hardens fast. It is aesthetical and environmental friendly.

C. History of RBI Grade-81

The History of RBI Grade-81 is summarized below according to its year wise development.

- 1990: South African scientists set out to develop a unique, environmentally friendly comprehensive and irreversible soil stabilizer for road construction.
- 1998: RBI Grade 81, after 10 years of R&D was granted a South African patent. □ 2001: First production facility set up in Israel, with production capacity of 30 ton/hour.
- 2005: Portugal, the first EU country to specify RBI Grade 81 in a government tender.
- 2006: Mapei, one of Europe's largest producers of auxiliary materials for building and industry, signs a

manufacturing license agreement with Road Building International on an exclusive basis in Italy.

- 2006: European Investment Bank confirms co-operation for future implementation of RBI in infrastructure and environmental projects

D. The Benefits of RBI Grade-81

The Benefits of RBI Grade-81 are as follows:-

- It reduces construction time by 40%
- It prevents foundation damage by making soil water-resistant.
- It reduces the Aggregate requirement
- It reduces cost of transport & earth-moving by 60%
- It reduces the cost of maintenance
- It is environment friendly and has a small Carbon Footprint

E. Laboratory test program

The alternate process of swelling and shrinking results in differential settlement which results in Cracks in the building. Hence the entire in – situ soil is to be replaced which is a very complicated process. This can be avoided by conducting soil stabilization by making use of RBI Grade 81 powder with lime. RBI Grade 81 and lime mix is a Cementations powder stabilizer which can be mixed in proper proportions to achieve desired results. Here I have conducted CBR test on soil mix in the following proportion 1%, 2%, 4%, 6% and get the CBR value for soil mix and also perform Modified Proctor Test on Black Cotton soil in the same proportions 1%, 2%, 4%, 6% and obtained results for Optimum Moisture Content and Maximum Dry density.

In this research, for the investigation of soil properties following test are conducted.

- CBR Test
- Modified Proctor Test

The tests used to evaluate the strength properties of soils may be broadly divided into three groups:

- 1) Shear tests
- 2) Bearing tests
- 3) Penetration tests

F. Dry Density and Optimum Moisture Content of Soils:-

In geotechnical engineering, soil compaction is the process in which a stress applied to a soil causes densification as air is displaced from the pores between the soil grains. It is an instantaneous process and always takes place in partially saturated soil (three phase system).

Calculations for Compaction Curve

- 1) Weight of Compacted Soil (W_s) in grams.

$$W_s = W_m - W_{ms}$$

- 2) Bulk Density (ρ) in gm/ml

$$\rho = \frac{W_s}{V}$$

- 3) Dry Density (ρ_d), w = water content

$$\rho_d = \frac{\rho}{1+w}$$

Compaction Curve of Soil – Maximum Dry Density and Optimum Water Content

The compaction curve is the curve drawn between the water content (X-axis) and the respective dry density (Y-axis). The observation will be initially an increase of dry

density with the increase in the water content. Once it reaches a particular point a decrease of dry density is observed.

The maximum peak point of the soil compaction curve obtained is called as the Maximum dry density value. The water content correspond to this point is called as the Optimum water content (O.W.C) or optimum moisture content (O.M.C).

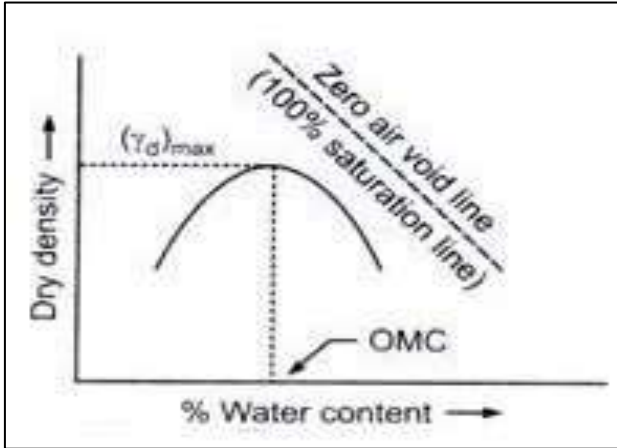


Fig. 3.6: Compaction Curve of soil

The graph shown in figure-3 is the compaction curve. Initially for a water content lesser than O.M.C the soil is rather stiffer in nature that will have lots of void spaces and porosity. This is the reason for lower dry density attainment.

III. EXPERIMENTAL INVESTIGATION

A. Grain size distribution

1) Dry sieve analysis

About 1kg of soil sample was taken and it was washed with water on 75 micron sieve thoroughly, soil mass retained on sieve was dried and weighed and used for sieve analysis. These dried soils were allowed to pass through stack of different sieves like 4.75mm, 2.36mm, 1.18mm, 600µm, 300µm, 150µm, 0.75µm. The soil sample that retained on these sieves were used for the grain size distribution curve.

B.I.S. Sieve	weight retained in (gm)	percentage weight retained (%)	Cumulative percentage retained (%)	Percentage Weight Passing (%)
4.75 mm	12.7	1.27	1.27	98.73
2.36 mm	5.1	0.51	1.78	98.22
1.18 mm	11.8	1.18	2.96	97.04
600 µm	22.9	2.29	5.25	94.7
300 µm	10	1.0	6.25	93.75
150 µm	20.2	2.02	8.27	91.73
75 µm	29.4	2.94	11.21	88.79

Table 4.1: The grain size distribution of this soil

B. Liquid limit test

A sample of 200gm of soil taken and appropriate water was thoroughly mixed to form a paste. The soil paste was then filled in the cup of the device of liquid limit test and a groove was made in middle of soil along the diameter, separating the soil sample into 2 parts. Then handle of the device was turned till the 2 parts in the cup joined. Then no of blows was noted and small quantity of soil was taken for determination of moisture content.

About 300 gm of soil sample was taken and mixed with required amount of water thoroughly and then a portion of soil was taken into a ball and rolled it into a thread of uniform diameter. After some time sample gets crumble and some crumbled soil pieces were taken for determination of moisture content.

IV. RESULTS & DISCUSSION

In this chapter the results of the study are presented and discussed with reference to the aim of the study, which was to determine the stability of the soil against the loading over the sample. The result of the test are provided the knowledge of stability of soil against the loading whenever the loading is increases the values of the test result is also changed. These aspects were described in the previous chapter that presented the methodology used in the study.

Soil Stabilizer (%)	CBR at 2.5mm	CBR at 5mm
0	2.19	1.87
2	5.74	5.66
4	8.93	7.83
6	11.34	10.51
8	15.72	14.89
10	16.20	15.18
15	17.35	16.13
20	20.4	17.2
25	18.3	15.9

A. Test on virgin soil

SOIL SAMPLE	OMC (%)	MDD (KN/M3)
1	14.56	16.50
2	15.11	17.00
3	15.20	17.10
4	15.35	16.90
5	15.62	17.20

Table 5.2: OMC and MDD % for Virgin Soil

Compaction of soil produce at a large scale the increase in dry density for soil when it is compacted at moisture contents drier than the optimum moisture content. It should be noted that for higher moisture content than the optimum moisture content, the heavier compaction effort will reflect a small effect on increasing dry unit weights.

B. MDD & OMC Test Result

SOIL SAMPLE	SOIL % IN SAMPLE	STBLIZER % IN SAMPLE	OMC IN %	MDD IN (KN/M3)
1	100	0	16.6	18.25
2	99	1	17.13	18.13
3	98	2	17.4	17.70
4	96	4	17.86	17.43

5	94	6	18.32	17.22
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Table 5.2: OMC% and MDD % for Soil Samples

V. CONCLUSIONS

A. Conclusions

In view of different analysis, it is observed that the engineering properties of soil can be improved by using RBI Grade 81 and lime. This serves to utilize local accessible soil to be use into sub grade furthermore while sub base and base layer. It is Improves the strength of the soil and other engineering properties. Its Also increasing the soil bearing capacity.

It can be provide more stability to the soil in slopes or other such places. The graphs mentioned in previous chapter provide a clear idea about the improvement in the engineering as well as mechanical property of soil after adding lime. It can prevent water from entering in to the soil and hence helps the soil from losing its strength and reducing the volume change due to change in moisture content and temperature. in the mix Lime is used as an effective soil stabilizer for highly expensive soils which undergo through frequent swelling and shrinking and improves various property of soil such as bearing capacity of soil, resistance to shrinkage during moist conditions, reduction in plasticity index, increase in CBR value and subsequent increase in the compression resistance with the time. The reaction and stabilization of soil starts within few hours.

- 1) When the increase in stabilizer dose there is a drastic change in optimum moisture content as well as maximum dry density.
- 2) By adding RBI Grade 81 stabilizer the geotechnical properties of BC soil is enhanced to a great extent.
- 3) Also we can conclude that RBI Grade 81 is suitable for any type of soils & also it can be concluded that CBR value varies based on soil texture.
- 4) When BC soil is cured RBI there will be a significant improvement of strength.
- 5) The above test results reveals that the Soil with Lime is more stable than the Virgin soil. OMC increases with increase in percentage of Lime as Lime absorbs some water at the start of reaction.
- 6) The value of MDD decreases with increase in lime percentage

B. Future Scope:

There is a lot of scope for research work in the future with RBI Grade-81. It is economical, eco-friendly, durable and significantly improve the Geotechnical properties of soil. it can be used with approximately all type of soils. It is a newly emerging stabilizer which came in India in 2008 and becoming popular day by day as compare to other stabilizers.

Indian army is regularly using this material from 2009. There is still no proper standards or codes available for use of this stabilizer for different type of soils. Some of areas in which research can be done in the future are:

There are lots of waste materials like plastic waste, quarry waste which has problems of dumping. A study can be carried out on the stabilization of soil by using these waste materials with RBI Grade-81. It will be economical and eco-friendly.

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