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Effect of RBI Grade81 on Engineering Properties of Black Cotton Soil

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Abstract - *A good pavement is needed for the safe, comfortable and economical movement of traffic. If the in-situ soil has no adequate strength, either soil from other sites are to be used or the available soil has to be stabilized so that it attains sufficient strength to carry the traffic load. The objective of this study is to determine the engineering properties of locally available black cotton soil, changes in the properties of soil with addition of different percentage of RBI Grade-81 and to find the optimum percentage of RBI Grade - 81 required for the stabilization of black cotton soil.*

***Key Words*: Black Cotton Soil, Atterberg's limit, California Bearing Ratio, RBI Grade81.**

1. Introduction

In India, soils are classified into six group's mainly alluvial soil, marine soil, laterite and lateritic deposits, expansive soils, sand dunes and boulder deposits. On an average 1 lakh sq km area is covered by lateritic soil deposits, 3 lakhs sq km area is covered by Black cotton soil, and 5 lakhs sq km area is covered by sand dunes. Marine soils are available in the coastal belts; laterite and lateritic soil deposits are available in Maharashtra, Karnataka, and parts of Kerala. Black cotton soil is available in Maharashtra, Gujarat, Madhya Pradesh, North Karnataka, parts of Andhra Pradesh and Tamil Nadu. Alluvial soils are available in Indo-Gangetic plains, and sand dunes in Rajasthan and boulder deposits are available in the Himalayan regions.

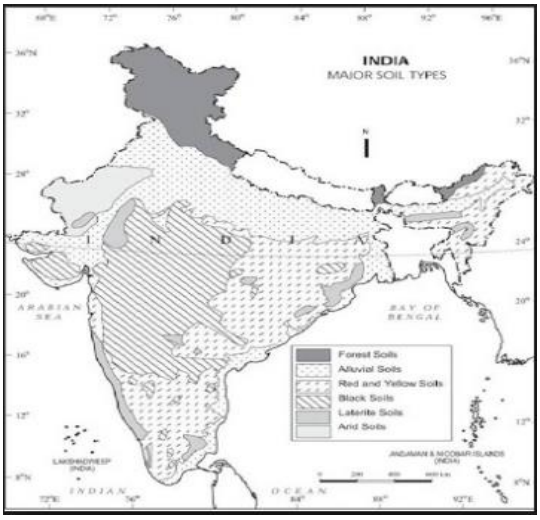

Fig-1: Types of soils in different regions

1.1 Black Cotton Soil

Black cotton soil contains a clay mineral called Montmorillonite which is having a peculiar behavior of swelling in the presence of moisture and developing shrinkage cracks in dry season. Because of volumetric change in behavior the structure constructed on such soils will undergo differential settlements, cracks in buildings or total destruction of the structure however the structures can be constructed on such a soil by treating the expansive soil with a non-expansive material. This can be done by using ground improvement technique like mechanical stabilization, chemical stabilization, freezing and heating, reinforcing earth technique etc.

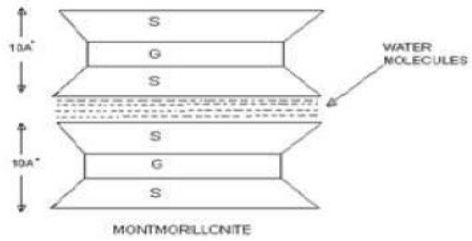

Fig-2: Structure of Montmorillonite Mineral

1.2 Index Properties of B. C. Soil

The properties of soil, which are not of primary interest to the geotechnical engineering, but are indicative of the engineering properties are called index properties. This includes –

1.2.1 Particle Size Analysis:

This is method of separation soils into different fraction bases on particles present into soils. It can be shown graphically on a particle size distribution curve.

1.2.2 Specific Gravity:

It can be classified as the ratio of the weights of a given volume of soil solid at a given temperatures of the weight of an equal volume of distilled water at that temperature both weight being taken in air. The range of specific gravity of coal ashes varies from 1.46 to 2.66 the low values of specific gravity is because of hollow particles chemosphere the sp. Gr. of soil solids is determined by –

1.50 ml density bottle or
2. A 500 ml flask or
3. A Pycnometer

The density bottle method is most accurate and is suitable for all types of soil the flask or Pycnometer method is suitable for coarse grained soil.

1.2.3 Atterberg's Limit:

The water content at which the soil changes from one state to other state are known as consistency limits or Atterberg's limit. The Atterberg's limits which are useful for engineering purposes are; Liquid limit, plastic limit and shrinkage limit. These limits are expressed as percent water content.

1. Liquid limit: - It is defined as the minimum water content at which the soil is still in liquid state but has a small strength against flowing which can be measured by standard available means.

2. Plastic limit: -It is defined as minimum water content at which soil will just begin to crumble water rolled into a thread approximately 3mm in diameter, Plasticity index is determined as difference of L.L. and P.L.

3. Shrinkage limit: - It is defined as the maximum water content at which a reduction in water content will not cause a decrease in the volume of soil mass.

Plasticity Index The plasticity index of a soil is the numerical difference between its liquid limit and its plastic limit, and is a dimensionless number. Both the liquid and plastic limits are moisture contents.

Calculation:
Plasticity Index = Liquid Limit – Plastic Limit PI = LL – PL

1.3 Compaction Test

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. When stress is applied that causes densification due to water (or other liquid) being displaced from between the soil grains, then consolidation, not compaction, has occurred. Normally, compaction is the result of heavy machinery compressing the soil.

1.4 California Bearing Ratio (CBR)

California Bearing Ratio (CBR) is commonly used by civil engineers particularly those involved in pavement construction to assess the stiffness modulus and shear strength of subgrade. It is actually an indirect measure, which represents comparison of the strength of subgrade material to the strength of standard crushed rock referred in percentage values. The method was originally developed at California Division of Highways in 1930's to provide an assessment of the relative stability of fine crushed rock base material.

1.5 Free Swell Index

Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence. A test for measuring the free swelling properties of coal; consist of heating 1 gram Of pulverized coal in a silica crucible over a gas flame under prescribed conditions to form a coke the size and shape of which are then compared with a series of standard profiles numbered 1 to 9 in increasing order of swelling.

1.6 Soil Stabilization

Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub grade to support pavements and foundations. Soil Stabilization is performed in much the same manner as full depth reclamation. A reclaiming machine first pulverizes the soil material. An additive is then placed on top of this material. This additive is mixed and re-mixed with the soil until the desired properties are achieved.

This process can vary depending on the soils and additives required. Soil Stabilization can be utilized on roadways, parking lots, site development projects, and in many other situations where sub soils are not suitable for construction.

The most common type of stabilization are listed below-

- Lime stabilization
- Cement stabilization
- Chemical stabilization
- Bitumen stabilization
- Salt stabilization

1.7 RBI Grade81

RBI Grade-81 is a unique and innovative product that was developed for the stabilization of wide spectrum of soils in an efficient, least-cost manner. RBI Grade-81 is an environment friendly, inorganic, hydration activated powder-based stabilizer that reacts with soil particles to create layers that are interconnected through a complex inter-particle framework.RBI-81 is a unique and highly effective natural inorganic soil stabilizer for Infrastructure development and repair.

RBI Grade-81 was originally developed by RBI for South African Army Road Building International for the in the beginning of 1990's for pavement engineering applications. RBI-81 is a natural inorganic soil-stabilizer which re-engineers and modifies the properties of the soil strength it for roads, paving and roads and pavement. Alchemist Technology is the exclusive manufacturer and distributor of RBI Grade-81 in India.

2. Literature Review

Anitha.K. R, R. Ashalatha, Arvee.Sujil, Johnson [1] investigates the effect of using a new stabilization product, RB1-81 on kaolinite, red soil, & Lateritic soil. This study revealed that both soaked and un-soaked CBR increased significantly with the addition of RB1-81 for kaolinite, Red soil & lateritic soil. During this experiment the CBR specimen were prepared with different percentage RB1- 81 i.e. (0%, 2%, 4%, 6%, & 8%) water content of 1% + OMC was added for preparation of specimen. CBR test were done at 0, 7 & 11 days of curing. CBR test at 11 days was done after soaking for 4 days, for the sample which has been cured for 7 days. After all experiment the authors came to the conclusion that un-soaked CBR did not vary much for red soil and lateritic but it increased 16 times for kaolinite. It has also been found that soaked CBR increased 16, 14 & 4 folds with the addition of optimum percentage of RB1-81 recommended for red soil, lateritic and kaolinite respectively.

3. Material

The present investigations have been made on the black cotton soil obtained from Maddur village H.D kotte Mysuru Karnataka State, India. This is a residual soil and is collected from open excavation, at a depth of 1.5m below the natural ground surface near tank bed. The soil was manually pulverized and sieved through IS sieve 425 μ before used in this investigation.

Table -1: Properties of Black Cotton Soil

Sl. No	Laboratory test	Results	Relevant codes
1	Grain size Distribution	72.66% finer	IS2720 Part IV
2	Specific Gravity (G)	2.6	IS2720 Part III
3	Water content (w)	11%	IS2720 Part II
4	Liquid limit (W_L)	58.5%	IS2720 Part V
5	Plastic limit (W_P)	27.10%	IS2720 Part V
6	Plasticity Index (I_P)	27.40%	IS2720 Part V
7	Free swell Index	28	IS2720 Part XI
8	Optimum moisture content (OMC)	20.02%	IS2720 Part VIII
9	Maximum Dry Density (MDD)	1.63g/cc	IS2720 Part VIII
10	California Bearing Ratio (CBR)	2.21%	IS2720 Part XVI
11	Unconfined Compressive Strength (UCS)	2.5kg/cm^2	IS2720 Part X

RBI Grad 81: RBI Grade 81 is a hydration activated powder based stabilizer which reacts with soil. Material for the testing work is received from M/S Alchemist Technology Limited, India. Chemical composition and properties of RBI Grade 81 are tabulated in table 2 (provided by the supplier)

Table -2: Properties of RBI Grade81 Stabilizer

Sl. No	Chemical Significance		Physical Significance	
1	Ca	Cao 52-56	Odor	Odorless
2	Si	Sio_2 15-19	pH	12.5
3	S	SO_2 9-11	Specific Gravity	2.5
4	Al	Al_2O_3 5-7	Solubility	In water 0.2pts/100 pt
5	Fe	Fe_2O_3 0-2	Freezing point	None, Solid
6	Mg	MgO 0-1	Flammability	Non-flammable
7	Mn, K, Cu, Zn	Mn, K, Cu, Zn 0-3	Shelf life	12 months (Dry storage)
8	Fibers (Polypropylene)	0-1	Storage	Dry storage Avoid moisture
9	Additives	0-4	Bulk Density	700 kg/m^3

4. Results and Discussions

Table 3: Tests results for Properties of Black Cotton Soil with & without addition of RBI Grade81

Sl.No	Particulars	Soil + 0% RBI	Soil + 2% RBI			Soil + 4% RBI			Soil + 6% RBI		
1	Liquid limit (W_L)	58.5%	55.8%			53.6%			51.5%		
2	Plastic limit (W_P)	27.10%	28.8%			30.1%			32.2%		
3	Plasticity Index (I_P)	27.40%	27.0%			23.5%			21.3%		
4	Free swell Index	28	19			9			6		
5	Optimum moisture content (OMC)	20.02%	24.25%			25.09%			26.4%		
6	Maximum Dry Density (MDD)	1.63 g/cc	1.575 g/cc			1.565 g/cc			1.563 g/cc		
7	California Bearing Ratio (CBR)	2.21%	7D	14D	28D	7D	14D	28D	7D	14D	28D
			6.6	9.5	10.6	14.65	16.8	18.9	19.2	24.5	30.6
8	Unconfined Compressive Strength (UCS)	2.5 kg/cm²	7D	14D	28D	7D	14D	28D	7D	14D	28D
			2.8	3.2	3.9	4.1	4.2	4.4	4.6	5.15	5.9

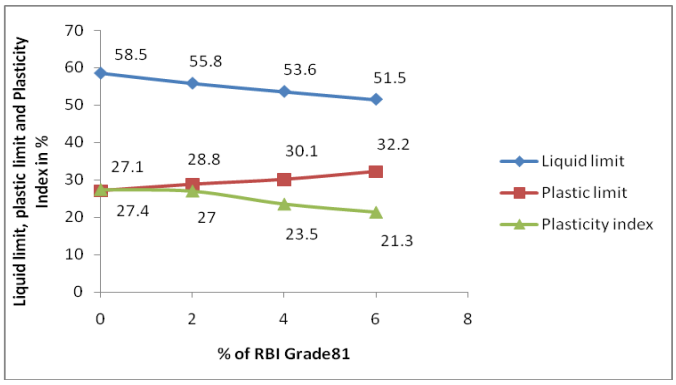

Chart -1: Variation of Liquid limit, Plastic limit and Plasticity Index with different percentages of RBI Grade81

As the percentage of RBI Grade81 is increased, the Liquid limit and Plasticity Index decreases considerably whereas the Plastic limit increases gradually.

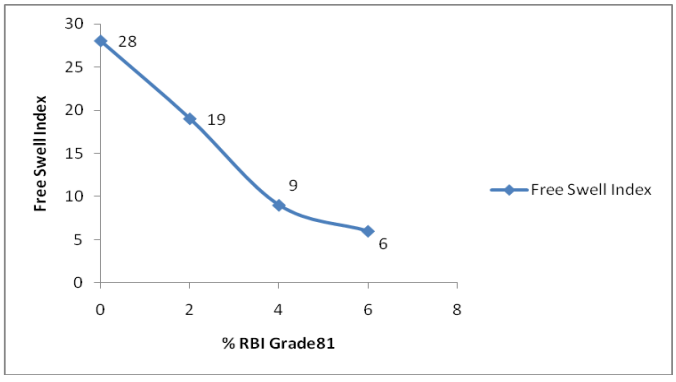

Chart-2: Variation of Free Swell Index value with different percentages of RBI Grade81.

As the Percentage of RBI Grade81 is increased, Free Swell Index value decreases considerably.

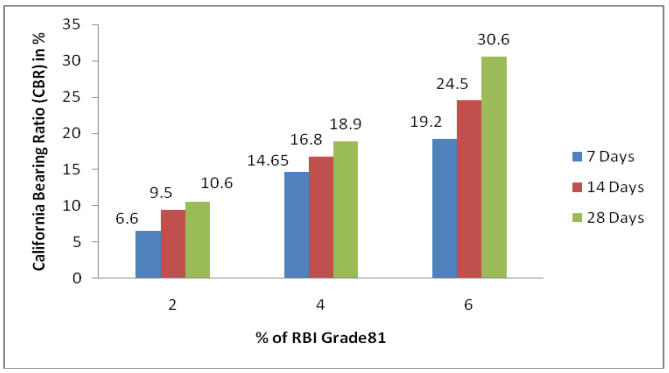

Chart -3: Variation of California Bearing Ratio (CBR) with different percentages of RBI Grade81

As the percentage of RBI Grade81 is increased, the CBR value increases gradually.

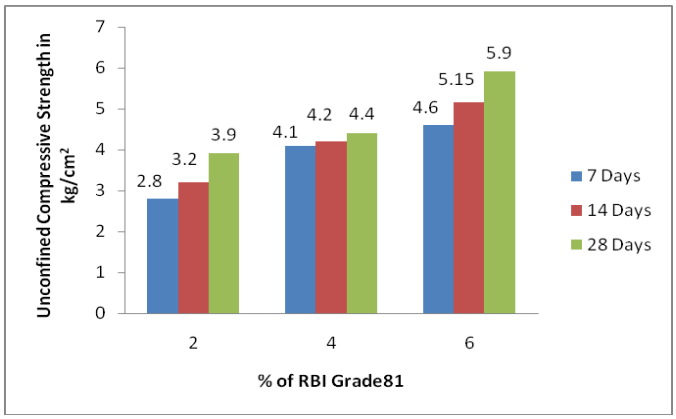

Chart-4: Variation of Unconfined Compressive Strength with different percentages of RBI Grade81.

As the Percentage of RBI Grade81 is increased, Unconfined Compressive Strength value increases considerably.

5. Conclusions

Scope of the work was to propose chemical stabilization for enhancing engineering properties of black cotton soils using RBI Grade81. Following conclusions are made on the basis of test results

1. The liquid limit, Plasticity index, Free Swells Index value decreases, whereas the plastic limit increases with irrespective of the percentage of addition of RBI grade 81 stabilizer

2. Unconfined Compressive strength, CBR (soaked) values increase with increase in RBI 81 addition suggest its suitability as good stabilizer to improve performance of soft soils

3. From the economic analysis, it is found that RBI grade 81 stabilizers up to 6% can be utilized for strengthening the subgrade of flexible pavement with a suitable save in cost of construction.

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