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Study on Shedi Soil Treated With a Cementitious Stabilizer for Use as Pavement Material

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Abstract**-- Road network in rural areas plays an important role in development of agricultural base country, like India. The life and maintenance of rural road depends on strength of subgrade soil and traffic intensity. Options for dealing with poor soils include attempting to dry and compact the subgrade; reinforcing the subgrade with a geo-synthetic material; applying a chemical stabilizer such as lime, cement, polymer or other amendment and/or designing a very thick and expensive pavement section. Traditional lime and cement treatment can be very effective, but the use of lime and cement are limited due to issues with dust control and other handling problems.**

Keywords**-- RBI Grade 81, soil stabilization, Heavy Compaction, CBR test, Unconfined Compressive Strength.**

I. INTRODUCTION

Road infrastructure in India is developing at a very fast pace. The subgrade soil is not uniform throughout the alignment of the road. A good pavement is needed for the safe, comfortable and economical movement of traffic. The soil of the subgrade which satisfies the conditions given by IRC: SP: 72-2007 are suitable as subgrade soil. If the soil has CBR value less than 2%, it must be replaced by good quality material.

Engineers are often faced with the problem of constructing facilities on or with soils, which do not possess sufficient strength to support the loads imposed upon them either during construction or during the service life of the structure. Many areas of India consist of soils with high silt contents, low strength and poor bearing capacities. These negative soil performance characteristics are quite often attributed to the nature and quality of the fines present in the material.

For better performance of structures built on such soils, the performance characteristics of such soils need to be improved. The poor engineering performance of such soils has forced Engineers to attempt to improve the engineering properties of poor quality soils.

II. SOIL STABILIZATION

Stabilization of soils is an effective method for improving the properties of soil and pavement system performance.

It is the alteration of the property of a locally available soil to improve its engineering performance, such as strength, stiffness, compressibility, permeability, workability, and sensitivity of soil and thus making it more suitable and stable. It is required when the soil available for construction is not suitable for the intended purpose. In its broadest sense, stabilization includes compaction, pre-consolidation, drainage and many other such processes, but more specifically stabilization means chemical modification of soil by mixing soils with various chemicals. The main objective is to increase the strength and stability of soil and to reduce the construction cost by making it best use of the locally available materials. A cementing material or a chemical is added to a natural soil for the purpose of stabilization.

III. MATERIALS

A. Proprietary Cementitious Stabilizer

The proprietary Cementitious Stabilizer called Road Building International Grade 81 (RBI Grade 81) is a product that was developed for the stabilization of a wide spectrum of soils in an efficient, least-cost manner. It is an environmental friendly, inorganic, hydration activated powder-based stabilizer that reacts with soil particles to create layers that are interconnected through a complex inter-particle framework. The properties of Proprietary Cementitious Stabilizer are shown in Table I.

Table I.
Physical properties of RBI-81 Stabilizer

Property	Description
Odour	Odourless
pH	12.5
Solubility	In water (0.2pts/100pts)
Freezing Point	None, Solid
Flammability	Non-flammable
Shelf Life	12 months (dry storage)
Bulk density	700/m^3

RBI Grade-81 is a unique technological breakthrough in soil stabilization, waste binding and pavement layer design for the road and highway building world. RBI Grade 81 is a unique and highly effective natural inorganic soil stabilizer for infrastructure development and repair. This meets the requirement for a well-proven, reliable and very cost-effective method by creating a strong and irreversible impermeable layer which is resistant to adverse climatic conditions, from very high temperatures to permafrost conditions, and accommodating all types of roads and load requirements.

RBI Grade-81 is environment friendly and emphasizes the use of recycled material, recognizing the lack of readily available resources. It reduces the Carbon Footprint of any project by reducing transportation requirements and carbon emissions. This makes it eligible for Carbon Credits in the environment friendly sensitive global market place. It is a natural inorganic soil-stabilizer which re-engineers & modifies the properties of soil to strengthen it for roads, paving and roads and pavement.

B. Shedi soil

Shedi soil is available in major parts of Dakshina Kannada District, Karnataka state. This is the name given to the locally available whitish, pinkish or yellowish silty sand. Shedi soils are also known as Lithomargic clays, which is present at a depth of 1-3 meters below the top lateritic outcrop (throughout the Konkan belt). This type of soil is abundantly available in the western coastal belt of Southern India, starting from Cochin to Goa.

These soils are the product of tropical or subtropical weathering. It does not contain bases and primary silicates, but it may contain large amounts of quartz and kaolinite. Its strength is high in dry condition, whereas significant reduction of strength takes place when there is an increase in moisture content. These types of dispersive soils are highly susceptible to erosion.

In the present study Shedi soil was collected from Mulki area, near Mangalore of Dakshina Kannada District of Karnataka state.

IV. Mechanism Of Soil Stabilization By Proprietary Cementitious Stabilizer

The reaction mechanism of stabilization with Proprietary Cementitious Stabilizer follows a hydration process, in characteristics to lime and cement. Water or better put moisture initiates the reaction process of Proprietary Cementitious Stabilizer. The initial stages of reaction are very important to the success of soil stabilization; however, the strength of the stabilized layer is achieved over a long-term time frame.

When the stabilizer is mixed with a soil, the soil and stabilizer exchange ions thus creating ionic bonds between the soil and stabilizer particles. The soil voids are then filled with 'crystalline reaction products', producing mechanical ties between the soil and stabilizer particles. This chemical process is described as continuing over a period of time, thus improving soil strength over time.

V. Preparation And Casting Of Test Specimens

A. Compaction Tests

Compaction test is carried out to determine the relationship between water content and dry density of a soil and to determine the optimum water content (OMC) to give maximum dry density (MDD). Standard test equipment and procedure available for compaction test was used in the present work for heavy compaction (IS: 2720 (Part 8) – 1983: Determination of Water content- Dry density relation using Heavy Compaction").

The heavy compaction test for the treated soils were conducted as per prescribed standards (IS: 4332 (Part 3) – 1967, "Tests for determination of Moisture content- Dry density relationships for stabilized soil mixtures").

Figure 1. Preparation of sample by IS Heavy Compaction to determine Maximum dry density and Optimum moisture content

B. Unconfined Compressive Strength Test (UCS Test)

Standard test equipment and procedure available for UCS test was used in the present work as per (IS: 2720 (part 10) – 1973, "Determination of Unconfined Compressive Strength"). After treating the soils with commercial stabilizer, the UCS test was carried as per prescribed standards (IS: 4332 (Part 5) – 1970, "Determination of Unconfined Compressive Strength of Stabilized soils").

The unconfined compression strength (UCS) test was carried out for both soaked and unsoaked conditions for heavy compaction densities. The soils were treated with 2%, 4% and 6% by weight of commercial stabilizer and test was conducted for the following conditions.

1. Specimens cured for 4 hours, 1 day, 3 days, 7 days and 28 days were tested for unsoaked condition.
2. Specimens cured for 4 hours, 1 day and 3 days were soaked for 2 hours and tested for soaked condition.
3. Specimens cured for 7 days and 28 days were soaked for 1 day and tested for soaked condition.

Three identical specimens were tested for each of the above conditions. Graphs of stress versus strain were plotted and average peak stress was obtained from the specimens was taken as unconfined compression strength.

Specimen preparation and curing

The type of specimen tested for unconfined compression test of the stabilized soil is 20cm in height and 10cm in diameter. A cylindrical specimen of length to diameter ratio of 2 is used. A cylindrical split mould of height 400mm and 10cm diameter provided with top end cap of height 50mm and bottom cap of 150mm height as shown in the figure was used for the preparation of the sample.

Figure 2. Mould assembly compressed under UTM and samples obtained for UCS Testing

Measured quantity of the soil and the water required to satisfy OMC and MDD conditions is thoroughly mixed. The oil is applied to the inner surface of the mould as well as the to the end caps. The mould is kept on the bottom end cap. The mixture is put inside the mould in layers suitably and top end cap is kept. The mix is compacted by keeping the mould assembly under the universal testing machine. Then, the specimen is suitably removed from the mould and weighed.

The specimen is protected by wrapping in polyethene bag to maintain it at its specified moisture content. After the curing period and before testing, the specimen shall again be weighed to check whether there is any change in the water content or weight.

Figure 3. Curing of samples prepared for Unconfined Compression Test

C. California Bearing Ratio (CBR) Test

Standard test equipment and procedure available for CBR test was used in the present work (IS: 2720 (Part 16) – 1979, "Laboratory Determination of CBR"). The tests were conducted for soaked and unsoaked condition for samples prepared under IS heavy compaction condition.

Figure 4. California bearing ratio testing machine and the specimen undergoing testing.

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VI. Results And Discussions

A. Compaction Test

Effect of Proprietary Cementitious Stabilizer on Maximum Dry Density and Optimum Moisture Content of Shedi Soil: With the increase in percentage of stabilizer, the maximum dry density of the soil increases gradually with the decrease in optimum moisture content continuously and gradually. There is a marked increase in the maximum dry density of soil with 2% stabilizer with a great reduction in optimum moisture content.

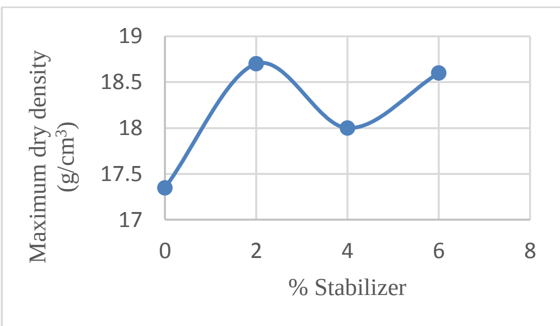

Figure 5. Variation of Maximum Dry Density with different percentages of stabilizer for Shedi soil

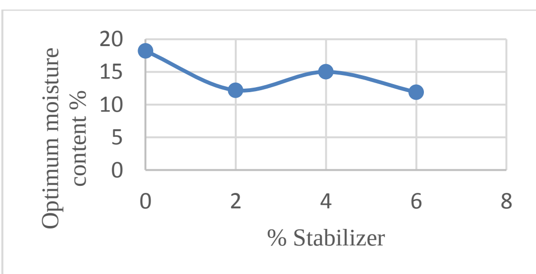

Figure 6. Variation of Optimum Moisture Content with different percentages of stabilizer for Shedi soil

B. Unconfined Compressive Strength Test

Effect of Proprietary Cementitious Stabilizer on Unconfined Compressive Strength of Shedi soil: Unconfined compressive strength test results (soaked and unsoaked condition) of shedi soil have been studied in this section. For unsoaked condition, the strength increases with increase in curing period and also with increase in percentage of stabilizer.

The strength before treating with stabilizer was 860 kN/m^2 which increased to 1820 kN/m^2 (increase of 111.62%) for 2% stabilizer, 2580 kN/m^2 (increase of 200%) for 4% stabilizer and 3100 kN/m^2 (increase of 260.46%) for 6% stabilizer at 28 days curing. There is dramatic reduction in strength of soil (and also stabilized soil) on soaking.

For soaked condition the improvement in strength is not so appreciable with increase in curing period. The strength of treated soil in soaked condition increased for 4 hours, 1 day and 3 days curing, but it decreased for 7 days curing – 1 day soaking and increased again for 28 days curing. UCC strength of soil treated with 2% stabilizer is 60 kN/m^2 which increased to 105 kN/m^2 (increase of 75%) for 4% stabilizer and 190kN/m^2 (increase of 216.6%) for 6% stabilizer at 28 days curing in soaked condition.

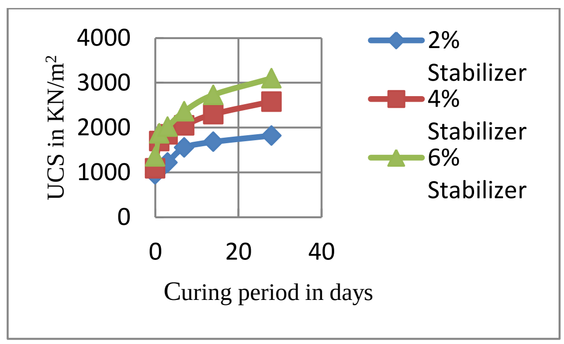

Figure 7. Variation of UCS (unsoaked) with curing period for different percentages of stabilizer for Shedi soil

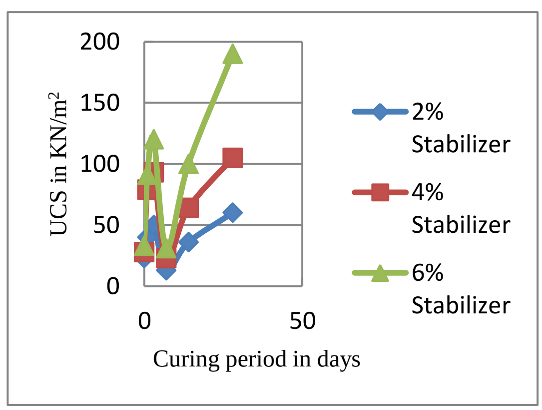

Figure 8. Variation of UCS (soaked) with curing period for different percentages of stabilizer for Shedi soil

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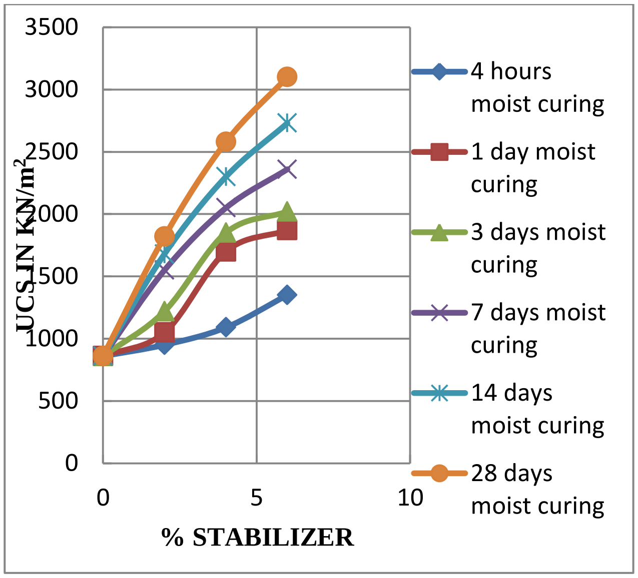

Figure 9. Variation of UCS (unsoaked) with different percentages of stabilizer for Shedi soil

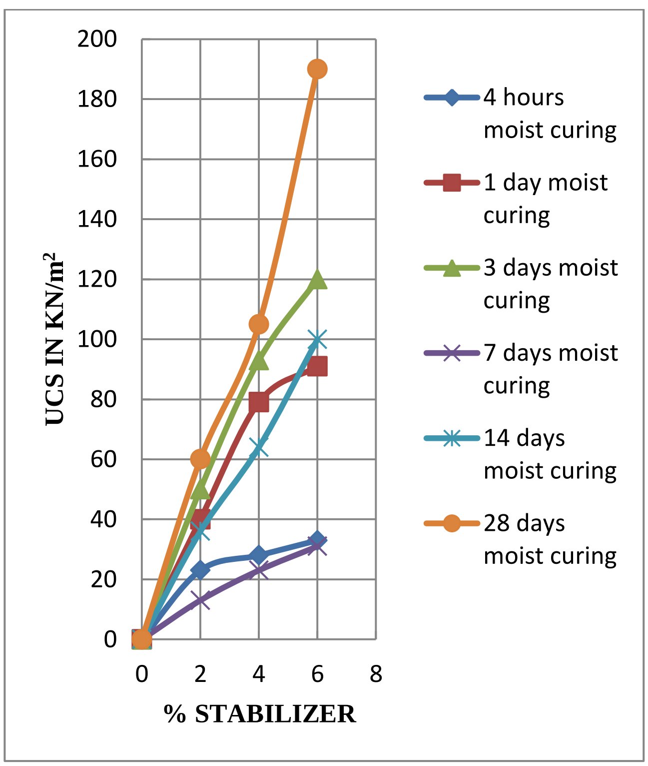

Figure 10. Variation of UCS (soaked) with different percentages of stabilizer for Shedi soil.

C. CBR Test

Effect of Proprietary Cementitious Stabilizer on CBR value of Shedi soil: The CBR value before treating with stabilizer was 1.94% which increased to 3.74% (increase of 92.78%) for 2% stabilizer, 8.95% (increase of 361.34%) for 4% stabilizer and 11.19% (increase of 476.80%) for 6% stabilizer at 7 days moist curing and 4 days soaking.

VII. Conclusions

1. RBI grade 81 stabilizer gives satisfactory results for both the soils in terms of strength and CBR value.
2. The improvement in UCC under soaked condition is not so significant in case of Shedi soil. Soil showed appreciable improvement in UCC strength under unsoaked condition which is of very much reliable in design. In fact, under unsoaked condition, treated Shedi soil shows best results, while under soaked condition there is a dramatic reduction in strength. This may probably have to do with the dispersive nature of the untreated (original) Shedi soil. Dispersive soils lose cohesion on soaking. This particular stabilizer seems to work well with cohesive and gravelly soils.
3. From the results of CBR test, Shedi soil treated with 6% stabilizer offers good improvement.
4. Untreated Shedi soil has low CBR values of 1.94%. On treating with 6% stabilizer this value increased upto 11.19%, which is a substantial increase. Also CBR values of treated soil is better and offer a good and economical design of pavements.
5. The use of locally available soils for subgrade saves natural granular material.
6. RBI Grade81 is of national importance to any country.

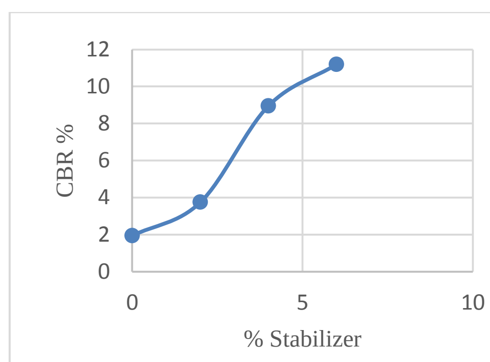

Figure 11. Variation of CBR with different percentages of stabilizer for shedi soil

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