Experimental Study on Engineering Properties of Subgrade Soil Stabilized By RBI 81 Along With Coir Fiber

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Abstract- *Subgrade soil failure due to insufficient strength, weak bearing capacity, excessive deformation and desiccation cracking of problematic soils is commonly observed on the road network, and this leads to huge expenditure in the maintenance and repair of highway projects every year. It is necessary to reduce these engineering problems and economic losses through environmentally and economically friendly methods. Previous studies have shown that randomly distributed fibers can significantly improve various soil properties. However, there is a lack of comprehensive study on the engineering properties of fiber reinforced high plastic clay. Also, limited mechanical models have been proposed for predicting the shear strength behaviour of fiber reinforced clay. In order to investigate these problems, a series of laboratory investigations including compaction, bearing capacity, one-dimensional consolidation, linear shrinkage, desiccation cracking, direct tensile strength, compression tests should be conducted on unreinforced and Coir fiber reinforced Clay. For this study, the soil samples were prepared with different proportions of RBI grade-81 i.e. (2%, 4%, 6% and 8% of soil) respectively. After that the coir fibers in different ratio i.e. 0.5%, 1%, 1.5% and 2% respectively will be added to the sample containing suitable content of RBI grade-81. Then OMC, MDD and CBR values evaluated for these sample.*

Keywords: Coir fiber, highway projects, RBI grade-81, tensile strength, OMC.

I. INTRODUCTION

Expansive soil is considered one of the most common causes of pavement distresses. Depending upon the moisture level, expansive soils will experience changes in volume due to moisture fluctuations from seasonal variations. During periods of high moisture expansive will “swell” underneath pavement structure. Conversely during periods of falling soil moisture, expansive soil will “shrink” and can result in significant deformation. These cycles of swell and/or shrinkage can also lead to pavement cracking. *Puppala et al. (2006)* implied that expansive soils encountered in various districts particularly in northern Texas are the primary causes of pavement failures. Expansive soils located in regions where cool and wet periods followed by hot dry periods are more prone to such problems.

Subgrade failure due to insufficient strength, weak bearing capacity, excessive deformation and desiccation cracking of problematic soils is commonly observed on the road network, and this leads to huge expenditure in the maintenance and repair of highway projects every year. It is necessary to reduce these engineering problems and economic losses through environmentally and economically friendly methods.

Fig.1. Cracking appears on the embankment shoulder in road

Expansive soils also known as swelling soils or shrink-swell soils are the terms applied to those soils, which have a tendency to swell and shrink with the variation in moisture content. As a result of which significant distress in the soil occurs, causing severe damage to the overlying structure. During monsoon’s, these soils imbibe water, swell, become soft and their capacity to bear water is reduced, while in drier seasons, these soils shrinks and become harder due to

evaporation of water. These types of soils are generally found in arid and semiarid regions of the world and are considered as a potential natural hazard, which if not treated well can cause extensive damages to not only to the structures built upon them but also can cause loss of human life. Soils containing the clay minerals montmorillonite generally exhibit these properties. The annual cost of damage to the civil engineering structures caused by these soils are estimated to be £ 150 million in the U.K., $ 1,000 million in the U.S. and many billions of dollars worldwide.

Expansive soils also called as Black soils or Black cotton soils and Regur soils are mainly found over the Deccan lava tract (Deccan Trap) including Maharashtra, Madhya Pradesh, Gujarat, Andhra Pradesh and in some parts of Odisha, in the Indian sub-continent. Black cotton soils are also found in river valley of Tapi, Krishna, Godavari and Narmada. In the the north western part of Deccan Plateau and in the upper parts of Krishna and Godavari, the depth of black soil is very large. Basically these soils are residual soils left at the place of their formation after chemical decomposition of the rocks such as basalt and trap. Also these type of soils are formed due to the weathering of igneous rocks and the cooling of lava after a volcanic eruption. These soils are rich in lime, iron, magnesia and alumina but lack in the phosphorus, nitrogen and organic matter.

Fig. 2. Typical dried Expansive soil

RBI Grade-81 was developed in 1990s. It was extensively used to construct all manner of roads. RBI Grade-81 was bought by MrJosy Cohen from the SA Government, and was further developed and optimized through continuous R&D. After 10 years of R&D South African patent was granted. It took a number of years to introduce soil stabilisers in India through numerous trials using RBI Grade-81. RBI Grade-81 is the pioneer of Soil Stabilisation in India. Road Building International (India) Pvt. Ltd. holds the exclusive license to manufacture and market RBI Grade-81 in India. RBI Grade 81 meets the requirement for a well-proven, reliable and very cost-effective method by creating a strong and irreversible impermeable layer resistant to adverse climatic conditions, from very high temperatures to permafrost conditions, and accommodating all vehicular loads. RBI Grade 81 is environmentally friendly and emphasises the use of recycled material, recognising the lack of readily available resources.

Engineering advantages of RBI GRADE-81

- Increases the California Bearing Ratio (CBR) manifolds.
- Increases Unconfined Compressive Strength (UCS) considerably.
- Increases Modulus of Elasticity value, which results in reduction of pavement crust.
- Reduces Plasticity Index (PI) value.
- Reduces Free Swelling Index (FSI) value.
- By strengthening the existing soil by 12 to 20 times the initial strength, it helps in replacing the conventional aggregate layers with soil stabilized layers, thus saving aggregate. It also reduces the quantity of bitumen in road construction.
- Since it reengineers any kind of soil and stabilizes it with increased strength, it eliminates removal and carriage of in-situ soil and replacing it with better soil suitable for construction.
- By using in-situ soil, it reduces the need to transport good soil & aggregate by about 40%-60%, thus reducing the carbon emission from the trucks.
- The treated areas are comparatively impermeable by water, thus preventing damage to the road foundation.
- Due to the reduced construction time, air pollution by heavy suspended particles is reduced considerably.
- Durability is increased thus the need for continuous maintenance is reduced.
- RBI Grade-81 technology is very simple and does not require skilled labor.
- RBI Grade-81 can also be used for cold recycling of existing pavement (flexible or rigid) layers, thus saving natural resources, as 90% of road material is being reused.

Fig. 3.RBI Grade-81 Powder

Following are the objectives of this work-

- To determine the effect of addition of RBI grade 81 to the soil sample in terms of atterberg limits, Dry density, OMC, CBR (Unsoaked).
- To determine optimum percentage quantity of RBI grade 81to be used as soil stabilizer.
- To determine suitable percentage of coir fiber for reinforcing given sample of expansive soil.

II. LITERATURE REVIEW

S.Gangadhara et.al. (2025) in this research, an attempt is made to understand the impact on strength characteristics of expansive soil treated with Road Building International Grade-81 (RBI-Grade-81) stabilizer. This stabilizer has a wide response spectrum range. A broad range of studies, such as Atterberg limit, Compaction, Unconfined compressive strength (UCS), and California bearing ratio (CBR) measures, are demonstrated on expansive soil and it is treated with percentages varying between 2 and 10% of RBI-Grade-81. Due to the creation of new cement materials, which is apparent in the SEM research micrographs, the improvement in intensity is achieved. The results suggest that considered stabilizer is effective in enhancing the engineering properties of expansive soil.

Kumar and Khatri (2025) This study presents and analyzes the results of a series of Atterberg's limit tests, Proctor compaction tests, California bearing ratio tests and Unconfined Compressive Strength tests performed on Black cotton soil treated with mixture of various Lime and Road Building International (RBI) Grade 81 contents and compacted under the optimum Proctor conditions. These test results show that the geotechnical parameters values are concordant and confirm the bearing capacity improvement of this natural clay, which is translated by a significant increase in soil strength. However, the best performances are obtained for a mix treatment corresponding to 6% Lime and 5% RBI Grade 81 contents. Using 6% Lime we can save up to 25% & using 5% RBI Grade 81 we can save up to 18% pavement cost.

Bernadette et.al (2023) the present study investigates the effect of reinforcing the sub grade soils with RBI 81 material. A soil nearby was collected and preliminary tests were conducted to classify the soil and it was found from the results that the sample collected was a poorly graded clay. Subsequently Tests such as Proctor Compaction, CBR, and UCC were conducted to study the various engineering properties of the identified soil. In addition to the above tests were also conducted on the soil by reinforcing with varying percentages of RBI 81. From the analysis of test results it was found that this material (RBI 81) will significantly improve the CBR value of the soil. However, it was confirmed that walnut shell can be used as light replacement material instead of fine aggregate up to 30% at 0.38 water/cement ratio without adversely affecting the acceptable compressive strength for structural Portland cement concrete.

Shiva and Darga (2022) the present study deals with the efect of Road Building International Grade 81 (RBI Grade 81) on strength characteristics of the clayey subgrade. A wide range of tests was conducted on various percentages of RBI Grade 81 subgrade mixtures such as Atterberg limits, compaction characteristics, California Bearing Ratio (CBR) and Unconfned Compression Strength tests (UCS). It can be noticed that the CBR of clayey subgrade has increased signifcantly with the addition of RBI Grade 81. Similarly, the maximum dry density (MDD) has decreased and the optimum moisture content (OMC) has increased with RBI Grade 81 addition to subgrade. The strength of clay subgrade at 8% of RBI Grade 81 has improved 3–3.5 times as compared to the natural clayey subgrade. Overall, it can be concluded that RBI Grade 81 is suggested as a potential stabilizing agent especially for clayey subgrades.

Kumar and Solanki (2017), in the present study, an attempt is made to modify the engineering properties of the expansive soil available in SVNIT campus of Surat city, Gujarat by stabilizing it with RBI Grade 81. The effect of adding this chemical stabilizer in expansive soil are characterized through various laboratory tests to determine Consistency Limits, Compaction Characteristics, Free Swell Index, Unconfined Compressive Strength, and California Bearing Ratio. The laboratory investigations indicate that RBI Grade 81 with up to 5% optimizes the engineering properties of expansive soil to be used as sub-grade.

III. MATERIAL USED

The following materials are used during the research work-

- Raw soil or B.C soil only
- RBI grade 81 Powder
- Coir Fiber
- Water

The soil used for this investigation is an expansive clay ,one type of most problematic soil for subgrade constructions is used for current research work which is locally available Black Cotton Soil collected from village

mugaliyachhap near sehore (Madhya Pradesh) from depth of 4.5 m from ground level. It contains deleterious substances and of various sizes. The soil was air dried and pulverized manually. This natural soil is black in colour.

Fig. 4. Black cotton Soil Sample

Table 1. Physical properties of Soil

S.No.	Properties	Values
1	Specific Gravity	2.75
2	Liquid Limit (%)	51.90
3	Plastic Limit (%)	22.90
4	Plasticity Index (%)	29
5	CBR (%)	1.67%

RBI Grade-81 was purchased from alchemist dealer Delhi it was coordinated by Road Building International.

Table 2. Properties of RBI Grade-81 taken

S. No.	Properties	Values
	SpecificGravity	2.5
	Appearance	Beige powder
	PH	12.50
	Solubility	In water 0.2pts/100pts
	Flammability	Inflammable

Coconut Fiber Material used is derived from coco fiber obtained by taking the residual yield (waste) of coconut use. Percentage of coconut coir fiber are taken by weight of soil mixture. The fibers were extracted manually and separated into strands.

Table 3. Physical Properties of Coir fiber

S. No.	Properties	Value
	Appearance	Thin like threads
	Specific gravity	0.128
	Length	1.5-2 cm

IV. METHODOLOGY

Following procedure has been adopted for the work:

Table 4. Cases considered for study

	Material prepared	**Test conducted**
Step 1	Raw soil or B.C soil only	Specific Gravity Consistency Indices Standard Proctor's Test (Light Compaction) CBR Test (Unsoaked)
Step 2	Black Cotton Soil with RBI grade-81	
	Black Cotton Soil with 2 % RBI grade-81	Consistency Indices Standard Proctor's Test (Light Compaction) CBR Test (Unsoaked)
	Black Cotton Soil with 4 % RBI grade-81	
	Black Cotton Soil with 6 % RBI grade-81	
	Black Cotton Soil with 8 % RBI grade-81	
From results of above performed tests, suitable RBI grade-81 percentage is chosen to carry out next step of experiment.		
Step 3	Black Cotton Soil with suitable RBI grade-81 percentage and Randomly Distributed coir Fiber percentage	
	Black Cotton Soil with suitable RBI grade-81 and 0.50 percent coir Fiber	Standard Proctor's Test (Light Compaction) CBR Test (Unsoaked)
	Black Cotton Soil with suitable RBI grade-81 and 1.00 percent coir Fiber	

	Black Cotton Soil with suitable RBI grade-81 and 1.50 percent coir Fiber	
	Black Cotton Soil with suitable RBI grade-81 and 2.00 percent coir Fiber	

V. RESULTS

5.1 Results for B.C soil with altered percentage of RBI grade 81

Table 5 Specific gravity of B.C Soil and Soil with altered RBI grade 81 percentages

RBI grade 81 used	%	%	%	%	%
Specific Gravity	.75	.610	.45	.35	.10

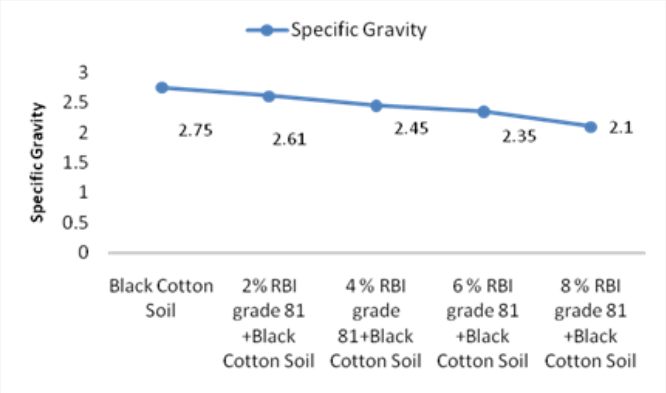

Fig. 8. Specific gravity of Soil with altered RBI grade 81 percentages.

Table 6 Consistency indices of B.C Soil with altered percentage of RBI grade 81

Consistency Indices	Liquid Limit(LL) %	Plastic Limit(PL) %	Plasticity Index(PI) %
Black Cotton Soil	51.9	22.90	29.00
2% RBI grade 81 +Black Cotton Soil	47.5	22.51	24.99
4 % RBI grade 81+Black Cotton Soil	46.21	23.22	22.99
6 % RBI grade 81 +Black Cotton Soil	44.1	24.11	19.99
8 % RBI grade 81 +Black Cotton Soil	41.8	25.21	16.59

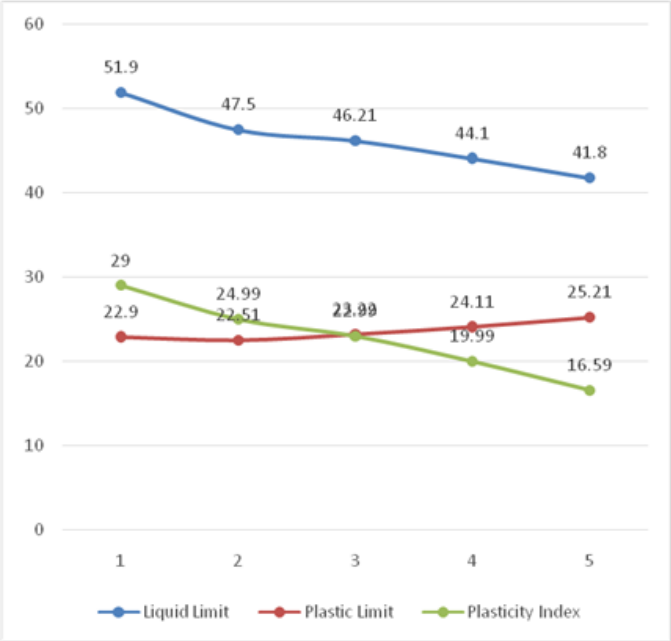

Fig. 9. Slump Values observed on coarse aggregate replacement

Table 7 Results for Clayey Soil treated with altered percentages of RBI grade 81

Material	MDD(gm/cc)	OMC (%)
Black Cotton Soil	1.75	17.55
2% RBI grade 81 +Black Cotton Soil	1.73	18.38
4 % RBI grade 81+Black Cotton Soil	1.72	19.34
6 % RBI grade 81 +Black Cotton Soil	1.71	20.18
8 % RBI grade 81 +Black Cotton Soil	1.70	21.15

Table 8CBR Test Results for Clayey Soil treated with varied percentage of RBI grade 81

Material	CBR (%)
Black Cotton Soil	2.3
2% RBI grade 81 +Black Cotton Soil	3.30
4 % RBI grade 81+Black Cotton Soil	4.10

6 % RBI grade 81 +Black Cotton Soil	6.80
8 % RBI grade 81 +Black Cotton Soil	9.50

5.2Results for B.C soil with 8% RBI grade 81 and altered fiber content

Table 9 standard Proctor's Test Results for Soil- RBI grade 81 mix with different fiber concentration

Material	MDD(gm/cc)	OMC (%)
0 % Fiber + 8 % RBI grade 81 + B.C Soil	1.70	21.15
0.5 % Fiber + 8 % RBI grade 81 + B.C Soil	1.73	21.20
1.0 % Fiber + 8% RBI grade 81 + B.C Soil	1.75	21.50
1.5 % Fiber + 8% RBI grade 81 + B.C Soil	1.71	21.50
2.0 % Fiber + 8% RBI grade 81 + B.C Soil	1.69	22.05

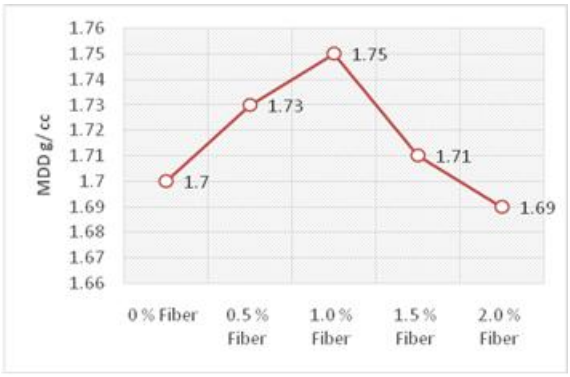

Fig.10. Comparison of MDD values after fiber addition

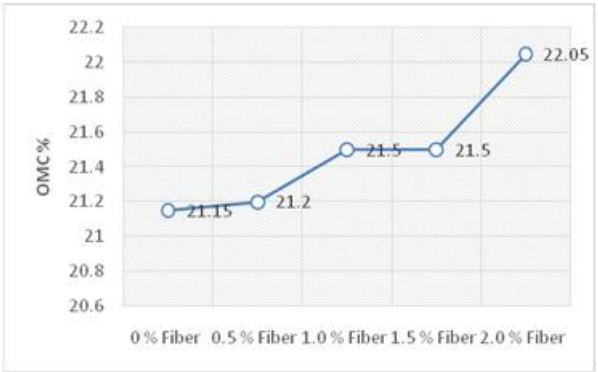

Fig.11. Comparison of OMC values after fiber addition

Table 10CBR Test Results for Soil- RBI grade 81 mix with different fiber concentration

Material	CBR %
0 % Fiber + 8 % RBI grade 81 + B.C Soil	9.50
0.5 % Fiber + 8 % RBI grade 81 + B.C Soil	9.70
1.0 % Fiber + 8% RBI grade 81 + B.C Soil	9.92
1.5 % Fiber + 8% RBI grade 81 + B.C Soil	9.90
2.0 % Fiber + 8% RBI grade 81 + B.C Soil	9.90

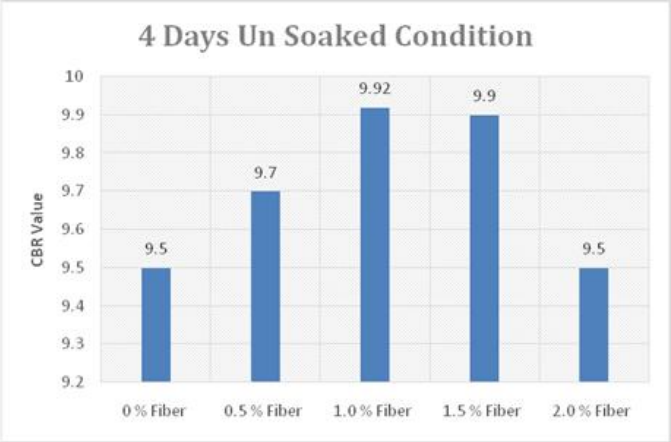

Fig.12. Comparison of CBR values after fiber addition

V. CONCLUSION

From the results we can conclude that

- Liquid Limit of the Black cotton Soil increases with increase in percent of RBI Grade 81.
- Plastic Limit of Black Cotton Soil increases with increase in percent of RBI Grade 81.
- Plasticity Index of the Black Cotton Soil decreases with increase in percent of RBI Grade 81
- The strength has been compared on the basis of CBR for virgin and RBI grade-81 reinforced soil under un-soaked conditions and it was found to be increasing as the percentage of RBI Grade 81 was increased.
- The result implies that when sub-grade was reinforced with RBI grade-81 its CBR increases as for virgin soil CBR was 2.3 and it increases to 9.5 with RBI grade-81 under un-soaked condition.
- 8% RBI grade 81 + B.C Soil mix gives maximum value of CBR hence 8% RBI grade 81 was selected as suitable percentage of RBI grade 81.

- On addition of fiber to the soil mixture with suitable stabilizing powder (8% RBI grade 81) the CBR value was increased but it became constant after 1% fiber dose.
- Finally it can be concluded that RBI grade 81 along with coir fiber is quite favorable for stabilization of the given expansive soil.

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