Variations in Strength Parameters in Base Layer of Pavement with RBI Grade 81

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***Abstract*: The overall performance of a flexible pavement structure underneath loading circumstance is ruled by the properties of materials used in base and sub base layer. The highway construction industry has made rapid studies in the field of new technology up gradation and adoption with increase in traffic volume and increase in demand for innovative design, repair& Rehabilitation of the available transportation infrastructure. New materials and strategies have been attempted with lot of emphasis on optimizing existence cycle cost and minimizing layout price.**

RBI Grade 81 is an odourless beige powder this is composed of a number of naturally going on compounds. It improves the structural residences of soil. It works by means of hydration reaction. Through the addition of low dosages of RBI Grade 81 the strength of the soil is increased notably. The response of RBI Grade 81 with granular particles produces an inter particle blend that binds the particles together right into a inflexible mass. This binding of the particle, thru both chemical bonds and fractional forces, serves to restrict the pore quantity of the created inflexible stabilized base layer.

In this study, an attempt is made to have a look at the effect of overall performance enhancers utilized in base layer. In addition to the laboratory experimental work, evaluation of results when the material is applied in field has also been studied. The California Bearing Ratio, Maximum Dry Density, Degree of compaction were determined for the samples collected from Ammapet Village, Erode district., Tamilnaduat different chainages and these results are compared with the design data. Economic analysis was performed for unmodified soil and soil modified with RBI Grade 81 and theresults were compared.

***Index Terms*: RBI Grade 81, CBR, Standard Proctor, Degree of compaction, fatigue, rutting**

I. INTRODUCTION

A. General

A pavement shape can be designed either as a flexible pavement or a rigid pavement based totally on its structural behavior, with flexible pavements being broadly desired in India due to its advantages over rigid pavements and in reasonably-priced point of view also. Flexible pavements have low or negligible flexural power and are as a substitute bendy of their structural action below the loads. These pavements are layered systems with the following factor layers

- Soil sub-grade
- Sub-base course
- Base course
- Surface course

The layered pavement shape transmits vertical or compressive stresses to the lower layers by means of grain to grain switch via the points of touch in the granular structure with the sturdy graded aggregates and must switch the compressive stresses to a wider place. A detailed structure of flexible pavementshown below in figure 1.1

Fig. 1.1 Layers in Flexible pavement

B. Significance of RBI Grade 81

- It is an inorganic soil stabilizer and pavement material
- It is a cementitious powder stabilizer and non-toxic in nature
- It can be used to increase the CBR for subgrade, sub base, base course and hard shoulders

1. Advantages of RBI Grade 81

- Construction time and cost reduction
- Drastically increases the strength

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- Treated layers are water resistant
- Reduces thickness, use of transport, and earth moving machinery substantially
- Longer durability which reduces maintenance

2. Environmental benefits of using RBI Grade 81 and properties of soil

1) Reduces, leaching and use of bitumen
2) Reduces energy consumption
3) Saves materials like Aggregates, Soil, Bitumen
4) Reduces carbon emission enabling, carbon credits

Table 1.1 Properties of soil

Description	Sample G1	Sample G2
Specific gravity	2.11	2.02
Liquid limit (%)	2.5	23
Plastic limit(%)	18	15
Plasticity index (%)	7	8
Shrinkage limit (%)	7	6
Shrinkage index(%)	31	33
IS Soil classification	SM	SM
Compaction characteristics		
MDD (g/cc)	1.97	1.98
OMC (%)	9.9	9.8

Fig 1.2 RBI Grade 81 Materials

C. Objectives of the Study

This study was carried out with following objectives:

1) To study the engineering properties of soil
2) To study the strength properties of soil by adding RBI Grade 81
3) To compare the results of samples collected from the project site with the design data
4) To conduct the Economic Analysis with soil and soil mixed with RBI Grade -81

D. Properties of RBI Grade-81

The Physical properties and Chemical properties of RBI Grade-81 are summarized in Tables respectively

1. Chemical equation

The concentration of Calcium (which imparts the strength) is less in untreated soil which is supplemented by the stabiliser. Hence in case of the treated soil the concentration of calcium increases with percentage of stabiliser. The increase in calcium concentration provides free Ca+ ions for the chemical reaction with silica and alumina present in the clay leading to the formation of cementitious compounds calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H).The chemical equation for the formation of C-S-H and C-A-H can be written as:

$$Ca(OH)_2 + H_4SiO_4 \rightarrow Ca^{2+} + H_2SiO_4^{2-} + 2H_2O \rightarrow CaH_2SiO_4\ 2H_2O \text{ (C-S-H)}$$

$$Ca(OH)_2 + Al(OH)_4 \rightarrow Ca_4H_{13}, Ca_3H_6 \text{ (C-A-H)}$$

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Table 1.2 Physical Properties of RBI Grade-81

Properties	RBI Grade 81
Appearance	Beige powder
Odour	Odourless
Ph	12.5(saturated paste)
Vapour pressure	Not measurable
Flammability	Inflammable
Specific gravity	2.5
Solubility	In water 0.2 parts/100 parts
Freezing point	None ,solid
Viscosity	None ,solid

Table 1.3 Chemical Properties of RBI Grade-81

Properties	%by Mass
Calcium oxide	52-56
Silicon dioxide	15-19
Sulphur trioxide	9-11
Aluminum oxide	5-7
Iron oxide	0-2
Magnesium oxide	0-1
Fibers (polypropylene)	0-1
Additives	0-4

E. *Organization of Thesis*

This thesis contains seven chapters including introduction chapter. In the next chapter a review of literature pertaining to usage of RBI Grade 81 in soil is discussed. Chapter three explains the PMGSY project details in the state Tamil Nadu. Chapter four explains the experimental investigation of soil and RBI Grade 81.Chapter five presents the results and discussions. Chapter six presents the Stress strain analysis and Economic Analysis of soil and soil with RBI Grade 81. The conclusions are given in chapter seven.

II. STUDY AREA

A. Introduction

The study area is selected in such a way that where the RBI Grade 81 implementation is to be carried out so that the field performance studies can be compared with laboratory studies.

Erode district is an inland district of the state Tamilnadu between latitude 10°35′00” and 11°58′00” and longitude 76°50′00” and 77°55′00”.It is bounded on north by Chamarajanagar district of Karnataka, on the east by Kaveri River. The headquarters of the district is Erode city. Depth of ground water level from 7m to 25m.The district receives an average rainfall of 697 mm and has a sub-tropical climate

In Erode, soil samples were collected from PMSGY road (Muniyamoorthi colony (H) to Koopukadu) in Ammapet block.

Table 2.1 List of seven PMGSY projects sanctioned by NRRDA for the state of Tamil Nadu to be constructed by using RBI Grade 81

S.NO	DISTRICT	Block	Name of Road	Length in km	Cost in Lakhs
1	Erode	Anthiyur	Kovilnatham to Chinnasengulum	1.86	87.00
2	Erode	Ammapet	Muniyamoorthi colony (H) to Koopukada	1.35	50.36
3	Erode	Nambiyur	ThylampalayamNalukalchavadi to karukkampalayam	1.64	62.80
4	Erode	Sathyamangalam	PavalakuttaiAthiyur to Perumathotti	3.20	130.06
5	Erode	Udamalpet	Sivasakthi colony to Avalkuttai (h)colony	4.45	128.28
6	Erode	udamalpet	Chinnakumarapalayam to Kondamadaiessalthitu	2.98	83.90
7	Erode	Dharapuram	Poolavadiroad to Kallipalayamdasarapatty road	1.02	29.20

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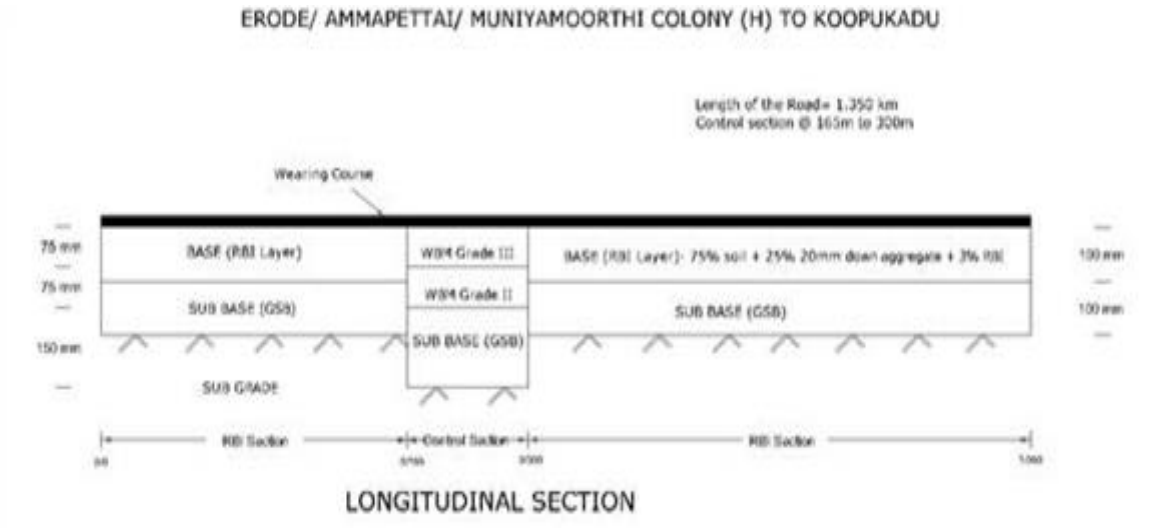
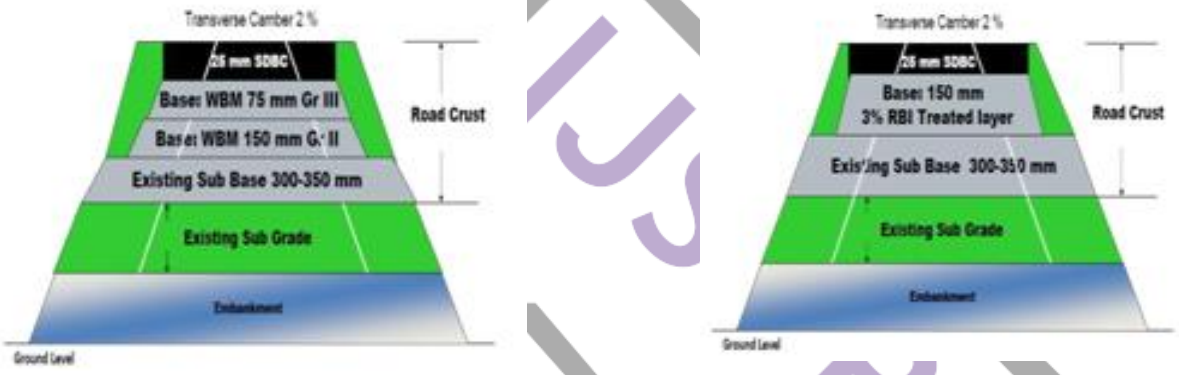


Fig.2.1 Longitudinal cross section of RBI Grade 81 road



Road Composition (Conventional) **Case Study with RBI Grade-81**

Fig.2.2 comparison between convention PMGSYand RBI grade 81 stabilized road

Table 2.2 Current status of RBI Grade 81 roads as on 21/12/2018

LIST of seven PMGSY projects sanctioned by NRRDA for the state of Tamilnadu to Be constructed by using RBI grade 81								
S.No	**District**	**Block**	**Road**	**Length in km**	**Current status of the roads**			
					Sub-grade	**GSB**	**RBI layer**	**Bt layer**
1	Erode	Anthiyur	Kovilnathamtochinnas engulam	1.866		InProgress		
2	Erode	Ammapet	Muniyamoorthi colony (h) to Koopukadu	1.35				
3	Erode	Nambiyur	Thylampalaya M nalukaicha Vadi to karak Kampalayam	1.64				
4	Erode	Sathyaam Angalam	Pavalakuttaiathiyur to peru mathoti	3.2				Yet to start
5	Tiruppur	Udumalpet	Sivasakthi colony to avalkuttai(h)co Lony	4.45	In progress			
6	Tiruppur	Udumalpet	Chinnakumara Palayam to kondamadiessalthitu	2.98				
7	Tiruppur	Dharapuram	Poolavadi road To kallipalaya M dasarpatty road	1.02				

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The following figures (Fig. 2.3 to 2.6) shows the work done at project site in Ammapet PMGSY road, Erode.

Fig. 2.3 Name of the PMGSY Road

Fig. 2.4 Name of the PMGSY Road

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Fig. 2.5 Placing of RBI material in field

Fig. 2.6 Spreading of RBI Grade 81 material

III. EXPERIMENTAL INVESTIGATIONS

A. General

This chapter deals with the general experimental investigations to be done for virgin soil and soil with RBI Grade 81 for determining the suitability of usage of the materials in base layer.

B. Soil and RBI Grade 81

Location of soil and RBI Grade 81 samples

The preliminary studies were conducted on the soil samples collected from the PMGSY live project site which is collected from Ammapet, Erode, Tamil Nadu and RBI Grade 81 was collected from Alchemist Pvt ltd, Erode, and Tamil Nadu

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C. Experimental Studies

1. Standard Proctor Test

To assess the quantity of compaction and the water content required within the discipline, compaction exams are important at the equal soil in laboratory. The water content at which the most density is attained is received from the relationships supplied by way of the assessments. According to IS:2720(Part-7)themould recommended is of 100mm diameter, 127.3mm height and 1000ml potential. The rammer endorsed is of 2.6kg with unfastened drop of 310mm.

2 California Bearing Ratio Test (CBR)

CBR take a look at changed into advanced by the California division of toll road in 1929. This test is used for comparing the suitability of sub-base materials. The check can be conducted on a organized specimen in a mould or on soil in-situ situations. The laboratory CBR apparatus consists of a mold 150mm diameter and 175mm high, having separate base plate and collar. The load is carried out by way of a loading body through a plunger of 50mm diameter. Dial gauges are used for measurement of the expansion of the specimen on a soaking and for dimension of penetration

D. Summary

This chapter explained all the experiments which need to be done for analyzing the behavior of soil before and after mixing with RBI Grade 81. All the experiments viz., Proctor compaction, California Bearing Ratio tests were done according to Indian Standards.

IV. RESULTS AND DISCUSSIONS

Compaction Test **:** Chainage 0/0 before mixing RBI Grade 81 & after mixing 3% of RBI Grade 81

Table 4.1 Weight of wet soil results of Before of wet Soil and After mixing RBI

Water content (%)	Before mixing RBI		After mixing RBI	
	Weight of wet soil (kg)	Dry Density	Weight of wet soil (kg)	Dry density
7.5	2.078	1.942	2.0962	1.95
8.5	2.109	1.953	2.1374	1.97
9.5	2.157	1.97	2.19	2
10.5	2.178	1.98	2.187	1.98
11.5	2.162	1.975	2.163	1.94
12.5	2.153	1.958	2.1037	1.87

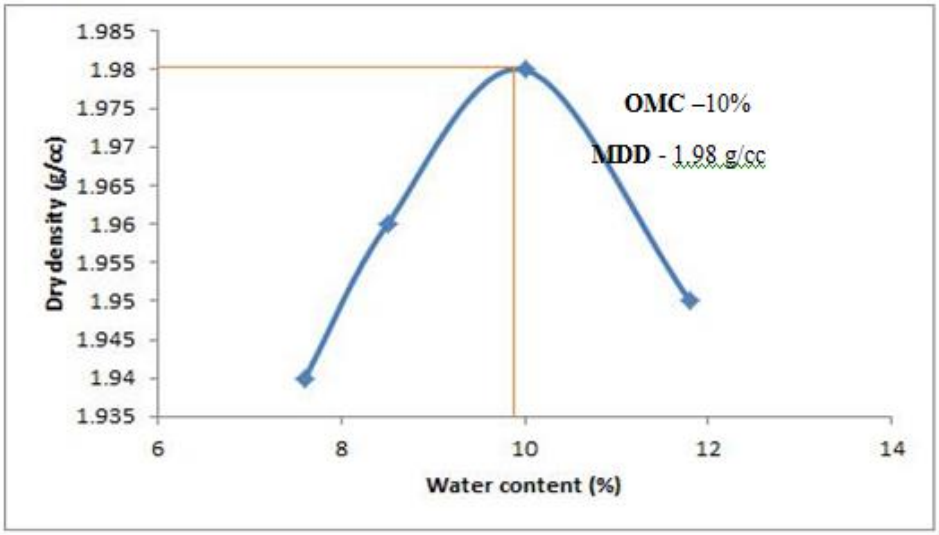

Fig. 4.1 at Chainage 0/0 before mixing with RBI

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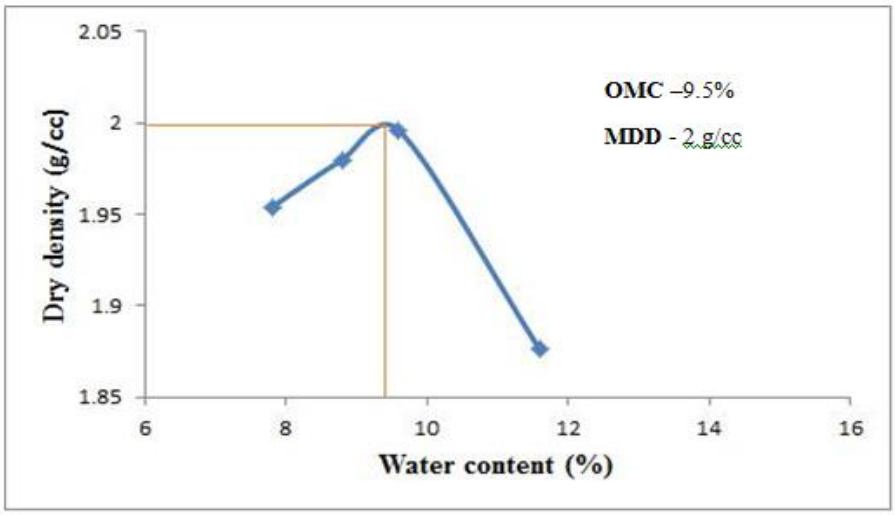

Fig. 4.2 at Chainage 0/0 after mixing with RBI

The most appropriate moisture content and maximum dry density values of soil pattern accumulated from the undertaking website at chainage 0/350 are 10.5% and 1.95 g/cc as proven in Fig. 5.3. After mixing with RBI at identical chainage gold standard moisture content material fee is decreased to 9.8 % and Maximum dry density is elevated to at least to 1.97g/cc as shown in Fig. 4.4.

Table 4.2 Weight of wet soil results of Before of RBI Grade 81 and After mixing of RBI Grade 81

Water content(%)	Before mixing of RBI Grade 81		After mixing of RBI Grade 81	
	Weight of wet soil (kg)	Dry density	Weight of wet soil (kg)	Dry density
7.5	1.924	1.79	2.021	1.88
8.5	1.953	1.8	2.061	1.9
9.5	2.102	1.92	2.102	1.92
10.5	2.154	1.95	2.176	1.97
11.5	2.129	1.91	2.158	1.93
12.5	2.126	1.89	2.081	1.85

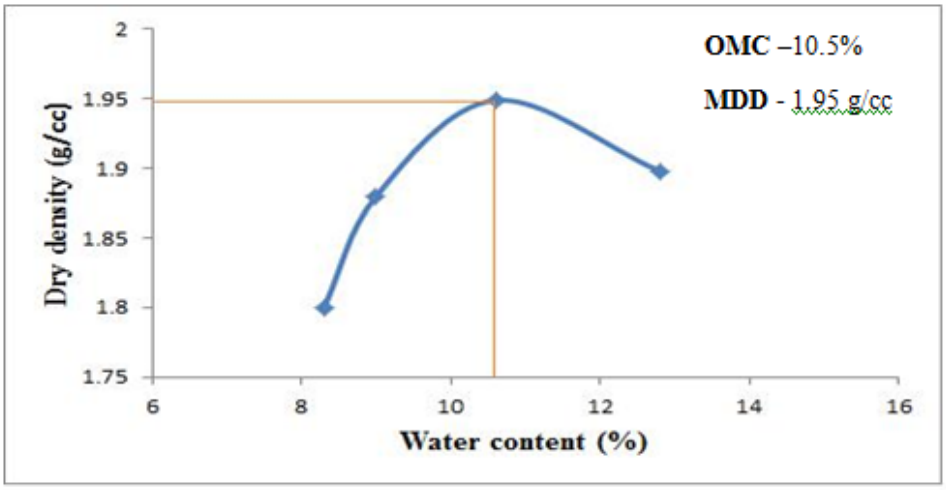

Fig. 4.3 at Chainage 0/350 before mixing with RBI

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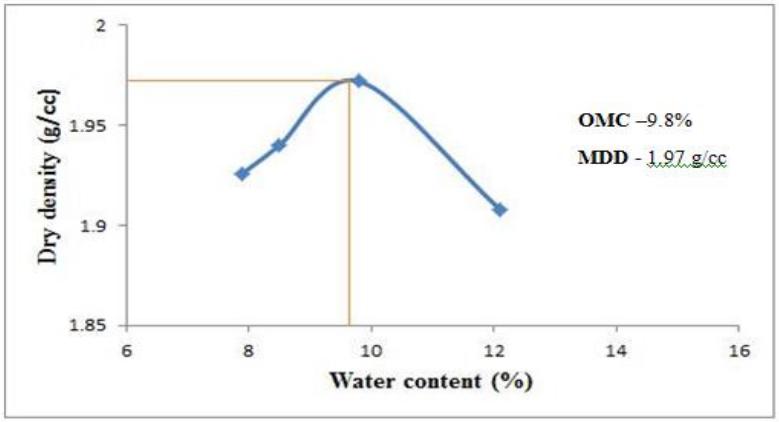

Fig. 4.4 at chainage 0/350 after mixing with RBI

COMPACTION RESULTS:

Table 4.3 OMC(%) and MDD(g/cc) results of of different chainage

chainage	OMC(%)		MDD (g/cc)	
	BM RBI	AM RBI	BM RBI	AM RBI
0/0	10	9.5	1.98	2
0/350	10.5	9.8	1.95	1.97
0/700	10.5	10.3	2.06	2.11
1/050	10.2	9.8	1.99	2.05
1/350	10.7	9.8	1.95	1.98

CBR VALUES: CBR values of soil sample collected from the project site at chainage 0/0 is 14.6% and after mixing of RBI grade 81 is it is increased to 55.8% as shown in below

Table 4.4 Results of chainage 0/0 before mixing and after mixing of RBI grade 81

chainage 0/0 before mixing of RBI grade 81				chainage 0/0 after mixing of RBI grade 81			
penetration	LOP (KG)	penetration	LOP(KG)	penetration	LOP(KG)	penetration	LOP(KG)
0	0	6.5	312.7	0	0	6.5	1234.8
0.5	48.8	7.5	321.8	0.5	280.3	7.5	1356.6
1	109.8	8.3	343.16	1	322.1	8.3	1387.5
1.5	158.4	8.9	350.12	1.5	546.2	8.9	1463.2
2	200.02	10	380.1	2	764.4	10	1521.2
2.5	215.5	10.5	387.4	2.5	834.5	10.5	1586.3
3	223.8	11.5	393.2	3	963.2	11.5	1603.4
4	261.72	12	462.12	4	1000.1	12	1696.2
5	293.89	12.5	496.3	5	1138.4	12.5	1796.1

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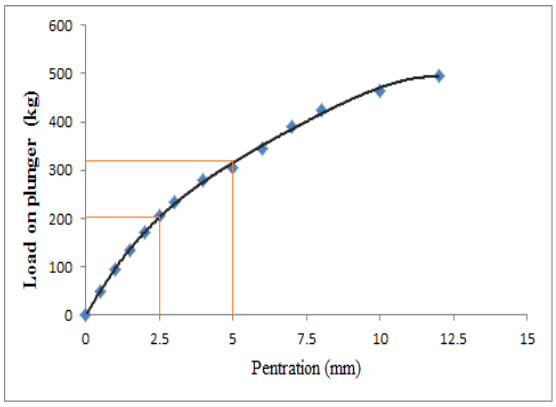


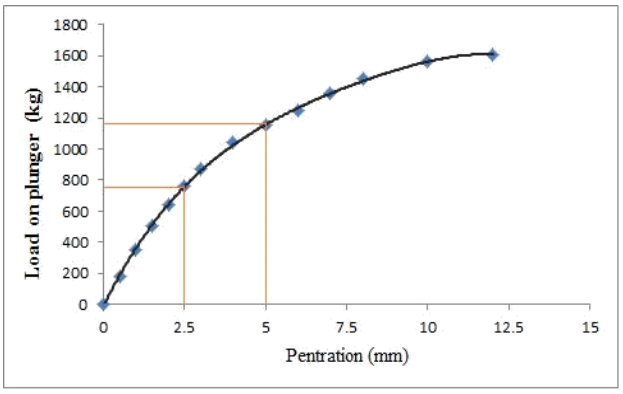


FIG.4.5 CHAINAGE 0/0 BEFORE MIXING OF 3% RBI GRADE CHAINAGE 0/0 AFTER MIXING OF 3% RBI GRADE

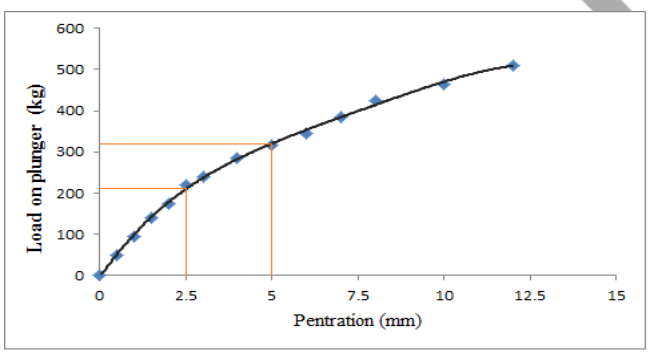
CBR at 2.5mm = 14.6%
CBR at 5mm = 14.3%
CBR 2.5 > CBR 5
CBR sample = 14.6%

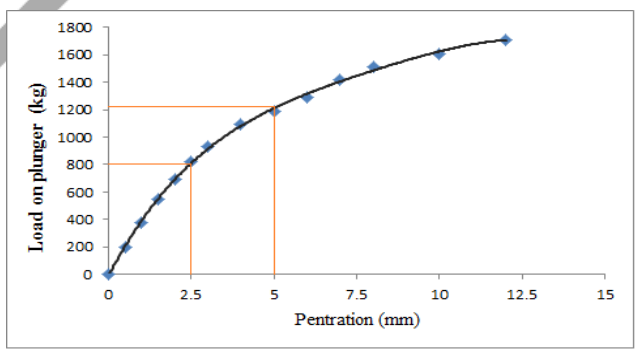
CBR at 2.5mm = 55.8%
CBR at 5mm = 55.4%
CBR 2.5 > CBR 5
CBR sample = 55.8%

CBR values of soil sample collected from the project site at chainage 1/350 is 14.2% and after mixing of RBI grade 81 is it is increased to 62% as shown in below

Table 4.5 Results of chainage 0/350 before mixing and after mixing of RBI grade 81

chainage 1/350 before mixing of RBI grade 81				chainage 1/350 after mixing of RBI grade 81			
Penetration	LOP (KG)	penetration	LOP(KG)	penetration	LOP(KG)	penetration	LOP(KG)
0	0	6.5	315.2	0	0	6.5	1303.7
0.5	35.9	7.5	320.3	0.5	273.1	7.5	1396.3
1	102.6	8.3	343.1	1	411.3	8.3	1406.5
1.5	148.4	8.9	351.3	1.5	710.3	8.9	1483.2
2	194.54	10	379.2	2	849.4	10	1521.3
2.5	213.5	10.5	381.1	2.5	931.3	10.5	1587.6
3	224.1	11.5	400.1	3	998.6	11.5	1648.4
4	253.2	12	419.3	4	1104.3	12	1701.6
5	285.64	12.5	448.32	5	1235.1	12.5	1791.3





CHAINAGE 1/350 BEFORE MIXING OF3% RBI GRADE

CHAINAGE 1/350 AFTER MIXING OF3% RBI GRADE

CBR at 2.5mm = 14.2%
CBR at 5mm = 13.9%
CBR 2.5 > CBR 5
CBR sample = 14.2%

CBR at 2.5mm = 62%
CBR at 5mm = 60.1%
CBR 2.5 > CBR 5
CBR sample = 62%

CBR RESULTS:

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Table 4.6 Results of BM RBI and AM RBI

chainage	CBR %	
	BM RBI	AM RBI
0/0	14.6	55.8
0/350	15	64.9
0/700	15.3	54.8
1/050	16.1	58.4
1/350	14.2	62

The most appropriate moisture content and maximum dry density values of soil sample accrued from the mission site at chainage 0/700 are 10.5% and 2.06 g/cc as proven. After blending with RBI at identical chainage ultimate moisture content material price is reduced to 10.3 % and Maximum dry density is increased to 2.11g/cc

Table 4.7 Dry density results

Sample No	Dry density in field (g/cc)
1	1.82
2	1.86
3	1.83

Average dry density in field = 1.83 g/cc
Maximum dry density obtained in the lab = 2.11 g/cc
Relative compaction =Dry density in field/ Max dry density obtained in the lab= 88%

ECONONIC ANALYSIS:
The difference between conventional PMGSY road and RBI Grade 81 stabilized road is in thickness of GSB layer and base layer. Reduction in the thickness of GSB layer is 50 mm and in the base layer is 75mm
Unit rates for material, machinery and labour were obtained from the live project data and calculations were made accordingly
A stretch of 1 km single lane (3.75 m) has taken for the analysis as in the live project
conventional road:.
*** Cost for GSB:**
For construction of single lane road for 1 km, 563 m³ of materials were needed (1000*3.75*0.15 = 563)
Total cost is 563*1600=9,00,800/-

For RBI Grade 81 stabilized road:

Cost for GSB:

100 mm Grade III

For construction of single lane road for 1 km, 282 m³ of materials were needed (1000*3.75*0.1 = 282)

Total cost is =282*1600 = 4,51,200/-

Cost for Base layer :

For construction of single lane road for 1 km, 375m³ of materials were needed (1000*3.75*0.10 = 375)

Total cost is 375*3150=11,81,250/-

Total cost for RBI stabilized road of length 1 km (GSB + Base) = 19,26,291/-

Cost comparison between conventional and RBI Grade 81 stabilized road
Total savings as compared to conventional road by using RBI Grade 81 per km is **1, 97,709**/-

V CONCLUSIONS

Based on the comparison of the test results of soil before mixing with RBI Grade 81 and the stabilized soil with RBI Grade 81 the following conclusions are drawn.

1. Optimum Moisture Content of soil has been decreased from 10.3% to 9.8% after the addition of 3% of RBI Grade 81.

2. Maximum Dry Density of soil has been increased from 1.98g/cc to 2.02g/cc after the addition of 3% RBI Grade 81 to it.

3. The CBR value of soil has been increased from 15% to 59% after the addition of 3% RBI Grade 81 to it.

4. OMC, MDD, CBR values of samples collected from the project site are almost matching with the design data.

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5. Relative compaction of 88% was observed in the base layer.

From economic analysis, a total cost savings of 64,130/- was achieved per kilometer by using RBI Grade 81 as compared to conventional section

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