International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056
Volume: 03 Issue: 07 | July-2016 www.irjet.net p-ISSN: 2395-0072

A REVIEW ON SOIL STABILIZATION USING RBI GRADE-81

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Abstract - *Soil stabilization is a major concern in India where the civil engineering infrastructure is developing at a very fast pace. Large area of country is covered with expansive soil which has poor engineering properties and not suitable for construction. So soil stabilization is necessary to enhance it's engineering performance such as workability, stiffness, strength, permeability, compressibility and sensitivity. This review paper deals with the soil stabilization using a chemical additive RBI Grade-81. It is a very effective stabilizer and can be used in sub grade, sub base and base layer. The industrial waste like Pond ash, Fly Ash, Stone dust, Foundry Sand, Steel Slag etc can also be used with RBI Grade-81 as stabilizer to reduce the cost.*

Key Words: *RBI Grade-81, Soil Stabilization, Black Cotton Soil, CBR, UCS, and DFS.*

1. INTRODUCTION

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. The poor engineering properties of soil have forced engineers to improve the properties of soil by various stabilizing techniques. Stabilization of soil is an effective method for improving the strength, stiffness and workability of the soil. Recently various polymer stabilizers have emerged and are being used for soil stabilization. RBI Grade-81 is one of them.

RBI Grade-81 (Road Building International Grade-81) is a chemical stabilizer which has been used by various researchers for improving the properties of different type of soils. It 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. It can be used with wide range of soils. The volume stability of the soil is increased significantly with the addition of low dosages of RBI grade-81. It reacts with soil by hydration reaction and strength of soil treated with it increases with age.

1.1 Properties of RBI Grade-81

The Physical properties and Chemical properties of RBI Grade-81 are summarized in Table-1 and Table-2 respectively.

Table 1 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 0.2pts/100pts
Freezing point	None, solid
Viscosity	None, solid

Table 2 Chemical Properties of RBI Grade-81

Properties	% By Mass
Calcium Oxide (CaO)	52-56
Silicon Dioxide (SiO_2)	15-19
Sulphur TriOxide (SO_3)	9-11
Aluminium Oxide ($Al_2O_{3)}$	5-7
Iron Oxide (Fe_2O_3)	0-2
Magnesium Oxide (MgO)	0-1
Fibers (polypropylene)	0-1
Additives	0-4

1.2 Benefits of RBI Grade-81

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

- It reduces construction time by 40%
- The soil strength increases drastically
- 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 has longer durability
- It is environment friendly and has a small Carbon Footprint

2. MECHANISM OF SOIL STABLIZATION USING RBI GRADE-81

Soil exchange the ions and creating ionic bonds between the stabilizer and soil particles. The reaction with soil particles produces an inter particle matrix that binds soil particles together into a rigid mass. The void of soil particles are filled with "crystalline reaction products", creating a mechanical tie between the stabilizer and soil particles. The binding of the soil particles through both chemical bonds and frictional forces serves the pore volume of created rigid stabilized soil system. This chemical process is continues over a period of time and thereby increasing the soil strength with time.

3. EXPERIMENTAL STUDIES

Some of the recent studies conducted with RBI Grade 81 as soil stabilizer are given below:

B.M. Patil, K.A. Patil and L.K. Kokate 2012 [1] conducted a study on use of Industrial Waste like Pond ash, Fly Ash, Stone dust, Foundry Sand and Steel Slag for Soil Stabilization. In the present investigation the different proportion of soil sample, Pond ash and RBI Grade-81 were prepared. Pond ash was mixed in the proportion of 10% and 20% and RBI Grade-81 was furthermore blended in the proportion of 0%, 2%, 4% and 6%. On the basis of result they concluded that with the addition of pond ash and RBI Grade-81 the CBR value increases. when soil: pond ash: RBI 81 were blended in the proportion of 74:20:6 the CBR value increased up to 775% of untreated soil. CBR qualities expanded with expansion in rate of RBI Grade 81. This inferred that the industrial waste materials like fly ash and pond ash can be used as stabilizer with clayey soil.

K.V. Madurwar, P.P. Dahale, A.N.Burile, 2013 [2] conducted a study on effect of sodium silicate and RBI Grade-81 on black cotton soil to improve it's engineering properties. The test results showed that Liquid limit decreased and plastic limit increased with the addition of admixture, thus resulting in reduction of plasticity index. The UCS and soaked CBR values increased with increase in RBI Grade-81, suggest its suitability as good stabilizer. But with the increasing dose of sodium silicate UCS and CBR value decreased, which indicating the limitation of sodium silicate to be used as a stabilizer. when the RBI Grade-81 was added to the soil the free swell index value was decreased but with the addition of sodium silicate it was increased.

B.M. Patil and K.A. Patil, 2013 [3] studied the effect of RBI Grade-81 and moorum to stabilize the soil. The RBI Grade-81 and moorum were mixed with soil in different proportions and tested for OMC, MDD and soaked CBR. The soaked CBR of untreated soil was 2.56%. when the soil and RBI were mixed in the proportion of 98:02 & 96:04 the soaked CBR values were increased to 4.89% & 8.79%. when soil was mixed with moorum in the proportion of 90:10 & 80:20 the soaked CBR values were increased to 2.41% and 2.84%. The soaked CBR values for the mixture of soil, moorum and RBI Grade-81 in the proportions of 88:10:02, 78:20:02, 86:10:04 & 76:20:04 were found to be 3.4%, 4.56%, 10.23% & 14.76%. The conclusion made on the basis of test results was that the CBR value of soil can be improved by using moorum and RBI Grade-81 as stabilizer.

Tejinder Singh, Navjot Riar, 2013 [4] studied the effect of RBI Grade-81 to stabilize the soil with the help of Atterberg's limit test, Standard Proctor test and CBR test and analyze the cost difference between conventional method and cost of pavement constructed using 2%, 4%, 6% and 8% RBI Grade-81. The CBR value of untreated soil was 2.14% which has increased to 28.9%, 60.82%, 105.01% and 135.5% with the addition of 2%, 4%, 6% and 8% RBI Grade-81 after 7 days of curing period and 4 days of soaking period. After the test, they concluded that RBI Grade-81 is very effective in stabilizing the highly plastic soil. This soil can be considered as stabilized sub base. They also concluded that expense of pavement reduced with RBI Grade-81. The pavement cost found to be minimum among all other cases, when it constructed with soil and 2% RBI Grade-81. The cost of pavement by conventional method was nearly 3 lacs which become approximately half with the addition of 2% RBI Grade-81.

Mamta, Mallikarjun Honna, 2014 [5] conducted a study to improve the engineering properties of BC soil and lateritic (red soil) by using RBI Grade-81. The black cotton soil and red soil mixed with 0%, 1% and 2% of RBI-81 were tested for Atterberg's limit test, CBR test and UCS test. The CBR value of black cotton soil was 4.5% which increased to 5.7% and 7.1% for soil mixed with 1% and 2% RBI stabilizer under unsoaked condition and 7% and 10% for soil mixed with 1% and 2% RBI stabilizer after 3 days curing period. The CBR value of red soil was 8.3% which increased to 11.4% and 12.3% for soil mixed with 1% and 2% RBI stabilizer under unsoaked condition and 13% and 15% for soil mixed with 1% and 2% RBI stabilizer after 3 days curing

period. This study concluded that RBI-81 is effective stabilizer from enhancement of geotechnical properties of lateritic soil & Black cotton Soil.

Lekha B.M. and A.U. Ravi Shankar, 2014 [7] conducted a study on performance of RBI Grade-81 in laboratory to stabilize the soil for pavements. The soil and stabilizer RBI-81 were mixed in different proportion and tested for atterberg's limit, OMC, MDD, UCS and CBR. The UCS of untreated soil was 380 kN/m^2 and unsoaked UCS of soil mixed with RBI-81 in the proportion 98:02, 96:04, 94:06 were found to be 265kN/m^2, 380 kN/m^2, 475 kN/m^2 after 1 day curing period and 830 kN/m^2, 1350 kN/m^2, 1800 kN/m^2 after 28 days curing. The CBR values for soil and stabilizer proportion 100:00, 98:02, 96:04, 94:06 were found to be 0.3%, 4.5%, 9.3% and 12.5% after 7 days curing and 4 days soaking period. On the basis of results, they concluded that the strength of BC soil improved appreciably with the stabilizer under unsoaked condition. The CBR value of soil showed good improvement when treated with 6% stabilizer. They also determined the fatigue life (number of cycles) of treated soil at repeated loads corresponding to one third and half of UCS strength of 98:02 soil : RBI mix cured for 7 days and 28 days. Best results were obtained with 6% stabilizer after 7 days and 28 days curing period at one third corresponding UCS strength values for 2% stabilizer both at 7 days and 28 days curing period in which fatigue life increased to 4172 after 7 days curing and 8005 after 28 days curing period. The fatigue life of untreated soil was obtained 3 after 7 days curing and 5 after 28 days curing period at one third corresponding UCS strength values for 2% stabilizer.

Manisha Gunturi at. Al., 2014 [6] carried out a study on CBR and swelling behavior of expansive soil when treated with RBI Grade-81. The soaked CBR value and free swell index of untreated soil and soil treated with 2%, 4% & 6% RBI Grade-81 at 3 days, 7 days and 14 days curing period were determined. The author has taken two soil sample A & B of expansive soils for testing. The results show that the CBR value of untreated samples A & B were 2% & 2.19% which increased to 9.56% & 10%, 16% & 15% and 20% & 18% after 3days, 7days and 14days curing period at 2% RBI Grade-81. At 4% RBI Grade-81, the CBR values were 9.93% & 10.4%, 22% & 22% and 34.9% & 30% after 3days, 7days and 14days curing period. At 6% RBI Grade-81 the CBR values were 10.8% & 11.5%, 27% & 26% and 53.6% & 40% after 3days, 7days and 14days curing period. Free Swell Index values decreased significantly with curing period as well as with addition of RBI Grade-81. They also carried out a study on strength properties of problematic soils with stabilizer RBI Grade – 81 on the same soil samples A1 and A2 and with same Soil and RBI proportions. The authors have tested the soil samples for atterbergs limit, compaction and UCS and Field Emission Scanning Electron Microscopy of untreated and treated soil with 6% RBI Grade-81 at 7 days curing period was conducted. The UCS value of version soil samples A1 and A2 were found to be 138 kPa and 122 kPa which were increased to 209 kPa and 130 kPa after 3 days curing and 217 kPa and 148 kPa after 7 days curing with 2% RBI Grade-81. The UCS value was increased to 742 kPa and 514 kPa after 3 days of curing and 794 kPa and 541 kPa after 7 days of curing with 6% RBI Grade-81. After the test investigation they were concluded that the UCS value was improved appreciably with the addition of RBI Grade-81 under the curing period of 3 days and 7 days with the increase in the percentage of RBI the rate of increase of UCS also increased. The UCS value of sample A1 and A2 increased by 425% and 430% respectively after 7 days of curing period with 6% RBI stabilizer.

To analyze the mineralogical properties of version soil, RBI Grade-81 and soil treated with 6% RBI stabilizer after 7 days of curing period, the individual morphology was studied by Field Emission Scanning Electron Microscopy (FESEM) images taken using FEI Quanta 200 FEG, presented below in figure 1, figure 2 and figure 3. The element compositions of the samples were analyzed using Bruker Energy Dispersive X-ray Spectrometer (EDS).

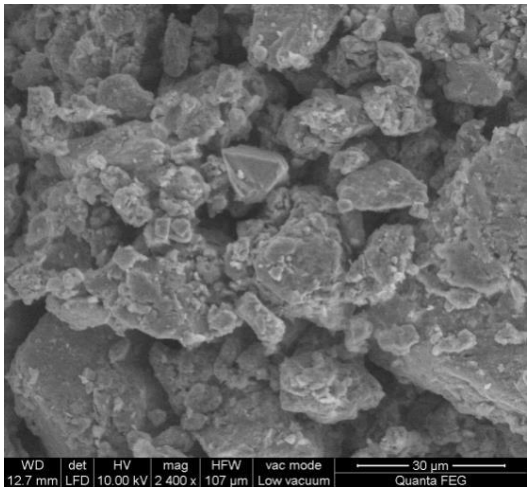

Figure 1: *Micrograph of virgin soil A1*

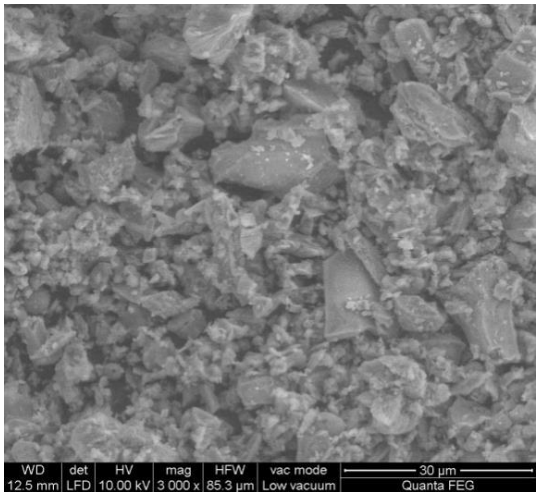

Figure 2 *Micrograph of RBI grade 81*

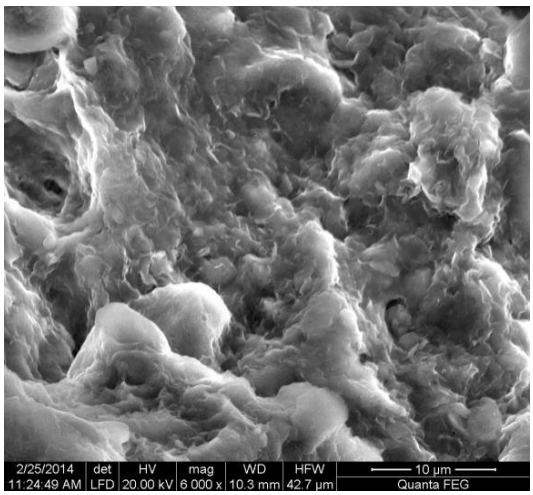

Figure 3 *Micrograph of soil A1 treated with 6% RBI Grade-81 with 7 days curing period*

The FESEM clearly indicate that pore space was reduced and microstructure of soil on treatment was changed. This indicates that RBI Grade-81 can be used as stabilizer with expansive soil.

4. FIELD APPLICATION

Various roads have been constructed in India by using RBI Grade-81. Some of successful projects using RBI Grade-81 are given below:-

(1) Construction of Approach Road to BBH Mines by PWD, SH-48, Chitradurga, Karnataka

(2) Construction of Kashipur -Thakurdwara Road by PWD, SH-45 Haldwani , Uttrakhand

(3) Construction of Road at Devasar near Jodhpur in Rajasthan by BRO

(4) Construction of a stretch of state Highway in J&K (Reasi Pauni Road near Katra) by BRO in 2008

(5) Construction of Road and Parking area at Siri Fort Sports Complex during common wealth games (2010) in Delhi

(6) Construction of Airfield at Nyoma (Leh) by Indian Army in 2009

(7) Construction of City Road and Parking area at Oil India Limited, Assam (2010)

(8) Mawali Tali Bhuria Dhora Desert Road, Mahajan Ranges, Suratgarh, Rajsthan

5. CONCLUSION

The RBI Grade-81 is a effective stabilizer for most type of soils. The increase in CBR value and UCS value depends upon type of soils. The other chemical like sodium silicates, pond ash, fly ash, moorum and sand stone can also be used with RBI grade-81 to improve the value of CBR and UCS. On the basis of studies conducted by various researches the following conclusions can be drawn:

- With the addition of RBI Grade-81 the plastic limit of soil increases and liquid limit of soil decreases and thus plasticity index of soil also decreases.
- MDD decreases and OMC increases with the addition of RBI Grade-81 but the strength does not decrease with decrease of MDD.
- With the addition of RBI Grade-81 and with the increase of curing period duration, the soaked CBR and UCS value also increases.
- According to Tejinder Singh, Navjot Riar (2013) the cost of pavement decreases when RBI Grade-81 is used with soil to construct pavement. The cost of pavement for 2% RBI Grade-81 was found to be minimum among all the other cases of soil and RBI Grade-81 mix.
- With the increase of RBI content, the free swell index of soil decreases.

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