A Comparative Analysis of Soil Stabilization using Lime, Cement and RBI Grade 81 Stabilizers

[1]Jaylesh Sahu, [2]Prof. Sanjay Saraswat,
[1]PG Student, [2]Assistant Professor,
[1]Department of Civil Engineering,
[1]SATI College, Vidisha, Madhya Pradesh, India

Abstract: Soil can be considered as a very first element of construction industry as no construction work can be done without it. Soil plays an important role in construction industry such as in foundation works, pavement subgrade etc. Soil used in construction industry is first treated and convert into a technically sound which fulfill the criteria of good foundation soil. Soil stabilization is such process which improves the properties of soil such as strength, stress parameters, Atterberg's limit etc by mixing external agent or compacting it. Hence the requirement of engineering soil can be achieved by such processes.
In this study, we are comparing the properties of soil by mixing calcium based stabilizers: cement, lime and RBI Grade 81 at different percent and studying their effects. Cement stabilization and lime stabilization are traditional method whereas the stabilization through RBI Grade 81 stabilizer is the latest research works and is used in construction nowadays. . The effect of these stabilizers on the geotechnical characteristics of Soil were investigated by conducting Sieve analysis, Atterberg's limit test, Standard proctor test, CBR tests. The tests were performed as per IS specifications. RBI Grade 81 stabilization shows effective results over Lime and Cement stabilization techniques.

IndexTerms **- Strength, External agent, Atterberg's limit, CBR, IS specifications..**

I. INTRODUCTION

A developing country like India which has a large geographical area and population, demands vast infrastructure i.e. network of roads and buildings. Everywhere land is being utilized for various structures from ordinary house to sky scrapers, bridges to airports and from rural roads to expressways. Almost all the civil engineering structures are located on various soil strata. The long-term performance of any construction project depends on the behaviour of soil stratum.
Soil stabilization is a major trend in India where the infrastructure is developing at a very fast speed. A large area of our country is covered with expansive soil with their poor engineering properties and is not suitable for construction. Soil stabilization is the process which involves enhancing the physical properties of the soil in order to improve its strength, durability, workability, stiffness, permeability, compressibility, sensitivity etc. by blending or mixing it with additives.
Mainly there are three types of soil stabilization; dewatering, compaction or adding chemicals. This paper was focused on adding chemicals; Lime, Cement and RBI Grade 81 independently in the soil.

II. MATERIAL USED IN THIS RESEARCH WORK

These are calcium based materials that when in contact with water or in the presence of pozzolanic minerals reacts with water to form cementitious composite materials.

1. **Lime:** Lime is produced by burning of lime stones in kiln. Addition of lime to soil is termed as Lime Stabilization. Lime or Pozzolanic Stabilization of soils improves the strength characteristics and changes the chemical composition of expansive soils. The most common varieties of lime for soil stabilization are hydrated lime [$Ca(OH)_2$], quick lime [CaO], and the dolomitic variations of these high calcium limes.
   Benefits of lime stabilization: Reduction in weather related construction delays, chemically transforms the soil, permanent increase in strength, resist cracking, shrinkage and swell characteristics.
   Disadvantages: Due to finer particle size, dusting occurs which is unsuitable for populated areas, requires more water due to evaporation loss, higher cost due to extra equipment required when slurry lime is used and also not practical for drying purposes.
2. **Cement:** Cement is a binding material made by calcining lime and clay which sets well under water, hardens quickly and attains strength. Due to its readily availability, Cement is one of the most popular stabilizer and generally can be applied to a wide range of materials. Soil with some quantity of cement is mixed to form 'Soil-Cement". As the cement hydrates and develops strength soil content becomes a hard and durable structural material. There are three type of soil-cement used commonly. Normal soil-cement (5-14% of cement by weight), Plastic soil-cement (5-14% of cement by weight but with more quantity of water) and Cement modified soil (> 5% of cement by weight).
   Nature of soil, quantity of cement, water, mixing, compaction and curing are the facors which affect cement stabilization.
   Advantages of cement stabilization: No slaking, decreases cohesiveness, compressibility and increases strength, elimination of ruts, permanent soil modification, faster construction techniques.

Disadvantages: Initial setting time of cement is a major problem, dusting occurs during construction, heat of hydration results cracks and also carbon dioxide gas releases due to reaction.

3. **RBI Grade 81:** RBI GRADE-81 is calcium driven, inorganic soil stabilizer patented globally used as the additive in soil stabilization without compromising the quality of the result, its specific formulation allows for stabilization of a wide range of materials. The main components that are used to create RBI GRADE-81 are a series of inorganic hydration activated powders; it is composed of a specific type of cement, a lime, several pozzolonas, rate governing additives, and a unique polypropylene fibres. The specific formulation allows for the uniqueness of the components to contribute to the reaction process and soil stabilization. The RBI Grade-81 Soil Stabilizer was selected for study which has been certified as cost effective, Eco-friendly, non toxic, non- leaching and suitable for road construction. It reduces pavement thicknesses and reduces aggregate consumption. The Physical properties and Chemical properties of RBI Grade-81 are as follows:

Table 1.1: physical properties of RBI Grade-81

Properties	RBI Grade 81
Appearance	Beige Powder
Odour	Odourless
pH	12.5(saturated paste)
Flammability	Inflammable
Specific Gravity	2.5
Solubility in water	0.2 pts/ 100 pts
Freezing Point	None, solid
Viscosity	None, solid

Table 1.2: chemical properties of RBI Grade-81 properties

Properties	RBI Grade 81
Calcium oxide (CaO)	52-56 %
Silicon dioxide (SiO2)	15-19 %
Sulphur trioxide (SO3)	9-11 %
Aluminium oxide (Al2O3)	5-7 %
Iron oxide (Fe2O3)	0-2 %
Magnesium oxide (MgO)	0-1 %
Fibres (polypropylene)	0-1 %
Additives	0-4 %

III. RESEARCH METHODOLOGY

Following test methods are used in this research work;

- **Liquid limit test:** Standard Liquid limit is defined as the minimum water content at which both faces of groove come close to each other at exactly 25 no. of falls in Standard Cassagrande's apparatus.
- **Plastic limit test:** It is defined as the minimum water content at which a soil will just begin to crumble when rolled into a thread approx. 3 mm in diameter.
- **Specific gravity test:** Pycnometer bottle is used for determination of specific gravity of soil. It is the ratio of the weight of a given volume of soil solids to the weight of an equal volume of distilled water.
- **Modified Proctor test:** For determination of optimum Moisture Content and maximum Dry Density, Proctor compaction test is done. Heavy compaction is done using 4.89 Kg hammer with 25 blows in each layer filled in proctor mould.
- **CBR Test:** California Bearing Ratio test is an important test used for determination of bearing capacity of soil. mould of 2250 cc volume is used and soil is filled in 5 layers with addition of water at OMC. 56 blows are given in each layer by 4.89 Kg hammer.

IV. RESULTS AND DISCUSSION

4.1 Results of Index properties of Soil

Table 4.1: Index properties of soil

Soils	Properties
Classification	OI (Organic clay with medium plasticity)
Specific Gravity	2.351
Liquid Limit	39.08%
Plastic Limit	28.83%
Plasticity Index	10.25%
OMC	13.75%

MDD	1.85 g/cc
CBR Value (Soaked)	4.96

4.2 Results of Soil when added with Lime

Table 4.2: Influences of Lime on Soil

Properties	Soil + 2% Lime	Soil + 4% Lime	Soil + 6% Lime
Liquid limit	36.38%	33.99%	33.35%
Plastic limit	29.02%	29.96%	29.88%
Plasticity Index	7.36%	4.03%	3.47%
OMC	12.5%	13.19%	12.3%
MDD	1.813 g/cc	1.86 g/cc	1.867 g/cc
CBR (Soaked, 96 hrs), cured for 7 days	6.37	9.48	12.13

4.2 Results of Soil when added with Cement

Table 4.3: Influences of Cement on Soil

Properties	Soil + 2% Cement	Soil + 4% Cement	Soil + 6% Cement
Liquid limit	34.26%	31.91%	30.64%
Plastic limit	27.87%	26.20%	26.41%
Plasticity Index	6.39%	5.71%	4.23%
OMC	10.15%	14.70%	11.10%
MDD	1.821 g/cc	1.901 g/cc	1.898 g/cc
CBR (Soaked, 96 hrs), cured for 7 days	8.03	10.22	13.55

4.3 Results of Soil when added with RBI Grade 81

Table 4.3: Influences of RBI Grade 81 on Soil

Properties	Soil + 2% RBI	Soil + 4% RBI	Soil + 6% RBI
Liquid limit	34.71%	33.345%	37.57%
Plastic limit	27.06%	28.89%	34.38%
Plasticity Index	7.65%	4.46%	3.19%
OMC	13.75%	12.12%	14.30%
MDD	1.864 g/cc	1.89 g/cc	1.813 g/cc
CBR (Soaked, 96 hrs), cured for 7 days	9.12	11.86	15.50

4.4 Effect of Admixtures on Plasticity Index of Soil;

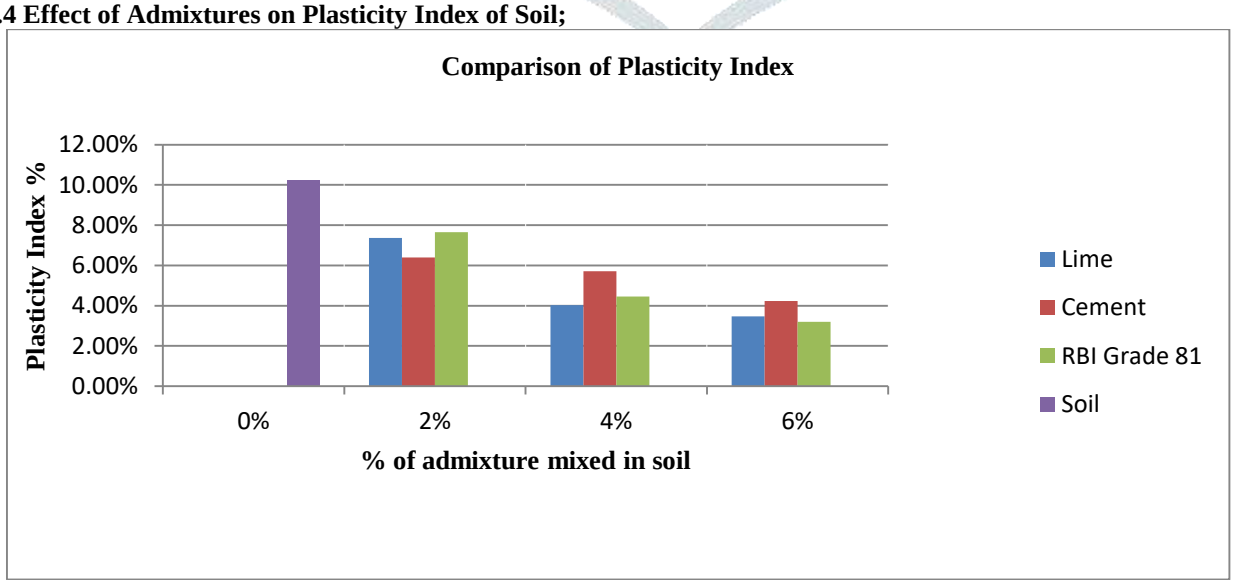

Fig. 4.1: Comparison graph of Plasticity Index of treated and untreated Soil

4.5 Effect of Admixtures on OMC of Soil;

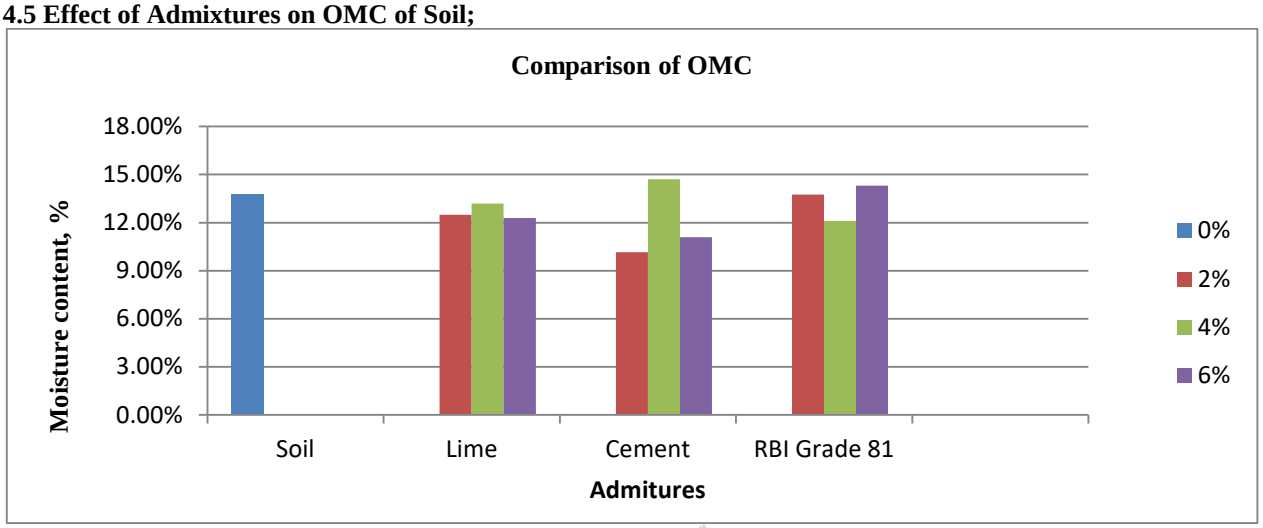

Fig. 4.2: Comparison graph of OMC of treated and untreated Soil

4.5 Effect of Admixtures on MDD of Soil;

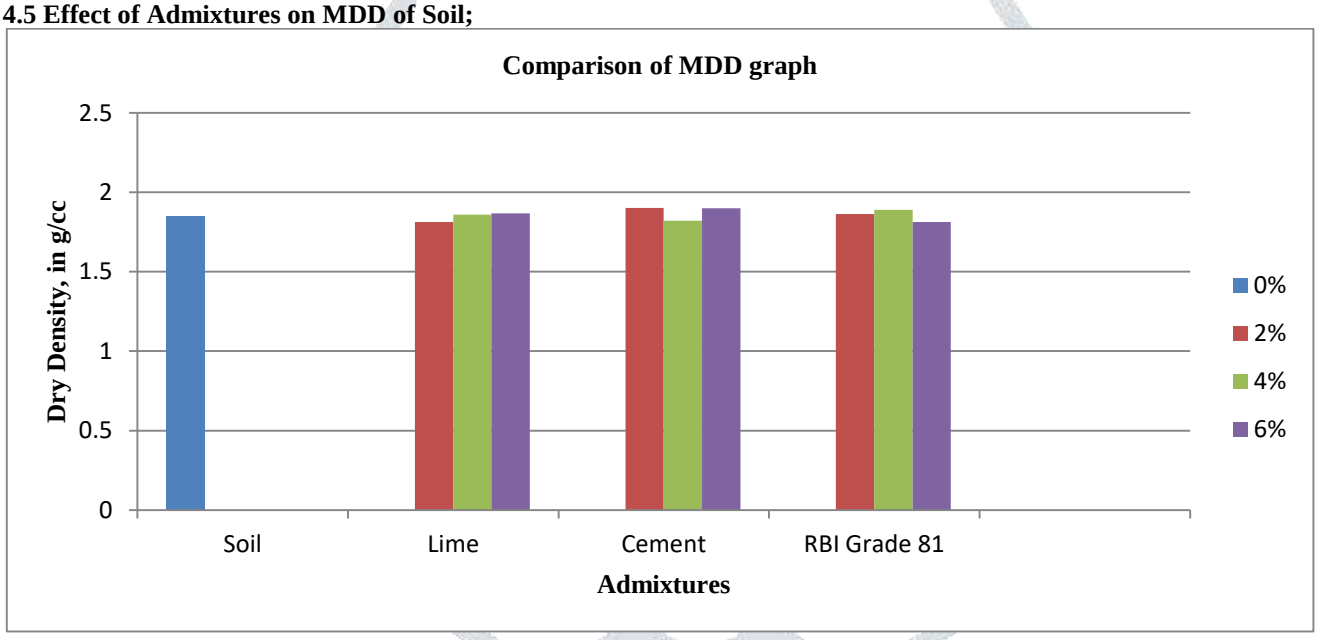

Fig. 4.3: Comparison graph of MDD of treated and untreated Soil

4.5 Effect of Admixtures on CBR Value of Soil;

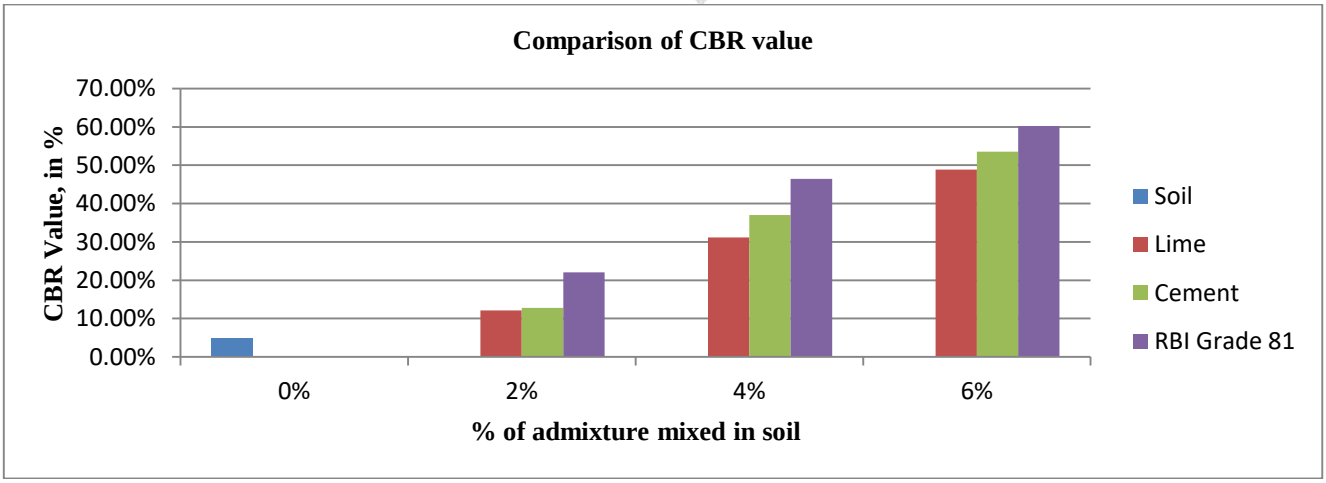

Fig. 4.4: Comparison graph of CBR Value of treated and untreated Soil

IV. CONCLUSIONS

On the basis of present study, the following conclusions are drawn

1. According to the Unified Soil Classification System, the black cotton soil sample has been categorized as OI (Organic clay of medium plasticity)
2. There is substantial decrease in Plasticity Index with addition of 2%, 4% and 6% Lime, Cement and RBI Grade 81 by weight. The phenomenon of decreasing liquid limit and increasing plastic limit is seen in Lime and RBI grade 81 whereas in case of Cement both liquid as well as plastic limit decreases.
3. There is substantial decrease in OMC with increase in addition of admixtures and MDD of soil improves.
4. The California bearing ratio (CBR) of the soil alone is obtained as 4.96 and it is increased with addition of admixtures, 6% RBI grade 81 has the maximum CBR value when it is cured for 7 days and soaked for 96 hours.
5. The percentage increase in CBR value of RBI Grade 81 is, 43%, 25% and 28% with respect to 2%, 4%, and 6% lime whereas 13.5%, 16% and 14.4% with respect to cement when added with 2%,4% and 6% respectively.
6. From the results, it is concluded that all three admixture (Lime, Cement and RBI Grade 81) has positive impact on soil.
7. It is seen that at same dosage, RBI grade 81 is more effective than Lime and cement. It can potentially reduce the ground improvement cost by adopting RBI grade 81 stabilizers.

V. FUTURE SCOPE OF PRESENT STUDY

Following works can be recommended for future study on this research work;

- Investigation to discover whether the improvement in soil properties brought about by the addition of these admixtures is permanent, when the material is subjected to weathering.
- Investigation of strength after subjecting specimen to long periods of curing. This may show the influence excess moisture has on the bonding action of soil-admixture.
- Investigation to discover the effect of Lime, Cement and RBI Grade 81 has on the angle of internal friction and cohesion constant of a clay soil.
- Investigation to discover the effect of Lime, Cement and RBI Grade 81 has on the Swelling Pressure and Free Swell Index of soil.
- Further testing for plasticity and strength changes due to higher quantities of admixtures.
- Comparison with other admixtures to find out the more economical and cost effective technique.

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