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Experimental study on strength properties of problematic soils with RBI – 81 stabiliser

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ABSTRACT

Rapid industrialization demands for developing engineering facilities even in difficult soils like soft clays and loose silts. Expansive soils which are generally termed as problematic soils cause swelling and shrinkage resulting in significant damage to the structures constructed on them. In this study an attempt is made to improve the strength and to stabilize the problematic soil by the use of chemical additive, RBI grade 81. Detailed experimental investigation including unconfined compression tests, SEM and EDAX analysis were carried out to know the effectiveness of addition of RBI grade 81 to improve the engineering properties, chemical composition and mineralogical properties of two soil samples (A1 and A2). Treated soil specimens at various stabilizer dosages (2, 4 and 6%) were tested for UCS after curing periods of 3 days and 7 days. It was observed that the unconfined compressive strength of the soil sample A1 and A2 increased by 475% and 430% with addition of 6% stabilizer after 7 days curing. The increase in strength can be due to the formation of new cementitious compounds which is evident in the micrographs from SEM and EDAX analysis.

Keyword: RBI, UCS, SEM, EDAX.

1. Introduction

Due to rapid industrialization there has been an increasing demand for developing engineering facilities even in difficult soils like soft clays and loose silts of several meters thickness. Such soil conditions pose challenges to the foundation engineers as the conventional foundation techniques are not possible to be adopted either from engineering or from economic considerations. The expansive soils are generally termed as problematic soils which cause swelling and shrinkage resulting in significant damage to structures such as buildings and pavements. This damage can be attributed to moisture fluctuations caused by seasonal variations.

An attempt is made to improve the soil strength and to stabilize the problematic soil by the use of chemical additive. A series of laboratory tests were carried out to study the effect of soil stabiliser RBI (Road Building International) grade 81 on two types of soil with various percentages (RBI grade 81) on the soil properties (engineering properties and mineralogical properties) such as, Unconfined Compressive Strength (UCS), chemical composition and Scanning Electron Microscope (SEM) analysis.

1.1 Literature review

Civil engineering projects located in areas with soft soils have different traditional methods to improve their soil properties. Several innovative techniques have been also suggested for

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improving the various problems of swelling soils which include the sand cushion technique (Satyanarayana, 1966), and belled piers (Chen, 1988). Apart from these techniques, the engineers, architects, and contractors have tried many ways to reduce the damaging effects of expansive soils.Their actions were often based on trial-and-error approaches. They have used mechanical stabilization to the extent practical but have found it also necessary to alter the physicochemical properties of clay soils in order to permanently stabilize them. By the mid-1950s Engineers described their successes in modifying clay behavior. Dubose (1955) described how to control heavy clays using compaction. Jones (1958) discussed stabilization of expansive clay using hydrated lime and Portland cement. Stabilisation of expansive soils with various additives including lime, cement, calcium chloride and fly ash (Shankar and Maruthi 1989, Desai and Oza 1997, Phanikumar and Nagareddayya, 2001, Cokca 2001) has also met with considerable success. Addition of lime to expansive soils reduces swell potential and shrinkage and increases the workability and shear strength under wet conditions. Pranshoo Solanki *et al.* (2007), evaluated the effectiveness of different percentages (5%, 10% & 15%) of Cement Kiln Dust (CKD) as a soil stabilizer on UCC and SEM analysis. SEM micrographs revealed that crystalline hydration products were assumed to be the major factor contributing the strength improvements. This paper presents test results on the effect of RBI Grade 81 soil stabilizer on problematic soil characteristics.

2. Materials and experimental procedure

2.1Test materials

In the present study, two soil samples are collected from the Thittagudi – Siruppakkam road (Sample A1) and Veppur – Eraiyur road (Sample A2), at a depth of 0.3 – 0.5 m below the ground surface. Laboratory tests were conducted on the representative soil samples for gradation, specific gravity, Atterberg's limit and compaction characteristics as per IS code of practice. The properties of soils used in this study are given in Table 1. Chemical compositions of the soils are shown in Table 2. RBI grade 81 is used as the stabilizer and its chemical composition is shown in Table 3.

Table 1: Properties of soil samples

Parameter		Value	
		Sample A1	**SampleA2**
Particle size distribution	Sand, %	4	2
	Silt, %	26	32
	Clay, %	70	66
Free swell index (%)		110	105
Specific gravity		2.36	2.65
Liquid limit (%)		75	72
Plastic limit (%)		38	39
Plasticity index (%)		37	33
Shrinkage limit (%)		7	6
Indian Soil Classification		CH	CH
Standard Proctor test	MDD g/cc	1.6	1.54
	OMC, %	20	24.5
UCC value (kPa)		138	122

Table 2: Chemical composition of soil samples

Description (%)	Sample A1	SampleA2
Loss on ignition (loi)	13.67	13.00
Insoluble residue (IR)	67.92	84.92
SO_3	0.34	0.12
SiO_2	53.17	53.36
Al_2O_3	13.77	14.79
Fe_2O_3	6.45	7.76
CaO	5.39	3.54
MgO	0.39	0.73

2.2 Test techniques and sample preparation

This experimental work was conducted to investigate the influence of curing period and percentage addition of RBI grade 81 on the unconfined compressive strength of soils. The unconfined compressive strength tests were conducted on virgin soil and soil mixed with RBI grade 81 mixture as per IS: 2720 Part 10 (1973). The soil sample A1 and A2 were mixed with various proportions of RBI Grade 81 ranging from 0, 2, 4 and 6 percentages and UCC samples were prepared. All the UCC samples were prepared by static compaction using a split mould at optimum moisture content and maximum dry density to maintain same initial dry density and water content. Curing period of 3days and 7days were adopted in this study. Three samples for each curing period were prepared in order to provide an indication of reproducibility as well as to provide sufficient data for accurate interpolation of the results. The samples placed in air-tight polythene covers were cured by placing them over wetted rice husk base and covering them with wet gunny bags. This helped in maintaining a constant temperature in order to avoid moisture loss from the samples prepared. The UCC tests were conducted at a constant strain rate of 0.9% per minute, it is lies between 0.5 to 2% as per IS:2720, Part 10 (1973).

Table 3: Chemical composition of RBI grade 81

Constituent	Percentage by
Ca	52-56
Si	15-19
S	9-11
Al	5-7
Fe	0-2
Mg	0-1
Mn, K, Cu, Zn	0.1-0.3
H_2O	1-3
Fibers	0-1
Additives	0-4

3. Results and discussions

Soil specimens of 38mm diameter and 76mm height were used to determine the unconfined compressive strength of both the soil samples (A1 and A2) treated with various stabilizer dosages of 0, 2, 4 and 6%. The treated soil samples, after curing for 3 days and 7 days, were tested for their UCC values. The results of UCC tests on soils A1 and A2 stabilized with 0, 2, 4 and 6% are presented in Table.4. Figure.3 shows the variation of UCC value with stabilizer dosage and curing period. It was observed that the unconfined compressive strength increases with the increase in stabilizer content for both the soils. This means that the soil hardens with an increase in the stabilizer content. Figure.1 and Figure.2 gives the stress-strain curve of UCC tests on soil samples from which it can be observed that the increase in strength is obtained with smaller strain.

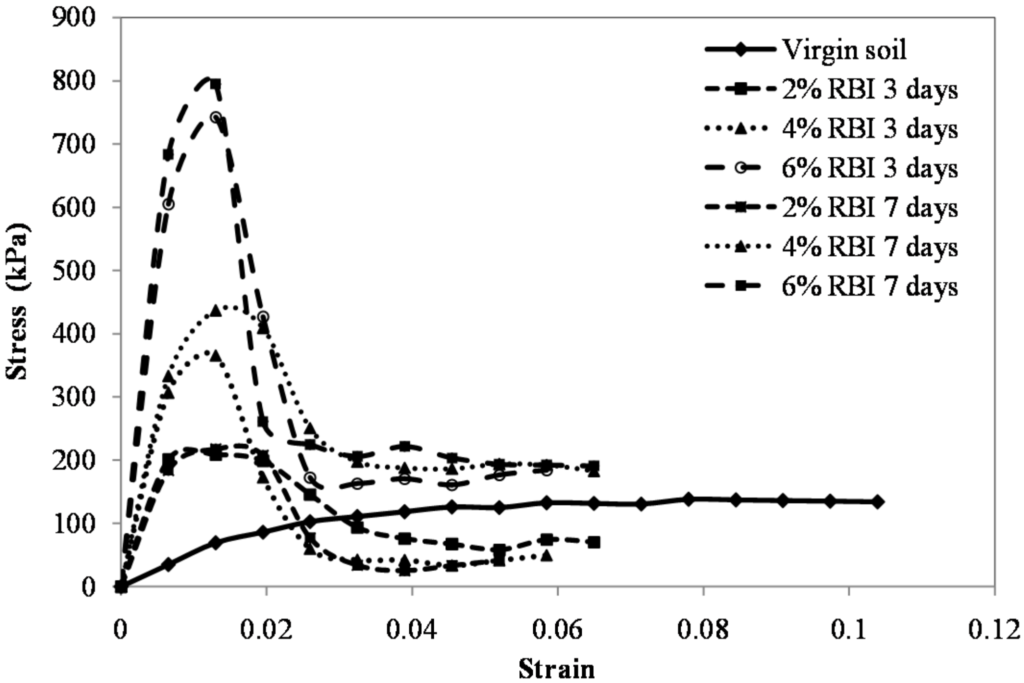

Figure 1: UCC test result for soil sample A1

For the sample A1 the strength increase was low at 2% of stabilizer content and the increase was more after 2% of stabilizer content. It was found that the increase in UCC values at 3 days curing for 2%, 4% and 6% were around 0.51, 1.64 and 4.4 times that of the virgin soil. Similar response was observed for soil sample A2 with the addition of stabilizer content except that intensity of UCC value changed.

From the tests conducted on the soil, it was observed that the UCC value of treated soil increases with the increase in curing period, however the increase is marginal for the curing periods under study (Table – 4).

For sample A1, the increase in UCS for 3 days curing period from a stabilizer dosage of 2 to 4% was around 75% and from 4 to 6% of stabilizer was about 103%. This shows that the soil strength increases with the increase in stabilizer content. Similar trend was observed in 7days curing and also for the sample A2.

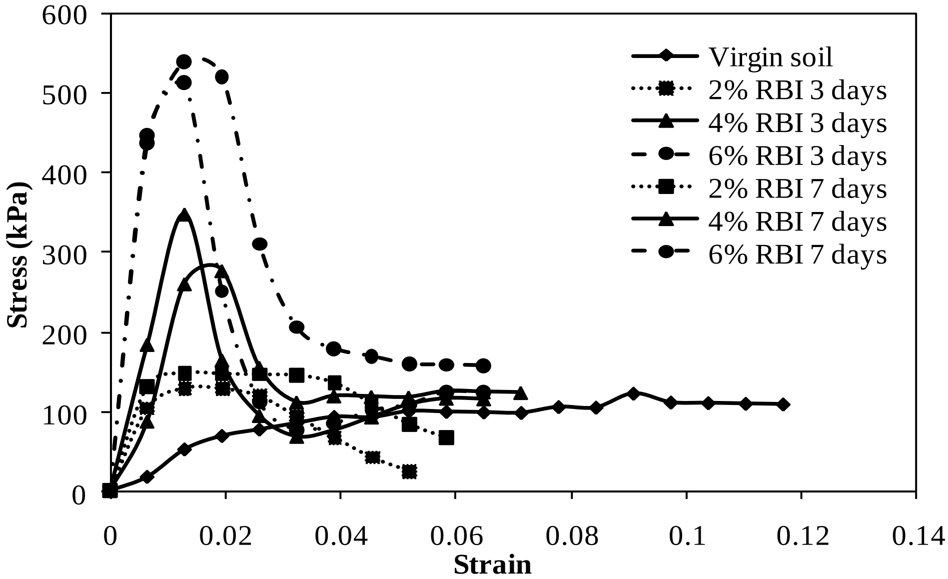

Figure 2: Test result for soil sample A2

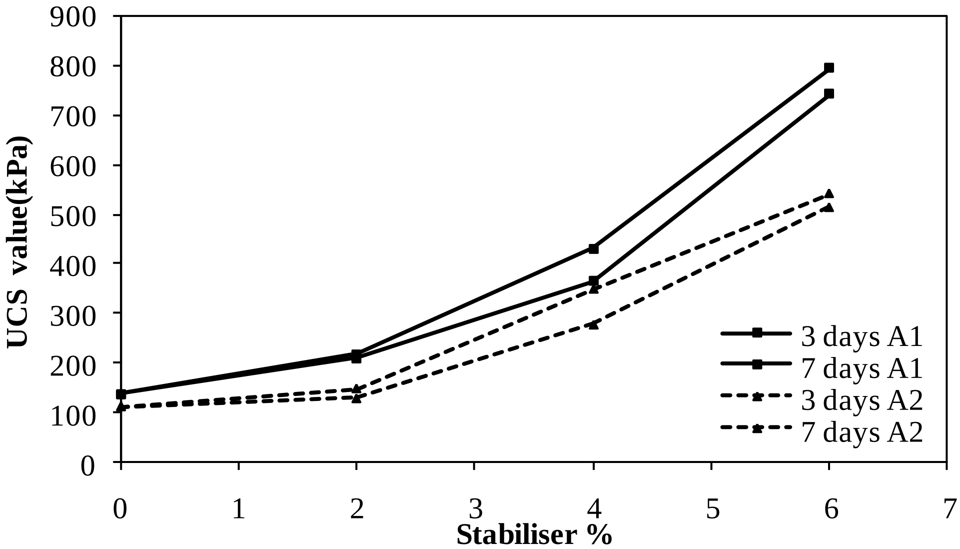

Figure 3: Comparison of UCS values for different percentage of additive and curing periods

Table 4: Unconfined compressive strength for the soil samples A1 and A2

Soil + % RBI	UCC Value (kPa)			
	Sample A1		Sample A2	
	3 days	7days	3 days	7 days
Soil + 0% RBI	138		122	
Soil + 2% RBI	209	217	130	148
Soil + 4% RBI	365	436	277	348
Soil + 6% RBI	742	794	514	541

3.1Sample characterization

The individual morphology was studied by Field Emission Scanning Electron Microscopy (FESEM) images taken using FEI Quanta 200 FEG and the element composition of the samples were analyzed using Bruker Energy Dispersive X-ray Spectrometer (EDS). The scanning electron microscope is one of the ideal tools available for the measurement of fabric of clays because of its higher resolution capacity together with large depth of focus and also it is possible to get the three dimensional view of the arrangement of the particles.

Samples for the microscopic observation were collected from the middle sections of untreated and 6% RBI grade 81 treated UCC specimens at 7 days curing period. A detailed microstructure study was conducted on virgin Soil-A1, stabilizer (RBI grade 81) and Soil A1 treated with 6% stabilizer at 7 days curing period and the micrographs are shown in Figure 4 - 7. From the micrographs it can be observed that the large voids which were present in the untreated soils diminished on treatment with 6% stabilizer which indicates the formation of new cementitious compounds.

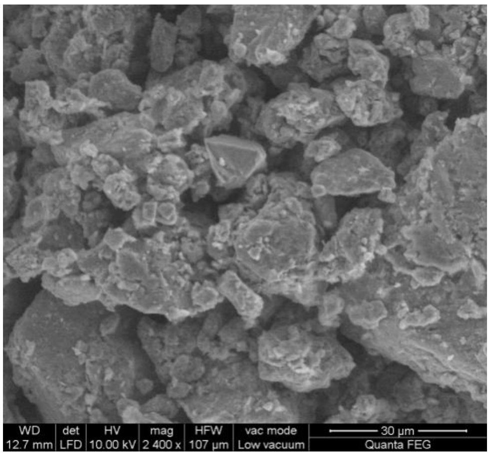

Figure 4: Micrograph of virgin soil A1

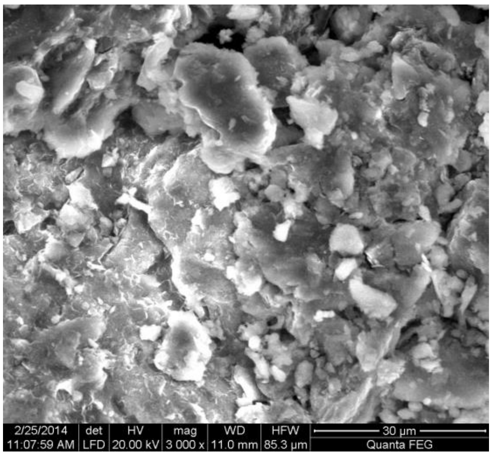

Figure 5: Micrograph of virgin soil A2

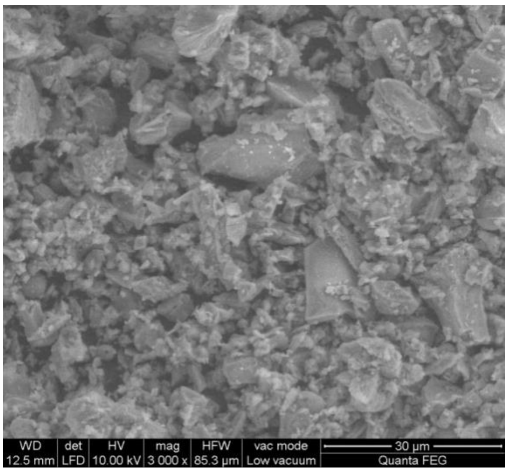

Figure 6: Micrograph of RBI grade 81

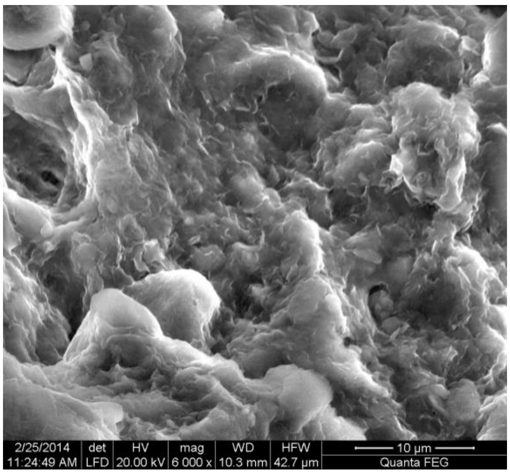

Figure 7: Micrograph of soil A1 treated with 6% RBI grade 81 at 7 days curing period

Figure 8-10 shows the EDS-spectra obtained from Bruker Energy Dispersive X-ray Spectrometer (EDS) for virgin soil, stabilizer and soil treated with 6% RBI grade 81 at 7days curing period. The variations in the element composition of the soil on treatment can be clearly observed.

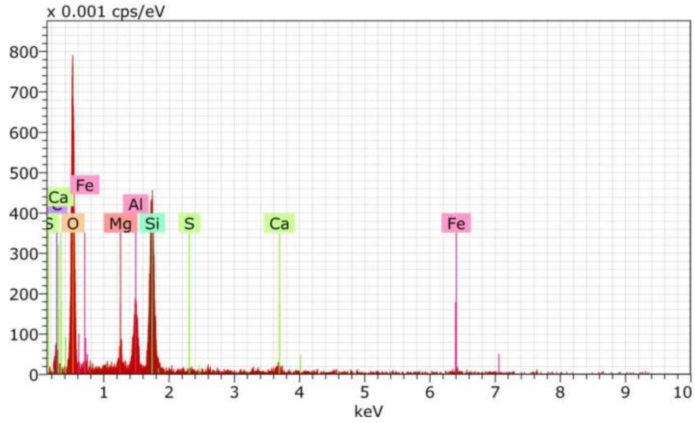

Figure 8: EDS spectra of a virgin soil A1

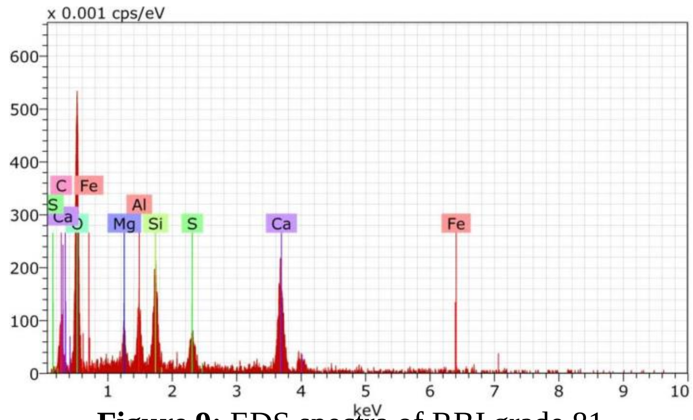

Figure 9: EDS spectra of RBI grade 81

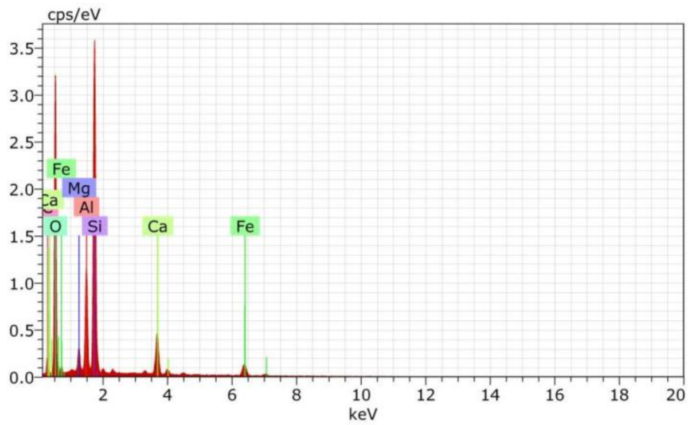

Figure 10: EDS spectra of soil A1 treated with 6% RBI grade 81 (7 Days curing)

4. Conclusions

Both the soils showed appreciable improvement in unconfined compressive strength with the addition of stabilizer under the curing periods of 3days and 7days. The rate of increase in the UCS increases with increase in percentage of stabilizer. It have been observed that the unconfined compressive strength of the soil sample A1 and A2 increased by 475% and 430% respectively after 7 days curing on the addition of 6%

stabilizer. From the observation, it was found that 3 days and 7 days unconfined compressive strength are more or less equal which indicate early reactions and formation of cementitious products in the early stage of curing. Evidence for stabilization can be seen from change in chemical composition of soils when treated with the stabilizer. The increase in strength for the treated soil can be as a result of formation of cementitious materials.

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