

STUDY ON STRENGTH CHARACTERISTICS OF SOIL USING SOIL STABILISER RBI – 81

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Abstract

Stabilization of soil is the moderation of one or more soil properties, by chemical or mechanical means, to create an improved geo material possessing the required engineering properties. Soils may be stabilized to increase strength and durability or to prevent erosion and dust generation. The present paper describes a study carried out to check the improvements in the properties of expansive soil with RBI grade 81 in varying percentages and different curing periods. Unconfined Compressive Strength (UCS) tests, XRF and SEM analysis were carried out on untreated and treated soils for different curing periods of 3 days, 14 days and 28 days. An increasing trend in UCS was observed with the increase in the percentage of chemical and curing period.

Keywords: UCS, RBI-81, SEM, XRF

1. INTRODUCTION

Engineering structures on expansive soils is a challenging task for the geotechnical engineers due to the peculiar swell – shrink behaviour of the soil. Due to the change in the moisture content in the soil, such soils tend to swell or shrink causing severe distress to the structures founded on them. Such soil needs to be stabilized in order to reduce the damaging potential to the structures founded on them and to increase the strength of such soil.

In recent years, researchers have attempted to solve the problems posed by expansive soils with various degree of success. Amer Ali Al-Rawas et al., [1] conducted a study on stabilization of soils with lime. With addition of 6% lime, both the swell pressure and swell percent reduced to zero. Stabilisation of expansive soils using various additives including cement, steel fibers, gasoline fuel and injection by cement grout revealed better improvement [2]. Strength development and microstructure relation was shown by the addition of lime and cement stabilized clays. Cementation and strengths of both stabilized clays increase with curing time and admixture contents [3]. In another study, stabilization of expansive soil was carried out by waste limestone dust and waste dolomitic marble dust, by-products of marble industry[4]. The test revealed that the swelling percentage decreased and rate of swell increased with increasing stabilizer percentage. In this paper, the influence of RBI grade 81 on the strength and microstructure of the soil has been studied.

2. MATERIALS AND METHODS

Two soil samples G1 and G2 used in this study were collected at a depth of 0.3 – 0.5 m below the ground surface and RBI grade 81 chemical additive was used as stabilizer. Grains size analysis, specific gravity, Atterbergs limits and standard proctor compaction tests were conducted on both the soil samples and UCC, SEM and XRF tests were conducted on the treated and untreated soil samples in accordance with the Indian standards.

The results of the geotechnical tests carried out on the virgin soil samples G1 and G2 are given in Table - 1. Based on the test results both the soils can be classified as high compressible clays (CH) as per IS soil classification system.

Table - 1: Properties of Soil

Description	Sample G1	Sample G2
Free Swell Index (FSI), %	110	105
Specific gravity	2.36	2.65
Liquid limit (%)	75	72
Plastic limit (%)	38	39
Plasticity Index, %	37	33
Shrinkage limit (%)	7	6
Shrinkage index (SI), %	31	33
IS soil classification	CH	CH
Compaction Characteristics		
MDD (g/cc)	1.6	1.54
OMC (%)	20	24.5
UCS (kPa)	138	122

Based on the test result, the soil can be categorized as an expansive soil of high to very high degree of expansion based on Holtz and Gibbs(1956) and IS:1498 classification system(Table - 2 and 3).

Table - 2: Degree of Expansion Characteristics of Soil (Holtz and Gibbs (1956)[5])

Degree of expansion	Plasticity Index	Shrinkage Limit
Low	<18	>13
Medium	15-28	8-18
High	25-41	6-12
Very high	>35	<10

Table - 3: Degree of Expansion Characteristics of Soil (IS: 1498- 1970)

Degree of expansion	Liquid limit	Plasticity Index	FSI	SI
Low	20-35	<12	<50	<15
Medium	35-50	12-23	50-100	15-30
High	50-70	23-32	100-200	30-60
Very high	70-90	>32	>200	>60

3. RESULTS AND DISCUSSIONS

The test results of UCS, chemical analysis, SEM and XRF on virgin and soil treated with various percentages of RBI are discussed in the following sections.

3.1 Unconfined Compression Test

Unconfined Compression test was conducted in accordance with IS:2720 (Part-10) with various percentages of RBI grade 81 using static compaction. 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 in order to maintain constant temperature and prevent moisture loss. These samples were tested on UCC testing machine at a constant strain rate of 1.2mm/min at the end of specified curing periods of 3 days, 14 days and 28 days. The results of UCC tests on soils G1 and G2 stabilized with 0, 2, 4 and 6% are presented in Table - 4. Figure 1 and 2 shows the stress – strain characteristics of virgin soil and soil treated with various percentages of stabilizer at various curing periods. The test result shows that, the increase in percentage of RBI on both the soils increases the UCS value of the soils irrespective of curing periods.

3.2 Microstructural Analysis for Stabilization Mechanism

A micro level study was carried out on the treated as well as untreated samples in order to understand the mechanism of

stabilization. XRF and SEM analysis were conducted on all the raw soils, raw additive and 28-day cured stabilized soil specimens to study the influence of stabilization on microstructure and mineralogical characteristics.

Table – 4: Unconfined Compressive Strength for the untreated and treated soil

RBI (%)	UCS Value (kPa)					
	Sample G1			Sample G2		
	3Day	14Day	28Day	3Day	14Day	28Day
0	138			122		
2	209	303	327	188	218	234
4	366	540	605	341	435	496
6	742	888	1201	461	571	749

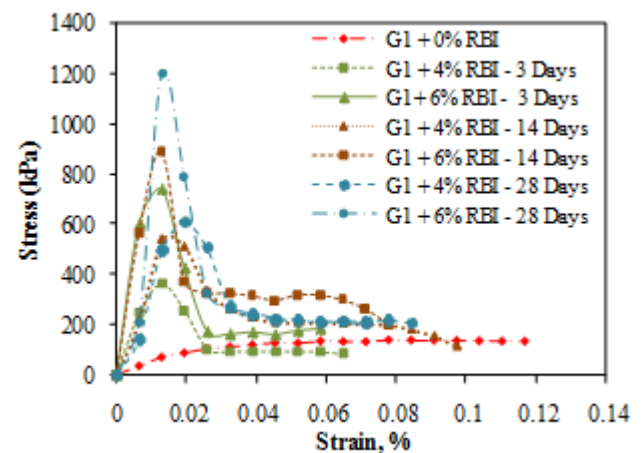


Fig - 1: Stress – Strain Characteristics of Soil G1 with and Without Stabiliser

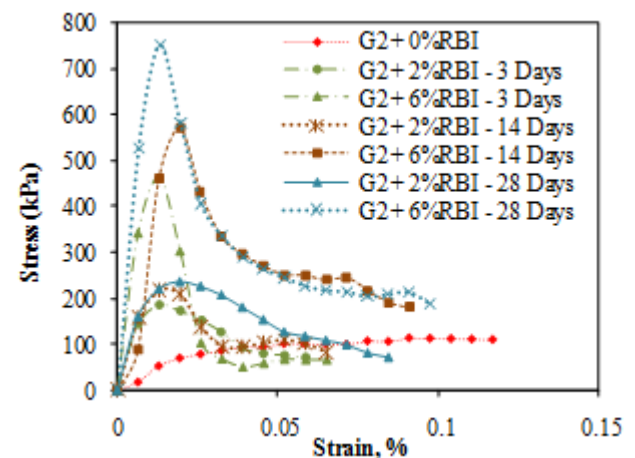
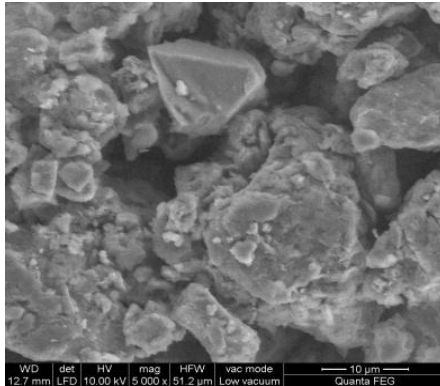


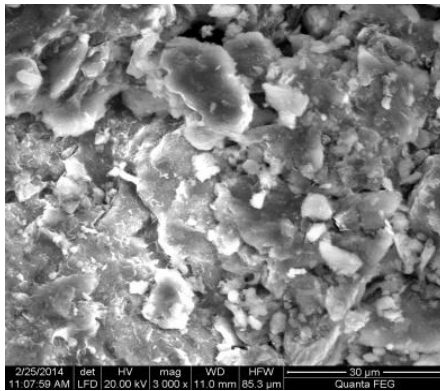
Fig – 2: Stress - Strain Characteristics of Soil G2 with and without Stabiliser.

3.2.1 SEM

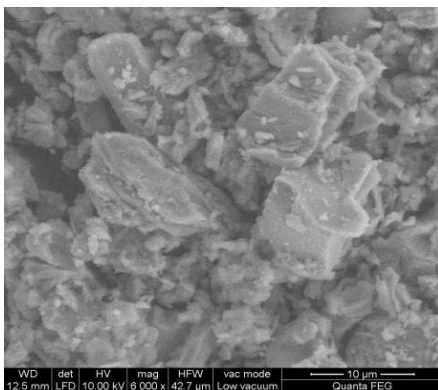
SEM analysis was carried out on samples for all the raw soils, raw additive and 28-day cured stabilized soil specimens. The SEM micrographs confirm the formation of cementitious material for the treated soil samples. Reduction in pore spaces can also be observed indicating the change in microstructure of the soil on addition of stabilizer (Fig.3).



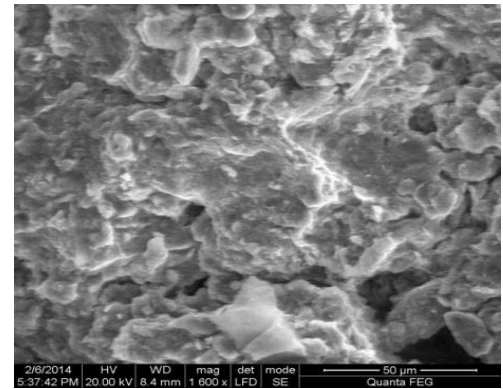
a. Virgin soil G1



b. Virgin soil G2



c. Soil stabilizer



d. Treated soil G1 with 6% RBI (28 days)

Fig – 3 SEM micrographs of soils, stabiliser and treated soil

3.2.2 XRF

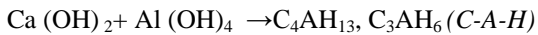
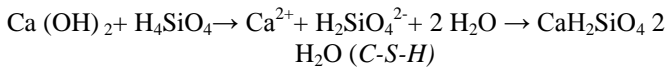
The X-Ray Fluorescence (XRF) analysis was conducted on the stabiliser, untreated and treated soil samples to identify the concentration of different compounds after the treatment in order to determine the extent of formation of cementitious compounds in soil on reaction with chemical admixture. The XRF results for the untreated and treated samples with stabiliser are shown in Table 5.

Table - 5: XRF results for soil, stabiliser, treated soil with 6% stabiliser (RBI-81)

Compound (cps)	RBI	Untreated		Treated (28 Day)	
		G1	G2	G1	G2
Na	38	26	30	23	20
Mg	14	10	7	14	7
Al	162	337	426	377	540
Si	1619	4031	3729	4306	3788
S	5600	107	312	464	722
K	735	727	1466	639	2229
Ca	60526	4859	3376	9702	6570
Fe	3560	23699	27032	21663	27323

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:



4. CONCLUSIONS

1. Unconfined compressive strengths of both the soil samples give satisfactory results after the treatment with RBI in terms of percentage of chemical as well as curing period.
2. The minimum increase of UCS value with 6% of RBI additions on soil G1 and G2 is 4.37 times and 2.77 times respectively at the end of 3 days curing period.
3. Failure pattern of the treated sample shows the alteration in the property of soil into a brittle material.
4. XRF results indicate the formation of cementitious compounds C-A-H and C-S-H.
5. SEM micrographs reveal the change in microstructure of the treated soil sample by the formation of cementitious material.

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