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A STUDY ON STABILIZATION OF SOIL WITH LIME AND CEMENT

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Abstract- This paper presents the study on the use of Lime and Cement for stabilization of soil. Poor sub-grade soil is problematic due to its settlement, swelling and strength issues. High strength soil in subgrade is recommended by IRC: 37-2012, the code for the design of flexible pavement, which recommends the use of select soil of minimum CBR 8% in the sub-grade when the traffic is 450 Commercial Vehicle per day or higher. This study aims to improve the engineering properties of sub grade soil by stabilization of soil with lime and cement. The stabilization of soil with lime and cement is an easy approach. In the present study experimental investigations have been conducted on locally available soil by mixing it with cement and lime in proportions of 1%, 2%, 3% and 2%, 4%, 6% respectively. The effects of stabilization on Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and California Bearing Ratio (CBR) of composite mixture have been assessed. The whole experimental study has been done in two steps. In first step, a series of experiments such as Atterberg Limits, Modified Proctor test and California Bearing Ratio tests have been conducted on untreated soil and in second step Modified Proctor tests and California Bearing Ratio tests have been performed on composite mixtures of soil plus lime and cement. It has been found that mixing of lime and cement with untreated soil proved to be effective in enhancing engineering properties of the subgrade soil.

Keywords— Chemical stabilization; Lime; Cement; California bearing ratio (CBR); Modified proctor test (MPT).

I. INTRODUCTION

Transportation plays a vital role in development of the human civilization. Transportation in India is accomplished by roadways, railways, airways and waterways. Among these modes of transportation, roadways are major components of transportation system. India's road network of 5.6 million kilometres is second largest road network in the world.
The process of soil stabilization is widely used to improve engineering properties of sub-grade soil and thus making it more stable. Stabilization is the process of blending and mixing materials with a soil to improve engineering properties of soil. Soil stabilization is used to reduce the permeability and compressibility of soil in earth structures, to reduce the swell in case of expansive soils and to increase its shear strength and bearing capacity of soil [1]. The usual method of soil stabilization is replacement of weak soil by stabilized soil. In recent decades, researchers have introduced a new technique for stabilization of soil, designated as chemical stabilization. In this technique, the soil having poor engineering properties are blended with stabilizers in order to initiate a suite of chemical reactions such cation-exchange, flocculation, carbonation and pozzolanic activity which consequently enhance the engineering properties of soil [2]. The improvement in soil properties depends on several factors such as mineralogical composition and water content of treated soil, the quantity and types of additives, curing time and temperature.
Soil compaction and California bearing ratio are the most commonly used properties in engineering projects such as highways, railways, pavements and foundations. The low strength soils need to be treated by means of soil stabilization technique, which is the process of enhancing the soil properties by different methods such as mechanical or chemical stabilization techniques. Soils are generally stabilized to increase their strength and durability or to prevent soil erosion. The properties of soil varies from one place to other, also in certain cases for a particular place variation in behaviour of stabilized soil can be easily detected which consequently depends on soil testing. The strength of the subgrade is expressed in terms of CBR value.
The main objective of present study is to stabilize soil by using chemical stabilizers such as lime and cement in definite proportions to improve engineering properties of soils such as dry density and CBR value.

II. MATERIALS AND METHODOLOGY

MATERIALS USED

In this study following materials have been used.
1. Sub-grade soil
2. Lime
3. Cement

Sub-grade soil

A road stretch of 21 km in Kurukshetra (Haryana) has been selected for sampling of soil for the work to be carried out.

Lime

The use of lime can modify almost all fine-grained soils to some extent, but the most dramatic improvement occurs in clay soils of moderate to high plasticity.

Lime is used as a stabilizing agent at varying percentages to study its influence on CBR strength. Calcium hydroxide (Slaked lime) is obtained from local market of Kurukshetra. Specific gravity of lime is obtained as 2.2.

Cement

Ordinary Portland cement (43 grade), manufactured by Birla Cement is used in the present study as one of the stabilizer is obtained from local market of Kurukshetra. Specific gravity of lime is obtained as 3.15.

METHODOLOGY

Laboratory tests such as Sieve analysis, Atterberg limits, Modified proctor test and CBR test (Un-soaked and Soaked condition) on untreated soil samples and chemically stabilised soil samples. The lime and cement used in proportion of 2%, 4%, 6% and 1%, 2%, 3% by weight of dry soil respectively. These tests were performed conforming to relevant Indian standards.

Modified proctor test has been performed for determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC). California bearing ratio tests were performed on untreated soil and stabilized mixes in un-soaked and soaked conditions using the standard method.

III. RESULTS AND DISCUSSION

The experimental results of untreated soil samples are summarized in Table-I and Table-II

Table I: Sieve analysis and Atterberg limits of untreated soil samples

Samples	weight retained (gm) on IS sieve				Atterberg limits (%)		
	10mm	4.75mm	.425mm	.075mm	LL	PL	PI
1.	0	2.35	8.92	12.19	25.2	21.2	4.1
2.	0	1.42	17.62	64.53	19.8	17.4	2.4
3.	0	12.13	14.34	22.81	24.2	17.6	6.6
4.	0	6.76	19.46	53.12	21.6	20.3	1.3
5.	0	0	5.94	8.83	28.7	22.6	6.1

Table I shows the experimental results of sieve analysis and Atterberg limits of untreated soil samples.

Table II: Properties of untreated soil samples

Soil Sample	MDD (g/cc)	OMC (%)	CBR (%)	
			Un-soaked	Soaked
1	1.94	13.3	12.3	4.2
2	1.94	12.2	3.4	2.0
3	1.95	12.4	13.6	6.0
4	1.88	12.9	17.0	7.1
5	1.94	13.5	12.0	5.8

Table II indicates that all the samples selected for the study had 4 days soaked CBR value less than 8 % requiring their stabilization to increase their strenth so as to make the subgrade sutable for high volume traffic road.

The typical results of experiments conducted on treated soil samples are shown in following tables:

Table III: Test results of treated soil sample I

S.N.	Properties	Untreated	Lime			Cement		
			2%	4%	6%	1%	2%	3%
1	MDD (g/cc)	1.94	1.932	1.926	1.910	1.935	1.929	1.920
2	OMC (%)	13.3	13.50	14.90	15.10	13.90	14.46	15.15
3	CBR%(Unsoaked)	12.33	13.00	14.87	16.90	13.18	15.28	17.01
	CBR % (Soaked)	4.27	5.78	6.83	8.20	6.02	7.16	8.48

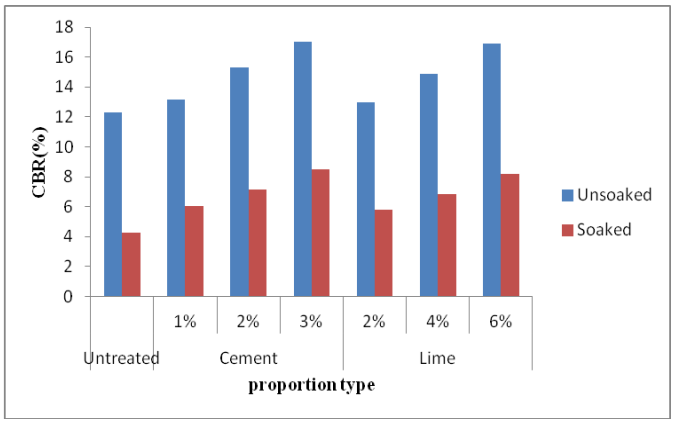

Fig I CBR results of soil sample I in unsoaked and soaked condition

Table IV: Test results of treated soil sample II

S.N.	Properties	Untreated	Lime			Cement		
			2%	4%	6%	1%	2%	3%
1	MDD (g/cc)	1.94	1.936	1.928	1.920	1.938	1.932	1.925
2	OMC (%)	12.2	12.40	12.75	13.10	12.45	12.78	13.15
3	CBR%(Unsoaked)	3.45	7.34	9.43	13.14	7.68	9.82	13.49
	CBR% (Soaked)	2	4.52	5.75	7.91	4.82	6.03	8.10

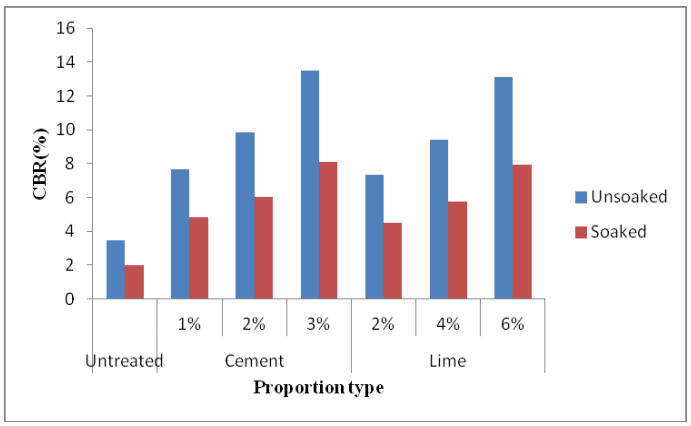

Fig II CBR results of soil sample II in unsoaked and soaked condition

Table V: Test results of treated soil sample III

S.N.	Properties	Untreated	Lime			Cement		
			2%	4%	6%	1%	2%	3%
1	MDD (g/cc)	1.95	1.948	1.940	1.935	1.946	1.938	1.930
2	OMC (%)	12.4	12.70	13.00	14.10	12.5	13.20	13.90
3	CBR%(Unsoaked)	13.6	14.28	15.87	18.92	14.99	16.29	19.07
	CBR% (Soaked)	6.0	6.23	7.41	8.18	6.7	7.81	8.53

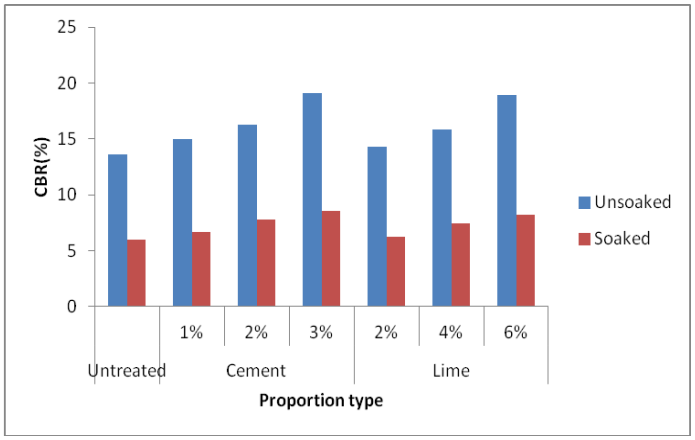

Fig III CBR results of soil sample III in unsoaked and soaked condition

Table VI: Test results of treated soil sample IV

S.N.	Properties	Untreated	Lime			Cement		
			2%	4%	6%	1%	2%	3%
1	MDD (g/cc)	1.88	1.879	1.873	1.865	1.879	1.870	1.866
2	OMC (%)	12.9	13.40	13.65	14.50	13.30	14.00	14.25
3	CBR%(Unsoaked)	17.08	16.42	17.81	18.29	17.46	18.21	20.12
	CBR% (Soaked)	7.15	7.28	7.79	8.09	7.31	7.89	8.31

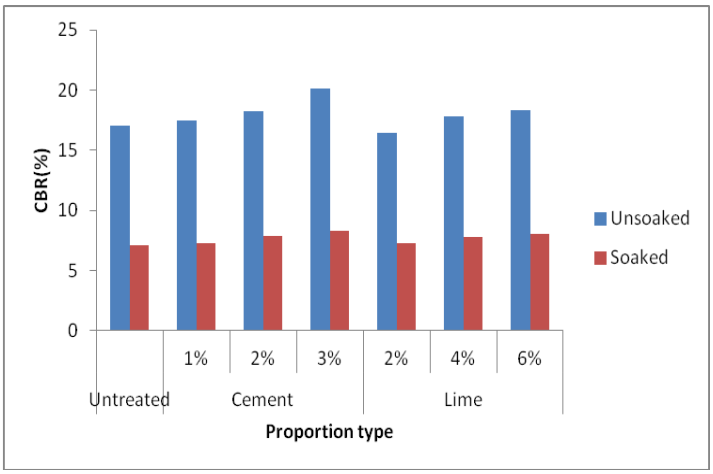

Fig IV CBR results of soil sample IV in unsoaked and soaked condition

Table VII: Test results of treated soil sample V

S.N.	Properties	Untreated	Lime			Cement		
			2%	4%	6%	1%	2%	3%
1	MDD (g/cc)	1.94	1.939	1.930	1.922	1.939	1.934	1.924
2	OMC (%)	13.5	14.00	14.20	14.90	13.90	14.00	14.75
3	CBR%(Unsoaked)	12.05	13.18	15.02	17.94	13.84	15.90	18.18
	CBR% (Soaked)	5.87	6.01	6.98	8.10	6.20	7.08	8.12

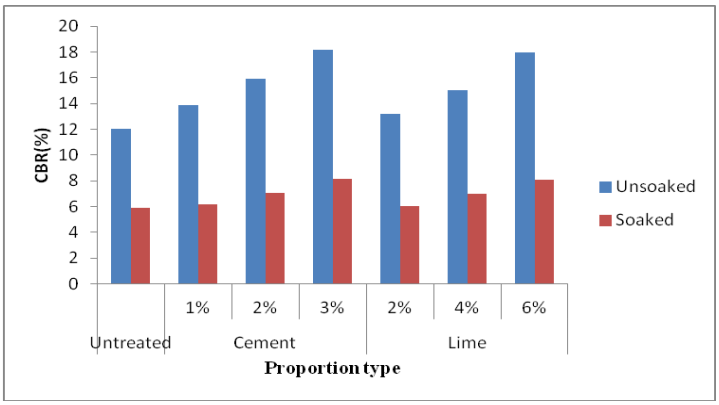

Fig V CBR results of soil sample V in unsoaked and soaked condition

It is observed from Table II to VII and fig. I to V that CBR value under both unsoaked and soaked condition increases with addition of Cement and Lime in various proportions. The desired value of 8% CBR under soaked condition is obtained with addition of 3% cement, or 6% lime for all selected soil samples for the study. The MDD and OMC value of treated soil samples decrease and increases respectively with the addition of cement and lime.

IV. CONCLUSIONS

The following conclusions are made from this study:

1. The MDD value of the soil samples tested in the study is found to decreases with the addition of cement and lime while OMC increases.
2. Chemical stabilizers in the form of cement (1%, 2% and 3% by weight of dry soil), lime (2%, 4% and 6% by weight of dry soil) increases the CBR value of the soil samples considered in the study.
3. The CBR value increases significantly and desired value of minimum CBR of 8% under soaked condition is obtained by adding to the soil with 3% of cement, or 6% lime.

V. REFERENCES

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