

Engineering Properties of Bentonite Stabilized With Admixture (Rubber Tyre Chips)

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ABSTRACT: Engineering structures are unsafe when constructed on weak or expansive soils. Improvement of load bearing capacity of the soil may be carried out by numerous ground improvement techniques. This study has been performed to evaluate the engineering properties of bentonite when it is mixed with the different percentage viz. 0.05%, 0.075%, 0.25%, 0.50%, 0.75% and 1.00% by weight of admixture that is rubber tyre chips. Admixture strips were cut into different sizes and were mixed with bentonite. Standard Proctor Compaction tests and California Bearing Ratio tests were performed to evaluate the mechanical response of reinforced soil in terms of compaction characteristics and penetration resistance.

KEYWORDS: Bentonite, California Bearing Ratio tests, Rubber Tyre Chips, Standard Proctor Compaction tests.

I. INTRODUCTION

One of the major environmental concerns worldwide is solid waste management. In India, the scrap tyres are being generated and accumulated in large volumes causing an increasing threat to the environment and thus recycling of these non-hazardous solid wastes is carried out in order to eliminate their hazardous effects. The potential of using rubber tyre chips in numerous civil engineering works has been studied for more than 20 years. Applications where tyres can be used have proven to be effective in protecting the environment and conserving natural resources.

Soil as available in the raw form is not suitable for construction purposes because of its weak strength, expansive and/or swelling characteristics. Soil stabilization is the alteration of soil to enhance its physical, mechanical and engineering properties so as to meet its purpose of use. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving its load bearing capacity to support various structures and sub-structures.

II. MATERIALS USED FOR STUDY

2.1 BENTONITE

The term Bentonite was first used for a clay found in about 1890 in upper cretaceous tuff near Fort Benton, Wyoming. Bentonite is a clay generated frequently from the alteration of volcanic ash, consisting predominantly of smectite minerals, usually montmorillonite. Other smectite group minerals include hectorite, saponite, beidelite and nontronite. Smectites are clay minerals, i.e. they consist of individual crystallites the majority of which are $< 2\mu\text{m}$ in largest dimension. Smectite crystallites themselves are three-layer clay minerals. They consist of two tetrahedral layers and one octahedral layer. In montmorillonite tetrahedral layers consisting of $[\text{SiO}_4]$ - tetrahedrons enclose the $[\text{M}(\text{O},\text{OH})]$ -octahedron layer (M = and mainly Al, Mg, but Fe is also often found).

In other words, Bentonite is an absorbent aluminium phyllosilicate clay consisting mostly of montmorillonite (exhibits large swelling and shrinkage). Bentonite was collected from a factory situated in the Basni area of Jodhpur district.

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2.2 RUBBER TYRE CHIPS

In recent decades, the worldwide growth of the automobile industry and the increasing use of cars as the main means of transport have tremendously boosted tyre production. This has generated massive stockpiles of used tyres. Extensive research projects were carried out on how to use used tyres in different applications. In case of fire, waste tyres generate toxic gases such as dioxin that could result in severe pollution problems.

The tyres are made up of mainly by rubber. Rubber consists of a complex mixture of elastomers, polyisoprene, polybutadiene and styrene-butadiene. Stearic acid (1.2%), zinc oxide (1.9%), extender oil (1.9%) and carbon black (31%) are also important components of tyres. The rubber tyres were cut into chips of different sizes varying from 1mm – 25mm in width and 3mm – 50mm in length. Added amount of rubber tyre had been varied in proportions of 0.05%, 0.075%, 0.25%, 0.50%, 0.75% and 1.00% by weight.

III. EXPERIMENTAL PROGRAMME

The following tests were conducted:

1. Standard Proctor Compaction test to determine the different dry densities of bentonite and maximum dry density at the optimum moisture content.
2. California Bearing Ratio test to determine the % CBR values for bentonite mixed with different mix composition of admixture (rubber tyre waste) in unsoaked conditions.

IV. TEST RESULTS

4.1 STANDARD PROCTOR TEST

The maximum dry density (MDD) of the bentonite without any admixture mixed is obtained as 1.35 gm/cc at the optimum moisture content (OMC) equal to 24%. The dry density variation with water content for bentonite is tabulated below in Table 1 and graphically shown below in Figure 1:

Table 1: Dry density variation with water content for bentonite

S. No.	% WATER ADDED (BY WEIGHT)	DRY DENSITY (gm/cc)
1	8	1.13
2	10	1.15
3	12	1.16
4	14	1.2
5	16	1.22
6	18	1.25
7	20	1.3
8	22	1.31
9	24	1.35
10	26	1.29

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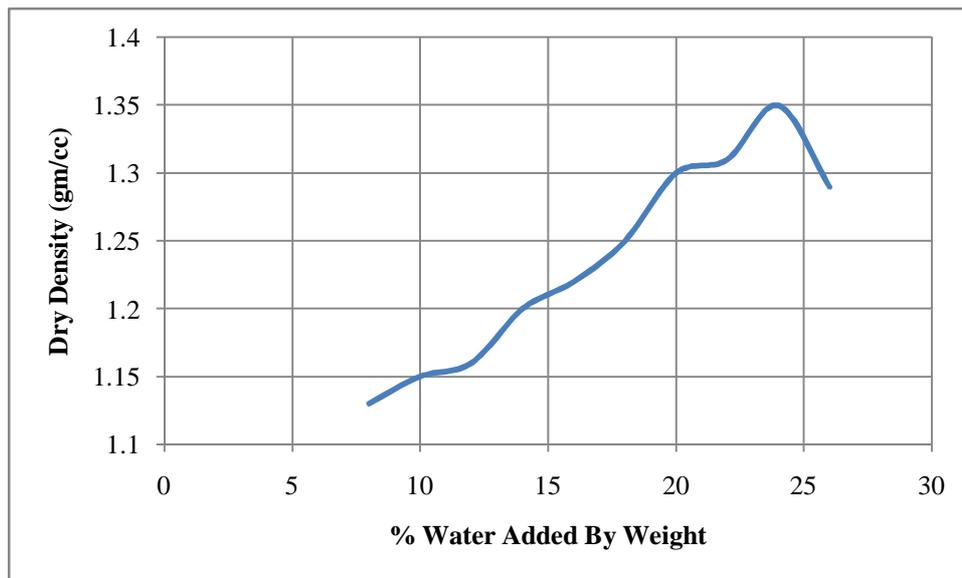


Figure 1: Dry density variation of bentonite clay with water content

4.2 CALIFORNIA BEARING RATIO TEST

The results of the unsoaked CBR tests conducted at MDD of 1.35 gm/cc, 1.29 gm/cc and 1.25 gm/cc are tabulated below:

TABLE 2: Mix Compositions, Symbols for Unsoaked CBR Test at MDD 1.35 gm/cc and % CBR Value of Bentonite Clay with Each Mix Composition

MIX NO.	MIX COMPOSITION	SYMBOL	% CBR VALUE
1	0.05% Admixture + Bentonite	CA1	4.138
2	0.075% Admixture + Bentonite	CA2	4.877
3	0.25% Admixture + Bentonite	CA3	5.088
4	0.50% Admixture + Bentonite	CA4	4.109
5	0.75% Admixture + Bentonite	CA5	3.675
6	1.0% Admixture + Bentonite	CA6	3.306

TABLE 3: Mix Compositions, Symbols for Unsoaked CBR Test at MDD 1.29 gm/cc and % CBR Value of Bentonite Clay with Each Mix Composition

MIX NO.	MIX COMPOSITION	SYMBOL	% CBR VALUE
1	0.05% Admixture + Bentonite	CC1	4.582
2	0.075% Admixture + Bentonite	CC2	4.631
3	0.25% Admixture + Bentonite	CC3	5.493
4	0.50% Admixture + Bentonite	CC4	4.487
5	0.75% Admixture + Bentonite	CC5	3.751
6	1.0% Admixture + Bentonite	CC6	2.949

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TABLE 4: Mix Compositions, Symbols for Unsoaked CBR Test at MDD 1.25 gm/cc and % CBR Value of Bentonite Clay with Each Mix Composition

MIX NO.	MIX COMPOSITION	SYMBOL	% CBR VALUE
1	0.05% Admixture + Bentonite Clay	CB1	3.767
2	0.075% Admixture + Bentonite Clay	CB2	4.023
3	0.25% Admixture + Bentonite Clay	CB3	4.865
4	0.50% Admixture + Bentonite Clay	CB4	3.577
5	0.75% Admixture + Bentonite Clay	CB5	3.062
6	1.0% Admixture + Bentonite Clay	CB6	3.232

The graphical variation of the percentage CBR values in unsoaked conditions for different mix compositions of admixture with Bentonite is shown below.

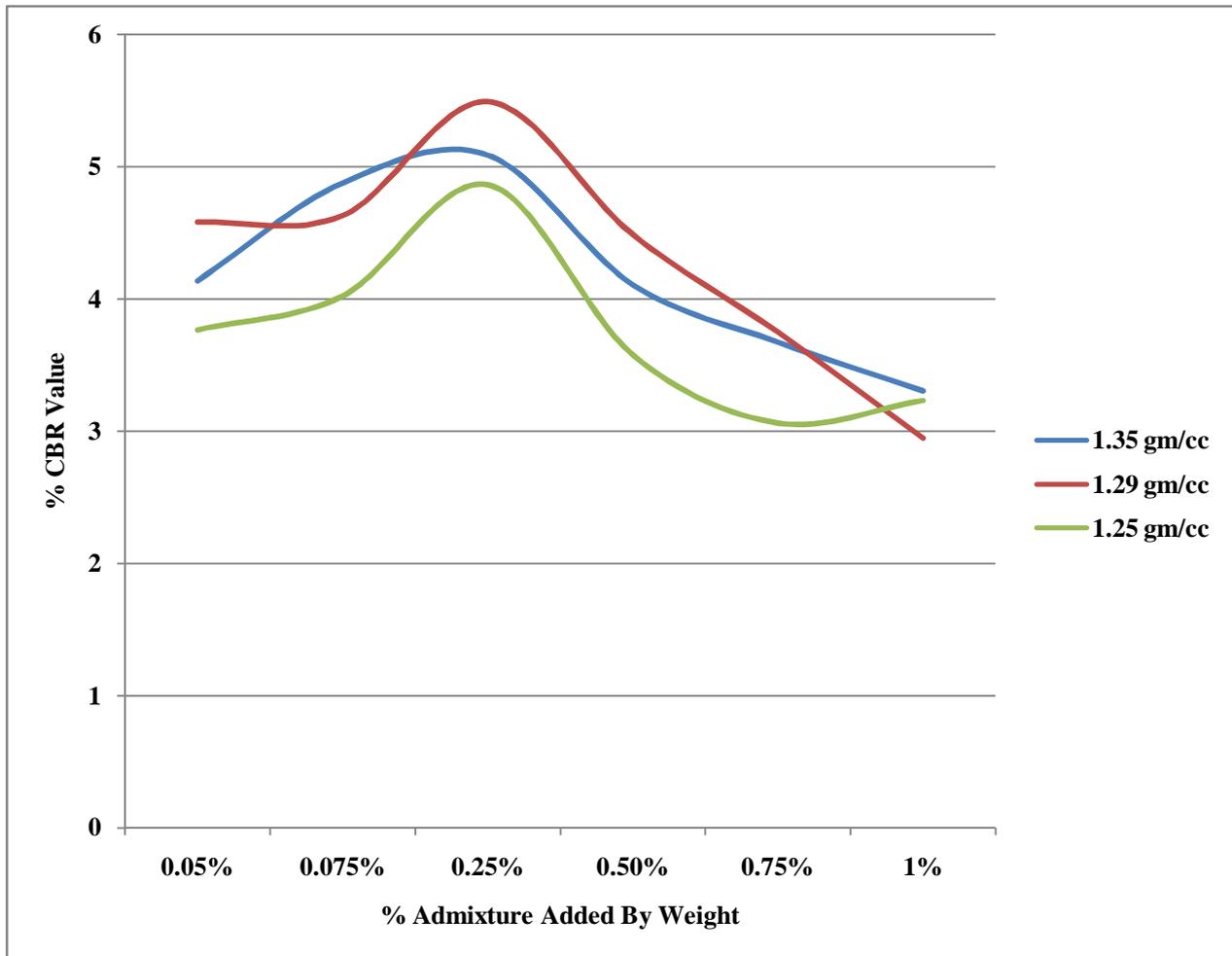


Figure 2: Variation of % CBR values in unsoaked conditions for different mix compositions of admixture with Bentonite of dry density 1.35 gm/cc, 1.29 gm/cc and 1.25 gm/cc

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From the above graph it is clear that among the three samples taken for the study, the maximum CBR value is obtained for dry density of bentonite of 1.29 gm/cc. It is also stated here that the maximum CBR value is obtained when the percentage by weight of admixture (rubber tyre chips) mixed with the bentonite is 0.25%.

V. CONCLUSIONS

The following conclusions can be made from the above study:

- 1) It is observed that the CBR values first increases when the percentage by weight of admixture (rubber tyre chips) mixed with the bentonite increases upto 0.25% and then with the increase in percentage by weight of admixture the CBR values decreases.
- 2) The above observation is same for all the three samples and thus it is concluded that the variation of CBR values with the percentage by weight of admixture is independent of the dry density of the bentonite.
- 3) It is also seen here that the maximum CBR value is obtained when the percentage by weight of admixture mixed with the bentonite is 0.25% irrespective of the dry density of the bentonite.
- 4) It is clear that among the three samples taken for the study, the maximum CBR value is obtained for dry density of bentonite equal to 1.29 gm/cc.
- 5) Rubber tyre chips can be used as admixture and thus its recycling helps in reducing environmental problem related to its dumping and/or disposal.

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