INFLUENCE OF COARSE FRACTION ON COMPACTION CHARACTERISTICS AND CBR STRENGTH OF A FINE GRAINED SOIL

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ABSTRACT
The present investigation aims at studying the influence of coarse fraction on compaction characteristics and CBR strength of a fine grained soil. Replacement levels of coarse fraction in the soil have been kept at 5%, 10%, 15%, 20%, 30%, 40%, 50%and 100%. The investigation is carried out by conducting the various tests to determine optimum moisture content (OMC), maximum dry density (MDD), California bearing ratio (CBR) on these mixtures. From the results, it is observed that OMC has been gradually decreased with the increased percentage of coarse fraction till some level and thereafter OMC has increased. Whereas, MDD has been increased with the increased percentage of coarse fraction till some level and thereafter this value has decreased. It is noted that the CBR value of 2.5 mm penetration is greater than or equal to 5mm penetration for all the mixes.

KEYWORDS: *California bearing ratio; Compaction; Optimum moisture content; Maximum dry density.*

I. INTRODUCTION

The mechanical behavior of sands was investigated by Coulomb in the 18th century [1]. Studies of these sand soils continued over the years as clean sands and pure clays define distinct boundaries of a wide spectrum of natural soils and thus set limits on expected performance. Studies of the mechanical behavior of pure clays were reported approximately 150 years later [2]. Most of the studies concerning the stress-strain and shear strength behavior of granular soils mainly inspected the response of clean sands. However, field observations show that granular soils may contain a considerable amount of clay and/or silt. Therefore, these fines should be expected to influence the engineering behavior of sandy soils. In contrast to the clean sands the behavior of sands with fines has complexities that have made it difficult for researchers to reach a general framework for their evaluation and this problem exists today for researchers.

1.1 Soil as a construction material

Clay is a fine-grained soil, it combines one or more clay minerals with traces of metal oxides and organic matter and clay is one of the oldest building materials on Earth, among other ancient, naturally-occurring geologic materials such as stone and organic materials like wood [3]. Between one-half and two-thirds of the world's population, in traditional societies as well as developed countries, still live or work in a building made with clay as an essential part of its load-bearing structure. Also a primary ingredient in many natural building techniques, clay is used to create adobe, cob, cordwood, and rammed earth structures and building elements such as wattle and daub, clay plaster, clay render case, clay floors and clay paints [3].

1.2. Research Significance

In this investigation an attempt has made to study the influence of amount of coarse fraction on compaction characteristics and CBR strength of a fine grained soil by conducting a series of tests. The replacement level of coarse fraction is varied from 0% to 50% by weight of the mixture of coarse grained and fine grained soil.

1.3. Outline of this paper

This paper includes material and test methods to find out compaction characteristics and CBR values, results and discussions.

II. MATERIALS AND METHODS

Generally, soils are placed into one of three major categories. They are coarse grained, fine grained, highly organic. The USCS further divides soils that have been classified into the major soil categories such as sand (S), gravel (G), silt (M), clay (C) and Organic (O) [4].A soil that meets the criteria for sandy clay would be designated as SC. There are cases of borderline soils that cannot be classified by a single dual symbol, such as GM frostily gravel. These soils may require four letters to fully describe them. For example,(SM-SC) describes sand that contains appreciable amounts of silt and clay [4].

2.1 Fine grained soil

The fine grained soil used in this investigation is a high swelling clayey soil. Fine grained soils are those in which more than half the material passes a 75µm (No.200) sieve[4]. The fine grained soils are not classified by grain size but according to plasticity and compressibility. This classification is based on the relationship between the Liquid Limit and the Plasticity Index. The index properties of the high swelling clayey soils (Water content [5], Specific Gravity [6], In-situ density [7], Particle size distribution [8], Plastic limit [9], Liquid Limit [10], Relative Density [11]) are determined as per the relevant codes of practice and are given in the Table 1.
This soil is classified as CH as per I.S. classification [12 &13] indicating that it is an inorganic clay of high plasticity. Its degree of expansiveness is high based on liquid limit, plasticity index and Free Swell index (FSI).

2.2 Coarse grained soils

The coarse grained soil used in this investigation is locally available sand. Coarse grained soils are defined as those in which at least half the material is retained on a 75µm (No.200) sieve. They are divided into two major divisions viz. gravel& sand. A coarse grained soil is classed as gravel if more than half the coarse fraction by weight is retained on a 4.75mm (No.4) sieve [4]. The symbol G is used to denote gravel and the symbol S to denote sand. Properties of coarse grained soil are shown in Table 2. Grain size distribution of coarse grained soil is shown in Fig. 1.

Table 1. Properties of fine grained soil

S. No	Properties of soil sample	Values
1	Gravel (%)	2.6
2	Sand (%)	13
3	Silt +Clay (%)	89.6
4	Liquid limit (%)	57.8
5	Plastic limit (%)	31.61
6	Plasticity Index (%)	26.18
7	IS Classification	CH
8	Free swell index (%)	60
9	Maximum dry density (KN/m^3)	1.534
10	Optimum moisture content (%)	21.5
11	C.B.R (%)	3.5

Table 2. Properties of coarse grained soil

S. No	Tests on sand sample	Values
1	Gravel %	4
2	Sand %	95.9
3	Fines %	0.1
4	Coefficient of uniformity of sample is Cu	2.72
5	Coefficient of Curvature Cc	1.16
6	Classification of sand sample	SP
7	Optimum moisture content (%)	14.00
8	Maximum dry density (g/cc)	1.620
9	CBR (%)	32.85

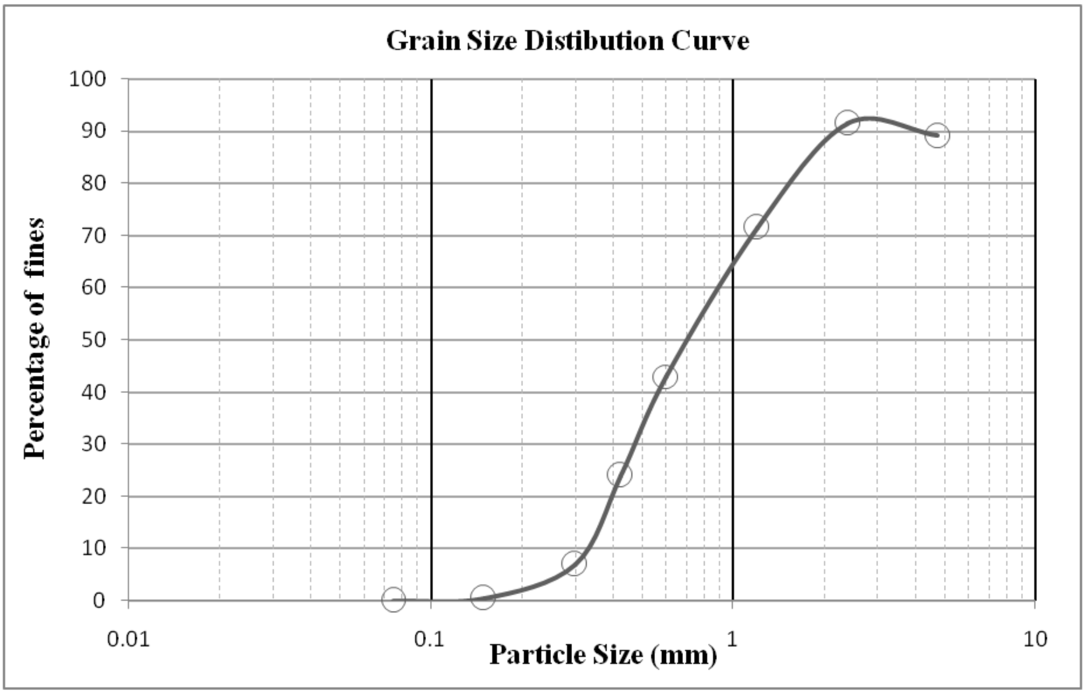

Fig. 1. Grain size distribution of coarse grained soil

III. EXPERIMENTAL PROCEDURE

The properties of clay soil were determined as per the relevant codes of practice [14 -17] and they are listed in the Table 1.

3.1 Compaction test

Standard proctor's compaction tests have been conducted on the soil [18-22]. The soil sample so prepared is then mixed with sand of varying percentages. The sand percentage by weight varied from 0 to 100% in increments of 5% for the determination of optimum pore fluid content and maximum dry unit weight [21]. The soil sample maintained at the desired pore fluid content is mixed thoroughly with soil and compacted in Proctor's mould (100mm diameter x 117 mm height). The soil is compacted in three layers giving 25 blows to each layer by using the standard rammer. The weight of compacted soil along with the mould and base plate is taken. Prior to that, the weight of the empty mould along with base plate is determined. A representative sample is taken from the center of the compacted specimen and kept for water content determination. Thus the bulk unit weight, pore fluid content and the corresponding dry unit weight for the compacted soil is obtained [21].

3.2. California bearing ratio test

The mould containing the specimen, with the base plate in position, shall be placed on the lower plate of the loading machine. Surcharge weights, sufficient to procedure a pressure equal to the weight of the base material and the pavement shall be placed on the specimen [23-26]. The annular weight above which the slotted weights are placed prevents the upheaval of the soil into the slots of the weights. The plunger shall be seated under a load of 39.2N (4 kg). So that, full contact is established between surface of the specimen and plunger. The dial gauges of the proving ring and those for penetration are set to zero.

The seating load for the plunger is ignored for the purpose of showing the load-penetration relation, load shall be applied such that the rate of penetration is approximately 1.25mm/min. Load readings shall be recorded at penetrations of 0,0.5,1.5,2.0,2.5,4.0,5.0,7.5,10 and 12.5mm. The maximum load and penetrations shall be recorded, if it occurs for a penetration of less than 12.5mm [27]. The plunger shall be raised and detached from loading machine. Load versus penetration curve is plotted. This curve will be mainly convex upwards. The California bearing ratio values are usually calculated for penetrations of 2.5mm and at 5mm [28&29].

Generally the California bearing ratio value at 2.5mm penetration will be greater than that at 5mm penetration [30]. The CBR values for various penetrations are presented in Table 3.

Table 3. CBR values for different penetrations

Depth of penetration(mm)	Unit standard load		Total standard load	
	kg/cm^2	kN/m^2	kg	kN
2.5	70	6,867	1370	13.44
5.0	105	10,300	2055	21.16
7.5	134	13,145	2630	25.80
10.0	162	15,892	3180	31.20
12.5	183	17,952	3600	35.32

IV. RESULTS AND DISCUSSION

The objective of the present investigation is to study the effect of Fine fraction on compaction characteristics and California bearing ratio of a coarse grained soil. For this purpose a series of tests are conducted on locally available sand, with and without adding a clay soil to determine compaction characteristics and CBR. The test result are presented and discussed in the following sections.

4.1. Compaction characteristics

Figs.2& 3 shows the compaction characteristics and Table 4represents the Compaction characteristics namely OMC and MDD of all the mixtures studied in this investigation. From the results, it is observed that the fine fraction has a falling effect on OMC and MDD and the effect depends on the percentage of clay.

OMC is observed to decrease uniformly with fine fraction level but it is increased at 40% of fine fraction amount. The change in MDD is also on the similar line but inversely. That is the MDD is observed to increase initially with fine fraction up to 20% beyond which there is decrease in MDD with fine fraction as shown in Fig.4.

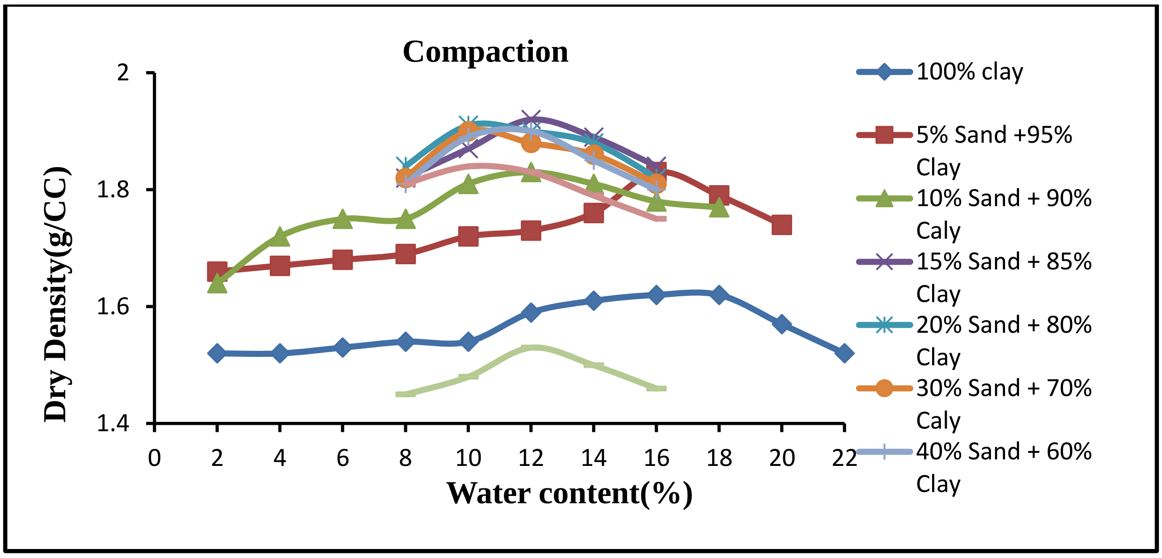

Fig.2. Water content Vs Dry density

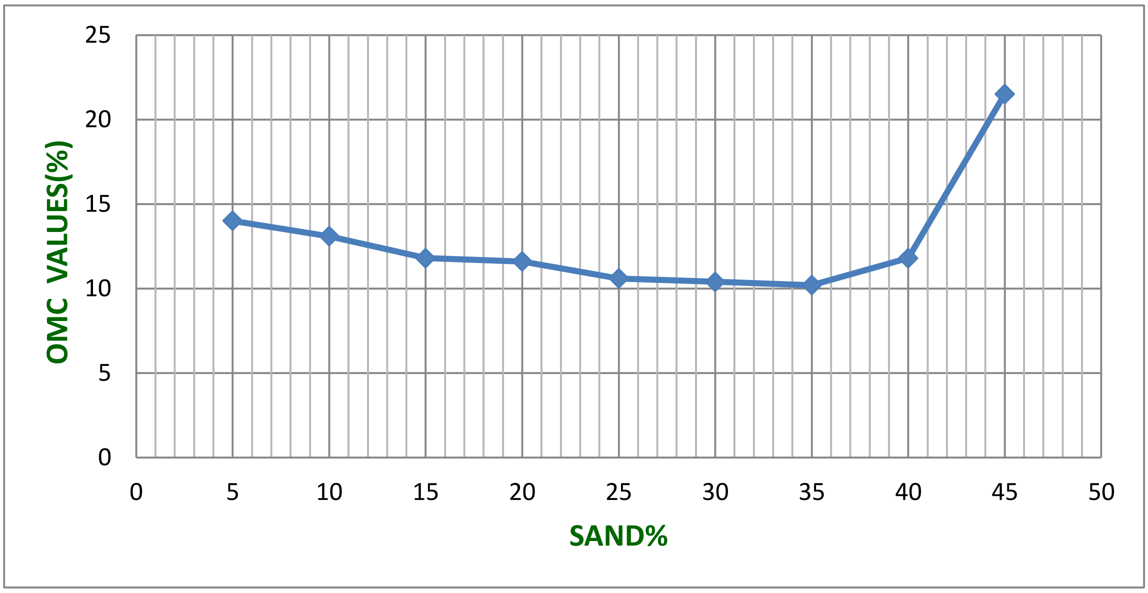

Fig.3. OMC Vs SAND

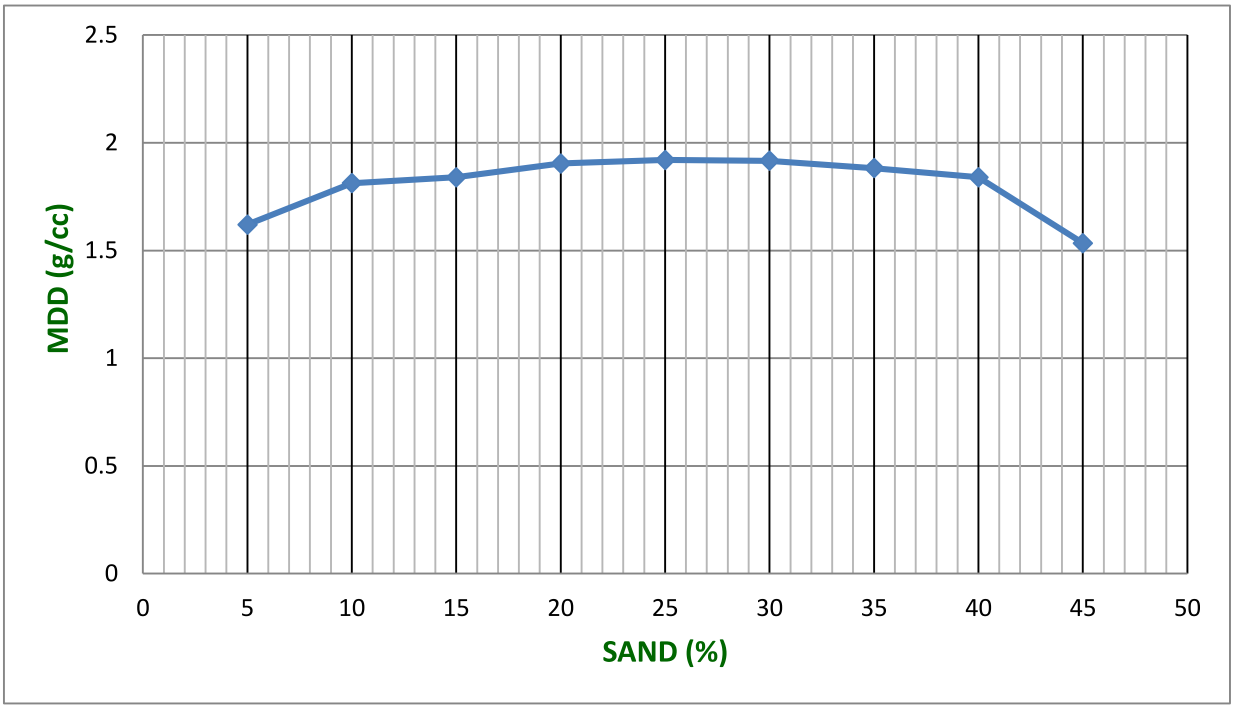

Fig: 4. MDD vs SAND

Table 4. Compaction Parameters

SI.NO	PERCENTAGE	OMC (%)	MDD (g/Cc)
1	100%clay	14	1.62
2	5Sand+95%clay	13.1	1.812
3	10Sand+90%clay	11.8	1.84
4	15Sand+85%clay	11.6	1.904
5	20Sand+80%clay	10.6	1.92
6	30Sand+70%clay	10.4	1.916
7	40Sand+60%clay	10.2	1.8818
8	50Sand+50%clay	11.8	1.8402
9	100 % sand	21.5	1.534

4.2. California bearing ratio values

The load-penetration curves of mixtures studied from California Bearing Ratio tests at different percentages of coarse fraction are presented in Fig.5 The load-penetration curve of Coarse sand and fine grained soil are also presented in Fig.5.

The top most curve corresponds to 0% of sand followed by 5%, 10%, 15%, 20%, 30%, 40%, 50%, and 100% respectively. The variation of California Bearing Ratio values at 2.5 mm penetration with different percentages of sand is plotted in Fig.6. Similarly, the variation of California Bearing Ratio values at 5.0 mm penetration with different percentages of sand is plotted in Fig. 7.

Figs.6 &7, it is observed that the increased level of coarse fraction decreased the CBR value. However, the decrease is marginal up to 10% and thereafter the sharp fall in CBR up to 15%. The rate of fall is significant once again after 15%. It is revealed that coarse fraction beyond 10% has a determined effect on CBR of fine-grained soil.

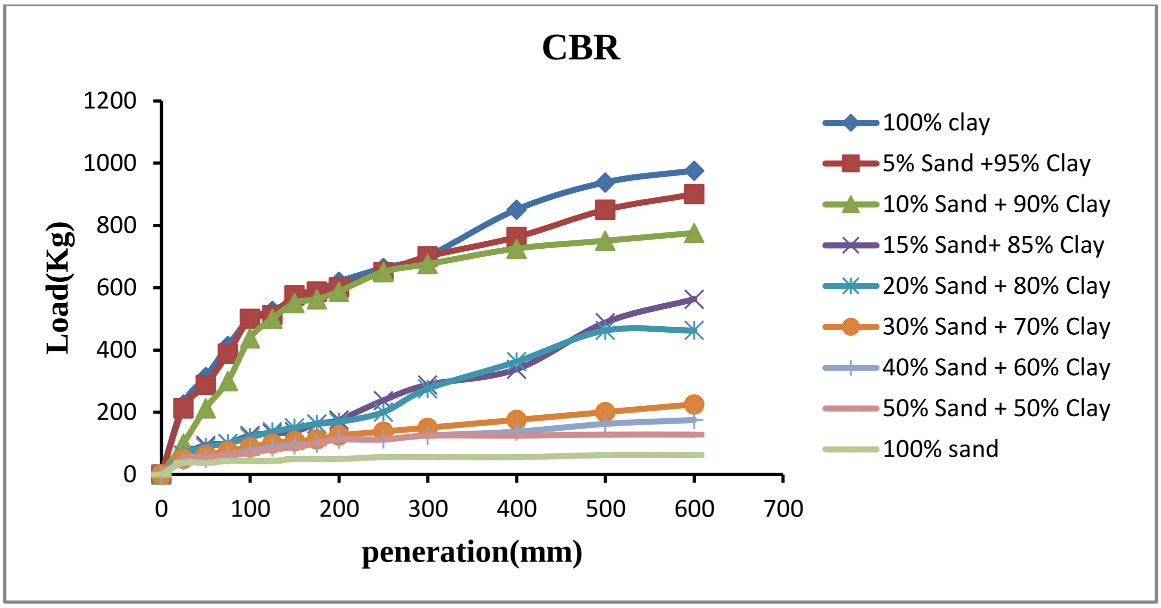

Fig 5. Load-Penetration Curves of Contaminated Clay with Different Percentages of Sand

Table 5.CBR Parameters

S.NO	Percentage	2.5 mm Penetration	5.0 mm Penetration
1	100%Clay	32.85	31.63
2	5%Sand+95%Clay	32.85	30.66
3	10%Sand+90%Clay	29.93	29.2
4	15%Sand+85%Clay	9.12	8.76
5	20%Sand+80%Clay	8.76	8.27
6	30%Sand+70%Clay	6.39	6.08
7	40%Sand+60%Clay	5.69	5.35
8	50%Sand+50%Clay	5.47	5.35
9	100%Sand	3.5	2.43

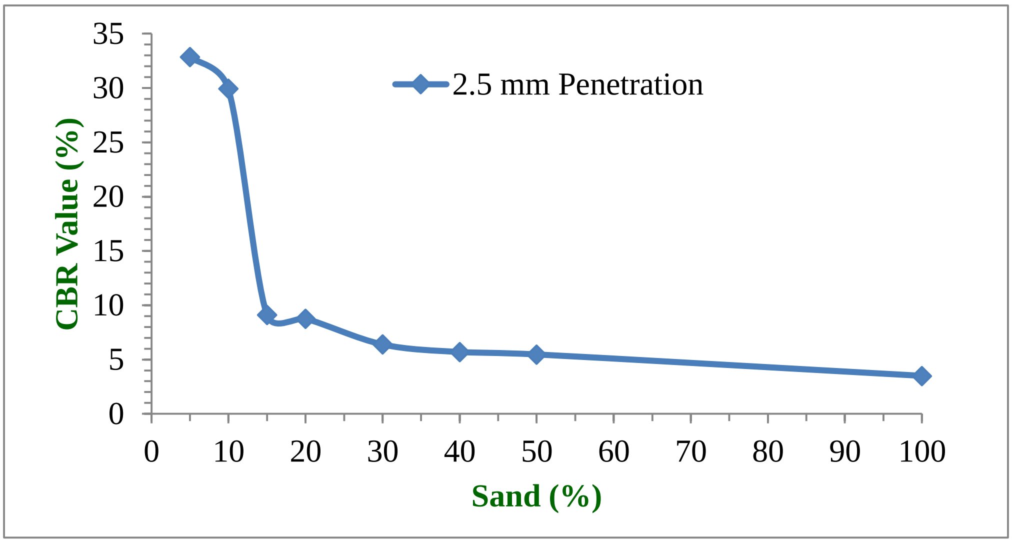

Fig. 6: Variation of California Bearing Ratio Values with Different Percentages ofsand at 2.5 mm penetration

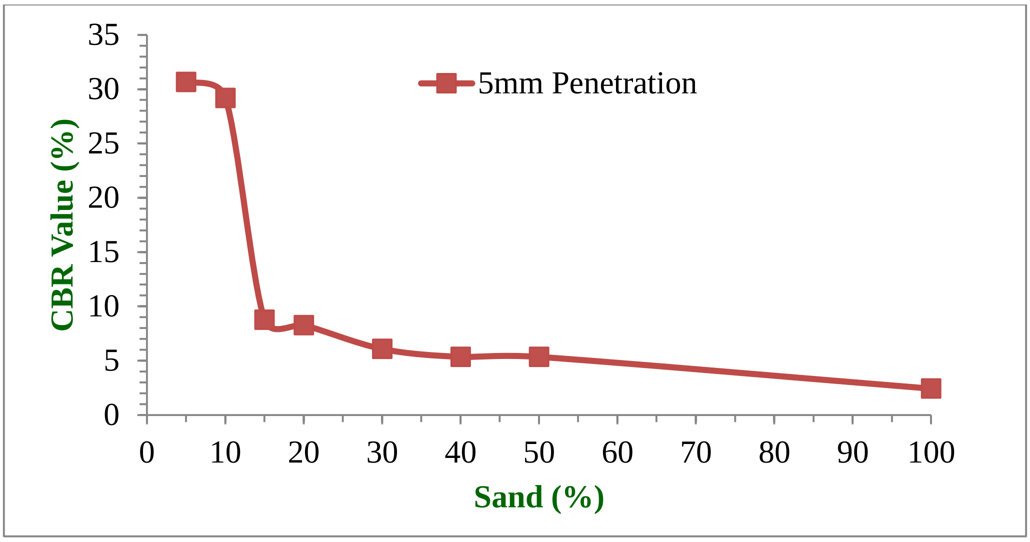

Fig. 7 Variation of California Bearing Ratio Values with Different Percentages of Sand at 5 mm Penetration.

V. Conclusions

Based on the results presented in this investigation the following important conclusions may be observed.

1. It is observed that the fine fraction has a falling effect on OMC and MDD and the effect depends on the percentage of clay.
2. OMC is observed to decrease uniformly with fine fraction level but it is increased at 40% of fine fraction amount.
3. MDD is observed to increase initially with fine fraction up to 20% beyond which there is decrease in MDD with fine fraction.
4. It is observed that the increased level of coarse fraction decreased the CBR value. It is revealed that coarse fraction beyond 10% has a determined effect on CBR of fine-grained soil.

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