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EFFECT OF PLASTIC FINES IN IMPROVEMENT OF ENGINEERING PROPERTIES OF POORLY GRADED SOILS

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ABSTRACT

Soil stabilization is a process which enhances the engineering properties like Compaction Parameters (MDD and OMC) and California Bearing Ratio, Shear Strength, Permeability, Compressibility of poorly graded soils. These engineering properties of poorly graded soils can be obtained by controlled compaction using the compaction equipment's or addition of suitable materials such as cement, fly ash, lime, Gypsum etc which enhance the properties. But as a matter of fact in recent years, cost of these materials particularly cement are also become so expensive. To minimize the uncertainties in view of cost and strength of soil, this opened the door widely for introducing the other kinds of materials. The objective of this research paper is to investigate the effect of plastic fines on the strength properties of poorly graded soil.This research study involves the investigation of the effect of plastic fines on poorly graded soil to which a series of compaction tests and California Bearing Ratio (CBR) tests are carried out on both virgin soil and soil with plastic fines of varying percentages (5%, 15%, 25%, 35% and 45%) The results from this experimental study shows that with addition of increase in plastic fines content, engineering properties of poorly graded soils such as Maximum Dry Density (MDD) and un-soaked CBR values are also improved significantly when compared with the properties of virgin soil. The quantum of improvement in the engineering properties of soils depends on the type of soil, percentage of plastic fines as it is observed from the study that, optimum values of MDD and CBR values are achieved at 25% of plastic fines.

Keywords: *Soil Stabilization, Poorly Graded Soil, Plastic Fines, MDD Value, CBR Value.*

I. INTRODUCTION

Soil stabilization is a process in which properties of soils by adding admixtures or suitable materials, either in wet or dry conditions to enhance the engineering properties of poorly graded soils. For effective soil stabilization, availability of better resources, research materials and necessary equipment's are required indeed. Now days, due to the availability of those resources, soil stabilization is emerging as a popular and cost-effective method to improve the engineering properties of poorly graded soils. In this research paper, experiments are carried out to enhance the engineering properties of poorly graded soils using different percentages of plastic fines.

Generally soil occurring in nature is composed of particles having different sizes in varying percentages. Poorly graded soils contain a large amount of void spaces. Compaction is the application of mechanical energy to soil particles to rearrange the particles and reduce the void ratio. Compaction of loose fills is a simple way of increasing the stability, compressibility characteristics and load bearing capacity of soils. The factors generally affect compaction are moisture content of soil, type of soil, amount of comp-active energy and type of admixtures. Generally soils are classified into gravel, sand, silt and clay based on their particle size. Gravel and sand are the coarse grained soils while silt and clay are called fine grained soils.

Plastic fines are also called as clays. Clays are defined as the materials with a size of grain below 2 µm. Clays differ from the granular materials as they are not generated through physical weathering processes: clays are the result of chemical weathering processes, which produce smaller particle sizes than physical weathering can produce. As a result of mechanical weathering only, no particles smaller than about 10 µm will be created (Terzaghi, Peck, Mesri, 1996). The clay particles are mainly thin and flat in shape ('plates' or 'flakes').

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Various attempts have been made earlier to understand the compaction characteristics of poorly graded soil using different admixtures. Very less research has been done on the effect of plastic fines on compaction characteristics and CBR value.

II. LITERATURE REVIEW

Kousik Deb et.al (2010) studied the behavior of poorly graded soils reinforced with plastic fines and non-plastic fines. Plastic and non-plastic fines with varying percentages 10%, 15%, 20%, 30%, 40% and 50% are added to two types of sands A and B. They conducted series of standard proctor compaction tests on reinforced soil with plastic and non-plastic fines. Test results reflect that MDD values are decreased and OMC values are increased after certain percentage of plastic and non-plastic fines.

K.J. Osinubi et.al (2012) studied the behavior of reinforced reconstituted lateritic soil with plastic fines to improve the engineering properties of soils. They have added plastic fines in varying percentages of 0, 20, 40, 60, 80 and 90% to form six different soil mixes (S1, S2, S, S4, S5 and S6 respectively). They carried out various tests to examine the effect of plastic fines on lateritic reddish brown color soil and the tests includes are index properties, compaction tests, unconfined compressive strength tests. Test results revealed that Atterberg limits are increased with increase of plastic fines. The MDD and OMC are decreased and increased respectively with increase of fines.

M.V.S Sreedhar and Zainab Fatima (2017) studied the effect of plastic fines on compaction and CBR characteristics of soil mixtures. The conducted a series of Standard Proctor Tests and Un-soaked CBR tests on reinforced sand soil with plastic clay fines. They have added to 5% to 50% plastic fines to sandy soil and tests revealed that 30% plastic fines gives maximum values of MDD and CBR values.

III. SCOPE OF THE STUDY

The scope of this research work includes adding of plastic clay fines to the poorly graded soils and to investigate the effect these plastic fines on the engineering properties of soil. The research work which is presented in this paper aims at investigating the improvement of poorly graded soil properties such as maximum dry density (MDD) and un-soaked CBR values by plastic fines. A series of laboratory tests are performed on both virgin soils and reinforced soil with plastic fines to compare the improvement of soil properties. The list of experiments conducted in the laboratory as per IS Codes are presented in Table 1

Table 1. List of Experiments performed in the study

S.NO	VIRGIN SOIL	REINFORCED SOIL WITH PLASTIC FINES
1	Specific Gravity of Soil Solids (IS:2720-Part 3-1980)	--
2	Particle Size Analysis (IS:2720-Part 4-1985)	--
3	Atterberg Limits (IS:2720-Part 5-1985)	--
4	Standard Proctor Test (IS:2720-Part 7-1980)	Standard Proctor Test
5	California Bearing Ratio Test (IS:2720-Part 16-1987)	Un-soaked California Bearing Ratio Test

IV. MATERIALS AND METHODOLOGY

4.1 Virgin Soil

In this section, the results for various tests such as specific gravity test, grain size analysis, liquid and plastic limit tests, standard proctor test and un-soaked CBR test are presented and which are performed on virgin soil. The results of various properties of virgin soil obtained from these experiments are shown in Table 2. The virgin soil used in this work is collected from the plain of Hyderabad (TS) near CMR College of Engineering & Technology (CMRCET).

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Dry sieve analysis is conducted on dry virgin soil to determine the percentages of coarse grained soil and fine grained soil. From Table 2, it is inferred that the percentage of soil retained on 0.075mm sieve is more than 50%, so the soil is classified as coarse grained soil.

Table 2. Index and Engineering Properties of natural soil

S.NO	PROPERTIES OF NATURAL SOIL		VALUE
1	Specific Gravity (G_s)		2.64
2	Particle Size Distribution	Gravel (4.75mm-20mm)	5%
		Sand (4.75mm-0.075mm)	71%
		Silt (0.075mm-0.002mm)	18%
		Clay (<0.002mm)	6%
3	Atterberg Limits	LL	15%
		PL	13%
		PI	2%
4	Compaction Properties	MDD	1.52g/cc
		OMC	14.2%
5	Un-Soaked CBR Test	CBR	10%

Further it is observed that, percentage coarse grained soil passing through 4.75mm sieve is more than 50%, so the soil is classified as Sandy soil. From the grain size distribution curve it is found that, coefficient of uniformity of the given soil (Cu) is less than 6 and coefficient of curvature is less than 1 and it is classified as poorly graded sand (SP). Further it is observed from the Table 2 that, percentage of silt particles is more than 12%. Finally the soil is classified as Poorly Graded Soil with Silt Content (SP-SM). From the table 2, it is inferred that, percentage of clay is very less and hence the soil may regarded as non-plastic. To determine Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) of given SP-SM soil, Standard Proctor Compaction test is performed. As per IS Code standards in compaction test, Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) for sandy soils are less than 1.54g/cc and 15% respectively. From the Table 2, it is found that MDD and OMC are within the limits for sandy soil sample as per the standards (MDD=1.52g/cc and OMC=14.2%). Un-Soaked CBR test is conducted on given virgin soil sample and the CBR value is found to be as 10% and is within the limits as per IS code for fine sandy soils. Since the CBR value for virgin soil without any reinforcement is relatively low and pavements which are laid under these soils, they do not resist higher amount of loads and durability decreases. It is indeed to enhance the CBR value of these sandy soils. In the case of stability of embankments, Maximum Dry Density should be high to resist lateral loads.

4.2 Plastic Clay Fines

Different percentages of plastic fines such as 5%, 15%, 25%, 35% and 45% by mass of dry virgin soil are added to the poorly graded soil and the mentioned all laboratory tests are performed on this reinforced mixed soil. It is suggested that, while mixing virgin soil and plastic fines, care should be taken such that all constituents such as soil particles and plastic fines mixed throughout the soil mass uniformly and this may be done by making soil sample partially wet. The quantity of plastic fines (W_p) to be added to a given amount of natural soil is obtained using the following formula given in Eq. n (1)

$$W_p = (a) \times W_d \tag{1}$$

Where a = 5%, 15%, 25%, 35% and 45% plastic fines.

W_d = Quantity of Dry Natural Soil (gm.)

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4.3 Experimental Procedure

A series of laboratory tests are performed on both virgin soil and reinforced soil with plastic fines. The list of experiments conducted in the laboratory as per IS codes are given in Table 1.The results and discussions for reinforced soil with plastic clay fines are discussed in the following sections. In this section, procedures for conducting the tests on both virgin soil and reinforced soil with plastic clay fines are discussed.

Standard Proctor Test

From the standard proctor compaction test, percentage of moisture content and dry density relationship of the poorly graded soil reinforced with different percentages of plastic clay fines (5%, 15%, 25%, 35% and 45%) is obtained. A series of Standard Proctor Compaction Tests are performed on reinforced soil with plastic fines as per (IS-2720 Part-VII) code procedure. At first, the quantity of plastic fines required to be mixed with given natural poorly graded soil (W_d =2500gm) is estimated for a particular percentage of plastic fines (5%, 15%, 25%, 35% and 45%) (a) as given by the Eq. (1). Plastic fines thus obtained are added to virgin soil after making dry natural soil into partially wet soil by adding sufficient amount of water to ensure reinforced soil sample becomes uniform and paste could be formed. Plastic clay fines and natural soil are mixed thoroughly until the mix becomes uniform and homogeneous. As per Standard Proctor Compaction Test procedure, reinforced mixed soil sample is filled in the compaction mould by three equal layers and each layer is being given with 25 blows of 2.6 kg hammer from height of 30 cm. Water contents and dry densities are evaluated from the test data and are presented in Table 3 in Results and Discussion section. The test as per the mentioned procedure is performed for all reinforced soil specimens containing different percentages of plastic clay fines.

California Bearing Ratio Test

A series of un-soaked California Bearing Ratio Tests are conducted on natural soil reinforced with varying percentages of plastic fines (5%, 15%, 25%, 35% and 45%) as per IS-2720 Part 16 procedure for light static compaction. At first, required quantity of plastic fines are estimated from the Eq. (1) and are blended with 5kg of dry natural soil. After adding plastic fines they are mixed thoroughly until homogeneous mix and uniformity is obtained. After blended soil sample is prepared, the sample is filled in the CBR mould with three equal layers and each layer is being given by 56 numbers of blows by a 2.6kg rammer for light static compaction. Load required for penetrating the piston through the reinforced soil with plastic fines sample up to 10mm penetration depths is recorded. From the loads obtained, CBR values for all reinforced soil samples are determined and the results are presented in Table 3 in Results and Discussion section.

V. RESULTS

In this section, results for reinforced soil sample with varying percentages of plastic fines (5%, 15%, 25%, 35% and 45%) are presented in detail. A series of standard proctor compaction tests and California bearing ratio tests are performed on reinforced soil with varying percentages of plastic fines and the corresponding results are shown in Table 3.

Table 3. Test Results of Reinforced Soil with Plastic Fines

S.NO	PERCENTAGES OF VIRGIN AND PLASTIC FINES SOIL		COMPACTION PROPERTIES		CBR RATIO
	Virgin Soil (%)	Plastic Fines (%)	OMC (%)	MDD (g/cc)	CBR (%)
1	100	0	14.2	1.52	10.2
2	95	5	13.3	1.67	12
	Percentage of Increment/Decrement* (%)		-6.3#	9.8	17.6
3	85	15	12.7	1.78	15.2
	Percentage of Increment/Decrement* (%)		-10.5#	17.1	49
4	75	25	12.1	1.95	18.3
	Percentage of Increment/Decrement* (%)		-14.7#	28.2	79.4
5	65	35	13.7	1.83	16.1

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	Percentage of Increment/Decrement* (%)		-3.5[#]	20.3	57.8
6	55	45	14.8	1.68	14.5
	Percentage of Increment/Decrement* (%)		4.2	10.5	42.1

Note: [*]Percentage of increment/decrement in properties of reinforced soil for all percentages of plastic fines is evaluated with respect to the properties of natural soil.
Note: [#] Negative sign indicates decrement in properties of reinforced soil with respect to the properties of natural soil.

Standard Proctor Compaction tests are conducted on reinforced soil samples with different percentages of plastic fines (5%, 15%, 25%, 35% and 45%). The corresponding results of Optimum Moisture Contents and Maximum Dry Densities from standard proctor tests are presented in Table 3. Compaction curves for both virgin soil and reinforced soil with plastic fines for different percentages are depicted in Fig.1

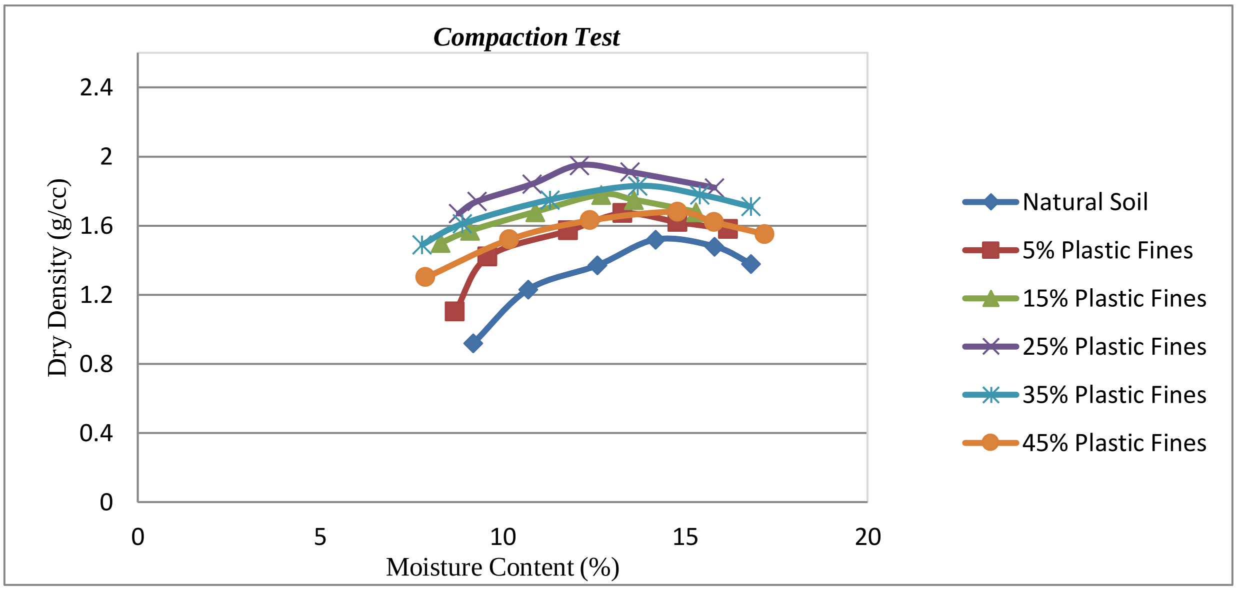

Figure 1: Compaction Curves for various percentages of plastic fines

Based on the data in Table 3 and from Fig.1 obtained from the standard proctor test, it is inferred that Maximum Dry Density (MDD) of virgin soil is observed to be 1.52g/cc and is being increased to 1.67g/cc at 5% plastic fines with increment of about 9.8%, further MDD value is increased to 1.78g/cc at 15% plastic fines with increment of about 17.1% comparing with MDD of virgin soil. If the percentage of plastic fines further increased to 25% then the MDD value also has been increased to 1.95g/cc with increment of about 28.2% compared to MDD of natural soil. With further increment in percentage of plastic fines up to 35% MDD values are decreased to about 1.83 g/cc from the MDD value of 25% plastic fines (1.95g/cc). For final conclusion, percentage of plastic fines are further increased to 45%, it is observed that MDD value has been further decreased to value of1.68g/cc. From the above analysis, it can be concluded that, there is an increment in maximum dry density of poorly graded soil with increase in percentage of plastic fines up to a certain percentage (shown in Fig. 2). It is also inferred that, there is decrement in optimum moisture content of reinforced soil with increase in percentage of plastic fines up to a certain percentage. In general, the maximum dry density of soil increases while optimum moisture content of soil decreases. So from the above analysis, it is observed that MDD and OMC values reinforced samples are analog to principles of compaction properties.

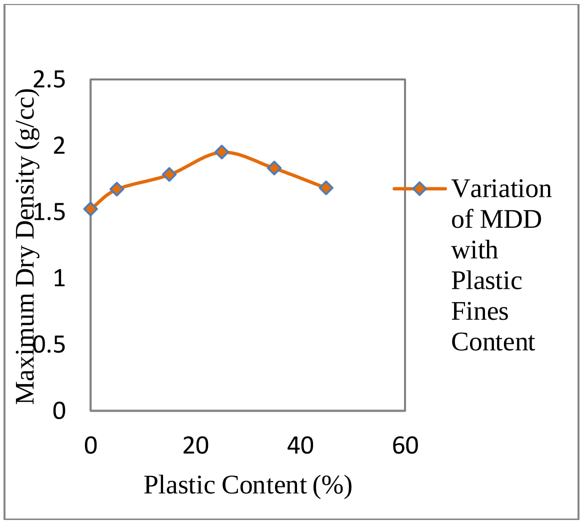

Figure 2: Effect of Plastic Fines on MDD

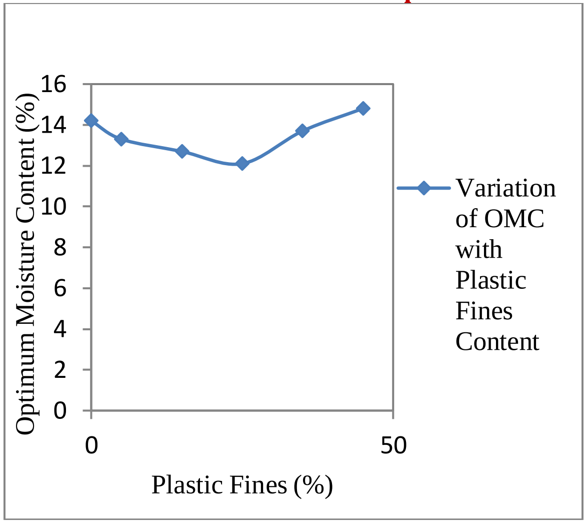

Figure 3: Effect of Plastic Fines on OMC

Increase in MDD value for higher percentage of plastic fines is attributed to a fact that as the amount of plastic fines content is increased, volume of soil solid fraction makes a very good bonding with the plastic fines since poorly graded soils contain more void spaces. It is well known fact that plastic fines are nothing but clay particles like bentonite and which is responsible for making good bonding of clay particles with sandy particles. When the plastic fines are added, void spaces present poorly graded soil sample are filled up with plastic fines and on static compaction, void ratio drastically reduces and ultimately increases the maximum dry density of the poorly graded soil.

So it is a fact that for increase of MDD, void spaces are reinforced with soil masses of plastic fines for higher percentages of plastic fines. This causes in further packing of soil grains with plastic fines together. In this way, compaction test on reinforced soil with plastic fines yields higher maximum dry density and lower optimum moisture content. As it is a known fact that maximum dry density increases with increase in specific gravity of soil sample. With increase in percentage of plastic fines, specific gravity of reinforced soil samples increases and dry unit density also increases. It is observed from the Fig.1 that for 25% plastic fines content, the compaction curve shows top on all other curves of percentages of plastic fines.

Un-Soaked California Bearing Ratio Tests are conducted on reinforced soil samples with plastic fines with varying percentages (5%, 15%, 25%, 35% and 45%) and the corresponding results of CBR tests are presented in Table 3. Load-Penetration curves for both virgin soil and reinforced soil samples with plastic fines for different percentages are shown in Fig.4.

Based on the data from the California bearing ratio tests is presented in Table 3 and from Fig. 4, it is inferred that CBR value for virgin soil is observed to be 10.2% and is increased to 12% with an increment of about 17.6% for 5% plastic fines. CBR value is further increased to 15.2% for 15% plastic fines with an increment of about 49% comparing with CBR value of virgin soil. If the percentage of plastic fines is further increased to 25% then the CBR value also increased to 18.3% with an increment of about 79.4% compared to virgin soil.

With further increase in percentage of plastic fines to 35% and 45%, CBR values are decreased. It is clearly observed that, addition of plastic fines to the soil increases CBR value to certain percentage (As shown in Fig.5). This implies thickness of sub grade can be reduced with the addition of plastic fines. The reduction in pavement thickness directly implies the reduction in cost of the construction of pavement. Increase in CBR value for reinforced soil with increase of plastic fines is due to the fact that, the void space in the soil mass is filled up with plastic clay fines and it offers higher resistance to the applied load due to increase of specific gravity of reinforced

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soil sample. Decrease in CBR value for higher percentage (35% and 45% plastic fines) is may to the fact that, volume of solid fraction to accommodate high quantity of plastic fines is difficult and there by decreases the specific gravity of the reinforced soil sample.

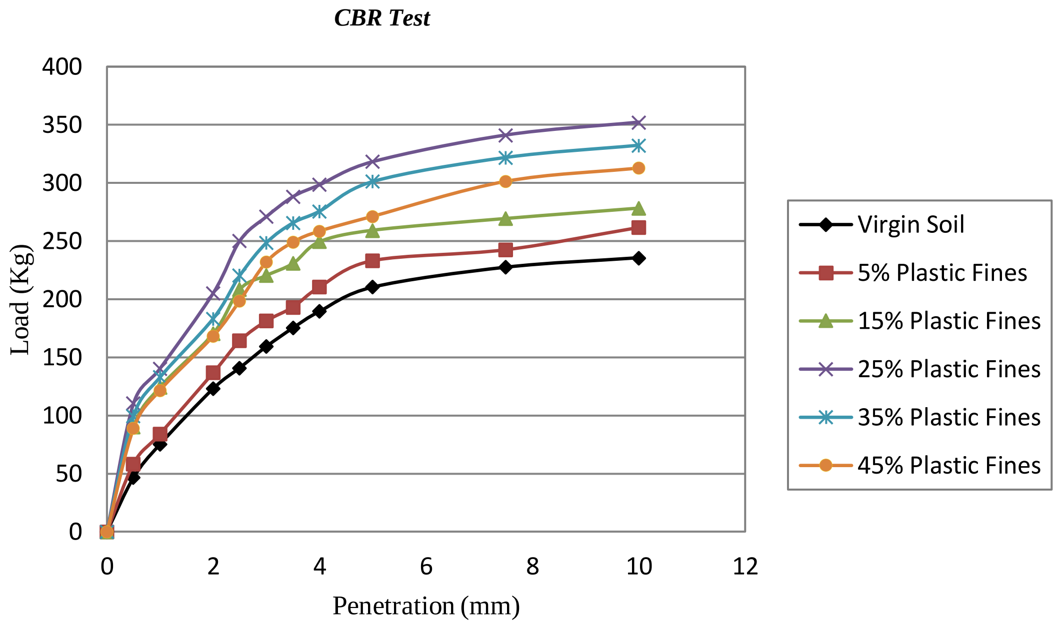

Figure 4: Load-Penetration behavior of reinforced samples with Plastic fines

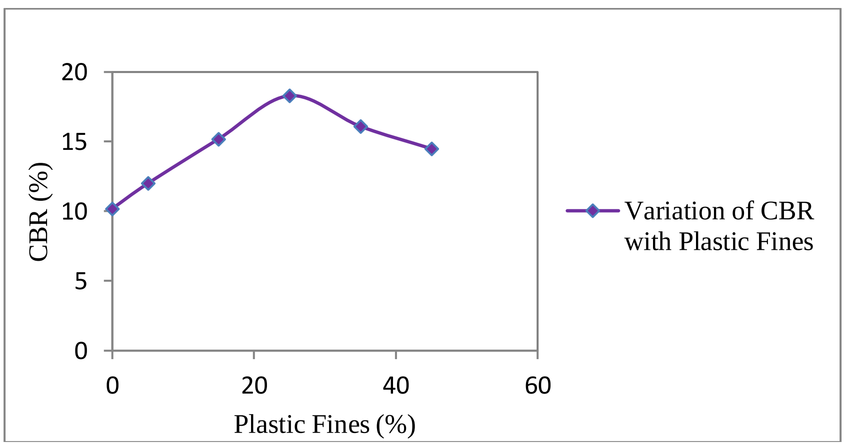

Figure 5: Effect of Plastic Fines on CBR

VI. CONCLUSIONS

As per data and results obtained from the experimental work on stabilization of poorly graded sandy soils with varying percentages of plastic fines (5%, 15%, 25%, 35% and 45%), the following conclusions can be drawn in the aspect of strength properties due application of plastic fines as a mean of stabilizing material.

Based on the results and discussions from the standard proctor test, it can be stated that with increase in percentage of plastic fines, the compaction parameters MDD in increased and OMC is decreased. From the above data, the maximum dry densities are found to be 1.67 g/cc for 5%, 1.78 g/cc for 15%, 1.95 g/cc for 25% , 1.83 g/cc for 35%

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and 1.68g/cc for 45% of plastic fines. This shows an increasing trend in MDD up to 25% of plastic fines. It is also observed that there is a decreasing trend in OMC with increase in percentage of plastic fines. So it is concluded that for effective soil stabilization 25% plastic fines give better results.

Based on CBR test results and discussions, it is observed that addition of plastic fines as stabilizing soil particles for poorly graded soils produces significant increase in CBR value. It is concluded that, with increase in plastic fines percentage, the CBR values are also increased considerably and CBR value is found to be 18.3% maximum for 25% plastic fines.

From the above discussions, it is concluded that addition of plastic clay fines to the poorly graded sandy soils there is considerable effect on the compaction parameters and bearing capacity of soil. It is also concluded that, expensive methods for stabilization of soils such as cement, fly ash etc. can be replaced together with plastic clay fines as an alternative method to improve the poorly graded soil properties. Plastic fines can be used for stabilization of embankments, pavement sub-grade and other fields of civil engineering as per needs for poorly graded soils.

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