Improvement of Geotechnical Properties of Red Soil using Waste Plastic

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Abstract — *Red soil covers a large portion of land in India. These soils are found in areas with low rainfall and they are not capable of retaining moisture. Due to high iron content these soils are red in colour. Red soil possess lower strength compared to other soils due to its porous and friable structure. To improve the engineering and strength properties of these soils, soil stabilization can be carried out by adding some additives to these soils. Use of plastic products such as polythene bags, bottles, chairs, toys etc. increasing day by day creates much environmental problems. So the use of waste plastics as a soil stabilizer is an economical utilization since there is scarcity of good soil for different engineering application. This project aims to evaluate the effect of addition of various percentages of waste plastic bag strips in order to enhance the properties of red soil.*

Keywords — *Red Soil, Waste plastic bags, Direct Shear Test, California Bearing Ratio, Standard Proctor Compaction Test*

I. Introduction

The rapid growth in population has resulted in the generation of large quantities of wastes. Disposal of these wastes produced from different industries and urban areas has become a great problem. Most of the wastes generated are non-biodegradable and possess severe environmental threat causing environmental pollution. Plastic is commonly used as shopping bags, for storage and for marketing as it is light in weight and easy to handle. After its use the plastic doesn't get degraded and gets accumulated posing ecological threat .The bulk plastic wastes which are disposed off from municipal and industrial areas pose severe threat to the environment. These waste plastics can be utilised effectively so as to improve the engineering behaviour of soil. The addition of these plastic wastes to the soil is beneficial as it acts as an effective soil stabilizer and simultaneously facilitates the safe disposal of the problematic plastics wastes that keep accumulating day by day.

II. Materials

A. Red Soil

Red soils are formed due to weathering of igneous rocks. They are deficient in nutrients and humus and have low water holding capacity. Red soils form the second largest soil group in India. The red color is mainly due to the presence of iron oxides. The red soil required for this experiment was collected from college campus of MREC, Secunderabad. The red soil was carried to the laboratory in sacks.

B. Waste Plastic

Waste house hold plastic bags were used to carry out these experiments. Experiments were done with Waste Plastic contents such as 0 %, 0.25 %, 0.50 %, 0.75 %, 1.00 % and 1.25%. Plastic contents more than 1.25% was not used in the study due to the difficulty of obtaining an even distribution of the waste plastic in the mix.

III.METHODOLOGY

A. Sieve analysis: [IS 2720 (Part 4)- 1975]

Sieve Analysis helps to determine the proportion of different grain sizes contained within the soil. It can be used to determine the distribution of the coarser, larger-sized and fine particles. Grain size analysis provides the grain size distribution and it is required in classifying the soil. About 500gms of red soil was taken and the soil sample was transferred to a set of sieves. The sample was sieved using a sieve shaker for 10 min. The cumulative percentage of soil retained on each sieve was found out. Grain size distribution curve was plotted.

B. Compaction test [IS 2720 (Part 7) – 1983]

To determine the effect of reinforcing fibers on the moisture density relationships, standard compaction tests were conducted as per Bureau of Indian Standard specifications on virgin red soil and soil - fiber mixtures. An even distribution of fiber and soil was achieved by consistent mixing procedure. About 2.5 kg of soil sample was taken and mixed with water content with varying percentages as 0.25 %, 0.5 %, 0.75 %, 1% and 1.25%.

C. Direct Shear Test [IS 2720 (Part 13) – 1986]

Direct Shear test helps to determine the shear strength of the soil. The soil specimen was prepared by mixing plastic strips to the red soil and then it was placed in shear box and the soil specimen was sheared at a constant strain rate under drained conditions.

D. CBR Test [IS 2720 (Part 16) – 1979]

The California bearing ratio test is penetration test meant for the evaluation of sub-grade strength of roads and pavements. The CBR test is carried out in a CBR mould where the soil specimen is subjected to penetrations. The load corresponding to 2.5mm and 5 mm penetration gives the CBR value.

IV. RESULTS AND DISCUSSION

A. Sieve analysis:

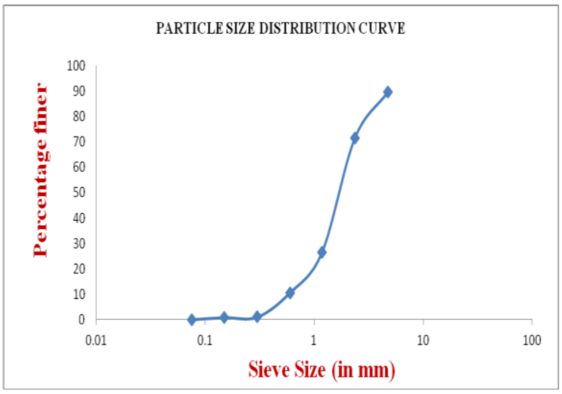

Fig. 1 Particle size distribution using Sieve Analysis

Co-efficient of curvature -
Cc = (D302) / (D10 * D60) = 1.457
Uniformity co-efficient –
Cu =D60 / D10 = 3.44

Soil is coarse grained as more than 50 % soil is retained on 75 micron sieve. Since greater than 50 % passes through 4.75 mm so it's coarse grained sand. The Cc value is between 1 and 3, hence its well graded but as Cu is less than 6, and the soil is poorly graded sand.

B. Compaction Test:

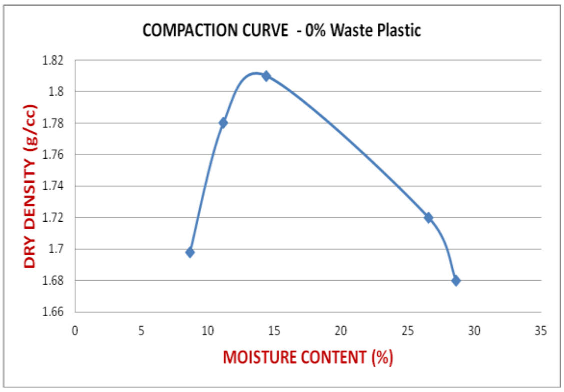

Fig. 2 Compaction curve for virgin soil

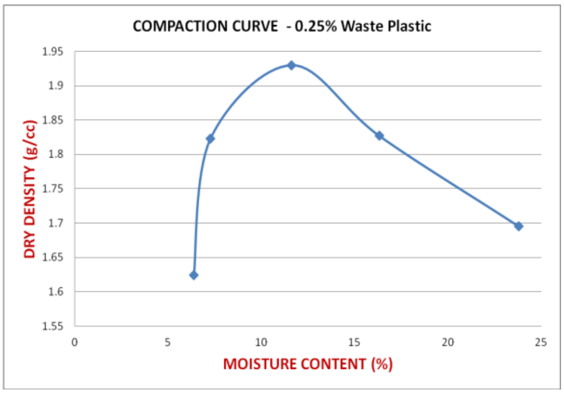

Fig. 3 Compaction curve for 0.25% Waste Plastic

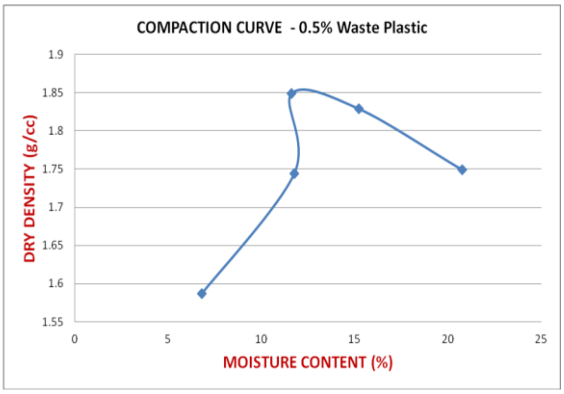

Fig. 4 Compaction curve for 0.5% Waste Plastic

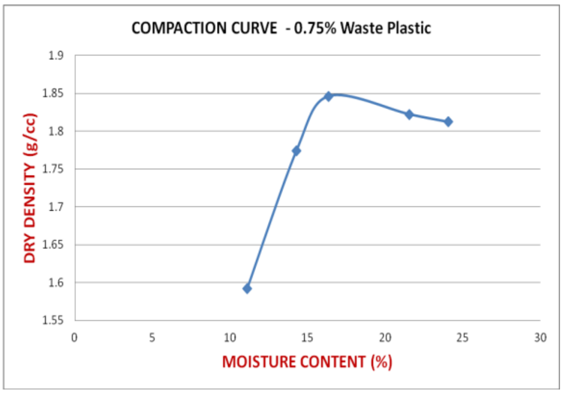

Fig. 5 Compaction curve for 0.75% Waste Plastic

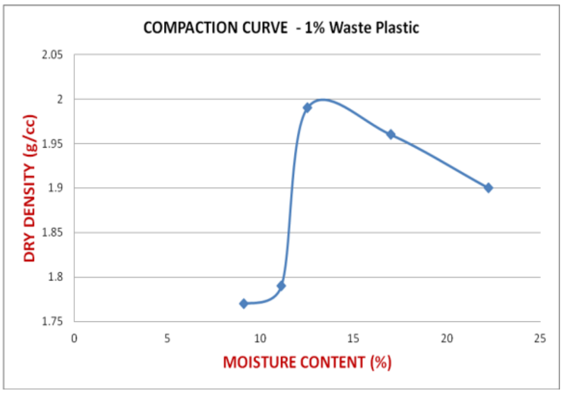

Fig. 6 Compaction curve for 1.0% Waste Plastic

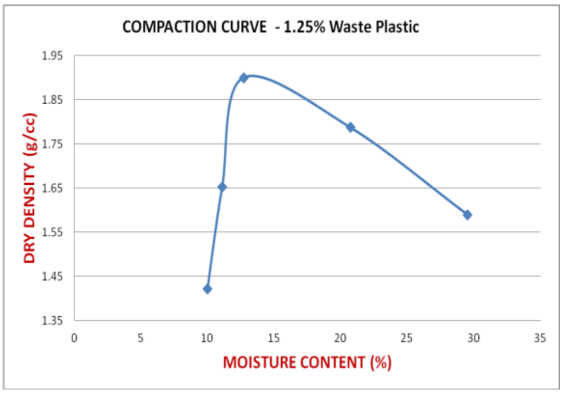

Fig. 7 Compaction curve for 1.25% Waste Plastic

TABLE I: VARIATION OF OMC AND MDD FOR VARIOUS % OF WASTE PLASTIC

Waste Plastic %	OMC	MDD
0	14.36	1.81
0.25	11.63	1.93
0.50	12.59	1.89
0.75	16.364	1.846
1.00	12.5	1.99
1.25	12.72	1.90

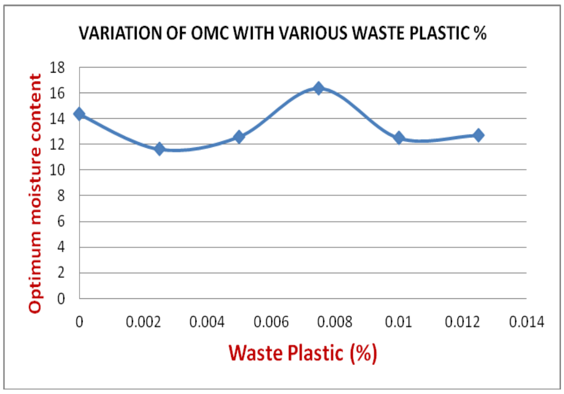

Fig. 8 OMC Variation with various % of Waste Plastic

Compaction is a mechanical method of soil stabilization, which is carried out to improve the engineering properties of soil. This results in finding out the optimum moisture content and maximum dry density.

Chart-8 illustrates that, there is increase in moisture content up to 0.75% addition of waste plastic and at 1.0% of the waste plastic content the value decreases to 12.5%. Again it increases for further addition of waste plastic (i.e. 1.25%).

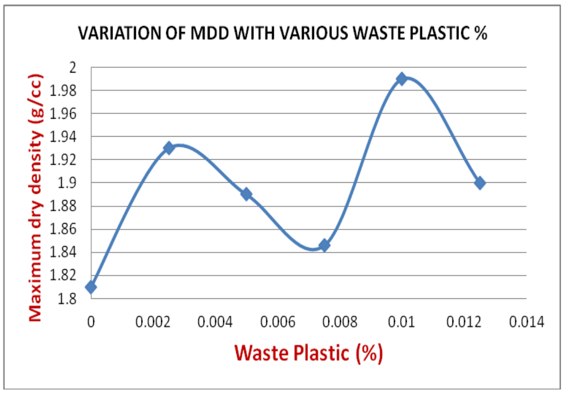

Fig. 9 MDD Variation with various % of Waste Plastic

The Value is Maximum Dry Density (MDD) was found to change with different contents of the waste plastics. Chart-9 illustrates that, the highest value observed being at plastic content 1% by weight of the soil taken. Initially MDD shows a decreasing up to 0.75% addition of plastic waste further reaches maximum at 1.0% of plastic waste and further decreases. The specific gravity of waste plastic is 0.92 that of soil is 2.73. As the plastic content increases the lower density plastic replace the higher density soil grains, resulting in a lower density soil plastic composite.

C. California Bearing Ratio Test:

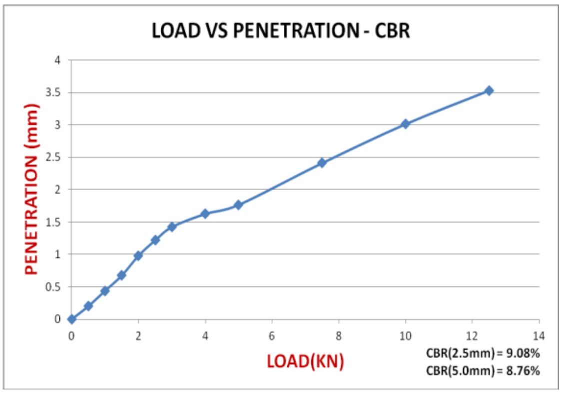

Fig. 10 CBR Test on Virgin Soil

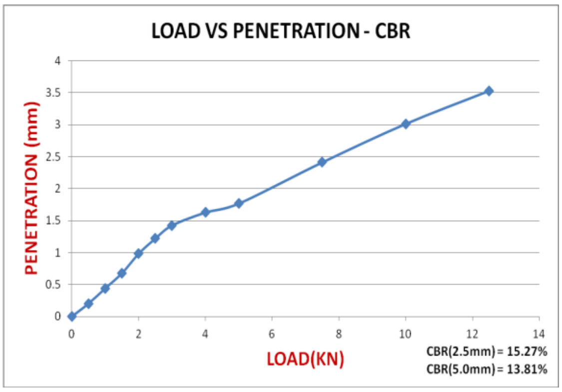

Fig. 11 CBR Test on soil mix with 0.25 % Waste Plastic

The CBR value of the virgin soil with 0% waste plastic corresponding to 2.5mm and 5.0mm penetration were found to be 9.08% and 8.76 %, which were increased to 15.27 % and 13.81 % respectively when waste plastic content was increased with 0.25% waste plastics.

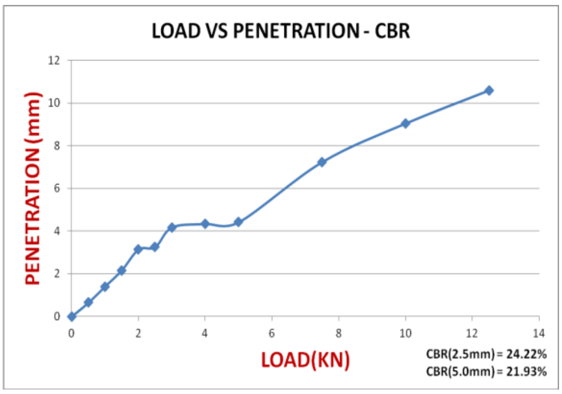

Fig. 12 CBR Test on soil mix with 0.5 % Waste Plastic

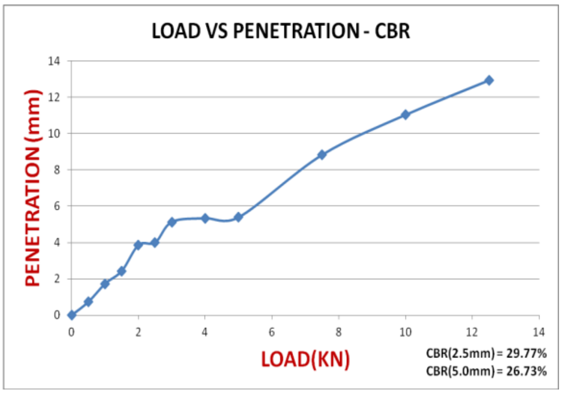

Fig. 13 CBR Test on soil mix with 0.75 % Waste Plastic

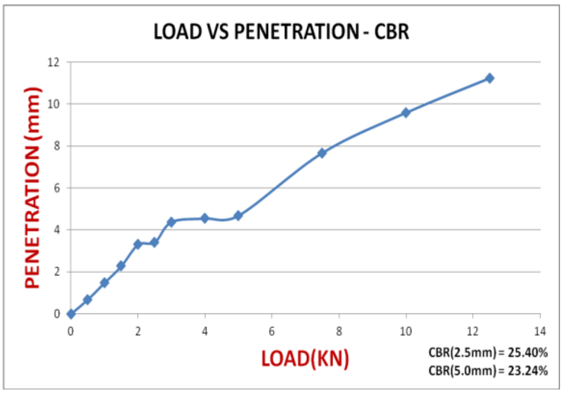

Fig. 14 CBR Test on soil mix with 1.0 % Waste Plastic

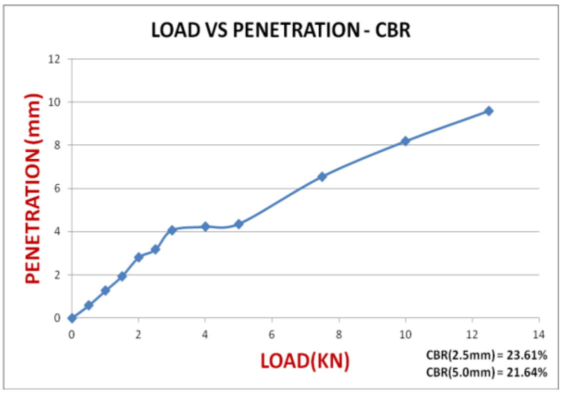

Fig. 15 CBR Test on soil mix with 1.25 % Waste Plastic

The CBR Value for 2.5mm and 5.0mm penetration further increase with the increase of waste plastic content with 0.5%(24.22 %, 21.93 %), 0.75% (29.77 %, 26.73 %). The CBR Value was maximum when the waste plastic content was 0.75%, further increase in waste plastic reduced the CBR value. The CBR values for 2.5mm and 5.0mm for 1% and 1.25% are 1%(25.40 %, 23.24 %) & 1.25%(23.61 %, 21.64 %).

D. Direct Shear Test:

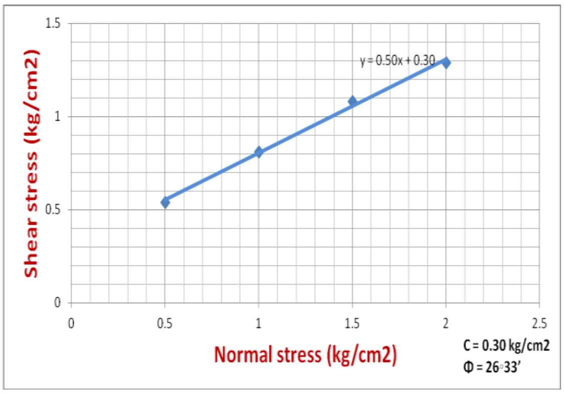

Fig. 16 DST Test on Virgin Soil

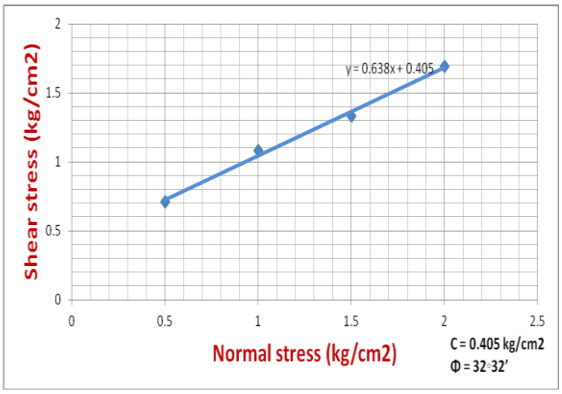

Fig. 17 DST Test on soil mix with 0.25 % Waste Plastic

The Cohesion(C) and Angle of Internal Friction(Φ) value of the virgin soil with 0% waste plastic corresponding were found to be 0.30 and 26◦33', which were increased to 0.405 and 32◦32' respectively when waste plastic content was increased with 0.25% waste plastics.

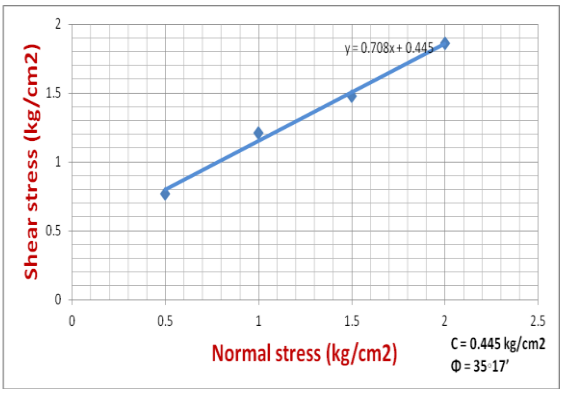

Fig. 18 DST Test on soil mix with 0.5 % Waste Plastic

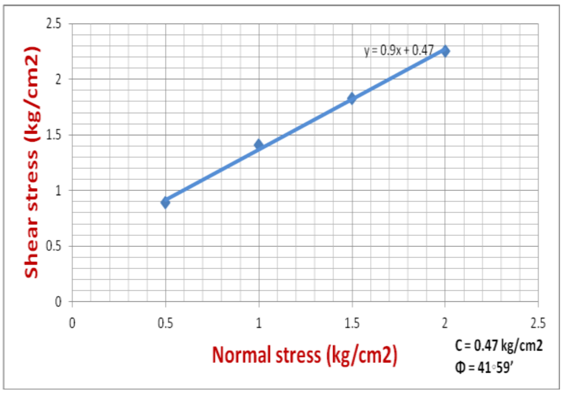

Fig. 19 DST Test on soil mix with 0.75 % Waste Plastic

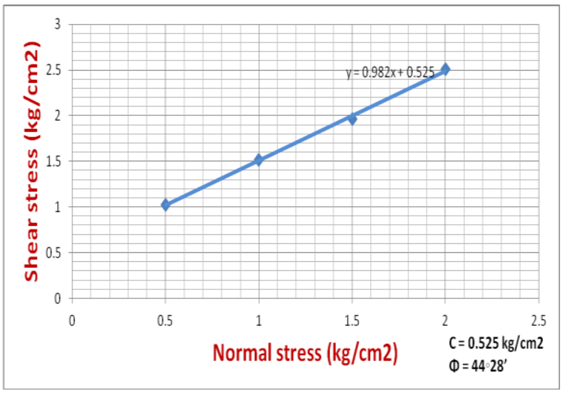

Fig. 20 DST Test on soil mix with 1.0 % Waste Plastic

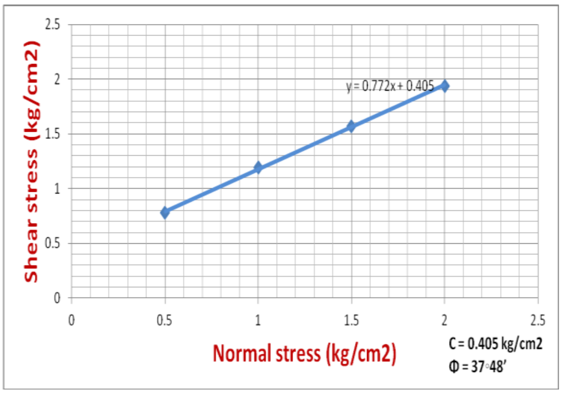

Fig. 21 DST Test on soil mix with 1.25 % Waste Plastic

The Cohesion(C) and Angle of Internal Friction(Φ) value further increase with the increase of waste plastic content with 0.5%(0.445 and 35◦17'), 0.75% (0.47 and 41◦59'). The Cohesion(C) and Angle of Internal Friction (Φ) value was maximum when the waste plastic content was 1.0 %(0.525 and 44◦28'), further increase in waste plastic reduced the Cohesion(C) and Angle of Internal Friction(Φ) value. The Cohesion(C) and

Angle of Internal Friction (Φ) value for 1.25% is 0.41 and 37◦48'.

TABLE -II: VARIATION OF C AND Φ FOR VARIOUS % OF WASTE PLASTIC

Waste Plastic %	C in kg/ cm^2	% change in C	Φ in degrees	% Change in Φ
0	0.3	0	26.3	0
0.25	0.405	35	32.32	23
0.50	0.445	10	35.17	9
0.75	0.47	6	41.59	18
1.00	0.525	12	44.28	6
1.25	0.405	-22	37.48	-15

Where,
C is Cohesion
Φ is Angle of Internal Friction

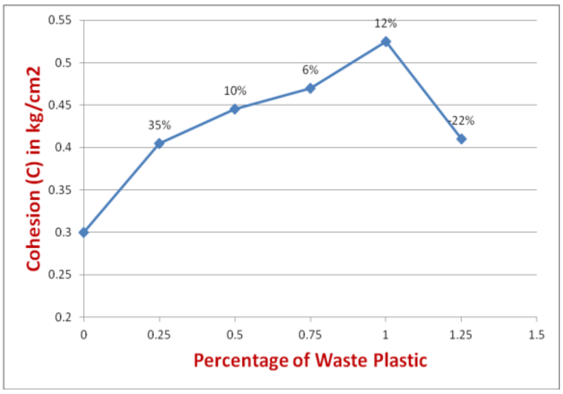

Fig. 22 Relationship between C and % of Waste Plastic

The shear strength parameters of soil were determined by direct shear test. Chart-22 illustrates that the increase in the value of cohesion of waste plastic mixed soil of 0.25%, 0.75%, 1% and 1.25% are 35%, 10%, 6%, 12%, -22% respectively.

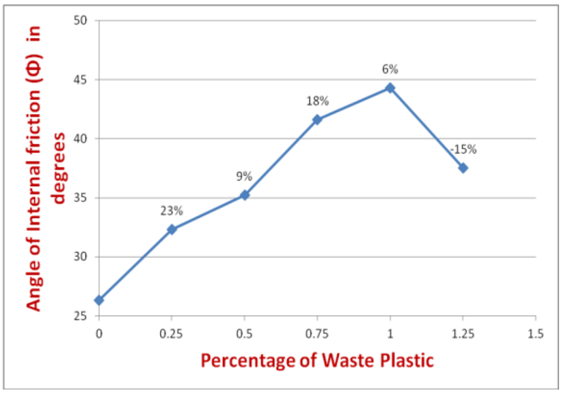

Fig. 23 Relationship between Φ and % of Waste Plastic

Chart-23 illustrates that the increase in the internal angle of friction (Φ) was found to be 23%, 9%, 18%, 6% and -15% respectively.

Thus, a net increase in the values of c and φ were observed to be 36%, from 0.3 kg/cm2 to 0.41 kg/cm2 and 42%, from 26.3 to 37.5 degrees. The maximum value of C and φ are observed when the waste plastic content was 1% i.e. 0.525 kg/cm2 & 44.28 degrees respectively. Therefore, the use of waste plastic for improvement of Geo-Technical properties for red soil is recommended till certain amount of plastic content (i.e. 1%).

V. CONCLUSION

Based on the present experimental results, here we concluded that

- The waste plastics can be used as a good stabilizing agent to enhance the Geo-Technical properties of the soil.
- As an additive to the soil, it increases the CBR value about 3 times more than that of the virgin soil i.e. 9.03% to 29.77%. The increase in CBR value shows that the use of waste plastics with appropriate percentage may prove beneficial for red soil stabilization.
- The shear strength parameters also increase when the plastic content increases up to certain percentage of shear strength.
- In a sense red soil can be seen as eroded soil that needs more attention and much more soil management, so that they can be used properly.
- As a result it can be observed that, plastic waste is the good non-biodegradable material, which can be used for improvement of geotechnical properties of such type of soils i.e. Red Soil.

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