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Effect of Tyre Shreds and LDPE Waste on Behaviour of Black Cotton Soil

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Abstract: In India Almost 20% of area is occupied by black cotton soil, on account of its high volumetric changes it is not suitable for construction. It swells and shrinks excessively due to presence of fine clay particles. Alternate swelling and shrinking of soil is responsible for differential settlement of structure so black cotton soil must be treated by using suitable admixtures to stabilize it. This works aim to study the effect of rubber tyre shreds and LDPE on properties of BC soil. In this program the various test such specific gravity (G), Atterbergs limit (liquid, plastic and shrinkage limit), optimum moisture content and maximum dry density, California bearing ratio, and triaxial compression test was performed on oven dry soil to know the basic properties of BC soil. The tyre shreds and LDPE are added as reinforcement in the soil with percentage (0.5%, 1%, 2%, 3%, 4%, 6%, 8 %,) of weight of soil. It was observed that for tyre shreds the MDD value increases upto 4% and then decreases considerably, in case of LDPE it increases up to 1% and decreases considerably. The CBR value is found to be increased with the increase in 1% of both rubber tyre shreds and LDPE. The cohesion and angle of friction value shows improvement up to 4% of reinforcement. In short we can say that the use of rubber tyre shreds and LDPE for stabilization approach is an economical and environmental settling of the problems connected with its disposal.
Keywords: - Rubber Tyre Shreds, Low Density Polyethylene Plastic Waste, Back Cotton Soil.

I. INTRODUCTION

Black cotton soil is problematic soil for civil engineer, because of its unconventional behavior. These soils show large volume changes with respect to variation of seasonal moisture content. These soils when subjected vehicular traffic, road pavement gets heaved and cracked due to swelling and shrinkage. Hence, these soils are to be stabilized before constructing the roads in order to have efficient and long lasting roads. The earliest of civilization used natural material to improve soil behavior. The material like dry branches and trees were used to reinforce soft soil on which heavy loaded trucks get bogged down during monsoon. In the vast water from area like Kerala, it has been age old custom to spread coconut leaves on the ground for the road formation. The walking on stolen of trees has enable man to cover even marshy lands. Today the situation in this century is that the geosynthetics and other stabilizing materials (Lime, Cement, And Fly ash etc.) are taking position as alternative construction material and to improve the index and engineering properties of soil.

1.1 Black Cotton Soil

Type of soil used in this investigation is Black Cotton Soil which is highly expansive in nature and studied for various engineering as well as index properties as per IS code. The soil is collected air dried and then dried in oven then pass through 425 micron IS Sieve.

1.2 Rubber Tyre Shreds

It is estimated that 13.5 million tons of scrap tires are disposed of every year worldwide. Stabilizing Material (Rubber Tyre Shred) Scrap tyres are being produced and accumulated in large volumes causing an increasing threat to the environment. Rubber Shredded tyre material were procured from tyre re-threading industries at Vidharbha Tyre Remolding, MIDC Amravati, Maharashtra. In order to eliminate the negative effect of these depositions and in terms of sustainable development there is great interest in the recycling of these nonhazardous solid wastes. Properties of rubber tyre shreds are given in table no. 1.1. These numbers include all sorts of tires from car tires to trucks and huge tractor tires and earth moving tires. Fig 1.1 shows the rubber tyre shreds.

Fig 1.1: Rubber Tyre Shreds

Table No. 1.1 Characteristic of Rubber Tyre Shreds

Properties	Rubber powder
Density	0.83
Size	1 mm – 3 mm
Elongation	420 (%)
Rate of steel fiber	0%

1.3 Low-Density Polyethylene (**LDPE**)

LDPE is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process via free radical polymerization. Its manufacture employs the same method today. The EPA estimates 5.7% of LDPE is recycled. Despite competition from more modern polymers, LDPE continues to be an important plastic grade. In 2013 the worldwide LDPE market reached a volume of about US$33 billion. Properties of LDPE is given in table no. 1.2

Fig. 1.2 LDPE Wastes From MIDC Amravati.

Table No. 1.2 Properties of LDPE

Sr. No.	Properties	Range
1	Density	0.910–0.940 g/cm^3.
2	Temperatures	80 °C- 95 °C
3	Carbon	2%
4	Tensile strength	Low
5	Resilience	High

II. LITERATURE REVIEW

Harsha Vardhan P. and Yamunna M. (2017) have conducted an experimental study on Stabilization of Black Cotton Soil Using Plastic Waste and concluded that, the project is focused on the performance of Plastic fiber as soil stabilization material. The study suggests that if the plastic fibers are properly mixed and applied then it can be used as a great soil stabilization technique. Optimum percentage of plastic is recommended at 0.5% which will improve the engineering characteristics of black cotton soil. ***Singh S. and Dhiman U. (2017)*** Conducted a model study on Soil Stabilization using Scrap Rubber Tyre and concluded that, there is an increase in the value of unconfined compressive strength due to increase in percentage of tyre scrap of various sizes indicting strength improvement of soil. For soil treated with 18% of tyre-scrap highest UCS value of 1.75kg/ cm^2 has been observed. **Langote *R. V. and Kolhe P. V. (2017)*** have conducted an experimental study on Black Cotton Soil Stabilized with Rubber Tyre Shred and LDPE waste and concluded that, The CBR values increases with increase in percentage of rubber tyre shreds and found to be maximum for 8% rubber tyre. The cohesion values considerably decreases with increase in percentage of rubber tyre shred may be due orientation of rubber tyre. The angle of friction considerably increases with increase in percentage of rubber tyre from 11.270 – 23.550. The OMC values decreases up to 4% rubber tyre and then considerably increases up to 10% The MDD values initially increases and then considerably decreases with increase in percentage of rubber tyre. It was found that the rubber tyre can be effectively used in road construction and pavement design as the CBR value can be improved.

III. LABORATORY TEST

The engineering behavior of clayey soil were determined by conducting various laboratory test in accordance with IS 2720 (1985).

3.1 Index Properties

The various laboratory tests were performed on the Black Cotton soil to determine the index properties of given soil and are summarized in Table 3.1.

Table 3.1 Engineering Properties of the Unreinforced Soil

Sr. No.	Index Property	Value
1	Liquid limit	40%
2	Plastic Limit	21.03%
3	Shrinkage Limit	4.63%
4	Plasticity Index	10.98%
5	AASHTO Classification	A-7-3
6	Maximum Dry Density (MDD)	1.41gm/cc
7	Optimum Moisture Content (OMC)	28%
8	Cohesion (c)	40kN/m^2
9	Angle of friction (φ)	19^0
10	California Bearing Ratio (CBR)	2.31%
11	Specific Gravity	2.50

3.1 Specific Gravity (G)

This test is performed as per IS 2720 Part III-1980 to determine the specific gravity of soil by using a Pycnometer. Specific gravity is the ratio of the mass of unit volume of soil at a stated temperature to the mass of the same volume of gas-free distilled water at a stated temperature. The specific gravity of a soil solid is used in calculating the phase relationships of soils, such as void ratio and degree of saturation. The specific gravity of black cotton soils lies between 2.1 to 2.6. Soils containing appreciable organic matter or soils with porous particles may have average specific gravity of 2.1 to 2.3.

3.2 Consistency Limits

3.2.1 Liquid Limit (LL)

According to Casagrandes procedure, liquid limit is defined as the water content at which a groove cut in a pat soil cut by a grooving tool of standard dimensions will flow together for a distance of 1.25 cm under the impact of 25 blows.

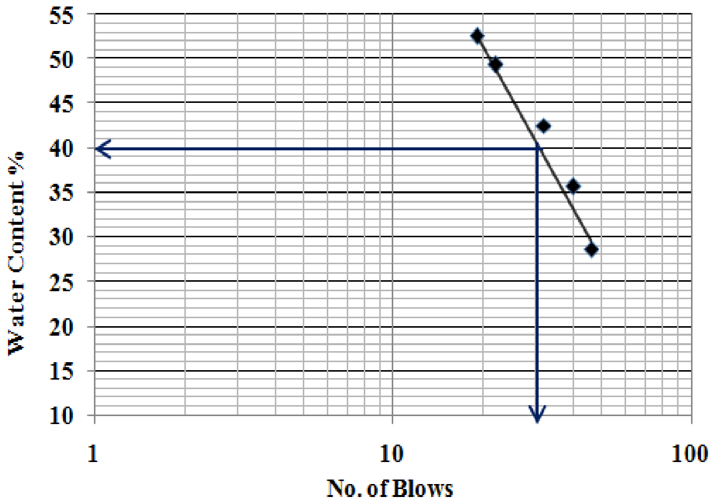

Fig. 3.1 Flow Curve for Liquid Limit Determination without Addition of Tyre Shreds

Liquid limit of unreinforced soil as obtained from graph = 40% (corresponding to 25 blows).

3.2.2 Plastic Limit (PL)

In procedure terms, it is defined as the water content at which a soil will just begin to crumble when rolled into a thread of approximately 3 mm diameter. The plastic limit for B.C. Soil was found to be 21.29%. With addition of reinforcement will not give sample so that plastic limit for varying percentage of reinforcement is not determined.

3.2.3 Shrinkage Limit (SL)

It is the water content after which further decrease in water content does not cause any decrease in the volume of the soil mass. In other words, it is the minimum water content (shrinkage limit) of black cotton soil when the soil is fully saturated. The shrinkage limit for the given unsaturated BC soil was found to be 4.63%. The variations of shrinkage limit with addition of reinforcement are tabulated as:-

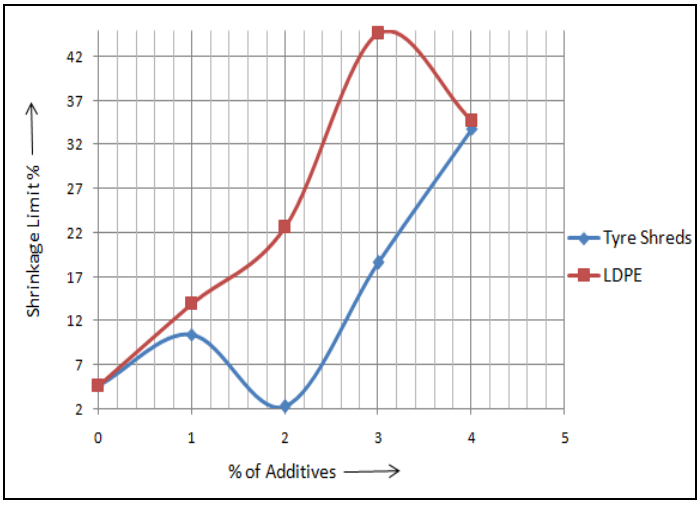

Fig. 3.2 Variation of Shrinkage Limit with Addition of Reinforcement A value of 4.63 % was recorded for the natural soil.

3.2.4 Plasticity Index and Shrinkage Index

The values of plasticity and shrinkage indexes are found to be 18.67% and 35.47%.

3.3 Standard Proctor Compaction Test

Test generally consists of compacting soil at known moisture content into a cylindrical mould of standard dimensions using a compactive effort of controlled magnitude. The soil is usually compacted into the mould to a certain amount of equal layers, each receiving a number of blows from a standard weighted hammer at a specified height. This process is then repeated for various moisture contents and the dry densities are determined for each. The graphical relationship of the dry density to moisture content is then plotted to

establish the compaction curve. The maximum dry density is finally obtained from the peak point of the compaction curve and its corresponding moisture content, also known as the optimal moisture content.
At the construction stage, the optimum dry density obtained from this test shall be at least 5% above the design dry density. Taking in to consideration the nature of the compaction equipment available the laboratory compaction standard may need slight modification.

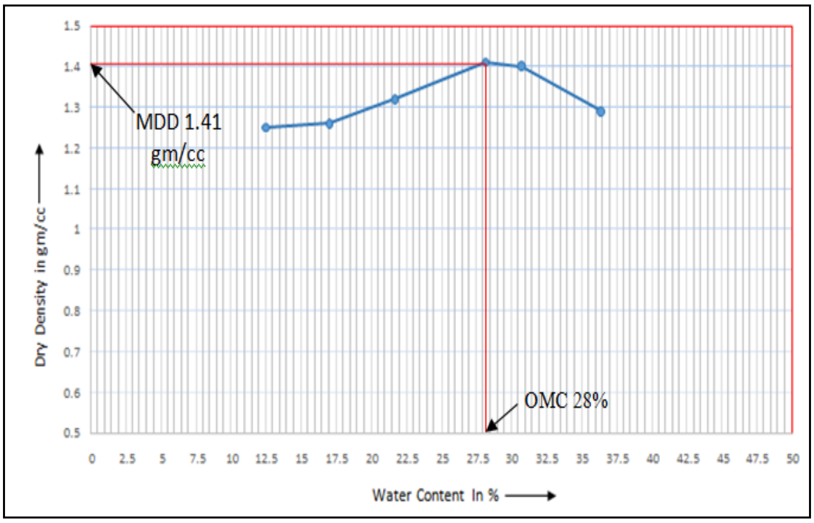

Fig. 3.3 MDD and OMC of Soil Sample without Addition of Reinforcement

From Figure 3.3 it is clear the crest of compaction curve gives the value of maximum dry density (MDD) of black cotton soil without any reinforcement content and found to be 1.41 gm/cc with OMC equal to 28%.

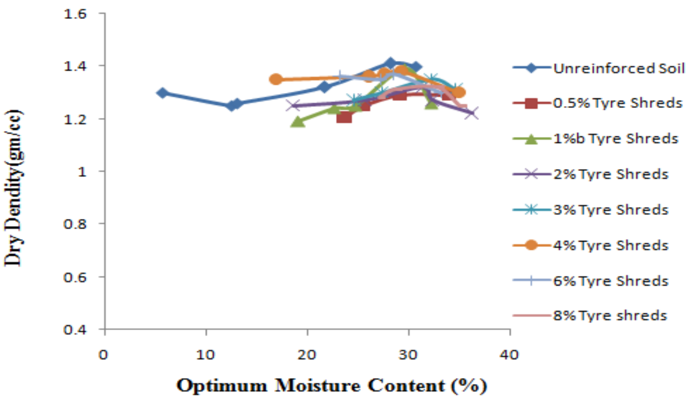

Fig. 3.4 Compaction Curve for Various % of Tyre Shreds

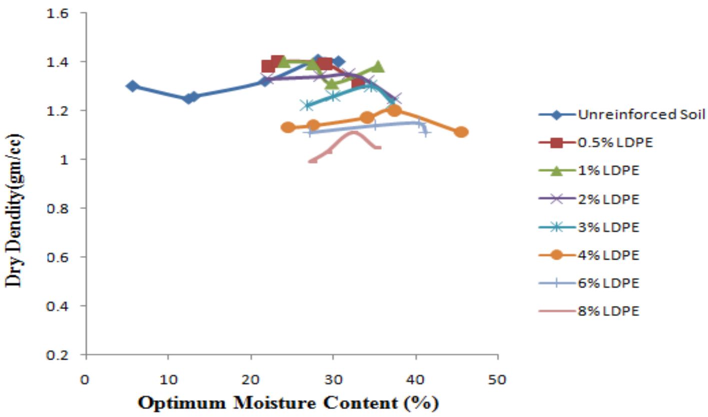

Fig. 3.5 Compaction Curve For Various % of LDPE

The variation of the optimum moisture contents (OMC) and maximum dry density (MDD) with reinforcement content is shown in Figure 3.4 and Figure 3.5. The OMC for unreinforced soil was found to be 28% and subsequent increase in OMC reached a value of 32.49% at 3% tyre shreds content. Further addition of tyre shreds lead to a decrement in the OMC to 32.19% at 6% tyre shreds, and finally, increase of OMC to 32.87% was observed at 8% tyre shreds content. And in case of LDPE, OMC greatly increases to 40.40% at 6% of LDPE, and further increment of LDPE leads to decrease in OMC to 32.24% at % and so on. From Figure it was seen that for 0% reinforcement, the maximum dry density was 1.41 gm/cm^3 and on addition of tyre shreds, an increase in MDD was observed to a value of 1.38 gm/cm^3 at 4% tyre shreds. Further increase in tyre shreds content lead to decrease in MDD value to 1.32gm/cm^3 at 8% tyre shreds and subsequently increase in tyre shreds lead to reduction in MDD value. And in case of LDPE the MDD value is increases to 1.40 gm/cm^3 at 1% of LDPE, further increment of LDPE leads to decrease in MDD to 1.11 gm/cm^3 at 8% of LDPE and so on.

3.4 California Bearing Ratio

The CBR test was carried out on unreinforced soil to determine the CBR value. The CBR value for unreinforced soil was found to be 2.65%. The CBR test was again performed to study the effect of tyre shreds and LDPE on CBR value with varying percentage of 0-3%

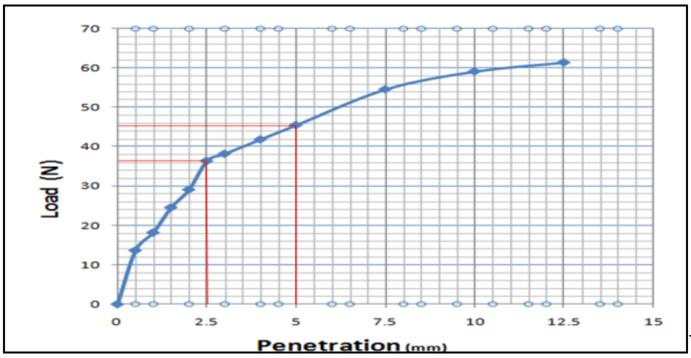

Fig. 3.6 Load Penetration Curve for Soil without reinforcement

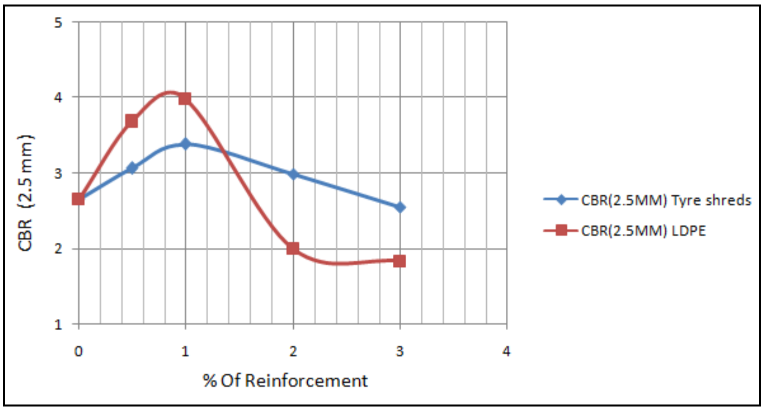

Fig. 3.7 Variation of CBR Value for 2.5 mm Penetration with Different % of reinforcement

From the above Figure 3.7 the CBR values goes on increase with increase in the % of tyre shreds up to 1% and from 1% it goes on decrease with increase in the % of tyre shreds. Same in case of LDPE.

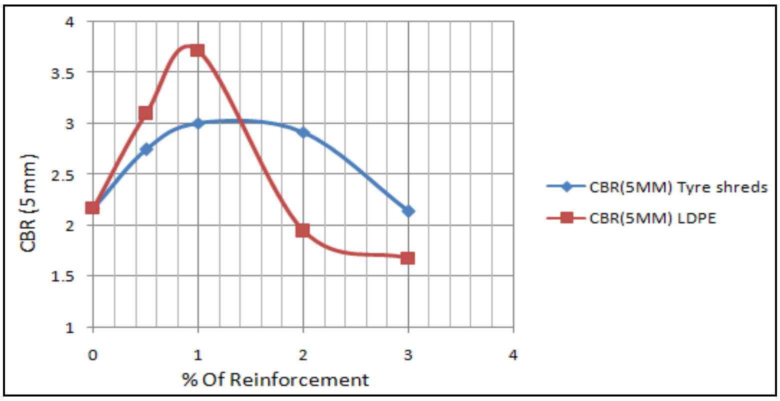

Fig. 3.8 Variation of CBR Value For 5 mm Penetration with Different % of Reinforcement

3.5 Triaxial Compression Test

Assuming the volume of the specimen to remain contact area of specimen to increase uniformly with decrease in length, the deviator stress is calculation the basis of changed area at varying and strain for each test. A graph is plotted between strain as abscissa and deviator stress as ordinate, from which the maximum value of deviator stress is read. A Mohr circle is drawn for each test at failure. A common tangent to the Mohr circles gives the failure envelope from which the parameters Cohesion and angle of friction of black cotton soil is 0.4 kg/sq.cm and 19^0.

Sample should be extracted from the mould prepared as for compaction test by means of universal sample extruder. The cell pressure is applied by means of hydraulic pressure. As the sample with LDPE is not possible to extract so that the triaxial compression test was performed only on tyre shreds.

Table 3.2 Observation Table Regarding Principal Stresses and Shear Parameters

Test No.	Cell pressure Kg/sq.cm	Deviator stress at failure Kg/sq.cm	Major stress Kg/sq.cm	Shear parameter from graph
1	0.5	1.72	2.22	C= 0.45 Kg/sq.cm Ø = 19^o
2	1.0	2.15	3.15	
3	1.5	2.80	4.3	

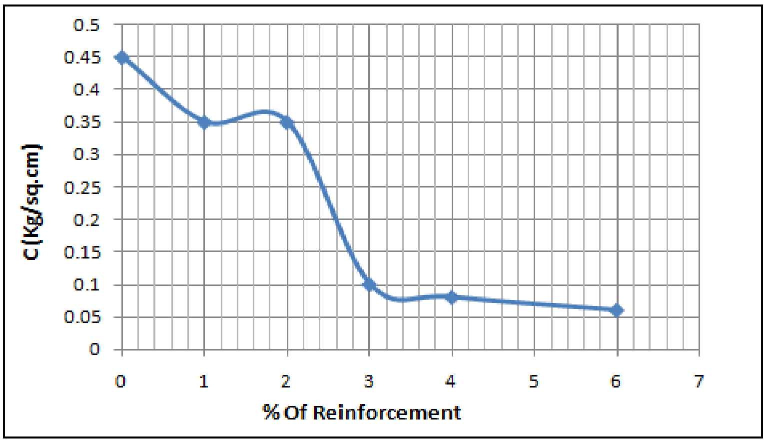

Fig. 3.9 Variation of Cohesion of Soil Sample with Different Tyre Shreds Percentage

Without use of tyre shreds content in black cotton soil the cohesion value was found to be 0.40 kg/sq.cm further increase in tyre shreds content in black cotton soil from 1% to 6% cohesion are 0.35 kg/sq.cm and 0.0.06kg/sq.cm respectively. From above graph, it was seen that increase in tyre shreds % in black cotton soil results in decrease in the value of cohesion from 1% to 6%.

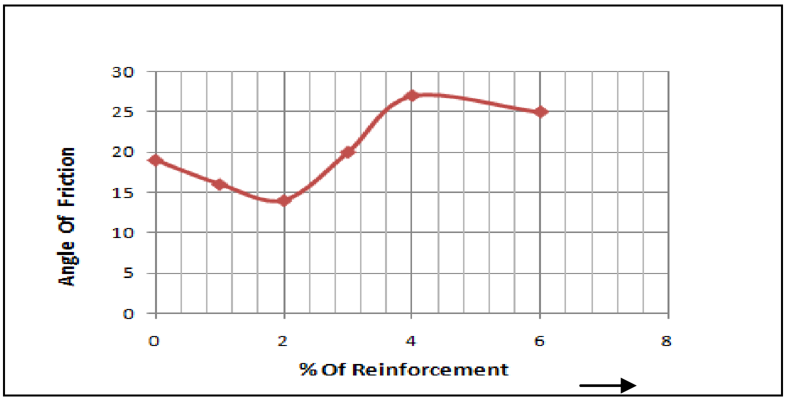

Fig. 3.10 Variation of Angle of Friction of Soil Sample with Different Tyre Shreds Percentage

Without use of tyre shreds content in black cotton soil of Angle of friction found to be 19^0 further increase in tyre shreds content in black cotton soil from 1% to 2% it was decreases to 16^0 and 14^0 respectively. And further increment of tyre shreds 3% and 4% the Ø value increases to 20^0 and 27^0 respectively. From above graph, it was seen that increase in tyre shreds in black cotton soil results in decrease in the value of angle of internal friction beyond 3% of tyre shreds.

IV. CONCLUSIONS

Based on the report following conclusions are drawn:

1. From the experimental study, it is observed that there is significant improvement in the properties of black cotton soil by inclusion of randomly oriented tyre shreds and LDPE.
2. The CBR value of black cotton soil is enhanced by the inclusion of tyre shreds and LDPE. The CBR value increases with increase in rubber tyre shreds & LDPE and found to be maximum for 1% of rubber tyre shreds and 1%of LDPE up to an extent but decreases with further increase in % of tyre shreds and LDPE.
3. The increase in CBR value due to inclusion of tyre shreds may prove to be beneficial in construction of pavement.
4. The compaction characteristic of clayey soil is changed by the investigation of tyre shreds and LDPE. As the % of tyre shreds and LDPE is increased MDD goes on decreasing and OMC goes on increasing. This is due to the lower density of tyre shreds and LDPE. This effect may be beneficial in case of backfill material for retaining walls.
5. The cohesion value decreases with increase in % of tyre shreds

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