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Soil Stabilization Using Plastic Waste Materials – A Research

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Abstract: The method of enhancing the soil's engineering qualities, such as its bearing capacity and shear strength is called soil stabilization. Because almost every structure needs a strong foundation on which it can stand firmly. Soils such as sandy soils always suffer from the problem of uneven settlement. Currently, one of the biggest problems facing the world is the disposal of plastic waste. The use of plastic waste for soil stabilization and the use of plastics as a soil stabilizer help solve environmental problems while reducing the problem of plastic waste disposal. The aim of this research is to determine how plastic waste can be used in large-scale civil engineering applications. Disproportionate plastic waste was used to stabilize the soil to improve its properties such as bearing capacity, compaction effect and shear strength parameters.

Keywords- Soil stabilization, California Bearing Ratio,Direct Shear Test, Sandy soil, Plastic waste.

I. Introduction

The plastics sector has grown over the previous few decades as a result of population expansion. Plastic recycling is an expensive and challenging process. Plastic garbage is not decomposable since it does not break down. It's challenging to dispose of so much plastic. In the subject of soil stabilization, several researchers attempt to make use of plastic trash. Stabilizing soil is one of the most common uses for plastic trash. The majority of the soil in India is costly, cohesive, and has poor engineering qualities. Expensive soils are improved by stabilization and become appropriate for building pavement.

Different compaction techniques, appropriate materials like cement, and waste materials like PET, PP, PS, HDPE, etc. can all be used to stabilize soil. To determine whether waste material is required as a soil enhancer, tests such as the CBR test, modified proctor test, sieve analysis, and plastic limits tests are noted to be carried out. The adjusted proctor test shows the sample's Maximum Dry density and optimal moisture content (OMC).

Plastic content is optimal as determined by the California Bearing Ratio test . The percentage of plastic applied to the soil sample that is greater than the CBR value is the optimal plastic content. Since the dirt used to build subgrades needs to be highly compacted, the modified proctor test is recommended over the conventional proctor test. Reducing environmental disposal issues is another benefit of using plastic waste in the soil.

II. Literature Review

(Mercy Joseph Poweth, 2013) This study involves disposal of dust, non-biodegradable waste and plastic waste by using themin the pavement's subgrade. To study the sample, a number of Standard Proctor test and the California Bearing Ratio were performed for figure out the optimum percentage of plastic in sample. The outcome depicts only dustenhances the maximum dry density which is useful for pavement subgrade. Only non- biodegradable materials are notsuitable for pavement subgrade. From this experimental study it has been stated that dust mixed with plastic maintains the California Bearing Ratio value in the optimum limit.

(Subhash,2016) The author conducted experimental activity on stabilization of soil by using plastic and glass with unproportionate mixture. The various tests such Proctor Tests were altered in order to investigate OMC and CBR .The results of the study show that the Maximum Dry Density (MDD) level falls with increasing glass and plastic content. About 6% of the total is made up of glass and plastic, with a maximum dry density of 1.51 gram/cm^3 being recorded .The highest OMC was recorded at 22.4% when the admixture was mixed at 5.9%. Additionally, a rise in the OMC level was noted, with a maximum value of 22.5%. Unconfined compressive strength based on 0.610 kg/cm^2 to 3.022 kg/cm^2, or over 4.5 times as much as the sample of soil. At 7.15%, the max. CBR value two times the CBR of the original soil sample was recorded.

(Mallikarjuna, 2016) The author experimented with employing plastic garbage to stabilize soil in black cotton fields. The trials to address the issues in Amaravathi, the capital of Andhra Pradesh, India, are mostly accommodated by the author. A black cotton soil sample is combined with different plastic strip weight percentages ranging from 0.0% to 8.5%.

Using the CBR Test, soil and the ideal proportion of plastic waste strips were examined. Plastic samples taken from discarded chairs are divided into several strips. Density of 0.40 gm/cc plastic strip mixed in different proportions of 1%, 3%, 5%, and 7% with black cotton soil. Several CBR tests as well as a modified Proctor test were run on the soil sample in this investigation. According to the author, the value of CBR rises by up to 5% when plastic is present.

(Prof. Harish, 2016) the research work includes the waste plastic materials in the shredded form of various sizes. The process of incorporating plastic bottle straps into a soil sample by adjusting its proportion and doing various tests such as CBR, plastic limit, liquid limit, and compaction tests etc, has proved out to be very effective. Bearing capacity of the soil increases drastically and engineering properties like shear strength improves within a specific limit of compaction.

Table 1 (Value of California Bearing Ratio of Red Soil)

Plastic content (%age)	CBR Values
0.0	2.3
0.2	2.0
0.4	2.1
0.6	2.4
0.7	2.9
0.8	1.8
1.0	1.7

Table 2 (California Bearing Ratio value of expensive Soil)

Plastic content (%age)	CBR Values
0.0	2.7
0.2	2.5
0.4	2.6
0.5	3.3
0.6	2.1
0.8	2.1

Red and black cotton soils, including 5% gravel, 86% sand, and 9% (silt and clay), are both used in the study. Following testing, it was found that the highest dry unit weight that a soil sample could produce was between 19.12 and 21.03 KN/m3.The modified Proctor test yielded an optimal moisture content (OMC) of 13% and 10%, respectively. The soil sample of black cotton has 82.4% silt, 15% sand, and 2.5%gravel.

(Ilies, N.M.,2017) This study paper involves two ways to enhance soil properties. The first way was to enhance soil mixing with plastic garbage. Another method to improve with cement. Source of waste plastic used in this experimental studyinvolves Polyethene Plastic Waste.

The research examine shearstrength parameters changes when different amount like 2%, 4%, 6% and 8% of cement or Polyethene are added. The studywas performed on a silty clay. Mixing the soil with 4% of Polyethene, various manipulations were observed. 4% Polyethene soil mixture compared with same amount of cementsoil mixture, the Polyethene mixture consists of less cohesiveness of around 51% and less internal friction angle of around 62%. Ultimately, even though the soil cement sample performed better, polyethene was more advantageous from an ecological standpoint.

(Kiran, 2017) An increase in soil stiffness and bearing capacity is the goal of stabilisation techniques. Both buildability and workability are requirements for the soil. The author of this experiment studied how to enhance the different engineering features of soil using plastic bottle and shopping bag strips. According to this study, the CBR values of soil increase, and the CBR maximum is seen when 0.74% of plastic bottle strips are combined with a soil sample. The CBR value falls as the number of strips is increased more. It was discovered that the optimal amount of plastic bag strips, in the second example using dirt, is around 2% of the soil's overall weight. The writer determined that since plastic bottle strips raise the soil sample's CBR value, they are preferable to soil bag strips.

(N. Vijay Kumar, 2017) This experimental research paperconsists with observation of waste of plastic material as a soil stabilizer mostly of black cotton soil. Drawbacks that observedin this soil were swelling in contact of moisture, shrinkage andunequal settlement throughout the surface. This research paper centres on soil stabilisation, for which a range of engineering experimental tests, including the plastic limit, liquid, and standard proctor tests as well as to confirm the alterations made to the soil's technical qualities, tests for unconfined compressive strength and the California bearing ratio are performed.. Plastic and bottle strips are used in the research article to increase the soil sample's bearing capacity. Table 3 presents the CBR value as a function of plastic strip length.

The CBR values for various lengths, such as 2.4 cm, 5.1 cm, and 7.4 cm, suitably increase from 5.22 to 6.21 between 2.5 cm and 5 cm, then decrease from 6.21 to 5.22 between 5 cm and 7.5 cm. Finally, conclusions have been drawn from the data indicating that the soil sample's shear strength increases up to a length of 5.0 cm before declining and vice versa. The ideal length of plastic strip for subgrade preparation, according to the values of CBR for 5.1 cm, is 6.21.

Value of CBR	Strip Length (in cm)
3.33	0
5.22	2.4
6.21	5.1
5.22	7.4

(Peddaiah, 2018) He examines the impact of plastic bottles on silty sand with the use of a variety of tests, such as the compaction test, the California Bearing Ratio test, and the direct shear test. Plastic components in the percentages of 0.20%, 0.40%, 0.60%, and 0.80% were mixed with plastic waste strips of 15.0 mm by 15.0 milimetre, 15.0 mm by 25.0 milimetre, and 15.0 milimetre by 35.0 mm. Properties include the maximum dry unit weight and shear strength characteristics increase together with the amount of plastic material. According to this study, the soil sample's CBR values range from 3.2 to 7.2 for 0.20% and 3.2 percent plastic, respectively. For 0.40% plastic content, to 16.4. In this study, when the plastic percentage of naturally silty sand is 0.4%, improvements in its engineering properties are observed and the plastic strips are 15.0 mm x 15.0 mm. Finally, this study concludes that plastic waste strips have structural utility and can be used to construct subgrades.

(Tarun Kumar, 2018) He mentioned that an alternative method for stabilising soil is to use strips of different sizes manufactured of plastic.Numerous examinations, such as unsoaked California bearing ratio tests and modified proctor exams, are conducted to investigate stabilisation brought about by the effects of different mixed strips of plastic. The outcome demonstrates that the MDD of the plastic mixed soil sample declines with a rise in the amount of plastic waste strips. As the percentage of plastic waste strips falling within an optimum range increases, CBR increases as well. Research indicates that while the values of Optimal Moisture Content rise, MDD levels fall. It has been observed that the degree of CBR values of the plastic strip made of leftover plastic components increases with the proportion of soil sample.

(Abdelsalam, 2019) experimented with incorporating a small amount of High-Density Polyethylene (HDPE) into cohesive soil. The author experimented with a number of tests, including the one-dimensional consolidation test and the direct shear test. to determine the soil sample's consolidation engineering characteristics and shear strength values. The addition of 5.0%, 10.0%, 15.0%, and 0.0% of HDPE content. The values of cohesiveness and internal friction angle vary from 25 kPa and 36 ° to 44 kPa and 45 °, in that order. HDPE content varied between 0% and 15%. A modest addition of 5.0% HDPE enhances the soil sample's coefficient of permeability and compressibility.

III. Material and Methodology

A. Soil

Sandy soil is collected from the ground of Bansal Instituteof Engineering and Technology, UP, India which is used for our experiment.


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B. Plastic Waste

Bottles of cold beverages are gathered and sliced into strips. The plastic bottle strips used in this experiment can have a diameter of 1.5 mm to 4.5 mm. These strips are incorporated in varying amounts.

C. Methodology

a) Specific Gravity
b) Sieve Analysis
c) Standard Proctor
d) Direct Shear Test
e) CBR Test

IV. Result And Discussion

TABLE 1: SPECIFIC GRAVITY BY PYCNOMETER

Observation	**1**	**2**	**3**
W_1(wt. of bottle)	52 g	52g	52g
W_2(wt. of bottle + drysoil)	77.5g	72.5g	64.5g
W_3(wt. of bottle + water + soil)	172g	168.5g	163.5g
W_4(wt. of bottle + water)	156g	156g	156g

$$G_s = (W_2 – W_1) / (W_4 – W_1) – (W_3 – W_2)$$

$$G_s = 2.60$$

TABLE 2: SIEVE ANALYSIS

Sievesize (mm)	**Weight retained(g)**	**Cumulative weight retained(g)**	**Cumulative % weight retained**	**% Finer**
4.75	0	0	0	100
2.36	0	0	0	100
1.18	32	32	1.067	98.933
0.6	1124	1156	38.53	61.47
0.425	489	1645	54.83	45.17
0.3	597	2242	74.76	25.27
0.15	611	2853	95.1	4.9
0.075	120	2973	99.1	0.9
PAN	27	3000	100	0

Uniformity Coefficient = (0.584 / 0.187) = 3.122

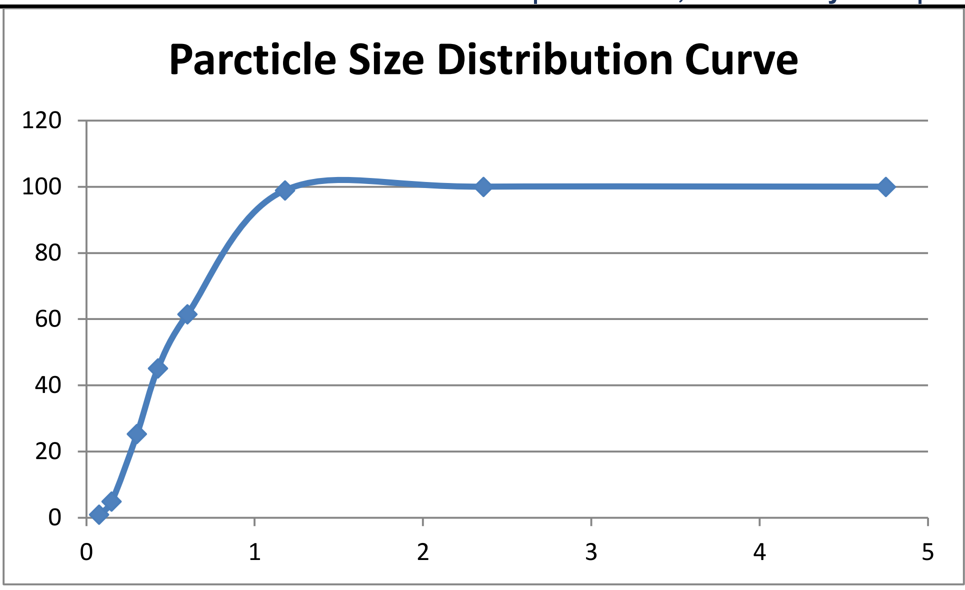


TABLE 3: STANDARD PROCTOR TEST

Volume of mould = 997.5cc

Observation	1	2	3	4	5
Mass of empty mold +base plate(g)(M_1)	3788	3788	3788	3788	3788
Mass of mold+ base plate+ compacted soil(g)(M_2)	5555	5702	5766	5840.5	5817
Mass of compactedsoil ($M=M_2-M_1$)(g)	1767	1914	1978	2052.5	2029
Bulk density ρ=M/V(g/cc)	1.771	1.91	1.982	2.057	2.034
Container no.	1	2	3	4	5
Mass of empty container + lid (g)	20.5	25.5	22	22	28
Mass of container +lid + wet soil (g)	76	80	73	80	76.5
Mass of container +lid + dry soil (g)	68	72	64	69.5	66
Water content (%)	16.84	17.20	21.42	22.10	27.6
Dry density ρ_d= (ρ/1+w)	1.515	1.629	1.632	1.684	1.594

MDD = 1.684 gram/cm^3
OMC = 22.1%

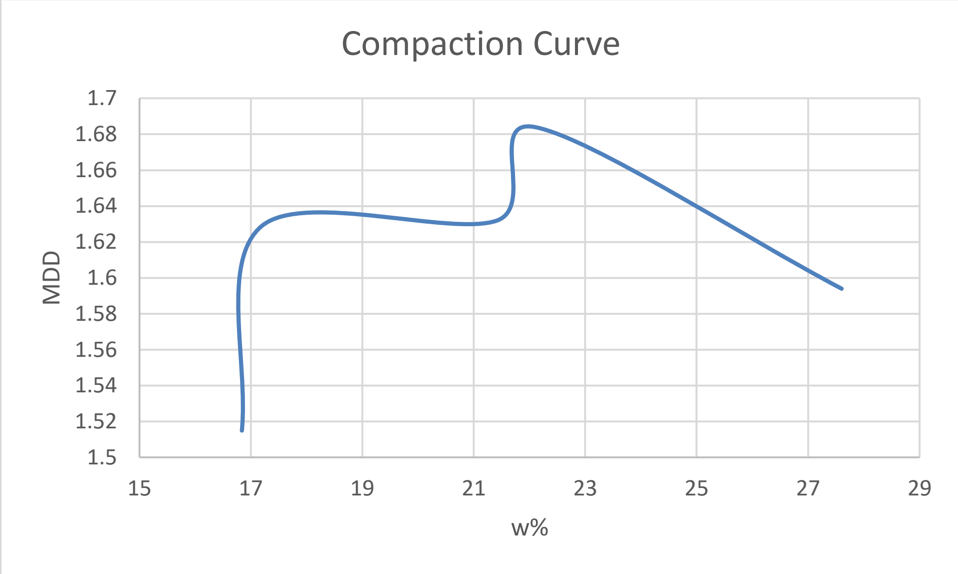
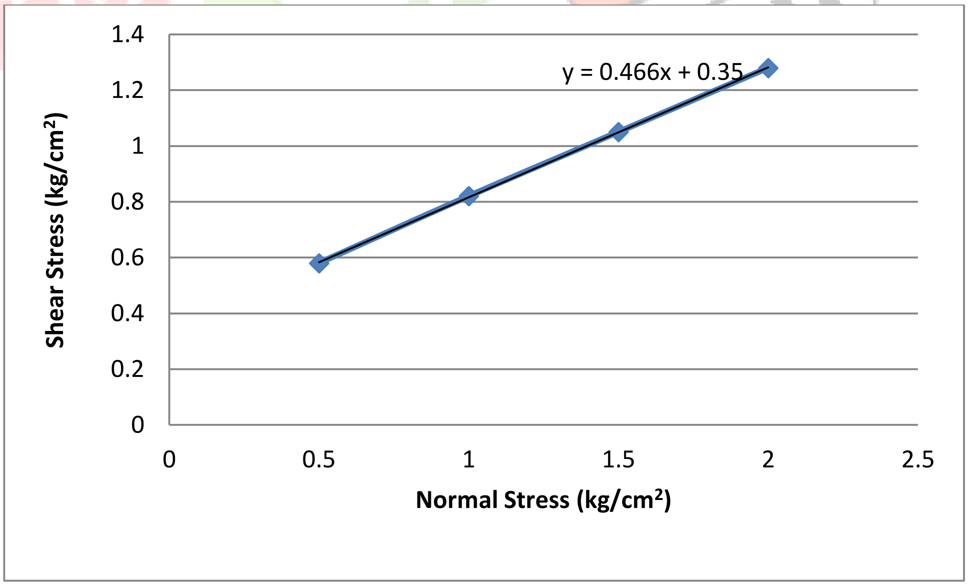


TABLE 4: DIRECT SHEAR TEST

Vol. of shear box	90 cc
MDD	1.684 gram/cm^3
OMC of soil	22.1%
Wt. of the soil to be loaded in the shear box	1.684*90 = 151.56g
Wt. of water that need to beadded	33.5g

i) Unreinforced sample

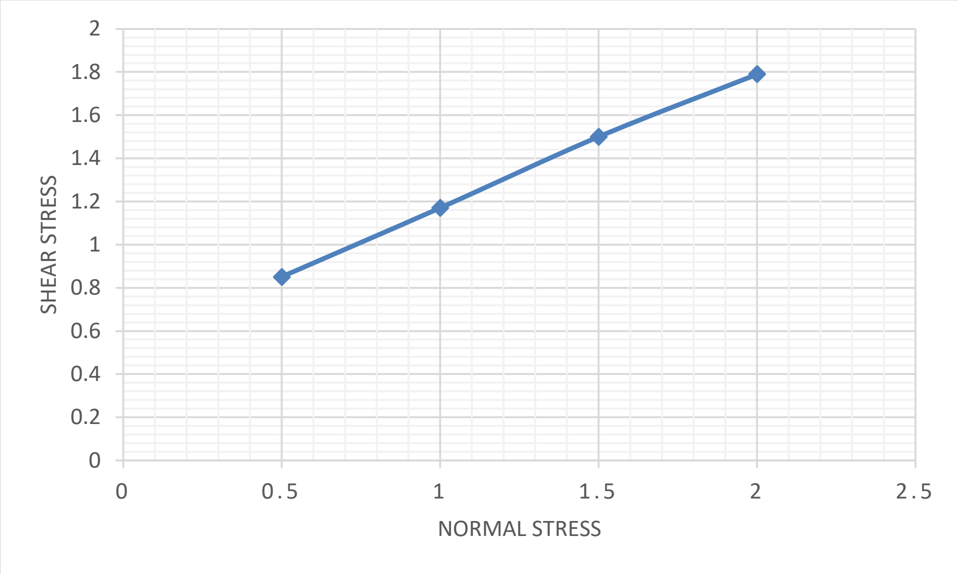
Trial no.	Normal stress (σ)	Shear Stress(kg/cm^2)
1	0.5	0.58
2	1	0.82
3	1.5	1.05
4	2	1.28



Computing from graph,
C=0.35kg/cm^2; Φ=24.985°

ii) Reinforcement = 0.25%

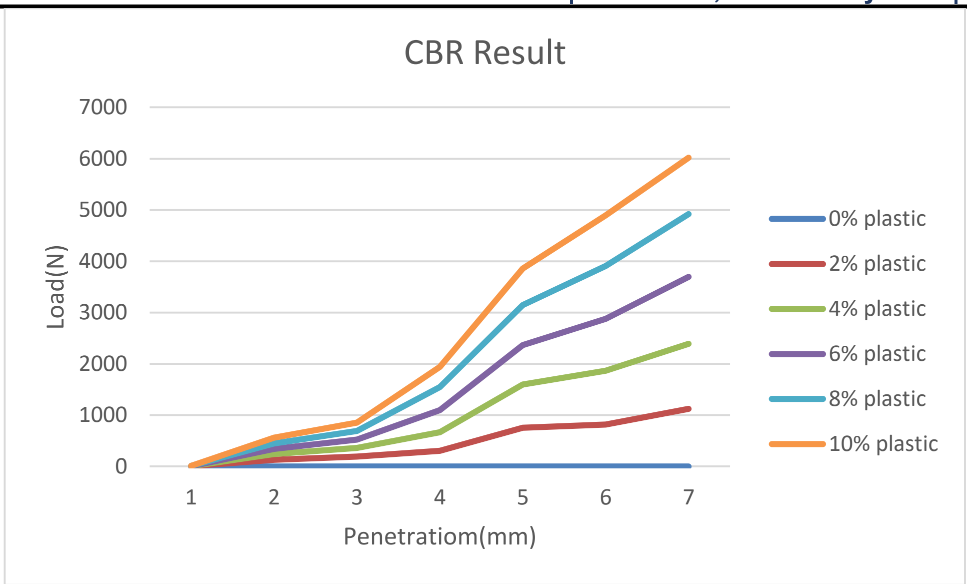
Trial no.	Normal Load(σ)	Shear Stress(kg/cm^2)
1	0.5	0.85
2	1	1.17
3	1.5	1.5
4	2	1.79



Computing from graph,
C=0.54kg/cm^2; Φ=32°

TABLE 5: CBR TEST

Penetration(mm)	0% Plastic	2% Plastic	4% Plastic	6% Plastic	8% Plastic	10% Plastic
In Newton	Load	Load	Load	Load	Load	Load
0	0	0	0	0	0	0
2.5	127.795	191.693	306.709	753.993	817.891	1124.600
5	242.811	357.827	664.536	1597.441	1865.814	2389.776
7.5	345.047	523.961	1099.041	2363.217	2875.399	3693.290
10	447.284	690.095	1546.325	3143.77	3910.543	4920.127
12.5	562.300	856.230	1942.492	3859.424	4894.568	6019.1693



V. Conclusion

From the various studies it has been formulated that the inertness of plastic materials such as HDPE, PE, LDPE, are useful in all weather conditions. Since they are non- biodegradable in nature and cost effective, they are the most favorable choice for stabilization of soil. The addition of variousplastic materials. It has been noted that the soil's engineering qualities make it appropriate for building. The California Bearing Ratio (CBR) and shear strength ratings rise as the strip length increases. Lastly, a variety of plastic materials can be utilised as a soil stabiliser for diverse soil stabilisation applications, such as pavement subgrade.

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