Soil Stabilization Using Plastic Waste as an Additive

Ankur Gupta[1], Vidit Saxena[2], Vinayak Gaur[3], Vishal Kumar[4], Tarun Kumar[5]
[1]*Assistant Professor, ABESIT, Ghaziabad, Uttar Pradesh,*
[2,3,4,5]*Student, ABESIT*

***Abstract*- Soil is the basic entity or to be more precise, it is a naturally occurring construction material which is primarily used for the foundation work. Naturally occurring soil (untreated soil) should have certain basic physical properties such as Bearing strength, Shear strength, etc. But with the advancement in the technology and modernization excessive construction has lead to the lack of good natural soil for the construction work. Poor quality soil needs to be treated with certain techniques of stabilization. But the fact being, these techniques are sometimes extremely expensive. This project serves the purpose as the alternative to these expensive stabilization techniques of soil. High Density Polyethylene(HDPE) is used as an additive in the soil to increase the physical parameters such as Bearing strength, Shear strength, etc. and to improvise the overall soil stabilization.**

1. INTRODUCTION

Soil stabilization is the process of improvising the various physical and chemical characteristics and properties of soil such as Bearing capacity, Shear strength, etc. These parameters can be achieved by adding various additives in the soil such as cement, fly ash, and other waste materials.

Stabilization of soil increases the bearing capacity, and shear strength of the soil. High Density Polyethylene is used as an additive to stabilize the soil. Properties such as Shrink well properties should be under permissible limits in order to keep the structure safe which has been built over that soil.

Plastic is a non-renewable and non-biodegradable material which can harm the environment if its use is over exploited. Therefore it becomes a primary concern to reuse and recycle this plastic waste in a useful manner. Such plastics and their derivatives should be used as an additive in the construction materials.

Although there have been a significant amount of contribution towards the soil stabilization using various kind of additives, but these additives could be of chemical class and also hazardous to the nature and environment. So it becomes a vital need to develop a more eco-friendly and economic alternate to these soil stabilization techniques.

The stabilized soils have higher resistance values for various forces and impacts and other physical or chemical parameters. These soils are more durable and has a higher durability and higher strength. These stabilized soils are a better choice for pavement construction, as their permeability is less, also it controls the shrink well properties of the soil, therefore implying lesser pavement thickness.

Several road testing are done to check if the physical characteristics such as bearing capacity, and shear strength of the material are under permissible limits.

Utilization of waste plastic has always been a matter of concern from the environment point of view, as it leads to the healthier and cleaner environment and an economical construction plan. The HDPE is added to the soil sample and various tests such as California Bearing Ratio (CBR) tests are performed to record the test values and conclude the relative increase and decline in the properties of the soil.

2. OBJECTIVE OF THE STUDY

- To improve the Bearing capacity and shear quality of the soil.
- To increase the CBR value of the soil.
- Utilization of High Density Polyethylene (HDPE) as a soil additive.
- Increase durability and strength of soil.
- To reduce the shrink well properties of the soil.

3. MATERIALS USED

- Soil: Alluvial soil sample from the northern plains of the country is taken for the study purpose (District Ghaziabad's sample).

Laboratory tests were performed on the soil sample to determine the engineering properties i.e. Atterberg limits. Laboratory tests were carried out as per relevant IS codes.

- High Density Polyethylene (HDPE): HDPE (waste plastic) sample from the furniture manufacturing unit was arranged to be added as an additive into the soil. Being a dense material with a density of 930 to 970 kg/m3 d, it is a favorable and a more economic choice for an soil stabilization additive.

4. METHODOLOGY

Tests performed on the soil sample for knowing its behavior and nature. Atterberg tests are performed on the soil sample without adding HDPE content in it. Properties such as shrinkage limit, plastic limit, and water content of the natural soil are determined. California Bearing Ratio for the varying percentages of HDPE (0%, 4%, 6%, 8%) are determined and the bearing values of the soil for 2.5mm penetration and 5.0mm penetration are recorded. A graph is plotted for plastic percentage versus CBR value. The highest value of CBR for the respective percentage of the HDPE is demonstrated as the optimum plastic percentage.

5. RESULTS & DISCUSSIONS

5.1 Alluvial soil: Alluvial soil sample was collected from the district Ghaziabad, (U.P). The sample has the Liquid limit of 27.10%, Plastic limit of 21.17%, and Plasticity index of 5.93%. This soil is found in the northern region of the country.

5.2 Atterberg's Calculations:

DETERMINATION	LIQUID LIMIT				PLASTIC LIMIT	
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 1	Trial 2
Blows/Penetration (mm)	16	22	29	33		
Container No.	45	46	47	48	49	50
Empty Wt. of container (gm)	11.70	12.70	11.35	10.90	12.50	10.82
Weight of container + Wet sample (gm)	43.63	47.26	40.51	43.90	26.44	26.14
Weight of container + Oven dry sample (gm)	35.89	39.51	34.77	37.71	23.99	23.48
Weight of water (gm)	7.74	7.75	5.74	6.19	2.45	2.66
Weight of dry sample (gm)	24.19	26.81	23.42	26.81	11.49	12.66
Moisture content (%)	32.00	28.91	24.51	23.09	21.32	21.01
					Average PL:	21.17

Table 1: Atterberg's calculations

5.3 Liquid Limit graphical representation:

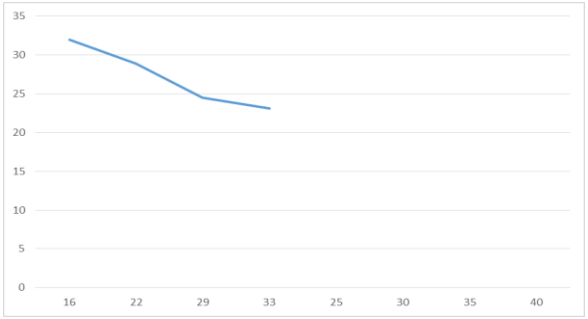

Figure 1: Liquid limit graphical representation

5.4 C.B.R Test of Soil with/without plastic content

(i). For 0% HDPE content:-

PENETRATION (mm)	0%	
	LOAD	PENETRATION READING
0.5	220.952	28.4
1	255.184	32.8
1.5	289.416	37.2
2	323.648	41.6
2.5	357.88	46
4	460.576	59.2
5	529.04	68
7.5	700.2	90
10	871.36	112
12.5	1042.52	134

Table 3: CBR penetration values for 0% HDPE content

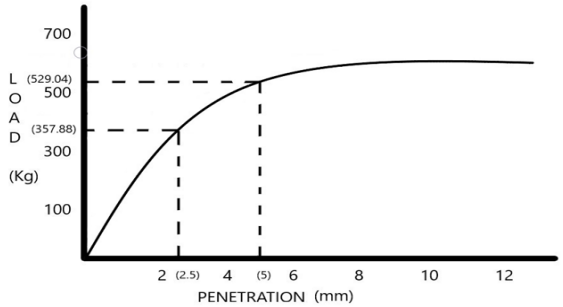

Figure 2: CBR graph for normal soil sample (0% HDPE)

(ii). For 4% HDPE content:-

PENETRATION (mm)	4%	
	LOAD	PENETRATION READING

0.5	233.38	29.99
1	272.6	35.038
1.5	311.4	40.02
2	350	44.98
2.5	389	50
4	505.4	64.96
5	583.5	75
7.5	778.75	100.096
10	974	125.192
12.5	1169.25	150.28

Table 4: CBR penetration values for 4% HDPE content

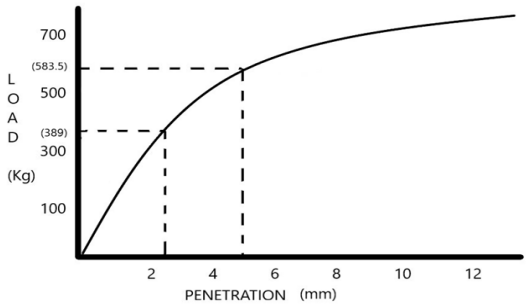

Figure 3: CBR graph for 4% HDPE

(iii). For 6% HDPE content:-

PENETRATION (mm)	6%	
	LOAD	PENETRATION READING
0.5	326.76	42
1	357.88	46
1.5	389	50
2	420.12	54
2.5	451.24	58
4	544.6	70
5	606.84	78
7.5	762.44	98
10	980.28	126
12.5	1198.12	154

Table 5: CBR penetration values for 6% HDPE content

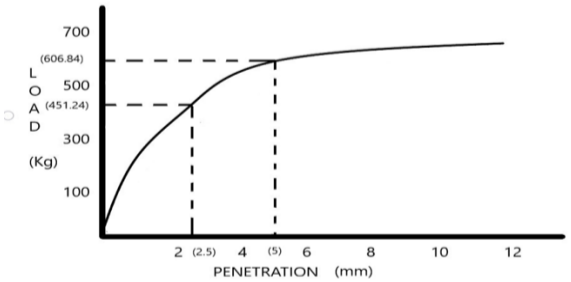

Figure 4: CBR graph for 6% HDPE

(iv). For 8% HDPE content:-

PENETRATION (mm)	8%	
	LOAD	PENETRATION
		READING
0.5	357.588	45.962
1	384.891	49.47
1.5	412.192	52.98
2	439.192	56.45
2.5	466.8	60
4	560.16	72
5	622.4	80
7.5	778	100
10	933.6	120
12.5	1089.2	140

Table 6: CBR penetration values for 8% HDPE content

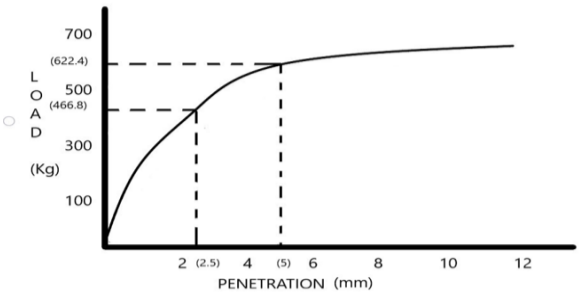

Figure 5: CBR graph for 8% HDPE

(a). For 2.5mm penetration:-

Plastic Percentage	C.B.R Value
0%	26.12
4%	28.39
6%	32.94
8%	34.07

Table 7: C.B.R value table for 2.5mm penetration

(b). For 5.0mm penetration:-

Plastic Percentage	C.B.R Value
0%	25.74
4%	28.39
6%	29.53
8%	30.29

Table 8: C.B.R value table for 5.0mm penetration

6. CONCLUSION

In our day to day life, the amount of plastic waste (HDPE) is significantly increasing, which may harm severely and has hazardous impact on our environment. The project has shown the numerical data which can draw inferences about the significant amount of reduction in plastic waste and its utilization as an alternative to the expensive construction material up to a permissible extent.

The increasing values of CBR shows the amount of improvement in the bearing capacity and the shear

strength of the soil to be used in the foundation work. The maximum value of CBR versus the amount or the percentage of the plastic used showcases the optimum percentage of the plastic used.

A general inference can be drawn from the following work, if the scale is increased the amount/volume of concrete/mortar can be replace by the HDPE, hence deducing the cost (HDPE being cheaper in cost and easily available in abundance).

REFERENCES

[1] IRC: 37-2001: (Guidelines for the design of flexible pavement).

[2] K.R Arora: Soil mechanics and foundation engineering book.

[3] IS-2720-7: Methods of test for soils.

[4] IS-2720-16: Methods of test for soil laboratory determination of CBR.

[5] Babu, G.L. Sivakumar et.al (2010). Comparison of strength of plastic mixed soil with reinforced soil. December 16–18, 2010 IGS Mumbai Chapter & IIT Bombay

[6] Choudhary A.K. et.al. (2010). CBR comparison of HDPE treated soil with other methods of stabilizing soil. Emirates Journal for Engineering Research, 15 (1), 51-57 (2010)

[7] Anas Ashraf et.al (2011). Conduction plate load tests and CBR tests for stabilization using plastic bottles.

[8] K.Geetha Manjari et.al. (2011). presented paper on 'Compressibility and permeability behaviour of plastic waste mixed Sand'. 10.1061/(ASCE)GM.1943-5622.0000392

[9] Choudhary, Jha and Gill et.al. in (2010). Potential of HDPE to convert as soil reinforcement by increasing subgrade properties. e-ISSN: 2395-0056 p-ISSN: 2395-0072

[10] Sharan Veer Singh, Mahabir Dixit. Stabilization of Soil by Using Waste Plastic Material:. ISSN(Online) : 2319-8753 ISSN (Print) : 2347-6710

[11] Achmad Fauzi et.al. in (2016). Soil Engineering Properties Improvement by Utilization of Cut Waste Plastic and Crushed Waste Glass as Additive. IACSIT International Journal of Engineering and Technology, Vol. 8, No. 1, February 2016

[12] Chebet et.al. in (2014). Laboratory investigation on re-using polyethylene (plastic) bag waste material for soil reinforcement in geotechnical engineering Civil Engineering and Urban Planning: An International Journal (CiVEJ) Vol.1, No.1, June 2014

[13] Vijay Kumar Patidar, Dr. Suneet Kaur (2016) A Review Literature on the Use of Waste Plastic to Improve Geotechnical Properties of Soil e-ISSN: 2395 -0056, p-ISSN: 2395-0072

[14] Prof. Harish C, Ashwini HM (2016) Stabilization of soil using plastic bottle strips as an additive e-ISSN:2395-0056, p-ISSN:2395-0072