

APPLICATION OF WASTE PLASTIC BOTTLE FOR THE IMPROVEMENT OF ALLUVIAL SOIL

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Abstract – In India, the stack of waste plastic bottles is increasing day by day, due to low recycling ratio. Disposal of waste plastic bottle has become one of the most serious problems. Hence, it is very important to utilize these waste materials with technical development in different fields. Due to large-scale constructional activities of roads, requirement of fill material is enormous, but available soils near construction sites may not be strong enough. Such soils need addition of some strengthening elements to increase the strength. The present study involves the stabilization of near surface alluvial clayey soils using randomly distributed waste plastic bottle at varying lengths and percentages by weight of soil. In this work, waste plastic bottles are cut into three different size of 1cm x1cm, 1cm x 2cm, & 1cm x 3cm, and mixed in different proportion of 0.25, 0.5, & 0.75 % by weight of dry soils and different compaction and strength properties have been evaluated. From the study it has been observed that with the increase in percentage of waste plastic bottle chips in cohesive soil, maximum dry density decreases whereas optimum moisture content increases. Also, there is an appreciable increase in California Bearing Ratio (CBR) values with the increase in percentage of waste plastic bottle chips in the soil up to certain limit.

Key Words: Alluvial soil¹, Waste Plastic Bottle², Optimum Moisture Content³, Maximum Dry density⁴ and CBR⁵.

1. INTRODUCTION

The population growth, industrialization, consumerism and technological development have led to uncontrollable accumulation of plastic waste. The widespread increase of single-use plastics in day to day consumer applications continues to contribute to an ever growing volume of plastic material in municipal solid waste generated across the world. These plastics are used for disposable applications and therefore reach the waste stream more quickly as their usage life is shorter than that of the plastics used in the construction or automotive industry (Azapagic et al., 2003). Landfills are thus continually being filled up by plastic material that has been used for only a short time with more than 50% of the discarded plastics coming from packaging applications, a third of which consists of plastic shopping bags (Nhamo, 2008) The bottled water is the fastest growing beverage industry in the world. According to the international bottled water association (IBWA), sales of bottled water have increased by 500 percent over the last decade and 1.5 million tons of plastic are used to bottle

water every year, unfortunately the recycling process is messy and inefficient. Plastic bottle recycling has not kept pace with the dramatic increase in virgin resin polyethylene terephthalate (PET) sales and the last imperative in the ecological triad of reduce / reuse /recycle, has emerged as the one that needs to be given prominence. The general survey shows that 1500 bottles are dumped as garbage every second. PET is reported as one of the most abundant plastics in solid urban waste(De mello et al.,2009). In 2007, it is reported a world's annual consumption of PET drink covers of approximately 10 million tons and this number grows about up to 15% every year. On the other hand, the number of recycled or returned bottles is very low (ECO PET, 2007).

2. REVIEW OF PAST WORKS

In the recent years several experimental studies have been conducted to investigate the effect of various parameters on Alluvial soil mixed with randomly distributed plastic waste strips/chips. Choudhary et.al. (2010) carried out a series of California Bearing Ratio tests on waste plastic strip(HDPE) randomly mixed with soil of varying percentage of 0.0%, 0.25%, 0.50%, 1.0%, 2.0% and 4.0% W2having a width and thickness of 12mm and 0.40mm respectively. These were cut into lengths of 12mm [Aspect Ratio (AR) =1], 24mm (AR=2) and 36mm (AR=3). From the results of CBR tests, it was concluded that the strength and deformation behavior of subgrade soils substantially improved with the inclusion of waste HDPE strips. The maximum improvement in CBR is obtained with plastic strip content and aspect ratio of 4% and 3 respectively which is 3 times that of original soil. Ashraf et.al (2011) conducted an experimental study on raw plastic bottles stabilized soil by conducting CBR and plate load tests on soil reinforced with layers of plastic bottles. They conducted soaked CBR test to determine the optimum amount of plastic strips in soil by mixing soil with varying percentages of plastic strips of 0.0%, 0.2%, 0.4%. They also conducted Plate load test on lateritic soil stabilized with full and halves plastic bottles and stabilized with optimum percentage of plastic strips. Test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil. They also found that the size and content of strips of waste plastic bottles have significant effect on the enhancement of strength of the soil. Dhattrak et al (2015) studied on various characteristic like compaction, strength and stress strain of soil and soft murum, mixed with varying percentage of randomly oriented plastic bottles strips/chips. They performed both soaked and unsoaked CBR

tests to determine the effectiveness as well as optimum percentage of plastic waste in the soil and soft murum by mixing plastic waste strips of different percentage of 0%, 0.5%, 1%, 1.5%, 2.0%, and 2.5% with soil and soft murum. From the test result, it was concluded that the strength soil can be improved by using plastic waste strips and can be used as sub grade. Sinha et al. (2015) studied the effect of stone dust reinforced with PET strips by conducting a series of CBR tests and standard proctor test. The plastic strips (PET) with width of 10mm and various length of 10mm, 20mm, and 30mm were mixed with stone dust at different percentage ranging from 0.25% to 2%. They observed that the maximum dry density of fiber mixed stone dust increases with increase of fiber content whereas optimum moisture content decreases with addition of plastic fibers. The addition of PET strips, increases the CBR value of stone dust. The reinforcement benefit increases with an increase in waste plastic strip content and length and the maximum CBR value of reinforced stone dust is approximately 2.79 times that of unreinforced stone dust. George et al. (2016) studied on the strength and drainage characteristics of soil mixed with waste plastic bottle strips. The plastic bottle strips were cut in different aspect ratio of 1, 3 & 4 and were mixed with soil sample at different percentages of 0.25%, 0.5% & 1%. They conducted California Bearing Ratio and falling head permeability. After analyzing the test results they found that on adding plastic strips into the soil, the CBR value increases and the permeability of soil decreases. The maximum CBR was obtained when plastic strips with aspect ratio of 3 have been added to the soil at a percentage of 0.5% by weight of soil.

In the present study, stabilization of near surface alluvial clayey soil has been done by using randomly distributed waste plastic bottle at varying lengths and percentages by weight of dry soil.

3. METHODOLOGY

3.1 MATERIALS USED

A. SOIL: The soil used in this study were collected from Beldanga of, Murshidabad district. The soil is classified as CI as per IS classification. The physical properties of soil are given in table 1.

Table 1: Physical properties of soil

Properties	Values
Specific Gravity(%)	2.3
Liquid Limit(%)	36.0
Plastic limit(%)	23.5
Plasticity Index	12.5
Maximum Dry Density(gm/cc)	1.68
Optimum moisture content (%)	17.0
Unsoaked CBR (%) at OMC	4.96
IS Classification	CI



Fig.1 Clayey Soil

B. PLASTIC STRIPS (PET):

Plastic waste (PET) strips used for this study were waste plastic water bottle locally known as kinley bottle. Each waste plastic were processed by cutting into small pieces of size 1cm X1cm, 1cm X 2cm, 1cm X 3cm and mixed in soil with various percentages of 0.25%, 0.5%, 0.75% by dry weight of soil.



Fig.2 Plastic waste (PET) strips

3.2 TEST PROGRAMME:

The stabilization of clayey soil has been done in the present study by using randomly distributed waste plastic bottle at varying lengths and percentages by weight of soil. In the present work, waste plastic bottles are cut into three different size of 1cm x1cm, 1cm x 2cm, & 1cm x 3cm, and mixed in different proportion of 0.25, 0.5, & 0.75 % and different compaction and strength properties have been evaluated.

In this study to investigate the effect of inclusion of waste plastic bottle on compaction and strength characteristics of cohesive soil, standard Proctor and un soaked CBR tests have been conducted for cohesive soil mixed with randomly distributed varying percentages and lengths of waste plastic bottle. All the tests were conducted as per relevant I.S. codal provision.

4. RESULT AND DISCUSSION

To study the reinforcing effects of randomly mixed PET bottle strips , a series of standard Proctor and un soaked CBR tests have been conducted for cohesive soil mixed with randomly distributed varying percentages and lengths of waste plastic bottle done for different series of cohesive soil- waste plastic bottle composite. The results of these tests are summarized in table 2.

4.1 Standard Proctor Test:

The Standard Proctor test has been conducted as per IS 2720 (Part-VII) on cohesive soil- waste plastic bottle mix composites to determine optimum moisture content (OMC) and maximum dry density (MDD). The cohesive soil is mixed with randomly distributed waste plastic bottle of varying percentages (0.25, 0.5, & 0.75 %) and sizes (1cm x 1cm, 1cm x 2cm, and 1cm x 4cm) and standard proctor test has been conducted on these mixtures. The OMC and MDD values obtained from the standard Proctor test are given in table 2 and variation of MDD and OMC with percentage of waste plastic bottle are shown in fig. 3 and 4 respectively.

Table 2 Experimental results

Mix property	% of plastic strips	OMC (%)	MDD (gm/cc)	unsoaked CBR (%)
Natural soil	0	17.0	1.68	4.96
soil + plastic strip 1cm x 1cm	0.25	16.2	1.69	6.69
	0.50	14.0	1.70	5.95
	0.75	14.0	1.67	4.54
soil + plastic strip 1cm x 2cm	0.25	16.0	1.66	3.12
	0.50	15.9	1.67	5.45
	0.75	15.5	1.65	5.30

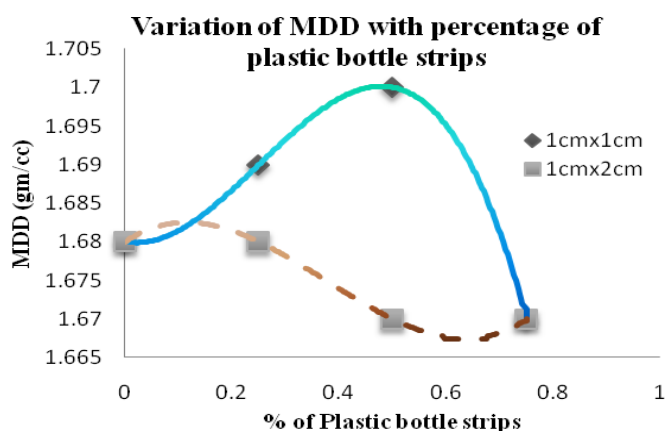


Fig 3: Variation of MDD with percentage of plastic bottle strips

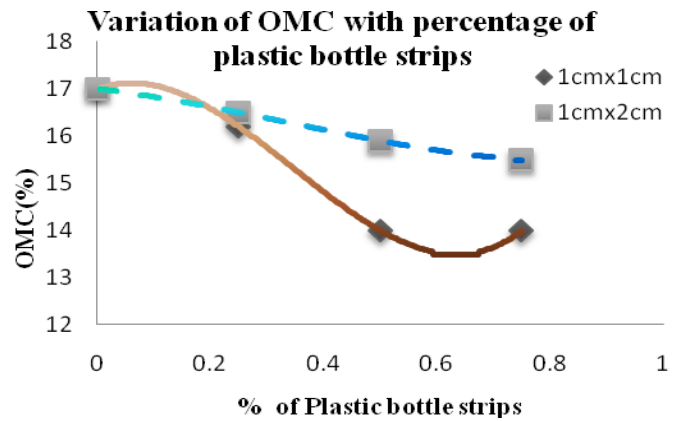


Fig 4: Variation of OMC with percentage of plastic bottle strips

From the fig. 3, it has been observed that the maximum dry density of plastic strips mix soil increases with increase of percent of plastic strips upto a certain percentage, whereas, the Optimum Moisture Content of plastic strips mix soil decreases with increase in plastic strips content in soil as shown in fig. 4.

4.2 California Bearing Ratio (CBR) Test:-

Laboratory unsoaked CBR test has been carried out on cohesive soil- waste plastic bottle mix composites as per IS-2720(PART-16),1979. The cohesive soil is mixed with randomly distributed waste plastic bottle of varying percentages (0.25, 0.5, & 0.75 %) and sizes (1cm x 1cm, 1cm x 2cm, and 1cm x 4cm) and unsoaked CBR test has been conducted on these mixtures. The CBR values obtained from Laboratory unsoaked CBR test are given in table 2 and variation of CBR with percentage of waste plastic bottle are shown in fig. 5. From the figure, it has been observed that the value California Bearing Ratio increases with increase of PET strips content and it is maximum at 0.25% of size 1cm x 1cm.

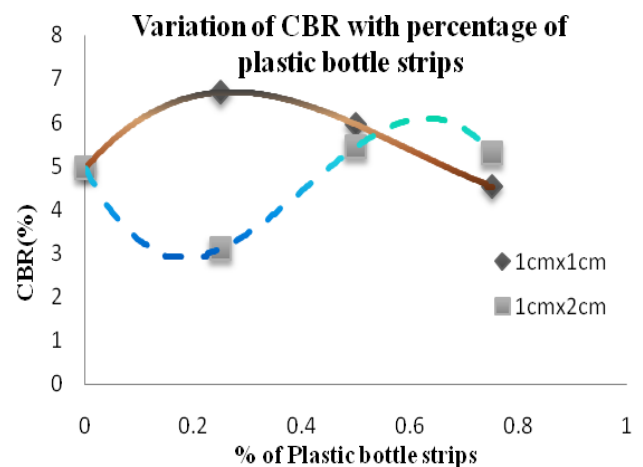


Fig 5: Variation of CBR with percentage of plastic bottle strips

3. CONCLUSIONS

On the basis of the results of experimental study made, following conclusion may be drawn-

- 1) Maximum dry density of plastic strips mix soil increases with increase of percent of plastic strips upto a certain percentage.
- 2) Optimum Moisture Content decreases with increase in plastic strips content in soil.
- 3) The value California Bearing Ratio increases with increase of PET strips content and it is maximum at 0.25% of size 1cm x 1cm.



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REFERENCES

- [1] Ashraf, A., Sunil A., Joseph, M., and Varghese, M. (2011), "Soil stabilization using raw plastic bottle" IGC December 2011.
- [2] Choudhary, A.K., Jha, J.N. and Gill, K.S. (2010), "A study on CBR behaviour of waste plastic strip reinforced soil" EJER January 2010, vol. 15, no. 1.
- [3] Dhattrak, A.I., Konmare, S.D. (2015), "Performance of randomly oriented plastic waste in flexible pavement" IJPRET March 2015, vol. 3, no. 9, p.193-202.
- [4] George, S., Damion, T., Ashique, M., Varkey, P.I., and Keerthi P., (2016) "Use of Plastic Bottle Strips as an Admixture in the Soil Sub-grade for Road Construction" International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395 -0056 Vol- 03 Issue-04, April, 2016.
- [5] IS: 2720 (Part VII) – 1980, Methods of tests for soil :Determination of water content- dry density relation using light compaction, Bureau of Indian Standards, New Delhi.
- [6] IS: 2720 (Part XVI) – 1987, Methods of tests for soil: Laboratory Determination of CBR value, Bureau of Indian Standards, New Delhi.
- [7] Sinha, A.K., and Mahali, K.P. (2015), "Utilization of Stonedust with Plastic waste for improving the subgrade in highway pavement" IJRET, June-2015, Vol.- 04 Issue-06.

BIOGRAPHIES



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