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PVC Waste Plastic Bottle Strip Used for Improvement of Engineering Properties of Clayey Soil

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Abstract. The influence of scrap plastic drinking bottles on the strength and swelling qualities of lean clay is investigated in this paper. Before use, waste plastic bottles (WPB) were cut into 4 mm strips and mixed with soil in proportions of 1, 2, 3, 4, and 5% (dry weight of soil). The prepared materials were subjected to three standard tests: Proctor test, swelling, and strength penetration test California Bering Ratio (CBR). The results of tests revealed that WPB have a substantial impact on the clay's compaction, swelling, and strength qualities.

Keywords. Plastic bottles, soil, CBR, Proctor test

1. Introduction

The expansive behaviour of clayey soils caused numerous technical challenges in structures, pavements, and slab subgrade. Locally available soil behaviour was one of the most prevalent problems that threatened the steadiness of buildings and highways. Many ways for improving expansive soils by stabilizing the soil with additives have been used. Stabilization can be accomplished in a variety of ways, including:

1.1. Mechanical Stabilization

According to research, this is the most common type of soil stabilization, as well as the cheapest and easiest. It is possible to mechanically stabilize the soil by applying dynamic force to it. Putting effort into the soil improve dry density and decreases moisture content, improving shear strength and, as a result, performance.

1.2. Chemical Stabilization

The reaction between chemical compounds and soil improve the engineering properties. The chemical likes lime, cement, sodium or calcium chloride commonly used in soil

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stabilization. Numerous waste materials, including natural and artificial fiber, fly ash, and plastic& metals residue can be used to stabilize expansive clayey soils. Recycled waste materials such as plastic & metals residue are used to stabilize expansive soils, and it is the most significant way to save resources, wealth's and reduces pollution, which is gaining popularity. These waste materials improve the soil's strength and durability. The reinforcement used in soil increase the tensile strength and also found to significantly in lessening of crack. Because of the increase in solid waste, waste disposal is one of the most difficult challenges for developing countries; therefore, must be serious debates about how to deal with this disposal issue. In this paper, plastic drinking bottles strips used by dry weight of soil as 1%, 2%, 3%, 4%, and 5% and to observe their consequence on the index properties, proctor test, and swelling characteristics of the soil.

1.3. Literature Review

In previous study many of researchers used the waste materials of increasing the engineering properties of soil. In aluminium production industries the waste were generated in large quantity, the aluminium waste used in expansive soil as additive by Mahasneh [1]. Results of different test such as unconfined shear strength, swelling and shrinkage show the improvement in its characteristics. Hainin et al. [2] examined the engineering characteristics of steel slag and its various applications in road construction. It use is less expensive in urban roads, but limited used in village roads due to more costs of transportation. Polypropylene fiber used for the improvement of the engineering properties of expansive soil by Malekzadeh and Bilsel [3]. The results of proctor, compression, tensile strength, and one-dimensional swell tests on 0%, 0.50%, and 1% fibre were discussed and concluded that the improvement in the results of all tests. Sachin and Ankit [4] investigated the impact of brick dust to solve the swelling issue. The soil is stabilized with 50% of its dry weight brick dust. A compaction test, an atterberg limit test, and linear and swelling tests were performed on both normal and stabilized soil to compare all properties. Bairagi et al. [5] study found that the expansive behaviour of clayey soil had decreased significantly. The California bearing ratio increased dramatically, as of 1.8 % to 4.1 %, and unconfined compression test results shows that it UCS value improved from 1.09 kg/cm^2 to 1.35 kg/cm^2. The use of cement bags waste in enhancement of the engineering properties of soil as reinforcement materials by Agarwal et al. [6]. The California bearing ratio test is performed on the several sample with different layer results shows that with the increase of the layer of cement bags waste CBR value increases. During the crushing of stone from industry large amount of solid waste is generated, the waste materials used by Agarwal [7] in soil as admixture to improve the properties of soil. The compaction and penetration test results shows that the improvement in the value. The CBR value increases up to 50% with the addition of stone admixture. Problematic soil properties is increased by the addition of lime by Utami [8]. The index properties of soil had increased by addition of lime and also a strength property improves.

In this paper main objective was stabilization of soil by addition of plastic waste bottles to improve the different soil properties such as compaction, CBR and swelling characteristics. The outcome shows the CBR value improves with the addition of waste plastic bottle strips while the swelling properties decrease.

2. Additive Used in Paper

2.1. Clayey Soil

Clayey soil samples were gathering from the Roorkee Campus Site. The clayey soil was collected from one meter below the top soil surface. Different properties of soil were determined, and the soil was classified according to IS Code Standard as shown in the table 1.

Table 1. Properties of the clayey soil.

S.N	Properties	Value	
1	Specificgravityg/cm^3	2.72	
2	Sieve analysis		
	Corse sand	0%	
	Fine sand	8%	
	Silt	40%	
	Clay	52%	
3	Consistency Limit [13]		
	Liquid limit(LL)%	42.66	
	Plastic limit(PL)%	18.63	
	Plasticity Index(PI) %	24.03	
4	Proctor Test		
	MDD (kN/m^3)	1.79	
	OMC (w%)	14%	
5	Soil Classification	CL	clay
6	Strength		
	CBR	2.6%	
7	Free Swelling	8%	
8	Unconfined compressive strength (UCS) (kPa)	57	

2.2. Waste Plastic Bottle (WPB)

PVC Plastic Waste bottle material is extremely light, with a specific weight of 2.7 (g/cm^3). Plastic Bottle is manufactured all over the world. PVC waste plastic bottles main property is its highly durable and resistive to deterioration. The mechanical and chemical properties of undeviating plastic strips 4 mm width and same size of length as shown in figure 1 were constant. Mixing them with clayey soil at a set percentage to enhance the properties of soil could save money and create safer and cleaner environment.

Figure 1. Preparation of stabilized material from waste plastic drinking bottle.

3. Methods

The Proctor Compaction experiment was executed in laboratory in accordance with IS-2720-PART-7-1980 [9][15] to determine the MDD and OMC of un-stabilized and stabilized soils. The swelling tests and CBR were also carried out in accordance with IS-2720-PART-16-1979 [16][17]. The specific gravity was calculated using IS-2720-PART-3-1980 [10][11], IS 2386-1 IS: 2720 (Part - IV) (1963) [12] is used for the Sieve analysis.

4. Result and Discussion

4.1. MDD and OMC Value with the Addition of Waste

Effect of waste plastic addition in soils results of MDD and OMC are show in figure 2. With the addition of PVC plastic waste materials increases the MDD but reduces the OMC.

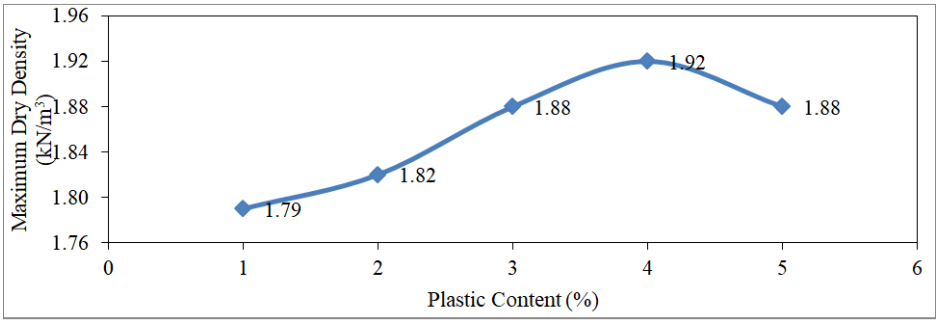

Figure 2. MDD versus plastic content.

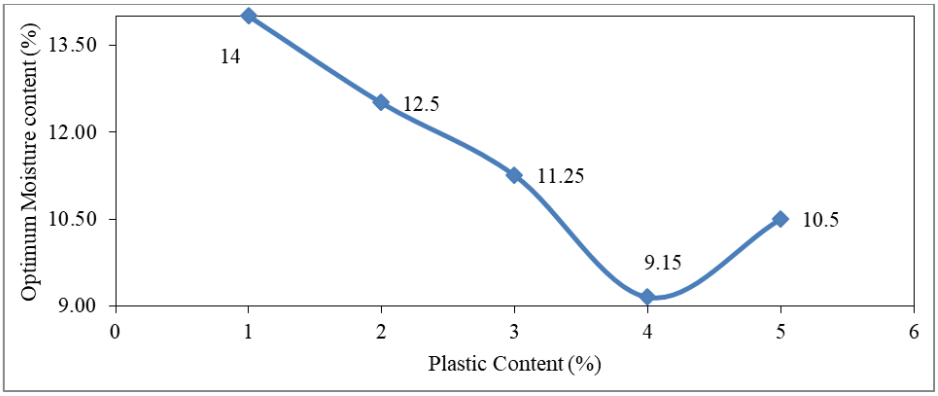

Figure 3. OMC versus plastic strip content.

The pure clayey soil with no addition of plastic waste the MDD vale is 1.79 g/cm^3, when waste was added the MDD increased upto 1.92 g/cm^3 for 4% of plastic bottle strip. This may be due to proper combination of reinforcement with soil. The moisture content (OMC) for non-reinforced soil is 14% while at the maximum density moisture content minimum, up to 9.15% shown in figure 3. Afterward, addition of more percentage the results verves means MDD decrease and OMC increases.

4.2. CBR and Swelling Characteristics

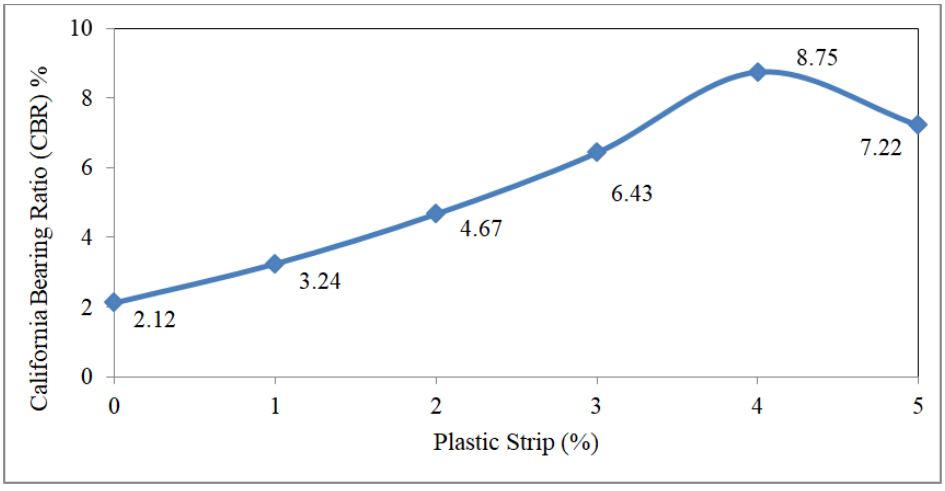

Figure 4. CBR value % versus waste plastic bottle strip.

CBR values are 2.12 percent with no waste plastic bottle strip content; however, CBR is 8.75 percent with 4% waste plastic bottle strip content and then drops to 7.22% with 5% waste plastic bottle strip waste materials, as presented in figure 4. Furthermore, the native clayey soil free swelling [14] is 4.14 percent, with massive enhancement in values observed with increased waste plastic bottle strip percentages in the mixture after 4 days of curing. The results show that adding 5% waste plastic bottle strip to the expansive soil reduces potential swelling to 2.07 percent similar types of results also

concluded by Agarwal et al. [6]. The effect of waste plastic bottle strip on free swelling is depicted in figure 5.

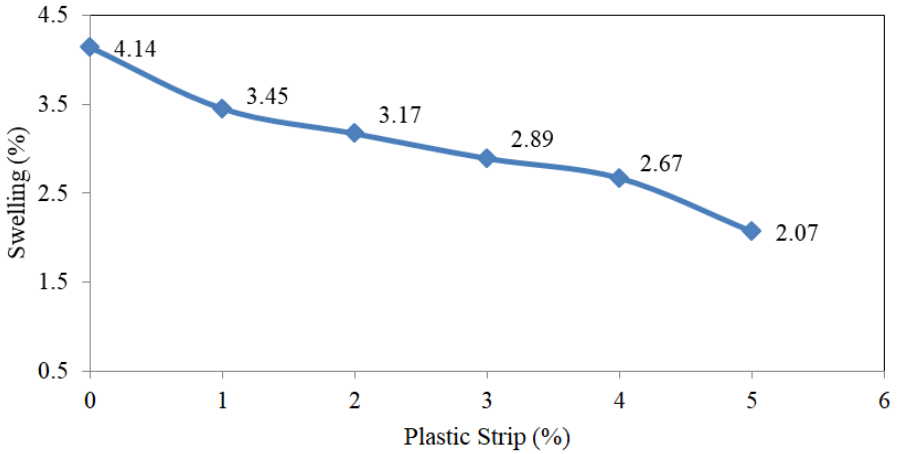

Figure 5. Swelling versus waste plastic bottle strip.

5. Conclusions

It is possible to conclude from the experimental results that addition of waste plastic bottle strip to expansive soil MDD increases, allowing for less effort to be considered during compaction and expansive soil stabilization. Because adding waste plastic bottle strip to expansive soil requires OMC, it may be recommended for specific projects with low water content to use stabilized expansive soil with waste plastic bottle strip. Stabilizing expansive soil with waste plastic bottle strip could be considered an environmentally friendly method because no manufacturing is required. Adding waste plastic bottle strip at 4% dry mass, which is considered the effective percentage of waste plastic bottle strip, could be used to achieve the best CBR improvement.

References

[1] Mahasneh BZ. Assessment of using cement, dead sea sand and oil shale in treating soft clay soil. European Journal of Scientific Research. 2015; 128(4):245-255.
[2] Hainin MR, Aziz MMA, Ali Z, Jaya RP, El-Sergany MM, Yaacob H. Steel slag as a road construction material. Jurnal Teknologi. 2015; 73(4): 33-38.
[3] Malekzadeh M, Bilsel H. Effect of polypropylene fiber on mechanical behavior of expansive soils. EJGE. 2012; 17: 55-63.
[4] Sachin NB, Ankit JP. Analysis of swelling and shrinkage properties of expansive soil using brick dust as a stabilizer. International Journal of Emerging Technology and Advanced Engineering. 2014; 4(12): 303-308.
[5] Bairagi H, Yadav R, Jain R. Effect of jute fibers on engineering characteristics of black cotton soil. International Journal of Engineering Science and Research Technology. 2014; ISSN: 2277-9655.
[6] Agarwal AK, Rajurkar V, Mokadam P. Effect of waste synthetic bag pieces on the CBR value of expansive soil. Journal of Materials and Engineering Structures. 2015; 2(1), 26-32.
[7] Agarwal N. Effect of stone dust on some geotechnical properties of soil. IOSR Journal of Mechanical and Civil Engineering. 2015; 12(1):61-64.

[8] Utami GS. Clay soil stabilization with lime effect the value CBR and swelling. ARPN Journal of Engineering and Applied Sciences. 2014; 9(10):1744-1748.
[9] Determination of water content (moisture content) IS:2720 (Part .II) 1973
[10] Determination of specific gravity of fine-grained soil IS: 2720 (Part. III) 1980 Sect/1
[11] Determination of specific gravity of fine, medium & coarse-grained soil. IS: 2720 (Part. III) 1980 Sect/2
[12] Grain size analysis IS: 2720 (Part.4) 1985.
[13] Determination of Liquid and plastic limit IS:2720 (Part.5) 1985.
[14] Determination of shrinkage factors IS: 2720 (Part. VI) 1987.
[15] Determination of water content - dry density relation using light compaction. IS: 2720 (Part. VII) 1980
[16] Determination of free swell index of soils IS: 2720 (Part. XI) 1977.
[17] Indian standard methods of test for soil part 16 laboratory determination of CBR: IS: 2720 (Part 16) – 1987.