IMPROVEMENT OF SOIL PROPERTIES USING RAW PLASTIC BOTTLES

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Abstract : Soil stabilization is the physical properties of soil in order to improve its strength, durability, or other parameters. It can be achieved by adding admixtures like cement, lime, waste material like fly ash, gypsum etc. the cost of these additives has increased in past few years; so there is need for development of other kind of soil additive such as a plastic, bamboo etc. The amount of plastic waste is growing yearly. Due to this the need of plastic waste management has increased so that it can be used as a soil stabilizer. The present study describes that the uses of waste plastic material, in the form of as a geo-cell matrix for improving the soil properties are useful because they are cheap. In this paper comparing the results of CBR value of natural soil with different percentage of waste plastic bottles used with soil and the strength of soil are increases. It is conclude that the use of waste plastic bottles to enhance properties of expansive soil is successful and beneficial.

IndexTerms **- Expansive soil, Waste plastic bottles, Waste management, Strength, CBR value.**

I. INTRODUCTION

Soil stabilization are to improve the bearing capacity of the soil, dealing with soft sub grade or clay soils is one of major problems, this situation probably might occur in roadways or highway construction or in geotechnical engineering [19]. Unstable soils creates significant problems for pavements or structures, therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure [2]. Particularly in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil [17].

Plastic waste has emerged as a major problem in rural areas and the issue of management of plastic waste will also become challenge overtime [5]. As population in India is forecasted to experience an unprecedented growth from currently 1.31 billion to 1.65 billion by 2030, the management of plastic waste in rural areas needs innovative solutions to address the challenge. There needs to be a development of plastic waste management in order to stop unsafe and hazardous methods to dispose plastic waste [6]. More than 15,000 tons of plastic waste are generated across India every day. An increasing fraction of this plastic waste is found in rural areas, as the reach of retail corporations and commercial organizations grows, and also as SMEs for plastic production increase in number. In spite of a shortage of reliable data on the volume and mix of plastic waste in rural areas, it is becoming increasingly clear that plastics are posing significant environmental and health challenges in rural communities. Plastics are disturbing local ecological balances and show up in water and land as micro-plastics [1, 16].

II. PLASTIC WASTE-

2.1 Plastic productions-

Poly (ethylene terephthalate) commonly abbreviated PET, PETE or the absolute PETP. It is a thermoplastic polymer resin of the polyester family and is used in synthetic fibers: beverage, food and other liquid container: thermoforming applications and engineering resin often in combination with glass fiber. Depending on its processing and thermal history, polyethylene terephthalate may exits both as on amorphous (transparent) and as a semi crystalline material. The semi crystalline might appear transparent (particle size < 500 mm) or opaque and white (particle size up to few micron) depending on its crystal and particle size. Its monomer can be synthesized by the etherification reaction between terephathalic acid and ethylene glycol and dimethyl terephthalate with methanol as a byproduct. Polymerization is through a polycondensation reaction of monomers with ethylene glycol as the byproduct. [5]

2.2 Plastic properties-

PET comprises of polymerized units of the monomer ethylene terephthalate with repeating $C_{10}H_8O_4$ units. There are lots of properties which are describe below-

Table 1: Properties of PET Bottles

Molecular formula	$(C_{10}H_8O_4)_n$
Density amorphous	1.370 g/ cm^3
Density crystalline	1.455 g/ cm^3
Young's modulus	2800- 3100 MPA
Tensile strength	55 -75 MPA
Elastic limit	50 -150 %
Notch test	3.6 kg/m^2
Glass temperature	75
Melting point	260

Specific heat	1.0 Kj
Water absorption	0.16

Source- A. K. vander vegt & L. E. govaert, polymeren, van ketan kunstof ISBN 90-407-2388-5

III. PREVIOUS INVESTIGATIONS

Numerous studies have been conducted by various researchers for the use of waste plastic to improve the engineering properties of weak soils.

Choudhary, Jha and Gill et al in 2010, demonstrated the potential of HDPE to convert as soil reinforcement by improving engineering properties of sub grade soil. From waste plastic HDPE strips are obtained and mixed randomly with the soil and by varying percentage of HDPE strips length and proportions a series of CBR tests were carried out on reinforced soil. There results of CBR tests proves that inclusion of strip cut from reclaimed HDPE is useful as soil reinforcement in highway application.

Raj Kumar nagle et al in 2014, In this research paper, researchers are study of comparison of test results of CBR value of soil with use of waste plastic material with different type of soil. . CBR and standard proctor tests were carried out to conclude change in index property of different type of soil samples by using optimum percentages of waste plastics. As the percentage of plastic waste in soil samples increases, the maximum dry density increases, thereby increasing the CBR value. Hence natural waste plastic material was mixed along with the soil, to increase its maximum dry density. Increase in percentage of waste plastic material resulted in increase of maximum dry density and CBR value. Hence Plastic was found to be suitable for pavement sub grade. Plastic mix with selected soil maintains the CBR value within the required range. The study after several experiments, found following significances in using Waste plastic material or strips as supporting/stabilizing agent. . The addition of reclaimed plastic waste material to local soil increases the CBR. The maximum improvement in CBR is obtained while using 1.0% plastics strips having aspect ratio 3.The CBR value at 0.25 & 0.50% plastic minimum increase.

Chebet et al in 2014, did laboratory investigations to determine the increase in shear strength and bearing capacity of locally available sand due to random mixing of strips of HDPE (high density polyethylene) material from plastic shopping bags. A visual inspection of the plastic material after tests and analysis indicates that the increased strength for the reinforced soil is due to tensile stresses mobilized in the reinforcements. The factors identified to have an influence on the efficiency of reinforcement material were the plastic properties (concentration, length, width of the strips) and the soil properties (gradation, particle size, shape).

Akshat Malhotra and Hadi Ghasemain et al in 2014, studied the effect of HDPE plastic waste on the UCS of soil. In a proportion of 1.5%, 3%, 4.5% and 6% of the weight of dry soil, HDPE plastic (40 micron) waste was added. They concluded that the UCS of black cotton soil increased on addition of plastic waste. When 4.5 % plastic waste mixed with soil strength obtained was 287.32KN/m2 which is Maximum because for natural soil it was 71.35KN/m2.

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IV. RESEARCH METHODOLOGY

Soil: The soil is collected from Ahmedpur Road, Vidisha (M.P.) and was air-dried, sieved and tested in SATI geotechnical laboratory.

Waste plastic bottles: Polyethylene terephthalate (PET) is found in disposable drinks' bottles, food jars, plastic films, etc. There are over 900,000 tones of PET produced in India annually. These waste bottles are collected from local landfills in Bhopal and Vidisha India

Preparation of material- In this research work firstly determine the basic properties of soil, like natural moisture content, wet sieve analysis, optimum moisture content, CBR value of soil, etc. Then after determining all basic properties of soil the waste plastic bottle are used as a geo cell matrix cell of plastic bottle. These individual cells were jointed together with a particular type of plastic tie wire.

Table 2 aspect ratio of plastic bottle waste

material	Aspect ratio
Plastic Bottle Waste + soil	1:1
Plastic Bottle Waste + sand filled	1:1
Plastic Bottle Waste + soil	1: .5
Plastic Bottle Waste + sand filled	1: .5

IV. RESULTS AND DISCUSSION

4.1 Index Properties of Natural Soil:

The index properties of soil are discussed below;

Table 3 engineering properties of the soil used

Soil properties	Values
Natural moisture content	9.69 %
classification	OI (Organic clay with medium compressibility)
Specific gravity	2.35
Liquid limit	39.08%
Plastic limit	28.83%

Plasticity index	10.25%
OMC	13.75%
MDD	1.85 g/cc
CBR (soaked)	4.96
Cohesion (c)	6.417 kg /cm^2
Angle of friction	0.54

4.2 Analysis of CBR Value:

The Test is performed under CBR mould, with waste plastic bottles cut into different aspect ratio (length/diameter) and the resultobtained is shown in tabular form below;

Table4 Analysis of data in tabular form

Aspect ratio (l/d)	Penetration, 2.5 mm	Penetration, 5.00 mm
Natural soil	4.96	4.25
Plastic Bottle Waste + soil filled (l/d)= .5	5.85	5.07
Plastic Bottle Waste + soil filled (l/d) = 1	6.82	6.32
Plastic Bottle Waste + sand filled (l/d) = .5	7.53	6.55
Plastic Bottle Waste + sand filled (l/d) = 1	**8.68**	**7.09**

The comparison of above CBR value is shown in graphical format below. The sand filled plastic bottle with aspect ratio of 1, has given the maximum CBR value of 8.68 at 2.5 mm. The percent increment is approx. 75% when compared with Soil.

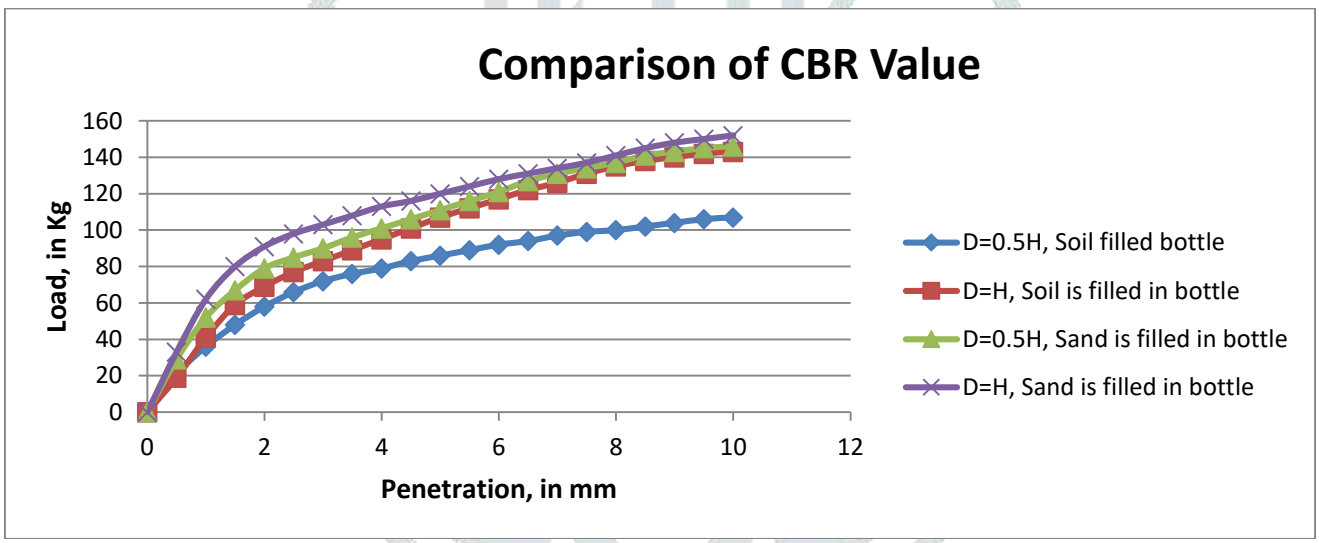

Fig.1 Analysis of CBR Value of different aspect ratio

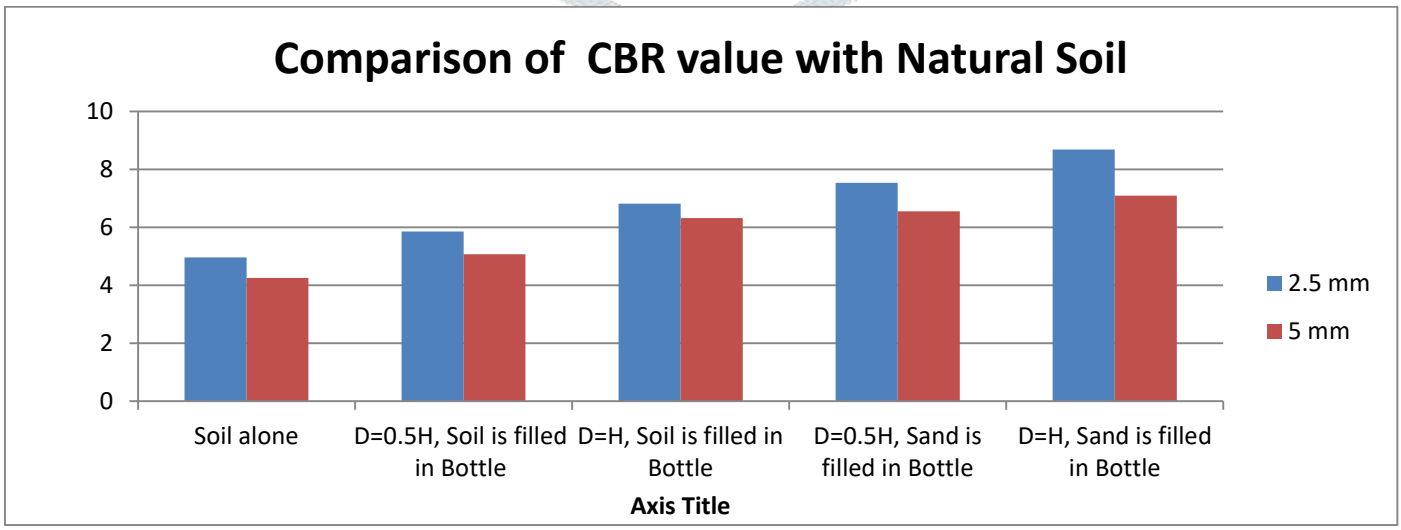

Fig.2 Comparison of CBR Value at 2.5 and 5 mm

4.3 Discussion-

On the basis of present experimental study, the following results are drawn; plastic wastes have shown effective results when mixed with Soil.

1. In this study, the CBR value of soil increases when the plastic bottles are used as geo cell matrix at different aspect ratio (l/d = 0.5, 1,).

2. The CBR value of natural soil is found 4.96 at 2.5 mm penetration and 4.25 at 5.00 mm penetration after four days soaking process.

3. When aspect ratio (l/d) = 0.5, and soil is filled in the plastic bottles, the CBR value increases with 5.85 at 2.5 mm penetration and 5.07 at 5.00 mm penetration.

4. When aspect ratio (l/d) = 1, and soil is filled in plastic bottles, then the CBR value is 6.82 at 2.5 mm penetration and 6.32 at 5 mm penetration.

5. Now, again taking aspect ratio (l/d = 0.5), and sand is filled in plastic bottles instead of soil, then CBR value increases to 7.53 at 2.5 mm penetration and 6.55 at 5 mm penetration.

6. Again take aspect ratio(l/d)= 1, and sand is filled in plastic bottles instead of soil, then CBR value is 8.68 in 2.5 mm penetration and 7.09 at 5.00 mm penetration.

V. CONCLUSIONS

On the basis of present experimental study, the following conclusions are drawn;

1. The USCS classification classified the soil as OI (Organic Clay of medium plasticity).
2. The result shows that plastic wastes have played an important role in improving the strength characteristics of expansive soil.
3. When the aspect ratio of plastic bottle is increases, the strength of soil increase.
4. When the sand is filled in bottles make as sandwich layer, at aspect ratio 1, the maximum value of CBR are recorded is 8.68.
5. The CBR value of soil increases approximately 75% when plastic bottle are used in aspect ratio 1 and sand is filled in bottles.
6. Utilization of waste plastic eliminates need of expansive borrow material and promotes cost saving through decreasing of pavement thickness. And solving waste plastic problem.
7. Result in this study gives positive indication to the possibility of using the plastic waste for soil stabilization. Successful application could help to reduce the amount of plastic waste is dispose off to landfills and contribute to sustainable development by providing low cost material to the resource intensive geotechnical industry.

Advantages-

1. It improves the strength of the soil, thus, increasing the soil bearing capacity.
2. It is beneficial in both terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.
3. It is also used to provide more stability to the soil in slopes or other such places.
4. Soil stabilization is also used to prevent soil erosion, the use of waste plastic bottles may give satisfactorily results.
5. Stabilization is also done for reduction of rutting and unevenness of pavement surface.

VI. FUTURE SCOPE

Following works can be recommended for future study on this research work;

- The present study is limited up to two aspect ratio of plastic bottle only due to limited time, further the variation in aspect ratio can be increased or decreases.
- The plastic waste can also be used with other traditional stabilizer such as lime, cement for more improvement of soil.
- The Aspect ratio of plastic waste can also change and their effect can be investigated.
- A Comparison of plastic waste with other waste material which can be used as a stabilizer.

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