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UTILISATION OF WASTE BOTTLE PLASTIC STRIPS AND LIME AS A SOIL STABILIZER IN CONSTRUCTION OF FLEXIBLE PAVEMENTS

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Abstract: The design of the flexible pavement layers to be laid over the sub grade soil so the estimation of subgrade strength and traffic volume to be carried. The design of the various layers of pavement are dependent on the sub grade soil strength over which they are going to be laid. Sub grade strength is expressed in the terms of CBR value. weaker sub grade causes high amount of failures on surface of Flexible Pavement like Pot holes, various types of cracks and rut depth which is supposed to reduce ride quality of vehicles

In this study, we are making the use of solid waste is used in the construction of pavements and reducing the waste for land fill and making utilization of raw material in the embankments of pavements and also making the soil improvement by stabilisation process. Therefore, the present study will focus on literature work related to the field of soil improvement and solid waste related problems. Here an attempt has been made to lime stabilisation of black cotton (BC) soil with various percentage i.e 0%, 2%, 4%, 6% of waste Plastic bottle strips and study the engineering properties of soils MDD, OMC, Compaction, including CBR at different percentages plastic strips

Keywords : Flexible Pavement, Sub Grade, Stabilisation, BC Soil, Lime, Plastic Strips, CBR.

1. INTRODUCTION

waste management is still a challenge in Worldwide which is brought about by urbanization, increase population and industrial growth. The methods of disposing of solid wastes are in landfill, recycling and incineration. However, landfill spaces are reducing, incineration process emits hazardous gases, and recycling seem to be expensive and laborious.

The current sustainable approach is to reduce, recycle and reuse. where it does not address properly the total waste which pollutes the nature and environment.

There are several products which are manufactured from plastic according to growth of usage of plastic products these plastic products classifies in to plastic as follow:

1. Polyethylene Terephthalate (PET),
2. High-Density Polyethylene (HDPE),
3. Polyvinyl Chloride (PVC),
4. Low-Density Polyethylene (LDPE),
5. Polypropylene (PP),
6. Polystyrene (PS), and
7. Others (like polyester, polyamides, and polycarbonate).

various use of plastic are packaging, furniture, automotive, agriculture, sport, electrical and electronics goods, health and safety, building and construction, and consumer and household appliances which Increase the uasge plastic products which makes increase in plastic waste, It has became a challenge to waste management authorities.

1.1 SUBGRADE

The crust of a pavement, whether flexible or rigid, rests on a foundation of the soil on an embankment or cutting, normally known as subgrade. Subgrade can be defined as a compacted layer, generally constructed with the avalibility of local material near to the project, assumed to be 500 or 300 mm in thickness, just beneath the pavement crust, providing a suitable foundation for the pavement. The subgrade in embankment is compacted in two or more layers based on the stability of foundation, usually to a higher standard than the lower part of the embankment .The soil in subgrade is normally stressed to certain minimum level of stresses due to the traffic loads and the subgrade soil should be of good quality and appropriately compacted so as to utilize its full strength to withstand the stresses due to traffic loads. This leads to reduce of the overall pavement thickness. On the other hand the subgrade soil is characterized for its strength for the purpose of analysis and design of pavement.

1.3 SUBGRADE PERFORMANCE

Subgrade performance mainly depends on three of the basic characteristics, which are described as follows:

1. Load bearing capacity: The load carried by the surface of the pavements which are supposed to transfer load to the lower subgrade foundation of the pavement
2. Moisture content: Moisture is supposed to affect subgrade properties such as load bearing capacity, shrinkage and swelling. It also influence the drainage, groundwater table elevation, rain water infiltration, Generally, excessively wet subgrades will deform excessively due to load.
3. Shrinkage and/or swelling: Some of the soils shrink or swell depending up on their moisture content. Due to high

amount fine content gets react with moisture content will tend to deform and crack any pavement type constructed over them.

1.2 DESIRABLE PROPERTIES

The desirable properties of subgrade soil as a highway material are

- Stability
- Compaction
- Strength
- Low change in volume during adverse conditions of weather and ground water table
- Proper drainage
- Incompressibility

The most common parameter used to evaluate pavement layer strength is the California Bearing Ratio (CBR). The CBR value is influenced by the water content and the dry density as well as the texture of the soil. Generally, the CBR test in the laboratory is conducted on test samples prepared at the dry density and water content likely to be achieved in the field. Whereas the Field dry density can be fairly well predicted the difficulty is to determine the stable moisture content at which to conduct the test.

1.4 RESEARCH OBJECTIVES

The main objective of the research was to determine the engineering properties of soil which is reinforced with waste bottle plastic strips and to achieve the goals which are given below

- To know the discuss environmental impact when soil is reinforced with waste bottle plastic strips.
- To improve shear strength and reduce the compressibility of soil
- To improve load carrying capacity of soil
- Using plastic strips and lime as a stabilizer which increases shear, tensile strength and CBR value of the soil.

2. LITERATURE REVIEW

In this chapter looks at previous journals of different researchers on this subject matter. It presents an overview of plastics, PET, fibre-reinforced soil, and case studies of fibre-reinforced soils. More over here it was discussed that behavior of soil-waste bottle plastic strips composite and potential applications of soil reinforced with waste bottle plastic strips in pavement construction. Lastly, a summary and conclusions discussed in this chapter are listed.

2.1 PLASTICS.

Plastics are resins or polymers that have been synthesised from petroleum or natural gas derivatives (EPA 1990). The term „plastics" encompasses a wide variety of resins each offering unique properties and functions. In addition, the properties of each resin can be modified by additives (EPA 1990). Different combinations of resins and additives have allowed the creation of a wide range of products meeting a wide variety of specifications (Randall 1991; EPA 1990).

Polymers are chemically inert large molecules made up of repeating chemical units (monomers) that bind together to form long chains or polymers (Crawford 2007, EC 2011). Polymers are pure materials formed by the process of polymerisation, though cannot be used on their own, but additives are added to form plastics (Crawford 2007). These additives include: antistatic agents, coupling agents, fillers, flame retardants, lubricants, pigments, plasticisers, reinforcements, and stabilisers (Harper 2006). Pure polymer may include silk, bitumen, wool, shellac, leather, rubber, wood, cotton and cellulose (Crawford 2007, Stephen 2009).

Figure 3.1: WASTE BOTTLE PLASTIC

- Design flexibility – plastics can be modified for a wide variety of end uses.
- High resistance to corrosion,
- Low weight, and
- Shatter resistance.

2.2 CATEGORIES OF PLASTIC

The Plastic Industry Trade Association (SPI), identifies plastic into seven (7) broad categories

Figure 3.2: Plastic Identification Code

2.3 Applications Of Plastic In Civil Engineering Field

Plastic is mainly use used in several applications In the civil engineering field, plastic is used as components in the construction of bridges, buildings, roads and highways, ports and terminals, railroads, landscaping, landfills, water retaining structures; etc. Now a days plastic is used in the in the construction of flexible pavements by preparing modified bitumen and in the manufacture rail with plastic instead of iron metal

- Plastics are very strong

- Plastics are durable, by withstand to varous weather condition.
- Plastics are easy to install and move around.
- Plastics promote energy efficiency in buildings since they are low conductors of heat, and can achieve a tight seal.
- Plastic products have low maintenance cost and do not need painting.
- Plastic building products can be recycled with low energy input and can as well be turned into energy.

Constructing using plastic products is cost effective since plastic is durable, of good quality, have low maintenance cost and saves labour.

V. Mallikarjuna1, T. Bindu Mani2 has made the present study, the improved CBR value of the soil is due to the addition of plastic strips. Plastic can be utilized as one of the material that can be used as a soil stabilizing agent but the proper proportion of plastic must be there, which helps in increasing the CBR of the soil. It can be concluded that CBR percentage goes on increasing up to 4% plastic content in the soil and thereon it decreases with increase in plastic content. Hence, we can say that 4% plastic content is the optimum content of plastic waste in the soil.

Maha Hatem Nsaif (2013) [10] This paper describes an experimental study on mixing plastic waste pieces with two types of soil (clayey soil and sandy soil) at different mixing ratios (0, 2, 4, 6, 8)% by weight respectively. For the two types of soils, the shear strength parameters (cohesion value and angle of internal friction) of reinforced and unreinforced samples were investigated by the direct shear test. In addition, a series of compaction tests were performed on clayey soil mixed with different percentages of waste pieces. It was found that, there is significant improvement in the strength of soils due to increase in internal friction. The percentage of increase in the angle of internal friction for sandy soil is slightly more than that in clayey soil, but there is no significant increase in cohesion for the two types of soils. Also, it was concluded that the plastic pieces decreases the maximum dry density

Amit Gawande et al., (2012) [11] in the present paper developed techniques to use plastic waste for construction purpose of roads and flexible pavements has reviewed. In conventional road making process bitumen is used as binder. Such bitumen can be modified with waste plastic pieces and bitumen mix is made which can be used as a top layer coat of flexible pavement. The waste plastic which is modified with bitumen mix shows better binding property, stability, density and more resistant to water.

Mariamma Joseph et al., (2011) [12] this project involves the detailed study on the possible use of waste plastic bottles for soil stabilisation. The analysis was done by conducting plate load tests on soil reinforced with layers of plastic bottles filled with sand and bottles cut to halves placed at middle and one third positions of tank. The comparison of test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil. The optimum percentage of plastic strips in soil was found out by California Bearing Ratio Test and using this percentage of plastic, plate load test was also performed. The size and content of strips of waste plastic bottles have significant effect on the enhancement of strength of the soil.

Brajesh Mishra has made his study on the basis of study and experimental investigations it was observed that the property of black cotton soil effectively improved by use of different percentage of lime contents. In this research varying percentage (3% and 5%) of lime was used to stabilize the black cotton soil. Points which were drawn from this study are listed below- It was observed that on addition of 3% of lime decreases the liquid limit by 2.70% while with 5% addition of lime reflects a decrease 15.27%. M.D.D. was increased slightly by 6.29% and 5.59% at 3% and 5% lime content respectively. It was observed that there was a decrease in O.M.C. of 3.4% and 10.7% at 3% and at 5% lime content. respectively. The C.B.R. value of black cotton soil improve considerably to 3.25 times and 4.76 times with 3% and 5% lime respectively.

3. MATERIALS AND METHODOLOGY

A variety of materials are used in geotechnical engineering field. Properties of these materials differ from place to place. Complete categorization of these materials in terms of their vital properties will be very much useful in understanding soil response to changes in stress levels and varying environmental conditions. Furthermore, it is a thorough understanding of material properties which are extremely much essential for developing appropriate stabilization methods. The engineering properties evaluated are:

- compaction
- CBR

3.1 THE MATERIALS USED

- B.C soil
- Lime
- WASTE BOTTLE PLASTIC STRIPS
- water

3.1.1 Black Cotton Soil

The tracks of expansive black cotton soil covers 20 percent of Land mass. India has large tracks of expansive soil known as Black cotton soil. This soil contains predominant montmorillonite clay mineral and lime segregation. The Black cotton soil has a potential for shrinking or swelling under changing moisture conditions. The primary problem that arises with regard to expansive soils is swelling and compressibility and avaliblity of high amount fine material. The deformation usually is in an uneven pattern and of such a magnitude as to cause extensive damage to the structures resting on them. The soils are usually found near surface, with the layers thickness varying from 0.5mts to more than 10mts. These soils cover vast area of Maharashtra, Karnataka,

Andhra Pradesh and Gujarat making 20% of the total area of the country. Similarly soils are also found in Burma, Australia, South Africa, Egypt and U.S. and Russia. Black cotton soils are highly expansive, sticky, plastic clays formed from residual weathering of deposits derived from volcanic rocks. Most expansive soils have residual origin while some are found valleys and on river banks, apparently formed from fine grained transported deposits.

Table 3.1 Physical Properties of Black Cotton Soil

Description	Values
In-situ field dry density in KN/M³	12.26
Specific gravity	2.62
Sieve analysis %	90% passing 75 micron sieve
Optimum moisture content %	24.02
Maximum dry density in KN/M³	16.28
Liquid limit %	67
Plastic limit %	35.36
Plasticity index %	31.62
Shrinkage limit %	13.71
Classification of soil	CH

3.1.2 Lime

Lime in the form of quicklime (calcium oxide – CaO), hydrated lime (calcium hydroxide – Ca $[OH]_2$), or lime slurry can be used to treat soils. Quicklime is manufactured through chemically transforming calcium carbonate (limestone – $CaCO_3$) into calcium oxide. Hydrated lime is formed when quicklime chemically reacts with water. It is hydrated lime that reacts with clay particles and permanently transforms them into a strong cementitious matrix One of the main properties of lime is its pozzolanic reactivity The pozzolanic reactivity of lime is due to reactive silica content. The strength increase depends mainly on its reactive silica content, and the adding of lime can improve this strength only up to a certain degree. The low permeability of the expansive soil is mainly due to the finer particles. therefore by the addition of lime the smaller soil particles grow to larger one and voids also become larger in size leading to the greater permeability of the lime stabilized expansive soil.

3.1.3 Waste Bottle Plastic Strips (PET)

Figure 3.3 WATER BOTTLES

Plastic waste strips of the type of Polyethylene Terephthalate (PET) were used as a reinforcing material in the black cotton soil for the present investigation. These were obtained from Kaytech factory located in Atlantis, The PET waste bottle plastic strips were of assorted colours and their sizes ranged between less than 5mm to greater than 1.18mm. The physical properties of the waste plastic strips.

Figure 3.3 Plastic strips

Table 3.3 Physical And Chemical Properties Of Plastic Strips

Appearance	Strip or fiber
Odour	Odorless to mild
Specific Gravity	1.25-1.55
Vapor Pressure (mm of mercury)	< 0.1
pH	Not Applicable-Solid

3.1.4 Water

Purified tap Water which free acids and de-ionised water or portable water is used which is available in the laboratory

3.2 TEST

The tests are conducted in the laboratory of various experiments conducted as follows.

- STANDARD PROCTOR TEST (COMPACTION TEST)
- CBR TEST

Table 4.2: CBR Values of various types of various soil

Type of soil	Plasticity	Range of CBR (%) values
Clay	CH	1.5 to 2.5
	CI	1.5 TO 3.5
Silty clay	CL	2.5 to 6
Sandy clay	PI = 20	2.5 to 8
	PI = 10	2.5 to 8 or more
Silt		1 to 2
Sand	poorly graded	20
Sand	well graded	40
Sandy gravel	well graded	60

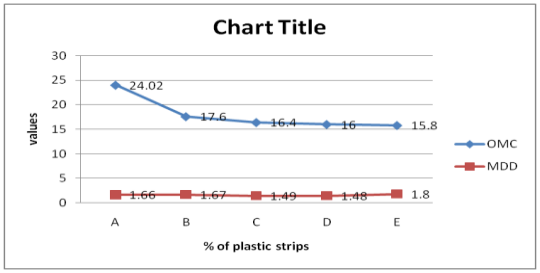
4. RESULTS AND DISCUSSIONS

4.2 Determination of Compaction Characteristics

The tests were conducted on Compaction characteristics on BC soil. The effect of PLASTIC STRIPS on lime treated BC soil on the compaction characteristics were studied. The results and discussions are presented in the following sections.

Table 4.1: Compaction characteristics of Black Cotton Soil with optimum percentage of Lime mixture treated with various percentages of PLASTIC STRIPS

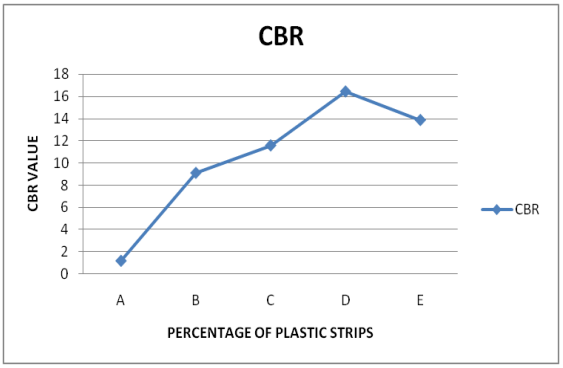
	Description	OMC%	MDD g/cc
A	BC Soil	24.02	1.66
B	BC Soil+5%Lime	17.6	1.67
C	BC Soil+5%Lime+2%PLASTIC STRIPS	16.40	1.49
D	BC Soil+5%Lime+4%PLASTIC STRIPS	16.00	1.48
E	BC Soil+5%Lime+6%PLASTIC STRIPS	15.80	1.80



GRAPH .1 :OMC & MDD of BC soil with plastic strips

Table 4.2: CBR VALUE Of Black Cotton Soil WITH LIME AND PLASTIC STRIPS

	Samples	CBR VALUES
A	BC Soil	1.19
B	BC Soil+5%Lime	9.11 %
C	BC Soil+5%Lime+2%PLASTIC STRIPS	11.58 %
D	BC Soil+5%Lime+4%PLASTIC STRIPS	16.44 %
E	BC Soil+5%Lime+6%PLASTIC STRIPS	13.87 %



GRAPH.2 :CBR values of soil with various % of plastic strips

CONCLUSION

In this study, the CBR value of the Black cotton soil is improved with addition optimum content of lime and waste bottle plastic strips in it. Now we can make use of plastic as soil stabilising agent for improving the properties expandable soils with proper proportion of plastic strips must be there, which helps in increasing the CBR of the soil. It can be concluded that CBR percentage of black cotton soil goes on increasing up to 4% plastic content in the soil and there on it decreases with increase in plastic content. Hence, we can say that 4% plastic and 5 % lime content is the optimum content of stabilizers used in stabilisation of the BC soil.

5.2 Future Scope

In future study test can be carried on black cotton soil or on different types of soil. The lime can be replaced by cement, marble polish waste Fly ash, sand and quarry dust. plastic can be replaced by waste plastic powder, polythene covers. From the above materials, different proportions and combinations can be made which can be used for

construction of subgrade and pavements. Few future studies are summarized below

- Several efforts to be made for the effective use of waste plastic to reduce the cost of construction and operation.
- Field application of this method has to be done by various construction techniques.
- Effective use of waste bottle plastic strips on strengthening of other types of soils.

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