APPLICATIONS OF PLASTIC WASTE MATERIAL (STRAWS) IN IMPROVING STRENGTH PROPERTIES OF BLACK COTTON SOIL

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Abstract: Large scale construction of roads, bridges, dams, irrigation schemes, and residential buildings demand optimum and efficient use of construction resources. Black Cotton Soil near construction site is highly expansive and it exhibits swelling and shrinkage when it subjected to changes in the moisture content this cyclic swelling and shrinkage of soil subjected to distress under moisture variations and these cause severe failures. Hence it needs addition of some strengthening elements to increase the strength and to reduce the compressibility of black cotton soil. Soil stabilization is a process that improves physical soil characters such as increased shear resistance, load capacity etc can be done by compacting or adding appropriate additives such as cement, lime, etc. The cost of introducing these additives has increased in recent years, On the other hand, the quantity of plastic waste used are increasing everywhere in an unprecedented rate Hence we are using plastic(Straws) as Stabilizer to improve the engineering properties of black cotton soil. The tests such as standard proctor compaction test, California bearing ratio (CBR) test and unconfined compressive strength (UCS) have been conducted on soil and plastic straws mixture to check the improvement in the properties of black cotton soil. From the test results, it was observed that with the increase in percentage and length of plastic straws in black cotton soil, maximum dry density decreases whereas optimum moisture content decreases in both cases. Further, the strength values increases with increase in percentage of waste milk plastic packets and then decreases with further addition of it. CBR value is maximum for 1.0 cm size and 0.4% of plastic straws. UCS value (qu) is maximum at 0.4% for same size of plastic straws mixed.

Keywords: Black Cotton Soil, Plastic Straws, CBR, UCS, MDD, OMC

1. INTRODUCTION

Soil is a most essential component of the earth's ecosystem. In INDIA, soils are classified into six group's namely alluvial soil, black soil, red soil, laterite soil, mountain soil and desert soil. India has large tracks of expansive soil known as Black Cotton soil (BC soil), covering an area of 0.8 million square kilometer, which is about 20% of total land area. For engineering consideration's, black cotton soil is one of the challenging material for construction purpose, which will not easily get stabilized due to its high potential of shrinking and swelling as an effect of change in moisture content. It will minimize the stability and shear strength of black cotton soil when compared to other types of soil. On the other hand, the quantity of plastic waste used are increasing everywhere in an unprecedented rate.. The disposed or stored plastic waste pollutes the soil mass and causes health problems. As a result efforts have been made all over the world in last two decades to consume them in construction for dual purpose of cost effective construction and eliminating of the problem of storage and other environment problem associated with these materials. Soil stabilization is a process that improves physical soil characters such as increased shear resistance; load carrying capacity etc. can be done by compacting or adding appropriate additives such as cement, lime, and waste materials such as ashes flying, foci, etc. The cost of introducing these additives has increased in recent years, the plastic waste material is serious problem to disposal to the outside so this plastic waste material(plastic straws and packets) are used as additive in the black cotton soil. The use of plastic as a stabilizer reduces the problem of plastic disposal as well as increases the density and increases the proportion of California Bearing (CBR) soils in an economical way. Arindam Saha, Bikash Chandra Chattopadhyay, Joyanta Maity et.al. **(2017)** presents the stabilization of clayey soil using randomly distributed waste plastic bags (Metro Diary Milk Packets) at varying size (1cmx1cm, 1cmx2cm, 1cmx4cm) & percentages (0.2%, 0.5%, 1%,1.5%) by weight of clayey soil. Compaction tests, CBR tests and UCS tests were conducted to investigate the behavior of clayey soil mixed with waste milk plastic packets. From the test results, it was observed that with the increase in percentage and length of waste milk plastic packets in clayey soil, maximum dry density decreases whereas optimum moisture content increases in both cases. Harish and Ashwini, H.M. (2016) studied the effect of plastic bottles strips as a stabilizer for two soil samples, red soil and black cotton soil. They observed an increase in the strength of soil and bearing ratio of 2.9 for red soil and 3.3 for the black cotton soil by mixing 0.7 % of waste plastic strips to red soil and 0.5 % for the black cotton soil. Jasmin Varghese Kalliyath et.al. (2016) studied the effect of plastic fibers. The test results also showed that with 1% replacement, MDD and UCC were less than the 0.5 % replacement but greater than the untreated soil. Further increase in the plastic replacement showed decrease in the MDD and the UCS. Subhash, K. et.al. (2016) conducted experimental study on soil stabilization using glass and plastic granules mixed with varying percentage. Akshat Malhotra et.al. (2014) demonstrated the potential of HDPE plastic waste on the UCS of soil. When 4.5 % plastic waste was added, 287.32 KN/m2 soil strength of the soil was obtained

which was more than untreated soil. Mercy Joseph Poweth et al. (2014) investigated the effect of plastic granules on weak soil sample with plastic and without plastic granules in varying percentage. S.W. Thakare and S. K. Sonule, (2013) carried out various laboratory tests to investigate the effect of reinforcement of sandy soil with model plastic water bottle through model plate load tests. The use of plastic bottles as reinforcement was recommended to reduce the quantity of plastic waste which creates the disposal problems. Bala Ramudu Paramkusam et.al. (2013) performed an experimental study to investigate the stabilization effect of waste plastic on dry density and CBR behavior of red mud, fly ash and red mud, fly ash mixed with different percentage of waste plastic (PET) content. Choudhary et.al. (2010) performed a laboratory evaluation on utilization of plastic wastes for improving the subgrade in flexible pavement. The study reveals that addition of waste plastic strip of appropriate size and proportions in soil result in increase in both CBR value and secant modules of soil.

2. MATERIALS

2.1 Soil:

Black Cotton Soil used in this investigation was collected from sriparru, near kaikaluru, West Godavari District, Andhra Pradesh and their Geotechnical Characteristics were listed below in table.1

2.2 Waste Plastic straws:

The plastic waste material like straws is collected from the plastic traders in eluru. Theses straws are generally used for the drinking purpose juices and coconut shops. Mostly maximum straws are used in now a day's coconut shops. These straws are generally made of polypropylene plastic.

3. METHODOLOGY

To study the effect of inclusion of waste plastic straws with varying percentages and lengths on compaction and strength characteristics and strength parameter of clayey soil, standard proctor tests, un-soaked cbr tests and unconfined compressive strength test have conducted as per relevant I.S. codal provision.

Table: 1 Geotechnical Characteristics of Black Cotton Soil

S.No	Laboratory Test	Result
1	Specific Gravity	2.71
2	**Grain size Analysis**	
	Gravel (%)	0
	Sand(%)	15
	Fines (%)	85
3	Atterberg Limits	
	Liquid Limit, LL (%)	61.98
	Plastic Limit, PL (%)	31.09
	Plasticity Index, PI (%)	30.89
4	Undrained Cohesive Strength (kg/cm^2)	0.6
5	Optimum Moisture Content, OMC (%)	22.5
	Maximum Dry Density, MDD (gm/cc)	1.65
6	California Bearing Ratio Test, CBR (%)	1.2

3.1. Experimental Results and Discussions

3.2. Effect of Plastic on Black Cotton Soil:

To study the effect of plastic on expansive soil, various sizes and percentages of plastic i.e. percentage by dry weight of soil was added and effectively mixed and tested for characteristics like unconfined compressive strength, MDD and CBR.

Table 2 black cotton soils with various percentages of plastic waste

% OF PLASTIC	SIZE OF PLASTIC					
	1 CM		1.5 CM		2 CM	
	OMC (%)	MDD (g/cc)	OMC (%)	MDD (g/cc)	OMC (%)	MDD (g/cc)
0.3	20.25	1.62	21.5	1.70	25.5	1.63
0.4	19.5	1.64	19.5	1.72	23.1	1.66
0.5	22.6	1.61	22.3	1.65	20.5	1.65

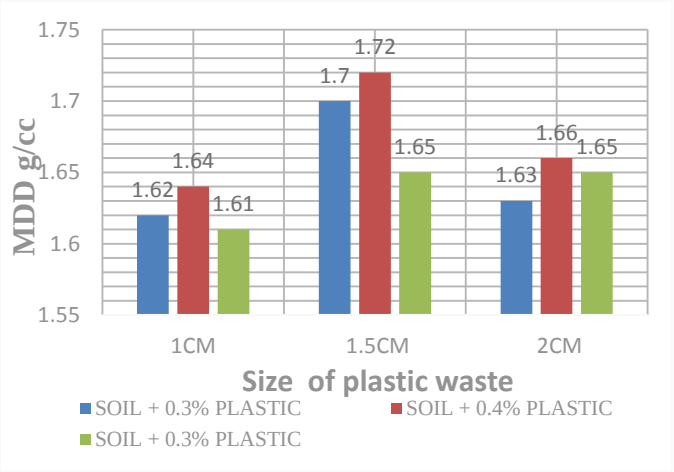
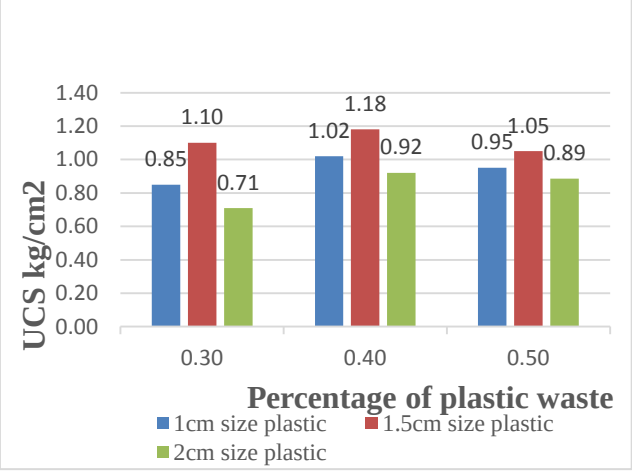


Fig.1. maximum dry densities withvarious percentages of plastic waste

For above results the OMC and MDD values are compared with different percentages and different sizes of plastic straws. In 1cm size of plastic straws for different % of plastic straws 0.3, 0.4 and 0.5. The OMC values are minimum at 0.4% and the maximum dry density is 1.64 g/cc. In 1.5 cm size for different % of plastic straws 0.3, 0.4 and 0.5. The OMC values are minimum at 0.4% and maximum dry density is 1.72 g/cc. In 2cm size for different % of plastic straws 0.3, 0.4 and 0.5, the OMC values are minimum at 0.4% and maximum dry density is 1.66 g/cc. Finally the minimum water content and maximum dry density is obtained at 1.5 cm size at 0.4% of plastic straws mixed. Further decrease of maximum dry density values are due to the used plastic material specific gravity is low and it occupies the more space in between of particles.

% of Plastic	Size of Plastic			Size of plastic		
	1 cm	1.5 cm	2 cm	1 cm	1.5 cm	2 cm
	UCC Kg/cm²			CBR (%)		
0.3%	0.85	1.10	0.95	4.4	3	4.3
0.4%	1.02	1.18	0.92	5	4.2	3.8
0.5%	0.95	1.05	0.89	4.3	2.5	2.2



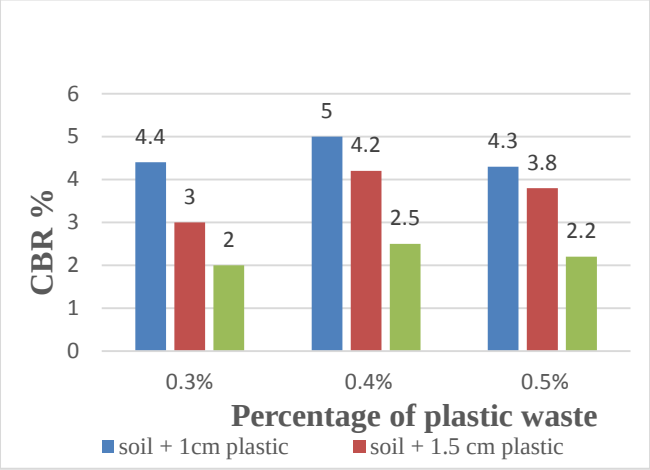


Fig.2 & 3 CBR and UCS bar chart for various % of plastic waste

For above results the undrained cohesive strength values and CBR values is compared with different percentages and different sizes. In 1cm, 1.5cm and 2cm size of plastic straws are used for a different percentages i.e 0.3, 0.4 & 0.5, in that UCS and CBR values is maximum at 0.4% i.e 1.18 kg/cm² and 5% in Fig.2. From the above table we are observed the maximum UCS and CBR values obtained at 0.4% only. So then the optimum % of plastic straws are 0.4 is considered.

Because of further increase of plastic material the UCS values are decreased due to loss of friction between the soil particles and plastic material will fails.

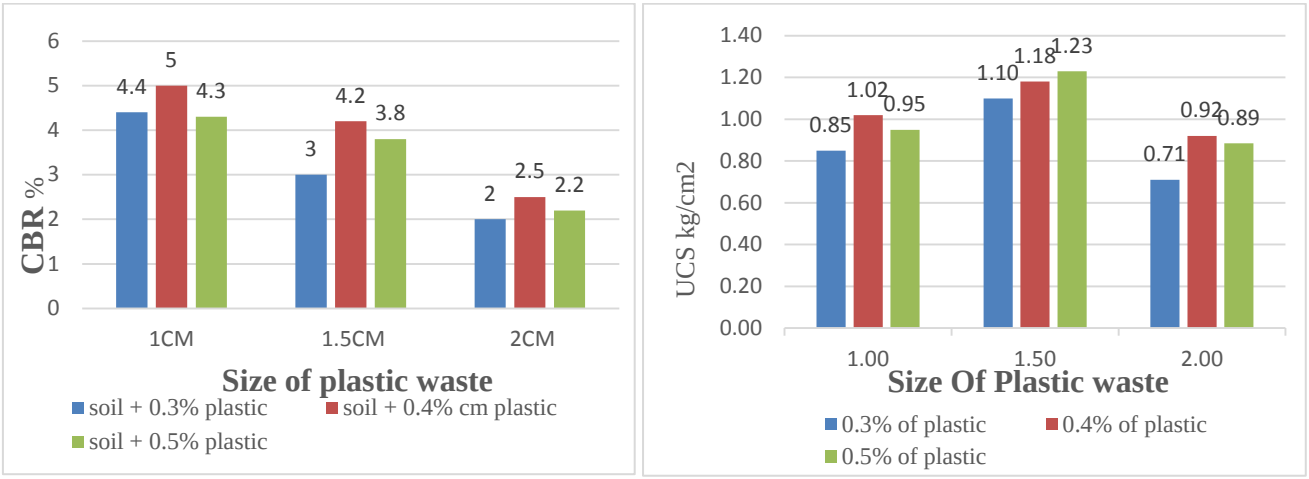


Fig.4 & 5 CBR and UCS bar chart for various sizes of plastic waste

UCS and CBR value is compared with different percentage and different sizes. In different percentages of plastic straws for different sizes are 1.0, 1.5 & 2cm, the UCS value is maximum at 1.5cm and the UCS value is 1.18kg/cm^2%. In different percentages of plastic straws for different sizes are 1.0, 1.5 & 2cm, the CBR value is maximum at 1.0cm and the CBR value is 5%. For above results the UCS values are at maximum at 1.5cm further it decreases due to loss of cohesiveness between soil particles and plastic strips. For CBR values at suddenly increase at 1.0cm and further in gradually decreases for sizes of strips. This nature due to increase size and percentages of plastic strips loss of friction and cohesive nature between the soil particles and straw strips.

4. CONCLUSIONS

From the test results detailed investigation of soil plastic composites at varying sizes & length of plastic

1. In this study maximum dry density was maximum at 0.4% and further its decrease with increase of percentage as well as length of plastic it is due to lighter weight of plastic is used.
2. Un-soaked CBR and UCC values are also was maximum at 0.4% and further its decrease with increase of percentage as well as length of plastic it is due to shear resistance of the soil and soil particles.
3. 0.4% and 1.5cm strips of straws are optimum for the soil plastic composites
4. In finally plastic waste material (straws) is safe disposal to soil and alternatively black cotton soil properties is increased.

5. REFERENCES

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