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Stabilization of Black cotton soil using plastic bottle granules

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Abstract— In design and construction of any structure, the role of soil is very crucial. Since the soil is in direct contact with the structure, it acts as a medium of load transfer and hence for any analysis of forces acting on structure, one has to consider the aspect of stress distribution through soil, as stability of structure itself depends on soil properties. Geotechnical study of site is crucial at feasibility stage, taking place before the design begins (a critical design input) in order to understand the characteristics of subsoil upon which the structure will stand. In this study we carried out with an intention to evaluate the effects of granules on the geotechnical properties of the available expensive soil of Nargund taluk Karnataka state. In this study the effect of granules on the index properties of black cotton soil stabilized with 2%, 4%, 6% & 8% granules by weight of the soil. In this study the Atterberg's limits, differential free swelling, compaction characteristics,CBR tests, were conducted as per relevant IS codes practiceThe test study shows the behavior of the Black cotton soil. The Atterberg limits i)Liquid limit (WL) is 51.9% ii) Plastic limit (WP) is 42.5% iii) Plasticity index (IP) is 9.65%. Swelling index of the soil is 50% and specific gravity is 2.45. Shrinkage limit (WS) is 7.46%. The optimum moisture content is 22% and maximum dry density is 1.501g/cm^3. Compaction and CBR tests were conducted as relevant IS code practice. The CBR test results show that unsoaked CBR value increases from 6.69% to 9.2% that is 2.51% increase in CBR value with addition of the granules.
Conclusion drawn from conducting the above experiments is that the black cotton soil is very weak and hence stabilization of soil is done by using plastic granules as stabilizer to control its stability, swelling and to increase its safe bearing capacity.

Keywords— soil stabilization, California bearing ratio, unconfined compressive strength, Black cotton soil.PTE granules

I. INTRODUCTION

Soil forms the integral matrix of land segregated in a number of layers. Various forms of soils are surrounded by the earth, with various compositions and has varied physical, chemical and physiological property which invariably comes into action when a soil is subjected to external loads or pressure. Some forms of soil may respond positively from engineering point of view and some are not. Thus stabilization of soil is an important task to be done before the construction is started. Particularly soil stabilization is nothing but improving the strength and bearing capacity of the soil by using various physical, chemical, biological or combined method of changing a natural soil to meet an engineering purpose.

Major soil deposits in the Navalgund (Dharawad dist, Karnataka state, India) is Black Cotton Soil which is very fertile and suitable for agriculture but not good for construction of Civil Engineering Structures because of its low Bearing Capacity and severe shrink-swell process which results in growth of cracks. Hence, a great range of ground development techniques such as soil stabilization and reinforcement are needed to be engaged to improve the behavior of soil, thereby enhancing the consistency of construction. Their use as reinforcing materials for weak soils to improve its strength is a way of recycling these materials in a meaningful, efficient and cost effective manner. Their applications in soil stabilization of base, sub base courses of pavement, reinforcements for earthen embankments and to reduce the settlement of soil in foundations are some examples of using these materials for civil engineering purposes. Also, waste plastic can be used in soil improvement as a replacement for other expensive admixtures like cement, lime etc. as plastic is a cheaper alternative.

Plastic products have become an integral part in our daily life as a basic need. It is producing on a massive scale worldwide and its production crosses150million tonnes, per year globally. As per survey conducted by Central Pollution Control Board (CPCB), India (Times of India, April 30 2015) in 60 cities of India, the quantity of plastic waste generation is estimated to be 15,342.6 tonnes per day (TPD) which is approximately 5.6 million per annum (TPA) while more than 6000 tonnes remain uncollected and littered. Soil stabilization using raw waste plastic bottle strips is an alternative method for improving sub grade and stability of earth embankments. This new technique of soil stabilization can be effectively used to meet the challenges of society and to reduce the quantity of waste plastic that lead to eco-friendly safe environment.

Plastic wastes generally include Poly-ethylene Terephthalate (PET), High Density Poly-ethylene(HDPE), Low Density Polyethylene(LDPE),Poly Vinyl Chloride (PVC), Poly Propylene(PP)and Polystyrene (PS). In this study, PET plastic bottle strips are used to improve the engineering properties.

II LITRETURE REVIEW

1. Vidal (1969) [19] to reduce the danger of slope stability, increase bearing capacity and reduce the lateral deformation by reinforcing the tensile resisting materials (Geo-synthetics etc.) into the weak soils.
2. Akshat Malhotra *et.al*. (2014) [04] demonstrated the potential 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 was added, 287.32 KN/m^2 soil strength of the soil was obtained which was more than untreated soil.
3. Mercy Joseph Powe*th et al*. (2014) [09]investigated the effect of plastic granules on weak soil sample with plastic and without plastic granules in varying percentage. The percentage of waste plastic was taken as 0.25%, 0.5 %, 0.75%. Maximum dry density was obtained when 0.25 % plastic was added and OMC was less than the soil without plastic for this percentage of soil. Further CBR value decreases when 0.25 % plastic is added but it was found to be increased for0.75 % of plastic. Authors also observed that for the same percentage of plastic, shear stress was maximum.

III MATERIALS AND METHODOLOGY

MATERIALS:

1. **Black cotton soil** : The Black cotton soil used for the study was collected from Navalgund (Dharawad dist, Karnataka state, India). Major soil deposits in the Navalgund is Black Cotton Soils which is very fertile and suitable for agriculture but not good for construction of Civil Engineering Structures because of its low Bearing Capacity and serious shrink- swell process which results in development of cracks.

2. **Plastic PET granules** : Polyethylene terephthalate is a great material overall. It has a unique blend of qualities that make it extremely useful. Due to its various advantages, It is regarded as a good additive for stabilization of soil to improve the engineering properties of soil. Waste plastic granules are the PET products. These are collected from N M Plastic's Vijayapur.

Fig.1 Plastic sample collected from N M Plastics Vijayapur.

METHODOLOGY :

A series of laboratory tests are conducted on both raw soils as well as on plastic reinforced soil. The results and discussions for natural soil are discussed in the following sections. Atterberg limits on plastic reinforced soils are not determined as these tests were found difficult to be performed with plastics added to the soil. If the plastics are added in powder form, then these tests will be easier to perform on plastic reinforced soils. First we conducted experiment on soil without addition of any plastic granules. After that we had added 2%, 4%, 6%, 8% of plastic granules to that soil and compared with results.

TABLE 1*: BASIC PROPERTIES OF BLACK COTTON SOIL*

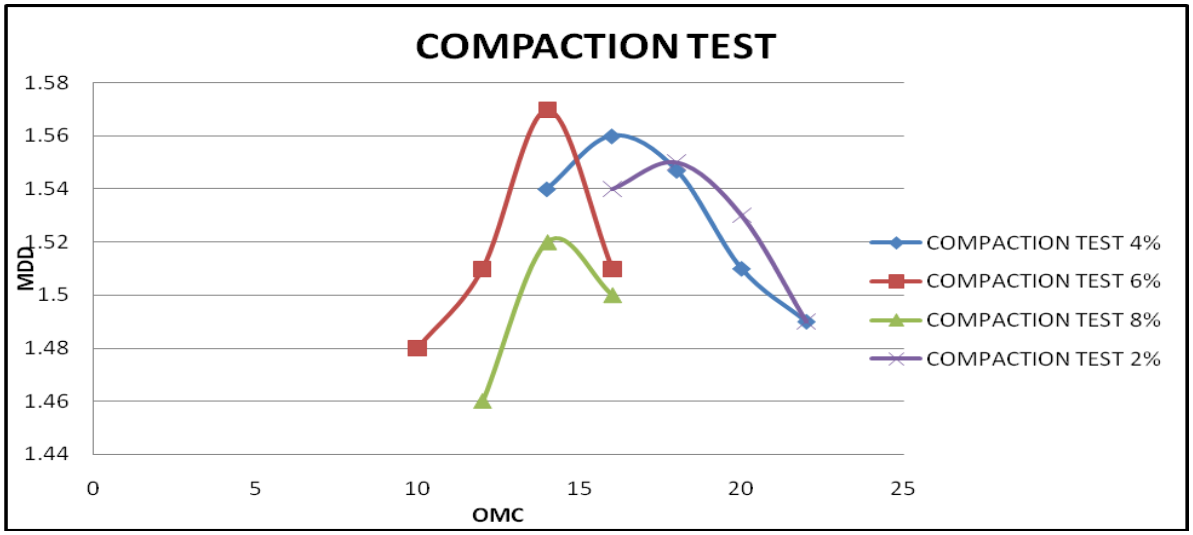
Sl no	Geotechnical properties	Values obtained
1	Specific gravity	2.45
2	Liquid limit(WL)	51.9%
3	Plastic limit(Wp)	42.25%
4	Plasticity index(Ip)	9.65%
5	Shrinkage limit	7.46%
6	Classification of soil	CH
7	Differential free swell	50%

8	Optimum Moisture Content (%) Max Dry Density(kN/m3)	22% 1.38kn/m^3
9	California Bearing Ratio Un soaked Soaked	 6.69% 1.19%
10	Unconfined compression strength(kN/m^2)	112.8

COMPACTION TEST :

TABLE.2 *COMPACTION CHARACTERISTICS RESULTS (SOIL +% OF PLASTIC)*

% of plastic	**MDD (kN/m^3)**	**OMC (%)**
0	1.50	22%
2	1.55	18%
4	1.56	16%
6	1.57	14%
8	1.52	14%

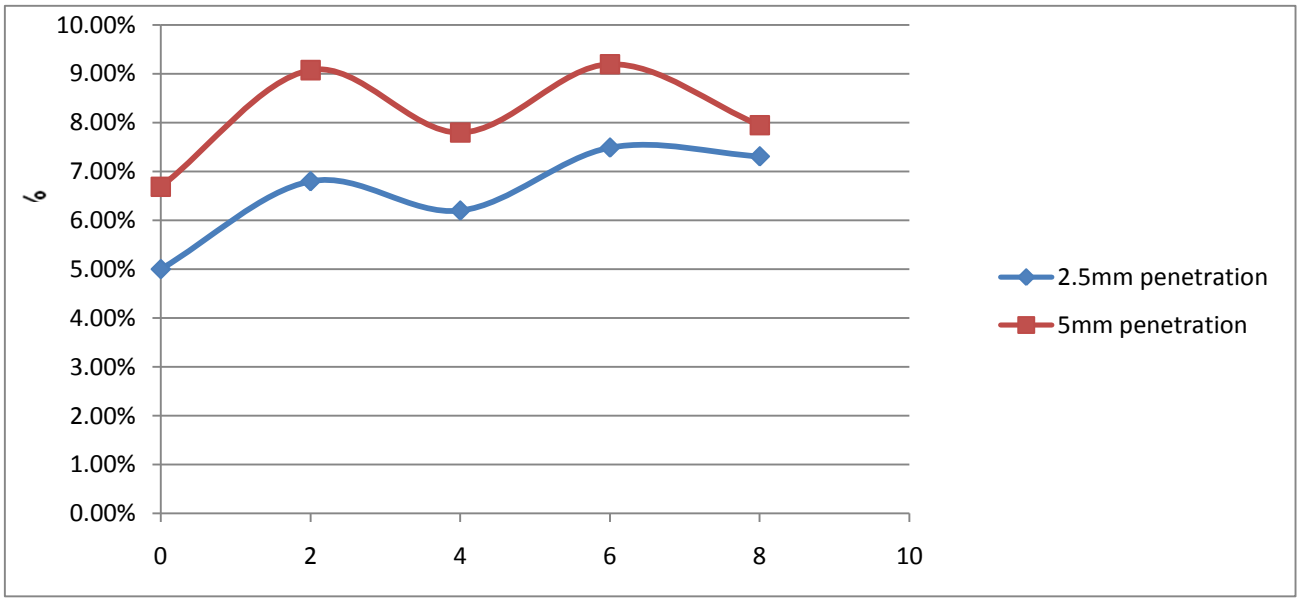


Graph 1 *curves showing the comparison between compaction test results with varying percentage of plastic granules*

CBR UNSOAKED TEST:

TABLE.2 *CBR UNSOAKED RESULTS (SOIL +% OF PLASTIC)*

% OF PLASTICS	**2.5MM PENENTRATION**	**5MM PENENTRATION**
0	5.0%	6.69%
2	6.8%	9.08%
4	6.2%	7.8%
6	7.49%	9.20%
8	7.31%	7.95%

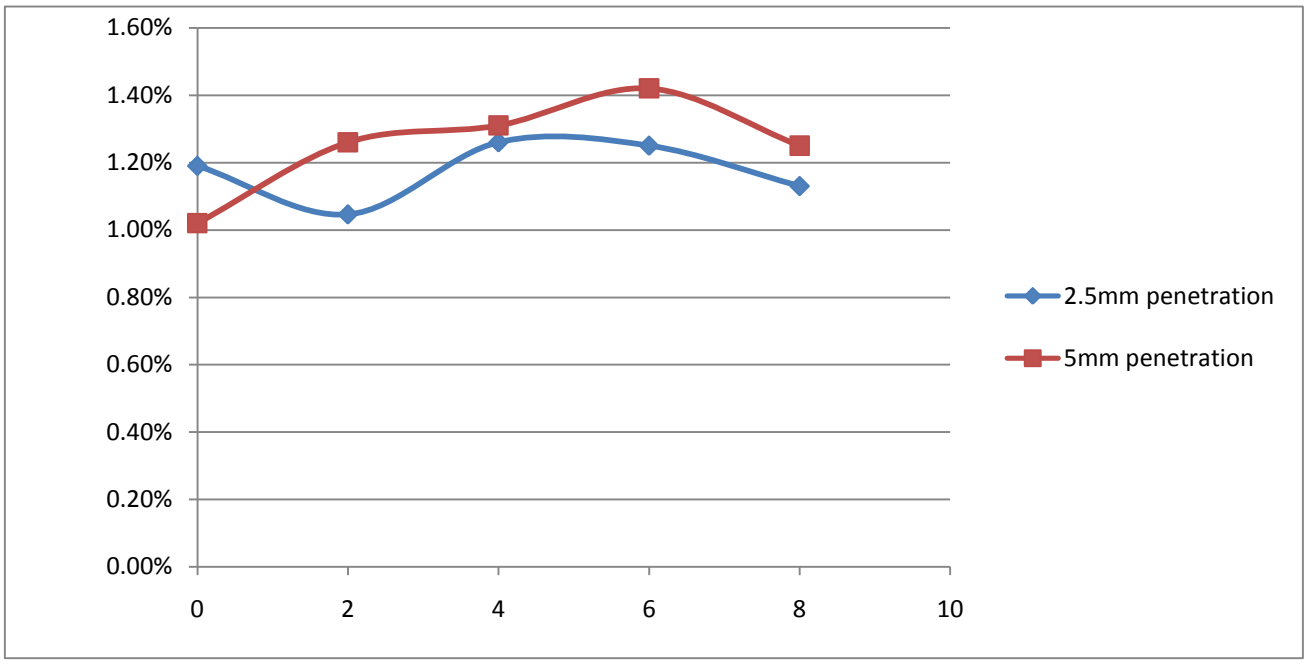


Graph 2. curves showing the un-soaked CBR test for BC soil with varying percentage of Plastic granules

CBR SOAKED TEST:

TABLE.4 *CBR SOAKED RESULTS (SOIL +% OF PLASTIC)*

% OF PLASTICS	2.5MM PENENTRATION	5MM PENENTRATION
0	1.19%	1.02%
2	1.046%	1.26%
4	1.26%	1.31%
6	1.25%	1.42%
8	1.13%	1.25%



Graph 3. curves showing the soaked CBR test for BC soil with varying percentage of Plastic granules

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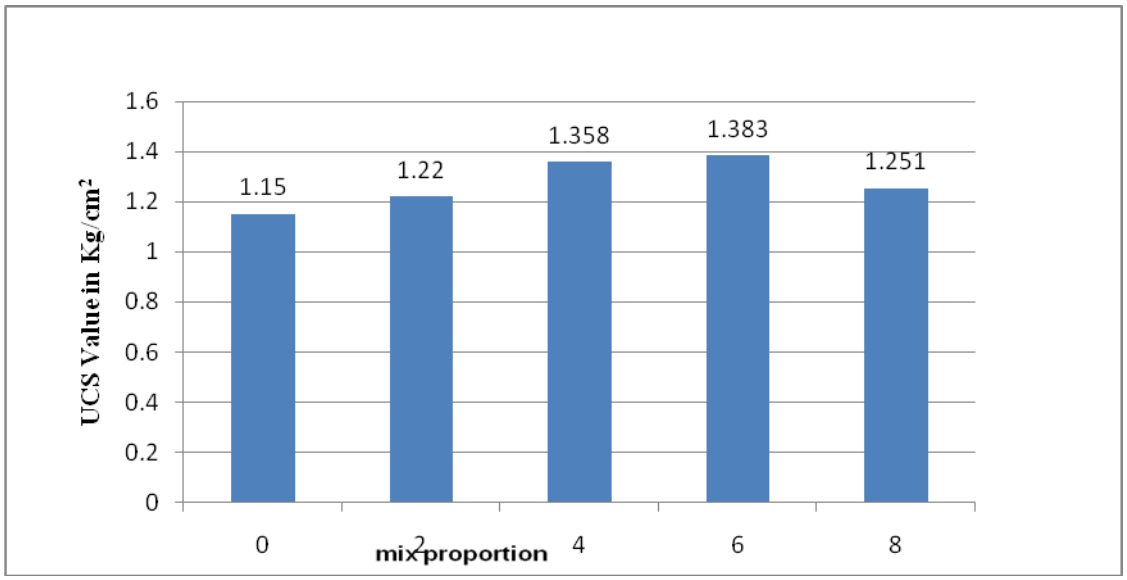
UNCONFINED COMPRESSIVE STRENGTH TEST:

Table 5. *UCS RESULTS WITH VARYING % PLASTIC*



Graph4. *UCS test for BC soil with varying percentage of Plastic granules*

TABLE6.*COMPARISON OF TEST RESULTS*

% of plastic added	OMC (%)	MDD (g/cc)	UCS (Kpa)	CBR (%) (UNSOAKED)	CBR (%) (SOAKED)
0	22	1.50	112.8	6.69	1.19
2	18	1.55	120.32	9.08	1.26
4	16	1.56	133.26	7.80	1.31
6	14	1.57	135.63	9.20	1.42
8	14	1.52	122.66	7.95	1.25

From above test results, we can observe the decrease in the OMC(Optimum Moisture Content) with the addition of different percentage of plastic leads to decrease swelling and shrinkage of the soil and MDD(Maximum Dry Density) increases. The UCS(Unconfined Compression Test) value increases as increase in percentage of plastic, from tb1 the UCS value of raw soil 112.8 Kpa increases to 135.63Kpa at optimum increase 6% of sample. The CBR value increase with addition of varying plastic and optimum is obtained at 6% of sample. From above results we can conclude that 6% of plastic is optimum for stabilisation of BC soil.

CONCLUSIONS

From the series of tests conducted on Black Cotton soil mixed with plastic granules, based on the results presented below, the following conclusions are drawn :

1. It was observed that the load carrying capacity of the soil was found to increase with addition of waste PET bottles. Hence, it is suggested to provide PET bottles with the soil to improve its strength.
2. End of use plastics are waste materials that can be cost effective when used in foundation along with clay soil.
3. With the increase in the plastic granules percentage has change the Proctor Compaction parameters. The optimum moisture content has decreased from 22% to 14%.
4. The max dry density increases from 1.50 Kn/m^3 to 1.57 Kn/m^3.
5. With the increase in the plastic granules percentage has improved the un-soaked CBR considerably from 6.69% to 9.25%.
6. With the increase in the plastic granules percentage has improved the soaked CBR from 1.19% to 1.42%.
7. From the test results it can be concluded that the soft clay like BC soil can be effectively stabilized with the addition of plastic granules to check its stability characteristics, increase in strength.

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