PERFORMANCE EVALUATION OF CRUMB RUBBER POWDER AS SOIL STABILIZER

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ABSTRACT

The present study mainly involved in the assessment of the performance of the crumb rubber powder as soil stabilizer. For this study, we were added crumb rubber powder to two different types of soils, black cotton soils and red soils. This paper presents the stabilization of soils using crumb rubber powder (CRP) with various proportions of 5%, 10% and 15%. The soil properties, compaction, California bearing ratio (CBR) and direct shear test were used to gauge the behaviour and performance of the stabilized soil. When soil blended with CRP, it is observed that maximum dry density and optimum moisture content decreases with increase in percentage of crumb rubber in soil. Blending has minimal impact on bearing capacity and shear strength. However the values remained within acceptable limits.

***IndexTerms* – Crumb rubber powder, soil stabilization, black cotton soil, red soil, direct shear test and CBR value.**

I. INTRODUCTION

1.1 General

In today's world due to rapid growth of urbanization and modernization leads to scarcity of land for construction. The increasing value of land and due to limited availability of site for construction of structures and roads are done on land having expansive clays. The stability of structure of road depends on soil properties on which it has built. The constructions can be economical if the soil is good at shallow depth below the ground surface. In this case shallow foundations such as raft foundations or footings can be used. However if the soil available on top surface is weak and strong stratum is available at greater depth foundations such as pile foundation, deep foundation, and well foundation can be used. Such foundations are not economical for small structures. In some cases soil condition are so poor even at greater depths.

Developing countries like India mainly depend on the transportation sector for their economic growth. There is a continuous development and growth in the usage of motor vehicles. The growth and usage of motor vehicles have not only caused noise pollution, air pollution etc. but also has created problems in discarding the tyre's. Rubber does not decompose and as a result, an economically feasible and environmentally sound disposal method has to be found out. One of the common and feasible ways to utilize these waste products is to go for construction of roads, highways and embankments. If these materials can be suitably utilized in construction of roads, highways and embankments then the pollution problem caused by the industrial wastes can be greatly reduced. Huge amount of soil is used in the construction of roads and highways but sufficient amount of soil of required quality is not available easily. Utilization of various industrial wastes such as crumb rubber as a soil replacement not only solves environmental problems but also provides a new resource for construction industry.

Structures are not only constructed on the soil but also with soil for example embankments, earth dams, airfield and highway pavements. Soils in general are used as constructed materials as available in nature with a little processing.

1.2 Soil stabilization

Soil stabilization is the process of improving the engineering properties of the soil and thus making it more stable. It is required when the soil available for construction is not suitable for the intended purpose. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures and to increase its shear strength. Soil stabilization is required to increase the bearing capacity of foundation soils.

Methods of stabilization may be grouped under two main types:

- Modification or improvement of a soil property of the existing soil without using any admixture and
- Modification of the properties with the help of admixture.

The examples of the first type are compaction and drainage, which improve the inherent shear strength of soil. The examples of the second type are stabilization with admixtures like cement, lime, bitumen, fly ash and chemicals. Deep soil deposits are stabilized by electrical methods, grouting, freezing etc. The use of lime, cement and bitumen has become common as stabilizing agents. The soil chosen for the purpose of the present study is a Black Cotton soil and the stabilizers used are crumb rubber powder. Soil is the basic material for construction of road.

1.3 Need of the Study

The review of literature shows that the rubber tire is a versatile material with attractive characteristics and advantages and as a result this material is now being used abundantly allthe population of vehicles both in developed and developing countries. The number of scrap tires may further increase due to rapid economic growth in some developing countries such as India where the demand for vehicles has been increasing significantly. The number of scrap tires worldwide is increasing every year due to the increase tires are disposed of every year.

A more productive, environmentally desirable use of these tires would be the construction of embankments and backfills with tire shreds or mixtures of tire shreds and sand (rubber sand).Such fills are lighter than traditional soil fills. Additionally, the present study shows that the strength of these materials is usually adequate for such applications.
Reuse of large amounts of scrap tires is beneficial, and several researchers have devoted their attention to the use of scrap tires for civil and environmental engineering application. One of these applications is the use of shredded scrap tires as drainage material in landfill cover systems. Landfill cover design generally consists of three layers: the barrier layer, the drainage layer, and the cover soil layer.

The purpose of the drainage layer is to allow any infiltrated water to drain from the overlying cover soil layer so that it is prevented from seeping into the underlying barrier layer and the waste. Tire shreds are very free draining. Even when they are compressed under the weight of overlying fill, they still have permeability greater than 1 cm/sec. With this high permeability, tire chips can be used as drainage layers in landfills and roads.

A useful property of tire shreds is that they have a high insulating value. When combined with their good drainage properties, this means that tire shreds can be used to limit frost penetration beneath roads and to remove excess water during the spring thaw. The number of scrap tires may further increase due to rapid economic growth in some developing countries such as India where the demand for vehicles has been increasing significantly.

II. MATERIALS AND EXPERIMENTAL METHODOLOGY

2.1 Materials

For the present study we have used the following materials:

a) Black cotton soil
b) Red soil
c) Crumb rubber powder

2.2 Preparation of samples

The first step in preparing a soil for testing was to air dry the soil**.** This was accomplished by spreading the soil over a large area**.** The soil was spread this enough so that it could completely air dry in a few days**.** When the soils had very high clay contents, much more time was invested in spreading the sample out**.** This typically included breaking the sample into s mall sections, so that it could air dry in a reasonable time**.** The length of time each sample was left out to air dry depends on its moisture content**.** Some of the very moist samples took up to five days to dry**.** In order make sure the samples were properly dried; the 20kg sample was placed in an oven at 60°c to 140°c for one day**.**

2.3 Tests conducted on samples

For the stabilized soil specimens, a step percentage of Crumb rubber powder (CRP) by dry weight of soil (0, 5, 10, 15 and 20%) was introduced into the soil.

Various tests and analysis were carried out to examine the effects of the Crumb rubber powder (CRP) on the Expansive soil namely

- Specific Gravity- By Pycnometer Method
- Free swell Index Test
- Particle Size Distribution- By sieve analysis
- Atterberg's Limits (Liquid limit, Plastic limit) By Casagrandes Apparatus
- CBR (California Bearing Ratio) – CBR Test
- Shear strength by DIRECT SHEAR TEST

Based on these tests, the required quantity of the Crumb rubber powder (CRP) for effective stabilisation of the soils was determined.

III. RESULT AND DISCUSSION:

The various tests were conducted on the prepared samples, were listed in previous section, and their results are tabulated as **table-1**. And also, the tests for calculating strength parameters like bearing capacity, cohesion and angle of internal friction, CBR test and direct shear tests conducted on the prepared samples with various proportions of crumb rubber powder. The CBR test results of black cotton soils and red soils shown in **table-2** and **table-3** respectively and their respective graphs shown in **figure-1** and **figure-2** respectively. The direct shear test results of black cotton soil and red soil shown in **table-4** and **table-5** respectively and their respective graphs shown in **figure-3** and **figure-4** respectively.

Table –1: Properties of Prepared samples

S. No.	Name of the parameter	For black cotton soils	For red soils
1	Specific gravity	2.423	2.84

2	Free swell index	82.14%	20%
3	Liquid limit	44.9%	17.2%
4	Plastic limit	33.72%	10.37%
5	Plasticity index	11.18	6.83

Table –2: California Bearing Ratio for black cotton soil

Penetration (mm)	**Load (Kg/cm²)**			
	0%of rubber powder	**5%of rubber powder**	**10%of rubber powder**	**15%of rubber powder**
2.5	6.109	9.175	10.233	4.963
5	4.649	7.978	9.759	7.715

Table –3: California Bearing Ratio for red soil

Penetration (mm)	**Load (Kg/cm²)**			
	0%of rubber powder	**5%of rubber powder**	**10%of rubber powder**	**15%of rubber powder**
2.5	0.60	0	0	0
5	4.14	1.25	0.57	0.60

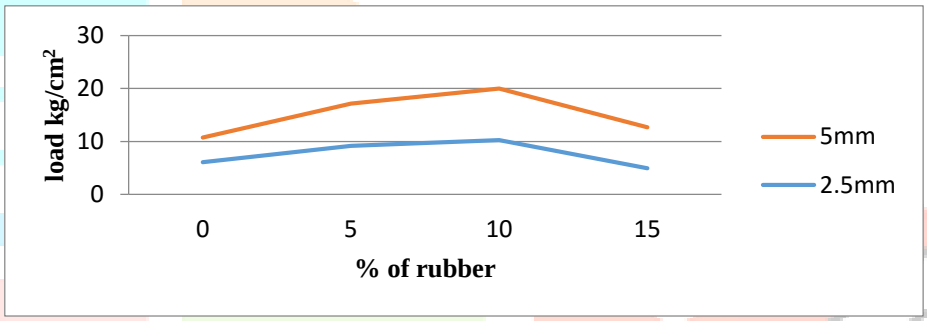

Figure-1: California Bearing Ratio for black cotton soil

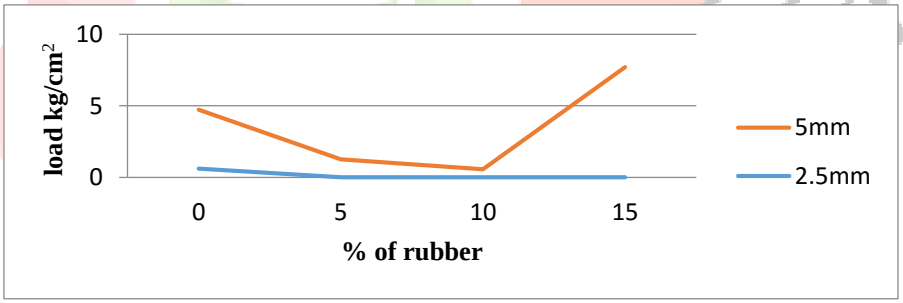

Figure-2: California Bearing Ratio for red soil

Table – 4: Direct shear for black cotton soil

Penetration (mm)	Shear stress (Kg/cm²)			
	0% of rubber powder	5% of rubber powder	10% of rubber powder	15% of rubber powder
0.5	1.94	2.5	2.78	2.91
1	2.5	3.19	3.33	3.33
1.5	2.5	3.61	3.89	3.75
2	2.63	4.16	4.30	4.16
2.5	2.77	4.44	4.72	4.58

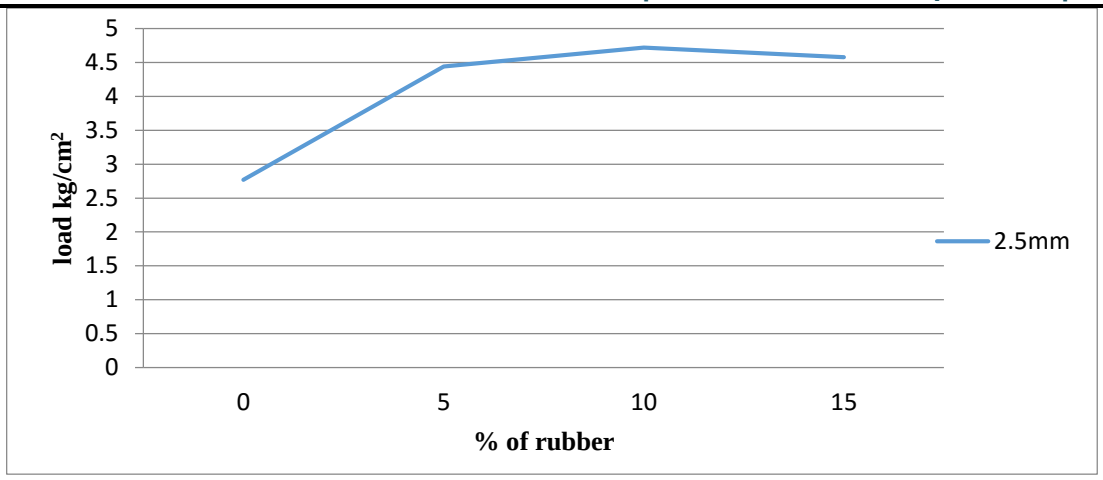

Figure-3: Direct shear for black cotton soil

Behaviour of soil at 2.5mm penetration when different percentages of rubber are added.

Table – 5: Direct shear for red soil

Penetration (mm)	Shear stress (Kg/cm²)			
	0% of rubber powder	5% of rubber powder	10% of rubber powder	15% of rubber powder
0.5	0.38	0.38	0.22	0.22
1	1.38	0.61	0.55	0.38
1.5	1.61	0.77	0.83	0.55
2	1.66	1.11	1.16	0.77
2.5	1.61	1.22	1.22	0.88

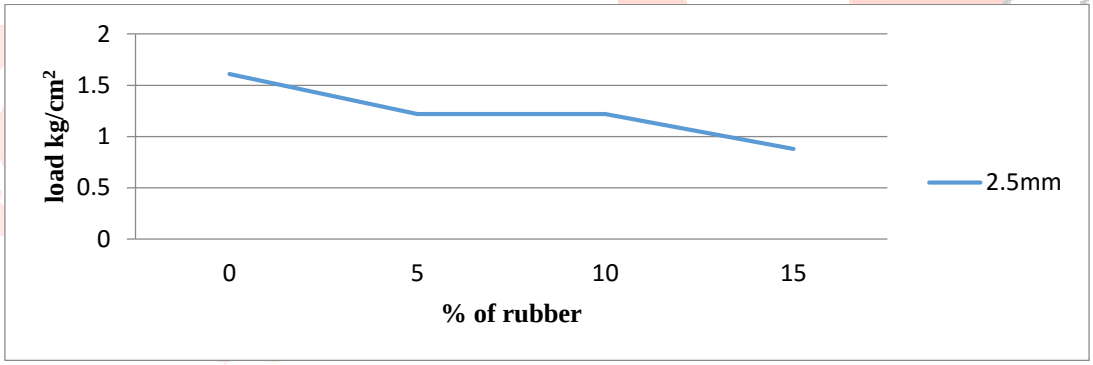

Figure-4: Direct shear test for red soil

Behaviour of soil at 2.5mm penetration when different percentages of rubber are added.

IV. CONCLUSION

- The shear strength of the black cotton soil is increased with the addition of 10% crumb rubber powder.
- The shear strength of the red soil is decreased with the addition of crumb rubber powder.
- From the investigations, addition of 10% of crumb rubber powder to the soil increases CBR value.
- If the percentage of rubber powder increases more than 10%, the soil strength gradually decreases.
- This investigation evaluates 10% is the optimum rubber powder for the stabilization of black cotton soil.
- This investigation evaluates the use of rubber for stabilization of red soil is not adoptable.

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