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EXPERIMENTAL STUDY ON THE UTILIZATION OF FINE STEEL SLAG AND RUBBER CRUMBS ON STABILIZING HIGH PLASTIC SUBGRADE SOIL

JANAKI RAMAN K [1], JEEVITHA K [2], KALYANI KUMAR M [3], NIVEDHA C R [4], NANDHINI J [5]

[1,2,3,4] Students, Department of civil engineering, SRM Valliammai Engineering College, Chengalpattu, Tamilnadu
[5] Assistant professor, Department of civil engineering, SRM Valliammai Engineering College, Chengalpattu, Tamilnadu

Abstract – Now a days, utilization of alternate materials which bear higher engineering quality than traditional materials have been increased. Soil is most important construction material. Soil improvement is necessary because of expansive and swelling nature of soil and low bearing capacity of soil. Soil stabilization is the process of improving its properties by changing its graduation. Millions of tons of waste will cause problems in both disposal, environmental contamination and health risk. Here the clay soil is mixed with steel slag and rubber crumbs in various proportion of the properties are taken into account. The strength properties of the soil were improved by increasing the percentage of rubber crumbs (5%, 10%, 15%) and keeping the steel slag constant (20%). Standard proctor test, California bearing ratio (cbr), unconfined compressive strength test was performed at various proportions into the clay soil. The conclusion drawn from this investigation is that the combination of rubber crumbs (10%) and steel slag (20%) is more effective for the improvement of properties of clay.

Key Words **- Rubber Crumbs, Steel Slag, Subgrade Soil, Stabilization.**

1. INTRODUCTION

Soil is used as the construction material. It supports the structures and substructures. Soil improvement is necessary because of expansive and swelling nature of soil or low bearing capacity of soil. Stabilization is the process, it improves the property of soil by changing its gradation. Stabilization is the process done for improvement of existing soil by using an admixture. The study here, was to use the rubber crumbs and fine steel slag in order to reduce the environmental impacts. Scrap tyre generation and steel slag generation are amongst increasing trend in the world. Tyres are worst when they are burnt as they cause huge environmental pollution. Soil can be mixed with rubbers crumbs and fine steel slag can be utilized as various construction and further use in road construction.

2. OBJECTIVES

To improve the strength of sub-base of high plastic soil. To make use of inferior quality of locally available materials for soil strengthen. To improve certain undesirable properties of soil such as excessive swelling(or) shrinkage, high plasticity, difficulty in compacting etc. To have a comparative study using the steel slag and tyre crumbs as an admixture to the soil in order to strengthen the subgrade. To ensure the usage of these admixtures to be cost effective for soil stabilization.

3. METHODOLOGY

(i) Soil are collected near Adyar river near Kundrathur. The soil we collected is a clay soil. These soils contain fine particles and other colloidal substance.

(ii) The rubber crumbs of 3 kg collected from tyre rebuilders. These are waste pieces obtained while making tread to the tyres. It is also cost efficient.

Fig 1 - Rubber Crumbs

PROPERTIES	VALUES/BEHAVIOUR
Melting point (C)	220-250
Tensile strength at 20º C	800-1200
Modulus of elasticity (GPa)	3-4
Strain at break (%)	50-150
Resistance against Alkalis	High
Resistance against Acids	High
Resistance against salts	High

TABLE 3.1 – PROPERTIES OF RUBBER CRUMBS

(iii). Collection of 5kg steel slag from Steel Fabrication Industry from the local steel fabrication industry situated near poonamallee.

Fig 2 - Steel Slag

TABLE 3.2 – Properties of Steel Slag

Sieve Size (mm)	Size of particles (mm)	Wt. of soil retained (g)	% retained	Cumulative % retained (g)	% Finer
4.75	4.75	1	0.95	0.95	99.05
2.36	2.36	3	2.8	3.75	96.25
1.18	1.18	4	13.3	17.5	82.95
600 micron	0.600	18	17.14	34.19	65.81
425 micron	0.425	21	20	54.19	45.81
300 micron	0.300	17	16.19	70.38	29.62
150 micron	0.150	19	18.09	88.47	11.53
75 micron	0.075	11	10.47	98.94	1.06
Pan	Pan	Nil	0	98.94	1.06

4. EXPERIMENTS AND CALCULATIONS

Sieve analysis is a technique used to determine the particle size distribution of a sample. This method involves in separating the sample into discrete size ranges which is placed in a sieve stack, and a sieve shaker is used to vibrate the sieve stack for a specific period of time.

4.1 Wet Sieve Analysis Test

Sieve analysis is conducted to determine the soil sample is either fine grained or coarse grained soil.

Total weight of soil taken for analysis = 500gms

Weight passed through 75 µ sieve = 401.06gms

Weight retained on 75 µ sieve = 98.94gms

- Fine grained particles are 80.21%
- Coarse grained particles are 19.79%

Thus, since the percentage of fine grains are more than 50%, the soil sample falls under Fine Grained Soil.

4.2 Dry Analysis Test

PROPERTIES	VALUES/BEHAVIOUR
Specific gravity	3.5
Water absorption %	1.02
Melting point ° C	1427
Moisture content %	3
Crushing strength %	29.5
Density Kg/m^3	7850
Tensile strength MPa	745
Yield strength MPa	470

TABLE 4.1– Dry Analysis Chart

4.3 Free Swell

It is defined as the increase in volume of a soil without any external constraints on submergence in water.

Differential Free Swell = $(V_d – V_k / V_k)$ x 100

Where,

V_d = Volume of soil specimen read from the graduated cylinder containing water.

V_k = Volume of soil specimen read from the graduated cylinder containing kerosene.

Observation

Free Swell index = (12-10 / 12) x 100 = 20 %

4.4 Plastic Limit

Plastic limit is the water content at changes from the plastic state to semisolid state

The Plastic limit is determined by rolling out a thread of the fine portion of soil on a flat, non-porous surface. The Plastic Limit is defined as the moisture content where the thread breaks apart at a diameter of 3.2 mm (about 1/8 inch). Plastic limit of the expansive soil is found to be 38.3 %

4.5 Shrinkage Limit

Shrinkage limit is the lost that determine the water content of a soil where loss of moisture not result in an additional volume reduction.

Shrinkage Limit W_s = W- $((V-V_d)\gamma_w/W_d)$ x 100

= 39.3 – ((23.4-13.9).0048/38) x 100

= 38.8%

Shrinkage Ratio SR = $W_o/V_o\ \gamma_w$

= 33/13.9

= 2.37

4.6 Standard Proctor Compaction Test *(SPCT)*

Standard Proctor compaction test is used to determine the compaction of different types of soil of the properties of soil with a change in moisture content.

4.6.1 SPCT For Untreated soil

4.6.1.1 Optimum Moisture Content

The water content at which a specified compactive force can compact a soil mass to its maximum dry density. The optimum moisture holding capacity of a untreated soil is found to be 12.5% by Standard Proctor Compaction Test.

4.6.1.2 Maximum Dry Density

The maximum dry density of material for a specific compactive efforts is the highest density obtainable when the compaction is carried out on the material at varied moisture contents. The maximum dry density of the soil is found to be 2.07 g/cc

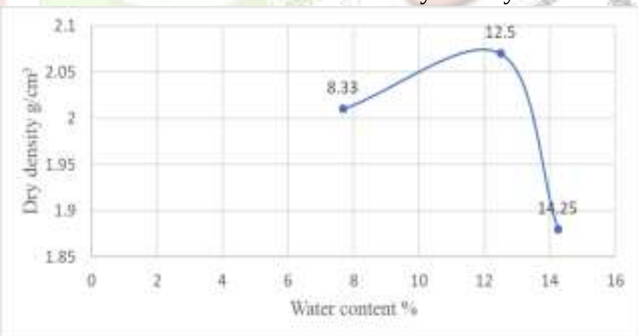

Fig 3 SPCT for untreated soil

4.7 Test On Soil On Addition Of Rubber Crumbs And Steel Slag

The Standard Proctor Compaction test for soil with addition of rubber crumbs and steel slag carried out and listed below.

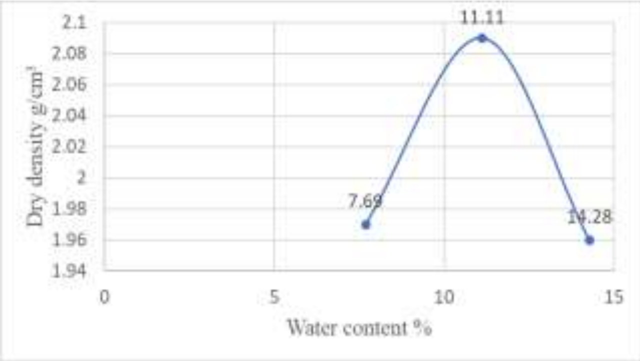

Fig 4 SPCT of Soil With 5% RC and 20% Steel Slag

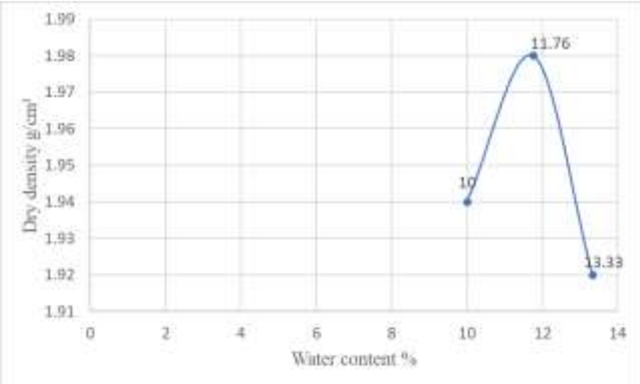

Fig 5 SPCT of Soil With 10% RC and 20% Steel Slag

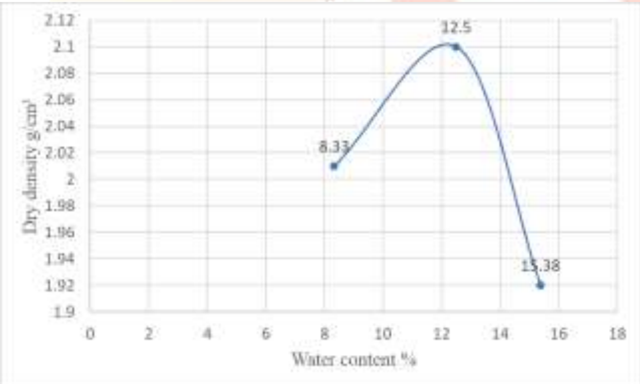

Fig 6 SPCT of Soil With 15% RC and 20% Steel Slag

Table 4.2 - Variation in OMC and MDD

Mix proportion	OMC (%)	MDD (g/cc)
Soil with 5% Rubber Crumbs and 20% Steel Slag	11.11	2.33
Soil with 10% Rubber Crumbs and 20% Steel Slag	11.76	1.98
Soil with 15% Rubber Crumbs and 20% Steel Slag	12.5	2.10

4.8 California Bearing Ratio Test *(CBR)*

CBR test is a penetration test used to evaluate the subgrade strength of roads and pavements. The results of these test are used with the curves to determine the thickness of pavement and it's component layers. This is the most widely used method for the design of pavement.

4.8.1 CBR for Untreated Soil

The CBR value are $CBR_{2.5}$ = 3.3% and CBR_5 = 2.9%

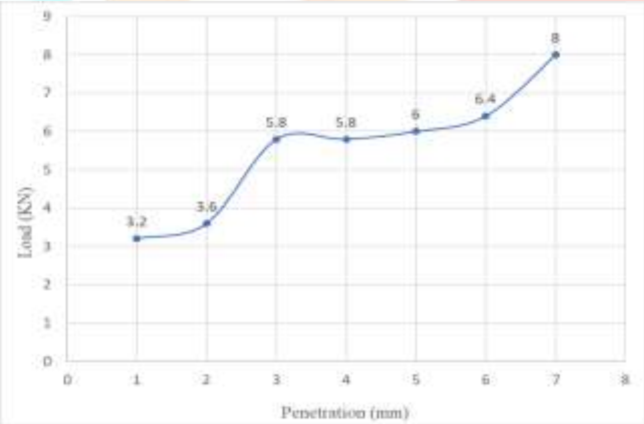

Fig 7 CBR for untreated soil

4.8.2 Test on soil on addition of Rubber Crumbs and Steel Slag

The CBR value are $CBR_{2.5}$ = 4.5% and CBR_5 = 3.9%

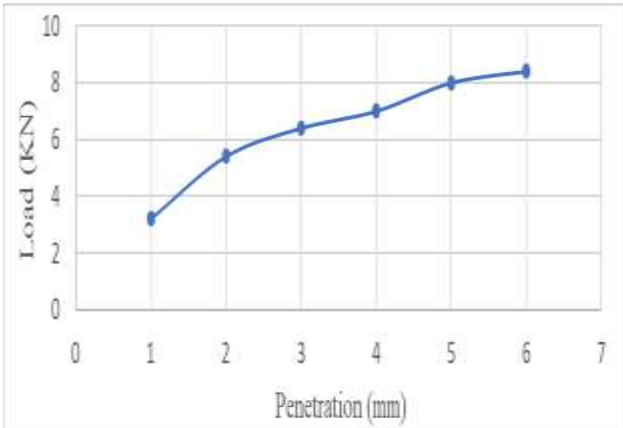

Fig 8 CBR for 5% rubber and 20% steel slag

The CBR value are $CBR_{2.5}$ = 5.2% and CBR_5 = 4.9%

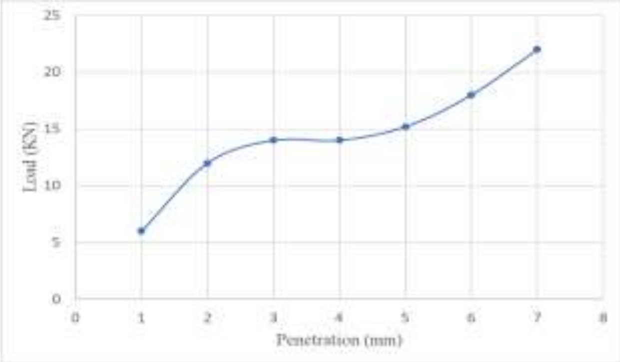

Fig 9 CBR for 10% rubber and 20% steel slag

The CBR value are $CBR_{2.5}$ = 4.5% and CBR_5 = 3.9%

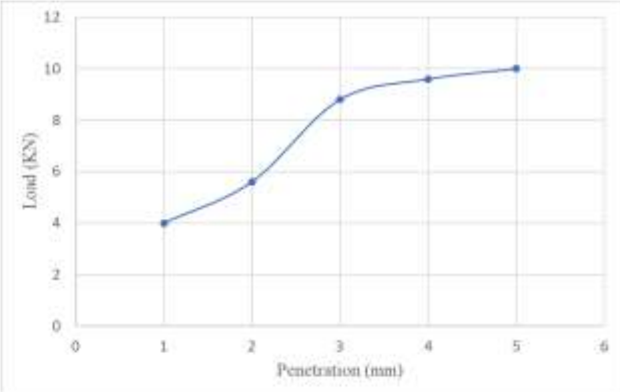

Fig 10 CBR for 15% rubber and 20% steel slag

4.8.3 The results of the CBR test of the soil sample with various percentage of rubber crumbs and steel slag is discussed below

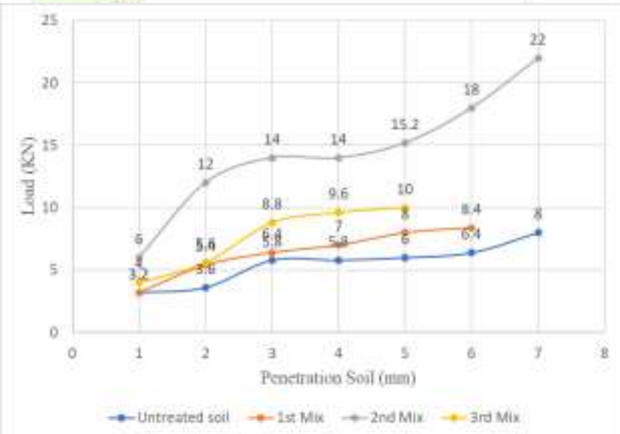

Fig 11 Variation on CBR on addition of Rubber Crumbs and Steel Slag

4.9 Unconfined Compression Test *(UCC)*

Here, a cylinder of soil without lateral support is tested to failure in sample compression, at a constant rate of strain. The compression load per unit area required to fail the specimen called as UCC strength of soil.

4.9.1 UCC for untreated soil

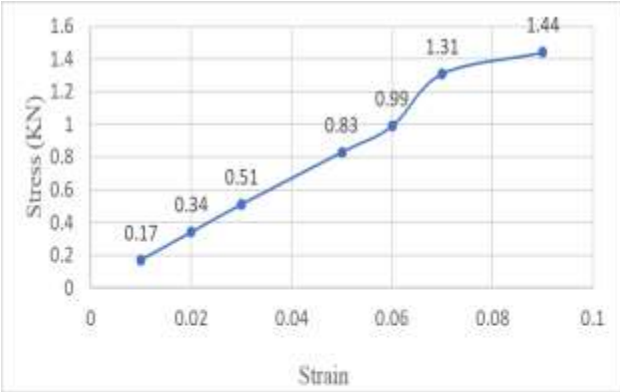

Fig 12 UCC for untreated soil

4.9.2 Test on soil on addition of Rubber Crumbs and Steel Slag

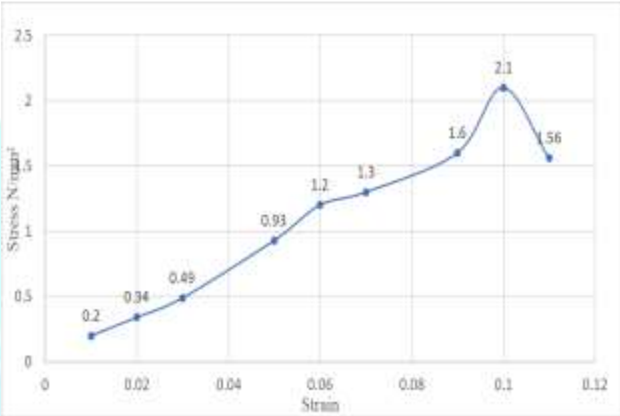

Fig 13 UCC for 5% rubber and 20% steel

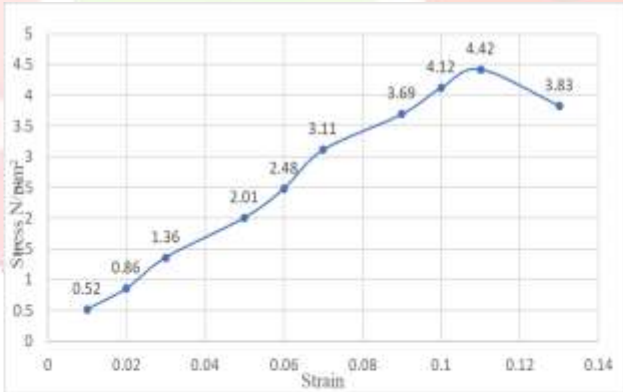

Fig 14 UCC for 10% rubber and 20% steel

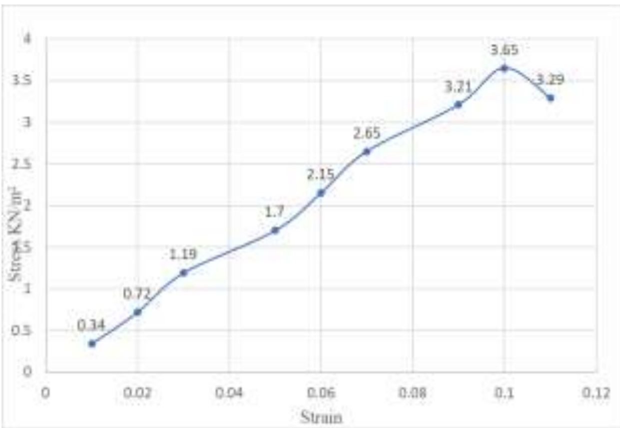

Fig 15 UCC for 15% rubber and 20% steel

4.9 The results of the UCC test of the soil sample with various percentage of rubber crumbs and steel slag is discussed below

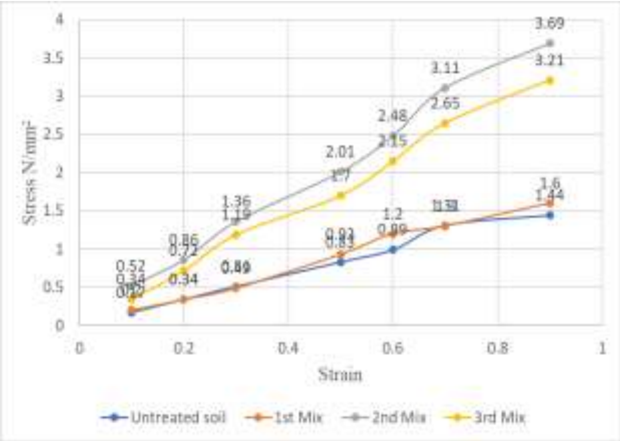

Fig 16 Variation on UCC on addition of Rubber Crumbs and Steel Slag

5. CONCLUSION

Based on the analysis of the results on the rubber crumbs and steel slag reinforced soil, the following are drawn

1. Rubber crumbs and Steel slag mixed with the soil showed improvement in CBR value with its addition up to 10% Rubber and 20% steel and there onwards decreased with increases in rubber crumbs

2. Increase in CBR value of stabilized soil can significantly reduces the overall thickness of the pavement and hence the total cost involved in the construction of road.

3.The use of rubber fibre as a stabilizer introduces a low cost method for stabilization and it significantly reduces the waste tyre disposal problem that currently exists.

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