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Regolith Counterpoise and Diminution of Pavement Thickness Using Rubber Tyre Shreds

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Abstract-In today's world, the vehicles are increasing day by day and at the same time more amount of tyres are being wasted going to be land filled and burnt creating a lot of environmental foot print. So we have to reduce the wastage to its minimum value. In this context, we got an idea to use the waste rubber which is shredded in soil as a stabilizing material to increase its index as well as engineering properties of soil. We conducted a number of tests to increase the soil strength by adding rubber tyre shreds. The shredded rubber size considered in our project is which passes through IS 2.36mm sieve. The tests conducted were Grain Sieve Analysis, Atterberg's limits i.e., Plastic Limit, Liquid Limit, Standard Proctor Compaction Test and CBR test. The shredded tyre is mixed with various proportions in the soil to increase its CBR value by determining its optimum moisture content.

Key Words-California Bearing Ratio, Liquid Limit and Plastic Limit, Standard proctor Compaction Test, Sieve Analysis, Environmental Foot Print, Shredded rubber, Optimum Moisture Content.

I. INTRODUCTION

Soil isdefined as theunconsolidated material, composed of solid particles, produced by the disintegration of rocks. In geology, earth's crust is assumed to consist of unconsolidated sediments, called mantle or regolith, overlying rocks.Adding any material to the soil which enhances the index as well as engineering properties of soil is referred as soil stabilization.The stabilization isa process to increase the stability of foundation material under heavy loads.The engineering properties of soil such as permeability, compressibility can be altered to improve the engineering properties of soil. The clayey soil is slow permeable in nature resulting in a very large water-holding capacity. Because the soil particles are small and close to each other, it takes water much longer to move through clay soil than it does with other soil types. Clay particles then absorb this water, expanding as they do so and further slowing the flow of water through the soil.Now-a-days pavements needs the soil stabilizationto decrease its thickness because the natural sources are slowly exhausting.

The soil stabilization can be done by addition of various materials like rice husk,jute fibre,hair fibre, cement and flyash with different percentages to improve its properties. The present research work enumerates the effect of waste material like rubber tyre shred on performance of clayey soil and silty soil.

The various index tests were performed on the oven dry soil to determine the index properties of soil. To study the effect of rubber tyre the rubber tyre shreds were added in the soil with varying percentages (2%, 4%, 6%, 8%, and 10%) by weight of soil. The effect was checked after performing compaction test (Standard Proctor Test), CBR (California Bearing Ratio) test on given soil.

II. MATERIALS

The soil sample was collected near a village known as saraipali which is located near JNTU College of Engineering, Pulivendula, Kadapa. The soil was found to be inorganic clay of high compressibility. Crumb tyres are small pieces of scrap waste tyre from light motor vehicles. In this study, the scrapped tyre pieces passing IS 2.36mm sieve considered as crumb tyre rubber.

III. STABILIZING MATERIAL (RUBBER TYRE SHREDS)

Scrap tyres are being produced and collected in large volumes causing an increasing threat to the environment. These waste is land filled and burnt causing an environmental threat to the atmosphere So to eliminate this negative effect of depositions and in terms of sustainable development there is a great interest in the recycling of these non-precarious solid wastes. The tyre waste generated can be used in geotechnical engineering as chips, powder, shredded and as a whole so that we can reduce the environment footprint. It is estimated that 13.5 million tonnes of scrap tires are disposed every year worldwide. These include all sorts of tires from car tires to trucks and huge tractor tires and earth moving tires etc.Shredded tyre material was obtained from waste generated from tyre re-threading industries at Anantapur.

IV. SOIL MATERIAL (CLAYEY SOIL AND SILTY SOIL)

The soil used was clayey soil and silty soil collected from our nearby to our college. The material for testing was collected by disturbed sampling method and brought to the testing lab. The soil was air dried, pulverized and sieved with Indian Standard Sieve No. 4 (4.75 mm aperture) as required for laboratory test.

V. EXPERIMENTAL TESTING PROGRAM

Tests on the natural and stabilized clayey soil and silty soil were carried out in accordance with the procedures outlined in IS 2720 (1985), step percentages of rubber tyre shred by dry weight of soil (0, 2, 4, 6, 8 and 10%) was introduced into the soil. The various tests carried out on the natural and stabilized soil are listed in Table-1.

TABLE 1:

TESTING PROGRAMME FOR NATURAL AND STABILIZED SOIL

S.no.	Property of Soil	Method
1	Moisture Content	Oven Drying Method
2	Particle Size Distribution	Sieve Analysis
3	Atterberg’s Limit (Liquid limit)	Casagrande’s Apparatus
4	Optimum Moisture Content & Maximum Dry Density	Standard Proctor Compaction Test
5	California Bearing Ratio Value	CBR Test

VI. RESULTS AND DISCUSSIONS

UNSTABILIZED CLAYEY AND SILTY SOIL

The results for Unstabilizedclayey soil and silty soil were determined by performing various tests in the laboratory as shown below. The rubber tyre shred was introduced in the given soil in different percentages from (2 – 10%).

S.no	Property of clayey Soil	Value
1	Liquid Limit	56%
2	Plastic Limit	29.6%
3	Plasticity Index	26.4%
4	Cu and Cc	7.33 and 2.48
5	Maximum Dry Density (MDD)	1.74g/cc
6	Optimum Moisture Content (OMC)	12.17%
7	CBR Value	2.54%

Properties for Clayey and Silty Soil

S.no	Property of silty Soil	Value
1	Liquid Limit	36%
2	Plastic Limit	32.07%
3	Plasticity Index	3.93%
4	Cu and Cc	6.78 and 2.70
4	Maximum Dry Density (MDD)	1.57g/cc
5	Optimum Moisture Content (OMC)	14.94%
6	CBR Value	3.11%

COMPACTION TEST (STANDARD PROCTOR TEST)

The standard proctor test was performed to study the effect of different percentages of rubber tyre shred on optimum moisture content (OMC) and maximum dry density (MDD). When the graph plotted between optimum moisture content versus different percentage of tyre shred for clayey sample and silty soil it was found that OMC increases from 0% to 10%. From Figure it was observed that for 0% rubber shred, the maximum dry density was 1.74 gm/cc and 1.57gm/ccand on addition of rubber shred, an increase in MDD was observed to a value of 1.66 g/ccat 2% rubber shred for clayey soil and 1.63g/cc at 2%rubber shred for silty soil. The variation for OMC and MDD was tabulated in Table 3,4,5and6.

TABLE 3

OMC VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED(CLAYEY SOIL)

S.NO	% of Rubber Tyre Shred	OMC %
1	0	12.17
2	2	20.63
3	4	23.8
4	6	25.7
5	8	25.9
6	10	26.3

TABLE 4

OMC VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED(SILTY SOIL)

S.NO	% of Rubber Tyre Shred	OMC %
1	0	14.94
2	2	18.71
3	4	22.73
4	6	23.19
5	8	23.3
6	10	25.01

TABLE 5

MDD VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED(CLAYEY SOIL)

S.NO	% of Rubber Tyre Shred	MDD
1	0	1.74
2	2	1.66
3	4	1.53
4	6	1.53
5	8	1.52
6	10	1.49

TABLE 6

MDD VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED(SILTY SOIL)

S.NO	% of Rubber Tyre Shred	MDD
1	0	1.57
2	2	1.63
3	4	1.605
4	6	1.61
5	8	1.59
6	10	1.53

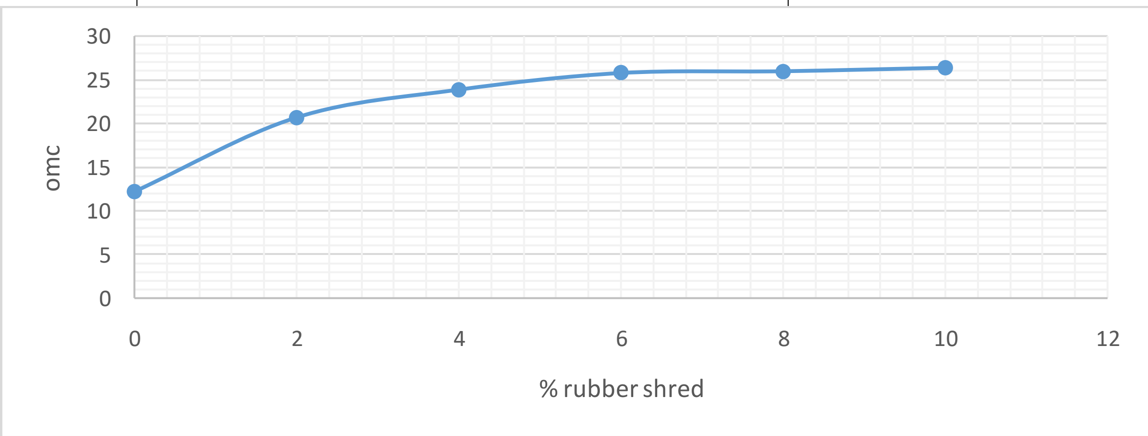

Fig. 1 Variation of OMC with Different Percentage of Rubber Tyre Shred (Clayey soil)

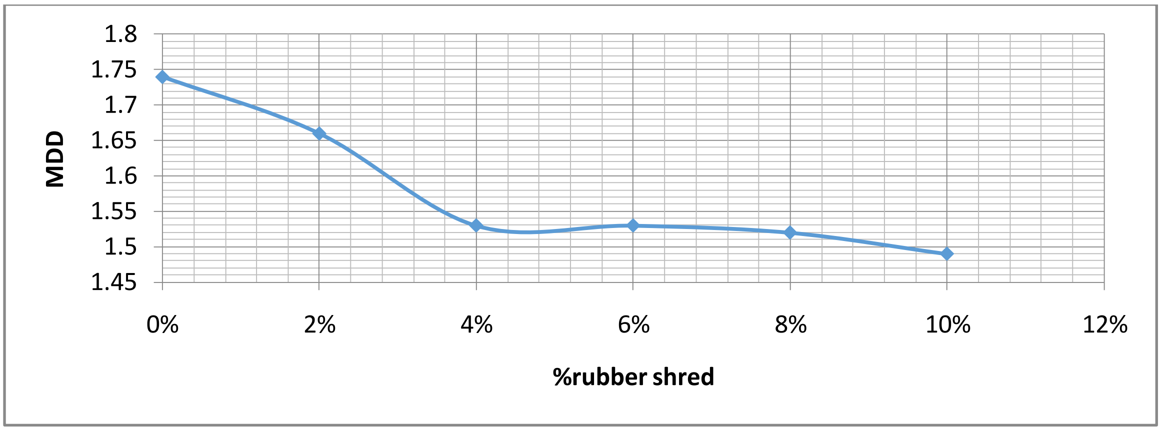

Fig. 2 Variation of MDD with Different Percentage of Rubber Tyre Shred (Clayey soil)

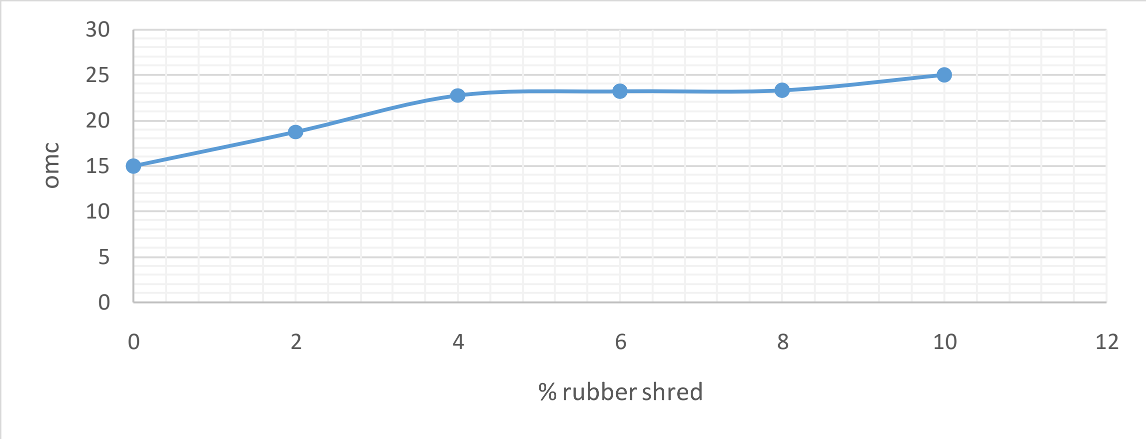

Fig. 3 Variation of OMC with Different Percentage of Rubber Tyre Shred (Silty soil)

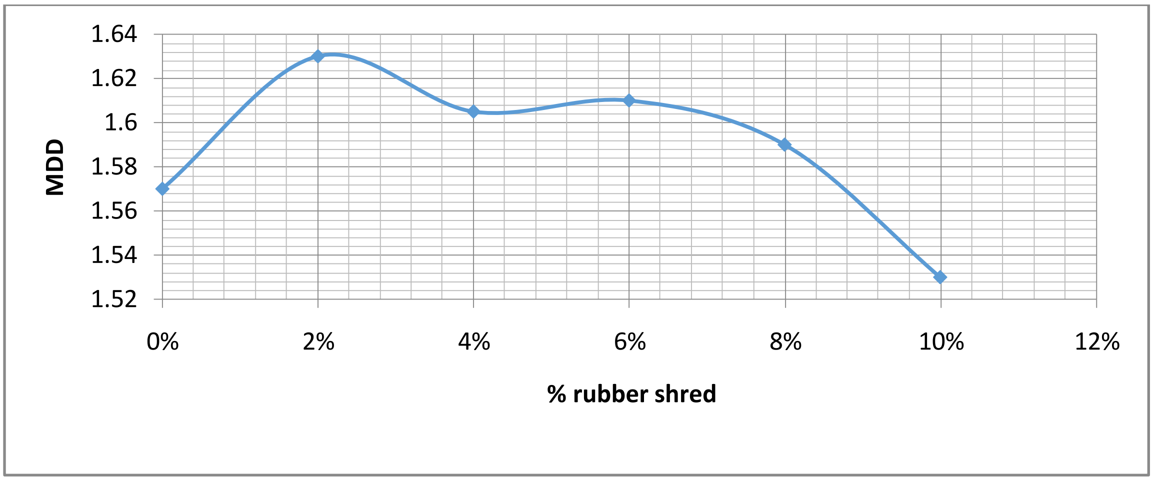

Fig. 4 Variation of MDD with Different Percentage of Rubber Tyre Shred (Silty Soil)

CALIFORNIA BEARING RATIO (CBR)

When CBR test was carried out without addition of rubber tyre content (Unstabilized), load versus penetration curve was plotted for the unsoaked condition. CBR value for 2.5 mm penetration was obtained as 2.54% for clayey soil and 3.11% for silty soil. The peak CBR value was obtained for 2.5 mm penetration at 8% rubber shred content with a CBR value of 6.21% for clayey soil and 6.38% for silty soil. Further increase in rubber shred percentage causes reduction in the CBR value to 5.74% for clayey soil and 6.08% for silty soil.

TABLE 7

CBR VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED (CLAYEY SOIL)

S.NO	% of Rubber Tyre Shred	CBR(%)
1	0	2.54
2	2	4.21
3	4	4.81
4	6	5.38
5	8	6.21
6	10	5.74

TABLE 8

CBR VALUES FOR DIFFERENT % OF RUBBER TYRE SHRED (SILTY SOIL)

S.NO	% of Rubber Tyre Shred	CBR(%)
1	0	3.11
2	2	4.27
3	4	5.01
4	6	5.74
5	8	6.38
6	10	6.08

Traffic Design: The recommended method considers design traffic in terms of the cumulative number of standard axles to be carried by the pavements during the design life. Axle load spectrum data are required where cementations bases are used for evaluating the fatigue damage of such bases for heavy traffic.

Computation of Design Traffic:

$$N=\frac{365*[(1+r)^{n}-1]}{r}*A*D*F$$

Where,

N = Cumulative number of standard axles to be catered for in the design in terms of msa.

A=Initial traffic in the year of completion of construction in terms of the number of Commercial Vehicles per Day (CVPD).

D = Lane distribution factor = 0.5

F = Vehicle Damage Factor (VDF) = 3.5

n = Design life in years = 15

r = Annual growth rate of commercial vehicles in decimal = 7.5%

The traffic in the year of completion is estimated using the followingformula:

$A= P (1 + r)^{x}$

Where,

P= Number of commercial vehicles as per last count = 2670

x = Number of years between the last count and the year of completion of construction.(Say 1 Year)

By substituting above Values, N Value is Computed as**: 47.88 msa**

Pavement composition interpolated as per MORT&H
(IRC37-2012 page 29 plate 2) for Clayey soil at 0% rubber tyre shred
(a) Granular Sub base = 460 mm
(b) Base course (WMM) = 250 mm
(c) DBM =175 mm
(d) BC =40 mm

Pavement composition interpolated as per MORT&H
(IRC37-2012 page 30 plate 2) for Silty soil at 0% rubber tyre shred
(a) Granular Sub base = 380 mm
(b) Base course (WMM) = 250 mm
(c) DBM =160 mm
(d) BC =40 mm

Case-I: Clayey Soil +8% rubber tyre shred- Total pavement thickness=675mm

Pavement composition interpolated as per MORT&H (IRC37-2012 page 33 plate 3)

Sl.no	Description	Layers	Layers Thickness
1	Soil +8% rubber shred	Granular Sub base	260
2		Base Coarse (WMM)	250
3		DBM	125
4		BC	40

Case-II: Silty Soil +8% rubber tyre shred- Total pavement thickness=670mm

Pavement composition interpolated as per MORT&H (IRC37-2012 page 33 plate 3)

Sl.no	Description	Layers	Layers Thickness
1	Soil +8% rubber shred	Granular Sub base	260
2		Base Coarse (WMM)	250
3		DBM	120
4		BC	40

VII. CONCLUSIONS

1. The value of CBR is increased with increase in the percentage of rubber tyre shreds and is found to be maximum at 8% rubber tyre.
2. From the test results it was observed that the Silty soil with 8% rubber tyre shred is suitable for the construction purpose for soil subgrade in comparison with Clayey soil with 8% rubber tyre shred.
3. The 8% rubber tyre will be more durable than any other percentages of rubber tyre because of higher value of CBR.
4. It is known that the rubber tyre shreds can be used in the subgrade soil effectively to decrease the thickness of the flexible pavement.

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TRAFFIC DATA

S.no	Timings:	HCV	MCV	LCV	TWO WHEELERS	CYCLES	Total
1	8:00 am - 9:00 am	81	9	199	498	4	791
2	9:00 am - 10:00 am	52	13	175	522	2	764
3	10:00 am - 11:00 am	38	14	178	501	2	733
4	11:00 am - 12:00 pm	44	9	147	450	3	653
5	12:00 pm - 1:00 pm	41	5	150	419	4	619
6	1:00 pm - 2:00 pm	47	13	157	358	3	578
7	2:00 pm - 3:00 pm	45	17	120	300	4	486
8	3:00 pm - 4:00 pm	58	6	121	285	2	472
9	4:00 pm - 5:00 pm	55	18	185	401	1	660
10	5:00 pm - 6:00 pm	78	9	145	320	2	554
11	6:00 pm - 7:00 pm	55	18	130	325	0	528
12	7:00 pm - 8:00 pm	71	13	154	295	0	533
	Total	665	144	1861	4674	27	7356

P=HCV+MCV+LCV= 2670

