Use of Lime And Crumb Waste Tyre Rubber in Improving Quarry Dust Stabilized Expansive Soil Subgrade

John Emmanuel Busi[1], B.Ganesh[2]
[1]Dept of Civil Engineering
[2]Associate Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract*- With the rise in development of countries the rate of production of wastes has increased tremendously in almost all parts of the world in the past few decades. Quarry dust is a waste material produced from aggregate crushing industries. The quantities of this waste material impose hazardous effect on environment and public health. Disposal of such waste material creates lots of problem to the environment and public. Performance of Flexible Pavement depends on the functions of the component layers especially Subgrade. Construction over problematic subgrade affects the performance of pavement and results in shorter life of pavement. The typical approach of stabilization of subgrade is to remove the problematic soil, and replace it with soil of high strength. The high cost of replacement of poor soil has caused highway agencies to assess alternative methods. One approach is to improve the properties of soil with addition of the waste materials. Considering this aspect an experimental study was planned to improve the locally available problematic expansive soil by mixing it with Quarry dust. Waste tyres have characteristics that make them not easy to dispose, and potentially combustible. Disposal of a variety of wastes in an eco-friendly way is the thrust area of today's research. This approach of using Quarry dust as a replacement to the problematic expansive soil and waste tyre rubber as reinforcement will solve two problems with one effort i.e. elimination of solid waste problem on one hand and provision of a needed construction material on other. The main objective of this investigation is to utilize Quarry dust, waste tyre rubber and also Lime as Binder to improve the problematic expansive soil by conducting the Laboratory Tests with the various proportions given below.*

Keywords- Waste Tyre, Rubber, Lime, Quarry Dust, Expansive Soil and Stabilization.

I. INTRODUCTION

For centuries mankind was wondering at the instability of earth materials, especially expansive soil. The swelling and shrinking properties of the soil depends on the water content of the soil. The water content of soil is considerably reduced during summer hence the soil becomes stiff and shrinkage cracks develop. During the rainy season the water content of the soil is increased resulting in swelling and when a building is constructed on this type of soils, the soil below the building is protected from excess heat even during summer. This soil swells because its evaporation is obstructed. However the soil adjacent to the building which is open to atmosphere will experience normal swelling and shrinkage. Thus, the differential movements occur during the hot weather. As a result, the superstructures usually result in damage to foundation systems, structural elements and architectural features.Even when efforts are made to improve swelling soil, the lack of appropriate technology sometimes results volumetric change that are responsible for billion dollars damage each year. Expansive soil deposits occur in the arid and semi-arid regions of the world and are problematic to engineering structures because of their tendency to heave during wet season and shrink during dry season (Mishra et al. 2008). Hence, expansive soil subgrade when encountered should be treated to eliminate the problems for construction of flexible pavements on them. Critical viewing of the literature revealed that stabilization of these soils can be done by mixing/replacing with industrial wastes. This prompted the present study of improving the locally available problematic expansive soil by mixing it with nearby Stone Crusher Industrial waste, Quarry dust and Crumb Waste tyre rubber as discrete reinforcing inclusions, thereby, solving two problems with one effort i.e. elimination of solid waste problem on one hand and provision of a needed construction material on other. Hence, the investigation programme planned and the results of the Laboratory experimentation with the various proportions are presented in this paper.

II. REVIEW OF LITERATURE

Expansive soils are composed primarily of hydrophilic clay minerals, such as Montmorillonite, and with significant swelling and shrinking characteristics. Compared with the common clay, expansive soil has three characteristics, expansive, crack and over-consolidation. Crack is concentrated expression of expansion and over consolidation. With the decline of water content expansive soil will shrink and result in crack the changing of environment leads to drying and wetting effect and the crack will further develop.

Effect of Nylon Fibers & Rice Husk on Engineering Properties of Soils .Optimum moisture content and maximum dry density decreases with increase in the lime content.CBR value decreases with increase in the quantity of rice husk. CBR value is high at 5% rice husk. CBR value is high at 20% lime when compared to 5%, 10%, 40% of lime mixed with soil. CBR value is high at 10% lime + 1.5% fiber when compared to the remaining proportions. CBR value for (soil +10% lime) and (soil + 40% lime) is same. CBR gradually increases with increase in fibers up to 2% (soil + 5% lime). CBR value increases up to 1.5% addition of fibers in and decreases at 2% fiber in (soil + 10% lime). CBR value gradually decreases with increase of fiber content in (soil+ 20%lime). CBR value gradually increases with increase of fibers in 40% lime with soil.From the observations, the strength at 20% lime is more. Hence 20% of lime may be used for strength purpose and for low traffic the rice husk may be used for economical purpose (**CH.MAHESH** and **Dr A.S.RAO)**.

An attempt was made to determine the utility of industrial wastes in Stabilization of medium plastic clays (CI). Fly ash (FA) and waste tire rubber (WTR) have been considered to investigate their potential in stabilizing the CI soils. Laboratory Experimentation is done to evaluate the optimum contents of fly ash and waste tire rubber Content to check the California Bearing Ratio strength (CBR), Differential Free Swell % and Unconfined Compressive Strength (UCC) strength. The results indicated that the 25% addition of fly ash to the medium plastic clay soils (CI) resulted in a CBR valueof 10% and a 7 Days UCC strength of 330 kN/Sq.m. 6% addition of waste tire rubber content to CI soil resulted in a CBR value of 4.36% and a 7 day UCC value of 80kN/Sqm. The differential free swell % evaluated for the optimal mixes indicated that the stabilized mixes exhibited low expansiveness. Industrial wastes namely fly ash and waste tire rubber can be effectively used to stabilize clay subgrades to achieve high strength values thus resulting in decreased pavement thickness and low maintenance (**Dr.K.V KRISHNA REDDY)**.

III. METHODOLOGY

MECHANICS OF SOIL STABILIZATION

Stabilization is the process of blending and mixing materials with a soil to improve the soil's strength and durability. Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Soils stabilized by additives often provide an all-weather working platform for construction operations

Properties of soil sample

The soil sample was collected from Bandarulanka near Amalapuram, in East Godavari District, Andhra Pradesh State, India. It was selected for the present study after conducting laboratory tests as per the IS Codes of Practice, by pulverizing the lumps into individual particles to determine the properties of the selected soil sample as mentioned here under**.**

Table 1: Properties of Expansive Soil

S.No	Property	Value
1	Specific gravity	2.64
2	Differential free swell Index (%)	101
3	Atterberg's Limits	
	i) Liquid limit (%)	63.2
	ii) Plastic limit (%)	24.6
	iii) Plasticity index (%)	38.6
5	Grain Size Distribution	
	i) Sand Size Particles (%)	11
	ii) Silt & Clay Size Particles (%)	89
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.46
	ii) Optimum Moisture Content (%)	28.3
8	Penetration Parameters	
	i) CBR - Unsoaked (%)	3.5
	ii) CBR - Soaked (%)	1.7
9	Shear Parameters at OMC & MDD	
	i) Cohesion, Cu (kPa)	44
	ii) Angle of Internal Friction, Øu (Degrees)	0

Crumb Waste Tyre Rubber

Solid waste management is one of the major environmental concerns worldwide. For the last 30 years many studies have been conducted in order to assess the feasibility of using industrial by-products and waste materials in civil engineering applications.

Table 2: Properties of crumb waste tyre rubber

S.NO	PROPERTY	VALUE
1	Specific gravity	1.4
2	Grain Size Distribution	
	i) Gravel Size Particles (%)	0
	ii) Sand Size Particles (%)	96
	iii) Silt & Clay Size Particles (%)	4

Quarry Dust

Quarry dust exhibits high shear strength which is highly beneficial for its use as a geotechnical material. It has a good permeability and variation in water content does not seriously affect its desirable properties. It is proved to be a promising substitute for sand and can be used to improve the engineering properties of soils.

Table 3: Properties of Quarry Dust

S. No	Property	Value
1	Specific gravity	2.71
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Gravel Size Particles (%)	6
	ii) Sand Size Particles (%)	84
	iii) Silt & Clay Size Particles (%)	10
4	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.88
	ii) Optimum Moisture Content (%)	10.4
5	Penetration Parameters	
	i) CBR - Unsoaked (%)	14.5
	ii) CBR - Soaked (%)	9.6

LIME

Lime is a calcium containing inorganic material in which carbonates, oxides and hydroxides predominate. In the strict sense of the terms, lime is calcium-oxide or calcium-hydroxide. It is also the name of the natural mineral (native lime) CaO which occurs as a product of coal seam fires and in altered limestone xenoliths in volcanic ejecta. The word "lime" originates with its earliest use as building mortar and has the sense of "sticking or adhering". These materials are still used in large quantities as building and engineering materials (including limestone products, cement, concrete, and mortar), as chemical feedstocks, and for sugar refining, among other uses. Lime industries and the use of many of the resulting products date from prehistoric times in both the Old World and the New World. Lime is used extensively for wastewater treatment with ferrous sulphate.

IV. RESULTS AND DISCUSSIONS

Evaluating The Optimum Content Of Quarry Dust

The percentage of Quarry dust (QD) was varied from 0%, to 30% has moderately improved the expansive soil. We can see that, there is a gradual increase in maximum dry density with an increment in the % replacement of Quarry dust (QD) up to 30% for strength characteristics. The addition of Quarry dust (QD) had mobilized little amount of friction to the pure Clayey soil without friction.

Table 4: Quarry Dust+ Expansive Soil

QD (%)	DFS (%)	LL %	PL %	PI %	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
30	69	56	27.1	28.9	1.6	22.6	8	3.8	104
20	81	58.2	26.5	31.7	1.54	25.1	6.9	3	99
10	94	60.9	25.8	35.1	1.49	26.9	5.1	2.4	94
0	101	63.2	24.6	38.6	1.46	28.3	3.5	1.7	88

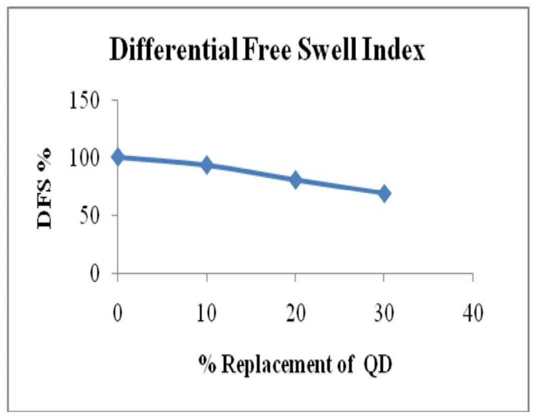

Figure1:Variation in DFS with % Replacement of Quarry Dust (QD)

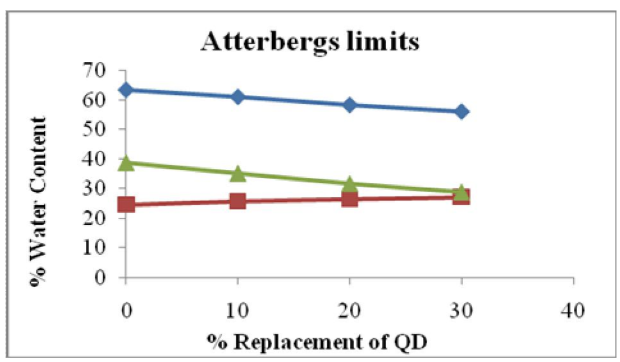

Figure 2: Variation in ATTERBERGS LIMITS with % Replacement of Quarry Dust (QD)

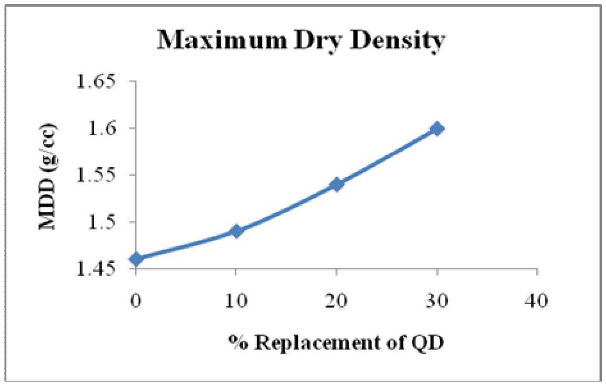

Figure 3: Variation in MDD with % Replacement of Quarry Dust (QD)

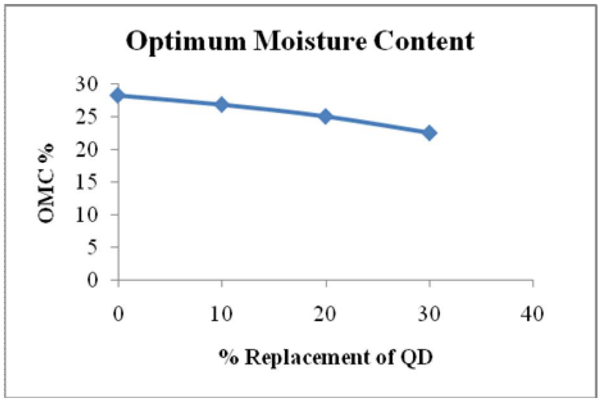

Figure 4: Variation in OMC with % Replacement of **Quarry Dust (QD)**

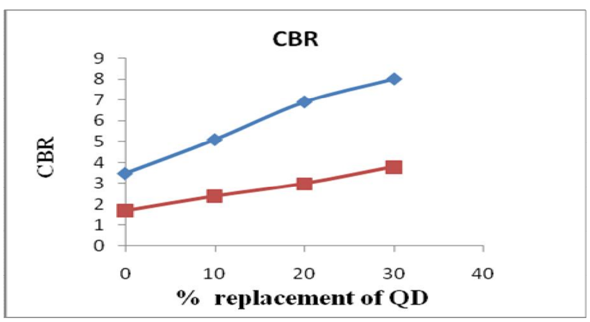

Figure5: Variation in CBR with % Replacement of Quarry Dust(QD)

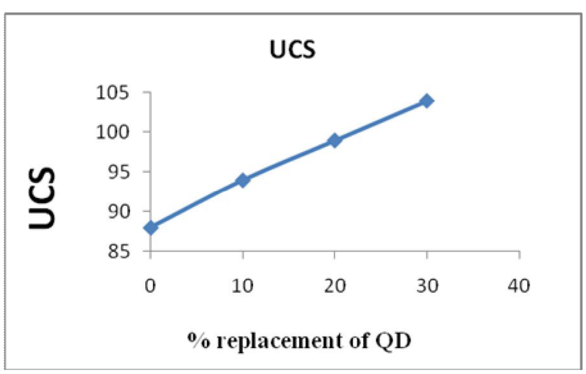

Figure6: Variation in UCS with % Replacement of Quarry Dust(QD)

Evaluating The Optimum Content Of Crumb Waste Tyre Rubber (Cwtr) With 30% Quarry Dust As Replacement

The percentage of crumb waste tyre rubber was varied from 0%, to 8% has moderately Improved the expansive soil. We can notice that, there is a gradual increase in maximum dry density with an increment in the % replacement of crumb waste tyre rubber up to 8% for strength characteristics. The addition of crumb waste tyre rubber had mobilized little amount of friction to the pure Clayey soil without friction.

Table 5: Expansive Soil (ES) + Quarry Dust (QD) + Crumb Waste Tyre Rubber (CWTR)

CWTR %	DFS %	LL %	PL %	PI %	MDD (g/cc)	OMC %	CBR (US) %	CBR (S) %	UCS kPa
8	56	51.5	28.8	22.7	1.5	21.7	7.9	3.5	108
4	60	52.3	28.4	23.9	1.55	21.9	8.3	4.2	114
2	64	54.6	27.5	27.1	1.57	22.4	8.1	4	107
0	69	56	27.1	28.9	1.6	22.6	8	3.8	104

From the above results the 30% replacement of Expansive soil with Quarry Dust can be considered

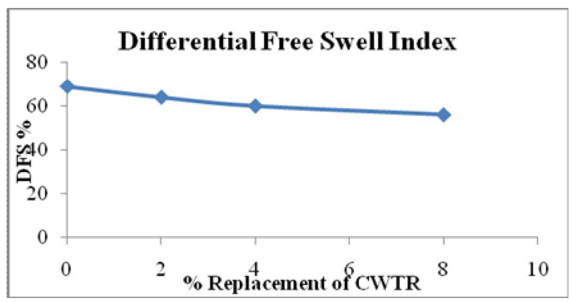

Figure7: Variation of DFS WITH Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

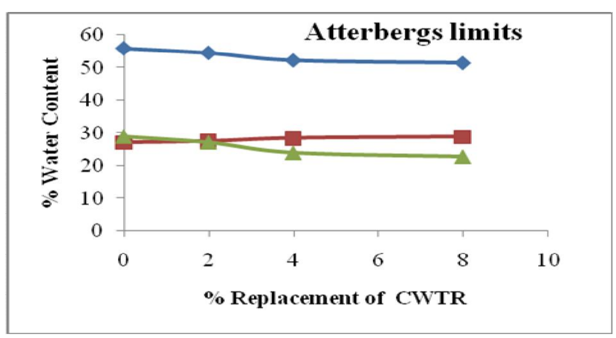

Figure8: Variation of ATTERBERG LIMITS with Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

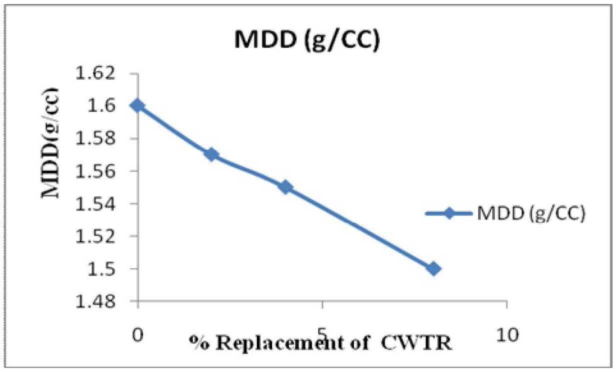

Figure9:Variation of MDD with Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

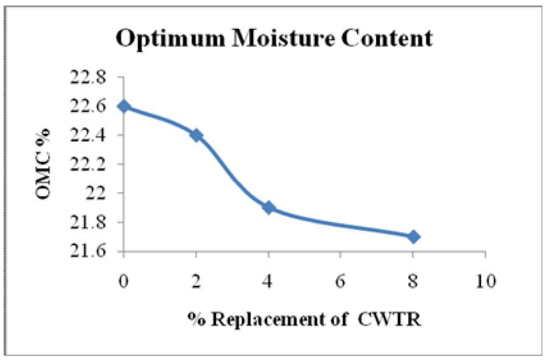

Figure10: Variation of OMC with Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

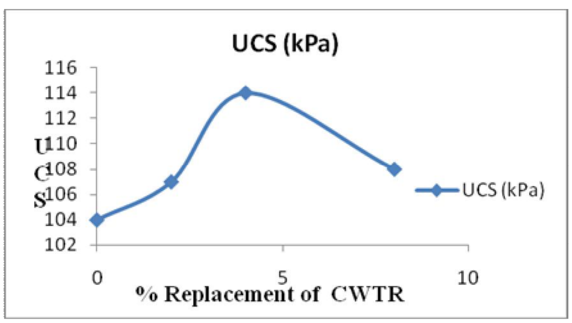

Figure11: Variation of COHESION with Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

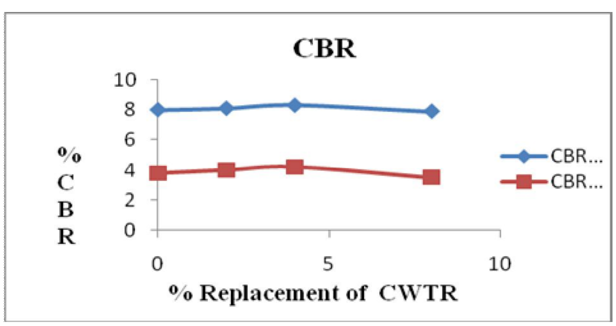

Figure12: Variation of CBR with Crumb Waste Tyre Rubber (CWTR) and 30% Quarry Dust as replacement

Evaluating The Optimum Content Of Lime Content With 4% Cwtr& 30% Qd As Replacement

The percentage of lime was varied from 0% to 8%. In the laboratory, tests were conducted by blending different percentages of lime to expansive soil + quarry dust + crumb waste tyre rubber mixes with a view to determine its optimum blend. It is observed that there is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content. From the above results it is evident that the addition of lime to the expansive soil + quarry dust + crumb waste tyre rubber mix had improved its Compaction and Strength characteristics.

Table 6: Expansive Soil (ES) + Quarry Dust (QD) + Crumb Waste Tyre Rubber (CWTR) + Lime

Lime (%)	DFS (%)	LL (%)	PL (%)	PI %	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	60	52.3	28.4	23.9	1.55	21.9	8.3	4.2	114
2	55	50.9	28.9	22	1.58	22.2	8.4	5.4	123
4	49	48.2	29.3	18.9	1.62	22.3	8.9	6.9	149
6	42	46.4	30.1	16.3	1.63	22.4	9.1	8.1	155

From the above results the Optimum Content of Crumb Waste Tyre Rubber (CWTR) with 30% Quarry Dust as replacement of Expansive soil is 4% based on CBR & UCS values

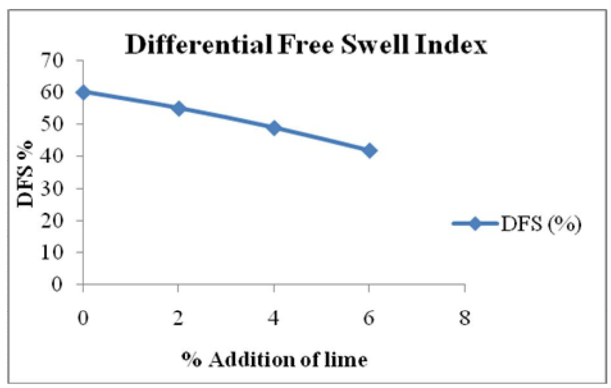

Figure13: Variation of DFSwithLime Content with 4% CWTR & 30% QD as replacement

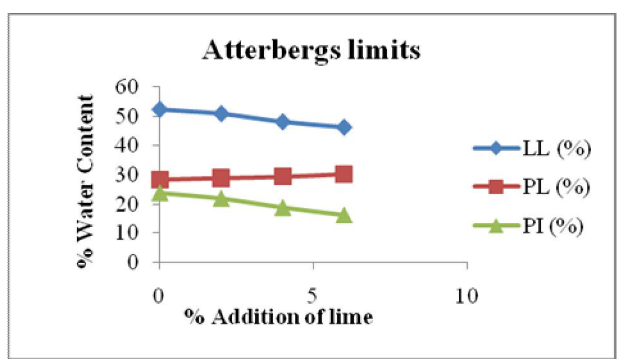

Figure14: Variation of ATTERBERG LIMITSwithLime Content with 4% CWTR & 30% QD as replacement

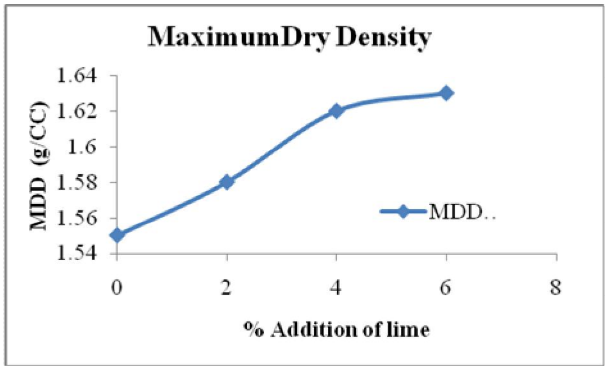

Figure15: Variation of MDDwithLime Content with 4% CWTR & 30% QD as replacement

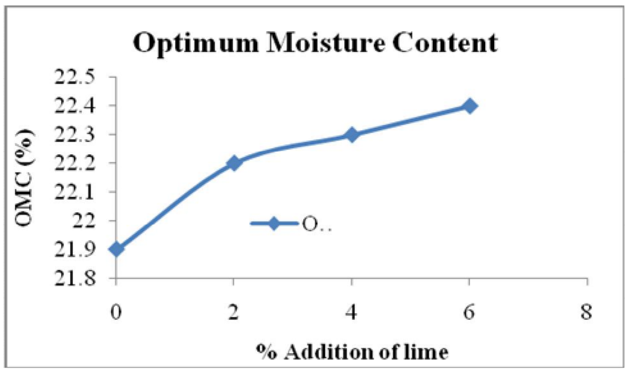

Figure16: Variation of OMCwithLime Content with 4% CWTR & 30% QD as replacement

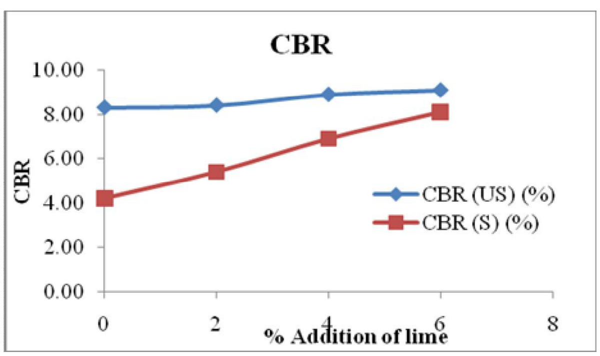

Figure17: Variation of CBRwithLime Content with 4% CWTR & 30% QD as replacement

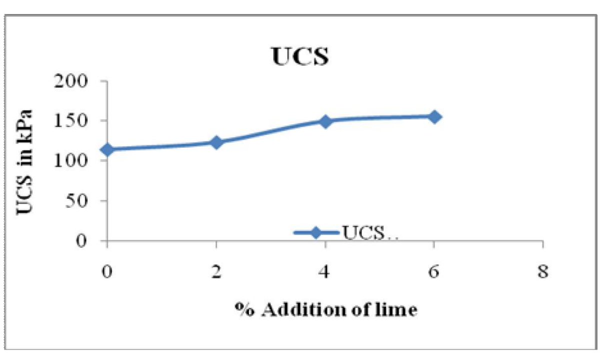

Figure18: Variation of COHESIONwithLime Content with 4% CWTR & 30% QD as replacement.

VI. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation.

I. From the laboratory studies, it is observed that the Expansive Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.

II. The percentage of Quarry dust (QD) was varied from 0% to 30% has moderately improved the expansive soil. There is a gradual increase in maximum dry density with an increment in the % replacement of Quarry dust (QD) up to 30% for strength characteristics.

III. The percentage of crumb waste tyre rubber added to quarry dust and expansive soil mix was varied from 0% to 8% has also moderately improved the expansive soil. There is a gradual increase in maximum dry density with an increment in the % replacement of crumb waste tyre rubber up to 8% for strength characteristics.

IV. The percentage of lime was varied from 0% to 8%. The laboratory tests conducted by blending different percentages of lime to expansive soil + quarry dust + crumb waste tyre rubber mixes revealed that there is an improvement in maximum dry density and also corresponding strength characteristics with an increase in the lime content.

V. It is evident that the addition of quarry dust + crumb waste tyre rubber to the virgin Expansive soil showed an improvement in Compaction and Strength characteristics to some extent and on further blending it with lime, the improvement was more pronounced.

VI. It can be summarized that the materials quarry dust , crumb waste tyre rubber and lime had shown promising influence on the Strength and Penetration properties of expansive soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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