Improving Marine Clay Subgrades with Quarry Dust, Lime and Crumb Waste Tyre Rubber

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Abstract- *The present study focuses on the analysis of material handling system with the help of discrete event simulation. The simple factory layout of packing system is considered and modeled with the queuing system based on time and the size delay function.it is found that the total system once modeled can helps in the improve modify or study the process in detail and helps to understand the system very effetely For any developing nation like India infrastructural development and transportation facilities are vital. In the present scenario of space scarceness, the developmental activities are often challenging when encountered with poor sub-soil conditions. In particular, marine deposits have very low shearing strength and are highly compressible. In addition to these, the problems arising out of high compressibility and low shear strength of these weak marine deposits expose geotechnical engineers to considerable changes in the construction of various coastal and offshore structures. All over the world, problems of marine soils have appeared as cracking and break-up of pavements in particular to the pavement infrastructure. The loss caused due to the damaged structures proved the need for more reliable investigation of such soils and necessitates methods to eliminate, or reduce, the effect of settlements. Stabilization is one of the processes available for improving the engineering properties of these kinds of soils and thus making it more stable. This led to initiate the present work in studying the effect of Quarry Dust, Lime and Crumb waste tyre rubber on the properties of marine soil. The work deals in assessing the strength behavior of marine clay stabilized with lime, quarry dust and Crumb waste tyre rubber thereby giving a two-fold advantage in improving a problematic marine clay and also solving a problem of waste disposal.*

Keywords- Marine clay, Crumb waste tyre rubber, Quarry Dust, Lime, Atterberg's limit test, CBR test, Un confined compression test, maximum dry density and optimum moisture content test.

I. INTRODUCTION

In many cases, clay deposit layers which are widely distributed over the Seaside show various aspects according to the type of base rock or distribution Characteristics. Marine clay deposits are encountered in the coastal regions of the world. Marine clay is soft in consistency and is characterized by high compressibility and low shear strength. They are fine grained soils with moderate to high clay fraction and are highly plastic in nature. Generally marine clay deposits vary from 10 to 30 m in thickness along the coast line. Calcareous material is expected to be present in these soils in the form of small sized shells. The properties of these deposits are complex and diverse and they mainly depend on the minerals present and micro structural arrangement of the constituent particles.

Transportation is necessary for the proper functioning and development of economic activities for any country, which involves production and distribution of goods and services from one place to other. Performance and life of road network is generally depending upon the design and construction. Sub grade is generally made up of locally available natural soils. The strength and performance of a pavement is dependent on the load-bearing capacity of the Sub grade soil. In case of poor soil in construction site, the poor soil can be removed or replaced with the soil of high strength. Design of pavement is depend upon the strength of the subgrade soil, which affects the thickness of pavement ultimately increase the cost of construction. Improvement in load bearing capacity of soil will improve the load-bearing capacity of pavement and thus, pavement strength and its performance.

The industrial revolution made mind-blogging changes in the trade and transport sector. Developing countries like India mainly depend on the transportation sector for their economical 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.

1. OBJECTIVES OF THE STUDY

The objectives of present experimental study are to develop correlations between engineering characteristics of marine clay.

- To determine the characteristic of marine clay in particular the basic Properties, strength and compressive characteristics.
- To evaluate the performance of Marine clay when stabilized with lime as an admixture and its suitability for the pavement sub grade.

To evaluate the performance of stabilized Marine clay with an optimum of quarry dust, lime and crumb waste tyre rubber and their suitability for the pavements.

2. GENERAL

Transportation fulfills the basic need of humanity. For the time immemorial everyone travels either for food or leisure. There is a strong correlation between the quality of transportation facilities and development of country, because of which everyone places a great expectation from transportation facilities. Major challenges among civil engineers today is that transportation system must be analytically based, economically sound, eco-friendly, socially credible, sustainable and practically acceptable. In current scenario, conventional construction methods are unsuitable and driving interest in technologies like ground improvement. Among all transportation modes, economical road network plays a vital role for advancement in the economy of developing countries like India. In case of a highway, if the sub grade layer of the pavement is weak then they require greater thickness of pavement that results in increase of pavement construction cost.

3. MARINE CLAY

Soft marine clay is very sensitive to change the stress system, moisture content and system chemistry of the pore fluid. Geotechnical engineers feel a necessity to improve the behavior of these deposits using anyone of the available ground improvement techniques for the construction of foundations. Soft clays known for their high compressibility, low stiffness and low shear strength are always associated with large settlement. The marine clay got cracks as shown in the plate on drying and in the worst cases the width of the cracks is almost 250mm to 500mm and travel down to 1.00m beneath the ground level.

II. LITERATURE REVIEW

In general, the soils which are existing in the coastal corridors are Soft Marine Clays formed by the deposits and generally weak and possesses high deformation values in nature. It is essential to study the various techniques for the improvement of marine clays, especially in case of infra-structure development.

Purushotham G. Sarvade and Prashant R She reports the findings of experimental studies with regard to geotechnical properties of both problem clay and stabilized clay, and to evaluate their suitability in tile industry. Also an investigation was carried out to study the effect of cement and lime on CRP stabilized clay.

Koteswara Rao. D, M.Anusha, P.R.T. Pranav, G.Venkatesh presents the experimental study on effect of Saw Dust and Lime on strength properties of marine clay.

Anjana Prakash , Anju Paul made an attempt to evaluate the effectiveness of using quarry dust in modifying the properties of marine sediments, by the means of laboratory tests to assess the compatibility of modifying the marine dredge soil as a construction material for the road construction.

Shiva Prasad.A, P.T.Ravichandran, R.Annadurai, P.R.Kannan Rajkumar paper presents the stabilization of soils using crumb rubber at varying percentages (5%, 10%, 15% and 20%). The soil properties, compaction and unconfined compression strength were used to gauge the behavior and performance of the stabilized soils.

Balasubramaniam, A.S et.al (2003), proved the effects of additives on Soft Clay behavior and concluded that the strength characteristics of the soft clays are improved by using various additives.

Basack,S et.al (2009), reported that the Engineering characteristics of marine clay collected form Visakhapatnam, India and the physical, chemical and mineralogical properties were presented and the strength, stiffness of the soil water matrix were established.

III. METHODOLOGY

MATERIALS USED AND THEIR PROPERTIES

Marine clay

Marine clay is a type of clay found in coastal regions around the world. In the northern, deglaciated regions, it can sometimes be quick clay, which is notorious for being involved in landslides. Clay particles can self-assemble into various configurations, each with totally different properties.

Properties of Marine Clay

Table 1. Properties of Marine Clay

S. No.	Property	Value
1	Specific gravity	2.62
2	Differential free swell Index (%)	32
3	**Atterberg's Limits**	
	i) Liquid limit (%)	68.4
	ii) Plastic limit (%)	24.2
	iii) Plasticity index (%)	44.2
4	**Grain Size Distribution**	
	i) Sand Size Particles (%)	9
	ii) Silt & Clay Size Particles (%)	91
5	IS soil classification	CH
6	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.4
	ii) Optimum Moisture Content (%)	29.1
7	**Penetration Parameters**	
	i) CBR - UnSoaked (%)	3.1
	ii) CBR - Soaked (%)	1.4
8	**Shear Parameters at OMC & MDD**	
	i) Cohesion, Cu (kPa)	38
	ii) Angle of Internal Friction, Øu (Degrees)	0

Quarry dust

Quarry dust is a waste obtained during quarrying process. Quarry dust/crusher dust is obtained as soil solid wastes during crushing of stones to obtain aggregates. 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. Quarry dust proved to be a promising substitute for sand and can be used to improve the engineering properties of soils. The dry density increased with the addition of quarry dust with attendant decrease in the optimum moisture content.

Properties of Quarry dust

Table 2. 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

The commercial Birla lime taken from market for the purpose of stabilizing soil, which imparts cementing property to the soil mix.

Properties of lime

- Lime is a white amorphous solid.
- It has a high melting point of 2600oC.
- It is highly stable and even fusion cannot decompose it.

CRUMB WASTE TYRE RUBBER

Disposal of waste tires is a challenging task because tires have a long life and are non-biodegradable. ... Crumb rubber is a term usually applied to recycled rubber from automotive and truck scrap tires. There are two major technologies for producing crumb rubber – ambient mechanical grinding and cryogenic grinding. Waste tyre rubber is collected from V.Maruthyretrading company in Kakinada. The mixing of waste tyre rubber in soil not only reduces the waste in the environment but also increases the strength .

LABORATORY EXPERIMENTATION:-

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the marine clay to find the properties of virgin marine clay.

The following tests were conducted as per IS codes of practice.

- Grain size distribution
- Specific gravity
- Index properties –liquid limit, plastic limit
- Compaction tests
- Penetration tests-California bearing ratio test.
- Unconfined Compression Test-Triaxial

IV. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by replacing different percentages of Quarry Dust and crumb waste tyre rubber in the Weak marine Soil and also further stabilizing it with lime as a binder. Liquid Limit, Plastic Limit and Compaction, CBR and Triaxial shear tests were conducted with a view to determine the optimum combination of Quarry Dust and crumb waste tyre rubber as replacement in weak marine soil and Lime as a binder.

The influence of the above said materials on the Index, Compaction and Strength properties were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice.

1. EFFECT OF % QUARRY DUST AS REPLACEMENT ON THE PROPERTIES OF WEAK MARINE SOIL

The individual influence of Quarry Dust on the Index, Compaction and Strength properties of marine soil are clearly presented in Figures 4.1, 4.2, 4.3, 4.4, and 4.5 respectively. The percentage of Quarry Dust was varied from 0%, to 30% with an increment of 10%. From the above graphs, it was observed that the treatment as individually with 30% Quarry Dust has moderately improved the marine soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % replacement of Quarry Dust up to 30% with an improvement of about 12%. Also maximum dry density is improved by an amount of 10% and it was about 28% for UCS and 83%, 128% for UnSoaked, Soaked respectively.

2. EFFECT OF % CRUMB WASTE TYRE RUBBER AS REPLACEMENT ON THE PROPERTIES OF WEAK MARINE SOIL

The individual influence of crumb waste tyre rubber on the Index, Compaction and Strength properties of marine soil are clearly presented in Figures 4.6, 4.7, 4.8, 4.9, and 4.10 respectively. The percentage of crumb waste tyre rubber was varied from 0%, 2%, 4%, 8% From the above graphs, it was observed that the treatment as individually with 4% crumb waste tyre rubber has moderately improved the marine soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % replacement of crumb waste tyre rubber up to 4% with an improvement of about 9%. Also maximum dry density is improved by an amount of 2% and it was about 10% for UCS and 19%, 21% for UnSoaked, Soaked respectively.

3. EFFECT OF LIME CONTENT ON THEPROPERTIES OF WEAK MARINE SOIL + QUARRY DUST AND CRUMB WASTE TYRE RUBBER MIXES

The influence of lime as binder on the Index, Compaction and Strength characteristics of weak marine Soil + quarry dust and crumb waste tyre rubber mixes are clearly presented in Figures 4.11, 4.12, 4.13, 4.14, and 4.15 for different percentages of lime respectively. The percentage of Lime was varied from 0%, to 6% with an increment of 2%.In the laboratory, tests were conducted by blending different percentages of lime to Weak Marine Soil + quarry dust and crumb waste tyre rubber mixes with a view to determine its optimum blend. It is observed from the graphs, that there is an improvement in plasticity & Strength characteristics with an increase in the lime content from 0% to 6% with an improvement of 16% for plasticity, 4% for MDD, 34% for UCS and 19%, 66% for UnSoaked, Soaked respectively.. From the above results it is evident that the addition of lime to the Quarry dust and crumb waste tyre rubber –Weak Marine Soil mix had improved its characteristics.

Table 3.

QD (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	1.4	29.1	3.1	1.4	76
10	1.44	28.6	3.8	1.9	82
20	1.49	27.8	4.9	2.6	90
30	1.54	27.5	5.7	3.2	98

Results of the tests conducted on marine clay replacement with different percentages of quarry dust

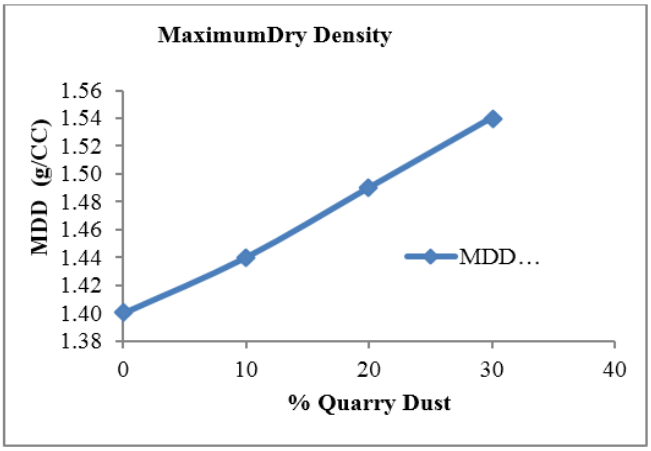

Figure 1. Plot showing the Variation in MDD with % Replacement of QD

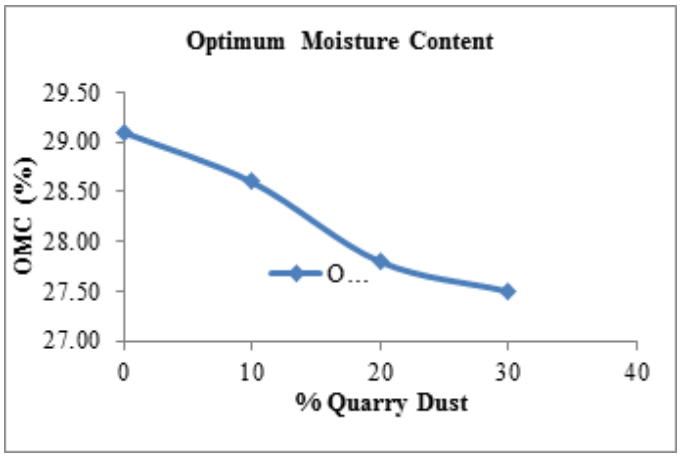

Figure 2. Plot showing the Variation in OMC with % Replacement of QD

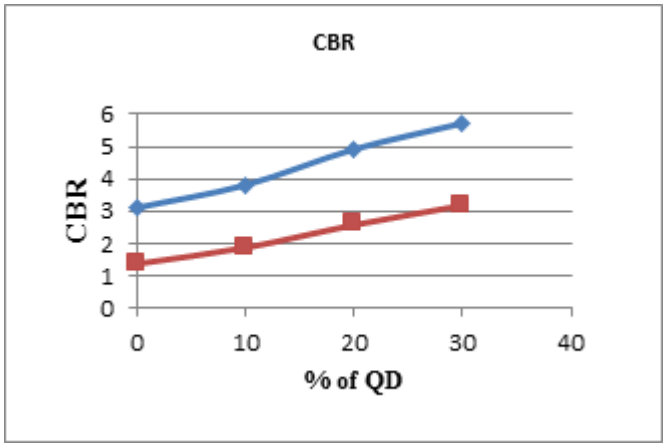

Figure 3. Plot showing the Variation in CBR VALUES with % Replacement of QD

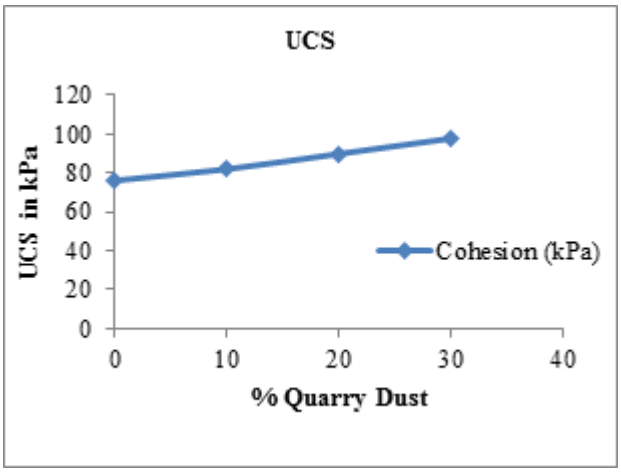

Figure 4. Plot showing the Variation in UCS with % Replacement of QD

Results of the tests conducted on marine clay replacement with different percentages of CWTR

Table 4.

CWTR (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	1.54	27.5	5.7	3.2	98
2	1.53	27.4	6	3.5	104
4	1.51	27.2	6.8	3.9	108
8	1.49	27.1	6.5	3.7	105

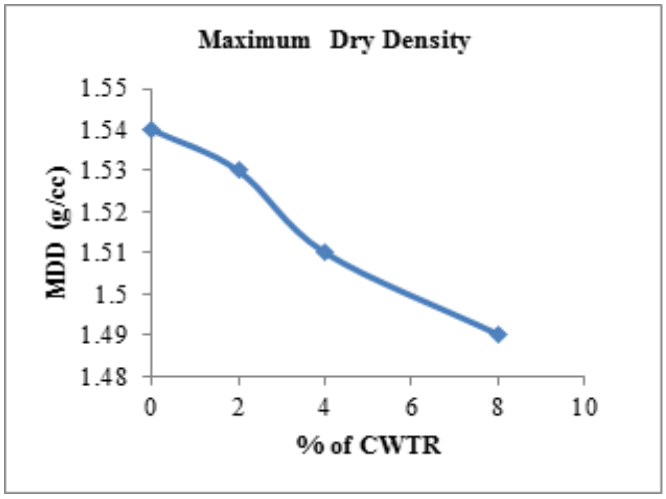

Figure 5. Plot showing the Variation of MDD With Crumb Waste Tyre Rubber (CWTR) AND 30% Quarry Dust as replacement

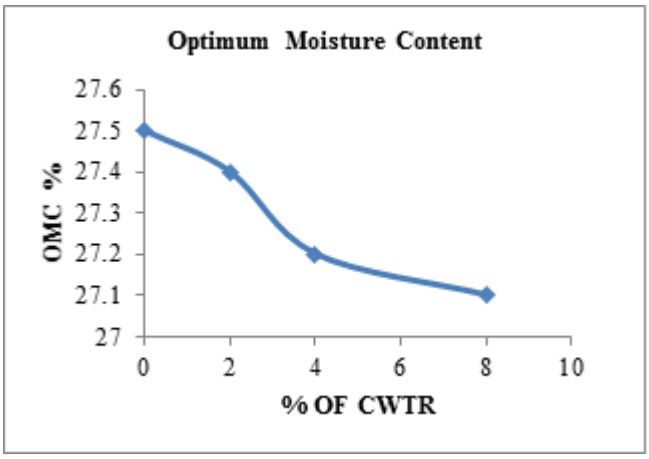

Figure 6. Plot showing the Variation of OMC With Crumb Waste Tyre Rubber (CWTR) AND 30% Quarry Dust as replacement

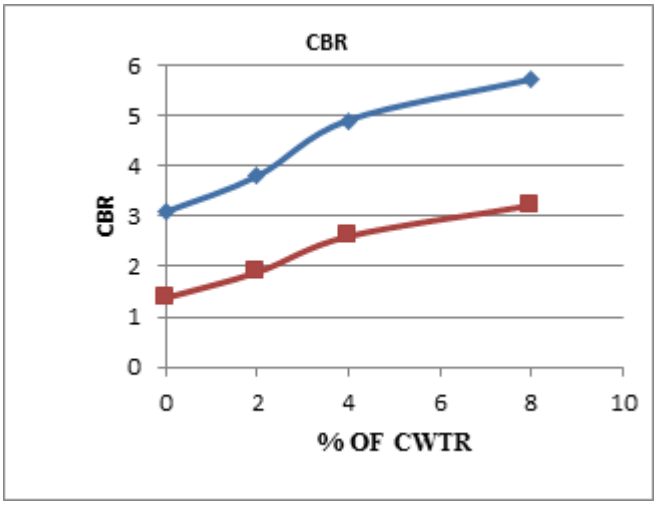

Figure 7. Plot showing the Variation of CBR Values With Crumb Waste Tyre Rubber (CWTR) AND 30% Quarry Dust as replacement

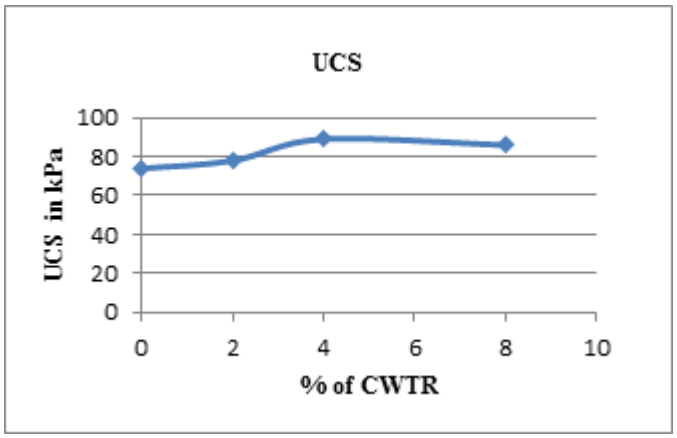

Figure 8. Plot showing the Variation of UCS With Crumb Waste Tyre Rubber (CWTR) AND 30% Quarry Dust as replacement

Results of the tests conducted on marine clay addition with different percentages of LIME

Table 5.

Lime (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	1.51	27.2	6.8	3.9	108
2	1.53	27.4	7	4.6	117
4	1.56	27.7	7.5	5.7	136
6	1.58	27.9	8.1	6.5	145

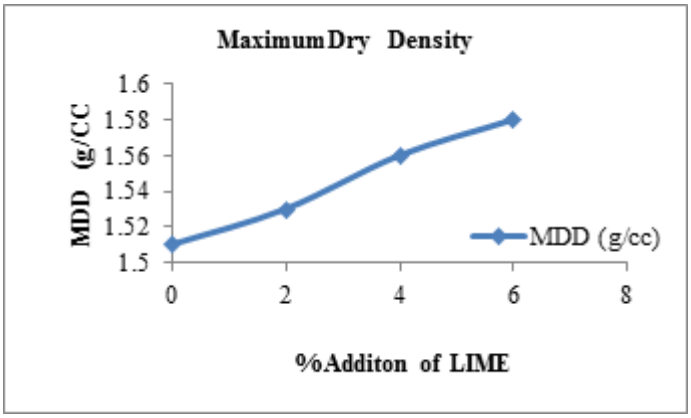

Figure 9. Plot showing the Variation of MDD With Lime Content and 4% CWTR & 30% QD as replacement

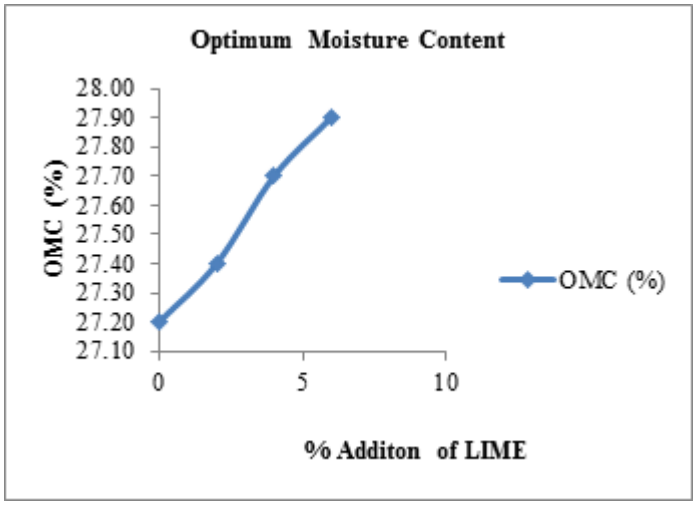

Figure 10. Plot showing the Variation of OMC With Lime Content and 4% CWTR & 30% QD as replacement

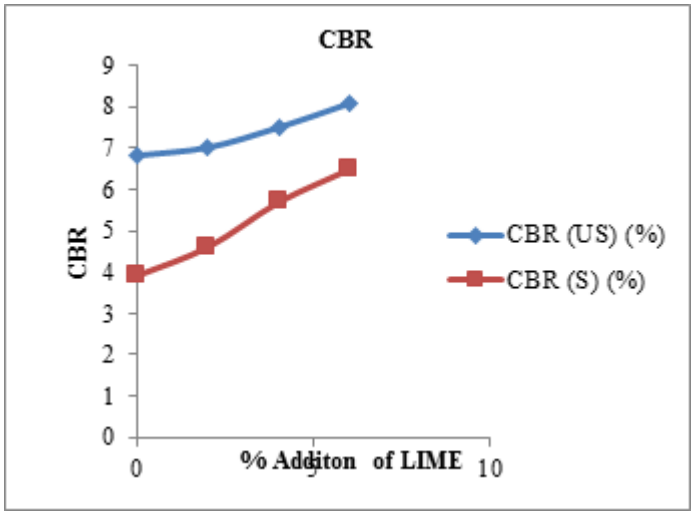

Figure 11. Plot showing the Variation of CBR With Lime Content and 4% CWTR & 30% QD as replacement

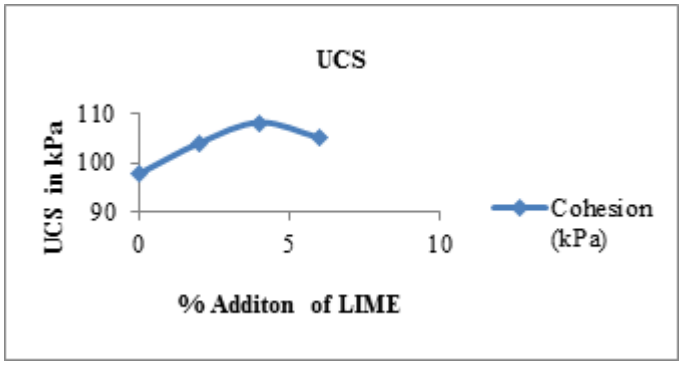

Figure 12. Plot showing the Variation of UCS With Lime Content and 4% CWTR & 30% QD as replacement

V. CONCLUSION

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

- From the laboratory studies, it is observed that the Marine Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- It was observed that the treatment as individually with 30% of Quarry Dust has moderately improved the marine soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of QD up to 30% with an improvement of about 10% and it was about 12% for plasticity characteristics.
- There is an improvement in CBR, Shear parameters also by an amount of 28% for UCS and 83%, 128% for UnSoaked, Soaked respectively.
- It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % adding of crumb waste tyre rubber up to 4% with an improvement of about 9%. Also maximum dry density is improved by an amount of 2% and it was about 10% for UCS and 19%, 21% for UnSoaked , Soaked respectively.
- There is an improvement in plasticity & Strength characteristics with an increase in the lime content from 0% to 6% with an improvement of 16% for plasticity, 4% for MDD.
- There is an improvement by an amount of 34% for UCS and 19%, 66% for UnSoaked, Soaked respectively.
- It is evident that the addition of Quarry dust and crumb waste tyre rubber to the virgin Marine soil showed an improvement in properties to some extent and on further blending it with lime, the improvement was more pronounced.
- Finally it can be summarized that the materials Quarry dust and crumb waste tyre rubber and lime had shown promising influence on the properties of Weak Marine soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

VI. ACKNOWLEDGEMENT

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