A Study On The Use Of DWP Inclusions In Quarry Dust And Lime Blended Weak Marine Clay As A Land Fill Material

K Siva[1], B Ganesh[2]
Department of Civil Engineering
[1]PG Student, Lenora College of Engineering, Rampachodavaram
[2]Associate Professor, Lenora College of Engineering, Rampachodavaram

Abstract- *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. Construction works on these weak marine clays are often very challenging and very complex task and also cause severe damage to structures. 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. In spite, the local clayey soils which otherwise are to be discarded were widely used for construction purposes due to economic reasons. Soil stabilization can be very effective in treating clayey soils for improving its strength properties. Stabilization is one of the processes available for improving the engineering properties of these kinds of soils and thus making it more stable. The weak marine clay behavior and the corresponding strength characteristics of these clays are improved by using various additives. The use of reinforcing elements is also being rapidly increasing these days. This led to initiate the present work in studying the effect of binary blends of Quarry Dust and Lime on the properties of weak marine clay and further more reinforcing with Discrete Waste Plastic (DWP) inclusions. The study also was focused on the need of developing an alternate and sustainable land fill material. This might yield a very useful filling material for the low lying areas to make them a part of the developmental activity. The work deals in assessing the strength behavior of weak marine clay stabilized with lime and quarry dust and further reinforcing with Discrete Waste Plastic (DWP) inclusions, thereby giving a three-fold advantage in improving problematic marine clay and solving a problem of waste disposal and also making the waste low lands suitable for infrastructural developments.*

Keywords- Marine clay, Discrete Waste Plastic (DWP) inclusions,, Quarry Dust, Lime

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.

The engineering properties like high compressibility, low shear strength and low permeability of marine clays pose serious challenges to geotechnical engineers in the various construction activities. Marine clay can be located onshore as well. 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. Aggregate crusher units produce large quantities of quarry dust, a waste product, produced during crushing of Gravel and rock. Disposal of these large quantities of quarry dust produces serious problem in environment and health hazard. There is requirement to utilize these waste materials. Quarry dust can be used in very large quantity, reducing the total cost of construction in addition to providing a solution to an environmental problem.

In this work it is attempted the study the effect of binary blends of Quarry Dust and Lime on the properties of weak marine clay and further more reinforcing with Discrete Waste Plastic (DWP) inclusions. To determine the characteristic of marine clay in particular the basic Properties, strength and compressive characteristics and to evaluate the performance of stabilized Marine clay with an optimum of quarry dust, lime and Discrete Waste Plastic inclusions and their suitability for the pavements.

II. REVIEW OF LITERATURE

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.

Marine clay can be located onshore as well. 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 sub grade 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.

Abhishek Patil, Girish Waghere presents a paper on Experimental Review for Utilisation of Waste Plastic Bottles in Soil Improvement Techniques and analysis was done by conducting "Tri-Axial Test & Direct Shear Test" on soil reinforced with Plastic Bottles Strips of size 1cm x 1cm. The comparison of test results showed that the soil sample using plastic strips gives better result than soil without plastic. The size and content of strips of waste plastic bottles have significant effect on the enhancement of strength of the soil. In this review paper, we have taken Black Cotton Soil. The soil is tested with 1% plastic by weight & with naturally obtained soil.and concluded that Our experimental results shows that, after adding plastic in soil, cohesion of soil increased by 67.18% by Triaxial test similarly we have performed Direct Shear test on the same soil where we have found that the cohesion increased by 24%. On the above basis we observed the increase in cohesive property of soil so bearing capacity of soil increases and settlement as well as compressibility decreases.

B N M KIRAN AND DVS PRASAD presents an experimental work on stabilization of marine clay using ferric acid and quarry dust and he concluded that From the experimental results it was observed that 1.0% FeCl3 treatment individually along with the combination of 20% Quarry Dust with marine clay had effectively improved the CBR value. It was noticed that, the load carrying capacity of the treated marine clay sub grade model flexible pavement has been increased by 254% at OMC and 225% at FSC. The total deformation of the treated marine clay sub grade model flexible pavement has been decreased by 40% at OMC and 38% at FSC when compared with the untreated marine clay sub grade model flexible pavement.

Purushotham G. Sarvade and Prashant R Shet 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 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.

Sridharan Benny Mathews Abraham did a research on Utilization of Quarry Dust to Improve the Geotechnical Properties of Soils in Highway Construction and concluded that cbr values are increasing with increment of quarry dust.

III. METHODOLOGY

The properties of different types of materials used during the laboratory experimentation were presented. And a brief description of the experimental procedures adopted in this investigation and the methodology adopted during the course of study are briefly presented.

Materials Used And Their Properties

The details of the various materials used in the laboratory experimentation are reported below.

Marine clay

The marine clays are soft clays characterized by low shear strength and high compressibility. Marine clays form one of the important groups of fine grained soils. Due to rapid infrastructure development along the coastal area, lots of civil construction activities take place in marine clays throughout the world. In India most of the areas consist of soft marine clay deposits.

The marine clay used in this study and was typical soft clay. The marine clay was collected at a depth of 0.30m to 1.00m from ground level from YETIMOGA area, Kakinada, Andhra Pradesh State, India. All the tests carried on the soil are as per IS specifications.

Table 1: properties of Marine clay

S. No.	Property	Value
1	Specific gravity	2.61
2	Differential free swell Index (%)	33
3	Atterberg's Limits i) Liquid limit (%) ii) Plastic limit (%) iii) Plasticity index (%)	 72.2 25.1 47.1
5	Grain Size Distribution i) Sand Size Particles (%) ii) Silt & Clay Size Particles(%)	 10 90
6	IS soil classification	CH
7	Compaction Parameters i) Max. Dry Density (g/cc) ii) Optimum Moisture Content (%)	 1.36 29.5
8	Penetration Parameters i) CBR - Unsoaked (%) ii) CBR - Soaked (%)	 3.2 1.5
9	Shear Parameters at OMC & MDD i) Cohesion, Cu (kPa) ii) Angle of Internal Friction, Øu (Degrees)	 37 0

Quarry dust

Quarry dust is a result of crushers while doing quarrying activities. 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. The quarry dust used was collected from a local quarry at prathipadu, east godavari District, Andhra pradesh. Experiments were conducted on the samples blended with waste materials at different percentages.

Table 2: Properties of Quarry Dust

S. No.	Property	Value
1	Specific gravity	2.73
2	Atterberg's Limits i) Plasticity index (%)	 NP
3	Grain Size Distribution i) Gravel Size Particles (%) ii) Sand Size Particles (%) iii) Silt & Clay Size Particles (%)	 7 81 12
4	Compaction Parameters i) Max. Dry Density (g/cc) ii) Optimum Moisture Content (%)	 1.9 10.1
5	Penetration Parameters i) CBR - Unsoaked (%) ii) CBR - Soaked (%)	 14.8 9.9

Waste Plastics

From the date of birth, plastic waste plastic is concerned in society mainly because of the use of plastic in packaging; disposable packaging material produced large amounts of waste, especially plastic bags, bottles, causing the so-called white pollution. So recycling of waste plastics directly involved to protect the environment and save resources, is a major event in the continuing restrictions on plastic packaging to save resources and form energy saving society.The world for treatment of municipal waste, including the earliest and most primitive method landfill, that is collected from a variety of urban and rural garbage compression in the barren desert to dig a pit, the compressed garbage buried in the soil , reinforced concrete masonry shop, to prevent harmful gas liquids into the soil, contaminating soil and groundwater, the formation of secondary pollution

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

Introduction

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapter. In this chapter a detailed discussion on the results obtained from various laboratory tests done on Weak Marine Soil are presented.

General

In the laboratory, various experiments were conducted by replacing different percentages of Quarry Dust and different waste plastic inclusions in the Weak marine Soil and also further stabilizing it with lime as a binder. Liquid Limit, Plastic Limit and Compaction, CBR and UCS tests were conducted with a view to determine the optimum combination of Quarry Dust and different waste plastic inclusions as replacement in weak marine soil and Lime as a binder and CBR and UCS are conducted for durability studies.

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.

Table 3: Results of the tests conducted on marine clay replacement with different percentages of quarry dust

QD (%)	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	72.2	25.1	47.1	1.36	29.5	3.2	1.5	74
10	70.4	26.8	43.6	1.4	29	4	2.1	80
20	67.6	27.7	39.9	1.48	28.2	5.1	2.8	89
30	66.3	28.5	37.8	1.52	27.4	5.8	3.5	96
40	64.9	29.2	35.7	1.53	26.9	5.7	3.2	92

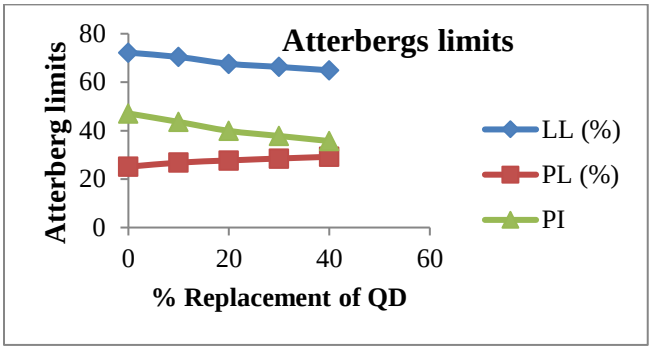

Fig 1 Plot showing the Variation in Atterbergs Limits with % Replacement of QD

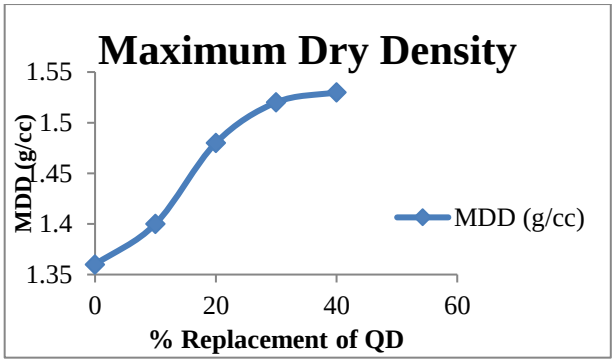

Fig 2 Plot showing the Variation in MDD with % Replacement of QD

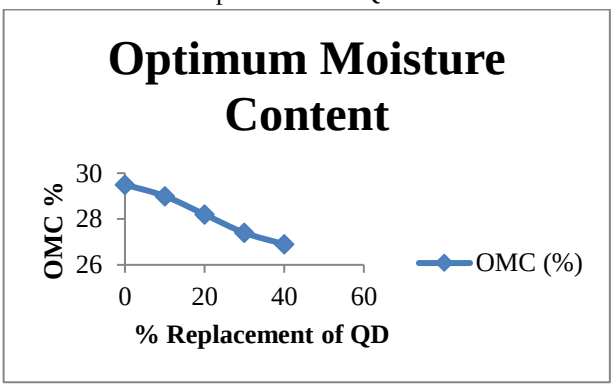

Fig 3 Plot showing the Variation in OMC with % Replacement of QD

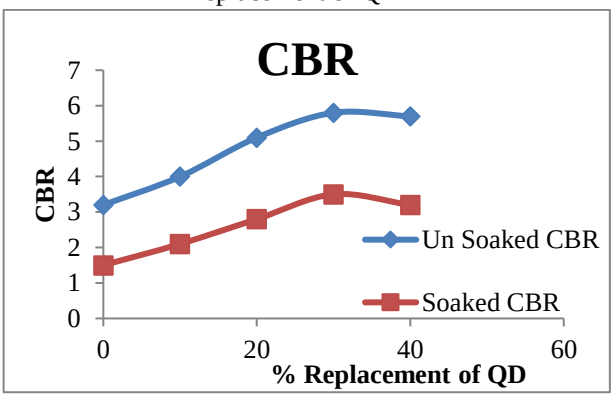

Fig 4 Plot showing the Variation in CBR VALUES with % Replacement of QD

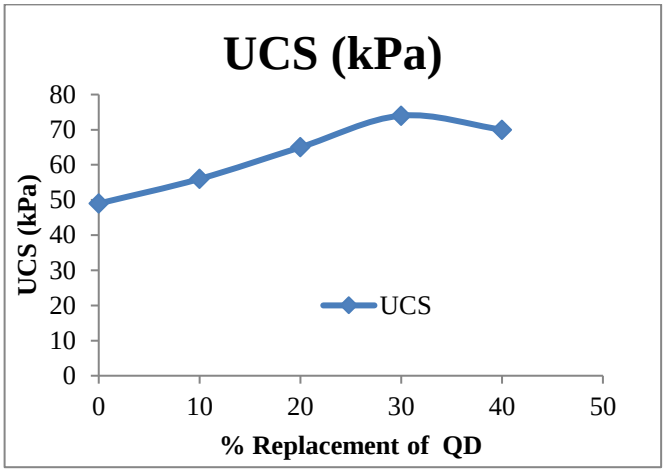

Fig 5 Plot showing the Variation in UCS with % Replacement of QD

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 1, 2, 3, 4, and 5 respectively. The percentage of Quarry Dust was varied from 0%, to 40% 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 19%. Also maximum dry density is improved by an amount of 11% and it was about 23% for UCS and 44%, 57% for UnSoaked, Soaked respectively.

Table 4: Results of the tests conducted on marine clay with different percentages of Lime Content with 30% QD as replacement

Lime (%)	LL (%)	PL (%)	PI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	66.3	28.5	37.8	1.52	27.4	5.8	3.5	96
2	62.8	29.2	33.6	1.54	27.7	6.3	4.1	109
4	60.1	29.8	30.3	1.58	28	6.9	4.9	125
6	58.2	30.2	28	1.6	28.3	7.6	5.5	144

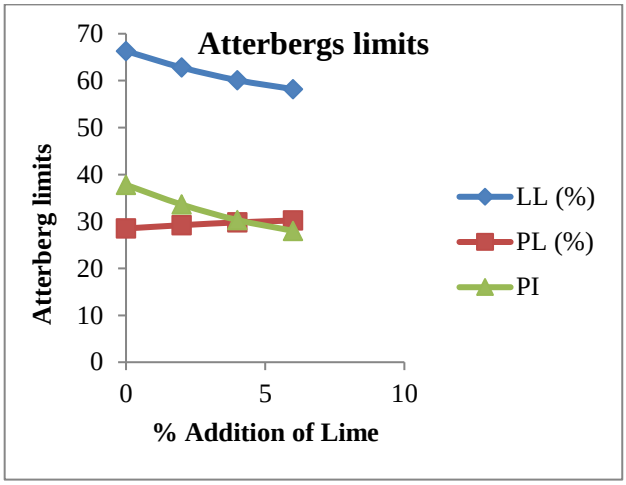

Fig 6 Plot showing the Variation in Atterberg limits with different % of LIME

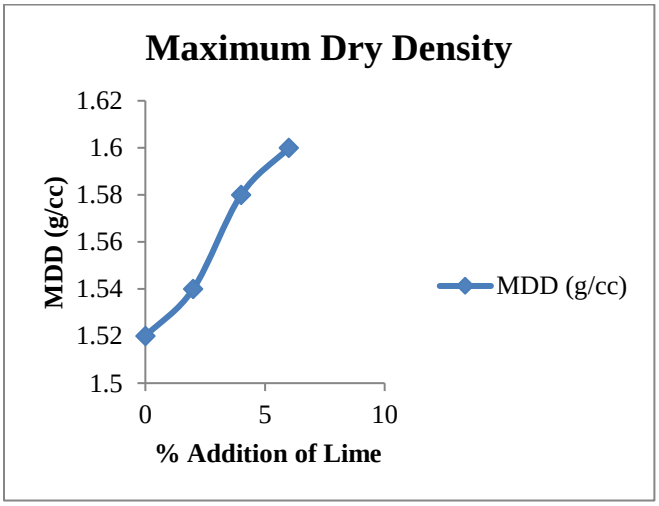

Fig 7 Plot showing the Variation in MDD with different % of LIME

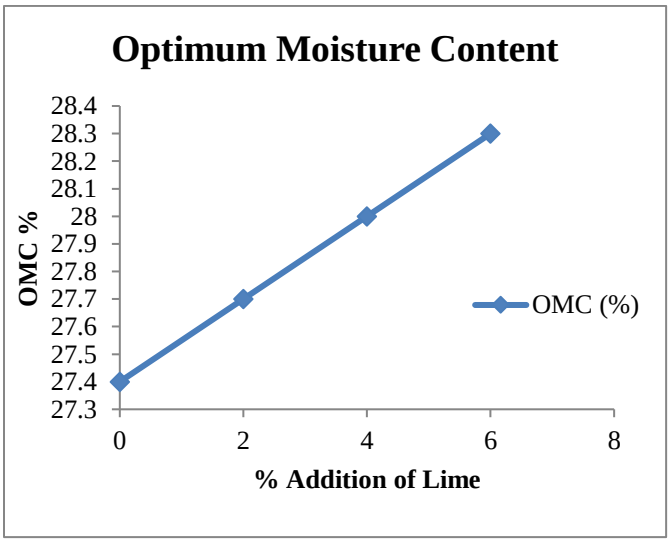

Fig 8 Plot showing the Variation in OMC with different % of LIME

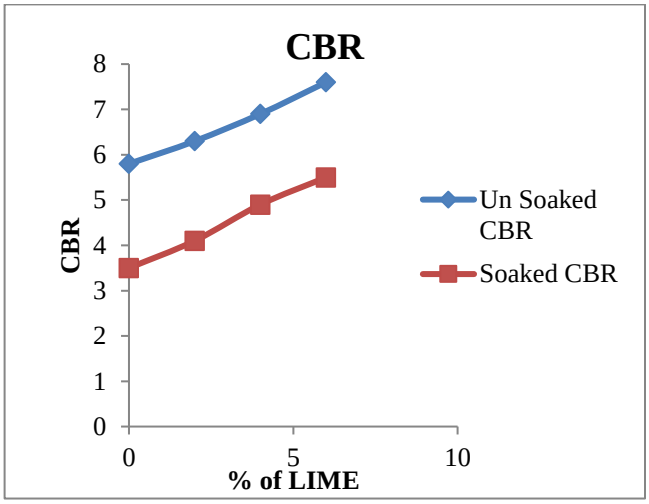

Fig 9 Plot showing the Variation in CBR with different % of LIME

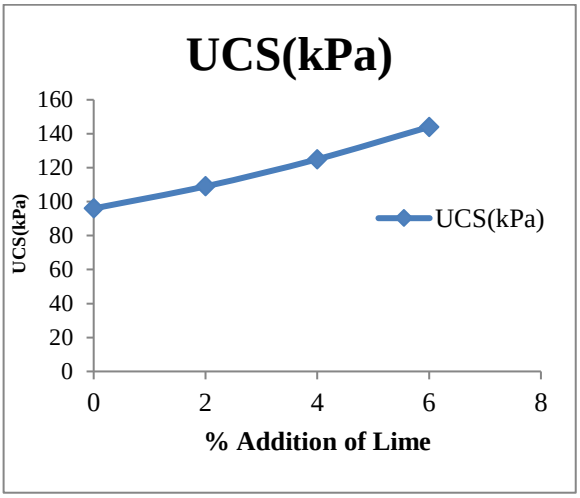

Fig 10 Plot showing the Variation in UCS with different % of LIME

Effect Of % Lime As Binder On The Properties Of Weak Marine Soil

The individual influence of Lime on the Index, Compaction, CBR, UCS properties of marine soil are clearly presented in Figures 6, 7, 8, 9, and10 respectively. The percentage of Lime was varied from 0%, 2%, 4%, and 6%. From the above graphs, it was observed that the treatment as individually with 6% lime 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 % addition up to 6% with an improvement of about 25%. Also maximum dry density is improved by an amount of 5% and it was about 33% for UCS and 23%, 26% for UnSoaked, Soaked respectively From the above results the Optimum Content of Lime with 30% Quarry Dust as replacement of Marine Clay is 6%

Table 5: Results of the tests conducted on marine clay different percentages of DWP Inclusions (DWPI) with 30% Quarry Dust as replacement + 6% Lime Content

DWPI (%)	MDD (g/cc)	OMC (%)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	1.6	28.3	7.6	5.5	144
0.5	1.61	28.1	7.9	5.9	158
1	1.62	27.8	8.2	6.4	173
1.5	1.63	27.7	8.4	6.6	185
2	1.61	27.6	8.3	6.5	180

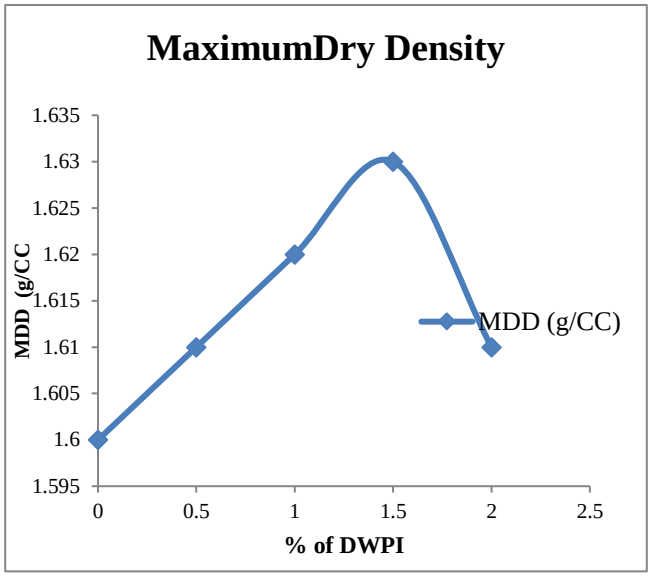

Fig 11 Plot showing the Variation in MDD with different percentages of (DWPI) with 30% QD + 6% Lime Content

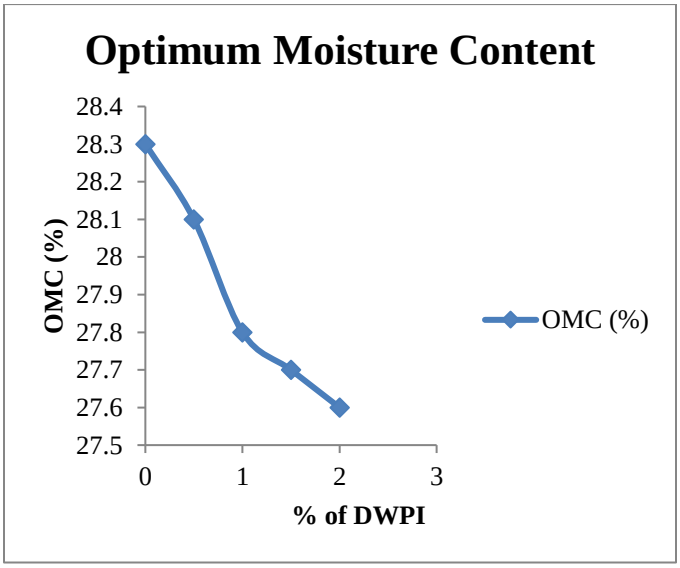

Fig 12 Plot showing the Variation in OMC with different percentages of (DWPI) with 30% QD + 6% Lime Content

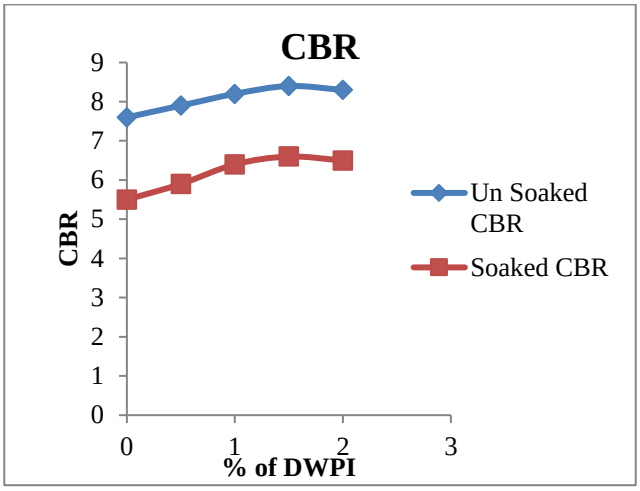

Fig 13 Plot showing the Variation in CBR with different percentages of (DWPI) with 30% QD + 6% Lime Content

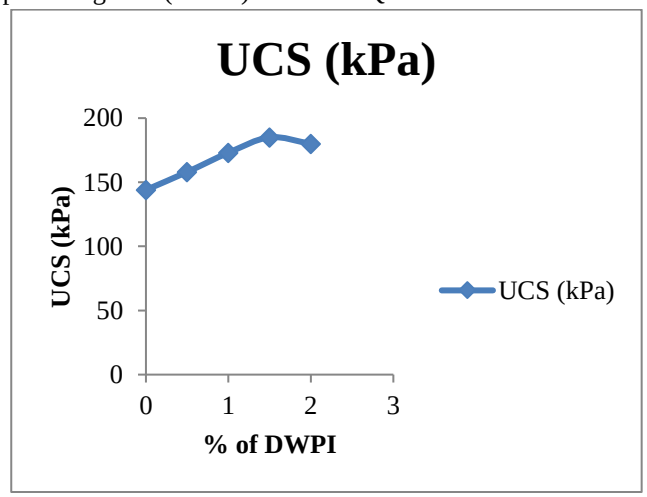

Fig 14 Plot showing the Variation in UCS with different percentages of (DWPI) with 30% QD + 6% Lime Content

4.5 Effect Of Dwpi On Theproperties Of Weak Marine Soil + Quarry Dust And Lime

The influence of DWPI on the Compaction CBR, UCS properties of weak marine Soil + quarry dust and lime mixes are clearly presented in Figures 11, 12, 13, 14, and 15 for different percentages of DWPI respectively. The percentage of DWPI was varied from 0%, to 2.5% with an increment of 0.5%.In the laboratory, tests were conducted by inclusing different percentages of DWPI to Weak Marine Soil + quarry dust and Lime .It is observed from the graphs, that there is an improvement in

Maximum dry density is improved by an amount of 2% and it was about 22% for UCS and 9.5%, 22% for UnSoaked, Soaked respectively. From the above results the Optimum Content of DWPI with 6% Lime + 30% Quarry Dust as replacement of Marine Clay is 1.5%

Table 6:Results of Durability Studies (Curing) on samples prepared with 1.5% DWPI + 6% Lime + 30% QD as replacement of Marine Clay

CURING PERIOD (DAYS)	CBR (US) (%)	CBR (S) (%)	UCS (kPa)
0	8.4	6.6	185
7	9	7.8	196
14	9.8	8.6	208
28	10.3	9.5	216

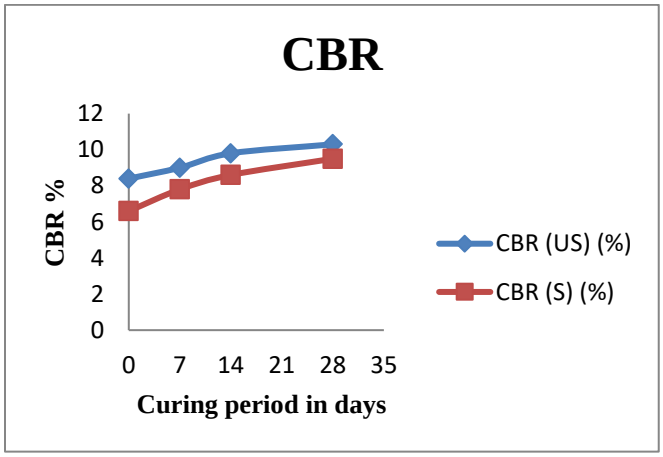

Fig 12 Plot showing the Variation in CBR at different curing periods

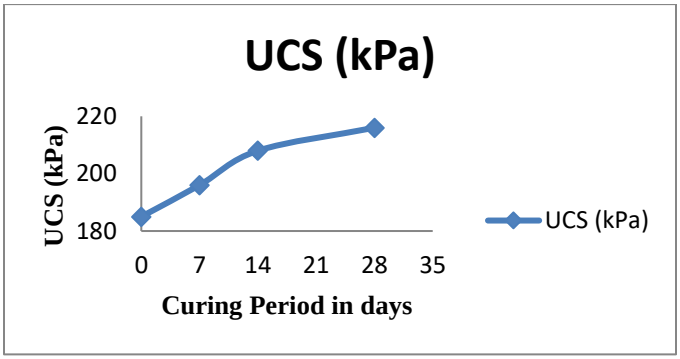

Fig 13 Plot showing the Variation in UCS at different curing periods

4.6 Effect Of (Curing) On Samples Prepared With 1.5% Dwpi + 6% Lime + 30% Qd As Replacement Of Marine Clay

From the above Figures 12 and 13 It is observed that samples prepared with 1.5% DWPI + 6% LIME + 30% QD as replacement of marine clay and the graph shows increment of UCS and CBR values with increment of curing periods.

Finally from the above discussions, it is clear that there is improvement in the behavior of Weak Marine soil stabilized with Quarry dust and crumb+ DWPI+ lime. It is evident that the addition of Quarry dust and Lime to the virgin Marine soil showed an improvement in plasticity, compaction and strength properties to some extent and on further blending it with lime, the improvement was more pronounced. This made the problematic weak marine soil which if not stabilized is a discarded material, a useful fill material with better properties. The Quarry dust and lime in the weak marine soil has reduced the plastic nature of the clay and upon further blending with lime, the plasticity was even reduced. It can be summarized that the materials Quarry dust and lime and DWPI had shown promising influence on the properties of marine soil, thereby giving a two-fold advantage in improving problematic marine soil and also solving a problem of waste disposal.

V. CONCLUSIONS

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 11% and it was about 19% for plasticity characteristics.
- There is an improvement in CBR, Shear parameters also by an amount of 23% for UCS and 44%, 57% 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 % Addition of lime up to 6% with an improvement of about 25%. Also maximum dry density is improved by an amount of 5% and it was about 33% for UCS and 23%, 36% for UnSoaked , Soaked respectively.
- There is an improvement in plasticity & Strength characteristics with an increase in the DWPI from 0% to 1.5% with an improvement of 2% for MDD.
- There is an improvement by an amount of 22% for UCS and 9.5%, 16.6% for UnSoaked, Soaked respectively.
- It is evident that the addition of Quarry dust and LIME to the virgin Marine soil showed an improvement in properties to some extent and on further addition of DWPI, the improvement was more pronounced.
- Finally it can be summarized that the materials Quarry dust and Lime and DWPI 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.

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