Experimental Study on The Use of Different Waste Plastic Bottle Strips on The Behaviour of Quarry Dust And Phospho Gypsum Mixed Soft Marine Clay

K.Harivardhan[1], D. Appanna[2]
[1] Dept of Civil Engineering
[2]Asst. Professor
[1, 2] Lenora College of Engineering,

Abstract- *Soft Marine Clays (SMC) are characterized with high moisture content and low shear strength, thereby exhibiting high compressibility. Utilizing such clays for resting the foundations is almost impossible without some means of improving the adverse properties. This gives the need for thinking different alternate stabilization techniques in improving the behavior of these soft marine clays. 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 Phospho Gypsum on the properties of weak marine clay and further more reinforcing with Waste Plastic bottle strips. 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 experimental work deals in assessing the strength behaviour of weak marine clay stabilized with Phospho Gypsum and quarry dust and further reinforcing with Different Waste Plastic bottle strips.*

Keywords- soft marine clay, Marine clay, Different Waste Plastic (DWP), Quarry Dust, Phospho Gypsum.

I. INTRODUCTION

Soil is a fundamental engineering material. The quality of soil used in construction affects the overall stability of a structure. Cohesion, angle of internal friction, capillarity, permeability, elasticity and compressibility are the properties of soil taken into account while considering it as a construction material. 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. Construction works on soft clay foundations are often very challenging and very complex task since they are since they are generally characterized by its low strength properties. Still clayey soils are widely used for construction purposes due to economic reasons. 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. Marine clays located in coastal and offshore areas of the world forms one of the important groups of fine grained soils and lots of civil construction activities take place in such marine clays throughout the world. Since these clays are characterized by low strength and high compressibility, the design and construction of many coastal and offshore structures in these deposits are confronted with many geotechnical problems.
The marine clays are not suitable as pavement sub grade & foundation soil beds and pose problems due to their inability of strength criteria. More and more construction projects are encountering soft clays and hence there is a need to better quantifying the properties of marine clays. It is prohibitively expensive to remove large volumes of unsatisfactory soils present at sites and replace them with more suitable material particularly, if it is to be transported for large distances. Therefore, much emphasis has been placed upon finding methods of modifying the properties of soils and improving their engineering behavior.

This process is generally referred to as soil stabilization, and in its widest meaning comprises every physical, physico-chemical, and chemical methods employed to enable a soil to serve better its intended engineering purpose.

Here, in this project, soil stabilization has been done with the help of different waste plastics obtained from waste plastic bottles. The improvement in the shear strength parameters has been stressed upon and comparative studies have been carried out using different methods.

II. REVIEW OF LITERATURE

Soil stabilization is a procedure where we improve engineering properties of soil with the use of natural or synthesized admixtures. A brief review of previous studies on Marine clay is presented in this section and past efforts most closely related to the needs of present work.

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.

Koteswara Rao, D (2006), the efficacy of Granulated Blast Furnace Slag- Fly ash mix as a fill material on soft soil beds for the foundations, CES-2006, Osmania University, Hyderabad.

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.

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..

Sridharan and soosan et.al (2005) identified that quarry dust manifest high shear strength and is beneficial for its use as a geotechnical material. Sabat et.al (2012) conducted compaction, triaxial and durability tests on lime stabilized Marine soil-quarry dust mixes.

Ken et.al (2012) exposes the qualities and applications of quarry dust as admixture during soil improvement and for a more economic approach. Agrawal and gupta et.al (2011) reported that the potential use of marble dust as stabilizing additive to Marine soil, which involves the determination of the swelling potential of Marine soil in its natural state as well as when mixed with varying proportion of marble dust.

G.Rajasekharan and S.Narasimha Rao done a experimental work on Strength characteristics of lime-treated marine clay The test results indicate an improvement in soil strength by eight to ten times that of untreated soil except for the quicklime-sodium sulphate system. This aspect encourages the application of both lime column and lime injection techniques to improve the engineering behavior of marine clays.

Further to understand the behavior of plastic strips as soil reinforcement, **Bhattarai et al. (2013)** considered a new gradation of soil such as inorganic silts. Different plastic concentrations (0.25, 0.5 and 1%) and different lengths of 10 mm (AR = 1), 20 mm (AR = 2), 30 mm (AR = 3) and 40 mm (AR = 4) are considered and mixed with inorganic silts. They performed series of CBR tests and observed that, with quite controversy to the strength improvement from the above findings, CBR values are only increased up to a certain limit of 0.50% strip content and AR of 3 and beyond which the properties had been decreased.

2.1 PROBLEMS ASSOCIATED WITH MARINE CLAYS

2.1.1 General

The entire stratum of marine clay soils in the field may not be active. The buildings in marine soils have posed serious problem of distortion and cracking throughout the world because of unlimited quantity of water being readily available to the foundation soil.

2.1.2 Damages to the Pavement Subgrades

Majority of the pavement failures could be attributed to the poor sub grade conditions and marine clay is one such problematic situation (Evans and McManus, 1999).

(A) Rutting

The rutting is mainly due to consolidation of one or more layers of pavement and also due to repeated application of the load along the same wheel path resulting in deformation of pavements.

(B) Longitudinal Cracks

This is due to differential volume changes that occur in marine soils. The deformation characteristics of the marine clay soils results in cracking through the full pavement thickness.

Fig 2.1: Sub-grade failure crack

Slope failure due to Liquefaction:

The shoulder and pavement from the north-bound lanes of Pan American highway were pushed into a near vertical face by a 400 m long slope failure induced by liquefaction at the toe of the slope.

Fig2.2: Failure Of Slopes

(C) Shrinkage Cracks:

A large sand boil feature at the southern end of the 400 m long slope failure with shrinkage cracks in the material.

Fig 2.3 Cracks in Marine Clay Deposits

Ground cracks in the marine terrace deposits. The Canetti formation, indicating the eastern edge of the failure mass, is seen in the background.

Fig 2.4: Failure of Pavement

Over the years, the slopes began to experience shallow slope failures at numerous locations and by 2002, the slope failures were widespread and affected many areas of the road pavement. A typical shallow failure is shown in the bottom photo.

III. STABILIZATION

Soil stabilization may be defined as a modification of an existing soil so as to improve its bearing or load absorbing characteristics. Such an effect may be accomplished by mechanical consolidation (compaction) or by the incorporation within the soil of certain additives which would provide the desired qualities of permanent stability.

IV. METHODOLOGY

4.1 MATERIALS USED AND THEIR PROPERTIES

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

4.1.1 Marine clay

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. The properties of soil are presented in the Table 3.1. All the tests carried on the soil are as per IS specifications.

Table 4.1: Properties of Marine Clay

Properties of Marine Clay		
S. No.	Property	Value
1	Specific gravity	2.6
2	Differential free swell Index (%)	38
3	Atterberg's Limits	
	i) Liquid limit (%)	73.1
	ii) Plastic limit (%)	25.9
	iii) Plasticity index (%)	47.2
5	Grain Size Distribution	
	i) Sand Size Particles (%)	8
	ii) Silt & Clay Size Particles (%)	92
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.31
	ii) Optimum Moisture Content (%)	30.5
8	Penetration Parameters	
	ii) CBR (%)	1.5
9	Shear Parameters at OMC & MDD	
	i) Cohesion, Cu (kPa)	36
	ii) Angle of Internal Friction, Øu (Degrees)	0

Table 4.2: 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) Sand Size Particles (%)	81
	ii) Silt & Clay Size Particles (%)	12
4	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.9
	ii) Optimum Moisture Content (%)	10.1
	ii) CBR - Soaked (%)	9.9

4.1.2 Phosphogypsum (PG)

Phosphogypsum (PG) is a waste by-product obtained by the processing of phosphate rock for the production of phosphoric acid in the fertilizer industry by the wet acid method. The PG used in this study is bought from the Sri Venkateswara Fertilisers Private Limited, Kakinada, Andhra Pradesh, India**.** It is a by-product obtained from the fertilizer industry. The PG is formed by the reaction between phosphate ore and sulphuric acid. By this reaction, phosphoric acid and Phosphogypsum are formed. The chemical formula of gypsum is CaSO4.2H2O. Phosphogypsum has almost similar properties to that of gypsum except for the presence of phosphate mineral.

Table 4.2 Properties of Phospho Gypsum (PG)

Properties of Phospho Gypsum (PG)		
S. No.	Property	Value
1	Specific gravity	2.12
2	Atterberg's Limits	
	i) Plasticity index (%)	NP
3	Grain Size Distribution	
	i) Sand Size Particles (%)	7
	ii) Silt & Clay Size Particles (%)	93
4	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.34
	ii) Optimum Moisture Content (%)	15.5

4.1.3 Waste plastic

Plastic strips are cut into different lengths of about 15, 25 and 35 mm keeping strip width at 15 mm to be constant. Plastic strips are mixed with virgin soil uniformly by applying little water to the soil and thus making it partially wet.

4.2 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.

4.2.1 LIST OF TESTS CONDUCTED

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

- Specific gravity of soil
- Determination of soil index properties (Atterberg Limits)
  - Liquid limit
  - Plastic limit
- Particle size distribution by sieve analysis
- Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test.
- Penetration tests-California bearing ratio test
- Unconfined Compression Test-Triaxial

V. RESULTS AND DISCUSSIONS

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 Phospho Gypsum (PG) 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 Phospho Gypsum (PG) as a binder and CBR and UCS are conducted for durability studies.

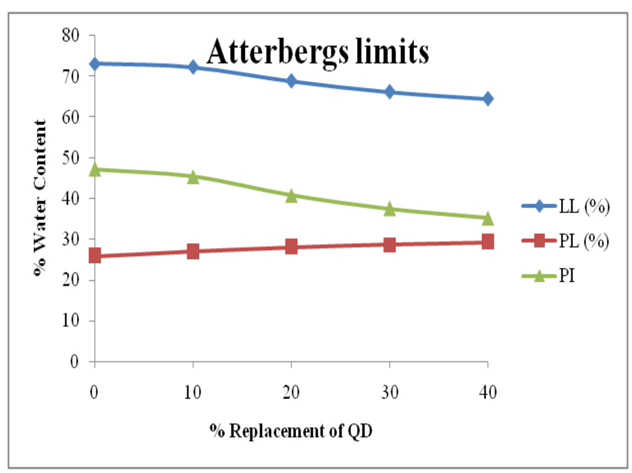

Fig 5.1 Plot showing the Variation in Atterberg's Limits with % Replacement of QD

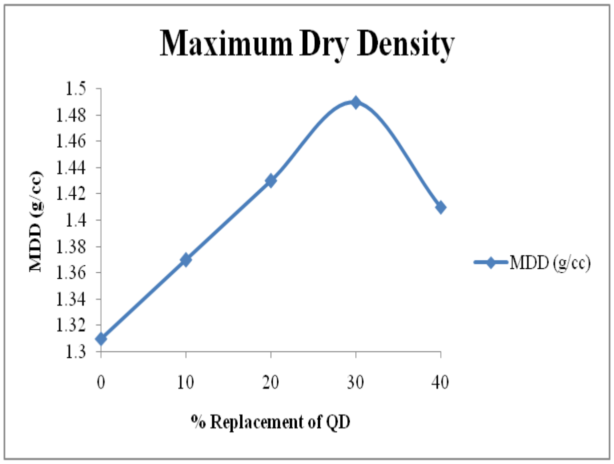

Fig 5.2 Plot showing the Variation in MDD with % Replacement of QD

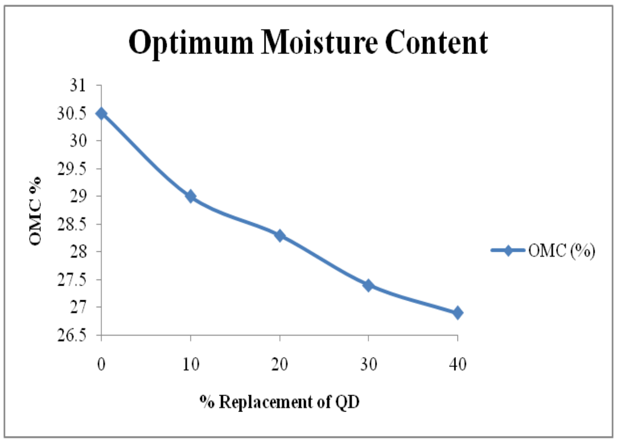

Fig 5.3 Plot showing the Variation in OMC with % Replacement of QD

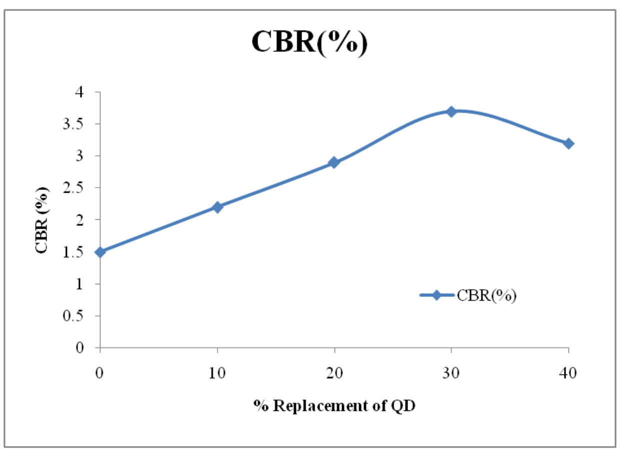

Fig 5.4 Plot showing the Variation in CBR VALUES with % Replacement of QD

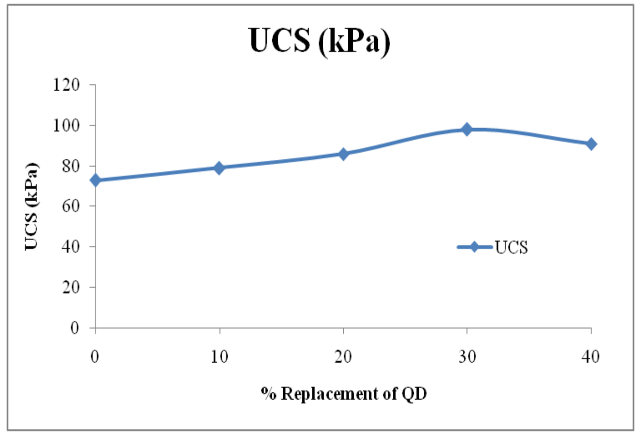

Fig 5.5 Plot showing the Variation in UCS with % Replacement of QD

It can be inferred from the graphs, that there is a gradual increase in SOIL PROPERTIES With percentage replacement of Quarry dust. From the above results the 30% replacement of Marine clay with Quarry dust can be considered as optimum.

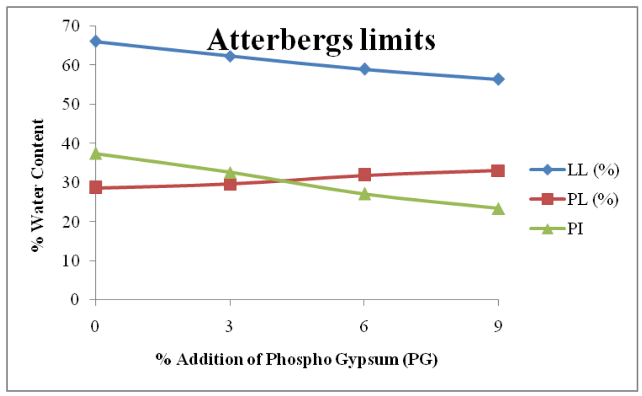

Fig 5.6 Plot showing the Variation in Atterberg limits with different % of PHOSPHO GYPSUM (PG)

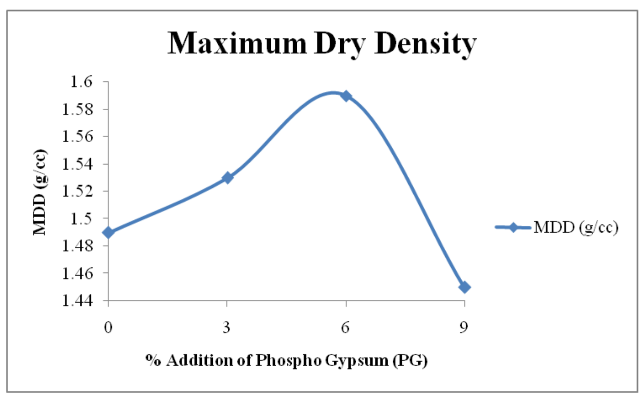

Fig 5.7 Plot showing the Variation in MDD with different % of PHOSPHO GYPSUM (PG)

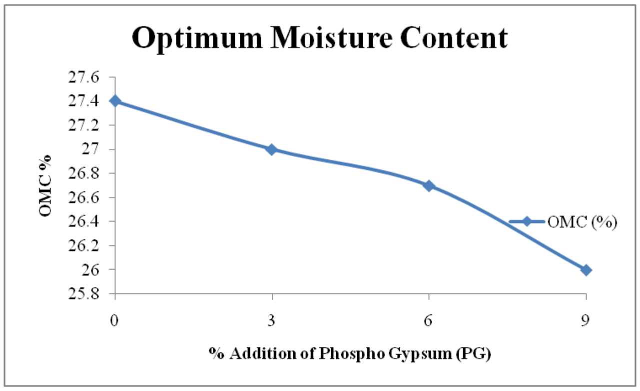

Fig 5.8 Plot showing the Variation in OMC with different % of PHOSPHO GYPSUM (PG)

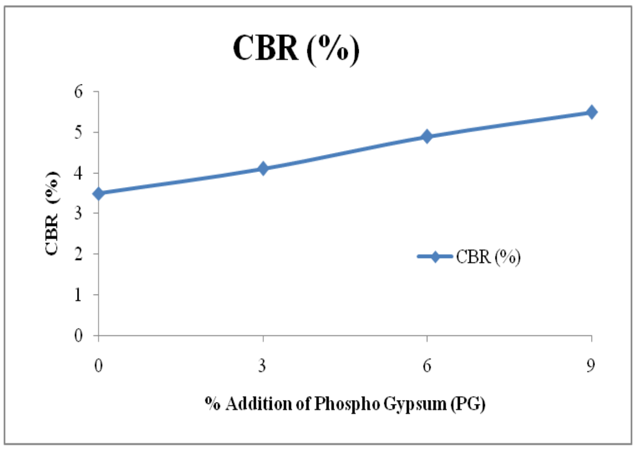

Fig 5.9 Plot showing the Variation in CBR with different % of PHOSPHO GYPSUM (PG)

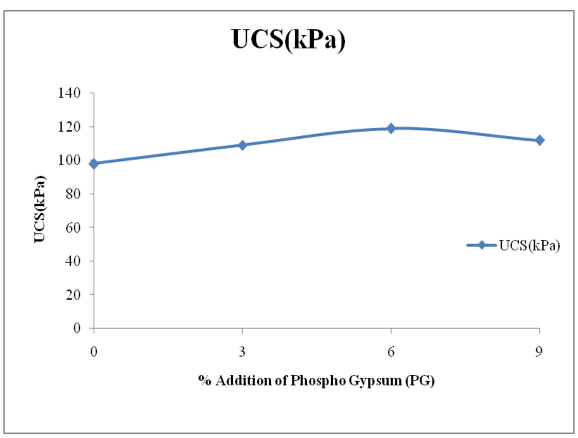

Fig 5.10 Plot showing the Variation in UCS with different % of PHOSPHO GYPSUM (PG)

It can be inferred from the graphs, that there is a gradual increase in SOIL PROPERTIES With percentage replacement of Quarry dust and percentage addition of Phospho Gypsum (PG). The percentage of Phospho Gypsum (PG) was varied from 0%, 2%, 4%, and 6%. From the above graphs, it was observed that the treatment as individually with 6% Phospho Gypsum (PG) 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% . Also maximum dry density is improved by an amount of 6.7% and it was about 21.4% for UCS and 75.6% for CBR respectively.From the above results the Optimum Content of Phospho Gypsum (PG) with 30% Quarry Dust as replacement of Marine Clay is 6%.

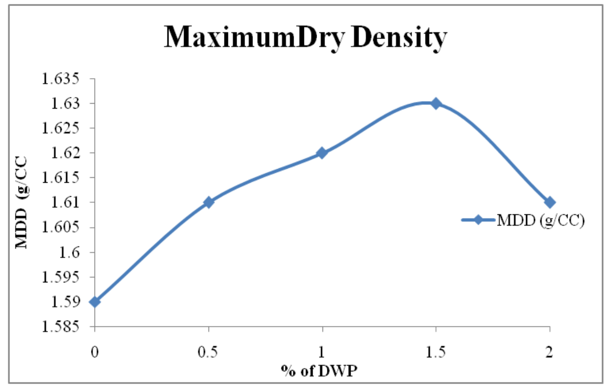

Fig 5.11 Plot showing the Variation in MDD with different percentages of (DWP) with 30% QD + 6% Phospho Gypsum (PG) Content

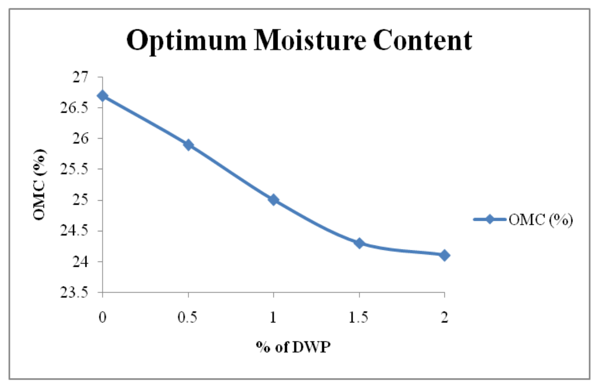

Fig 5.12 Plot showing the Variation in OMC with different percentages of (DWP) with 30% QD + 6% Phospho Gypsum (PG) Content

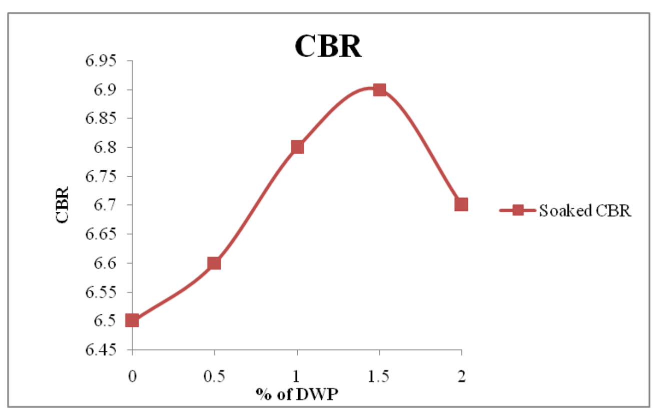

Fig 5.13 Plot showing the Variation in CBR with different percentages of (DWP) with 30%QD + 6% Phospho Gypsum (PG) Content

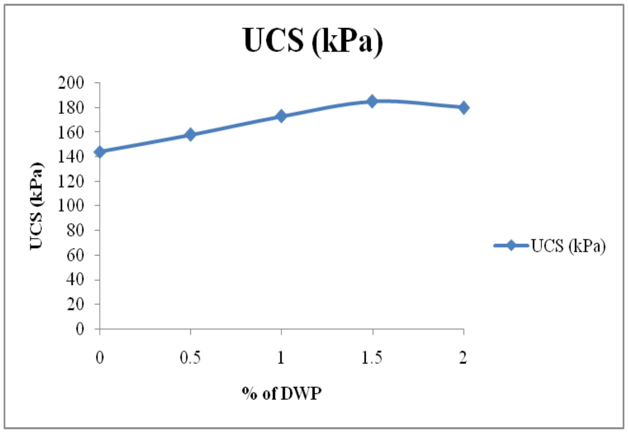

Fig 5.14 Plot showing the Variation in UCS with different percentages of (DWP) with 30% QD + 6% Phospho Gypsum (PG) Content

The influence of DWP on the Compaction CBR, UCS properties of weak marine Soil + quarry dust and Phospho Gypsum (PG) mixes are clearly presented in Figures for different percentages of DWP respectively. The percentage of DWP was varied from 0%, to 2% with an increment of 0.5%.In the laboratory, tests were conducted by inclusing different percentages of DWP to Weak Marine Soil + quarry dust and Phospho Gypsum (PG) .It is observed from the graphs, that there is an improvement in Maximum dry density is improved by an amount of 2.5% and it was about 51.2% for UCS and 6.15% for CBR respectively. From the above results the Optimum Content of DWP with 6% Phospho Gypsum (PG) + 30% Quarry Dust as replacement of Marine Clay is 1.5% .

5.4 DURABILITY STUDIES - (CURING)

Durability Studies (Curing) on samples prepared with 1.0% WPI + 6% Lime + 20%VPW as replacement of Marine Clay

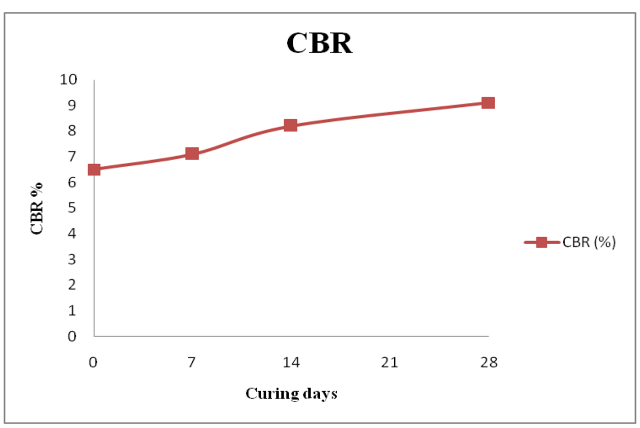

Fig 5.15 Variation of CBR VALUES with different Curing periods

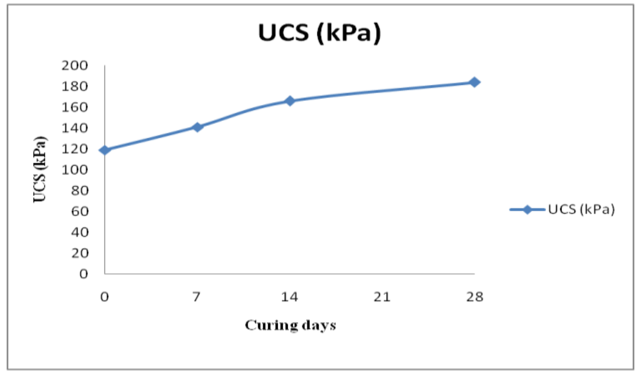

Fig 5.16 Variation of UCS VALUES with different Curing periods

From the above results It is observed that samples prepared with 1.5% DWP + 6% PHOSPHO GYPSUM (PG) + 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+ DWP+ Phospho Gypsum (PG). It is evident that the addition of Quarry dust and Phospho Gypsum (PG) to the virgin Marine soil showed an improvement in plasticity, compaction and strength properties to some extent and on further blending it with Phospho Gypsum (PG), 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 Phospho Gypsum (PG) in the weak marine soil has reduced the plastic nature of the clay and upon further blending with Phospho Gypsum (PG), the plasticity was even reduced.

VI. CONCLUSIONS

The influence of Quarry dust and phosphogypsum combined with different waste plastics is utilized in different proportions for improving the strength properties of the Marine clay. The following conclusions have drawn from the experimental studies:

- From the laboratory studies, it is observed that the Marine Soil chosen was a problematic soil having high swelling, and high plasticity characteristics.
- The Quarry dust, Phosphogypsum and different waste plastics has substantial influence in improving the strength properties of the Marine clay through pozzolanic reaction, binder development, and discrete reinforcing effects

- 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 13.74 % and it was about 20.5 % for plasticity characteristics.
- There is an improvement in CBR, Shear parameters also by an amount of 34.1% for UCS and 146% for CBR respectively.
- An overall improvement of 146%, 34.2% is observed in the CBR and UCS values respectively when treated with 6% PG. Further, an overall improvement of 6.15%, and 51.2% is noted in the CBR and UCS values respectively when reinforced with 1.5% DWP at 30% QD+6% PG.
- The optimum percentages of PG and DWP are determined as 6% and 1.5% respectively.
- It can be stated that the soil-PG-CRW matrix has a high initial strength which is substantiated in later stages. Upon curing for 28 days, an overall improvement of 40% and 54.6% in the CBR and UCS of the soil are observed.
- In all the cases, the CBR values are found to be highly sensitive to the QD, PG and DWP proportions. Thus, it is found that at the optimum proportions the CBR values are improved in high percentages compared to unsoaked CBR and UCS values.

It is evident that the addition of Quarry dust and Phospho Gypsum (PG) to the virgin Marine soil showed an improvement in properties to some extent and on further addition of DWP, the improvement was more pronounced. Finally it can be summarized that the materials Quarry dust and Phospho Gypsum (PG) and DWP had shown promising influence on the properties of Weak Marine soil, thereby giving a two-fold advantage in improving problematic Marine soil and also solving a problem of waste disposal.

REFERENCES

[1] Gopal Ranjan and A.S. R. Rao (2006), Basic and Applied Soil Mechanics, New Age International Publishers.

[2] Sridharan A, Rao SM, Chandrasekaran S (1989), Engineering Properties of Cochin and Mangalore Marine Clays, Indian Geotech, J.1:265-278. 31.

[3] Balasubramaniam, A.S., Bergado, D.T., Buensuceso, B.R. and Yang, W.C.,(1989), Strength and deformation characteristics of lime treated soft clays, Geotechnical Engineering (AIT), 20, 1989, pp. 49-65.

[4] S. Narasimha Rao and Rajasekaran.G (1994), Lime Injection Technique to improve the behavior of Soft Marine Clay, Ocean Engineering, Vol.21, Issue 1, January 1994, p.p 29-43.

[5] Rajasekaran, G and Narasimha Rao. S (2000), Strength Characteristics of lime treated marine clay, Journal of Ground Improvement, Vol.3, pp 127 -136. 27.

[6] Sridharan, A. and Miura, N (2000), Physico -chemical and engineering behaviour of Ariake clay and its comparison with other marine clays, proc. lnt. Symposium. IS Yakahama 2000. 2:203 -213.

[7] Rajasekaran, G and Narasimha Rao, S (2002), Compressibility behaviour of lime treated marine clay, Ocean Engineering, 29,545-559. 26.

[8] Koteswara Rao, D (2004), The performance studies on Geo -grid as reinforcement in the flexible pavement construction, IGC-2004, pp 457-460.

[9] Koteswara Rao, D (2006), the efficacy of Granulated Blast Furnace Slag- Fly ash mix as a fill material on soft soil beds for the foundations, CES -2006, Osmania University, Hyderabad.

[10] Basack and Purkayastha (2009), Engineering properties of Marine Clays from the eastern coast of India. Journal of Engineering and Technology Research Vol.1 (6), pp. 109-114, September,2009.

[11] Sridharan, A. et al.(2005) “Utilization of Quarry Dust to Improve the Geotechnical Properties of Soils in Highway Construction”, Geotechnical Testing Journal (GTJ) Volume 28, Issue 4.

[12] Bhattarai P, Bharat Kumar AVA, Santosh K, Manikanta TC, Tejeswini K (2013) Engineering behavior of soil reinforced with plastic strips. Int J Civ Struct Environ Infrastruct Eng Res Dev 3(2):83–88.

[13] Chebet FC, Kalumba D (2014) Laboratory investigation on reusing polyethylene (plastic) bag waste material for soil reinforcement in geotechnical.

[14] Amrutha TP, Krishnan A (2015) An overview on plastic waste as soil stabilizing agent. Int J Adv Res Trends Eng Technol 2(10):36–39.