International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 10, October-2015

Performance of Geotechnical Properties of Fly Ash and Quarry dust Mixtures for use in Highway Embankments with varying

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***Abstract*— Road network plays a crucial role in promoting social, economical and cultural development of a region. Construction of infrastructure over a weak or a soft soil is highly risky in terms of geo-technical setbacks like differential settlements, poor shear strength and high compressibility. Poor sub-grade conditions will result in inadequate pavement support and ultimately brings down the pavement life. Hence, highway construction over the soft clayey sub-grades is the most common challenge encountered by highway engineers. To address the problems posed by clays, the sub-grade is either replaced by better quality material or treated with additives. However, replacement is advantageous only at shallow depths. The effectiveness of the additive depends on the type of soil and the amount of additive used. The load bearing capacity of clayey soil can be improved by adopting various techniques like soil stabilization, introducing reinforcement etc. Soil stabilization involves improving the soil properties by blending soil with various cementing agents to produce sustainable pavements. The present study is carried out to assess the improvement in the performance of clayey sub-grade stabilized with Fly ash and Quarry dust in varying percentages. In this comparative study laboratory tests such as Atterberg's limit, Compaction test, CBR were carried out for both treated and untreated clayey soil. In view of its benefits, soil stabilization has gained importance in construction engineering.**

Keywords*— *Claye soil, Fly ash, Quarry dust, Stabilization, CBR.

INTRODUCTION

Soil is a gathering or deposit of earth material, derived naturally from the breakdown of rocks that can be excavated readily with power equipment in the field. Subgrade soils consist of the in-situ, prepared, and compacted soils below the pavement structure that affect the structural design. Although a pavement's wearing course is most prominent, the success or failure of a pavement is more often depend upon the underlying sub-grade and the material upon which the pavement structure is built. The Desirable Properties of Subgrade soil as a highway material is (i) Stability, (ii) Incompressibility, (iii) Permanency of strength, (iv) Superior drainage and (v) Ease of compaction.

For pavement design, the sub-grade strength should be determined in terms of CBR at the most critical moisture condition. Poor sub-grade soil can simply be removed and replaced with high quality fill. Although this is simple in concept, it can be expensive. Strength parameter of poor soil can be improved by various techniques of soil modifications by addition of waste materials. Various industries produce million tons of waste materials such as Fly ash, Iron such inferior materials can be utilize as admixtures in soil modification technique.

The objectives of this project are: Firstly To study and evaluate few waste materials for their adequacy and bulk utilization through stabilizing a clayey sub-grade soil. Secondly, To study the effects of stabilization on index and engineering properties of soil using two types of waste materials as admixtures. Thirdly To compare and suggest choice of admixture based on their relative influence and optimum content on properties of sub-grade soil. The work in this paper is divided in 5 sections as follows: (i) Introduction (ii) Literature Review-describes the work carried out by various authors and influence of various waste materials on properties of soil. (iii)Methodology and Experimental study- describes the methodology and experimental procedures that were carried out on clayey soil Subgrade and two waste materials are used in the work. The experimental procedure includes lab tests. (iv) Results and Discussion- tells us the result of tests carried out on clayey soil with different percentages of admixture. A detailed discussion of results is presented. The

performance of results and efficacy of a given admixture is presented through performance ratio. Finally (v) Conclusions- describes the summary of work and conclusions drawn from present study.

I. EXPERIMENTAL STUDY

Experimental studies for determination of index and engineering properties on clayey soil are carried out. The engineering properties are determined on soil samples in lab. Two types of waste materials are used for study. The details of materials used their properties and details of engineering properties determined in lab presented below.

Materials used

In this present work unmodified soil was collected near Sri Sai Ram Narasimha Enterprises, NH-5, Anandapuram junction, Visakhapatnam District–Andhra Pradesh. The soil was collected at a depth of approximately 1.0 m from the existing road level and blackish gray in colour. Soil sample consist of 65% finer particles. The fly ash used in the project is obtained from the Sri Vishnu Sai Saravana Enterprises, Visakhapatnam District, Andhra Pradesh. The grade of fly ash used in the experimental work is "F" grade. Fly ash consists of Sand size particles (27%) and Fine size particles of (73%). The quarry dust used was collected from a local quarry. It consists mainly of sand size particles (97%).

Parameter studied

The following parameters are studied in experimental work

- Specific gravity of soil
- Grain size distribution of soil
- Compaction characteristics of soil
- California bearing ratio (CBR) of soil.

Fly ash

Quarry dust

Test Procedures

Laboratory tests are conducted on prepared specimens of soil and soil-admixtures mixtures.

Specific Gravity:-Specific gravity is determined as per IS-2720 (Part-3) - 1987.

Grain Size Analysis:-Mechanical sieve analysis is conducted on soil sample according to IS 2720 (Part-4) - 1985.

Atterberg's Limits:-Atterberg's limits viz, Liquid and plastic limit are determined on clayey soil as per IS: 2720 (Part-5) -1985.

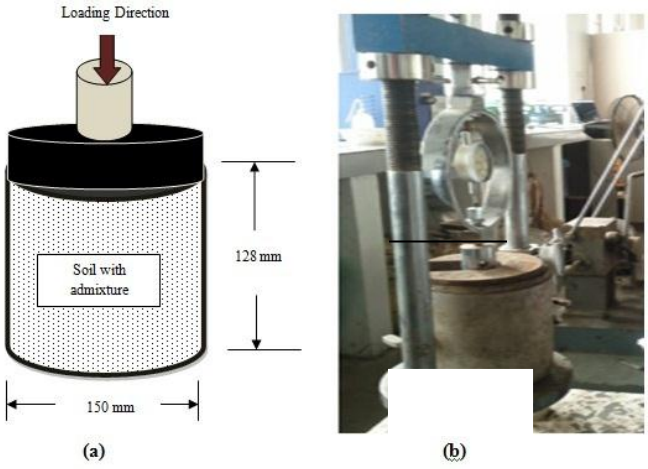
Compaction characteristics:-Proctor test is conducted on the soil sample as per IS 2720 (Part-7) -1980.

CBR Test:-California Bearing Ratio for the given soil is determined as per IS 2720 (Part-16) -1987.

I. PREPARATION OF SOIL - ADMIXTURE SPECIMEN

Naturally available clayey soils are mixed with admixtures like Quarry dust and Fly ash at varying percentages to the dry weights of soils. Experiments are conducted on the samples blended with these admixtures to determine the index and engineering properties of the modified soils. Compaction test is to determine the proper amount of mixing water to be used and degree of denseness which can be expected from compaction at optimum moisture content.

CBR test are conducted on samples prepared by maintaining density and moisture content as obtained from compaction test, as shown in below figure



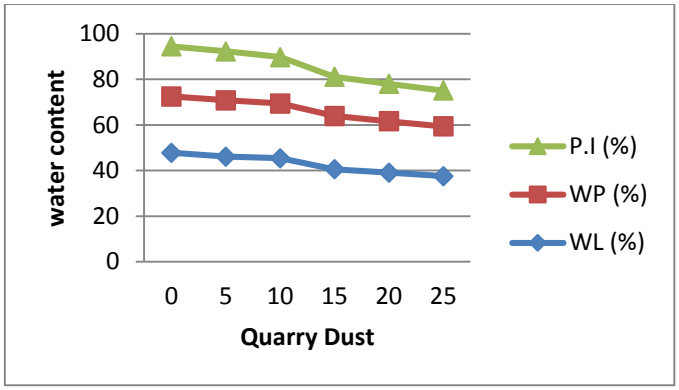
a) Cross section for CBR sample b) CBR test set up

RESULT ON SOIL AND ADMIXTURE

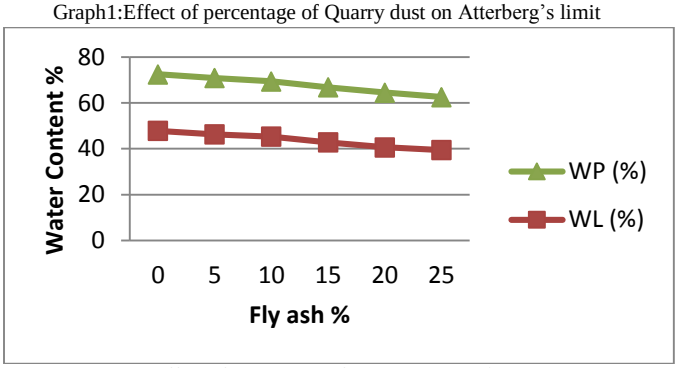
The soil sample used for this study is collected near Sri Sai Ram Narasimha Enterprises, NH-5, Anandapuram junction, Visakhapatnam District–Andhra Pradesh. Experiments were conducted on the samples blended with waste materials at different percentages. Naturally available clayey soils are mixed with admixtures like Quarry dust, Fly ash at varying percentages to the dry weights of soils. Experiments are conducted on the samples blended with these admixtures to determine the index and engineering properties of the modified soils.

Properties of unmodified soil and Admixtures

Properties	Soil	Quarry dust	Fly ash
Specific gravity	2.51	2.63	2.20
W_L (%)	47.80	NP	NP
W_P (%)	24.65	NP	NP
P.I (%)	22.00	NP	NP
Gravel size particles (%)	2	1	0
Sand size particles (%)	33	97	27
Fines size particles (%)	65	2	73
ISCS	CI	SP	SM
γd (kN/m³)	18.02	16.02	14.09
W_O (%)	15.80	8.90	17
S_C (%)	1.82	-	-
U_C (%)	3.46	-	-



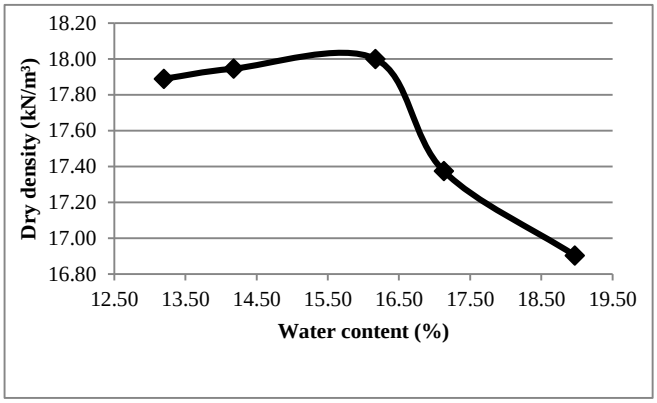
Graph1:Effect of percentage of Quarry dust on Atterberg's limit



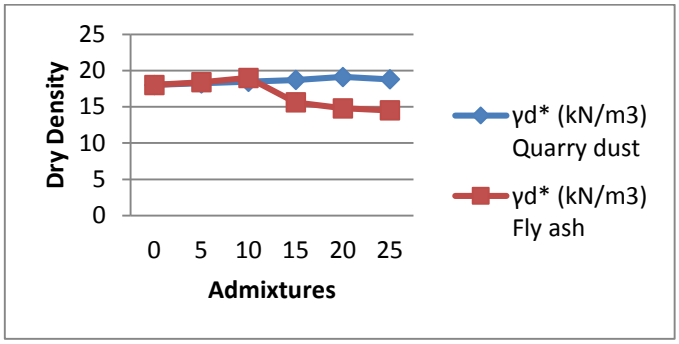
Graph2: Effect of percentage of Fly ash on Atterberg's limit

It is observed that as the percentage of Quarry dust increases, there is a marked reduction in liquid limit and plastic limit of clay tested. Furthermore, the applications of the Quarry dust on the soil results in reduction in the plasticity index of this soil. Plasticity index of soil reduced from 22.00% to 15.75%. As percentage of Fly ash increases, liquid limit of soil decreases from 47.80% to 39.45%. At 25% of Addition of Fly ash results in reduction in the plasticity index of this soil from 22.00% to 16.35 %.

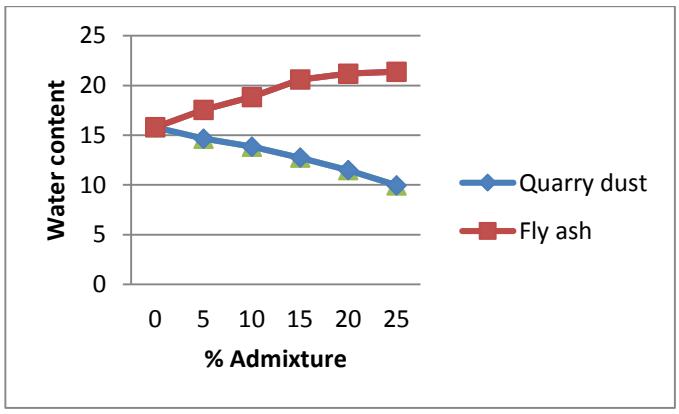
From the Compaction curve for the unmodified soil Maximum dry density of 18.02 KN/m³ is obtained at optimum moisture content of 15.80%.



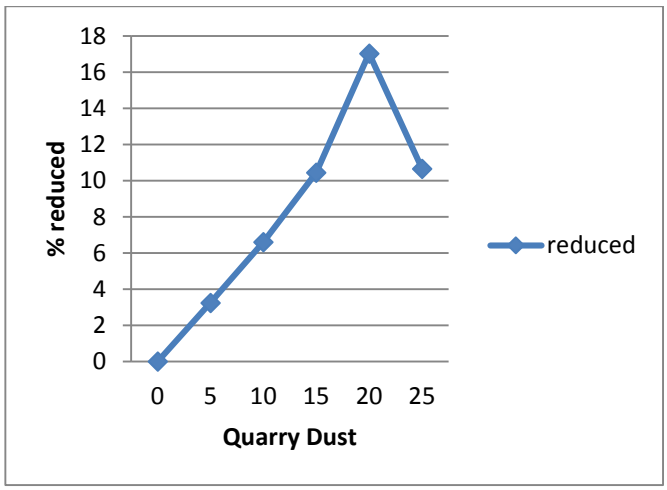
Graph3: Compaction curve for Unmodified Soil



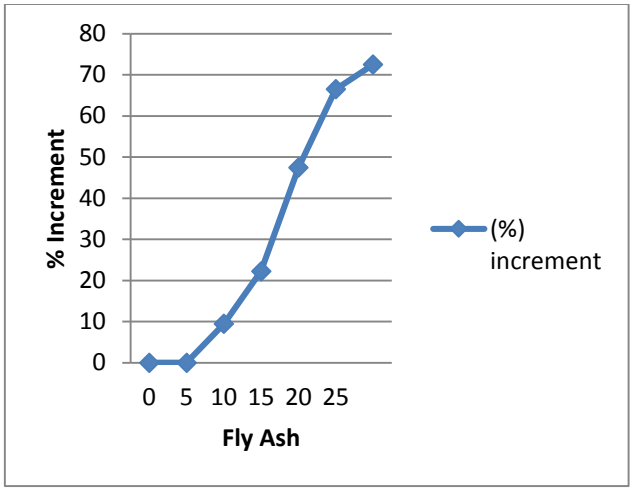
Graph4: Effect of percentage of Admixture on MDD



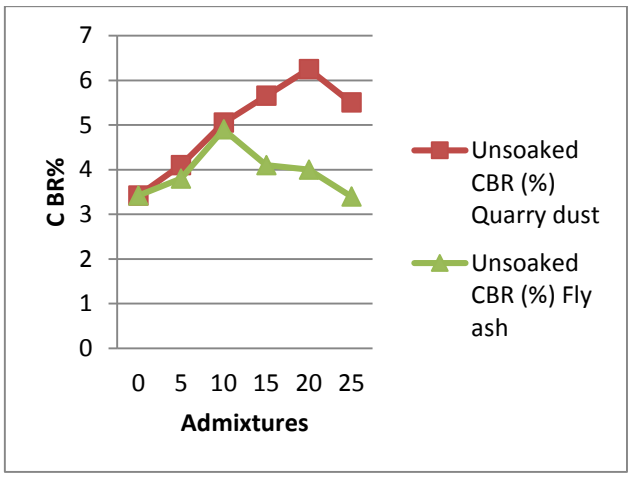
Graph5: Effect of percentage of Admixture on OMC



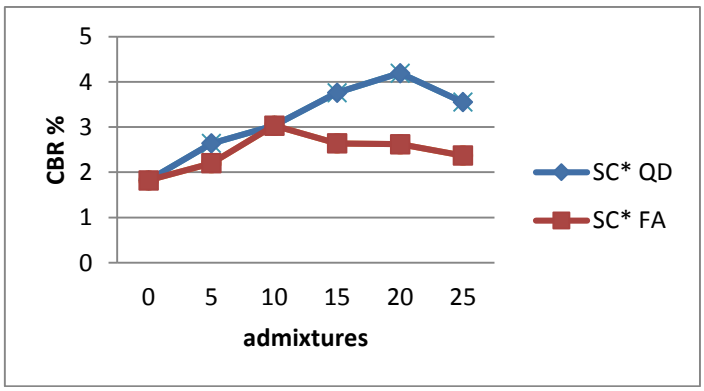
Graph6: Void ratio reduction with in Quarry dust



Graph7: Void ratio increase with increase in Fly ash



Graph8: Variation of (Unsoaked) CBR value with different percentage of Admixtures



Graph9: Variation of (Soaked) CBR value with different percentage of Admixtures

CONCLUSIONS

1. The effect of all the admixtures on various properties is significant in general and of Quarry dust in particular. Among two admixtures it is observed that workability of Quarry dust is better than Fly ash.

2. A decrease in consistency limits is observed with admixtures. A decrease of liquid limit to0.96, 0.94, 0.84, 0.81 and 0.78 times and plasticity index decreased by 0.97, 0.92, 0.77, 0.74 and 0.71 times for Quarry dust.

3. A decrease of liquid limit to0.96, 0.94, 0.89, 0.85 and 0.82 times and plasticity index decreased by 0.98, 0.92, 0.83, 0.75 and 0.74 times for Fly ash.

4. The composite soil has exhibited lower void ratios in Quarry dust. The variation of void ratio is same in quarry dust due to similar physical properties. Fly ash content increases void ratios due to same size particles with that of soil.

5. A Compaction characteristic maximum dry density increases to 1.06 times for (20%) Quarry dust and 1.05 times for (10%) Fly ash. Optimum moisture content decreases to 0.62 times (25%) for Quarry dust and increase to 1.34 times (20%) for Fly ash.

6. CBR studies were done and it was observed that both Soaked and Unsoaked has been improved with admixtures. However the improvement is more pronounced in soaked performance over Unsoaked. Soaked CBR value of Quarry dust stabilized soil is found to increase up to 20 % and there after the increase is nominal, hence the optimum in case of Quarry dust is found to be 20%

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