A Study on The Influence of Bituminous Emulsion And Flyash In Improving The Strength of Weak Laterite Soil

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Abstract- *Increase in regional growth and development leads to increase in infrastructure like buildings, bridge, tunnel, canal or dam and especially roads. Southern region of India forms a major tropical part, where lateritic soils are used as a road making material and they form the sub-grade of most tropical roads as either natural or formed. Due to presence of clay minerals like kaolinite and in some cases montmorillonite they turned as problematic lateritic soils. The reason being they have reputation of being problematic in road construction. Numerous research works have been carried out on stabilization of laterite soils to make them suitable especially as a material for road construction. It is important to use innovative techniques by utilizing local available industrial waste material for the modification and stabilization of deficient soil. Laterite soil stabilization with bitumen emulsion is environmentally accepted and makes soil stronger and improves resistance capacity against water and frost. This study is done to know the change in index properties and strength characteristics of laterite soil corresponding to different proportions of bitumen emulsion and fly ash. This paper presents the laboratory study carried out on the influence of bitumen emulsion and fly ash in improving the geotechnical properties of lateritic soil.*

Keywords- Lateritic soil, Bituminous emulsion, Fly ash, Atterberg's limit test, CBR test, Un confined compression test, maximum dry density and optimum moisture content test.

I. INTRODUCTION

Laterite is a soil and rock type rich in iron and aluminum, and is commonly considered to have formed in hot and wet tropical areas. Southern region of India forms a major tropical part, where lateritic soils are used as a road making material and they form the sub-grade of most tropical roads as either natural or formed. Most tropical laterite soils are composed predominantly of kaolinite clay mineral and in some cases they contain swelling clay mineral, montmorillonite. When lateritic soils contain swelling clay mineral type, they are known as problematic lateritic soils. The reason being they have reputation of being problematic in road construction. Numerous research works have been carried out on stabilization of laterites to make them suitable especially as a material for road construction. It is important to use innovative techniques by utilizing local available industrial waste material for the modification and stabilization of deficient soil. In the process of soil stabilization and modification, emphasis is given for maximum utilization of local material so that cost of construction may be minimized to the minimum extent.

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One of the most effective ways in terms of environmental benefits, product-type versatility and cost effectiveness in treating contaminated soils in order to make it suitable for engineering purposes such as the construction of road sub-grade (i.e. the natural foundation which receives load from pavement) is by using industrial wastes. Soil-stabilization is any treatment applied to a soil to improve its strength and reduce vulnerability to water.

Industries serves to be one of the most important sectors of production all over the world. Production of large quantity of industrial wastes becomes a major problem of waste management. The improper management of such waste cause serious environmental problems like air pollution, water pollution finally influencing the local ecosystems. Disposal of large quantities of industrial by-products as fills on disposal sites adjacent to industries not only require large space but also create many geo-environmental problems. The disposal of the agro industrial wastes fly ash also faces these problems. However, these ashes were found to have pozzolanic properties, therefore have been used as stabilization agent in lateritic soils.

In this research work, the laboratory study carried out on the individual and combined influence of bitumen emulsion and fly ash in improving the geotechnical properties of lateritic soil. The effects of the ash on geotechnical properties of the soil were investigated.

1.2 OBJECTIVES OF THE STUDY

The objectives of present experimental study are to develop correlations between engineering characteristics of lateritic soil. The study is focused on

- Improvement of locally available soil using some eco-friendly and cheap waste materials.
- Evaluation of strength characteristics of virgin as well as blended soil using bitumen emulsion and fly ash
- Determination of appropriate bitumen emulsion and fly ash content ratio co achieve the maximum gain in strength of soil.

II. LITERATUREREVIEW

2.1 Studies on lateritic soil

Research into new and innovative use of waste material is continually advancing and particularly concerning the feasibility, environmental suitability and performance of the beneficial reuse of industrial and agro industrial waste products. Recent research works conducted on stabilization of lateritic soil using different stabilizing agents were referred and their summary was listed below:

The common chemical compositions of laterites according to Gidigasu (1976), Ola (1983) and Osinubi (2003) are silica (SiO2), sesquioxide of iron (Fe2O3) and aluminum (Al2O3), and in some few cases, little quantities of manganese (Mn), titanium (Ti), chromium (Cr) and vanadium (V). Though silica is low in most laterite deposits, higher amounts are found in some few laterite deposits where the parent rock contains a lot of quartz.

In order to evaluate the effects of Sawdust Ash on the geotechnical properties of lateritic soils, Ogunribido performed tests on three samples of lateritic soils A, B and C, where he dealt with Consistency Limits, Specific Gravity, Compaction, Unconfined Compressive Strength, Shear Strength and California Bearing Ratio (CBR). These tests were conducted at non-stabilized and stabilized states by adding 2%, 4%, 6%, 8% and 10% sawdust ash (SDA). He obtained optimum results from a combination of 6% sawdust ash (SDA) and concluded that sawdust ash was an effective stabilizer for lateritic soils. However, he did not consider the addition of lime.

George R. Otoko presents the experimental study on Soft Soil Stabilization Using Palm Oil Fibre Ash and the analysis shows that the palm ash is classified as class F according to ASTM C618. It is siliceous and aluminous with virtually little or no cementation value. Therefore for pozzolanic reaction it has to be combined into a little POFA. An Optimum of 5% POFA was obtained for pozzolanic reaction. This combines with 3% optimum palm ash to give best results of soaked and unsoaked CBR. Thus, the palm ash can successfully be used for soil subgrade stabilization

M. Chittaranjan et al used agricultural wastes such as Metakaolin, rice husk ash and groundnut shell ash to stabilize the sub grade soil. The sub grade soil was treated with these waste materials separately at 0%, 3%, 6%, 9%,12% and 15% and CBR test was carried out for each per cent .The results of tests showed improvement in CBR value with the increase in percentage of waste up to a certain optimum content.

O. S Aderinola and E. S. Nnochiri studied stabilizing lateritic soil using Terrasil solution. Geotechnical tests such as compaction Test and California Bearing Ratio Test were performed on both the natural soil samples and the stabilized lateritic soil samples which were stabilized by adding terrasil solution in percentages ranging from 0% to 16% at 2% interval. The result indicated that between 0% and 12% terrasil solution, the MDD values and the unsoaked CBR values increased while the OMC values generally reduced. They concluded that the terrasil solution serves as a cheap and effective stabilizing agent for poor soil.

K.S.Gandhi (2012) worked on improving the sub grade soil using gasse ash. Metakaolin effectively dries wet soils and provides an initial strength gain, which is useful during construction in wet, unstable ground conditions. Various lab tests were performed with the percentage of Metakaolinvarying from 0 % to 10%. It was observed that as proportion of Metakaolinincreased in the soil sample, there was notable increment in engineering properties of the subgrade.

J. A. Sadeeq(2015) drawn a conclusion that the CBR values of soil samples treated with Metakaolinincreased but reduced with used oil contamination. The unsoaked CBR values of soil – BA mixtures right from 4 %BA content and above met the minimum CBR value of 30% specified by (BS

1990) for materials suitable for use as base course material when determined at MDD and OMC.

Based on the literature reports, the present is set out to evaluate the individual and combined influence of bitumen emulsion and fly ash in improving problematic lateritic soils. Different combinations of bitumen emulsion and fly ash are added to the problematic soil to determine the optimum mix proportions. Further, the effect of curing period over the improvement in the strength properties is also studied to evaluate the long-term strength profile.

2.2 STABILIZATION

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils.. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

3.2 METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. METHODOLOGY

MATERIALS USED AND THEIR PROPERTIES

Laterite soil collected from Orissa region at 1.0m depth is used for the study. The lateritic soil was sealed in the air tight plastic bags and transported to the college laboratory for testing. After collecting the soil is dried for 2 weeks.

TABLE 3.1 Properties of Lateritic Soil

Properties of Lateritic Soil		
S. No.	Property	Value
1	Specific gravity	2.66
2	Differential free swell Index (%)	68
3	Atterberg's Limits	
	i) Liquid limit (%)	49.2
	ii) Plastic limit (%)	23.7
	iii) Plasticity index (%)	25.5
4	Grain Size Distribution	
	i) Gravel Size Particles (%)	35
	ii) Sand Size Particles (%)	26
	iii) Silt & Clay Size Particles (%)	39
5	Compaction Parameters	
	i) Max. Dry Density (g/cc)	1.52
	ii) Optimum Moisture Content (%)	22.3
6	Penetration Parameters	
	i) CBR	7.8
7	Unconfined Compressive Strength (UCS) at OMC & MDD (kPa)	108

Bitumen Emulsion

Generally an additive is a substance which is added in small quantities to a specific material to improve its properties. Moreover it's used to act as a binder, after the effect of moisture, increase the soil density. Some of the most widely used additives: Portland cement, Fly Ash, Quicklime or Hydrated Lime, Bitumen Calcium Chloride, etc. But, mechanical soil stabilization implies to either compaction or the introduction of well built and other non-biodegradable reinforcement of soil. Emulsified Bitumen usually consists of bitumen droplets suspended in water. Most emulsions are used for surface treatments. Because of low viscosity of the Emulsion as compared to hot applied Bitumen, The Emulsion has a good penetration and spreading capacity. The type of emulsifying agent used in the bituminous emulsion determines whether the emulsion will be anionic or cationic. In case of cationic emulsions there are bituminous droplets which carry a positive charge and Anionic emulsions have negatively charged bituminous droplets. Based on their setting rate or setting time, which indicates how quickly the water separates from the emulsion or settle down, both anionic and cationic emulsions are further classified into three different types. Those are rapid setting (RS), medium setting (MS), and slow setting (SS). Among them rapid setting emulsion is very risky to work with as there remains very little time before setting. The setting time of MS emulsion is nearly 6 hours. So, work with medium setting emulsion is very easy and there is sufficient time to place the material in proper place before setting. The setting rate is basically controlled by the type and amount of the emulsifying agent. The principal difference between anionic and cationic emulsions is that the cationic emulsion gives up water faster than the anionic emulsion. In this case mixing the soil with slow setting bitumen emulsion is not so much effective and rapid setting is not easy to work with soil. So here we use cationic medium setting emulsion as main stabilizing agent. In cationic emulsion the emulsifier used is a long chain amine.

The fly ash used as a filler material was procured in a 1 kg bag were purchased from National Thermal Power Corporation (NTPC), Visakhapatnam and stored in a dry place away from weather effects.

Different laboratory experiments conducted with different combinations of materials. Detailed discussion on the results obtained from various laboratory tests done on untreated and treated lateritic soil are presented in the results and discussions chapter.

IV. RESULTS AND DISCUSSIONS

In the laboratory, various experiments were conducted by replacing different percentages of bitumen emulsion and addition of fly ash to the optimum percentage in the Weak Laterite Soil. Liquid Limit, Plastic Limit and Compaction, CBR and UCS tests were conducted with a view to determine the optimum percentage of Bitumen emulsion as replacement in weak Laterite Soil and flyash 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.

EFFECT OF % BITUMEN EMULSIONAS REPLACEMENT ON THE PROPERTIES OF WEAK LATERITE SOIL

The individual influence of Bitumen emulsion on the Index, Compaction and Strength properties of Laterite Soil are clearly presented in Figures 4.1, 4.2, 4.3, 4.4, and 4.5 respectively. The percentage of Bitumen emulsion was varied from 0%, to 12% with an increment of 3%. From the above graphs, it was observed that the treatment as individually with 9% Bitumen emulsion has moderately improved the laterite soil. It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % replacement of Bitumen emulsion up to 9% with an improvement of about 54%. Also maximum dry density is improved by an amount of 12.13% and it was about 32.4% for UCS and 94.8% for CBR respectively.

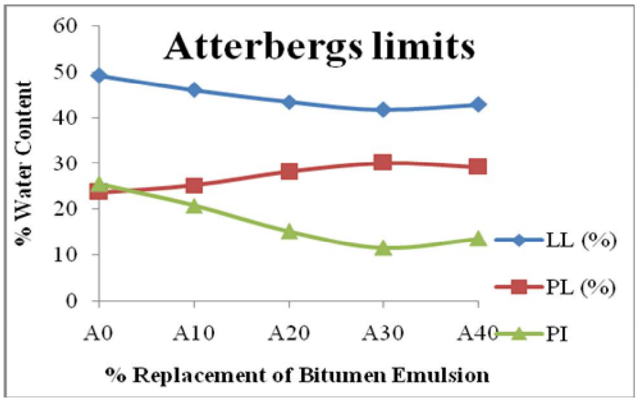

Fig 4.1 Plot showing the Variation in Atterberg's Limits with % Replacement of bitumen emulsion

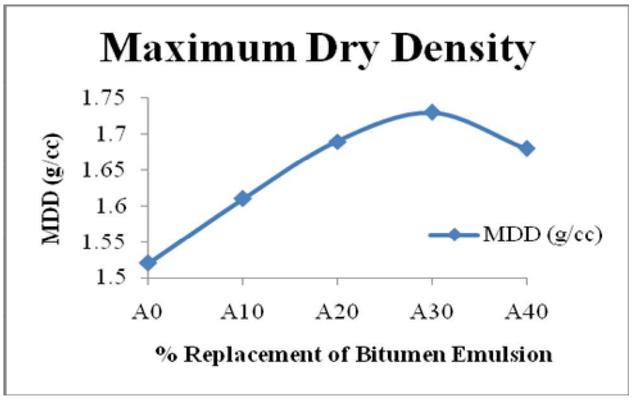

Fig 4.2 Plot showing the Variation in MDD with % Replacement of bitumen emulsion

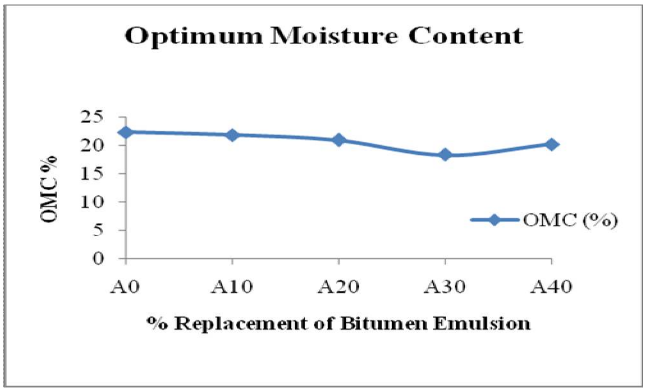

Fig 4.3 Plot showing the Variation in OMC with % Replacement of bitumen emulsion

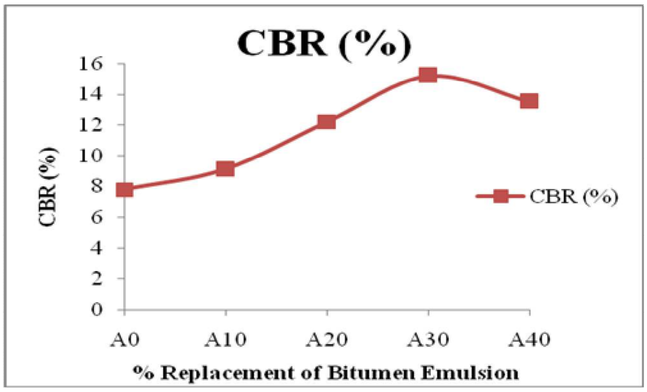

Fig 4.4 Plot showing the Variation in CBR VALUES with % Replacement of bitumen emulsion

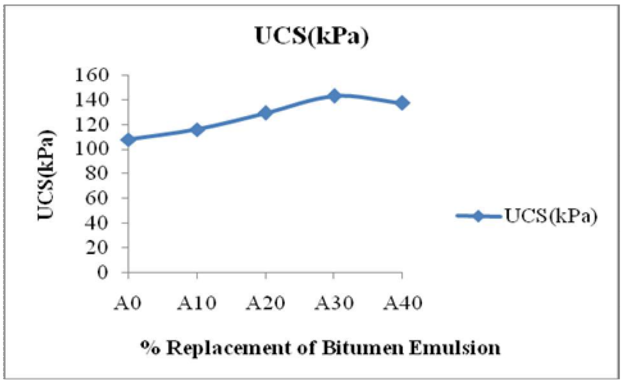

Fig 4.5 Plot showing the Variation in UCS with % Replacement of bitumen emulsion

4.4 EFFECT OF % FLY ASH AS BINDER ON THE PROPERTIES OF WEAK LATERITE SOIL

The influence of Fly ash with optimum content of bitumen emulsion on the Compaction, CBR, UCS properties of Laterite Soil are clearly presented in Figures 4.6, 4.7, 4.8 respectively. The percentage of Fly ash was varied from 0%, 2%, 4%, 6% and 8%. From the above graphs, it was observed that the treatment with 6% fly ash and 9% bitumen emulsion has moderately improved the laterite soil. It can be inferred from the graphs, that there is a gradual improvement in the maximum dry density with an increment in % addition up to 6% with an improvement of about 6% and it was about 22% for UCS and 16% for CBR respectively. From the above results the Optimum Content of addition of Fly ash with 9% Bitumen emulsion of Laterite Clay is 6%

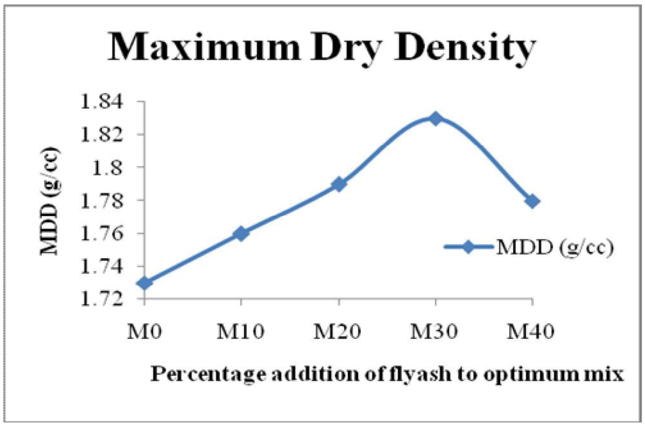

Fig 4.6 Plot showing the Variation in MDD with different % of fly ash to the optimum mix

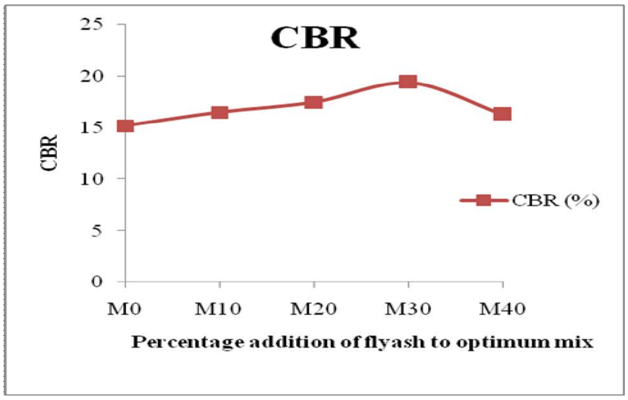

Fig 4.7 Plot showing the Variation in CBR with different % of fly ash to the optimum mix

4.5 EFFECT OF (CURING) ON SAMPLES PREPARED WITH 9% BITUMEN EMULSION AS REPLACEMENT AND 6% FLY ASH AS ADDITION TO THE LATERITE SOIL

From the above results It is observed that samples prepared with 9% bitumen emulsion as replacement and 6% fly ash as addition to the laterite soil 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 Laterite Soil stabilized with Bitumen emulsion and fly ash. It is evident that the addition of Bitumen emulsion and Fly ash to the virgin Laterite Soil showed an improvement in plasticity, compaction and strength properties to some extent and on further blending it with fly ash, the improvement was more pronounced. This made the problematic weak Laterite Soil which if not stabilized is a discarded material, a useful fill material with better properties. The Bitumen emulsion and fly ash in the weak Laterite Soil has reduced the plastic nature of the soil and upon further blending with fly ash, the plasticity was even reduced. It can be summarized that the materials Bitumen emulsion and fly ash had shown promising influence on the properties of laterite soil, thereby giving a twofold advantage in improving problematic Laterite 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 Laterite Soil chosen was a problematic soil.
- It was observed that the treatment as individually with 9% of Bitumen emulsion has moderately improved the laterite soil.
- There is a gradual increase in maximum dry density with an increment in the % replacement of bitumen emulsion up to 9% with an improvement of about 12% and it was about 54% for plasticity characteristics.
- There is an improvement in CBR, Shear parameters also by an amount of 32.4% for UCS and 94.8% for CBR respectively.
- It can be inferred from the graphs, that there is a gradual improvement in the Plasticity index with an increment in % Addition of fly ash up to 6% Also maximum dry density is improved by an amount of 6% and it was about 22% for UCS and 16% for respectively.

It is evident that the addition of Bitumen emulsion to the virgin Laterite Soil showed an improvement in properties to some extent and on further addition of fly ash, the improvement was more pronounced.

Finally it can be summarized that the materials Bitumen emulsion and Fly ash had shown promising influence on the properties of Weak Laterite soil, thereby giving a two-fold advantage in improving problematic expansive soil and also solving a problem of waste disposal.

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