Compaction and Strength Characteristics of Lithomargic soil stabilized with Flyash and Polypropylene Fibre

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***Abstract*—The coastal area of Karnataka has a hard crust on the top; these top layers of the laterite formations are highly porous but hard and strong. In between this top low level laterites and bottom high level laterites some of the beds are having size distribution between Jedi (clay) and Godi (silt) soils, but do not show the behavior of the clay nor silt. These soils dissolve and flow like water when water gushes through this layer during monsoon and many times washes off the fine soil, creates cavities and at time causes heavy settlement and sliding of the top layers after the application of load. This bed soil is termed as Lithomargic Shedi soil. The strength property of Shedi soil depends on density and compactive effort. Further the strength of weak soils can be altered by the addition of admixture. The widespread availability of fly ash has promoted its use to stabilize soils. Soils which are highly susceptible to erosion, on mixing with fly ash and curing for a sufficient period of time not only become resistant to erosion but also gain the strength. However, strength depends mainly on its reactive silica and lime content. This paper includes the evaluation of shedi soil properties like Optimum moisture content, dry density, and strength parameter (Unconfined compressive strength). Different quantities of Polypropylene fibre (percent by weight) are added to the flyash treated shedi soil and the experiments conducted on these soil mixes. The result shows that the use of Polypropylene fibre and Fly ash increases the Unconfined compressive strength values.**

***IndexTerms*—Laterite, Shedi soil, Lithomargic soil, Polypropylene fibre**

I. INTRODUCTION

Lithomargic clay is locally available whitish, pinkish or yellowish silty sand. It is mainly composed of hydrated alumina and kaolinite powder. This soil is present in between weathered laterite and hard granite gneiss and is present at a depth of 1-3 meters below the top lateritic outcrop. This type of soil is abundantly available in the western coastal belt of Southern India, starting from Cochin to Goa. These soils are the product of tropical or subtropical weathering. and contain hydrated alumina, primary silicates, and kaolinite. Lithomargic soils comprise 50% - 90% lateritic constituents, while soils with 25% - 50% laterite content are known as lateritic lithomarges. Lithomargic soils are considered as a major problematic soil in the western coastal belt of Southern India. Their strength is high in dry conditions, whereas significant reduction of strength takes place when there is an increase in moisture content. These types of dispersive soils are highly susceptible to erosion. As long as this soil is confined and dry, there is a very little or no problem, but on the exposure in a cutting or when it comes in contact with water, it loses its strength drastically. Slope failures, landslides etc., are quite common in this type of soils. The infrastructural developmental activities due to rapid urbanization and fast growing industries in coastal Karnataka are forcing the civil engineers to put to the best use of even the poorest sites available and discarded by our ancestors. These poor sites are characterized by low bearing capacities and large settlements. Low lying agricultural and marshy lands in and around is being converted into estates with locally available soils mentioned above as lithomargic clay. Large hills are cut for these purposes. These filled up areas pose problems of low bearing capacity as well as excessive settlements because of improper compaction and poor drainage.

II. LITERATURE REVIEW

Pal et al.(2014) have found that Silt content, porous surface, lower specific gravity and lower MDD of fly ash increased the unconfined compressive strength of the soil when soil and fly ash layers placed successively. The unconfined compressive strength of the constituent samples were significantly increased with the curing period and it is more consistently increases upto the first 14 days. Dr.H.N.Ramesh et al (2013) have carried out to laboratory studies to determine the effect of sodium salts on shedi soil optimized with Neyveli Fly ash. Considerable changes in the index properties and compaction characteristics were observed. Addition of Neyveli fly ash improved the workability of shedi soil considerably. There was an increase in optimum moisture content and decrease in maximum dry density with the increasing percentage of Neyveli fly ash to shedi soil. Sujit Kumar P. Suresh Praveen Kumar et al. (2009) have evaluated the properties of Shedi soil collected from Surathkal, Mangalore, Karnataka by adding the pond ash collected from Raichur Thermal Power Station (RTPS) and coir. They have studied the performance of stabilized soil conducting the laboratory compaction, unconfined compressive strength and CBR tests. They have inferred that to satisfy the sub-base requirement the per cent placement of pond ash and coir to soil, based on laboratory investigation was 15% and 0.8% respectively. Maximum value of unconfined compressive strength was exhibited in the soil mix with 15% pond ash with 0.8% coir for both one day and 7 days curing. And also Maximum value of CBR was obtained at OMC for 0.6% of coir and 15% of pond ash in the soil mix. Chittanahally Ramakrishnegowda et. al (2011) have studied the effect of interaction of shedi soil containing both kaolinite and smectite minerals with alkali on various geotechnical properties such as the index properties, compaction characteristics, volume change behaviour, strength characteristics and hydraulic conductivity. It was observed that though the plasticity index of soil decreases and optimum moisture content increases with increased concentration of alkali content in the fluid. The decrease in the shear strength of soil was essentially due to decrease in the cohesion of the soil particles. The hydraulic conductivity of the soil was increased with higher concentrations of alkali solution. Senol et al. (2013) have conducted a study on Effect of fly ash and different lengths of polypropylene fibers content on the soft soils. The soil samples were prepared at three different percentages of fiber content (i.e. 0.5%, 1% and 1.5% by weight of soil) and two different percentages of fly ash (i.e. 10% and 15% by weight of soil). A series of tests were prepared in optimum moisture content and laboratory unconfined compression strength tests, compaction tests and Atterberg limits test were carried out. The fiber inclusions increased the strength of the fly ash specimens and changed their brittle behavior into ductile behavior. Kaniraj and Havanagi (2001) conducted a study on a soil–fly ash mixture reinforced with 1% polyester fibres (20 mm length) and demonstrated the combined effect of fly ash and fibre on the soil and indicated that the fiber inclusions increase the strench of raw fly ash-soil speciments as well as that of the cement stabilized speciments and change brittle behavior to ductile behavior. Jadhao and Nagarnaik (2008) have studied the influence of polypropylene fibers on the engineering behavior of soil fly ash mixtures by using different fiber lengths in the range of 0-1.5% by dry wet of soil and observed that maximum improvement in strength was achieved at a fiber length of 12 mm with fiber content of 1%.

III. MATERIALS AND METHODOLOGY

Materials Used

1. Lithomargic soil

Lithomargic soil was obtained from Usman Nagar in Bhatkal taluk, Karnataka state, India. The soil was excavated from a depth of 2 m from the natural ground level. The soil was dark yellowish in color. The physical properties of lithomargic soil are shown below:

Table 1: Physical Properties of Lithomargic soil

S.No.	Properties of Lithomargic soil	Value
1.	Grain size distribution	
	Gravel size fraction (%)	0
	Sand size fraction (%)	85.8
	Fines size fraction (%)	14.2
2.	Atterberg’s limits	
	Liquid Limit (%)	41.00
	Plastic Limit (%)	28.00
	Plasticity Index (%)	13.00
	Shrinkage limit (%)	35.44
3.	IS-Classification	MI
4.	Specific gravity	2.67

2. Flyash

Fly ash class-F fly ash was collected from Udupi Power Corporation Ltd., Padubidri, Udupi district. Fly ash is air dried and pulverized. The physical properties of fly ash are shown in Table 2.

Table 2: Physical Properties of Flyash soil

S.No.	Properties of Lithomargic soil	Value
1.	Grain size distribution	
	Sand fraction (%)	0
	Silt size fraction (%)	74.00
	Clay size fraction (%)	26.00
2.	Atterberg’s limits	
	Liquid Limit (%)	39.00
	Plastic Limit (%)	NP
4.	Specific gravity	2.16

Methodology

Lithomargic soil was mixed with flyash and polypropylene fibre. All the tests were conducted as per BIS: 2720 guidelines, except for compaction test. Compaction test was conducted using both mini compaction test apparatus (Sridharan et al., 2005 and Light compaction test as per BIS; 2720 Part VII (1980). UCS tests were conducted to evaluate strength characteristics of lithomargic soil treated with flyash and polypropylene fibre for 3, 7 and 15 days curing period.

IV. RESULTS AND DISCUSSION

Compaction Characteristics

1. Compaction characteristics of Shedi soil mixed with Fly ash

The compaction characteristics govern the strength and deformation behaviour of the soil and thereby the performance of soil flyash mixture. Results of compaction tests with virgin soil as well as various soil-flyash mixes have been presented in Figure 1 and 2.

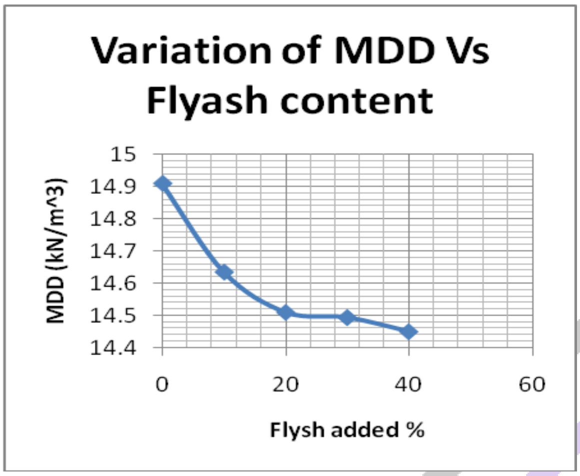

Figure1 Effect of Flyash on MDD

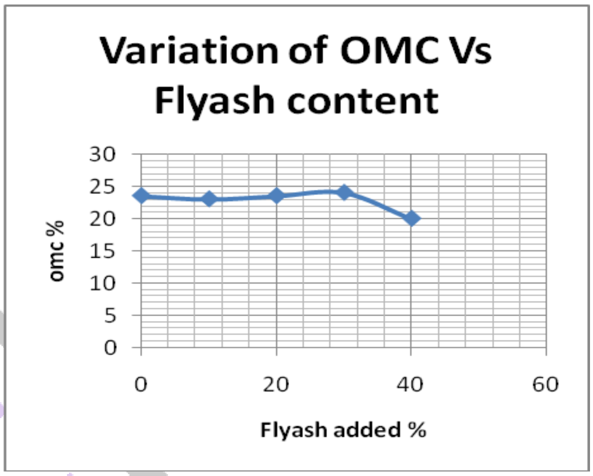

Figure2 Effect of Flyash on OMC

As seen from the Fig.1 and 2, the maximum dry density of shedi soil alone is 14.91kN/m3 and the optimum moisture content is 23.5%. Addition of 10% fly ash reduces the maximum dry density and optimum moisture content. Further addition of fly ash beyond 20% the maximum dry density still reduces and optimum moisture content increases. This is due to the fact that percentage of fine fly ash requires more water for inter particle lubrication and at the same time reduces the unit weight. Fly ash generally consists of spherical particles, called cenosphere of low specific gravity and high porosity. The decrease in MDD is due to the presence of flyash having low specific gravity. The increase in OMC can be attributed to the increasing amount of fines which requires more water content because of their larger surface area. MDD and OMC values for various percentages of flyash is shown in Table 3.

Table 3 Compaction characteristics of Shedi soil +Fly ash

Mixture	Maximum Dry Density (KN/m^3)	Optimum Moisture Content (%)
Shedi soil (SS) alone	14.910	23.5
Shedi soil (SS) + 10%fly ash	14.635	23
Shedi soil (SS) + 20%fly ash	14.510	23.5
Shedi soil (SS) + 30%fly ash	14.494	24
Shedi soil (SS) + 40%fly ash	14.450	20

2. Compaction characteristics of Shedi soil mixed with Polypropylene fibre(PPF)

The relationship between dry density and moisture content of samples obtained by Mini compaction test is presented in Figure1. The compaction test has been performed on soils with different fibre contents of 1%, 2%, 3% and 4 % of dry mass.

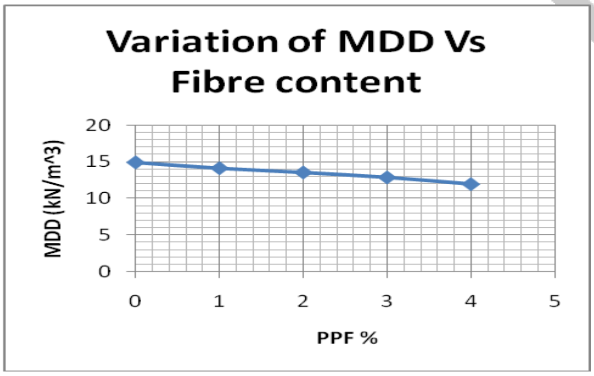

Figure 3 Effect of PPF on MDD

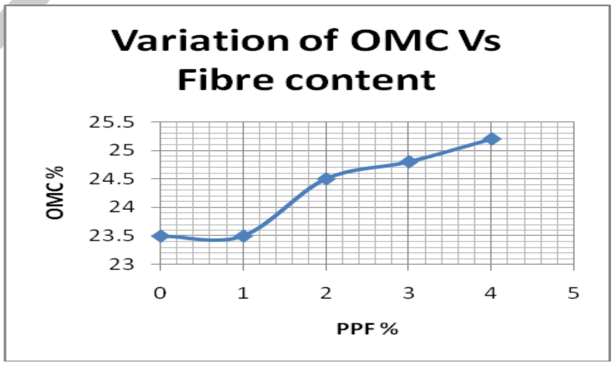

Figure 4 Effect of PPF on OMC

From the figure 3, it is observed that with increase in percentage addition of polypropylene fibre the MDD goes on decreasing. The reason of such type behavior is the replacement of soil particles by fibres, which have less specific gravity (0.91) than the specific gravity of soil (2.67) and lubricating effect of absorbed moisture by fibres, which reduces the compaction impact.

Fig.4 shows the variation of OMC of soil with different percentages of polypropylene fibre. From the figure it is observed that with increase in percentage addition of polypropylene fibre, the OMC goes on increasing. The reason of such type of behavior is greater water absorption capacity of fibres in comparison to soil.

The variation of MDD and OMC with fibre content is presented in table 4 shown below.

Table 4 Compaction characteristics of Shedi soil + Polypropylene fibre

Mixture	Maximum Dry Density (KN/m^3)	Optimum Moisture Content (%)
Shedi soil (SS) alone	14.910	23.5
Shedi soil (SS) + 1% Polypropylene fibre	14.125	23.5
Shedi soil (SS) + 2% Polypropylene fibre	13.545	24.5
Shedi soil (SS) + 3% Polypropylene fibre	12.880	24.8
Shedi soil (SS) + 4% Polypropylene fibre	11.960	25.2

3. Compaction characteristics of Flyash Stabilized Shedi soil +Polypropylene fibre

Table 3 shows the variation of MDD of fly ash stabilized soil with different percentages of polypropylene fibre. It is observed that with increase in the polypropylene fibre, the MDD goes on decreasing. The reason of such type behavior is the replacement of soil particles by fibres, which have less specific gravity (0.91) than the specific gravity of soil (2.67) and lubricating effect of absorbed moisture by fibres, which reduces the compaction impact.

The table also shows the variation of OMC of fly ash stabilized soil with different percentages of polypropylene fibre. From the table, it is observed that with the increase in the percentage addition of polypropylene fibre, the OMC goes on increasing. The reason of such type of behavior is greater water absorption capacity of fibres in comparison to soil.

Table 3 Compaction characteristics of Shedi soil treated with Polypropylene fibre

Mixture	Maximum Dry Density (KN/m^3)	Optimum Moisture Content (%)
Shedi soil (SS) alone	14.91	23.5
SS +10% flyash+ 1% Polypropylene fibre	13.98	24
SS +20% flyash+ 2% Polypropylene fibre	13.60	26
SS+30% flyash + 3% Polypropylene fibre	13.46	26.5
SS+40% flyash + 4% Polypropylene fibre	13.20	28

Strength characteristics of Flyash Stabilized Shedi soil +Polypropylene fibre

The effect of curing period on various flyash stabilized shedi soil mixes with different combinations fibre contents is examined on the unconfined compressive strengths (UCS). The values of the strengths of all mixes are found to increase with increase in curing period. The strength is found to be gained rapidly in the beginning; but thereafter, it decreases. The increase in strength with a addition of fly ash with the curing period is due to the formation of Pozzolanic compounds.

Table 4 Strength Charcteristics of Lithomargic soil mixed with Flyash and Polypropylene fiber

Mixture	Average Unconfined Compressive Strength (KN/m^2)			
	0 Days	3Days	7Days	15Days
Shedi soil (SS) alone	61.59	-	-	-
Shedi soil (SS) +10% flyash+ 2% Polypropylene fibre	65.93	74.74	84.22	103.18
Shedi soil (SS) +20% flyash+ 2% Polypropylene fibre	94.05	96.52	121.97	182.95
Shedi soil (SS) +30% flyash + 2% Polypropylene fibre	74.17	91.48	116.65	119.65
Shedi soil (SS) +40% flyash + 2% Polypropylene fibre	70.13	107.39	138.43	148.70

V. CONCLUSIONS

[1] Addition of higher percentages of flyash content to the Lithomargic soil tends to decrease the MDD.For the flyash contents of 20% and 30 % there occurs an increase in the OMC.

[2] Inclusion of Polypropylene fibres into the Lithomargic soil decreases the MDD and increases the OMC.

[3] For the composite mixtures containing increased percentages of flyash and polypropylene fibres MDD decreases continuously. Also, for the composite mixtures containing increased percentages of flyash and polypropylene fibres OMC increases continuously.

[4] Unconfined compressive strength of flyash mixed Lithomargic soil increases initially with the increased percentages of flyash. Soil mixed with 20% of flyash and 2% of fibre gives higher Unconfined compressive strength.

[5] As the curing period increases flyash treated Lithomargic soil attains higher values of Unconfined compressive strength.

[6] Lithomargic soil with 20 % flyash and 2% Polypropylene fibre attains higher values of Unconfined compressive strength with the increased curing periods compared to other composite mixtures.

Hence, from this study it is inferred that 20 % flyash and 2% Polypropylene fibres are optimum to improve the compaction and strength charcateristics of Lithomargic soil.

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