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Study on properties of lateritic soil using fly ash and coir fibers.

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Abstract :- **The feature of a flexible pavement depends on the strength of its subgrade. Materials selected for use in the construction of subgrade must have sufficient strength and at the same time it must be cost-effective for use. For soils to be fit in civil engineering projects, they must meet obtainable local requirements for index properties in addition to certain strength criteria. Some lateritic soils in their natural state need some treatment/alteration to meet the specification requirements. Fly ash (FA) is a waste produced from the burning of coal in thermal power stations. Efforts are underway to improve the use of fly ash in several ways, with the geotechnical utilization also forming an important aspect of such efforts. An experimental program is to be undertaken to examine the effects of fly ash and coir fibers on the compaction and strength performance of lateritic soil. The soil samples are prepared with different proportions of fly ash and coconut fiber content, i.e. (5%, 10%, 15% of FA) and (0.25%, 0.50%, 1.0% fibers) respectively. A series of test are conducted including Index Properties, Consistency Limits, Modified Proctor Test, laboratory Unconfined Compression Strength Tests properties of soil. The probable variations in the strength of Fly ash specimens, fiber specimens and the combination of Lateritic Soil + FA + Coir Fiber specimens are observed and recorded. Based on the laboratory test data variance in the test results is found by using data analysis tool in Microsoft Excel and a value of each test result is established.**

Keywords: - **Coir fiber, fly ash, lateritic soil, UCS, variance**

I. INTRODUCTION

Lateritic soils are extensively used as fill materials for various construction mechanisms. These soils are weathered under conditions of high heats and humidity with well-defined alternating wet and dry seasons resulting in poor engineering properties such as high plasticity, poor workability, low strength, high permeability, tendency to retain moisture content. The effective use of these soils is therefore often hindered by difficulty in handling particularly under moist and wet conditions typical of tropical regions and can only be utilized after modification/stabilization.

The modification/stabilization of engineering properties of soils is recognized by engineers as an important process of improving the performance of problematic soils and makes marginal soils perform better as a civil engineering material. Stabilization, in a broad sense, includes the various methods the engineering properties and performance of soil. Every year millions of tonnes of fly ash is produced all over India which is categorized as hazardous waste material. It is better to use such waste materials in variety of ways, including roadbeds, construction fill or cement admixture.

Latest studies have shown that many of the soil problems can be enhanced by addition of fly ash and fibers, like S.M. Hejazi et al. [20] reviewed the history, benefits, applications, and possible executive problems of using different types of natural and/or synthetic fibers in soil reinforcement through reference to published scientific data, S.Chakraborty et al. [18] carried out investigation with easily available materials like lime and rice husk ash mixed individually and also in combination with locally available clayey soil in different proportions at optimum moisture content (OMC). The laboratory test results show marked improvement of strength of soil on addition of admixtures in terms of California Bearing Ratio (CBR). Based on the laboratory test data a correlation has been established in the form of an equation of CBR considering it as a function of different soil parameters by multiple linear regression analysis. Afeez Adefemi BELLO [2] considered the use of regression analysis that may have correlation between index properties and California Bearing Ratio (CBR) of some lateritic soil within Osogbo town of South Western Nigeria. Saravut Jaritngam, William O. Yandell and Pichai Taneerananon [17] found the strength properties of lateritic soil-cement and modulus using multiple regression models. The study presented a methodology for predicting the unconfined compressive strength (UCS) and modulus of lateritic soil-cement (LSC) by making use of the cement content and the curing time values. P. Suroso et al. [14] discussed the addition of fiber in this mix can reduce or even eliminate the process of shrinkage and hydration. It was found by the study that Palm fibers can increase the compressive strength of soil-cement between 54, 71%-68, 38% and CBR between 1, 91%-43, 39%. Palm fibers 5% by weight of cement is an ideal amount of soil-cement mixture. C. Gumuser, A. Senol [3] investigated the 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. A.A. Bello and C.W. Adegoke [1] presented a study on the geotechnical properties of lateritic soil found within Southwestern Nigeria and environs. For this to be achieved, the following laboratory soil tests were carried out during the course of research viz: particle size analysis test, Atterberg limit test, British standard light compaction test, specific gravity, and California bearing ratio in accordance with British Standard 1377 (1990) and Head (1992). Shah, S.J, Abdurahiman, P and Shah, S.H. [19] presents an excel sheet providing a collection of correlations of different soil properties so that practicing engineers can get immediate insight into the empirical and engineering behaviour of soils. Correlations of the index and engineering soil properties have been collected and entered as formulae into the spread sheet so that upon entering test result data, possible behaviour of soil will be output C. Pohl [15] discussed that there is significant discretion in the determination of characteristic soil values and this influences the results of geotechnical verifications. If results of field- and laboratory tests are available in an adequate sample size, statistical methods are an effective tool to determine characteristic soil values in a verifiable way and to get best possible information from realized site investigations. B. Pandey, K. Bajaj and A P Singh [5] described about making economical pavement following pozzolanic materials such as fly ash, jute, lime and water proofing compounds are used for improving the properties of black cotton soil. It is concluded that mixing of 1% jute fiber, 20% fly ash and 5% lime together in a soil gives better result.

By studying and reviewing the above presented literature, it is found that no study has been reported on the use of fly ash and coconut coir fiber in different percentages for stabilization of lateritic soil. The present investigation deals with the effect of fly ash and coir fiber on the engineering properties of lateritic soil.

II. MATERIALS USED

a. Lateritic Soil

Representative soil sample used for this investigational study was Lateritic soil, which is generally observed soil type. The engineering properties of the soil are shown below.

Table 1- Properties of soil used

Soil Properties	Values
Soil IS Classification	CH
Sand (%)	23
Silt (%)	72
Clay (%)	5
Specific Gravity (G)	2.59
Liquid Limit (%)	55.55
Plastic Limit (%)	63.33
Maximum Dry Density (g/cc)	1.3
Optimum Water Content (%)	19.73
Unconfined Compressive Strength (kN/mm^2)	61.6
Cohesion (c) (N/mm^2)	7.67
Angle of internal friction (φ)	39.7°

The following are the engineering problems of lateritic soil in relation to its property/condition.

Table 2- Engineering Problems of lateritic soil

Condition/Property of soil	Related Engineering Problems
Variation in parent rock material & extent of weathering	Difficulty in quality control
Presence of sesquioxides	1) High Plasticity
	2) Difficult to obtain reproductive results of classification & index tests.
	3) Difficulty in handling / workability
Collapsible behaviour of the soil structure	Loss of strength & compressibility due to wetting.
Wet field condition due to frequent seasonal & heavy rainfall.	1) Difficulty in handling.
	2) Effective compaction.

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b. Fly Ash

The physical, geotechnical and chemical parameters to characterize fly ash are the same as those for natural soils, e.g., specific gravity, grain size, Atterberg limits, compaction characteristics, permeability coefficient, shear strength parameters and consolidation parameters. The procedures for determination of these parameters are also similar to those for soils. The engineering properties of the fly ash are shown below.

Table 3- Geotechnical properties of fly ash

Parameters	Range
Specific Gravity	1.90 – 2.55
Plasticity	Non plastic
Maximum dry density (gm/cc)	0.9 – 1.6
Optimum moisture content (%)	38.0 – 18.0
Cohesion (c) (N/mm^2)	Negligible
Angle of internal friction (φ)	$30^0 – 40^o$

c. Coconut (coir) Fibers

The fiber is also very long lasting, with infield service life of 4-10 years. The water absorption of that is about 0.1-0.6 mm. Coir contains much of its tensile strength when wet. It has low tenacity, but elongation is much higher.

For coir stabilized lateritic soils, the maximum dry density (MDD) of the soil decreases with addition of coir & optimum moisture content (OMC) increases.

IV. OBJECTIVE AND SCOPE OF PRESENT STUDY

The investigation is carried out on Lateritic soil. Objectives of present investigations are:

1. To determine the optimum measure of fly ash and coconut coir fiber for the locally available lateritic soil.
2. To study the engineering properties of lateritic soil stabilized with optimum measure of fly ash and coir.
3. To determine the variance in the test results and perform the analysis using Microsoft Excel.

V. METHODOLOGY

The following method was adopted for preparation of lateritic soil, fly ash and coir fibers combinations in all tests.

Table 4- Combinations of fly ash and coir fibers with soil

Components	No. of Mix
Original Soil Sample	1
Soil + Fly ash	3
Soil + Coir fibers	3
Soil + Fly ash + Coir fibers	9

Variances related with many uncertainties, which are combined by simple addition when the uncertainties are additive and statistically independent. Laboratory tests on soil specimen with or without mixing fly ash and coir fibers are prepared. The test program for the investigation is carried out as per the following table.

Table 5- Test program

Soil Properties	No.of tests
Soil IS Classification	16
Specific Gravity (G)	16
Liquid Limit (%)	16
Plastic Limit (%)	16
Maximum Dry Density (g/cc)	16
Optimum Water Content (%)	16
Unconfined Compressive Strength (kN/mm^2)	16

Table 6- Mix Designations for various mixes with

Description	Mix Designation
Soil	S
Soil + 5% FA	Mix 1
Soil + 10% FA	Mix 2
Soil + 15% FA	Mix 3
Soil + 0.25% Fibers	Mix 4
Soil + 0.5% Fibers	Mix 5
Soil + 1% Fibers	Mix 6
Soil + 5% FA + 0.25% Fibers	Mix 7
Soil + 10% FA + 0.25% Fibers	Mix 8
Soil + 15% + 0.25% Fibers	Mix 9
Soil + 5% FA + 0.5% Fibers	Mix 10
Soil + 10% FA + 0.5% Fibers	Mix 11
Soil + 15% + 0.5% Fibers	Mix 12
Soil + 5% FA + 1% Fibers	Mix 13
Soil + 10% FA + 1% Fibers	Mix 14
Soil + 15% FA + 1% Fibers	Mix 15

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Fig.1. Samples of (b) lateritic soil, (a) coir fiber and (c) fly ash

Fig. 2. Mixture of lateritic soil, coir fiber and fly ash

Fig.3. Sample preparation for compaction test

Fig.4. Samples of Unconfined compression test

VI. RESULTS AND DISCUSSIONS

Laboratory tests are performed on soil samples as per standard procedure including tabulation of test results. The results of these tests have been presented in the form of tables and graphs in this chapter.

Table 7- Test Results

Mix Designation	Sp. Gr.	LL (%)	PL (%)	Modified Proctor		UCS kN/m^2
				MDD (g/cc)	OMC (%)	
S	2.69	55.5	18	1.3	19.73	61.66
Mix 1	2.6	43.4	17.1	1.32	17.07	7.95
Mix 2	2.69	41.7	18	1.1	22.06	2.39
Mix 3	2.66	47.3	17.7	1.26	22.88	62.15
Mix 4	2.71	40.3	14.6	1.13	23.16	59.3
Mix 5	2.7	37.3	18	1.22	17.7	2.43
Mix 6	2.7	44.2	18.6	1.3	17.95	60.85
Mix 7	2.65	49.8	17.6	1.2	28.38	60.85
Mix 8	2.74	36.5	18.7	1.35	15.58	2.5
Mix 9	2.72	36.3	18	1.31	19.17	60.85
Mix 10	2.68	44.7	17.5	0.96	19.5	76.49
Mix 11	2.73	37.4	18	1.14	18.97	3.38
Mix 12	2.73	34.9	19.9	1.12	20.49	70.81
Mix 13	2.73	35.7	21.4	1.26	22.88	76.4
Mix 14	2.59	34.8	21.3	1.26	22.62	3.5
Mix 15	2.64	35.3	21.4	1.28	20.24	70.81

Brief discussions on the laboratory test results are given below.

A. Specific Gravity test as per IS: 2720, Part – III.

The specific gravity was found out for lateritic soil, fly ash and coir fiber mixtures in different proportion. The specific gravity of soil is 2.69and as per the variance analysis specific gravity is 2.702 which have the highest frequency of results.

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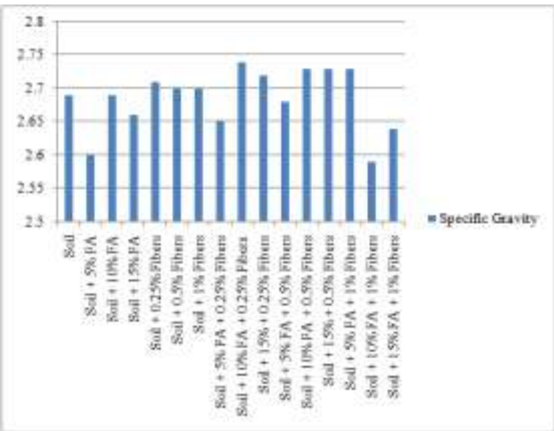

Fig.5.Results of Specific gravity test

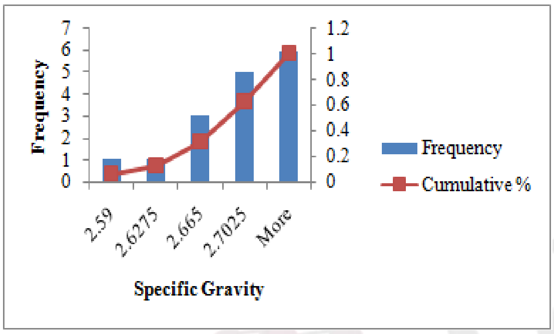

Fig. 6.Variance in Specific Gravity

B. Liquid Limit test as per IS: 2720, Part-V

The liquid limit with different percentages of fly ash and coir fiber has been plotted in fig.7.As per the variance analysis the value of liquid limit is 39.97% as shown in fig. 8.

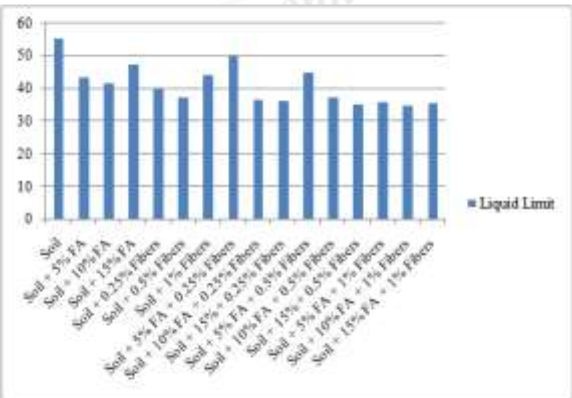

Fig. 7. Results of liquid limit test

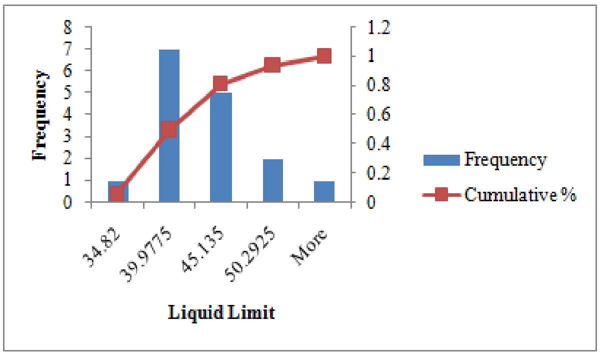

Fig. 8. Variance in liquid limit

C. Plastic Limit test as per IS: 2720, Part-V

The plastic limit has been plotted against different percentages of fly ash and coir fibers as in fig. 10. Fig.11. shows the percentage variance as 16.315% observed in the test result.

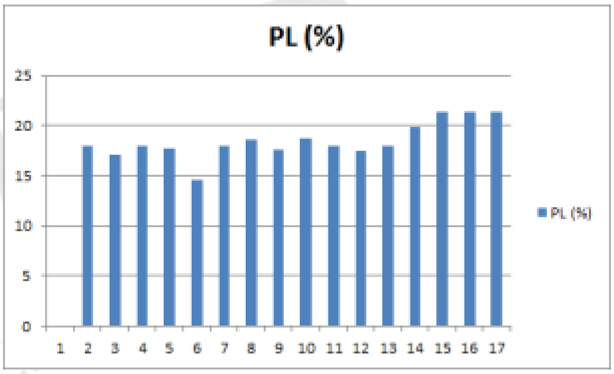

Fig. 9. Results of plastic limit test

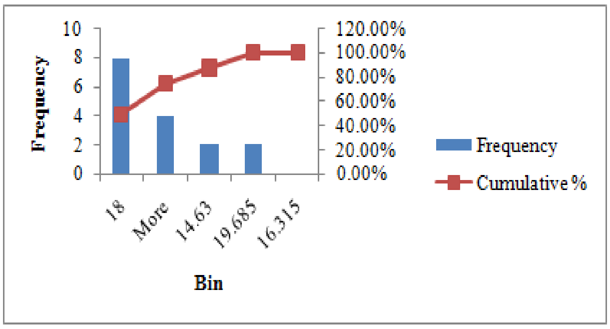

Fig. 10. Variance in Plastic Limit

C. Compaction Test (Modified Proctor) as per IS: 2720, Part-II.

The variation of MDD and OMC with the different percentages of fly ash and coir fiber combinations has been shown in fig 11, 12, 13. It is observed that the MDD value is constant for the varying percentages of fly ash and coir, whereas the OMC values decrease due to the addition of coir fibers.

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As per the variance analysis value of MDD is 1.25 g/cc and that for OMC is 21.98%.

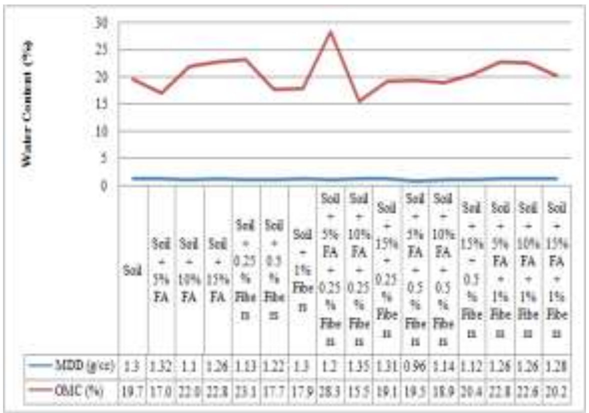

Fig. 11. MDD v/s OMC for Soil + % Fly ash + % Fibers

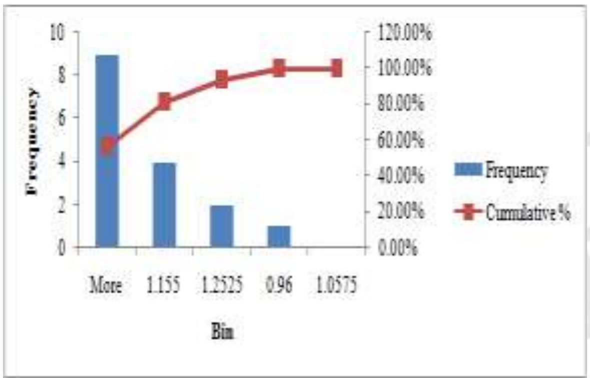

Fig. 12. Variance in MDD

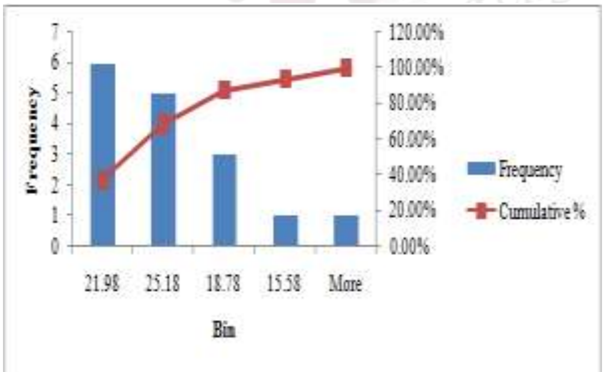

Fig. 13. Variance in OMC

D. Unconfined Compression Test as per IS: 2720, Part-X.

It is found in the experimentation that the value of unconfined compression test increases due addition of different percentages of fly ash and coir. As per variance the UCS value found is 2.39 kN/mm^2.

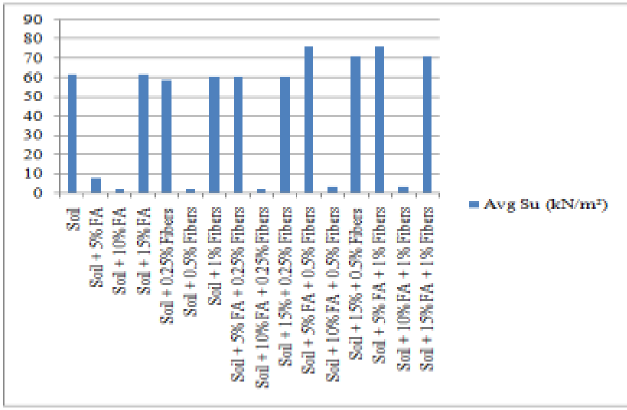

Fig. 14. Results of UCS test

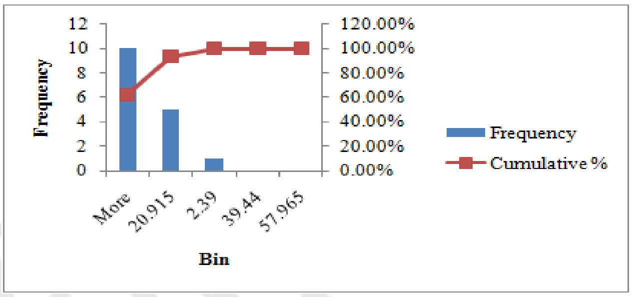

Fig.15. Variance in UCS test results

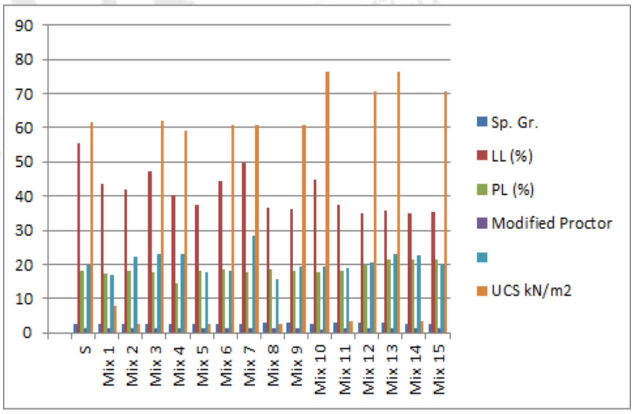

Fig.16. Various test results

VII. CONCLUSION

From the results of the study, the following conclusions are made in relation to the objectives of the study:-

- For the mix Soil + 5% FA + 0.5% Fibers the UCS value is maximum i.e., 76.49 kN/sq.m;
- The compaction characteristics of the soil has been improved due to the addition of fly as & coir fibers, as per the variance analysis value of MDD is 1.25 g/cc and

that for OMC is 21.98%.

- The plastic limit of the mix of soil has decreased to a greater extent.
- For the mix Soil + 5% FA + 0.5% Fibers, most of the tests give the optimum results.

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REFERENCES

[1] A.A. Bello, a. C. (2010). "Evaluation of Geotechnical Properties of Ilesha East Southwestern Nigeria's Lateritic Soil.". *The Pacific Journal of Science and Technology , 11* (2), 617-624.

[2] A.A.Bello. (2013), "Reliability assessmnet of reddish brown tropical soil as a liner material", *Geotech Geological Engineering , 31*, 35-45.

[3] A.Senol, C. (2013). "Effect of fly ash and different lengths of polypropylene fiber content on the soft soils". *International Journal of Civil Engineering, Geotechnique, Transaction B Geotechnical Engineering , 12* (2).

[4] Adunoye, G. (2014,). "Study of relationship between fines content and cohesion of soi"l. *British Journal of Applied Science and Technology. , 4* (4), 682 – 692.

[5] B.Pandey, K. A. (2013). "Soil Stabilization Using Pozzolanic Material and Jute Fibre.". *Proceedings of Indian Geotechnical Conference*, (pp. 1-8). Roorkee.

[6] D. Kumar, S. A. (2015). "Improvement in CBR Values of Soil Reinforced with Jute fiber". *International Journal of Engineering and Technical Research* , 290-293.

[7] *IS 2720 (1980) , "Methods of test for doils : part 3 determination of specific gravity."*. Bureau of Indian Standards (BIS), Govt. of India.

[8] *IS 2720 (1983),"Methods for determination of water content dry density relation using heavy compaction."*. Bureau of Indian Standards (BIS), Govt. of India.

[9] *IS 2720 (1985),"Methods for determination of liquid and plastic limit, part 5."*. Bureau of Indian Standards (BIS), Govt. of India.

[10] *IS 2720 (1985),"Methods for test for soils, part 4, grain size analysis."*. (1985). Bureau of Indian Standards (BIS), Govt. of India.

[11] *IS 2720 (1987) part 16,"Methods of test for soils, laboratory determinationof CBR."* . Bureau of Indian Standards (BIS), Govt. of India.

[12] *IS 2720 (1991), part 10,"Methods of tests for soils, laboratory determination of unconfined compressive strength."*. Bureau of Indian Standards (BIS), Govt. of India.

[13] Jaritngam, S. (2003). " Design concept of the soil improvement for road construction on soft clay",. *Proceedings of the Eastern Asia Society for Transportation Studies,, 4*, pp. 313-322.

[14] P.Suruso, L. W. (2013), "Palm fibers influence the compressive strength & CBR on soil-cement",*International Conference on Asian & Pacific Coasts (APAC 2013)*, (pp. 826-830), Bali, Indonesia.

[15] Pohl, C. (2013). "Determination of characteristic soil values and this influences the results of geotechnical verifications.". *Geotechnical Engineering Journal* , 51-56.

[16] S. Jaritngam, O. S. (2012), "An investigation of lateritic Soil Cement for Sustainable Pavements",*Indian Journal of Science and Technology* , 3603-3606.

[17] S. Jaritngam, W. &. (2013). "Development of strength model of lateritic soil-cement". *Engineering Journal , 17* (1), 69-77.

[18] S.Chakraborty, S. S. (2013). "Stabilization of cohesive soil of low strength by admixtures". *Proceedings of Indian Geotechnical Conference.*, (p. 22.24). Roorkee.

[19] S.J.Shah, P. S. (2010). "Development of spreadsheet for correlation of soil propeties ". *Indian Geotechnical Conference- 2010, GEOtrendz* (pp. 16-18). Mumbai: IGS Mumbai Chapter & IIT Bombay.

[20] S.M.Hejazi, M. M. (2012). "A simple review of soil reinforcement by using natural & synthetic fibers". *Construction & Building materials. , 30*, 100-116.

[21] S.Yashwant, B. S. (2015). "Experimental studies on laterite soil stabilized with cement and aggregate",. *International Journal of Research in Engineering and Technology , 4* (8), 187-192.

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