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AN INVESTIGATION ON THE EFFICIENCY OF LIME AND SILICA FUME TREATED MARINE CLAY AS SUBGRADE IN FLEXIBLE PAVEMENTS

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ABSTRACT: Marine clay is highly deformable soil in nature, available along the coastal corridor. Marine clays are highly deformable and possess moderate swelling behavior. Marine clays are moderate in expansive nature due to the presence of chlorite, illite, kaolinite. The natural water content of the marine clay is always greater than its liquid limit. The properties of marine clay differ significantly in moist and dry conditions. Due to the poor engineering characteristics of these marine clay soil deposits causes several problems in pavement design and has potential to destroy foundations of buildings. These problems are due to its soil moisture, reducing soil moisture is the best thing to reduce the damages that are caused due to marine clay. Marine clays are fully saturated, soft and sensitive which possess low density and low shear strength due to which they are consolidated over a period of time. The present study deals with the experimental work on the efficiency of Lime and Silica Fume treated Marine Clay as subgrade in flexible pavements.

Key words— Marine Clay, Silica Fume, Lime, OMC, MDD, CBR, Atterberg Limits, Grain Size distribution.

I. INTRODUCTION

Transportation play a vital role in the development of any country. In every country, transportation consumes large portion of budgets in case of maintenance and replacement of pavement. Methods for maintaining pavement and reducing cost of construction can help in maintaining better road networks which helps the transportation department. Modern pavements are expected to provide high level safety to the users. Pavements are designed according to the empirical approach which helps in selecting appropriate soil and pavement parameters. Variations in the thickness sub base can occur and are to be expected gradually over short distances depending on the geological conditions of the surface soil. Higher variations in sub grade soil characteristics may lead to poor performance of pavements which cost in higher maintenance estimates. To minimize these problems, some of the methods have been developed to minimize the variability in sub grade characteristics.

The soil formed in the ocean bed as well as located on shore can be classified as marine clay. The properties of saturated marine clay may vary considerably from moist soil to dry soil. Marine clay is microcrystalline in nature, it contains clay minerals like chlorite, illite, kaolinite and non-clay minerals like quartz and feldspar are present in marine soil. Marine clay imposes great problems in pavement design due to uncertainty associated with their performance. Marine clays tend to swell when wetted and may shrink when dried. These volume changes may create problems in structures that come in to their contact.

Several remedial measures like soil replacement, pre-wetting, moisture control, chemical stabilization have been done in various degrees of success. Unfortunately, the limitation of these techniques questioned their adaptability in all conditions. So, work is being done all over, to evolve more effective and practical treatment methods, to alleviate the problems caused to any structures laid on marine clay strata.

The comprehensive review of literature says that a considerable amount of work, related to strength characteristics, deformation characteristics and consolidation characteristics has been carried out worldwide almost for 50 years. From the various contributions, the investigation on marine clay conducted by S. Narasimha rao et al.,(1987,1996), Mathew et al., (1997), Investigation on chemical stabilizatin has been conducted by (Petry and Armstrong, 1989; Prasada Raju, 2001) revealed that electrolyted like potassium chloride, calcium chloride and ferric chloride may be effectively used in place of conventionally used lime because of their readiness to dissolve in water and supply adequate cations for cation exchange.

Babu T. Jose, A. Sridharan and Benny Mathews Abraham (1988) reported the engineering properties of Cochin marine clays and concluded that These marine clays are characterized by high Atterberg limits and natural water contents. They are moderately sensitive with liquidity indices ranging over 0.46 to 0.87. The grain size distribution shows almost equal fractions of clay and silt size with sand content varying around 20%. The pore water has low salinity which results in marginal changes in properties on washing. Consolidation test results showed a preconsolidation pressure of up to about 0.5 kg/cm with high compression indices. These clays have very low undrained shear strength.

Aswani kumar and Mehata (1998) reported by the laboratory investigation that the stabilize granulated blast furnace slag is used in road construction and concluded that the load carrying capacity has been improved on addition of fly ash when lime and cement has been used as admixture.

Narasimha Rao et al., (1996) stated that the permeability (k) values shows an enormous improvement by using lime column technique and the permeability value was improved up to 23times. This shows good promise for improving the soft coastal deposits and the offshore deposits.

Phani Kumar and Radhey Sharma (2004) reported that fly ash can be used as additive in improving the engineering characteristics of soils. They observed that there is decrease in plasticity and hydraulic conductivity and increase in penetration resistance of blends with increase in Fly ash content. Basak and Purkayastha (2009), reported that the engineering characteristics of marine clay collected from visakhapatnam, India and the physical, chemical and mineralogical properties were presented and the strength, stiffness of the soil matrix were established. e. Improving the strength of soil by stabilization technique was performed by Rajasekhar.G and Narasimha Rao.S (2000) and Supakji N, Sanupong B et.al (2004), Dr. D. Koteswara Rao (2011, 2012) and further, made suitable for construction of foundations over it and also for the flexible pavement sub grades.

Dr. D. Koteswara Rao (2011) studied the efficiency of calcium chloride, potassium chloride, GBFS with marine clay and the test results concluded that load carrying capacity of marine clay foundation bed has been improved. Dr. D. Koteswara Rao (2012) studied the efficiency of lime and rise husk ash treated marine clay and the test results concluded that the ultimate load carrying capacity of the treated marine clay model flexible pavement has been compared with untreated marine clay model flexible pavement.

II. OBJECTIVES OF THE STUDY

The objectives of the present experimental study are

- To determine the properties of the Marine clay.
- To evaluate the performance of Marine clay the when treated with Silica Fume as an admixture and lime as an additive.
- To study the performance of un-treated and treated marine clay sub grade flexible pavements under cyclic pressures.

III. MATERIALS USED

Marine Clay

The Marine clay used in this study is obtained at a depth of 0.5m to 1m in Kakinada Sea Ports Limited, Kakinada which is located on east coast of India at a latitude of 160 56' North and longitude of 820 15' East.

Silica Fume

The Silica Fume used in this study is collected from GRR ASSOCIATES, Visakhapatnam, Andhra Pradesh.

Table 3.1 Physical Properties of Silica Fume Courtesy to GRR Associates, Vizag

PROPERTY	VALUE
Particle size(typical)	<1m
Bulk density As Produced Slurry Densified	 130-430kg/m3 1320-1440kg/m3 480-720kg/m3
Specific Gravity	2.5
Surface Area	13,000-30,000m2/kg

Table 3.2 Chemical Composition of Silica Fume Courtesy to GRR Associates, Vizag

Lime

The lime is used in this study is a high-quality hydrated lime mainly consisting of 59.67% of Cao and 8.4% Silica was used in the study. The quantity of lime was varied from 6% to 10% by dry weight of soil.

Constituents	Composition (%)
SiO_2	93.68
K_2O	0.27
Na2O	0.36
Fe_2O_3	0.88
MOISTURE	0.79
+45 MICRON	2.42
Al_2O_3	0.70

IV. LABORATORY TEST RESULTS

PROPERTIES OF MARINE CLAY (MC)

Visual characteristics of soil

The following properties were observed from visual classification in dry condition.

Colour -- Black in colour
Odour -- Odour of decaying vegetation
Texture -- Fine grained

Table 4.1 Properties of Marine clay

S.No	Property	Symbol	MC Value
1	Gravel (%)		0
2	Sand (%)		6
3	Fines (%)	Silt	27.4
		Clay	66.5
4	Liquid Limit (%)	WL	73
5	Plastic Limit (%)	WP	40.65
6	Plasticity Index (%)	IP	32.35
7	Soil Classification	----	CH
8	Specific Gravity	G	2.63
9	Free Swell (%)	FS	120
10	Optimum Moisture Content (%)	O.M.C	34.81
11	Maximum Dry Density (g/cc)	M.D. D	1.398
12	CBR (%)	----	0.827

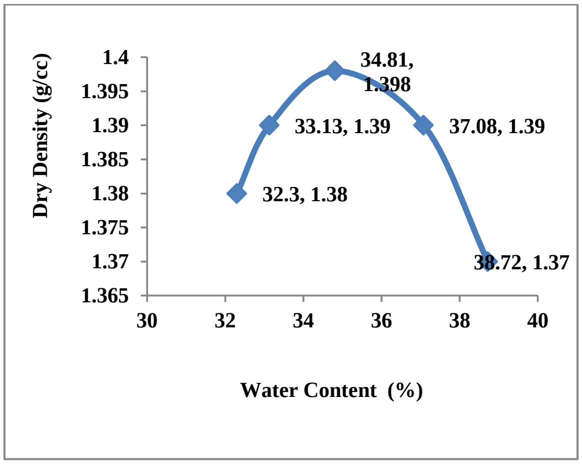

Fig 4.1 Compaction curve of Untreated Marine clay

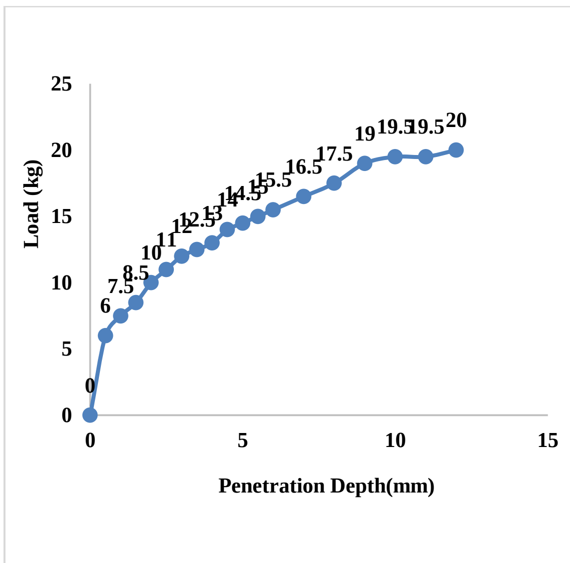

Fig 4.2 CBR curve for Untreated Marine Clay

Table 4.2 OMC and MDD values of % variation with Silica Fume

S.No	MIX PROPORTIN	WATER CONTENT (%)	DRY DENSITY (g/cc)
1	100%SOIL	34.81	1.398
2	84%SOIL+ 16% SILICA FUME	29.5	1.426
3	83% SOIL+ 17% SILICA FUME	33.3	1.437
4	82% SOIL+ 18% SILICA FUME	30.3	1.453
5	81% SOIL+ 19% SILICA FUME	30.1	1.432
6	80% SOIL+ 20% SILICA FUME	28.3	1.426

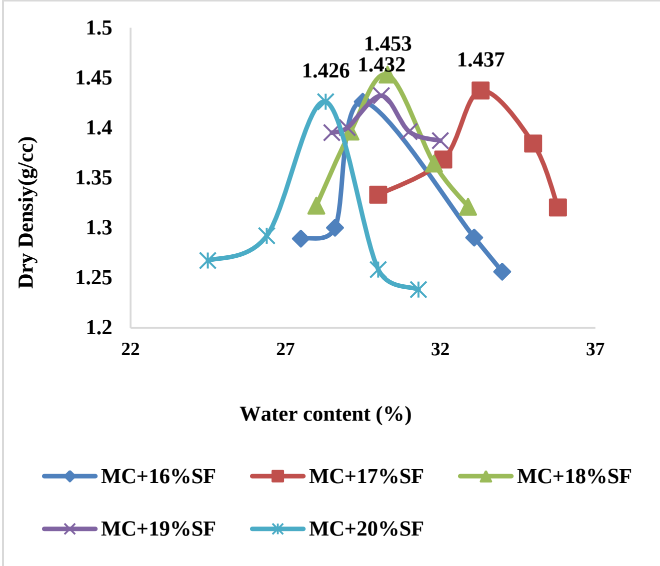

Fig 4.3 OMC and MDD Values of Marine Clay Treated with various % of Silica Fume

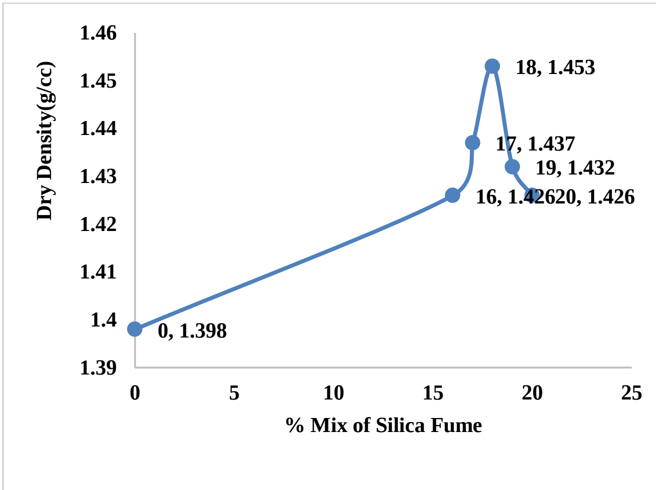

Fig 4.4 Curve showing variation of MDD with % variation of Silica Fume

Table 4.3: Variation of soaked CBR values with Silica Fume (%)

S.No	MIX PROPORTION	SOAKED CBR (%)
1	100% SOIL	0.827
2	84% SOIL+16% SILICA FUME	3.72
3	83% SOIL+17% SILICA FUME	4.23
4	82% SOIL+18% SILICA FUME	4.81
5	81% SOIL+19% SILICA FUME	4.67
6	80% SOIL+20% SILICA FUME	4.01

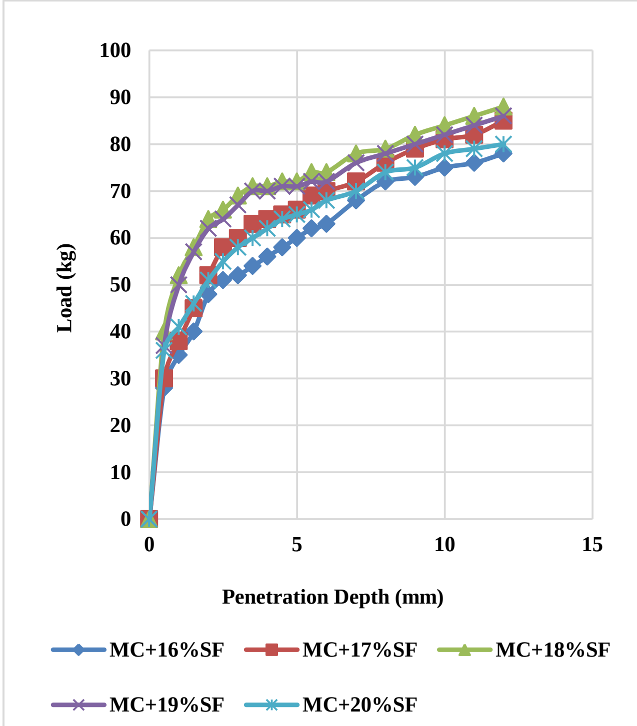

Fig 4.5 CBR Values of Marine Clay Treated with various % of Silica Fume

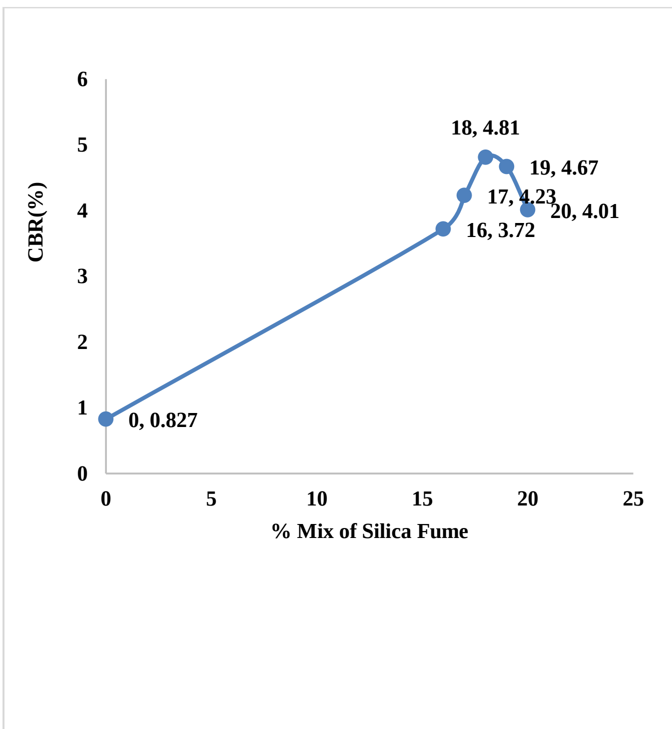

Fig 4.6 Curve showing Variation of CBR with %variation of Silica Fume

Discussion-1

As per IRC 37-2012 the sub grade soil should possess the minimum CBR value of 8%. In the present study silica fume treated marine clay has exhibited the CBR value of 4.81% which is les as per codes of practice. To achieve required CBR value as per codes of practice, an attempt has been taken to improve the CBR of silica fume treated marine clay with the percentage variation of lime to suite it as sub grade for flexible pavements.

Table 4.4 Variation of OMC and M.D.D values of Lime (%) with Silica Fume Treated Marine Clay

S.No	MIX PROPORTION	WATER CONTENT (%)	DRY DENSITY (g/cc)
1	MC+18% SF + 6% LIME	31.6	1.443
2	MC+18% SF+ 7% LIME	30.2	1.484
3	MC+18% SF+ 8% LIME	32	1.513
4	MC+18% SF+ 9%LIME	31.8	1.493
5	MC+18% SF+ 10% LIME	31.3	1.482

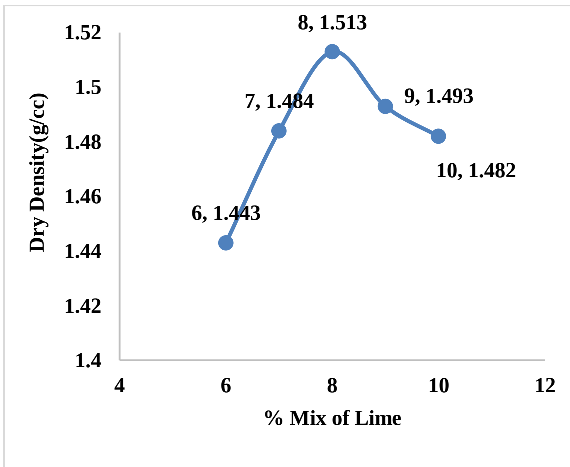

Fig 4.7 Curve showing MDD values with %variation of Lime

Table 4.4 Variation of CBR values of Lime(%) with Silica Fume Treated Marine Clay

S.No	MIX PROPORTION	SOAKED CBR (%)
1	MC+18% SF+ 6% LIME	8.00
2	MC+18% SF+ 7% LIME	8.64
3	MC+18% SF+ 8% LIME	9.39
4	MC+18% SF+ 9% LIME	8.79
5	MC+18% SF+ 10% LIME	8.27

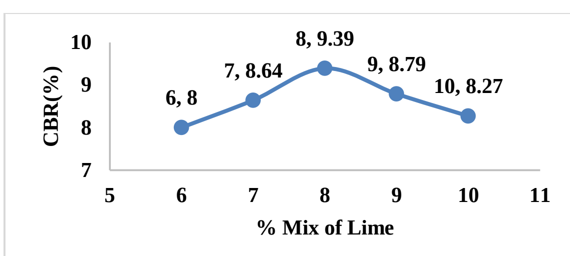

Fig 4.8 Curve showing CBR values with % variation of lime

Discussion-2

From the above study, 18% silica fume treated marine clay has exhibited the CBR value of 9.8% on addition of 8% lime as an optimum. Hence this treated marine clay is suitable as subgrade for flexible pavements as per IRC 37-2001, 2012 codes of practice.

Table 4.5 Properties of Treated and Untreated Marine Clay

S.No	PROPERTY	SYMBOL	MC	MC + 18% SF	MC + 18% SF + 8% LIME
1	Liquid Limit (%)	WL	73	66.69	42.8
2	Plastic Limit (%)	WP	40.65	41.4	24.25
3	Plasticity Index (%)	IP	32.35	24.99	18.55
4	Soil Classification	----	CH	CH	CH
5	Specific Gravity	G	2.63	2.72	2.75
6	Optimum Moisture Content (%)	O.M.C	34.81	30	32
7	Maximum Dry Density (g/cc)	M.D. D	1.398	1.453	1.513
8	CBR (%)	----	0.827	4.81	9.39

CONCLUSIONS

- It is noticed that the liquid limit of the marine clay has been decreased by 9.05% on addition of 18% Silica Fume and further silica fume treated marine clay has been decreased by 41.36% with an optimum of 8% lime addition.
- It is observed that the plasticity index of the marine clay has been improved by 21.42% on addition of 18% Silica Fume and further silica fume treated marine clay has been improved by 42.65% with the addition of 8% lime as an optimum.
- It is found that the Maximum Dry Density of the marine clay has been improved by 3.93% on addition of 18% Silica Fume and further silica fume treated marine clay has been improved by 8.22% when 8% lime is added.
- It is observed that the C.B.R. value of the marine clay has been increased by 482.62% on addition of 18% Silica Fume as an optimum and further it has been improved by 1035.42% when 8% lime is added.

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