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RESEARCH ARTICLE

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A LABORATORY STUDY ON THE INFLUENCE OF LIME ON SAW DUST TREATED ON MARINE CLAY SUBGRADE FLEXIBLE PAVEMENTS UNDER CYCLIC PRESSURES

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ABSTRACT

India has large coastline exceeding 7,517kms. In view of the developments on the coastal area in the recent past, large number of ports and industries are being built. The fine clay deposits that are present along the coastal corridor are fully saturated, low density, low shear strength deformation problems and are subject to consolidation over a period of time. These soils are termed as marine clays. Fine grained soils are very sensitive and change the stress systems, moisture contents and system chemistry of pore fluid. These weak marine deposits pose great damage to the civil engineering applications. The soil is hard as long as it is dry, but losses its stability completely on wetting. Generally, the natural water content of the marine clay is always greater than its liquid limit. Majority of the pavement failures could be attributed to the presence of poor sub grade conditions and expansive sub grade is one such problematic situation. Accumulation of waste materials has been one of the major problems in the world. Saw dust is one of the waste materials obtained from the by-product of wood and timber industries. Saw dust contains little cementitious properties which in the presence of moisture reacts chemically and forms cementitious properties and improve the characteristics of the soil. So in order to achieve both the need of improving the properties of marine clay to make it suitable for the subgrade of the flexible pavements, an experimental study has been taken up in the paper to study the effect of Saw dust and Lime on the marine clay for the improvement of the strength properties.

Keywords: - Marine Clay, Saw Dust, Lime (CaO), OMC, MDD, CBR.

1. INTRODUCTION

The rapid development strategies and the associated urbanization in certain parts of India has compelled engineers to construct earth structures such as embankments and major highways over marine clay deposits having low bearing capacities coupled with excessive settlement characteristics. Construction activities on marine clay deposits have proven to be a challenging task for engineers. The marine clay deposits are very soft and it possess very high natural moisture content. This clay soil is characterized by its low permeability and high compressibility.

These soils usually have low density and low shear strength and also highly compressible in nature. The properties of saturated marine soil differ significantly from moist soil and dry soil. Marine clay is microcrystalline in nature and clay minerals like chlorite, Kaolinite and illite and non-clay minerals like Quartz and feldspar are present in the soil. The soils have higher proportion of organic matters that acts as a cementing agent.

Marine clay in particular can impose great problems in pavement design due to uncertainity associated with their performance. They are often unstable beneath the pavement and are mostly susceptible to various problems with slight changes in moisture content. These soils are highly saturated, soft, sensitive and normally consolidated. These usually have low density, low shear strength and are expansive in nature. Marine clays tend to swell and become soft when wetted and may shrink and become stiff when dried.

Marine clays have the tendency to swell when they come in contact with moisture and to shrink if moisture is removed from them. These volume changes in swelling soils are the cause of many problems in structures that come into their contact or constructed out of them. The marine clays in India have liquid limit values ranging from 50-100%, plasticity index ranging from 20-65% and shrinkage limit from 9-14%.

A substantial literature has concluded this severity an extent of damage inflicted by soil deposits of swelling nature, to various structures, throughout the world (Ganapathy, Joneqs and Jones, Abduljauwad, Osama and Ahmed, Zhang). The loss caused due to damaged structures proved the need for more reliable investigation, of such soil and necessary methods to eliminate or reduce the effect of soil volume change.

Additives, including lime, fly ash, Portland cement, saw dust and more recently synthetics are available that will lessen these problems when mixed in the proper amounts with problem soils. These additives may be used separately or in combination and each has construction issues related to its performance.

2 OBJECTIVES OF THE PRESENT STUDY

The objectives of the present experimental study are

- To determine the properties of the Marine clay.
- To evaluate the performance of Marine clay when treated with Saw dust 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.

3. STABILIZATION OF MARINE CLAY

The main objective of stabilization is to improve the performance of a material by increasing its strength, stiffness and durability. The performance should be at least equal to, if not better than that of a good quality natural material.

The term 'stabilization' is the process whereby the natural strength and durability of a soil or granular material is increased by the addition of a stabilizing agent. In addition, it may provide a greater resistance to the ingress of water. There are many types of stabilizer that can be used, each with their own advantages and disadvantages.

The type and quantity of stabilizer added depends mainly on the strength and performance that needs to be achieved. The strength of a stabilized material will depend on many factors. These include:

- The chemical composition of the material to be stabilized:
- The stabilizer content;
- The degree of compaction achieved;
- The moisture content;
- The success of mixing the material with the stabilizer;
- Subsequent external environmental effects.

Cation exchange capacity (C.E.C.) has major significance in determining clay mineral properties, particularly the facility with which they absorb water. Cation exchange capacity (C.E.C.) measures two of the fundamental properties of clays:

1. The surface area and the charge on this surface area.
2. There are two methods for the determination for charge on the clay i.e external and internal.

The function of number of cations measured on the clay surface once it is washed free of exchange salt solution is known as internal exchange capacity. The operation is performed by immersing a quantity of clay in an aqueous solution containing a salt, usually chloride or ammonium hydroxide. The soluble ions adsorbed with the water onto the interlayer structure can affect the adsorbed water arrangement in several ways. Principally, they act as a bond of varying strength holding the structural layer together and controlling the thickness of adsorbed water. Their effectiveness will depend on the size and charge. Thus Na+, K+ will tend to be weak and a clay-water system containing these ions will be capable of adsorbing large amounts of water. Ca2+, Mg2+, on the other hand, will have stronger links and a clay-water system containing them will possess substantially lower water content.

4. SAW DUST

Wood cutting factories, generates a by-product known as Saw dust. This surrounds the Forestry area. During cutting of trees about78% of weight is received from trees. Rest 22% of the weight of trees is received as dust. This dust is used as fuel in burning of bricks & generates steam for the parboiling process.

As transportation system expand, they are more likely to be supported by less desirable foundation soils, such as highly compressible deposits. The mass of the earthwork for such systems can cause unacceptable long –term settlement or even shear failure of these deposits. Ground improvement techniques may not be effective in stabilizing such soils. Although not a composite, geo-foam provides a very lightweight manufactured fill for embankments on such materials. The development of light weight fill has led to engineering of fills. Consisting of soil-like particulate materials that are lighter than soil, not prohibitively expensive and environmentally safe. Saw dust and Lime are excellent examples of such materials.

Figure 1: Saw Dust

Table 1:Physical Properties of Saw dust

S.No	Property	Value
1	Particle size(typical)	
	4.75	100
	2	96
	0.6	80
	0.425	50
	0.21	29
	0.075	8
2	Specific Gravity	2.01

Table 2: Chemical Composition of Saw dust

S.No	Constituent	Composition(%)
1	SiO_2	86
2	Al_2O_3	2.6
3	Fe_2O_3	1.8
4	CaO	3.6
5	MgO	0.27
6	Loss on Ignition	4.2

4. LIME

Commercial grade lime mainly consisting of 58.67% of Cao and 7.4% Silica was used in the study. The quantity of lime was varied from 6% to 10% by dry weight of soil. Lime chemically known as Calcium oxide(Cao),commonly known as quicklime or burnt lime, is widely used chemical compound. It is a white ,caustic, alkaline crystal solid at room temperature shown

Figure 2: Lime powder

PROPERTIES OF LIME

- Lime is white amorphous solid.

- It has a high melting point of 2600 centigrade.
- It is highly stable and even fusion cannot decompose it.

CHEMICAL PROPERTIES OF LIME

On hydration, quicklime forms slaked lime or lime water. When water is added to lime it becomes hot and cracks to form a white powder. This is called slaking of lime.

$$Cao+H_2O \rightarrow Ca\ (OH)_2$$

Calcium oxide is basic oxide. It can react with acids to give calcium salts

$$Cao+ H_2SO_4 \rightarrow CaSO_4+H_2O$$

With acidic oxides like silicon dioxide and phosphorous pent oxide, it forms silicates and phosphates. This property makes lime useful as flux in metallurgy to remove impurities.

$$Cao+SiO_2 \rightarrow CaSiO_3$$

$$3Cao+P_2O_5 \rightarrow Ca_3(PO_4)_2$$

5. MARINE CLAY

TABLE 3: PHYSICAL PROPERTIES OF MARINE CLAY

Sl. No	Property	Symbol	Untreated Marine Clay
1	Liquid Limit (%)	WL	73
2	Plastic Limit (%)	WP	40.65
3	Plasticity Index (%)	IP	32.35
4	Soil classification	--------	CH
5	Specific Gravity	G	2.63
6	Free Swell (%)	FS	120
7	Optimum Moisture Content (%)	OMC	34.81
8	Maximum Dry Density(g/cc)	MDD	1.398
9	Cohesion(kN/m^2)	C	112
10	Angle of Internal Friction(o)	Ø	2.3
11	CBR (%)		0.827
12	Natural Moisture Content (%)	-----------	83.3

Fig 3 : Marine soil in the field

6. LABORATORY STUDIES

The laboratory studies were carried out on the samples of Marine clay, Marine clay+ Saw Dust, Marine clay+ Saw Dust and Lime mixes.

Liquid limit Liquid limit test was conducted on Marine clay, Marine clay+18% Saw Dust, Marine clay+18% Saw Dust + 8% lime using Casagrande's liquid limit apparatus as per the procedures laid down in IS: 2720 part 4 (1970). **Plastic limit** Plastic limit test was conducted on Marine Clay, Marine Clay+18% Saw Dust, Marine clay+18% Saw Dust+ 8%lime as per the specifications laid down in IS: 2720 part 4 (1970).

Shrinkage limit This test is also conducted on to Marine Clay, Marine Clay+18% Saw Dust, Marine clay+18% Saw Dust+ 8% lime as per IS: 2720 part 4 (1972).

Free swell index

This test is conducted by taking 10 gm of dry soil, 10 gm of (soil+ Saw Dust) passing through 425 micron sieve, in two different 100 cc glass jar filled with distilled water. The swell index of Marine Clay, Marine Clay- Saw Dust, Marine clay, Saw Dust and lime mixes are recorded as per IS 2720 part 40 (1985).

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$$\text{Free swell (\%)} = \frac{\text{Final volume} - \text{Initial volume}}{\text{Initial volume}} \times 100$$

Proctor's standard compaction Test Preparation of soil sample for proctor's compaction test was done as per IS: 2720 part-6 (1974).

California bearing ratio Test The California bearing ratio tests are conducted on Marine Clay, Marine Clay+ Saw Dust, Marine clay, Saw Dust, lime mixtures as per IS 2720 part 16 (1979). A constant strain rate of 1.25mm/min is applied on the soil sample. For every 50 divisions proving ring reading is noted and is continued until 3 or more readings are decreasing or constant. The samples are tested under soaked conditions.

CBR(%)=

$$\frac{\textit{Load carried by soil sample at defined penetration level}}{\textit{Load carried by standard crushed stones at the same penetration level}} X100$$

Differential Free Swell Test Differential Free Swell (DFS) is a parameter used for the identification of the expansive soil. For the determination of the differential free swell of a soil, 20g of dry soil passing through a 425µ size sieve is taken. One sample of 10g is poured into a 100c.c capacity graduated cylinder containing water, and the other sample of 10g is poured into a 100c.c capacity graduated cylinder containing kerosene oil.

Both the cylinders are kept undisturbed in a laboratory. After 24 hours, the settled volumes of both the samples are measured.

DFS=

$$\frac{\text{Settled soil volume in water} - \text{Settled soil volume in kerosene}}{\textit{Settled soil volume in Kerosene}} X\ 100$$

S. No.	Degree of expansion	DFS
1	Low	< 20%
2	Moderate	20 - 35%
3	High	35 – 50%
4	Very High	>50%

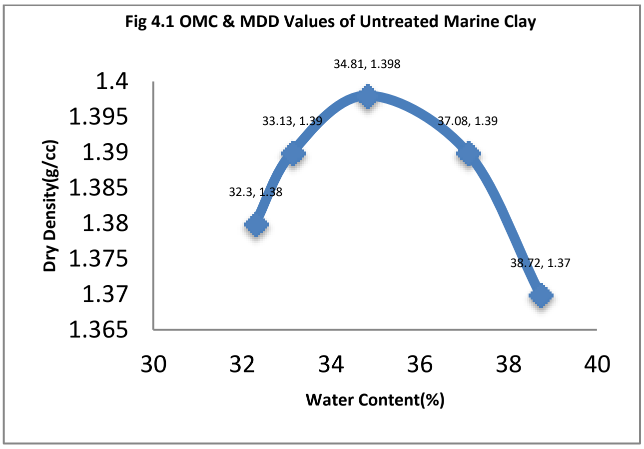
7. TEST RESULTS AND DISCUSSIONS

CBR TEST AND PROCTOR COMPACTION TEST RESULTS FOR MARINE CLAY AND SAW DUST

COMPACTION TEST RESULTS

A) UNTREATED MARINE CLAY

From the heavy weight compaction the OMC and MDD values obtained for soil treated with 16%, 17%, 18%, 19% and 20% of saw dust are as follows

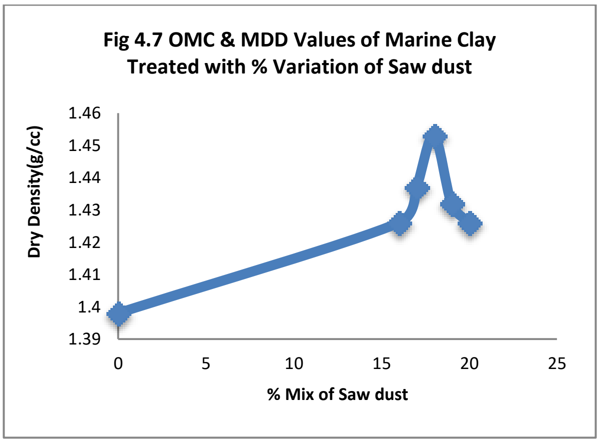


Optimum Moisture Content=34.81 %

Maximum Dry Density=1.398 g/cc

Table 4: OMC and MDD of Untreated Marine Clay and Marine Clay treated with percentage Variation of Saw dust

Mix Proportion	Water content (%)	Dry Density(g/cc)
100% soil	34.81	1.398
84% soil + 16% SD	29.5	1.426
83% soil + 17% SD	33.3	1.437
82% soil + 18% SD	30.3	1.453
81% soil + 19% SD	30.1	1.432
80% soil + 20% SD	25.3	1.426



B) CBR TEST RESULTS FOR MARINE CLAY AND % OF SAW DUST

From the CBR test results the CBR values in both unsoaked and soaked condition are tabulated below. The performance of a subgrade can be ultimately evaluated from the CBR test results for the soil stabilized with different percentages of saw dust.

Fig 4: Author conducting CBR test

1) CBR CURVE FOR UNTREATED MARINE CLAY

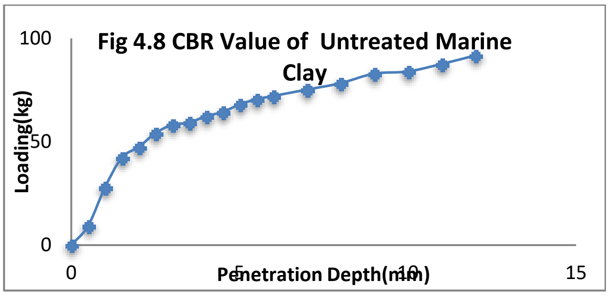


Fig 4.8 CBR Value of Untreated Marine Clay

CBR Value = 0.827%

2) CBR CURVE FOR 84% MARINE CLAY + 16% SAW DUST

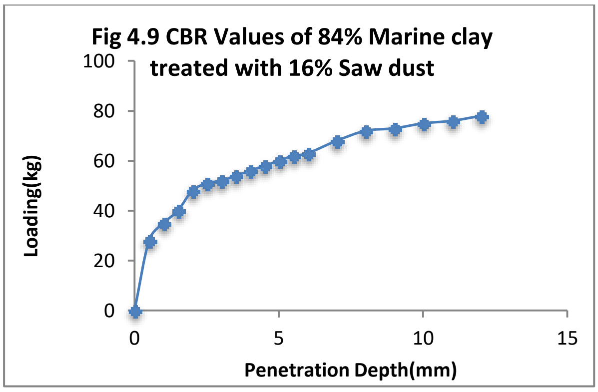


Fig 4.9 CBR Values of 84% Marine clay treated with 16% Saw dust

CBR Value = 3.72%

3) CBR CURVE FOR 83% MARINE CLAY + 17% SAW DUST

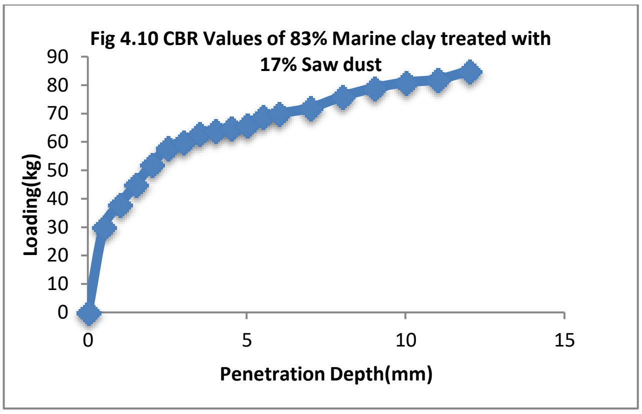


Fig 4.10 CBR Values of 83% Marine clay treated with 17% Saw dust

CBR Value = 4.23%

4) CBR CURVE FOR 82% MARINE CLAY + 18% SAW DUST

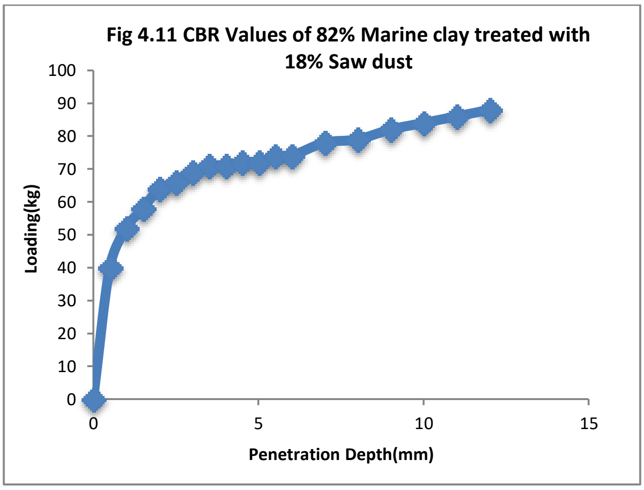


Fig 4.11 CBR Values of 82% Marine clay treated with 18% Saw dust

CBR Value = 4.81%

5) CBR CURVE FOR 81% MARINE CLAY + 19% SAW DUST

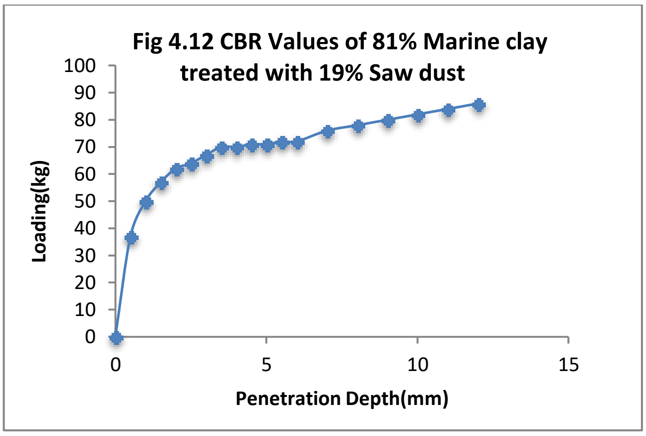
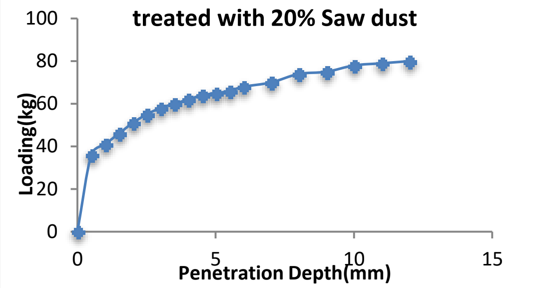


Fig 4.12 CBR Values of 81% Marine clay treated with 19% Saw dust

CBR Value = 4.67%

6) CBR CURVE FOR 80% MARINE CLAY + 20% SAW DUST



CBR Value = 4.01%

Table 5: CBR Values of Marine Clay treated with Percentage Variations of Saw dust

S.No	Mix Proportion	CBR (%)
1	Untreated Marine Clay	0.827
2	84% Marine Clay + 16% Saw dust	3.72
3	84% Marine Clay + 17% Saw dust	4.23
4	84% Marine Clay + 18% Saw dust	4.81
5	84% Marine Clay + 19% Saw dust	4.67
6	84% Marine Clay + 20% Saw dust	4.01

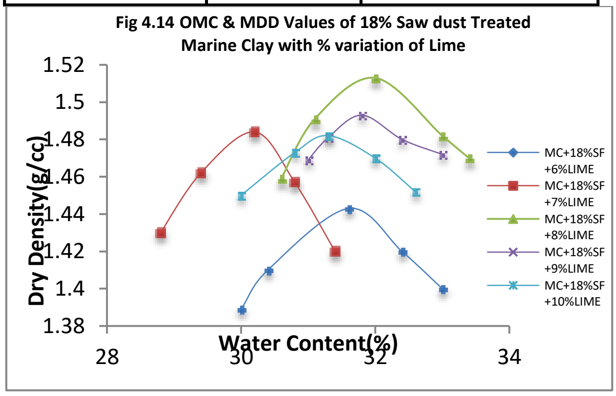
Table 6: Properties of Marine Clay treated with an optimum of 18% Saw dust

Sl.NO	Property	Symbol	Marine Clay	MC+18% Saw dust
1	Liquid Limit (%)	WL	73	66.39
2	Plastic Limit (%)	WP	40.65	41.4
3	Plasticity Index (%)	IP	32.35	24.99
4	Soil classification	--------	CH	CH
5	Specific Gravity	G	2.63	2.72
6	Optimum Moisture Content (%)	O.M.C	34.81	30
7	Maximum Dry Density(g/cc)	M.D.D	1.398	1.453
8	CBR (%)		0.827	4.81

A) MODIFIED PROCTOR COMPACTION AND CBR TEST RESULTS OF 18% SAW DUST TREATED MARINE CLAY WITH PERCENTAGE VARIATION OF LIME

Table 7: Optimum Moisture Content and Maximum Dry Density of 18% Saw dust Treated Marine Clay with Percentage Variation of Lime

Mix Proportion	Water content (%)	Dry Density(g/cc)
84% Soil + 18% SD + 6% LIME	31.6	1.443
84% Soil + 18% SD + 7% LIME	30.2	1.484
84% Soil + 18% SD + 8% LIME	32	1.513
84% Soil + 18% SD + 9% LIME	31.8	1.493
84% Soil + 18% SD + 10% LIME	31.3	1.482



A) CBR TEST RESULTS FOR MARINE CLAY, % OF SAW DUST & % OF LIME

1) CBR OF 18% SAW DUST TREATED MARINE CLAY WITH 6% LIME

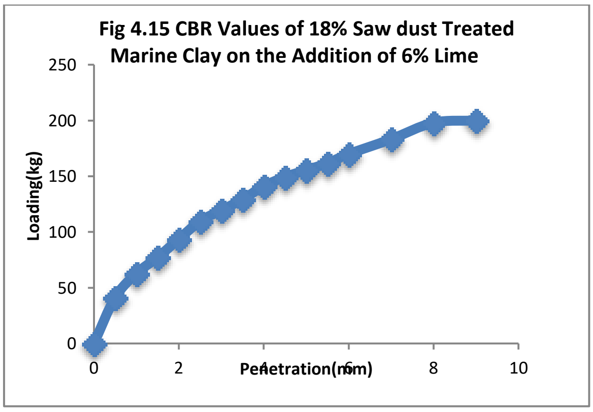


Fig 4.15 CBR Values of 18% Saw dust Treated Marine Clay on the Addition of 6% Lime

CBR Value = 8%

2) CBR OF 18% SAW DUST TREATED MARINE CLAY WITH 7% LIME

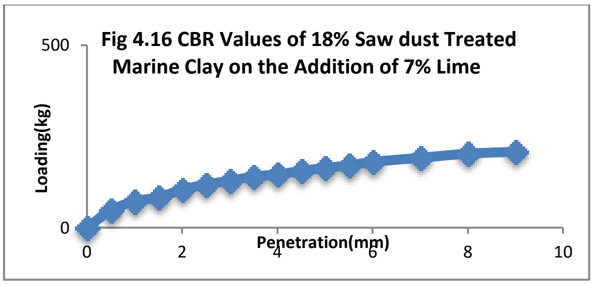


Fig 4.16 CBR Values of 18% Saw dust Treated Marine Clay on the Addition of 7% Lime

CBR Value = 8.64%

3) CBR OF 18% SAW DUST TREATED MARINE CLAY WITH 8%LIME

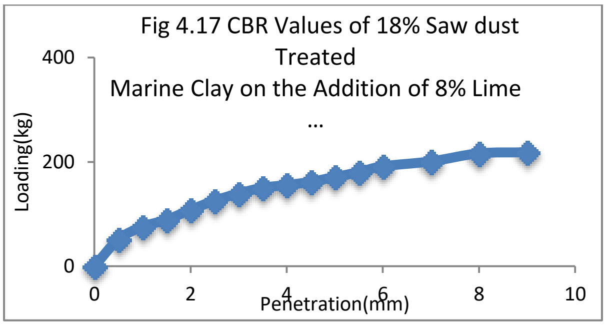


Fig 4.17 CBR Values of 18% Saw dust Treated Marine Clay on the Addition of 8% Lime

CBR Value = 9.39%

4) CBR OF 18% SAW DUST TREATED MARINE CLAY WITH 9% LIME

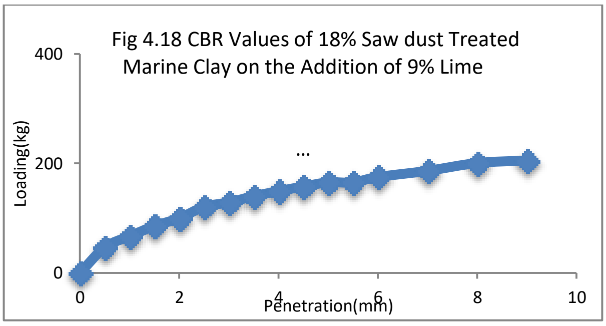


Fig 4.18 CBR Values of 18% Saw dust Treated Marine Clay on the Addition of 9% Lime

CBR Value = 8.79%

5) CBR OF 18% SAW DUST TREATED MARINE CLAY WITH 10% LIME

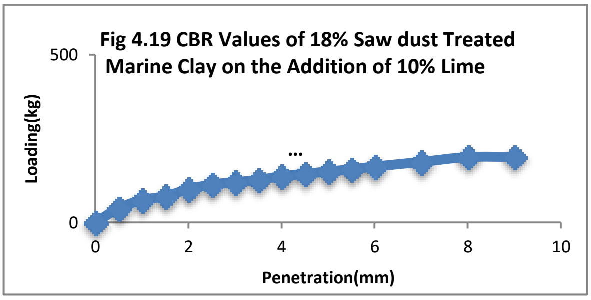


Fig 4.19 CBR Values of 18% Saw dust Treated Marine Clay on the Addition of 10% Lime

CBR Value = 8.27%

Table 8: CBR Values of 18% Saw dust Treated Marine Clay with various percentages of Lime

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

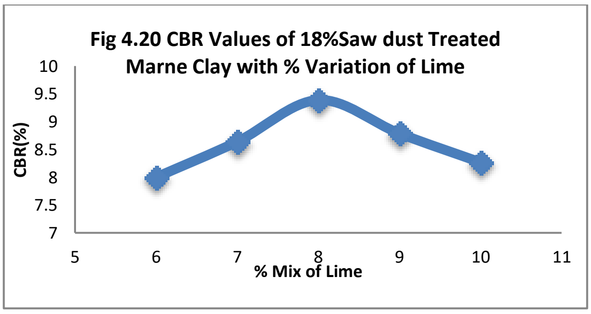


Fig 4.20 CBR Values of 18%Saw dust Treated Marne Clay with % Variation of Lime

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Vol.7., Issue.4, 2019
July-Aug

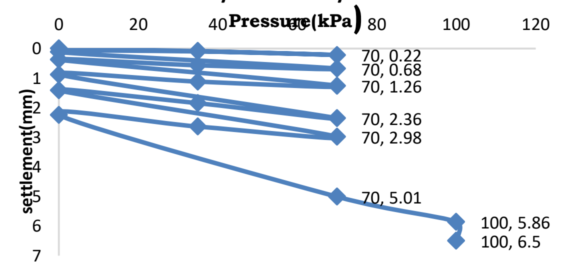
Table 9: Properties of Treated and Untreated Marine Clay

S.No	PROPERTY	SYMBOL	MARINE CLAY	Marine Clay + 18% Saw dust	Marine Clay + 18% Saw dust + 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

8) LABORATORY CYCLIC PLATE LOAD TESTS ON UNTREATED AND TREATED MARINE CALY USING MODEL TANKS FOR FLEXIBLE PAVEMENTS

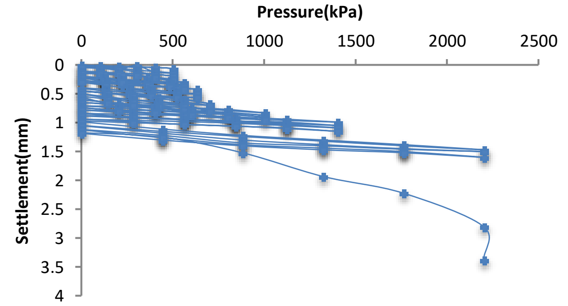
Cyclic plot load tests were carried out on untreated and treated Marine Clay for flexible pavements in separate model tanks under cyclic pressures 500kPa, 560kPa, 630kPa, 700kPa, 1000kpa, 1400kPa. The tests were conducted until the failure of the Expansive soil as model flexible pavements at OMC conditions.

Fig 4.22 Laboratory Cyclic Plot Load Test Results of only Marine Clay at OMC



Above graph shows the laboratory cyclic plot load test results of Marine Clay. The Marine clay alone has exhibited the ultimate cyclic load of 70kN/m2 with the deformation of 2.98mm at OMC.

Fig 4.26 Laboratory Cyclic Plot Load Test Results of 8% Lime + 18% Saw dust + Double Geotextile as reinforecement and seperator for treated Marine Clay flexible pavement at OMC



Above graph presents the laboratory cyclic plot load test results of (%8Lime +18% Saw dust + Double Geotextile as reinforcement and separator) treated Marine Clay flexible pavement. This treated Expansive Soil flexible pavement has exhibited the ultimate cyclic load of 2200kN/m2 with the deformation of 1.6mm at OMC.

Table 10: laboratory cyclic plate load test results of treated and untreated Marine Clay for flexible pavements at OMC.

S.No	Type of Subgrade	Sub-Base	Base course	Pressure (kPa)	Settlement (mm)
1	Marine Clay	-----	-----	70	2.98
2	Untreated marine clay	Gravel	WB M-III	620	2.5

3	Marine Clay+ 18% Saw dust + 8% Lime	Grav el	WB M-III	1000	2.3
4	Marine Clay + 18% Saw dust + 8% Lime + Single Geotextile as reinforce ment & separator provided between Sub grade and Sub-Base	Grav el	WB M-III	1400	2.1
5	Marine Clay+ 18% Saw dust + 8% Lime + Double Geo-textile as reinforce ment & separator provided between Sub Base and Base Course	Grav el	WB M-III	2200	1.6

9) CONCLUSIONS

The following conclusions were drawn based on the laboratory studies carried out on this study.

1) It is noticed from the laboratory test results that the liquid limit of the marine clay has been decreased by 9.05% on addition of 18% saw dust and further liquid limit of saw dust treated marine clay has been decreased by 41.36% with an optimum of 8% lime addition when compared with untreated marine clay.
2) It is observed from the laboratory test results that the plasticity index of the marine clay has been improved by 21.42% on addition of 18% saw dust and further plasticity index of saw dust treated marine clay has been improved by 42.65% with the addition of 8% lime as an optimum when compared with untreated marine clay.
3) It is found from the laboratory test results that the Maximum Dry Density of the marine clay has been improved by 3.93% on addition of 18% saw dust and further maximum dry density of saw dust treated marine clay has been improved by 8.22% when 8% lime is added with respect to untreated marine clay.
4) It is observed from the laboratory test results that the C.B.R. value of the marine clay has been improved by 482.62% on addition of 18% saw dust as an optimum and further C.B.R. value has been improved by 1035.42% when 8% lime is added with respect to untreated marine clay.
5) It is noticed from the laboratory test results of cyclic plot load test that the ultimate pressure of treated marine clay subgrade flexible pavement has been increased by 249.20% with respect to untreated marine clay subgrade flexible pavements.
6) It is noticed from the laboratory test results of cyclic plot load test that the total deformations of treated marine clay subgrade flexible pavement has been improved by 36% with respect to untreated marine clay subgrade flexible pavements.

REFERENCES

[1]. Agarwala, V.S and khanna, J.S (1969), Construction techniques for foundations of buildings on black cotton soils, Proceedings of the symposium on characteristics and construction techniques in black cotton soil, the college of military Engg., Poon, India.

[2]. Al Quadi, I.L(1994), Laboratory Evaluation of Geosynthetics Reinforced Pavement Sections, TRR-1739, TRb, 1994, pp-25-31.

[3]. Ali Jawaid S.M., Shukla. V.K (1996) "Stabilization of silty sand using RHA and

Gypsum" Indian Geotechinical conference, Madras.

[4]. Al-omarum R.R and oraibi, W.K (2000), Cyclic behaviour of reinforced expansive clay, Jr. of the japanese Geotechinical society of Soils and Foundations, Vol. 40, No. 2:2000, pp.1-8.

[5]. Al-Rawas, N.m (2000), Effect of curing and temperature on VWP stabilization, proc. of second Australian Conf. on Engineerig Materials, Sydney, 1981, pp.611-662.

[6]. Ambily, A.P and Gandhi, S.R (2004), Experimental and Theoritical Evaluation of Stone Column in Soft Clay, ICGGE, pp 39-46.

[7]. KoteswaraRao.D et al., (2011),Stabilization of expansive soil with rice husk ash,lime and gypsum-an experimental study, IJEST, Vol.3, No.11.Nov. 2011.

[8]. KoteswaraRao.D et al.,(2012),A laboratory study on the stabilization of marine clay using saw dust and lime, IJESAT,July 2012.

[9]. Prasad, D.S.V and Prasad raju, G.V.R (2008), Use of waste plastic and tyre in pavement systems, IE (I) journal – CV, Vol. 89, August2008.

[10]. Prasad, D.S.V and Prasad raju, G.V.R (2008), Utilization of Industrial waste in flexible pavement construction, EJGE, Vol.13, Bund D, pp1-12.