A STUDY ON THE INFLUENCE OF LIME ON FLYASH TREATED MARINE CLAY

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ABSTRACT

Different types of soils are available in our country, but some of them are not suitable for pavement design. Since India is a peninsular country, a vast area coming under coastal region. The soil which exists in these coastal regions is marine clay and is generally weak and highly compressible in nature. Since there is a great need for improving the transportation facilities in coastal regions, it is essential to improve the marine clay for the construction of pavements, because the successful performance of the pavement depends on the nature of subgrade soil. In the present study the geotechnical properties of marine clay i.e. OMC & MDD, CBR, Atterberg limits , DFS and strength characteristics were determined before and after treatment by using flyash and lime.

KEY WORDS*:* MDD, OMC, $Ca(OH)_2$, CBR, Strength characteristics

1.1 INTRODUCTION

The marine clay is available in fully saturated condition and the natural moisture content is always greater than its liquid limit. The review of literature shows that some research has been done for the determination of characteristics of the marine clay deposits worldwide. Marine clay deposits of Kakinada were used for this study with the aim to investigate its Geotechnical properties (Penner and Bum (1978); Tan(1983); Narasimha Rao and Swamy (1984); Shridharan et al.(1989); Chong (1991); Buddhima Indraratna et al.,(1991); Anandarajah and Chu (1997) ; Chong et al.,(1998); Thiam-Soon Tan et al.,(2002); Chu et al.,(2002); Supakij Nontananandh et al.,(2004); Oh and Chai (2006); Matchala Suneel et al.,(2008); Basak and Purkayastha (2009); Gang Ren (2010)) and further, made suitable for foundation constructions over it and also for the flexible pavement sub grades.

In this investigation, marine clay deposits of Kakinada were collected at a depth of 0.4m to 1.0m from the Kakinada Sea Ports Limited, Kakinada, AP, India.

1.2 OBJECTIVES OF THE STUDY

The objectives of the present experimental study

- To determine the properties of marine clay and fly ash

- To evaluate the performance of marine clay when treated with fly ash and its suitability as subgrade
- To evaluate the performance of treated marine clay with fly ash on the addition of lime and its suitability as subgrade for flexible pavements.

1.3 MATERIALS USED

Marine clay (M.C)

The soil used for the study was collected from Kakinada Sea Ports Limited, Kakinada. This soil was tested in the Geotechnical Engineering laboratory, Department of Civil Engineering, University College of Engineering; Kakinada to assess the properties of the soil based on the relevant IS codes of practice. The results were presented in table 1.

Fly Ash (F.A)

The Fly Ash used for this work was brought from Vizag Steel Plant, Vishakhapatnam and the properties were determined as per IS codes of practice and presented in table 2.

Lime (Ca $(OH)_2$)

Commercial grade lime mainly consisting of 58.67% CaO and 7.4% silica was used in the study. The quantity of lime was varied from 5% to 7% by dry weight of soil.

Table 1: Properties of marine clay

SL. No	Property		Symbol	Value
1	Gravel (%)		---	0
2	Sand (%)		---	14
3	Fines	Silt (%)	---	30
		Clay (%)	---	56
4	Liquid Limit (%)		W_L	74.5
5	Plastic Limit (%)		W_P	26.9
6	Plasticity Index		I_P	47.6
7	Shrinkage limit (%)		W_s	10.678
8	Soil Classification		---	CH
9	Specific Gravity		G	2.35
10	Differential Free Swell (%)		DFS	80
11	Optimum Moisture Content (%)		O.M.C.	35
12	Maximum Dry Density (gm / cc)		M.D.D.	1.27
13	Cohesion (t /m^2)		C	12 .20
14	Angle of Internal Friction (0^0)		ϕ	2
15	CBR Value (soaked) (%)		---	0.754
16	NMC (%)		---	86.15

Table 2: Properties of Flyash

Sl. no	Properties	Flyash
1	**Grain size distribution** **Gravel (%)** **Sand (%)** **Silt size (%)** **Clay size (%)**	 **…….** **25** **70** **05**
2	**Atterberg limits** **Liquid limit (%)** **Plastic limit (%)** **Plasticity index** **Shrinkage limit (%)**	**Non Plastic**
3	**Optimum moisture content (%)** **Maximum dry density (g/cc)**	**20.7** **1.35**
4	**Un-soaked CBR (%)** **Soaked CBR (%)**	**5.5** **3.15**
5	**Specific gravity**	**2.10**
6	**Free swell index**	**…..**
7	**Cohesion C (t/m^2)** **Angle of internal friction (0^0)**	**0.80** **31**
8	**Soil classification**	**ML**

1.4 LABORATORY EXPERIMENTATION

Index properties:

The atterberg limits of the treated and untreated marine clay were determined as per the code, IS 2720 (part V), 1970. It was observed that the liquid limit and the plasticity index of the treated marine clay have decreased when compared with the untreated marine clay as given in table 15.

Compaction properties of the treated marine clay with Flyash and lime

It was noticed from the laboratory test results that the marine clay has exhibited an increase in dry density and CBR values up to the addition of 20% fly ash and then with further addition of flyash, the dry density and the CBR values were decreased and the test results were presented in table 3 to 9 and Figures 1 to 4.

Table: 3 Moisture Content and Dry Density of Untreated Marine Clay

Sl. No	Water Content (%)	Dry Density (g/cc)
1.	29.78864	1.14112
2.	33.933	1.266483
3.	41.42937	1.226205
4.	46.36902	1.167528

Table: 4 Moisture Content and Dry Density of 85%M.C+15%Fly ash

Sl. No	Water Content (%)	Dry Density(g/cc)
1.	22.950	1.407
2.	27.252	1.429
3.	30.370	1.390
4.	32.512	1.368
5.	34.268	1.345

Table: 5 Moisture Content and Dry Density of 82%M.C+18%Fly ash

Sl. No	Water Content (%)	Dry Density(g/cc)
1.	21.848	1.39
2.	23.550	1.426
3.	27.755	1.479
4.	30.135	1.413

Table: 6 Moisture Content and Dry Density of 80%M.C+20%Fly ash

Sl. No	Water Content (%)	Dry Density(g/cc)
1.	23.691	1.426
2.	25.479	1.448
3.	29.938	1.486
4.	32.686	1.425
5.	35.652	1.406

Table: 7 Moisture Content and Dry Density of 78%M.C+18%Fly ash

Sl. No	Water Content (%)	Dry Density(g/cc)
1.	21.365	1.346
2.	24.862	1.368
3.	27.364	1.432
4.	29.637	1.382
5.	31.265	1.375

Table: 8 Moisture Content and Dry Density of 75%M.C+25%Fly ash

Sl. No	Water Content (%)	Dry Density(g/cc)
1.	22.785	1.323
2.	26.773	1.386
3.	28.425	1.355
4.	30.126	1.325

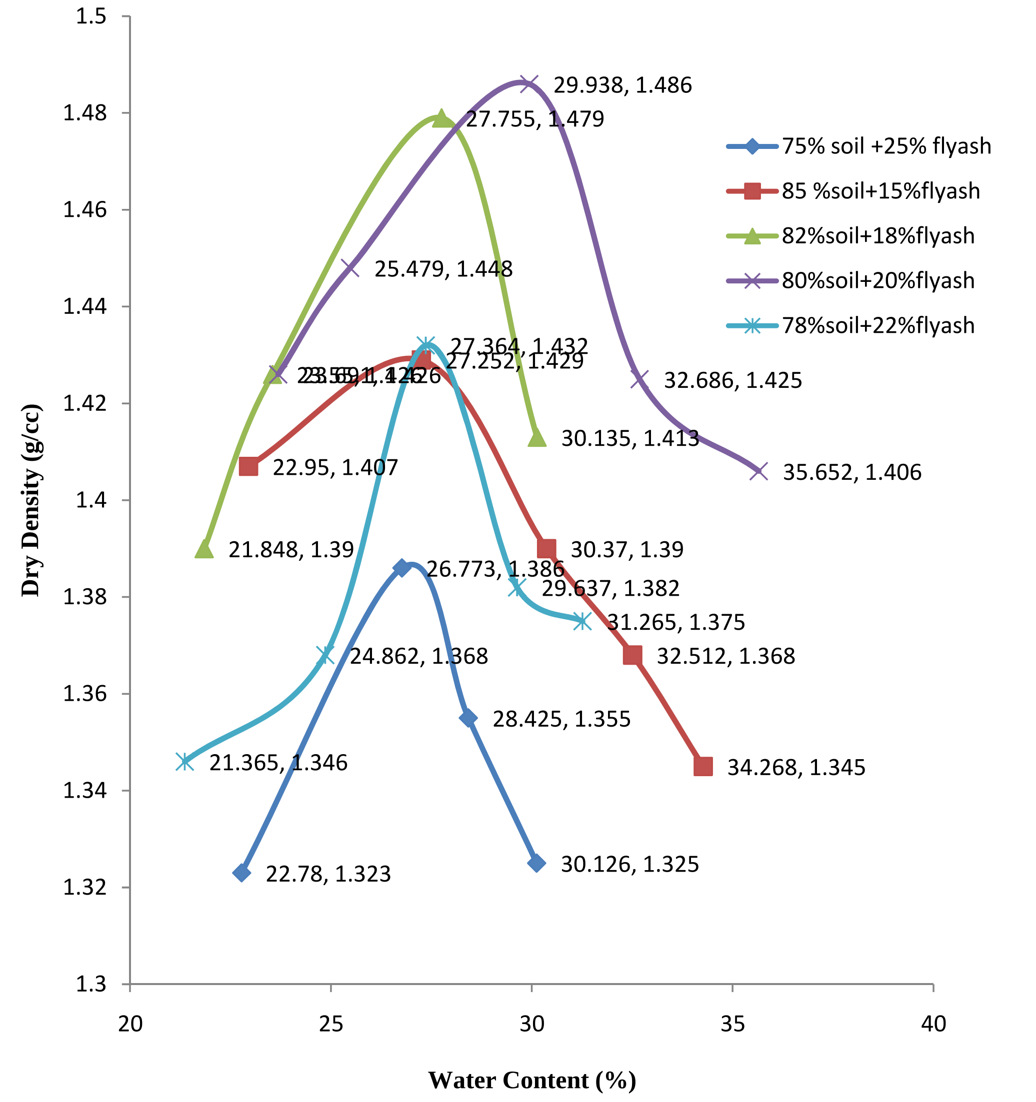


Fig1: Variation of OMC and MDD of Untreated Marine Clay with the addition of % Variation in flyash

Table 9: Variation of Dry Density and CBR Values of Marine Clay with % Variation in Flyash

Sl.No.	Mix proportion	Water Content (%)	Max Dry Density (g/cc)	Soaked CBR
1	100% soil	35	1.27	0.74
2	85%soil+15%FA	27.2	1.43	2.554
3	82%soil+18%FA	27.6	1.48	3.002
4	80%soil+20%FA	29.9	1.49	3.473
5	78%soil+22%FA	27.3	1.43	2.913
6	75%soil+25%FA	26.7	1.39	2.683

Fig: 2. Variation of Dry Density of Marine Clay with % Variation in Flyash

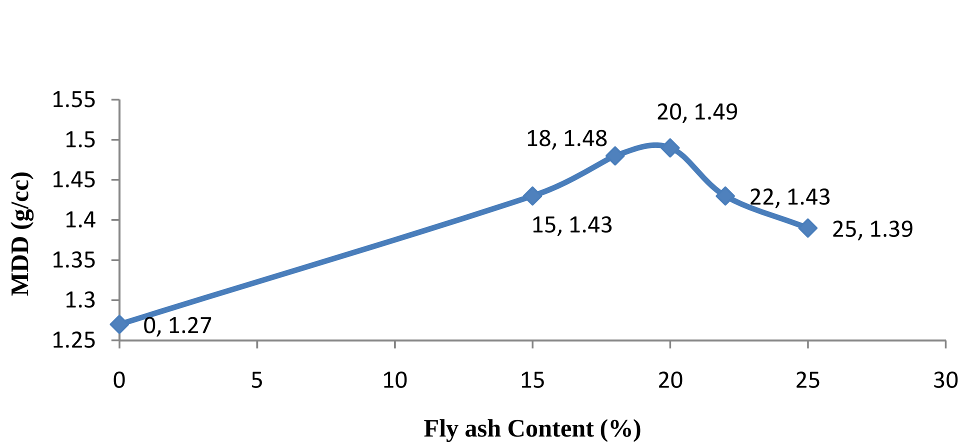


Fig: 3 CBR Plot of 80% M.C and 20%Fly ash

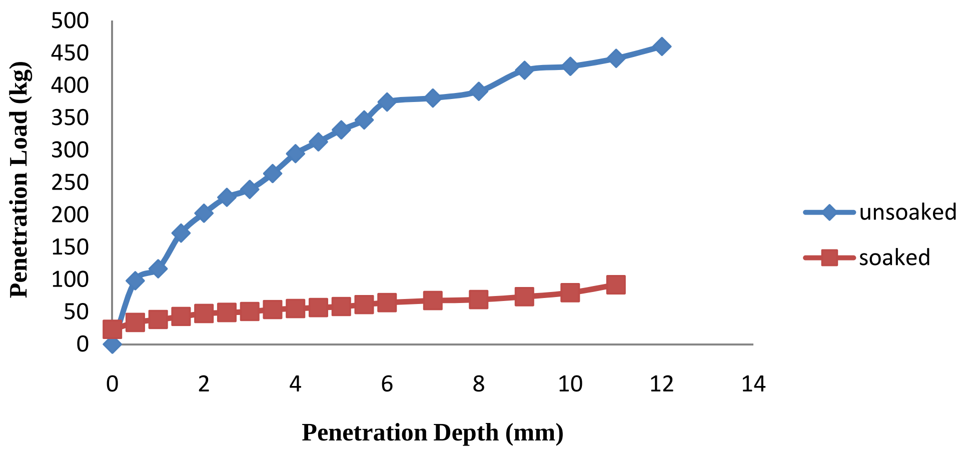
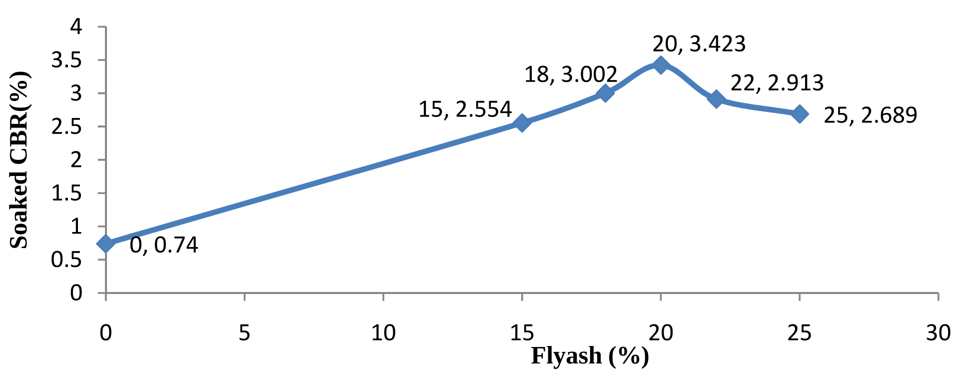


Fig: 4.Variation of Soaked CBR of Marine Clay with % Variation in Flyash



It was also observed that the dry density and CBR values of "80% M.C+ 20%Fly ash mix" has been increased up to the addition of 6.5 %lime and then the dry density and CBR values has been decreased with further increase in the percentage of lime content. The test results were presented in table 10 to 14 and Figures 5 to 8. The plate 1 shows that the authors were conducting the modified proctor compaction test in the laboratory.

Table: 10 Variation in Dry Density of 80% M.C + 20% F.A + 5% Lime on Variation in Water Content

Sl. NO	Water Content (%)	Dry Density(g/cc)
1.	18.56	1.346
2.	21.36	1. 394
3.	22.68	1.401
4.	23.65	1.386
5.	23.21	1.342

Table: 11 Variation in Dry Density of 80% M.C + 20% F.A + 6% Lime on Variation in Water Content

Sl. NO	**Water Content (%)**	**Dry Density(g/cc)**
1.	18.63	1.364
2.	20.05	1.396
3.	21.03	1.421
4.	22.98	1.395
5.	26.56	1.376

Table: 12 Variation in Dry Density of 80% M.C + 20% F.A + 6.5% Lime on Variation in Water Content

Sl. NO	Water Content (%)	Dry Density(g/cc)
1.	16.35	1.376
2.	19.36	1.403
3.	20.65	1.432
4.	23.56	1.412
5.	26.78	1.395

Table: 13 Variation in Dry Density of 80% M.C + 20% F.A + 7% Lime on Variation in Water Content

Sl. NO	Water Content (%)	Dry Density(g/cc)
1.	17.53	1.343
2.	19.64	1.387
3.	19.96	1.412
4.	21.36	1.382

Table: 14 Variations in MDD and CBR of 80% M.C + 20% F.A with % Variation in Lime

Sl.No.	**Proportion**	**Water content (%)**	**MDD gm/c.c**	**Soaked CBR (%)**
1	100% soil	35	1.27	0.754
2	80%soil+20%FA	29.9	1.49	3.473
3	Soil+20%fly ash+5%lime	22.68	1.401	4.48
4	Soil+20%fly ash+6%lime	21.03	1.421	4.92
5	Soil+20%fly ash+6.5%lime	20.695	1.432	6.48
6	Soil+20%fly ash+7%lime	19.96	1.412	5.82

Fig 5 . Variations in MDD and CBR of 80% M.C + 20% F.A with % Variation in Lime

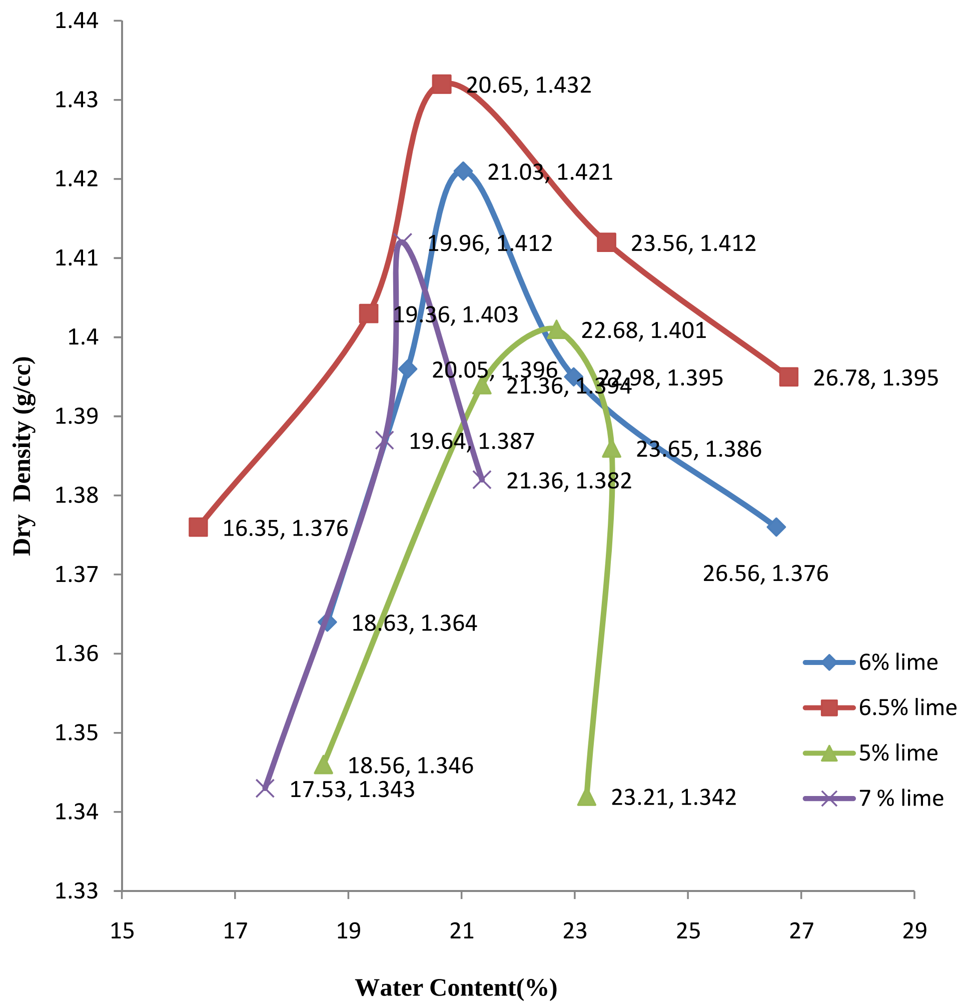
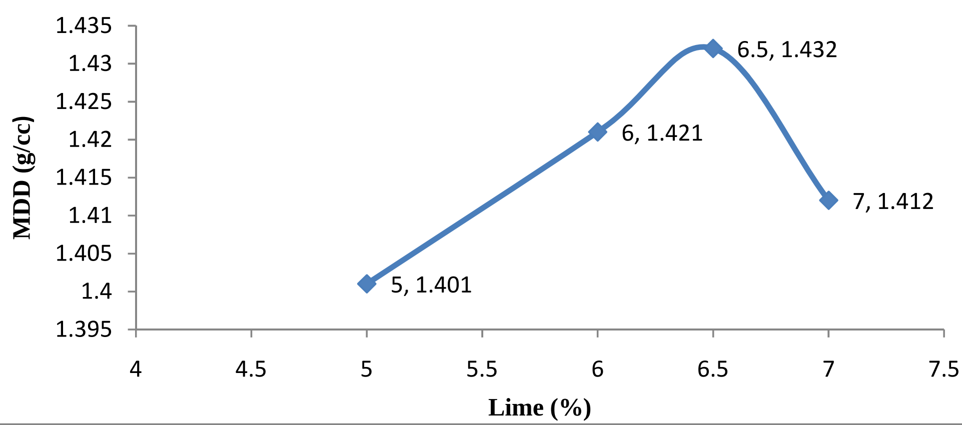


Fig 6.Variation in MDD of 80% M.C + 20%F.A with % Variation in Lime



Fi g 7. CBR Plot of 80% M.C + 20% F.A with addtion of 6.5%lime

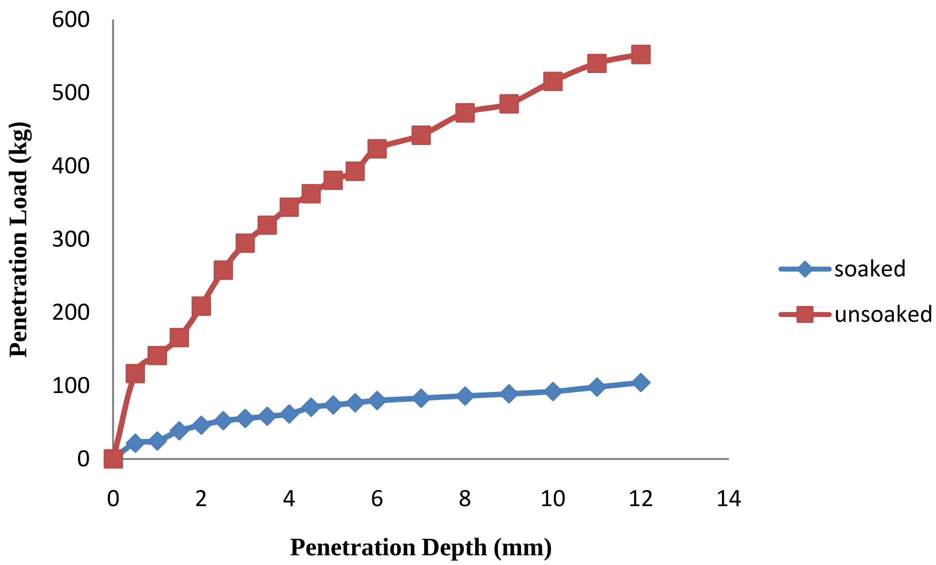


Fig: 8 Variation in Soaked CBR of 80% M.C + 20%F.A with % Variation in Lime

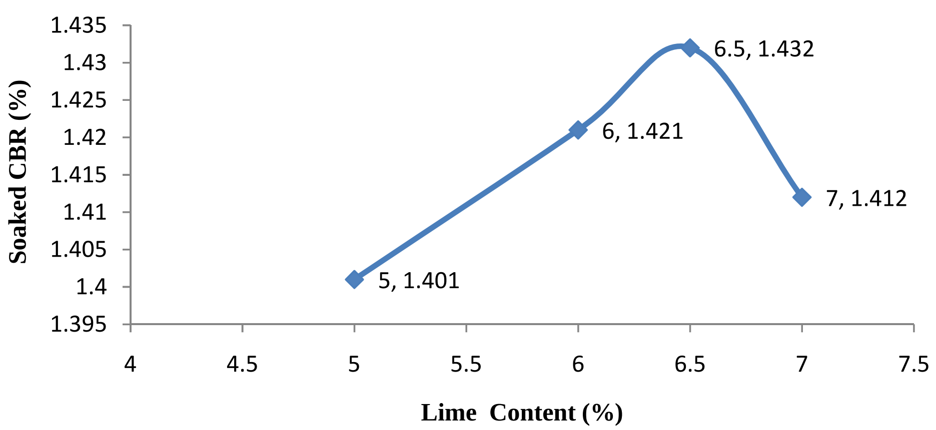


Table 15: Properties of Treated Marine Clay with an optimum of 20% Flyash and 6.5% Lime

Sl. No.	Property	Soil	Soil+20%Fly Ash	Soil+20%Fly Ash+6.5%lime
1	Liquid Limit (%)	74	63	54
2	Plastic Limit (%)	27	29	31
3	Plastic Index (%)	47	33	23
4	Shrinkage limit (%)	12	12.22	18.23
5	Specific Gravity	2.38	2.45	2.55
6	Differential Free Swell (%)	80	43	32
7	Optimum Moisture Content (%)	36	29.9	20.6
8	Maximum Dry Density (gm/c.c)	1.377	1.49	1.432
9	Cohesion (t/m^2)	12.2	9.23	7.45
10	Angle of Internal Friction	2^0	8^0	10^0
11	Soaked CBR Value	0.754	3.43	6.48

Plate 1. The Authors are conducting Modified Proctor Compaction Test

1.5 CONCLUSIONS

The following conclusions were drawn based on the laboratory test results.

- It was noticed that the liquid limit of the untreated marine clay has been decreased by 11% with the addition of 20% flyash as an optimum. Further it was also observed that the liquid limit of the 80%M.C + 20% F.A mix has been decreased by 9% on the addition of 6.5% lime as an optimum.
- It was observed from the laboratory test results that the plasticity index of the untreated marine clay has been decreased by 13% on the addition of 20% Fly ash as an optimum and further the plasticity index of the 80%M.C + 20% F.A mix has been decreased by 10% on the addition of 6.5% Lime as an optimum.
- It was noticed from the laboratory test results that the specific gravity of the untreated marine clay has been increased by 2.94% with the addition of 20% Fly ash as an optimum and with the further addition of 6.5% lime as an optimum on the 80%M.C + 20% F.A mix, an increase of 4% in the specific gravity was observed.
- It was found from the laboratory test results that the dry density of the untreated marine clay has been increased by 8.75% on the addition of 20% Fly ash as an optimum and a decrease of 4% dry density was observed on the addition of 6.5% Lime as optimum to the 80%M.C + 20% F.A mix.
- It was observed from the laboratory test results that the C.B.R. value of the untreated marine clay has been increased 361% on addition of 20% Fly ash as an optimum and further the CBR value of the 80%M.C + 20% F.A mix has been increased by 87% with the addition of 6.5% Lime as an optimum.
- It was observed from the laboratory test results that the DFS value of the untreated marine clay has been decreased by 47% on addition of 20% fly ash as an optimum
- With the addition of 6.5%lime and 20% Fly ash as an optimum, the DFS of untreated marine clay has been decreased by 53%.
- It was noticed from the results that the cohesion of the untreated marine clay has been decreased by 24.3% on the addition of 20% Flyash as an optimum and further the cohesion of the Flyash treated marine clay has been decreased by 19.3% with the addition of 6.5%lime.

- It was noticed that the angle of internal friction of the untreated marine clay has been increases by 300% on the addition of 20% Flyash and further an increase of 25% in the angle of internal friction was observed with the addition of 6.5%lime as an optimum of Flyash treated marine clay.

  Note: The soaked CBR of the MC on stabilizing is found to be 6.48% and is satisfying MORTH specifications. So finally it is concluded from the laboratory test results that the treated marine clay is suitable to use as subgrade material for the pavement construction.

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