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Research Paper

A study on geotechnical properties of marine clay stabilized with lime and recron-3s fibre

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Abstract

The necessity to tap natural marine resources from the ocean beds represents a considerable challenge for the construction of offshore structures on weak marine deposits. Weak marine soil deposits have been found both on the coast and in several offshore areas spread over many parts of the world. When clay particles precipitate in salt water, there is a tendency for the clay particles to flocculate and stick together giving rise to some sort of edge-to-face arrangement. As a result, clay, silt, and fine sand particles settle almost at the same rate and the final sediment formed consists of particles with a very loose card house-like structure. In this study, an attempt has been made to study the Index Properties, Differential Free Swell , Compaction and CBR characteristics of marine clay mixing with different percentages of lime and Recron-3s fibre with a view to determine the optimum percentages and its effect on strength characteristics. Test results show that stabilizing marine clay with lime and imparting Recron - 3s fibre enhance the strength.

Keywords: *Marine Clay; Lime; Recron-3s Fibre; Differential Free Swell; Compaction; CBR.*

1. Introduction

The soil found in the ocean bed is classified as marine soil. It can even be located onshore as well. The properties of marine soil depend significantly on its initial conditions. All over the world, problems of marine clay have appeared as cracking and break-up of pavements. Marine or soft clays exists in these region are weak in nature. For any construction works soil surrounding it plays an important role. Most of the soils especially in marine areas are not at all suitable for any construction works. Improvement in the soil properties can make it suitable for use especially for road pavements, since pavement constructed with marine clay will show very low durability and the cost of maintenance will also be very high. The marine deposits have very low shearing strength and are highly compressible. Stabilization is the process of improving the engineering properties of the soil and thus making it more stable. Teresa Sunny and Annie Joy [1] study is to investigate the use of waste material such as banana fibre in geotechnical applications. Various tests such as unconfined compression (UCC), California Bearing Ratio (CBR), Atterberg limits, Compaction were carried out and from the results; addition of banana fibre improved the properties of marine clay. OMC value increased with the addition of banana fibre and dry density decreases, shear strength increased from 8. 5 kN/ m^2 to 32.91 kN/m^2 and CBR value increased from 2.79 to 13.2 at 0.75% which makes it suitable for subgrade soil for road pavements. The optimum value for marine clay stabilized with banana fibre was obtained at 0.75%. Vara Prasad et al., [2] conducted experiments on marine clay blending different percentages of saw dust and lime and observed that liquid limit of the marine clay has been decreased, plasticity index of the marine clay has been improved, MDD increased, CBR value of the marine clay has been increased by 360% and differential free swell (DFS) value has been decreased by 60% on addition of 20% saw dust. Hence the optimum % of sawdust is 20% which improves the strength characteristics. Prasada Raju et al., [3], were study the effect lime and recron-3s fibre on index properties, compaction parameters and CBR values of the expansive soil by adding different percentages. From the experimental results addition of lime has shown decrement in Atterberg's limits when the lime content varies from 0% to 6% mixed in expansive soil as a result of cation ions from the lime which reduces the volumetric changes, MDD decreased due to the agglomerated and flocculated particles of lime mix soil occupy large voids and the OMC has increases and also OMC increasing and MDD decreases with the addition of different percentages of fibre. Unsoaked CBR values increases up to the addition of 4% of lime, further goes increasing from 7.3 % to 12.7% up to the addition of 1% fibre, beyond it is decreased with the addition fibbers. The overall CBR values increases due to the reason that lime has effectively bonded the soil particles to form a closely packed mass that resists the ingress of water. Prasad et al., [4] investigates the effect of Rice Husk Ash (RHA) on marine clay and from the results specific gravity of the marine clay decreases up to the addition of 20% of rice husk ash beyond that the addition of rice husk ash not shows much improvement in the specific gravity. The liquid limit continuously increases for the marine clay due the addition of rice husk ash, because of high water absorbing capacity of the add mixture, plastic limit increases up to the addition of 20% of rice husk ash, beyond the addition of add mixture not much effective. The compaction parameters, Maximum Dry Density (MDD) increased by 66.66 % and Optimum Moisture Content(OMC) value by 31.54 % , CBR values are increased by 240 % up to the addition of 20 % of rice husk ash. Dayakar Babu et al., [5] present the effect on compaction parameters and CBR values by addition different % of quarry dust, lime and waste plastic. There is a gradual increase in maximum dry density and decrease the optimum water content values with an increment in the % replacement of quarry dust up to 20 %. There

is an improvement of 80 % in cohesion when the original clay was replaced with 20 % quarry dust and the angle of internal friction was further improved by about 66 % when the mix was blended with 1 % waste plastic. There is an improvement in soaked CBR values. Koteswara Rao et al., [6] ,were studied the effect of lime and rice husk ash on marine clay and observed that liquid limit of the marine clay has been decreased , plastic limit improved and plasticity index decreased , OMC decreased by 18.52 % and further decreased by 42.63 % ,MDD improved by 17 % further improved by 12.70 % ,CBR value increased by 282 % and further improved by 449.14 % and DFS decreased by 72.80 % and further decreased by 77.28% addition of 25% Rice Husk Ash and it has been further decreased by addition of 9% lime respectively. Rajasekaran, G et al., [7], reported that the permeability and Engineering behaviour of marine clay changes by introducing lime columns and lime column treated marine clays shows and increase in permeability up to a maximum value of 15-18 times that of untreated soil with time. Thus, it can be concluded that stabilization of marine clay using lime is a good way of improving then engineering behavior. In the present work, an attempt has been made to study Atterberg limits, Differential Free Swell , Compaction and CBR tests were conducted with varying percentages of lime and Recron-3S fibre blending in marine clay with different percentages with a view to determine the optimum percentage. From the test results overall CBR values increases due to the lime has effectively bonded the soil particles to form a closely packed due to fibre.

2. Material used

Details of various materials used during the laboratory experimentation are reported in the following section.

2.1. Marine clay (MC)

The soil found in the ocean bed is classified as marine soil. It can even be located onshore as well. The properties of marine soil depend significantly on its initial conditions. The soil collected from Kakinada, East Godavari Dt. as shown in the Fig.1. The soil was air dried before the commencement of experiments. The properties of the marine clay are Specific Gravity = 2.3, Liquid limit (W_L) = 73%, Plastic Limit (W_P) = 23%, Plasticity index (Ip) = 50% I.S. Classification = CH (Clay of High Compressibility), MDD = 1.75 g/cm^3, OMC = 19.7% Coefficient of Uniformity (C_U) = 7.66, Coefficient of gradation (cg) = 4.03 and CBR = 2.04.

2.2. Lime

The commercial Birla lime taken from market for the purpose of stabilizing soil, which imparts cementing property to the soil mix. Commercial grade lime mainly consisting of 58.67% of Cao and 7.4% Silica was used in the study as shown in the Fig.2. The quantity of lime was varied from 0% to 6% by dry weight of soil. The specific gravity of lime was 2.37. Lime in the form of lime stone $CaCo_3$, was first sieved through 150 micron sieve and stored in airtight container for subsequent use.

2.3. Recron 3S - fibre

Recron 3s- fibre used in this study is the most commonly used synthetic material fibre due to its low cost and hydrophobic and chemically inert nature which does not allow the absorption or reaction with soil moisture or leachate and it is a polypropylene fibre which is a stabilizer to improve CBR and UCS values. Recron -3sfibre used in the experiment is of 12mm length and it was manufacture by Reliance industries shown in Fig. 3. Fibre are randomly mixed in soil due to the fact for making a homogeneous mass and maintaining the isotropy in strength. The Properties of Recron 3s- fibre are Colour = White, Specific gravity = 1.334, Cut length = 12 mm, Equivalent diameter (um) = 32-55, Water absorption (%) = 85.22, Tensile strength (MPa) = 600, Acid resistance = Excellent, Melting Point (°C) = >250 and Alkali resistance is Good (courtesy Reliance industries).

Fig. 1: Marine Clay.

Fig. 2: Lime.

Fig. 3: Recron 3S-Fibre.

3. Laboratory experimentation

To find the effectiveness of lime and recron-3s fibre were blending with different percentages in marine clay and various tests were carried out in the laboratory for finding the index and other important properties used during the study. The overall testing program is conducted in two phases. In first phase, marine clay was stabilized with lime mixed with different percentages, i.e. 2%, 4% and 6% by weight was used for preparing different soil samples. Index Properties, DFS, Modified Proctor Compaction and California Bearing Ratio (CBR) tests were conducted with a view to determine the optimum percentage. In second phase marine clay with 4 % of optimum lime from first phase results was stabilized by adding different percentages of recron-3s fibre varied from 0.5 %, 1 %, 1.5 % and 2 % by weight was used for preparing soil samples and conducted the same tests in the laboratory to know the improvement in geotechnical and strength characteristics of marine clay when compared to untreated marine clay.

3. 1. Index properties

Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

3.2. Differential free swell (DFS)

Differential Free Swell Index (DFS) test was conducted as per IS Code of practice: 2720 (Part 40) 1977.

3.2. Compaction properties

Optimum Moisture Content(OMC) and Maximum Dry Density (MDD) of untreated and treated marine clay with different percentages of lime and recron-3s fibre mixes were determined according to I.S heavy compaction test IS: 2720 (Part VIII).

3.3. California bearing ratio (CBR)

Different samples were prepared for CBR test using marine clay mixing with different percentages of lime and recron-3s fibre with a view to determine optimum percentages. The CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979) under soaked condition.

4. Results and discussions

Laboratory test results of marine clay blending with different percentages of lime and recron-3s fibre with without admix with a view to find its effect on geotechnical properties and the optimum percentages and the results are furnished below.

4.1. Effect of lime on index properties

Liquid limit values were reduced from 73, 70, 64, and 59 and the plastic limit values are increased from 23, 25, 27 and 30 by adding 0 %, 2 %, 4 % and 6 % of lime respectively blended with the marine clay as shown in the Fig. 4.

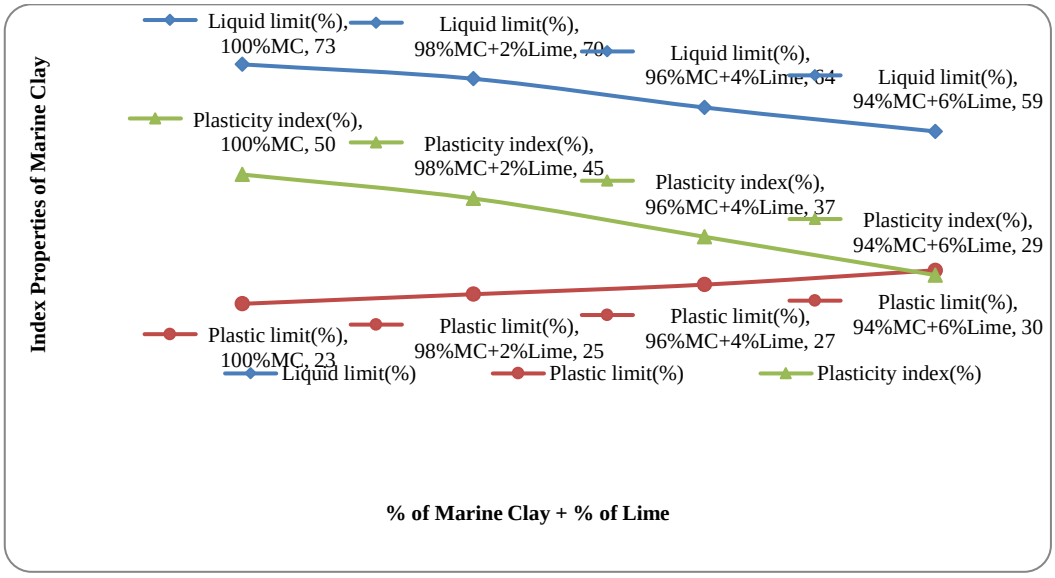

Fig. 4: Variation of Index Properties of Marine Clay Blended with Different Percentages of Lime.

4.2. Effect of lime on DFS

The variation of Differential Free Swell for different percentages of the lime mixing in marine clay is shown in the Fig: 5. there is a great change in the value of DFS due to the addition of lime in an increasing order of percentages 0 %, 2 %, 4 % and 6 % respectively. The reduction in DFS values could be supported by the fact that the double layer thickness is suppressed lime reaction with the soil water which is acting as layer on to the surface of the soil particles.

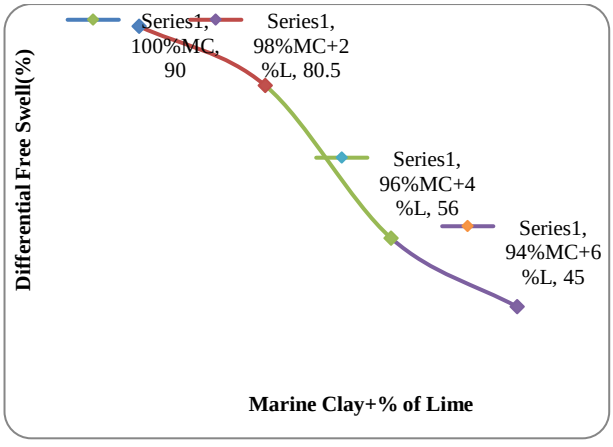

Fig. 5: Variation of Differential Free Swell of Marine Clay Blended with Different Percentages of Lime.

4.3. Compaction test

Graphs drawn between water content and dry density for each percentage of additives, from these results Optimum Moisture Content and Maximum Dry Density values are arrived. The test results were presented Figs. 6 & 7. From the compaction test results the maximum dry density values are decreases from 17. 19 kN/m^3, 16.61 kN/m^3, 16.13 kN/m^3 and 15.89 kN/m^3 the Optimum Moisture Content values are increasing from 19.7 %, 20.5 %, 21.62 %, 23.8 % respectively when the soil is mixed with 0 %, 2 %, 4 %, and 6% of lime. From the compaction test results the maximum dry density values are decreases from 16.13 kN/m^3, 16 kN/m^3, 15.98 kN/m^3, 15.2 kN/m^3, 14.71 kN/m^3 optimum moisture content values are increasing from 21.62%, 23 %, 23.4 %, 24 %, 24.5 % respectively and when the soil is mixed with optimum of 4% of lime and varying percentages of recron-3s fibre 0 %, 0.5 %, 1.0 %, 1.5 % and 2.0 % respectively. The optimum percentage of recron-3s fibre is 1%. The decrease in dry unit weight is attributed to the fact that lime reacts quickly with marine clay resulting Base Exchange aggregation and flocculation which leads to increase in void ratio of the mixture leading to decrease in the dry unit weight of the marine clay -lime mixture. This increase in optimum moisture content is attributed to the fact that additional water held within the flocs resulting from flocculation due to lime reaction.

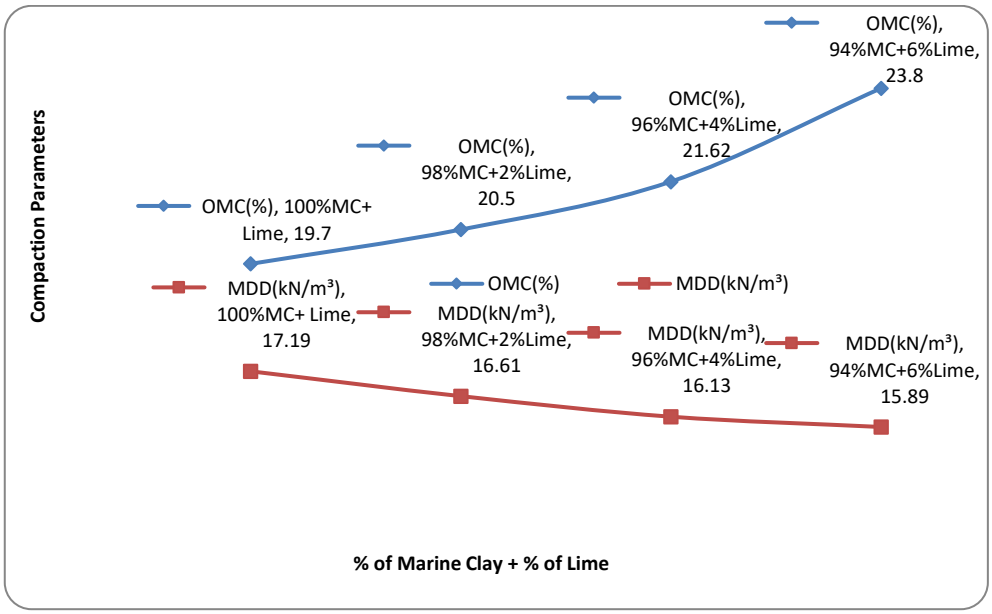

Fig. 6: Variation of Compaction Parameters with Different Percentages of Lime Blended with Marine Clay.

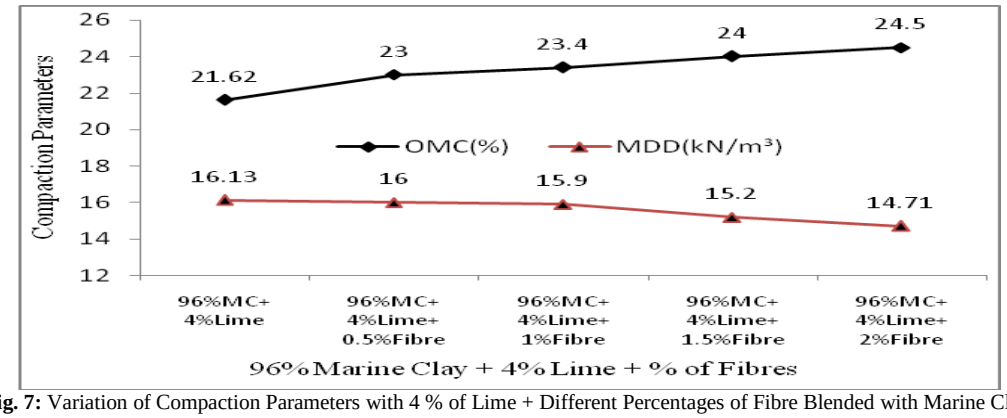

Fig. 7: Variation of Compaction Parameters with 4 % of Lime + Different Percentages of Fibre Blended with Marine Clay.

4.4. California bearing ratio (CBR) test

CBR tests were conducted for marine clay mixed with different percentages of lime and Recron-3s fibre and the results were presented in the Figs. 8 & 9. It is observed from that Marine clay mixed with different percentages of lime the unsoaked CBR values are 2.04, 4.38, 6.94 and 5.1 for 0%, 2%, 4% and 6% of lime respectively. From the above results the optimum percentage of lime is 4%. The unsoaked CBR values are increased from 6.94, 9.48, 11.3,8.7 and 6.6.4 for the addition of recron - 3s fibre 0 %, 0.5 %, 1.0 %,1.5 % and 2 % respectively at 4 % of optimum lime marine clay mixture and the optimum percentage of recron -3s fibre is 1%.

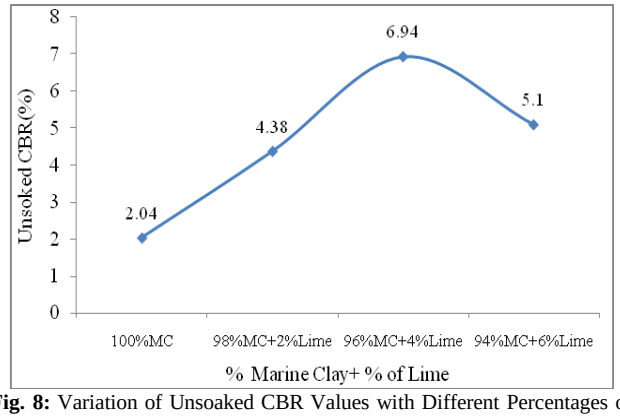

Fig. 8: Variation of Unsoaked CBR Values with Different Percentages of Lime Blended with Marine Clay.

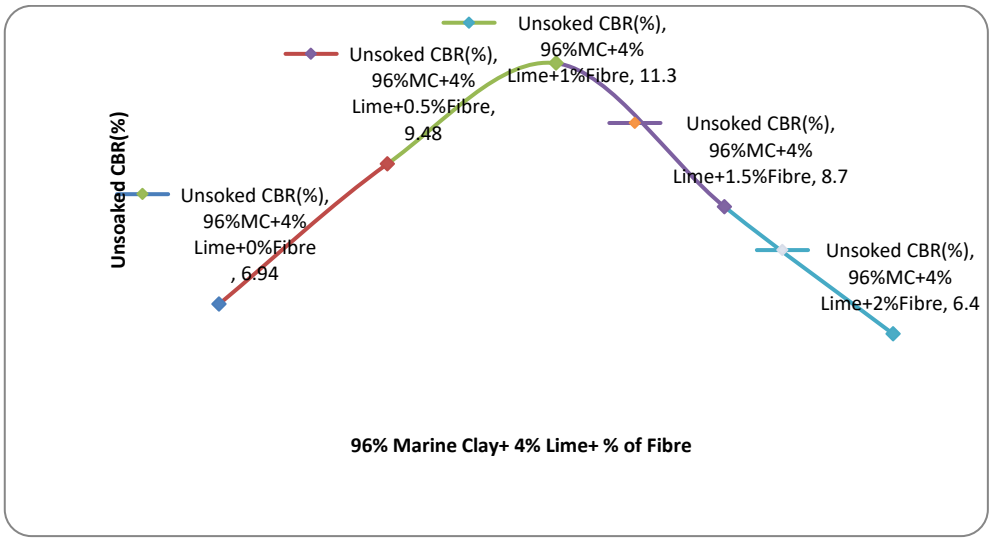

Fig. 9: Variation of Unsoaked CBR Values with 4 % of Lime + Different Percentages of Fibre Blended with Marine Clay.

5. Conclusion

The following conclusions are made based on the laboratory experiments carried out in this investigation.

Addition of lime has shown good decrement in liquid limit value and increment in plastic limit value, eventually decreases plasticity index value from 50 % to 30 % at 6 % lime and swelling of marine clay as a result of cation ions from the lime which reduces the volumetric changes.

On increasing lime differential free swell decreases steadily to lowest value of 45 % from 90 % at 6% of lime due to the of cation exchange which occur when Ca^{2+} ions from lime replace weaker cation in marine clay, thereby causing a better sealing of voids.

With the increase in the percentage of lime the MDD decreased due to the agglomerated and flocculated particles of lime mix soil occupy large voids and the OMC has increases due to the action of lime which needed more water for pozzolanic action.

Compaction characteristics of lime treated (at its optimum 4%) marine clay such as OMC goes increasing and MDD goes decreasing with the addition of different percentages of fibre due to of the reason that as fibre content increases, soil packing becomes loose and it's become difficult to make samples even.

Unsoaked CBR values increases up to the addition of 4% of lime, then beyond addition it decreases. From the evaluation of CBR test, it was decided that 4% is the optimum content of lime for treating marine clay.

Unsoaked CBR value goes on increasing maximum at 1% addition of 1% fibre and beyond it decreased to the lime treated(at its optimum 4 %) marine clay. The overall CBR values increases due to the reason that lime has effectively bonded the soil particles to form a closely packed mass that resists the ingress of water..

From the above experimental results the optimum percentage of lime and Recron - 3S fibre are 4 % and 1% respectively. This work shows that the potential benefit of stabilizing clayey soils with lime and imparting Recron 3s fibre to enhance the strength. And the disadvantage of lime i.e. brittle nature is overcome by the inclusion of fibre which gives ductility to the soil.

References

[1] Teresa Sunny and Annie Joy (2016)," Study on the Effects of Marine Clay Stabilized with Banana Fibre", International Journal of Scientific Engineering and Research (IJSER), Volume- 4 Issue 3, pp.96-98.

[2] Vara Prasad, ASS. N Avas S Ashok Kumar (2016), "Stabilization of Marine Clay with Sawdust and Lime for Pavement Subgrades", International Journal for Scientific Research & Development, Vol. 4, Issue 07, Pp. 1033-1037.

[3] Prasada Raju, GVR, P. Sowmya Ratna, DSV Prasad, (2016), "Performance of Recron-3s Fibre with Lime in Expansive Soil Stabilization", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), Volume 13, Issue 6, Pp. 74-79.

[4] Prasad DSV, H Venkateswarlu, N Janardhan Rao, J Chaitanya Kumar (2015) "Strength Behaviour of Marine Clay Treated with Rice Husk Ash", International Journal of Engineering Sciences & Research Technology, ISSN: 2277-9655, PP 561-567.

[5] Dayakar Babu ,R, K. V. S. Raja Praveen, K.Vijay Teja, , K. V. N. S. Raviteja (2013) "Strength Behaviour of Marine Clay Stabilized with Lime – Quarry Rock Dust and Waste Plastics" Proceeding of Conference Paper June 2013

[6] Koteswara Rao.D, G.V.V. Rameswara Rao, P.R.T. Pranav (2012) "A Laboratory Study on the Affect of Rice Husk Ash & Lime on the Properties of Marine Clay" International Journal of Engineering and Innovative Technology (IJEIT), Volume 2, Issue 1, PP 345-353.

[7] Rajasekaran, G and Narasimha Rao, S (2002), Compressibility Behaviour of Lime Treated Marine Clay, Journal of Ocean Engineering, volume-29, pp. 545-559.