# An Efficacy of Waste Plastic Fibres And Quarry Dust on The Strength Characteristics of Lime Treated Marine Clay

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***Abstract-*** *Marine clays is the most inventive field of geotechnical engineering. Marine deposits are sensitive to changes in the stress system and the system chemistry of the pore fluid. Ground improvement of marine clays is the most inventive field of geotechnical engineering. Various techniques such as use of prefabricated vertical drains (PVDs), vacuum consolidation, stone columns, etc., are available for improving the mechanical and engineering properties of the marine clay. Majority of the population in India are living in costal corridor, where the existing soils are weak and more deformative. It is becoming a great challenge for the civil engineers to increase the strength parameters of marine clay by using stabilization. In the present investigation, waste plastic fiber has been chosen as reinforcing material and Quarry dust and lime as the binding agents. The optimum replacement of soil by Quarry dust can be determined by conducting compaction test with proportions 0%,5%,10%,15%,20% and 25% by weight of soil. Waste plastic fibers which is included in soil mix at different percentages by the weight of the soil .The investigation has been focused on the strength behavior of the soil reinforced with randomly included waste plastic fiber, optimal replacement of quarry Dust by soil and 2% lime as constant. The samples were subjected to California bearing ratio test and UCS test. The test results were compared to virgin soil properties and determining the optimum content of stabilizers to improve the properties of soil.*

## I. INTRODUCTION

Marine clay is a type of clay found in coastal regions around the world. In the northern, deglaciated regions, it can sometimes be quick clay, which is notorious for being involved in landslides. Clay particles can self-assemble into various configurations, each with totally different properties. When clay is deposited in the ocean, the presence of excess ions in seawater causes a loose, open structure of the clay particles to form, a process known as flocculation. Once stranded and dried by ancient changing ocean levels, this open framework means that such clay is open to water infiltration. Construction in marine clays thus presents a geotechnical engineering challenge. Where clay overlies peat, a lateral movement of the coastline is indicated and shows a rise in relative sea level.

Swelling of marine clay has the potential to destroy building foundations in only a few years. Due to the changes in climatic conditions on the construction site, the pavement constructed on the marine clay (as sub grade) will have less durability and requires lot of maintenance cost. Some simple precautions, however, can reduce the hazard significantly during the construction of Marina Barrage in Singapore, marine clay was found at the site. Since marine clay was the cause of the Nicolle Highway collapse years previous, the construction team removed all the marine clay to ensure the stability of Marina Barrage. Later on, they found marine clay mixed with seawater even in the deeper underground. Geotechnical problems posed by marine clay can be handled by various ground improvement techniques. Marine clay can be densified by mixing it with cement or similar binding material in specific proportions. Marine clay can be stabilized using wastes of various industries like porcelain industry and tree- cutting industries. This method is usually adopted in highways where marine clay is used as a sub grade soil. The clays can cause problems in several ways, ranging from major structural damage in houses to poor drainage in yards. Fortunately, most types of structural damage can be repaired. In addition, homeowners can eliminate some causes of potential problems in Marine Clay. Some types of damage are much more common than others. The various types of damage can occur singly or in combination with each other. House problems usually develop slowly at first and then become more serious as years go by. For example, minor cracks in a basement wall of a ten- year old house may progressively worsen over the next five years, eventually resulting in wall failure. Damage has been noted to occur in less than five years to greater than 30 years after construction. Although the types of damage caused by Marine Clay can be grouped into a few categories, no two houses are alike. Building and foundation design, age of the house, soil characteristics, yard grading, vegetative plantings, and homeowner maintenance history make each diagnosis of the problem unique. Correctly identifying the problems usually requires a thorough investigation of the soil and structural conditions by a qualified professional. Repairs should be based on a careful analysis of the soil conditions under and around the building. As some homeowners have discovered, an incomplete or improper repair will likely result in recurring problems in the future. For this reason, consult a qualified engineer experienced in soil and foundation investigations for design and inspection of difficult repairs. Why are the Marine Clays such a problem? The main reason is that they contain a type of clay, montmorillonite, which shrinks and swells during natural changes in soil moisture. The clays shrink during dry periods of the year and swell during wet periods. Slight changes in moisture content are sufficient to cause detrimental shrinking and swelling. The pressures that the clays exert upon swelling can far exceed the strength of basement walls and even the weight of a house’s wall and footing. Uneven settling can cause cracking and warping of the foundation and frame. Problems tend to be more common in some Marine Clay areas than others. The Marine Clays contain a variable mixture of fine-textured soils – clay and silt – with frequent discontinuous sand layers. The most troublesome areas occur on steeper slopes and where the content of clay and silt is much higher than other soil types. Many houses located within Marine Clay may never have problems, while others will undergo foundation distress at some time in the life of the structure. Surface drainage is often a problem since water percolates very slowly through the clays and does not drain well from level yard areas.

## II. REVIEW OF LITERATURE

**Yu Lu, Wenbin Fu, et al.,(2020)**In this paper, a comprehensive series of undrained triaxial tests under cyclic loading with low frequency was conducted to investigate the deformation characteristics of soft marine soil. The results demonstrate that soil specimens accumulate plastic deformation and pore pressure under cyclic loading. Specimens tested under conditions such as high confining stress, high-stress ratio, and long cyclic period generally reveal higher deformation and pore pressure. Meanwhile, the rectangular wave presents the largest contribution to plastic strain and pore pressure, followed by the trapezoidal and triangular waves, respectively, whereas the difference between the various waves decreased gradually with the increasing load level and cyclic period.

**Samaila Saleh, Nur Zurairahetty Mohd Yunus,et al.,(2018)** Characterization of the soil geotechnical properties was carried out by conducting laboratory test that includes natural moisture content, Atterberg limits, grains sizes analyses, specific gravity, moisture-density relationship, unconfined compressive strength (UCS), organic matter content and PH tests. Unconfined compressive strength test at optimum moisture content with varying the dose of the Polyurethane content was conducted to test the effectiveness of Polyurethane as a chemical stabiliser. The result of the preliminary tests of the sample shows that the soil has a liquid limit of 65%, plastic limit of 26% and plasticity index of 53%. The percentages of gravel, sand and fines in the marine clay sample were 0 %, 1.32 % and 98.68 % respectively %.Results showed that the soil has all the attributes of marine clay such as a liquid limit of65%, plastic limit of 26% and plasticity index of 53%, percentages of gravel, sand and fines in the sample respectively equal to 0 %, 1.32 % and 98.68 %. Compaction characteristics of the soil (OMC and MDD equal to 25% and 1440kg/$m^3$) respectively. A soil PH of 3.25 and LOI equal to 8%. All these confirmed that the soil is marine clay and is not suitable for construction purposes at its natural condition. Stabilizing the marine with the polyurethane improved the shear strength of the marine clay from 75 kpa to 250 kpa it further reduces the cumulative strain of the soil from 5.18% to 2.92% which correspond to improvement by 230% increase in shear strength and 77% decrease in cumulative strain.

**A. Ananthi, A. Jay Tamil Eniyan,et al.,(2017)**In this project, we used plastic cups as a fiber with mean aspect ratio 158.75 and 26.49. The result proved that the addition of concrete increases the compressive strength and split strength. Hence plastics can be added as fiber to enhance the properties of concrete. Soft marine clay is very sensitive to change the stress system, moisture content and system chemistry of the pore fluid. Geotechnical engineers feel a necessity to improve the behavior of these deposits using anyone of the available ground improvement techniques for the const ruction of foundations. Marine clay normally possesses soft consistency marine clay deposits of Kakinada were used for the testing with the aim to investigate its Engineering properties (S. Narasimha Rao et.al:1996; Shridharan et.al:1989; Thiam-Soon Tan et.al:2002; Supakij Nontananandh et.al:2004; Basak et.al:2009, Gang Ren: 2010) and further, made suitable for foundation constructions over it. It is a recognized fact that, whenever a new material or a technique is introduced in the pavement constriction, it becomes necessary to experiment it for its validity by constructing a test track

### Materials Used and Their Properties

The details of the various materials used in the laboratory experimentation are reported in the following sections.

### Marine Clay

The marine clay used in this study and was typical soft clay. The marine clay was collected at a depth of 0.30m to 1.00m from ground level from YETIMOGA area, Kakinada, Andhra Pradesh State, India. The properties of soil are presented in the Table of Marine Clay properties All the tests carried on the soil are as per IS specifications.

Table 1.

**Table:** Properties of Marine clay

| S.No | Property | Value |
|---|---|---|
| | **Grain size distribution** | |
| 1 | Sand (%) | 4 |
| | Silt (%) | 28 |
| | Clay (%) | 68 |
| | **Atterberg limits** | |
| 2 | Liquid limit (%) | 67.5 |
| | Plastic limit (%) | 32.5 |
| | Plasticity index (%) | 35 |
| | **Compaction properties** | |
| 3 | Optimum Moisture Content, (%) | 33 |
| | Maximum Dry Density, (g/cc) | 1.32 |
| 4 | Specific Gravity (G) | 2.68 |
| 5 | IS Classification | CH |
| 6 | Soaked C.B.R (%) | 0.64 |
| 7 | Differential free swell (%) | 18 |
| | **Shear Strength Parameters** | |
| 8 | Cohesion (kN/m²) | 38 |
| | Angle of internal friction (°) | 0 |

Table 2. Properties of QD

| S.No | Property | Value |
|---|---|---|
| | **Grain size distribution** | |
| 1 | Sand (%) | 27 |
| | Silt (%) | 66 |
| | Clay (%) | 7 |
| | **Atterberg limits** | |
| 2 | Liquid limit (%) | 48 |
| | Plastic limit (%) | NP |
| | Plastic index (%) | NP |
| | **Compaction properties** | |
| 3 | Optimum Moisture Content, (%) | 19.7 |
| | Maximum Dry Density, (g/cc) | 1.45 |
| | **CBR Properties** | |
| 4 | Un Soaked CBR | 9.9 |
| | Soaked CBR | 2.85 |

Table 3.

**Table:** Chemicals Present in QD

| S.No. | Chemical | Composition |
|---|---|---|
| 1 | CaO | 30-50% |
| 2 | $SiO_2$ | 28-38% |
| 3 | $Al_2O_3$ | 8-24% |
| 4 | MgO | 1-18% |
| 5 | MnO | 0.68% |
| 6 | $TiO_2$ | 0.58% |
| 7 | $K_2O$ | 0.37% |
| 8 | $N_2O$ | 0.27% |

- **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 0% to 12% by dry weight of soil + QD.

- **Waste Tire Inclusions**

In the present study, locally available tire waste collected from various dumping yards was used. The waste tyres were cut into small strips of 50mm length, 3mm wide and 1mm thickness. The quantity of these waste tyre strips was varied from 0% to 1.5% by dry weight of soil + QD + Lime, with an increment of 0.5%.

- **List of Laboratory Tests**

  - The grain size distribution
  - Specific gravity
  - Swell Tests- Differential Free swell
  - Index properties –Liquid Limit, Plastic Limit
  - Compaction tests
  - Penetration tests- California bearing ratio tests.
  - Strength tests- Tri- axial shear tests

## SAMPLE PREPARATION

The soil was initially air dried, pulverized and then was sieved through 4.75mm sieve, prior to the testing. The samples were prepared by mixing the pulverized and sieved soil with the needed stabilizing agents in dry condition and then required amount of water is added to make a consistent mix by thorough mixing. The following tests were conducted as per IS Codes of practice to assess the influence of QD, Lime and Waste plastic fibres(WPF) on the Soft Marine Clay.

i. Compaction tests
ii. Penetration tests- California Bearing Ratio test.
iii. Strength tests- Tri-axial shear test

The following table lists the different variables and their respective contents used in the present study.

Table 4.
**Table** Different variables studied

| S.No. | Stabilizing Agent | % Content |
|---|---|---|
| 1 | Quarry Dust (QD) | 0, 5, 10, 15, 20 & 25 |
| 2 | Lime | 0, 4, 8 & 12 |
| 3 | Waste plastic fibres(WPF) | 0, 0.5, 1.0 & 1.5 |

## III. RESULTS AND DISCUSSIONS

Details of the laboratory experimentation carried-out with different combinations of materials have been discussed in the previous chapter including the laboratory proctor's test and tri axial tests on untreated and treated marine clay.

Table 4. Table4.1 Variation of OMC & MDD with % of QD

| S. No. | % of QD | OMC (%) | MDD (gm/cc) |
|---|---|---|---|
| 1 | 0 | 33 | 1.32 |
| 2 | 5 | 28.1 | 1.37 |
| 3 | 10 | 26.3 | 1.42 |
| 4 | 15 | 24 | 1.44 |
| 5 | 20 | 23.2 | 1.47 |
| 6 | 25 | 22.1 | 1.45 |

Table 5.
Table 4.2 Variation of OMC & MDD with % of Lime to the Soil + QD optimum mix

| S. No. | % of Lime | OMC (%) | MDD (gm/cc) |
|---|---|---|---|
| 1 | 0 | 23.2 | 1.47 |
| 2 | 4 | 25 | 1.49 |
| 3 | 8 | 26 | 1.52 |
| 4 | 12 | 27.3 | 1.51 |

Table 6.
Table 4.3 Variation of OMC & MDD with % of WPF to the Soil + QD + Lime Optimum mix

| S. No. | % of WPF | OMC (%) | MDD (gm/cc) |
|---|---|---|---|
| 1 | 0 | 26.1 | 1.52 |
| 2 | 0.5 | 26 | 1.51 |
| 3 | 1 | 25.8 | 1.49 |
| 4 | 1.5 | 25.4 | 1.48 |

Table 7.
Table 4.4 Variation of Cohesion with % of WPF

| S. No. | % of WPF | $C_u$ (Kpa) | % increase in $C_u$ |
|---|---|---|---|
| 1 | 0 | 84 | - |
| 2 | 0.5 | 93 | 10.7 |
| 3 | 1 | 104 | 23.8 |
| 4 | 1.5 | 101 | 20.2 |

Table 8.
Table 4.5 Variation of Angle of Internal Friction with % of WPF

| S. No. | % of WPF | Øu (Degrees) | % increase in Øu |
|---|---|---|---|
| 1 | 0 | $9^0$ | - |
| 2 | 0.5 | $12^0$ | 33.3 |
| 3 | 1 | $15^0$ | 66.6 |
| 4 | 1.5 | $14^0$ | 55.5 |

Table 9.
Table 4.6 Variation of CBR values with % of WPF

| S. No. | % of WPF | Soaked (%) |
|---|---|---|
| 1 | 0 | 8.9 |
| 2 | 0.5 | 9.6 |
| 3 | 1 | 11.4 |
| 4 | 1.5 | 11.3 |

Table 10.
Table4.7 Variation of OMC & MDD (g/cc) with various mix proportions

| S. No. | Mix Proportions (P) | OMC (%) | MDD |
|---|---|---|---|
| 1 | Only Soil (P1) | 33 | 1.322 |
| 2 | Clay+20%QD (P2) | 23.2 | 1.47 |
| 3 | Clay+20%QD+8%Lime (P3) | 26.1 | 1.52 |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 26 | 1.51 |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 25.8 | 1.49 |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 25.4 | 1.48 |

Table 11.
Table4.8 Variation of Shear Parameters with various mix proportions

| S. No. | Mix Proportions (P) | $C_u$ | AIF |
|---|---|---|---|
| 1 | Only Soil (P1) | 38 | $0^0$ |
| 2 | Clay+20%QD (P2) | 68 | $4^0$ |
| 3 | Clay+20%QD+8%Lime (P3) | 84 | $9^0$ |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 93 | $12^0$ |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 104 | $15^0$ |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 101 | $14^0$ |

Table 12.
Table4.9 Variation of Unconfined Compressive Strength with various mix proportions

| S. No. | Mix Proportions (P) | UCS ($kN/m^2$) |
|---|---|---|
| 1 | Only Soil (P1) | 76 |
| 2 | Clay+20%QD (P2) | 145 |
| 3 | Clay+20%QD+8%Lime (P3) | 197.4 |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 230 |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 271.4 |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 258 |

Table 13.
Table4.10 Variation of Soaked CBR with various mix proportions

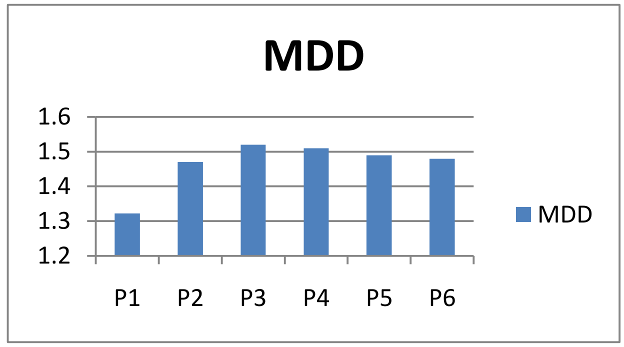
| S. No. | Mix Proportions (P) | CBR Soaked |
|---|---|---|
| 1 | Only Soil (P1) | 3.34 |
| 2 | Clay+20%QD (P2) | 4.8 |
| 3 | Clay+20%QD+8%Lime (P3) | 8.9 |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 9.6 |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 11.4 |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 11.3 |

Table 14.
Table 15 Variation of Safe Bearing Capacity with various mix proportions

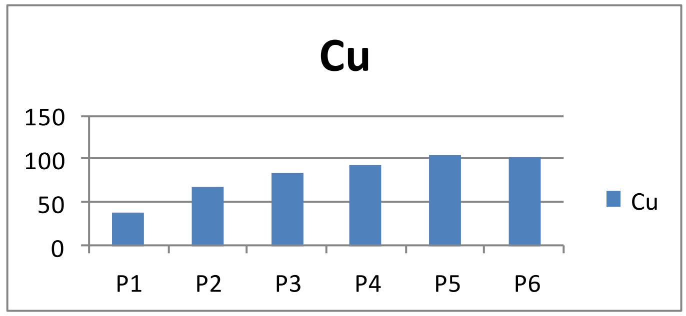
| S. No. | Mix Proportions (P) | SBC ($kN/m^2$) |
|---|---|---|
| 1 | Only Soil (P1) | 93.5 |
| 2 | Clay+20%QD (P2) | 171.98 |
| 3 | Clay+20%QD+8%Lime (P3) | 328.82 |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 436.55 |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 576.31 |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 530.53 |

Table 15.
Table 16 Variation of Thickness of Pavement with various mix proportions

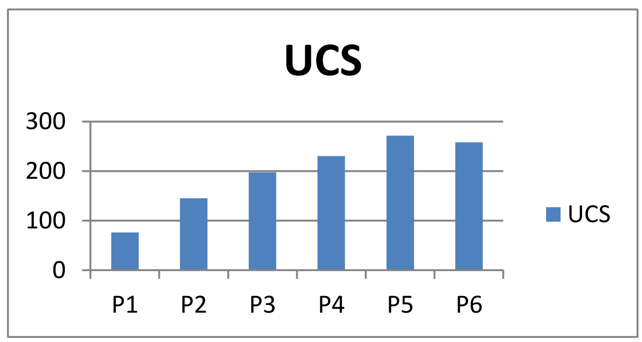
| S. No. | Mix Proportions (P) | Thickness (Cm) |
|---|---|---|
| 1 | Only Soil (P1) | 104.77 |
| 2 | Clay+20%QD (P2) | 36.12 |
| 3 | Clay+20%QD+8%Lime (P3) | 24.88 |
| 4 | Clay+20%QD+8%Lime+0.5%WPF (P4) | 23.67 |
| 5 | Clay+20%QD+8%Lime+1.0%WPF (P5) | 21.04 |
| 6 | Clay+20%QD+8%Lime+1.5%WPF (P6) | 21.17 |



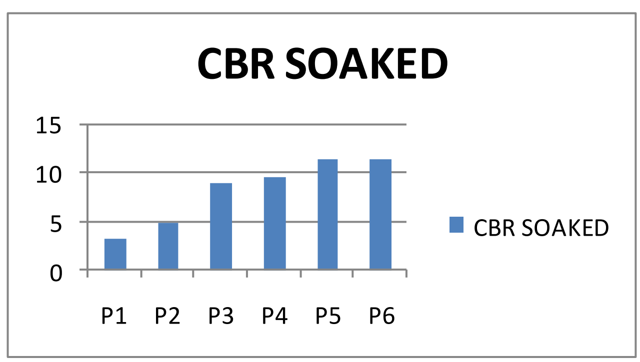

*Bar chart showing the effect of QD, lime and Waste Plastic fibers on compaction parameters of marine clay*



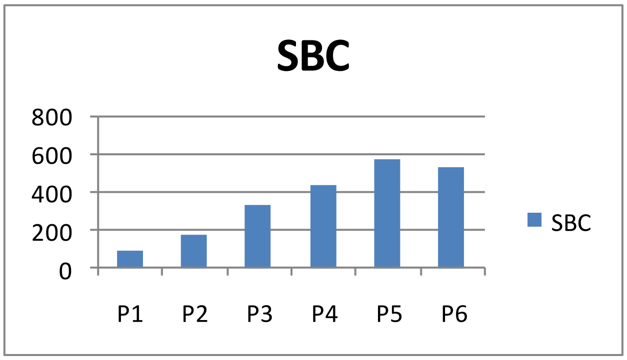

*Bar chart showing the effect of QD, lime and Waste Plastic fibers on Tri –axial parameters of marine clay*



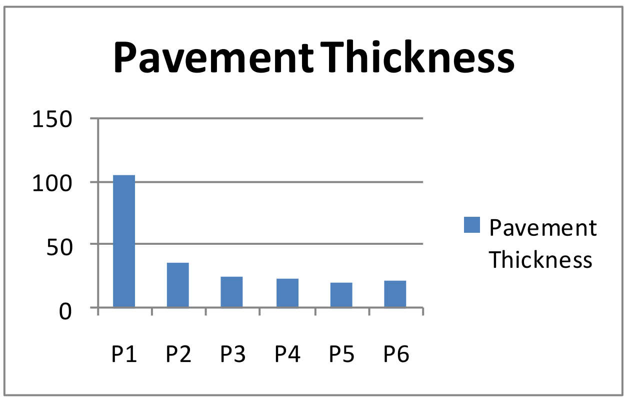

*Bar chart showing the effect of QD, lime and Waste Plastic fibers on unconfined compressive strength results of marine clay*




*Bar chart showing the effect of QD, lime and Waste Plastic fibers on CBR parametersof marine clay*




*Bar chart showing the effect of QD, lime and Waste Plastic fibers on Safe bearing capacity parameters of marine clay*




*Bar chart showing the effect of QD, lime and Waste Plastic fibers on Pavement thickness values of marine clay*

## IV. CONCLUSIONS

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

1. From the laboratory studies, it is observed that the Marine Clay chosen was a problematic soil having high compressibility, with high plasticity and low strength characteristics
2. There is a gradual increase in maximum dry density with an increment in the % replacement of QD up to 20% with an improvement of 3.2% and upon further increment there is a marginal decrease in MDD value. The corresponding optimum moisture content values decreased with a % reduction of 30%
3. There is an improvement of 80% in cohesion when the original clay was replaced with 20% QD and when it is further blended with lime, it improved by about 24% further
4. The angle of internal friction was further improved by about 66% when the mix was blended with 1% Waste Plastic fibers and also the cohesion has improved by about 173% when compared to that of virgin marine clay
5. The corresponding unconfined compressive strength was improved by about 257%. There is an improvement in soaked C.B.R values also by about 21 times
6. It is evident that there is a significant reduction in pavement thickness by about 77% in soaked CBR condition.

## REFERENCES

[1] 1.Abduljauwad, S.N (1991), Characteristics and chemical treatment of soft clay in Al- Qatif, Saudi Arabia. Journal of Engineering Geology, Vol.31 Issue, 2, 1991

[2] Akshaya Kumar Sabat (2012)“ A Study on Some Geotechnical Properties of Lime Stabilised Expansive Soil –Quarry Dust Mixes”.International Journal of Emerging trends in Engineering and Development ISSN 2249-6149 Issue 2, Vol.1( January-2012)

[3] Ali and Koranne (2011),“Performance analysis of expansive soil treated with stone dust and fly ash”,EJGE

[4] Al-Rawi, N.M (2000), The effect of curing and temperature on lime stabilization, Proc. Of Second Australian Conf. on Engin eering Materials, Sydney, 1981, pp.611-662

[5] 5.Ambily, A.P and Gandhi, S.R (2004), Experimental and Theoretical Evaluation of Stone Column in Soft Clay, ICGGE, pp 201 -206

[6] Amu, O.O., Fajobi, A.B. and Oke, B.O.,(2000), Effect of Eggshell Powder on the Stabilizing Potential of Lime on an Expansive Clay Soil, Research Jr. of Agriculture and Biological Sciences, 1(1), 2005, pp. 80 -84

[7] Anand J.Puppala, Ekarin Wattanasanticharoen and Laureano R.Hoyos,(2003), Ranking of Four Chemical and Mechanical Stabilization Meth ods to Treat Low- Volume Road Subgrades in Texas, Jr.-Transportation Research Record, Vol. 1819B, 2003, pp. 63-71

[8] Anandarajah. A and Chu. J (1997), Laboratory Determination of shear strength parameters for marine clay, Journal of the Institution of Enginee rs, Singapore, Vol.14, No.3, pp 39-46