Influence of Terrazyme on The Strength Properties of Different Soils At Various Curing Periods

S.Vidya Sagar Dora[1], G.Mani Kumar[2]
[1]Dept of Civil Engineering
[2]Assistant Professor, Dept of Civil Engineering
[1, 2] Lenora College of Engineering, Rampachodavaram

Abstract- *Many areas in India and around the world are dominated by soft soils such as red soil, marine soil and clay soil. These can become problematic when developed upon due to their low shear strengths and bearing capacities, potential to experience shrinkage/swelling, differential settlement and liquefaction when subjected to ground vibrations and cyclic loads. Many researchers, all over the World are working, to evolve more effective and practical treatment methods, to alleviate the problems caused to pavements laid on these types of soils. Many stabilization techniques are in practice for improving the clayey soils and red soils in which the characteristics of the soils are altered or the problematic soils are removed and replaced which can be used alone or in conjunction with specific design alternatives. Terrazyme is a natural, non-toxic, non-flammable, non-corrosive liquid enzyme formulation fermented from vegetable extracts that improves the engineering properties of soil, facilitates higher soil compaction and increases strength. In this experimental study, three different soil samples such as clay soil, marine soil and red soil have been selected and collected. Various laboratory tests like atterberg limits tests, grain size analysis, standard Proctor compaction tests, unconfined compression tests and California bearing ratio tests have been conducted to determine the physical, index and mechanical properties of soil samples. The selected soil samples have been stabilized using bio-enzymes in three different dosages such as 0.5 ml, 1 ml, 1.5 ml for every 5 kg of soil samples. The prepared soil samples are allowed for curing periods of 1 and 7 days.*

Keywords- Red soil,Clayey soil, Terrazyme, bio-enzymes, plasticity, compaction and strength characteristics

I. INTRODUCTION

High quality soil as materials for soil engineering construction are rare in many parts of the world, and most often than not, engineers are forced to seek alternatives to reach the stipulated requirements. A developing country like India which has a large geographical area and population, demands vast infrastructure i.e. network of roads and buildings. Majority of the population in India depends on road-based transport having proper geometric design, pavement condition and maintenance. Hence, it is necessary to have a proper reseaarch on the soil to be used as a subgrade. Since there is a different types of soils, an adequate knowledge of the different types of soils and thier properties, therefore, essential for proper design and construction of road pavements.

Red soil is generally found in commonly observed in the southern and semi-arid regions and spread over an area of 61.5 million hectares mainly in Maharashtra, Chhattisgarh, Tamil Nadu, Odisha ,Karnataka, West Bengal, Mirzapur , Uttar Pradesh, Udaipur, Durgapur, Batswana and Bhilwara districts (Rajasthan), Chotanagpur plateau of Jharkhand, Andhra Pradesh. It is generally, is derived from weathering of ancient metamorphic rocks of the ancient Deccan plateau. It is red colour due to the abundance of iron in it. When iron content is suitably lower, the colour will be yellow or brown colour. Red soil is usually that group of soil that develops in warm temperature and is generally abundant in moist climate where deciduous or mixed forests are present.

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 pavements Etc…..Aggregate crusher units produce large quantities of quarry dust, a waste product, produced during crushing of Gravel and rock.

Soil stabilization is a technique to improve the soil parameters such as shear strength, compressibility, density, hydraulic conductivity etc. Soil stabilization can be explained as the alteration of the soil properties by chemical or physical means in order to enhance the engineering quality of the soil. The main objectives of the soil stabilization are to increase the bearing capacity of the soil, its resistance to weathering process and soil permeability. The long-term performance of any construction project depends on the soundness of the underlying soils. Unstable soils can create significant problems for pavements or structures, Therefore soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of

the superstructure especially in case of soil which are highly active, also it saves a lot of time and millions of money when compared to the method of cutting out and replacing the unstable soil.

Bio-Enzymes have come to the market which can be used as stabilizing agent. Bio-Enzyme is a natural, non-toxic, non-flammable, non-corrosive liquid enzyme formulation fermented from vegetable extracts that improves the engineering properties of soil, facilitates higher soil compaction and increases strength. One such stabilizing agent is Terrazyme, which is used in the present investigation to further stabilize blended soil. Terrazyme is a natural, nontoxic liquid, formulated using vegetable extracts.

In this experimental study, three different soil samples such as red soil and marine soil have been selected and collected. Various laboratory tests have been conducted to determine the physical, index and mechanical properties of soil samples. The selected soil samples have been stabilized using bio-enzymes in three different dosages such as 0.5 ml, 1 ml, 1.5 ml for every 5 kg of soil samples. The prepared soil samples are allowed for curing periods of 1 and 7 days. The physical, index and mechanical properties of these modified soil samples have been determined using various laboratory tests. The best modified soil samples have been selected in each type of soil based on its strength, economic and feasible criteria to be used as a subgrade soil for highway pavements.

1.2 OBJECTIVES OF THE STUDY

The objectives of present experimental study are to develop correlations between engineering characteristics of marine clay and red soil.

- To analyse the physical and mechanical properties of various control soil samples.
- To evaluate the performance of Marine Clay and red soil when treated with terrazyme as admixture.
- To compare the properties of various modified soil samples which are stabilized using terrazyme of different dosages.
- To study the performance of treated marine clay and red soil as foundation beds
- To analyze the intrusion of bioenzyme in strength variation of different soils for various curing periods.

II. LITERATUREREVIEW

2.1PREVIOUS RESEARCH PAPERS AND CONCLUSIONS

Research about stabilization of the clay with adding stabilizer is usually done in order to increase the quality of the clay soils. The addition of stabilizer is usually intended to reduce the swelling on the clay soils that can reduce the strength. Clay has high plasticity index and swelling potential, so the stabilization is usually done in order to overcome the problems. Research about clay soils stabilization is commonly done with adding some additive such as lime, cement, cane pulp ash. Nowadays, a research of clay stabilization is still interesting subjects to be observed.

Soil stabilization is a procedure where we improve engineering properties of soil with the use of natural or synthesized admixtures. In the past many researchers have carried out their research work for improving the strength of marine clays and red soils using different types of admixture at different percentages. A brief review of previous studies on marine clays and red soils is presented in this section and past efforts most closely related to the needs of present work.

In general, the soils which are existing in the coastal corridors are Soft Marine Clays formed by the deposits and generally weak and possesses high deformation values in nature. It is essential to study the various techniques for the improvement of marine clays and red soils, especially in case of infra-structure development.

Shridharan A et.al (1989), reported the Engineering properties of Cochin and Mangalore Marine Clays. A research has been done on the Physico-Chemical effects on the engineering behavior of Indian marine clays by Rao, M.S et.al (1992)

Thiam-Soon et al (2002), reported on improving the strength of the marine clay by the stabilization technique. Chu, J et.al (2002), reported the consolidation and permeability properties of the Singapore marine clay based on the laboratory and field investigations.

Balasubramaniam, A.S et.al (2003), proved the effects of additives on Soft Clay behavior and concluded that the strength characteristics of the soft clays are improved by using various additives.

Oh, E.Y.N et.al (2006), presented the engineering properties and the characterization of marine clay for road embankment design in coastal area and the engineering properties of the marine clay were improved using various stabilization techniques.

MatchalaSuneel et.al (2008), represented the compressibility characteristics of Korean marine clay. W.L.

Sing et.al (2008), reported an improvement in the engineering properties of peat soils stabilizing with cement and ground granulated blast furnace slag and proved a remarkable increase in the pH and unconfined compressive strength, significant reduction in linear shrinkage, compressibility and permeability of the stabilized peat soils.

Basack,S et.al (2009), reported that the Engineering characteristics of marine clay collected form Visakhapatnam, India and the physical, chemical and mineralogical properties were presented and the strength, stiffness of the soil water matrix were established.

D. KoteswaraRao et al.(2011) studied the efficiency of CaCl2,KCl,GBFS with marine clay and the test results concluded that load carrying capacity of the marine clay foundation soil bed has been improved.

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Thomas et al (2017) studied the effect of alkali activated GGBS and enzyme as compared to ordinary Portland cement (OPC) on the soil. They found that with increase of dosages of enzyme deceases the MDD and increase the OMC. After 28days of curing UCS and shear parameter increases.

Maharana et al (2018) studied the effects of terrazyme on atterberg limits, compaction characteristics and shearing characteristics. They found that liquid limit decreases from 48% for original untreated soil to 37% for treated soil, while plastic limit reduces from 26% to 17% with decrease in plasticity index from 22% to 19%. UCS value increase from 102.32 kPa to 637.58 kPa when compared to the original soil after 28 days of curing periods.

2.2 STABILIZATION

Soil stabilization may be defined as a modification of an existing soil so as to improve its bearing or load absorbing characteristics. Such an effect may be accomplished by mechanical consolidation (compaction) or by the incorporation within the soil of certain additives which would provide the desired qualities of permanent stability. Ever since the beginning of road building, it has been recognized that some soils were extremely unstable, particularly in the presence of moisture, and that other soils were stable and would support traffic with less deformation.

METHODS OF SOIL STABILIZATION

- Mechanical Stabilization.
- Soil Cement Stabilization.
- Soil Lime Stabilization.
- Soil Bitumen Stabilization.
- Thermal Stabilization.
- Chemical Stabilization.

III. METHODOLOGY

The methodology of this project is carried out by collection of brown clayey soil sample from proposed area and various tests on soil have been performed as per IS (2720) on red soil and marine clay with proportion of Terrazyme. Based on test reports various discussions have been present as per the strength variations criteria.

The various physical properties of soil were assessed using methods below given in different parts of Indian standards (IS 2720). The specific gravity, grain size analysis, atterberg limits and shrinkage limits were derived as per the methods given in IS 2720: part 3(1980), IS 2720: part (1980), IS 2720: part 5(1980),IS 2720: part 6(1972) respectively. Compaction test as per IS 2720: part 7(1980) was performed to determine optimum moisture content and maximum dry density of the soil specimen.

In this chapter, a brief description of the experimental procedures adopted in this investigation and the methodology adopted during the course of study are briefly presented.

MATERIALS USED AND THEIR PROPERTIES

3.1 RED SOIL

The soil used was collected from Orissa region at 1.0m depth is used for the study. The red soil was sealed in the air tight plastic bags and transported to the college laboratory for testing. After collecting the soil is dried for 2 weeks. The properties of soil are presented in the Table All the tests carried on the soil are as per IS specifications.

Table 3.1 shows properties of soil.

S. NO.	PROPERTY	VALUE
1	Specific gravity	2.66
2	Atterberg's Limits	
	i) Liquid limit (%)	34.2
	ii) Plastic limit (%)	26
	iii) Plasticity index (%)	8.2
2	Grain Size Distribution	
	i) Sand Size Particles (%)	47.8
	ii) Silt & Clay Size Particles (%)	27.3 & 23.2
3	Classification	Well graded coarse grained soil
4	Compaction Parameters	
	i) Max. Dry Density (kN/m^3)	18.78
	ii) Optimum Moisture Content (%)	18.51
5	Penetration Parameters	
	i) CBR (%)	6
6	Unconfined compressive strength (kPa)	123

3.2 Marine clay

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.
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 3.1. All the tests carried on the soil are as per IS specifications.

Table 3.1: Properties of Marine Clay

S. No.	Property	Value
1	Specific gravity	2.34
2	Differential free swell Index (%)	33
3	Atterberg's Limits	
	i) Liquid limit (%)	72.2
	ii) Plastic limit (%)	25.1
	iii) Plasticity index (%)	47.1
5	Grain Size Distribution	
	i) Sand Size Particles (%)	10
	ii) Silt & Clay Size Particles (%)	90
6	IS soil classification	CH
7	Compaction Parameters	
	i) Max. Dry Density (kN/m^3)	16.2
	ii) Optimum Moisture Content (%)	15.16
8	Penetration Parameters	
	i) CBR (%)	3
9	Unconfined compressive strength (kPa)	75

3.3 TERRAZYME

Terrazyme is a natural, non-toxic, non-flammable, noncorrosive liquid enzyme formulation fermented from vegetable extracts that improves the engineering properties of soil. A commercially available organic, enzyme based stabilizer known as Terrazyme is used as additive to the soil. This bio-enzyme has been collected from the Avijeet Agencies (P) Ltd ,Visakhapatnam, India. Terrazyme is added to the control soil samples in three different dosages such as 0.5 ml, 1 ml and 1.5 ml for every 5 kg of the soil samples. The mixed and prepared soil samples have been kept aside for a curing periods of 1 day and 7 days. The required bio-enzyme is taken in a hydraulic syringe and applied to the soil. Then, the soil mixed thoroughly in such a way that the applied bio-enzyme is evenly distributed throughout the soil sample. Two sets of modified soil samples for each soil in all the three dosages of bio-enzyme are prepared. One set has been kept aside for the curing period of 1 day. The other set has been kept for the curing period of 7 days.

IV. LABORATORY EXPERIMENTATION

The soil was initially air dried prior to the testing. The tests were conducted in the laboratory on the marine clay to find the properties of virgin marineclay.

- Grain sizedistribution
- Specificgravity
- Index properties –liquid limit, plasticlimit
- Compaction tests
- Penetration tests-California bearing ratiotest.
- Unconfined CompressionTest-Triaxial

V. RESULTS AND DISCUSSIONS

5.1GENERAL

In the laboratory, various experiments were conducted by adding different percentages of Terrazyme in the soil samples and Compaction, Strength and CBR tests were conducted with a view to determine the optimum combination of Terrazyme as admixtures in red soil and marine soil.

The influence of the above said materials on the Compaction and Strength characteristics were discussed in following sections. In the laboratory, all the tests were conducted per IS codes of practice. Experimental Investigations have been carried out on red soil and marine soil with the addition of varying percentages of Terrazyme (0.5%, 1% and 1.5%). The specific gravity, Atterberg limits, compaction, unconfined compressive strength (UCS), consolidation and swelling characteristics of soil samples was determined according to the Indian Standards.

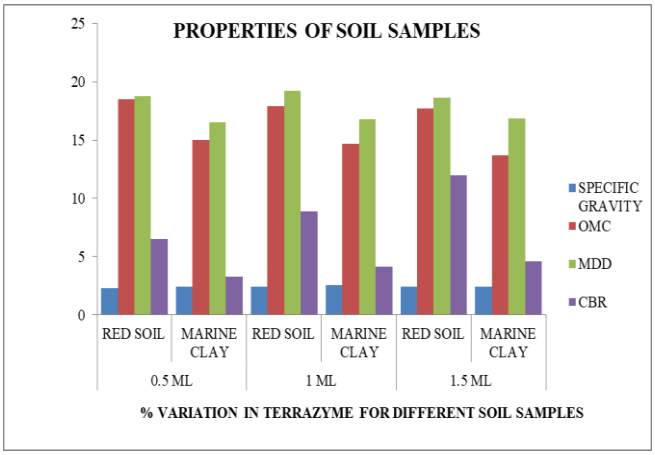

Fig.5.1 shows the Variation in properties of Red soil and Marine clay at percentages of terrazyme for 1 DAY cuing

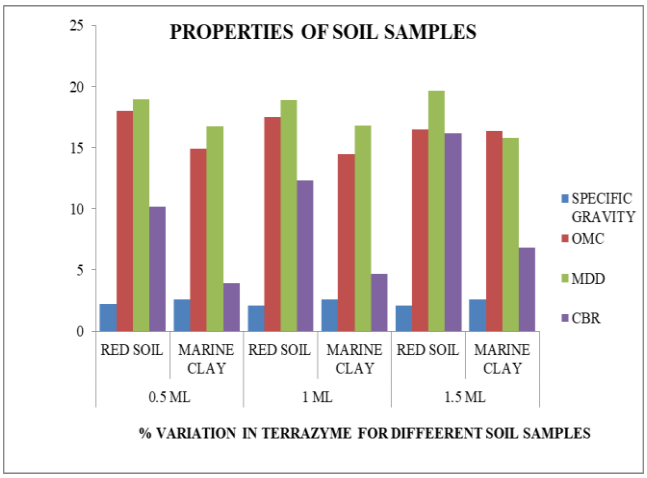

Fig.5.2shows the Variation in properties of Red soil and Marine clay at percentages of terrazyme for 7 DAY cuing

5.2 EFFECT OF % TERRAZYME ON THE COMPACTION PROPERTIES OF RED SOIL AND MARINE CLAY

The above figure shows the variation in Compaction properties for different percentages of terrazyme added to red soil cured for 1 day and 7 days. The percentage of terrazyme was varied from 0 ml to 1.0 ml with an increment of 0.5ml. From the graphs, it was observed that the treatment of red soil with terrazyme shows that the maximum dry density of the modified samples treated at 7 days has more than that of samples treated at 1 day.

Figures shows the variation Compaction properties for different percentages of terrazyme added to marine clay cured for 1 day and 7 days. The percentage of terrazyme was varied from 0 ml to 1.0 ml with an increment of 0.5ml. From the graphs, it was observed that the treatment of marine soil with terrazyme shows that There is no significant difference in the maximum dry density.

5.3 EFFECT OF % TERRAZYME ON THE STRENGTH PARAMETERS OF MARINE CLAY AND RED SOIL

Figure shows the variation in CBR values for different percentages of terrazyme added to red soil cured for 1 day and 7 days. The percentage of terrazyme was varied from 0 ml to 1.0 ml with an increment of 0.5ml. From the graphs, it was observed that the treatment of red soil with terrazyme shows that the CBR values of modified samples have more prounceed in 7 days CBR values when compared to that of 1 day CBR values.

Figure shows the variation in CBR values for different percentages of terrazyme added to marine clay cured for 1 day and 7 days. The percentage of terrazyme was varied from 0 ml to 1.0 ml with an increment of 0.5ml. From the graphs, it was observed that the treatment of marine soil with terrazyme shows that the CBR values of modified samples have shown tremendous increment in 7 days CBR values when compared to that of 1 day CBR values but the effect of terrazyme on red soil is more when compared to marine clay. The same is happened in case of UCS Values also. From the figures it was observed that The UCS values of modified samples have been increased linearly, both in terms of dosage and curing periods for both the soils but the values are more for red soil compared to marine clay.

VI. CONCLUSIONS

The following conclusions are made based on the laboratory experiments carried out in this investigation. In this study, based on the laboratory investigation, a series of test were performed to study the effect terrazyme on the strength behaviour of red soil samples and marine soil samples.. Based on the results presented in this paper, the following conclusions are made:

From the laboratory studies done on control soil samples, it is observed that the marine clay and red soil chosen was a problematic soil and it was also observed that red soil and marine clay treated with terrazyme has moderately improved the properties of soils.

RESULTS OF RED SOIL SAMPLES

- The addition of terrazyme to the red soil decreased liquid limit and plasticity index. The optimum moisture content (OMC) was found to decrease while the maximum dry density (MDD) increased with increasing with binding content. The optimum moisture content of the modified samples has decreased slightly with increase of bioenzyme dosage. The maximum dry density of the

modified samples treated at 7 days has more than that of samples treated at 1 day.

- CBR and Unconfined compressive strength (UCS) tests were conducted with terrazyme added independently and blended to the red soil samples. The UCS values of modified samples have been increased linearly, both in terms of dosage and curing periods. The CBR values of modified samples has shown significant increment in 7 days when compared to that CBR values of 1 day.
- Enzyme stabilization works very effectively on clay particle, it reduces the stabilization time.

RESULTS OF MARINE CLAY SAMPLES

- The results presented that the type and amount of additives play a crucial role in the stabilization process. It is immensely important to select the additive based on different properties, and there chemical composition is the most important among these properties.
- The specific gravity of the treated marine clay with terrazyme have no significant changes when compared to specific gravity of the control sample. The OMC of the modified samples has decreased slightly with increase of terrazyme dosage.
- The MDD of the modified samples has no significant difference. The UCS values of modified samples have been increased linearly and decreased when treated with1.5 ml dosage of bio-enzyme (1 day). The UCS values of modified samples treated with various dosages (7 days) have been linearly increased.
- The CBR values of modified samples have shown tremendous increment in 7 days CBR values when compared to that of 1 day CBR values.
- It is found that the modified samples has enough CBR value and they are categorised as Fair-Poor material. Hence, fair combination of material (Marine Soil + 1.5 ml Bio-enzyme + 7 days) can be used as the soil subgrade material for the highway pavements.

REFERENCES

[1] PuneetAgarwal and SuneetKaur. 2014. Effect of Bio-Enzyme Stabilization on Unconfined Compressive Strength of Expansive Soil. International Journal of Research in Engineering and Technology (IJRET), 3(5), 30 - 33.

[2] A.U. Ravi Shankar, Harsha Kumar Rai and RameshaMithanthaya I. 2009. Bio-Enzyme Stabilized Lateritic Soil as a Highway Material. Journal of the Indian Roads Congress, Paper No. 553, 143 – 151.

[3] H.N. Ramesh and Sagar S.R. 2015. Effect of Drying on the Strength Properties of Terrazyme Treated Expansive and Non-Expansive Soils. 50th Indian Geotechnical Conference, 1 – 12.

[4] Alan F. Rauch, Jacqueline S. Harmon, Lynn E. Katz and Howard M. Liljestrand. 2012. Measured Effects of Liquid Soil Stabilizers on Engineering Properties of Clay. Transportation Research Board, Paper No. 2 – 3244, 33 - 41.

[5] Usha Patel, Shalini Singh and ShivaniChaudhari. 2018. Improvement of Strength Characteristics of Bio-Enzyme Terrazyme Treated Expansive Soil by Gypsum as an Additive, International Journal of Advance Research and Innovative Ideas in Education (IJARIIE), 4(2), and 1005 - 1012.

[6] Rajesh Prasad Shukla, Niraj Singh Parihar Stabilization of Black Cotton Soil Using Micro-fine Slag J. Inst. Eng. India Ser. A (September 2016) 97(3):299–306 DOI 10.1007/s40030-016-0171.

[7] R.P. Shukla, N. Parihar, R.P. Tiwari, B.K. Agrawal, Black cotton soil modification using sea salt. Electron. J. Geotech. Eng. 19, 8807–8816 (2014).

[8] G. P. Ganapathy, R. Gobinath, I. I. Akinwumi, S.Kovendiran Bio-Enzymatic Stabilization of a Soil having Poor Engineering Properties, Int J CivEng (2017) 15:401–409 DOI 10.1007/s40999-016- 0056-8.

[9] Brazetti R (1998) Considerations about the influence of different additives in organic micromorphological, mineralogical, physical, mechanical and hydraulics characteristics of a lateritic soil. EscolaPolitecnica de Sao Paulo, Sao Paulo.

[10] Brazetti R, Murphy SR (2001) Objective performance measurement of actual road sites treated with an organic soil stabilizer. In: First road transportation technology transfer conference in Africa, Dar Es Salaam, Tanzania.

[11] Guthrie WS, Simmons DO, Eggett DL (2015) Enzyme stabilization of low-volume gravel roads. Transp Res Rec J Transp Res Board 2511:112–120.

[12] Isaac KP, Biju PB, Veeraragavan A (2003) Soil stabilization using bio-enzyme for rural roads. In: Integrated development of rural an arterial road networks for socio-economic development, Delhi.

[13] SravanMuguda and H. B. Nagaraj, Effect of enzymes on plasticity and strength characteristics of an earthen construction material, Muguda and Nagaraj Geo-Engineering (2019) 10:2

[14] Mahesh G. Kalyanshetti, SatishBasavarajThalange, ”Effect Of Fly Ash On The Properties Of Expansive Soil” International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013 ISSN 2229-551.

[15] Pratik Somaiya, YashwantZala, RushikeshDangar, “Stabilization Of Expansive Soil Using Fly Ash”. SudheerChoudari and Y. BhargavaGopi Krishna “Effect Of Flyash On Compaction Characteristics Of Expansive

Soils, Nearanandapura, Visakhapatnam, Andhra Pradesh, India" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 4 Issue 03, March-2015.

[16] Magdi M. E. Zumrawi, Mohammed H. Mohammed "Effect of Fly Ash on the Characteristics of Expansive Soils in Sudan".

[17] Vijay Rajoria, SuneetKaur, "A Review on Stabilization of Soil Using Bio-Enzyme" International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321- 7308.

[18] G. P. Ganapathy, R. Gobinath, I. I. Akinwumi, S.Kovendiran Bio-Enzymatic Stabilization of a Soil having Poor Engineering Properties, Int J CivEng (2017) 15:401–409 DOI 10.1007/s40999-016- 0056-8.

[19] Gowshik, A. V. KarthickRajeshwar, M. Mohanasundram, "Experimental Study Of Expansive Soil Stabilized With Terrazyme" International Journal of Engineering Research & Technology (IJERT).

[20] Ansu Thomas, R. K. Tripathi, L. K. Yadu, A Laboratory Investigation of Soil Stabilization Using Enzyme and Alkali-Activated Ground Granulated Blast-Furnace Slag, Arabian Journal for Science and Engineering (2018) 43:5193–5202.

[21] IS 2720-Part XL: Methods of test for soils – Determination of Free Swell Index of Soils, Bureau of Indian Standards, New Delhi (1977).

[22] IS 2720-Part 5: Methods of test for soils – Determination of Liquid Limit and Plastic Limit, Bureau of Indian Standards, New Delhi (1985).

[23] IS 2720-Part 6: Methods of test for soils – Determination of Shrinkage Factors, Bureau of Indian Standards, New Delhi (1972).

[24] IS 2720-Part 10: Methods of test for soils – Determination of Unconfined Compressive Strength, Bureau of Indian Standards, New Delhi (1991).

[25] IS 2720-Part 16: Methods of test for soils – Laboratory Determination of CBR, Bureau of Indian Standards, New Delhi (1987).