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A STUDY ON SATURATION ON SOIL SUBGRADE STRENGTH USING NATURAL AND SYNTHETIC ADDITIVES IN ROADS

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ABSTRACT:

This study aims to have an experimental investigation to check the enhancement in the properties of highly compressible or expansive clay soil reinforced with randomly oriented natural and synthetic fibers such as coir fiber and nylon tyre-cords respectively. The demand for transportation leads to increase in roadways, railways, airways and waterways. Except waterways the other means of transports requires good pavement with high subgrade strength. In place of highly compressible or highly expansive soil the achievement of good subgrade strength is the challenging task. In order to improve the strength of the soil various methods have been adopted. The area chosen for investigation was urban roads of Telangana district. Consistency limits identified were used in classification of soil as per IS standards. The Engineering properties of soil sample collected were investigated by treating it with these fibers as additives in the percentage of 0.1%, 0.2%, 0.3% and 0.4%. The Engineering properties includes maximum dry density, unconfined compressive strength and California bearing ratio were determined in the laboratory for both soil treated with and without fibers. The focus on this research is on the improvement of engineering properties of two natural residual soils and mixed with different proportions of liquid chemical. Series of laboratory test on engineering properties, such as Modified Proctor Test, Consistency limits, moisture-density relationship (compaction) and California Bearing Ratio was undertaken to evaluate the effectiveness and performances of this chemical as soil stabilizing agent.

Keywords: High way crash analysis, infrastructure, residents.

1. INTRODUCTION

The Flexible Pavement Design System is known in the Department designates this as the eleventh major version of the system. The Test was extensive in its test features and produced design concepts for both flexible and rigid pavements. The major accomplishment, possibly, of the Road Test was the defining of the serviceability concept or the ability of a pavement to serve traffic for which it was designed. There was one major flaw in the Road Test concept. The demand for transportation leads to increase in roadways, railways, airways and waterways. Except waterways the other means of transports requires good pavement with high subgrade strength. In place of highly compressible or highly expansive soil the achievement of good subgrade strength is the challenging task. In order to improve the strength of the soil various methods have been adopted. The ground improvement by additives is the evolution of recent researches, which

includes both natural and manmade synthetic materials Also reduction of dump wastes, is also essential for the eco-friendly environment. Waste dump material found in abundant and also can be used as an additive for the stabilization of expansive soil includes quarry dust, ceramic dust, fly ash, reinforcement concept by various fibers in various proportions. Of which the soil reinforcement by natural or synthetic fibers are the findings of recent research. The present study includes the utilization of Coir fiber, Tyre cord fiber and Bio enzyme in the stabilization of expansive soil thereby enhancing the subgrade strength by improving the geotechnical properties and economization by reducing the thickness of subgrade. (Black soil) of Telangana districts. The reason behind the selection of these area was due to its high expansive or compressible in nature. The main aim of this experimental study is to enhance the geotechnical properties of these sites by soil reinforcement through randomly oriented fibers and designing the reduced thickness of the subgrade.

General:

Over the past few decades several factors have led to an increase in the number of people migrating to large cities. Consequently these large cities are getting over populated and quite expectedly necessity of business, residential construction has increased the civil engineering projects located in areas with unsuitable soil is one of the most common problems in many parts of the world. The unsuitable soil (Black cotton Soil) can be stabilized by performing soil stabilization. In India black soil is the most problematic soil when it comes to construction. In rainy season black cotton soil swells and become sticky. Whereas in summers the moisture present in the soil evaporates and soil shrinks resulting in the crack of approximate 10 to 15 cm wide and up to 1 meter deep. The percentage covered by black cotton soil in geotechnical areas of India is 16.6%, which says huge amount of soil in India needs stabilization. Mechanical, chemical, electrical, thermal and other methods are in practice to improve the engineering properties of soil. In developing countries like India the biggest handicap to provide a complete network of road system is the limited finances available to build road by the conventional methods. Therefore there is a need for low cost road construction to meet the growing needs of the road traffic. The construction cost can be considerably decreased by selecting local materials including local soils for the construction of the lower layers of the pavement such as the embankment and sub-base course. If the stability of the local soil is not adequate for supporting wheel loads, the properties are improved by soil stabilization techniques. Thus the principle of soil stabilized road construction involves the effective utilization of local soils and other suitable stabilizing agents.

Types of Soil

Black cotton soil:

In this study, the soil under scrutiny was gathered from the vicinity of Flora Institute Of Technology, Pune. At first, so as to distinguish the wide soil sorts in the field with no research facility testing, a visual characterization is done, which demonstrates that soil under scrutiny is brown in shading, further examination is completed with water to make a paste and rubbed in middle of fingers leaves a stain which is not watched for residues. When it is wet it doesn't get to be dry soon. In like way, display swelling and shrinkage and are described by a typical shrinkage pattern. The soil has an expansive surface zone because

of level and lengthened molecule shapes that stick together when wet, avoiding typical waste procedures. When it is wet it doesn't get to be dry soon. In like way, when completely dry, it is not soon wetted and shrinks causing breaks.

Red soil: Red soil is derived from weathering of ancient metamorphic rock of the Deccan plateau. Red soil is any of a group of soil that grows in a humid temperature, moist climate under deciduous and mix forests and that have raw mineral. Thin organic layers overlying a yellowish brown leached deposit resting on an alluvial. Their colour is mostly ferric oxides occurring a slight coatings on the soil particle through the iron oxide arise as hematite as hydrous ferric oxide, the colour is red and when it happen in the hydrate system as limonite the soil become to be yellow colour. Generally the surface soils are red while the horizon under gets yellowish colour.

River sand:

Sand is natural occurring granular material composed of finely divided rock & mineral particles. It is defined by size, being finer than gravel & coarser than silt. Sand can also refer toward textural class of soil or soil type that is a soil containing more than 85% sand size particles (by mass). The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO_2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.

Pavement Layers:

The uppermost layer of a pavement is the wearing course a typical pavement design may have up to 5 layers above the foundation level The wearing course directly carries the traffic and is the most highly stressed layer that is typically highly abrasion resistant, readily sheds water to designed drainage channels and resists penetration of water to lower levels. Immediately below the wearing course is the base layer, which can comprise of a stabilized granular layer for flexible pavement or concrete (typically having a compressive strength of 35 MPa) in a rigid pavement design. The base layer is the strongest part of the pavement. The base layer in a flexible pavement design can be a material stabilized using cement or lime to provide enhanced structural properties. Such materials fall under the broad classification of road bases that are defined as granular materials which when correctly placed and compacted form a stiff pavement layer in road construction The next layer down is the sub base, which can be a road base material or a lean mix concrete, usually having a compressive strength at 28 days of 5 MPa. Beneath the sub base is a layer of select fill known as sub grade. This is usually won from a nearby quarry and is produced to meet a minimum performance level. Lower again is a sub grade that is usually produced from material excavated on the site during construction of the road. Finally there is the foundation layer, which is typically the original site material with topsoil and other low strength materials removed.

2. LITERATURE SURVEY

G.W., Yeo, R., Sharp, K.G. (1995) Noise and vibration are of concern with many mechanical systems, including industrial machines, home appliances, vehicles, Noise and vibration can also be used as the source of signals for machinery diagnostics and health monitoring, although this topic will not be discussed here.4,5 Once noise and vibration sources have been identified, the noise and vibration of machinery can be reduced by the use of vibration isolation, barriers, sound-absorbing materials, Sound-absorbing materials have been used increasingly in the construction of aircraft, spacecraft and ships because of their low weight and effectiveness when used correctly. This trend is driven by demands for higher load capacity and reduced fuel consumption for cars, trucks and aerospace structures. This has been due mainly to both improve technology and public concern about noise in everyday life. Architects and acoustical engineers now have a wide choice of sound-absorbing materials that not only provide the desired acoustical properties, but also offer an extremely wide variety of colors, shapes, sizes, light reflectivity, fire ratings, and methods of attachment – to say nothing of the costs of purchase, installation, up keep

P. Taylor and M. Balat. (2011) Most of the porous sound-absorbing materials commercially available are fibrous. Fibrous materials are composed of a set of continuous filaments that trap air between them. They are produced in rolls or in slabs with different thermal, acoustical, and mechanical properties. Fibers can be classified as natural or synthetic (artificial). Natural fibers can be vegetable (cotton, kenaf, hemp, flax, wood, etc.), animal (wool, fur felt) or mineral (asbestos). Synthetic fibers can be cellulose (bamboo fiber, for example), mineral (fiberglass, mineral wool, glass wool, graphite, ceramic, etc.), or polymer (polyester, polypropylene, Kevlar, etc.). Synthetic fibrous materials made from minerals and polymers are used mostly for sound absorption and thermal isolation. However, since they are made from high-temperature extrusion and industrial processes based on synthetic chemicals, often from petrochemical sources, their carbon footprints are quite significant. Recently, the use of natural fibers in manufacturing sound absorbing materials has received much attention

Kim,S. Jung, and J. Kim. (2010) Natural fibers are essentially completely biodegradable and modern technical developments have made natural fiber processing more economical and environmentally friendly. These new methods may result in increased use of high-quality fiber at competitive prices for industrial purposes. The absorption properties of sound-absorbing materials made of these fibers can be similar to those made from minerals. These properties can be modified by pre-treatments such as drying, carbonizing, impregnation, and mineralization. In addition, natural fibers are also safer for human health compared with most mineral synthetic fibers, since they do not need precautions in handling. An important microscopic parameter of a fiber is its diameter. The fiber diameter is directly related to the sound-absorbing characteristics of the material. Table 1 shows a comparison of the average fiber diameters of several types of industrial fibers measured using electronic microscopy techniques. In general, the diameter of natural fibers tends to be larger than the diameter of synthetic fibers obtained by extrusion. some scanning-electron micro scope images of samples of hemp, cotton and polyester fibers. It is evident that natural fibers have more irregular shapes and variable diameters compared to synthetic fibers.

C.N.V. Satyanarayana Reddy and N.V (2004) Changes in the biosciences and their relations to society over the last decades provide a unique opportunity to examine whether or not such changes leave traces in the language we use to talk about them. In this article we examine metaphors used in English-speaking

press coverage to conceptualize a new type of (interdisciplinary) bioscience: synthetic biology. Findings show that three central metaphors They exploit social and cultural knowledge about books, computers and engines and are linked to knowledge of three revolutions in science and society These three central metaphors are connected to each other through the concepts of reading/ writing, designing and mass production and they focus on science as a revolutionary process rather than on the end results or products of science. Overall, we observed the use of a complex bricolage of mixed metaphors and chains of metaphors that root synthetic biology in historical events and achievements, while at the same time extolling its promises for the future.

T. Gnanada Rao and C.N.V. (2014) Synthetic biology is a new field of study which has its roots in a wide range of disciplines, approaches and traditions, each using quite different Did the collaboration and integration of many different disciplines within synthetic biology, which is hailed by some as the next industrial revolution, contribute to a revolution in the use of metaphors or lead to the construction of new metaphors However, there are discontinuities too in the language and framing, between for example the Human Genome Project, billed as enabling us to read the book of life and synthetic biology which, at least according to Venter, should enable us to move "from reading the genetic code to writing it Apart from this reversal in metaphorical direction, there are other differences, relating, not entirely surprisingly, to the aims and the methods used in synthetic biology, of which many are rooted in mechanical and computer engineering. Another, more important, difference emerges in the promises that are made around this new field. Instead of promising to cure all human ills, as was implicit in promoting the Human Genome Project, the focus here is more on curing the ills of the planet

3. RELATED STUDY

Soil is the essential component of this nature and road development industry knows the significance of it for pavement work. India is confronted with the colossal test of protecting and upgrading the transportation framework to meet the constantly expanding hassles because of heavier burdens delivering layers to the hidden soil. Roads running through expansive soil regions are subjected to severe distress resulting in poor performance and increased maintenance cost. An imperative step is being taken by this study to accomplish monetary utilization of development materials by endeavoring to keep the wastage of soil material through the change of its properties to meet the prerequisites of pavement configuration from its planned utilization. Chemical stabilization of expansive soil comprises of changing the physico-synthetic around and within clay particles where by the earth obliges less water to fulfill the static imbalance and making it troublesome for water that moves into and out of the framework so as to fulfill particular designing road ventures and administration life of the asphalt. The most widely recognized chemical admixtures utilized as a part of soil adjustment are terrasil and zycobond

Flexible pavement designs will provide the following:

- Sufficient compaction of the subgrade and of each layer during construction to prevent objectionable settlement under traffic
- Adequate drainage of base course

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- Adequate thickness above the subgrade and above each layer together with adequate quality of the select material, sub base, and base courses to prevent detrimental shear deformation under traffic and, when frost conditions are a factor, to control or reduce to acceptable limits effects of frost heave or permafrost degradation.
- A stable, weather-resistant, wear-resistant waterproof, non-slippery pavement

Materials:

The materials for this study includes the soil sample collected from the two village roads of Telangana District, soil reinforcement by Coir fibers from coconut and Nylon tyre cord fibers extracted from the waste tyres. Nontraditional stabilizer Bio enzyme was also used as an additive for stabilization.

Bio-Enzyme:

One commercially available Bio-enzyme has been used in the present investigation. It is available as a concentrated liquid and is to be diluted with water in specified proportion before mixing with the soil. The manufacturer's information available for this product is presented in Table According to the literature, when mixed with water and applied, the enzyme solution combines the inorganic and organic material in the soil through a catalytic bonding process, producing a "cementation" action. Soil stabilization using enzymes is a relatively new approach to soil improvement.

Enzyme promotes the development of cementations compounds using the following, general reaction. The organic cation also reduces the thickness of the electrical double layer. This allows the enzyme treated soils to be compacted more tightly together.

Figure: Coir Fiber

Figure: Nylon Tyre Cord fiber

Enzyme promotes the development of cementitious compounds using the following, general reaction. The organic cation also reduces the thickness of the electrical double layer. This allows the enzyme treated soils to be compacted more tightly together

4. METHODOLOGY

High-quality materials must be used in base courses of flexible pavements. These high-quality materials provide resistance to the high stresses that occur near the pavement surface. Guide specifications for graded crushed aggregate, lime rock, and stabilized aggregate may be used without qualification for design of roads, streets, and parking areas. Guide specifications for dry- and water-bound macadam base courses may be used for design of pavements only when the cost of the dry- or water-bound macadam base does not exceed the cost of stabilized-aggregate base course, and the ability of probable bidders to construct pavements with dry- or water-bound macadam base to the required surface smoothness and grade tolerances has been proved by experience in the area.

Wearing Course:

The wearing course has a number of key functions. It must:-

• Allow water to freely drain from the driving surface to minimize aquaplaning

• Have a high skid resistance which is maintained over time, and

• Minimize moisture penetration to the lower structural layers of the pavement In flexible pavements, wearing courses are normally spray seal, bituminous surfacing or asphaltic concrete. The asphaltic concrete can contain FA as mineral filler. FA can aid in distributing the asphalt binder more evenly through the mix and improves grading of fine aggregate fractions to enhance physical characteristics. With rigid pavements, conventional pre-mixed concrete is used to achieve a stiff and durable product. While concrete normally can have a higher capital cost, it normally achieves a longer service life. Rigid pavements may also be topped with asphalt for noise control. In this instance, FA is used in asphalt as a filler and in concrete as a supplementary cementations material (SCM) In all pavements, water penetration is the biggest threat to premature failure. When pavement layers beneath the wearing course are exposed to water they weaken. If loaded before the water is removed, permanent damage can result. Hence a waterproof wearing course and excellent subsoil drainage will reduce the risk of premature pavement failure.

Base Layer:

The layer directly below the wearing course is described as the base layer which is a highly loaded structural layer. Typically it incorporates crushed rock or gravels that can be placed and compacted under the right moisture conditions to provide a stiff and stable support for the wearing course. The base layer would normally comprise of a blend of specially selected aggregates and finer materials. To minimize transport costs, gravels and aggregates are generally quarried near the site of the road construction. If local materials are inadequate for the intended application, they can be modified or stabilized by the use of additional materials. Imported materials are normally more plastic cementations, or pozzolanic (they harden in the presence of lime). Base layers are often made with concrete having a compressive strength around 35 MPa in addition to other criteria such as flexural strength. Details on FA concretes are available in the technical literature (8, 9). In flexible pavements, FA is commonly used as an additive where it forms part of a binder as a cement stabilized material or is lime stabilized. A cement stabilized base course will utilize

FA as part of the binder in proportions typically 70:30 cement to FA. Cement used alone as a stabilizing binder tends to harden rapidly for pavement applications (typically hardening in a couple of hours following placement) and thus needs to be designed taking this factor into account. Construction typically requires sufficient time for placement and compaction of the road base into the pavement. FA can be blended with the cement to slow the rate of early hydration and thus allow time for placement and compaction of the road base. The compacted FA/cement blend continues to react to stiffen the base layer. Blends of FA and lime are commonly used in the construction of flexible pavement base layers. The FA and lime binder react slowly and gain strength over longer periods of time such that their structural capacity improves. In operation, the base layer will be subject to repeated cycles of loading and unloading and it has to be designed to resist such cyclic loading without deformation over time. The pavement life is usually designed in terms of the number of cycles of loading and unloading. The measurement of load cycles is based on the concept of the Equivalent Standard Axle (ESA) which represents a load of 80 kN on a single axle distributed over 4 truck tyres (2 pairs). Typical design criteria might be 106 ESA's over a 20 year life without failure.

Experimental Programmed:

The results of the experimental study obtained by conducting various tests in the laboratory for determining the enhancement in the geotechnical properties using fibers in different proportions were tabulated and shown in figures.

Standard Proctor Test:

The relevant calculations were carried out and the compaction curve was plotted for the dry density corresponding to moisture content. The maximum dry density is finally obtained from the maximum point of the compaction curve and its corresponding water content, also known as the optimal moisture content.The results obtained for trials with no fibers added, coir fibers and tyre cord fibers in different percentages were shown graphically in figure

Unconfined Compression Test:

Shear strength properties of purely cohesive soil ($\varphi=0$) is determined in the laboratory quickly and easily by using unconfined compression test. The test was conducted for various percentages of coir fiber and tyre cord fiber and these results were compared with unconfined compressive strength of sample without fiber. The test results were shown graphically in figure

California Bearing Ratio Test:

It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25 mm/min. to that required for the corresponding penetration of a standard material.

C.B.R. = {Test load/Standard load} ×100 ……(3)

The test may be performed on undisturbed specimens and on remolded specimens which may be compacted either statically or dynamically. By Conducting a load penetration test in the laboratory the CBR value was determined. The CBR value obtained for both Sample A and B by adding fibers with different percentages were compared with the samples without fiber. The results obtained were shown graphically in figure

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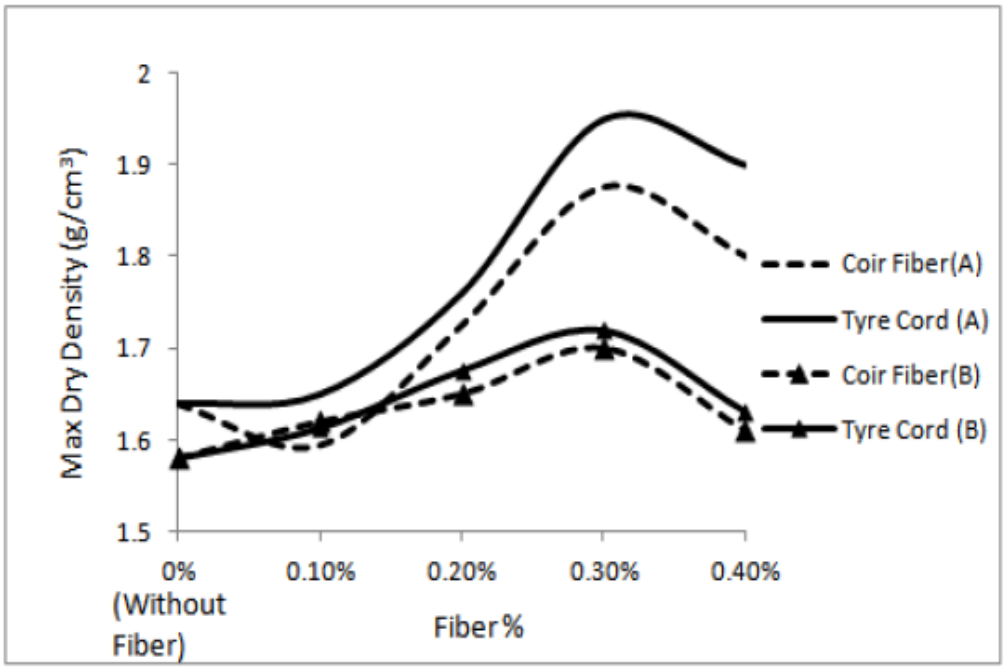
Figure: Proctor Compaction Mould



Graph: Standard Proctor test results

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Figure: Unconfined Compression Strength Test

Design of Sub grade Thickness:

The sub grade thickness was calculated as per IRC recommendation The length of the road was assumed to be 1km and width of the lane as per recommendation.

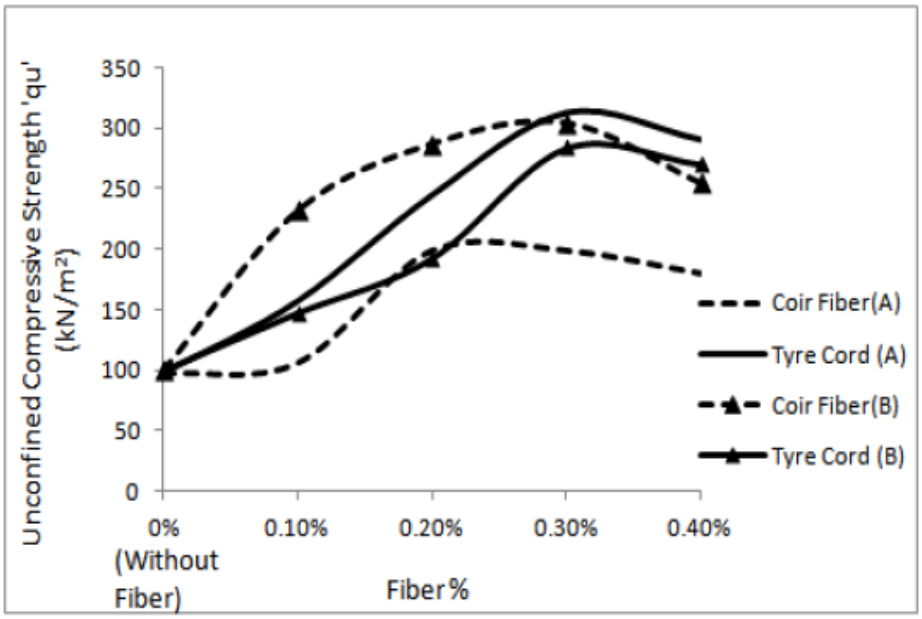

Figure: UCC Test Results

4 RESULTS EXPLANATION

Soil has various meaning, depending upon the general professional field in which it is being considered in general soil mean the top layer of the earth surface in which plants can grow consisting of rocks and minerals particles mixed with decayed organic matter and having the capability retaining water. And thus stabilizing soil gives better bearing capacity

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In conventional method 10% of natural river sand is used as additives to the soil i.e. both red and black cotton soil by weight of soil. All the test such as liquid limit, plastic limit, specific gravity, modified proctor & C.B.R test were performed on respective soils. The soil investigated in this project is collected kukatpally ,Nizampeta, LB Nagar The sample is taken for conducting soil tests. The properties of soil were found from the soil test according to IS 2720. Sieve analysis is done for grain size analysis of the sub grade. Further, uniformly co-efficient and co-efficient of curvature are found. By conducting the pycnometer test, the specific gravity of the soil is determined. Swell index is the increase in volume of a soil, without any external constraints, on submerge in water. The Atterberg's limits are a basic measure of the critical water contents of a fine grained soil, such as its shrinkage limit, plastic limit and liquid limit. The objective of finding Atterberg's limits is to determine the shrinkage and settlement characteristics of soil. Swell index is the increase in volume of a soil, without any external constraint on submerge in water. The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of natural ground, sub grades and base course beneath new carriageway construction.

Red soil Liquid limit:

Red soil with 10% sand

No	I	II	III
No. Of blows	24	25.5	28
Container no	1	2	3
Mass of container + wet soil(g)	25	33	27
Mass of container + dry soil(g)	22.5	28.5	24
Mass of water (g)	2.5	4.5	3
Mass of container (g)(W_1)	16	16	16
Mass of oven dry soil (g)(W_2)	6.5	12.5	8
Water content (%)	38.46	36	37.5

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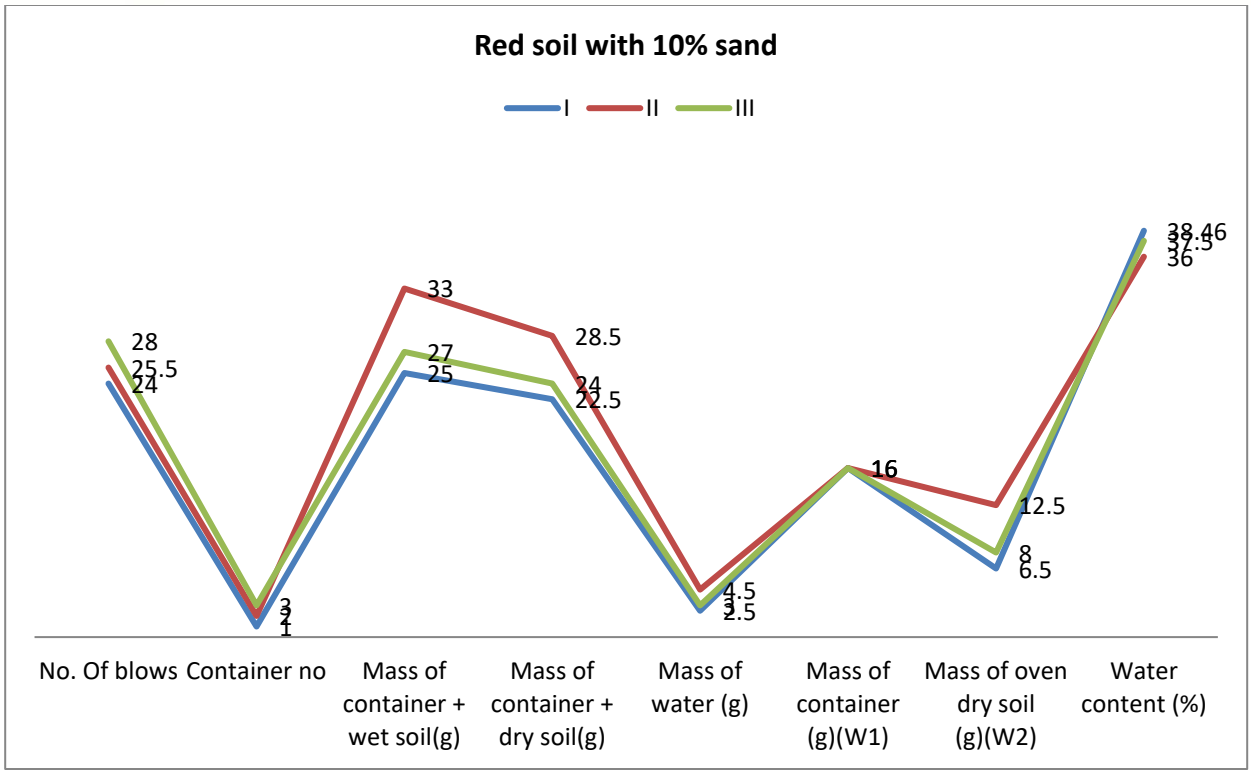

Table: Summary of CBR values Soil properties Nizampeta

Determination no	I	II	III	IV
Wt of mould + compacted soil	8254	5345	5718	5564
Wt of mould	5450	4575	5546	4548
Volume of mould	3250	3247	2250	3756
Wt of compacted soil	3415	4787	4244	5547
bulk density	2.25	2.68	1.88	2.47
Dry density	2.42	2.58	1.70	2.45
Percentage of water use	5	8	7	6

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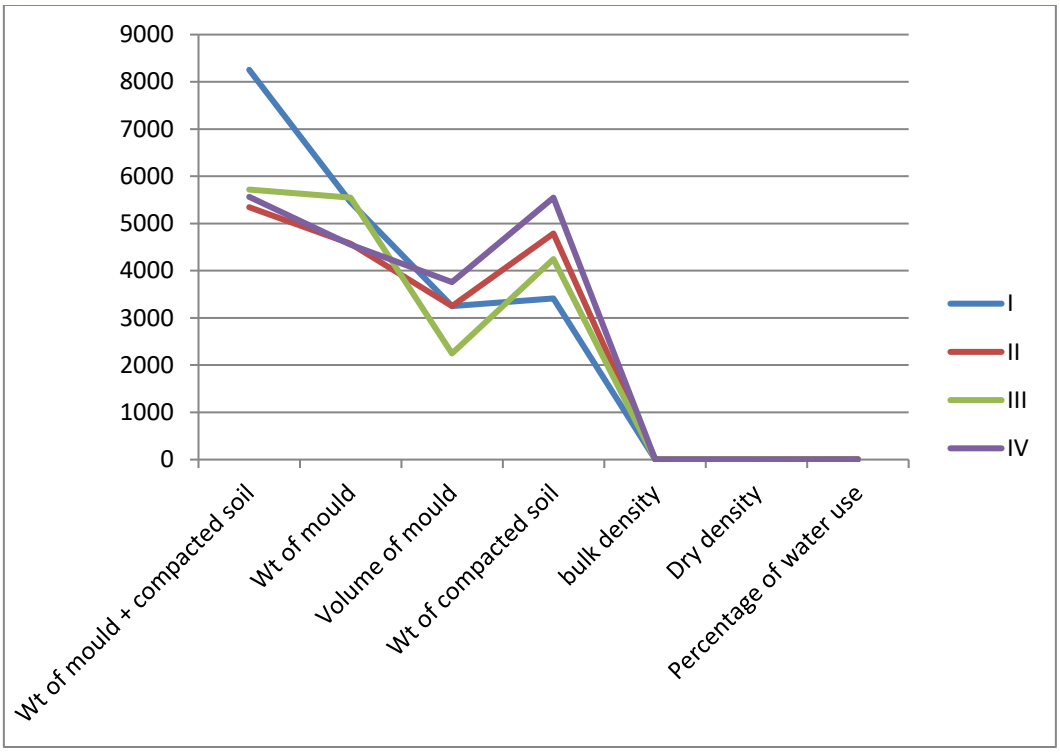

Table: Summary of CBR values Soil properties LB Nagar

Determination no	I	II	III	IV
Wt of mould + compacted soil	9278	8346	6717	7565
Wt of mould	6447	5575	5574	5548
Volume of mould	3250	3247	2250	3756
Wt of compacted soil	3415	5681	4156	4780
bulk density	2.25	2.68	2.88	3.47
Dry density	4.42	4.58	2.70	3.45
Percentage of water use	7	7	8	9

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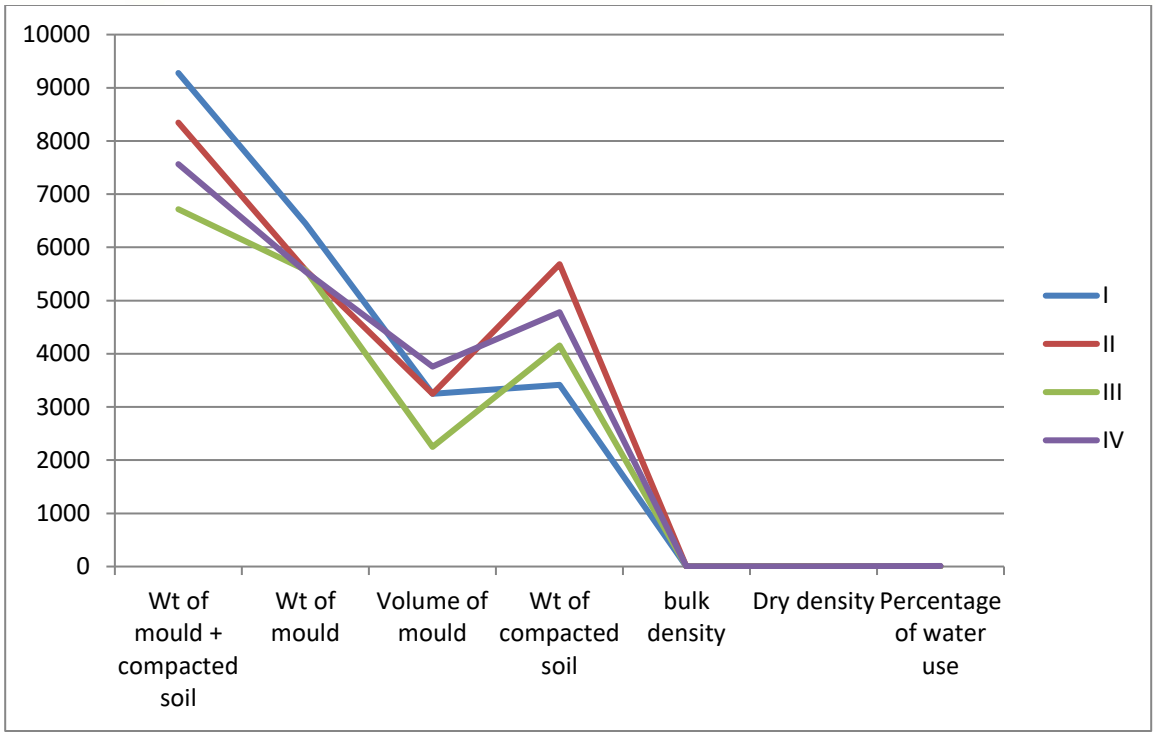

To development and industrialization created the utilization of transportation office to convey business heavier vehicle loads and redundant uses of it subsequently delivering heavier focuses particularly on roads running in clayey soil zones are known for bed condition and unusual conduct for which the way of the clayey soil add to some degree. The disappointments of asphalt in from of hurl dejection splitting and unevenness are brought about by the occasional dampness variety in subgrade soil. Instead of cutting out and replacing the unstable soil, soil adjustment is the only alternative as it saves lot of time and millions of money too. Soil adjustment can be clarified as the change of the soil properties by synthetic or physical means keeping in mind the end goal Roads are the major channel of transportation for carrying goods and passengers which forms the basic infrastructure for the development and economic growth of the country. Construction of such pavements has to be planned and executed carefully and a pavement which is not designed properly deteriorates fast. In Telangana flexible pavements have been widely constructed.

5. CONCLUSION

Thus the study was carried out in three phases and in all three phases the results obtained using the fiber mix and enzyme mix in different percentages showed improved results when compared with the soil without additives.

- Based on the tests conducted for the enhancement in the shear strength properties of soil the subgrade thickness was designed.
- Also the study showed significant results in the reduction of pavement thickness which greatly minimized the requirement of quantity of soil.

- Since it reduces the quantity of soil required by addition of low cost fibers and natural enzymes, the project was proved to be an economic and also ecofriendly by greatly minimizing and reusing the harmful waste at the dumpsites.

To improve the designing nature of the soil properties from road design The fundamental destinations of the soil adjustment are to build the bearing limit of the soil to sustain repetition of vehicle loads, its imperviousness to weathering process and soil penetrability. to investigated from Telangana urban areas soil properties verified from kukatpally, Nizampeta LB Nagar regions chose the graphs to concluded that compared to the two remaining regions LB Nagar region soil properties is very high.

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