A PROJECT REPORT ON

SOIL STABILIZATION USING PLASTIC BAGS AND JUTE BAGS&

CONTROLLING HEAVE BEHAVIOUR OF BLACK COTTON SOIL

UNDER GUIDANCE OF

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<u>CERTIFICATE</u>

I hereby declare that the work presented in the project entitled “**Strength and Stiffness response of Chambaghat soil reinforced with jute fibre& Controlling heave behaviour of Black Cotton soil**” submitted towards the completion of the project in eighth semester at Jaypee University of Information and Technology, Waknaghat, is an authentic record of my original work carried out under the guidance of Mr.SaurabhRawat, Assistant Professor, Department Of Civil Engineering, JUIT, Waknaghat.

I have not submitted the matter embodied in this project for the award of any other degree.

Sign of Supervisor	……………………..
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ABSTRACT

The main objective of this study is to investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste PLASTIC AND JUTE fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests on two different soil samples. The results obtained are compared for the two samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement, as a cost effective approach. For any land-based structure, the foundation is very important and has to be strong to support the entire structure. In order for the foundation to be strong, the soil around it plays a very critical role. So, to work with soils, we need to have proper knowledge about their properties and factors which affect their behavior. The process of soil stabilization helps to achieve the required properties in a soil needed for the construction work .

Keywords: *Plastic and jute waste, cost effective approach, shear strength, soil stabilization, fiber reinforcement.*

INTRODUCTION

Reinforced soil is a composite material which is formed by the association of frictional soil and tension resistant elements in the form of sheets, strips, nets or mats of metal, synthetic fabrics or fiber reinforced plastics and arranged in the soil mass in such a way as to reduce or suppress the tensile strain which might developed under gravity and boundary forces. The reinforcement in soil is placed more or less in the same way as steel in concrete and the end product is called reinforced soil. It is very effectively used for retaining structures, embankments, footings, sub grade etc. The incorporation of reinforcement in the earth mass, particularly in case of non-cohesive soils is not only for carrying the tensile stresses but instead meant for anisotropic suppression or reduction of one normal strain rate. Soil reinforcement technique with randomly distributed fiber is used in a variety of applications like, retaining structures, embankments, footings, pavement sub grade. During last 25 years, much work has been done on strength deformation behavior of fiber reinforced soil and it has been established beyond doubt that addition of fiber in soil improves the overall engineering performance of soil. Among the notable properties that improved are greater extensibility, small loss of post peak strength, isotropy in strength and absence of planes of weakness etc. Fiber reinforced soil has been used in many countries in the recent past and further research is in progress for many hidden aspects of it. Fiber reinforced soil is effective in all types of soils (i.e. sand, silt and clay). Use of natural material such as Jute, coir, sisal and bamboo, as reinforcing materials in soil is prevalent for a long time and they are abundantly used in many countries like India, Philippines, and Bangladesh etc. The main advantages of these materials are they are locallyavailable and are very cheap. They are biodegradable and hence do not create disposal problem in environment.

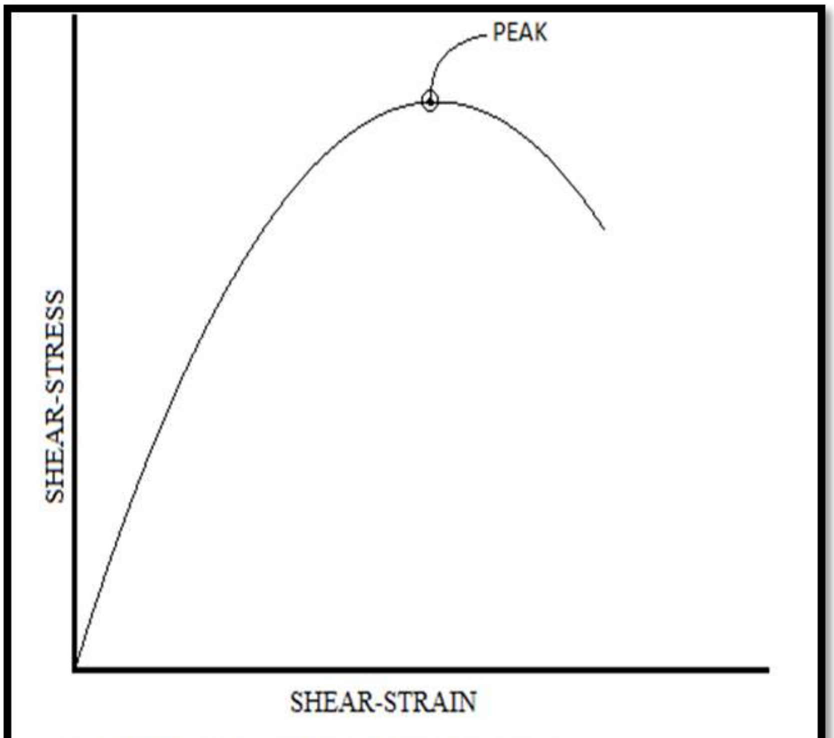
Shear strength is perhaps the most important property of soil. It represents the ability of soil to withstand shear stresses. Unlike normal stresses which, when they are compressive in nature tend to squeeze the soil. Shear stresses tend to displace in a particular direction, a portion of soil in relation to test. Knowledge of shear strength is necessary for solution of large number of problems that a consulting geotechnical engineer encounters. The stability of slopes, natural or man-made, the bearing capacity of foundations, the lateral pressure exerted by soil on retaining walls and similar structures are all dependent on shear strength of soil.

Shear strength is perhaps the most complex engineering property of soil. Unlike other civil engineering materials such as concrete and steel, the shear strength of a soil is not only a function of material but is a function of stresses applied to it, and of course the manner in which these stresses are applied. The shear strength of soil therefore can be tabulated in codes of practice since the same soil can exhibit markedly different shear strength under different field and engineering conditions.

Apart from inherent complexity, the subject of shear strength has had complexity thrust upon, since consulting geotechnical engineers, like other mortals, have mind sets and are often reluctant to revise beliefs when confronted with newer, conclusive but contrary evidence. To understand shear behavior of soil, it is useful to ignore complexity and to concentrate only on first principles so that we have some basic to hold on and to rely upon as we engage in the design process.

Practically soil consists of individual particles that can slide and roll relative to each other. Shear strength of a soil is equal to the maximum value of shear stress that can be mobilized within the soil mass without failure taking place. The failure may be in the form of sinking of footing or movement of wedge of soil behind a retaining wall forcing it to move out or slide in an earth embankment.

Shear strength is term used in soil mechanics to describe the magnitude of shear stress that a soil can sustain. The shear resistance of a soil is result of friction and interlocking of particles and possibly cementation or bonding of particle contacts. Due to interlocking, particulate material may expand or contract in volume as it is subject to shear strains.



TYPICAL STRESS-STRAIN CURVE FOR A DRAINED DILATANT SOIL

The term soil stabilization means the improvement of the stability or bearing power of the soil by the use of controlled compaction, proportioning and or the addition of suitable admixture or stabilizer. The basic principles in soil stabilization may be stated as follows:

1. Evaluating the properties of the given soil.

2. Deciding the method of supplementing the lacking property by the effective and economical method of stabilization.

3. Designing the stabilized soil mix for intended stability and durability values.

4. Considering the construction procedure by adequately compacting the stabilized layers.

For stabilizing soils we will use geosynthetics in our project :

The two main type of geosynthetics used are as follows:

1. Geotextiles
2. Geomembranes

GEOTEXTILE

Itis made of plastic threads that allow water to pass around them, but not very small particles of soil beneath them. Geotextile separates and contains the base from the underlying soil subgrade .Jute is one such example of geo-textile which we will use in our project.

Geotextiles were one of the first textile products in human history. Excavations of ancient Egyptian sites show the use of mats made of grass and linen. Geotextiles were used in roadway construction in the days of the Pharaohs to stabilize roadways and their edges. These early geotextiles were made of natural fibers, fabrics or vegetation mixed with soil to improve road quality, particularly when roads were made on unstable soil. Only recently have geotextiles been used and evaluated for modern road construction. Geotextiles today are highly developed products that must comply with numerous standards. To produce tailor-made industrial fabrics, appropriate machinery is needed

GEOTEXTILES APPLICATION

Civil engineering works where geotextiles are employed can be classified into the following categories –

Road Works: The basic principles of incorporating geotextiles into a soil mass are the same as those utilized in the design of reinforced concrete by incorporating steel bars. The fabrics are used to provide tensile strength in the earth mass in locations where shear stress would be generated. Moreover, to allow rapid dewatering of the roadbed, the geotextiles need to preserve its permeability without losing its separating functions. Its filtration characteristics must not be significantly altered by the mechanical loading.

Railway Works: The development of the railway networks is being greatly boosted by the present state ofeconomy because of their profitability in view ofincreasing cost of energy and their reliability as a result of the punctuality of trains even in the adverse weather conditions. The woven fabrics or nonwovensare used to separate the soil from the sub-soil without impeding the ground water circulation where ground is unstable.

River Canals and Coastal Works: Geotextiles protect river banks from erosion due to currents or lapping. When used in conjunction with natural or artificial enrockments, they act as a filter. For erosion prevention, geotextile used can be either woven or nonwoven. The woven fabrics are recommended in soils of larger particle size as they usually have larger pore size. Nonwovens are used where soils such as clay silt are formed. Where hydrostatic uplift is expected, these fabrics must be of sufficiently high permeability.

Drainage: In civil engineering, the need for drainage has long been recognized and has created the need for filters to prevent in-situ soil from being washed into the drainage system. Such wash in soil causes clogging of the drains and potential surface instability of land adjacent to the drains. The use of geotextiles to filter the soil and a more or less single size granular material to transport water is increasingly seen as a technically and commercially viable alternative to the conventional systems. Geotextiles perform the filter mechanism for drainages in earth dams, in roads and highways, in reservoirs, behind retaining walls, deep drainage trenches and agriculture.

Sports field construction: Geotextiles are widely used in the construction of Caselon playing fields and Astro turf. Caselon playing fields are synthetic grass surfaces constructed of light resistance polypropylene material with porous or nonporous carboxylated latex backing pile as high as 2.0 to 2.5 cm. Astro Turf is a synthetic turf sport surface made of nylon 6,6 pile fibre knitted into a backing of polyester yarn which provides high strength and dimensional stability. The nylon ribbon used for this is of 55 Tex. It is claimed that the surface can be used for 10 hr/day for about 10 years or more. Modern Astro Turf contains polypropylene as the base material.

Agriculture: It is used for mud control. For theimprovement of muddy paths and trails those used by cattle or light traffic, nonwoven fabrics are used and are folded by overlapping to include the pipe or a mass of grit.

FUNCTIONS OF GEOTEXTILES

Every textile product applied under the soil is a geotextile.
The products are used for reinforcement of streets, embankments, ponds, pipelines, and similar applications Depending on the required function, they are used in open-mesh versions, such as a woven or, rarely, warp-knitted structure, or with a closed fabric surface, such as a non-woven. The mode of operation of a geotextile in any application is defined by six discrete functions: separation, filtration, drainage, reinforcement, sealing and protection. Depending on the application the geotextile performs one or more of these functions simultaneously.

Application areas of Geotextiles

Separation: Separation is defined as, “The introduction of a flexible porous textile placed between dissimilar materials so that the integrity and the functioning of both the materials can remain intact or be improved”. In transportation applications separation refers to the geotextile’s role in preventing the intermixing of two adjacent soils. For example, by separating fine subgrade soil from the aggregates of the base course, the geotextile preserves the drainage and the strength characteristics of the aggregate material. National Conference on Recent Trends in Engineering & Technology.

They are used in all classes of roads and similar civil foundation as the base of construction on contaminated layer is the single most cause of premature failure. The use of separator prevents pumping effect created by dynamic load and also helps the passage of water while retaining soil particles. In these types of geotextiles, thickness and permeability are most important characteristic properties.

Some of the applications areas are:

- Between subgrade and stone base in unpaved and paved roads and airfields
- Between subgrade in railroads
- Between land fills and stone base courses
- Between geomembranes and sand drainage layers
- Beneath sidewalks slabs
- Beneath curb areas

- Beneath parking lots
- Beneath sport and athletic fields

Filtration:
It is defined as “the equilibrium geotextile-to-soil system that allows for adequate liquid flow with limited soil loss across the plane of the geotextile over a service lifetime compatible with the application under consideration”. In filtration, fabrics can be either woven or non-woven, to permit the passage of water while retaining soil particles. Porosity and permeability are the major properties of geotextiles which involves in filtration action. Application helps the replacement of graded aggregate filters by a geotextiles warping. These applications are also suitable for both horizontal and vertical drains. A common application illustrating the filtration function is the use of a geotextile in a pavement edge drain.

Drainage (Transmissivity):
This refers to the ability of thick nonwoven geotextile whose three-dimensional structure provides an avenue for flow of water through the plane of the geotextile. Figure 6 also illustrates the transmissivity function of geotextile. Here the geotextile promotes a lateral flow thereby dissipating the kinetic energy of the capillary rise of ground water.

Reinforcement:
This is the synergistic improvement in the total system strength created by the introduction of a geotextile into a soil and developed primarily through the following three mechanisms:

- lateral restraint through interfacial friction between geotextile and soil/aggregate
- forcing the potential bearing surface failure plane to develop at alternate higher shear strength surface
- membrane type of support of the wheel loads.

In this method, the structural stability of the soil is greatly improved by the tensile strength of the geosyntheticmaterial. This concept is similar to that of reinforcingconcrete with steel. Since concrete is weak in tension, reinforcing steel is used to strengthen it. Geosyntheticmaterials function in a similar manner as the reinforcing steel by providing strength that helps to hold the soil in place. Reinforcement provided by geotextiles or geogrids allow embankments and roads to be built over very weak soils and allows for steeper embankments to be built.

Sealing Function:
A non-woven geotextile performs this function when impregnated with asphalt or other polymeric mixes rendering it relatively impermeable to both cross-plane and in-plane flow. The classic application of a geotextile as a liquid barrier is paved road rehabilitation. Here the non-woven geotextile is placed on the existing pavement surface following the application of an\ asphalt tack coat. The geotextile absorbs asphalt to become a waterproofing membrane minimizing vertical flow of water into the pavement structure.

FUTURE OF GEOTEXTILES

When looking to future generations of geotextiles, an examination of the role of nanotechnology in the functional enhancement of geotextiles is in order. By reducing fiber diameter down to the nanoscale, an enormous increase in specific surface area to the level of 1000 m2/g is possible. This reduction in dimension and increase in surface area greatly affects the chemical/biological reactivity and electroactivity of polymeric fibers. Because of the extreme fineness of the fibers, there is an overall impact on the geometric and thus the performance properties of the fabric. There is an explosive growth in worldwide research efforts recognizing the potential nanoeffect that will be created when fibers are reduced to nanoscale.

GEOMEMBRANE

They are made from various types of polymers usedto enhance, augment and make possible costeffective environmental, transportation andgeotechnical engineering construction projects.We are using plastic bags as geosynthetics .The geomembrane materials discussed in this document are those used most often at the time of writing. However, there are other polymer types that are also used. Aspects of quality assurance of these materials can be inferred from information contained in this document. In thefuture, new materials will be developed and the reader is advised to seek the appropriateinformation for evaluation of such new or modified materials.

Different types of Geomembranes are:

Natural fibres: Natural fibers in the form of paper strips, jute nets, wood shavings or wool mulch are being used as geotextiles. In certain soil reinforcement applications, geotextiles have to serve for more than 100 years. But bio-degradable natural geotextiles are deliberately manufactured to have relatively short period of life. They are generally used for prevention of soil erosion until vegetation can become properly established on the ground surface.

The commonly used natural fibres are –
Ramie: These are subtropical bastfibres, which are obtained from their plants 5 to 6 times a year. The fibres have silky luster and have white appearance even in the unbleached condition. They constitute of pure cellulose and possess highest tenacity among all plant fibres.

Jute: This is a versatile vegetable fibre which is biodegradable and has the ability to mix with the soil and serve as a nutrient for vegetation. Their quick biodegradability becomes weakness for their use as a geotextile. However, their life span can be extended even up to 20 years through different treatments and blendings. Thus, it is possible to manufacture designed biodegradable jute geotextile, having specific tenacity, porosity, permeability, transmissibility according to need and location specificity. Soil, soil composition, water, water quality, water flow, landscape etc. physical situation determines the application and choice of what kind of jute geotextiles should be used. In contrast to synthetic geotextiles, though jute geotextileas are less durable but they also have some advantages in certain area to be used particularly in agro-mulching and similar area to where quick consolidation are to take place. For erosion controland rural roadconsiderations, soil protection from natural and seasonal degradation caused by rain, water, monsoon, wind and cold weather are very important parameters. Jute geotextiles, as separator, reinforcing and drainage activities, along with topsoil erosion in shoulder and cracking are used quite satisfactorily. Furthermore, after degradation of jute geotextiles, lignomass is formed, which increases the soil organic content, fertility, texture and also enhance vegetative growth with further consolidation and stability of soil.

Synthetic Fibres: The four main synthetic polymers most widely used as the raw material for geotextiles are – polyester, polyamide, polyethylene and polypropylene. The oldest of these is polyethylene which was discovered in 1931 by ICI. Another group of polymers with a long production history is the polyamide family, the first ofwhich was discovered in 1935. The next oldest of the four main polymer families relevant to geotextile manufacture is polyester, which was announced in 1941. The most recent polymer family relevant to geotextiles to be developed was polypropylene, which was discovered in 1954.

Polyamides (PA): There are two most important types of polyamides, namely Nylon 6 and Nylon 6,6 but they are used very little in geotextiles. The first one an aliphatic polyamide obtained by the polymerization of petroleum derivativecaprolactam. The second type is also an aliphatic polyamide obtained by the polymerization of a salt of adipic acid and hexamethylenediamine. These are manufactured in the form of threads which are cut into granules. They have more strength but less moduli than polypropylene and polyester They are also readily prone to hydrolysis.

Polyesters (PET): Polyester is synthesised by polymerizing ethylene glycol with dimethyleterephthalate or with terephthalic acid. The fibre has high strength modulus, creep resistance and general chemical inertness due too which it is more suitable for geotextiles. It is attacked by polar solvent like benzyl alcohol, phenol, and meta-cresol. At pH range of 7 to 10, its life span is about 50 years. It possesses high resistance to ultraviolet radiations. However, the installation should be undertaken with care to avoid unnecessary exposure to light.

Polyethylene (PE): Polyethylene can be produced in a highly crystalline form, which is an extremely important characteristic in fiber forming polymer.

Three main groups of polyethylene are – Low densitypolyethylene (LDPE, density 9.2-9.3 g/cc), Linear low density polyethylene (LLDPE, density 9.20-9.45 g/cc) and High density polyethylene (HDPE, density 9.40- 9.6 g/cc).

Polypropylene (PP): Polypropylene is a crystalline thermoplastic produced by polymerizing propylenemonomers in the presence of stereo-specific Zeigler-Natta catalytic system. Homo-polymers and copolymers are two types of polypropylene. Homo polymers are used for fibre and yarn applications whereas co-polymers are used for varied industrial applications. Propylene is mainly available in granular form. Both polyethylene and polypropylene fibres are creep prone due to their low glass transition temperature. These polymers are purely hydrocarbons and are chemically inert. They swell by organic solvent and have excellent resistance to diesel and lubricating oils. Soil burial studies have shown that except for low molecular weight component present, neither HDPE nor polyethylene is attacked by micro-organisms.

Polyvinyl chloride (PVC): Polyvinyl chloride is mainly used in geo membranes and as a thermo plastic coating materials. The basic raw materials utilized for production of PVC is vinyl chloride. PVC is available in free- flowing powder form.

Ethylene copolymer Bitumen (ECB): Ethylene copolymer bitumen membrane has been used in civil engineering works as sealing materials. For ECBproduction, the raw materials used are ethylene and butyl acrylate (together forming 50-60%) and special bitumen (40-50%).

Chlorinated Polyethylene (CPE): Sealing membranes based on chlorinated poly ethylene are generally manufactured from CPE mixed with PVC or sometimes PE. The properties of CPE depend on quality of PE and degree of chlorination.

LITERATURE REVIEW:

In the recent years, several researchers are trying to develop solutions for the reuse of different types of wastes generated which has become one of the major challenges for the environmental issues in many countries. Wastes such as plastic waste tire shreds mixed with soil behave similar to fiber reinforced soils and several researchers presented technique of using discrete fibers to enhance the strength of soil. Most of them used different types of fibers as reinforcing materials, such as natural fibres , glass fibres, plastic fibres, polypropylene and polyester fibres. Experimental results reported by various researchers
(Shewbridge and Sitar, 1989, Maher & Gray, 1990; Maher and Ho, 1994, Li et al. 2001, Rao&Balan, 2000, Consoli et al., 2002, 2003, 2004, 2009, SivakumarBabu&Vasudevan 2008 a, b; SivakumarBabu&Chouksey 2010) showed that the fibre reinforced soil is a potential composite material which can be advantageously employed in improving the structural behaviour of soils. The tests were carried with different types of fibres in different proportions and the effects of fibre in improving strength and stability of soil were identified.

Shewbridge and Sitar (1989) conducted experiments with sand reinforced with fibres to observe the deformation pattern and to quantify the width of shear zone in sand. The results showed that deformation pattern of reinforcement was found curve- linear and symmetric about the centre of the shear zone. Maher and Gray (1990) carried out triaxial compression tests on sand reinforced with discrete, randomly distributed fibres and observed the influence of various fibre properties on soil behaviour. Using the experimental results they have proposed a force equilibrium model based on statistical analysis for randomly distributed discrete fibre reinforced sand. Maher and Ho (1994) reported that the fibre reinforcement increased the shear strength and ductility of clay. Li et al. (2001) carried out centrifuge model test to study the behaviour of fibre reinforced cohesive steep slope using poly propylene fibres. It was found that critical height of slope can be increased due to reinforcing. Consoli et al. (2002) carried out an experimental study of the utilization of the polyethylene fibres derived from plastic wastes in the reinforcement of uncemented and artificially cemented sand and showed that the plastic waste improved the stress strain response of uncemented and cemented sands. This is perhaps one of the earliest attempts advocating the
use of plastic waste. Consoli et al. (2003) proposed a field application for such materials designed for increasing the bearing capacity of spread foundations when placed on a layer of

fibre-reinforced cemented sand built over a weak residual soil stratum. Consoli et al. (2004) carried out triaxial compression test on cemented and uncemented sand reinforced with various types of fibres to study the effect of fibres on mode of failure, ultimate deviator stress, ductility and energy absorption capacity. They observed that the inclusion of fibres changed the mode of failure from brittle to ductile. Studies were also conducted on tire shreds as reinforcing material (Hataf and Rahimi 2006, Yoon et al. 2008). Hataf and Rahimi (2006) carried series of laboratory tests on the model of shallow footing resting on reinforced sand. Tire shreds were used as reinforcement elements. It was found that addition of 10% shreds by volume contributed to improvement of bearing capacity, expressed in terms of the bearing capacity ratio (BCR) in the range of 1.17 to 1.83 where as use of 50% tire shreds increased BCR to values in the range of 2.95 to 3.9 for different sizes of shreds. Yoon et al. (2008) presented a method for the reuse of waste tires called ‘tirecell’ for soil improvement. The results indicated that tirecell reinforced sand produced higher bearing capacities and lower settlements. SivakumarBabu et al. (2007) presented the results based on numerical analysis of stress strain response of fibre reinforced sand. Numerical simulation results indicate that the presence of random reinforcing material in soils make the stress concentration more diffused and restricts the shear band formation. Numerical simulation results also indicate that pull-out resistance of fibres governs the stress strain response of random-reinforced soil. SivakumarBabu and Vasudevan (2008a, 2008b and 2008c) presented comprehensive experimental results using compacted soil-fibre specimens, with coir fibres randomly distributed in the soil specimen. Experiments were carried out for various fibre parameters such as fibre content, fibre length and fibre diameter. Results showed that the improvement in strength and stiffness response, reduction in compression indices, reduction in swelling behaviour of soil. It is also observed that fibres reduce the seepage velocity of plain soil considerably and thus increase the piping resistance of soil. Based on critical state concepts, SivakumarBabu and SandeepChouskey (2010) proposed a constitutive model to obtain stress strain response of coir fibre reinforced soil as a function of fibre content. The above literature review clearly indicates that studies are available on the use of wastes from plastic water bottles are limited. The soil mixed with plastic waste is expected to behave as a fibre reinforced soil. The patented procedures for the use of fibre-reinforced soil in the field are also available (Freed 1988)). To promote the recycling of plastic wastes on a large-scale in geotechnical applications where bulk utilization of waste materials is possible, work is carried out and presented in this report.

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Stated that Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

Principles of Soil Stabilization:

• Evaluating the soil properties of the area under consideration.

• Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.

• Designing the Stabilized soil mix sample and testing it in the lab for intended stability and durability values.

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases.

1. It improves the strength of the soil, thus, increasing the soil bearing capacity.

2. It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.

3.It is also used to provide more stability to the soil in slopes or other such places.

4. Sometimes soil stabilization is also used to prevent soil erosion or formation of dust, which is very useful especially in dry and arid weather.

5. Stabilization is also done for soil water-proofing; this prevents water from entering into the soil and hence helps the soil from losing its strength.

6. It helps in reducing the soil volume change due to change in temperature or moisture content.

7.Stabilization improves the workability and the durability of the soil.

SUMMARY OF LITERATURE REVIEW

- Many investigators have conducted the studies on fiber-reinforced materials. The results of direct shear tests performed on sand specimens indicated increased shear strength.
- These results were supported by a number of researchers. Investigations were also conducted to determine the behavior of material properties of fiber-reinforced sands. The failure envelopes for fiber-sand composites were bilinear.
- The critical confining stress was a function of surface friction properties of the fibers and soil. The inclusion of discrete fibers increased both the cohesion and angle of internal friction of the specimens.
- The improvement of the engineering properties due to the inclusion of discrete fibers was determined to be a function of a variety of parameters including fiber type, fiber length, aspect ratios,, fiber content, orientation, and soil properties.
- The peak strength reportedly increased with increasing fiber content and length up to a limiting amount of each beyond which no additional benefits were observed.
- The results showed an increase of more than 20% increase in angle of internal friction, which would consequently result in significant increases in shear strength and soil bearing capacity.
- These results further suggest that the use of this type of reinforcement may prove beneficial with embankments and other foundation/geotechnical works.

- The use of plastic shopping bags and jute bags wastes as a reinforcement material could provide an alternative to waste accumulation and an economic means of resource recovery

OBJECTIVE OF THE PROJECT

Literature concerning the strength and stiffness of plastic waste reinforced soils clearly indicates there are limited studies in this area and there is need for detailed studies in this area.

Based on this observation the following are the objectives of our project:

1. Study the change in strength of the Chambaghat soil using geosynthetics which are available from daily use (i.e plastic bags and jute bags).
2. Study of various properties such as gsd, atterberg limits, compaction, shear parameters using various combinations of geosynthetics (plastic bags and jute bags) with soil.
3. Recommending the most suitable geosynthetics (plastic or jute) based on the comparative study done.

SCOPE OF THE STUDY

1. Soil stabilization techniques have a great future in coming years this technique can improve the quality of marginal soils and good foundations for new structures can be made .

2. Now we can use readily available jute and plastic bags as soil stabilizing materials which serves two purpose at one time that is soil stabilization and effective use of jute and plastic bags.

3. Here we are focusing on strength parameters of soil on addition of plastic bags and jute bags , durability of plastic bags and jute bags is the sphere where researches are to carried on .

MATERIALS AND METHODS

ESSENTIAL PROPERTIES OF PLASTIC BAGS AND JUTE BAGS WHICH HELP IN SOIL STABILISATION

1. PLASTIC BAGS

1.***Strength***--can withstand considerable pressure without stretching or breaking.
2.*Durability*--will last for hopefully centuries without degradation, especially when protected by a covering of plaster, and is not adversely affected by moisture or normal temperatures.
3.Low cost--not too expensive for common use.
***4.Availability*--**readily available in a form that can be used. I suggest that you check with the manufacturer of the material in question and see how it compares to polypropylene, which rates very high in each of the categories.

2. JUTE BAGS

1. High moisture absorption capacity,flexibility , drainage properties .
2. Erosion control,separation,filtration .
3. Lower costs compared to synthetic geotextiles.
4. Ease of installation and bio-degradable properties.

WHY PLASTIC BAGS AND JUTE BAGS??

1. **PLASTIC BAGS**
2. Plasticbagsare commonly used for shopping , storage and marketing for various purposes due to its most advantage character of less volume and weight.
3. Most of these plastic are specifically made for spot use, having short life span and are being discarded immediately after use.
4. Though, at many places waste plastics are being collected for recycling or reuse, however; the secondary markets for reclaimed plastics have not developed as recycling program.

5. Therefore, the quantity of plastics that is being currently reused or recycled is only a fraction of the total volume produced every year. The estimated municipal solid waste production in India up to the year 2000 was of the order of 39 million tons per year. From this plastics constitute around 4 % of the total waste.

2. JUTEBAGS

1. Worldwide, the natural fiber with the largest use after cotton is jute.
2. India is the world's largest producer of raw juteand the biggest manufacturer of jute goods

METHODS:

1.Mechanical method of Stabilization

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

2. Additive method of stabilization

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two methods:

a) Oriented fiber reinforcement-

The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation.
Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

b) Random fiber reinforcement-

This arrangement has discrete fibers distributed randomly in the soil mass.
The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are

generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil , between void ratio (e) versus normal pressure (p) was obtained.

The results in the form of e versus log p for plain sand and sand mixed with different percentages of plastic wastes .

Soil properties

Atterberg Limits

1) Liquid Limit:

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrande’s apparatus and is denoted by $\mathbf{W_1}$.

Fig. 1. CASSAGRANDE,S APPARATUS

2) Plastic Limit

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is nonporous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by w_P. This is determined by rolling out soil till its diameter reaches approximately 3 mm and measuring water content for the soil which crumbles on reaching this diameter. Plasticity index (I_p) was also calculated with the help of liquid limit and plastic limit.

3) Shrinkage Limit

This limit is achieved when further loss of water from the soil does not reduce the volume of the soil. It can be more accurately defined as the lowest water content at which the soil can still be completely saturated. It is denoted by $\mathbf{w_S}$.

$I_p = w_L - w_P$
w_L- Liquid limit
w_P- Plastic limit

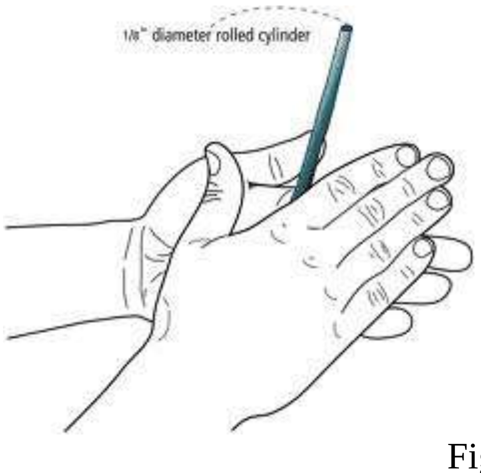


Fig.2. PLASTIC LIMIT TEST

Particle Size Distribution

Soil at any place is composed of particles of a variety of sizes and shapes, sizes ranging from a few microns to a few centimeters are present sometimes in the same soil sample. The distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc. Particle size distribution is found out by two methods, first is sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample. Both are followed by plotting the results on a semi-log graph. The percentage finer N as the ordinate and the particle diameter i.e. sieve size as the abscissa on a logarithmic scale. The curve generated from the result gives us an idea of the type and gradation of the soil. If the curve is higher up or is more towards the left, it means that the soil has more representation from the finer particles; if it is towards the right, we can deduce that the soil has more of the coarse grained particles. The soil may be of two types- well graded or poorly graded (uniformly graded). Well graded soils have particles from all the size ranges in a good amount. On the other hand, it is said to be poorly or uniformly graded if it has particles of some sizes in excess and deficiency of particles of other sizes. Sometimes the curve has a flat portion also which means there is an absence of particles of intermediate size, these soils are also known as gap graded or skip graded. For analysis of the particle distribution, we sometimes use D10, D30, and D60 etc. terms which represents a size in mm such that 10%, 30% and 60% of particles respectively are finer than that size. The size of D10 also called the effective size or diameter is a very useful data. There is a term called uniformity coefficient Cu which comes from the ratio of D60 and D10, it gives a measure of the range of the particle size of the soil sample.

Specific gravity

Substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water. Different types of soil have different specific gravities, general range for specific gravity of soils:

Table 1.

Sand	2.63-2.67
Silt	2.65-2.7
Clay and Silty clay	2.67-2.9
Organic soil	<2.0

Proctor compaction test

This experiment gives a clear relationship between the dry density of the soil and the moisture content of the soil. The experimental setup consists of (i) cylindrical metal mould (internal diameter- 10.15 cm and internal height-11.7 cm), (ii) detachable base plate, (iii) collar (5 cm effective height), (iv) rammer (2.5 kg). Compaction process helps in increasing the bulk density by driving out the air from the voids. The theory used in the experiment is that for any compactive effort, the dry density depends upon the moisture content in the soil. The maximum dry density (MDD) is achieved when the soil is compacted at relatively high moisture content and almost all the air is driven out, this moisture content is called optimum moisture content (OMC). After plotting the data from the experiment with water content as the abscissa and dry density as the ordinate, we can obtain the OMC and MDD. The equations used in this experiment are as follows:

Shear strength

Shearing stresses are induced in a loaded soil and when these stresses reach their limiting value, deformation starts in the soil which leads to failure of the soil mass. The shear strength of a soil is its resistance to the deformation caused by the shear stresses acting on the loaded soil. The shear strength of a soil is one of the most important characteristics. There are several experiments which are used to determine shear strength such as DST or UCS etc. The shear resistance offered is made up of three parts:

i) The structural resistance to the soil displacement caused due to the soil particles getting interlocked,

ii) The frictional resistance at the contact point of various particles, and

iii) Cohesion or adhesion between the surface of the particles.

In case of cohesionless soils, the shear strength is entirely dependent upon the frictional resistance, while in others it comes from the internal friction as well as the cohesion.

Methods for measuring shear strength:

a) Direct Shear Test (DST)

This is the most common test used to determine the shear strength of the soil. In this experiment the soil is put inside a shear box closed from all sides and force is applied from one side until the soil fails. The shear stress is calculated by dividing this force with the area of the soil mass. This test can be performed in three
conditions-undrained, drained and consolidated undrained depending upon the setup of the experiment.
This test is used to find out the cohesion (c) and the angle of internal friction (φ) of the soil, these are the soil shear strength parameters. The shear strength is one of the most important soil properties and it is required whenever any structure depends on the soil shearing resistance. The test is conducted by putting the soil at OMC and MDD inside the shear box which is made up of two independent parts. A constant normal load (ς) is applied to obtain one value of c and φ. Horizontal load (shearing load) is increased at a constant rate and is applied till the failure point is reached. This load when divided with the area gives the shear strength 'τ' for that particular normal load. The equation goes as follows:
After repeating the experiment for different normal loads (ς) we obtain a plot which is a straight line with slope equal to angle of internal friction (φ) and intercept equal to the cohesion (c). Direct shear test is the easiest and the quickest way to determine the shear strength parameters of a soil sample. The preparation of the sample is also very easy in this experiment.

b)Unconfined Compression Test (UCS test)

This test is a specific case of triaxial test where the horizontal forces acting are zero. There is no confining pressure in this test and the soil sample tested is subjected to vertical loading only. The specimen used is cylindrical and is loaded till
it fails due to shear.
q_u= load/corrected area (A')
q_u- compressive stress
A'= cross-sectional area/ (1- ε)
This experiment is used to determine the unconfined compressive strength of the soil sample which in turn is used to calculate the unconsolidated,

undrained shear strength of unconfined soil. The unconfined compressive strength (qu) is the compressive stress at which the unconfined cylindrical soil sample fails under simple compressive test. The experimental setup constitutes of the compression device and dial gauges for load and deformation. The load was taken for different readings of strain dial gauge starting from $\varepsilon = 0.005$ and increasing by 0.005 at each step. The corrected cross-sectional area was calculated by dividing the area by $(1- \varepsilon)$ and then the compressive stress for each step was calculated by dividing the load with the corrected area.

MATERIALS USED

Table 2.

MATERIAL REQUIRED	QUANTITY	SOURCE
PLASTIC BAGS	2 kg	FACTORY AT BADDI
JUTE BAGS	4-5 (BIG SIZE)	FROM MOKSH (WAKNAGHAT)
SOIL	8-10 kg	FROM CHAMBAGHAT

CUTTING OF VARIOUS MATERIALS

Fig.3 Cutting of plastic

Fig.4 Jute Strips after cutting

Fig.5 cutting of jute

Fig.6 plastic strips

DIMENSIONAL PARAMETERS OF VARIOUS MATERIALS

Table 3.

SR. NO.	DIMENSIONS	JUTE	PLASTIC
1	MASS PER UNIT AREA	5.5	30
2	THICKNESS	NIL	0.05 mm
3	DIAMETER	3 mm	NIL
4	LENGTH	35 mm	26 mm
5	WIDTH	NIL	13 mm

Soil was brought from a sand quarry near Chambaghat,Solan *(H.P)*

RESULTS & DISCUSSION

1.GRAIN SIZE DISTRIBUTION

a) We have taken 1 kg of soil sample and performed GSD test for three times to achieve accuracy in results.

b) We tested soil on sieves of size 2mm,710 microns,600 microns,425 microns,300 microns,250 microns,150 microns,75 microns

c) We used sieve shaker for sieving

d) The results obtained were as follows:

Table 4(a).

WT. OF SIEVE + SOIL RETAINED [gm]	**TEST 1**	**TEST 2**	**TEST 3**
SIEVE SIZE [mm]			
40	830	830	830
20	830	830	830
10	470	470	470
4.75	390	390	390

Fig. 7 PERFORMING SEIVE ANALYSIS FOR GSD

WT OF SIEVE + SOIL RETAINED [gm]	TEST 1	TEST 2	TEST 3
SIEVE SIZE [mm]			
2mm	401	400	400
710 microns	550	540	545
600 microns	410	400	410
425 microns	480	480	481

WT OF SIEVE + SOIL RETAINED [gm]	TEST 1	TEST 2	TEST 3
SIEVE SIZE [mm]			
300 micron	440	451	446
250 micron	460	461	461
150 micron	401	399	400
75 micron	361	359	362

Table 4(b) & (c)

FOR COARSE GRAINED SOIL 4.75 mm AND ABOVE

SIEVE SIZE [mm]	**MASS OF SIEVE [gm]**	**MASS OF SIEVE + SOIL RETAINED[gm]**	**MASS OF SOIL RETAINED [gm]**	**% OF MASS OF SOIL RETAINED [gm]**	**CUMULATIVE % OF SOIL RETAINED [gm]**	**% FINER [passing]**
[1]	[2]	[3]	4=[3-2]	5	6	7= 100-[6]
40	830	830	0	0	0	100
20	830	830	0	0	0	100
10	470	470	0	0	0	100
4.75	390	390	0	0	0	100

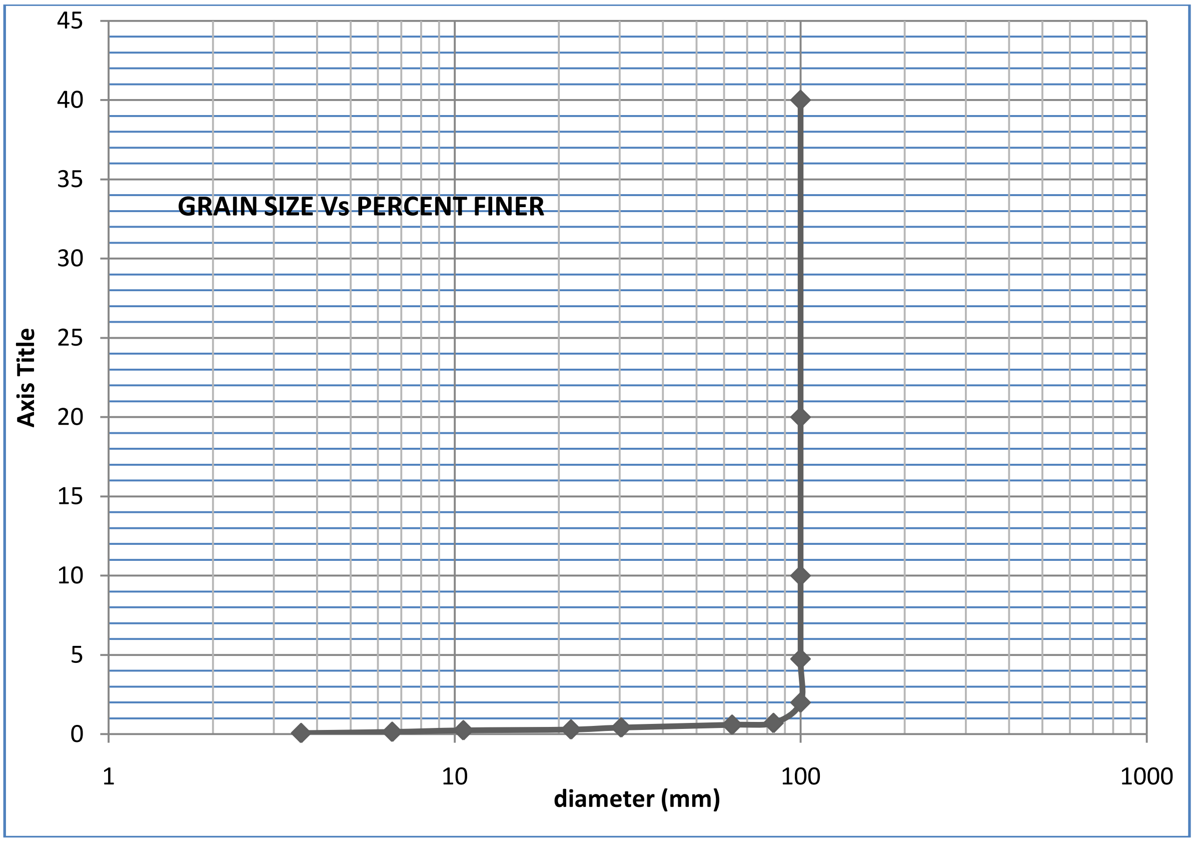
Table 4 (d)

For Fine Grained Soil 2mm-75 microns

Table 4 (e)

SIEVE SIZE	MASS OF SIEVE [gm]	MASS OF SIEVE + SOIL RETAINED[gm]	MASS OF SOIL RETAINED [gm]	% of MASS OF SOIL RETAINED [gm]	CUMULATIVE % OF SOIL RETAINED [gm]	% FINER [passing]
[1]	[2]	[3]	4=[3-2]	[5]	[6]	7= 100-[6]
2mm	400	400	0	0	0	100
710 micron	380	545	165	16.5	16.5	83.5
600 micron	370	406	36	20.1	36.6	63.4
425 micron	350	480	130	33.1	69.7	30.3

The concluded graph between percent finer and particle size was as follows (Fig. 8)



2.SPECIFIC GRAVITY TEST USING PYCNOMETER

Fig. 9Pycnometer

1.We use pycnometer method to find specific gravity of soil .

We performed this test three times to achieve accuracy in results.

2.pecific gravity test value helps us to classify soil to someextent as-

Its value ranges as follows –

1. Coarse grained soil= [2.6-2.7]
2. Fine grained soil=[2.7-2.8]
3. Organic soil=[2.3-2.5]

The readings of this test are shown in this table 5.

WEIGHT OF PYCNOMETER BOTTLE AT VARIOUS STAGES [gm]	**TEST 1**	**TEST 2**	**TEST 3**
W1= WEIGHT OF EMPTY PYCNOMETER	465.5	465.5	465.5
W2= WEIGHT OF PYCNOMETER PARTIALLY FILLED WITH SOIL	665.6	665.4	665.6
W3= WEIGTH OF PYCNOMETER WITH SOIL AND WATER FILLED UPTO BRIM	1387.9	1387.8	1387.8
W4= WEIGHT OF PYCNOMETER FILLED WITH WATER	1261	1260	1260

RESULT OF SPECIFIC GRAVITY TEST

- After taking readings we took their average and put them into the formula given below for calculating specific gravity.
- Gs= [W2-W1] / [W2-W1]-[W3-W4]
- We found the value of Gs to be 2.7 , which tells us that it is a fine grained soil .

Figure 10.PERFORMING SPECIFIC GRAVITY TEST

ATTERBERG LIMIT TEST

1. PLASTIC LIMIT:

1. The moisture content at which soil can be moulded to different shapes without rupture , is called as plastic limit .
2. Experimentally the water content at which soil can be moulded to a thread of 3mm dia is plastic limit of soil.
3. In our case the soil cracked down even when it was just rolled to a ball.
4. We tested the 4 samples of chambaghat soil.
5. By using formulation as= $(W_2\text{-}W_1)/(W_3\text{-}W_4)$.

P.L= (weight of moist sample-weight of dry sample)/(weight of dry sample in box – weight of box)

THE READINGS ARE AS SHOWN IN TABULAR FORM:

s.n.o	Sample box no.	Sample box weight (gm)	Sample box + dry soil sample weight (gm)	box + oven dried sample weight (gm)	weight of water in each sample (gm)	Plastic limit (%)
1	45	27	53.9	49.1	4.8	21.71
2	24	27	47.2	43.2	4	24.69
3	22	27	52.4	43.3	9.1	21
4	36	27	41.2	38.8	2.4	20.33

Table 6.

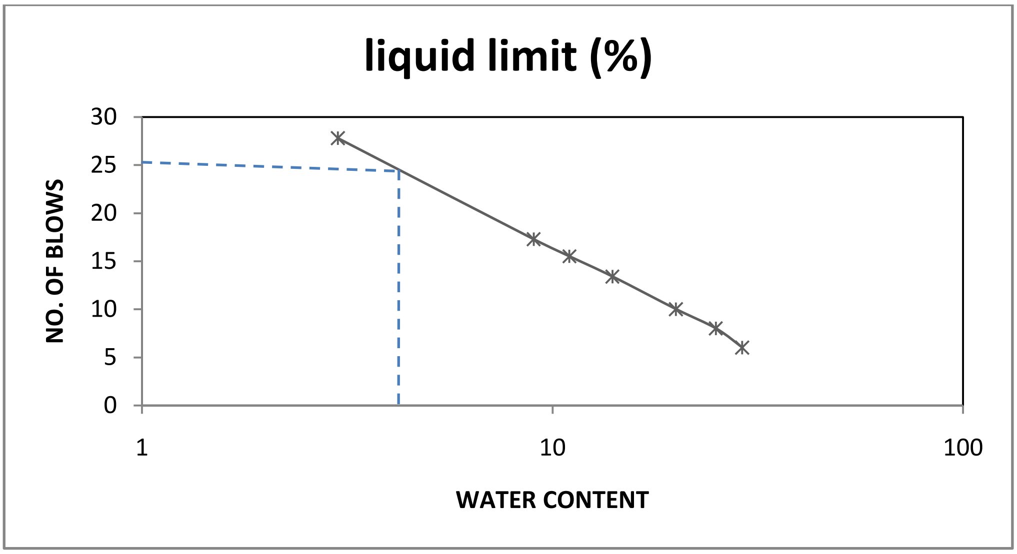
After taking average of the four plastic limits , plastic limit of sample was found to be 22%

1. LIQUID LIMIT:
   1.Water content at which soil is practically in liquid state but bears infinitesimal resistance against flow . Experimentally water content at which groove made through grooving tool of casagrande apparatus touches it by giving blows and counting them too.
   2. We took 7 sample readings for this experiment .

3. A plot between water content and number of blows is made .

4. Water content for 25th blow is the liquid limit of the soil.

SR. NO.	Water content %	No. of blows
1	27.8	3
2	17.28	9
3	15.5	11
4	13.4	14
5	10	20
6	8	25
7	6	29



From graph we found the liquid limit of the soil sample to be 14.8%. **(Fig. 11.)**

PROCTOR TEST:

1. This test is done to know the maximum compaction or maximum dry density , and at what water content it could be achieved.
2. This water content is called as optimum moisture content (OMC).
3. The procedure include to detect the dry density at various water levels (5% , 8% , 10% , 14% , 16% , 18% as we have done in our experiment.)

4. A plot between dry density and water content is made .
5. The peak of graph gives the OMC.
6. Key formulations used in this test is=

$$\gamma_d = \gamma /1+w$$

Table 8.

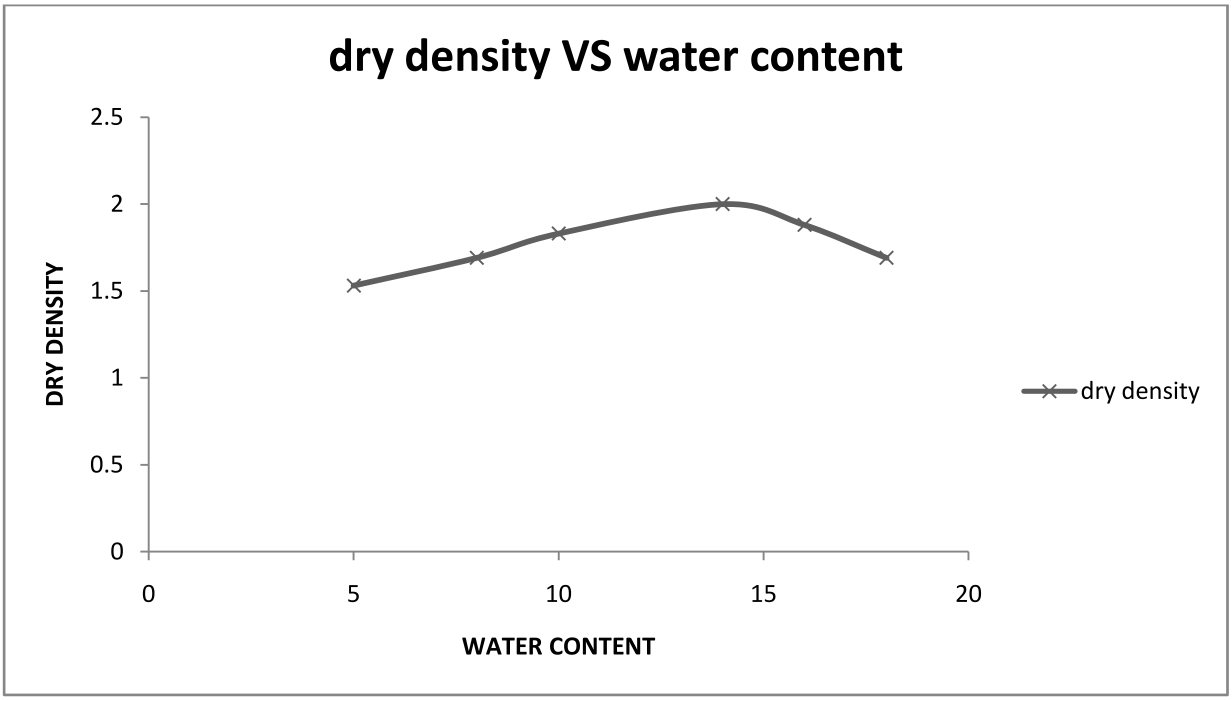
γ = density&w = water content

Where d = dry density

Water content w %	**Dry density γ_d (g/cc)**
5	1.53
8	1.69
10	1.83
14	2
16	1.88
18	1.69

Figure 12.

MAKING SAMPLE FOR COMPACTION TEST



THE OMC was found out to be 14.5% and dry density (Figure 13.)

to be 2g/cc or 19.6 kN/m^3 .

DIRECT SHEAR TEST RESULTS:

- Main objective is to determine shear strength parameters of the given soil sample at known density and moisture content by direct shear test.
- Internal friction which is the resistance due to friction between individual particles at their contact points and interlocking of particles.
- Cohesion which is resistance due to inter-particles forces which tend to hold the particles together in the soil mass.
- The purpose of direct shear test is to get the ultimate shear resistance , peak shear resistance cohesion, angle of internal friction, Φ and shear stress-strain characteristics of the soils.
- Shear parameters are used in the design of earthen dams and embankments. These are used in calculating the bearing capacity of soil-foundation systems.
- Parameters help in estimating the earth pressure behind the retaining walls. The values of these parameters are also used in checking the stability of natural slopes, cuts and fills.

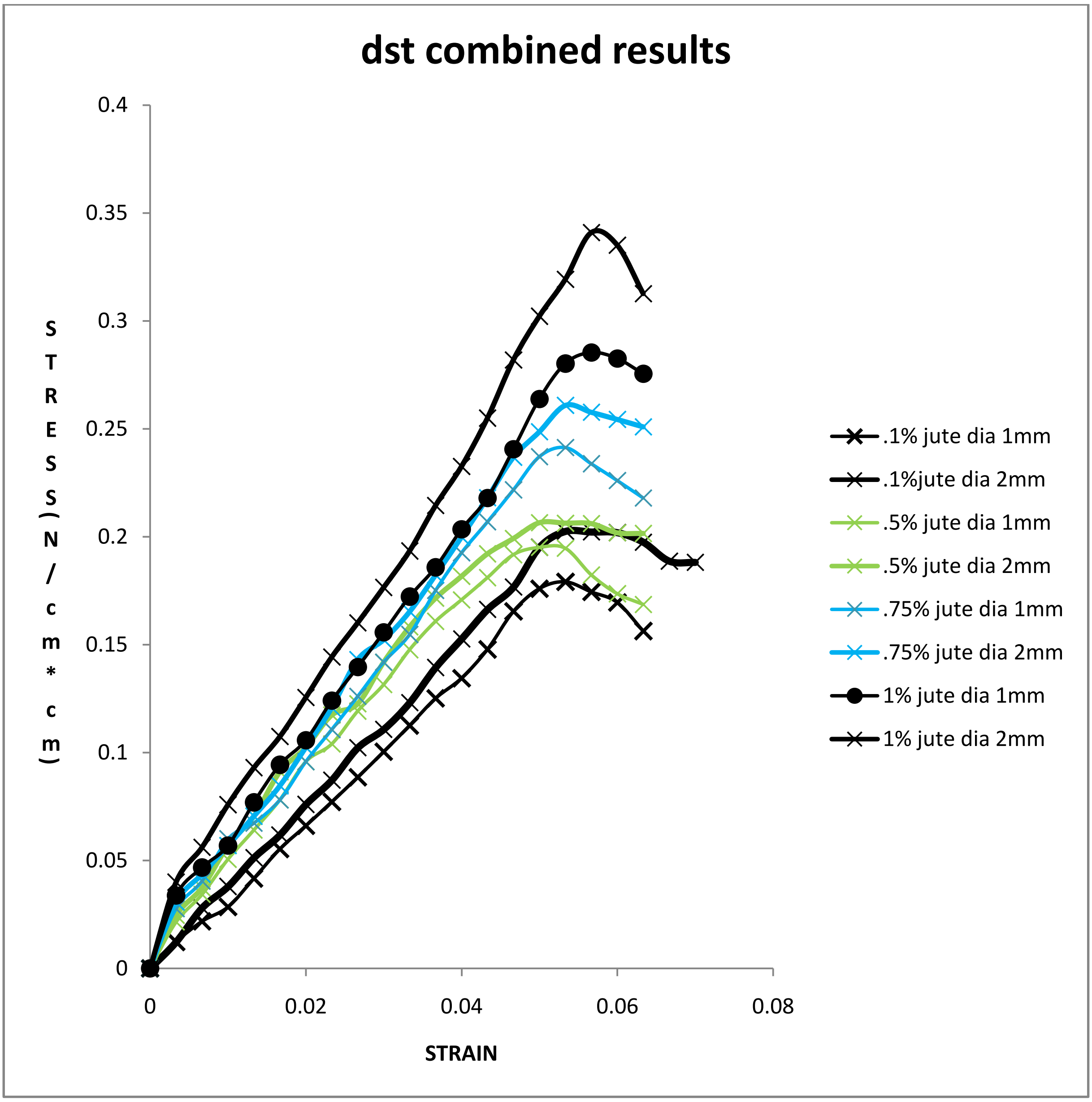


Figure 14.

TABULATED DST RESULTS FOR JUTE DIA=1mm

Sr. No.	PROPORTION OF JUTE(%/WT OF SAMPLE)	SHEARING STRESS(KN/m*m)	NORMAL STRESS(KN/m*m)
1.	.1%	1.79	4.025
2.	.5%	1.95	3.954
3.	.75%	2.413	4.025
4.	1%	2.853	4.098

CONCLUSION

- Visible effect is seen in strength parameters of soil by reinforcing with jute fiber.
- There is increase in strength parameters by increasing the proportion of jute fiber in the soil.
- Increase in strength parameters is also seen with increasing diameter of jute fiber.
- About 197% increase was seen in shearing stress of normal soil and soil reinforced with 1% jute of dia=1mm.
- It was observed that the soil has shear strength after the addition of the plastic strips the strength of the soil was found to increase by 25% with 1% of plastic strips and 65% with 35 strips.

- Soil stabilization techniques have a great future in coming years this technique can improve the quality of marginal soils and good foundations for new structures can be made .
- Now we can use readily available jute and plastic bags as soil stabilizing materials which serves two purpose at one time that is soil stabilization and effective use of jute and plastic bags.
- Here we are focusing on strength parameters of soil on addition of plastic bags and jute bags, durability of plastic bags and jute bags is the sphere where researches are to carried on.
- With improvements in research and result it would be possible to make skyscrapers and other heavy structures on poor quality foundation by reinforcing it with plastic and jute.
- Other geosynthetic and geotextiles should also be studied for soil stabilization as they may give better results than jute and plastic.
- Many admixtures can be studied which would improve the strength parameters of marginal soils significantly.

- Strength of soil can also be tested by adding flyash and stone dust and noting the results carefully.

PART – II

CONTROLLING HEAVE BEHAVIOUR OF BLACK COTTON SOIL BY USING DIFFERENT COMPOUNDS

ABSTRACT

Expansive soils are causing number of damages to the structures particularly light buildings and pavements compare to other natural hazards like earthquake, floods, etc. Thus, worldwide these soils are considered to be problematic soils and pose several challenges for engineers. So, as to utilize these soils in an effective way, proper treatment to the soil is required. With the same intention, an attempt is made to modify engineering properties of black cotton soils by using RBI Grade 81 and sodium silicate. Atterberg's limit, Compaction, tests were carried out on the samples of soil and soil with stabilizers. Curing of samples is done for 7 days, 14 days and 28 days. RBI Grade 81 added to the soil in dry state in percentage (by weight) varying from 2% to 6% and sodium silicate 3% to 6% in solution (molar concentration). Comparisons of these two admixtures are done on the basis of test results obtained.

Keywords: Plasticity Index, Unconfined Compressive Strength, California Bearing Ratio, RBI Grade 81, Sodium Silicate

INTRODUCTION

Expansive soil deposits occur in the arid and semi-arid regions of the world and are problematic to the engineering structures because of their tendency to heave during the wet season and shrink during dry season. Different damages in the form of cracking, undulation, differential settlements, etc are experienced by the roads, buildings, irrigation canals, water and sewer lines, etc. An exercise is carried out to improve the performance of this soil by using chemical admixtures RBI Grade 81 and Sodium silicate. Addition of admixtures done by weights and curing is done for 7 days, 14 days and 28 days in desiccators and using gunny bags. Atterberg's limits, Compaction,.test carried out on the sample prepared and results are tabulated below.

Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lakh sq.km .Black cotton soils or the expansivesoils in India are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Extensive research is going on to find the solutions to black cotton soils. Our project reviews on one of the innovative solutions along with conventional foundation practices to counteract the dual problem of swelling and shrinkage posed by expansive soils. Expansive soils are problematic soils because of their inherent potential to undergo volume changes corresponding to changes in the moisture regime. When they imbibe water during monsoon, they expand and on evaporation thereof in summer, they shrink. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged. The annual cost of damage to the civil engineering structures is estimated at thousands of crores. Utilization of industrial wastes like fly ash, quarry dust, silica fume, copper slag, tannery sludge, etc. in the geotechnical engineering field will solve the problem of disposal of thesewastes. Extensive research is carried and carrying by the geotechnical investigators to reducethe swelling of expansive soils by using industrial wastes. Copper slag, which is produced during hydrometallurgical production of copper from copper ores, contains materials like iron, alumina, calcium oxide, silica etc. For every tonne of metal production, about 2.2 ton of slag is generated. Dumping and disposal of such huge quantities of slag cause environmental and space problems. Thus, we use the industrial waste – Copper Slag to reduce the swelling of expansive soils. Chemical stabilization of expansive soils can be adopted to alleviate the problems posed by these soils to civil engineering structures. Chemical stabilization of expansive clays consists of changing the physico-chemical around and inside of clay particles where by the clay requires less water to satisfy the static imbalance and making it difficult for water that moves into and out of the system. The most common chemical admixtures used in soil stabilization are lime and cement.

Generally, 2 to 6% cement is added to produce a soil that acts as a semi rigid slab. Cement reduces liquid limit, the plastic index and the potential of volume change, it increases the shrinkage limit and shear strength. The present paper elucidates about the studies been carried out using copper slag as a cushioning material. Developments of cohesive bonds in a cement-stabilized copper slag cushion, when stabilized with cement, are expected to consequently arrest heave. The results of the study show a new solution to the problem heave of expansive soil. It also solves the problem of copper slag utilization and disposal to some extent.

Expansive soils expand due to the clay content. Expansive soils have a relatively high percentage of clay minerals and are subject to changes in volume with changing moisture conditions. The mineral for most expansive clay soil damage includes smectite and montmorilionite (along with Bentonite and illite) which can swell up to 40 times its own size. The soil under a house swells and shrinks with the seasons. This movement is not a problem as long as it is uniform or not great enough to damage the foundation and/or house. Damage to the house may appear and disappear on a regular basis as the seasons change. Significant defects occur when the movement is uneven or localized.

Expansive soils contain clay or other minerals that cause them to expandwhen absorbing water. These soils often expand by 10 per cent or more during a rainfall. When the soils dry out, they shrink back to their original size.

DAMAGE DUE TO EXPANDING: When soils expand, they put pressure on structures. They exert enough force to crack foundations, floors and walls. The most damage is usually done to the lower levels of the structure, although damage to higher levels may also be sustained if the soil expansion causes motion within the structure.

DAMAGE DUE TO CONTRACTING: If a structure is built while the soil is expanded, damage can occur when the soil dries out and shrinks. Soil shrinkage can weaken structural support. This puts buildings at risk of collapse.

SOIL FISSSURES: When soil contracts, it can cause fissures, or splits, in the soil itself. These splits Expansive soils contain clay or other minerals that cause them to expand when absorbing water. These soils often expand by 10 per cent or more during a rainfall. When the soils dry out, they shrink back to their original size. When soils expand, they put pressure on structures. They exert enough force to crack foundations, floors and walls. The most damage is usually done to the lower levels of the structure, although damage to higher levels may also be sustained if the soil expansion causes motion within the structure.

If a structure is built while the soil is expanded, damage can occur when the soil dries out and shrinks. Soil shrinkage can weaken structural support. This puts buildings at risk of collapse.This causes a cycle of expansion and shrinkage that puts continual pressure on the structure. The repetitive pressure can weaken structures.

LITEATURE REVIEW

A. RBI GRADE 81

RBI Grade 81 is an odorless beige powder that is composed of a number of naturally occurring compounds. The pH of saturated paste is 12.5. It improves the structural properties of a wide range of soils. It is particularly effective with silty-clayey soil with low geo-mechanical qualities. RBI Grade 81 works by hydration reaction. Pore space is filled by a crystalline growth. Through the addition of low dosages of RBI Grade 81 the volume stability of the soil is increased significantly. The reaction of RBI Grade 81 with soil particles produces as an inter-particle matrix that binds soil particles together into a rigid mass. This binding of the soil particle, through both chemical bonds and frictional forces, serves to limit the pore volume of the created rigid stabilized soil system.

RBI Grade 81 is insoluble in water, non UV degradable, inert and chemically stable. It forms a dust free surface and is simple to apply and hardens fast. It is durable and permanent. It is environmental friendly and aesthetically pleasing. Strength of soil treated with RBI Grade 81 increases with age. RBI Grade 81 converts clay irreversibly into cementitious calcium silicate and aluminum hydrates. RBI Grade 81 creates a volume stable layer with very small capillary spaces. Application of RBI Grade 81 was carried out by researchers in the past and observations of investigation program are summarized below; SushantBhuyan carried out an investigation program to study the influence of RBI Grade 81 and lime on the stabilization of blast furnace slag and flyash. He has carriedout standard proctor test and unconfined compressive strength test for different combinationsof the stabilizingagents and reported that UCS of stabilized sample increases with increase in the days of curing however increase in strength with lime is more compare to RBI Grade 81.

Anitha K.R. et al studied the effect of stabilizer RBI Grade 81 in the stabilization of kaolinite, red soil and lateritic soil. The application of RBI Grade 81 stabilizer was studied by comparing the strength parameter of subgrade soil in terms of CBR value before and after the application of different percentages of RBI Grade 81 varying from 2% to 8%. From the test results it is observed that substantial reduction in plasticity index for soil with RBI Grade 81 viz 42 percent for kaolinite, 4 percent for red soil and 116 percent for laterite. Soaked CBR value increased for all three soils with RBI. OMC increased and MDD decreased with addition of RBI Grade 81 for red soil and kaolinite.

Figure 15. Usage of RBI Grade 81

B. SODIUM SILICATE

Sodium silicate grouts are the most popular grouts due to their environmental and safety compatibility. Moreover, sodium silicates have been developed into a wide variety of different grout systems. Practically, all systems are assumed on reactinga silicate solution to form a colloid which polymerizes further to form a gel that binds sediment particles or soil together and fills voids. Sodium silicate grouts have been used to cut off water flowing through permeable foundations and to stabilize or strengthen foundations composed of fractured rock and granular materials. Also, granular materials that have been saturated with silicate grout develop quite low hydraulic conductivity if the gel is not allowed to dry out and shrink. Even though shrinkage may occur, a low degree of hydraulic conductivity is usually obtained. Treatment with sodium silicate grout will enhance the strengthand the load-bearingcapacity of any groutable granular material coarser than the 75-µm sieve. Factors that influence strength are particle-size distribution, grain size, particle shape, the ability of the grout to adhere to the particle surfaces, absorption, moisture content, method of loading and curing environment. Also Sodium silicate solutions are basic. As this alkaline solution is neutralized, colloidal silica will aggregate to form a gel if the sodium silicate is present in concentrations above 1 or 2 percent (by volume). Sodium silicate and a reactant solution can be injected as separate solutions, or the sodium silicate can be premixed with the reactant to form a single solution that is injected.

HosseinMoayedi et al carriedout number of experiments using composition of alkaline earth metals grout to treat organic soils, in order to provide a better understanding of the engineering behavior of organic soil after stabilization. Series of batch tests conducted using composition of sodium silicate system binders to find their effects on physic-chemical properties of the organic soil. The results show that in the batch tests unconfined compressive strength (UCS), increases of up to 220% of the soil's baseline strength can be achieved by adding the 3 mol/L Na_2Sio_3, while UCS results enhanced to 270% having an activator $CaCl_2$ and/or $Al_2(SO_4)_3$ additives.

Bujang B.K. Haut et al reported that Soft clay soil can be stabilized by the adding of small percentages, by weight, of sodium silicate for enhancing many of the engineering properties of the soil. Series of tests were carriedout on the kaolinite. From the test results it is observed that addition of 5mol/L sodium silicate showed the highest unconfined compressive strength results. However the effect of chemical molarities on UCS become less and less, with longer curing time. This is because of its solubility after immersing through water. It means after injection and finishing the chemical reaction if the adjust environment become fullysaturated the bonding between clay structures probably will lost and caused significant reduction in UCS.

Ajith (1993) [1] studied the effect of using fly ash and lime on red soil. The optimum value of additive combination was found to be 15% fly ash and 5% lime. Gaulkar (1999) [2] investigated the effect of using lime as stabilizing agent on black cotton soil. He found that, by adding 4% to 6% of lime to black cotton soil, the soaked CBR increased considerably. Biju (2003) [3] studied about the use of TerraZyme for pavement subgrade stabilization. TerraZyme is one of the bio-enzyme stabilizers used for stabilizing the soil. This method was found to be most effective for soils containing larger percent of silt. Kunal (2006) [4] investigated the effect of using cement as stabilizing agent on two different types of sands A & sand B. The optimum value of cement was found to be 3% for rural roads. Mithra, et al., (2009),[5] study was undertaken with the objective to find the fast pavement construction technology using in-situ soil by stabilization with a natural soil stabilizer “RBI Grade 81”. For the study, a stretch constructed on ReasiPauni Road, Jammu is taken into consideration. Atterberg’s Limits, Compaction, CBR, tests were conducted on soil samples with different percentages of RBI 81 with 0% to 8%. VENU GOPAL.N; (2009),[6] Studied of soil Properties With Silica fume As Stabilizer And

SUMMARY OF LITERATURE REVIEW

- RBI Grade 81 is a powder that is composed of a number of naturally occurring compounds. It is odourless, the pH of saturated paste is 12.5. It improves the structural properties of a wide range of soils.
- An irreversible interparticle matrix is formed. Through the addition of low dosages of RBI Grade 81 the volume stability of the soil is increased significantly.
- RBI Grade 81 is insoluble in water, non UV degradable, inert and chemically stable. It forms a dust free surface and is simple to apply and hardens fast.
- Strength of soil treated with RBI Grade 81 increases with age. It gains strength till about one year after application to soil.
- Permeability of soil mass decreases with addition of RBI Grade 81 as they reduces pore spaces. The use of RBI Grade 81 does not produce expansive salts when used in soils with clay content. Hence they do not cause cracks due to volume change.
- RBI Grade 81 creates a volume stable layer with very small capillary spaces. The stabilized soil is bound into an irreversible matrix where cracking is highly improbable. Hence maintenance costs are low or non-existent for roads constructed using RBI Grade 81.

OBJECTIVE OF THE PROJECT

Literature concerning the use of fewer compounds in controlling heave behavior of Black cotton soil clearlyindicates there are limited studies in this area and there is need for detailed studies in this area. For this many compounds are being experimented with Black Cotton Soil, as such RBI Grade 81 & Sodium Silicate to control its heave behavior.

Based on this observation the following are the objectives of our project:

1. Study the change in volume of swellof the Black Cotton Soil, which is present in civil engineering laboratory of JUIT Waknaghat soil using RBI Grade 81 and Sodium Silicate.

2. Also determine the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) of Black Cotton Soil using RBI Grade 81.

MATERIAL

SOIL: Soil is obtained from JUIT Waknaghat's civil engineering laboratory. Tests were carried out to determine the various properties of soil and results are tabulated in table 9.given below:

Sr. No.	Particulars	Value
1.	Liquid limit (%)	73
2.	Plastic limit (%)	38.6
3.	Plasticity index (%)	34.4
4.	Maximum Dry Density, γd (kN/m3)	1.84
5.	Optimum Moisture Content, OMC	27

RBI Grad 81: RBI Grade 81 is a hydration activated powder based stabilizer which reacts with soil. Material for the testing work is received from M/S Alchemist Technology Limited, India. Chemical composition and properties of RBI Grade 81 are tabulated in table 10. (provided by the supplier);

PHYSICAL PROPERTIES	
Odor	Odorless
pH	12.5 (saturated paste)
Specific Gravity	2.5
Solubility	In water (0.2pts/100 pts)
Freezing Point	None, Solid
Flammability	Non-Flammable
Shelf Life	12 month (dry storage)
Storage	Dry, Avoid moisture
Bulk Density	700 kg/m^3

CHEMICAL COMPOSITION (Table 11.)

SR. NO.	CHEMICAL COMPOUNDS	PRECENTAGE (%)
1.	Ca (Cao)	52-56
2.	Si (SiO_2)	15-19
3.	S (SO_2)	9-11
4.	Al (Al_2O_3)	5-7
5.	Fe (Fe_2O_3)	0-2
6.	Mg (MgO)	0-1
7.	Mn, K, Cu, Zn	0-3
8.	Fibers (Polypropylene)	0-1
9.	Additives	0-4

Sodium Silicate: Sodium silicates are commonly used as a grouting material. Following are the typical characterization of sodium silicate.

Table 12.

SR. NO.	PARTICULARS	VALUES
1.	Total Alkalinity (Na_2O)	11.5
2.	Silicate (SiO_2)	28.12
3.	Ratio by weight (Na_2O:SiO_2)	1 to 2.43
4.	Molecular Ratio (Na_2O:SiO_2)	1 to 1.66

RESULT AND DISCUSSION

TEST RESULT WITH RBI 81 (Table 13.)

Sr. no.	Particulars	Soil	Soil+ 2% RBI 81	Soil+ 4% RBI 81	Soil+ 6% RBI 81
1.	Liquid Limit (WL) (%)	56.5	53.5	52.4	51.7
2.	Plastic Limit (WP) (%)	29.10	30.85	33.5	33.89
3.	Plasticity Index (IP) (%)	27.4	22.65	19.05	17.81
4.	Free Swell Index (F.S.I)	30	20	10	5
5.	Optimum Moisture Content (O.M.C.) (%)	20.02	24.25	25.09	26.40
6.	Maximum Dry Density (MDD) (g/cc)	1.63	1.575	1.565	1.563

We observe that liquid limit and plasticity index decreases by increasing percentage of RBI Grade 81. That means by increasing the percentage of RBI Grade 81 Black Cotton Soil becomes less liquid.

We also see that Free Swell Index deceases by adding more RBI Grde 81, which means soil's heave behavior is controlled by increasing RBI 81.

OMC is increasing that means dry density is increasing by increasing % of RBI 81, which means water is reduced.

1. TEST RESULT WITH SODIUM SILICATE

(Table 14.)

Sr. No.	Particulars	Soil	Soil+ 3% sodium silicate	Soil+ 4.5% sodium silicate	Soil+ 6% sodium silicate
1.	Liquid Limit (WL) (%)	56.50	57.05	58.66	56.84
2.	Plastic Limit (WP) (%)	29.10	36.54	46.74	43.54
3.	Plasticity Index (IP) (%)	27.40	20.51	11.92	13.30
4.	Free Swell Index (F.S.I) 30	30	50	50	40

Soil is becoming more liquid as Sodium Silicate % is increased.
But Swelling is controlled best between 3% and 4.5% of Sodium Silicate.

A. Consistency Limit: Liquid limit and Plastic limit of the soil mixed with varying percentage of RBI 81 and Sodium Silicate are given respectively. Study of Atterberg's limit indicate that LL and PI reduces with increasing percentage of RBI 81 whereas increases with sodium silicate addition. Observed variation of WL and IP under stabilizer dose given below in the fig. 16. It is observed that plastic limit of RBI Grade 81mixed soil increases with the increasing proportion, comparatively substantial improvement in WP observed with Sodium silicate up to 4.5% but thereafter reduces. P.I. of mixed soil improved by 35% and 51% under 6% RBI and Sodium silicate respectively.

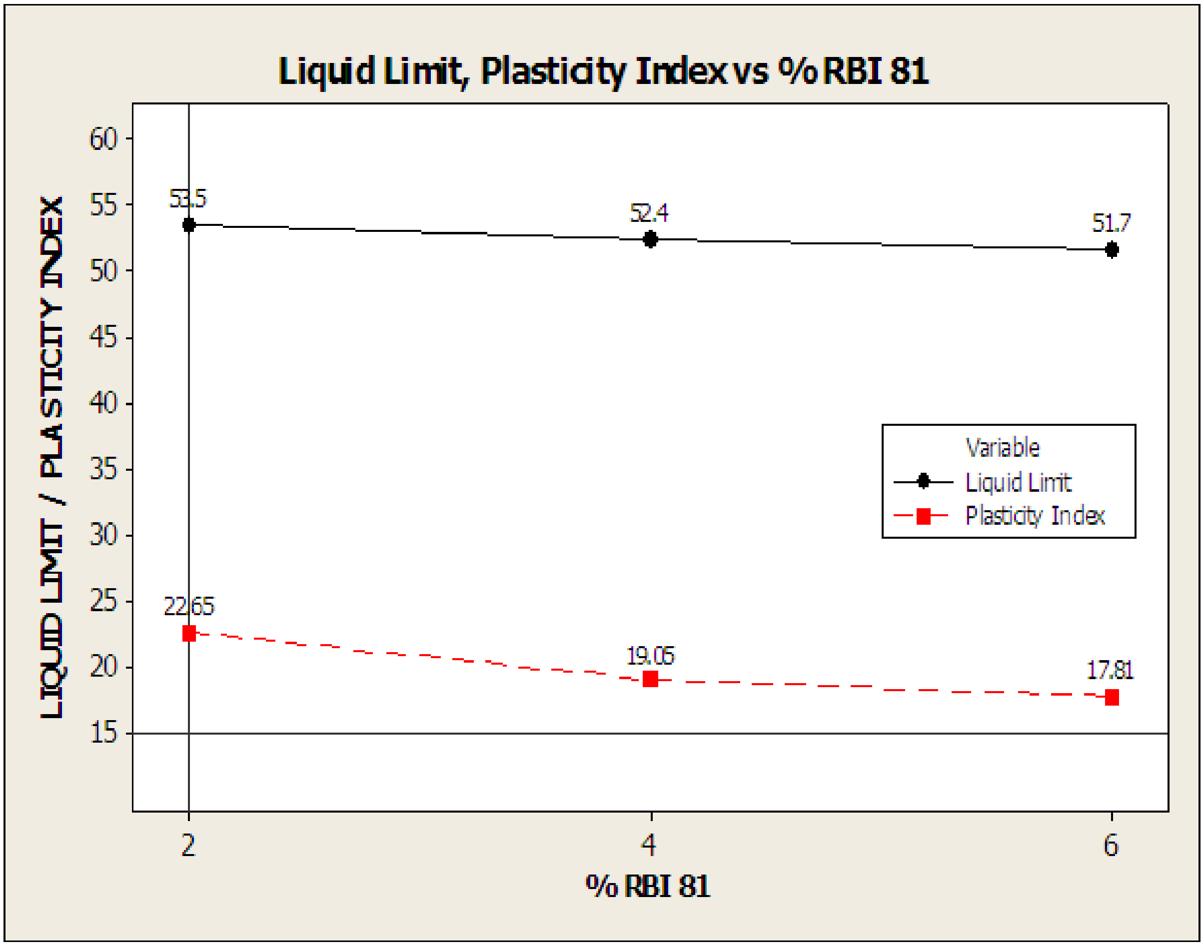


Figure 16. Consistency limit vs % o RBI 81

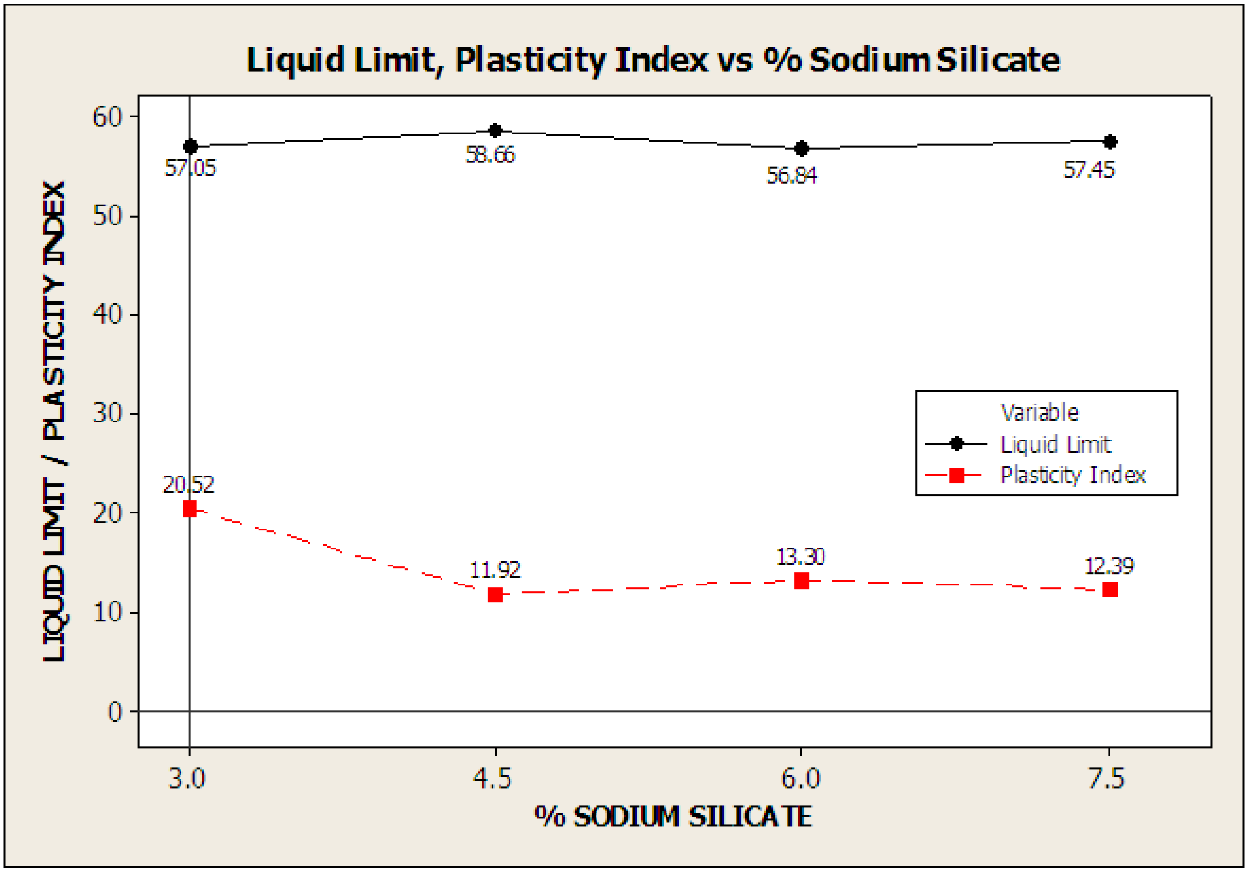


Fig 17: Consistency limit vs % Sodium Silicate

B. Free Swell Index: Swelling potential of mixed soil with RBI Grade 81 reduces by 83% whereas Swell Index increases with sodium silicate and increase of about 166% observed for 6% sodium silicate addition. FSI indicates potential of expansiveness of soil which is not desirable for soil treated with sodium silicate and pose limitation of sodium silicate to be used as stabilizer for black cotton soil.

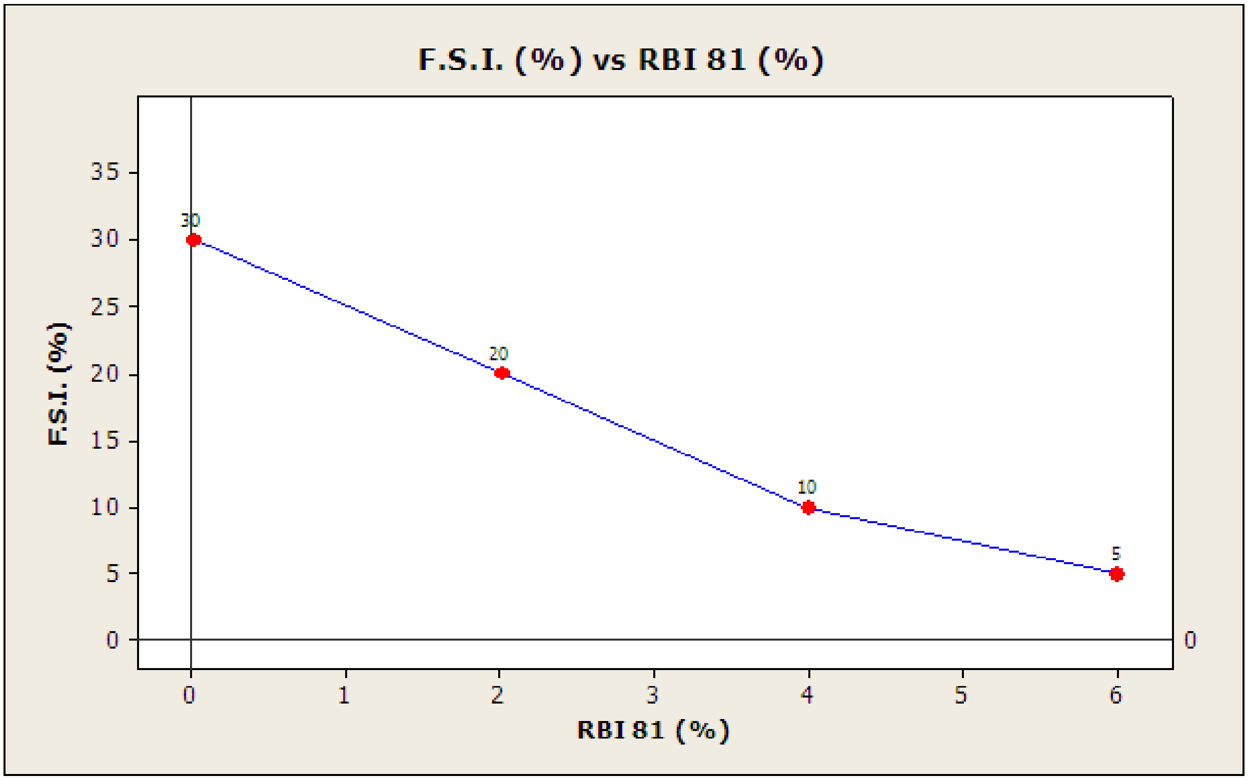


Figure 18.FSI Variation under RBI 81

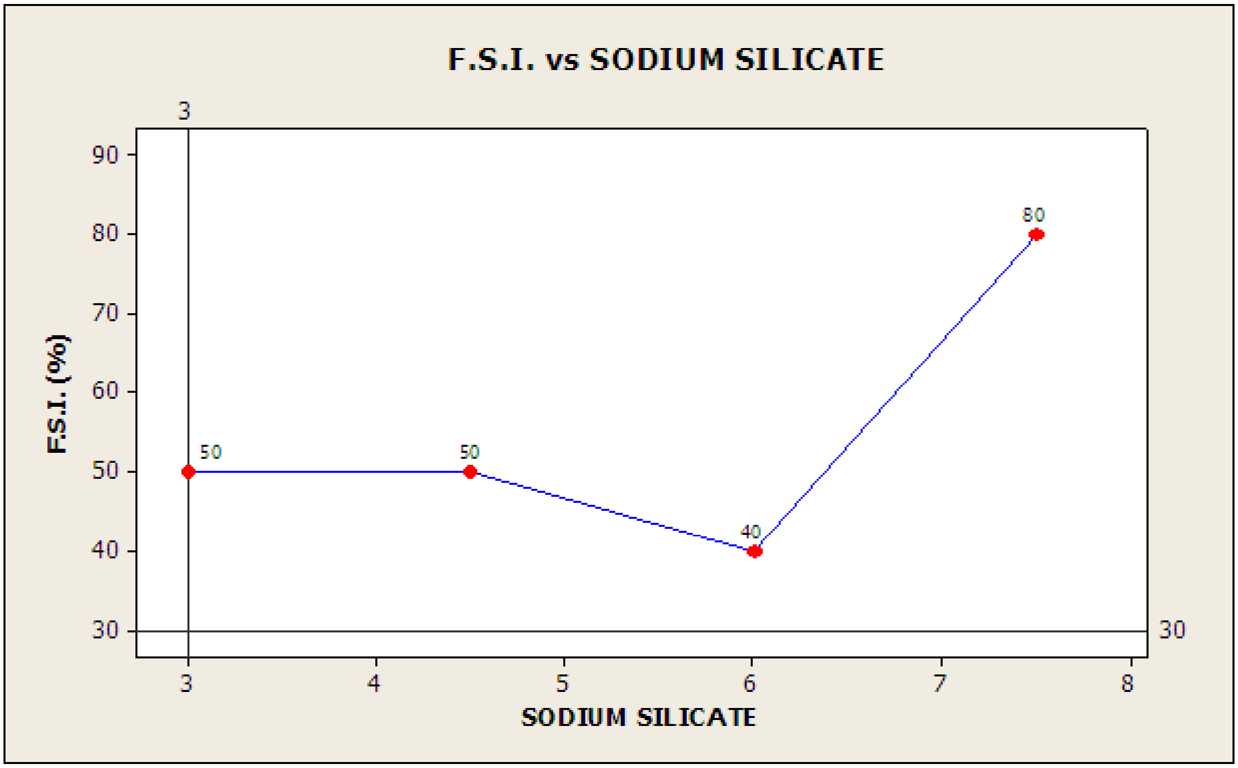


Fig. 19: FSI Variation under Sodium Silicate

CONCLUSION

- Scope of the work was to propose chemical stabilization for enhancing engineering properties of black cotton soils using RBI Grade 81 and sodium silicate.
- Liquid limit decreases as the admixture content increases whereas reverse trend observed with plastic limit as it increases with the increase of admixture, results in net reduction of plasticity index.
- Solubility of sodium silicate in water limits its use alone as a stabilizer in soil, whereas sodium silicate if applied with lime orcement for stabilization may found suitable because sodium silicate helps in increasing pH of soil environment which is necessary for the strength developments.
- Highly plastic soil can be stabilized with RBI Grade 81 and can be considered as stabilized sub base. So RBI Grade 81 is a good stabilizer.
- OMC increased and MDD decreased with addition of RBI Grade 81. MDD is decreasing with addition of RBI Grade 81.
- Strength does not decrease with decrease in MDD.

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