© 2017 IJSRST | Volume 3 | Issue 7 | Print ISSN: 2395-6011 | Online ISSN: 2395-602X
Themed Section: Science and Technology

A Study on Durability Characteristics of Natural Fiber Reinforced in Weak Soil

Mohan M*[1], Manjesh L[2]
*[1]Research Scholar, Department of Civil Engineering, University Visveswaraya College of Engineering, Bangalore University, Bangalore, Karnataka, India
[2]Associate Professor, Department of Civil Engineering, University Visveswaraya College of Engineering, Bangalore University, Bangalore, Karnataka, India

ABSTRACT

Engineers are often faced with the problem of constructing facilities on or with soils, which do not possess adequate strength to support the loads imposed upon them either during construction or during the service life of the structure. Stabilization of soils with low-bearing capacity is an economical way to strengthen the earth for construction purposes. Use of natural fibre in civil engineering for improving soil properties is advantageous as they are cheap, locally available, biodegradable and eco-friendly. The natural fiber reinforcement causes significant improvement in CBR values, Unconfined Compressive Strength of the soil and Durability characteristics of the soil and other engineering properties of the soil. The natural fibers are bio-degradable hence it is necessary to treat the fibers with chemically. In the present study sodium hydroxide (NaOH) and hydrogen peroxide (H2O2) solutions are used to increase the durability of the coir and jute fiber. The strength and durability of fibers treated with Sodium chloride, sodium hydroxide and hydrogen peroxide are studied and among these chemicals sodium hydroxide offered better durability and hence delays in degradation.

Keywords : Chemical Treatment, Sodium Hydroxide (NaOH), Hydrogen Peroxide (H2O2), Durability, Soil Stabilization.

I. INTRODUCTION

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 to 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 by superior soil and hence, soil stabilization is must.

Fibers of banana, jute, sugarcane, coconut, rice straw, sisal and mainly cotton are the most important commercial varieties of fibers and they are responsible for 93% of the national production. Some plants are cultivated only for fiber extraction, however, in most cases, the sources of fiber are agricultural by products, and these could become a main source for not only fibers but also chemicals and other industrial products. 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. 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.

Cohesive soils are known to be weak soils. There are previous instances regarding the use of coir fiber for stabilizing for pavements, but there are less known facts about the biodegradability of the fibers used. It is also known that disposal of coir from industry is a big problem. Hence the study mainly aims at to improve the characteristics of soil and also addresses as potential problem of disposal of coir. The maximum production of coir fibers is in southern states of India and in Sri Lanka, where the best quality fibers are produced, the average yield is 80 to 90 grams per husk. The maximum total world production of coir fiber is estimated to be between 5 and 6 million tons per year. In India the production of coir fiber is 600 tonnes per year out of which 300 tonnes is used for exporting, 60 tonnes for small scale purposes and the remaining 240 tonnes is waste. The disposal of coir waste is a major issue. Therefore it can be used as stabilizing material for weak soil. The fibers are subjected to biodegradability hence it is necessary to treat the fiber with the chemicals to increase the life of the fiber.

Objectives of the present Study

- To determine optimum molarity of chemical and soaking period for coir fiber and Jute Fiber in Sodium Hydroxide (NaOH) & Hydrogen Peroxide (H2O2) solution.
- To determine the durability of the chemically treated Coir and Jute fiber stabilized mix by varying curing period.
- To determine the durability and strength of chemically treated coir and jute fiber stabilized soil mix.

The present study is required to improve the strength characteristics of the soil. Since the soil sample which is used for the study is having lower strength characteristics. It has been witnessed in Progress Report 3 that reinforcing of soil with coir and jute fiber increased the strength properties of soil. But on the other hand both coir and jute are naturally available fibers and are prone to biodegradation. Upon biodegradation of these materials the strength of the pavement may decrease substantially. Hence in order to delay the degradation various literatures have been reviewed and found that treating the fibers with alkaline Solution viz., Sodium Hydroxide(NaOH) & Hydrogen Peroxide(H_2O_2) may increase the durability of the fibers. The durability in this study has been evaluated by wetting and drying test method.

Brigida A. I. S et al (2010) have studied Green coconut fiber was treated by three chemicals NaCl, NaOH or H_2O_2. The effect of these treatments on the structure, composition and properties of fibers was studied using SEM, FTIR, XPS, TGA and other analyses. SEM showed that treatment with H_2O_2 is the most efficient in terms of waxy and fatty acid residues removal but it does not modify the surface chemical composition, that it can be seen by FTIR and wettability results. The fiber morphology analyses showed that the treatment with H_2O_2 is indicated for applications where decolorized fibers are required and when the presence of waxes and fatty acids on fiber surface are undesirable. Cellulose presence increases the potential of using this fiber when free OH is fundamental. Fiber treatments with H_2O_2, through the oxidation of hydroxyl groups to carboxyl groups (confirmed by FTIR), promoted a smooth cationic potential on fiber surface. Furthermore, this treatment is shown to maintain the native hydrophilic/hydrophobic characteristic of green coconut fiber and to increase its thermal stability.

Ayyavoo Karthikeyan et al (2014) have studied the effect of surface modification through sodium hydroxide (NaOH) treatment and fiber length on the tensile strength of coir fiber of reinforced epoxy composites. The coir fibers were treated with 2%, 4%, 6%, 8%, and 10% concentration of NaOH for 10 days. The tensile strength of untreated and alkali-treated fiber was determined. For each group of the coir fiber, experiments were conducted on different fiber lengths, namely, 10, 20, and 30 mm. The results showed that increasing the NaOH concentration leads to a decrease in fiber diameter in a linear fashion. This reduction in diameter naturally ends up with reduced tensile strength. The treated coir fiber was used as a reinforcement and epoxy as a matrix to fabricate the composites. The tensile strength of different samples of composites was determined. Increased NaOH concentration (up to 4%)

in fiber treatment was found to increase the tensile strength, and further increase in NaOH concentration reduced the tensile strength, increased fiber length was found to increase in tensile strength. The maximum tensile strength of the composite was observed at 4% NaOH-treated samples.

Ferreira Saulo Rocha et al (2014) have studied the chemical and mechanical behavior of coir fibers treated with aniline polymerization, H_2O_2 and untreated. The fibers were characterized using Fourier transform infrared spectroscopy, X-ray diffraction, thermo gravimetry analysis and scanning electron microscopy. The obtained data shows that the presence of H_2O_2 produces some extension of oxidation of the hydroxyl groups. After the treatment of polymerization new characteristic bands are formed.

Arun Kumar Rout et al (2016) have studied effect of chemical treatment to palm tree leaf stalk fibers with a 5% NaOH solution for 1h, 2h, 6h and 12 h. The treated fibers were then characterised by tensile strength testing, chemical analysis X-ray diffraction, Fourier transform infrared spectroscopy, scanning electron microscopy, and solid state NMR. The tensile strength of the fibers was improved with an alkali treatment, and 6h treatment resulted in the maximum fiber strength. The maximum cellulose content was present in the 6h treated fibers. Cellulose content was reduced with a long treatment 12h. Similarly SEM, FTIR, XRD, AND NMR confirmed the removal of hemicellulose, lignin, and wax from the fiber surface, making it rough to the raw fiber surface and the formation of new hydrogen bonds between the cellulose fibril chains with respect to the duration of the treatment. The 5% alkali treatment also improved the fiber density from .85 gm/cc of raw fiber to 1.05gm/cc, 1.13 gm/cc, 1.17 gm/cc, and 1.25 gm/cc after the 1h, 2h, 6h and 12h treatments respectively.

Andréa Rodrigues Marques et al (2014) have studied the effects of the climatic conditions during a seasonal cycle of rain and droughts were evaluated on the structural and mechanical properties of coir geotextile fibers that were treated with lime. Analyses of the tensile strength of coir fibers showed that after 12 months of exposure untreated fiber had retained 23% and treated fiber 19% of their initial strength. Two principal factors were considered in evaluating the structural properties of the coir fibers after environmental exposure: (i) initial cellulose retention and its stability after lime-treatment; (ii) lignin degradation and its loss to the environment. The structural changes seen by thermo gravimetry (TGA) and Fourier Transforms in Infrared spectroscopy (FTIR) analyses explained the changes seen in coir mechanical properties. The greater cellulose contents of fiber structures treated with lime explained their greater tensile strength and high Young's modulus measures after the first three months of exposure in local weather conditions. Considering that lime treatment improved coir fiber properties, lime applications are indicated when coir geotextiles are to be used in acidic Brazilian Cerrado soils.

Ghosh S.K et al (2014) have studied biodegradability of jute nonwoven fabrics intact during its performance period. In this study Bitumen emulsion with essential additives has been applied following a special technique, apart from the conventional method, on the Grey Jute Nonwoven Fabrics in different add on percentages to make a comparative assessment of the performance of both Grey Jute Fabrics and Bituminized Jute Nonwoven Fabrics by Soil Burial Test as per the BIS standard test method. The test results revealed that the durability and performance of the Bituminized Nonwoven Jute Fabrics are much better than that of Grey Jute Nonwoven Fabrics.

Amit Rawal et al (2014) have studied the enhancement of tensile and mechanical properties of jute fibers were treated with 4 % sodium hydroxide (NaOH) solution. A series of needle punched nonwoven geotextiles were then fabricated by formulating blends of untreated jute and polypropylene fibers and corresponding sets of nonwovens containing alkali treated jute and polypropylene fibers in defined weight proportions. Subsequently, a comparison has been made between the physical and mechanical properties of these blended nonwoven geotextiles. In general, the alkali treated jute blended nonwoven geotextiles offer higher puncture resistance in addition to higher tensile and tearing strengths in the cross-machine (preferential) direction than their corresponding blended geotextiles consisting of untreated jute fibers. Blended nonwoven geotextiles consisting of more than 40% jute fibers were not found to be useful in enhancing the mechanical properties.

II. METHODS AND MATERIAL

The experimental work was carried out in three stages. In the first stage basic tests like Physical properties of soil and fibers(coir and jute) were evaluated along with the optimum fiber content to be mixed with the soil [1]. Second stage consisted of determining Optimum Molarity for the chemical solutions to treat the fibers. The molarity was varied as 0.5M, 1.0M, 1.5M, and 2.0M. From the literature it was noted that the soaking period played a major role in deciding the performance of the chemically treated fibers. Hence the soaking period was varied as 2hrs, 4hrs, 6hrs and 8hrs. The optimum soaking period and optimum molarity is decided based on the strength parameter by conducting unconfined compressive strength test. In the third stage durability is assessed by conducting wetting and drying test (ASTM D4843-88) for 12 cycles.

Total eight identical specimens are prepared to conduct the test for each chemical. The prepared specimens are subjected to 12 cycles of freeze and thaw. Out of eight specimens 2 specimens tested for unconfined compressive strength after 3rd cycle, 2 specimens tested for unconfined compressive strength after 6th cycle, 2 specimens tested for unconfined compressive strength after 9th cycle and remaining 2 specimens tested for unconfined compressive strength after 12th cycle. The specimens are prepared by using optimum fiber length optimum fiber content [1] and optimum molarity. Another 8 specimens are prepared without chemical treatment to the fiber. In this 2 specimens are subjected to unconfined compressive strength after 3rd cycle, 6th cycle, 9th cycle and 12th cycle.

III. RESULTS AND DISCUSSION

Table 1. Physical and Engineering Properties of Jute

Sl. No.	Properties	Value
1	Specific gravity	1.12
2	Cut length	30mm
3	Diameter	0.7mm
4	Colour	Yellowish brown
5	Optimum Aspect ratio	43

Table 2. Physical and Engineering Properties of Coir fibers

Sl. No.	**Properties**	**Value**
1	Specific gravity	0.71
2	Cut length	30 mm
3	Diameter	0.25 mm
4	Colour	Golden Brown
5	Optimum Aspect ratio	120

Table 3. Results of physical properties of soil

Colour	Red
Particle size distribution: Gravel, % Sand, % Silt % Clay %	 0.00 48.12 24.426 27.454
Atterberg's limits Liquid limit, % Plastic limit, % Plasticity index, %	 36 16 20
Standard compaction test Maximum dry density, (KN/m^3) Optimum moisture content, %	 18.80 15.30
CBR, % (soaked)	2.54
Unconfined compressive strength (KN/m^2)	70.67
Free Swell Index,%	2

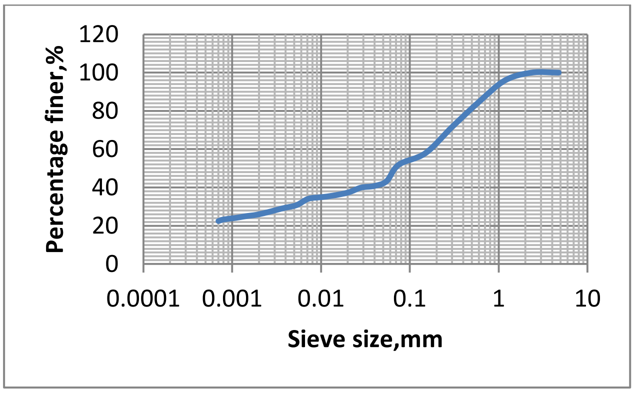

Figure 1. Particle Size Distribution Curve of Soil

Durability Tests on Chemically Treated Jute Fiber Reinforced Soil Mix

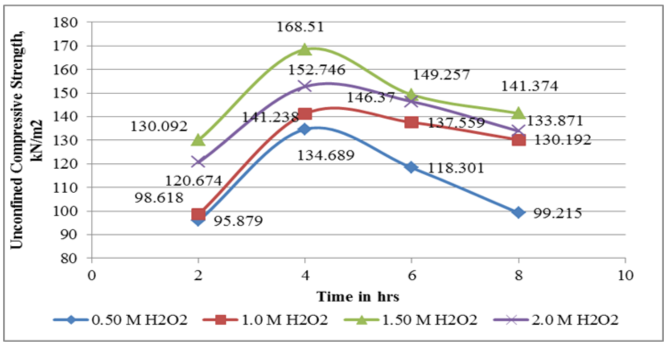

Figure 2. Unconfined Compressive Strength with Varying Soaking Period for Varying Molarity Of H_2O_2 for Jute Fibers

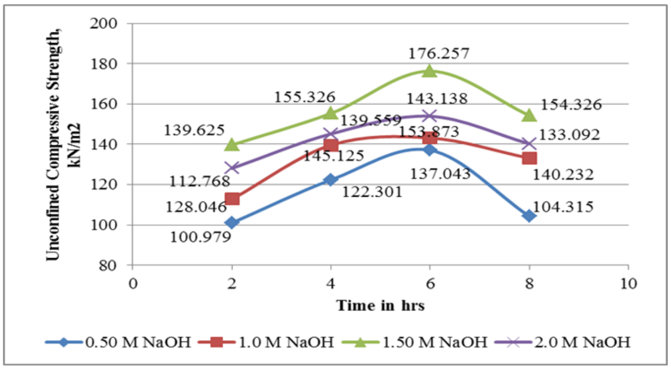

Figure 3. Unconfined Compressive Strength with Varying Soaking Period for Varying Molarity of NaOH for Jute Fibers

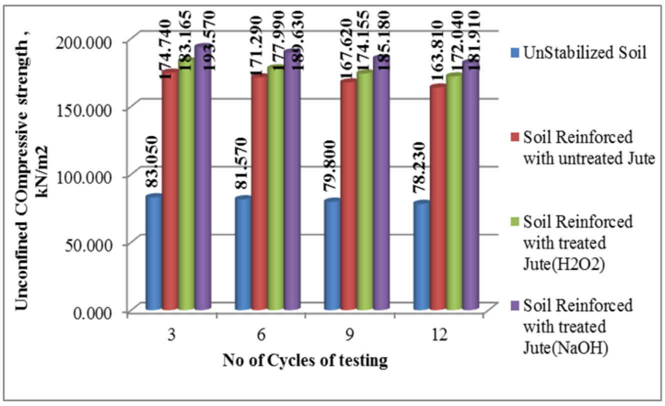

Figure 4. Unconfined Compressive Strength v/s Test Cycles of Wetting and Drying for Treated Jute Fibers Reinforced Soil

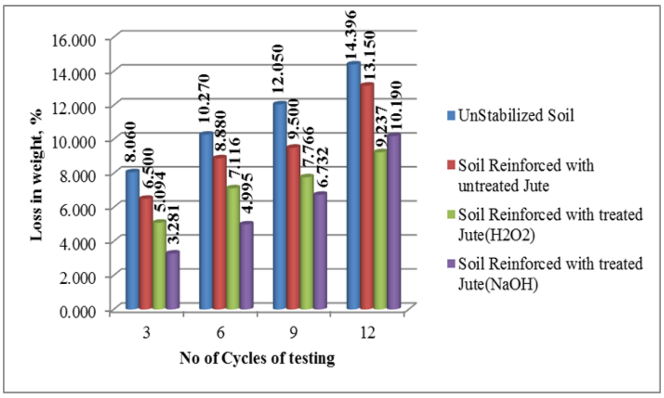

Figure 5. Percentage Loss in Weight v/s Test Cycles of Wetting And Drying for Treated Jute Fibers Reinforced Soil

Durability Tests on Chemically Treated Coir Fiber Reinforced Soil Mix

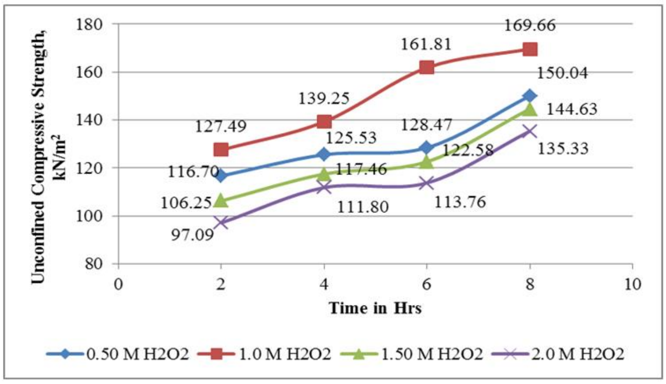

Figure 6. Unconfined Compressive Strength with Varying Soaking Period for Varying Molarity of H_2O_2 for Coir Fibers.

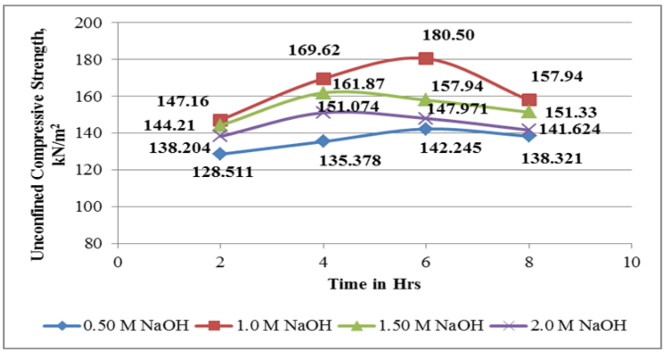

Figure 7. Unconfined Compressive Strength with Varying Soaking Period for Varying Molarity of NaOH for Coir Fibers

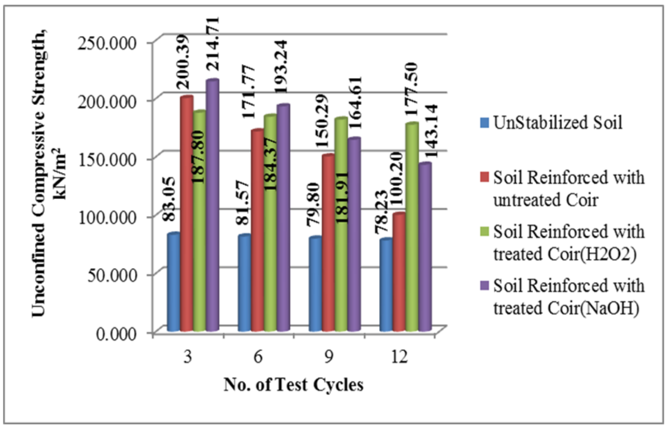

Figure 8. Unconfined Compressive Strength v/s Test Cycles of Wetting and Drying for Treated Coir Fibers Reinforced Soil

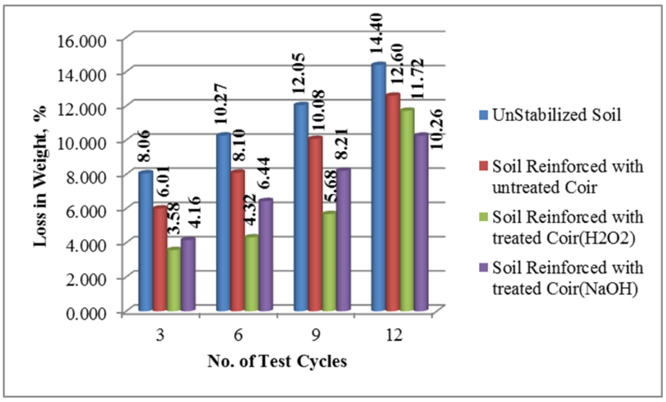

Figure 9. Percentage Loss in Weight v/s Test Cycles of Wetting And Drying for Treated Coir Fibers Reinforced Soil

IV.CONCLUSION

According to IS code 1498:1970, Indian Soil Classification the type of soils are medium compressible clayey soil (CI) and High compressible clayey soil. The result of laboratory investigation shows that, the addition of fiber to the soil, improves the strength characteristics of soil. There is decrease in the percentage loss in weight(which shows the betterment in durability) with soil and chemically treated fiber. .It was found that the strength and durability offered by the Hydrogen peroxide treated fibers were comparatively high. But keeping the economy in consideration the Sodium Hydroxide solution of 1M (6hrs soaking period) and 1.5M(6hrs Soaking Period), for coir and jute respectively is used for further studies which includes construction of test track for conducting Plate load tests and deflection bowl studies under static loading.

V. REFERENCES

[1] Mohan M & Manjesh L, 2017. A Study on Stabilization of Subgrade Soil Using Natural Fibers (Coir and Jute) (September 2017), ISSN: 2347-6710, DOI:10.15680/IJIRSET.2017.

[2] Brígida A I S, Calado V.M.A., Gonçalves L.R.B. , Coelho M.A.Z.,2010. Effect of chemical treatments on properties of green coconut fiber, ISSN: 0144-8617 DOI:10.1016/j.carbpol.2009.10.005

[3] Karthikeyan A, Balamurugan K Effect of alkali treatment and fiber length on impact behavior of coir fiber reinforced epoxy composites. (September 2012), Journal of Scientific & Industrial Research 71, 627-631 ISSN:0022-4456

[4] Ferreira, Saulo & Maria Da Silva, Andréa & Souza Jr, Fernando & Toledo Filho, Romildo & Silva, Flávio. (2014). Effect of Polyaniline and H_2O_2Surface Modification on the Tensile Behavior and Chemical Properties of Coir Fibers. Journal of Biobased Materials and Bioenergy. ISSN:578-586. DOI:10.1166/jbmb.2014.1478.

[5] Rout, A.K.; Kar, J.; Jesti, D.K.; Sutar, A.K. Effect of Surface Treatment on the Physical, Chemical, and Mechanical Properties of Palm Tree Leaf Stalk Fibers. BioResources 2016, 11, ISSN: 1930-2126

[6] Rodrigues Marques, Andréa & Patricio, Patrícia & Soares dos Santos, Fábio & Monteiro, Monisa & de Carvalho Urashima, Denise & Rodrigues, Conrado. (2013). Effects of the climatic conditions of the southeastern Brazil on degradation the fibers of coir-geotextile: Evaluation of mechanical and structural properties. Geotextiles and Geomembranes. 42, DOI:10.1016/j.geotexmem. 2013.07.004.

[7] Ghosh S.K., Bhattacharyya R., Mondal M.M., A REVIEW ON JUTE GEOTEXTILE – PART 1, pISSN: 2321-7308, Volume: 03 Issue: 02 Feb-201.

[8] Amit Rawal, Sayeed M.M.A., "Tailoring the structure and properties of jute blended non-woven geo textiles via alkali treatment", Materials and Design 2014; 53: 7101-705