Application and Evaluation of Bitumen Coating On Jute Agave Americana for Geotextiles

By

Yasotha Kumari, S

(13PBX007)

A Thesis submitted to the

Avinashilingam Institute for Home Science and Higher Education for Women

Coimbatore - 641 043

In Partial Fulfillment of the Requirements for the

Degree of Master of Science

in

Bio- Textiles

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Certified as Bonafide Research Work

27/3/15

Signature of the
Head of the Department

Signature of the
Guide

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1. INTRODUCTION

The Indian textile Industry is one of the oldest industries in the world. It has always been a major player in global trade over the two decades. Textiles are a part of our ancient heritage and traditions. Textile industry has been one of the most important sectors in Indian economy. Textile industries are facing a challenging condition in the field of quality and productivity due to the globalization of the world market (Chakrabarthi, 2010). From the earliest times people have used textiles of various types for covering, warmth, personal adornment and even to display personal wealth (Singh, 2008). The textile industry provides the second largest employment opportunities in the country, next to agriculture (Goyal and Deshpande, 2006). Textile industry is an independent industry involved in the production of basic raw materials to the final products with huge value addition at every stage of processing (Pandy and Manex, 2011).

Natural fibres are the essential alternatives in ever expanding horizon of textile fibres. They have high length to diameter ratios and they are bonded together by natural gums and resins. In textiles, natural fibres are widely used in different areas and for different applications mainly clothing, home furnishing, industrial textiles and technical textiles (Singh *et al*., 2010). Among the natural fibres, seed fibres, fruit fibres, bast fibres, leaf fibres and animal fibres are important in terms of production volume, industrial activity and usage patterns (Ghosh and Grow, 2004). Natural fibres present important advantages such as low-density, appropriate stiffness, mechanical properties, high disposability and renewability. Moreover they are recyclable and biodegradable (Das and Gon, 2012).

Presently, the Advanced Materials and Processes Research Institute (AMPRI), Bhopal has started an activity on applications of the sisal based geotextiles, which is more superior over others. The possible market for sisal geotextiles is bigger though it is not yet being completely utilized. In order to get benefits of the prospects, the research on sisal based geotextile must be carried out and industries should take a more market driven approach, reacting to the requirement of customer's and must develop standards for its products (Ramakrishnan *et al*., 2008).

Technical Textiles is high technology sunrise sector which is steadily gaining ground in India. Technical textiles are functional fabrics that have applications across various industries including automobiles, civil engineering and construction, agriculture, healthcare, industrial safety and personal protection based on usage there are twelve technical textile segments namely agrotech, meditech, buildtech, mobiltech, clothtech, oekotech, geotech, packtech, hometech, protech, indutech and sportech. Technical textile products derive their demand from development and industrialization in a country (www.technotex.gov.in). The economic scope and importance of technical textiles extend far beyond the textile industry itself and has an impact upon just about every sphere of human economic and social activity (Anand, 2000).

Geotextile is a newly emerging field in the civil engineering and other sectors which offers great potential in varied areas of applications globally. Geotextiles play a significant part in modern pavement design and maintenance techniques. Geotextiles are ideal materials for infrastructural works such as roads, harbours and many others (Saravanan, 2014).

Natural fibre geotextiles have been used for thousands of years and references and found in Holy Bible. Natural fibre geotextiles can replace synthetics due to properties of biodegradability and ecofriendliness. Ability of natural fibre is to absorb water and to degrade with time. Natural fibres such as jute, coir, sisal, agave, bamboo and pineapple are known to have very high strength and can be effectively utilized for various applications (Nandan *et al*., 2008).

The growing consciousness regarding environment preservation has changed the situation in the recent years. Some major advantages of jute in this context include agro origin, soil friendly complete biodegradable nature eco compatibility and improvement of soil fertility and texture. Jute geotextile is an engineering fabric which, when placed in or on soil, helps to improve its engineering performance against extraneous loads by acting as a change agent or a catalyst (Ghosh, 2014).

Agave *americana* plant of Mexican origin which belongs to *Agavacea* family has powdery blue – grey leaves. It produces a gigantic flower after attaining full height, the size of the plant being 5-7 feet high, spread over 8-12 feet. The fibres from these leaves are stiff, strong and are used for making ropes and handicraft items. Agave plant has more than 200 species all over the world. The Agave *americana* fibres are preferred these days because they are environmentally friendly in that they are biodegradable (Zwane and Masarirambi, 2011).

The textile industry is having on the environment, more and more textile researchers, producers and manufacturers who are looking for biodegradable and sustainable fibres as an effective way of reducing the impact on the environment (Richard Blackburn, 2005). In an agriculture country like India lack of availability of synthetic geotextiles, high cost, stringent environmental concern and shortage and power lead the researches to explore possibility of natural geotextile in place of synthetic based material (Loui and Satyakumar, 2013).

Bitumen is used for coating the jute fibre to protect them from microbial attack and degradation. Bitumen coating is done in the hot state at a temperature of 160^{o}C, (Aggarwal and Sharma, 2011).

Considering all the above facts, the study on **“Application and Evaluation of Bitumen coating on Jute Agave *americana* Fabric for Geotextiles’’** has been carried out with the following objectives.

- To spin and fabricate the selected yarns
- To improve the life span of the natural fibres
- To evaluate and compare the effect of treated fabrics for geotextiles

2. REVIEW OF LITERATURE

The literature reviews done for the study are expressed under the following heads.

2.1 Natural fibres

Natural fibres come from animals, plants and minerals or they are mined from the ground (Fletchor, 2012). Among the natural fibres seed fibres (cotton) fruit fibres (coir), bastfibres (jute, ramie, kenaf and hemp), leaf fibres (Sisal, pineapple, banana, raffia, palm) and animal fibres (wool, hair and silk) are important in terms of production volume, industrial activity and usage patterns (GhoshandGraw, 2004). Natural fibres are green biodegradable and have good properties such as low density and low cost when compared to synthetic fibres (Bavan and Kumar, 2013).Coir is a natural insulation material produced from flax fibres, intertwined together into non-woven matting, which can then be set in lofts or put into wall cavities coir geotextiels are applied in areas of erosion control, soil conservation and other other civil and bioenginerring applications (Nandan, 2008). In India, sisal is not cultivated and the sector is unorganized. Sisal is currently found on embankments, bunds and roadsides, serving the purpose of soil conservation and protection as hedge plantation. Presently sisal fibres are collected and utilized for conventional purposes live roper, anchor, cordage and handicrafts (Ramakrishnan, 2008). The growth of jute base geotextiles is huge due to its various applications in infrastructure development. There were eight Indian jute mills which started production of jute on the base of 50 tons a day of geotextiles with open mesh structures in June 1998, and in the recent time production and uses of these types of jute geotextiles have improved drastically (Ghosh, 2000).

2.1a Agave fibre

The Agave *americana*fibres are white to yellowish in colour, and have a hard touch due to the existence of lignin on the surface. The Agave *americana* fibre has a high resistance to chemical agents such as acids and alkalis. Compared to other plant textile fibres, the Agave *americana* fibres are more hydrophilic than cotton, flex and other vegetable fibres wit0h a regain equal to 17%. The long technical fibres are generally hard, stiff, and coarse in texture (Slah et al., 2006). In Tunisia the Agave *americana* fibres are used to make ropes and twines for agricultural and marine purposes. In India the plant is extensively used for hedges along railroads currently in Kenya the plant is mostly used as an outdoor plant for aesthetic appearance, the fibre can also be used in technical applications such as making reinforced materials and geotextiles (Jose, 2009).

2.1b Jute fibre

Jute is a type of the best fibre extracted from the stem of the jute plant having long length and soft with a shiny appearance. Jute is the cheapest natural fibre and is considered the “golden fibre” due to its colour and cashvalue (Muthu, 2014). The uses of jute include twine, sacking, and backing for coarser fibres. Where it is a competitor to polypropylene. Finer fibres blended with wool or other fibre are woven into upholstery fabrics, rugs, and textiles, (Netravali, 2014). Jute fibres possess good pliancy and render a high degree of flexibility and fineness to fabric construction. High rigidity and low percentage of elongation at break make jute a suitable fibre for geosynthetics (Sanyal, 2011). The other remarkable property of jute is its capacity to absorb water because of its high cellulosic content. Jute fibre can absorb water up to about 500% of their dry weight. Hygroscopic property of jute is the highest amount all fibres (Ghost, 2000). Effect of acids cold concentrated acids damage jute fibre. Dilute acids can damage in hot conditions. Effect of alkalis Strong alkalis damage jute fibres leading to loss of weight (Muthu, 2014). Jute is natural multifilament fibre, durable and simple to both produce and dispose. Biodegradable woven jute is accessible in a number of weave densities, initially anticipated as a geotextile to avoid land sliding and consequent to deforestation. Jute is available in India in large quantities at a cheaper rate. Jute geotextiles can perform a vital function in the control of soil erosion by revegetation and it has many uses, which cheaper as well as easy to accomplish. It has many benefits as geotextiles, because of its high water absorption capability, flexibility and drapability (Ghosh, 2000).

2.2 Yarn and Fabrics

2.2a Yarn

Yarn defines as the result of twisted fibres which are spun together to create continuous threads (Harder, 2004). Simple yarn is the construction of only one kind of fibre and the manner in which the fibres are twisted will be the same throughout the length of the yarn (Parvathi, 2007). Twisted fibres or yarns have diagonal lines that correspond with the cross bars in the letters S or Z. Flex, ramie, milk weed and Indian hemp fibres always show S twist, (Buchanan, 1999). A higher tensile strength of the natural fibre sliver could be achieved by twisting (Fakirov and Bhattacharyya, 2007).

2.2b Fabrics

Geotextiles are a permeable synthetic material made of textile materials. They are usually made from polymers such as polyester or polypropylene. The geotextiles are further prepared in three different categories-

- Woven fabrics.
- Nonwoven fabrics.
- Knitted fabrics.

2.2b.1 Woven fabrics

Woven consist of perpendicular strands interlaced into a tight weave, much like clothing would be made. Many types of weave patterns affect porosity, strength, and elongations. By specifying the characteristics of the fabric needed a manufacturer can recommend a particular weave and products to best suit the requirement (Hopper, 2012). Braided fabrics are also commonly used to develop technical textiles (Gandhi, 2012). The plain woven fabrics have no right or wrong side till they are not printed or given a finish, These fabrics tend to wrinkle readily and are less absorbent than other weaves by using various fibres (Meenakshi, 2009). The range of application of plain weave is wide as it produces a relatively stronger fabric that is obtained by any other simple combination of threads, excepting that a ‘gauze’ or ‘Cross Weaving’ (Gokarneshan, 2009). Plain weave finds extensive uses. It is used in cambric, muslin, blanket, canvas, dhothi, saree, shirting and suiting productions (Kadolph *et al*., 2002). A mixture is when one fibre is spun into a yarn for the warp thread and a different fibre is spun to make the weft threads, the mixing occur during the weaving process (Aldrich et al., 2007).

2.2b.2 Nonwoven fabrics

The most common product in the family of geosynthetics is nonwoven geotextiles fabrics. This product is a random assembly of synthetic fibres, put together, which are mechanically and thermally bonded to make into a single layer, commonly made of nonwoven polypropylene geotextiles and polyester type. Nonwoven geotextile fabrics are manufactured that based on typical required (www.ipnonwovens.com).

2.2b.3 Knitted fabrics

Knitting geosynthetics are manufactured using another process which is adopted from the clothing textiles industry, namely that of knitting. In this process interlocking a series of loops of yarn together is made (www.textileleaner.com). These geotextiles are highly extensible and have relatively low strength compared to woven geotextiles, which limits its usage (Kumar, 2013).

2.2b.4 Advantage of woven fabrics

The plain weave is tightest having smallest pore opening in the fabric. Woven fabric performs the functions of separation, filtration, initial re-enforcement and drainage when used in the interface of road sub-grade and sub-base, there by helps soil consolidation and increases the CBR%. Woven jute geotextile overlain with nonwoven jute geotextiles when applied on the surface of weak formation arrest scope of infringement of ballasts into the soil below and also allow passage of precipitation along the plane of the fabric there by keeps the soil dry and tight and ultimately check the possibility of settlement of railway tracks. Properly designed woven fabric with appropriate porometry treated with suitable additives is used as filter material in river bank production.

2.3 Technical Textile

Technical textiles are defined as Textile material and products manufacture primarily for their technical performance and functional properties rather than aesthetic and decorative characteristics (Richard, 2000). Technical textiles have attracted considerable attention, for the use of fibres, yarns and fabrics for applications other than clothing and furnishing. Natural fibres such as cotton, flax, jute and sisal have been used for centuries in applications ranging from tents and tarpaulins to ropes, sailcloth and sacking. The economic scope and importance of technical textiles extends far beyond the textile industry itself and has an impact upon just about every sphere of human economic and social activity (Anand, 2000). Technical textiles are different from the conventional textiles, As these are semi-finished or finished textiles and textiles products manufactured for performance characteristics (Kumar, 2013). An exceptional feature of technical textile is the use of innumerable varieties or raw materials, processes, products and application for their production. Some of the materials used for making technical textiles are Metals, (steel), Mineral, (asbestos and glass). Synthetic polymers, (PES, PA, PAN, PP) Regenerated fibres (rayon fibre and acetate fibre) Natural fibres(cotton fibre, jute fibre, wool fibre) (www.teonline.com).

Technical textiles have been categorized on the basis of their use in different sectors of the industry and termed as agrotech – agriculture, horticulture, forestry and aquaculture textiles; Buildtech-building and construction textiles;clotech-technical component of shoes and clothing and linings;geotech-geo textiles and civil engineering materials;hometech-technical component of furniture, household textiles floor coverings;indutech-textiles for industrial applications filtration, conveying, cleaning; medtech-hygiene and medical products;mobiletech-automobiles, shipping, railways and aerospace; oekotech-environmental protection; packtech-packaging materials; protech – personal and property protection and sporttech-sport and leisure (www.technitex.or).

2.4 Geotextiles

The geotextiles are used in foundation, soil, rock earth, or any other geotechnical engineering related applications an and integral part of human – made project, structure or system," (Chattapadhyay, 2009). Mass per unit area, thickness, flexibility, specific gravity, compressibility, strip and wide-width tensile test, breaking elongation, trapezoidal tear, grab tensile, penetration resistance (drop cone), puncture resistance, tear, burst strength, impact and puncture strength, interface friction resistance, confined strength, elongation, pullout, sewn seam strength, durability, resistance, physiochemical degradation, resistance to clogging, biological clogging, swelling in water, moisture regain permittivity. Gross-plane permeability, in-plane permeability, apparent opening size, creep strength, gradient ratio, ultraviolet stability, and biological degradation are the important properties of geotextiles to be tested (Shukla *et al*., 2008).

2.4a Functions of geotextiles

Separation is the basic use of geotextiles and is extensively practiced in road works and railway constructions. A strong and flexible geotextile is placed between different layers in the construction, preventing migration and mingling of materials. Yet allowing free movement of water. This increases the bearing capacity of the construction and provides long term stability of the foundation layers (Sahu, 2009). The filtration drains are vertically sided trenches, lined with a geotextile and filled with coarse gravel initial loss of soil particles will be adjacent to the geotextile this cause a zone to bridge over the pores in the geotextile and retain smaller particles (Massey, 2010). The drainage function of geotextile involves transmission of liquid in the plane of fabric without soil loss (Chattopadhyay, 2009). The geotextiles increase the stability by helping to span over weak areas, preventing failure of the pavement (Hopper, 2012). Geotextiles are widely used for protection in waste disposal systems and funnel constructions to ensure the integrity of a sealing material for geomembrance when fill material and loads are applied (Sahu, 2009).

2.4b Applications

Geogrids

Geogrids are plastic materials formed into a very open grid like configuration with very large apertures (Saravanan, 2014)

Geonets

Geonets, called geo spacers by some constitute another specialised segment within the geosynthetic area their design function is completely within the drainage area where they have been used to convey fluids of all types (Dhandhania, 2014).

Geomembrances

Geomembranes are available with a variety of physical, mechanical, and chemical properties designed to meet the requirements of a wide range of applications Different combinations of these properties exist in various geosynthetic lining materials to cover a wide spectrum of geotechnical applications and designs several methods are used to join the geosynthesis lining materials in the factory and in the field (Asian Technical Textiles, 2013).

Geocomposites

A geocomposites consist of a combination of geotextiles, geogrids, and geonets and geomembranes in a factory fabricated unit. The high tenacity polyester yarns with high tensile strength and low creep performs the function of reinforcement and the non-woven performs the functions of separation, filtration and drainage and is widely used for road and railway application, The application area are numerous and constantly growing (Sahu, 2009).

2.4c Advantages of using Natural fibres in Geotextile

The vegetable fibres have the greatest potential for use in geotextile because of their superior engineering properties (Anand, 2000). The Natural fibres are available in plenty, economic price-range compared the synthetic fibres and are Eco-campatibile, (Bhattacharyya et al., 2002). The Natural fibres are robust, superior strength / durability properties, good drapeable and biodegradable and environment friendly (Anand, 2002).

2.5 Bitumen in textiles

2.5a Bitumen Properties

Bitumen is water resistant but under some conditions water may be absorbed by minute quantities of inorganic salts in the bitumen or filler in it. Bitumen has the ability to adhere to a solid surface in a fluid state depending on the nature of the surface. The presence of water on the surface will prevent adhesion. The flow properties of bitumens vary considerably with temperature and stress conditions. Deterioration, or loss of the desirable properties of bitumen, takes the form of hardening. Ductility test is conducted (www.aboutcivil.org). The properties of bitumen are expressed in the Table I.

TABLE – I

PROPERTIES OF BITUMEN

S.No	Parameters	Values
1	Grade	80-100
2	Softening point (^oC)	65
3	Flash point (^oC)	185
4	Specific (G_B)	1.06

Source:Aggarwal and Sharma (2011)

2.5b Uses of bitumen

One of the most important uses of bitumen for geotextiles is as filter in drainage and erosion control applications. Geotextiles may be used as armour materials in diversion ditches and at the ends of culverts to prevent erosion and the most common application is for silt fences, which are a substitute for hay bales or brush piles, to remove suspended particles from sediment-laden runoff water (Den, 2002).

2.5c Grades of bitumen

Bitumen 80/100: The characteristics of this grade confirm to that of s 90 grade of IS-73-1992. This is the softest of all grades available in India. This is suitable for low volume roads and is still widely used in the country. Bitumen 60/70: This grade is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that S 35 grade of IS-73-1992. It is presently used mainly in construction of national highways and state highways. Bitumen 30/40: This is the hardest of all the grades and can withstand very heavy traffic loads. The characteristics of this grade confirm to that of S 35 grade of IS-73-1992. Bitumen 30/40 is used in specialized applications like airport runways and also in very heavy traffic volume roads in coastal cities in the country (www.hindustanpetroleum.com).

3. METHODOLOGY

The experimental procedure followed for the study is explained under the following heads.

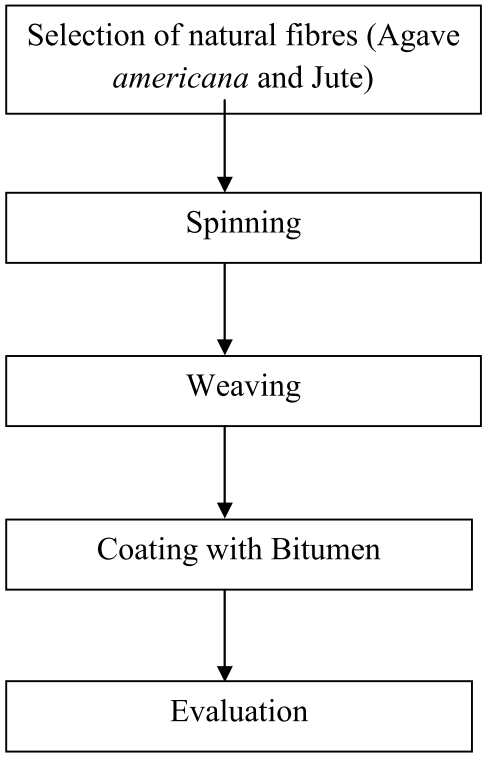


Figure:I Schematic diagram.

3.1 Fibre selection and procurement

Development of jute geotextiles in geotech category of technical textiles is to be emphasized besides its effectiveness in Carbon sequestration and eco-compatibility from cradle to grave. The diverse applications of jutegeotextiles being conceptualized with thrust on research and development the unique technical attributes of jute can meet most of the technical requirements needed for the major geo-technical applications. (Swapan, 2000). Fibres of Agave *americana* can be used in the production of composites and geotextiles. Fibres of Agave *americana* can be used as a substitute of imported kenaf fibres and plastics for composites and geotextiles manufacture (Boguslovsky et al., 2007). Considering the above facts the investigator selected Jute and Agave *americana* fibers for making it suitable for the application of geotextiles (Plate- I).

3.2 Spinning of fibres

The bast fibre jute and leaf fibre Agave *americana* were spun individually which consisted of the following steps.

3.2a Softening of fibres

Fritz and Cant (1980) are of the view that oils are often used on fibres as lubricants to help spinning efficiency. Hence, to lubricate and soften, the Agave *americana*, and Jute fibres, these were cut into suitable length and then treated with Turkey Red Oil and piled up for 24 hours. Then the treated fibres were passed through softener containing eight pairs of spirally fluted cast iron rollers in carriages of two rollers each. Thus the fibres were softened uniformly (Plate-II).

3.2b Carding of fibres

The softened fibres of Agave *americana*, and Jute were carded using breaker and finisher cards.

3.2b.1 Breaker carding

Breaker carding machine is a heavy unit and comprises of steel tubes, a number of rollers with reversing arrangements with one another. The main organs of breaker card which do the carding action are feed roller, cylinder, stripper, weaker and doffer with the help of which the softened Agave *americana* and Jute fibres were fed one by one in suitable weight to the feed roller, and turned into the form of sliver (Plate-III).

3.2b.2 Finisher carding

The construction of finisher carding machine is quite identical with the breaker carding except slight variations in setting, pinning arrangement and speed. Slivers obtained from breaker card were fed into this machine ten slivers at a time for obtaining uniform slivers of Agave *american*a and Jute.

3.2c Drawing of fibres

The slivers obtained from the finisher card were fed into intersecting drill draw frames of passage I, II and III subsequently for drawing. Two or more slivers from the finisher's card were fed into the passage 1. This was passed through passage II and passage III of the drawing machines to obtain more regularity and uniformity in the yarns. This was carried out for all the slivers of Agave *american*a and Jute samples (Plate- IV).

Plate I: Agave *americana* plant

Plate II: Softening of Fibres **Plate III: Carding of Fibres**

Plate IV: Drawing of Fibres

Plate V: Spinning of Fibres

3.2d Spinning of fibres

The machinery utilized for spinning was the one innovated by Brownick, Calculators. This equipment was utilized for spinning Agave *americana* and Jute fibres. Spinning process was carried out as explained by Walfhorst *et al*., (2006), the sliver of Agave *americana*, jute were first drafted in the flyer drafting field indidually which is often designed on a three-roller-two apron drafting unit. From the drafting field the drawn sliver is transported over the flyer top into the flyer log which exists at the bottom. A finger guide leads the sliver to the bobbin surface. With this mechanism the sliver obtains one twist on each revolution of the flyer. The winding itself is caused by a lead of the bobbin against the flyer top. The vertical movement necessary for the winding is accomplished by the bobbin. Because the flyer operates at a constant speed the vertical movement and the revolution per minute have to be adjusted continuously according to the bobbin diameter. The limit of rotation per minute for the flyer is about 1300 to 1500 rpm. Thus spun yarns of Agave *americana* and jute were obtained (Plate- V). The spun yarn samples are shown in Appendix – I.

3.3 Weaving process

Yarn from the spinning frame was removed and converted into cones in cone winding process for subsequent weaving process. Warping was done with Agave *americana* yarn which involved the preparation of the back beam for slashing and normally required putting 400-600 ends of yarns onto the beam. The length of individual threads depends on the diameter of the beam and ranks from 20 to 40 thousand yards so that the weight of the beam will be somewhat in the range of 500-1500 1b depending on the yarn count. Sizing of the warp threads was done to Agave *americana* to reduce the effect of friction during weaving sized threads were assembled on to a weaver’s beam. These were drawn in through the eyes of the headless and the clients of the reeds. The weft yarn namely the jute yarn was wound onto the pirns or bobbins, to be inserted into the shuttle to facilitate weaving. Warp and weft threads were interlaced to produce a fabric that was strong and compact with some measure of elasticity (Plates- VI). Thus Agave *americana* and jute mixture fabric was prepared.

3.4 Coating with Bitumen

The bitumen used for the study was 80/100 grade which confirmed 90 grade of IS-73-1992. The prepared Agave *americana* and jute mixture fabric was coated with bitumen in order to protect it from microbial attack and degradation to make it suitable for geotextile

Plate VI: Weaving

Plate VII: Agave Jute Fabric

Plate VIII: Preparation of Bitumen

Plate IX: Application of Bitumen

Plate X: Kerosene & Bitumen coated Fabric

Plate XI: Bitumen Coated Fabric

application. To coat the bitumen over the fabric, bitumen was heated up to a temperature of nearly 160^0C. Then the fabric was spreaded on the floor and coated with the mixture of bitumen and kerosene with the help of a brush on either sides such that the fabric was completely and uniformly coated with this mixture and left for drying for 24 hours. Thus the sample AJB1 was prepared (Plate- VIII,IX,X,XI). The agave jute mixture fabric was coated with cent percent bitumen in the same procedure explained by Aggarwal and Sharma (2011).

3.5 Evaluation

The yarn samples were objectively evaluated for essential properties and the fabric samples were subjectively and objectively evaluated for the basic physical parameters as well as special geotextile properties.

3.5.1 Evaluation of yarn samples

Yarn samples were objectively evaluated for important properties as explained under the follow headings.

3.5.1.1 Single yarn Tenacity and Elongation

Among the various yarn properties, the tensile properties of yarns significantly affect the behavior of yarns during their conversion into fabrics and the properties of the final structure, say Kothari *et al.,* (2002). Single yarn tenacity and elongation were analysed using Uster Standard method. The velocity of the equipment was 5000 mm per minute with the clamp pressure of 562 N/cm^2 (50%) and guage length was 50 cm. The load limit was adjusted to 15 Kgf and elongation was adjusted to 10 per cent. The results were recorded in Gm/tex. Fifty samples were tested and the value was found and recorded. Using these specifications the test was carried out for both the yarn samples namely agave and jute.

3.5.1.2 Twist per inch and Twist Direction

The twist is a basic feature of a spun yarn (Chattopadhyay *et al.,* 2002). Twist of the yarn was tested using microprocessor according to ASTM D 1422-99. The tests were carried out with specimen length of ten inches. The Clamp of the twist tester was set at the specified gauge length of +/1 1.0 mm. The yarn specimen was mounted in the twister clamps. One end of the specimen was secured in the non-rotatable clamp and the other end of the yarn was inserted through the pointer attached to the non-rotatable clamp. At this point the rotatable clamp was tightened and was revolved in the direction which untwists the specimen, releasing the tension as soon as the specimen started to elongate. The rotation was continued in the same direction, removing the original twist and imparting twist to the specimen in the direction opposite to the original twist. The reinsertion of twist was continued until the indicator returned to its initial position when the specimen was assumed to have its original length and tension. Twenty five samples were tested and the mean was calculated and recorded. This test was repeated for both the yarn samples agave and jute.

The direction of the twist was also found out for both the yarn samples.

3.5.1.3 U% imperfection

The irregularity or unevenness of yarn is commonly defined as the variation in fineness along its length and more appropriately as the variation in mass per unit length along the yarn. It is expressed as U% or CV%. The imperfections are frequently occurring yarn faults, which include thin places, thick places and naps, (Gowda, 2003). Hairiness in yarns leads to fuzzy and hairy appearance of fabric. Fifteen percent of fabric defects and quality problems stem from hairiness (Balasubramanian, 2007).

The U% imperfection of the yarn samples was found out as per ASTM D 1425-96. The velocity of the equipment was 50 metre per minute with the time of 1 minute. Tension of 100 per cent was applied to yarn samples. Three samples were tested and the mean was calculated and recorded. The thick places, thin places and the neps were observed and recorded. This test was repeated for both the yarn samples of agave and jute.

3.5.1.4 Yarn Diameter

Image analyzer was utilized for finding the yarn diameter in mm. Twenty samples were viewed and recorded. The mean was calculated and the diameter was recorded in mm. The same was repeated for both the yarn samples of agave and jute.

3.5.1.5 Yarn Count

The count of yarn is a numerical expression which defines its fitness. It is also called a yarn number or linear density. Yarn samples were tested as directed in ASTM (2005) test method D 1907 samples were randomly selected for testing. Yarn packages were conditioned in standard atmosphere for 3 hours. The yarns were converted into a skein in the automatic wrap reel. The perimeter of the reel was 1.5 yard and 80 wraps were wound to get 120 yards of length. After reeling the skeins were preconditioned before testing, in a standard atmosphere for testing textiles, 21 +/ 1oC (70 +/-2oF) and 65+1/2 per cent relative humidity, until moisture equilibrium was reached, that is until the mass of the specimen increased by not more than 0.1 per cent after 2 hours in that atmosphere. After preconditioning, the skeins were weighed in an electronic balance. Five samples were tested, the findings were recorded and the mean was calculated. The test was repeated for all the yarn of agave and jute.

3.5.2 Evaluation of woven sample

The woven samples were subjectively and objectively evaluated for important properties.

3.5.2.1 Subjective Evaluation

The original and coated samples were analysed visually by 30 judges belonging to post graduate course of Department of Textiles and Clothing, Avinashilingam University. The evaluation was carried out to find the difference in the characteristics of original and treated samples of the fabric for general appearance, colour, texture and lustre. The Proforma utilized for evaluation is enclosed in Appendix – II.

3.5.2.2 Objective Evaluation

The method used for fabric evaluation objectively is explained under the following heads.

3.5.2.2a Fabric Stiffness

A measure of the interaction between fabric weight and fabric stiffness as shown by the way in which a fabric bends under its own weight. ASTM D1388-96 (2002). A 5” x1” rectangular strip of fabric is mounted on a horizontal platform in such a way that it overhangs, like a cantilever and bends downwards. From the length and angle a number of values are determined. Each specimen is tested four times, at each end at face and backsides. Thus the fabric stiffness was observed and recorded for all the three fabric samples in warp direction (Plate- XII).

3.5.2.2b Fabric weight

Fabric weight is the weight per square meter of woven fabric. It may be expressed as the weight of a particular size piece, such as gram per square meter or ounces per square yards. Fabric weight is the relative weight of the fabric (Saini, 2004). A sample was cut using GSM cutter and it was weighed in electronic weighing balance directly (Plate-XIII). Then five samples cut were individually weighed and the reading was recorded. Then the mean value was calculated. This procedure was followed for all the three fabric samples and the reading were recorded. As grams per square meter.

3.5.2.2c Fabric Thickness

The thickness of a textile material is the distance between two plane parallel plates, as the pressure foot and other as the Anvil (Pala and Sewel, 2005). Thickness is measured to an accuracy of at least 0.01mm under the prescribed pressure ranging from 0.005 Psi depending on the type of fabric under test (Stoker *et al.,* 2005). Thus the thickness of the bitumen treated, bitumen and kerosene treated and original samples were assessed and compared (Plate-XIV).

3.5.2.2d Absorbency Test

- **Drop Test**

The ability of a fabric to take up moisture is determined as absorbency. Wettability is the time take in seconds for a drop of water to sink into the fabric. If it takes more than 200 seconds to absorb the water through fabric it is considered as unwettable. A burette filled with distilled water was clamped in a stand. The sample was mounted in an embroidery frame and was placed at the base of the stand. The distance between sample and nozzle of burette was kept constant. The nozzle of the burette was opened just allow a drop of water to fall on the sample. The stop watch was started simultaneously and the time was noted. The same procedure was repeated for all samples. The mean values were calculated and recorded (Plate-XV).

- **Sinking Test**

In sinking test the samples were cut with the size of 5 cm x 5 cm square. A 1000 ml beaker was filled with distilled water. The sample was dropped on surface of the water from a standard height. The stop watch was started when the fabric struck the surface of water and stopped when the last corner sank below the water surface and the time required for the sample to sink completely was noted. The same procedure was repeated for all the samples. The mean value was calculated and recorded (Plate-XVI).

- **Capillary Test**

The capillary rise test method measures the rapidity of absorption. Samples were cut into size of 15 cm length and 2.5 cm width from all the samples. One end of the sample strip was placed with a glass rod and to other end two gram weight was attached to keep the sample straight. The sample placed in glass rod was placed on heavy wooden blocks. About 2 cm of the sample was allowed to immerse in a tray of distilled water. The rise of the water level in the strip was measured. The same procedure was repeated for all the samples and recorded (Plate-XVII).

Plate XII: Stiffness Tester

Plate XIII: GSM Cutter

Plate XIV: Fabric Thickness Tester

Plate XV: Drop Test

3.5.2.2e Abrasion resistance (ASTM D 3885)

The abrasion resistance was measured as per ASTM D 3885 by subjecting the specimen to unidirectional reciprocal folding and rubbing over a specific bar under specified conditions of pressure, tension and abrasive action by flex abrasion testing machine. The pressure and tension used is varied, depending on the mass and nature of the material and the end-use application (Plate-XVIII). Testing machine consist of balanced head and flex block assembly that has two parallel, smooth plates. The balanced head is rigidly supported by a double lever assembly to provide free movement in a direction perpendicular to the plate of the flex block. A positioning device is provided to position the flexing bar and yoke assembly while loading the specimen such that the edge of the flexing bar is parallel to the fold of the specimen during the test. Number of strokes required for abrasion of the fabric was observed. The same procedure was repeated for all the samples and recorded.

3.5.2.2f Trapezoid Tear Strength (ASTM D5587)

Geotextile samples are cut in the shape of an isosceles trapezoid and then a small cut is made on one side of the trapezoid and then a small cut is made on one side of the trapezoid. The two non-parallel sides of the geotextile are gripped in parallel flat faced clamps in a manner which allows the tear to propagate as the jaws move apart and the required strain rate is applied. A continuous tear is propagated in this way and the maximum force is recorded. The trapezoid procedure requires the jaw faces to be at least 2 inches x 3 inches. This test was carried out for all the fabric samples in both warp and wept directions (Plate-XIX).

3.5.2.2g Index punctures Resistance (ASTM D483)

ASTM D4833-RA 2013 was used for evaluating the puncture resistance of the fabric for determining the puncture resistance of Geomembranes. This is used as acceptance criteria for testing of Geomembranes and related materials (Plate-XX).

A test specimen is clamped without tension between circular plates of a ring clamp attachment secured in a tensile machine. A force is exerted against the center of the unsupported portion of the test specimen by a solid steel rod attached of the load indicator until rupture of the specimen occurs. The maximum force recorded is the value of the puncture resistance of the specimen. This test was carried out for all the fabric samples.

3.5.2.2h Cone drop test EN ISO 13433

This method is used to determine the resistance of geosynthetics to penetration by a steel cone dropped from a fixed height, as a simulation of dropping sharp stones on their surface. The specimen is clamped between two steel rings. A steel cone (45^0 tip angle, 1000 g) is dropped from a height of 500 mm onto the centre of the specimen. The degree of penetration is measured by insertion of a graduated cone into the hole. Five specimens are tested. If the material to be tested is known to have different characteristics on the two faces, then the complete test shall be carried out separately on each face. Results are expressed as the diameter of the hole in mm to an accuracy of 0.1mm average and coefficient of variation are reported. This test was carried out for all the three fabric samples (Plate-XXI).

3.5.2.2i Mullen Bursting (ASTM D3786)

The mullen bursting tester was devised in 1887 as a measure for the puncture strength of paper and was adapted to textiles. Mullen burst determines how much force is required to rupture the geotextile as it is distended. An inflatable rubber membrane is used to deform the geotextile into the shape of a hemisphere through a 30mm diameter ring until it bursts it is literally blown up like a balloon. The resulting value is reported in pounds per square inch. This test was carried out for the original sample and kerosene bitumen coated sample (Plate-XXII).

3.5.2.2j Apparent Opening Size (ASTM D4751)

Apparent opening size is an important parameter in assessing a geotextile's soil filtration capability. Spherical solid glass beads are dry sieved through a geotextile for a specified time and at a specified frequency of vibration. The amount of beads retained by the geotextile sample is then measured. The test is carried out on a range of sizes of glass beads. The apparent opening size is the pore size at which 90% of the glass beads are retained on and within the fabric. This test was carried out for the original sample and kerosene bitumen coated sample (Plate-XXIII).

Plate XVI: Sinking Test

Plate XVII: Capillary Test

Plate XVIII: Abrasion Resistance Tester

Plate XIX: Trapezoid Tear Strength Tester

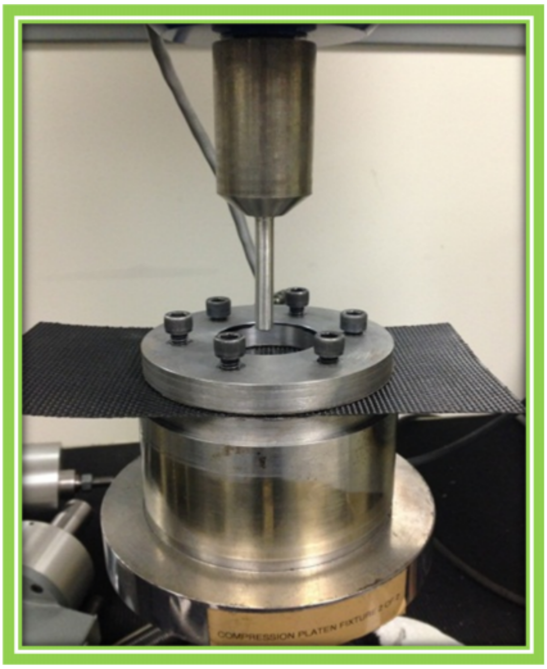


Plate XX: Index puncture Resistance

Plate XXI: Cone Drop Tester

Plate XXII: Mullen Bursting Tester

Plate XXIII: Apparent Opening Size

3.5.2.2k Soil Burial Test BS EN ISO 11721

This test was done manually as per BS EN ISO 11721 following steps as explained under.

The soil was prepared as a mixture of various types like red, black soil and sand. Then a pot made of black soil was taken. The specimen was prepared by cutting into 5cm x 5cm from all the three fabric samples. Three pots were taken and each was filled with mixed soil to the half way and then specimen was placed and balance portion was filled with the soil. The experiment was kept in ambient condition in sunlight and kept untouched for 30days. Then the specimen was taken and tested for antimicrobial property and Scanning Electron Microscopic appearance (Plate-XXIV, XXV, and XXVI).

3.5.2.2l Antimicrobial Test

The antimicrobial test was carried out by the following steps.

- **Selection of species**

The effect of the extract on the test organisms were studied by following agar diffusion methods. The bacterial strain E.coil and a fungal strain Candida SP were used in this study.

- **Agar Diffusion method**

Agar diffusion is an easy and direct way of achieving the result. A small volume of the culture was swabbed in the Petri plate evenly. The dispersed cells develop into isolated colonies (Chabra *et al., 2007)* reveal that the treated sample were tested for their antimicrobial activity. Qualitative assessment was done by the zone of inhibition. The incubated plates were examined for interrupted growth or clear zone of inhibition on either side of the wall (Prescott *et al.,* 2005).

- **Procedure for antimicrobial test**

Nutrient agar was prepared and sterilized for antibacterial activity. Rose Bengal chioremphenicol and agar agar was prepared and sterilize for antifungal activity. It was poured in the petri plate which was allowed to solidify. The test organism evenly swabbed on parallel sterile plates method was used spread the species. The original coated fabric sample were placed at the center of the petri plate and was incubated for 24 hours at $37^{o}C$ for bacteria and fungi in room temperature for 3 days. The zone of inhibition that forms around the fabric samples revealed the antimicrobial activity of the samples (Plate- XXVIII)

Plate XXIV: Soil Preparation

Plate XXV: Sample Buried soil

Plate XXVI: Sample after Soil Burial Test

3.5.2.2m Scanning electron microscopic appearance (SEM)

Scanning electron microscope was used to study the longitudinal view of all the three fabric samples. SEM is the imaging system with its wide range of magnification and great depth of focus, remarkably suited to the needs of the textile technology. The main reasons for this are, fibres are small but are not microscopic and hence may be imaged easily, clearly and quickly. In the SEM, an electron beam of current is scanned over a specimen's surface. The response of the specimen to this beam is such that the negative charge input from the beam is balanced by the combined effect of charge conduction to ground from the specimen and secondary emission at the specimen's surface (Kaplan, 2001). The SEM appearances obtained are given in the results and discussion (Plate-XXVII).

3.5 Nomenclature of yarn and fabric sample

The nomenclature used for the yarn and fabric samples are presented in Table II.

TABLE-II

NOMENCLATURE

S.NO.	Description	Nomenclature
1	Agave *americana* yarn	AY
2	Jute yarn	JY
3	Agave *americana* and jute mixture fabric	AJO
4	Original fabric coated 50% bitumen and 50% kerosene	AJB1
5	Original fabric coated 100% bitumen	AJB2
6	Agave *americana* and jute mixture after soil burial	AJSB
7	Original fabric coated with 50% bitumen and 50% kerosene after soil burial	AJB1SB
8	Original fabric coated with 100% bitumen after soil burial	AJB2SB

4.RESULTS AND DISCUSSION

The results obtained in various tests are tabulated and discussed as under.

4.1 Strength, Elongation and Breaking Tenacity of yarn sample

The result of the yarn strength, elongation and breaking tenacity are exhibited in Table III and Figure- 2, 3,4.

TABLE-III

STRENGTH, ELONGATION AND BREAKING TENACITY OF YARN SAMPLE

S.NO.	Sample	Strength (gms)	Elongation (%)	Breaking Tenacity (g/tex)
1	AY	6370.5	7.22	11.55
2	JY	6140.0	2.16	8.74

From the Table - III it is obvious that the strength of the yarn sample AY was 6370.5 gms and sample JY was 6140.0 gms. The strength was noted to be higher in the sample AY.

As for the elongation the samples AY and JY exhibited an elongation of 7.22 percent and 2.16 percent respectively. The elongation of the sample AY was higher than the sample JY.

As far as the breaking tenacity is concerned, it was noted that the yarn sample AY was 11.55 g/tex, where as it was 8.74 g/tex in sample JY.

Hence it could be concluded that the sample AY exhibited more strength elongation and breaking tenacity than the sample JY.

4.2 Twist per inch and Twist Direction

The result of the yarn twists per inch and twist direction are exhibited in Table IV and Figure- 5.

TABLE-IV

TWIST PER INCH AND TWIST DIRECTION

S.NO.	Sample	Twist Per inch	Twist Direction
1	AY	5	Z
2	JY	4.5	Z

From the Table - IV, it is evident that both samples are having same twist direction Z twist, and twist per inch was noted to be 5.0 tpi for AY and 4.5 tpi for JY.

4.3 Yarn Imperfection

The results of the Yarn Imperfection are exhibited in Table V and Figure- 6, 7, 8, 9.

TABLE-V

YARN IMPERFECTION

S.NO.	Sample	Thick places +50%	Thin places +50%	Nep+200%	U% Imperfection
1	AY	987	1418	160	21.39
2	JY	1187	1867	13	26.80

From the Table - V, it is clear that the thick places, thin places and nep were found to be 987,1418 and 160 in the sample AY where as in the sample JY the thick places ,thin places and nep were observed to be 1187,1867 and 13 respectively.

The U% imperfection in samples AY and JY were observed to be 21.39 and 26.80 respectively.

Hence it could be concluded that the U% imperfection was more in sample JY.

4.4 Yarn Diameter

The results of the Yarn Diameter are exhibited in Table VI and Figure- 10.

TABLE-VI

YARN DIAMETER

S.NO.	Sample	Yarn diameter (mm)
1	AY	1.01
2	JY	1.094

From the Table - VI, it is obvious that the diameter of the yarn sample AY was 1.01(mm) and sample JY was 1.094 (mm). The diameter between the yarns did not show much difference

4.5 Yarn Count

The results of the yarn count are exhibited in Table VII and Figure 11

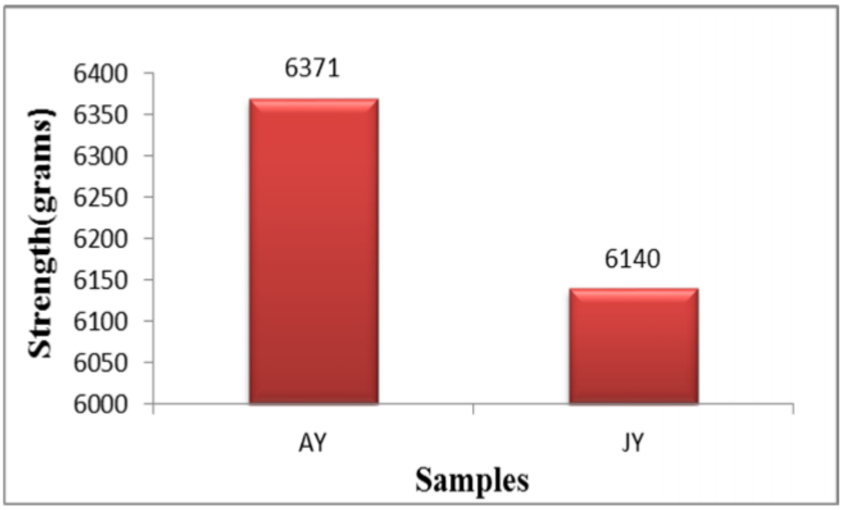


Figure -2 YARN STRENGTH

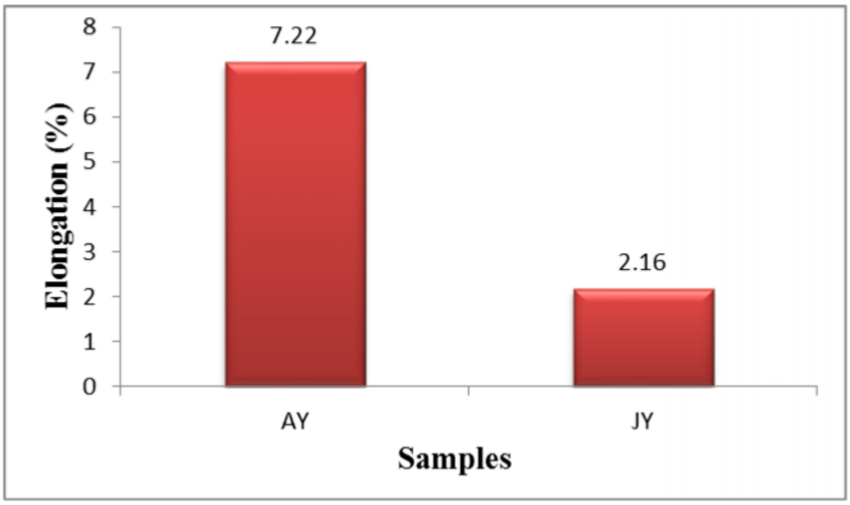


Figure - 3 YARN ELONGATION

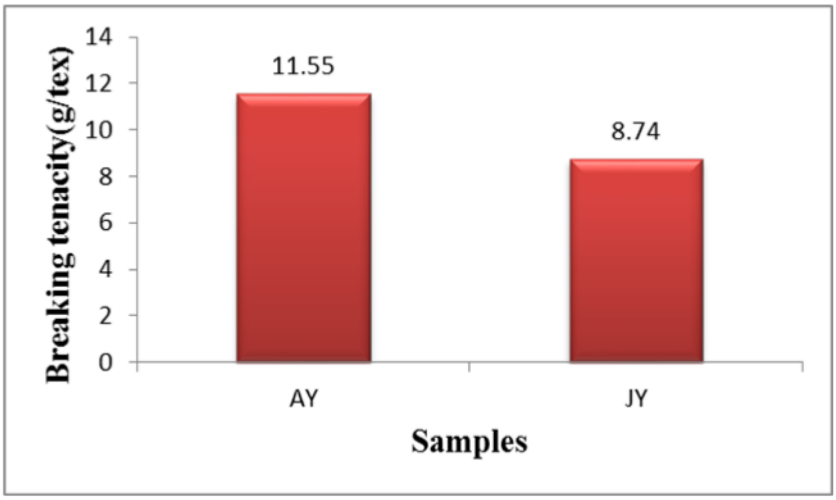


Figure -4 YARN BREAKING TENACITY

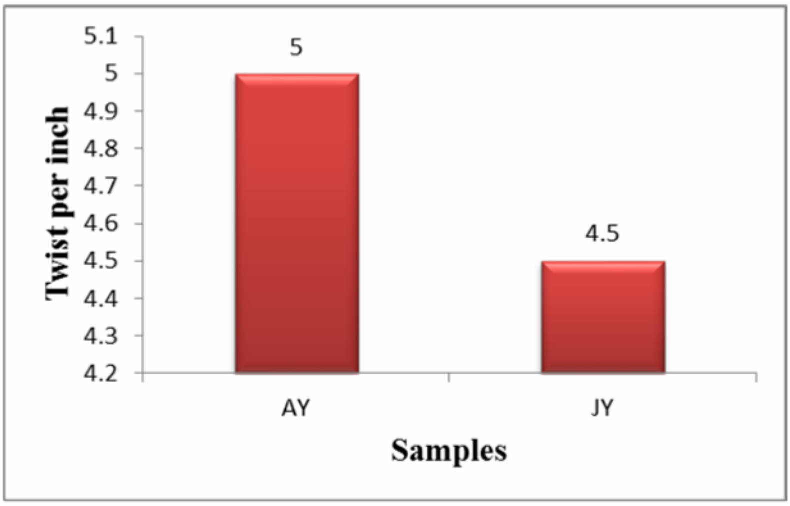


Figure-5 YARN TWIST PER INCH

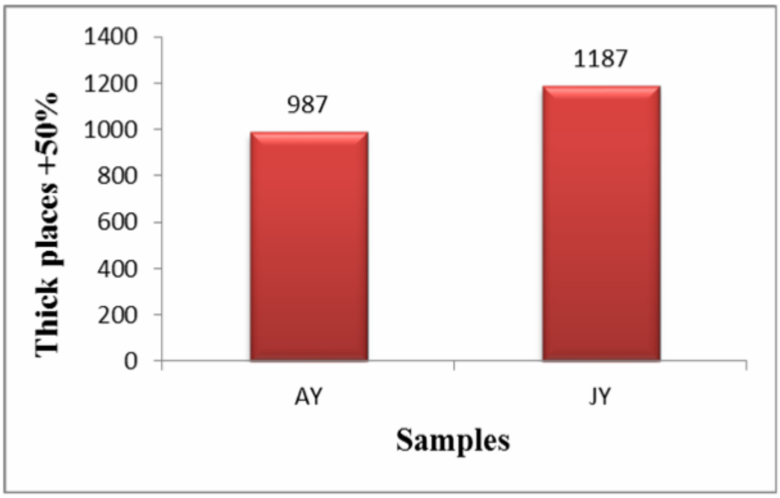


Figure-6 YARN THICK PLACES

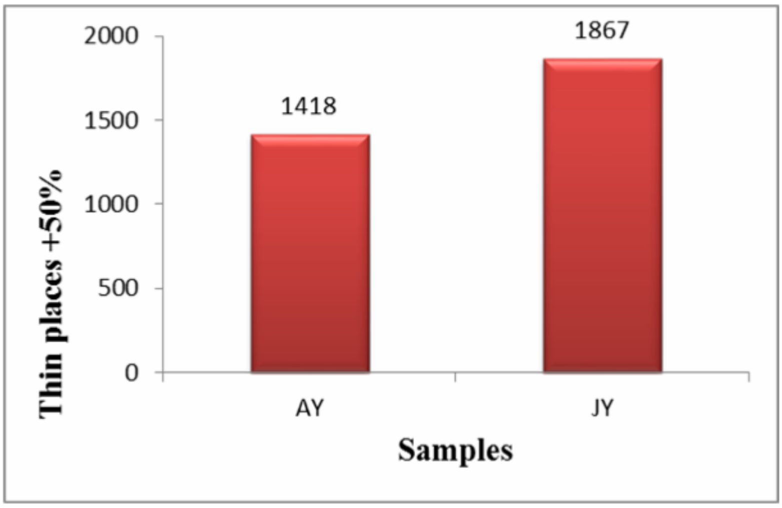


Figure-7 YARN THIN PLACES

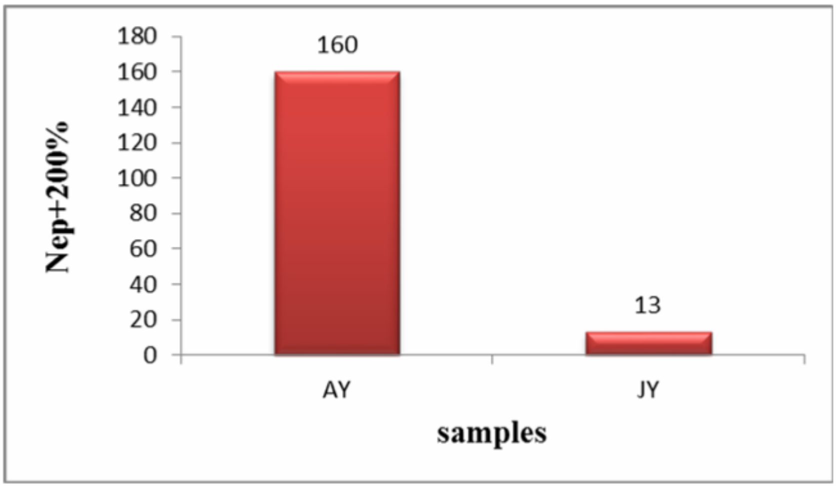


Figure-8 YARN NEPS

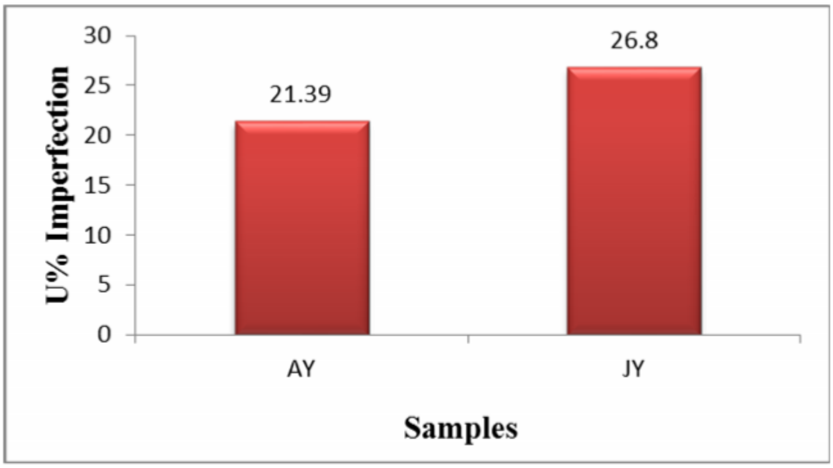


Figure – 9 U% IMPERFECTION

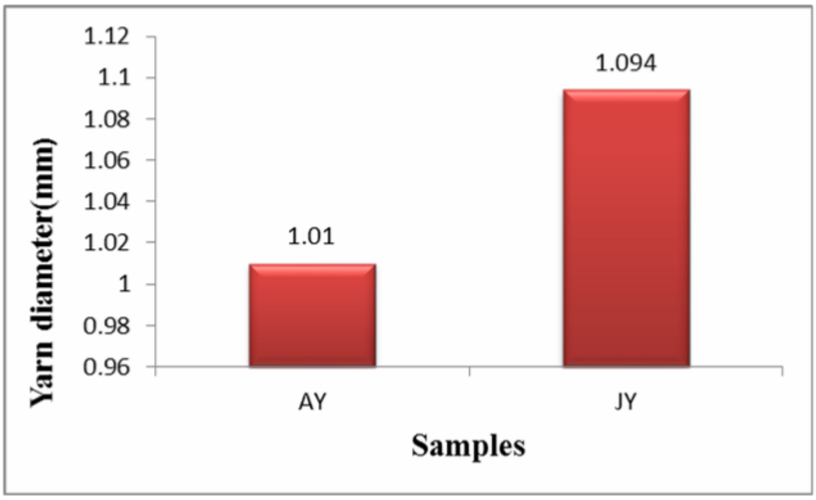


Figure – 10 YARN DIAMETER

TABLE-VII

YARNCOUNT (Ne)

S.NO.	Sample	Yarn count (Ne)
1	AY	1.07
2	JY	0.84

From the Table - VII, it is obvious that the count of the yarn sample AY was 1.07 (Ne) and sample JY was 0.84 (Ne).The yarn count was noted to be higher in samples AY.

4.6 Visual Assessment

The ratings obtained by the visual assessment are expressed in Table VIII

TABLE-VIII

VISUAL ASSESSMENT OF ORIGINAL AND TREATED FABRIC SAMPLES

S. NO	Sample	Colour			Lustre			Texture			General appearance		
		Half white	Greyish Black	Black	High	Moderate	Low	Smooth	Coarse	Very course	Good	Fair	Poor
1	AJO	100	-	-	57	33	10	-	10	90	50	24	26
2	AJB1	-	100	-	67	20	13	2	48	50	70	17	13
3	AJB2	-	-	100	70	13	17	1	49	50	53	20	27

Colour

From the Table - VIII, it was clear thecolourwas rated to be half white for the sample AJO by cent percent of the judges. It was rated to be greyish black and black by cent percent of the judges for the samples AJB1 and AJB2 respectively.

Hence it could be concluded that the colour changed on the bitumen coatings.

Lustre

As far as the lustre is concerned the maximum of 70 percent of the judges rated the sample AJB2 to have high lustre followed by the samples AJB1 and AJO with 67 and 57 percent ages respectively.

Texture

The maximum of 90 percent of the judger rated the sample AJO as very coarse followed by both the samples AJB1 and AJB2 which were rated by 50 percent of the judges.

General appearance

The maximum of 70 percent of the judges rated the sample AJB1 to have good general appearance followed by the samples AJB2 and AJO with 53 and 50 percentages respectively.

Hence it could be concluded that the colour turned to black in the sample AJB2, The lustre increased and the texture turned coarse in coated samples, and general appearance was good in sample AJB2.

4.7 Fabric Stiffness

The results of the fabric stiffness are presented in Table IX and Figure- 12.

TABLE-IX

FABRIC STIFFNESS (cm)

S.NO.	Sample	Mean value	Loss /Gain Value	Loss /GainPercentage
1	AJO	4.6	-	-
2	AJBI	6.82	2.22	48.26
3	AJB2	7.8	3.2	69.56
F value				48.38**

** Significant at one percent level.

From the Table -IX, it is clear that the stiffness of the sample AJO was 4.6. This increased in both the treated samples of which it was higher in sample AJB2 of 69.56 percent followed by the sample AJB1 of 48.26 percent, increase.

Statistical analysis also shows a significant difference at one per cent level.

Hence it could be concluded that both the treated samples exhibited increase in stiffness of which it was higher in the sample AJB2.

4.8 Fabric weight

The results of the fabric weight are presented in Table - X and Figure-13.

TABLE-X

FABRIC WEIGHT (GSM)

S.NO.	Sample	Weight (GSM)	Loss /Gain Value	Loss /GainPercentage
1	AJO	510	-	-
2	AJB1	754	244	48
3	AJB2	1544	1034	203
F value				8190**

**Significant at one per cent level.

From the Table - X, it is clear that the weight of the sample AJO was 510 gsm. This increased in both the treated samples of which it was higher in sample AJB2 with of 1034 gms and sample AJB1exhibited increase of 244 gsm.

Statistical analysis also shows a significant different at one per cent level

Hence it could be concluded that there was a gain in weight in both the treated samples of which it was higher in sample AJB2.

4.9 Fabric Thickness

The results of the Fabric thickness are presented in Table XI and Figure- 14.

TABLE-XI

FABRIC THICKNESS (mm)

S.NO.	Sample	Mean value	Loss /Gain Value	Loss /GainPercentage
1	AJO	2.34	-	-
2	AJBI	2.40	0.06	2.56
3	AJB2	2.84	0.5	21.36
F value				4.21 **

**Significant at one per cent level.

From the Table - XI, it is clear that the thickness the sample AJO was noted to be 2.34mm which increased by 2.56 percent is sample AJB1, the sample AJB2 showed more increase of 21.36 percent.

Statistical analysis also shows a significant difference at one per cent level.

Hence it could be concluded that both the treated samples exhibited increase in thickness and it was higher in sample AJB2.

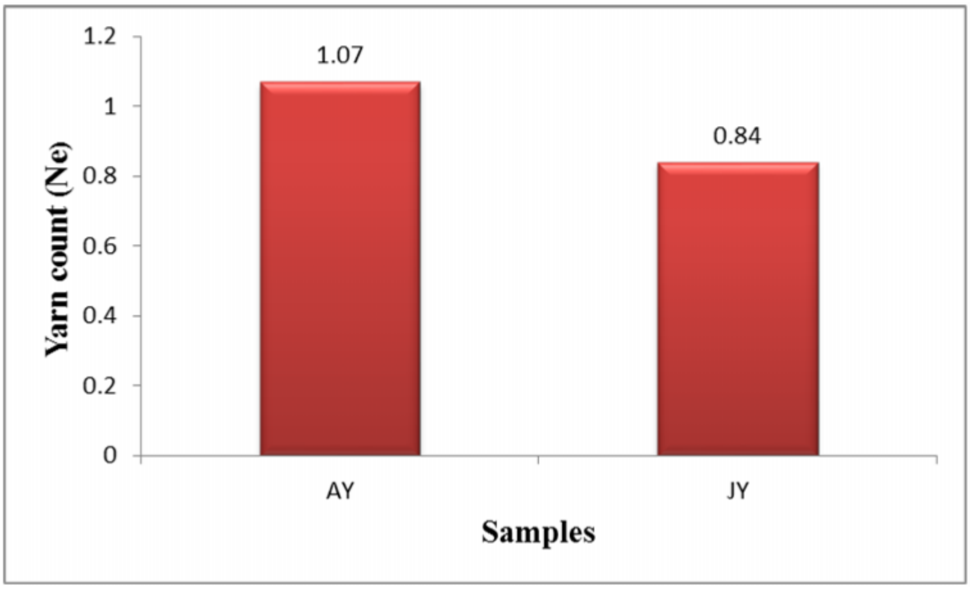


Figure – 11 YARN COUNT

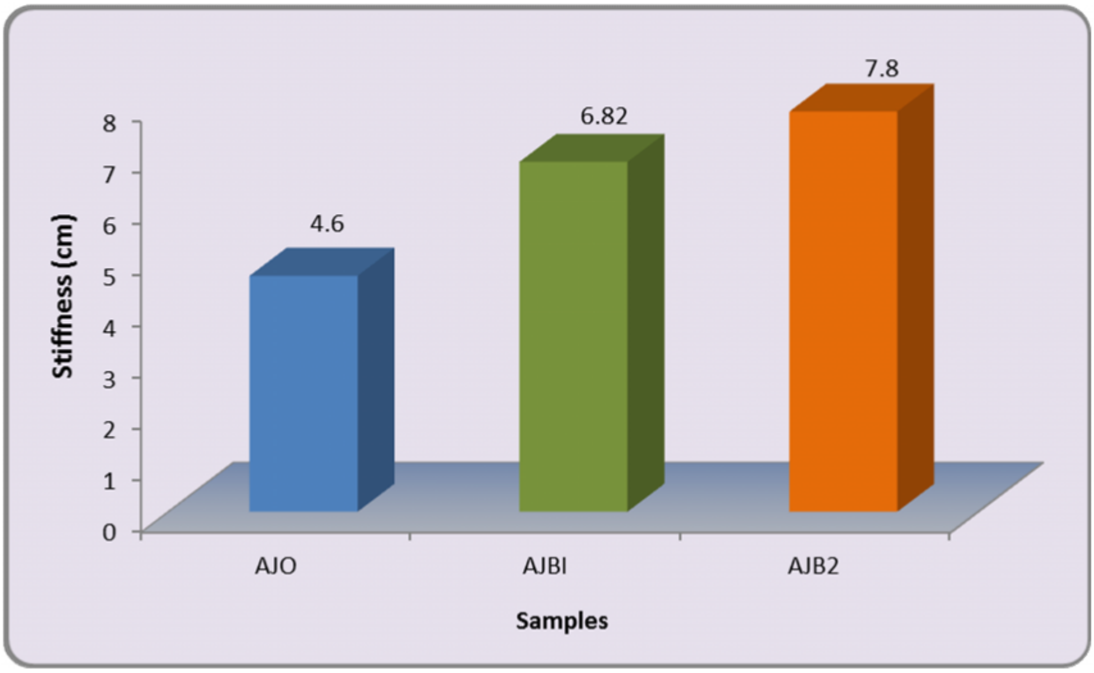


Figure-12 FABRIC STIFFNESS (cm)

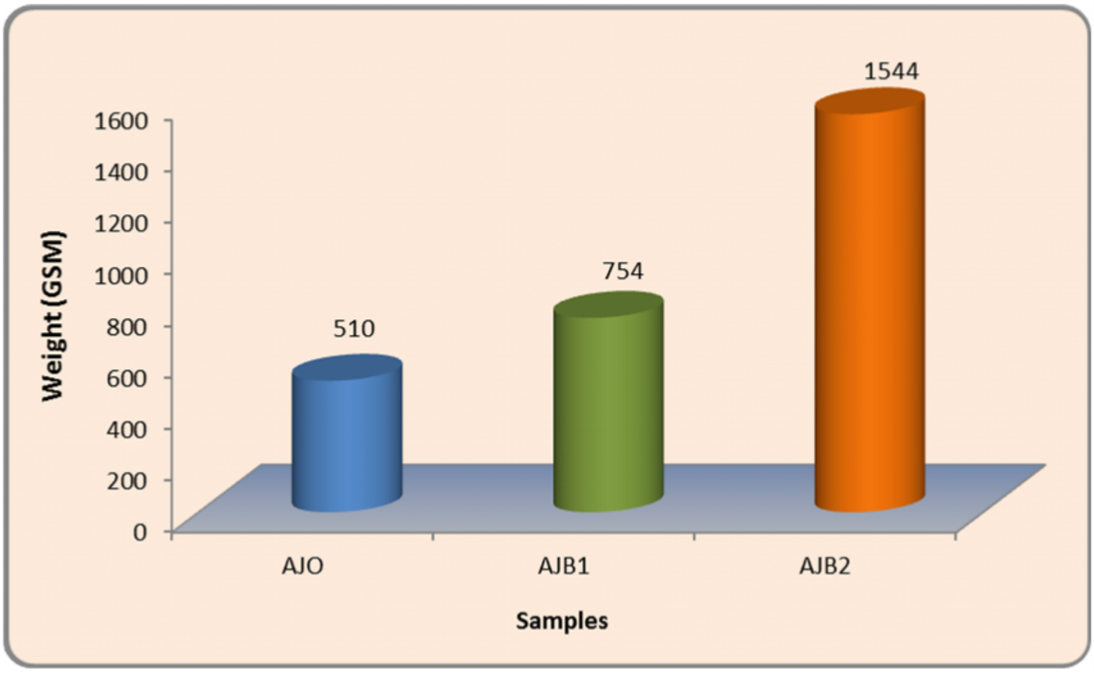


Figure-13 FABRIC WEIGHT (GSM)

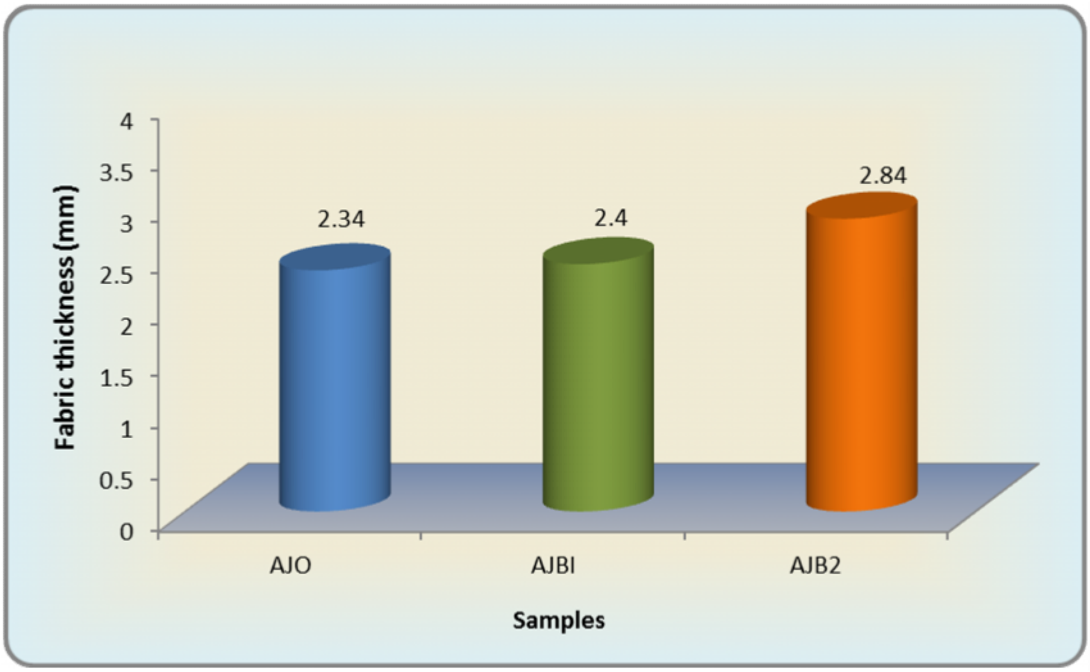


Figure -14 FABRIC THICKNESS (mm)

4.10 Absorbency Test

The results of the fabric absorbency tests are presented in Table XII.

TABLE-XII

ABSORBENCY TEST (Sec)

S.NO.	Sample	Drop	Sinking	Wicking
1	AJO	38	135	300
2	AJB1	Nil	Nil	Nil
3	AJB2	Nil	Nil	Nil
F value				1.0 NS

NS- Not Significant

From the Table - XII, it is clear that the untreated sample AJO had absorbency property which took 38 seconds, 135 seconds and 300 seconds for drop penetration, sinkingand wicking respectively. Both the samples AJBI and AJB2 showed no absorbency.

Statistical analysis also proves that there was no significant difference in the comparison made between the original and treated samples with the F value of 1.00.

Hence it could be concluded that there was no absorbency noted in both the treated samples namely AJB1 and AJB2.

4.11 Abrasion Resistance

The results of abrasion resistance are exhibited in Table XIII.

TABLE-XIII

ABRASION RESISTANCE – WARP AND WEFT

S.NO.	Sample	No. of strokes	
		Warp	Weft
1	AJO	1646	221
2	AJBI	11948	*
3	AJB2	*	*
F value			17.93**

*abrades beyond 26900 stokes. **Significant at one per cent level.

From the Table - XIII, it is clear that in warp direction the abrasion resistance of the untreated sample AJO was 1646 strokes. It increased drastically in sample AJB1 to 11948 strokes. The sample AJB2 took more than 26900 strokes and did not abrade.

In weft direction, the number of strokes was 221 for the sample AJO and both the samples AJB1 and AJB2 did not abrade over at 26900 strokes.

Statistical analysis also shows a significance of at one per cent level

Hence it could be concluded that the abrasion resistance improved in both the samples AJB1 and AJB2 in both warp and weft directions.

4.12Trapezoid Tear Strength

The results of Trapezoid Tear Strength are exhibited in Table XIV and Table XV and Figure- 15.

TABLE-XIV

WARP TRAPEZOID TEAR STRENGTH (kgf)

S.NO.	Sample	Tear strength (kgf)	Loss /Gain Value	Loss/Gain Percentage
1	AJO	38.16	-	-
2	AJB1	35.51	-2.65	7
3	AJB2	66.66	28.5	75
F value				97.11**

** Significant at one per cent level.

From the Table- XIV, it is obvious that the tear strength in warp direction of the sample AJO was 38.16 kgf. This reduced in the sample AJB1 to 7 percent. But the tearing strength increased drastically in the sample AJB2 to 75 percent.

Statistical analysis also shows a significant at one per cent level

Hence it could be concluded that the tearing strength increased drastically in sample AJB2.

TABLE-XV

WEFTTRAPEZOID TEAR STRENGTH (kgf)

S.No	Sample	Tear Strength (kgf)	Loss /Gain Value	Loss/Gain Percentage
1	AJO	13.61	-	-
2	AJB1	18.70	5.09	37
3	AJB2	22.32	8.71	63.9
F value				72.17**

** Significant at one per cent level.

From the Table -XV, Figure-16, it is clear that in weft direction the Trapezoid tear strength was 13.61 kgf. This increased drastically in both the treated samples of which it was higher in sample AJB2 with 63.9 percent than sample AJB1 which showed an increase of only37 percent.

Statistical analysis also shows a significant difference at one per cent level

Hence it could be concluded that the tear strength increased more in the sample AJB2.

In the comparison made between Tables XIII and XVI all the samples AJO, AJB1 and AJB2 showered higher strength in warp direction than in weft direction. Hence it could be concluded that tearing strength was higher in warp direction than in weft direction in all the samples.

4.13 Index Puncture Resistance

The results of Index Puncture Resistance are exhibited in Table XVI and Figure-17.

TABLE-XVI

INDEX PUNCTURE RESISTANCE (N)

S.NO	Sample	Mean value	Loss / Gain Value	Loss/GainPercentage
1	AJO	378	-	-
2	AJB1	385	7	1.85
3	AJB2	378	0	0
F value				0.30 NS

NS Not significant.

From the Table- XVI, it is obvious that the index puncture resistance was observed to be 378 N. This increased slightly in the sample AJB1 by 1.85 percent. But in the case of sample AJB2, no change was observed.

Statistical analysis also proves that there was No significant difference in the comparison made between the original and treated samples.

Hence it could be concluded that the index puncture resistance was higher in the sample AJB1.

4.14 Dynamic Perforation (Cone Drop)

The results of Dynamic Perforation (Cone Drop)are exhibited in Table XVII and Figure- 18.

TABLE-XVII

DYNAMIC PERFORATION (CONE DROP) (mm)

S.NO	Sample	Perforation size(mm)	Loss /Gain Value	Loss/GainPercentage
1	AJO	9.2	-	-
2	AJB1	10	0.8	8.69
3	AJB2	9.6	0.4	4.34
F value				0.059 NS

NS Not significant.

From the Table - XVII, it is clear that the dynamic perforation by cone drop test was noted to be 9.2 mm. The perforation size increased in both the treated samples of which it was higher in sample AJB1 with 8.69 percent followed by the sample AJB2 with 4.34 percent.

Statistical analysis also proves that there was No significant difference in the comparison made between the original and treated samples.

Hence it could be concluded that the dynamic perforation was the highest in sample AJB1.

4.15 Mullen Bursting

The results of Mullen Bursting test are exhibited in Table XVIII.

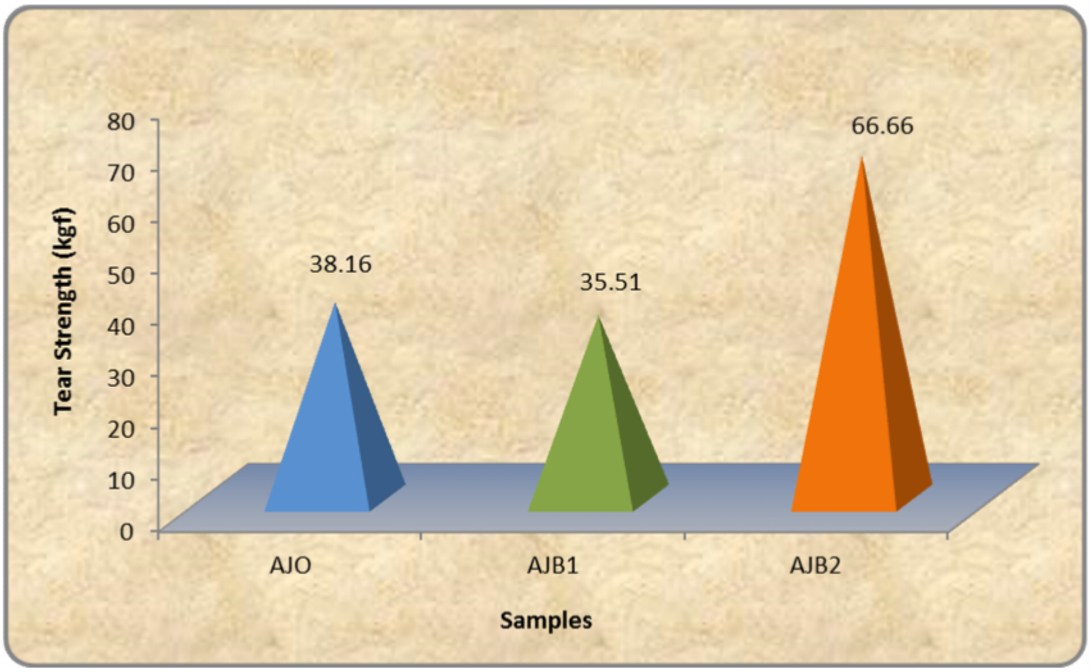


Figure-15 WARP TRAPEZOID TEAR STRENGTH

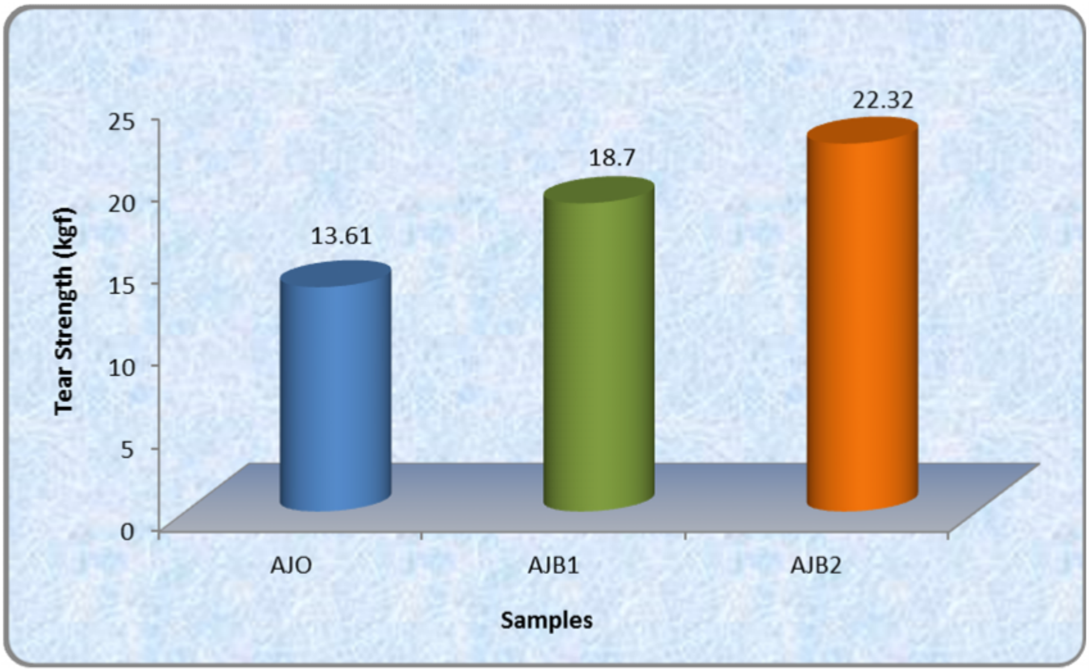


Figure-16 WEFT TRAPEZOID TEAR STRENGTH

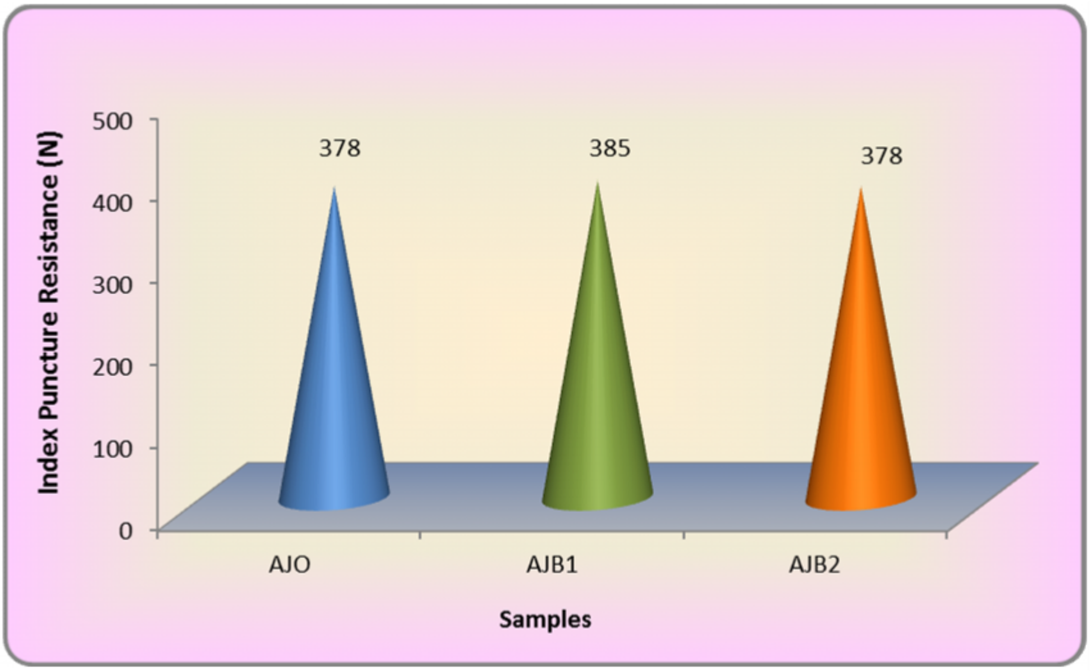


Figure-17 INDEX PUNCTURE RESISTANCE

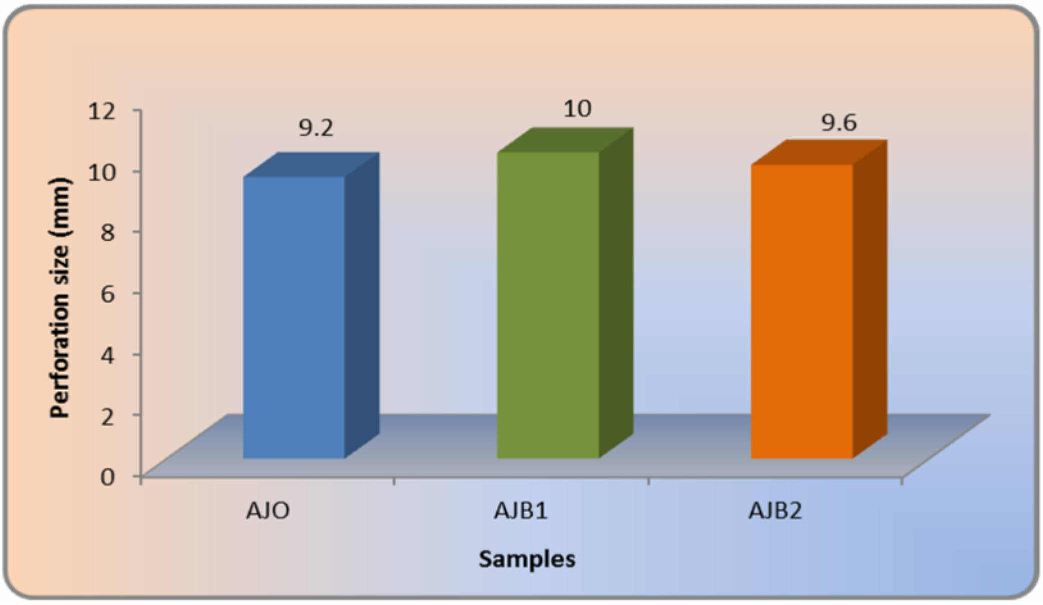


Figure-18 DYNAMIC PERFORATION - CONE DROPTEST

TABLE-XVIII

MULLEN BURSTING (kPa)

S.NO.	Sample	Mean	Loss /Gain Value	Loss/GainPercentage
1	AJO	1663	-	-
2	AJB1	2148	485	29.16
F value				80.84 **

** Significant at one per cent level.

From the Table-XVIII, it is clear that the bursting strength was noted to be 1663 kPa in sample AJO. This increased in the sample AJB1 to 29.16 percent.

Statistical analysis also shows a significant at one per cent level.

Hence it could be concluded that the bursting strength increased in the sample AJB1.

4.16 Apparent Opening Size

The results of Apparent Opening Size are exhibited in Table XIX.

TABLE-XIX

APPARENT OPENING SIZE (mm)

S.NO.	Sample	Mean	Loss /Gain Value	Loss/Gain Percentage
1	AJO	1.2	-	-
2	AJB1	1.4	0.18	14.89
F value				80.84 **

** Significant at one per cent level.

From the Table-XIX, it is obvious that the apparent opening size was 1.2 in sample AJO. This slightly increased in sample AJB1 with 14.89 percent over sample AJO.

Statistical analysis also shows a significance at one per cent level.

Hence it could be concluded that the apparent opening size increased in the sample AJB1, over sample AJO.

4.17 Soil Burial Test

The results of Soil Burial Test are exhibited in Table XX.

TABLE-XX

SOIL BURIAL TEST

S.NO.	Samples	Original Weight (g)	Weight of soil buried sample	Loss value	Loss percentage
1	AJO	3.5	1.9	1.6	46
2	AJB1	3.9	3.2	0.7	18
3	AJB2	5.4	5.2	0.2	4

From the Table - XX, it is clear that there was a loss in weight in soil buried sample of AJO of 46 percent which was lesser in sample AJB1 of 18 percent over their respective originals. The loss in weight was observed to be only 4 percent in the soil buried sample of AJB2. This shows that there was minimum attack of microbes, in the sample AJB1 and AJB2.

Hence it could be concluded that the minimum loss in weight of soil buried sample was observed in the sample AJB2.

4.18 Antibacterial Activity

The results of Antibacterial activity are exhibited in Table – XXI and plate – XXVII.

TABLE- XXI

ANTIBACTERIAL ACTIVITY TEST(mm)

S.NO.	Sample	Zone of inhibition	
		Test organisms	
		E.Coli	Staphylococcus aureus
1	AJOSB	-	-
2	AJB1SB	10	11
3	AJB2SB	14	14.5

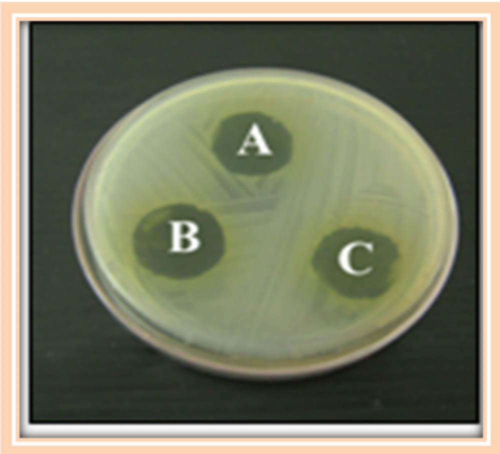
From the Table - XXI, it is clear that the kerosene and bitumen treated fabric AJB1 showed a zone of inhibition of 10mm for E.coli and 11 mm for Staphylococcus aureus. Bitumen treated fabric AJB2 showed a zone of inhibition of 14 mm for E.coli and 14.5 mm for staphylococcus. Hence it could be concluded that bitumen treated fabric had the bitumen antibacterial activity against E.coli and staphylococcus. Bitumen is used for coating the Jute Agave *americana* fiber to protect them from microbial attack and degradation (Aggarwal and Sharma, 2011). This was proved in this study on agave jute fabric also (plate XXVIII).

4.19 Scanning Electron Microscopic appearance

From the Scanning Electron Microscopic appearance in plate XXVIII the sample AJO showed the clear structure of the fabric AJO whereas the sample AJOSB showed the attack of microbes. In the comparison made between the samples, AJB1 and AJB1SB, the sample AJB1 showed the clear appearance of the woven pattern whereas, sample AJB2SB showed the slight attack of microbes.

Both the samples AJOSB and AJB2SB exhibited similar structure depieting the antimicrobial effect.

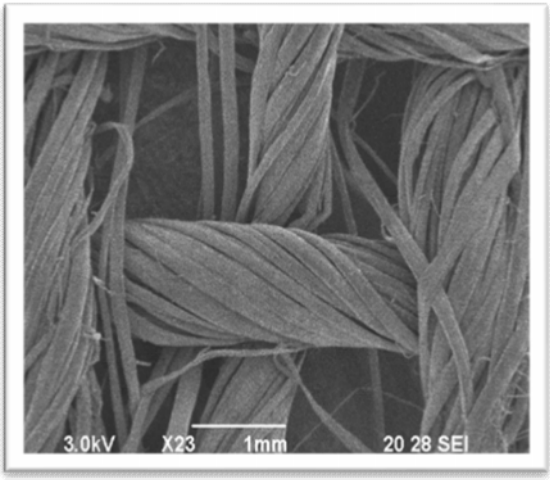
Hence it could be concluded that the sample AJB2SB was not much attacked by microbe.

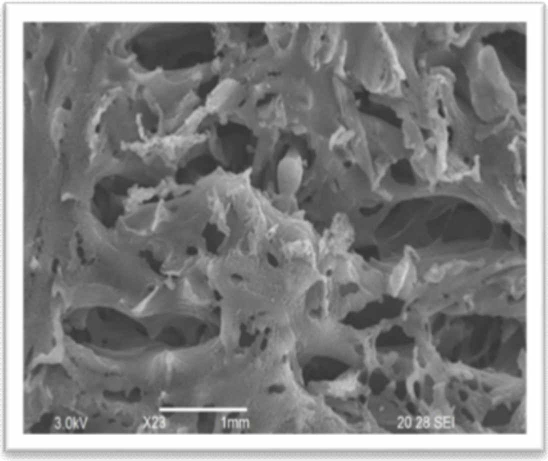


a.E-coli

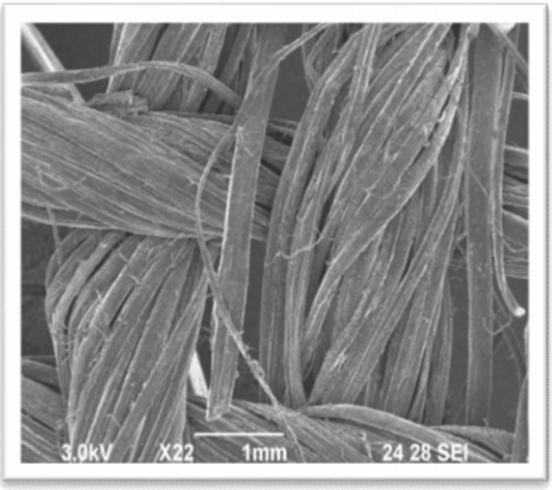
b.Staphylococcus Aureus

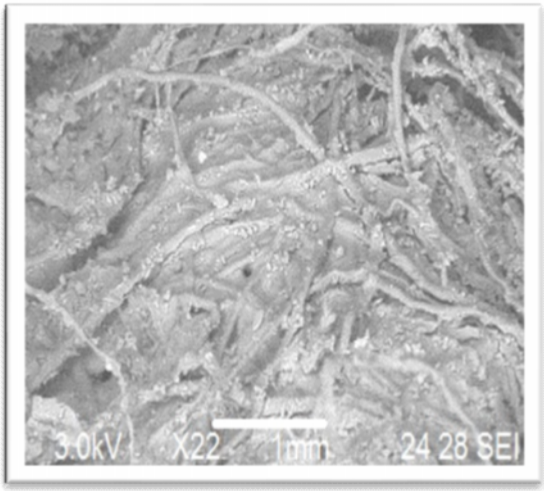
Plate XXVIII: Anti-Bacterial Activity



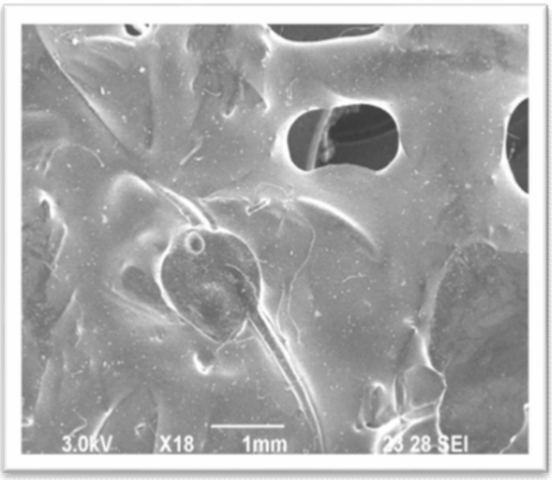


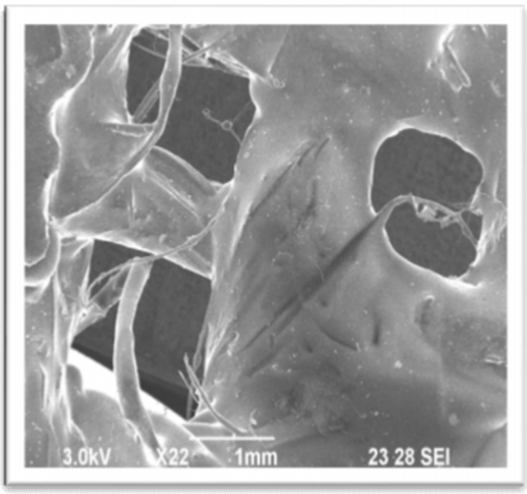
a.AJO b. AJOSB





c. AJB1 d. AJBISB





e. AJB2 f.AJB2SB

Plate XXVII: Scanning Electron Microscopic Appearance

5. SUMMARY AND CONCLUSION

The Indian textile Industry is one of the oldest industries in the world. It has always been a major player in global trade over the two decades. Textiles are a part of our ancient heritage and traditions. Textile industry has been one of the most important sectors in Indian economy. Natural fibres are the essential alternatives in ever expanding horizon of textile fibres. In textiles, natural fibres are mostly used in different areas and for different applications mainly clothing, home furnishing, industrial textiles and technical textiles. The possible market for sisal geotextiles is bigger though it is not yet being completely utilized. In order to get benefits of the prospects presented, the research on sisal based geotextile must be carried out and industries should take a more market driven approach, reacting to the requirement of customer's and must develop standards for its products. The economic scope and importance of technical textiles extends far beyond the textile industry itself and has an impact upon just about every sphere of human economic and social activity.

Geotextile is a newly emerging field in the civil engineering and other sectors, offer great potential in varied areas of applications globally. Geotextiles play a significant part in modern pavement design and maintenance techniques. Natural fibre geotextile have been used for thousands of years and references and found in the Bible. Natural fibre geotextiles can replace synthetics due to properties of biodegradability and ecofriendliness. Ability of natural fibre is to absorb water and to degrade with time. These fibres are stiff, strong and used for making ropes and handicraft items. Agave plant has more than 200 species all over the world, The Agave *americana* fibres are preferred these days because they are environmentally friendly in that they are biodegradable. Bitumen is used for coating the jute fiber to protect them from microbial attack and degradation.

Considering all the above facts, the study on **"Application and Evaluation of Bitumen coating on jute Agave Americana fabric for geotextiles''** has been carried out with the following objectives

- To spin and fabricate the selected yarns
- To improve the life span of the natural fibres
- To evaluate and compare the effect of treated fabrics for geotextiles

METHODOLOGY

The methodology pertaining to the study is explained under.

Considering the above fact the investigator selected Jute and Agave *americana* fibres for making it suitable for the application of geotextiles. The bast fibre jute and leaf fibre Agave *americana* were spun individually to lubricate and soften, the Agave *americana,* and jute fibres, these were cut into suitable length and then treated with Turkey Red Oil and piled up for 24 hours. The softened fibres were fed one by one in suitable weight to the feed roller, and turned into the form of sliver. The drawing was done to obtain regularity and uniformity in the yarns. This was carried out for both the slivers of Agave *american* a and jute samples. The machinery utilized for spinning both the yarn was the one innovated by Brownick, calculators for spinning. The weaving was carried out with the agave as warp yarns. The weft yarns namely the jute yarn were would onto the pirns or bobbins, to be inserted into the shuttle to facilitate weaving. Warp and weft threads were interlaced to produce a fabric that was strong and compact with some measure of elasticity. The prepared Agave *americana* and jute mixture fabric was coated with bitumen To coat the bitumen over the fabric, bitumen was heated up to a temperature of nearly 160^0C. The evaluation carried out for the yarn sample were objective evaluated for Single yarn Tenacity and Elongation, Twist per inch and Twist Direction, U% imperfection, Yarn Diameter and Yarn Count. The three fabric samples were evaluated subjectively and objectively for visual inspection. Fabric Stiffness, Fabric weight, Fabric Thickness, Drop Test, Sinking Test, Capillary Test, Abrasion resistance, Trapezoid Tear Strength, Index punctures Resistance, Cone drop test, Mullen Bursting, Apparent Opening Size, Soil Burial Test, Scanning electron microscopic appearance and Antimicrobial Test. The result were statistically analysed by F test.

Findings of the study

- The sample AY exhibited more strength elongation and breaking tenacity than the sample JY
- The samples AY,AJ had same twist direction namely Z twist
- The U% imperfection was more in sample JY
- The diameter was noted to be similar in both samples AY, AJ
- The yarn count was noted to be higher in samples AY
- The colour turned to black in the sample AJB2, The lustre increased and the texture turned coarse in coated sample and general appearance was good in sample AJB2

- The treated samples exhibited increase in stiffness of which it was higher in the sample AJB2
- The weight increased in both the treated samples of which it was higher in sample AJB2
- The treated samples exhibited increase in thickness and it was higher in sample AJB2
- The absorbency rate there was no absorbency observed in both the treated samples AJB1 and AJB2
- The abrasion resistance improved in both the samples AJB1 and AJB2 in both warp and weft direction
- The tearing strength was higher in warp direction than in weft direction in all the samples.
- The index puncture resistance was higher in the sample AJB1
- The dynamic perforation was the highest in sample AJB1
- The bursting strength increased in the sample AJB1
- The apparent opening size increased in the sample AJB1
- The bitumen treated fabric had antibacterial activity against E.coli and staphylococcus

Conclusion

Both the bitumen coated samples namely AJB1(50% Kerosene and Bitumen), AJB2 (100% Bitumen) exhibited to have good properties suitable for geotextiles in index puncture resistance and dynamic perforation tests. This was proved in both the scanning electron microscopic appearance test as well as antimicrobial activity test.

Recommendations

- The bitumen coated agave jute and fabric sample may be used in the field of geotextiles.
- It can be used also for agrotextiles.

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APPENDIX – I

SPUN YARN SAMPLE

APPENDIX - II

Details of Selected Material

AJO

AJBI

AJB2

APPENDIX-III

PERFORMA FOR VISUAL ASSESSMENT OF WOVEN SAMPLE

S. No	Sample	Colour			Lustre			Texture			General appearance		
		Half white	Greyish Black	Black	High	Moderate	Low	Smooth	Coarse	Very course	Good	Fair	Poor
1	AJO												
2	AJB1												
3	AJB2												

APPENDIX-III a
BTRA TESTING REPORT

THE BOMBAY TEXTILE RESEARCH ASSOCIATION

LAL BAHADUR SHASTRI MARG,
GHATKOPAR (WEST),
MUMBAI - 400 086.

Phones : 022 - 2500 1811
022 - 25003651 / 2652
2117 / 1119 / 1135
Fax : 91-22-2500 0459
Email : btra@vsnl.com
btralabs@yahoo.co.in
Website: www.btraindia.com

MINISTRY OF SCIENCE & TECH · Recognised by Govt. of India · DSIR

BL / 03A
Analysis & Testing of All Textile Materials Including Eco Testing, Trouble Shooting for Providing Complete Solutions

BTRA TEST LABORATORIES

TEST REPORT

Report Details : BTL/TR/ TTG-86 / 2015 DT.: 26.02.2015
Sample : GEO-TEXTILE

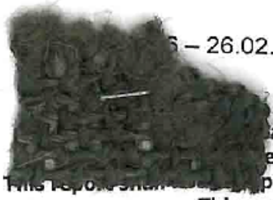
Customer : Ms. YESHOTHA KUMARI
D/O, E.M. Srinivasan, D.No.812, Chettukkarar St., Ellappalayam (PO), Pogalur (Via) 641697, Coimbatore (Dist.)
Code: BTL TTG/09
Reference : LETTER DTD.: 27.12.2014
No. of Samples : ONE
Received on : DTD.: 03.01.2015
Total Pages: 1 OF 1
Date of performance of Test : 06.01.2015 TO 26.02.2015
Despatched on :

TEST RESULTS

SAMPLE No.	:	**BTL TTG/09**
SAMPLE MARK	:	**Sample 3 : Bituman + Kerosene Coated**

SR. NO.	TEST PARAMETERS	RESULTS	METHODOF TEST
1.	Index Puncture Resistance, (N)	385	ASTM D:4833–RA 2013
2.	Apparent Opening Size, (mm)	1.404	
	Range		
	Minimum	1.19	
	Maximum	1.778	
	CV%	11.1	
3.	Mullen Bursting Strength, (kPa)	2148	ASTM D:3786–M 2013
4.	Dynamic Perforation [Cone Drop],(mm)	9.6	ISO:13433–2006

Note : Since the sample was quite open in structure the opening size could not be determined as per ASTM D: 4751 and hence measured on Profile Projector.



6 – 26.02.2015)

26/02/2015
(V.K. Patil)
Authorized Signatory

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APPENDIX-III b

THE BOMBAY TEXTILE RESEARCH ASSOCIATION

LAL BAHADUR SHASTRI MARG,
GHATKOPAR (WEST),
MUMBAI - 400 086.

Phones : 022 - 2500 1811
022 - 25003651 / 2652
2117 / 1119 / 1135
Fax : 91-22-2500 0459
Email : btra@vsnl.com
btralabs@yahoo.co.in
Website: www.btraindia.com

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BL / 03A

Analysis & Testing of All Textile Materials Including Eco Testing, Trouble Shooting for Providing Complete Solutions

BTRA TEST LABORATORIES

TEST REPORT

Report Details : BTL/TR/ TTG-85 / 2015 DT.: 26.02.2015 — Sample : GEO-TEXTILE

Customer : Ms. YESHOTHA KUMARI — Code: BTL TTG/08
D/O, E.M. Srinivasan, D.No.812, Chettukkarar St., Ellappalayam (PO), Pogalur (Via) 641697, Coimbatore (Dist.)

Reference : LETTER DTD.: 27.12.2014 — No. of Samples : ONE

Received on : DTD.: 03.01.2015 — Total Pages: 1 OF 1

Date of performance of Test : 06.01.2015 TO 26.02.2015 — Despatched on :

TEST RESULTS

SAMPLE No.	:	**BTL TTG/08**
SAMPLE MARK	:	**Sample 2 : 100% Bituman**

SR. NO.	TEST PARAMETERS	RESULTS	METHODOF TEST
1.	Index Puncture Resistance, (N)	378	ASTM D:4833–RA 2013
2.	Dynamic Perforation [Cone Drop],(mm)	10	ISO:13433–2006

Note : Bitumen coating spoils the test apparatus and hence we are unable to do other tests.

26/02/2015

(V.K. Patil)
Authorized Signatory

(1/TR/TTG 85 – 26.02.2015)

APPENDIX-III c

THE BOMBAY TEXTILE RESEARCH ASSOCIATION

LAL BAHADUR SHASTRI MARG,
GHATKOPAR (WEST),
MUMBAI - 400 086.

Phones : 022 - 2500 1811
022 - 25003651 / 2652
2117 / 1119 / 1135
Fax : 91-22-2500 0459
Email : btra@vsnl.com
btralabs@yahoo.co.in
Website: www.btraindia.com

BL / 03A
Analysis & Testing of All Textile Materials Including Eco Testing, Trouble Shooting for Providing Complete Solutions

BTRA TEST LABORATORIES

TEST REPORT

Report Details : BTL/TR/ TTG-84 / 2015 DT.: 26.02.2015 | Sample : GEO-TEXTILE

Customer : Ms. YESHOTHA KUMARI
D/O, E.M. Srinivasan, D.No.812, Chettukkarar St., Ellappalayam (PO), Pogalur (Via) 641697, Coimbatore (Dist.)

Code: BTL TTG/07

Reference : LETTER DTD.: 27.12.2014 | No. of Samples : ONE

Received on : DTD.: 03.01.2015 | Total Pages: 1 OF 1

Date of performance of Test : 06.01.2015 TO 26.02.2015 | Despatched on :

TEST RESULTS

SAMPLE No.	:	**BTL TTG/07**
SAMPLE MARK	:	**Sample 1 : Untreated Original Sample**

SR. NO.	TEST PARAMETERS	RESULTS	METHODOF TEST
1.	Index Puncture Resistance, (N)	378	ASTM D:4833–RA 2013
2.	Apparent Opening Size, (mm)	1.222	
	Range		
	Minimum	0.663	
	Maximum	1.882	
	CV%	26.6	
3.	Mullen Bursting Strength, (kPa)	1663	ASTM D:3786–M 2013
4.	Dynamic Perforation [Cone Drop],(mm)	9.2	ISO:13433–2006

Note : Since the sample was quite open in structure the opening size could not be determined as per ASTM D: 4751 and hence measured on Profile Projector.

26/02/2015
(V.K. Patil)
Authorized Signatory

(1/TR/TTG 84 – 26.02.2015)

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