EFFECT OF SALINE WATER ON THE MECHANICAL PROPERTIES OF NONWOVENS AND COMPOSITES

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Abstract : Textile materials find wide usage in day today life. Apart from clothing for the human body, there is technical textiles which is used in many fields. Composites have made a very significant advances because of their high strength and stuffiness combined with low weight and less bulk. Life cycle analyses on composites show that, although they can be more expensive to produce, they are generally more environmentally friendly because they consume less fuel during their lifetime compared to the heavier metallic items they replace. Yet composite technology is still in its infancy compared to the use of metals. More advanced fabric structures are being developed. These are extending the score of composites for all industrial applications, including transportation. The use of natural plant fibres as reinforcement in polymer composites for making low cost engineering materials has generated much interest in recent years. New environmental legislation as well as consumer pressure has forced manufacturing industries (particularly automotive, construction and packaging) to search for new materials that can substitute for conventional non renewable reinforcing materials such as glass fibre. One of the main concerns for the use of natural fibre reinforced composite materials is their susceptibility to moisture absorption and the effect on physical, mechanical and thermal properties. The present investigation was designed to study the effect of various factors on the properties of needle punched fabrics, and to enable a detailed understanding to be obtained on the fundamental basis of their mechanical behavior. The selected nonwoven and composites were tested for its mechanical properties such as tensile, flexural and impact properties after the immersion in saline water. The study revealed that there is a overall drop in the mechanical properties of the composites.

***IndexTerms* - Saline Water, Nonwovens.**

I. Introduction

A Composites are used to produce a variety of economical, efficient and sophisticated items, ranging from toys and tennis rackets to reentry insulation shields and miniature printed circuits for spacecraft. Until early in the 20th century, the major fibres available for technical and industrial use were cotton and various coarser vegetable fibres such as flax, jute and sisal. They were typically used to manufacture heavy canvas type products, ropes and twines and were characterized by relatively heavy weight, limited resistance to water and microbial fungal attack as well as poor flame retardency. Textile materials are used in various marine products for function and fashion purpose including mooring covers, boat tops, shading, sail covers etc., Industrial textiles made their way into the sail boat industry a long time ago. The requirements for these textiles include low stretch, high strength along with good resistance to weather, ageing and of course the material must be waterproof as well.

In this era of explosive advances in technology, business has to maintain a strong technological base to provide the critically necessary information that will allow both current products and more importantly new products to be profitable (Bursk, 1966; Bingham, 1966)

Composites should find expanding use in construction, public transportation, automobiles, storage tanks, pipelines, appliances, furniture, and data processing equipment. There are also products to be used in the most rapidly growing industries, education, medicine, and recreation. Combined with the current general interest in nonwovens fabrics of all sorts, these advances have made needled fabrics an interesting area of textile technology.

II. Review of Literature

The developments in composite material after meeting the challenges of aerospace sector have cascaded down for catering to domestic and industrial applications. Composites, the wonder material with light-weight, high strength – to – weight ratio and stiffness properties have come a long way in replacing the conventional material like metals, woods etc. The material scientists all over the world focused their attention on natural composites reinforced with Jute, Sisal, Coir, Pineapple, primarily to cut down the cost of raw materials expressed by Richard Scott (2005).

Different geometries of these fibres, both singly and in combination with glass, have been employed for fabrication of uni-axial, bi-axial and randomly oriented composites. Today with all the advancement in life, growing population and its increasing needs, we have to consider how to meet those needs by producing the best and making it available for all. Fiber reinforced composites are helping to fulfill the needs of this growing population. They have been and are being studied in order to maximize their utilities in different fields points out Akira Nakamura (2000)

Before composites and light aluminum structures were available, all boats and ships were made from wood. They were very costly, vulnerable to environmental impacts and had a lot of maintenance problems. With complex structures such as ship, wood was found to be very hard to shape as well. Fiber composites boats are now much more famous because of their new interesting shapes, less cost, less maintenance etc. With the advent of fiber composites, new light weight structures of Warfare ships have been introduced which are fuel efficient, fast, fire resistant, non magnetic and with a minimum cost of maintenance says Micheal. W (1999)

Borden (1993) states that natural fibres in Sails were first replaced by nylon and polyester, which are lighter, more rot resistant, have lower water absorption and have higher sunlight resistance. Sail development has progressed to some lighter laminated types where film is bonded to the fabric. Thus the fabric does not form the surface of the Sail, only the reinforcing structure.

Natural fibres are hydrophilic with many hydroxyl groups (-OH) in the fibre structure forming a large number of hydrogen bonds between the macromolecules of the cellulose and polymer. With the presence of a high –OH group percentage, natural fibres tend to show low moisture resistance. This leads to dimensional variation of composites products and poor interfacial bonding between the fibre and matrix, causes a decrease in the mechanical properties. Water absorbed in polymer is generally divided into free water and bound water. Water molecules (which are contained in the free volume of polymer and are relatively free to travel through the micro voids and holes) are identified as free water. Water molecules that are dispersed in the polymer matrix and attached to the polar groups of the polymer are designated as bound water

III. Methodology

The advantages of natural plant fibres over traditional glass fibres have the good specific strengths and modulus, economically viability, low density, reduced tool wear, enhanced energy, reduced dermal and respiratory irritation and good biodegradability. All polymer composites absorb moisture in humid atmosphere and when immersed in water. The effect of absorption of moisture leads to the degradation of fibre matrix interface region creating poor stress transfer efficiencies, resulting in a reduction of mechanical and dimensional properties.

Moisture diffusion in polymetric composites is known to be governed by three different mechanisms. The first involves of diffusion of water molecules inside the micro gaps between polymer chains. The second involves capillary transport into the gaps and flaws at the interfaces between fibre and the matrix. This is a result of poor wetting and impregnation during the initial manufacturing stage. The third involves transport of micro cracks in the matrix arising from the swelling of fibres (particularly in the case of natural fibre composites). Generally, based on these mechanisms, diffusion behavior of polymeric composites can further be classified according to the relative mobility of the penetrant and of the polymer segments which is related to either fickian, non fickian or anomalous, and an intermediate behavior between fickian and non fickian. In general moisture diffusion in a composite depends on factors such as volume fraction of fibre, voids, viscosity of matrix, humidity and temperature.

Composite testing is usually done in three areas : resins and reinforcement structures; composite parts; and finished products made of composite. Mechanical testing included tensile test, compression test, flexural test, shear test and toughness test. Tensile test determines the tensile strength, tensile modulus and elongation of the composite.

The flexural test is a mixture of tensile and compression tests because the sample is subjected to compressive stresses on the top and to tensile stresses on the bottom. The flexural strength of composite specimens were tested using the Instron testing machine. Impact tests were carried out with different masses and at different heights as mentioned in the respective chapters. The compressive strength is usually obtained experimentally by means of a compressive test.

The above test were carried out to find out the tensile, flexural impact and compression strength of the selected samples and their findings are given in Result and Discussion.

IV. Result and Discussion

Fibre incorporated plastics have been very popular due to their flexibility, their lightness and the ease of fabrication of complicated shapes with economic savings in contrast to fibre reinforced metals / alloys. In addition, these composites can easily substitute for conventional materials in several areas such as the building industry, transportation and consumer goods. Some of the attempts made in recent times for the utilization of natural fibres through composite material technology have indicated their potential as substitutes for conventional materials such as wood and Glass Fibre Reinforced Plastics (GFRP) in many applications.

The tensile properties of the nonwovens tested in machine and cross wise direction are given in Table I.

Table – I – Tensile strength of the Nonwoven Tested in Machine Wise Direction

Type	Tensile Strength in (KN/m^2)		Tensile Elongation (%)		Initial Modulus (KN/m^2)	
	Machine Direction	Cross Direction	Machine Direction	Cross Direction	Machine Direction	Cross Direction
Jute	15.0787	6.8632 to 8.6088	22.8 to 28.5	22.8 to 29.925	45.08	23
Coir	11.28 to 12.125	2.0832 to 2.9109	16.235 to 18.25	26.2625 to 31.0375	39.06	14.88
Banana	10.681	1.5895 to 3.09485	10.8 to 16.0032	6.8676 to 16.16	61.88	18.5
Jute Coir	9.12 to 12.85	1.5895 to 3.09485	19 to 25.33	6.8676 to 16.16	43.7	11.28
Jute Banana	5.499 to 7.3639	1.425 to 1.7765	16.8 to 22.59	28.5866 to 34.93	45.36	9.45
Banana Coir	3.458 to 3.8855	0.062075 to 0.94545	16.88 to 19.1	21.7488 to 24.625	28.8	8.55
Jute Banana Coir	5.5385 to 8.474	0.4992 to 0.6432	19 to 26.82	10.7217 to 18.9783	41.85	9.55

From the Table 1 it can be seen that there is 8-10% drop in tensile properties of the nonwovens compared to that of the parent samples. There is also significant drop in the initial resistance to deformation as the material becomes soft and supple on exposure to the saline water. Among the various nonwoven samples tested with other blended nonwovens offer more resistance compared to that of the primary samples. This is attributed to the resistance offered by the presence of both fibres. Among the single nonwovens, banana nonwovens offer the lowest tensile strength drop compared to the other single nonwovens.

The decrease in mechanical properties with increases in moisture content may be caused by the formation of hydrogen bonding between the water molecules and cellulose fibre.

The study carried out on the Tensile modulus of the Composites in Saline Water, Tensile strength of the composites in Saline Water, Flexural Modulus of the Composites, Flexural strength of the Composites, Impact properties of the Composites are given in Table II and VI.

Table – II - Tensile Modulus of the Composites in Saline Water

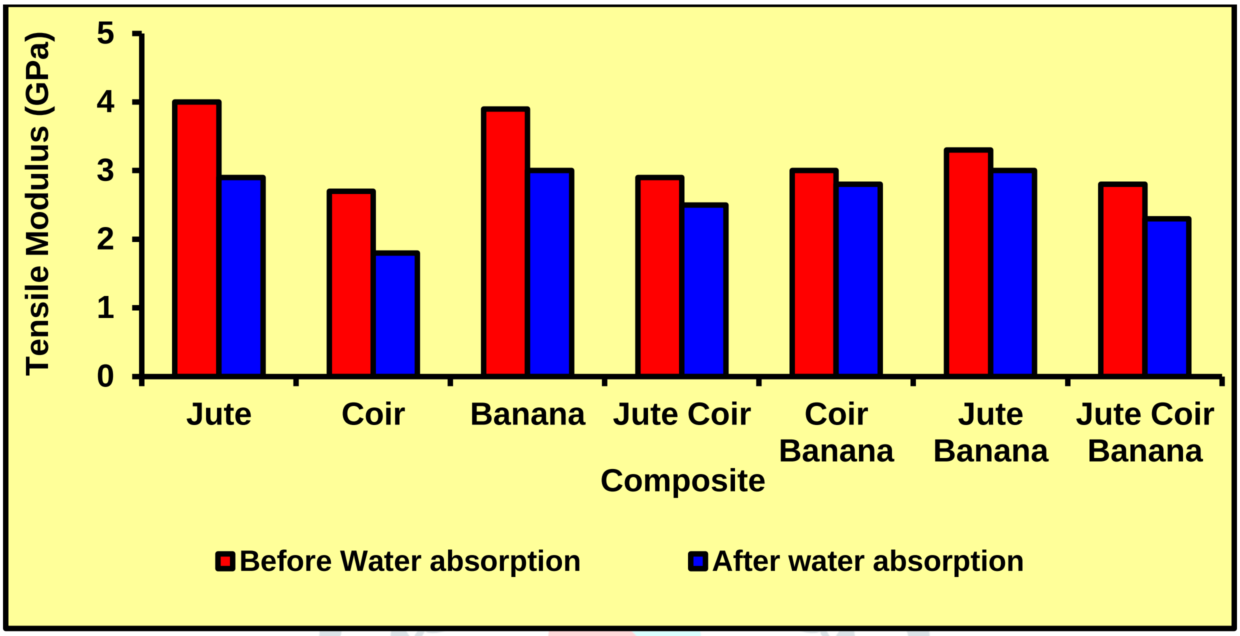


Table III - Tensile Strength of the Composites in Saline Water

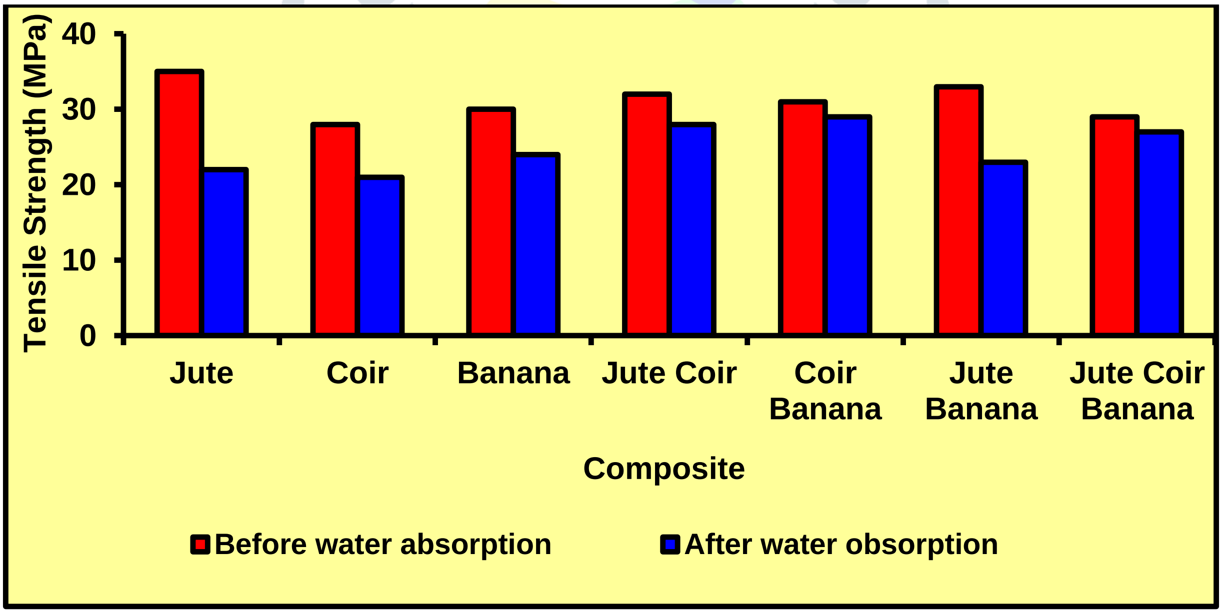


Table IV - Flexural Modulus of the Composites

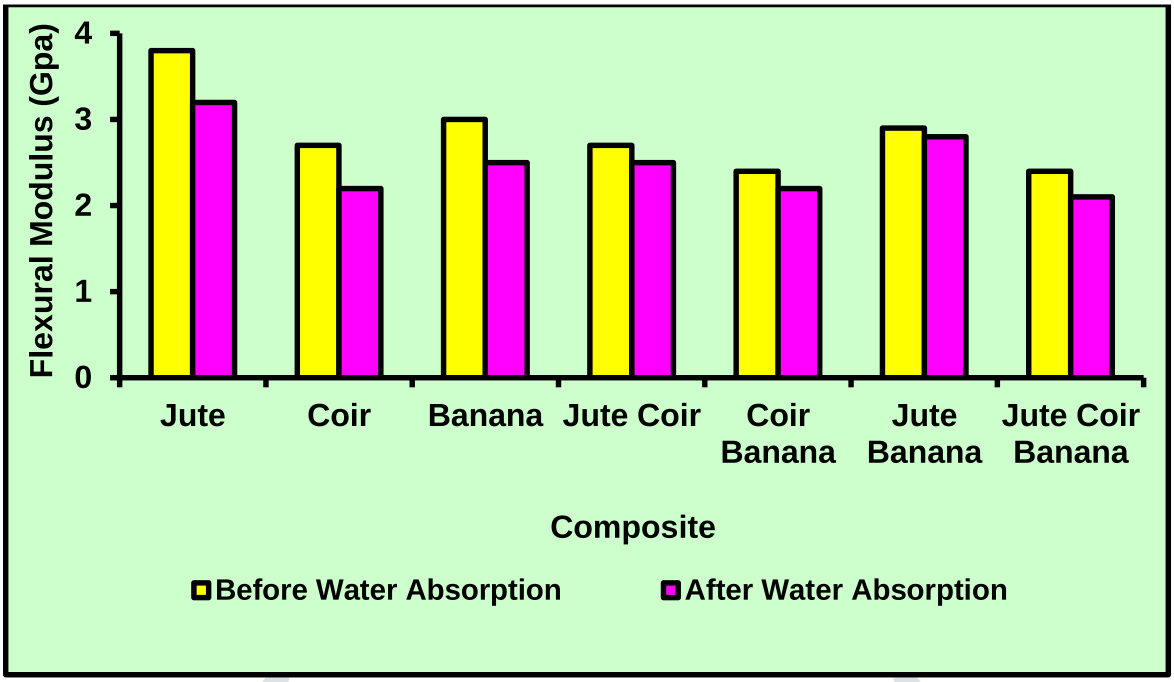


Table – V - Flexural Strength of the Composites

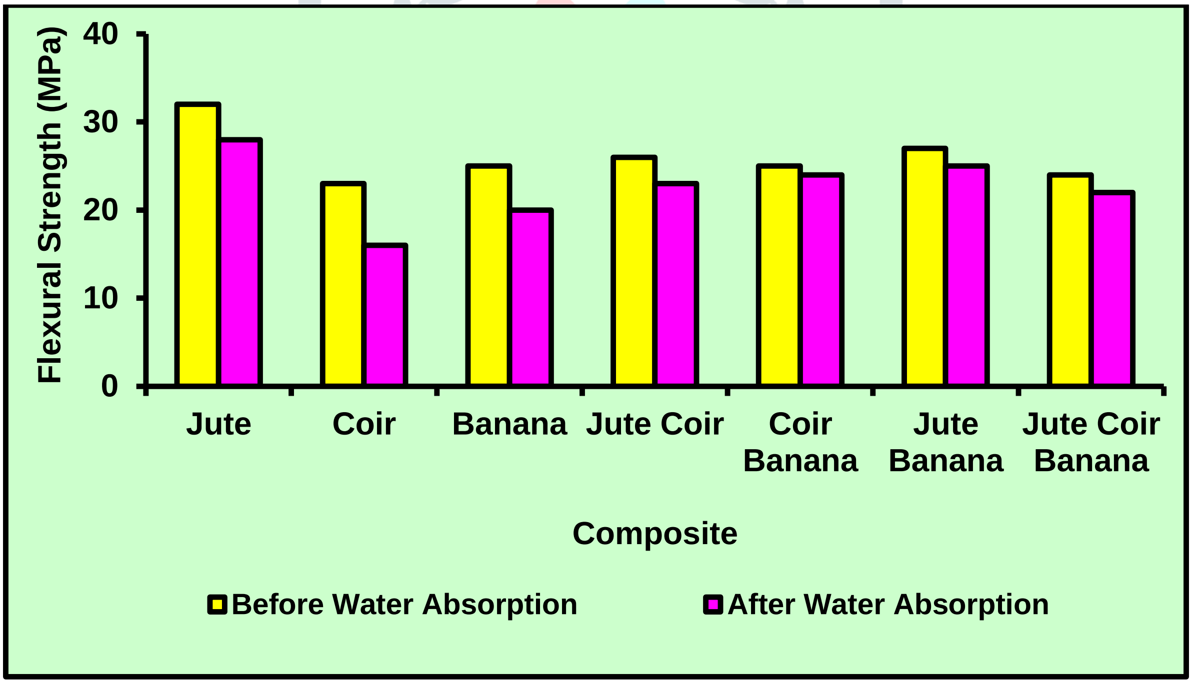
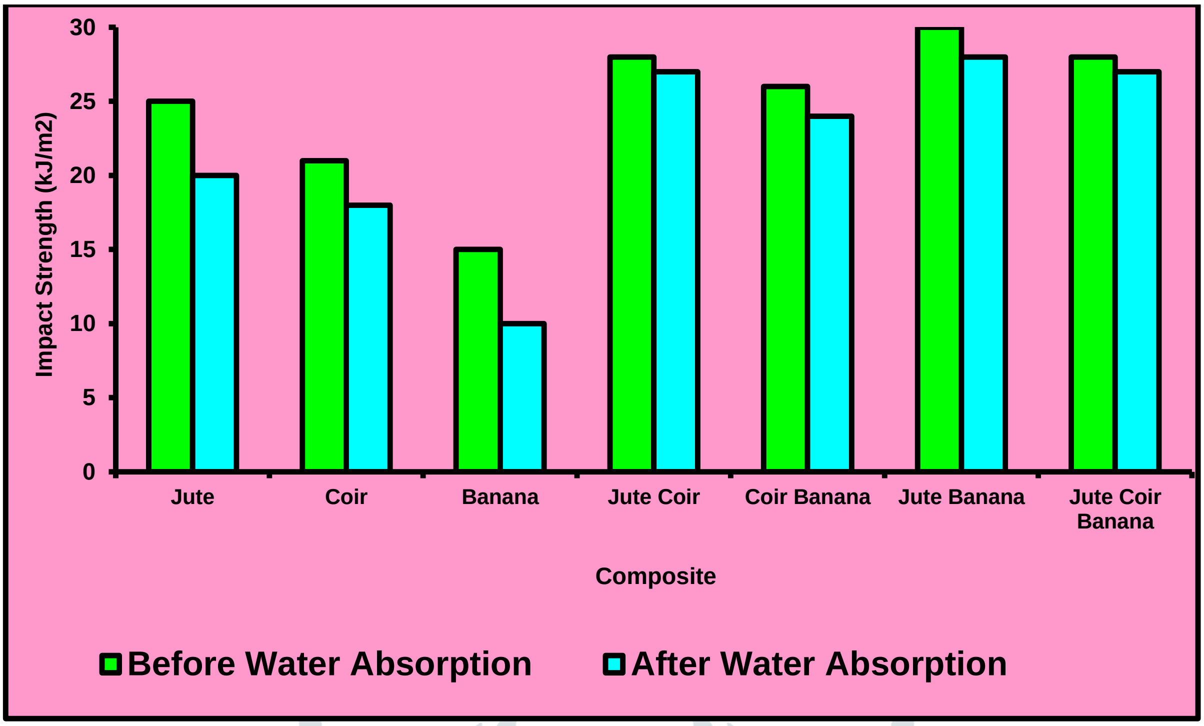


Table VI - Impact Properties of the Composites



From the study it was noted that the characteristics of water immersed specimens are influenced not only by the nature of the fibre and matrix materials but also by the relative humidity and manufacturing technique, which determines factors such as porosity and volume fraction of fibres. Water uptake can be advantageous for some natural fibres (such as Duralin fibre) at 66% relative humidity as can fibre plasticizing effect as a result of from the presence of free water. Excessive water absorption, however, leads to an increase in the absorbed bound water and a decrease in free water. In this situation, water can penetrate into the cellulose network of the fibre and into the capillaries and spaces between the fibrils and less bound areas of the fibrils. Water may attach itself by chemical links to groups in the cellulose molecules. The rigidity of the cellulose structure is destroyed by the water molecules in the cellulose network structure in which water acts as a plasticizer and it permits cellulose molecule to move freely. Consequently the mass of the cellulose is softened and can change the dimensions of the fibre easily with the application of forces.

V. Summary and Conclusion

There is a overall drop in the mechanical properties of the composites. This is due to water molecules act as a plasticizer agent in the composite material, which normally leads to an increase of the maximum strain for the composites after water absorption. Treatment with saline water has led to a drop in tensile modulus, tensile strength, flexural modulus and flexural strength of all composites.

Impact strength of the composites also had shown a drop in saline water. Jute / Banana blend was least affected by saline water treatment.

Sea water treatment did not have any effect on the areas of density of the fibre whilst for nonwovens an increase was noticed. Weight increase in the composite was less in saline water in comparison with the nonwovens.

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