Development and Study on the Properties of Eco-friendly Coir Latex Composites

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Abstract. Composites are made of two or more constituents in which one is the reinforcing fibre and the other is the matrix. Composites can play a vital role in weak subgrade soil by reducing the cost of construction and extend the service life of pavements. Non-woven geotextile allows inplane permeability and can be used as a separator in pavements, but its tensile strength is low. Composites can provide the required strength and in-plane permeability. Synthetic fibres are used in non-woven fabrics in various matrices for the development of polymer composites. Polymer composites developed from man-made fibres are not biodegradable and eco-friendly. Natural fibres are replacing manmade fibres as reinforcement due to their cost effectiveness, biodegradability, low density, good specific properties and environment friendly nature. Natural fibre composites are hybrid materials which combine the property of natural fibre with polymer matrix. Among the natural fibres, coir is a better natural fibre due to its high lignin content. Coir composites have great potential to be used for pavement stabilization of weak subgrade. In this study, coir latex composites were developed having different mass per unit area and varying the percentage of latex. The properties of developed composites, tensile strength, trapezoidal tear strength, puncture strength tests were determined. Significant increase in the mechanical properties was obtained with increase in latex content.

Keywords: composites, coir latex composites, natural fibres, pavement, coir - fibre

1 Introduction

Composites are defined as two or more constituents having one of the constituent as the fibres which form the reinforcing phase and the matrix phase being the other constituent [1]. From nonwoven fabrics coir composites can be developed.

Four stages which are involved in the development of nonwoven fabric – preparation of fibre, formation of web, web bonding and post treatment. In order to bond the filaments of web together, the processes used are – heat bonding, resin bonding or needle punching [6]. Nonwoven fabrics are gaining popularity due to the fact that nonwoven fabrics are simple, cost effective and flexible [11]. A nonwoven needle punched fabric is developed from web of fibres in which the barbed needles drive the fibres upward or downward. The needling action of the barbed needles interlocks the fibres and by frictional forces holds the fabric together [6]. Even though various manufacturing methods are available for the production of nonwoven fabrics, the popular and most widely used method for different engineering applications after spun bonding is needle punching [8]. When the fibres are fed into the machine, a carded web is formed and the barbed needles penetrate the web which results in the fibres being captured by the barbed needles. The movement of the barbed needles are from the horizontal plane to the vertical plane and bottom surface. When the barbed needles return, fibre bundles are formed resulting in the mechanical entanglement of fibres inside the web [13]. The factors that govern the properties of needle felt nonwoven are nature of component fibres and the arrangement of fibres in the structure [8]. It was reported that needle punched jute nonwoven fabrics have greater strength in warp direction than in weft direction. As the weight increases, tenacity increases initially and later on either the rate of increase slows down or the tenacity decreases. Longer and finer fibre results in greater fabric strength of nonwoven [8]. When the same raw material and web weight was used for the development of nonwoven fabric, it was reported that denser nonwoven possesses lower air permeability, elongation and higher strength. With higher needling density and needle penetration, greater consolidation in nonwoven fabric can be achieved. The strength and abrasion resistance of fabric gets improved due to the higher fabric weight and presence of scrim, provided the fabric is developed using suitable needling parameters. If the fibre breakage is controlled, longer and finer fibre results in greater fabric strength [8].

Composites are replacing conventional materials due to its superior properties like light weight, high strength to weight ratio and stiffness properties [5]. Polymer composites were developed from polymer fibres in various matrices like latex [10], ABS matrix [2], epoxy resin [4]. Fibre reinforced composites developed from synthetic fibres are not biodegradable and environmental friendly [5]. In order to reduce the price of raw materials, material technologists are focussing on natural fibre composites like jute, sisal, coir, pineapple etc. as the reinforcement [12]. Natural fibres are replacing synthetic fibres as reinforcement due to several advantages over manmade fibres [4]. Natural fibres with biodegradability, environmental friendly character, low cost, low density, good specific properties, low abrasiveness are good alternative to synthetic fibres [5]. Among the natural fibres, coir is a better natural fibre due to its high lignin content.

Coir fibre/polyester composites with the matrix as polyester resin was developed and its mechanical and structural properties were studied. Rigid composites were obtained when the weight of fibres was 50%. When the amount of fibre was more than 50% by weight, the composites performed like flexible agglomerates [9]. Rubber can be used as a binding material in composites. Adding rubber as the base element in a product imparts properties like elasticity and flexibility. The requirement of rubber product is the need of stiffness as well as flexibility in a particular direction. This property can be imparted in the composites by the reinforcement of rubber with long or short fibres [3]. Natural rubber latex was used as a binder for viscose rayon. With the initial addition of latex, the fabric strength and modulus increases and the extensibility decreases. With further addition of latex, the bonded area increases which in turn increase the strength of fabric. The bonded area attains a maximum value and further addition of binder does not have any impact on strength, which then remains as a constant value [7]. Impregnation of nonwoven needle punched fabrics by latex, a porous composite material with enhanced mechanical properties was obtained. By diluting the latex with distilled water, variation in degree of impregnation of latex can be achieved [1]. Natural rubber (NR) matrices can be effectively reinforced with cellulose fibres. The latex treated NR/jute composites showed superior performance than NR/jute treated high ammonia natural rubber latex [10].

This study deals with the development of coir latex composites using natural fibre coir and latex as the binding material and to determine the engineering properties of developed coir composite.

2 Materials

2.1 Coir fibre

The coir fibre used for the study was procured locally from a small scale industry in Neyyattinkara, Trivandrum. The physical property of the coir fibre was tested using Instron 5969 Universal Testing machine. The linear density of coir fibre was tested as per ASTM D1577 and the tenacity of coir fibre was determined according to ASTM D3822/D3822. The properties of coir fibre are given in Table 1.

Table 1. Properties of coir fibre

Parameter	Value
Diameter (mm)	0.25
Breaking load (N)	7.79
Breaking extension (mm)	21.84
Linear density (Tex)	73.77
Tenacity (N/Tex)	0.104

2.2 Prevulcanised latex

Prevulcanised latex was used as the binding material for the coir composite. Natural rubber prevulcanised latex was collected from KA Prevulcanised Pvt. Ltd., Kanyakumari. The properties of the prevulcanised latex given by the supplier are shown in Table 2.

Table 2. Properties of prevulcanised latex

Properties	Test result
Total solid content (%)	59
Alkalinity as Ammonia (%)	0.71
Coagulum content (ppm)	13
MST (sec)	698
pH	10.99

3 Methodology

3.1 Development of Coir Latex Composite

The development of coir latex composites was done at Neyyattinkara Coir Cluster Society, Thirupuram, Thiruvananthapuram. The first step involved was the development of nonwoven needle punched coir felt. The bale of coir fibre was opened and air dried properly. Thereafter the fibres were opened up and cleaned in the willowing machine. The fibres were then fed into the autofibre feeder unit and taken through a conveyor and fibres passed through the carding process. In the needle punching unit, fibres were interlocked by the vertical needle punching action of barbed needles resulting in the mechanical entanglement of fibres. Thus nonwoven needle punched coir felt was obtained. Nonwoven coir felt of 400, 600 and 800 GSM were developed. Prevulcanised latex of 10%, 25%, 40% and 50% of the weight of the nonwoven felt was sprayed on the felt manually using a hand sprayer at a pressure of 0.5 kg/cm^2. After sun drying for 10 minutes, the felt was roller pressed for proper penetration of latex into the coir fibre to obtain coir composite. It was found that latex percentage of more than 50% of the weight of the felt was not practical to apply. Table 3 shows the representation of coir composites. The needle punching unit is shown in Fig. 1. The developed coir composites of different GSM are shown in Fig. 2.

Table 3. Representation of coir composites

Representation	Composite	Latex content (%)
4NWCLC	400 GSM nonwoven coir latex composite	0, 10, 25, 40, 50
6NWCLC	600 GSM nonwoven coir latex composite	0, 10, 25, 40, 50
8NWCLC	800 GSM nonwoven coir latex composite	0, 10, 25, 40, 50

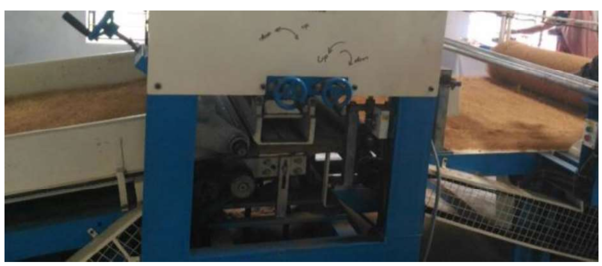

Fig. 1. Needle punching unit

Fig. 2. Developed coir composite

3.2 Testing Procedure

The physical and engineering properties of developed coir composites of different GSM and latex content were tested. Mass per unit area of the composite was determined as per ASTM D5261 and tensile strength test according to ASTM D4595. Trapezoidal tear strength was determined as per ASTM D4533 and puncture strength test was conducted according to ASTM D6241.

4 Results and Discussion

4.1 Tensile Strength of Coir Composite

Tensile strength is an important property for quality control and design purpose as all applications depend on this property. Fig. 3 shows the tensile strength of coir composites with increase in latex. The tensile strength of coir composite increased with increase in percentage of latex for a particular GSM. For 4NWCLC, 100% increase in tensile strength was observed at 50% latex content when compared to 400 GSM nonwoven geotextile without latex. The tensile strength also significantly increased with increase in GSM of the coir composite. This is in agreement to the outcome that impregnation of nonwoven needle punched fabrics by latex, a porous composite material with enhanced mechanical properties can be obtained [1]. At 50% latex content, maximum tensile strength was obtained for 8NWCLC and the percentage increase was 24% more than that of 4NWCLC at 50% latex content. It was also observed that for a particular GSM, the tensile strength in cross machine direction is lower than the tensile strength in machine direction.

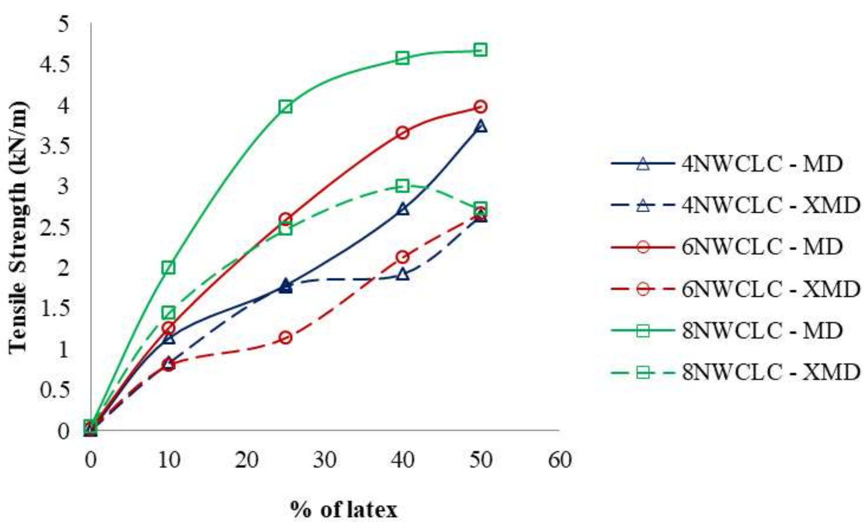

Fig. 3. Tensile strength of coir composite

4.2 Trapezoidal Tear Strength of Coir Composite

Trapezoidal tear strength provides information about the ability to resist continuous tear. Fig. 4 shows the trapezoidal tear strength of coir composites with increase in latex content. Trapezoidal tear strength is found to increase with increase in latex content for a particular GSM. With the increase in GSM, the trapezoidal tear strength was also found to increase. The maximum trapezoidal tear strength at 50% latex content for 6NWCLC was 0.245 kN in machine direction and was found to remain constant with further increase in GSM. The percentage increase in trapezoidal tear strength between 4NWCLC and 8NWCLC was found to be 142% at 25% latex content, 72% at 40% latex content and 14% at 50% latex content. As the weight increases, trapezoidal tear strength increases initially and later on the rate of increase slows down. For 4NWCLC, only marginal difference in trapezoidal tear strength was observed in machine and cross machine direction. For 6NWCLC and 8NWCLC, the trapezoidal tear strength in cross machine direction is less than that in machine direction.

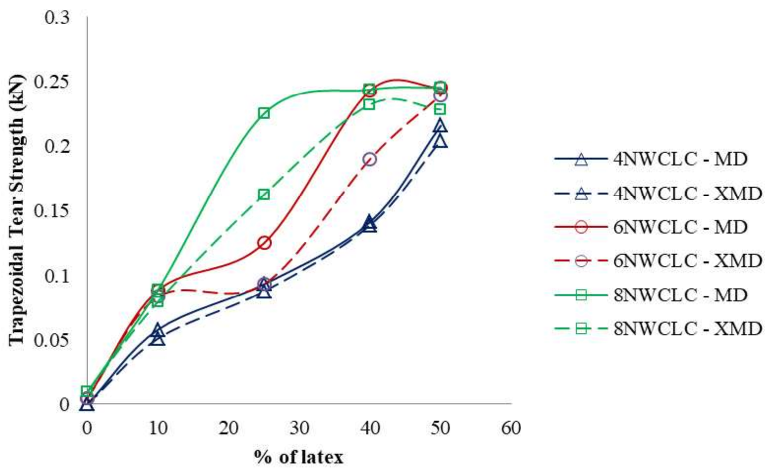

Fig. 4. Trapezoidal tear strength of coir composite

4.3 Puncture Strength of Coir Composite

Puncture strength is an important property when composites are used as separators. Fig. 5 shows the puncture strength of coir composites with increase in latex content. The puncture strength increased with increase in latex for a particular GSM and also with increase in GSM. Maximum puncture strength was obtained at 50% latex content for all coir composites. At 50% latex content, for 8NWCLC the percentage increase in puncture strength was 66% when compared to 4NWCLC.

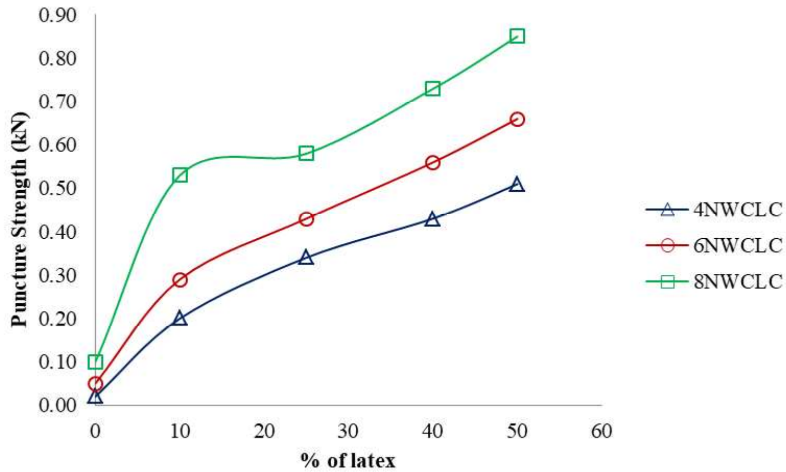

Fig. 5. Puncture strength of coir composite

5 Conclusions

The present study has shown encouraging results regarding development and significant increase in the properties of coir composites and following conclusions were derived regarding the use of coir composites for various engineering applications:

1. The tensile strength, trapezoidal tear strength and puncture strength of coir composite were found to increase with the addition of latex and with increase in GSM.
2. The tensile strength was found to be maximum for 800 GSM coir latex composite at 50% latex content.
3. The tensile strength and trapezoidal tear strength in cross machine direction is less than that in machine direction for a particular GSM.
4. Increase in GSM does not increasing the trapezoidal tear strength beyond 600 GSM nonwoven coir latex composite.
5. Maximum puncture strength was obtained for 800 GSM nonwoven coir latex composite at 50% latex content and the percentage increase was 66% when compared to 400 GSM coir latex composite.

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