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Flexural Strength and Drilling Parameter of Natural Fiber Composites with Usage of Epoxy Resin

Ravindra Pratap Singh*

Abstract

An attempt that has been made to take use of the advantages offered by natural composite materials in light of the fast advancement of research and development in this field over the course of the previous two decades, from the laboratory to the factory floor. During the manufacturing process of laminates, polymer matrices are used, while cotton, jute, and sisal are utilised as reinforcing materials. Epoxy resin is used to create this sort of composite material. The primary focus of this work is on determining the tensile and flexural strengths of the materials at hand, as well as the circularity of the holes drilled into the materials and the surface roughness of those holes. In addition, this work examines the surface roughness of the holes drilled into the materials. After conducting a large number of experiments, substantial conclusions have been drawn in order to demonstrate that machining is an option for use in applications that take place in the real world and to reduce the component weight. The hole produced by a drill spinning at 750 RPM with a feed rate of 0.05 mm/min has a high surface quality, low wear, and a low friction coefficient. Both an increase in spindle speed and a change in point angle have a detrimental effect on circularity; however, we are not exploring these variables here. The impact of feed rate on circularity is negligible. Our findings show that the best circularity (0.0185) for cotton laminate is achieved with a spindle speed of 0.05 mm/min at 750 rpm for the feed rate.

Keywords: Natural fiber composites, flexural strength, surface roughness, drilling circularity.

INTRODUCTION

Composites are materials in which one or more of the basic materials is made up of another material. At that point, the final structure will be a composite of its constituent parts, each of which will have its own unique physical and chemical features. The reinforcement, made of a composite material, takes on a unique form since it is embedded in a matrix tailored to its specific properties. If the design goes as planned, the applied reinforcement will boost the mechanical characteristics of the specific matrix, resulting in a material with superior strength to that of the component materials used in its construction. Depending on the specifics of the use case, it may be preferable than more conventional materials.

***Author for Correspondence**
Ravindra Pratap Singh
E-mail: pratap.ravindra@gla.ac.in

Assistant Professor, Department of Mechanical, GLA University, Mathura, Uttar Pradesh, India

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There were starting to be some really intriguing uses for bio fibre reinforcements [1–4]. Researchers found that in a hybrid fiber composite of hemp and propylene, the layer immediately adjacent to the bond interface was subject to the highest levels of transient stress. Researchers found that the percentage of plastic waste composite fibers had no effect on the material's tensile strength [5–6]. Researchers observed that treatment of unwoven jute with a polymer resembling phenol polymerisation ground nut shells liquid formaldehyde [7] reduced the fiber's absorption of water. Natural fiber reinforced polymer composites' tensile properties were investigated [8–9]. Scientists, engineers, and researchers have been attracted by the innovative potential of natural fibres as substitute strengthening for fiber reinforced polymer (FRP) composites [10]. According findings's alkali treatment has the potential to significantly alter composites' physical characteristics. Experiments on the tensile and impact characteristics of jute and casual fiber composites showed poor results, whereas jute and curaua fiber composites treated with a combination of alkali and salt water produced the best results looked into the issue, and found that the reinforcing design had no impact [11–12]. Toughness was significantly influenced by the fiber volume percentage. Strength of the bleached hemp fibre reinforced composite is found to rise dramatically with fiber loading, as reported [13–14].

Preparing bio composite laminates from a wide range of natural fibers in this experimental workshop. tensile How laminates will respond to a variety of studies, including a tensile, surface roughness, and circularity test, etc., will be determined once the method has been carried out [15].

EXPERIMENTAL PROCEDURE

Laminate Preparing

This procedure employs a manufacturing method known as wet-lay, sometimes known as hand-lay. To achieve the correct length, breadth, and thickness of the laminate, several grits of emery paper are employed to smooth down the moulds and spacers. Finally, acetone is used to clean the mould, and then waxpol is rubbed into the spacers and the bolts to produce a high-quality surface finish. By use of Ellen keys, the spacers are fastened to the moulds with the aid of Ellen bolts. So that the matrix doesn't cling to the mould, waxpol is applied in 0° and 90° alignments. Figure 1 shows laminate cotton, sisal, jute. The next thing to do is to weigh out 10 parts resin to 1 part hardener and mix them together. While the hardener is responsible for curing the epoxy resins, those resins are what give the composite its durability, chemical resistance and strength. Combination of resin and hardener may be applied to the fibres once the exothermic reaction between the two has commenced and the resultant heat has been dissipated. In order to achieve the necessary lamination thickness, dust treatment and manipulation are required due to the nature of these fibres being natural. Figure 2 shows hydraulic press. After the fibres are spread out in the mould, laminae (or layers) of the resin-hardener mixture are applied to get the appropriate laminate thickness. Next, mould is sealed, moved to hydraulic press, inserted into punch plate, and press is calibrated. After curing for 24 hours at room temperature, the laminate is removed from press, bolts are undone with Ellen keys, and laminate is carefully loosened. Figure 3 shows Natural fiber composite cotton, sisal jute. This is how lamination is manufactured.

Resulting laminate is subsequently transferred to cutting facility. Specimens are cut using a computer numerically controlled machine to the exact dimensions specified by American Society for Testing and Materials (ASTM). Furthermore, these specimens are drilled using a 6 mm drill bit with a 118° point angle. Typically, the drill bit is a multi-pointed rotary cutting instrument. Figure 4 shows drilled Specimens. Again, with the right instructions, the CNC trimming equipment can drill holes of the correct size. The method involves pressing the bit into the material to be machined while spinning it at rates between several hundred and several thousand revolutions per minute. Table 1 Drilling holes Parameters on laminate. By changing the cutting speed and feed rate, the cutting edge is pressed against the workpiece, removing chips as the hole is drilled. Three holes has been done in the specimen of laminated cotton, sisal and jute with drilling parameters.

Figure 1. laminate cotton, sisal, jute

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Figure 2. Hydraulic press.


Figure 3. Natural fiber composite cotton, sisal jute.


Figure 4. Drilled Specimens.

Table 1. Drilling holes Parameters on laminate

Holes	Feed rate (mm/min)	Cutting speed (rpm)
A	0.09	1000
B	0.13	1250
C	0.05	750

TESTING

Before the composites can be used in regular applications, their mechanical properties need to be tested and assessed for reliability and safety. CMM (coordinate measuring machine) and surface roughness measurement tools are used to check for circularity and measure surface roughness, respectively. Table 2 shows Input parameter determined for compression analysis Once the mechanical properties are well understood, potential uses may be identified. So, to compare the results, a tensile test and a compression test might be useful. In order to achieve a more precise reading of flexural strength, test specimens are created and experimented with in accordance with ASTM guidelines. Each test specimen's starting values were recorded. Table 3 Shows Output parameters of bio composite The experimental results were plotted to reveal the relationships between load, peak elongation, and the forces responsible for the flexural stresses seen in the specimen. A specimen's flexural strength is calculated using geometric considerations.

Flexural strength (σf) formulae of rectangular cross-section

$$\sigma_f = \frac{3FL}{2bd^2}$$

b = beam width

σ_f = flexural strength

d = beam depth

F =load (N)

L = support span

Compression tests, flexural tests, circularity tests, and surface roughness tests were conducted on sisal, jute, and cotton based natural composites to improve machining

Table 2. Input parameter determined for compression analysis

laminated Material	Specimen Parameters					
	Shape	*Thickness (mm)*	*Width (mm)*	*Maximum Deflection (mm)*	*Maximum Load (kN)*	*Cross-section area (mm²)*
Sisal	Flat	6.62	29.87	200	100	164.100
Jute		5.47	30			178.323
cotton		5.96	29.92			197.739

Table 3. Output parameters of bio composite

Laminate Material	Specimen output parameters			
	Elongation (mm)	*Load (KN)*	*Flexural strength (N/mm²⁾*	*Compression strength (N/mm²⁾*
jute	3.110	1.680	231.01	8.496
cotton	1.580	3.865	775.04	23.553
sisal	2.160	0.960	162.59	5.383

According to plot, the load and elongation both rise steadily over time. Fracture occurs at 0.960 kN and 2.160 mm of elongation. A large portion of the applied force is removed immediately following the fracture, yet the specimen continues to elongate until it reaches 7 mm, at which point it fractures in two.

The ductile character of sisal fibre is demonstrated by the load reduction following fracture. From the looks of the graph, the load applied has increased dramatically, yet the elongation has changed just slightly. Fracture occurred at an elongation of 3.110 mm and a peak load of 1.680 KN. Rapid load reduction occurred up to 0.1 KN after the fracture, and then 0.04 KN, and Table 4 shows Input parameters tensile test of bio composite the load remained constant up to 23 mm of elongation, at which point it snapped in two.

Initial loading causes no elongation in the specimen; after 3 KN, elongation steadily rises; at maximum load of 3.865 KN, specimen fractures with elongation of 1.8 mm. Use of tensile testing allows for the estimation of a material's ultimate tensile strength. Load, peak elongation, tensile strength, and yield strength may all be measured and plotted after specimens have been put in the cross heads and pushed apart.

Table 4. Input parameters tensile test of bio composite

laminated Material Type	Specimen Input Parameters						
	Shape	*Thickness (mm)*	*Width (mm)*	*initial G.L. for % elongation (mm)*	*Maximum Deflection (mm)*	*Maximum Load (kN)*	*Cross-section area (mm²)*
Sisal	Flat	6.58	20.09	50	100	200	164.100
Jute		6.51	20.04				178.323
cotton		5.45	20.09				197.739

Table 5. output parameters of tensile test of bio composite

Laminated material	Specimen output parameters			
	Elongation (mm)	*Load (KN)*	*Tensile strength (N/mm²)*	*UTS/YS*
cotton	5.670	2.935	26.805	18.756
sisal	5.360	5.815	43.989	--
jute	4.510	5.900	45.224	--

According to the graph, the load began operating gradually, reaching its maximum value at 2.935 KN, and Table 5 shows output parameters of tensile test of bio composite the fracture occurred at an elongation of 5.670 mm. At 56 KN, the specimen cracked in half and the load was steadily raised until the fracture occurred again. No lengthening occurs, as seen by the graph's straight line, although the load does grow steadily up to 56 KN.

The load grew progressively in relation to the maximum elongation, and failure occurred at 5.9 KN and 4.510 mm. The material cracked in half after being subjected to 5.4 KN with an elongation of 4.6 mm. According to graph, 5.815 KN has been maximum load, and maximum elongation was 5.360 mm. At this point, material cracked. The load and elongation gradually decrease when the material fractures; Input (in/minute), the fracture occurred at 4.6 KN with elongation of 5.4 mm.

CIRCULARITY TEST RESULTS

Hole 'A' is the most round and has the least degree of inaccuracy with cutting speed at 0.05 mm/min feed rate with 750 rpm. In the circularity test, the point angle is 118° and nominal diameter of each hole 0.000.

The difference value of the circularity test tends to decrease as cutting speed and feed are reduced. Table 6 shows Circularity values composite. It is therefore advisable to do the machining operations with a slower cutting speed and feed. Comparison of sisal, jute, and cotton in terms of surface roughness

In the cutting low feed rate is applied on the specimen due to low feed rate low chip produce with higher surface finish. Table 7 shows Sisal Surface roughness. To produce superior surface finish coupled with improved accuracy due to the strain hardening effect. The hole in the sisal fibre table has the smoothest surface, at 1.35 µm mas, when compared to the other two tables.

Table 6. Circularity values composite

S.N.	Prepared specimen	Feed rate (mm/min)	Cutting speed (rpm)	Actual diameter for each hole
		0.05	750	0.0390
1	Sisal	0.09	1000	0.0420
		0.13	1250	0.0592
		0.05	750	0.0185
		0.09	1000	0.0244
2	Cotton	0.13	1250	0.0533
		0.05	750	0.0220
3	Jute	0.09 0.13	1000 1250	0.0280 0.0469

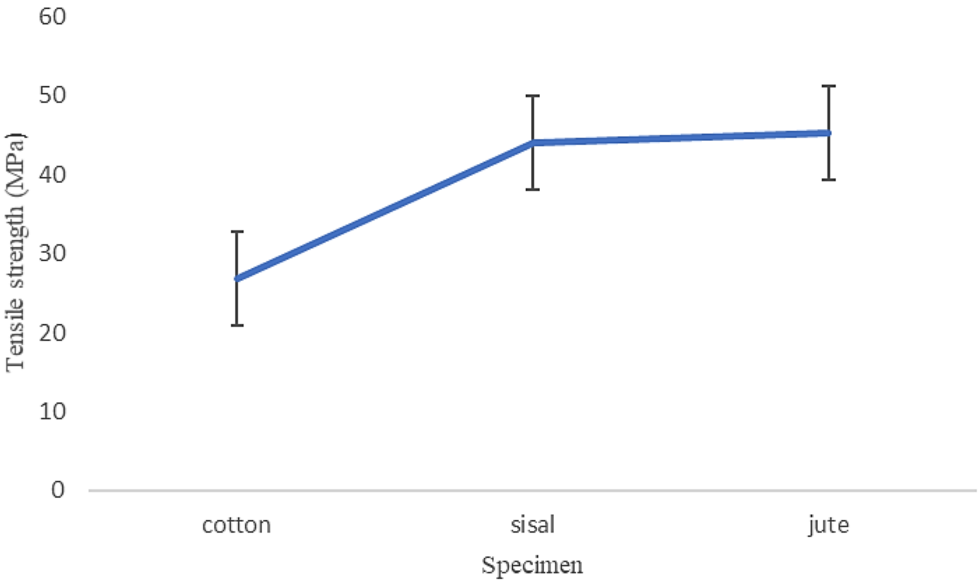
Table 7. Sisal Surface roughness

Holes (Surface roughness (µm))	A	B	C
sisal	2.885	1.35	3.332
jute	2.9	2.531	2.960
cotton	2.823	1.366	2.996

CONCLUSIONS

Drilling parameters, mechanical properties and hole quality of natural fibre polymer composites made from sisal, jute, and cotton were all studied and determined to be optimal.

It is evident from the graphs that jute has a greater tensile strength. Jute fibre reinforcing improves tensile strength in comparison to other fibres. Partition boards, walls, and prefab buildings intended for usage in the event of natural disasters can all benefit greatly from composites manufactured with jute fibres. Figure 5 shows analysis of mechanical properties of prepared specimen



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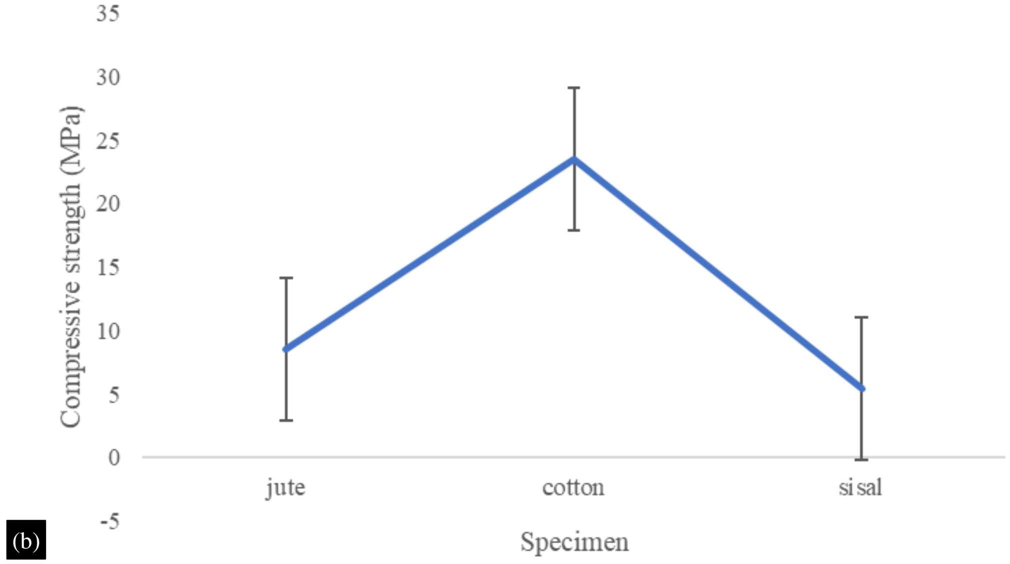


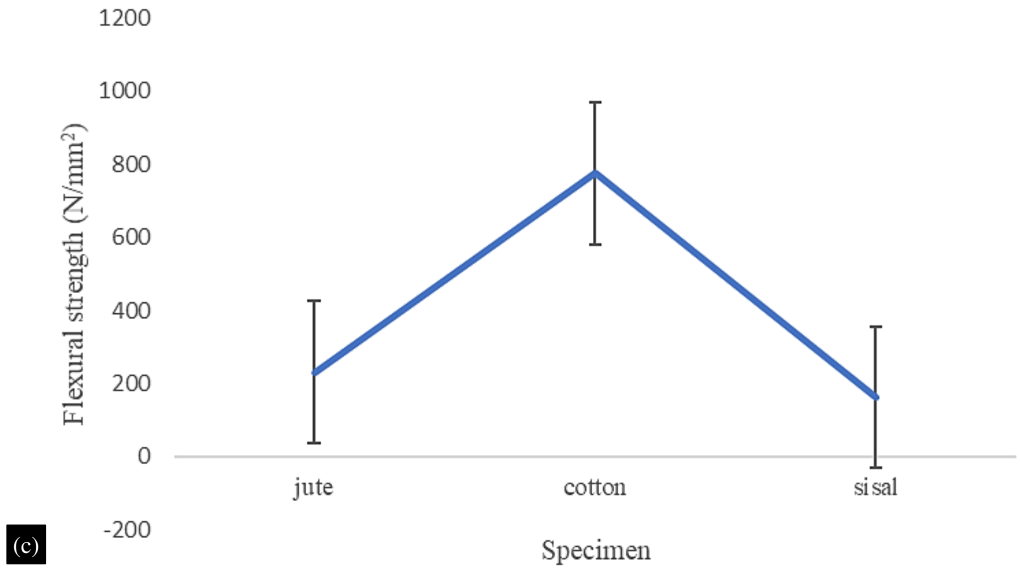


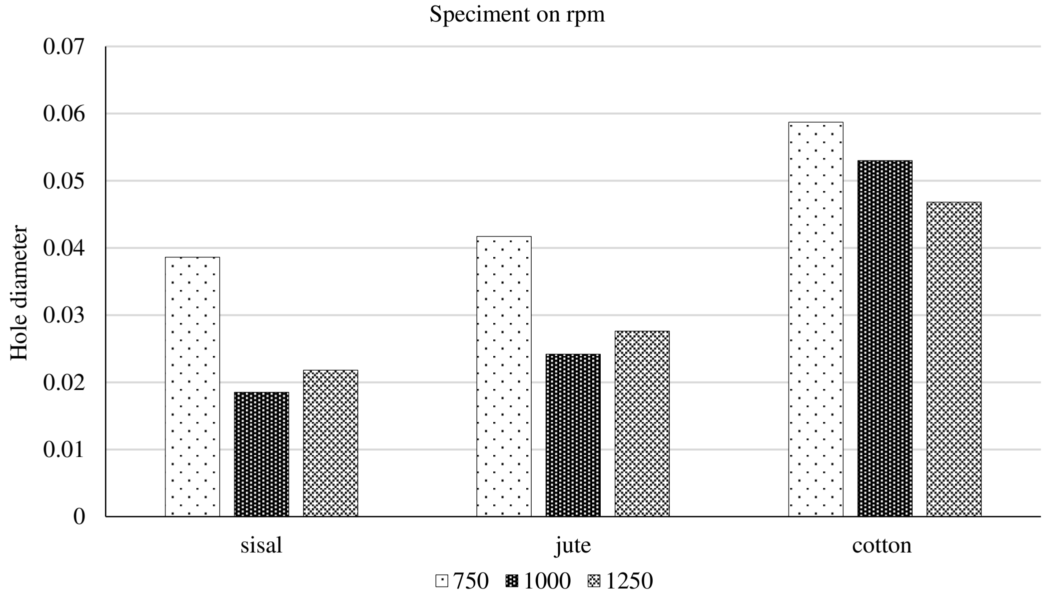
Figure 5. Analysis of mechanical properties of prepared specimen.

Cotton is more robust than other laminates because of its high flexural and compression strengths, which enable it to withstand large loads and loads that normally diminish the size of samples (the values of compressive strengths are given in the above table.

Circularity Test Conclusions

A higher spindle speed has a negative impact on circularity, as does a shift in point angle, however we are not experimenting with these factors in this project. Circularity is little affected by feed rate. Based on our data, we know that a spindle speed at 0.05 mm/min feed rate with 750 rpm yields the best circularity (0.0185) for cotton laminate.

Drilling a hole with the least possible variation from the nominal value, or excellent circularity, necessitates the use of cotton laminate with the aforementioned attributes. Based on the information in the aforementioned tables, a chart was drawn up to show the deviation between the actual and specified diameters and Figure 6 shows Hole diameter and surface roughness of drilled holes. the accompanying cutting speeds researcher has been compared cutting speeds and hole roughness during drilling to get the graph.



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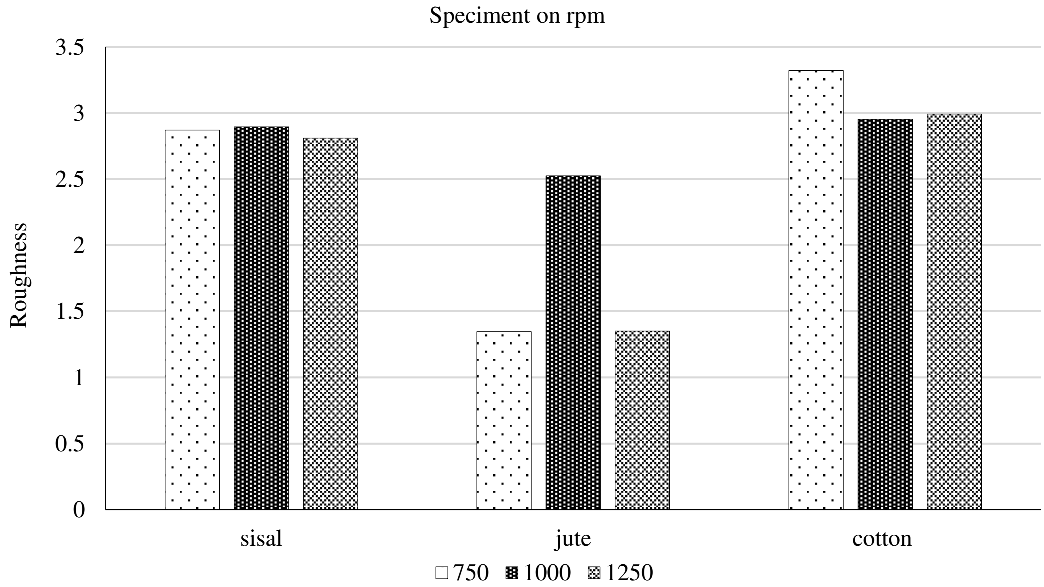

(a)

Figure 6. Hole diameter and surface roughness of drilled holes.

Drilling at 0.05 mm/min feed rate with 750 rpm results in a hole with high surface quality, little wear, and low friction coefficients, as shown by associating reflection tables and surface roughness graph. The aeronautical industry must reduce the weight of its components in order to meet environmental concerns and financial criteria linked to lower emissions and fuel consumption. These natural composites are achieved by the application of fibre reinforcements. For the purpose of using fasteners such bolt nuts, screws, and rivets to affix various components together, these factories require drilled holes with improved surface roughness and circularity. Cotton fibre composites have found usage in both semi-structural and automotive settings.

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