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Tensile test on pine needles and crack analysis of pine needles short fiber reinforced composites

*1 Litton Bhandari,2 C.S.Upadhyay, 2 P.M. Mohite, 1 Anirudh Gupta,1 S.C. Sarkar, ,1 Vipin Singh Panwar

1 *Department of Mechanical Engineering, Bipin Tripathi Kumaon Institute of Technology, Dwarahat, Almora, Uttarakhand ,India*

2 *Department of Aerospace Engineering, Indian Institute of Technology, Kanpur, India*

Abstract: *Natural fibers are widely used as reinforcing material in composites. Pine needles can be used as natural fibers which are abundantly found in the hilly areas of India. A study on tensile test of pine needles and the crack analysis of pine needles short fiber reinforced composites has been presented in this paper.ASTM D638-10 standard is followed for tensile testing and a number of specimen is tested for the statistical analysis.ASTM D5045 standard is used for the crack analysis of a number of specimen .Paper tab method is used for the tensile testing of the pine needles fiber. Measuring the modulus and strength by conducting a tensile test by paper tab method is very popular in fibre manufacturing industry. The experimental procedures to determine the axial Young's modulus and ultimate axial tensile strength of single fibre as well as fabrication procedure and crack analysis of pine needles short fiber reinforced composites have been explained in detail in this work.*

Keywords: *Pine needles,natural fiber, short fiber, tensile test, Fracture, crack analysis*

I. Introduction

Advancement in the natural fiber reinforced composites has been growing rapidly in the recent years. Researchers are shifting towards the natural composites for various reasons such as health concern, environmental concern, economic concern and reduced energy consumption [1]. Natural fibers such as jute, flax, hibiscus sabdariffa, pinus, jute, pineapple leaf fiber, oil palm fiber have all been proved to be good reinforcements in composites. Pine needles one of them which can be used as the reinforcement in composites.Pine needles are one of the major biowaste generated by pinus*roxburgii plant*. Pines are coniferous , evergreen,resinous tress belonging to genus pinus of family pinaceae abundantly found in the Himalayan region of India. Pine needles posses variety of ability to act against cancer tumours, DNA damage and have an antibacterial ability [3,4,5].Pine needles can also help in bio monitoring of pollution by absorption of atmospheric polycyclic aromatic hydrocarbons. They can also be used to remove dye from water[8].Apart from this,pine needle fiber possesses better mechanical strength[10] that triggeredits use in composites and found applications in automotive andcivil construction.

The bulk density of pine needles can be typically about40-200 kg/m3 which can be increased to densities as high as600-800 kg/m3[6].Researcher have been investigating the use of pine needles as the reinforcement in cement since 1980s[7].

However ,the possibility is raised to use pine needles as the reinforcement in the composites later with the phenol-formaldehyde[11], isocyanate[12],urea-formaldehyde[13],polypropylene[14],etc.

Despite, of various recent work on pine needles and composites ,there appears no data on the crack analysis of pine needles short fiber reinforced composites.

Therefore,in this work researchers have conducted tests for the crack analysis of pine needles short fiber reinforced composites and test to find out the tensile strength & modulus of elasticity of the pine needles fiber. Pine needles were collected from the Himalayan region of Uttarakhand,India.

Table 1. Various components of Pinusroxburgiifiber[15]:-

Sample	Cellulose %	Hemice-llulose %	Lignin %	Other %
Pinusroxburgii	60	20	15	5

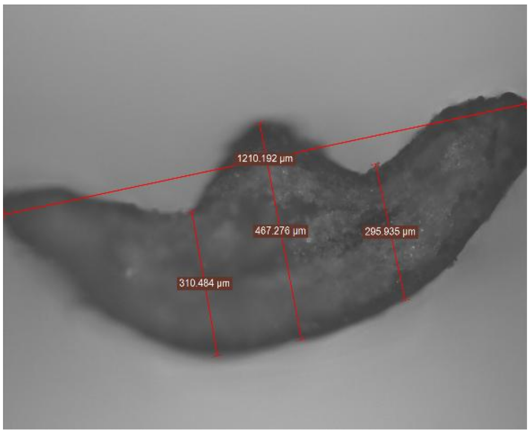

Fig.1.1 Optical micrograph of cross section of Pine needles with 200X resolution

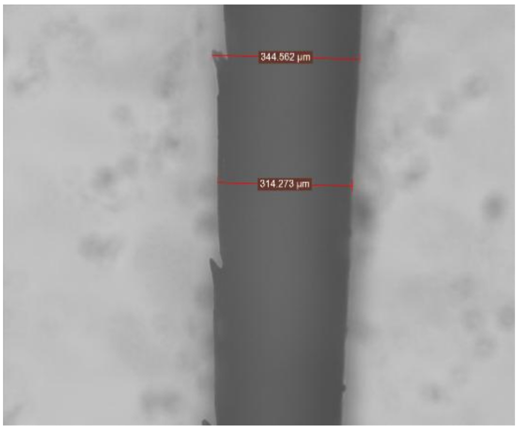

Fig.1.2 Longitudnal optical micrograph of Pine needles with 200X resolution

II. Experimental And Testing

2.1 Tensile Test

The tensile test is performed on single filament pine needle in order to find their axial tensile modulus and ultimate strength according to ASTM D638-10 . A TINIUS OLSEN machine is used with a 250 N load cell. The cross-sectional area of the pine needles fiber is determined using the method discussed in the next section. Paper tab method is used for the tensile testing of pine needles fiber.

2.1.1 Preparation of specimens

A thick paper is taken to prepare the tab for mounting the specimen. A slot of length equal to gauge length is cut out in the middle of the tab as shown in figure.2.1. A single filament is randomly chosen from the fiber bundle and pasted at both the ends of the slot in the paper tab using suitable adhesive. The gauge length of the fiber taken is 30mm**.**

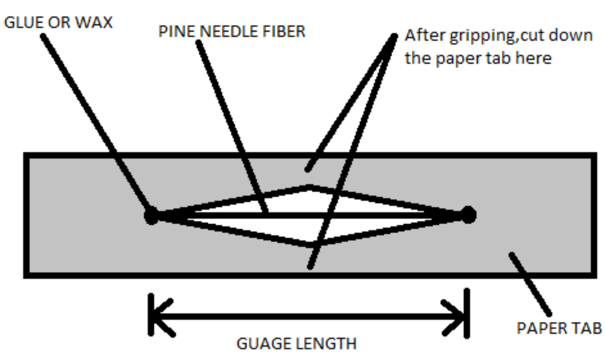

Fig.2.1-Paper tab specimen

2.1.2 Testing of specimen

The specimen to be tested is mounted on the TINIUS OLSEN machine. One should carefully align the pine needles in-line with the axis of cross-head in order to simulate a uniform stress condition over the cross-section of the fiber.

A 250N load cell is used and strain rateor position rate is taken as 0.5mm/min.Once the specimen is mounted on the machine, the data of the force and its corresponding displacement is obtained and the force-displacement graph is plotted.

And for the calculation of stress , the cross sectional area of the pine needles is determined as described in the next section.

Fig.2.2- Specimen clamped on machine

2.1.3determination Of Coss-Sectional Area

The cross-sectional area of pine needles is determined by counting the number of grids occupied by the micrograph of the cross-section given that the area of individual grid is known. The micrograph is obtained from advanced optical microscope (model ZIESS AXIO Imager, M1M, with maximum possible magnification up to 1000X).

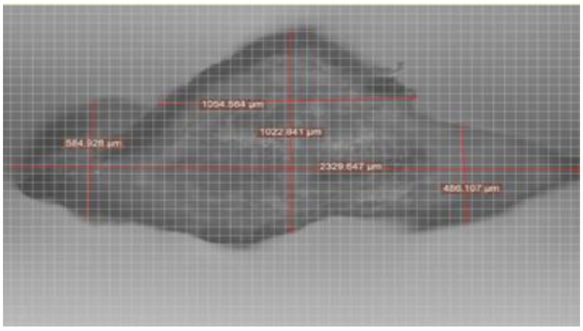

Fig.2.3- Cross-sectional view of pine needles   with grid

III. Crack Analysis Of Short Fiber Reinforced Composite

3.1 Materials

The composites were fabricated using pine needles fiber and epoxy resin. The pine needles fiber were chopped with the help of hand scissors and cleaned with mesh, all dirts are removed from the pine needles fiber. Then the pine needles is dried in oven at 80°C and 1 atmospheric pressure.

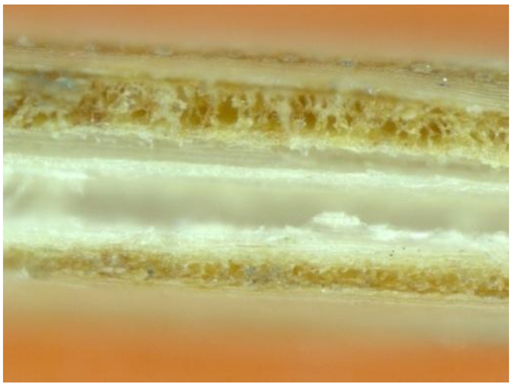

Fig.3.1-Longitudnal stereo-microscopic Image of pine needle

3.2 Composite Fabrication

The mould was taken with 150mmx45mmx4mm inner dimension. The mould was cleaned properly with acetone. Then the wax and silicon spray is applied on the surface which acts as releasing agent.The pine needle fiber and the epoxy resin is mixed properly with the help of magnetic stirrer till it mix properly. Hardener is added to the mixture proportionally. Then the mixture is poured into the mould.

Fig.3.2-Pine needle short fiber reinforced composites

3.3 Crack analysis test

In the crack analysis of short fiber reinforced composites, we will determine the fracture toughness of the specimen. Fracture toughnes measures the resistance of the material to the propagation of crack.The fracture toughness can be determined by fracture toughness test.If a material has high fracture toughness ,it is more prone to ductile fracture.A parameter called the stress intensity factor(K_{Ic}) is used to determine the fracture toughness of most material.

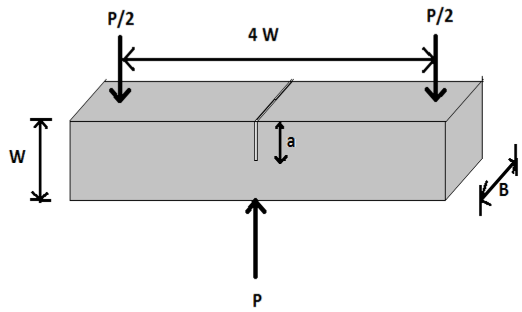

Fig.3.3- Specimen for crack analysis

$$K_{Ic}=\left(\frac{4P}{B}\right)\left(\frac{\sqrt{\pi}}{W}\right)\left[1.6\left(\frac{a}{W}\right)^{\frac{1}{2}}-2.6\left(\frac{a}{W}\right)^{\frac{3}{2}}+12.3\left(\frac{a}{W}\right)^{\frac{5}{2}}-21.2\left(\frac{a}{W}\right)^{\frac{7}{2}}+21.8\left(\frac{a}{W}\right)^{\frac{9}{2}}\right]$$

Where,
K_{Ic}- Stress intensity factor
P- Applied load
a- Crack length
w- Width of specimen
B- Breadth of specimen

3.3Preparation of specimen

The specimens were prepared by cutting the composite sheet with the help of saw. Initially a notch is made with diamond saw. Natural crack is initiated with the blade. The specimen were prepared according to the ASTM standard as shown in figure. ASTM D5045 standard is used.

Fig.3.4-Specimen for crack analysis

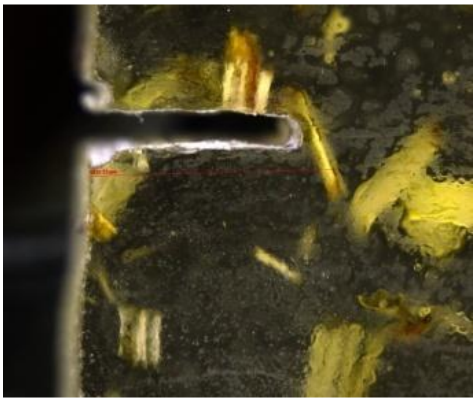

Fig.3.5- Stereo-microscopic image of the crack along with notch

3.5 Testing of specimen

The specimen should be carefully clamped on the TINIUS OLSEN machine. A load cell of 250 N is used for the crack analysis. The strain rate is kept 1mm/min. Once the specimen is clamped ,it is properly covered by the casing to avoid accidents.

The data of the force and its corresponding displacement is obtained and the force-displacement graph is plotted.

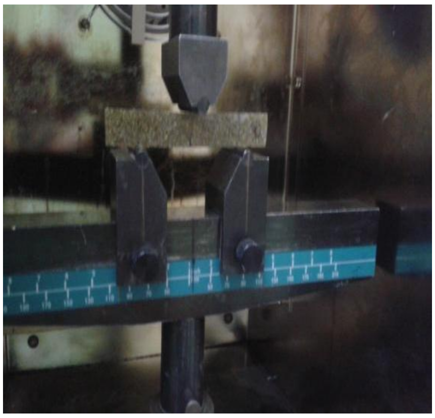

Fig.3.6- Specimen clamped on machine

IV. Results And Discussion

4.1 Measurement of axial modulus and Ultimate Tensile strength

The axial modulus and the ultimate tensile strength are measured for the gauge length of 30 mm. The stress-strain curve for all specimen is shown in figure 4.1. The stress at the given load is calculated by measuring the effective area.The curves are almost linear. This indicates that the pine needles fiber are brittle in nature. From the curve it can be noted that there is a little scatter in the axial modulus and the ultimate tensile strength. The scatter in the axial modulus is shown in figure 4.2 and the scatter in ultimate tensile strength is shown in figure 4.3.The mean and the standard deviation for the axial modulus and the strength is shown in table 2.

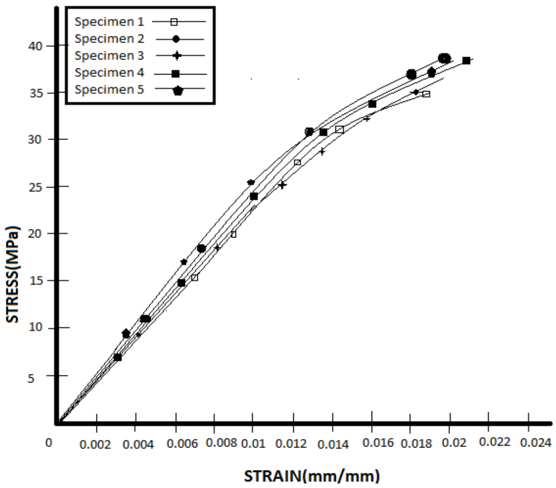

Fig.4.1- Stress-strain curve for pine needle fiber

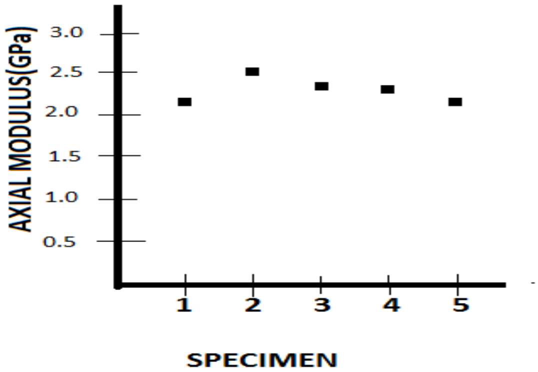

Fig.4.2- Scatter in axial modulus of pine needles fiber

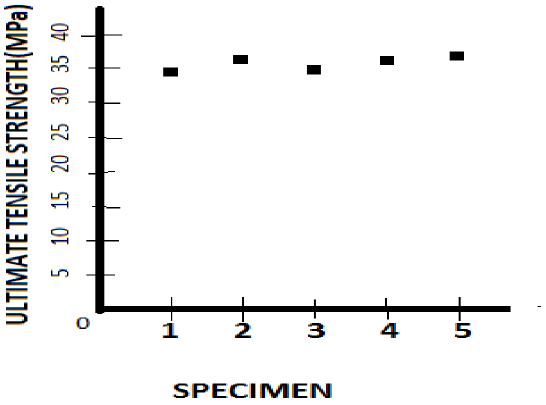

Fig.4.3- Scatter in ultimate tensile strength of pine needles fiber

Table 2- Mean and standard deviation in Young's modulus and Ultimate tensile strength of pine needles fiber

Property	**Modulus**	**Strength**
Mean	**2.325 GPa**	**35.8 MPa**
Standard Deviation	**0.10934 GPa**	**1.72046 MPa**
Standard Deviation(%)	**4.703%**	**4.8057%**

It can be seen from the above result that the modulus and strength properties of the pine needle fiber are in good agreements. The statistical data obtained from the study can be used as the sample data.

4.1 Measurement of fracture toughness

The stress intensity factor for the pine needle reinforced composite is calculated. The force-displacement curve for all the specimen is shown in figure 4.4. The stress intensity factor is calculated by using the formula as discussed earlier in this paper.From the curve it can be noted that there is scatter in the maximum force which results in the scatter in the stress intensity factor. The mean and the standard deviation in stress intensity factor is shown in the table 3.

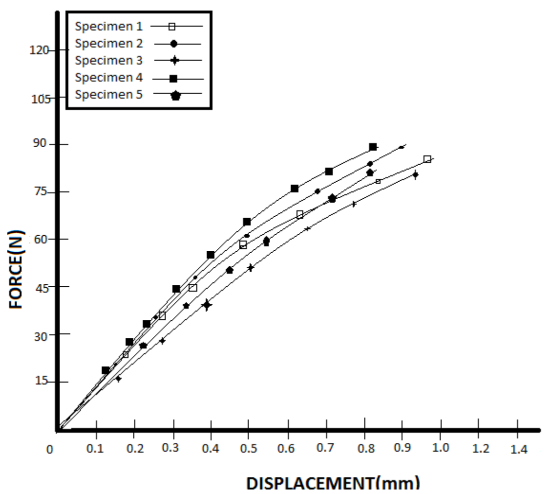

Fig.4.4- Force-Displacement curve for pine needle short fiber reinforced composites

Table 3- Mean and standard deviation in stress intensity factor of pine needle short fiber reinforced composites

Property	Stress Intensity Factor(K_{Ic})
Mean	$2.735\ MPa.m^{\frac{1}{2}}$
Standard Deviation	$0.227552\ MPa.m^{\frac{1}{2}}$
Standard Deviation(%)	8.32%

From the above data of stress intensity factor ,it may be noted that pine needle reinforced composite have relatively low stress intensity factor which implies that it is more prone to brittle fracture.
The statistical data obtained from the above study can be used as the sample data.

V. Conclusions

A study on the pine needle and the pine needle short fiber reinforced composites has been presented in this work.The axial modulus and ultimate tensile strength of pine needle fibers have been determined using ASTM D638-10 and the crack analysis of the pine needle short fiber reinforced composites is done using ASTM 5045. The mean axial Young's modulus and ultimate tensile strength are found to be 2.325 GPa and 35.8 MParespectively.The standard deviation in these values are 0.10934GPa and 1.72046 MParespectively.

The mean and standard deviation in stress intensity factorare $2.735\ MPa.m^{\frac{1}{2}}$ and $0.227552\ MPa.m^{\frac{1}{2}}$ respectively.These values are supposed to be in good agreement for the future study and can be used these as a sample data.

The scatter in the measured values of the axial modulus, strength and stress intensity factor is an important information for the statistical analysis of the various properties of pine needle short fiber reinforced composites . Further, this methodology can be used for the further advancement in the field of natural composites.

It may be concluded from the above study that pine needle in a composite can be used for low or medium strength application .

References

[1]. Faruk O, Bledzki AK, Fink HP, Sain M (2012) Biocomposites reinforced with natural fibers: 2000–2010. ProgPolymSci 37:1552–1596
[2]. Jang-Kyo Kim and Yiu-Wing Mai 'Engineered Interfaces in Fiber Reinforced Composites' Book, Elsevier Science Ltd, 1998.
[3]. Zeng WC, He Q, Sun Q, Zhong K, Gao H (2012) Antibacterialactivity of water-soluble extract from pine needles of Cedrusdeodara. Int J Food Microbiol 153:78–84
[4]. Jeong JB, Seo EW, Jeong HJ (2009) Effect of extracts from pineneedle against oxidative DNA damage and apoptosis induced byhydroxylradical via antioxidant activity. Food Chem Toxicol47:2135–2141
[5]. Kong Z, Liu Z, Ding B (1995) Study on the antimugenic effect ofpine needle extract. Mutat Res 347:101–104
[6]. Rabindra Prasad DhakalSudip Pandey, "Pine NeedleBriquettes: A Renewable Source of Energy," InternationalJournal of Energy Science, vol. 3, no. 3, June 2013.
[7]. Kleeb TR, Caprio JA (1987) Properties and service experience oforganic fiber-containing monoliths. Indust Heat 54(4):19–21
[8]. Hamdaoui O, Chiha M, Naffrechoux C (2008) Ultrasoundassistedremoval of malachite green from aqueous solution bydead pine needles. UltrasonSonochem 13:799–807
[9]. ChensongDong ,Daniel Parsons , Ian J. Davies(2014)"Tensile strength of pine needles and their feasibility as reinforcement in composite materials"
[10]. Singha, A. S.; Thakur, V. K. BioResources2009, 292, 4.
[11]. Thakur VK, Singha AS (2010) Mechanical and water absorptionproperties of natural fibers/polymer biocomposites. Polym-Plast TechnolEng 49:694–700
[12]. Gupta M, Chauhan M, Khatoon N, Singh B (2010) Compositeboards from isocyanate bonded pine needles. J ApplPolymSci 118:3477–3489
[13]. Prasanna Kumar Ilankeeran, Preetamkumar M. Mohite, SudhirKamle(2012) "Axial Tensile Testing of Single Fibres"
[14]. Malkapuram R, Kumar V, Negi YS (2010) Novel treated pine needle fiber reinforced polypropylene composites and their characterization. J ReinfPlast Compos 29(15):2343–2355
[15]. Singha AS, Thakur VK (2009) Study of mechanical properties of urea–formaldehyde thermosets reinforced with pine needle powder. Bioresources 4(1):292–308
[16]. Subhankar Biswas, Qumrul Ahsan, Ahmed Cenna, Mahbub Hasan, and AzmanHassan(2013)," Physical and Mechanical Properties of Jute, Bamboo and Coir Natural Fiber"Fibers and Polymers 2013, Vol.14, No.10, 1762-1767