Characterization and Investigation of Bending Test on Hybrid(Sisal and Banana) Fiber Reinforced Polyester Composite Material

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***Abstract*—Biomechanics involves modeling and simulation of biological objects using mechanical laws. Femur bone is the largest and strongest part of human body and each femur bone carries half weight of human body. In this research work the investigation of mechanical properties of Bi-Directional Hybrid Natural fiber or orthotropic form or Mat type polymer composite material with +/- 0 to 900 orientation used as implant material. The bending tests are performed with the aid of preparing various percentage of common specimen. It's located that there may be considerable growth in bending residences of 10%, 20%, 30% and 40% HFRPC material. This gain knowledge of suggests 30% and 40% of HFRPC material is also compatible for the unique application within the replacement of human bone. From the Experimental outcome it's observed that by using increasing the load fraction of the fiber or percent of fiber so they can increase the bending force and likewise increases the density and mass of composite specimen.**

***Index Terms*—Natural Fiber-Sisal Banana Jute and Hemp fiber in orthotropic form Hybrid Polymer composite material, cortical, bending test and Hand lay-up Technique. UTM.**

I. INTRODUCTION

In recent days Natural fibres characterize an environmentally pleasant replacement by way of advantage of a number of appealing attributes incorporate cut down density, scale down cost, non-toxicity, ease of processing, renewability and recyclability [1-3],Bio-composites based on biopolymers and average fibers used as bone implants [4], and sisal fiber Reinforcement epoxy resin composite material used for orthopedic implants [5] normal fibers gift predominant benefits corresponding to low density, right and mechanical homes and high disposability and renewability .Additionally, they are recyclable and bio-degradable[6]. Much of typical product received from crops having possess medicinal values comparable to biologically energetic photochemical are ordinarily gift in leaves roots, barks and plant life[7], natural fiber bolstered polymer composite substances which are much less rigid than metals could also be good possible choices seeing that of properties towards bone mechanical properties. It was observed that they aid to hinder stress shielding and increase bone remodeling[12, 13]. Orthopaedic surgeons had been utilizing metallic bone plates for the fixation of humerus bone fractures. It sounds as if, metallic prosthesis, which can be traditionally stainless steel and titanium alloys, reason some issues like metal incompatibility, corrosion, magnetism outcome, anode-cathode reactions, together with a slash in bone mass, expand in bone porosity, and delay in fracture medication[8, 9, 10,18]. Thus now a day's fabrication of polymer (NFRP)composite plate material by using utilizing bio epoxy resin are propose to use as a substitute of titanium, cobalt chrome, stainless steel and zirconium). NFRP composite (biocoated with bone graft substitutes such as calcium phosphate and hydroxyl apatite used for each inside of fixation and external fixation of fractured human bone [6].And on this study work by using considering the mechanical properties of femur [14] and in addition the Femur is the longest and strongest skeleton is almost flawlessly cylindrical in the larger a part of its extent[11] and fig.1 shows the femur bone [18]

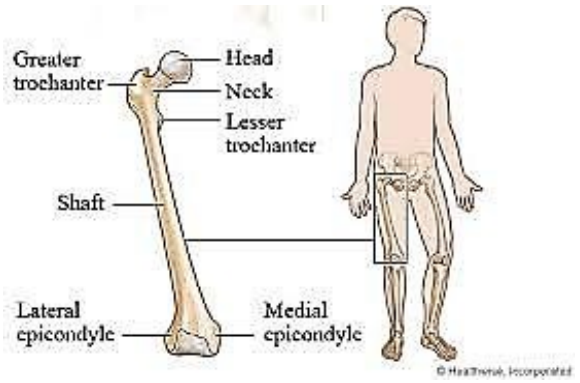

Fig.1femur bone overview

A Biomaterial is a non-viable material used in medical device, so it's intended to interact with biological systems[5].Requirements of Biomaterials are it must be inert or specifically interactive. It must be Biocompatible. Mechanically and chemically stable. Biodegradable. Process able (manufacturability): It must be machinable, and moldable. Sterilizable. Non-carcinogenic, nonpyrogenic, non-toxic, non-allergenic, blood compatible, non-inflammatory. Physical Characteristics Requirements: Strength, Toughness, Elasticity, Corrosion-resistance, Wear resistance, Long term stability [3]

II. RELATED WORK

Muhammad Shahzad Masood, Atique Ahmad, Finiteelement analysis principles is used for analysis of human femur bone. Using 3D animated Blender 2.63a software polygonal model of femur bone was made. This polygons mesh model was imported into ANSYS software for further analysis by converting it into cad model with the help of Pro/ENGINEER [19].

Sandeep Das, Saroj Kumar Sarangi, Finite Element analysis of simple bone plate of different biomaterial was carried out to examine the biomechanical feasibility. A boneplate was modeled in Solid works CAD software and using CTscan was performed on femur bone with horizontal and oblique crack and this was saved in DICOM format thento get3D model of femur bone, it was imported into Mimics software. Across the fracture line on the femur bone the boneplate was fixed using screws. The assembly was imported into ANSYS software for further analysis. By applying torsional as well as compressive loadings along with various stages, the stress distribution near to femur fracture bone was obtained. Also results are found out by using different biomaterials like titanium, cobalt chrome and stainless steel for bone plate. From results it concluded that titanium generates higher stresses as compared to other two materials and provides better stability to fracture fixation [20].

K. S. Zakiuddin, I.A.Khan, Roshni A. Hinge, from this paper It observed that human body experiences various types offorces during their daily living activities. Also in uncertain cases like twist, accidents, while heavy loads carryin getcandit increases the chances of human femur bone fracture. In present paper analysis of femur bone as carried out based upon the structure, material properties, load resistance and chance of failure of human femur. Vibrational analysis was done using Elmer software and ANSYS software was used forfinite element analysis. This analysis was helpful for the problems and issues faced by the orthopedic surgeons during hip implant [21].

Sandeep Kumar Parashar, Jai Kumar Sharma, This paper presents the state of art review on finite element modeling application in the four areas of bone biomechanics, i.e.analysis of stress and strain, determination of mechanical properties, fracture fixation design (implants) and fracture load prediction. The aim of this review is to provide a comprehensive detail about the development in the area of application of FEM in bone biomechanics during the last decades. It will help the researchers and the clinicians alike for the better treatment of patients and future development of new fixation designs [22].

Nithin Kumar KC, Tushar Tandon, in this study, the finite element analysis of femur bone was carried to find outstresses generated at hip contact region during normal activities like walking, running, jumping, standing. Author has considered different load acting on femur bone during activities like standing, walking, running and jumping. Human femur bone behavior was found out by applying different loading conditions. Femur bone model was created in Solid Edge V19 CAD modeling software and analysis was carried out using ANSYS 14.0 software. This analysis is helpful to find out stress generated in fractured bone and also useful to predict which type of artificial material is necessary to rejoin the fractured bone[23].

P.S.R. Senthil Maharaj, R. Maheswaran, Fracture of femur bone is one of the common problems found now adays. Fractured femur bone can be joined/ repaired by using boneplates. But as this bone plated is fitted

into human body major precaution should have to take while selection boneplates material. In this study, author has suggested best suitable material for bone plate by doing analysis of boneplates which are made from different materials such as stainless steel, Alumina, Titanium, Nylon and PMMA. Femur bone, bone plate model was created in Solid works CAD modeling Software and further imported into ANSYS software for doing analysis. Investigation was carried out by considering 75Kg weight male during normal position and stress distribution, fatigue failure and total deformation of femur bone found out. More deformation of bone was on head side while on lower side less deformation occurs. Total equivalent stress obtained for Titanium is less as compared with other. Titanium is best suited material for boneplate [24].

Dr A Thimmana Gouda, Jagadish S P, mechanical properties of SS316L which is used for orthopedic implantation was found out. The test was conducted on electronic UTM machine. It is necessary to know mechanical properties such as tensile, compressive and bending strength of SS316L to check whether this is having as good strength as natural femur bone. Properties required during selection of biomaterial for orthopedic implantation. Finally, results obtained by carrying out test using electronic UTM machine was matches with femur bone prosthesis [25].

The present work thus aims to develop this new class of natural fiber based polymer composites with fiber lengths and to analyze their mechanical behavior by experimentation and compare strength with cortical bone.

III. SYSTEM DESIGN

Fabrication of HYBRID (SISAL AND BANANA) based composites.

- To prepare the specimens as per ASTM standards.
- To Study the mechanical behavior of hybrid fiber reinforced polyester based composites
- Evaluation of mechanical properties of the composites such as bending strength.
- Compare the results with cortical properties.

Besides all these the main objective is to develop a low cost, low weight, low density & high bending strength natural fiber based composite that can be used for orthopedic implant applications (cortical bone).

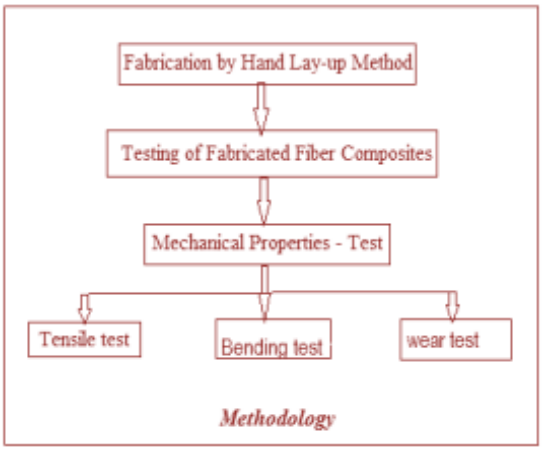

Fig .2 Methodology

i) Fiber Extraction: Hybrid (sisal & banana) fibers are collected and extracting from plant using manual or mechanical extraction procedure.

ii) Hybrid fiber preparation: Here continuous fibers are used to fabricate the natural fiber composites. First clean the natural fibers in distilled water. After cleaned natural fibers are dried in the sun light. The dried natural fibers area gain cleaned by chemical cleaning process. In chemical cleaning process the 80% sodium hydroxide is mixed with20% distilled water. The dried natural fibers dipped in the diluted sodium hydroxide solution. It's again dried in sunlight .The dried natural fibers are cut to the length of 300mm by manually. The cut natural fibers are used to fabricate the natural fiber composites.

Fig. 3 Hybrid (sisal+ banana) fiber extractions

iii) Materials and pattern used for fabrication: The pattern is designed as per ASTM standard. The pattern is made up of mild steel. The pattern Size is 300 x 300 x 3 mm the pattern consist of three parts Base plate, frame and weight. The main purpose of the weights

applied is for even distribution of load on mixture which is filled in the pattern.

Fig .4 patterns

Materials used for fabrication work are polyester resin, Hardener, fiber, Sodium Hydroxide (NaOH), Weighing Machine, Roller, Bowl, and Stirrer.

iv) Mould preparation for bending test: In mould preparation the resin is mixed with hardener in the ratio of 4:1. The mixer is strewed with stirrer for 15minutes continuously.

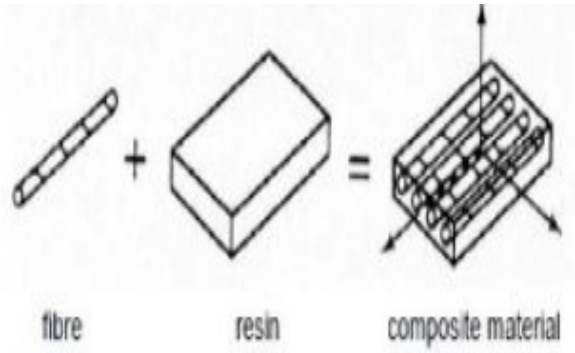

Fig.5 Mould Preparation

Take the top mould or Die and bottom mould which is made from cast iron of size 360mm* 300mm* 20mm in rectangular form and situation these mould one above the other and tight these plates by using of 2″ Clamps. Surrounding Die very thick rubber sheet is used to hinder the material and to hinder air or blow holes on the specimens and this rubber sheet is face up to as much as temperature of 1000c The working floor used to be cleaned with thinner to take away grime and a thin coat of wax is utilized on the outside to get smooth conclude. Then a thin coat of polyvinyl alcohol (PVA) is utilized for effortless removal of mould.

v) Fabrication Process

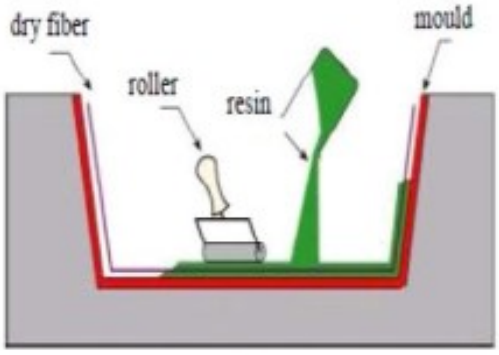

Fig.6 Hand layup method

Fig.7 Fiber arrangement

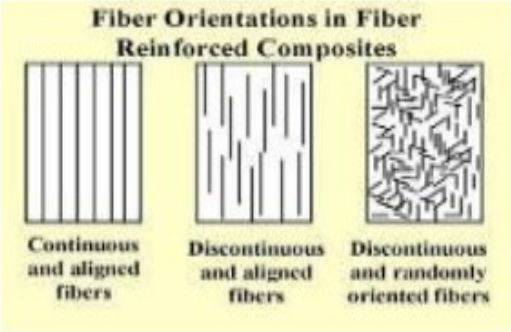

Fig.8 Fiber orientation

Here Hand Laminating Molding is used for fabricate the natural FIBER composites. The base plate is fixed inside the frame for fabricate the natural fiber composites 70% of rein hardener mixture and remaining natural fibers are used. The mixed resin and hardener is filled in the pattern. The prepared natural fibers are randomly poured in the resin hardener mixture without any gap. The roller is rolled in the mould. Again the mould is filled in pattern by next layer and fibers poured randomly .This process is simultaneously done till the height of the mould. The

weights is fixed on the top of the frame for distribute the load evenly on the mould. The setup is kept in the dry place for 24 hours. After 24hours the mould is take away From the pattern, finally the natural fiber composite is fabricated.

Fig. 9 Natural Fiber composite fabricated

The mould is prepared and loses the clamps and removes the fabricated material and for this go for annealing process for dries the material by maintaining the temperature of 82^0cfor a 15 minutes and take out the material Mould Preparation. Cutt the fibers required dimensions for test. All test specimens were molded and prepared according to ASTM standards to avoid edge and cutting effect, thereby minimizing stress concentration effect. Fabrication steps showed in the figures.

Fig.10 Furnace for annealing

Vi) Fabricated Composites

Polymer hybrid matrix composites, the compositions of polymer composites with long fiber are given in the following table.

Table.1Composites of fiber reinforced polymer

Composites	Orientation	Composition	
		Resin In Wt %	Fibers In Wt %
H1	Long fiber	90	10
H2	Long fiber	80	20
H3	Long fiber	70	30
H4	Long fiber	60	40

Fig.11 Electronic Universal Testing Machine interfaced with computer

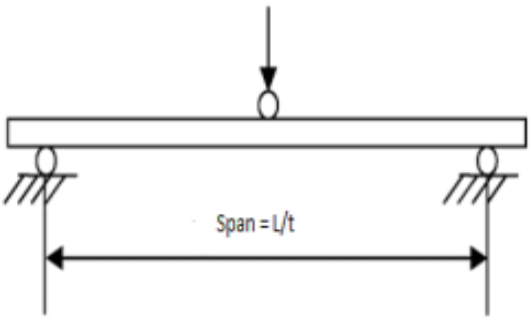

Fig.12 Bending Test/Flexural strength test

Bending tests were conducted using universal testing machine Flexural analysis was carried out at room temperature through three-point bend testing as specified in ASTM D790-02, using universal testing machine. The speed of the crosshead was 5 mm/min. Three composites specimens were tested for each sample and each test was performed until failure occurred. Flexural strength was calculated from the Equation.

σf = (3PL) / (2bd2),

Where, P = Load at a given point on the load deflection curve in Newton (Peak load)

L = support span in mm, b =width of the samples in mm d = thickness of the samples in mm, bending testing.

IV. CONCLUSION

From experimental results it is found that HYBRIB fiber will have good bending strength2. From experimental results it is found 10%, 20%, 30%and 40% HFRPC, that out of 30% and 40% HFRPC is having good bending strength and it may be suitable for cortical bone Properties.

REFERENCES

[1] [1] A.K. Bledzk and J. Gassan, Composites reinforced withcellulose-based fibres, Prog.Polym. Sci.24, 211-274(1999).

[2] [2] A.N. Netravali and S. Chabba, paper entitled Compositesget greener, Materials Today 6, 22-29 (2003)

[3] [3] G. Marsh, paper entitled A guide for green composites,Reinforced Plastics 48, 18-26 (2004)

[4] [4] D. Chandra Mohan et al. paper entitled "Bio compositematerials based on bio polymers and natural fiberscontribution as bone implants" (ijamsar) internationaljournal of advanced medical sciences and applied researchvolno. 1, issue no. 1, 009 –012.

[5] [5] K R Dinesh, Jagadish S P and A Thimmanagouda paperentitled "Characterization and Analysis of Wear Study onSisal Fiber Reinforcement Epoxy Composite MaterialsUsed As Orthopaedic Implant" international journal ofadvances in engineering & technology, Jan. 2014. ©IJAETISSN: 22311963 vol. 6, issue 6, pp. 2745-2757.

[6] [6] D. Chandramohan and K. Marimuthu Department ofMechanical Engineering, Coimbatore Institute ofTechnology, Coimbatore, Tamilnadu, India Paper Entitled"Characterization of Natural Fibers And Their ApplicationIn Bone Grafting Substitutes"Acta of Bioengineering AndBiomechanics Original paper. Vol. 13, No. 1,2011Received: January 8th, 2011 Accepted ForPublication: February 25th, 2011.

[7] [7] Thillai Siva Kumar N and Venkataraman R, paper entitledDer Pharmacia Sinica, 1 (1): 1-6 (2010)

[8] [8] K. Fujihara, 'Design of carbon / epoxy braided compositebone plate', National University of Singaporehttp://iris14.cadcam.nus.edu.sg/~p81313a/phdwork.html.

[9] [9] Ramakrishna S, Mayer J, winter mantel E, Leong KWBiomedical Applications of polymer-composite materials:a review. Comp Sci Tech 2001; 61:1189–224.

[10] [10] Yildiz, Composite Hip Prosthesis Design, Ph.D Thesis,Stanford University, 1993.

[11] [11] D. Amalraju and Dr. A.K.Shaik Dawood Fernandez PaperEntitled "Mechanical Strength Evaluation Analysis ofStainless Steel and Titanium Locking Plate for FemurBone Fracture" IRACST – Engineering Science AndTechnology: An International Journal (ESTIJ), ISSN:2250-3498, Vol.2, No.3, June 2012

[12] [12] M.S. Ali, et al., 'Carbon Fiber Composite Bone Plates: Dtal Experience', J. Bone & Joint Surg. [Br], 72-B, 586-91,1990

[13] [13] Baixauli, et al., Carbon Fiber Composite Bone Plates forFixation of Forearm Fractures, J. Bone & Joint Surg. [Br],77-B (2), 227, 1995

[14] [14] Raviraj Havaldar, S.C.Pilli and B.B.Putti Paper Entitled"Effects of Magnesium on Mechanical Properties ofHuman Bone" IOSR Journal of Pharmacy and BiologicalSciences (IOSR-JPBS) E-ISSN: 2278-3008, P-ISSN: 2319-7676. Volume 7, Issue 3 (Jul. – Aug.2013), Pp 08-14Www.Iosrjournals.Org

[15] [15] Advanced Materials Araldite ® Ly556 Aradur ® 5021Hardener Xb3403, Hardener Xb 3471, Page 1 of 6October 2010.[16] Ciba Specialty Chemicals, Performance PolymersStructural Composites-Matrix Systems for IndustrialComposites Data Sheet.

[16] [17] Giuseppe Cristaldi, Alberta Latteri, Giuseppe Recca andGianluca Cicala Paper Entitled "Composites Based onNatural Fiber Fabrics" University of Catania –Depart ofMethodologies for Engineering, Catania-Italy.

[17] [18] Google.com

[18] [19] Muhammad Shahzad Masood, Atique Ahmad, RizwanAlim Mufti, "Unconventional Modeling and StressAnalysis of Femur Bone under Different BoundaryCondition",

International Journal of Scientific &Engineering Research, Volume 4, Issue 12, December- 2013, pp. 293-296.

[19] [20] Sandeep Das, Saroj Kumar Sarangi, "Finite ElementAnalysis of Femur Fracture Fixation Plates",International Journal of Basic and Applied Biology,Volume 1, pp. 1-5, 2014.

[20] [21] K.S.Zakiuddin, I.A.Khan, Roshni A. Hinge, "A reviewpaper on biomechanical analysis of human femur",international conference on Emerging trends inEngineering and Management Research, March 2016pp.425-432,.

[21] [22] Sandeep Kumar Parashar, Jai Kumar Sharma, "A reviewon application of finite element modeling in bonebiomechanics", Recent trends in Engineering andMaterial science, volume 8, 2016, pp. 696-698,.

[22] [23] Nithin Kumar KC, Tushar Tandon, "Biomechanical stressanalysis of a Human Femur bone using ANSYS", 4thInternational Conference on Materials Processing andCharacterization, volume 2, 2015, pp. 2115-2120.

[23] [24] P.S.R. Senthil Maharaja, R. Maheswaran, "NumericalAnalysis of Fractured Femur Bone with Prosthetic BonePlates", International conference on design andmanufacturing (icondm), pp. 1242-1251, 2013.

[24] [25] Dr A Thimmana Gouda, Jagadish S P, "Evaluation ofmechanical properties of existing material SS316L usedas femur bone implant material", International Journalof Innovative Research in Technology & Science, Volume2, pp. 52-58