IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684,p-ISSN: 2320-334X, Volume 11, Issue 4 Ver. II (Jul- Aug. 2014), PP 40-52
www.iosrjournals.org

"Characterization and Investigation of Mechanical Properties of Hybrid Natural Fiber Polymer Composite Materials Used As Orthopaedic Implants for Femur Bone Prosthesis"

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Abstract: *This Research Paper constitutes the study of Mechanical Properties of Tensile, Compression and Bending Strength of the 12%, 24% and 36% of Hybrid Fiber (Natural fiber- Sisal, Jute and Hemp) polymer composite material used as Bio-material. Characterization of 12%, 24% & 36% Hybrid Natural fiber polymer composite material with the low density, economical for prosthetic bone with respect to biocompatibility and the mechanical behavior of long human bones, such as Femur Bone. According to the ASTM Standards the specimen is fabricated by using the Epoxy resin- LY556 as the matrix material and the Hardener-HY 951 with the 12%, 24% and 36% of the Natural Fibers (Sisal, Jute and Hemp) as the reinforcement material with fiber weight fraction, randomly continuous long fiber orientation. By using the Hand Layup fabrication technique the specimen are prepared. This Research work concentrated on study of Femur Bone and collection of the strength and other parameters of bone and compared the experimental results of the 12%, 24% and 36% Hybrid Natural fiber Polymer composite material with the Femur bone. This Research work suggesting the low weight, low Density and high strength, Bio-composite, Biocompatible material use or suggest to the orthopedic Implants Especially for Femur bone. From the Experimental results all the strengths of 12%, 24% &36% Hybrid Natural fiber Polymer composite materials will match the femur Bone Strengths and also it is found that by increasing the weight fraction of the fiber or percentage of fiber which will increase the Tensile, Compression, Bending strength and increases the density and mass of composite of the specimen. Finally we suggest the 36% Hybrid Natural fiber polymer composite material for Femur bone Prosthesis and hence it is a Natural Bio-compatible Hybrid Natural fiber polymer composite material.*

Keywords: *Hand layup Fabrication Technique, Mechanical Properties, Bio-Material, 12%, 24% and 36% of Hybrid Natural fiber polymer composite material, orthopaedic application-Femur Bone.*

I. Introduction

Natural fibres represent an environmentally friendly alternative by virtue of several attractive attributes that include lower density, lower cost, non-toxicity, ease of processing, renewability and recyclability [1-3], Sisal Fiber Reinforcement epoxy resin composite material used for orthopedic implants [4] and Biocomposites materials based on biopolymers and natural fibers used as bone implants [5], Much of natural product obtained from plants having own medicinal values such as biologically active photochemical are normally present in leaves, roots, barks and flowers [6], Natural fibers present important advantages such as low density, appropriate stiffness and mechanical properties and high disposability and renewability. Moreover, they are recyclable and biodegradable [7]. Natural fiber reinforced polymer composite materials which are less rigid than metals may be good alternatives because of properties closer to bone mechanical properties. It was found that they help to avoid stress shielding and increase bone remodeling [12, 13]. Orthopaedic surgeons have been using metallic bone plates for the fixation of humerus bone fractures. Apparently, metallic prosthesis, which are generally made of stainless steel and titanium alloys, cause some problems like metal incompatibility, corrosion, magnetism effect, anode-cathode reactions, including a decrease in bone mass, increase in bone porosity, and delay in fracture healing [8, 9, 10]. The Femur is the longest and strongest bone in the skeleton is almost perfectly cylindrical in the greater part of its extent [11]. Fabrication of (Hybrid) natural fiber reinforced polymer (NFRP) composite plate material by using bio epoxy resin. Instead of orthopaedic alloys (such as titanium, cobalt chrome, stainless steel and zirconium). NFRP composite (bio composite plate material) can be coated with bone graft substitutes such as calcium phosphate and hydroxyl apatite and this plate material can be used for both inside fixation and external fixation of fractured human bone [7].

II. Fabrication Method And Preparation Of Hybrid Natural Fiber Polymer Composite Materials

2.1 Methodology

Characterization is carried out using Epoxy resin -LY556 as a matrix material and hardener -HY 951 with 12%, 24% and 36% Natural fibres as the reinforcement material (with fiber weight fraction, randomly continuous long fibre orientation) by using hand layup fabrication technique the specimens are prepared as per ASTM standards for Tensile Tests specimens are prepared by ASTM D-3039, For Compression Tests specimens are prepared by ASTM D-3410 and for Bending Tests specimens are prepared by ASTM D-790.

2.2 Objective

The present Research work concentrates on the progress of biomaterials in the field of orthopaedics, an effort to utilize the advantages offered by renewable resources for the development of biocomposites materials based on polymer (Epoxy Resin) and natural fibers. The present invention focuses on the enhanced properties of natural fiber as bone implant. It is a challenge to the creation of better materials for the improvement of quality of life and Economical one suggest to use Femur Bone Prosthesis (Rods, Plates etc.,).

2.3 Extraction And Preparation of Natural Fibers

The natural fibers such as Sisal, Jute and Hemp were extracted by the decorticating process. Here continuous fibre is used for fabricate the natural fibre composites. First the natural fibres are cleaned in the distilled water. The cleaned natural fibres are dried in the sun light. The dried natural fibres are again cleaned by chemical cleaning process. In chemical cleaning process the 80% sodium hydroxide (NaOH) is mixed with 20% distilled water. The dried natural fibres dipped in the diluted sodium hydroxide solution which it cleans from muddy particles and we get the smooth fibers. It is again dried in sun light .The dried natural fibres are cut in the length of different size by manually. The cut natural fibres are used in fabricate the natural fibres reinforced epoxy composite material. In this Research we make use of the following three Natural fibers that is Sisal, Jute and Hemp.



(a)Sisal Fiber (b)Jute Fiber (c) Hemp Fiber

2.4 Properties of Natural Fibers Used For Fabrication Work

Table 2.1: Properties of Natural Fibers Used For Fabrication Work. [14]

PROPERTY	SISAL	JUTE	HEMP
Density [g/cm^3]	1.33	1.46	1.48
Tensile strength [N/mm^2]	600-700	400-800	550-900
Stiffness [kN/mm^2]	38	10-30	70
Elongation at break [%]	2-3	1.8	1.6
Moist absorption [%]	11	12	8
Price of raw fibre [$/kg]	0.6-0.7	0.35	0.6-1.8

2.5 Materials Used For Fabrication Work

1. Selection of Matrix material: Matrix material selected is Epoxy resin LY556 and HY-951 as binder for the resin.
2. Reinforcement of Natural Fibres-Sisal fibre, Jute and Hemp
3. Requirements for the Fabrication of Composites- Epoxy resin, Hardener, Natural Fibre, Sodium Hydroxide (NaOH), Weighing Machine, Roller, Stirrer and Oven or Furnace to dry the specimen.

2.6 Mould Preparation And Fabrication Process For Tensile, Compression And Bending Tests Specimens


(a)


(b)


(c)


(d)


(e)


(f)


(g)


(h)


(i)

Fig (a): Mould for the preparation of tensile, compression & Bending tests Specimens as per ASTM Standards. Fig (b): Cutting of long Fibers to required Length. Fig (c): Required length of fibers for fabrication. Fig (d) Weighing of Fibers to Fabricate. Fig (e): Applying Epoxy Resin, Hardener & Fiber layer by layer. Fig (f): Completed all Layers of applying Fibers, Epoxy Resin & Hardener. Fig (g): Applying Weights on Fabricated Surface. Fig (h): Furnace for Annealing Process. Fig (i): Full length Fabricated Plate.

2.6.1 Preparation of the Specimen

2.6.11 Mould

A mould made up of steel plate of dimension 300X300X3 mm is prepared. Casting of the composite materials is done in this mould by hand layup process. Later specimens are cut from the prepared casting according to the ASTM Standards.

2.6.12 Weight Fraction of the Fiber

The weight of the matrix was calculated by multiplying density of the matrix and the volume (volume in the mould). Corresponding to the weight of the matrix the specified weight percentage of fibers is taken. For hybrid combination the corresponding weight of fiber obtained is shared by three natural fibers.

2.6.13 Specimen

Mixing the Epoxy resin LY556 and the hardener HY-951 with a ratio of 10:1. This solution is used as Matrix and the different types of natural fibers are used as a reinforcement that is Sisal, Jute and Hemp; then the hybrid Natural fiber polymer composite material is Prepared. The Hybrid natural fibers are used in varying weight percentages of 12%, 24% and 36%.

2.6.14 Calculation For To Find the Mass of the Fiber for Tensile Specimen

Epoxy resin, Hardener, Jute, Hemp and Sisal (For preparing the Hybrid polymer composite materials)

Volume of the die = 300 x 300 x 2.5 = 225000mm^3=225cm^3,

Density of the Fibers/Epoxy in g/cm^3 (Density= Mass/Volume (or) Volume=Mass/Density)

1. Sisal=1.33 g/cm^3
2. Jute=1.46 g/cm^3

3. Hemp=1.48 g/cm^3
4. Epoxy Resin=1.2 g/cm^3 [15, 16]

$V_c = V_{Epoxy} + V_{Sisal} + V_{Jute} + V_{Hemp}$ .... (1)

$m_c/\rho_c = m_{Epoxy}/\rho_{Epoxy} + m_{Sisal}/\rho_{Sisal} + m_{Jute}/\rho_{Jute} + m_{Hemp}/\rho_{Hemp}$

$1/\rho_c = 1/\rho_{Epoxy}\ (m_{Epoxy}/m_c) + 1/\rho_{Sisal}\ (m_{Sisal}/m_c) + 1/\rho_{Jute}\ (m_{Jute}/m_c) + 1/\rho_{Hemp}\ (m_{Hemp}/m_c)$……… (2)

$1/\rho_c = (0.88/1)\ (1/1.2) + (1/1.33)\ (0.04/1) + (1/1.46)\ (0.04/1) + (1/1.48)\ (0.04/1)$

$1/\rho_c = 0.73 + 0.03 + 0.02 + 0.028 = 0.08\ cm^3/g$

$\rho_c = 1.23\ g/cm^3$ (For 12% Hybrid polymer Composite material)

Similarly we calculated for 24% and 36% Hybrid Natural Fiber polymer Composite material.

$m_c = \rho_c \times V_c$............ (3)

$m_c = 1.23 \times 225 = 276.75$gms

2.7 Density Of Composite, Mass Of Composite And Mass Of Each Fiber For Fabrication

Table 2.2: Density of composite, Mass of composite and Mass of each fiber for Fabrication.

Sl No	% of Natural Fibers Used	Density of Composite (g/cm^3)	Mass of composite (gms)	Mass of Fiber (Each Fiber Weight) (gms)
1	12% (4+4+4) and remaining % of Epoxy resin & Hardener	1.23	276.75	Sisal, Jute & Hemp 4%=276.75 X 4% =11.07
2	24% (8+8+8) and remaining % of Epoxy resin & Hardener	1.243	280.00	Sisal, Jute & Hemp 8%=280 X 8% =22.40
3	36% (12+12+12) and remaining % of Epoxy resin & Hardener	1.277	287.32	Sisal, Jute & Hemp 12%=276.75 X 12% =34.47
Similarly the calculation is done for Compression and Bending Test Specimen				

III. Experimental Process

3.1 Cutting Of Laminates Into Samples Of Desired Dimension

A Wire Hacksaw blade was used to cut each laminate into smaller pieces, for Tensile test specimens were made according to the ASTM D-3039 size of (250x25x2.5) mm to measure the tensile properties, for Compression test specimens were made according to the ASTM D-3410 size of (155x25x3.17) mm to measure the Compression properties and for Bending test specimens were made according to the ASTM D-790 size of (127x12.7x3.2) mm to measure the Compression properties. The No. of the test specimen is three and average strength has been taken from respective testings.

3.2 Fabricated Specimens

SPECIMENS BEFORE TESTING

Tensile Test Specimens

12% HNFPCM 24%HNFPCM 36%HNFPCM

Compression Test Specimens

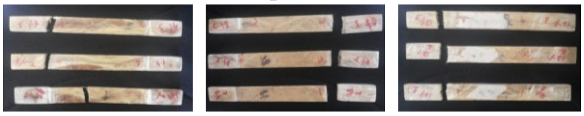
12% HNFPCM 24%HNFPCM 36%HNFPCM

Bending Test Specimens

12% HNFPCM 24%HNFPCM 36%HNFPCM

SPECIMENS AFTER TESTING

Tensile Test Specimens



12% HNFPCM 24%HNFPCM 36%HNFPCM

Compression Test Specimens

12% HNFPCM 24%HNFPCM 36%HNFPCM

Bending Test Specimens

12% HNFPCM 24%HNFPCM 36%HNFPCM

Fig 3.1: Fabricated Specimens Before and After Testing

3.3 Testing Methods

Fig 3.2: UTM.

Fig 3.3: Tensile Testing.

Fig 3.4: Compression Testing.

Fig 3.5: Bending Testing

Universal testing machine specification

Capacity: 40ton

Motor: 2.3hp

Voltage: 400 to440 volts

Dimension: L*W*H (2060*750*2180)

Standard Attachments
1. Compression plates 2 no's diameter 120 mm
2. Shear attachments 1 set
3. Extensometer 1 no's
4. Single point bending tool 1 no's

3.3.1 Tensile Properties Static tensile properties, such as tensile strength, tensile modulus, failure strain, and Poisson's ratio of flat composite materials, are determined according to ASTM D 3039 standards, fiber-reinforced polymer composites, but should not be used for highly oriented composite materials because of their tendency to split longitudinally at the neck-down region of the specimen 3039 should be utilized for highly oriented specimens and specifies a straight-sided, rectangular test specimen geometry, with the standard primarily focusing upon the appropriate procedures for applying cyclic versus quasi-static loading

3.3.2 Compressive Properties Unlike metals, properties of a composite in tension and compression are not the same in general. Compression testing is one of the most difficult tests which can be performed on composites. A number of test methods together with specimen designs have been proposed, with a primary focus on the avoidance of the specimen buckling or global instability under a compressive load. In-plane static compressive properties can be determined using D 3410 test methods. D 3410 are recommended only for unidirectional or cross-plaid fiber-reinforced polymer composites one of the most commonly used is the **IITRI** fixture (named after researchers at the Illinois Institute of Technology Research Institute).

3.3.3 Bending Test Static and fatigue flexural properties, such as flexural strength and modulus, are determined by ASTM D 790 test method. In this test, a composite beam specimen of rectangular cross-section is loaded in either a three-point or a four-point bending mode. In either mode, a large span (L) to thickness (t) ratio of 16, 32, 40, or 60 is usually recommended to minimize inter laminar shear deformation.

IV. Results And Discussion

4.1 Tensile Results

4.1.1 Tensile Test Results For 12% HNFPCM

Graph 4.1: 12% HNFPCM for Tensile Test (Specimen No.2).

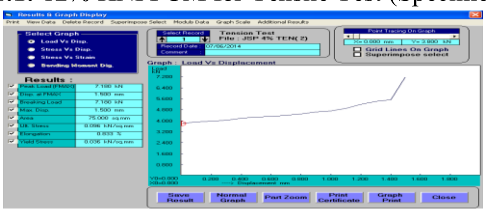


Table 4.1: Tabular column shows Experimental results (Graph) of Tensile Test 12% HNFPCM.

Sl No	Peak Load (Fmax) kN	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Ultimate Stress (kN/mm^2)	Elongation %	Yield Stress (kN/mm^2)	Femur Bone Tensile Strength or Ultimate Stress [17]
1	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								43.44±3.62 Mpa or 0.04344±0.00362 (kN/mm^2)
2	7.180	1.500	7.180	1.500	75	0.096	0.833	0.036	
3	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								

Conclusion: From this Experimental Results concluded that the Specimen No.2 having Tensile Strength of $0.096 kN/mm^2$. Hence comparing these results to the Femur Bone Tensile Strength 0.04344 ± 0.00362 kN/mm^2, the specimen No.2 results will match.

4.1.2 Tensile Test Results For 24% HNFPCM

Graph 4.2: 24% HNFPCM for Tensile Test (Specimen No.3).

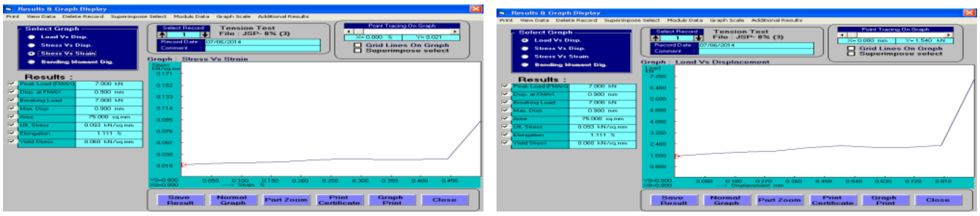


Table 4.2: Tabular column shows Experimental results (Graph) of Tensile Test 24% HNFPCM.

Sl No	Peak Load (Fmax) kN	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Ultimate Stress (kN/mm^2)	Elongation %	Yield Stress (kN/mm^2)	Femur Bone Tensile Strength or Ultimate Stress [17]
1	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								43.44±3.62 Mpa or 0.04344±0.00362 (kN/mm^2
2	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								
3	7.000	0.900	7.000	0.900	75	0.093	1.111	0.030	

Conclusion: From this Experimental Results concluded that the Specimen No.3 having Tensile Strength $0.093kN/mm^2$ respectively. Hence comparing these results to the Femur Bone Tensile Strength 0.04344 ± 0.00362 kN/mm^2, the specimen No.3 results will match.

4.1.3 Tensile Test Results For 36% HNFPCM

Graph 4.3: 36% HNFPCM for Tensile Test (Specimen No.1).

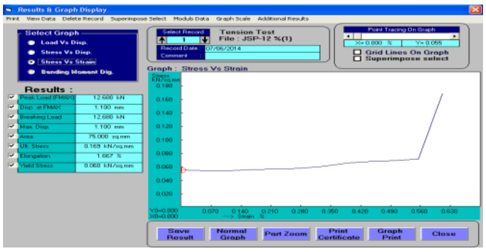


Table 4.3: Tabular column shows Experimental results (Graph) of Tensile Test 36% HNFPCM.

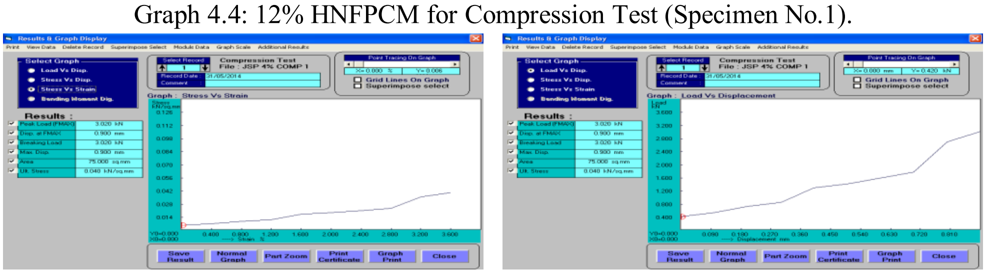
Sl No	Peak Load (Fmax) kN	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Ultimate Stress (kN/mm^2)	Elongation %	Yield Stress (kN/mm^2)	Femur Bone Tensile Strength or Ultimate Stress [17]
1	12.680	1.10	12.680	1.100	75	0.169	1.667	0.060	43.44±3.62 Mpa or 0.04344±0.00362 (kN/mm^2)
2	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								
3	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated								

Conclusion: From this Experimental Results concluded that the Specimen No.1 having Tensile Strength of $0.169kN/mm^2$. Hence comparing these results to the Femur Bone Tensile Strength 0.04344 ± 0.00362 kN/mm^2, the specimen No.1 results will match.

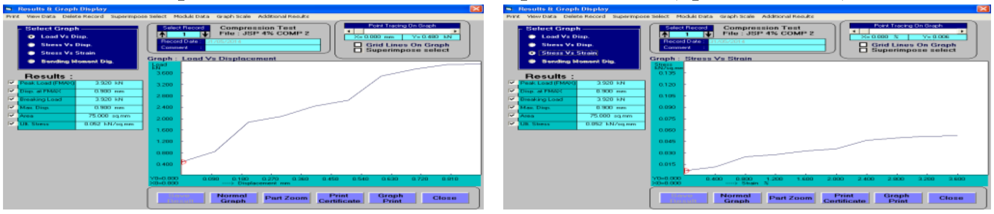
4.2 Compression Test Results

4.2.1 COMPRESSION TEST RESULTS FOR 12% HNFPCM

Graph 4.4: 12% HNFPCM for Compression Test (Specimen No.1).



Graph 4.5: 12% HNFPCM for Compression Test (Specimen No.2).



Graph 4.6: 12% HNFPCM for Compression Test (Specimen No.3).

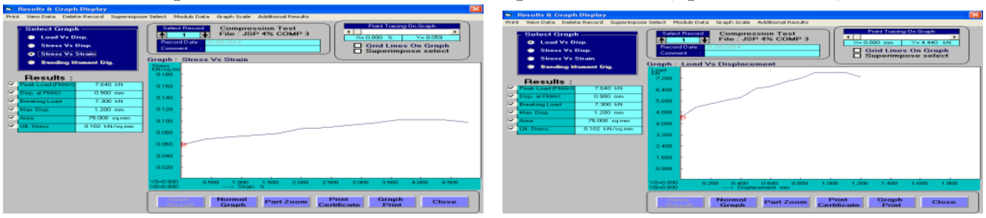


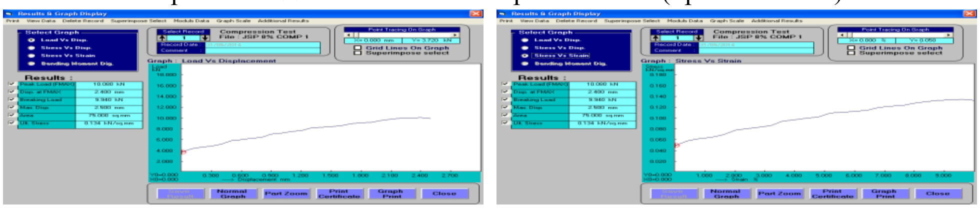
Table 4.4: Tabular column shows Experimental results (Graph) of Compression Test 12% HCPM.

Sl No	Peak Load (FMAX) kN	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Compressive strength (PKL/Area) (kN/mm^2)	Femur Bone Compressive Strength [17]
1	3.020	0.900	3.020	0.900	75	0.040	115.29±12.94(Mpa) or 0.11529±0.01294 (kN/mm^2)
2	3.920	0.900	3.920	0.900	75	0.052	
3	7.640	0.900	7.300	1.200	75	0.102	

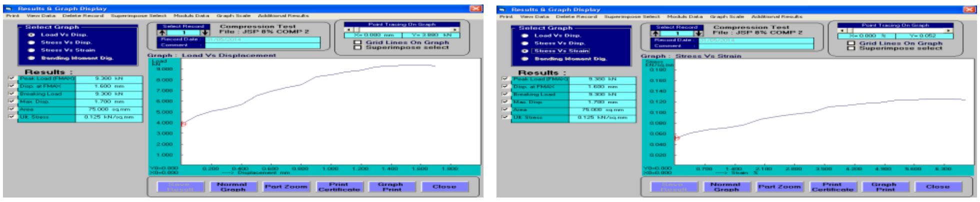
Conclusion: From these Experimental Results concluded that the Specimen No.3 have Highest Compressive Strength i.e., 0.102 kN/mm^2 . Hence comparing these results to the Femur Bone Compressive Strength of 0.11529±0.01294 kN/mm^2, the specimen No.3 results will match.

4.2.2 Compression Test Results For 24% HNFPCM

Graph 4.7: 24% HNFPCM for Compression Test (Specimen No.1).



Graph 4.8: 24% HNFPCM for Compression Test (Specimen No.2).



Graph 4.9: 24% HNFPCM for Compression Test (Specimen No.3).

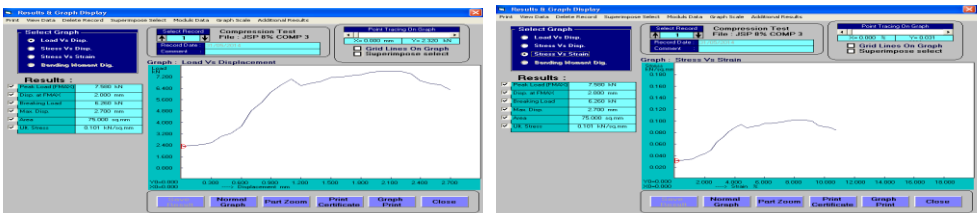


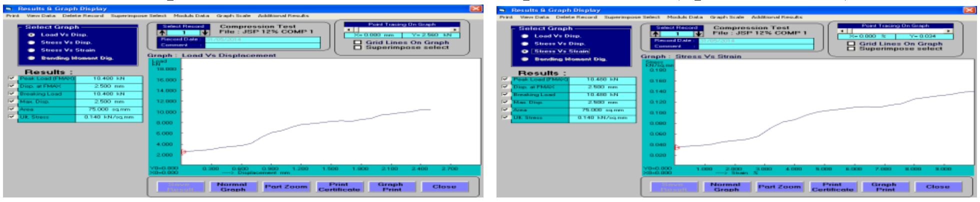
Table 4.5: Tabular column shows Experimental results (Graph) of Compression Test 24% HNFPCM.

Sl No	Peak Load (FMAX) (kN)	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Compressive strength (PKL/Area) (kN/mm^2)	Femur Bone Compressive Strength [17]
1	10.080	2.400	9.940	2.500	75	0.134	115.29±12.94(Mpa) or 0.11529±0.01294 (kN/mm^2)
2	9.380	10300	9.300	1.700	75	0.125	
3	7.580	2.000	6.260	2.700	75	0.101	

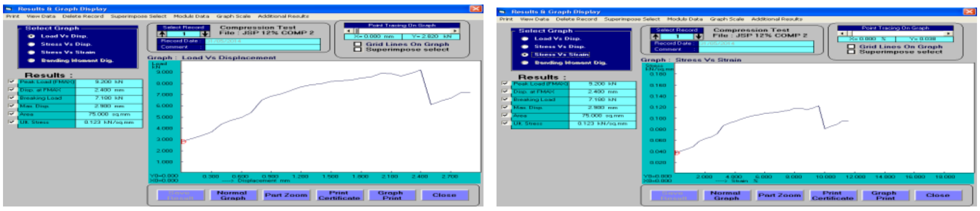
Conclusion: From this Experimental Results concluded that the Specimen No.1&2 have Highest Compressive Strength i.e., 0.134 kN/mm^2 & 0.125 kN/mm^2. Hence comparing these results to the Femur Bone Compressive Strength of 0.11529±0.01294 kN/mm^2, the specimen No.1&2 results will match.

4.2.3 Compression Test Results For 36% HNFPCM

Graph 4.10: 36% HNFPCM for Compression Test (Specimen No.1)



Graph 4.11: 36% HNFPCM for Compression Test (Specimen No.2).



Graph 4.12: 36% HNFPCM for Compression Test (Specimen No.3).

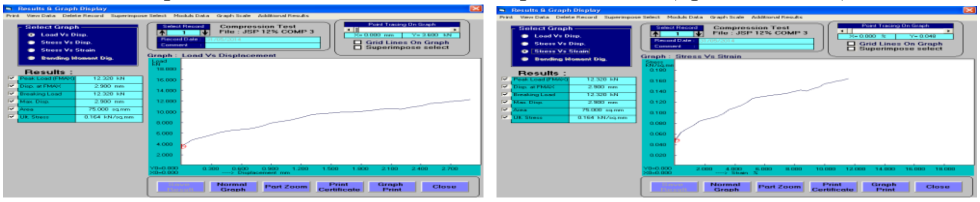


Table 4.6: Tabular column shows Experimental results (Graph) of Compression Test 36% HNFPCM.

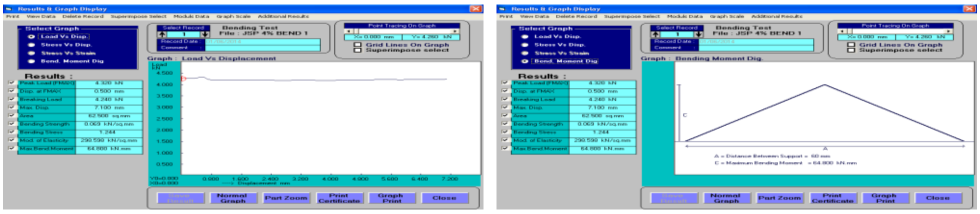
Sl No	Peak Load (FMAX) (kN)	Displacement at Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	Area mm^2	Compressive strength (PKL/Area) (kN/mm^2)	Femur Bone Compressive Strength [17]
1	10.480	2.500	10.480	2.500	75	0.140	115.29±12.94(Mpa) or 0.11529±0.01294 (kN/mm^2)
2	9.200	2.400	7.180	2.900	75	0.123	
3	12.320	2.900	12.320	2.900	75	0.164	

Conclusion: From this Experimental Results concluded that the Specimen No.1, 2 & 3 have Compressive Strength 0.140 kN/mm^2, 0.1230 kN/mm^2 and 164 kN/mm^2. Hence comparing these results to the Femur Bone Compressive Strength of 0.11529±0.01294 kN/mm^2, the specimen kN/mm^2 results will match.

4.3 Bending Test Results

4.3.1 Bending Test Results For 12% HNFPCM

Graph 4.13: 12% HNFPCM for Bending Test (Specimen No.1)



Graph 4.14: 12% HNFPCM for Bending Test (Specimen No.2)

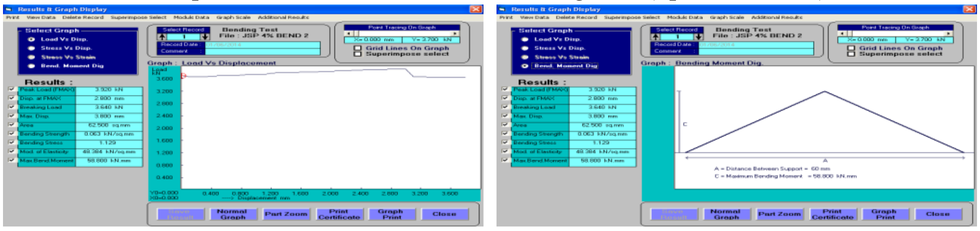


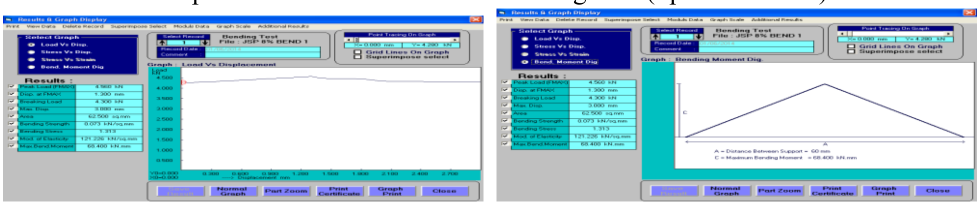
Table 4.7: Tabular column shows Experimental results (Graph) of Bending Test 12%HNFPCM.

Sl No	Peak Load (Fmax) kN	Displacement At Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	C/S Area mm^2	Bending Strength (kN/mm^2)	Bending Stress (kN/mm^2)	Modulus of Elasticity (kN/mm^2)	Maximum Bending Moment kN.mm	Femur Bone Bending Strength [17]
1	4.320	0.500	4.240	7.100	62.500	0.069	1.244	298.598	64.800	84.03±9.91 (Mpa) or 0.0840.00991 (kN/mm^2)
2	3.920	2.800	3.640	3.800	62.500	0.063	1.129	48.384	58.800	
3	While conducting the Experiment the specimen is broken suddenly due to this the Graph is Not generated									

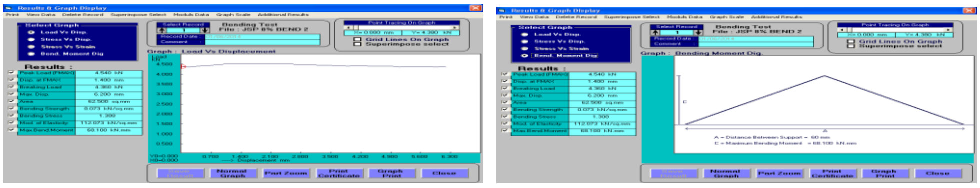
Conclusion: From this Experimental Results concluded that the Specimen No.1 & 2 have Bending Strength 1.244 kN/mm^2 and 1.129 kN/mm^2. Hence comparing these results to the Femur Bone Bending Strength of 0.084± 0.00991 kN/mm^2, the specimen No.1 & 2 results will match.

4.3.2 Bending Test Results For 24% HNFPCM

Graph 4.15: 24% HNFPCM for Bending Test (Specimen No.1)



Graph 4.16: 24% HNFPCM for Bending Test (Specimen No.2)



Graph 4.17: 24% HNFPCM for Bending Test (Specimen No.3)

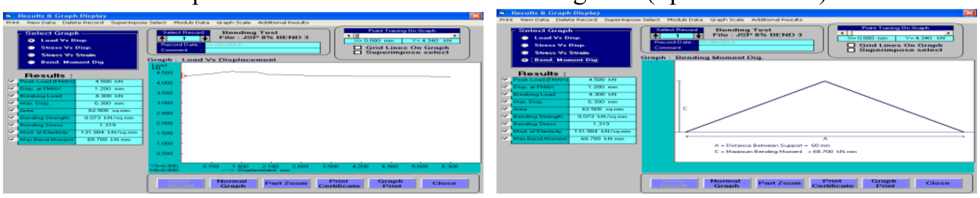


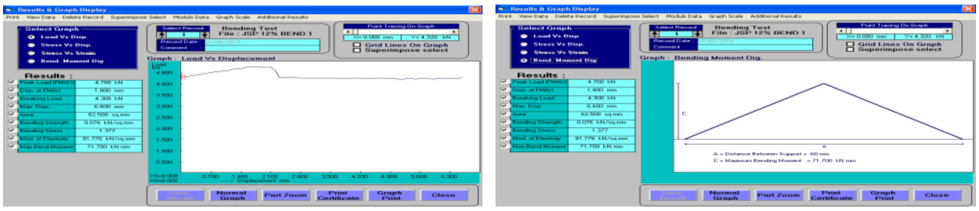
Table 4.8: Tabular column shows Experimental results (Graph) of Bending Test 24%HNFPCM.

Sl No	Peak Load (Fmax) kN	Displacement At Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	C/S Area mm^2	Bending Strength (kN/mm^2)	Bending Stress (kN/mm^2)	Modulus of Elasticity (kN/mm^2)	Maximum Bending Moment kN.mm	Femur Bone Bending Strength [17]
1	4.560	1.300	4.300	3.000	62.500	0.073	1.313	121.226	68.400	84.03±9.91 (Mpa) or 0.084±0.00991 (kN/mm^2)
2	4.540	1.400	4.360	6.200	62.500	0.073	1.308	112.073	68.100	
3	4.580	1.200	4.300	6.300	32.500	0.073	1.319	131.904	68.700	

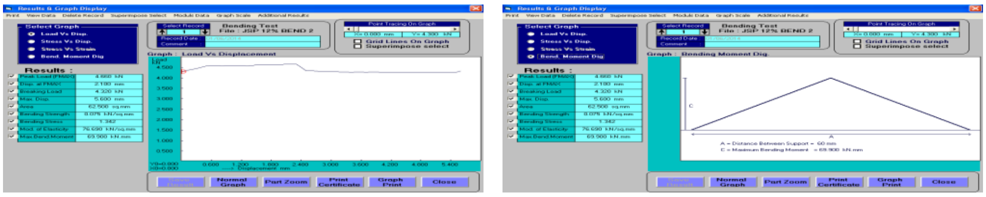
Conclusion: From this Experimental Results concluded that the Specimen No.1, 2 & 3 have Bending Strength 1.313 kN/mm^2, 1.308 kN/mm^2 and 1.308 kN/mm^2. Hence comparing these results to the Femur Bone Bending Strength of 0.084± 0.00991 kN/mm^2, the specimen No.1, 2 & 3 results will match.

4.3.3 Bending Test Results For 36% HNFPCM

Graph 4.18: 36% HNFPCM for Bending Test (Specimen No.1)



Graph 4.19: 36% HNFPCM for Bending Test (Specimen No.2).



Graph 4.20: 36% HNFPCM for Bending Test (Specimen No.3)

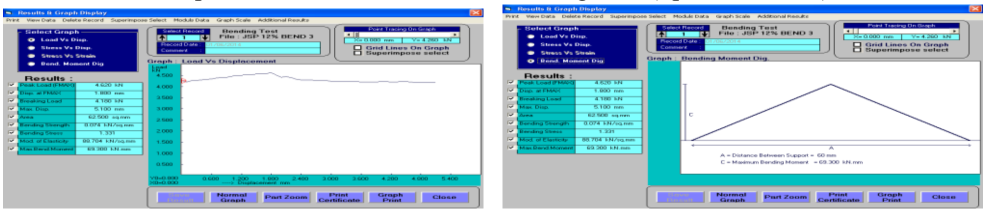


Table 4.9: Tabular column shows Experimental results (Graph) of Bending Test 36%HNFPCM.

Sl No	Peak Load (Fmax) kN	Displacement At Fmax (mm)	Breaking Load (kN)	Maximum Displacement (mm)	C/S Area mm^2	Bending Strength (kN/mm^2)	Bending Stress (kN/mm^2)	Modulus of Elasticity (kN/mm^2)	Maximum Bending Moment kN.mm	Femur Bone Bending Strength [17]
1	4.780	1.800	4.300	6.600	62.50	0.076	1.377	91.776	71.700	84.03±9.91 (Mpa) or 0.084±0.00991 (kN/mm^2)
2	4.660	2.100	4.320	5.600	62.50	0.075	1.342	76.690	69.900	
3	4.620	1.800	4.180	5.100	62.50	0.074	1.331	88.704	69.300	

Conclusion: From this Experimental Results concluded that the Specimen No.1, 2 & 3 have Bending Strength 1.377 kN/mm^2, 1.342 kN/mm^2 and 1.331 kN/mm^2. Hence comparing these results to the Femur Bone Bending Strength of 0.084± 0.00991 kN/mm^2, the specimen No.1, 2 & 3 results will match.

V. Conclusion

- From the Tensile Experimental test results it is found that 12%, 24% and 36% HNFPCM will match the Femur bone tensile property anyhow from this results we suggest 36% HNFPCM is the best material which is having high Tensile strength, high Density when compare to 12% & 24% HNFPCM.
- From the Compression Experimental test results it is found that 12%, 24% and 36% HNFPCM will match the Femur bone Compression property anyhow from this results we suggest 36% HNFPCM is the best material which is having high Compressive strength, high Density when compare to 12% & 24% HNFPCM.
- From the Bending Experimental test results it is found that 12%, 24% and 36% HNFPCM will match the Femur bone Bending property anyhow from this results we suggest 36% HNFPCM is the best material which is having high Bending strength, high Density when compare to 12% & 24% HNFPCM.

VI. Scope For The Future Work

- Corrosion test can be conducted to the present composite materials (HNFPCM).
- Coating can be done by using any suitable different bio-compatible coating material (Example: calcium phosphate and hydroxyapatite) for to use orthopaedic field or can be used for both internal and external fixation on the human body for fractured bone.
- Characterization can be done by using different types Natural fibers to improve the strength.
- Characterization of the fibers can be done by the using Advanced techniques i.e., Vacuum bag moulding to get very good bonding between or interlink between the fiber and the matrix material.
- Further we can make use of Advanced or Bio-Matrix materials (high density polyurethane or PEEK etc.).
- Characterization of the fibers can be done by the using Mat type and also with Fine powder type.
- SEM and Finite Element Analysis can be carried out.
- Testing like Fatigue test, shear test, Impact test, Moisture content test and thermal test.
- We can compare the Natural fiber to S-Glass fiber or E-Glass fiber and also it can compare to the existing/ widely using material (SS316L) for Orthopaedic Implants especially for Femur Prosthesis.

Acknowledgement

We Cordial thank to Research Center R.Y.M.E College Bellary, RPI Industry R.T Nagar Bangalore for their support for the fabrication of my Research work, REVA Institute of Technology & Management, Bangalore their support to conduct the Mechanical Testing's of my Research Work.

References

[1] A.K. Bledzk and J. Gassan, Composites reinforced with cellulose-based fibres, Prog.Polym. Sci.24, 211-274 (1999).
[2] A.N. Netravali and S. Chabba, paper entitled Composites get greener, Materials Today 6, 22-29 (2003)
[3] G. Marsh, paper entitled A guide for green composites, Reinforced Plastics 48, 18-26 (2004).
[4] K R Dinesh, Jagadish S P and A Thimmanagouda paper entitled "Characterization and Analysis of Wear Study on Sisal Fibre Reinforcement Epoxy Composite Materials Used As Orthopaedic Implant" international journal of advances in engineering & technology, Jan. 2014. ©IJAET ISSN: 22311963 vol. 6, issue 6, pp. 2745-2757
[5] D. Chandramohan et al. paper entitled "Bio composite materials based on bio polymers and natural fibers -contribution as bone implants" (ijamsar) international journal of advanced medical sciences and applied research vol no. 1, issue no. 1, 009 – 012.
[6] Thillai Sivakumar N and Venkataraman R, paper entitled Der Pharmacia Sinica, 1 (1): 1-6 (2010)
[7] D. Chandramohan and K. Marimuthu Department of Mechanical Engineering, Coimbatore Institute of Technology, Coimbatore, Tamilnadu, India Paper Entitled "Characterization of Natural Fibers And Their Application In Bone Grafting Substitutes" Acta of Bioengineering And Biomechanics Original Paper Vol. 13, No. 1, 2011 Received: January 8th, 2011 Accepted For Publication: February 25th, 2011
[8] K. Fujihara, 'Design of carbon / epoxy braided composite bone plate', National University of Singapore, http://iris14.cadcam.nus.edu.sg/~p81313a/phdwork.html
[9] Ramakrishna S, Mayer J, winter mantel E, Leong KW. Biomedical Applications of polymer-composite materials: a review.Comp Sci Tech 2001; 61:1189–224.
[10] Yildiz, Composite Hip Prosthesis Design, Ph.D Thesis, Stanford University, 1993.
[11] D. Amalraju and Dr. A.K.Shaik Dawood Fernandez Paper Entitled "Mechanical Strength Evaluation Analysis of Stainless Steel and Titanium Locking Plate for Femur Bone Fracture" IRACST – Engineering Science And Technology: An International Journal (ESTIJ), ISSN: 2250-3498, Vol.2, No. 3, June 2012
[12] M.S. Ali, et al., 'Carbon Fiber Composite Bone Plates: Development, Evaluation and Early Clinical Experience', J. Bone & Joint Surg. [Br], 72-B, 586-91, 1990
[13] Baixauli, et al., Carbon Fiber Composite Bone Plates for Fixation of Forearm Fractures, J. Bone & Joint Surg. [Br], 77-B (2), 227, 1995

[14] Giuseppe Cristaldi, Alberta Latteri, Giuseppe Recca and Gianluca Cicala Paper Entitled "Composites Based on Natural Fibre Fabrics" University of Catania – Department of Physical and Chemical Methodologies for Engineering, Catania-Italy. www.Intechopen.Com

[15] Advanced Materials Araldite ® Ly556 Aradur ® 5021 Hardener Xb3403, Hardener Xb 3471, Page 1 Of 6 October 2010.

[16] Ciba Specialty Chemicals, Performance Polymers Structural Composites-Matrix Systems for Industrial Composites Data Sheet.

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