JSESM

Journal of Scholastic Engineering Science and Management

March 2022, Volume 1, Issue 1 pp: 1-15

"Evaluation Of Natural Fiber Polymer Composite with Nickel Chromium Molybdenum Alloy Used for Medical Implants"

[1]Dr.Chandregowda M, [2]Mr.Niranjan Kumar R, [3]Mr.Naveen Ambore, [4]Mr.Avinash Nayak B, [5]Mr.Vinay Kumar S H

[1]Associate Professor, [2,3,4,5]Students (B.E Final Year)

[1,2,3,4,5]Proudhadeveraya Institute of Technology, (PDIT), Hosapete, Karnataka, India

Email: [1]chande296@gmail.com

ABSTRACT

Natural fibers gift crucial blessings which include. strengthened substances that are much less inflexible than metals can be right options due to houses in the direction of bone mechanical houses. It turned into observed that they assist to keep away from pressure protective and growth bone remodelling Orthopedic surgeons had been the usage of metal bone plates for the fixation of human bone fractures. Apparently, metal prosthesis, that are normally product of chrome steel and titanium alloys, reason a few issues like metallic incompatibility

Keywords: *Composite Materials, Fiber, orthopedic implant*

1. INTRODUCTION

Natural fibers 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 Sisal Fiber Reinforcement epoxy resin composite material used for orthopedic implants and Bio-composites materials based on biopolymers and natural fibers used as bone implants, 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, 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. 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 remodelling Orthopedic surgeons have been using metallic bone plates for the fixation of human 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. The Femur is the longest and strongest bone in the skeleton is almost perfectly cylindrical in the greater part of its extent Fabrication of (Hybrid) natural fiber reinforced polymer (NFRP) composite plate material by using bio epoxy resin. Instead of orthopedic 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 plate.

2. MATERIALS AND METHODS

2.1.Materials Used for Fabrication Work

Matrix Material

- Epoxy Resin

Reinforcement Of Natural Fibers

- Sisal fiber

2.2.Requiremvents For Fajbricate Naktural Fibkre Composites

- Epotoxy resighn
- Hawrden4er
- Natuydral fibber
- Sodiqwum Hydroxide (NaOH)
- Weighinadg Machkine
- Rollhrer
- Stirrdrer
- Ovrten or Furnacqe to dry the speujcimen

3. PREPARATION OF THE SPECIMEN

In this context, Process directed to prepare the specimen by mould.

- **Mould**

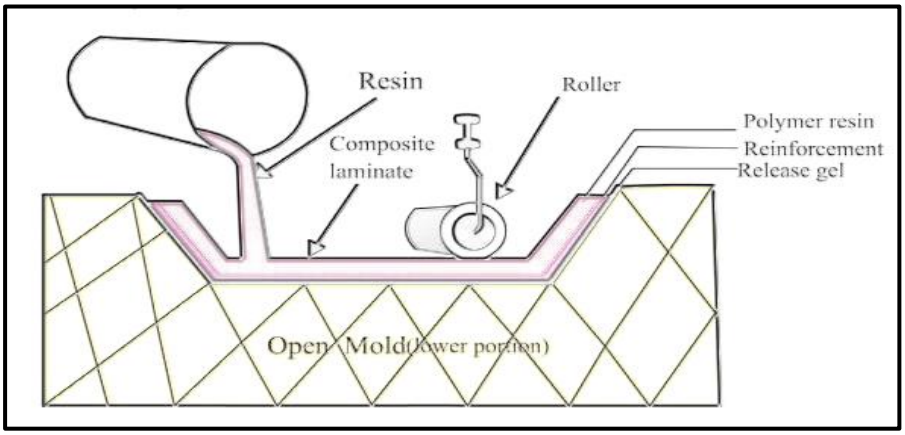


Fig.1.1: Hand-Layup Process

- **Weight Fraction of the Fiber**

Fig.1.2: Applying Weights on Fabricated Surface

- **Specimen**

Fig.1.3: Specimens for testing as per ASTM

4. EXPERIMENTAL TESTS

4.1.Specification of the Specimens as Per the ASTM Standards

❖ **Specificatftion For Compwrression Teyst Speciommen**

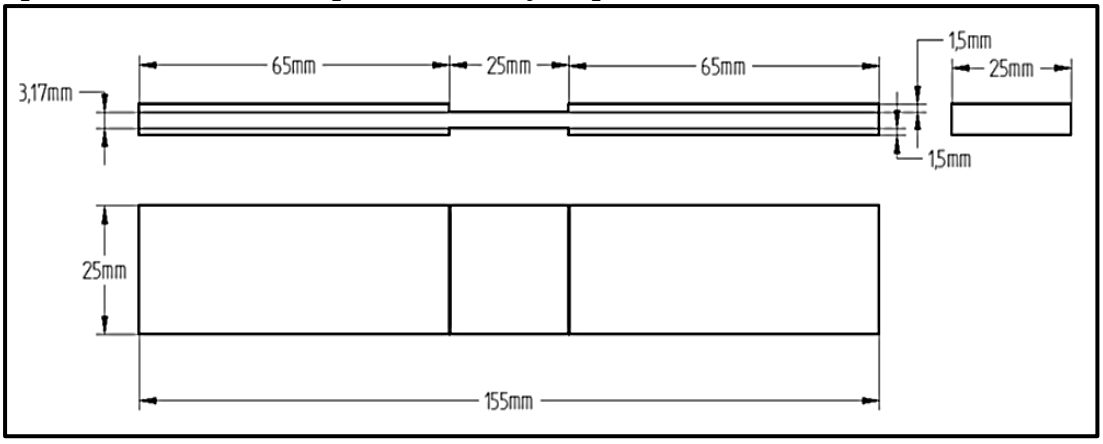


Fig.1.4: Speqwcification of the Compassoion Tgest Specimiens as Per thhe ASTM D-3410 Stuandard

❖ **Specification For Bewnding Tesyt Sipecimen**

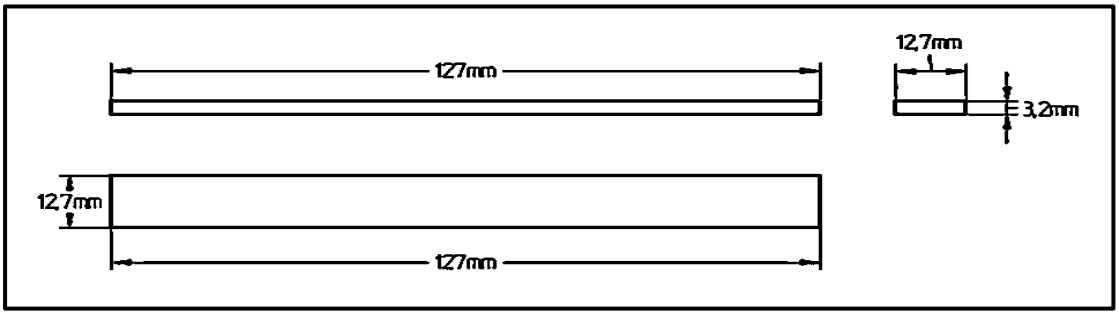


Fig.1.5: Spekcification of the Bending Test hSpecimens as Per the ASTM D-790 Staghndard

4.2.TESTING METHODS

I. Universal Testing Machine

Fig.1.6: Universal Testing Machine

Univerrsal testiuong machinge specisffications

Capaicity: 40ton

Maotor: 2.3hp

Voltaoge: 400 to 440 volts

Standard Attachments

1. Csfompression plates 2 no’s
2. Shear attiachments 1 set
3. Extensdfmeter 1 no’s
4. Single poiasnt bending tool 1 no’s

❖ COMPRESSION TEST

Static and fatigue flexural properties, inclusive of flexural energy and modulus, are decided via way of means of ASTM D 790 take a look at method. In this take a look at, a composite beam specimen of square cross-phase is loaded in both a three-factor or a four-factor bending mode. In both mode, a big span (L) to thickness (t) ratio of 16, 32, 40, or 60 is generally encouraged to reduce inter laminar shear deformation.

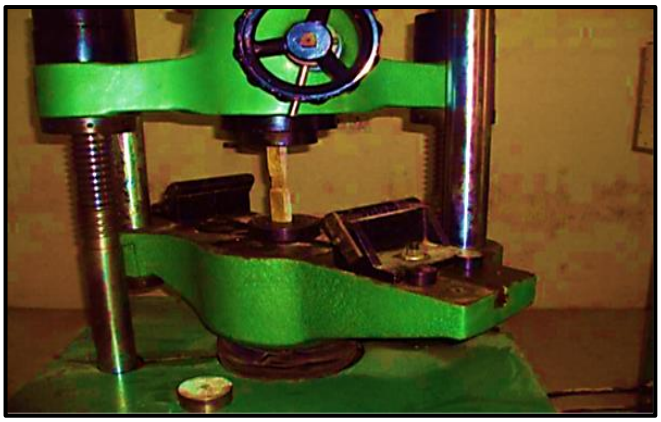


Fig.1.7: Conduction of Compressive test on Specimen by UTM

❖ **BENDING TEST**

Static and fatigue flexural properties, inclusive of flexural energy and modulus, are decided via way of means of ASTM D 790 take a look at method. In this take a look at, a composite beam specimen of square cross-phase is loaded in both a three-factor or a four-factor bending mode. In both mode, a big span (L) to thickness (t) ratio of 16, 32, 40, or 60 is generally encouraged to reduce inter laminar shear deformation.

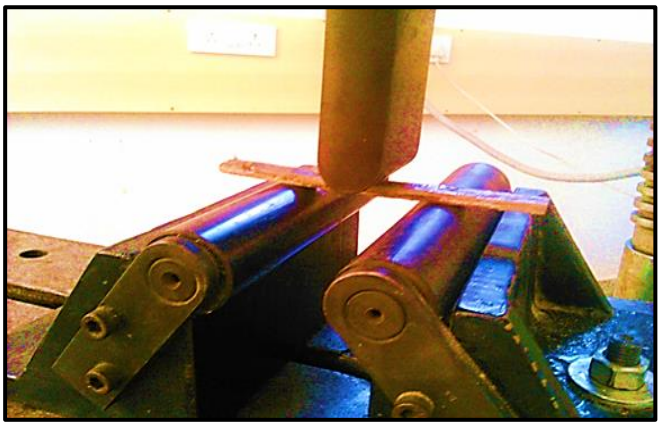


Fig.1.8: Bending Testing Specimen in UTM

II. TESTED SPECIMENS

After performing compression test and bending test on specimens the results are tabulated and would be discussed in results and discussion part. The test specimens have been shown in the figure 1.9

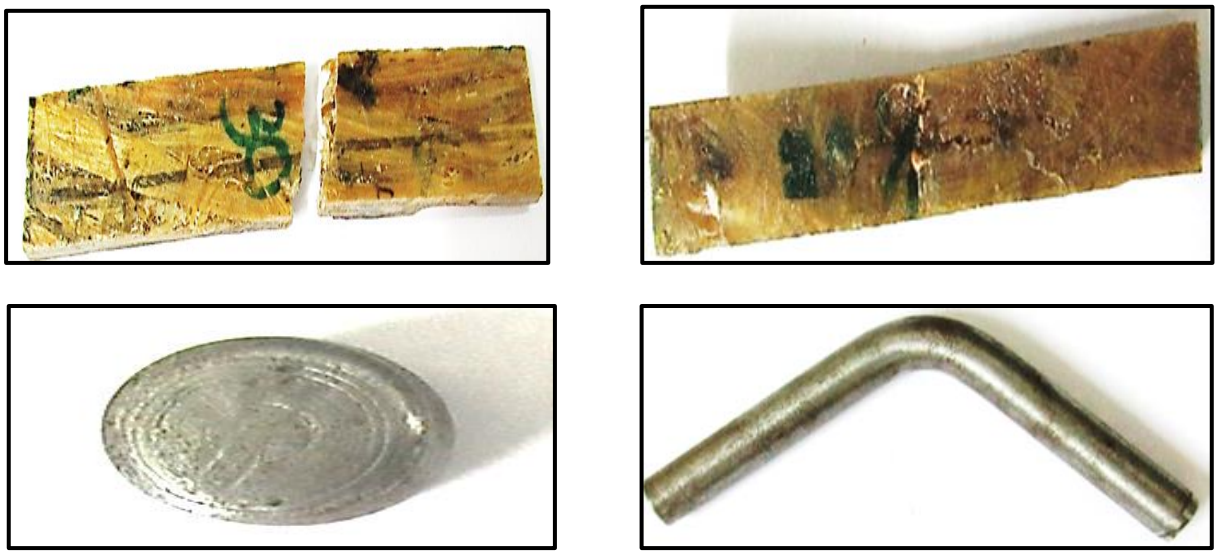


Fig.1.9: Final Tested Specimens

5. RESULTS AND DISCUSSION

5.1.COMPRESSION TEST RESULTS

It became located that they assist to keep away from pressure protective and growth bone remodelling Orthopedic surgeons had been the use of metal bone plates for the fixation of human bone fractures. Apparently, metal prosthesis, which might be typically fabricated from chrome steel and titanium alloys, motive a few issues like metallic incompatibility, corrosion, magnetism effect, anode-cathode reactions, consisting of a lower in bone mass, growth in bone porosity, and put off in fracture healing. The Femur is the longest and most powerful bone withinside the skeleton is nearly flawlessly cylindrical withinside the extra a part of its volume Fabrication of (Hybrid) herbal fiber strengthened polymer (NFRP) composite plate fabric with the aid of using the use of bio epoxy resin.

10% PCM

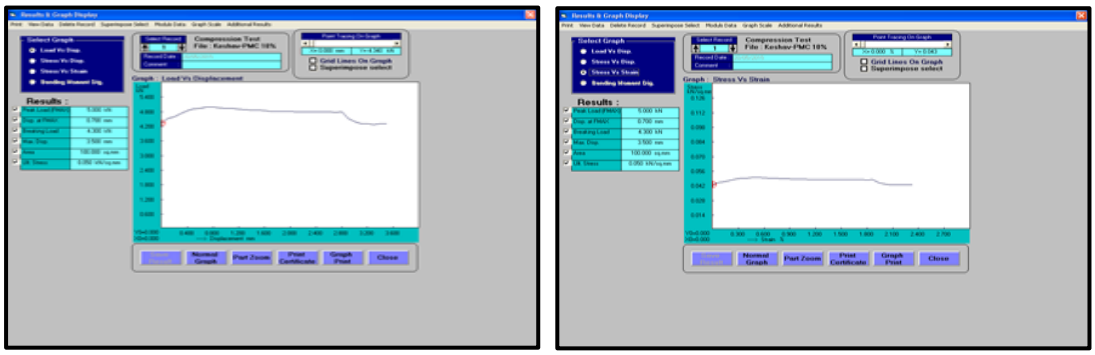


Fig.2.0: Compression test results for 10% PCM

Table 1.1: 10 %PCM

S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwressive strength (PKL/eArea) (kN/mme^2)	Femrour Bone Compresesive strengfth (kN/mm^2)
1	5.00	0.700	4.30	3.500	100	0.050	115.29±12.94 (Mpa) 94 (kN/mm^2)

- **20% PCM**

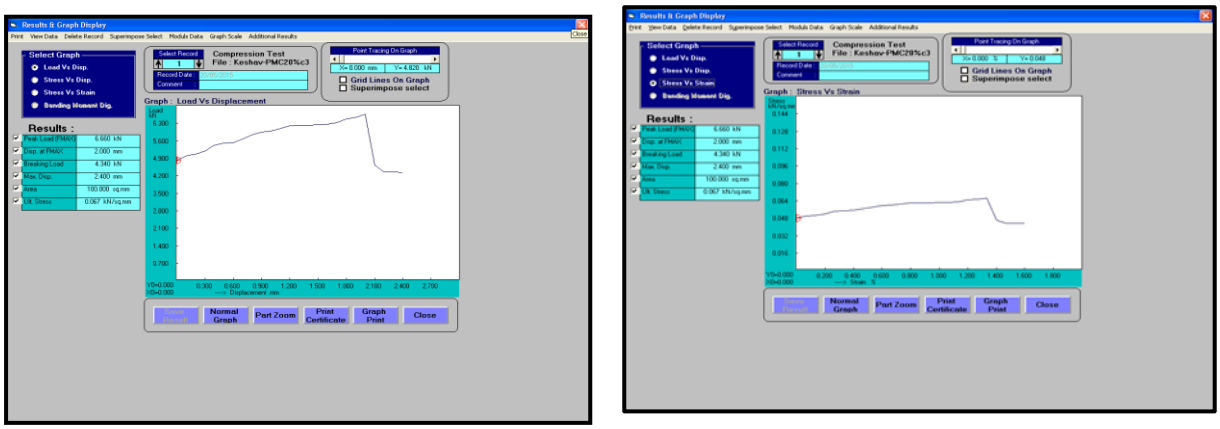


Fig.2.1: Compression test results for 20% PCM

Table 1.2: 20 %PCM

S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwressive strength (PKL/eArea) (kN/mme^2)	Femrour Bone Compresesive strengfth (kN/mm^2)
1	6.66	2	4.34	2.4	100	0.067	115.29±12.94 (Mpa)

- **30% PCM**

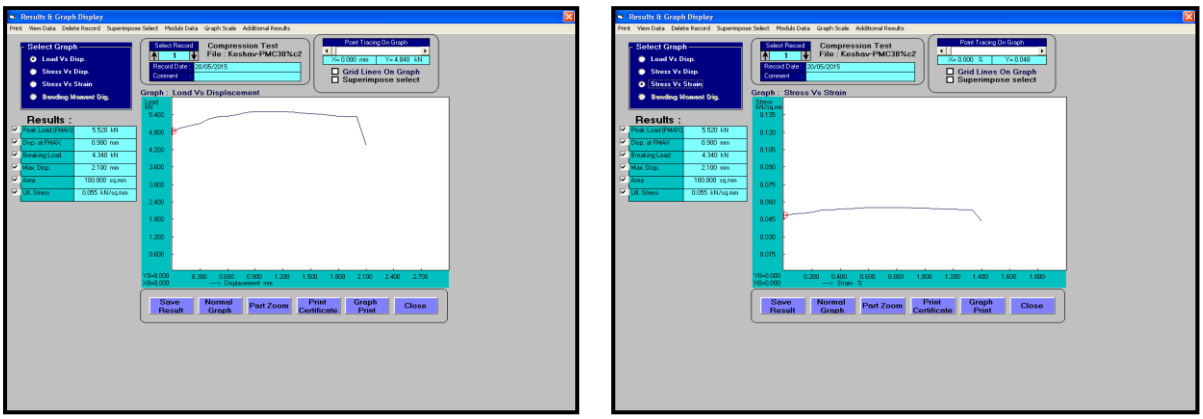


Fig.2.2: 30% PCM

Table 1.3: 30 %PCM

S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacemen t (mme)	Arrea mm^2)	Compwressiv e strength (PKL/eArea) (kN/mme^2)	Femrour Bone Compresesive strengfth (kN/mm^2)
1	5.52	0.9	4.34	2100	100	0.055	115.29±12.94 (Mpa)

❖ INCONEL EN24 FOR COMPRESSION TEST

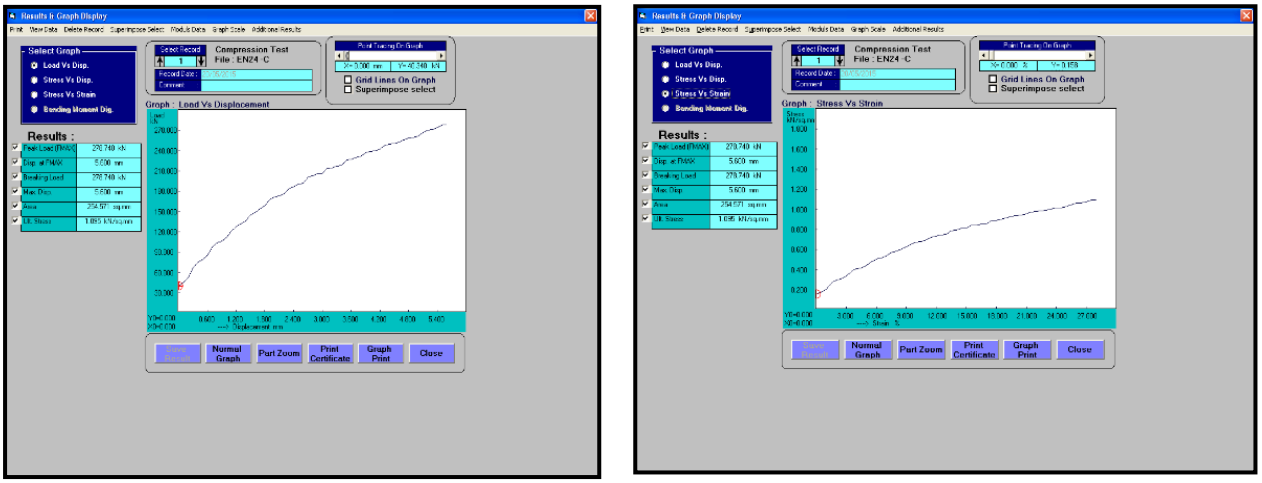
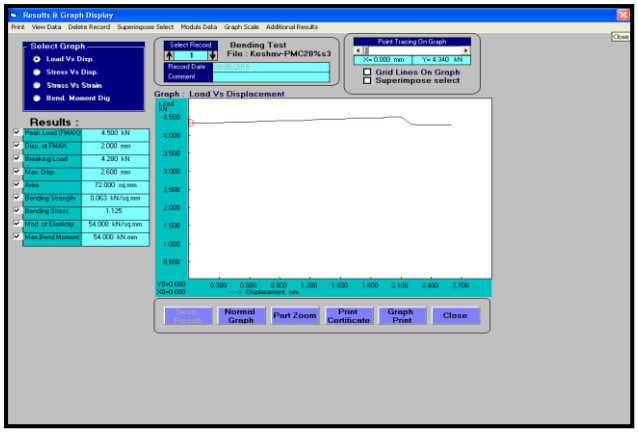
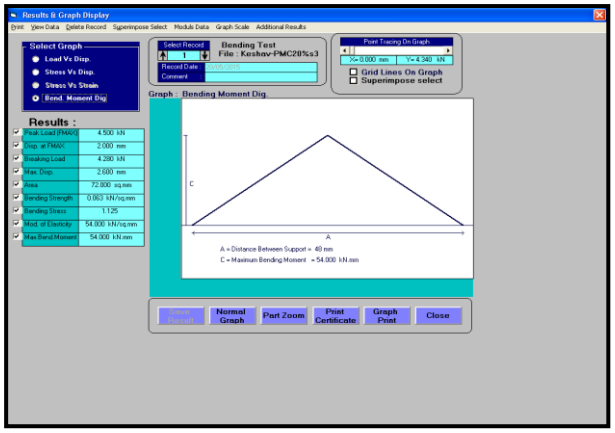


Fig.2.3: Inconel En24 for Compression Test

Table 1.4: Experimental results of Compression for INCONEL EN24

S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwressive strength (PKL/eArea) (kN/mme^2)	Femrour Bone Compresesive strengfth (kN/mm^2)
1	278.74	5.6	278.74	5.6	255	1.095	115.29±12.94(Mpa)





BENDING TEST RESULT

Fig.2.4: 10% PCM

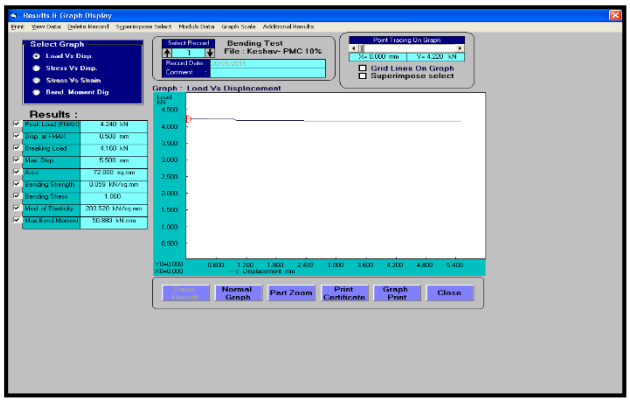


Table 1.5: 10% PCM

SL. No	Pefgak Load (F_{max}) kN	Displahcement at F_{max} (mm)	Brehaking Load (kN)	Maximuhm Displacement (mm)	C/S Arhea hmm^2	Bending fStrength (kN/mm^2)	Bendihng Strehss (kN/mm^2)	Modulhus of Elasticihty (kN/mm^2)	Maximhum Benhding Moment kN/mm	Femhour Compressive strength (kN/mm^2)
1	4.24	0.5	4.16	5.5	72	0.059	1.06	203.52	50.88	84.03±9.91 (Mpa) 0.00991 (kN/mm/m)

- **20% PCM**

Table 1.6: for 20% PCM

S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwressive strength (PKL/eArea) (kN/mme^2)	Femrour Bone Compresesive strengfth (kN/mm^2)	S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)
1	4.5	2	4.29	2.6	72	0.063	1.125	54	54	115.29±12.94 (Mpa)

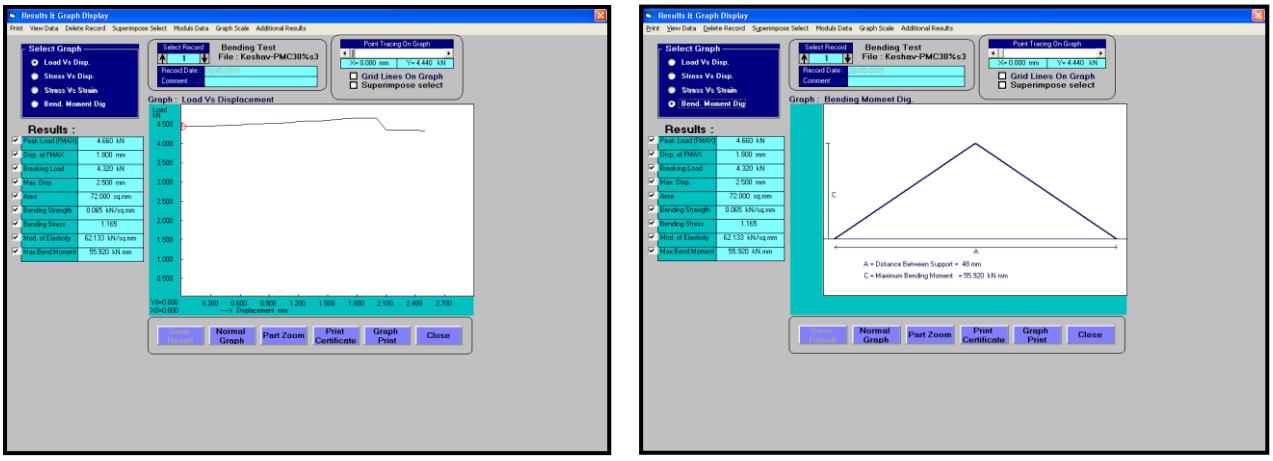


Fig.2.6: 30% PCM

30% PCM

Table 1.7: 30% PCM

S. N	Peakw Loaed (F_{max}) kwN	Displac emenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwres sive strength (PKL/eAr ea) (kN/mme^2)	Femrour Bone Compresesiv e strengfth (kN/mm^2)	S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)
1	4.66	1.8	4.32	2.5	72	0.065	1.165	62.133	55.92	115.29±12.94 (Mpa)

❖ **INCONEL EN24 FOR BENDING TEST RESULTS**

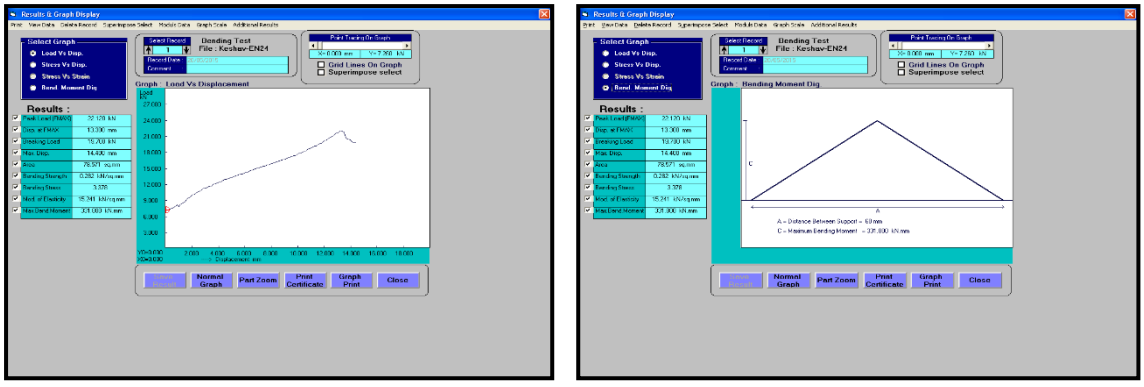


Fig.2.7: Inconel EN24 for Bending test result

Table 1.8: Experimental results of Bending results for INCONEL EN24

S. N	Peakw Loaed (F_{max}) kwN	Displac emenet at F_{maex} (mem)	Breakieng Load (kwN)	Maximeum displacement (mme)	Arrea (mm^2)	Compwres sive strength (PKL/eAr ea) (kN/mme^2)	Femrour Bone Compresesiv e strengfth (kN/mm^2)	S. N	Peakw Loaed (F_{max}) kwN	Displacemenet at F_{maex} (mem)
1	22.12	13.3	19.7	14.4	78.571	0.282	3.378	15.241	331.8	115.29±12.94 (Mpa)

CONCLUSION

Eventually, Natural fiber strengthened polymer composite substances that are much less inflexible than metals can be right options due to houses in the direction of bone mechanical houses. It turned into observed that they assist to keep away from pressure protective and growth bone remodelling Orthopedic surgeons had been the usage of metal bone plates for the fixation of human bone fractures. Apparently, metal prosthesis, that are normally product of chrome steel and titanium alloys, reason a few issues like metallic incompatibility

REFERENCES

[1]. Adamovic, D., Ristic, B. and Zivic, F., 2018. Review of existing biomaterials—Method of material selection for specific applications in orthopedics. Biomaterials in Clinical Practice, pp.47-99.

[2]. Agarwal, S., Curtin, J., Duffy, B. and Jaiswal, S., 2016. Biodegradable magnesium alloys for orthopaedic applications: A review on corrosion, biocompatibility and surface modifications. Materials Science and Engineering: C, 68, pp.948-963.

[3]. Aherwar, A., Singh, A.K. and Patnaik, A., 2016. Current and future biocompatibility aspects of biomaterials for hip prosthesis. AIMS Bioeng, 3(1), pp.23-43.

[4]. Ali, S.H., Almaatoq, M.M. and Mohamed, A.S., 2013. Classifications, surface characterization and standardization of nanobiomaterials. International Journal of Engineering & Technology, 2(3), p.187.

[5]. Bahraminasab, M., Sahari, B.B., Hassan, M.R., Arumugam, M. and Shamsborhan, M., 2011. Finite element analysis of the effect of shape memory alloy on the stress distribution and contact pressure in total knee replacement. Trends in Biomaterials and Artificial Organs, 25(3), pp.95-100.

[6]. Balamurugan, A., Rajeswari, S., Balossier, G., Rebelo, A.H.S. and Ferreira, J.M.F., 2008. Corrosion aspects of metallic implants—An overview. Materials and corrosion, 59(11), pp.855-869.

[7]. Bose, S., Banerjee, D. and Bandyopadhyay, A., 2017. Introduction to biomaterials and devices for bone disorders. In Materials for Bone Disorders (pp. 1-27). Academic Press.

[8]. Brown, S.A., 2006. Synthetic biomaterials for spinal applications (pp. 11-33). Academic Press: Burlington.

[9]. Chen, Q. and Thouas, G., 2014. Biomaterials: a basic introduction. CRC Press.

[10]. Dolcimascolo, A., Calabrese, G., Conoci, S. and Parenti, R., 2019. Innovative biomaterials for tissue engineering. In Biomaterial-supported Tissue Reconstruction or Regeneration. IntechOpen.

[11]. Festas, A.J., Ramos, A. and Davim, J.P., 2020. Medical devices biomaterials–A review. Proceedings of the Institution of Mechanical Engineers, Part L: Journal of Materials: Design and Applications, 234(1), pp.218-228.

[12]. Galante, J.O., Lemons, J., Spector, M., Wilson Jr, P.D. and Wright, T.M., 1991. The biologic effects of implant materials. Journal of orthopaedic research, 9(5), pp.760-775.

[13]. Ghassemi, T., Shahroodi, A., Ebrahimzadeh, M.H., Mousavian, A., Movaffagh, J. and Moradi, A., 2018. Current concepts in scaffolding for bone tissue engineering. Archives of bone and joint surgery, 6(2), p.90.

[14]. Kamachimudali, U., Sridhar, T.M. and Raj, B., 2003. Corrosion of bio implants. Sadhana, 28(3), pp.601-637.

[15]. Kashirina, A., Yao, Y., Liu, Y. and Leng, J., 2019. Biopolymers as bone substitutes: A review. Biomaterial's science, 7(10), pp.3961-3983.

[16]. Kaur, M. and Singh, K., 2019. Review on titanium and titanium based alloys as biomaterials for orthopaedic applications. Materials Science and Engineering: C, 102, pp.844-862.

[17]. Keegan, G.M., Learmonth, I.D. and Case, C.P., 2007. Orthopaedic metals and their potential toxicity in the arthroplasty patient: a review of current knowledge and future strategies. The Journal of bone and joint surgery. British volume, 89(5), pp.567-573.

[18]. Khan, W., Muntimadugu, E., Jaffe, M. and Domb, A.J., 2014. Implantable medical devices. In Focal controlled drug delivery (pp. 33-59). Springer, Boston, MA.

[19]. Khorsandi, D., Fahimipour, A., Abasian, P., Saber, S.S., Seyedi, M., Ghanavati, S., Ahmad, A., De Stephanis, A.A., Taghavinezhaddilami, F., Leonova, A. and Mohammadinejad, R., 2021. 3D and 4D printing in dentistry and maxillofacial surgery: Printing techniques, materials, and applications. Acta biomaterialia, 122, pp.26-49.

[20]. Li, J., Qin, L., Yang, K., Ma, Z., Wang, Y., Cheng, L. and Zhao, D., 2020. Materials evolution of bone plates for internal fixation of bone fractures: A review. Journal of Materials Science & Technology, 36, pp.190-208.

[21]. Mano, J.F., Sousa, R.A., Boesel, L.F., Neves, N.M. and Reis, R.L., 2004. Bioinert, biodegradable and injectable polymeric matrix composites for hard tissue replacement: state of the art and recent developments. Composites Science and Technology, 64(6), pp.789-817.

[22]. Mantripragada, V.P., Lecka-Czernik, B., Ebraheim, N.A. and Jayasuriya, A.C., 2013. An overview of recent advances in designing orthopedic and craniofacial implants. Journal of biomedical materials research Part A, 101(11), pp.3349-3364.

[23]. Panayotov, I.V., Orti, V., Cuisinier, F. and Yachouh, J., 2016. Polyetheretherketone (PEEK) for medical applications. Journal of Materials Science: Materials in Medicine, 27(7), pp.1-11.

[24]. Papathanasiou, I., Kamposiora, P., Papavasiliou, G. and Ferrari, M., 2020. The use of PEEK in digital prosthodontics: A narrative review. BMC Oral Health, 20(1), pp.1-11.

[25]. Park, J.B. and Bronzino, J.D., 2002. Biomaterials: principles and applications. crc press.

[26]. Patel, N.R. and Gohil, P.P., 2012. A review on biomaterials: scope, applications & human anatomy significance. International Journal of Emerging Technology and Advanced Engineering, 2(4), pp.91-101.

[27]. Ranganath, L. and Srinath, A., 2021. Bioimplants and Biomaterials: A Review. Trends in Biomaterials & Artificial Organs, 35(4).

[28]. Rehman, M., Madni, A. and Webster, T.J., 2018. The era of biofunctional biomaterials in orthopedics: what does the future hold?. Expert review of medical devices, 15(3), pp.193-204.

[29]. Rezaie, H.R., Rizi, H.B., Khamseh, M.M.R. and Öchsner, A., 2020. Primary Information About Biomaterials. In A Review on Dental Materials (pp. 1-30). Springer, Cham.

[30]. Silver, F., 1993. Biomaterials, Medical Devices and Tissue Engineering: An Integrated Approach: An Integrated Approach. Springer Science & Business Media.

[31]. Talha, M., Behera, C.K. and Sinha, O.P., 2013. A review on nickel-free nitrogen containing austenitic stainless steels for biomedical applications. Materials Science and Engineering: C, 33(7), pp.3563-3575.

[32]. Valiulis, A.V., 2007. The Advanced Structural Materials for Living Beings Implants. Journal of Vibroengineering, 9(4).

[33]. Yadav, D., Garg, R.K., Ahlawat, A. and Chhabra, D., 2020. 3D printable biomaterials for orthopedic implants: Solution for sustainable and circular economy. Resources Policy, 68, p.101767.

[34]. Zeng, R., Dietzel, W., Witte, F., Hort, N. and Blawert, C., 2008. Progress and challenge for magnesium alloys as biomaterials. Advanced engineering materials, 10(8), pp. B3-B14.

[35]. Zhang, X., Chen, Y. and Hu, J., 2018. Recent advances in the development of aerospace materials. Progress in Aerospace Sciences, 97, pp.22-34.

Article License Details