International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 04 Issue: 09 | Sep -2017 www.irjet.net p-ISSN: 2395-0072

EXPERIMENTAL INVESTIGATION OF FLEXURAL PROPERTIES OF WOOD POLYMER COMPOSITES UNDER WET CONDITIONS

Dr. K.C.Devendrappa[1], Guruchethan A M[2], Suresh K S[3], Deviprasad N Mirashi[4]

[1]Associate Professor, Department of Mechanical Engineering,
[2,3,4] Assistant Professor, Department of Mechanical Engineering
Bapuji Institute of Engineering and Technology, Davangere-577004

---***---

Abstract - *The use of waste wood will help solving the severe environmental problem. The successful usage of waste wood increases the economic level of developing nation. This view motivates any of the researchers to innovate the effective usage of waste wood as an applicative engineering material. Over the past decade there has been a growth noticed in the development of consumer and industrial products composed of wood fillers combined with thermosetting resins. Wood composite is a very promising and sustainable green material to achieve durability without using toxic chemicals. The material property plays the major role in design of components to meet the functional requirements of the designed system. Improper material selection leads to the catastrophic failure. Since natural fibres are hydrophilic having a high hydroxyl (–OH) group percentage and high molecular polarity. They tend to show low moisture resistance, which leads to dimensional variation of composite products and poor interfacial bonding between fibers and polymers. The mechanisms of the effect of moisture on the properties of wood plastic composites are not yet clearly understood, but it is affected by the rates of moisture absorption. The aim of the present work is to experimentally study the bending properties of wood-epoxy composite mixed in varying proportions that is 30%, 40%, 50% of waste wood (includes both fiber and flour). In the present work it has been verified for four weeks. The waste wood composites are primed by casting in moulds with the constituents of wood flour, short fibers (flakes) of wood and epoxy resin (adhesive), varied in definite proportions along with the hardener in appropriate ratio. Tests were performed accordingly to ASTM standards. From the investigation it was found that the behavior of wood polymer composites was not found to be mimicking under varied conditions*

Key Words: *Wood flakes, Epoxy resin, Flexural Strength*

1. INTRODUCTION

Polymeric matrices reinforced with wood flour filler or natural fiber show a rapid growth recently due to their many advantages such as light weight, reasonable strength, and stiffness. Their processing is flexible and economical. The use of wood flour-polymer composites has been considerably studied both from a scientific and a commercial point of view .over the last decades, as these materials are particularly attractive for their reduced environmental impact and the globally pleasant aesthetical properties [1–11].Wood plastic composites (WPC) are generally prepared to overcome the inherently deficient properties of wood and to sustain improved quality with the increased tensile properties, durability and ability to resist bio-deterioration. Wood–plastic composites are widely used in USA, the most common type of such panels are produced by mixing wood flour and plastics to produce a material that can be processed similar to 100% plastic-based products [13-14]. Wood composites are materials in which wood is impregnated with monomers that are then polymerized in the wood to tailor the material for special applications. There are several ways to improve overall properties of WPC , namely using right size of raw material, optimum mixture and preparation of the elements in the product, and adding small amounts of additives such as coupling agents, pigments, antimicrobials or light stabilizers during their production [5, 6, 7].The resulting properties of these materials, from lightness, enhanced physical and mechanical properties to greater sustainability, has meant a growing number of applications in such areas as building, construction marine automotive and aerospace engineering. Wood composite products continue to be among the most widely utilized structural materials throughout the world. They are commonly manufactured as lumber, flooring, roofing, paneling, palettes, decking, fencing, cabinets, furniture, millwork, structural beams, etc [8]. The increased number and importance of wood composite products are directly related to the decreased supply of high quality large timber, and as the quality and variety of wood composite products increases, and new applications for them are found. The trend towards usage and importance of wood composites are increasing day to day in the green global market [9]. Wood composites offer numerous advantages over lumber. They can be produced from waste wood, agricultural residues, little used and low commercial value wood species, as well as smaller and fast growing trees, which can relieve stress on old growth forests that are increasingly unavailable for use [10]. The increased homogeneity of the raw material obtained by combining small wood elements allows a wide variety of composite products to be produced that have consistent and high quality properties [11]. The exact properties and the appropriate end use for a composite depends on the wood species and wood adhesive, and are very dependent on the size, shape, and arrangement of the wood in the composite. The elements (species and adhesive) can be changed with far less effect on properties than changing wood geometry [12]. Andrea Wechsler, Salim Hiziroglu [13] has studied some of the important properties of experimentally manufactured wood–plastic composites. Jahan-Latibari [14] studied the response of quaking aspen flake surface treatments with chemicals on their strength and elastic properties. He also reported a 47% lower modulus for flakes compared to the modulus of solid wood. The procedure for making a wood composite begins with the raw wood being processed by removal of leaves and bark, then being cut into pieces of the desired size and shape, followed by drying to the desired moisture content, and then going through a sorting process to ensure the wood pieces meet the selection criteria. This process is followed regardless of wood species or wood geometry. The aim of this study is to investigate the technical viability to manufacture wood plastic composites made of waste wood powder and epoxy resin. The objectives include the detail processing of the constituents, experimental investigation of varied composition under varied wet condition and to determine the flexural strength.

2. MATERIALS AND SPECIMEN PREPARATION

Dry wood is principally composed of cellulose, lignin, hemicelluloses, and minor amounts (5% to 10%) of extraneous materials. Cellulose, the major component, constitutes approximately 50% of wood substance by weight, is a high-molecular-weight linear polymer consisting of chains of 1 to more than 4 b-linked glucose monomers. Lignin constitutes 23% to 33% of the wood substance in Softwoods and 16% to 25% in hardwoods. Although lignin occurs in wood throughout the cell wall, it is concentrated toward the outside of the cells and between cells. Lignin is often called the cementing agent that binds individual cells together. The fiber lengths vary depending on the type of wood. Generally, deciduous wood fiber lengths are typically 1-1.5mm and coniferous fibers are 3-3.5mm. The commercially available sources of wood are sawdust, wood flour, wood fiber, and cellulose. Wood flour is a particulate form of wood and is obtained by drying sawdust. A range of particle size and distributions are available and the length to diameter ratio ranges from 2:1 to 4:1. Wood flour is available commercially and is graded by particle size ranges, i.e. 50-150µ, 100-200µ, 200-450µ and 250-700µ and bulk density is 0.1 - 0.3 g/cm^3.The epoxy LY554 is assorted with wood powder and wood flakes in a pre-measured ratio and is let it to soak for an overnight, then mixed with hardener HY951 and is poured into a mould. The mixture is rammed lightly to get off air in between and is left to settle for 24 hours to obtain the genuine wood composite material. Thus the wood composite material was synthesized. Three different compositions of wood powder epoxy resins used were:-

30% wood powder+70% epoxy resin
40% wood powder+60% epoxy resin
50% wood powder+50% epoxy resin

The specimens were made by making use of the above compositions and tested for its bending properties. Epoxy content of the blend for different compositions was selected based on its optimized value during composition testing.

2.1 MOLDING DESIGN FOR SPECIMEN TEST:

The dimension of the waste wood fibers composite was 300mm (L) x 300 mm (W) and the boards had 10 mm thickness. The required equipments for the mold that was used to lay the material down into mats were including glass, transparency plastic for the bottom layer and spacer frame.

2.2 EXPERIMENTAL PROCEDURE

Flexural test were performed on the same machine using the 3-point bending method according to ASTM D790. The specimen dimensions were 191 mm (L) x 12 mm (W) and had 10 mm thickness. The specimens were tested at a crosshead speed of 1 mm/min.

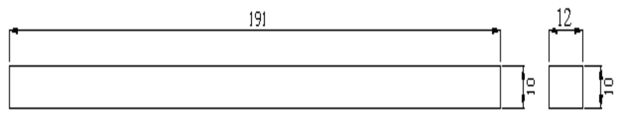

Fig. 1. Bending test Specimen

3.0 RESULTS AND DISCUSSION

The results obtained from the bending tests are presented in the graphs below.

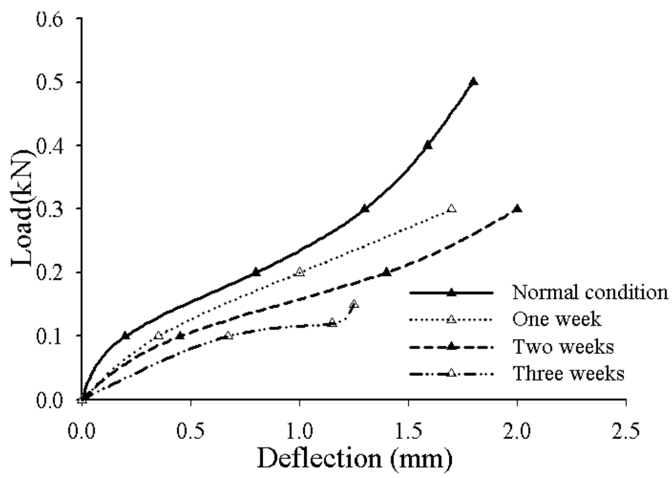

Fig. 2. 30% specimens soaked in sea water

The Fig.2 shows the curve of 30% bending specimen soaked in sea water for max of three weeks. It is observed that the load taking capacity of the specimen reduced as the weeks increased, as it is high in normal condition as 0.5KN. The flexural stress has reduced from 32 MPa to 15 MPa. The modulus of Elasticity has also reduced from 4 GPa to 1.7 GPa.

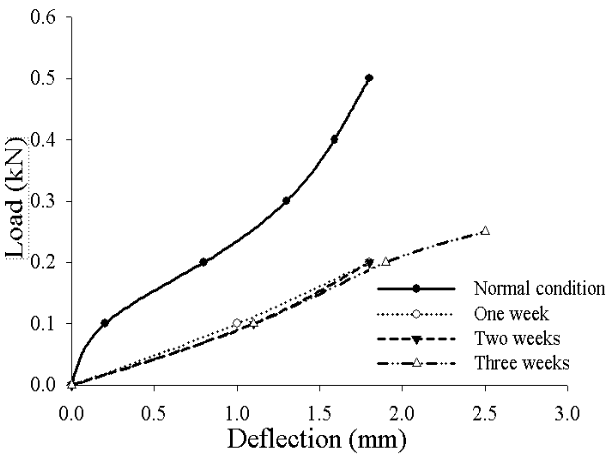

Fig. 3. 30% specimens soaked in drinking water

The Fig.3 illustrates the graph of 30% bending specimen soaked in drinking water. From the graph it is evident that the load taking capacity of the specimen reduced by the weeks, as it is high in normal condition as 0.5KN. But there is increase in deflection from 2 mm to 2.7 mm for fourth week. The flexural stress has reduced from 32 MPa to 26 MPa. The variation in the load to deflection for the specimen soaked from second to fourth is approximately linear.

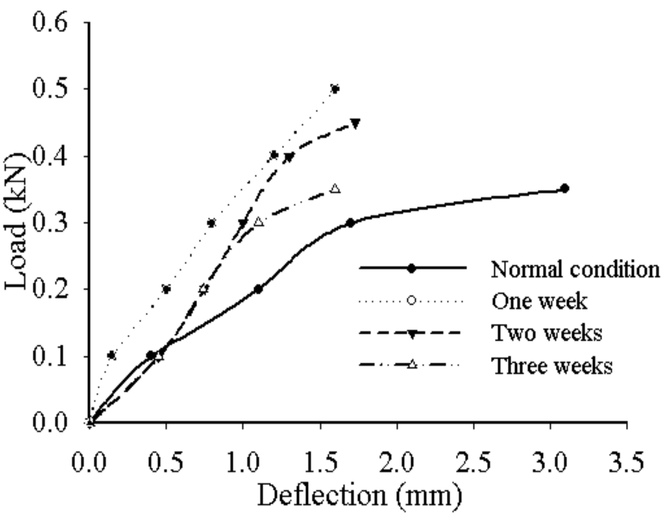

Fig. 4. 40% specimens soaked in Sea water

The Fig.4 portrays the 40% specimens soaked in sea water. The deflection of specimen has decreased from3.5 mm to 2 mm and the load bearing capacity 0.35 KN to 0.5 KN. The trend shows that there is increase in young's modulus from 0.68 to 1.33 GPa and reaches max of 1.98 GPa in the first week.

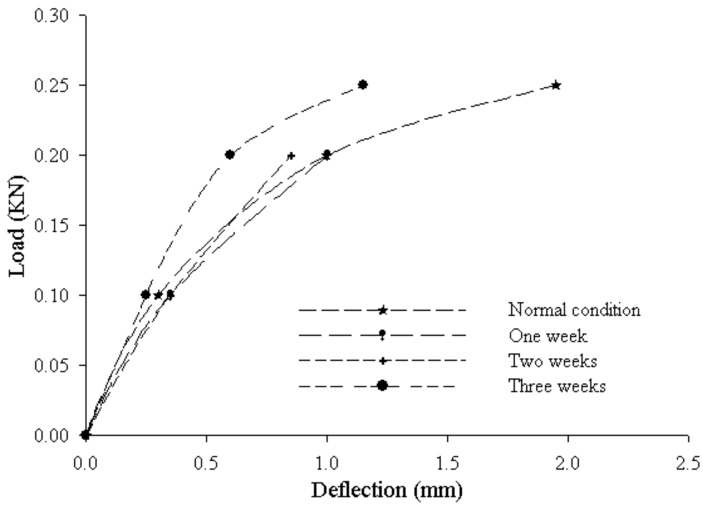

Fig. 5. 40% specimens soaked in drinking water

The Fig.5 demonstrates the graph of 40% tested specimens soaked in drinking water. The graph follows the comparative drift as that of Fig.5.

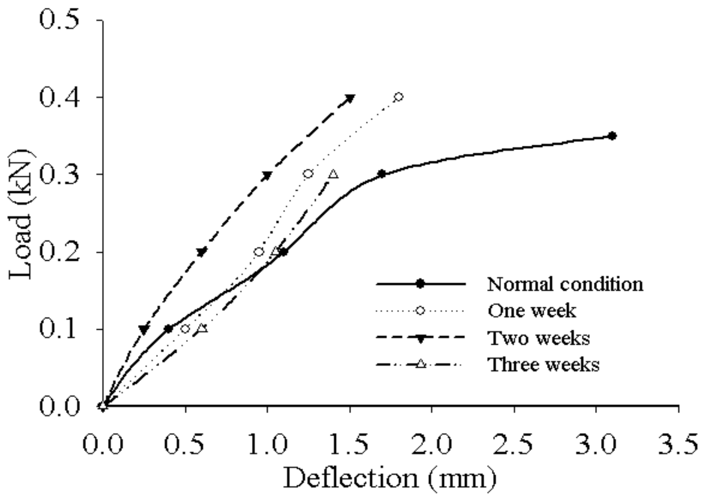

Fig. 6. 50% specimens soaked in sea water

The above fig.6 shows the graph of specimens soaked in sea water. It be can be observed that the load taking capacity of the specimen reduced by the weeks, as it is high in third week specimen as 0.25KN, but large deflection in normal specimen. It was noticed that the modulus of rupture has a constant for the varied two weeks. For the third week the modulus of rupture was found to be raised to the normal condition. The modulus of Elasticity was found to be increased from 0.65 GPa to 1.19 GPa.

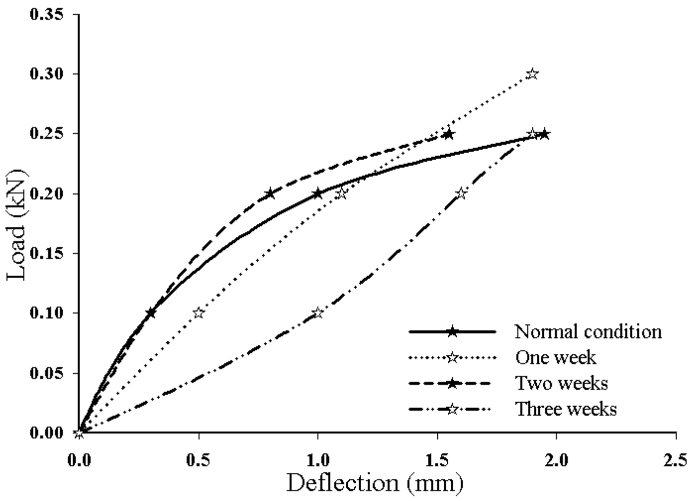

Fig. 7. 50% specimen soaked in drinking water

The Fig. 7 depicts 50% specimens soaked in sea water. It was observed that the load taking capacity of the specimen reduced by the weeks, as it is high in two week specimen as 0.3KN. By considering the normal condition and the third week specimens, it looks as if the material behavior has the mirror image

4.0 CONCLUSION

Based on the observation on this work following conclusions can be briefly summarized as follows. Bending tests were conducted to calculate the bending modulus of elasticity (MOE) and the modulus of rupture (MOR) for wood-composites. Test data consisted of load and center point deflection values. Specimen failure typically occurred directly under the load head, which is the location of the maximum moment. The failure was propagated on the tension (bottom) face of the specimen. The loss in bending strength with the addition of wood flour is inconsequential in service design because the MOE values of the lower wood percentage panels are unable to meet typical deflection requirements. Also, the bending MOR is decreased only 48% while the bending MOE increased by 90% comparing the 0% and 50% wood content mean values. 40% wood-filler content appears to be a practical choice for applications requiring a higher MOE. But for the same specimens tested under wetting conditions for different weeks, the behavior is not mimic. Further detail investigation is essential to predict the behavior.

REFERENCES

[1]Yang, H.-S., Kim, D.-J., Kim, H.-J. “Rice straw–wood particle composite for sound absorbing wooden construction materials”. Bio-resource. Technol. 86, 117– 121.

[2]Coutinho FMB, Costa THS, Carvalho DL. J Appl Polym Sci 1997;65:1227–35

[3]Balasuriya PW, Ye L, Mai YW, Wu J. J Appl Polym Sci 2002;83:2505–21.

[4]Wool RP, Raghavan D, Wagner GC, Billieu S. J Appl Polym Sci 2000;77:1643–57

[5]Sharma N, Chang LP, Chu YL, Ismail H, Mohd Ishak ZA. Polym Degrad Stab 2001;71:381–93

[6]Danjaji ID, Nawang R, Ishiaku US, Ismail H, Ishak ZA Mohd. J Appl Polym Sci 2000;79:29–37.

[7]La Mantia FP, Tzankova Dintcheva N, Morreale M, Vaca-Garcia C. Polym Int 2004;53:1888–91.

[8]Ballerini A. Fondef Project N D04I1185: Development of chemical additives from tall oil to improve the compatibility of wood–plastic composites.

[9]Charrier MP. Ploymeric materials and processing: plastics, elastomers, and composites. New York: Oxford University Press; 1991

[10]Groom L, Shaler SM, Mott L. “Mechanical properties of lignocellulosic fibers. In: Proceedings of wood fiber plastic composites”. Forest Products Society, Masidon, Wisconsin; 1996. p. 33–40.

[11]Simonsen J. “The mechanical properties of wood fiber–plastic composites: theoretical vs. experimental. In: Proceedings of wood fiber plastic composites”, Forest Products Society, Proceedings No. 7293.

[12]Nielsen LE, Landen RF. “Mechanical properties of polymer and composites”. New York, NY: Marcel Dekker, Inc; 1994

[13]Plueddemann EP. Silane coupling agents. New York, NY: Plenum Press; 1982 p:1–28.

[14]Verhey AS, Lacks EP, Richter LD, Keranen DE, Larkin MG. “Use of field takes to evaluate the decay resistance of wood fiber– thermoplastic composites”. Forest Products Journal 2002; 53(5):67–74.