MECHANICAL CHARACTERIZATION OF MMT NANO CLAY/EPOXY/ BASALT FIBER COMPOSITES

Susilendra Mutalikdesai, Vani R, Arpan Bhandari, Aishwarya Jain Y
Department of Mechanical Engineering, Yenepoya Institute of Technology, Moodbidri, India
arpanbhandary75@gmail.com

Abstract. The importance of composite fibers have been rapidly increasing since the inception of its discovery, in almost every engineering field. They possess beneficial properties such as low weight, high strength, highly resistive towards corrosion which makes them unique. The objective of present study is to fabricate composite using epoxy as polymer and basalt fiber as reinforcement and to investigate the influence of dispersing MMT Nano clay (Montmorillonite Nano-clay) in polymer. Conventional hand lay-up technique was used for the fabrication of composite laminate. The bi-directional basalt fiber was used as reinforcement and epoxy was taken as matrix material. Mechanical Characterization of MMT Nano clay/epoxy/basalt fiber composites was carried out for tests such as tensile, flexural and impact test, the results showed that the laminate had comprehensible properties, concluding usage of composite material is more beneficial and cost effective than conventional materials in many ways.

Keywords. Hand lay-up technique, Tensile Test, Flexural Test, Impact Test

1. Introduction
Two or more dissimilar material combined together forms a composite material which has the properties superior to its parent material. In the finished structure, the blended materials remain separate and distinct, differentiating composites from solid solutions and mixtures [1]. Researchers have started to include computation, sensing, communication and actuation into composite material known as Robotic Materials. Wattle and Daub is one of the oldest composite synthetic materials, more than 6000 years old. [2]. There are also greener ways of acquiring fibers from the nature which are eco-friendly and do not leave any traces behind at end life. Natural fibers can be obtained from plants, animals and many other sources as well. The world's second most plentiful natural polymer is Chitin, whereas collagen is first. It is a “linear polysaccharide of β-(1-4)-2-acetamido-2-deoxy-D-glucose” [3].

A notable change in the use of natural fibers was reported for the manufacture of composites all over the world [4-6]. Natural fibers, moreover, have the potential to replace synthetic fibers, such as glass, spandex, and nylon, in many ecological factors but not in respect of mechanical strength. Basalt fibers are extruded continuously from selected basalt stones (volcanic, effusive rocks with 45-25% silica) of high temperature melt (around 1500°C) [7]. The chemical structure of basalt fiber is similar to that of glass, with slightly higher density (0.26 g/cm3 than glass) [8]. The more important factor is that basalt fibers are chemically more stable when compared to glass fibers, especially in an acidic environment [9]. This allows basalt fibers for more effective binding to sizing agents, such as...
organ silanes, resulting in reduced usage of chemicals which has to be used along glass fibers [10]. Also, basalt fibers can be used in a wide range of temperatures, from 200°C to 600°C [11].

Synthetic resins are viscous substances that are industrially manufactured and processed into rigid/solid polymers through the curing process. Resins typically contain reactive end groups in order to undergo curing [12], such as acrylates or epoxides. Some synthetic resins may have identical qualities to natural plant resins, too [13]. Epoxy resin, made by polycondensation or polymerization-polyaddition reactions, is the classic variety used as a thermoset polymer for composites and adhesives [14]. Epoxy resin, seamless and waterproof, is two times stronger than concrete. Therefore, it has been primarily in use since the 1960s for commercial flooring purposes. However, since 2000, epoxy and polyurethane resins have also been used in interior designs, particularly in Western Europe.

In present work Nano composite is fabricated by dispersing MMT Nano clay with varying weight ratio 0%, 2%, 4%, 6% with epoxy resin (LY556) and basalt fiber as re-enforcement. The present work also focuses on mechanical characterization of MMT Nano clay (Montmorillonite Nano-clay) /epoxy/basalt fiber Nano composites.

2. Material selection, Fabrication and Material characterization

2.1. Material Selection

The details of the processing of the composites and the experimental procedures carried out for their characterization and tests to which the composite specimens are subjected are described in material selection and manufacture. In this job, the raw materials used are:

- Basalt fiber
- Nano clay-15A
- Synthetic Epoxy text.

2.1.1. Basalt fiber. A recent rise can be seen globally in the use of eco-friendly, natural fibres as reinforcement for the manufacture of lightweight, low-cost polymer composites. Basalt fibre, which provides outstanding properties over glass fibres, is one such material of interest currently being used extensively. High basic mechano-physio-chemical properties, synthetic degradability, and non-abrasive qualities, to name a few, are the prominent advantages of these composites. This paper provides a brief analysis of basalt fibres used as a composite reinforcement material and explores them as an alternative to the use of glass fibres. The paper also addresses the basics of and classification of basalt chemistry. In addition, the growing trend in research publications and activities in the field of basalt fibres is also discussed in an attempt to show. The improvement in mechanical, thermal and chemical resistant properties achieved for applications in specific industries is discussed in further sections.

2.1.2. Nano Clay. Nano clays are clay minerals designed for use in multi-functional structures with many property improvements aimed at unique applications in Nano composites. Polymer clay- Nano composites are a particularly well-researched class of materials of this kind. Nano clays are a wide class of naturally occurring inorganic minerals, the most widely used material applications of which are plaques such as montmorillonites. Nanoaoclay-15A was selected for the present job.

2.1.3. Epoxy LY 556. The chemically synthesised high molecular polymer is synthetic resin, short for resin. Therefore, after the name of the synthetic resin it is made from, various kinds of plastic can be named. Synthetic resin makes up 30% to ~60% or more of its composition, the essential raw material of plastic. It has the feature of agglutination, not only binding together but also binding strongly together the other materials. The physical and mechanical properties of plastic often change as the form, property, and amount of synthetic resin change. The key characteristics of plastic are therefore based on the synthetic resin from which it is made. LY 556 is a medium viscosity epoxy resin based on bisphenol-A with excellent mechanical properties which can be modified by using different hardeners as well as fillers.

2.2. Fabrication. The composite laminate fabrications are carried out using traditional hand lay-up techniques. The bi-directional basalt fibre is used as a reinforcement and the matrix content taken is epoxy LY556. Basalt fibre is manufactured by Nickunje Exhimp Entp P Ltd. Zenith Polymers India Ltd supplied with epoxy resin and the accompanying hardener. The synthetic epoxy resin and hardener are combined by weight percentage at a ratio of 10:1. Composites of varying compositions with three
distinct filler content percentage. The most commonly used and simple process for producing fibre-reinforced polymer composites is the hand lay-up technique. Hand Layup technique was adopted for fabrication of laminates. Number of fibre layers and weight of resin mixture was taken according for calculation. Apply resin layer by layer by using hand lay-up method. For curing, the laminate is kept for 24 hours of recovery at room temperature. After curing specimens of standard sizes are cut from laminates for different mechanical testing.

2.3. Material Characterization. On prepared laminates, the mechanical properties of basalt and Nano clay composites have been determined. In compliance with ASTM standards ASTMD 638 and ASTMD 790, tensile and flexural tests were performed on the universal test unit. The tensile test is the most widely used mechanical test in which the sample is steadily loaded until it breaks or fails. One of the main mechanical properties of any material is flexural strength. Flexural strength is the ability of the composite material to withstand bending forces applied perpendicular to its longitudinal axis before the three-point flexural test technique breaks or begins to yield permanently. Impact strength is the material's ability to withstand a suddenly applied load, or it can also be described as the material's ability to absorb mechanical energy in the deformation and fracture process under impact loading. Impact experiments were carried out on the impact measuring unit, according to ASTMD 179EU.

3. Result

3.1. Tensile test. The specimen has been prepared in compliance with the ASTMD 638 requirements and it can be inferred by examining tensile tests for various composites that the dispersion of filler content in synthetic epoxy resin results in a decrease in tensile strength. Synthetic epoxy basalt composite with 0% filler content having 388MPa has demonstrated material tensile strength.

![Figure 1. Tensile strength of different laminates](image1.png)

![Figure 2. Tensile test specimens (a) before (b) after](image2.png)

3.2. Flexural Test. According to the ASTMD 790 standards the specimen has prepared and tested. From graph analysis and test it is obtained that composite Nano clay as the filler material 2% has exhibit good flexural strength 387MPa compared to others.
3.3. Impact Test. According to the ASTM D 1796 EU standards the specimen has prepared and tested. From graph analysis and test we concluded that 6% Nano clay has good impact strength 153.34kJ/m² compared other.

4. Conclusion
Experimental tests were conducted on basalt fibre reinforced plastic laminates with Nano clay dispersed by 0%, 2%, 4%, and 6%. Mechanical experiments have been carried out, such as tensile tests, bending tests and impact tests.

Findings on examination of materials and conclusions, based on the experimental results and analysis, the following conclusions were arrived at,

- Tensile measurements also helped assess the tensile strengths of various percentages of fillers.
388MPa, 377MPa, 347MPa and 295MPa respectively are the tensile strength of laminates with 0 percent, 2 percent, 4 percent and 6 percent Nano clay fillers. The findings show that the tensile strength of the material is not quite appreciable with the addition of filler to the composites.

The overall obtained flexural strength was 2 percent Nano clay 387MPa. Followed by 0 percent Nano clay 369MPa, 4 percent Nano clay has 347MPa and 6 percent Nano clay has 324MPa. Improves the flexural strength of composites by specifically showing the inclusion of filler.

With the addition of fillers, impact strength has also increased. The impact strength of 153.43kJ/m² is improved by 6% Nano clay.

References
[1] Fazeli, Mahyar; Florez, Jennifer Paola; Simão and Renata Antoun (April 2019). Improvement in adhesion of cellulose fibers to the thermoplastic starch matrix by plasma treatment modification. Composites Part B: Engineering. 163: 207–216.
[2] Shaffer and Gary D. (Spring 1993). An Archaeomagnetic Study of a Wattle and Daub Building Collapse. Journal of Field Archaeology. 20 (1): 59–75.
[3] Meyers, M.A.; Chen and P.Y. (2014). Biological Materials Science. United Kingdom: Cambridge University Press.
[4] Maya Jacob John and Sabu Thomas, Biofibers and biocomposites. Carbohydr. Polym 2008; 71(3):343-64.
[5] Uma Devi L, Bhagawan S S and Sabu Thomas, Mechanical properties of pineapple leaf fiber-reinforced polyester composites. J. Appl. Polym. Sci 1997; 64(9):1739-48
[6] Murali Mohan Rao K, Mohana Rao K and Ratna Prasad A V, Fabrication and testing of natural fiber composites: vakka, sisal, bamboo and banana. Mater. Des2010; 31(1): 508-813.
[7] Czigány T and Vad JPK. Basalt fiber as reinforcement of polymer composites. Period Polytech Mech Eng 2005; 49:3–14
[8] Susilendra Mutalikdesai, G. Sujaykumar, Amal Raju, C. J. Moses, Jithin Jose and Vishak Lakshmanan, Mechanical Characterization of Epoxy/ Basalt Fiber/ Flax Fiber Hybrid Composites. American Journal of Materials Science 2017, 7(4): 91-94 DOI: 10.5923/j.materials.20170704.04.
[9] Wei B, Cao H and Song S. Environmental resistance and mechanical performance of basalt and glass fibers. Mater Sci Eng A 2010; 527:4708–15.
[10] Ivashchenko E. Sizing and finishing agents for basalt and glass fibers. Theor Found Chem Eng 2009; 43:511–6.
[11] Deak T and Czigany T. Chemical composition and mechanical properties of basalt and glass fibers: a comparison. Text Res J 2009; 79:645–51.
[12] Chemistry, International Union of Pure and Applied. IUPAC Compendium of Chemical Terminology. iupac.org. IUPAC. doi:10.1351/goldbook.RT07166
[13] Collin and Gerd; et al. (2005). "Resins, Synthetic". Ullmann's Encyclopedia of Industrial Chemistry. Weinheim: Wiley-VCH. doi:10.1002/14356007.a23_089. ISBN 3527306730.
[14] Cripps and David. "Epoxy Resins". NetComposites. Retrieved 28 September 2018.