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Hygrothermal effect on natural frequency and damping characteristics of basalt/epoxy composites

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Abstract

This research focuses on the experimental and analytical study of hygrothermal effects on natural frequency of fibre reinforced plastic composites. Fiber reinforced composites are widely used in structural applications like aero industry, marine industry, civil industry ext; due to its good strength and stiffness. But these composites absorb moisture or water when it is used in the moisture environment and the composites will be swollen and which reduces the strength and stiffness of the material. This moisture may lead to reduction of strength and stiffness Natural frequency of materials is connected to stiffness of the material. This work is concentrated on how the natural frequency of Basalt Fiber reinforced composites (BFRP) are affected due to weave pattern, thickness of the material, water absorption at various immersion conditions. Three types of Basalt fabrics are selected (Plain weave, twill weave and qudraxial) BFRP composites with two different thickness(3mm, 5mm)are fabricated using hand lay-up process..Fabrication of composite materials using basalt fibres has been done. We have chosen materials with two different thickness and also basalt fibre with different weave patterns. The experimental setup for beams has been done. Moisture absorption co-efficient is determined by immersing the material in mineral water at various time durations. Modal analysis have been carried out to determine the natural frequency and damping coefficient for BFRP composites with three different weave patterns and two different thickness. Results shows that damping coefficient varies with weave pattern and moisture conditions.

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*Keywords:*Hygrothermal, Fiber orientaions, BFRP composites, Natural frequency, Damping coefficient.

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1. 1. INTRODUCTION

Fiber reinforced plastics (FRP) composites are available in various forms like unidirectional fiber, bidirectional Woven fabrics, twill weave, quadraxial fiber etc. Basalt fiber is one of the structural fiber recently developed from molten lava called basalt rock. Composites made out of basalt are having very good static and dynamic properties. Due to these properties, Basalt Fiber reinforced composite (BFRP) can be used for various structural applications like ship building, aircraft constructions, automobile applications etc. Aircraft structures are subjected to aerodynamic flutter during their service, due to air load. At resonance the structure may fail. This can be controlled by structural damping. Many research works have been carried out in the dynamic characteristics of composite material [1-6]. Biggerstaff J.M and Kishi.H et al proved that through toughening of polymer matrix the damping effect can be improved[7,8].Senthil Kumar et.al proved that an increase in fibre content increases the mechanical and damping properties in natural composites[9]. XuLe et.al. have proved the natural frequency and damping coefficients of Glass fibre reinforced composites are varying with respect to weave pattern. Very less works have been carried out based on weave pattern of BFRP composites. In this present research work the variation of natural frequency and damping characteristics of BFRP composites with respect to weave pattern, thickness and various hygrothermal conditions.

2. 2. Experimental Details

2.1Materials

Basalt fibre of plain weave, twill weave and quadraxial fibre purchased from Germany were used as reinforcement materials and epoxy LY556 and Hardener HY951 purchased from Javanthi Enterprises, Chennai, India were used as matrix materials.

2.2 Fabrication of laminate and Mechanical testing

Three laminates were prepared by using hand layup process of size 300mmx300mmx3mm. Plain weave, twill weave and quadraxial respectively. And other three laminates with 5mm thick with same material as mentioned above. The resin and hardener are mixed at 10:1 ratio. The hardener is mixed with the resin to speed up the curing these laminates were cured at room temperature conditions for 24 hours. The volume fraction of the fibre is measured using burning test. The fibre resin volume fractions are found to be approximately 60:40.Specimens were prepared as per ASTM standards for mechanical testing and vibration testing.

2.3Hygrothermal treatment

Specimens of 40mmx250mm size were cut from each laminate (from all 6 laminates) for vibration test. One set is used for vibration analysis at room temperature, one set weighed individually by using electronic balance and immersed inside the distilled water for one week time, another set of specimens were immersed inside distilled water for two weeks and the fourth set of specimens were immersed inside the distilled water for about one month. Specimens are immersed inside the water to check the variation of natural frequency and damping coefficient variation due to moisture absorption with respect to time.

2.4 Modal Analysis

Modal analysis test is carried out in order to get the dynamic response of the BFRP materials as a combination of its modes, modal frequencies and damping ratios .The experimental set up used for free vibration analysis is shown in fig 1.The test is carried out for all 24 specimens. Only cantilever condition is used for all specimens. Accelerometer is attached at the free end of the beam and attached to the one of the channels of 16 channels Data Acquisition System (DAQ) and the free vibration is generated by using a hammer. One adapter is used to receive