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Research Paper

PREPARATION AND EVALUATION OF MECHANICAL AND WEAR PROPERTIES OF HYBRID FRP COMPOSITES

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The technologically advancing society is continuously challenging the limits of conventional materials and placing newer demands on material performance. Composite materials form a material system composed of a mixture or combination and are insoluble in each other. Composite material comes under one class of engineered material developed specifically to meet such a challenge. Glass fiber reinforced resin matrix composites were first introduced in the early 1940s. Since then, the use of composites is growing steadily in various industries such as aircraft, marine, automobile, sporting goods, etc. Some of the advantages of composites include high specific strength, high specific stiffness, fatigue strength and impact resistance, thermal conductivity, corrosion resistance, and good dimensional stability. Composite materials are usually designed to possess certain specific properties desirable in that application. Unusual combination of properties not easily obtainable with alloys such as higher fracture toughness, higher oxidation and corrosion resistance, directional properties, good resistance to heat, cold and moisture, ease of fabrication and low cost could be brought out; of course, not all together simultaneously. In our project work we have developed hybrid FRP composites (Glass and Fly ash reinforced vinyl ester polymer) using hand lay-up process. The materials are subjected to tensile and bending tests as per ASTM standards.

Keywords: FRP, Glass-fiber, Flyash, Vinyl ester, Hand lay-up method, ASTM standards

INTRODUCTION

Polymer Matrix Composites (PMCs) are increasingly becoming attractive materials for advanced aerospace applications because their properties can be tailored through the addition of selected reinforcements (Pihtili and Tosun, 2002; and Amar and Mahapatra, 2009). In particular, Fiber Reinforced Plastics (FRP) have recently found special interest because of their specific strength and specific stiffness

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at room or elevated temperatures (Chauhan *et al.*, 2009). The various reinforcements that have been tried out to develop Polymer Matrix Composites (PMCs) are E-glass fiber, silicon carbide, titanium carbide, tungsten, boron, Al_2O_3, flyash, Zr, TiB_2. Addition of hard reinforcements such as silicon carbide, alumina, and titanium carbide improves hardness, strength and wear resistance of the composites (Amar and Mahapatra, 2009; and Chauhan *et al.*, 2009). Vinyl ester based polymer Matrix Composites (PMCs) has received increasing attention in recent decades as engineering materials. The introduction of a glass fiber into a polymer matrix produces a composite material that results in an attractive combination of physical and mechanical properties which cannot be obtained with monolithic alloys (Schwartz, 1984). The Fiber reinforced PMCs is mainly used due to easy availability of glass fibers and economic processing technique adopted for producing the Fiber-reinforced PMCs. Vinyl ester based polymer-reinforced composites have a large potential for a number of engineering applications. Interest in reinforcing glass fiber in vinyl ester matrices along with fly ash is mainly due to the low density, low coefficient of thermal expansion and high strength of the reinforcements and also due to their wide availability. Among the various useful polymer matrices, vinyl ester is typically characterized by properties such as fluidity, corrosion resistance and high strength-weight ratio (Piggot, 1980; Kukureka *et al.*, 1999; and Suresha *et al.*, 2007). Amongst different kinds of the recently developed composites, Fiber-reinforced polymer matrix composites have already emerged as candidates for industrial applications.

In the present work attempt has been made to study the influence of glass fiber/fly ash addition on the mechanical and wear behavior of vinyl ester polymer matrix. For this purpose 5wt%, 10wt% and 20wt% of fly ash is added to glass fiber/vinyl ester PMC's to evaluate mechanical and tribological properties as per the ASTM standards.

EXPERIMENTAL DETAILS

The following section highlights the material, its properties and methods of composite preparation and testing.

Materials Used

Vinyl Ester is a resin produced by the esterification of an epoxy resin with an unsaturated monocarboxylic acid. The reaction product is then dissolved in a reactive solvent, such as styrene, to 35-45% content by weight. It can be used as an alternative to polyester and epoxy materials in matrix or composite materials, where its characteristics, strengths, and bulk cost intermediate between polyester and epoxy. Vinyl ester has lower resin viscosity (approx 200 cps) than polyester (approx 500 cps) and epoxy (approx 900 cps).

The vinyl ester resin used for our experiment is polyflex GR-200-60 which is a general purpose resin. The resin combines the strength properties of epoxy resins and ease of processing of unsaturated polyester resins. It is based on bisphenol epoxy backbone and is known for its outstanding long-term performance at elevated temperatures and under stress conditions. GR 200-60 is easily processible using FRP making techniques such as layup, spray up and filament winding, etc.

Resin (POLYFLEX GR 200-60): 100 gms

Accelerator (3% cobalt octoate): 1.5 ml

Promoter (10% N, N-dimethyl aniline): 1.5 ml

Catalyst (50% methyl ethyl ketone peroxide): 1.5 ml

Preparation of Composites

Hand layup technique is the basic manufacturing technique used for the manufacture of FRP composites.

Testing of Composites

The obtained hybrid FRP composites are subjected to tensile tests as per ASTM standards D3039-76. The tensile strength parameters of specimens were shown in Table 1 and the Tensile tested specimens were shown in Figure 1.

Table 1: Tensile Strength of A, B, C and D Specimens

Specimens	Tensile Strength (MPa) (Average of 3 Readings)
A	129.52
B	132.79
C	135.63
D	138.48

Figure 1: Tensile Specimens with 0%, 5%, 10% and 20% Fly Ash Content

RESULTS AND DISCUSSION

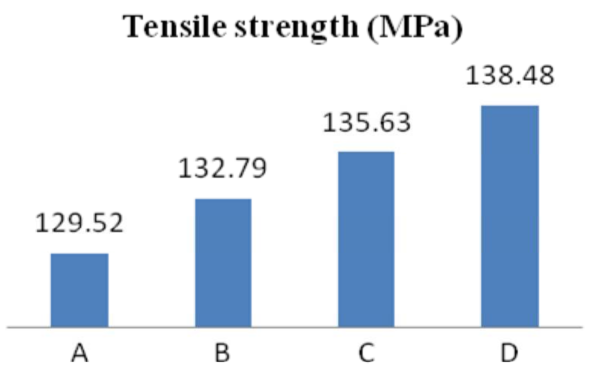
Tensile Strength

- A – 0% Fly ash content, vinyl ester, E-glass fiber.
- B – 5% Fly ash content, vinyl ester, E-glass fiber.
- C – 10% Fly ash content, vinyl ester, E-glass fiber.
- D – 20% Fly ash content, vinyl ester, E-glass fiber.

Tensile Strength

From the study of Figure 2 it can be seen that the tensile strength increases with increasing percentage of fly ash content.

Figure 2: Showing Bar Graph Representation of Tensile Strengths



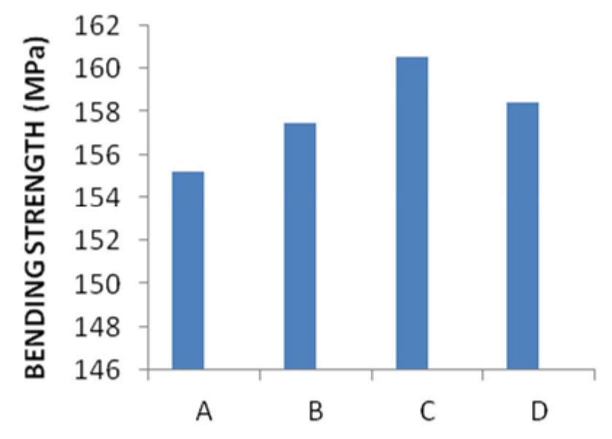
Three Point Bending Test

Three point bending test is performed as per ASTM Standards D790-1 (Table 2 and Figure 3).

Table 2: Experimental Parameters of Bending Specimens

Specimens	Flextural Strength (MPa)
A	155.22
B	157.45
C	160.53
D	158.42

Figure 3: Bar Graph Representation of Bending Strength



CONCLUSION

- Experimental evaluation of mechanical properties like tensile and bending strength on hybrid FRP composite as per ASTM standards has been successfully completed.
- Displacement increases with increase in tensile load which is indicated in the graphs.
- Tensile strength increases with increasing percentage of Fly ash content.
- Tensile modulus increases with increasing percentage of Fly ash content.
- Bending strength increases with increasing percentage of Fly ash upto 10% and thereafter a marginal decrease in bending strength is observed. This may be due to improper wetting among matrix and fiber. It may cause delamination or leads to first fly failure at considerably lower load.

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