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Analytical and Experimental Investigation of Adhesive Bonded GFRP Nano Composites and M.S Girders

¹R.Vigithra, ²K. Raja Karthikeyan, ³V. Sharun, ⁴S. Shanmugasundaram and ⁵D. Joseph Manuel

¹Assistant Professor-(Grade-1)Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India

²Assistant Professor Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India.

³Assistant Professor Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India.

⁴Assistant Professor-(G-1) Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India

⁵Assistant Professor Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India

Address For Correspondence:

R.Vigithra, Assistant Professor-(Grade-1) Department of Mechanical Engineering Panimalar Institute of Technology Chennai-600123, TN, India.

E-mail: vige23@gmail.com

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ABSTRACT

As the application has huge demand in Fiber reinforced polymer (FRPs) composites, they have been applied in a many application like aero modeling, automotive, ships and constructional work. GFRP has Omni-potential properties such as in specific strength, in specific stiffness, with good damping, less thermal expansion, great dimensional stability, design flexibility, etc. A great deal of work has been done already which discuss about the mechanical behavior of glass fiber reinforced polymer composites based on ASTM (Plastic) standards. Against this background, the present research work has been undertaken with the aim, to find out both the physical and mechanical behavior of GFRP based on ASTM (Composite) standards. The objective of the present work is to study about the physical and mechanical behavior of GFRP composites. Also this work includes the investigation of the behavior of adhesively bonded GFRP composites with steel girders. In this work E-glass fiber is used as reinforcing agent with the epoxy matrix. GFRP composites are fabricated by both Pultrusion and Sheet molding compound process. This research work results in comparing the values of testing of GFRP composites by both the ASTM standards, the best suited adhesive for bonding of composites is selected based on the results. Also the behavior of adhesively bonded of GFRP composites with steel girders is experimentally studied.

INTRODUCTION

Composites are one of the most increasingly used important engineering materials. Progresses in the field of materials science and technology have given birth too many new composite materials (Jen, Y.M., 2012).

Composites are heterogeneous in nature, developed by the assembly of many components with fillers or reinforcing fibers and a compactable matrix.

The matrix may be metallic in nature, ceramic or polymeric by birth. It gives the composites in its shape, appearance, overall tolerance and increased in durability while the fibrous reinforcement carries most of the structural loads thus giving macroscopic stiffness and strength. A composite material provides versatile and unique mechanical and physical properties because it combines the most desirable ultimate properties of its constituents while suppressing their least desirable properties (Ishii, K., 1998). At present these materials play a master role in aerospace, shipbuilding, automobile industry and other than engineering applications as they show outstanding rigid strength to weight and modulus to weight ratio. High performance rigid composites made from glasses, graphite's, boron or silicon carbide fibers in polymeric matrices have been vastly studied because of their application in aero modeling and space automotive vehicle technology.

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A. *Fiber Reinforced Composites:*

Fiber reinforced composites persist reinforcements which has lengths higher than cross sectional dimension. Fibrous reinforcement suits physicals rather than a chemical means of changing a material to suit various engineering applications. This is widely classified as reinforcing fiber in a single layer composite may be short or long based on its overall dimensions (Yang, Z., 2011).

Composites of long fibers are called continuous fiber reinforcement and composite of short or staple fibers are enhanced in the matrix are termed as discontinuous fiber reinforcement (short fiber composites).

a. *Hybrid composites:*

Composite materials are associated with more than two different types of fillers especially fibers in a individual matrix are most generally known as hybrid composites. Hybridisation is commonly used to improve the properties and for reducing the cost of conventional composite materials (Moroni, F., 2010).

There are various types of hybrid composites characterized as: Interplay or tow-by-tow, in which tows of more the two constituent types of fiber are mixed with one on one (regular) or random manner; sandwich hybrids, also known as core-shell, in which one material is arranged like a sandwich between two layers of another; Interplay or laminated, where alternate layers of the two (or more) materials are stacked in the form of regular manner; the mixed hybrids, where the constituent fibers are prepared to mix as randomly as easy as possible so that it doesn't exceeds-concentration of any one type is present in the material; Other kinds, such as those are reinforced with external ribs, Pultruded thin wires, thin veils of fiber or combinations of the above.

b. *Laminates:*

A laminate is one of the most fabricated by stacking all number of laminate in the thickness direction. Generally three layers are arranged one by one alternatively for good bonding between reinforcement and the polymer matrix, for example plywood and paper can be considered.

B. *Particulate Reinforced Composites:*

A composite whose reinforcement in a particle with all the dimensions roughly equal are called particulate reinforced composites. Particulate filler materials are employed to improve high temperature performance, minimize the friction, increase wear resistance and to reduce shrinkage (Ishii, K., 1998). The particles will also share the load with the matrix, but to a lesser extent compared than a fiber. A particulate reinforcement will therefore keep improving the stiffness but will not generally strengthen.

Advantages of Composites:

Lower density
Higher Fatigue endurance.
Higher toughness than ceramics and glasses.
Versatility and tailoring by design.
Easy to machine.

Disadvantages of Composites:

Low recyclability.
Cost can fluctuate.
Can be damaged.
Anisotropic properties.
Low reusability.



Fig. 1: GFRP composite materials used Pultruded bar (160*55*20 mm).



Fig. 2: SMC bar (160*55*20 mm).

II. Properties To Be Tested:

Table 1: Astm Standards Used For Testing.

Mechanical Properties	ASTM Standards
Tensile Strength	D638
Tensile Modulus	D638
Tensile elongation	D638
Compressive strength	D695
Compressive modulus	D695
Flexural strength	D790
Shear strength	D2344

Table 2:

Physical Properties	ASTM standards
Water Absorption	D570
Density	D792
Specific Gravity	D792
Fibre Weight Fraction	D3171

ASTM D638:

Tensile Strength
Tensile Modulus
Tensile elongation



Fig. 3: Pultruded bar (170*19*6 mm).



Fig. 4: SMC bar (170*19*6 mm).

ASTM D695:

Compressive strength
Compressive modulus



Fig. 5: Pultruded bar (30*10 mm).



Fig. 6: SMC bar (30*10 mm).

ASTM D790:

Flexural strength



Fig. 7: Pultruded bar (100*12.7*6 mm).



Fig. 8: SMC bar (100*12.7*6 mm).

ASTM D2344:
Shear strength



Fig. 9: Pultruded bar (65.5*12.7*6 mm).



Fig. 10: SMC bar (65.5*12.7*6 mm).

III. Testing Instrument Used & Tests Performed:

A. UTM (Universal Testing Machine)



Fig. 11: Pultruded bar Before test.



Fig. 12: After Test.



Fig. 13: SMC bar Before test.



Fig. 14: After Test.

Compressive Test:



Fig. 15: Pultruded bar Before test.



Fig. 16: After test.



Fig. 17: SMC bar Before Test.



Fig. 18: After test.



Fig. 19: Pultruded bar Before test.

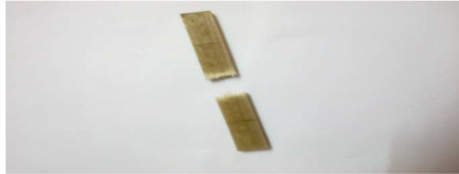


Fig. 20: After test.

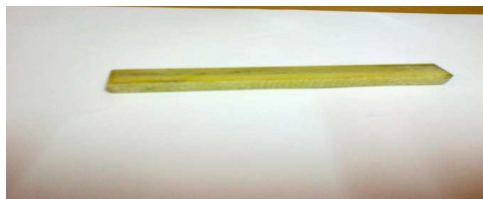


Fig. 21: SMC bar Before test.



Fig. 22: After test.



Fig. 23: Shear Test Pultruded bar Before test.



Fig. 24: After test.



Fig.25: SMC bar Before test.



Fig. 26: After test.

IV. Results:

Table 3: Gfrp Materials Properties.

Mechanical Properties	ASTM Standards	Units	Value
Tensile Strength	D638	MPa	562
Tensile Modulus	D638	MPa	3875
Tensile elongation	D638	%	15.50
Compressive strength	D695	MPa	475
Compressive modulus	D695	MPa	13194
Flexural strength	D790	MPa	82
Shear strength	D2344	MPa	235

Table 4: Physical Properties.

Physical Properties	ASTM Standards	units	value
Water Absorption	D570	%max	0.001
Density	D792	Kg/m ³	2150
Specific Gravity	D792	-	2.15
Fibre Weight Fraction	D3171	%	80

Table 5: Smc Bar Mechanical Properties.

Mechanical Properties	ASTM Standards	Units	Value
Tensile Strength	D638	MPa	410
Tensile Modulus	D638	MPa	3215
Tensile elongation	D638	%	17.30
Compressive strength	D695	MPa	314
Compressive modulus	D695	MPa	10130
Flexural strength	D790	MPa	58
Shear strength	D2344	MPa	204

Table 6: Physical Properties.

Physical Properties	ASTM Standards	Units	Value
Water Absorption	D570	%max	0.001
Density	D792	Kg/m ³	2110
Specific Gravity	D792	-	2.11
Fibre Weight Fraction	D3171	%	70

Conclusion:

As per the current scenerio the wide usage of composite materials have been bloomed. In this work the various tests are conducted for various properties with different testing machine.

This research work results in comparing the values of testing of GFRP composites by both the ASTM standards, the best suited adhesive for bonding of composites is selected based on the results. Also the behavior of adhesively bonded of GFRP composites with steel girders is experimentally studied.

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