AC Load Effects on Mechanical properties of Glass fiber-reinforced polymers Laminates

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Abstract- **The demand for Glass fiber-reinforced polymers (GFRPs) in rehabilitation of infrastructure is increasing. New techniques use the light weight, high strength, and formability of GFRP fabrics and laminates in various applications. This paper presents the behavior of different types of GFRP laminates under load conditions produced using resin transfer moulding technique. Now days this technique is the most used in field and industrial applications of GFRPs like automotive structures. The scope of the paper is limited to only one mode of failure that is laminate failure under loading. It is noted that another form of failure is the bond at the interface. A total of 50 specimens were prepared using polyester and glass fiber with unidirectional fabrics in this study. The samples were exposed to normal environments and subjected to tensile test, flexural test and bending test. The results showed a significant ultimate tensile strength , breaking strength and bending load where glass FRP (GFRP crack was initiated at different Weight fraction of fibre and matrix.**

Index Terms- **Glass fiber; fiber-reinforced polymer; Resin transfer moulding machine technique ultimate tensile strength and breaking strength.**

I. INTRODUCTION

Fiber-reinforced polymers (FRP) are increasingly attracting the attention of mechanical and civil engineers because of their unique properties for retrofitting of structures. The excellent tensile strength, light weight, resistance to electrochemical corrosion, and formability of FRPs make them materials of choice for repair and retrofit of automotive structures. These materials have been used in different engineering fields, such as aerospace, automotive, marine, and chemical, for many years; and, in general, they have shown good long-term performance. The methods of fabrication and quality control in mechanical and civil engineering projects, however, are quite different from those in the aerospace or defense industry. In this study, the authors attempted to simulate the process that is used to install FRP in different structures to achieve realistic results of the long-term performance, as such performance is greatly affected by the manufacturing process. The purpose of this research was to look at the behavior of the resin transfer moulding technique of applying FRP to different automotive and civil structures, which is by far the most common method of application in construction. Due to the many sources of imperfection in hand application in the field, as compared to the machine application in controlled manufacturing facilities, the durability issues of resin transfer moulding methods are quite different than those of FRP produced in factory settings.

In addition, the FRP used in civil engineering projects are exposed to different environments than those in other fields of engineering. Therefore, to address the rising concerns about the long-term performance of FRP in civil engineering projects, durability of these materials must be investigated according to the installation process and the unique civil engineering environments that they will be exposed to several investigators have addressed the durability of FRP materials. Most of the research was concentrated on the effect of the moisture and temperature on FRP tendons, reinforcing bars, pultruded sections, and laminates made with standard vacuum bagging procedures under controlled temperature and curing cycles.1-2 The results of such studies have been used initially to answer some of the concerns of structural engineers. Because the durability of FRP materials is significantly affected by their manufacturing process and quality control, however, studies are needed to address durability issues specifically for the type of projects involving the wet lay-up procedures as used in construction.

RESEARCH SIGNIFICANCE

During the past decade, FRPs have been used in numerous projects to increase the capacity of existing automotive parts concrete bridges and buildings. Many investigations have shown the effectiveness of these materials for increasing the strength and ductility of existing field of applications. There is significant concern in the industry, however, as to the long-term performance of these materials. This research addresses this important question by examining the load effects on the mechanical properties of FRPs that are produced in a manner typical of that used in construction and subjected to simulated mechanical and civil engineering environments.

II. EXPERIMENTAL METHODOLOGY

2.1 Production of laminates using RTM

The materials used for production of GFRP laminates using resin transfer moulding machine (RTM) are E-Glass fibre as reinforcement material which is supplied by Leo enterprises, Nagercoil,India, General purpose polyester resin, accelerator as cobalt nathylene and catalyst as methyl ethyl keypricperoxide. The Resin transfer moulding (RTM) machine which has a closed mould process and consists of resin injection equipment. The resin injection equipment has a hollow cylinder fitted with pressure gauge, valve and pressure pump and mould plates as shown Fig.1. The glass fibre mats are placed in mould cavity and and polyester resin mixed with 2% of accelerator (cobalt nathylene) and 2% of catalyst (methyl ethyl keypricperoxide) then poured into the cylinder through the valve. The weight fraction of glass fibre and resin at ratio of 60:40. The mould allowed to solidification for 4 to 5 hourse then open the mould cavity remove laminate from the mould. This laminate is converted into test specimens as per the standarded of ASTM D 638.

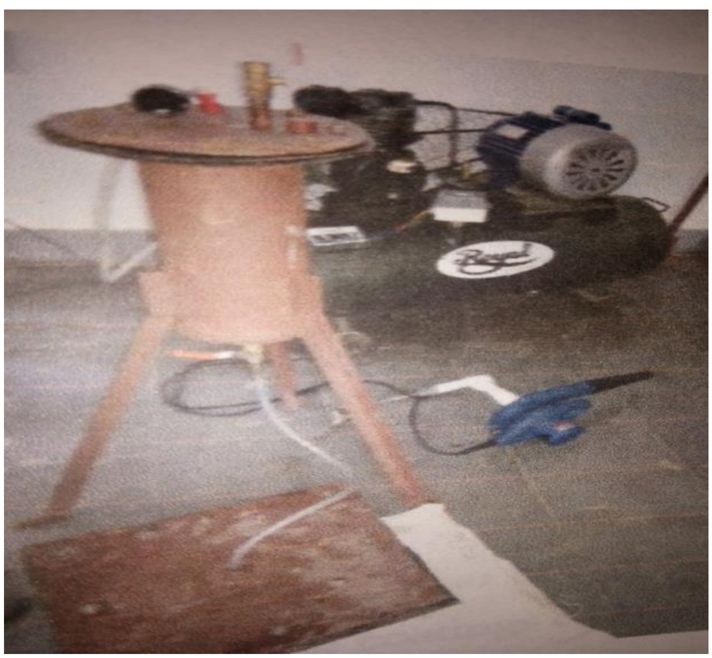

Figure 1. Resin transfer molding machine

2.2 Testing of the GFRP Specimens

The number of specimens are prepared as per the standarded and carriedout tensile test , flexural test and bending test.

2.2.1 Tensile Test

The prepared tensile specimens as per the standard ASTM D 638 as shown in fig.2. Tensile test is carried out on glass fibre specimens to know the ultimate tensile strength and cross breaking strength. The mechanical properties of materials are determined by performing carefully designed laboratory experiments that replicate as nearly as possible the service conditions. The results are presented in table.1.

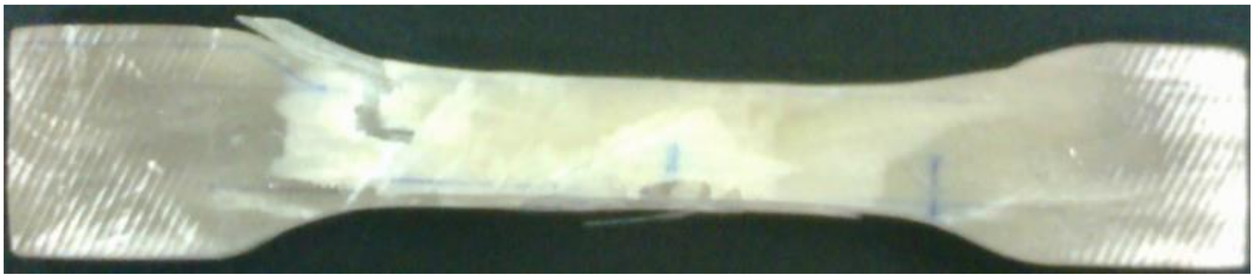

Figure 2 Tensile test specimen before testing

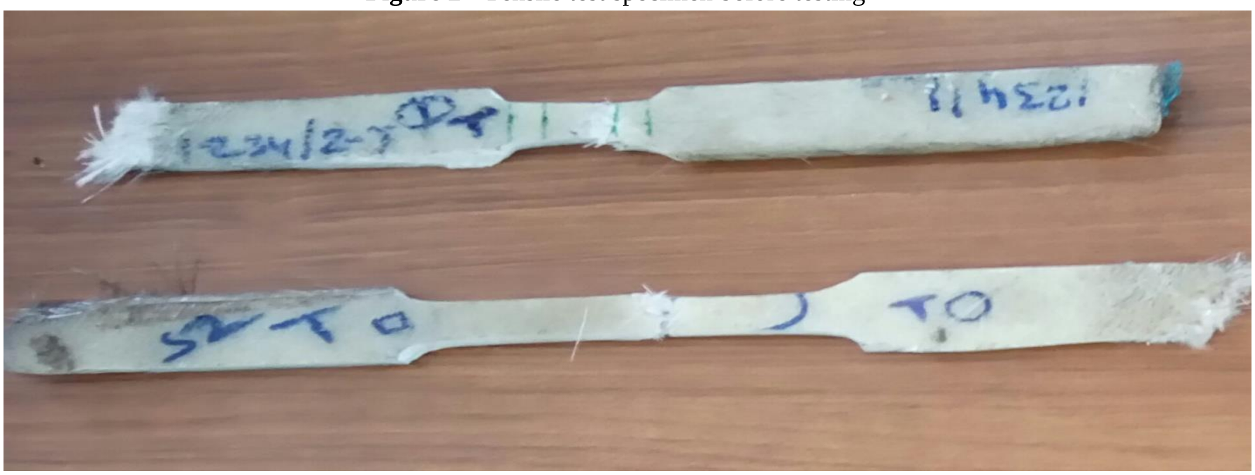

Figure 3 Tensile test specimen after testing

2.2.2 Flexural Test

These test methods cover the determination of flexural properties of unreinforced and reinforced plastics, including high-modulus composites and electrical insulating materials in the form of rectangular bars molded directly or cut from sheets, plates, or molded shapes. The prepared flexural specimens according to ASTM D790-2003 as shown in fig.4. The results are noted in table.1

Figure 4 Flexural test specimens after testing

2.2.3 Bending Test

The bending test methods are generally applicable to both rigid and semi rigid materials. In this investigation bending test is carried out on molded fibre glass grating to observe where the cracks are being obtained. Bending test is carried out as per ASTM D790-2003 standards. The specimen dimensions were determined according to the ASTM D790-2003 standards and tested as shown in fig.5.

Figure 5 Bending test specimen after testing

III. RESULTS AND DISCUSSION

The presented work consisting production of Gfrp laminates at varying weight fraction of reinforcement material and matrix materials and testing at different loading. The experimental results revealed mechanical properties of the GFRP samples subjected to tensile test, flexural test and bending test, for varying weight fractions of reinforcement material as glass fiber and matrix material as polyester resin are presented in Table1. In this examination the weight fraction of glass fiber and polyester resin considered as 60:40 and 70:30.The results shows tensile strength appeared to be increased as glass fiber content is increasing this is because of hardness and strength of fiber as compare to polyester resin. The investigation includes determination of Ultimate tensile strength, breaking strength and crack formation under bending load. From the experimental results observe that increment in the breaking strength is more as compared increment in the tensile strength at same incremental weight fraction**.** The changes of mechanical properties of lamintes for varying weight fraction due to strong bond at fiber matrix interface.

IV. CONCLUSIONS

For this investigation GFRP samples were prepared by using Resin transfer molding process and samples were tested with tensile test, flexural test and bending test and determine the Ultimate tensile strength, breaking strength and at which crack formation take place under bending load.. The following points drawn from test results in this study:

i. The Ultimate tensile strength and load at weight fraction 60:40 is 84.053MPa, 8.560kN and 70:30 is 88.052 MPa, 9.460 kN
ii. The breaking strength at weight fraction 60:40 is 103.56 N/mm^2 and 70:30 is 110.6 N/mm^2 therefore fiber content increases strength increases.
iii. The incorporation of E-glass fibre in the polyester resin can improve wear resistance of the composites.
iv. Based on the bending test results the bending load capacity is increases as increasing fiber content in the composite.

Table.1 Experimental test Results at different Weight fraction of fibre and matrix

Weight fraction of fibre and matrix in percentage=Fibre:Matrix			
Fibre:Matrix	Tensile test	Flexural test	Bending test
60:40	Width of the specimen : 13.4 mm Thickness of specimen : 7.6 mm Cross sectional area : 101.84 mm^2 Ultimate load : 8.560 kN **Ultimate tensile strength : 84.053 MPa**	Load at fracture : 960 N Gage length: 100 mm Width of the specimen : 20.68 mm Thickness: 8.2 mm **Calculated cross breaking strength:103.56 N/mm^2**	Width of the specimen : 20.68 mm Thickness of the specimen : 8.2 mm **Bending load where cracks observed : 1020 N**
70:30	Width of the specimen : 13.4 mm Thickness of specimen : 7.6 mm Cross sectional area : 101.84 mm^2 Ultimate load : 9.460 kN **Ultimate tensile strength : 88.052 MPa**	Load at fracture : 960 N Gage length: 100 mm Width of the specimen : 20.68 mm Thickness: 8.2 mm **Calculated cross breaking strength:110.6 N/mm^2**	Width of the specimen : 20.68 mm Thickness of the specimen : 8.2 mm **Bending load where cracks observed : 1110 N**

REFERENCES

1. R.M. Jones, mechanics of composite materials,Mc Graw Hill Company, New York, 1975.

2. L. R. Calcote, Analysis of laminated composite structures, Van Nostrand Rainfold, New York, 1969

3. P. K. Mallik, Fiber Reinforced Composites, 2nd Edition, Marcel Dekker Inc., USA, 1993.

4. Jones,R.M. (1999) Mechanics of composite materials (2nd edition) Phidelphia: Taylor & Francis.

5. The "Durability of bamboo-glass fiber reinforced polymer matrix hybrid composites" by author MOE MOE THWE, KIN LIO publised in journal of Composites Science and Technology 63 (2003) 375–387.

6. Eskim E.A, Kolesnik,K.I A.S Startsev O.V.,and Meletov,V.P.(1982) “Problemy Prochnosti” NO.10 pp91-96

7. Nishizaki and Meiarashi,S (2002) Long term Deteration GFRP in Water and Moist Environment Journal of Composite for Construction, Vol.6 NO.1 PP21-27

8. The "Durability of bamboo-glass fiber reinforced polymer matrix hybrid composites" by author MOE MOE THWE, KIN LIO publised in journal of Composites Science and Technology 63 (2003) 375–387

9. Environmental effects on bamboo-glass-polypropylene hybrid composites Moe Moe KinLiao 38 (2003) 363– 376

10. .P.Sampath Rao, and Dr. M. Manzoor Husain, Hydrothermal ageing effects on Flexural Properties of gfrp composite laminates, Indian Journal of Engineering and Material Science Volume-20 October 2013, pp 415-424,Publisher: CSIR-NISCAIR