Three point bending test of fibre reinforced particulate Composites

A. Saha, P. C. Roy, N. Modak

Abstract— Three point bending test of a carbon fibre reinforced particulate composite are made by graphite, Al_2O_3, $Mg(OH)_2$, carbon fibre and epoxy. The flexural stress, flexural strain and maximum bending strength are investigated by 'Instron testing machine' to study material characteristics. In this work graphite, Al_2O_3, $Mg(OH)_2$, carbon fibre and epoxy are mixed in different composition and prepared five samples of composite material. It is observed that the composite with a composition of 13% graphite, 13% Al_2O_3, 13% $Mg(OH)_2$, 3% carbon fibre and 58% epoxy shows high bending strength of about 135 X 10^6 N/m2 among the other composites.

Index Terms— Epoxy Composite, Carbon Fibre, Instron, Three Point Bending Test

1 Introduction

COMPOSITE is a material which is made by two or more constituent material. When these materials are combined, produce a material with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure [1]. Metallic materials are the heavily used material in different field, such as – engineering project, automobile industry and in our daily life as well. This shows good property when working in the discussed field. But the main problem with this is more density which causes heavy weight. This is a big disadvantage in many fields. To overcome this problem metallic material can be replaced by composite material, which has lesser density, less weight, higher stiffness, higher strength, and better fatigue resistance. Different composite materials are developed and tested by several researchers for the replacement of metallic material. Moreno *et al.* shows three-point bending test of unidirectional carbon fibre laminates. The optical microscope shows non-symmetric stress states produced in the central cross section of the specimen. Smaller thickness will caused in shear damage but increase in thickness will develop flexural failure mode [2]. Zhang *et al.* shows bending properties of carbon fibers reinforced of Al-alloy matrix composites. The bending strength of the Al–Mg matrix is 149 MPa, which can be enhanced by the addition of woven carbon fibers and the ductility is not also significantly lower [3]. Wang *et al.* shows three-point bending performance of a new aluminum foam composite structure. The bending strength is higher in the specimens with epoxy resin. The bending strength is also depends on thickness of aluminum sheet, the type of glass fiber and the amount of epoxy [4].

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Azzam *et al.* showed an experimental investigation on the three-point bending behavior of composite laminate to study progressive failure mode consisting of fiber failure, debonding (splitting), and delamination [5]. Maleque *et al.* chosen various material as candidate materials for automotive brake disc based on the properties, potential. It is observed that 20% SiC reinforced Al-Cu alloy (AMC 2) gives better compressive strength, friction coefficient, wear resistance, thermal capacity, specific gravity. It has lower density as well [6]. Nimhal *et al.* made an analysis of disc brake system with different material such as aluminium metal matrix composites, E glass fiber, S2 glass fiber. It is observed that the S2 glass fiber will be the ideal substance for the braking operation [7].

In the present work, five different composite materials are fabricated by mixing graphite, epoxy, carbon fibre, $Mg(OH)_2$, Al_2O_3 at different composition. Three point bending test are contacted on these composite materials to determine the flexural stress, flexural strain and maximum bending strength.

2 Material fabrication

Five sets of composite material sample are prepared by mixing graphite, epoxy, carbon fibre, $Mg(OH)_2$, Al_2O_3 in different proportions in the composite material laboratory, Department of Mechanical Engineering, Jadavpur University. In each case 58% by weight epoxy is produced by mixing net epoxy and hardener with a ratio of 10:1 with the different composition of graphite, $Mg(OH)_2$, Al_2O_3 by weight measured in electronics weight machine tabulated in Table 1. The whole mixture are poured in a rectangular die (200mm X 300mm) where mechanical pressure are applied by using nut and bolt. It requires almost 24 hours to get rectangular composite plate comes out from the die. Total weights of the plates are depicted in Table 1.

TABLE 1
MIXING % OF DIFFERENT MATERIAL AND WEIGHT OF THE PLATE

Sample no.	% of Graphite	% of Al_2O_3	% of $Mg(OH)_2$	% of Carbon fibre	% of Epoxy	Total weight of the plate
Sample 1	14	14	14	-	58	450
Sample 2	39	-	-	3	58	464
Sample 3	13	13	13	3	58	478
Sample 4	19.5	-	19.5	3	58	449
Sample 5	19.5	19.5	-	3	58	472

3 EXPERIMENTAL PROCEDURE

Three point bending testing is done to understand the Bending Stress, Flexural Stress, and Flexural Strain of the composite materials. The 3 point bending test is carried out in an Instron Testing Machine in the department of mechanical Engineering, Jadavpur University shown in the Fig. 1. The test samples are prepared according to ASTM D 790 standard. A 4 mm thick-ness, 12.7 mm width and 77 mm length strip is cut from the rectangular composite plate with the help of electrical power saw. The strip is polished with emery paper for make its edges smooth.

Fig.1 Instron three point bending testing machine.

4 RESULT & DISCUSSION

In each sample loading is done at the rate of 0.01 mm/ sec to determine the flexural stress, flexural strain etc. and test data is stored by the machine console. With the test data stress strain curve are plotted and bending strength of the composite during braking are calculated shown in Figures (a-e).

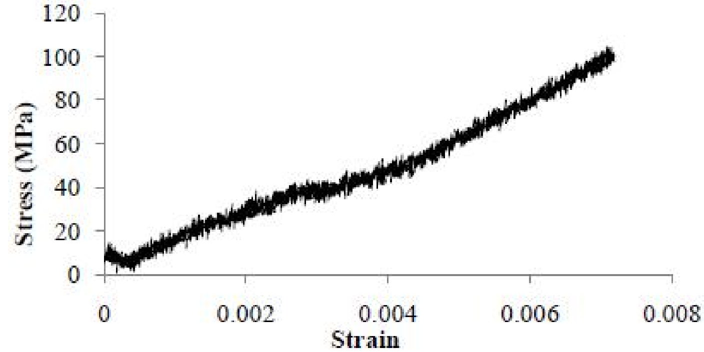

Fig.2 (a) Sample 1: Maximum load = 175 N, Bending strength= 82.71 X 10^6 N/m^2

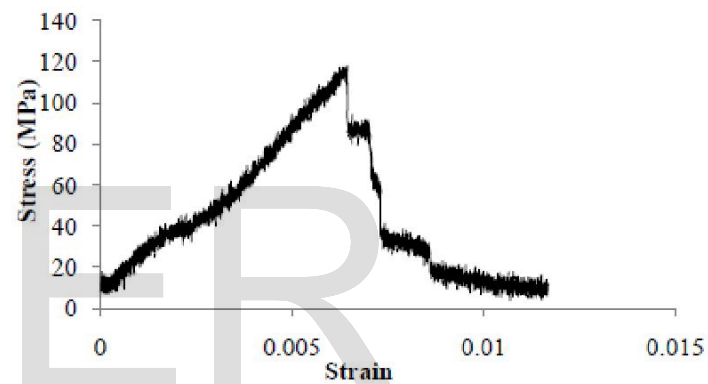

Fig. 2. (b) Sample 2: Maximum load = 196 N, Bending strength= 92.46 X 10^6 N/m^2

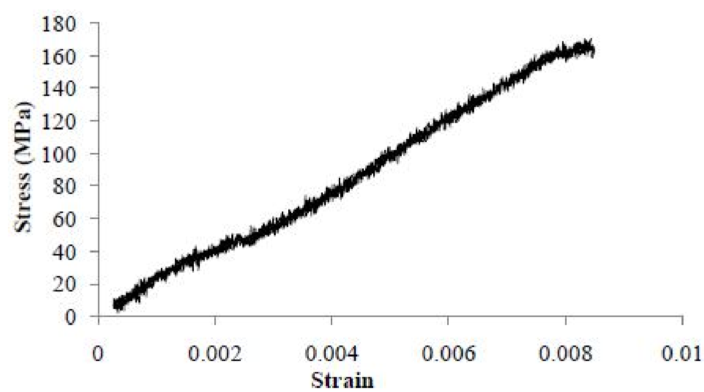

Fig. 2. (c) Sample 3: Maximum load = 285 N, Bending strength = 134.71 X 10^6 N/m^2.

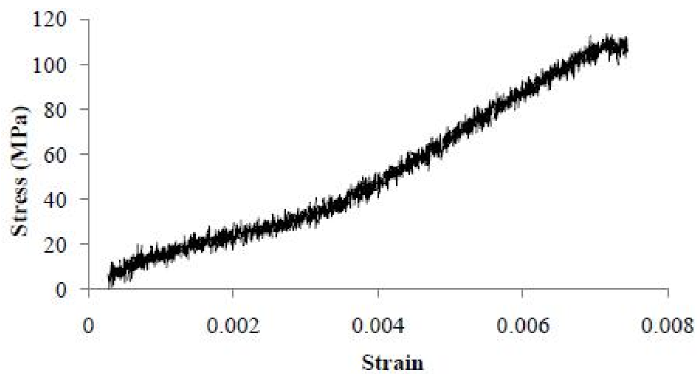

Fig. 2. (d) Sample 4: Maximum load = 188 N, Bending strength= 88.86 X 10^6 N/m^2

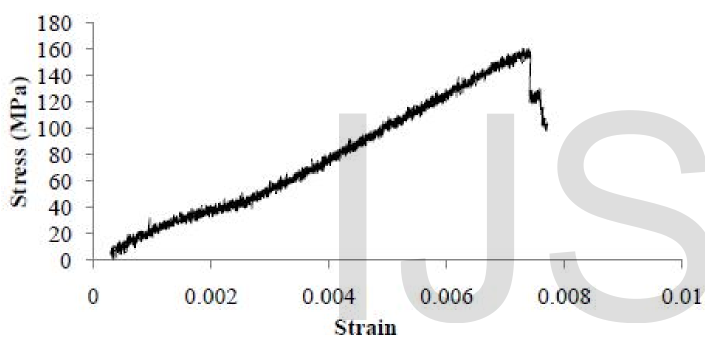

Fig. 2. (e) Sample 5: Maximum load = 167 N, Bending strength= 126.14 X 10^6 N/m^2.

In Figures 2 (a-e) a comparison of the performance of the different samples can be drawn based on flexural stress-strain diagram. In absence of carbon fibre in the sample 1, its load withstands capacity reduced. The flexural stress is also less as compared to other composite samples, but it shows stress and strain almost proportional to each other. In sample 2, alumina and magnesium hydroxide are replaced by carbon fibre which increases the load withstand capacity and flexural stress of the material compared to sample 1. In sample 3, alumina and magnesium hydroxide are also used with carbon fibre and it is clearly increased the load withstand capacity of the composite. It shows highest flexural stress compare to other samples. In absence of alumina from the sample 3, reduces the load with-stand capacity drastically. But absence of magnesium hydrox-ide from the sample 3, reduce load withstand capacity slightly of the composite and the bending strength is became almost same as sample 3. Due to increase in percentage of Al_2O_3 the flexural stress is also increased.

5 Conclusion

Three point bending test of a carbon fibre reinforce particulate Composite impregnated with graphite, Al_2O_3, $Mg(OH)_2$ are studied to determine the flexural stress, flexural strain and maxi-mum bending strength. In the work graphite, Al_2O_3, $Mg(OH)_2$, carbon fibre and epoxy are mixed in different composition and prepared five samples of composite material. It is observed that the composite with a composition of 13% graphite,13% Al_2O_3, 13% $Mg(OH)_2$, 3% carbon fibre and 58% epoxy shows high bending strength of about 135 X 10^6 N/m^2 among the other com-posites. Absence of carbon fibre and Al_2O_3, reduces its bending strength, and the increase in % of carbon fibre and Al_2O_3, will enhance the bending properties. The bending property and flex-ural stress is greatly influences by Al_2O_3.

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