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Prediction on Mechanical Properties of Fly Ash Reinforced Polymer Composite Material

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Abstract

Fly ash with different weight ratios was used as a reinforcing material for the composite material (polyester + 5% short carbon fiber) to make a hybrid composite material. The weight ratio of the carbon fiber used with the polymer was constant, and the weight ratios used for fly ash were (5%, 10%, 15%) wt. The mechanical properties of the hybrid composite material were studied and compared with the composite material without the addition of fly ash. The results showed an increase in the tensile strength and modulus of elasticity by increasing the weight percentage of fly ash, while there was no significant increase in the compressive strength value except for the composite material reinforced by 15% of fly ash. The results showed a significant improvement in the measured mechanical properties of the hybrid composites samples with an increase in the addition percentage of fly ash.

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1. Introduction

Currently, protecting the environment from industrial waste and other waste produced by man in his daily life and providing the necessary energy from oil products and other energy sources are among the main problems facing the current and future generations. It was directed to the recycling of industrial waste that results in pollution in water, soil and air, by merging it with other materials and benefiting from it in advanced applications. Fly ash is considered one of the combustion residues resulting from electric power generation stations, which results in environmental pollution that directly affects human health. As a result of many efforts and scientific research, it was found that mixing fly ash with various polymeric materials as reinforcement material results in improving the durability and mechanical properties of these materials, which qualifies them for use in advanced applications [1]. Composite materials are characterized by having different behaviors from other materials. Each component has special characteristics that differ from the properties of the rest of the components in the composite material، the advantages of its properties are taken to improve the material [2]. Natural and synthetic fibers are used as a secondary phase with composite materials to develop advanced materials in engineering applications, where an improvement in the mechanical properties was observed without affecting the rest of the properties [3].

Literature survey for researchers has been found agreement with our work to recognize the influence of adding fly ash as filler in different amounts with fiber / polymer composites.

In a study done by Lakshmi and Subha [4] showed that the mechanical properties for composites depend on the filler's chemical nature, size of particles, distribution of filler in the matrix, aspect ratio, volume fraction of filler and matrix and adhesion strength between the composite layer's surfaces. Singla and Chawla [5], accurate the material characterizations data calculated experimentally through active dissimilar weight percentage for fiber glass (G.F.) using E-300, mat. form in epoxy as a resin and compared with fly ash reinforced composite. Fracture behavior for composite be able to study using (SEM) test. The (SEM) study was prepared to obtain apportionment for fly ash particles with matrix interface, glass fibers with matrix interface and glass fiber with matrix distribution etc. Nantha Kumar and Rajadurai [3] investigated the effect of using carbon fiber, silica and fly-ash as reinforcement with epoxy and polyester on impact and tensile behavior. There was an increase in impact and tensile properties within carbon fiber content increase, and when fly ash added the properties was decreased. Another study made by Sangamesh et al. [6], by using silica fumes and fly ash as reinforcement for epoxy, and compared the results that obtain for mechanical properties. Fly ash / epoxy composite had better strength than silica fumes/ epoxy composite. Verma et al. [2], prepared a hybrid composite consist of fly ash/E-glass fiber with epoxy resin. Mechanical properties (tensile, compressive and flexural strength) were studied. There results showed improvement in tensile and compressive strengths and had highest values when fly ash alone. Sandeep et al. [7] fabricated a hybrid composite fly ash / carbon fiber / epoxy. Results showed improvement in

tensile, flexural strengths and hardness. Tambrallimath et al. [8] focused in their research on improving of polymer composite, via using Acrylonitrile Butadiene Styrene (ABS) with fly ash in different ratios, they noticed that an enhancement in tensile strength. Rao [9] have showed that addition of fly ash as a macro filler was increased the strength and durability of composite. Mishra [10] investigated fly ash's mechanical properties-based hybrid composites which showed that the tensile can be promote as addition of filler is increased. Srivastava and Shembekar [11] investigation that fly ash particles have decreased the elasticity modulus as the addition increased of fly ash. Pradeep et al. [12] studied the mechanical characteristics of epoxy-fly ash composites prepared using the method of hand lay-up. The results showed that mechanical properties were improved when fly ash is reinforced with the glass fiber polymer. Tiwari et al. [13] studied the tensile behavior for fly ash/polystyrene composite. They were founded that the decrease in tensile stress, strain and young's modulus of composites due to the increase in plasticity of composite. Ibrahim Gunes et al. [14] investigate the hardness and trobological properties of fly ash / epoxy composite. The hardness and surface roughness of fly ash composites were increased as ratio of fly as increased. Patra et al. [15] studied mechanical properties for fly ash / epoxy composites (tensile and hardness) in which they showed that at 30% and 40% ratios of fly ash the tensile strength and hardness had the highest values.

In our current work, we aim to study the effect of adding different percentages of fly ash on the mechanical properties of the composite material reinforced with fibers.

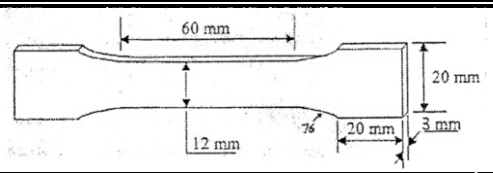
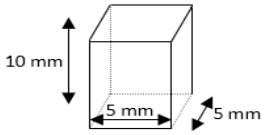
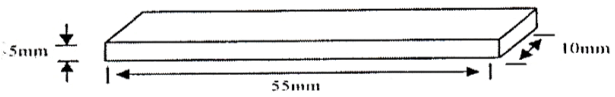
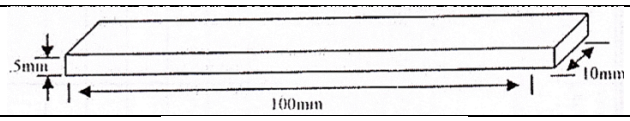
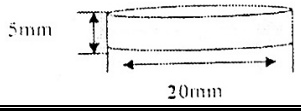
2. Materials and Experimental Procedures

Unsaturated polyester (UP-matrix) is most widely used resin; has a density (1.19 gm/ cm^3). Methyl ethyl ketone peroxide (MEKP) is the hardener which used with UP was within ratio (2 wt. %), galvanized cobalt octate (0.5wt. %) like accelerator. Carbon Fibers (chopped fiber with length = 3 mm) and fly ash (particle size = 52 -75 μm) were chosen as primary and secondary reinforcements to obtain the hybrid composite.

Preparation of samples composite:

1. Composite was made using a glass mould having dimensions (20.5×20.5×1.5) cm, length, width and height respectively, for all type of composites. The ratio of hardener which was added to polyester is (98:2), (98 gm) from polyester adding (2 gm) hardener, then mixed the solution very well before poured it to obtain homogeneity. Then mixing (5 %) carbon chopped fiber and putting in mould.
2. he mould left for 48 hours to get solid samples curing process.
3. To get full curing, samples would place in an oven at 60 ^oC for three hours.
4. The second section in the preparation hybrid composite materials is fixing the 5%wt. carbon chopped fiber and added fly ash as a powder with different weight fraction (5%, 10%, 15%) wt.; with repeated steps 2, 3.
5. After finished production the composites portions; and according to (ASTM) standards necessary experiment specimens are cutting a tensile, compression, impact, bending and hardness specimens. Table 1 shows the sample dimensions and standard specimens.

Table 1. Sample's dimensions and standard specimens.

Test	Specification	Sample's dimensions
Tensile	ASTM-D-638	
Compression	ASTM-D695	
Impact	ISO-197	
Bending	ASTM-D790	
Shore D hardness	ASTM-D2240	

3. Results and Discussions

3.1 Tensile test:

The tensile test behavior of composite (polyester +5 % carbon chopped fiber) with (fly ash.) reinforced polymer within different weight (5%, 10%, 15%) is presented.

3.1.1 Tensile strength behavior of composites materials:

Figure 1 shows that tensile strength of the addition for the mixture of fly ash powders (5%, 10%, 15%)wt. to polyester resin increases the value of tensile strength but the addition of the mixture of particles powders (5%, 10%.15%) with fixed ratio (polyester+5%C.F.) to the composite materials appeared increasing of value of strength, it is appeared that tensile strength value increasing (76 MPa) when the weight fraction of fly ash(F.A.) increase (15 %). Fly ash has an effective role in impeding the progression of cracks within the composite material subjected to mechanical loads, and thus provides good resistance against fracture [8].

3.1.2 Elasticity modulus:

The values of elasticity modulus for hybrid composites materials for all samples that were fabricated in the current work are illustrated in Figure (2) it is shows the significant increasing of elasticity modulus (8.1 GPa) for samples of fly ash (15%).; but when the addition of the mixture of particles powders (5%,10%.15%) with fixed ratio (polyester+5%C.F.) to the composite materials observed increasing of value of elasticity modulus to (10.65 GPa) in(polyester +5% C.F.+15% F.A), comparing with (7 GPa) for sample (5 % C.F) only.

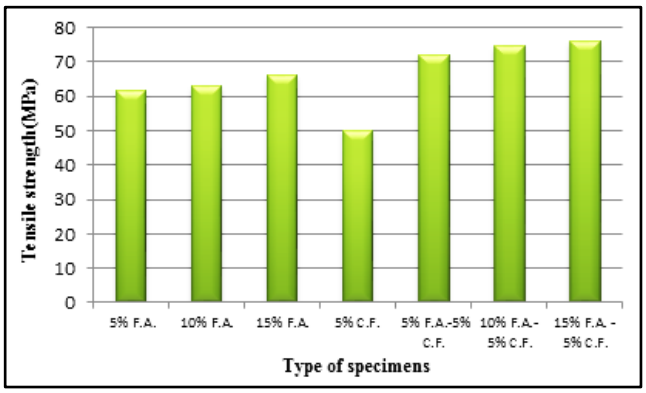


Figure 1. Tensile strength behavior of composites materials.

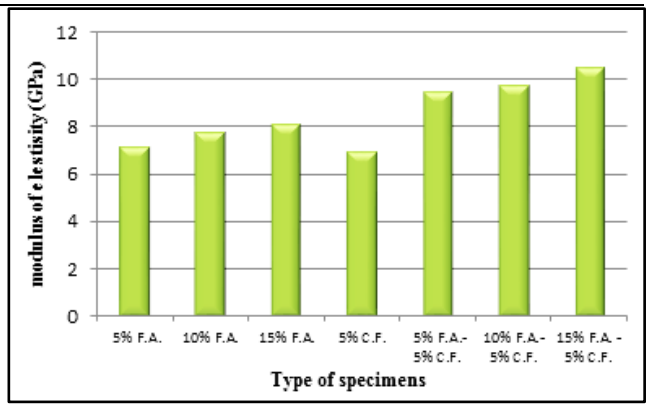


Figure 2. Elasticity modulus of composite materials.

3.2 Compression behavior of composites:

The compression behavior for different (fly ash.) reinforced composites is obtainable. Test was approvedaccording to standard shows in Table 1. The samples.were.tested and their.values were taked as in Figure 3. It was observed increasing of comprssive strength when (fly ash.) was added due to the penetration of the particles with polyester material and the fly ash have high compression strength [2], and a significant increase was observed in the hybrid composites, due to good distribustion of fly ash particale among fiber composite.

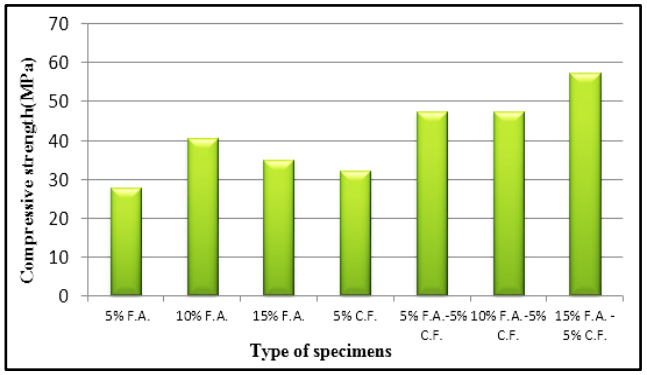


Figure 3. Compressive strength of composite materials

3.3 Impact behaviour of composites:

Figure 4 represents one of important dynamic mechanical tests impact behavior of composite, where the specimen exposed to very fast moving load. From this test, the impact strength of composite materials can be calculated by depending on the energy needed to fracture of specimen, an impact behavior for different (fly ash.) reinforced composites is presented.Impact test was approved according to (ASTM) standards as shown in Table 1, it is shows the significant increasing of impact strength as fly ash increase (4.6 KJ/m^2), but when the addition of the mixture of particles powders (5%, 10%, 15%) with fixed ratio of composite (polyester+5%C.F. with value (3.114 KJ/m^2)),it was observed increasing of impact strength reached to (7.42289KJ / m^2) in hybrid composite, due to good distribustion of fly ash particale among fiber composite.

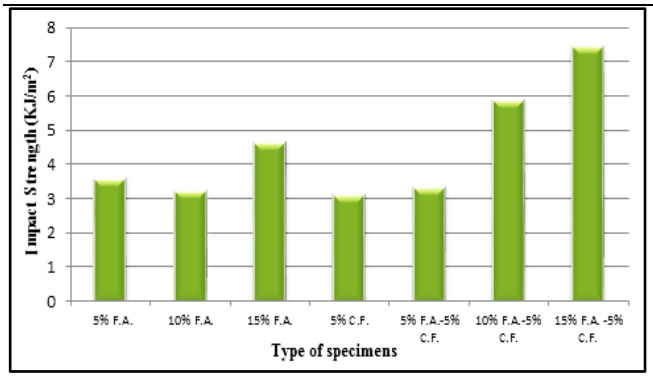


Figure 4. Impact behavior of composite materials.

3.4 Bending behavior of composites:

Figure 5 shows the bending behavior for different (fly ash) reinforced polymer. Composites which is carried out according to standard shows in Table 1. The specimens result is varying in its bending behavior according to were subjected the test and their values were high when the hybrid composite has the ratio (5% C.F +15% F.A (81.816 GPa)). In composite materials, polyester is a medium that transmits the stresses applied to it to the fibers, and therefore its ability depends on the performance of the matrix to deliver the stresses across the interface [2].

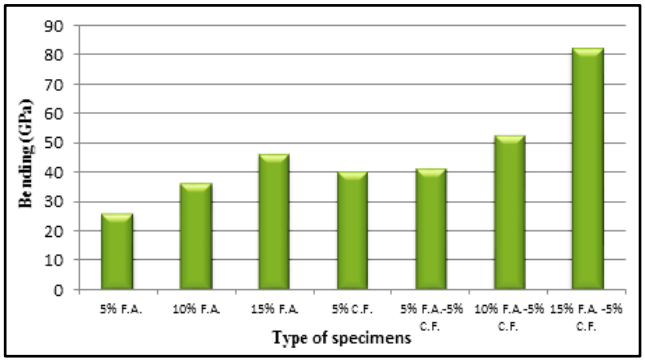


Figure 5. Bending behavior test of composite materials.

3.5 Hardness behavior of composites:

Figure 6 represent the shore D hardness behavior test for different reinforced polymer, composites, hardness test was approved according to standard shown in Table 1. The specimens show that the value of hardness significant increase when fly ash is added and increased when increase the weight fraction of (fly ash) [12], the highest value was the hardness in hybrid composite reached about (86.4) comparing without powder (75.9).

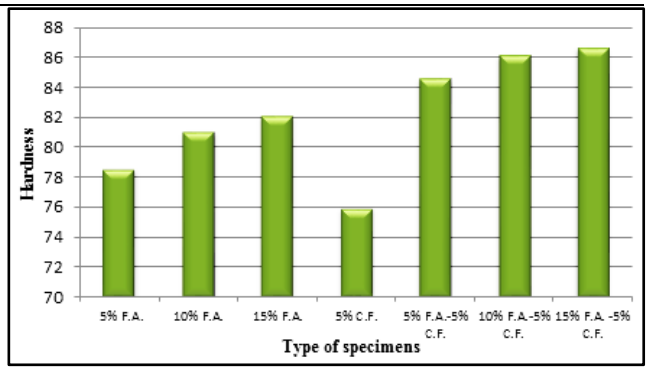


Figure 6. Shore D hardness behavior of composite materials.

4. Conclusion

Hybrid composite reinforced with two types of materials (filler + fiber) has been prepared, mechanical properties was done. From results we can conclude:

1. In the tensile test, the higher the filling percentage, the tensile strength and modulus of elasticity increase.
2. In compressive test, increasing of comprssive strength as fly ash content increases.
3. Impact strength increases with the increase of the filler alone and the presence of the filler and the fibers together.
4. From bending test, it is noticed that obtain higher values as filler ratio increases.
5. Hardness for both (FA/UP) and (FA/CF/UP) increases as ratios of filler and fiber increase.
6. All the points mentioned above indicate an improvement in the mechanical properties of the hybrid materials.

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