Property Evaluation of Fly Ash Polyester Composite Material Under Different Loading Conditions

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Abstract: **Fly ash mixed with polyester composites are distinguished by its high strength and light weight. Because of their light weight and superior mechanical properties, they are finding very wide applications in every field of applications. Unsaturated polyester resin mixed with fly ash as filler at different concentrations, testing specimens are fabricated. The present study reports the results of testing composite under tensile and compressive loading. The required test specimens are fabricated as per ASTM D695 and ASTM D638 standards. Fly ash concentration of 10% to 50% by volume in steps of 10% are fabricated and tested. The results indicate that specimen with 50% fly ash bear highest tensile load where as specimen containing 10% composite bear highest compressive load. This study helps in effectively utilizing industrial waste or byproduct of combustion process for the development and utilization through material development.**

Key Words: fly ash, unsaturated polyester, polymer composites, tensile strength, compressive strength.

I. INTRODUCTION

Fly ash is the most commonly existing coal combustion byproduct which improves performance and also cost-effectiveness when added to suitable binding medium. It gives a superior performance at lesser cost. It is a resource for different kinds of innovative applications. Its application areas include brick manufacturing, partial replacement of cement, in land filling and reclamation of land, as soil fertilizer, etc. Lot of research going on how to utilize fly ash in developing the new materials and suitable applications are being suggested by many involved researchers.

During the burning of powdered coal or wood in power plants, as material crosses through the high temperature zone inside the furnace, absolute burning of the material occurs and later it solidifies as spherical particles, in which some quantity forms ash at the bottom. But majority quantity flies out with the flue gases and it is called fly ash. As the fly ash is generated in plentiful quantities (in terms of tons), one has to find suitable applications for it. The research findings on fly ash based composites shows that, country like India not effectively utilizing byproduct of combustion. Neither in construction field nor in development of new materials which may find wide applications.

Fly ash, a by-product of industry where wood or coal is burnt, which is available in plenty, is non eco-friendly because of environment pollution and also health hazards. Due to extensive research there are many ways identified which are resulting in development of advanced materials and hence contributing for reduction in environmental pollution. One of the techniques to achieve low pollution is to involve fly ash in to polymer base and develop composite material. The fly ash particles are generally hollow in structure, exhibit lower densities whereas oxides present in as ingredients make them bear high modulus and strength and hence thereby improving its specific strength and stiffness. The polymer based systems show nature such as low density compared to metal matrix composites and metal alloys. An efficient and effective way to fabricate composite with fly ash is by adopting the mechanical mixing route. Because of mechanical mixing, air bubbles are formed in the mixture and seen as voids in the casted composite material. Non-destructive testing techniques can help in assessing and evaluating the defect in the specimen. Fly ash, without any prior separation of the different particle types, has been previously examined as the filler for polymer by a number of researchers.

Some attempt is also made to find out wear behavior, water absorption capacity, impact strength of fly ash filled composite materials. In the present work, an attempt is made to utilize this waste material as fillers in composites with unsaturated polyester as the matrix and tensile and compressive properties of these composites are determined.

II. MATERIALS AND EXPERIMENTATION

The raw materials used in the preparation of composite are: Polyester resin, the general purpose unsaturated polyester resin used as a matrix. Methyl ethyl ketone peroxide was used as a catalyst and cobalt napthanate as accelerator. The solution may be cured or polymerized under the influence of heat or at room temperature to produce rigid

cross linked structure. The degree of flexibility, hardness and toughness depends upon the chemical nature of the resin, curing time, method of curing etc.

The fly ash produced from Grasim Industries Pvt. Ltd. Harihar, is utilized for the development of composite material. The burning of pulverized coal or wood in a boiler is a fine-grained, powdery particulate material(1 - 10µ), that is carried off in the flue gas and usually collected from the flue gas by means of electrostatic precipitators, bag houses, or mechanical collection devices. In Grasim Industries Pvt. Ltd. Harihar huge quantities has been causing problems of disposal. Fly ash is a fine particulate material. For every 100 tons of fuel burnt=12 tons of fly ash are produced. Disposal of this fly ash has always been a problem. It would be preferable to use it in so beneficial way. The composition of fly ash will vary depending on the properties of wood and coal and the combustion process. The main constituents are shown below

Table 1Fly ash contents with percentages

Material	Percentage
Silica	60-64
Alumina	16-23
Ferric oxides	10.96
Calcium oxides	2.09
Magnesium oxides	0.77
Sulfur trioxide	1.33

Composite specimens are prepared according to ASTM standards by mixing different weight ratio of fly ash with polymer. Form 10% to maximum of 50% by weight. Fluidity of the mixture decreases with increase in fly ash percentage beyond 50%. Because of low fluidity, it is very difficult to fill the mixture in the mold. The present study restricted to maximum of 50% fly ash. For the preparation of compression test specimen ASTM D695 and for tensile test specimen ASTM D638 standards are used. This mixture of fly ash and polyester is stirred well under lower speeds to avoid entrapment of air and hence uniform distribution of fly ash particles takes place in polyester. Then the mixture is poured into the dies. Allow the specimen in the die for complete curing about 24 hours. The polymerization process is exothermic, lot of heat is liberated. Suitable releasing agents are applied to the die so that component can be easily removed from die.

The tests were conducted in accordance with ASTM method. Both the tests are conducted at room temperature. Slow spindle speed of 2 mm/min is employed for conducting the test. The standard specimens are subjected to uni-axial compression and uni-axial tension.

III. RESULTS AND DISCUSSION

The behavior of the composite specimen under tensile load is discussed below. It behaves like brittle material. Brittle fracture takes place. The variation in tensile strength for different percentage of fly ash is plotted in fig(1). The composite specimen with 10% fly ash takes very less load of 2.64 KN with deformation of 2.4mm. The maximum load of 7.38 KN taken by the specimen containing 50% fly ash with deformation of 3mm. The presence of fly ash will put the restriction for the growth of crack. As the percentage of fly ash increases, more will be the restriction for the propagation of crack. So specimen with 50% fly ash, which is highest possible reinforcement, will take maximum load when subjected to tension. The ultimate strength and fracture strength of specimen with 10% fly ash is very less, while for component containing 50% fly ash is having maximum ultimate strength and fracture strength.

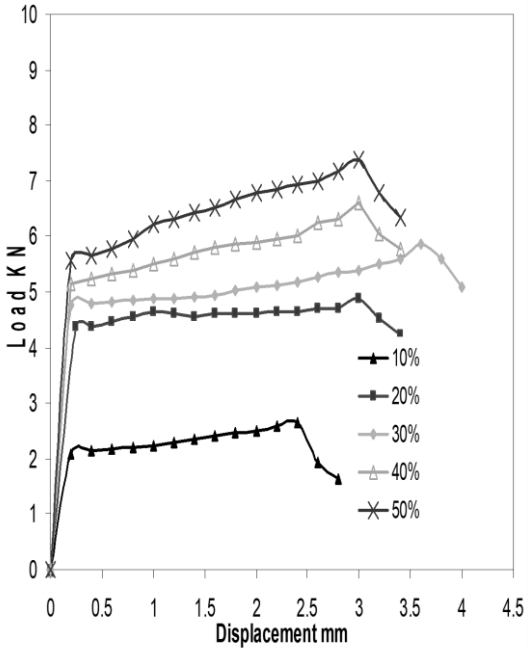

Figure 1: Variations in tensile strength with filler content in flyash-polyester composites.

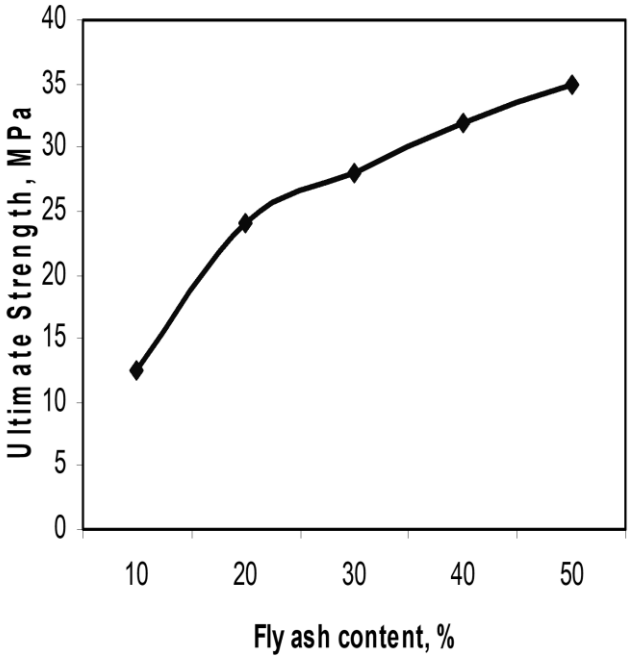

Figure.2: Effect of fly ash content on ultimate strength subjected to tensile loading

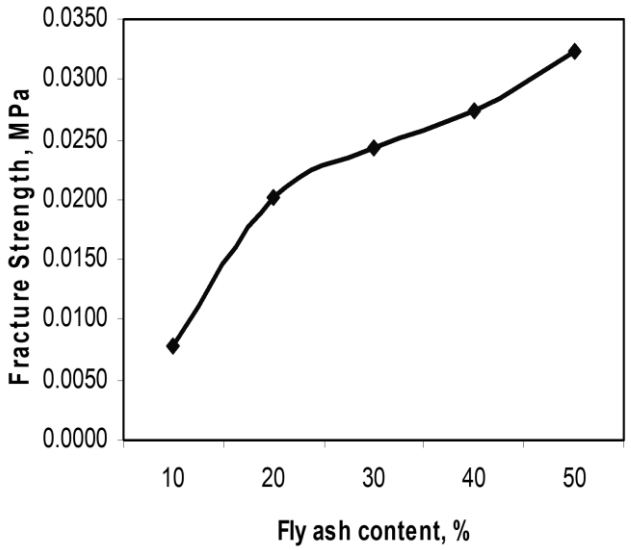

Figure.3: Effect of fly ash content on fracture strength under tensile load under tensile load

The behavior of the composite specimen under tensile load is discussed below. As the fly ash based composite is brittle in nature, the fracture takes place 45º to the horizontal plane when subjected to uni axial compression. Compressive strength of component containing 10% fly ash is 40.76 KN with deformation of 2.4 mm. Similarly, component containing 50% fly ash take less load of 32.90 KN with deformation of 1.3 mm. When fly ash percentage is varied, ultimate strength gradually reduces and again increases with 40% fly ash. When fly ash percentage is increased fracture strength gradually decreases up 30% and for 40% again it will increase.

By observing the failed component, it is clear that failure takes place because of de-bonding between fly ash and polyester matrix. Due to de-bonding small cracks develops on the component and further these cracks join together to form a large cleavage.

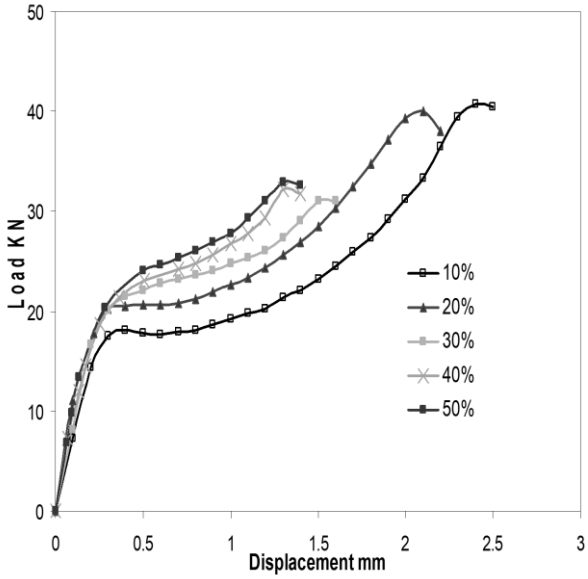

Figure.4: Variations in compressive strength with filler content in flyash-polyester composites.

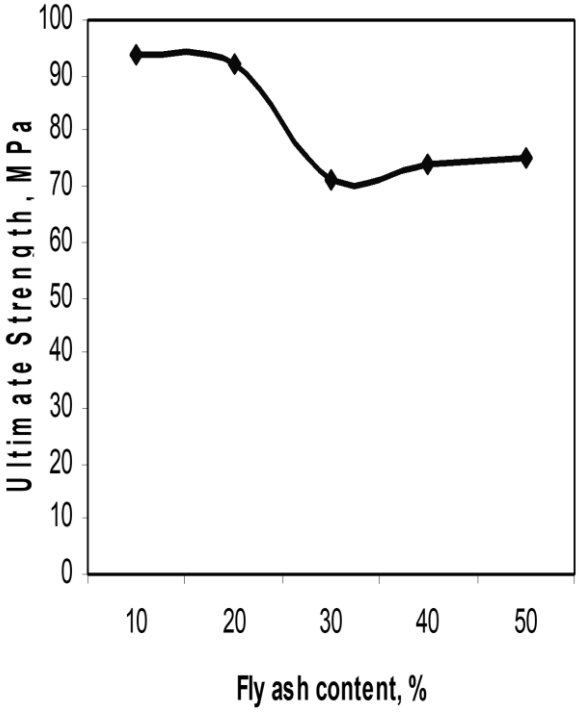

Figure.5: Effect of fly ash content on ultimate strength under compressive load

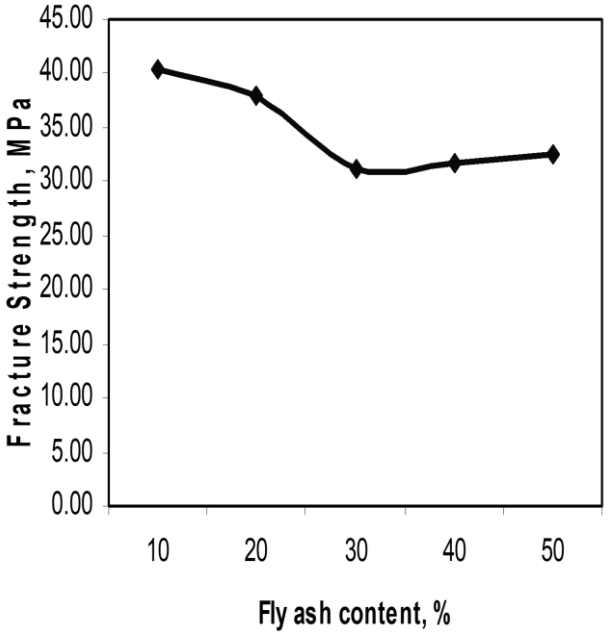

Figure.6: Effect of fly ash content on fracture strength under compressive load

IV. CONCLUSION

The mechanical properties of fly ash based composite materials are significantly changed by varying the percentage of fly ash. It was found that increase in fly ash content up to 50% increases the tensile strength of the material but decreases the compressive strength. Composite containing small amount of fly ash i.e. 10% show good compressive strength and increase in fly ash to 50% show less compressive strength. As the percentage of fly ash increase in the component, flow ability decreases and hence it is very difficult to cast the specimen. Because of its good mechanical

properties, the composite may be used in various engineering applications. Further strength can be enhanced by reinforcing fibers in composite material.

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