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FABRICATION AND CHARACTERIZATION OF NANO FLYASH REINFORCED POLYMER LAMINATES

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Abstract - *The present work deals with the fabrication and characterization of fly ash/ Epoxy nano composite laminates by using ultra sonication and hand layup technique. In this process, nano fly ash particles of size 45-60 nm were well diffused and loaded with different weight percentage (0 wt%, 1 wt%, 2 wt%, and 3 wt%,) in an epoxy matrix is taken. The fabricated samples with a thickness of 4mm were prepared for testing as per ASTM standards and subjected to ASTM D 3039 for tensile tests, ASTM D790 for flexural tests and ASTM D2583 hardness testing to analyze the mechanical properties such as tensile strength, flexural modulus, hardness and the growth of fly ash particles. It was found that the tensile strength and flexural modulus were improved with increase of fly ash addition up to 2 wt% and at the addition of 3 wt% fly ash strength is decreased. Hardness increased up to 2 wt% of fly ash and then decreased at 3 wt% .The failure analysis on the fracture test specimens has been done using FESEM to know the failure in the fabricated specimens at their failure zone. The reasons for the mechanical property changes are discussed, also by using various testing and fracture surface morphology of specimens and size, distribution of fly ash were observed.*

***Key Words*: Hand layup techniques, Glass Fibre, Nano Fly ash, Polymer laminate Composite, Tensile Test, Flexural, hardness test**

1. INTRODUCTION

Fly ash is one of the residue generated in the combustion of coal. It is an industrial by product recovered from the flue gases of coal burning electric power plant. The fly ash particles are generally glassy, solid or hallow and spherical in shape. Fly ash that results from burning sub-bituminous coals is referred as ASTM Class C fly ash or high calcium fly ash contains more than 20% of CaO. On the other hand, fly ash from the bituminous and anthracite coals is referred as ASTM Class F fly ash or low-calcium fly ash. It consists of mainly an alumina-silicate glass, and has less than 10percent of CaO.

1.1 Composite Laminates

A composite laminate is a structural plate consisting of multiple layers of fiber reinforcement encased in cured resin. The number of layers, the type of fiber (carbon, glass, or other), the fabric configuration (e.g., woven, stitched mat, unidirectional), the type of resin, and other factors can be varied to design a structural element that is suitable for a particular need. Raw materials(fiber, resin, and usually some filler) in themselves are not useful a structural member, but when combined together, the product takes on new properties that make them desirable for use in structures. Laminates, or hardened sheets of composite material, usually are cut up into coupons for mechanical testing to A composite laminate is a structural plate consisting of multiple layers of fiber reinforcement encased in cured resin. The number of layers, the type of fiber (carbon, glass, or other), the fabric configuration (e.g., woven, stitched mat, unidirectional), the type of resin, and other factors can be varied to design a structural element that is suitable for a particular need. Raw materials(fiber, resin, and usually some filler) in themselves are not useful a structural member, but when combined together, the product takes on new validate the predicted properties

2. MATERIALS

The matrix material used was medium Epoxy resin widely used in industries due to their strong adhesive properties, chemical resistance and toughness. The reinforcement material employed was E-glass which is a popular fiber. Fly ash has been used with different wt%. The matrix materials are epoxy resin LY556 and hardener HY951 mixed in appropriate ratio 100:11

3. FABRICATION OF THE SPECIMENS

Nano Fly ash is mixed with epoxy with different wt% of fly ash. The weight of epoxy is taken according to weight of E-glass fiber. The Nano fly ash glass/Epoxy laminates are fabricated using simple hand layup technique. The procedure consists of placing the E-glass fibers thoroughly, layer by layer and applying liquid epoxy mixed with hardener on the glass fibers in order to form a solid network cross-linked polymer. The layup assembly is pressed with the help of roller so that excess air between the layers is expelled out. The laminate is cured at ambient conditions for a period of about 24hrs. The laminate is prepared for 4 different compositions of E-Glass/Epoxy with a size of 300x300 x4mm.

Fig-1: laminates with different wt% of flyash

4. EXPERIMENTATION:

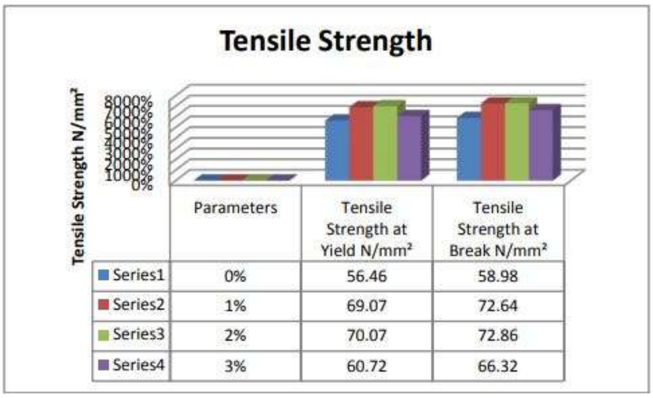
The laminates are prepared for 4 different wt% of nano fly ash and then cut down according to the ASTM standards in order to carry out tensile, flexural and hardness tests.

Plan of Experiments for conducting tests*:*

Tensile, flexural &3-point bending tests performed according to ASTM standards.

4.1 Tensile Test

This test was performed on Universal Testing Machine (UTM). Tensile testing, also known as tension test. The test was performed with 7kn load. Properties that are directly measured via a tensile test are ultimate tensile strength, maximum elongation and reduction in area.

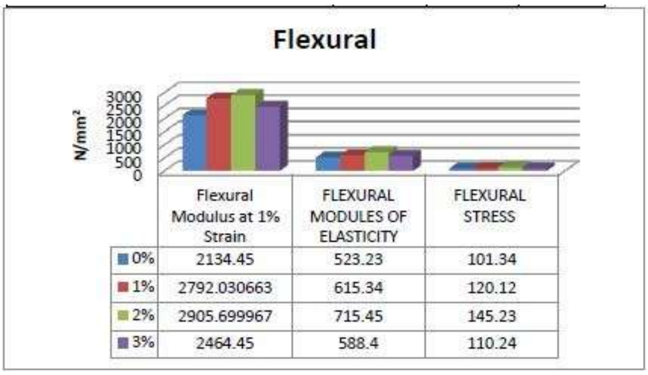


	Parameters	Tensile Strength at Yield N/mm²	Tensile Strength at Break N/mm²
Series1	0%	56.46	58.98
Series2	1%	69.07	72.64
Series3	2%	70.07	72.86
Series4	3%	60.72	66.32

Chart-1: Relation between Tensile Strength and wt % of Fly ash

4.2 Flexural Test

Universal testing machine is used to conduct flexural test (three point bend test) on the fabricated Laminates. The flexural modulus of composite specimens varies by varying weight% of fly ash (0 wt%, 1wt%, 2 wt%, and 3 wt %) was calculated and compared. Variation of flexural modulus with wt% of fly ash Reinforced Polymer Laminates is shown in Figure



	Flexural Modulus at 1% Strain	FLEXURAL MODULES OF ELASTICITY	FLEXURAL STRESS
0%	2134.45	523.23	101.34
1%	2792.030663	615.34	120.12
2%	2905.699967	715.45	145.23
3%	2464.45	588.4	110.24

Chart-2: Relation between Flexural Modulus and wt. % of fly ash

4.3 Hardness Test

Barcol hardness test is performed on fabricated samples. The hardness of fabricated specimens varies by varying wt% of fly ash (0 wt%, 1wt%, 2 wt%, and 3 wt %) is calculated and compared.

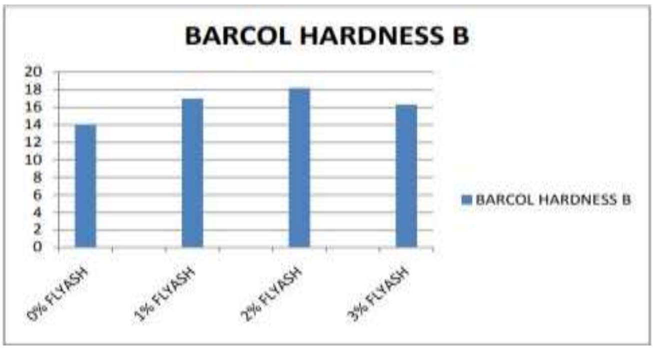


Chart-3: Relation between Barcol hardness and Weight% of fly ash

4.4 flexural failure characterizations by FESEM

The fabricated samples are well examined by characterizing them using field emission scanning electron microscopy (FESEM). Flexural failure zones of the specimens with different wt% of nano fly ash can be clearly seen as follows

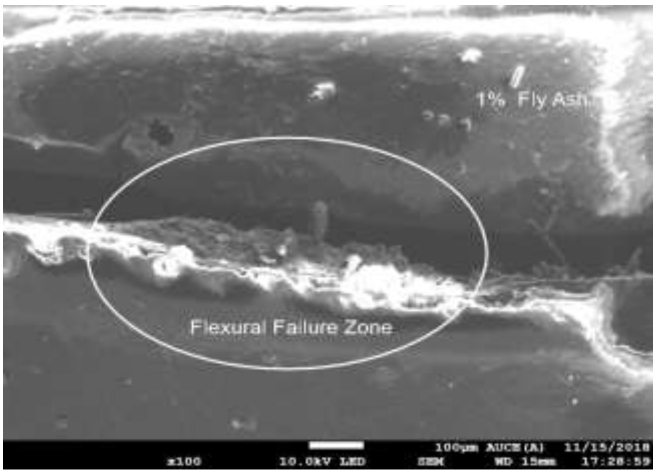


Fig-2: Failure zone of laminate with 1 wt% of Nano fly ash

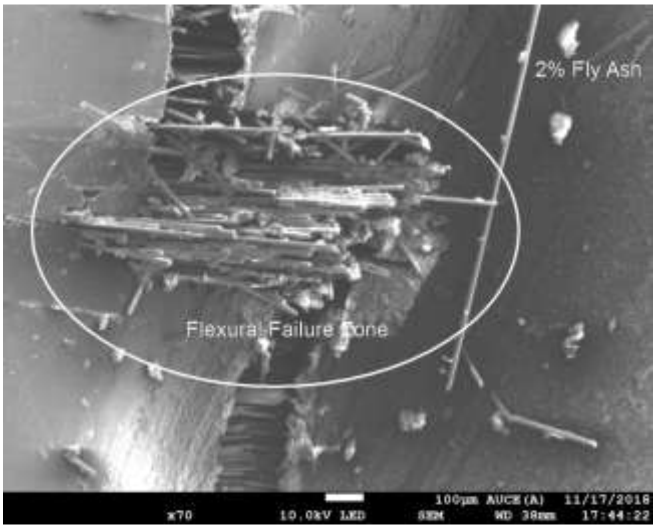


Fig-3: Failure zone of laminate with 2 wt% of Nano fly ash

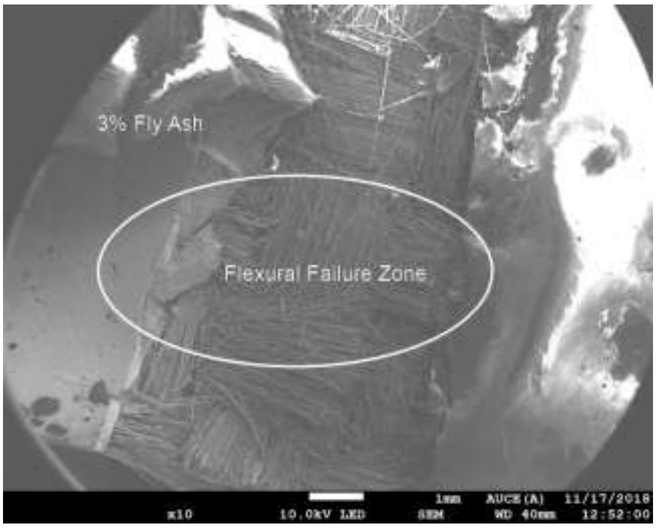


Fig-4: Failure zone of laminate with 3 wt% of Nano fly ash

5. CONCLUSIONS

The fabricated polymer laminates with different wt% of nano fly ash particles were tested for tensile test, flexural test and hardness test according to ASTM D3039, ASTM D790, ASTM D258 standards respectively for different mechanical properties.

The tensile test and flexural tests showed that the tensile strength and flexural strength of the polymer laminates increased as the fly ash wt% increased up to 2% with respect to 0 wt% of nano fly ash and then decreased at 3 wt% of the nano fly ash with respect to 2 wt% of nano fly ash.

From the tensile test results of fabricated samples, the 2 wt% nano fly ash sample has the highest strength value among all the compositions with the highest tensile strength value of 72.86N/mm^2 and lowest at 3 wt% of nano fly ash with strength value of 66.32N/mm^2

From flexural test results of the fabricated samples, the 2 wt% nano fly ash sample has the highest among all the compositions with the flexural modulus value of 145.23 Mpa and lowest at 3 wt % of nano fly ash with value of 110.24 Mpa.

The failure zones of the flexural test fabricated samples are characterized using FESEM and how the failure is progressed can be clearly seen at different magnification levels.

Field emission scanning Electron Microscope (FESEM) was also applied to investigate damage mechanisms occurred in the fabricated specimens. The figure shows that the surfaces of the specimens.

The de-bonding between glass fibers and epoxy is obviously visible in all areas, but as it is seen, the surface is covered by nano fibrous material in most parts. Thus, the possibility of crack penetrating between the glass fibers was very low.

In this way, the risk of separating between glass fibers and epoxy is lower. The nano fibers made bridges between composite layers which reduced crack propagation and absorbed more energy by two phenomena occurred in this situation.

Failure of a composite sample may get triggered in a certain “mode”, but its propagation and final failure modes may be significantly different. In a large number of cases, composite failure gets initiated internally, and it is only once failure has propagated beyond a certain extent, that changes in composite’s behavior and appearance are observed.

• The internal failure of the fabricated samples

Could manifest as:

- breaking of fibers
- Development of micro-cracks in matrix
- De-bonding between fibers and matrix

Delamination, i.e. separation of different layers of a laminate. From Barcol test results of the fabricated samples, the 2 wt% of fabricated sample has the highest hardness value with respect to the other compositions with the Hardness value of 18.2B

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