EXPERIMENTAL INVESTIGATION OF MECHANICAL PROPERTIES OF EGG SHELL POWDER REINFORCED WITH EPOXY

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Abstract— Over the last century polymers have emerged as one of the most indispensible components used in everyday life, epoxy being one such example. Until recently synthetic filler materials have been the preferred choice for reinforcement of epoxy to improve its toughness. However natural filler and fiber materials are emerging as suitable alternatives to synthetic materials for reinforcing polymers such as epoxy due to their environment friendliness, high abundance, renewability and cost effectiveness. The present work deals with mechanical behavior of egg shell reinforced epoxy composites. Composites samples with 0, 10 and 20% weight fraction of egg shell are made using hand layup method. The fabricated composite materials were cut according to the ASTM standards for different experiment, such as flexural test and Vickers hardness test and water absorption test. It is observed that maximum flexural strength and Vickers hardness number is obtained from the composite sample made up of 20% ESP. Water absorption percentage increases with increase in filler content.

Index Terms—polymer matrix (PMC), Egg shell powder (ESP).

I. INTRODUCTION

Composite materials are combination of more than one material which is superior to those of their constituents. Due to combination of more than one material, the properties of composite are influenced by many factors such as filler content and filler characteristics. Polymers are used for various fields like construction, automotive industries and sports due to their lightweight and high specific stiffness and strength [1]. Composite materials are evolving in the field of automotive industry, and use composite materials offers to reduce the weight of vehicle and improve the fuel efficiency and reduce the CO2 emissions. Due to deforestation and reduced harvesting there is perceived shortage of wood fiber in recent years. The previous studies have proved that chicken egg shell (ES) is agriculture byproduct that has been listed worldwide as one of the worst environmental problems, especially in those countries where the egg product industry are well developed.
The main objective of the our work is to prepare a PMC using egg shell powder as reinforcement and epoxy as matrix material to study the mechanical behavior of composite sample. Out of many available composite manufacturing processes we adopted hand layup technique to prepare the PMC [2,3]. Specimens were prepared for mechanical studies by mixing different volume percentage of egg shell powder mixed with epoxy.

II. MATERIALS AND METHODS

Egg shell powder of 150µm is used as filler material and Epoxy resin (Araldite AW 106) is used as matrix material to prepare composite material. The composite used in present study is listed in table 1. Hand layup technique is used for manufacturing of composite.

Table 1: list of composite samples

Sample	Epoxy(% volume)	Egg shell powder (ESP) in % volume
E1	100	0
E2	90	10
E3	80	20

Preparation of egg shell powder

The large amount of egg shell was collected form the local seller. The collected egg shell is exposed to sunlight for drying process for 24 hours. After drying these egg shells were dipped in sodium hydroxide (NaOH) for cleaning purpose. The egg shells were converted into powder by manual crushing. The grain size of 150µm was obtained by pouring the powered egg shell in sieve shaker machine and separating them in different grain size.

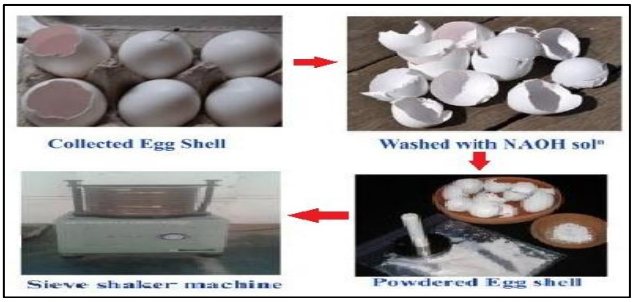

Fig 1: Preparation of egg shell powder

Preparation of mould box

Composite samples were prepared using the mould box, it was manufactured manually by cutting the plywood in square shape and lay the thin sheet on the upper surface of the board [4]. Now fix the wooden bits of 7mm thickness on the glass sheet with the help of adhesives and nails. Cavity of 170mm×80mm×07mm is obtained, now the mould is ready for further process.

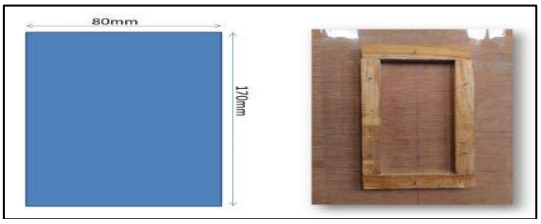

Fig 2: Mould box dimension

Preparation of composite specimens

The solution is prepared by mixing the epoxy and egg shell with hardener in right proportion. Once the solution a prepared pour it into the wooden mould cavity and is allowed to cool at the room temperature for 72 hours. Later separate the sample with proper care from the mould cavity and further experimentation is carried out.

Fig 3: Specimen preparation

Flexural strength

Flexural strength was carried out using 3-point bending method according to ASTM D2344-84 standard procedure. It is ability of material to withstand bending forces applied perpendicular to its longitudinal axis[5]. The below figure shows universal testing machine and loading arrangement of specimen.

Fig 4: Universal testing machine

Flexural strength was calculated by the equation 1:

$$\sigma_{max} = \frac{3P_{max}L}{bh^2} \quad (1)$$

Flexural modulus was determined by the equation 2:

$$E = \frac{2L^3}{4bt^3d} \quad (2)$$

Vickers hardness test

Hardness is defined as the resistance to indentation, and it is determined by measuring the permanent depth of indentation. The Vickers hardness test method, also referred to as a microhardness test method consists of indenting the test material with a diamond indenter, in the form of a right pyramid with a diamond indenter, in the form of a right pyramid with a square base and angle of 136 degrees between opposite faces subjected to a load ranging from 5kg to 129kg.

Vickers hardness number is determined by the given equation:

$$V.H.N = \frac{2F\sin\frac{\propto}{2}}{d^2} \quad (3)$$

Water-Absorption Test

In the water absorption test the specimens are placed inside the bowl of water completely immersed in order to find the absorption behavior of the composite sample at room temperature. Each specimen are carefully removed and cleaned with dry cloth and weighed immediately for every 24 hour duration[6,7]. This was repeated for 5 days and the data was recorded. The percentage of increase in weight was calculated by using equation 4 as follows.

$$\text{Increase in weight } \% = \frac{\text{Wet weight} - \text{Initial weight}}{\text{Initial weight}} \times 100 \quad (4)$$

III. RESULT AND DISCUSSION

Flexural Strength

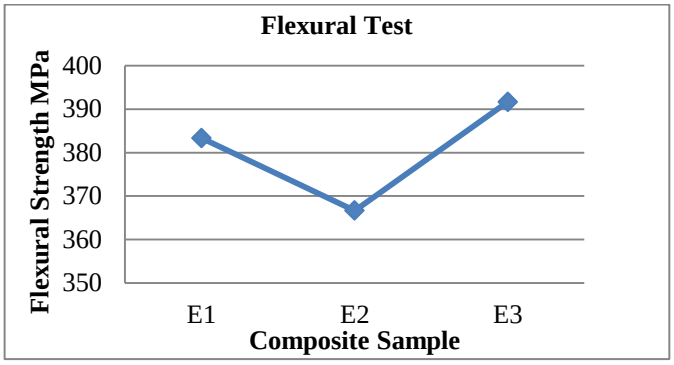

Fig 5: Flexural test graph

Figure 5 shows the variation in flexural strength for different volume of egg shell powder reinforced composite. By the graph we see that flexural strength of the composite with 20% egg shell powder has the highest flexural strength and has dropped drastically in 10% egg shell powder composite compared to neat epoxy.

Vickers hardness test

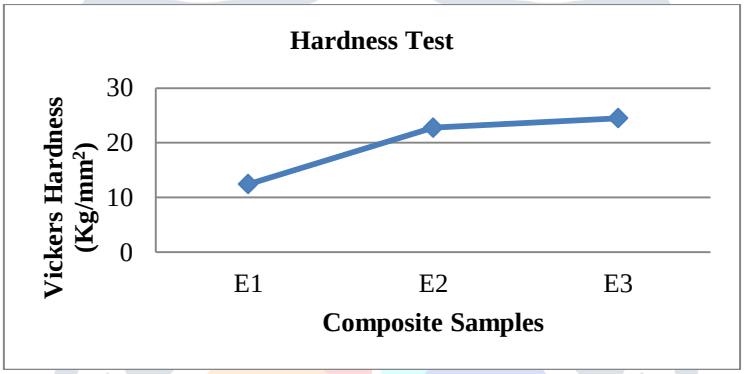

Fig 6: Vickers hardness graph

The obtained hardness number form Vickers hardness test for different samples is plotted in a graph. From the graph we can see that the hardness has gradually increased from neat epoxy to 20% egg shell reinforced epoxy composite with increase in the egg shell filler content. 20% egg shell composite has maximum values among all three samples.

Water Absorption Test

From the graph of water absorption percentage versus time in hours, we can observe that there is increase in water absorption with increase filler content in epoxy. Neat epoxy has lowest water absorption percentage compared to all three samples and 20% ESP epoxy has maximum absorption percentage.

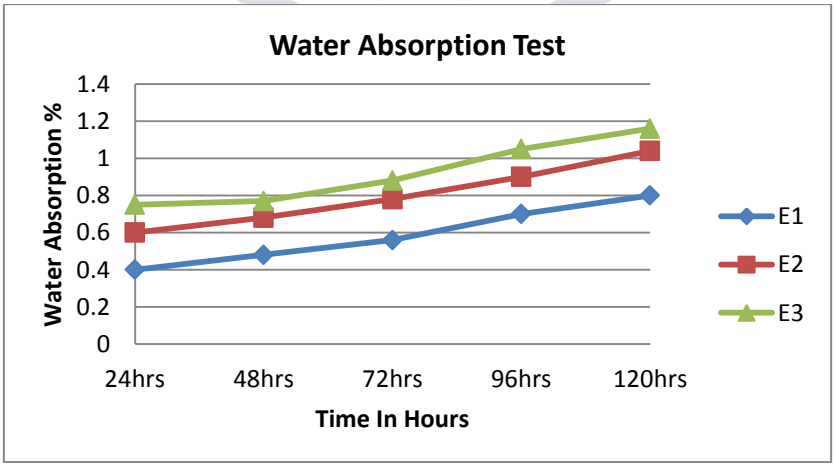

Fig 7: water absorption graph

IV. CONCLUSION

The investigation of mechanical behavior of egg shell powder with epoxy leads to the following conclusion.

- The addition of the filler content in the composite material and great influence in mechanical properties.
- Composite with 20% Egg shell reinforced epoxy has the better flexural strength compared to other samples.
- Composite with 20% Egg shell reinforced epoxy exhibits better hardness number then other composite samples.
- Neat epoxy has lower water absorption percentage, and absorption has increased with increased filler content.

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