

# AN EXPERIMENTAL STUDY & STRUCTURAL ANALYSIS OF EGG SHELL POWDER REINFORCED COMPOSITE MATERIAL

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**ABSTRACT-** Composite materials are the onewhich that are formed by the combination of the two or more materials to achieve the properties that are superior to those that of their constituents. In this project an egg shell powder reinforced composite specimen is fabricated and it is been analysed experimentally and also intheoretically. Considerable interest has been generated in the manufacturing of the egg shell powder reinforced composite materials due to their unique properties, also including their good mechanical properties, and also their thermal stability, andare also a reduced product cost.In order to conserve the natural resources and also economize the energy, weight reduction has been taken as the main focus of the machine parts manufacturers in this present scenario. Weight reduction can also be achieved primarily by the introduction of the better material, design optimization and also the better manufacturing processes. The egg shell powder reinforced composite is one of the most potential items for the weight reduction of about 20% - 30%. The introduction of this egg shell powder composite materials has made it possible to reduce the weight without any reduction on the load carrying capacity, more elastic strain, energy storage capacity and high strength to weight ratio are as compared with those that of steel.

**Keywords:** Egg shell powder, Hand Lay Up, Universal Testing Machine (UTM), Rockwell Hardness tester.

## I. SCOPE OF THE PROJECT

This subject gives a brief look on the suitability of egg shell powder reinforced composite material and also the advantages of the materials. Efforts have been made to reduce the cost of the egg shell powder reinforced composite material to that of steel material. The achievement of weight reduction with the adequate improvement of the mechanical properties has made the egg shell powder reinforced composite a very replacement material for convectional steel. Material and the manufacturing process are selected based upon the cost and also the strength factor. The design method has been selected on the basis of the mass production.

From the comparative study, it is been seen that the egg shell powder composite material are higher and more economical than conventional material.

## II. INTRODUCTION

### A. COMPOSITE MATERIAL

According to the literature, by the beginning of the next century the wood will be scarce source for the whole world. This situation has been led to the development of alternative material. Among various synthetic materials that have been explored and advocated, plastics claim a major share such as wood substitutes. Plastics are being used for almost everything from the articles of daily use to the components of complicated engineering structures and heavy industrial applications.

Hardware item like door and window frames, flushing cisterns, overhead water storage tanks and water fitting are also commercially available and are the finding acceptance in the building industry. Plastics are used to manufacture various sanitary wares, which include wash basins, bathtubs, sinks, shower cabins,

and washing racks and also the others. Plastic pipes are widely used in the installation of various industrial purposes, and also in water supply etc.

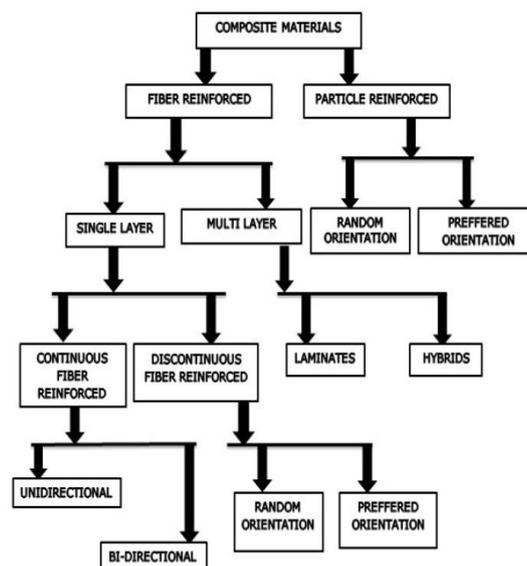
However, during the last decade, the study of the filled plastic composites has simulated the immense interest in meeting the future shortage of the plastic materials. In fact, synthetic fibers such as the nylon, rayon, aramid, glass, polyester and even carbon are the extensively used for the reinforcement of the plastics. Nevertheless, these materials are more expensive and are also a non-renewable resources. Because of the uncertainties prevailing in the supply of and due to the price of the petroleum based products, there is every need to make use of the naturally occurring alternatives.

## B. COMPOSITE

In this chapter the technical and the historical introduction on composites are been presented. An overview of the most common production process of composites is been given. At the end of this an integrated design process, typical for composites, are been discussed. At the end of this the relevance of composites for industrial and also socio-economic development in developing countries are been discussed.

Composite materials are the hybrid materials made of a polymer resin reinforced by the fibers, and by combining the high mechanical and the physical performance of the fibers and also the appearance, bonding and the physical properties of the polymer. The short and the discontinuous fiber reinforced composite materials are more responsible for the biggest share of the successful application, whether it is measured by the number of parts or the quantity of the material that is been used. Less visible however, but is growing enormously since the last decade, are the application of the continuous fiber reinforced polymer materials.

## C. TYPES OF COMPOSITE MATERIALS



According to the type of the matrix material used in, composites can be categorized or classified as Polymer Matrix Composites (PMC), Metal Matrix Composites (MMC), and Ceramic Matrix Composites (CMC). MMC consists of at least two components one is the metallic part which functions as the matrix and the other part may be the ceramic or an organic material. MMC have many advantages over monolithic metals, such that they possess higher specific strength, high specific modulus, low thermal coefficient of expansion and also the excellent wear resistance. But the toughness of the MMC is lower than the metals. CMC consists of fiber embedded in the ceramic matrix. They are not widely being established in

the service like PMCs because the processing temperature of CMCs is very high compared to PMCs. In PMC, the matrix is a polymer which may be a thermoplastic or thermoset plastic and is reinforced by fiber or fillers. Compared to the MMC and CMC, PMC are widely used because of the relative easiness to produce or to manufacture them and also due to its light weight and low cost. They possess application in the aircraft, space shuttle, rocket, rotor blades and etc. There are several criteria, on which composite material can be classified, such like on the basis of type of matrix material used, type of reinforcement used, type of fibers used. Figure 3 shows the classification of composite material on the basis of the physical structure and the geometry.

#### **D. OBJECTIVE OF THE PRESENT RESEARCH WORK**

The knowledge gap in the present literature review has helped us in setting the objectives of this research work which are pointy highlighted below:

- Fabrication of a new class of epoxy based composites reinforced with the egg shell powder.
- Evaluation of mechanical properties such as the tensile strength, impact strength, flexural strength, and micro-hardness etc of composites.
- To study the influence of the fiber length and loading on the mechanical behavior of the composites.

#### **III. MATERIALS AND METHODS**

This chapter deals with the details of the processing of the composite materials and the experimental procedures that are followed for their mechanical characterization. The raw materials used in are

- Epoxy resin.
- Egg shell powder egg shell powder fiber.
- Hardener

#### **A. MANUFACTURING PROCESS**

##### **(i) Open Molding**

In open molding method, the raw materials (such as resins and fiber reinforcements) are exposed to the air as they cure (or) harden. Open molding method utilizes the different processes, including the hand lay-up, the spray-up, the casting, and the filament winding. The manufacturing process of composites carried out in this material manufacturing is the Hand Lay-up method.

##### **(ii) Hand Lay-up:**

Hand lay-up is the most common and least the expensive open-molding method because it requires only the least amount of equipment. Fiber reinforcements are placed by hand in a mold and the resin is applied with a brush or the roller. This process is used to make both large and small sized materials, including boats, storage tanks, tubs and the showers.

Hand lay-up process is an open molding method suitable for making a wide variety of composites products from very small to very large scale. Production volume per mold is low; however, it is feasible to produce the substantial production quantities using multiple molds. Hand lay-up is the simplest composites molding method, offering low cost tooling, and simple processing, and a wide range of part sizes. Design

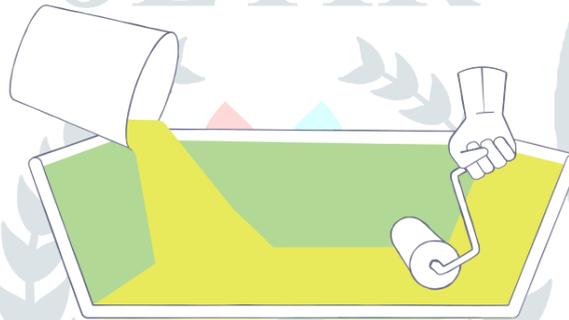
changes can be readily made. There is a minimum level investment in equipment. With skilled operators, good production rates and also consistent quality are obtainable.

### (iii) Process:

Gel coat is the initial stage and is first applied to the mold using a spray gun for a high quality surface. When the gel coat has cured sufficiently, roll stock fiberglass reinforcement is been manually placed on the mold. The laminating resin is applied by pouring, brushing, spraying, or using a paint roller manually. FRP rollers, paint rollers, or squeegees are also used to consolidate the laminate, thoroughly wetting the reinforcement and removing the entrapped air. Subsequent layers of fiberglass reinforcement are added to build the laminate thickness. Low density core materials such as end-grain balsa, foam, and honeycomb, are the commonly materials used to stiffen the laminate. This is known as the sandwich construction.

### (iv) Molds:

Simple, single cavity molds of fiberglass composites construction are been generally used. Molds can range from small to very large scales and are low cost in the spectrum of the composites molds.



**Fig (1):** Hand Lay Up Method

### (v) Advantages of Composites

- **Light Weight** - Composites are light in weight, when compared to most woods and metals. Their lightness is much important in automobiles and aircraft, for example, where less weight means better fuel efficiency (more miles to the gallon). People who design the airplanes are greatly concerned with the weight, since reducing a craft's weight reduces the consumption amount of fuel it needs and increases the speeds it can reach. Some of the modern airplanes are built with more composites than metal including the new Boeing 787, Dreamliner.
- **High Strength** - Composites can be designed to be far stronger than the aluminum or the steel. Metals are equally strong in all the directions. But the composites can be engineered and designed to be strong in a specific direction.
- **Strength Related to Weight** - Strength-to-weight ratio is said as a material's strength in relation to how much it weighs. Some of the materials are very strong and also heavy, such as steel. Other materials can be strong and also light, such as the bamboo poles which are strong and light. Composite materials can be designed to be both the strong either the light. This is the property which why composites are used to build airplanes, which need a very high strength material at the lowest possible weight. A composite material can also be made to resist the bending in one direction, for example; when something is built with metal, and the greater strength is needed in one direction,

the material usually must be made much thicker, which adds the weight. Composite materials can be strong without being much heavy. Composites have the highest strength-to-weight ratios compared to the structures today.

- Corrosion Resistance – Composite materials resist damage from the weather and from harsh chemicals that can eat away at other materials. Composite reinforcements are good choices where chemicals are handled or stored. Outdoors, they stand up to the severe weather and wide changes in temperature.
- High-Impact Strength– Composite materials can also be made to absorb impacts such as the sudden force of a bullet, for instance, or the blast from an explosion. Because of this property, composite material reinforcements are used in bulletproof vests, and also to shield airplanes, the buildings, and the military vehicles from explosions.
- Design Flexibility - Composites can be molded into the complicated shapes more easily than the most other materials. This gives designers the freedom to create almost any shape or any form. For Example; Most of the recreational boats today, are built from the fiberglass composites reinforcements because these materials can be easily molded into the complex shapes, which improve the boat design while lowering costs. The surface of the composites can also be molded to mimic any surface finish, from smooth to the pebbly.
- Part Consolidation - A single piece made of composite materials can replace the entire assembly of the metal parts. Reducing the number of parts in a machine or a structure saves the time and cuts down on the maintenance that is needed over the life of the item.
- Dimensional Stability - Composites retain their shape and size when they are hot or cool, or even wet or dry. As well as wood on the other hand, swells and shrinks as the humidity changes. Composites can be a better choice in situations demanding tight fits that do not vary in any of the humidity changes. For example; they are used in aircraft wings, so that the wing shape and size do not change as the plane gains or losses altitude.
- Nonconductive - Composites are nonconductive materials, ie; they do not conduct electricity. This property of material makes them suitable for such items as electrical utility poles and the circuit boards in electronics. If electrical conductivity is needed, it is also possible to make some composites conductive.
- Nonmagnetic - Composites contain no metals; such that they are not magnetic. They can also be used around sensitive electronic equipment. The lack of magnetic interference allows large magnets used in MRI (magnetic resonance imaging) equipment to perform better manner. Composites are used in both the equipment for housing and table. In addition with, the construction of the room uses composites rebar to reinforced the concrete walls and floors in the hospital.
- Radar Transparent - Radar signals pass through the composites, that is a property that makes the composite material ideal materials for use in anywhere the radar equipment is operating, whether on the ground or in the air. Composite materials play a key role in the aircraft, such as the U.S. Air Force's B-2 stealth bomber, which is nearly invisible to the radar.

- Low Thermal Conductivity - Composites are good insulators that they do not easily conduct heat or cold. They are used in buildings for doors, panels, and windows where extra protection is needed from severe weather changes.
- Durable - Structures that are made of composites have a long life and need little maintenance. We do not know how long composites last, because of which we have not come to the end of the life of many original composites. Many composite materials have been in service for half a century.

## IV. RESULTS AND DISCUSSIONS

### A. Tensile Strength

The tensile test of the composite material is been performed as per the ASTM (D3039) standards. The test is done using the universal testing machine.

A universal testing machine (UTM), is used for the testing of the tensile stress and also the compressive strength of the materials in this project.

It is named that the fact that it also can perform as many of the standard tensile and compression tests on this material, components, and its structures.



**Fig (2):** Universal Testing Machine Setup

### B .Components

Load frame - Usually it consists of two strong supports for the machine. Some small machines have only single support.

Load cell - A force transducer or any other means of measuring the load is required. Periodic calibration is usually required by governing regulations or quality of the system.

Cross head - A movable cross head (crosshead) is being controlled to move up or down. This is sometimes called a constant rate of extension (CRE) machine. Some machines can program the crosshead speed or conduct cyclical testing, testing at a constant force, testing at a constant deformation, etc. Electromechanical, servo-hydraulic, linear drive and resonance drives are used.

Means of measuring extension or deformation - Many tests require a measure of response of the test specimen to the movement of the cross head. Extensometers are also sometimes used.

Output device - A means of providing the test result is been needed. Some of the older machines have dial or digital displays and chart recorders. Mostnew machines have a computer interface for analysis and printing.

Conditioning - Many tests require the controlled conditioning for (temperature, humidity, pressure, etc.). The machine can be in a controlled room or a special an environmental chamber can be placed around the test specimen for the testing.

Test fixtures, specimen holding jaws, and the related sample making equipment are called for in many testing methods.

The set-up and usage are detailed in a test method, and are often published by a standard organization. This specifies the sample preparation, fixturing, gauge length (the length which is under study or observation), and the analysis, etc.

The specimen is being placed in the machine between the grips and an extensometer, if required can automatically record the change in gauge length while the test is been conducted. If an extensometer is not fixed, the machine itself can record the displacement between its cross heads on which the specimen is being held. However, this method not only records the change in length of the composite but also all other extending / elastic components of the testing machine.

Once the machine is been started it begins to apply an increasing load on the specimen. Throughout the tests, the control system and its associated software records the load and extension or compression of the composite. Machines range from a very small table top system to ones with over 53 MN (12 million lbf) capacities.

### C. Observation:

Dimension of the specimen in mm = 250x25x2.5

Area of the specimen = 62.5 mm<sup>2</sup>

Tensile strength = Load/ Area

### D. Tabulation:

For specimen at 10% fiber

Strength	Load kg			Tensile Strength (N/mm <sup>2</sup> )		
	A	B	C	A	B	C
Elastic	46	45	46	7.22	7.06	7.22
Yield	55	55	55	8.63	8.63	8.63
Plastic	63	64	63	9.89	10.05	9.89
Ultimate	71	73	72	11.14	11.46	11.3

Breaking	84	86	86	13.18	13.51	13.51
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Mean Tensile strength = 13.4 N/mm<sup>2</sup>

Epoxy (Wt %)	Alkali treated Egg shell powder Fiber (Wt %)	Inden ter	Load( kg)	RHN			Mean RHN
				A	B	C	
90	10	1/16 inches Ball	150	111	109	104	108

**Table(1): Hardness Property**

#### E. Rockwell Hardness:

Rockwell Hardness ASTM D785 is a hardness measurement test based on the net increase in depth of impression such as a load is applied. Hardness numbers have no units and are also commonly given in the R, L, M, E and K scales. Higher numbers indicate the harder materials. A standard composite is placed on the surface of the Rockwell Hardness tester. A minor load is being applied and the gauge is set to zero. The major load is been applied by tripping a lever. After 15 seconds the major load applied is removed. The composite is allowed to recover for 15 seconds and then the hardness is read off the dial with the minor load still applied.



**Fig (3):** Rockwell hardness setup

## V. CONCLUSION

A detailed study has been conducted on the mechanical behavior of the egg shell powder/epoxy reinforced composite on the basis of different weight concentration of fiber and filler. The study led to the conclusions that is been mentioned below. Epoxy resin reinforced with alkali treated fiber and the untreated fiber has been fabricated by the hand lay-up method. Egg shell powder Epoxy composite has also been fabricated with same technique.

Mechanical properties such as the tensile strength and the hardness of the composites have been evaluated and tabulated. The tensile strength of the egg shell powder reinforced fiber based epoxy composite with 10% designation contributes a maximum tensile strength of 14.85 N/mm<sup>2</sup>. But the hardness of the material is reduced when the percentage of fiber is being increased.

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