# Studies on the influence of fibre parameters on the flexural properties of polymer fibre composites

[1]M.Jayavelu, [2]I.Sureshkumar, [3]E.Hemameeakshi, [4]G.Kaliraj

*[1] Lecturer, Plastic Technology,VSVN Polytechnic College,Virudhunagar, Tamilnadu, India*
*[2] Lecturer, Mechanical Engineering,VSVN Polytechnic College,Virudhunagar, Tamilnadu, India*
*[3] Lecturer, Polymer Technology,Tamilnadu Polytechnic College,Madurai, Tamilnadu, India*
*[4] Lecturer, Polymer Technology,Tamilnadu Polytechnic College,Madurai, Tamilnadu, India*

## ABSTRACT

*Fibre-reinforced polymer composite materials for engineering structures are used everywhere. Their low densities, combined with high strength and high stiffness, provide excellent benefits in performance and long life.. When combined with the expertise of the current generation of engineers and latest composite materials prepared to accept the complexity of designing and fabricating structures using anisotropic materials, the range of applications becomes less surprising. Some 25 years ago, the majority of high performance composite materials were manufactured from individual layers of unidirectional reinforced material. But in the present scenario, a number of reinforcing materials are used to manufacture fibre reinforced composites. This chapter deals with the various types of polymer matrix and reinforcing materials used to manufacture composites. Also deals with the improvement in Compressive properties by the addition of different types of fibres.*

**Keyword**: - *polymer matrix, anisotropic material, composites.*

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## I. INTRODUCTION

Fibre-reinforced polymer matrix composite play a major role in our day today life. They have a number of unique properties like low densities, excellent strength and high stiffness combined with moderate impact strength make FRP to be highly useful in performance and durability;. This chapter begins with a brief introduction to continuous fibre-reinforced composite materials before describing the various major types of textile-reinforced polymer matrix composite materials based on the following fabric types: two-dimensional woven, braided, knitted, stitched, three-dimensional woven. In each case, an introduction to the mechanical and damage accumulation behaviour, together with approaches to modelling the composite, is provided. It is the material consisting of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods. Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties: tensile strength of one of the strongest polymers - epoxy resin is 20000 psi (140 MPa).e
The strength and other properties composites depends upon the nature of resin and fibre used for the manufacture of the composite. In this paper the flexural properties of composites studied by varying the quantity and nature of fibres.

## II. MATERIALS AND PROCEDURE

### 2. 1.TYPES OF COMPOSITES

#### 2.1.1 Metal matrix composites (MMC)

High specific modulus, high specific strength, better properties at elevated temperatures and lower coefficient of thermal expansion are the main advantages of metal Matrix Composites over monolithic metals. Because of these attributes metal matrix composites are under consideration for wide range of applications viz. combustion chamber nozzle (in rocket, space shuttle), housings, tubing, cables, heat exchangers, structural members, aerospace applications , medical applications etc.

#### 2.1.2 Ceramic matrix Composites (CMC)

One of the main objectives in producing ceramic matrix composites is to increase the toughness. Naturally it is hoped and indeed often found that there is a concomitant improvement in strength and stiffness of ceramic matrix composite.

#### 2.1.3 Polymer Matrix Composite (PMC)

It is the material consisting of a polymer (resin) matrix combined with a fibrous reinforcing dispersed phase. Polymer Matrix Composites are very popular due to their low cost and simple fabrication methods.
Use of non-reinforced polymers as structure materials is limited by low level of their mechanical properties: tensile strength of one of the strongest polymers - epoxy resin is 20000 psi . In addition to relatively low strength, polymer materials possess low impact resistance.

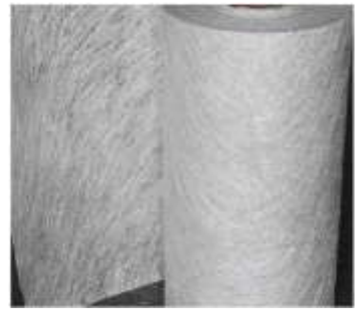
### 2.2 PROPERTIES OF POLYMER MATRIX COMPOSITES

- Very good strength
- Excellent stiffness
- Very high Fracture Toughness
- Good abrasion resistance
- Good puncture resistance
- Good corrosion resistance
- Moderate price.

### 2.3 INTRODUCTION TO GLASS FIBRE

Glass fibers are therefore used as a reinforcing agent for many polymer products; to form a very strong and relatively lightweight fiber-reinforced polymer (FRP) composite material called glass-reinforced plastic (GRP), also popularly known as "fiberglass". Glass fibers are most commonly used fibers. They come in two forms Continuous fibers, Discontinuous fibers
Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.





E- Glass Fibre S- Glass Fibre C- Glass Fibre

**2.3.1 Introduction of E-Glass Fibre**

Glass fiber is a material consisting of numerous extremely fine fibers of glass. E-glass have excellent strength & electrical resistivity. It was later found to have excellent fibre forming capabilities and is now used almost exclusively as the reinforcing phase in the material commonly known as fibre glass.

**2.3.2 Properties of E-Glass fibre**

- Low cost
- High strength
- High stiffness
- Non-flammable
- Resistant to heat
- Good chemical resistance
- Relatively insensitive to moisture
- Good electrical insulation
- Higher density compared to carbon fibres and organic fibres.
- Good electrical insulation
- Able to maintain strength properties over a wide range of conditions

## 2.4 INTRODUCTION OF GRAPHENE

Graphene is a one-atom-thick layer of carbon atoms arranged in a hexagonal lattice. It is the building-block of Graphite (which is used, among other things, in pencil tips), but graphene is a remarkable substance on its own - with a multitude of astonishing properties which repeatedly earn it the title “wonder material”.

Graphene is the thinnest material known to man at one atom thick, and also incredibly strong - about 200 times stronger than steel. On top of that, graphene is an excellent conductor of heat and electricity and has interesting light absorption abilities. It is truly a material that could change the world, with unlimited potential for integration in almost any industry.

Graphene is an extremely diverse material, and can be combined with other elements (including gases and metals) to produce different materials with various superior properties. Researchers all over the world continue to constantly investigate and patent graphene to learn its various properties and possible applications.

**2.4.1 Properties of Graphene**

Due to the strength of its 0.142 Nm-long carbon bonds, graphene is the strongest material ever discovered, with an ultimate tensile strength of 130,000,000,000 Pascals (or 130 gigapascals), compared to 400,000,000 for A36 structural steel, or 375,700,000 for Aramid (Kevlar). Not only is graphene extraordinarily strong, it is also very light at 0.77milligrams per square metre (for comparison purposes, 1 square metre of paper is roughly 1000 times heavier). It is often said that a single sheet of graphene (being only 1 atom thick), sufficient in size enough to cover a whole football field, would weigh under 1 single gram.

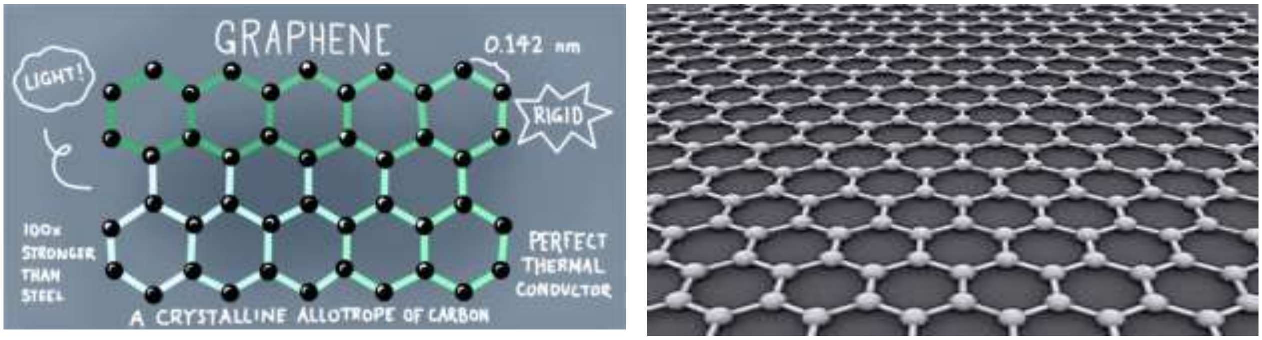



Figure 1 Graphene is an atomic-scale hexagonal lattice made of carbon atoms

**2.4.2 Advantage of Graphene**

- It is two hundred times stronger compare to steel and incredibly flexible.
- It is thinnest material possible and it is completely transparent which can transmit more than 90 % of the light.
- It can transfer electrons at much faster rate compare to silicon. It can pass at the speed of 1000 Kms/sec which is about 30 times fast compare to silicon.
- It can be used in flexible electronic newspaper, foldable televisions etc.
- It can be used in clothing which uses graphene based photo-voltaic cells as well as super conductors. Due to this tablets and mobile phones can be charged in minutes while in the pockets itself.
- It can be used for wide variety of applications such as flexible displays (OLEDs, LCDs), RAM, energy efficient transistors, energy storage devices, textile electrodes, copper nano wires, thermal management, spintronics etc.

## 2.5 INTRODUCTION TO EPOXY RESIN

Epoxy resins are much more expensive than polyester resins because of the high cost of the precursor chemicals most notably epi chloro hydrin. However, the increased complexity of the 'epoxy' polymer chain and the potential for a greater degree of control of the cross linking process gives a much improved matrix in terms of strength and ductility. Most epoxies require the resin and hardener to be mixed in equal proportions and for full strength require heating to complete the curing process. This can be advantageous as the resin can be applied directly to the fibres and curing need only take place at the time of manufacture. And known as pre-preg or pre impregnated fibre.

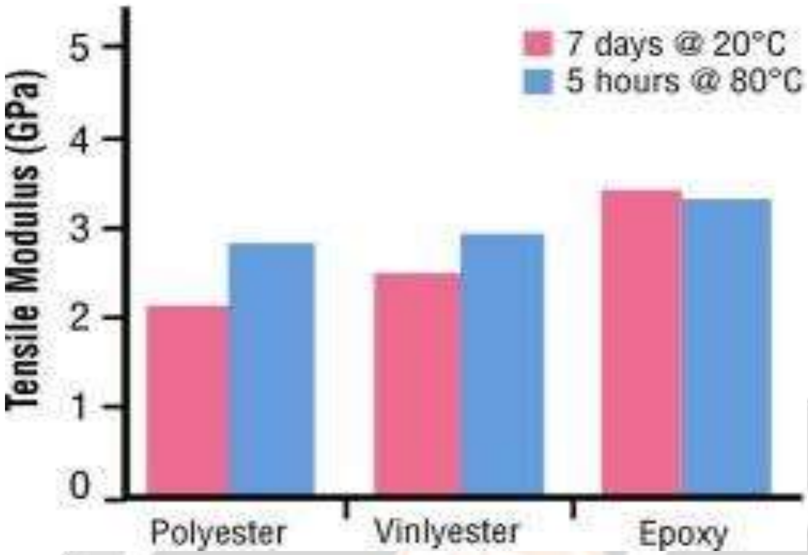
**2.5.1 Properties of Epoxy**

- High shear and peel strength
- Tough and resilient
- Good resistance to dynamic loading
- Bonds a wide variety of materials in common use
- Epoxy also has excellent resistance to chemical.

**2.5.2 Advantages of Epoxy Resin**

- Low shrink during cure
- Excellent moisture resistance
- Excellent chemical resistance
- Good electrical properties
- Increased mechanical and fatigue strength
- Impact resistant.

Figure 2. Comparison of polyester, vinylated, epoxy Tensile Modulus




**2.6 COMPRESSION MOLDING**

Compression molding is a popular manufacturing technique for composite parts. In particular, the development of high-strength sheet molding compounds drove wide adoption of compression molding process in automotive and appliance applications. In this chapter, we present some advantages and disadvantages of compression molding. We also introduce molding materials for compression molding such as sheet molding compound and bulk molding compound. To obtain high quality products, it is important to optimize mold design and processing conditions. Process modeling, such as flow and cure analysis, is especially useful to predict the knit line formation, part curing, fiber orientation and separation in the final product.

**Figure 3. Compression Molding machine**

**2.6.1 Advantages of the Compression Molding Process**

- Good surface finish with different texture and styling can be achieved.
- High part uniformity is achieved with compression molding process.
- Good flexibility in part design is possible.
- Maintenance cost is low.

**2.7 FABRICATION OF COMPOSITE MATERIAL**

**2.7.1Compositions of composite material**

Compositions of composite material for preparation of sample for Testing are shown in table 2.2

| Specimen No.: | Epoxy Resin :Hardner Ratio | Graphene Weight (%) | E-Glass Fibre (No. of layers) |
|---|---|---|---|
| 1 | 10:6 | 9 % | 3 layers |
| 2 | 10:6 | 12 % | 3 layers |

**Table 1 Compositions of composite material**

The fabrication of the polymer matrix composite was done at room temperature. The required ingredients of resin and hardener were mixed thoroughly in beaker.

**2.7.2 Dough Preparation**

The required mixture of resin & hardener were made by mixing them in (10:6) and (10:5) parts in a beaker by stirring the mixture in a beaker by a rod taking into care that no air should be entrapped inside the solution. graphene were mixing with dough ratio is 9 % and 12% of the epoxy composition.

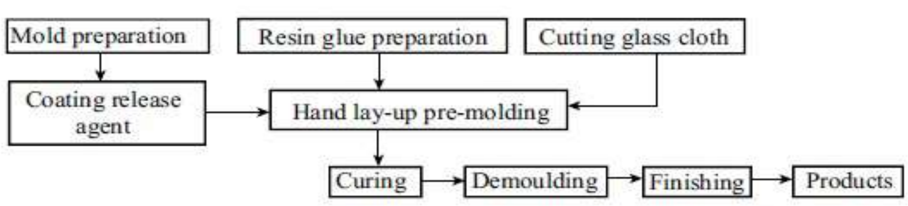
**Figure 4. Dough and Mould preparation**

**2.7.3 Mould preparation**

Two mild steel moulds of size 300 X 300 X 10 (mm) were used for casting of polymer matrix composite slabs. The moulds made of mild steel. The mould comprises of two plates one top & other bottom &third square mould cavity inside.

**2.7.4 Castings of samples**

The dough prepared is transferred to mould cavity by care that the mould cavity should be thoroughly filled. Leveling was done to uniformly fill the cavity.It is done by hand layup technique as shown below



**2.7.5 Curing**

Curing was done at room temperature for approx. 24 hrs in Compression mouding machine. After curing the mould was opened slab taken out of the mould and cleaned.

**Figure 5. Curing in Compression MoldingMachine**

**2.8 FLEXURAL TESTING**

Flexural strength, also known as modulus of rupture, bend strength, or fracture strength a mechanical parameter for brittle material, is defined as a material's ability to resist deformation under load. The transverse bending test is most frequently employed, in which a rod specimen having either a circular or rectangular cross-section is bent until fracture using athree point flexural test technique. The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress, here given the symbol. When an object formed of a single material, like a wooden beam or a steel rod, is bending, it experiences a range of stresses across its depth. At the edge of the object on the inside of the bend (concave face) the stress will be at its maximum compressive stress value. At the outside of the bend (convex face) the stress will beat its maximum tensile value. These inner and outer edges of the beam or rod are known as the 'extreme fibers'. Most materials fail under tensile stress before they fail under compressive stress, so the maximum tensile stress value that can be sustained before the beam or rod fails is its flexural strength.


**Figure 6**. Flexural Testing Machine

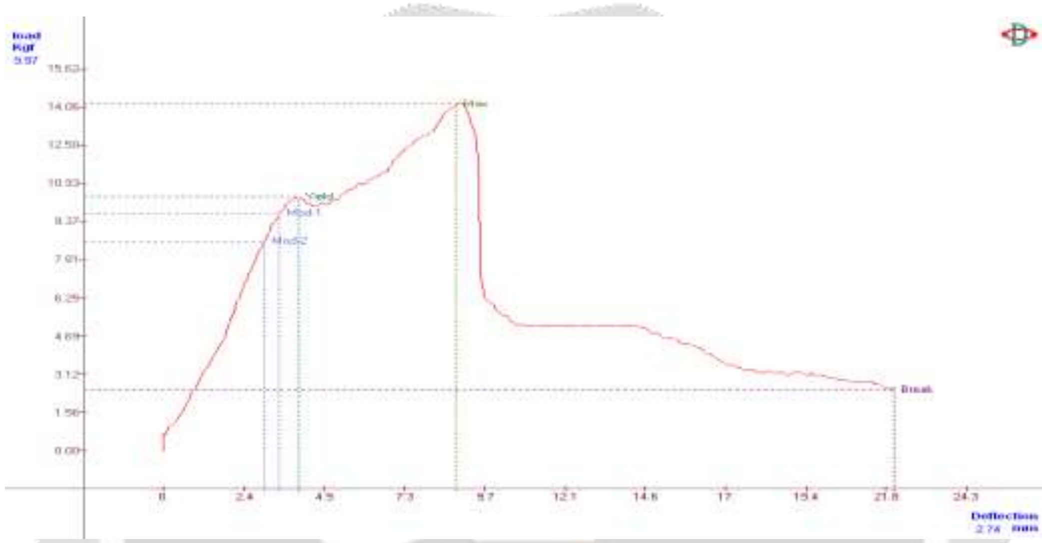
## RESULTS AND DISCUSSION

### 2.8.1 FLEXURAL TEST REPORT FOR SPECIMEN - 1

| | | |
|---|---|---|
| 1 | Span Length(mm) | 125 |
| 2 | Thickness (mm) | 3 |
| 3 | Width (mm) | 13 |
| 4 | Ref.Standard | ASTM D 790M |

**Table 2: Sample specifications**

**Graph View**



**Result Obtained**

| Specimen | Force (kg) | | Deflection(mm) | | Stress at mode1 N/mm2 | Stress at Mode 2 N/mm2 | Flexural modulus N/mm2 |
|---|---|---|---|---|---|---|---|
| | Mode 1 | mode2 | mode1 | mode2 | | | |
| 1 | 9.72 | 8.51 | 3.49 | 3.03 | 15.51 | 13.74 | 918.23 |

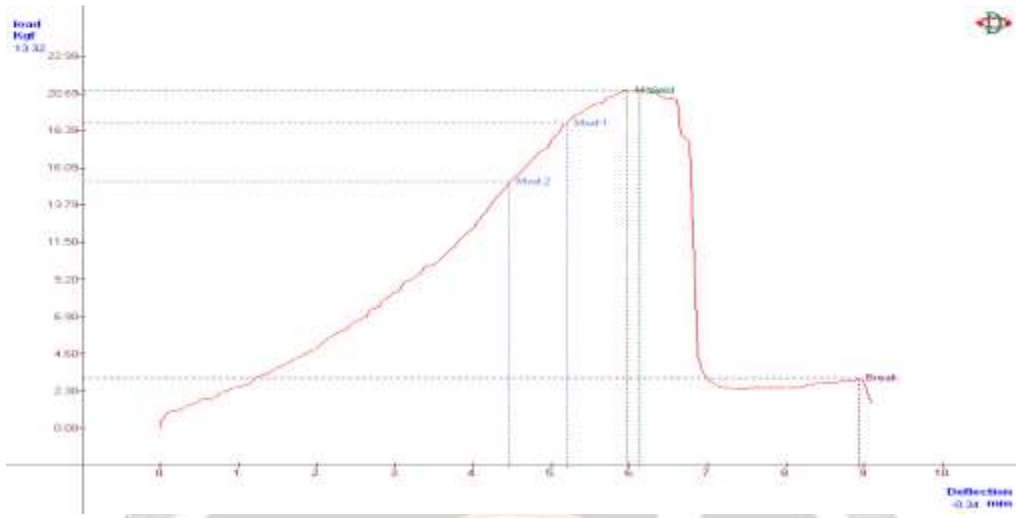
**Table 3 : Results obtained in specimen 1**

### 2.8.2 FLEXURAL TEST REPORT FOR SPECIMEN - 2

| | | |
|---|---|---|
| 1 | Span Length(mm) | 125 |
| 2 | Thickness (mm) | 3 |
| 3 | Width (mm) | 13 |
| 4 | Ref. Standard | ASTM D 790M |

**Table 4 : Sample specifications**

**Graph View**



**Result Obtained**

| Specimen | Force (kg) | | Deflection(mm) | | Stress at mode1 N/mm2 | Stress at Mode 2 N/mm2 | Flexural modulus N/mm2 |
|---|---|---|---|---|---|---|---|
| | Mode 1 | mode2 | mode1 | mode2 | | | |
| 2 | 18.85 | 15.24 | 5.20 | 4.46 | 30.21 | 24.42 | 2890.32 |

**Table 4: Results obtained in Specimen 2**

## IV CONCLUSION

- The Mechanical properties of the composites are Improving, when graphene is added with matrix as Epoxy Resin during the prepare the composite.
- Flexural strength of 9 % Graphene Specimen is 918.23 N/mm$^2$ and 12 % Graphene Specimen is 2890.32 N/mm$^2$ .Here The 12 % Graphene the composite. Flexural Strength excellently improved by adding of Graphene to the Composite.

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