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**CODEN: IAASCA** **ORIGINAL ARTICLE**

# Analysis and Fabrication of Polymer Reinforced Fly-Ash Composites

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## ABSTRACT

*This project deals with the mechanical and physical investigations on polymer composite based on fly ash (cenospheres). The performance of the composites can further be improved by adding particulate fillers to them. This work successful y uses cenosphere as a filler material in polymer. The process used to fabricate the material along with the physical properties of the material is first described. Under uniaxial tension, the material is tested in UTM and the compressive test is analysed in compressive testing machine. The present work includes the processing, characterization and study of the tensile and compressive behaviour of a series of such cenosphere filled glass-epoxy composites and calculating its parameters. It is observed that the material exhibits good tensile and compressive strength that is typical of energy absorbing materials such as thin-walled metallic. In tension, the material fractures similar to most traditional brittle materials such as glass and ceramics. As a result, uniaxial tension test and compressive test performed on different samples to evaluate the influence of the different ratio reveals promising results with increase in young's modulus and compressive strength. However, in addition to its low processing costs, the new material presents important properties that are desirable for materials used in aerospace application. Finally, the cenosphere with the material are analysed structurally in analysing software to investigate the effectiveness of the reinforcement, showing highly improved structural performance..*

***Keywords****: Polymer Composite, fly ash, cenosphere.*

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## INTRODUCTION

The aerospace industry and manufacturer's unrelenting passion to enhance the performance of commercial and military aircraft is constantly driving the development of improved high performance structural materials. Composite materials are one such class of materials that play a significant role in current and future aerospace components. The constant and continuous search and development lead to fibre-reinforced composites.

Composites can be defined as a combination of dissimilar materials to perform a task that neither of constituent material can perform alone. Composite materials are one such class of materials that play a significant role in current and future aerospace components. Composite materials are particularly attractive to aviation and aerospace applications because of their exceptional strength and stiffness-to-density ratios and superior physical properties.

Major constituents in a fibre-reinforced composite material are the reinforcing fibres and a matrix, which acts as a binder for the fibres. Other constituents that may also be found are coupling agents, coatings, and fillers.

## MATERIALS

### POLYMER MATRIX COMPOSITE (PMC)

The most common matrix materials for composite are polymeric. Polymers are finding an ever-increasing application as structural materials in various components and engineering systems. The high specific strength and stiffness of polymers are primarily responsible for their popularity. However, the resistance of polymers to solid particle erosion has been found to be very poor. In fact, it is two or three orders of magnitude lower than metallic materials.

## GLASS FIBER

Glass fiber is material made from extremely fine fibers of glass. It is used as a reinforcing agent for many polymer products; the resulting composite material, properly known as fiber-reinforced polymer (FRP) or glass-reinforced plastic (GRP). Glass fibres are made of silicon oxide with addition of small amounts of other oxides.

The glass fiber is unstiff and unstrong in shear—that is, across its axis. Therefore if a collection of fibers can be arranged permanently in a preferred direction within a material, and if the fibers can be prevented from buckling in compression, then that material will become preferentially strong in that direction.

## STRENGTHENING

The strength of polymer matrix fiber-reinforced composites can be enhanced by using appropriate fillers, the filler that had been desired for use is Cenosphere.

## CENOSPHERE

The ash produced by coal fired thermal plants has long been regarded as a waste material with potential environmental implications. The material we will be presenting is based on cenospheres from fly ash which is a by-product of coal gasification during power generation. A cenosphere is a lightweight, inert, hollow sphere filled with inert air or gas, The color of cenospheres varies from gray to almost white and their density is about 0.4–0.8 g/cm$^3$, which gives them a great buoyancy. Cenospheres are hard and rigid, light, waterproof, innoxious, and insulative. This makes them highly useful in a variety of products, notably fillers.

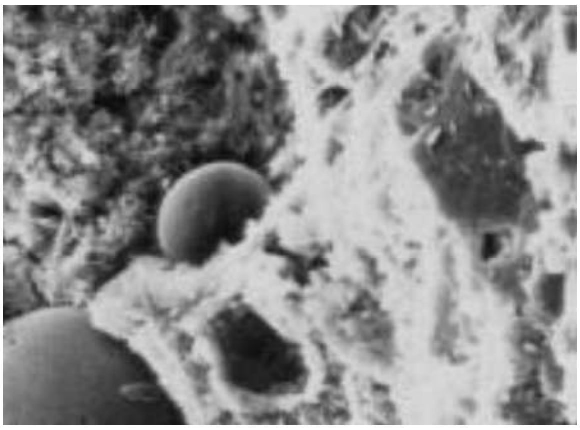
***TABLE I: CENOSPHERES CHEMICAL COMPOSITION. SILICIUM AND ALUMINIUM OXIDES ARE THE MAIN CONSTITUENTS***

| $SiO_2$ | $Al_2O_3$ | $Fe_2O_3$ | $K_2O$ | $Na_2O$ | CaO | MgO | $TiO_2$ |
|---|---|---|---|---|---|---|---|
| 55 % | 31% | 5% max | 5% | 1% | 0.5% | 1.5% | 1% |

***TABLE II:*** **CENOSPHERES PHYSICAL PROPERTIES. THE PARTICLE SIZE SHOWS A GREAT VARIATION, WHICH INCREASES THE SPHERES PACKING.**

| Specific gravity | Min particle size | Max Particle size | Mean particle size |
|---|---|---|---|
| 0.7 g/cc | 5 microns | 540 microns | 130 microns |

FIGURE: I: CENOSPHERE



## FABRICATION

Fabrication is the process of building of metal structures by cutting, bending, shaping and assembling.
There are two types of moulding in fabrication,

- Open moulding
- Closed moulding

The type of fabrication used here is Hand lay-up moulding open moulding, which is an open moulding process, it has been chosen specifically because of it simplest and most versatile of all composite manufacturing techniques and requires little capital investment.

## FABRICATION OF TEST SPECIMEN

*TABLE III:* **SELECTION OF MATERIALS**

| | |
|---|---|
| Fiber | E-glass |
| Polymer resin | Epoxy |
| Filler | Cenosphere |

*TABLE IV:* **QUALITY OF MATERIALS (IN GRADES)**

| **Materials** | **Grades** |
|---|---|
| Fiber | Rovenwoving 360 |
| Epoxy | LY556 |
| Hardener | HY951 |
| Cenosphere | Class- C |

*TABLE V:* **PROPERTIES OF MATERIALS**

| | |
|---|---|
| Glass Fiber | 1000 kg/m3 |
| Epoxy | 2350 kg/m3 |
| Cenosphere | 400kg/m3 |
| Cenosphere Dimension | 5-300μm |

TABLE VI: QUANTITY OF MATERIALS (IN RATIOS)

| | |
|---|---|
| Fiber to matrix ratio(volume fraction) | 2:1 |
| Fiber to matrix ratio(weight fraction) | 1:2 |
| Hardener | 10:1 |
| Addition of cenosphere | 5% , 10%, 20% (2 specimen in each proportion) |
| Cross ply angle | +45/-45 in each layer. |
| Volume of specimen | 40*6*1cm3 |

TABLE VII: QUANTITY OF MATERIALS

| **Materials** | Quantity |
|---|---|
| Glass Fiber | 3 m2 |
| Epoxy resin | 3 litres |
| Cenosphere | addition in 5 %, 10%, 20% |

### *B.CALCULATION OF DENSITY*

***i) Without Cenosphere :***

Mass (M) of the material= 344g
Volume = 40*6*1 =240cm3
Density, (ρ) = mass/ volume =344/240 =1.433g/cm3

**ii) With 5% Cenosphere:**

Mass (M) of the material = 353.5g
Volume = 40*6*1 =240cm3
Density, (ρ) = mass/ volume =353.5/240 =1.47291g/cm3

***iii) With 10% Cenosphere:***

*Mass (M) of the material = 363g*
Volume = 40*6*1 =240cm3
Density, (ρ) = mass/ volume =363/240 =1.5125g /cm3

**iv) With 20% Cenosphere:**

Mass (M) of the material = 336g
Volume = 40*6*1 =240cm3
Density, (ρ) = mass/ volume =336/240 =1.400g/cm3

### *C.TENSILE TESTING*

Tensile test is a measurement of ability of material to with stand forces that tends to pull it apart and to determine to what extent the materials stretches before breaking. UTM gives highly accurate force measuring system with hi-tech design and is available in different models for testing a variety of materials. Load cells, grips, fixtures can be interchanged easily to perform different tests like flexural, compression, co-efficient of friction, peeling and bonding strength.

**Standards:** ASTM D 638, D 882, D 790, D 695,C 1275, ISO R527, BS 2782 and other equivalent standards.

### i) Calculations of young's modulus & shear modulus (without Cenosphere)

Maximum Load = 119.9 KN

Initial Displacement = 2.65* 10-2 mm

TABLE VIII: STRESS AND STRAIN (WITHOUT CENOSPHERE**)**

| Load (KN) | Displacement | Deflection | Stress | (σ | Strain (ϵ) | Young's |
|---|---|---|---|---|---|---|
| | $*10^{-2}$mm | (mm) | (N/mm) | | | modulus, E |
| | | | | | | (N/mm$^2$) |
| 1.24 | 0.11 | 0.276 | 2.0667 | | $5.52*10^{-4}$ | $3.744*10^3$ |
| 2.48 | 1.08 | 0.0373 | 4.133 | | 7.46*10-4 | $5.54*10^3$ |
| 3.72 | 1.36 | 0.0401 | 6.2 | | 8.02*10-4 | $7.730*10^3$ |
| 4.96 | 1.53 | 0.0418 | 8.267 | | 8.36*10-4 | $9.888*10^3$ |
| 6.2 | 1.99 | 0.0464 | 10.33 | | 9.28*10-4 | $11.131*10^3$ |
| 7.44 | 2.27 | 0.0492 | 12.4 | | 9.84*10-4 | $12.601*10^3$ |
| 8.68 | 2.50 | 0.0515 | 14.467 | | 1.03*10-3 | $14.045*10^3$ |
| 9.92 | 2.86 | 0.0551 | 16.533 | | 1.102*10-3 | $15.002*10^3$ |
| 11.16 | 3.07 | 0.0572 | 18.6 | | 1.144*10-3 | $16.258*10^3$ |
| 12.4 | 3.47 | 0.0612 | 20.67 | | 1.224*10-3 | $16.887*10^3$ |
| 14.88 | 3.64 | 0.0629 | 24.8 | | $1.258*10^{-3}$ | $19.713*10^3$ |

Average Young's Modulus, E = 12.049 Gpa

**Calculation:**

Area,(A) = 60 * 10 = 600 mm2

Stress,(σ)=Load / Area = (1.24*1000)/600 =2.0667 N/mm2 Strain,(ϵ) = Change in Length / Original Length

= 0.0276/50 = 5.52 * 10-4

Young's Modulus, E = Stress / Strain

= 2.0667/ (5.52 * 10-4)

= 3.744 * 103 N/mm2 = 3.744 GPa

Ultimate Tensile Stress,(U.T.S) = 543.43 MPa

% of elongation = (65-50)/50 =0.3

Poisson's ratio, (ν) = lateral strain/ longitudinal strain

**δt = 0.8, t = 10.**

**δl = 15, l = 50**

ν = (δt/t) / (δl/l) = -(-0.8/10) / (15/50) = 0.267

Shear modulus**, (G) = E / (2*(1+ν))** = 4.775GPa

FIGURE: II: THE GRAPH BETWEEN LOAD AND DISPLACEMENT OF WITHOUT CENOSPHERE

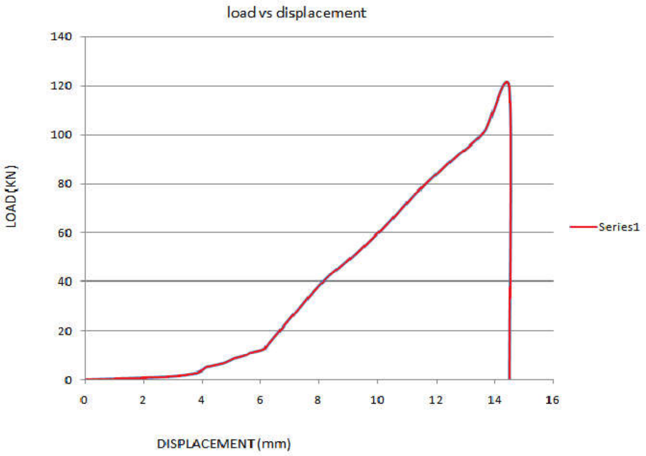
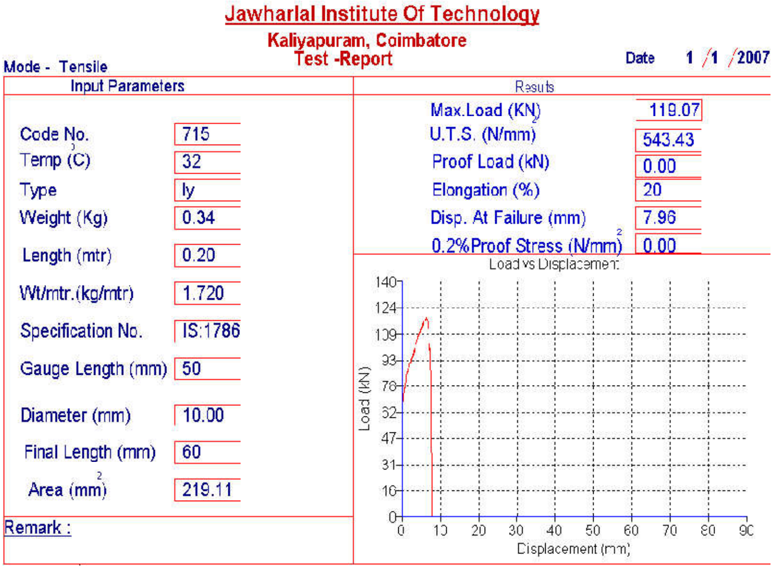


FIGURE: III: TENSILE TEST RESULT (WITHOUT CENOSPHERE**)**



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Kaliyapuram, Coimbatore
Test -Report

Mode - Tensile

Date 1 /1 /2007

| Input Parameters | |
|---|---|
| Code No. | 715 |
| Temp ($^{\circ}$C) | 32 |
| Type | ly |
| Weight (Kg) | 0.34 |
| Length (mtr) | 0.20 |
| Wt/mtr.(kg/mtr) | 1.720 |
| Specification No. | IS:1786 |
| Gauge Length (mm) | 50 |
| Diameter (mm) | 10.00 |
| Final Length (mm) | 60 |
| Area (mm$^2$) | 219.11 |

| Results | |
|---|---|
| Max.Load (KN) | 119.07 |
| U.T.S. (N/mm$^2$) | 543.43 |
| Proof Load (kN) | 0.00 |
| Elongation (%) | 20 |
| Disp. At Failure (mm) | 7.96 |
| 0.2%Proof Stress (N/mm$^2$) | 0.00 |

Remark :

## ii) Calculation of Young's modulus & Shear modulus (with 5% Cenosphere)

Maximum Load = 75.66 KN
Initial Displacement = 1.71* 10-2 mm

TABLE IX: STRESS AND STRAIN (WITH 5% CENOSPHERE**)**

| Load (KN) | Displacement | Deflection | Stress | (σ) | Strain (ϵ) | Young's |
|---|---|---|---|---|---|---|
| | $*10^{-2}$ (mm) | (mm) | (N/mm$^2$) | | | modulus (E) |
| | | | | | | (N/mm$^2$) |
| 1.24 | 0.34 | 0.0205 | 2.0667 | | $4.1*10^{-4}$ | $5.043*10^{3}$ |
| 2.48 | 0.91 | 0.0262 | 4.133 | | $5.24*10^{-4}$ | $7.887*10^{3}$ |
| 3.72 | 1.42 | 0.0313 | 6.2 | | $6.26*10^{-4}$ | $9.904*10^{3}$ |
| 4.96 | 1.70 | 0.0341 | 8.267 | | $6.82*10^{-4}$ | $12.121*10^{3}$ |
| 6.2 | 2.05 | 0.0376 | 10.33 | | $7.52*10^{-4}$ | $13.736*10^{3}$ |
| 7.44 | 2.39 | 0.041 | 12.4 | | $8.2*10^{-4}$ | $15.121*10^{3}$ |
| 8.68 | 2.67 | 0.0438 | 14.467 | | $8.76*10^{-4}$ | $16.510*10^{3}$ |
| 9.92 | 2.78 | 0.0449 | 16.533 | | $8.98*10^{-4}$ | $18.410*10^{3}$ |
| 11.16 | 3.07 | 0.0478 | 18.6 | | $9.56*10^{-4}$ | $19.456*10^{3}$ |
| 12.4 | 3.29 | 0.05 | 20.67 | | $1*10^{-3}$ | $20.67*10^{3}$ |
| 13.64 | 3.52 | 0.0523 | 22.733 | | $1.046*10^{-3}$ | $21.733*10^{3}$ |
| 14.88 | 3.81 | 0.0522 | 24.8 | | $1.104*10^{-3}$ | $22.463*10^{3}$ |
| 16.12 | 3.98 | 0.0569 | 26.867 | | $1.138*10^{-3}$ | $23.608*10^{3}$ |
| 17.36 | 4.16 | 0.0587 | 28.933 | | $1.174*10^{-3}$ | $24.645*10^{3}$ |
| 19.81 | 4.49 | 0.062 | 33.017 | | $1.24*10^{-3}$ | $26.627*10^{3}$ |

Average Young's Modulus, E = 17.194 Gpa

**Calculation:**

Area,(A) = 600 mm
Stress,(σ) =2.0667 N/mm2
Strain,(ϵ) = 4.1* 10-4
Young's Modulus, E = Stress / Strain = 5.043 GPa Ultimate Tensile Stress,(U.T.S) = 336.50 MPa
% of elongation = 0.2852

Poisson‘s ratio, (ν) = 0.286 Shear modulus, **(G)** = 6.685GPa

FIGURE: IV: THE GRAPH BETWEEN LOAD AND DISPLACEMENT OF WITH 5% CENOSPHERE

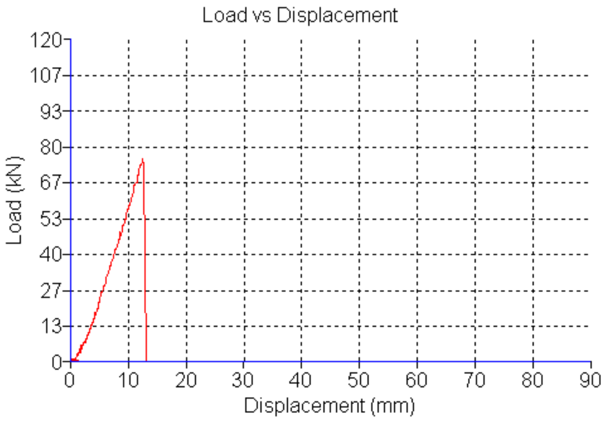
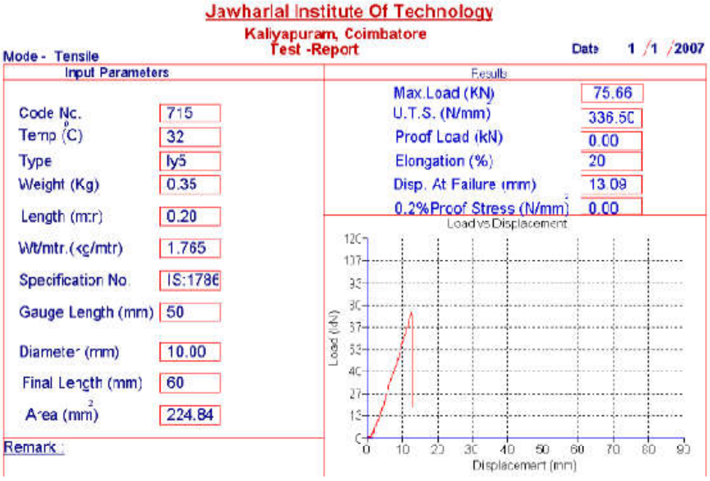


FIGURE: V: TENSILE TEST RESULT (WITH 5% CENOSPHERE **)**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Kaliyapuram, Coimbatore
Test -Report

Mode - Tensile
Date 1 /1 /2007

Input Parameters

| | |
|---|---|
| Code No. | 715 |
| Temp (°C) | 32 |
| Type | ly5 |
| Weight (Kg) | 0.35 |
| Length (mtr) | 0.20 |
| Wt/mtr.(kg/mtr) | 1.765 |
| Specification No | IS:1786 |
| Gauge Length (mm) | 50 |
| Diameter (mm) | 10.00 |
| Final Length (mm) | 60 |
| Area (mm²) | 224.84 |

Remark :

Results

| | |
|---|---|
| Max.Load (KN) | 75.66 |
| U.T.S. (N/mm) | 336.50 |
| Proof Load (kN) | 0.00 |
| Elongation (%) | 20 |
| Disp. At Failure (mm) | 13.09 |
| 0.2%Proof Stress (N/mm²) | 0.00 |

### iii) Calculation of Young’s modulus & Shear modulus (with 10% Cenosphere)

Maximum Load = 95.5 KN

Initial Displacement = 2.77* 10-2 mm

TABLE X: STRESS AND STRAIN (WITH 10% CENOSPHERE**)**

| Load (KN) | Displacement | Deflection | Stress | (σ) | Strain (ϵ) | Young‘s |
|---|---|---|---|---|---|---|
| | *$10^{-2}$ (mm) | (mm) | (N/mm$^2$) | | | modulus (E) |
| | | | | | | (N/mm$^2$) |
| 1.24 | 0.11 | 0.0288 | 2.0667 | | 5.76*$10^{-4}$ | 3.588*$10^3$ |
| 2.48 | 0.85 | 0.0362 | 4.133 | | 7.24*$10^{-4}$ | 5.708*$10^3$ |
| 3.72 | 1.31 | 0.0408 | 6.2 | | 8.16*$10^{-4}$ | 7.598*$10^3$ |
| 4.96 | 1.65 | 0.0442 | 8.267 | | 8.86*$10^{-4}$ | 9.351*$10^3$ |
| 6.2 | 1.82 | 0.0459 | 10.33 | | 9.18*$10^{-4}$ | 11.252*$10^3$ |
| 7.44 | 2.10 | 0.0487 | 12.4 | | 9.74*$10^{-4}$ | 12.731*$10^3$ |
| 8.68 | 2.27 | 0.0504 | 14.467 | | 10.08*$10^{-4}$ | 14.352*$10^3$ |
| 9.92 | 2.61 | 0.0538 | 16.533 | | 10.76*$10^{-4}$ | 15.365*$10^3$ |
| 11.16 | 2.90 | 0.0567 | 18.6 | | 11.34*$10^{-4}$ | 16.402*$10^3$ |
| 12.4 | 3.12 | 0.0589 | 20.67 | | 11.78*$10^{-4}$ | 17.546*$10^3$ |
| 13.64 | 3.35 | 0.0612 | 22.733 | | 12.24*$10^{-4}$ | 18.572*$10^3$ |
| 14.88 | 3.58 | 0.0635 | 24.8 | | 12.7*$10^{-4}$ | 19.527*$10^3$ |
| 16.12 | 3.81 | 0.0658 | 26.867 | | 13.16*$10^{-4}$ | 20.415*$10^3$ |
| 17.36 | 3.98 | 0.0675 | 28.933 | | 13.5*$10^{-4}$ | 21.431*$10^3$ |
| 18.6 | 4.20 | 0.0697 | 31.0 | | 13.94*$10^{-4}$ | 22.238*$10^3$ |

Average Young‘s Modulus, E = 14.404 Gpa

**Calculation:**

Area,(A) = 600 mm2
Stress,(σ) =2.0667 N/mm2
Strain,(ϵ) =5.76 * 10-4
Young‘s Modulus, E = 3.58 GPa
Ultimate Tensile Stress,(U.T.S) = 413.06 MPa
% of elongation = 0.28
Poisson‘s ratio, (ν) = 0.303
Shear modulus, (G) **=** 5.527GPa

FIGURE: VI: THE GRAPH BETWEEN LOAD AND DISPLACEMENT OF WITH 10% CENOSPHERE

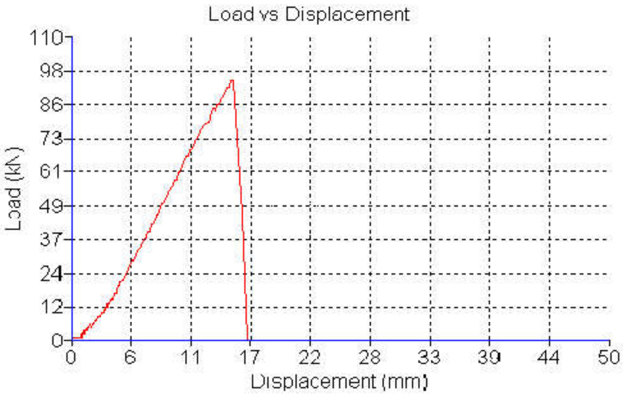
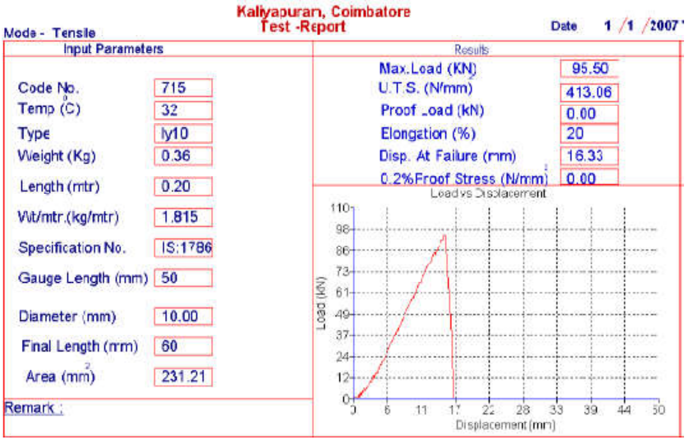


FIGURE: VII: TENSILE TEST RESULT (10% CENOSPHERE)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Kaliyapuram, Coimbatore
Test -Report

Mode - Tensile

Date 1 /1 /2007

Input Parameters

| | |
|---|---|
| Code No. | 715 |
| Temp (°C) | 32 |
| Type | ly10 |
| Weight (Kg) | 0.36 |
| Length (mtr) | 0.20 |
| Wt/mtr.(kg/mtr) | 1.815 |
| Specification No. | IS:1786 |
| Gauge Length (mm) | 50 |
| Diameter (mm) | 10.00 |
| Final Length (mm) | 60 |
| Area (mm²) | 231.21 |

Remark :

Results

| | |
|---|---|
| Max.Load (KN) | 95.50 |
| U.T.S. (N/mm²) | 413.06 |
| Proof Load (kN) | 0.00 |
| Elongation (%) | 20 |
| Disp. At Failure (mm) | 16.33 |
| 0.2%Proof Stress (N/mm²) | 0.00 |

**iv) Calculation of Young's modulus & Shear modulus (with 20% Cenosphere)**

Maximum Load = 73.18 KN
Initial Displacement = 1.30* 10-2 mm

TABLE XI: STRESS AND STRAIN (WITH 20% CENOSPHERE)

| Load (KN) | Displacement $*10^{-2}$ (mm) | Deflection (mm) | Stress (N/mm$^2$) | (σ) | Strain (ϵ) | Young‘s modulus (E) (N/mm$^2$) |
|---|---|---|---|---|---|---|
| 1.24 | 0.57 | 0.0187 | 2.0667 | | $4.1*10^{-4}$ | $5.525*10^3$ |
| 2.48 | 1.25 | 0.0255 | 4.133 | | $3.74*10^{-4}$ | $8.103*10^3$ |
| 3.72 | 1.87 | 0.0317 | 6.2 | | $5.1*10^{-4}$ | $9.779*10^3$ |
| 4.96 | 2.27 | 0.0357 | 8.267 | | $7.14*10^{-4}$ | $11.578*10^3$ |
| 6.2 | 2.56 | 0.0386 | 10.33 | | $7.72*10^{-4}$ | $13.380*10^3$ |
| 7.44 | 2.78 | 0.0408 | 12.4 | | $8.16*10^{-4}$ | $15.196*10^3$ |
| 8.68 | 3.01 | 0.0431 | 14.467 | | $8.62*10^{-4}$ | $16.783*10^3$ |
| 9.92 | 3.47 | 0.0477 | 16.533 | | $9.54*10^{-4}$ | $17.330*10^3$ |
| 11.16 | 3.86 | 0.0516 | 18.6 | | $10.32*10^{-4}$ | $18.023*10^3$ |

| | | | | | | |
|---|---|---|---|---|---|---|
| 12.4 | 3.92 | 0.0522 | 20.67 | | $10.44*10^{-4}$ | $19.770*10^{3}$ |
| 14.88 | 4.56 | 0.0586 | 24.8 | | $11.72*10^{-4}$ | $21.160*10^{3}$ |
| 16.12 | 4.71 | 0.0601 | 26.867 | | $12.02*10^{-4}$ | $22.357*10^{3}$ |
| 17.36 | 5.11 | 0.0641 | 28.933 | | $12.82*10^{-4}$ | $22.568*10^{3}$ |
| 19.81 | 5.41 | 0.0671 | 33.017 | | $13.42*10^{-4}$ | $24.602*10^{3}$ |
| 21.0 | 5.62 | 0.0692 | 35.0 | | $13.84*10^{-4}$ | $25.289*10^{3}$ |

Average Young‘s Modulus, E = 16.762 Gpa

**Calculation:**

Area,(A) = 600 mm2
Stress,(σ)=2.0667 N/mm2
Strain,(ϵ) = 3.74 * 10-4
Young‘s Modulus, E =5.525 GPa
Ultimate Tensile Strength,(U.T.S) = 341.93 MPa
% of elongation = 0.4
Poisson‘s ratio, (ν) = 0.25
Shear modulus, (G) == 6.7048GPa

FIGURE: VIII: THE GRAPH BETWEEN LOAD AND DISPLACEMENT OF WITH 20% CENOSPHERE

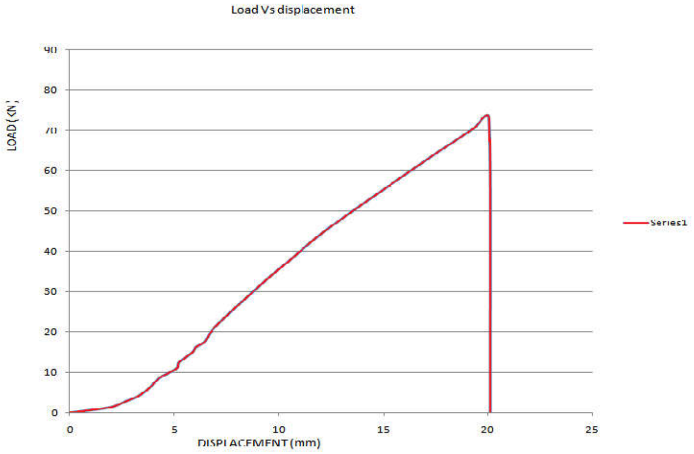
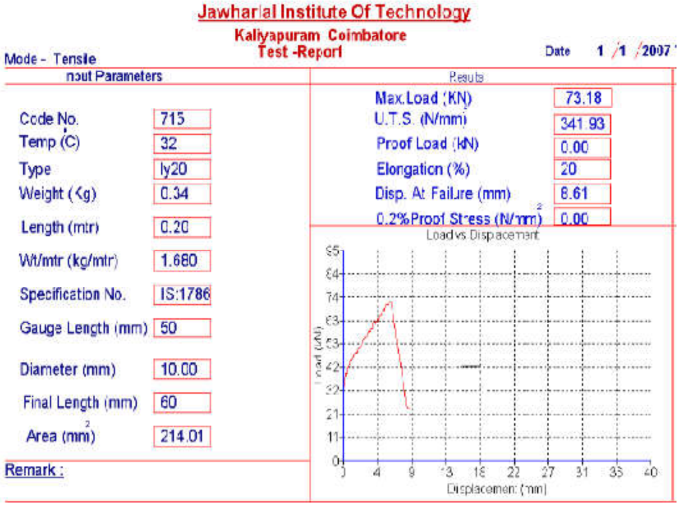


FIGURE: IX: TENSILE TEST RESULT (20%CENOSPHERE**)**



Jawharlal Institute Of Technology
Kaliyapuram Coimbatore
Test -Report

Mode - Tensile
Date 1 /1 /2007

nput Parameters

| | |
|---|---|
| Code No. | 715 |
| Temp (C) | 32 |
| Type | ly20 |
| Weight (Kg) | 0.34 |
| Length (mtr) | 0.20 |
| Wt/mtr (kg/mtr) | 1.680 |
| Specification No. | IS:1786 |
| Gauge Length (mm) | 50 |
| Diameter (mm) | 10.00 |
| Final Length (mm) | 60 |
| Area (mm$^2$) | 214.01 |

Remark :

Results

| | |
|---|---|
| Max.Load (KN) | 73.18 |
| U.T.S. (N/mm$^2$) | 341.93 |
| Proof Load (kN) | 0.00 |
| Elongation (%) | 20 |
| Disp. At Failure (mm) | 8.61 |
| 0.2%Proof Stress (N/mm$^2$) | 0.00 |

*D.COMPRESSION TESTING*

A compression test is essentially the opposite of the more common tension test. Purpose of Compression Tests: The goal of a compression test is to determine the behavior or response of a material while it experiences a compressive load by measuring fundamental variables, such as, strain, stress, and deformation

Testing Apparatus: Compression Testing Machine (Electrically cum Hand Operated-Three Gauges) CTM-3G.

TABLE XII: SPECIMEN AND APPLIED LOAD

| Specimen | Load |
|---|---|
| Without Cenosphere | 280 KN |
| 10% | 567 KN |
| 20% | 420 KN |

Compressive strength = Ultimate load / area

**Without Cenosphere:**

Area,(A) = 2000 mm2

Compressive strength = 140 MPa.

**With 10% Cenosphere:**

Area,(A) = 2000 mm2

Compressive strength = 283.5 MPa.

**With 20% Cenosphere:**

Area,(A) =2000 mm2

Compressive strength = 210 MPa.

### *E. FINITE ELEMENT ANALYSIS*

The basic idea of FEM is to divide the body into finite elements, often just called elements, connected by nodes, and obtains an approximate solution. This is called the finite element mesh and the process of making the mesh is called mesh generation. The FEM provides a systematic methodology by which the solution, in the case of our example, the temperature field, can be determined by a computer program.

### PREPROCESSING

#### Step 1: Creating the Finite Element Mesh

To make assumptions about where the gradients are expected to be the highest, and you must adjust the mesh accordingly. For example, for the turbulence model, the region near the walls must have a much denser mesh than would be needed for laminar problem. If it is too coarse, the original mesh may not capture significant effects brought about through steep gradients in the solution. Conversely, elements may have very large aspect ratios with the long sides along directions with very low gradients. For most accurate results, use mapped meshing. It more effectively maintains a consistent mash pattern along the boundary. For flow analyses, especially turbulent, pyramid elements should not use in the region near the walls because it may lead to inaccuracies in the solution. A mapped mesh is restictedd in terms of the element shape it contains and the pattern of the mesh. A mapped area mesh contains either only quadrilateral or only triangular elements, while a mapped volume mesh contains only hexahedron elements. In addition, a mapped mesh typically has a regular pattern, with obvious rows of elements. This type of mesh, must build the geometry as a series of fairly regular volumes and/or areas that can accept a mapped mesh.

#### Step 2: Applying boundary conditions

Apply boundry condition before or after mesh the domain. Consider every model boundary. If a condition is not specified for a dependent variable, a zero gradient of that value normal to the surface is assumed. Change boundary conditions between restarts. Changing a boundary condition or accidentally omit it, so no need to restart the analysis unless the change causes instabilities in the analysis solution.

#### Step 3: Results File

The results of a ANSYS analysis are not stored in the software database automatically. At the end of every solution, the software program adds a set of results to the results file, jobname.rst. The defaults given in the description of the ANSYS, OUTP command reflect ansys determination of what the results file should store based on the options you choose. The software program stores a set of results while begin an analysis(before the first iteration), then stores results again when one of the termination criteria is reached. Between those events, you can append the results to the Jobname.RST file.

FIGURE: X: DISPLACEMENT OF THE MATERIAL WITHOUT CENOSPHERE

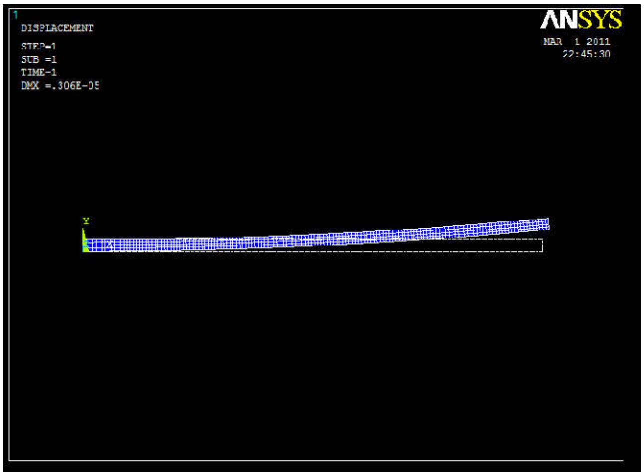


FIGURE: XI: STRESS OF THE MATERIAL WITHOUT CENOSPHERE

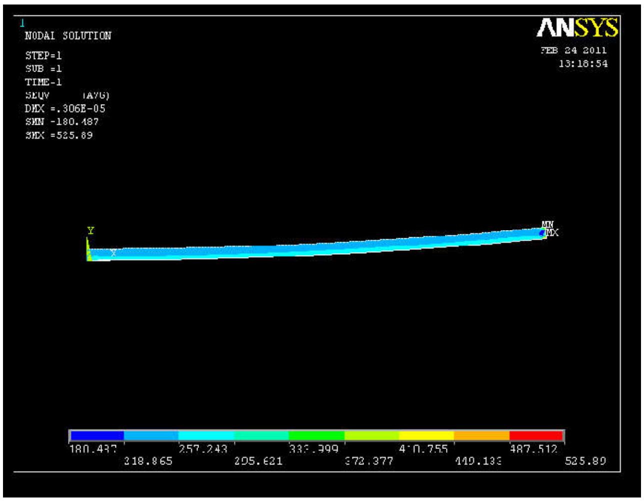


FIGURE: XII: DISPLACEMENT OF THE MATERIAL 5% CENOSPHERE

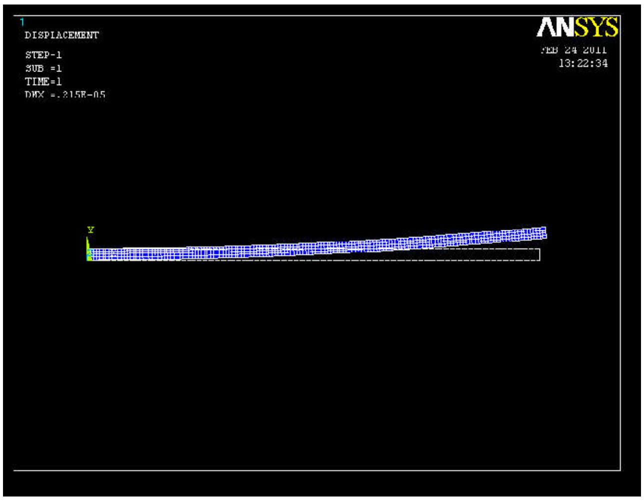


FIGURE: XIII STRESS OF THE MATERIAL 5% CENOSPHERE

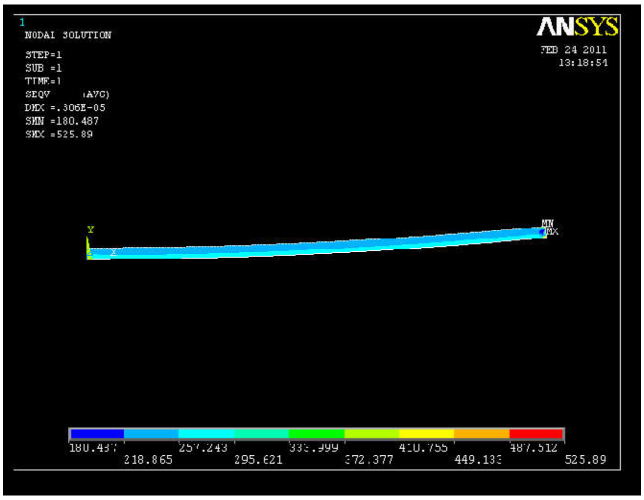


FIGURE: XIV: DISPLACEMENT OF THE MATERIAL 10% CENOSPHERE

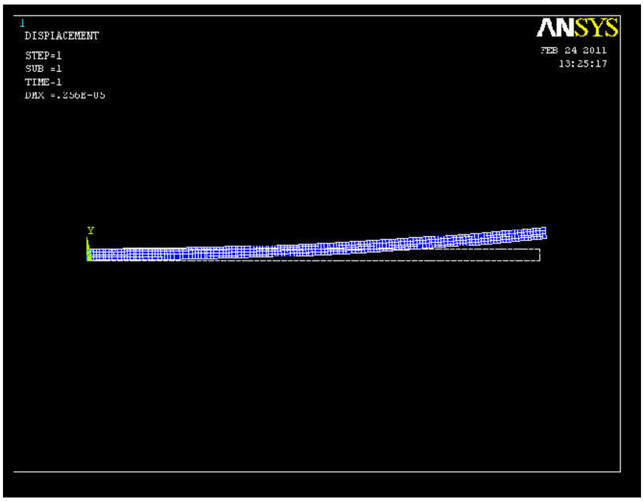


FIGURE: XV: STRESS OF THE MATERIAL 10% CENOSPHERE

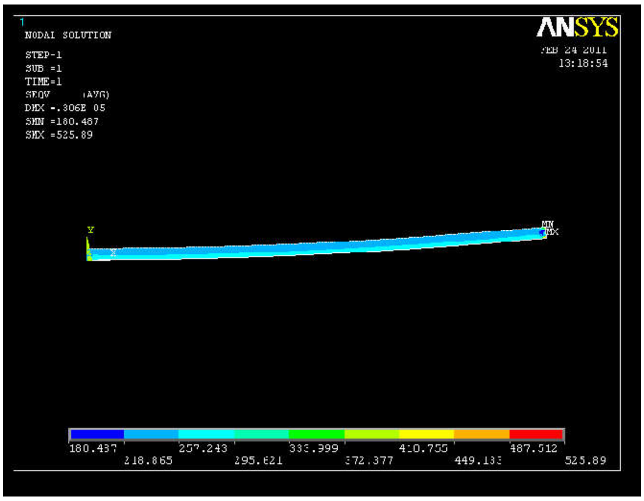


FIGURE: XVI: DISPLACEMENT OF THE MATERIAL 20% CENOSPHERE

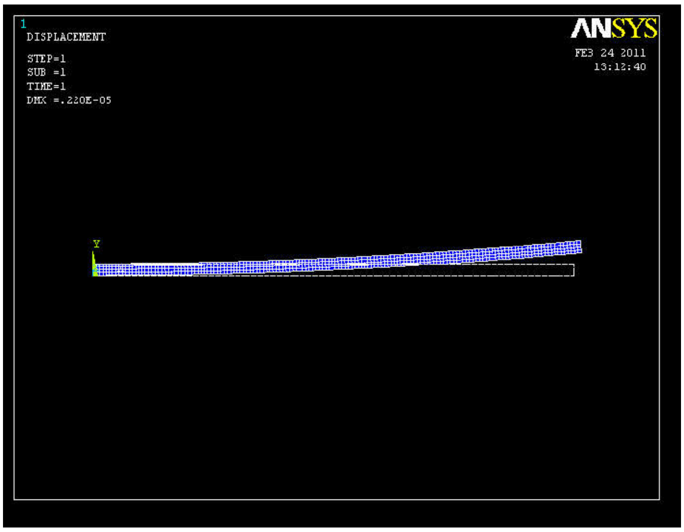
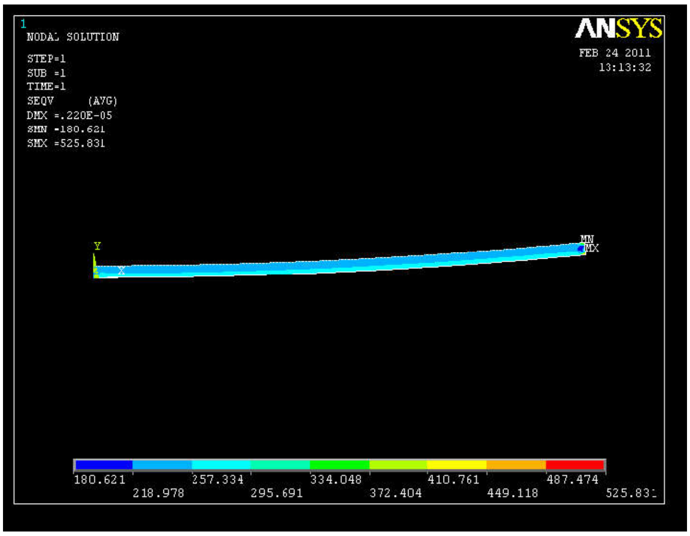


FIGURE: XVII:STRESS OF THE MATERIAL 20% CENOSPHERE



## COMPOSITE CHARACTERIZATION

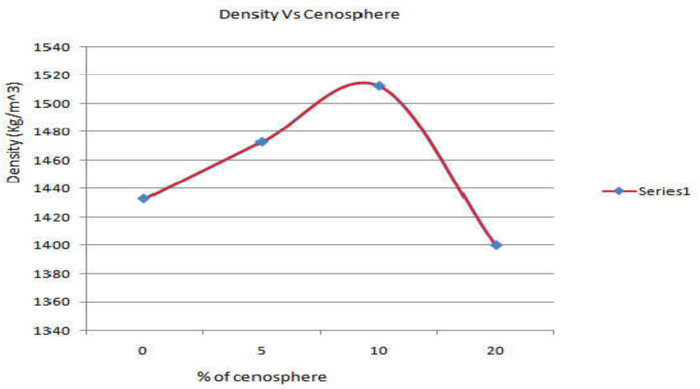
### *A. INTRODUCTION*

The physical and mechanical characterization of the class of polymer matrix composites developed for the present investigation. They are short glass fibre Reinforced epoxy resin composites Short glass fibre reinforced epoxy resin filled with different weight percentage of Cenosphere details of processing of these composites and the tests conducted on them have been described in the previous chapters. The comparative result of various parameters is reported here.

### *B.DENSITY*

Density of a composite depends on the relative proportion of matrix and reinforcing materials and this is one of the most important factors determining the properties of the composites. It can be seen that the density increases with the increase in filler content till 10%. After that the density got reduced to such smaller value of 1400 kg/m3 than the parent one with 1433 kg/m3.

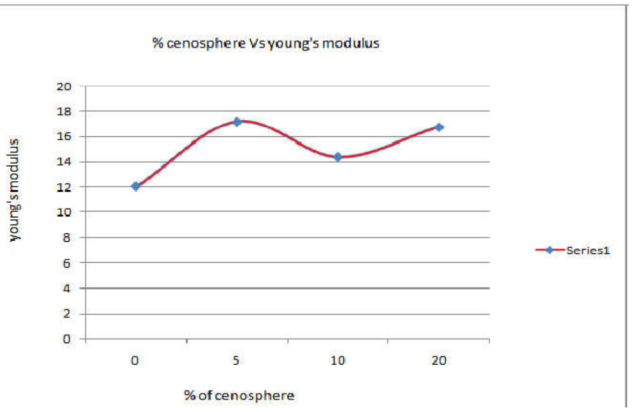
FIGURE: XVIII: THE GRAPH BETWEEN DENSITY AND CENOSPHERE



## C.YOUNG'S MODULUS

In this study, the reinforcement of cenosphere particulate in glass fiber reinforced epoxy resin has shown encouraging results in terms of mechanical properties. The tensile strengths of the composites with 5wt% and 20 wt% are recorded as 17.194 GPa and 16.762 GPa respectively where as that of neat epoxy with short glass fiber is about 12.249 GPa.

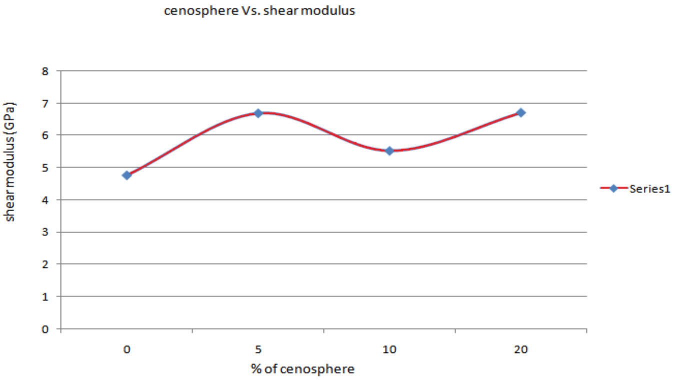
FIGURE: XIX: THE GRAPH BETWEEN YOUNG'S MODULUS AND CENOSPHERE



## D. SHEAR MODULUS

Similarly. The shear modulus also increased in 5% and 20% with values of 6.685 GPa and 6.704 GPa respectively while the parent one is with 4.755 GPa.

FIGURE: XX: THE GRAPH BETWEEN SHEAR MODULUS AND CENOSPHERE

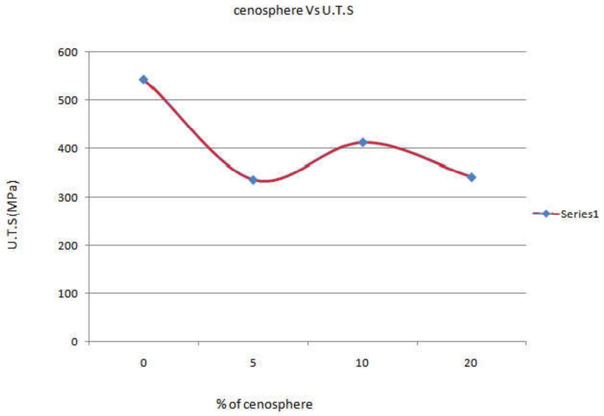


The possible reason for this increase in strength could be only due to the interaction between the particulate and matrix. This shows that there is strong bonding between the resin and filler.

## E.ULTIMATE TENSILE STRENGTH

Though the young‘s modulus, and shear modulus shows promosing result over the filler content, the ultimate tensile strength exhibit contrary result. The Ultimate tensile strength of parent specimen is 543 MPa while 5%, 10% and 20% shows only 336 MPa, 413 MPa and 341 MPa respectively.

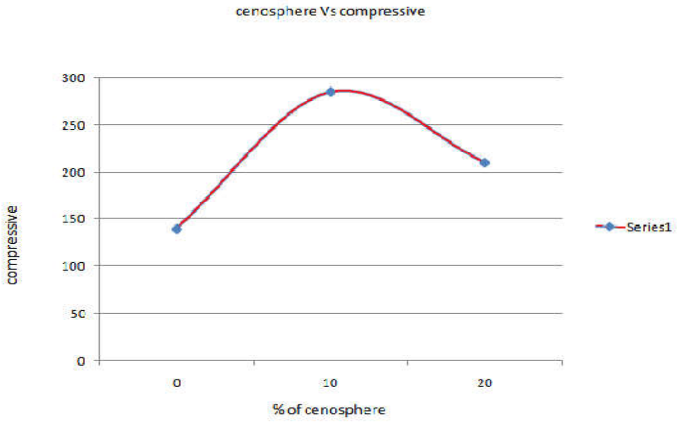
FIGURE: XXI: THE GRAPH BETWEEN CENOSPHERE AND U.T.S



*F.COMPRESSIVE STRENGTH*

The compressive test of specimen with fillers showed better strength than the specimen without fillers. The strength is so high that its twice the value of latter one.

FIGURE: XXII: THE GRAPH BETWEEN CENOSPHERE AND COMPRESSIVE STRENGTH.



*G. COMPARISON WITH OTHER STANDARD MATERIALS USED IN AIRCRAFT*

Considering the Ultimate Tensile Strength of Epoxy Glass Fibre is about 330-570 MPa, which is more than UTS of many brittle material and metals like Magnesium, Stainlesss steel, cast iron and equivalent to Alumimium.The overall young‘s modulus of Epoxy Glass Fibre with and without Censphere is around 12-17 GPa. It is a Brittle material. While comparing the result with other standard metal like Magnesium, which has Young,s modulus of 41- 45 GPa, it is less than what we require. The density of this material is around 1400- 1520 Kg/m3, which is far more less than any of the metal and less than the Brittle material like glass.Finally comparing the compressive strength (140 – 280 MPa) of various materials, this material‘s strength is so high than many materials known.

Therefore based on the above discussion it can seen that this material can be replaced in the area where the need for ultimate strength is maximum and the young‘s modulus is around the obtain results. The compressive strength of the material is so high that it can be used in areas where compressive load plays vital. The additional cenosphere into the epoxy glass fibre composites showed the better results, than the epoxy glass fibre itself. Since the density is much more lower than the other materials used in the aircraft. The weight of the component can be highly reduced. Therefore the strength to weight ratio is high in the case, which is the prominent character desirable for the design in the field of aeronautical and aerospace. The material is non corrosive, so its application is convenient in the area, where humidity is high ( in the sail boat and marine aircraft).

## CONCLUSION

From the study it is concluded that we can use fly ash for the production of composites and can turn industrial waste into industrial wealth. This can also solve the problem of storage and disposal of fly ash.

- Fly ash upto 20% by weight can be successfully added to epoxy by hand lay up method to produce composites.
- The Young's modulus of pure epoxy increased with addition of fly ash. Moreover on addition of fly ash in epoxy, there was appreciable reduction of density.
- Most importantly the Ultimate Tensile strength of cenosphere reinforced Epoxy Glass fibre has increased more than many metals and any of the brittle material.
- The Compressive strength showed improved strength than the parent material, about twice the value with the addition of fillers at 10%.
- Strengthening of composite is due to dispersion strengthening and particle reinforcement.

## REFERENCES

1. Fabrication of automotive brake composites from unburned carbon.V. M. Malhotra', P. S. Valimbe', and M. A. Wright' Department of Physics Center for Advanced Friction Studies Southern Illinois University, Carbondale, IL62901-440.
2. Review of the Research Program of the Partnership for a New Generation of Vehicles: Seventh Report. The journal on Energy and Environmental Systems, the national academy press, wasington D.C
3. Temperature-dependent surface topography analysis of Illinois Class F fly ash using ESEM and AFM. S.R. Mishraa,*, S. Kumarb, A. Waghc, J.Y. Rhoc, T. Gheyid
4. High-Performance Structural Fibers for Advanced Polymer Matrix composites. The journal on the National Materials Advisory Board, The academy press.
5. Surface Fracture Analysis of Glass Fibre Reinforced.
6. Epoxy Composites Treated with Different Type ofCoupling Agent Rozli Zulkifli Department of Mechanical and Materials Engineering.
7. Sliding Wear Behavior Of Glass Fibre Reinforced Tio2 Filled Epoxy composite. Bachelor of Technology in Mechanical Engineering by Tarun aggarwal
8. Effect of Particle Size and Concentration of Flyash on Properties of Polyester Thermoplastic Elastomer Composites. M.S. Sreekanth 1, V.A. Bambole2, S.T. Mhaske1, P.A. Mahanwar1* Department Polymer Engineering & Technology Institute of Chemical Technology, Matunga, Mumbai-400019, India
9. Cenosphere Separation from Fly Ash Using Pneumatic Transport, Triboelectric processing Tapiwa Z. Gurupira, Charles L. Jones and John M. Stencel Center for Applied Energy Research,University of Kentuck2540 Research Park Drive, Lexington, KY 40511-8410.