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# Experimental study of mechanical properties of epoxy resin nanoclay composites

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**Abstract:** Composite materials play a vital role in many industrial applications. Researchers are working on fabrication of new composite materials worldwide to enhance the applicability of these materials. This study focuses on Mechanical Properties of epoxy resin nanoclay composites.In view of this, the objective of the present work is to analyse the effect of nanoclay content on the mechanical behaviour of chopped strand mat with nanoclay filler. The mechanical and impact properties of the nanocomposites were characterized in terms of tensile, flexural, interlaminar shear tests and low velocity impact tests. The epoxy resin and hardener are of 10:1 weight ratio. The results of the study show that the incorporation of nanoclay has a significant effect on the mechanical behaviour of composites.

**Keywords:** Interlaminar shear strength, Flexural strength, Tensile strength, low velocity impact test, Nanoclay, Epoxy resin, Araldite LY556.

## I. Introduction

Fiber reinforced polymer composites are very widely used because of their favourable properties such as high specific tensile and compressive strength, controllable electrical conductivity, low coefficient of thermal expansion, good fatigue resistance and suitability for the production of complex shape materials. These materials have become the alternative of conventional structural materials such as steel, wood or metals in many applications. Typical areas of composite applications are car industry, aircraft fabrication, wind power plant, boats, ships, etc. During the human history, composites made occasionally large breakthroughs in construction and other materials. Among the composites, Chopped strand mat E-glass/ epoxy composite is emerging as a promising material for marine application due to their excellent superior strength, moisture resistance and electrical and fire insulation than that of other composites in making boat hulls,fiber glass boat.

## Experimental Procedure

The type of epoxy resin used for experimental study is Araldite LY556 and hardener is HY951. They are mixed in 10:1 weight ratio. The epoxy in the four composites are 70wt%, 69wt%, 65wt% and 63wt% of total weight of the composite and nanoclay is of 0wt%, 1 wt% , 5 wt% and 7wt %.

The selected nanoclay is a type of nanoclay, which has its surface modified with 25-30wt% methyl dihydroxyethyl hydrogenated tallow ammonium. The selected samples are then subjected to hardness test,Tensile test, Flexural test,Interlaminar shear strength. The tests were carried out according to ASTM standard (D 638-03) using a minimum of 4 specimens epoxy nanocomposites for tensile test . Length of the samples was 250mm and the nominal thickness was 4mm, while the width was maintained at 25mm.

Hardness test is performed in Rockwell L-Scale, Tensile test and Flexural test is carried out in universal Testing machine of capacity 5 tons.

Fig .1 0wt% nanoclay composite

Fig.2 1wt% nanoclay composite

  


Fig.3 5wt% nanoclay composite


Fig.4 7wt% nanoclay composite

## Testing of Mechanical Properties

The four varieties of composites are evaluated for their mechanical properties by conducting hardness test, tensile test, flexural test, charpy impact test and interlaminar shear strength test.. The test specimen are shown in Fig.5 to Fig.8.

**Hardness Test**

The test was conducted using Rockwell L- scale, which is especially for plastic materials, bakellite and vulcanized fibre. The indenter chosen is of steel ball of 1/4$^{th}$ inch diameter. A load of 60 kg was used for the test.


Fig.5- Specimen after hardness test

**Tensile test**

The tensile test was carried out using an universal testing machine of capacity 5 tons. The test specimen is prepared according to ASTM D 638-03 standard. The tensile strength is calculated according to the following formula

$\sigma_t = P / bh$ - - - - - - - - (1)

(Where,

P-ultimate load on the specimen (N)

b- Initial width of specimen (mm)

h- Initial thickness of specimen (mm))

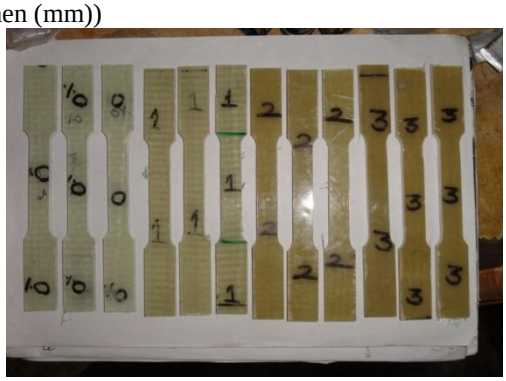

Fig.6- Specimen before tensile test

**Table 1 Tensile test results of CSM/epoxy nanocomposites**

| Nanoclay Sample (wt%) | Tensile strength (MPa) | % Gain/Loss in strength | Tensile modulus (GPa) | % Gain/Loss in modulus |
|---|---|---|---|---|
| Neat epoxy | 220 | - | 31.60 | - |
| 1 | 268 | 21.81 | 34.24 | 8.35 |
| 3 | 302 | 37.27 | 38.00 | 20.25 |
| 5 | 276 | 25.45 | 36.47 | 15.41 |

**Flexural test**

The flexural test is carried out using the universal testing machine of capacity 5 tons. The test specimen was prepared according to ASTM D790 standard. The flexural strength is calculated according to the following formula

Flexural strength: $\sigma_f = 3PL/2bh^2$ - - - - - -(2)

(Where,

P is the maximum load (N)

L- Span length of the specimen (mm)

b- Width of specimen (mm)

h- Thickness of the specimen (mm))

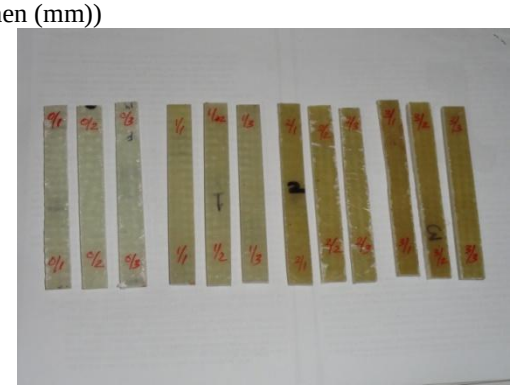

Fig.7- Specimen before flexural test

**Table 2 Flexural test results of CSM/epoxy nanocomposites**

| Nanoclay Sample (wt%) | Flexural strength (MPa) | % Gain/Loss in strength | Flexural modulus (GPa) | % Gain/Loss in modulus |
|---|---|---|---|---|
| Neat epoxy | 271 | - | 24.82 | - |

  

| | | | | |
|---|---|---|---|---|
| 1 | 312 | 15.12 | 28.26 | 13.85 |
| 3 | 340 | 25.46 | 32.62 | 31.42 |
| 5 | 308 | 13.65 | 27.40 | 10.39 |

**Charpy impact test**

The charpy impact test, also known as the charpy v – notch test, is a standardized high strain – rate test which determines the amount of energy absorbed by a material during fracture. The test specimen was prepared according to ASTM D 256 standard.

Fig.8- Specimen before charpy impact test

**Interlaminar shear strength test**

The Interlaminar shear strength test is carried out using the universal testing machine of capacity 5 tons. The test specimen was prepared according to ASTM D2344 standard. The Interlaminar shear strength is calculated according to the following formula

$\square_{13}$=0.75P/bh

(Where ,

P=break load (N),

b=width of the specimen (mm),

h=thickness of the specimen (mm)

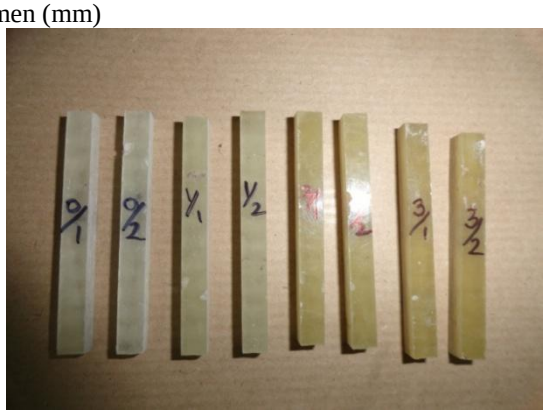

Fig.9-Specimen before ILSS test

  

**Table 3 Impact test results of CSM /epoxy nanocomposites**

| Nanoclay (wt %) | Height of Fall (m) | Impact Velocity (m/s) | Impact Energy (J) | Maximum Load (N) | Deflection at Max Load (mm) | Energy Absorbed (J) |
|---|---|---|---|---|---|---|
| 0 | 0.50 | 3.13 | 12.45 | 2245 | 8.22 | 12.16 |
| 1 | 0.50 | 3.13 | 12.45 | 2350 | 6.02 | 12.17 |
| 3 | 0.50 | 3.13 | 12.45 | 2435 | 8.07 | 12.19 |
| 5 | 0.50 | 3.13 | 12.45 | 2300 | 6.12 | 12.14 |
| 0 | 0.75 | 3.83 | 18.67 | 2325 | 4.26 | 17.62 |
| 1<br>3 | 0.75<br>0.75 | 3.83<br>3.83 | 18.67<br>18.67 | 2700<br>3175 | 4.18<br>4.2 | 17.78<br>18.35 |
| 5 | 0.75 | 3.83 | 18.67 | 2380 | 3.75 | 17.26 |
| 0 | 1 | 4.42 | 24.89 | 2105 | 3.86 | 17.47 |
| 1 | 1 | 4.42 | 24.89 | 2650 | 4.82 | 23.36 |
| 3 | 1 | 4.42 | 24.89 | 2965 | 3.80 | 22.30 |
| 5 | 1 | 4.42 | 24.89 | 2710 | 3.65 | 21.74 |

## II. Results and Discussion

From the results of hardness test it is observed that the hardness decreases with increase in % nanoclay upto 5wt%. However, further increase in % wt nanoclay hardness starts increasing. The results are shown in fig.10.

  

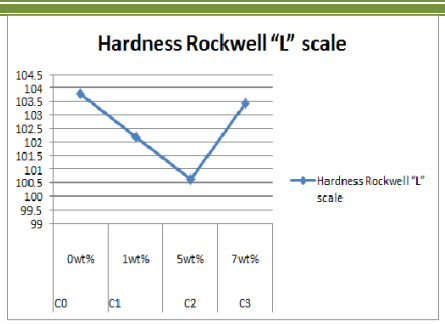


Fig.10- Hardness of four composites

Fig.11 shows the results of tensile test. The results indicate that tensile strength decreases with increase in wt% of nanoclay and reaches minimum value for 7wt% nanoclay composite.

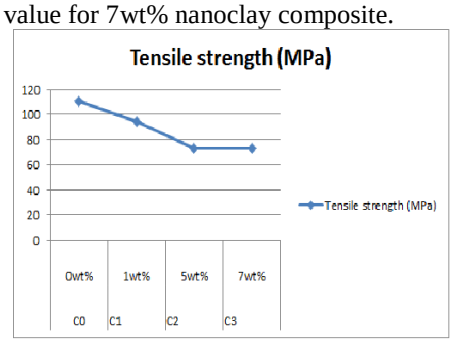


Fig.11- Tensile strength behaviour of four composites

Test results on flexural strength, indicate that it increases from the 0wt% nanoclay composite to 1wt% nanoclay composite and then decreases with further addition of nanoclay. The flexural strength of 1wt% nanoclay composite is the maximum among the four composites.(Fig.12)

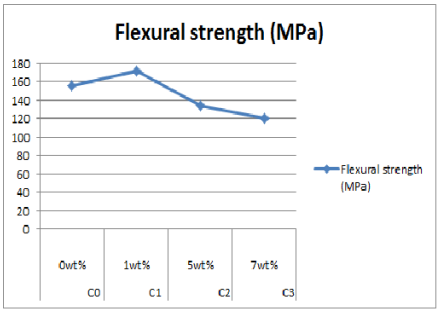


Fig.12- Flexural strength of four composites

Results of impact energy test, indicate that impact energy decreases with addition of nanoclay upto 1wt% . However, further increase in % wt nanoclay impact energy starts increasing. The results are shown in fig.13.

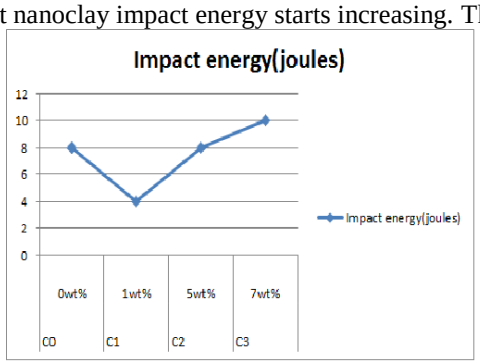


Fig.13- Impact energy of four composites

From the interlaminar shear strength test it is observed that ILSS increases with increase in % nanoclay upto 1wt%. However, further increase in %wt nanoclay ILSS starts decreasing. The results are shown in Fig.14.

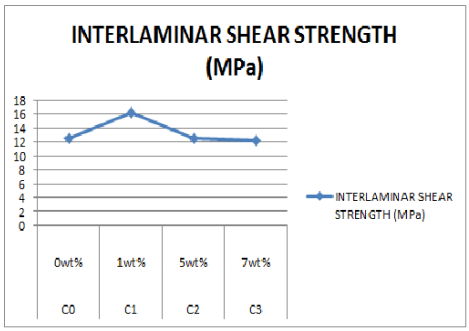


Fig.14-ILSS of four composites

## III. Conclusion

From the study, following observations were made:

(i) Due to the increase in nanoclay addition, tensile strength keep on decreases because of reduce in wettability as the matrix content is reducing.

(ii) The fiber matrix interaction is increases from 0wt% to 1wt% nanoclay and on further increase in nanoclay the fiber matrix interaction is reduced, hence the flexural strength is more in 1wt% nanoclay composite.

(iii) Due to the chopped strand mat on top and bottom in all composites, density of mat is different in different places because of randomly oriented discontinuous fibers; hence the hardness is irregular even in increase in nanoclay addition.

(iv) The amount of energy absorbed during fracture is decreases from 0wt% to 1wt% nanoclay and on further increase in nanoclay results in increase in impact energy.

(v) The interlaminar shear strength for 1wt% nanoclay composite is the highest compared to 0wt%, 5wt% and 7wt% nanoclay composite because upto 1wt% the bonding strength increases and then decreases to 7wt% nanoclay composite.

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