



# Development of Epoxy-Thermoplastic Based Syntactic Foam for Structural Application

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## ABSTRACT

The present work is focused on the synthesis and study of the deformation behavior of epoxy resin/ plastic syntactic foams. Different densities syntactic foams with different layer of waste thermoplastic were prepared by casting method for the present investigation. The high viscosities of the resin- plastic mixture (putty like consistency) beyond 4 layer prevents processing of higher plastic content syntactic foam. The effect of plastic content on tensile, compression, Hardness and impact properties were studied in detailed. Syntactic Foam means a closed packed cell or matrix. In this project we make a composite material with the help of Epoxy Resin and Adding the Reinforcement is waste Thermoplastic and study the mechanical properties of this composite material.

**Keywords:** Epoxy resin, Hardener, Syntactic foam, Waste Thermoplastic,.

## 1. Introduction

Syntactic foam are composite materials. It is closed cell composite material mixed in a resinous matrix. Which have very good mechanical properties, insulation properties, low thermal expansion and low moisture absorption capacity, etc. It is developed for sea application because it is light in weight also its application in ship structure and spacecraft. Syntactic foam are used as core material as a sandwich structure in composite. The advantage of syntactic foam have over conventional open cell structure, honey comb structures. A composite material is a material made from two or more constituent materials with significantly different physical or chemical properties. When combined, produce a materials with characteristics different from the individual components. The individual components remain separate and distinct within the finished structure, differentiating composites from mixtures and solid solutions.

## 2 . Constituents materials

### 2.1 Matrix Materials

Epoxy resin (Araldite LY556) and hardener (HY951) supply by Herenba Instruments & Engineers Chennai, India was used as a matrix material and curing agent respectively. Araldite (LY556) was highly viscous having density and viscosity of 1.15g/cc and 10000-12000 mPa-s respectively. Hardener (HY951) was low viscous having density 0.98g/cc was used for room temperature curing. The resin to hardener ratio used was 10:1.

### 2.2 Reinforcement

The reinforcement is used in this project waste thermoplastic. Which is banned in some states because it is not destroy easily. This is major problem of pollution and rises the very dangerous disease.

## 3. Methodology and Experimental procedure

### 3.1 Specimen processing

The present work is focused on making the composites material by adding the reinforcement and check its mechanical and physical characteristics. In this project we used the (0 to 4) layer. First of all we make a zero percentage based specimen and perform mechanical characteristic like impact test ,hardness test, tensile test and

compressive test. The zero percent based specimen make without adding reinforcement. In this type of specimen only epoxy hardener are mixed according to its calculation. After this we make other specimen to use the (0 to 4) layer of reinforcement and perform the above test measured value is compared with the zero based sample measured value. By analysis of the above observed value we plot the graph for the showing the behavior of composites material. Casting method was used, in the present study, to process syntactic foams with varying different layer (0-4 layer) of thermoplastic. Required amount of resin, hardener, and thermoplastic, depending on the different layer of the resultant foam were calculated (as shown below).

### 3.2 Preparation of Mold

In the present study the dimension of the mould used to prepare specimen for tensile and flexural testing is 150mm×65mm×8mm. At first wooden bits (of thickness 8.0mm) were cut according to the dimension of 150mm and 65mm respectively. Then these wooden bits were wrapped with plastic tape. A flat wooden board fixed with a transparent plastic sheet was used to form the base of the mold. The wrapped wooden bits were fixed firmly (with the help of nails) in rectangular shape as shown in figure. The purpose of the transparent plastic sheet is to prevent sticking of the mixture and easy removal of the specimen after room temperature curing.



Fig 3.2- Preparation of mold

### 3.3 Preparation of syntactic foam

The flow chart for preparation of the syntactic foam is shown in figure-

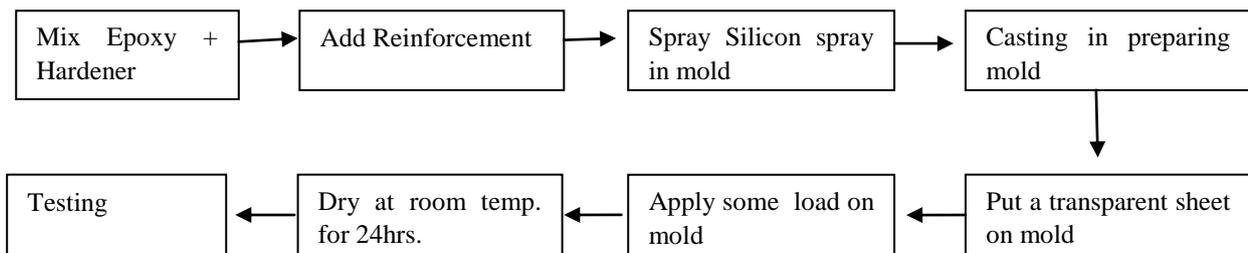


Fig 3.3- Flow chart for preparation of Syntactic foam



Fig 3.3-Prepare Sample

#### 4. Mechanical Characterization

##### 4.1 Impact Test



Fig 4.1-Impact testing machine

In this test the components are subjected to Impact (Shock) loads, these loads are applied suddenly. The stress induced in these are performed to assess shock absorbing capacity of materials subjected to suddenly applied loads. These capabilities are expressed in form of Rapture energy, Impact strength, & Modulus of rapture. Two types of Impact test are commonly used i.e. Charpy test and Izod Test. In presence work only perform Charpy test.

In Charpy test, the specimen is placed as cantilever position and specimen have V- shaped notch of  $45^{\circ}$ . The notch is located on tension side of specimen during impact loading. Depth of notch is generally taken as  $t/5$  to  $t/3$  where  $t$  is thickness of specimen.

#### 4.2 Hardness Test (Rockwell Hardness)



**Fig-Hardness testing machine**

The resistance to plastic deformation usually measured by indentation is known as hardness. It makes a smaller impressions on the surface and the specimen under test does not suffer any dimensional change during the application of load. An initial load of 10kgf is applied on specimen through the indenter to set the specimen and eliminate the surface imperfection. A major load of 60kgf, 100kgf, 150kgf is then applied and the depth of indentation is recorded as hardness number on dial gauge. There are two scales on the dial gauge. The “C” scale marked in black and the “B” in red. For “B” scale ball indenter is used and for “C” scale diamond indenter are used.

#### 4.3 Tensile Test

The test is performed on universal testing machine. A universal testing machine has a rigid frame containing upper, middle and lower cross heads. Upper and lower cross heads are fixed where as the position of middle cross head is adjustable. The space between upper and middle cross head is for tension test and the space between middle and lower cross head is for compression test. For Tensile test the specimen is dog bone type in shape.

#### 4.4 Compressive Test

\The test is performed on universal testing machine. A universal testing machine has a rigid frame containing upper, middle and lower cross heads. Upper and lower cross heads are fixed where as the position of middle cross head is adjustable. The space between upper and middle cross head is for tension test and the space between middle and lower cross head is for compression test. For compression test the specimen is cylindrical in shape.

### 5. Results and Discussion

#### 5.1 Impact testing

Impact strength curve of the syntactic foam with different layer of thermoplastic are shown below.

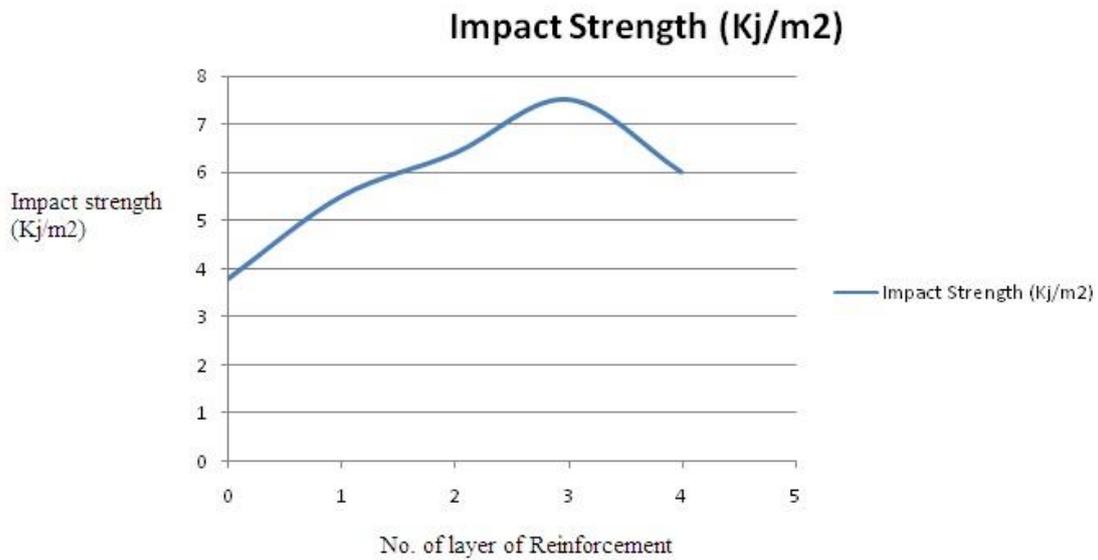


Fig 5.1- Variation of impact strength with different layer of Reinforcement

5.2 Hardness test

Hardness curve of the syntactic foam with different layer of thermoplastic are shown below.

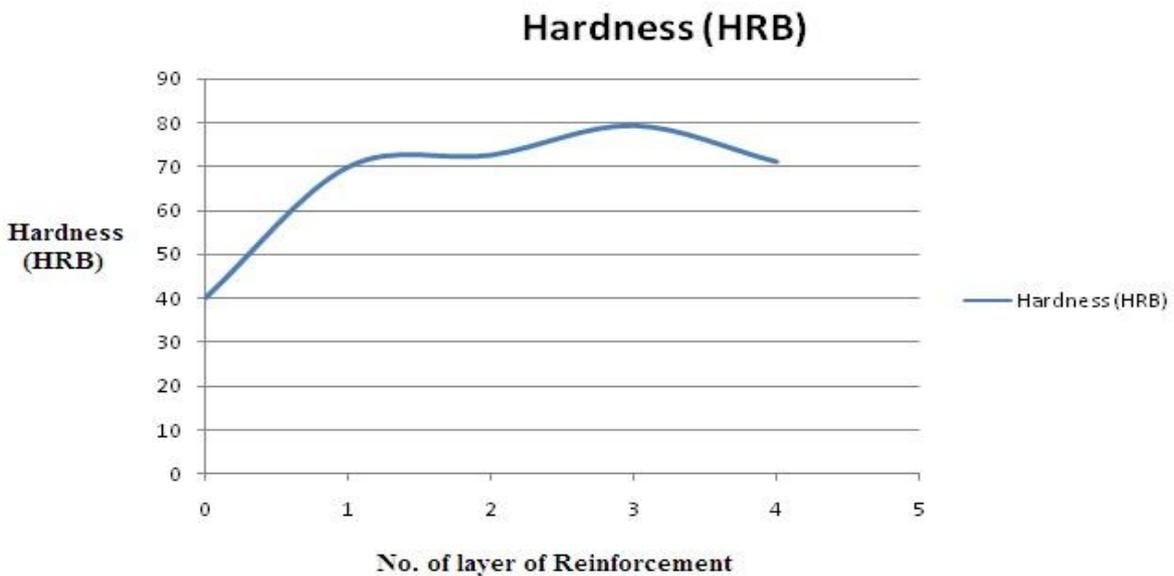


Fig 5.2- Variation of Hardness with different layer of Reinforcement

5.3 Tensile Test

Tensile strength curve of the syntactic foam with different layer of thermoplastic are shown below.

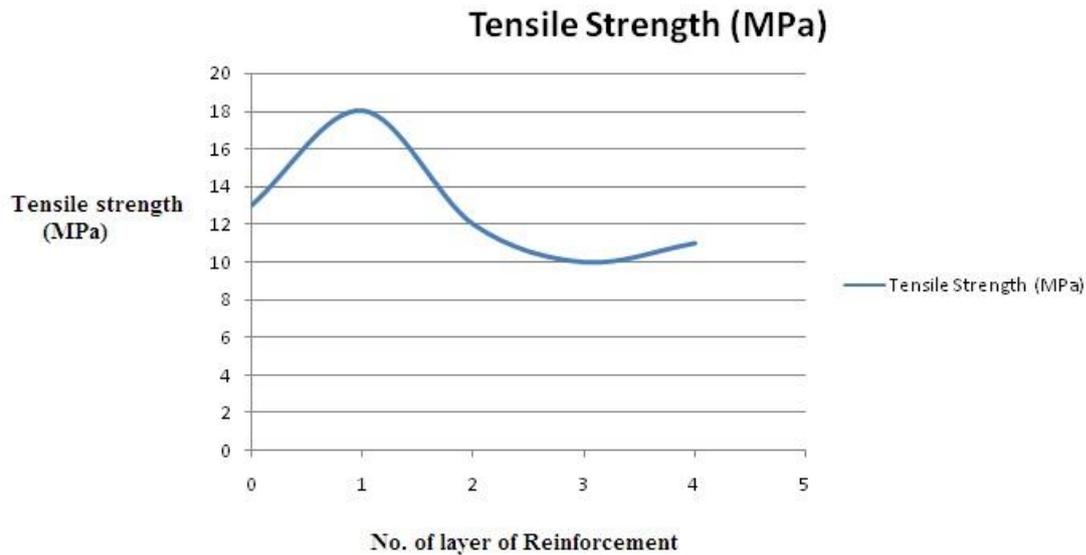


Fig 5.3- Variation of tensile strength with different layer of Reinforcement

5.4 Compressive Test

Compressive Strength curve of the syntactic foam with different layer of thermoplastic are shown below.

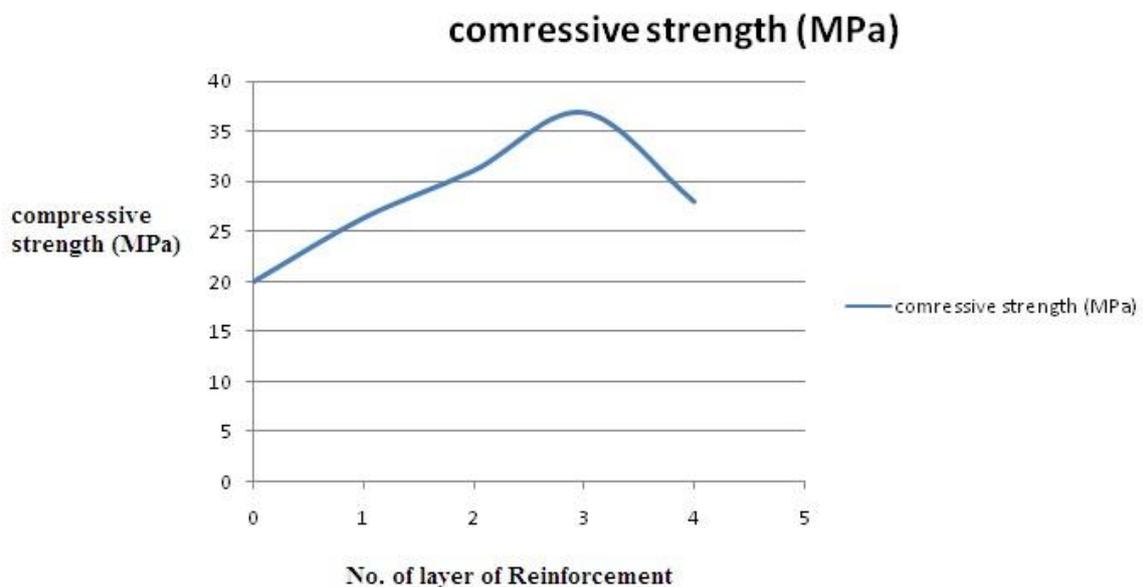


Fig 5.4- Variation of compressive strength with different layer of Reinforcement

**6. Calculation for required amount of casting material for different volume % of syntactic foam**

In this subsection, calculation of required amount constituent materials (e.g. epoxy resin, hardener, and thermoplastic) are described for x volume% of epoxy and hardener.

The calculation for weight estimation for matrix and filler are as follow:

Calculation for matrix:

Density of epoxy =1.15g/cc

Density of hardener =0.98g/cc

Density of thermoplastic =0.95 g/cc



Here epoxy to hardener ratio used was 10:1  
Percentage of epoxy in matrix =  $(10/11) \times 100 = 90.9\%$   
Percentage of hardener in matrix =  $(1/11) \times 100 = 9.09\%$

By applying rule of mixture for obtaining density of matrix

Density of matrix = density of epoxy  $\times$  volume fraction of epoxy + density of hardener  $\times$  volume fraction of hardener

Density of matrix =  $(90.9/100) \times 1.15 + (9.09/100) \times 0.98$

Density of matrix = 1.12 g/cc

Volume of mould =  $150 \times 65 \times 8 \text{ (mm}^3\text{)} = 78000 \text{ mm}^3$

Let volume percentage of epoxy taken x.

Density = mass/volume

$1.12 \times 10^{-3} = \text{mass} / (x \times 78000)$

Mass of matrix = 87.36x g

Mass of epoxy =  $(90.9 \times 87.36x) / 100$

**Mass of epoxy = 79.41x g**

Mass of hardener =  $(9.09 \times 87.36) / 100$

**Mass of hardener = 7.94x g**

Similar manner it was calculated in respective places for different tests.

## 7. Conclusions

- [1] In impact test the impact strength of composite material is varying according to different layer of thermoplastic. Impact strength of various sample is increases with increasing layer of Reinforcement up to 3 layer and then start decreasing.
- [2] In Hardness test the Hardness of composite material is varying according to different layer of thermoplastic. Hardness of various sample is increases with increasing layer of Reinforcement up to 3 layer and then start decreasing.
- [3] In Tensile test the tensile strength of composite material is varying according to different layer of thermoplastic. Tensile strength of 1 layer sample is increases then further decrease at 2 and 3 layer of reinforcement & at 4 layer of reinforcement the tensile strength is increases. It means the properties of tensile strength of composites material is not poor.
- [4] In compressive test the compressive strength of composite material is varying according to different layer of thermoplastic. compressive strength of various sample is increases with increasing layer of Reinforcement up to 3 layer and then start decreasing. It means the properties of compressive strength of composites material is very good as compare to tensile strength.

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