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STUDY OF EFFECTS OF VARIOUS FILLER MATERIALS ON MECHANICAL PROPERTIES OF CARBON-EPOXY COMPOSITE

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ABSTRACT

This Paper complies the study of effects of various filler materials on Mechanical Properties of Carbon-Epoxy Composite. The paper gives the diversified description of the behavior of the Carbon-Epoxy Composite, under different loadings and conditions. The Carbon-Epoxy Composite was fabricated using various fillers such as, Coremat, Aerosil and Granite. The Composition of the Carbon-Epoxy Composite consists of 50% Carbon Fiber, 40% Resin and 10% fillers by weight. Three different types of Carbon-Epoxy Composite specimen were fabricated using three different Fillers, as mentioned above. The Method Adopted to fabricate the Carbon-Epoxy Composite is conventional Hand Lay-up technique. Furthermore, the Carbon-Epoxy Composite specimen was subjected to various Test Conditions, namely Tensile Test, Impact Test and Water Absorption Test and the behavior of the same is recorded and described in this paper.

KEYWORDS: Carbon-Epoxy Composite, Aerosil, Coremat, Granite, Hand Lay-up Technique, Tensile Test, Impact Test, Water Absorption Test.

INTRODUCTION

Composite Materials are combination of two materials in which one of the materials, called the reinforcing phase, which is in the form of fiber sheets or particles and are embedded in the other material called the matrix phase. The primary functions of this matrix are to transfer stresses between the reinforcing fibers or particles and to protect them from mechanical and environmental damage whereas the presence of fibers or particles in a composite improves its mechanical properties such as strength, stiffness etc. Carbon-Epoxy composites have been of significant importance to engineering community for many years. Components made of epoxy-based materials have provided outstanding mechanical, thermal and electrical properties. Using an additional phase (ex- inorganic fillers) to improve the properties of epoxy resins has become a common practice.

MATERIALS AND METHODS

Matrix	Araldite LY 556 - Epoxy resin
	Hardener HY 917
	Accelerator DY 070
Fiber	Carbon – Woven – 360GSM
Fillers	Granite powder
	Aersoil (Fumed Silica)
	Coremat

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FABRICATION

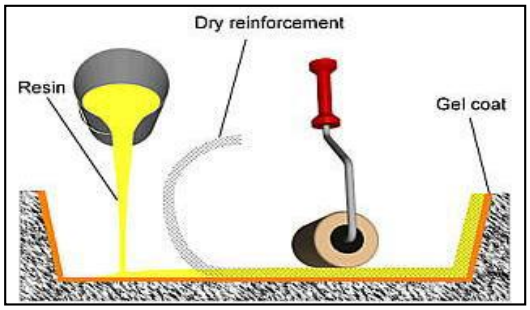

Figure 1 Hand Layup technique

Resin preparation – The required quantity of resin was taken in proper proportionate. Weight of the fiber: weight of the resin: weight of filler = 50: 40: 10 To this measured weight of the resin, hardener and accelerator were added such that the weight of the hardener was 10% of the total weight of the resin. The resulting mixture was properly stirred to ensure proper mixing. Addition of hardener is done to facilitate easy hardening of the composite laminate during curing. A flat table with glass laid on it was made ready for the laying of the material by cleaning and polishing it.

1. A release agent (wax) coat was then applied to the surface of the table to aid easy removal of the composite laminate.
2. Initially a thin coat of resin was applied on the glass.
3. A layer of 360GSM Carbon fiber was laid over it.
4. A coating of resin which was prepared initially was applied uniformly on top of the fiber.
5. Rolling was done under uniform pressure, so that the resin properly penetrates the fiber mat. A roller was used for this purpose.
6. Later second layer of carbon mat was laid, and again uniform coating of resin was applied, followed by proper rolling.
7. The process was repeated till 5 woven fiber mats were laid one over the other (with resin in between)
8. Finally a coat of resin was applied above the top mat.
9. The laminate was left for curing for 24 hours and later post cured in an oven at 120^0C for 2 hrs.

TESTING

MECHANICAL TESTS - Following tests were conducted in the present work to study the various properties of the fabricated composites.

Sl. No.	TEST	ASTM	Specimen size (mm)
1	Tensile Test	D3039	250 x 25
2	Impact Test	D65	
3	Water Ageing Test	C272	

RESULTS AND DISCUSSION

1. TENSILE TEST (ASTM D3039) Tensile testing is used to measure the force required to break a polymer composite specimen and the extent to which the specimen stretches or elongates to that breaking point. Tensile tests produce a stress-strain diagram, which is used to determine tensile modulus.

Data: From tensile test results the following calculations can be made :

1. Tensile strength (MPa)
2. Tensile modulus of elasticity (MPa)
3. Tensile Strain

Figure 2 Tensile Test Specimen

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DISCUSSION

Sl. No.	Filler	Tensile Strength (N/mm^2)	% Elongation	Tensile Modulus (N/mm^2)
1	Carbon-Epoxy	172	16.5	1042.42
2	Granite	240	10.95	2191.78
3	Aerosil	256	11.9	2151.26
4	Coremat	192	21.6	888.89

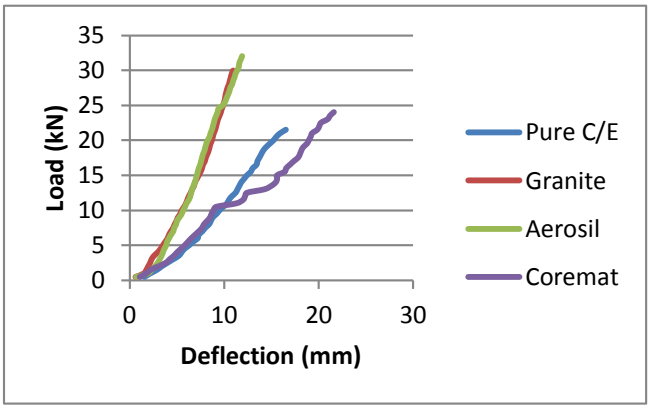

Figure 3 - Load V/s. Deflection for all 4 Specimens

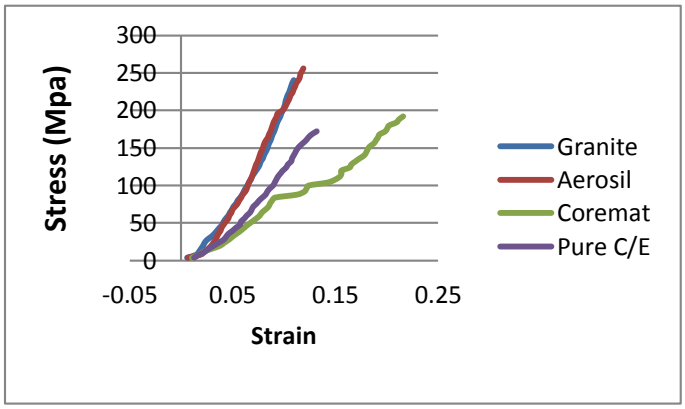

Figure 4 - Stress V/s. Strain for all 4 Specimens

DISCUSSION ON TENSILE RESULTS

1. From above graphs we can say that Aerosil filled Composite exhibits highest Tensile Strength.
2. Tensile Modulus is greater for granite filled composites.
3. The strain taken up is highest for coremat filled composite.

2. IMPACT TEST (ASTM D65)

The impact behavior of the Carbon-Epoxy Composite is experimentally studied with the aid of a notched charpy impact specimen.The standard specimen for ASTM D256 is 10 x 4 x 55 mm. The depth under the notch of the specimen is 8mm.

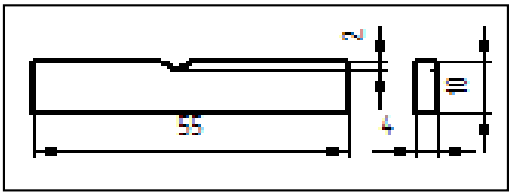

Figure 5 - Impact Test Specimen

Data: From Impact test results, we can find out the following:
1. Impact Energy (Joules)
2. Impact strength of the material (J/mm2)

Filler	Specimen Code	Impact Energy (J)	Impact Strength (J/mm^2)	Average Impact Strength (J/mm^2)
GRANITE	G-I-1	20	0.5	0.56
	G-I-2	23	0.575	
	G-I-3	24	0.6	
AEROSIL	A-I-1	27	0.675	0.675
	A-I-2	28	0.70	
	A-I-3	26	0.65	
COREMAT	C-I-1	15	0.375	0.425
	C-I-2	16	0.40	
	C-I-3	20	0.50	

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DISCUSSION

1. From average values of Impact test, we can find that, the Impact Strength is highest in case of aerosil filled composites, whereas granite filled contributes next, with coremat being last.
2. The reason may be, since aerosol & granite powder gets bonded uniformly throughout the matrix, it is able to take up higher amount of impact loads than coremat filler.

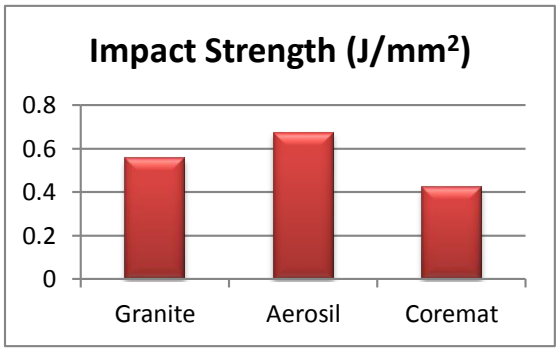

Figure 6 - Average Value for all 3 fillers

3. **WATER ABOSRPTION TEST (ASTM C272) -** This test is carried out to study the behavior of the material in relative humid conditions or when immersed in water. The initial weight of the specimen is noted before the test is conducted. These specimens are then placed in sea water. The different specimens are weighed after specific time intervals (5, 10 and 15 days). The average weight change and percentage increase in the weight of the specimen is calculated.

Filler	Increase in Weight (gms.)	Water Absorption Rate (%)
GRANITE	0.1467	2.177
AEROSIL	0.0746	1.107
COREMAT	0.0733	0.902

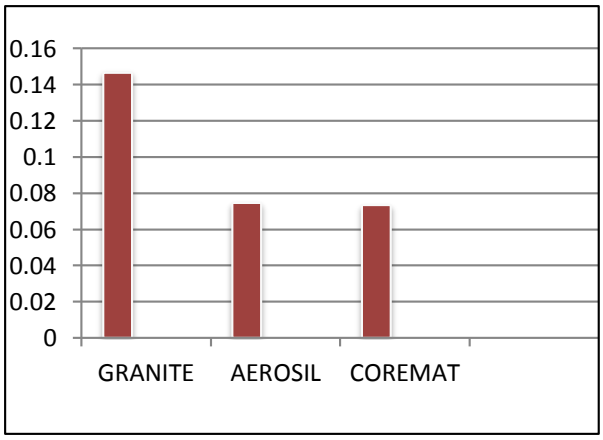

Figure 7 Weight increase in grams

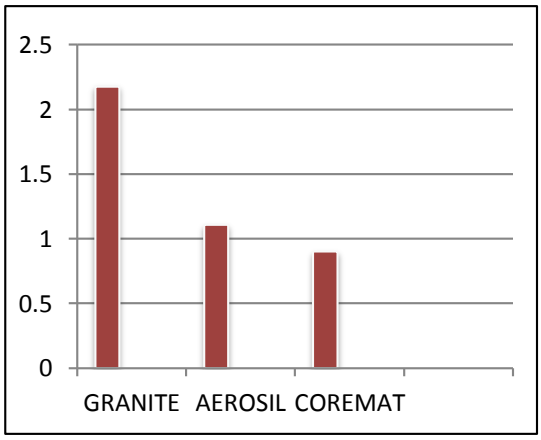

Figure 8 - Water absorption rate (%).

DISCUSSION

1. The Ageing test was carried out on all the 3 filler materials where the initial weight of the specimens was noted and after 5, 10 & 15 days the final weight of the specimens were noted to determine the absorption rate.
2. From Average table & graph we can notice that, there is very negligible effect of water on all three fillers.

CONCLUSION

1. TENSILE TEST

From the tensile test conducted it can be concluded that,

$$UTS_{aerosil} > UTS_{granite} > UTS_{coremat}$$

Aerosil & granite being in powder form mixes thoroughly with the resin matrix therefore, have good binding properties.

$Strain_{coremat} > Strain_{aerosil} > Strain_{granite}$

Coremat is a kind of mat which is laid along the carbon mat, thereby it takes maximum elongation before failure. The composite fails when coremat is failed rather after failure of matrix-fibre failure.

2. IMPACT TEST

From the Impact test conducted it can be concluded that,

$$\text{Impact Strength}_{aerosil} > \text{Impact Strength}_{granite} > \text{Impact Strength}_{coremat}$$

Aerosil & granite being in powder form mixes thoroughly with the resin matrix therefore, have good binding properties.

3. WATER AGEING

- ✓ Granite filler has higher tendency to absorb more water, than other 2 fillers.
- ✓ Coremat filler has least absorption rate as it is water resistant material.

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