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Study of Effect of Various Fillers on Mechanical Properties of Carbon-Epoxy Composites

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Abstract - *The Objective of this dissertation work was to study the effect of various filler materials on Mechanical Properties of Carbon-Epoxy Composites. For this purpose, 3 filler materials were selected based on their end applications. The fillers used are - Granite Powder, Aerosil (Fumed Silica) and Coremat. The composition selected was 40% Epoxy + 50% Carbon fiber + 10% Fillers. The fabrication method used was conventional hand lay-up technique. The mechanical tests carried out were Tensile Test, Hardness Number and 3-P Bending Test. The Tensile Test gave the results for Tensile Strength, Tensile Modulus & Strain. The Bending Test gave results for Flexural Strength, Flexural modulus & Interlaminar shear strength. The Shore-D hardness test gave the hardness Number. The results indicated that Aerosil Filled Composites showed best results for Tensile strength whereas hardness and Bending results were good for Coremat filled ones. Also Water ageing test was conducted to determine the water absorption rate. The specimens were kept in sea water and ambient atmospheric conditions. The specimens were tested during three intervals of time i.e. 5, 10 & 15 days. The final weight was noted and the calculations were made. The results concluded that coremat filled composites showed negligible absorption rate. Micro-structure Analysis was carried out before and after ageing.*

Keywords: Carbon-Epoxy, Granite powder, Aerosil (Fumed Silica), Coremat, Tensile, Hardness, Bending Tests, Water absorption rate.

1. 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.

2. SPECIMEN FABRICATION

2.1 Materials

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

2.2 Fabrication

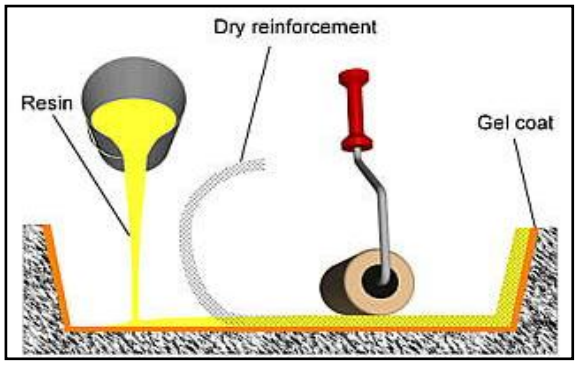

Figure 1 Hand Lay-up Process

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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^{0}C for 2 hrs.

3. *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	Bending Test	D790	127 x 12.7
4	Shore Hardness	D2240	30 x 30

3.1 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

3.2 SHORE HARDNESS (ASTM D2240)

The test determines the indentation hardness of the fabricated specimen. It is done with the help of Shore Durometer. A Durometer is an instrument that is commonly used for measuring the indentation hardness of rubbers/elastomers, vinyl and epoxy composites. The test measures the penetration of a specified indentor into the material under specified conditions of force and time.

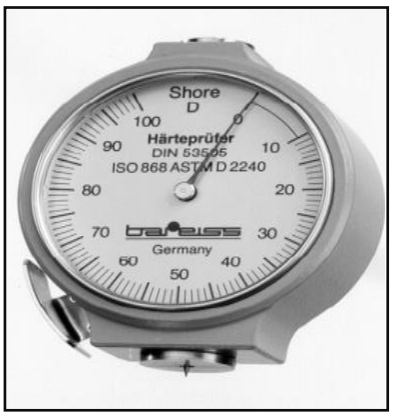

Figure -3. Shore Hardness

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3.3 BENDING TEST (ASTM D-790)

3-Point bend Testing was carried out on rectangular specimens (127 x 12.7mm) of composites using Universal testing machine (TUE-C-400) of 400kN capacity with ±1% accuracy at ambient temperature according to the procedure described in ASTM D-790.

Data:
From 3-Point Bend Test we can calculate the following:

1. Flexural Strength (MPa)
2. Flexural Modulus (MPa)
3. Inter Laminar Shear Strength (MPa

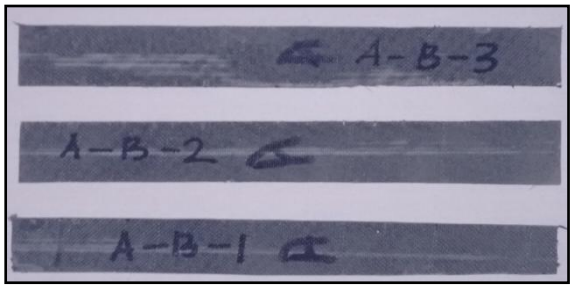

Figure -4. Bending Test Specimen

4. RESULTS AND DISCUSSION

4.1 TENSILE TEST

Table -1: Average Tensile test Results

FILLER	Tensile Strength (MPa)	Strain	Tensile Modulus (GPa)
GRANITE	254.8	0.112	2.282
AEROSIL	266.0	0.121	2.236
COREMAT	205.6	0.233	0.883

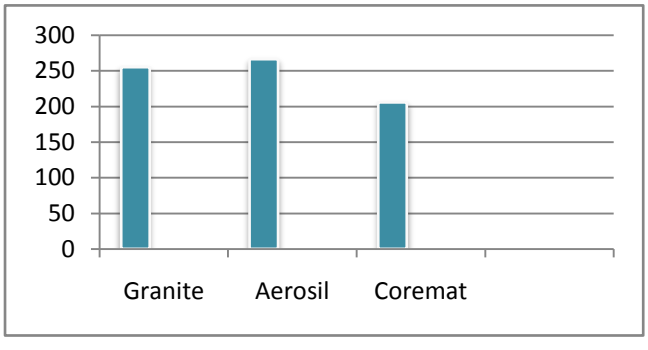

Chart 1. Tensile Test Graph (In MPa.)

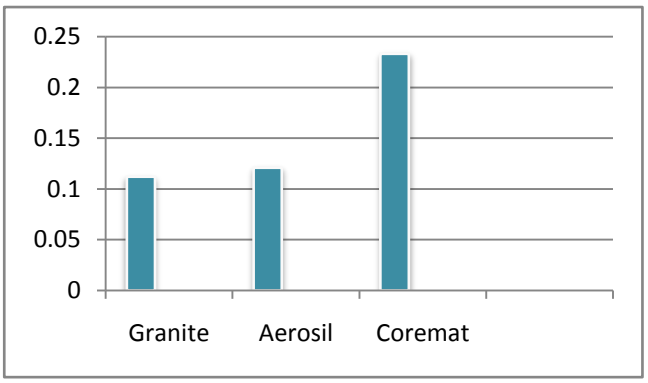

Chart 2. Strain Values

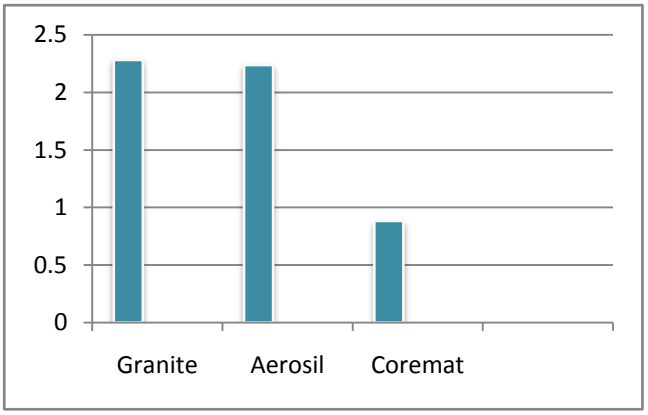

Chart 3. Tensile Modulus (In GPa.)

4.2. SHORE HARDNESS TEST

Table -2: Average Hardness Results

FILLER	SHORE-D HARDNESS NO.
GRANITE	45
AEROSIL	55
COREMAT	59

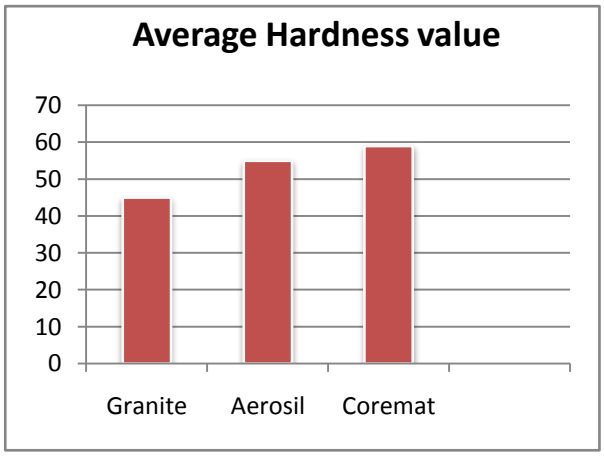

Chart 4. Average Hardness Values

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4.3. 3-POINT BENDING TEST

FILLER	Flexural Strength (MPa)	Flexural Modulus (GPa)	ILSS (MPa)
GRANITE	2458.16	13.731	65.55
AEROSIL	2447.09	15.539	65.26
COREMAT	2482.15	14.193	66.18

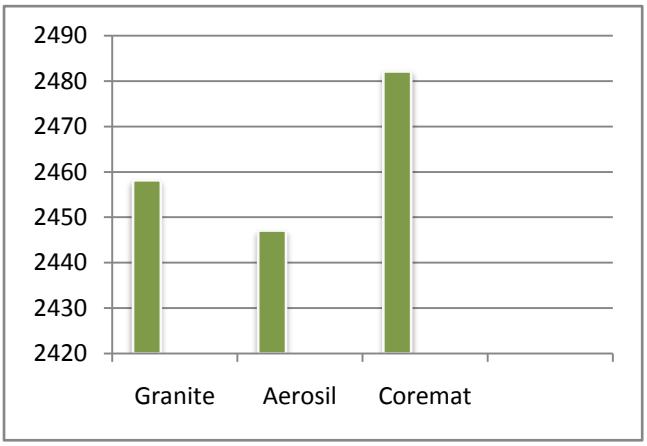

Chart 5 Flexural Strength (In MPa.)

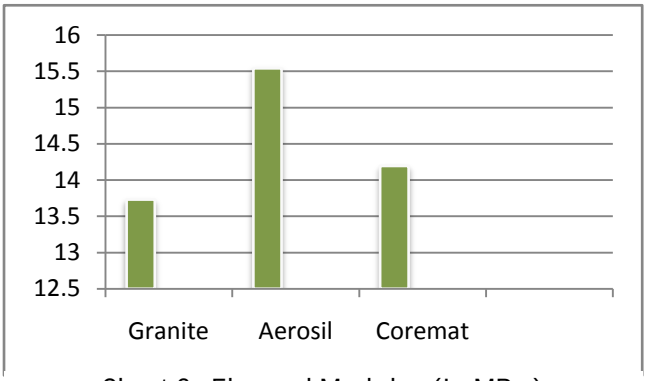

Chart 6- Flexural Modulus (In MPa.)

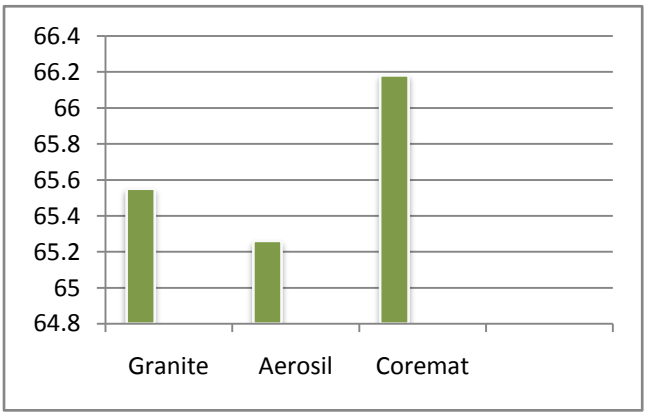

Chart 7- Inter-Laminar Shear Strength (In MPa.)

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.

DISCUSSION ON HARDNESS RESULTS

1. The Shore-D hardness value for coremat filled composite is higher compared to other fillers.

DISCUSSION ON BENDING RESULTS

1. The Flexural Strength and Flexural modulus values are excellent for coremat filled composite.
2. The Inter Laminar Shear strength (ILSS) is better for Aerosil filled composite.

WATER AGEING TEST

From the ageing test the following observations were made -

FILLER	Duration (Days)	Increase in Weight (gms)	Water Absorption Rate (%)
GRANITE	5	0.0875	1.171
	10	0.1305	2.034
	15	0.2220	3.325
AEROSIL	5	0.0260	0.389
	10	0.0470	0.740
	15	0.1510	2.192
COREMAT	5	0.0345	0.440
	10	0.0835	1.019
	15	0.1020	1.248

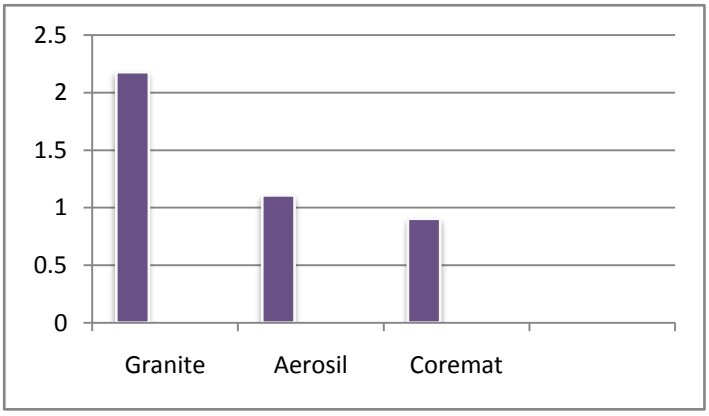

Chart 8- Water Absorption Rate

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From above Table & graph it is observed that –

1. Water increase in terms on gms is more for Granite filled composite and least in case of coremat filled.
2. Water absorption rate is highest in granite filled.

5. CONCLUSION

Based on the results of this study, the following conclusions can be drawn.

1. The tensile strength is highest for aerosil filled composite whereas, tensile modulus is highest for granite filled.
2. This may be due to the reason that since both these fillers has excellent mixing and bonding characteristics.
3. The strain taken by coremat filled is highest without much stress experienced.
4. The hardness value is highest for coremat filled composite, the reason being coremat offers the uniform filler property as compared to aerosol and granite.
5. The flexural Strength & Inter laminar shear strength is excellent for coremat whereas Flexural modulus is excellent for aerosol filled.
6. The water ageing test showed that the coremat filled composite is less susceptible to water absorption rate as compared to other two. The reason being coremat is water proof material.
7. To summarize it can be said that coremat filled composite show excellent mechanical properties

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