Fabrication and Characterization of Garment Waste Reinforced Polymer Composite

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Abstract- **Traditional materials have been continuously replacing by composite materials, because of their superior properties, such as high tensile strength, low thermal expansion and high strength-to-weight ratio. Textile fibre reinforced composites are more attractive due to their high specific strength, light weight and finding increased applications in many engineering fields especially in interior construction of buildings.**

In the present study is to develop composite material from garment waste recycling technology that will reduce in the increasing environmental impact by garment waste and introducing a new product. Textile waste reinforced polymer composites were fabricated with different weight ratio of reinforcement and matrix material by using hand lay-up technique. The mechanical properties of fabricated composite material such as tensile strength, compressive strength, flexural strength, impact strength and also water absorption property were studied on fabricated garment waste composite samples according to ASTM standards. From the experimental results, it has been observed that 30% chopped garment waste, 60% epoxy resin and 10% fly ash composite specimens perform better than other composite specimens. It is suggested that these hybrid composites can be used as an alternative material for interior applications such as ceiling panels, sound barrier panels for acoustic, roof tiles and building insulation material.

Key words- **Recycling, Waste garment, Epoxy, Role of Mixture, Mechanical Properties**

I. INTRODUCTION

The amount of waste has been regularly increasing due to increasing human population and urbanization. A typical waste management system comprises collection, transportation, pre-treatment, processing and final abatement of residues [2] Ayhan Demirbas. The various stages where the garment is being wasted in garment industry is fabric store, waste in the cutting room, bundling room, production floor, dyeing & washing, printing and finishing [1] Kavitha S and G. Manimekalai. Recently the research for new high performance material at affordable costs has been expanded which is led from the growth of environmental awareness. There search has also focused on developing, creating and innovating eco-friendly materials. Earlier classification of textile material as reinforcement was established by scardino. He divided the textile structures or reinforcement form in to four categories; discontinuous chopped fibres, continuous filament yarns, simple fabrics and advanced fabrics [5] Jayantha Ananda Epaarachchi, of course his classification of textile material is applied for high performance fibre such as glass, carbon and aramid but it can also be used for natural textile material to same extent.

To discusses how best to make use of the textile waste which is produced by the garment industries in to useful product. Since the main concern for this work is to fabricate the garment textile composites by using hand lay-up process and recycling technologies and to evaluate mechanical properties of the fabricated composite material. Utilization of a prepared composite material as a roof tiles and finally to show the role of waste textile in the composite materials.

II. MATERIALS AND METHODS

2.1 Materials

2.1.1 Chopped Garment Waste

In this investigation chopped textile waste fibre was used as a reinforcement material for the fabrication of the composite specimen. Textile waste were procured from Sri Sai Garment Industries Davangere, Karnataka, India. The term textile has a very broad meaning considering its evolvement over millennia. This term applies to product forms (fibre, yarn and fabric) either they are from natural or synthetic source as well as a product derived from garments. That includes all type of yarns and all types of fabrics. The chopped textile waste is shown in figure 1.

Fig. 1Chopped Textile Waste

2.1.2 Fly Ash

Fly ash is one of the most inexpensive and low density reinforcement available in large quantities as a solid waste by-product during combustion of wood and coal in thermal power plants. Hence composites with fly ash as a reinforcement are likely to over come the cost barrier for wide spread applications. It is there fore expected that the incorporation of fly ash particles in polymer matrix composite will promote mechanical properties and in some cases to improve process ability.

2.1.3 Epoxy Resin

Epoxy resin was used as a matrix material for fabrication of composite material. The reason for choosing the epoxy resin is that it is another familiar type of thermoset which offers more strength and good dimensional stability. The constituents of matrix system is shown in table 1.

Table 1 Details concerning the constituents of matrix system

Constituents	Trade Name	Chemical Name	Density gm/cm^3
Resin	LAPOX L-12	Diglycidyl ether of Bisphenol A (DGEBA)	1.162
Hardener	K-6	Tri ethylene Tetra amine (TETA)	0.954

2.2 Hand Lay-Up Technique

The hand lay-up is one of the oldest, simplest and most commonly used method for composite parts construction. According to rule of mixture, the resin and hardener are mixed thoroughly in the bowl. Then the chopped textile waste and fly ash are mixed thoroughly with resin and hardener. The mixture is put into entire mould cavity and then it is closed by the top plate of the mold with required load. The setup is keep in the dry place for 24 hours and the fabricated composite material is taken away from the mold. It has some advantages are low capital investment on equipment, raw materials are easy to use and flexible in orientation of fibres. The Composition of fabricated Composite materials are shown in table 2.

Table 2 Composition of fabricated Composite materials

Designation	Compositions
A1	Chopped Textile Waste (40%) + Epoxy Resin (50%) + Fly Ash (10%)
A2	Chopped Textile Waste (30%) + Epoxy Resin (60%) + Fly Ash (10%)
A3	Chopped Textile Waste (20%) + Epoxy Resin (70%) + Fly Ash (10%)
A4	Chopped Textile Waste (10%) + Epoxy Resin (80%) + Fly Ash (10%)

III. RESULTS AND DISCUSSIONS

3.1 Tensile Strength

The fabricated hybrid composite specimens were subjected to tensile load and the results were analysed. The experiments were carried out as per ASTM D3039 standards. According to the results, composite specimens with fibre weight fraction of A2 perform better than other compositions and itholds the highest value, and also can withstand the tensile strength of 12.8 MPa. The Tensile strength properties for fabricated specimens is shown in Table 3. This is due to the increase in the matrix material and the material will become brittle hence reduces its strength. In the presence of voids in the fabricated specimens, leading to stress concentrations and therefore the material becomes brittle and weak. It can be concluded that specimens with 30% textile waste, 60% epoxy resin and 10% fly ash indicates better strength. The specimens before test and after test are shown in figure 2 (a) and figure 2 (b) respectively.

Table 3Effect of tensile strength on garment waste hybrid polymer matrix composite material

Designation	Load at Peak (N)	Tensile Strength (MPa)	Elongation at Peak (mm)	Tensile Strain at Peak	Modulus (MPa)
A1	900	2.40	0.80	0.0058	414.00
A2	4800	12.80	2.96	0.0215	596.76
A3	600	1.60	0.19	0.0014	1162.10
A4	988	2.64	6.67	0.0483	556.14

a) Specimens before test

b) Specimens after test

Fig. 2 Garment waste composite specimens for tensile test

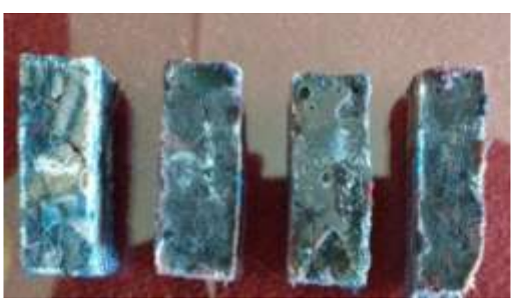
3.2 Compressive strength

The compressive strength of a material is the maximum amount of compressive stress that it can take before failure**.** The fabricated hybrid composite specimens were subjected to compressive load and the results were analysed. The experiments were carried out as per ASTM D3410 standards. According to the results, composite specimen with fibre weight fraction of A4 perform better than other compositions, having highest value and can withstand the compressive strength of 52.8MPa. The Compressive strength properties for fabricated specimens is shown in Table 4. This is because of the average compressive strength values are directly proportionate with the percentage increase in the matrix material. As increases the matrix material in hybrid composite material the brittleness of the hybrid composite is also increases. The brittleness property is proportionate to the compressive strength, hence as matrix material increase the compressive strength also increases. The specimens before test is given in Figure 3(a) and the specimens after compression test is shown in figure 3(b).

Table 4 Effect of compressive strength on garment waste hybrid polymer matrix composite material

Designation	Load at Peak (N)	Compressive Strength (MPa)	Elongation at Peak (mm)	Compressive Strain at Peak	Modulus (MPa)
A1	1170	5.20	0.620	0.021	251.61
A2	7320	32.53	1.060	0.035	920.67
A3	8040	35.74	0.870	0.029	1234.41
A4	11880	52.80	1.150	0.039	1375.00

a) Specimens before test



b) Specimens after test

Fig. 3 Garment waste composite specimens for compressive strength

3.3 Flexural Strength

The flexural test specimen are prepared as per ASTM D760 standards, and subjected to loading by using a universal testing machine. In flexural strength test the load is applied in the transverse direction of the fibre and the bending capacity of the material can be calculated. Flexural Strength (FS) = $3PL/2bt^2$

Where, P is maximum load, b is the width of specimen, L is the span length of the specimen and t is the thickness of specimen. The Flexural strength properties of fabricated specimens is shown in table 5.

The results indicated that for the composite specimens with fibre weight fraction of A2 perform better than other compositions, holds the highest value, and can withstand the flexural strength of 59.28MPa. The flexural strength of any composite specimen is determined using the following equation 1.

Table 5 Effect of flexural strength on garment waste hybrid polymer matrix composite material

Designation	Load at Peak (N)	Flexural Strength (MPa)
A1	1010	35.02
A2	1710	59.28
A3	960	33.28
A4	1290	44.72

From the test results it is clearly observed that the specimen A2 indicates higher flexural strength than the other specimens.It can be reasoned that specimens with 30% Textile waste, 60% epoxy resin and 10% fly ash indicates better strength. The increase in the flexural strength is due to reinforcing action of the textile fibre that is in the specimens and both reinforcing and matrix phase will blend appropriately with no voids. The specimen before flexural test is given in figure 4(a) and the specimen after the flexural test is shown in figure 4(b).

a) Specimens before test

b) Specimens after test

Fig. 4 Garment waste composite specimens for flexural test

3.4 Impact Strength

The impact strength capability of the material is analysed by using Charpy impact test. The energy loss due to the impact load is observed by means of the impact testing machine. The impact test specimens are prepared as per ASTM D256 standards. It has been reported that, composite specimens with fibre weight fraction of A2 perform better than other compositions, holds the highest value, and can withstand the impact strength of 0.01265 J/mm^2. The Impact strength properties for fabricated specimens is shown in Table 6. This is because of chopped textile fibre absorb more energy than the matrix material. It is clear that, in the case of A2 hybrid composite specimens, the presence of fibres arrest the crack propagation in the test specimens and the final failure was due to delamination between layers in the compression zone, therefore fibre weight fraction plays a crucial role in the impact strength of hybrid composite material. The specimen before test is shown in figure 5(a) and the specimen after test is given in figure 5(a).

Table 6: Effect of impact strength on garment waste hybrid polymer matrix composite material

Designation	Absolute Energy (J)	Impact Strength (J/mm^2)
A1	89.8	0.1105
A2	102.5	0.1261
A3	67.7	0.0834
A4	43.8	0.0539

a) Specimens before test

b) Specimens after test

Fig. 5 Garment waste composite specimens for impact test

3.5 Water Absorption Test

The water absorption is defined as the amount of water gained by a material under specified test conditions. The test specimens are prepared as per ASTM D570 standard. The percentage increase in weight is observed during the water absorption test. The water absorption of the composite was determined by using the following relationship:

Water absorption = W1–W0/ W0 * 100%

Where, W_0= Weight of composite before immersion and

W_1= Weight of composite after immersion.

It has been reported that for normal matrix material, composite specimens with fibre weight fraction of A1 shows highest value than other compositions. With respect to the fibre content, composite specimen A1, holds the highest value, and increase in weight is 17.64%. The Water Absorption properties for fabricated specimens is shown in table 5. The specimen A1 consist of highest weight percentage of chopped textile fibre. This behaviour was expected because the water absorption of these composites is mainly due to the chopped textile fibres. The water absorption test specimens before test is shown in figure 6(a) and the specimen after test is shown in figure 6(b).

Table 7 Effect of water absorption on garment waste hybrid polymer matrix composite material

No of Soaking Days	Percentage increase in weights			
	A1	A2	A3	A4
2	17.64	0	12.5	6.66
4	17.64	0	12.5	6.66
6	17.64	12.5	12.5	6.66
8	17.64	12.5	12.5	6.66
10	17.64	12.5	12.5	6.66

a)Specimens before water absorption

b) Specimens after water absorption

Fig. 6Garment waste composite specimens for water absorption test

IV. CONCLUSIONS

From the experimental investigation on chopped textile waste fibre reinforced polymer composites the following conclusions were drawn:

- A textile waste hybrid composite has been fabricated successfully by reinforcing industrial wastes such as textile waste with fly ash, using a epoxy resin matrix by hand-lay-up technique.
- The maximum tensile load has been absorbed by the composite specimen A2, with the maximum tensile strength of 12.8MPa, followed by the composite specimens A4, A1 and A3 with the values of 2.6MPa, 2.4MPa and 1.6MPa respectively.
- The maximum compressive strength of 52.8MPa was observed for the hybrid composite specimen A4 followed by specimens A3, A2 and A1 having the compressive strength of 35.74MPa, 32.53MPa and 5.2MPa respectively.
- The maximum flexural strength of 59.02MPa is observed for the hybrid composite specimen A2 followed by the specimens A4, A1 and A4 with the values of 44.72MPa, 35.02MPa and 33.28MPa respectively.
- The maximum impact strength of 0.1261 J/mm^2 is observed for specimen A2 followed by the specimens A1, A3 and A4 with values of 0.1105 J/mm^2, 0.0834 J/mm^2 and 0.0539 J/mm^2 respectively.
- From the water absorption test it is found that A1 absorbs more amount of water, percentage increase in weight for A1 is 17.64%. And A2 gain amount of water, increase in weight for A2 is 5% for minimum fabricated hybrid composite material.
- From the experiment it has been found that, according to the weight fraction, 30% chopped textile waste, 70% epoxy resin and 10% fly ash composite specimens perform better than other weight fraction composite specimens.
- It is suggested that these hybrid composites can be used as an alternative material for ceiling panels, sound barrier panels, and building insulation material.

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