A Review on Mechanical Properties of Glass And Okra Fiber Reinforced Composite

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Abstract- *In this fast growing technology there is always a search on new and substitute materials in terms of high strength, durability, and light weight. Due to which the emergence of the composite materials has been taken place. Currently ample research is going on in the field of composite materials comprising different fibers and their constituents. In this study okra fiber and glass fiber are considered. These fibers are combined together in different proportion and orientation to study the effect on strength of the material. Okra and glass fibers are properly bonded with the resin to avoid flaws. This study mainly focuses on the tensile strength, bending strength and impact strength of the composite.*
Keywords: *Okra, resin, composite material*

I. INTRODUCTION

A composite material can be defined as a combination of two or more materials that results in better properties than those of the individual components used alone. In contrast to metallic alloys, each material retains its separate chemical, physical, and mechanical properties. The two constituents are reinforcement and a matrix. The main advantages of composite materials are their high strength and stiffness, combined with low density, when compared with bulk materials, allowing for a weight reduction in the finished part. The reinforcing phase provides the strength and stiffness. In most cases, the reinforcement is harder, stronger, and stiffer than the matrix. The reinforcement is usually a fiber or a particulate. Fibers produce high-strength composites because of their small diameter; they contain far fewer defects (normally surface defects) compared to the material produced in bulk. As a general rule, the smaller the diameter of the fiber, the higher its strength, but often the cost increases as the diameter becomes smaller. In addition, smaller-diameter high-strength fibers have greater flexibility and are more amenable to fabrication processes such as weaving or forming over radii. Typical fibers include glass, aramid, and carbon, which may be continuous or discontinuous.

The final behavior of a composite material depends to a great extent on the adhesion between the reinforcing fiber and the matrix. The adhesion between two different materials is a function of several factors among which are the surface roughness and surface polarity [1, 2]. In order to improve adhesion between cellulosic material and polymeric matrix, several fiber surface modifications such as reaction with acid [3-6], organosilane [8-11] and alkaline treatment (Mercerization) [5, 11-13] have been reported.

Mercerization as proposed by ASTM D1965 is the process of subjecting vegetable fiber to an interaction with a fairly concentrated aqueous solution of a strong base, to produce great swelling with resultant changes in the fine structure, dimension, morphology and mechanical properties [14]. When natural fibers are stretched, such arrangement amongst the fibrils would result in a better load shearing by them and hence result in higher stress development in the fiber.

1.1 Use of natural fibers

This study aims to develop natural fiber composite from a relatively new but widely available okra fiber. Investigation of the mechanical and water absorption properties of okra – glass fiber hybrid composite and the effect of varying concentration of NaOH on fiber modification was studied.

Natural fibers are assuming much significance as processing materials for engineering applications today due to growing environmental consciousness and their high strength and stiffness. They also possess some good advantages over synthetic fibers such as their low cost, low density, renewability, manufacturing ease and biodegradability [1].There is a growing interest in the use of natural fibers as reinforcing components for thermoplastics and thermosets. Although thermoplastics have the added advantage of recycling possibilities; thermosets are targeted to obtain much improved mechanical properties as compared to thermoplastics in the resulting bio-composites [2]. One of the most important focuses inachieving this goal is to develop a new material, with an improved strength to weight ratio over any of the materials presently in use [3].There are various types of natural fibers today, and the variety continues to increase. Some examples in use include ramie, hemp, kenaf, jute, sisal, bamboo, banana, and oil palm fibers [4]. The mechanical properties of natural fiber composites are much lower than those of the synthetic fiber composites and they are hydrophobic. Synthetic fibers have very good mechanical properties, moisture repellency, but these are difficult to recycle. To take advantage of both natural and synthetic fibers, they can be combined in the same matrix to produce hybrid composites that take full advantage of the best properties of the constituents.

Studies are still ongoing in the use of established natural fibers in composites materials development and also in the establishing some new ones as potential reinforcement candidates in composites materials, okra fiber is one of such. De Rosa et al., [5] studied the Morphological, thermal and mechanical characterization of okra (Abelmoschusesculentus) fibers as potential reinforcement in polymer composites and concluded that these fibers show potential as reinforcement in polymer matrix composite. Shamsul et al., [6] studied the chemical analysis of okra fiber and its physico- chemical properties. The chemical compositions of okra fiber values are 67.5 % cellulose, 15.4 % hemicellulose, 7.1 % lignin, 3.4 % pectic matter, 3.9 % fatty andwaxy matter, and 2.7% aqueous extract. The effect of varying fiber length and hybridization ratio on the mechanical properties of natural and hybridized fiber composites have been studied by many researchers. These include the use of flax in polypropylene.

Okra is an allopolyploid of uncertain parentage. Okra (Lady's finger) fibers are extracted from the bark of the okra bahmia plant, a plant of the Malvaceae family, known botanically as Abelmoschus esculentus, well diffused for example in North-East India. These were demonstratedby FTIR investigations as being of cellulose origin, and not dissimilar from plants whose fibers found some use as a reinforcement in composites, such as pineapple.5 However, the main use of okra fibers in materials has been confined to employing the mucilage as a moisture absorber.6 Okra mucilage can be a source of polysaccharides, which can be used, with suitable chemical grafting e.g., using poly acrylonitrile, for the synthesis of biodegradable polymers.7 The use of these fibers in composites would possibly be considered.

However, the difficult extraction of okra fibers, which may possibly lead to fiber properties degradation would suggest, as a first attempt in making composites, to adopt a cheap chemical treatment and an equally widely available

And low cost polymer matrix, which proved suitable for the introduction of plant fibers in it, such as Bakelite (phenol-phormaldehyde) resin.8 the first results obtained in this work, would hopefully suggest whether the use of these fibers as a reinforcement or filler in composite can be pursued.

Figure 1.1 Okra (Abelmoschus esculentus)

1.2 Use of Glass fiber

Glass fiber also called fiberglass. It is material made from extremely fine fibers of glass Fiberglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fiber and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favorable when compared to metals, and it can be easily formed using molding processes. Glass is the oldest, and most familiar, performance fiber. Fibers have been manufactured from glass since the 1930s.

Glass fibers are useful because of their high ratio of surface area to weight. However, the increased surface area makes them much more susceptible to chemical attack. By trapping air within them, blocks of glass fiber make good thermal insulation, with a thermal conductivity of the order of 0.05 W/ (mK).

The strength of glass is usually tested and reported for "virgin" or pristine fibers those which have just been manufactured. The freshest, thinnest fibers are the strongest because the thinner fibers are more ductile. The more the surface is scratched, the less the resulting tenacity. Because glass has an amorphous structure, its properties are the same along the fiber and across the fiber. Humidity is an important factor in the tensile strength. Moisture is easily adsorbed, and can worsen microscopic cracks and surface defects, and lessen tenacity.

In contrast to carbon fiber, glass can undergo more elongation before it breaks. There is a correlation between bending diameter of the filament and the filament diameter. The viscosity of the molten glass is very important for manufacturing success. During **drawing** (pulling of the glass to reduce fiber circumference), the viscosity should be relatively low. If it is too high, the fiber will break during drawing. However, if it is too low, the glass will form droplets rather than drawing out into fiber.

1.3 Objectives:

The aim of the research is to study the properties of short okra-glass fiber hybrid composite with the following objectives keeping in view of the current status of research the scope of the present research work.

1. Fabrication of a new class of epoxy based hybrid composite reinforced with hybrid okra and glass fibers.
2. To study the influence of fiber loading and fiber orientation on physical, mechanical and flexural behavior of composites.
3. To select the best alternative from a set of alternative materials.
4. To determine the critical fiber length of okra.
5. To study the degree of mechanical reinforcement that could be obtained by the hybridization of glass and okra fibers.
6. To investigate the effect of varying concentration of NaOH treatment on fiber modification**.**

II. LITERATURE REVIEW

Md. Moniruzzaman et.al., (2009) evaluated testing on okra fibers (Abelmoschus esculentus) when included in a ®Bakelite matrix was performed. Two types of treatment were considered for the fibers to be included in the composite, scouring and bleaching. These led to surface modifications on the fibers, which were detailed using SEM micrographs. In particular, composites obtained including a small amount of scoured okra fibers, not exceeding 5%, resulted in some improvement in the tensile and flexural strength. In contrast, the introduction of higher volumes of okra fibers resulted in the degradation of mechanical properties: this was attributed to the presence of high void content in the composite. They stated that Composites were prepared using Bakelite from a Bangladesh supplier, and local okra fiber, kept at a dry environment for seven days for the partial removal of moisture.

N. Srinivasababu et.al., (2009) increasing the needs for different engineering applications invite the development of new materials. In the present research new natural fiber okra was introduced for the preparation of okra fiber reinforced polyester (FRP) composites. Already established fibers sisal and banana were also extracted for the preparation of sisal and banana FRP composites and to determine tensile properties. The tensile properties of okra FRP composites were compared with sisal and banana FRP composites. Hand lay-up technique was used for the preparation of composites. Chemically treated okra fiber reinforced polyester composites at maximum volume fraction showed tensile strength, modulus of 154.17%, 114.13% and specific tensile strength and modulus of 12.26%, 129.82% higher than that of the pure polyester specimen, respectively. Tensile strength of the untreated LF-PP composites containing 15 wt% LF decreased from 33 to 19.5 Mpa which corresponds to the 41% decrease (Demir et al., 2006). For modified filler (Epoxy based materials) the stress at break is 1.76 ± 0.13 MPa, modified filler unsaturated polyester based materials 0.72 ± 0.06 Mpa (Hamid Kaddami et al., 2006). The mechanical properties of flax / polypropylene compounds, manufactured both

With a batch kneading and an extrusion process were determined and compared with the properties of NMT composites (Harriette L. Bos et al., 2006).

A.Alavudeenl et.al.,(2010) evaluated the research works which is carried out in the field of woven natural fiber composites with special reference to weave pattern, chemical modification and the theory behind it. Here they took two types of natural fibers, woven - banana and pandanus (Kenaf) were utilized as reinforcement is studied. These two types of natural fibers are taken for study is because of their ability to be produced in a continuous form, and hence able to produce into a woven mat form. Further, literatures on other types of natural fiber woven composites were discussed briefly. In recent years, owing to the increased environmental awareness, the usage of natural fibers as a potential replacement for synthetic fibers such as carbon, aramid and glass fibers in composite materials have gained interest among researchers throughout the world. K.G.Satyanrayana et al. N.Srinivasababu et al. presented new natural fiber namely okra for the preparation of okra fiber reinforced polyester composites. Chemically treated (chemical treatment-2) okra woven FRP composites showed the highest tensile strength and modulus of 64.41MPa and 946.44MPa respectively than all other composites investigated in the present research.

Vivek Mishra et.al., (2013) considered during last few years, the interest in using natural fibers as reinforcement in polymers has increased dramatically. Natural fibers are not only strong and lightweight but also relatively very cheap. In this research work, an investigation has been carried out to make use of jute fiber, a natural fiber abundantly available in

India. The present work describes the development and characterization of a new set of natural fiber based polymer composites consisting of bidirectional jute fiber mat as reinforcement and epoxy resin as matrix material. The composites are fabricated using hand lay-up technique and are characterized with respect to their physical and mechanical properties. Experiments are carried out to study the effect of fiber loading on the physical and mechanical behavior of these composites. Result shows the significant effect of fiber loading on the mechanical properties of the composites. Also, the formation of voids in the composites is an influencing factor on the mechanical properties. Over the past few decades there is a rapid increase in the demand of the fiber reinforced polymer (FRP) composites because of the unique combination of high performance, great versatility and processing advantages at favorable costs by permutation and combination of different fibers and polymers . Bidirectional jute fiber mat has been obtained from the local sources as a reinforcing material. Epoxy resin and the corresponding hardener are supplied by Ciba Geigy India Ltd. The polymers composites are fabricated by hand lay-up technique. Composite specimens with different fiber loading (0, 12, 24, 36 and 48 wt %) were prepared and subjected to post curing for 24 hours at room temperature.

Begum K. et.al., (2013) considereda brief overview of the improvement of the mechanical properties (tensile and flexural strength and the corresponding modulus of elasticity) of natural fiber reinforced polymer materials. The mechanical strength of the natural fiber reinforced polymer composites (NFRPCs) has been compared with that of glass fiber reinforced polymer composites and it is found that for achieving equivalent mechanical strength of the material, the volume fraction of the natural fiber should be much higher than that of the glass fiber. The eco-friendly nature (emission, economy of energy) of the production of components of NFRPCs has also been briefly discussed. It is concluded that NFRPCs have already been proven alternative to SFRPCs in many applications in automotive, transportation, construction and packaging industries, and the production of natural fiber being labor-intensive, the NFRPC industry will create new employment and will contribute to the poverty alleviation program in developing countries. Since the 1990s, researchers have begun to focus attention onNFRPCs in response to the increasing demand forenvironmentally friendly materials and the desire to reduce thecost of traditional fibers (i.e., carbon, glass and aramid)reinforced polymer composites. Due to the low density and satisfactorily high specific propertiesof natural fibers, the composites based on natural fibers havevery good implications in the automotive and transportationindustry. There are numerous examples of the use of NFRPCs inautomotive applications.

III. METHODOLOGY

3.1 Okra-Epoxy Composite Specimen Preparation

The okra fibers were chopped to various lengths of 10mm, 20mm, 30mm, 40mm and 50mm respectively. Preliminary loading of the short okra fiber in the pre-calculated matrix showed that the mean loading capacity was 15 wt %, compared to the 20.4 wt % reported by Srinivasababu et al., [11]. The total fiber weight was maintained at 15 wt % of the total composite weight. The various lengths of the fibers were then weighed to the corresponding weight based on the total weight of the matrix required for the 4mm and 10mm composite sample thickness respectively.

The composite samples were made respectively by mixing the pre calculated volume of epoxy and hardener in the ratio of 5:1 by weight in a plastic cup and stirred thoroughly for 10 minutes. A portion of the mixture was poured into the prepared mound and some quantity of the weighed 10mm fiber was loaded in random orientation. Brush was used to apply the matrix to ensure the fibers were properly coated with the matrix. The procedure was repeated until the remaining fiber and the matrix was exhausted. The sample was cured at room temperature for 24 hours under load. It was then demoulded and further post-cured in an oven at 700C for 3 hours. The procedure was repeated for the 20mm, 30mm, 40mm and 50mm fibers lengths respectively.

Figure3.1 Okra-Epoxy Composite Specimen Preparation

3.2 Glass-Epoxy Hybridized Composite Specimen Preparation

The glass fibers were chopped to 20mm fiber lengths respectively. Based on the 15 wt % fiber loading established, okra and glass fibers' weight were varied and calculated based on the following ratios (90:10, 80:20, 70:30, 60:40 and 50:50) respectively. The calculated amount of the various ratios were weighed and used to produce the hybrid composites. The composite samples were made respectively by mixing the pre calculated volume of epoxy and hardener based on thein the ratio of 5:1 in a plastic cup and stirred thoroughly for 10 minutes. A portion of the mixture was poured into the prepared mound and some quantity of the weighed hybridized 90:10 (okra: glass) fiber was loaded in random orientation using hand lay-up method. Brush was used to apply the matrix to ensure the fibers were properly coated with the matrix. The procedure was repeated until the remaining fiber and the matrix was exhausted. The sample was cured at room temperature for 24 hours under load. It was then de-moulded and further post-cured in an oven at 700C for 3 hours. The procedure was repeated for the other hybridized okra: glass fibers ratio of 80:20, 70:30, 60:40 and 50:50 respectively.

3.3Use of Epoxy resine (L 12)

Epoxy is either any of the basic components or the cured end products of epoxy resins, as well as a colloquial name for the epoxide functional group. Epoxy resins, also known as polyepoxides, are a class of reactive prepolymers and polymers which contain epoxide groups. Epoxy resins may be reacted (cross-linked) either with themselves through catalytic homopolymerisation, or with a wide range of co-reactants including polyfunctional amines, acids (and acid anhydrides), phenols, alcohols and thiols. These co-reactants are often referred to as hardeners or curatives, and the cross-linking reaction is commonly referred to as curing. Reaction of polyepoxides with themselves or with polyfunctional hardeners forms a thermosetting polymer, often with high mechanical properties, temperature and chemical resistance. Epoxy has a wide range of applications, including metal coatings, use in electronics / electrical components/LED, high tension electrical insulators, paint brushes manufacturing, fiber-reinforced plastic materials and structural adhesives. Epoxy resins are low molecular weight pre-polymers or higher molecular weight polymers which normally contain at least two epoxide groups. The epoxide group is also sometimes referred to as a glycidyl or oxirane group.

Figure3.2 Resine and Hardener

3.4 Use of NaOH

Sodium hydroxide (NaOH), also known as lye and caustic soda, is an inorganic compound. Its highly caustic metallic base and alkali of sodium which is available in pellets, flakes, granules, and as prepared solutions at different concentrations.

Sodium hydroxide forms an approximately 50% (by mass) saturated solution with water.

We used NaOH for alkali treatment of okra fiber and we dipped the 250 gm f okra fiber into 500ml of NaOH solution and left it for 8 hours at room temperature and after 8 hours we took okra fiber out of solution and washed it 5 times with fresh water and it became very smooth and separated

Figure3.3. NaOH Solution

IV. RESULTS AND DISCUSSION

4.1 Tensile Test

Tensile testing, is also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. We placed our prepared specimen between the UTM machine by which we did the tensile test we prepared two specimens for tensile test. Followings are the results of tensile tests;

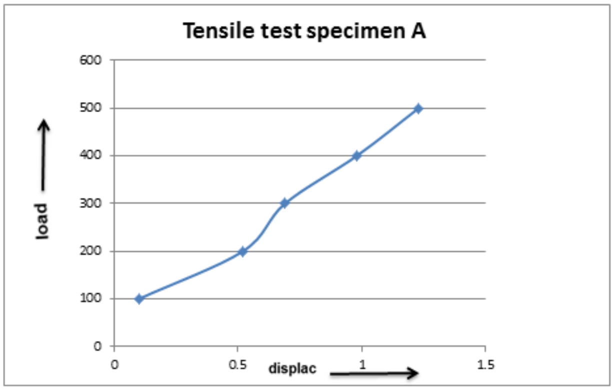
Figure 4.1 Tensile test specimens

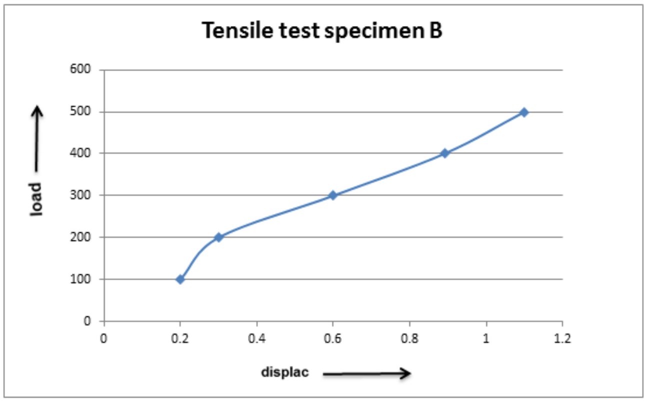
Table 4.1 Tensile Test Specimen A

Load F in N	Displacement Δl in mm	Stress σ in Mpa	Strain ε	Tensile Modulus E Mpa
100	0.2	$6.11996X10^{-3}$	$9.3023X10^{-4}$	$6.578976X10^{-8}$
200	0.30	0.01224	$1.39534X10^{-3}$	$8.772056X10^{-6}$
300	0.3	0.01836	$2.79069X10^{-3}$	$6.579018X10^{-6}$
400	0.89	0.02448	$4.1395X10^{-3}$	$5.9137577X10^{-6}$
500	1.1	0.3060	$5.11627X10^{-3}$	$5.9809197X10^{-6}$
600	1.3	0.0368	$6.046511X10^{-3}$	$6.0861545X10^{-6}$
700	1.6	0.0428	$7.44186X10^{-3}$	$5.7512504X10^{-6}$
800	1.89	0.04896	$8.790698X10^{-3}$	$5.5695237X10^{-6}$
900	2.13	0.05508	$9.906976X10^{-3}$	$5.5597188X10^{-6}$
1000	2.22	0.06119	0.010326	5.925818323
1100	2.9	0.06732	0.013489	0.072008472
1200	3.4	0.073440	0.015813	4.655280023
1300	3.6	0.79560	0.016745	4.751269036
1400	3.8	0.08568	0.017675	4.847525
1500	4.1	0.9180	0.019070	4.813843734
1600	4.5	0.09792	0.02093023	4.678400572
1700	4.8	0.10404	0.0223255814	4.660124999
1800	4.8	0.11016	0.0223255814	4.660124999
1900	4.9	0.11628	0.02279070	5.102081112

Table 4.2 Tensile Test Specimen B

Load F in N	Displacement Δl in mm	Stress σ in Mpa	Strain ε	Tensile Modulus E Mpa
100	0.1	$6.11996X10^{-3}$	$4.651163X10^{-4}$	$1.3157913X10^{-7}$
200	0.52	0.01224	$2.418605X10^{-3}$	$5.0607685X10^{-6}$
300	0.69	0.01836	$3.2093023X10^{-3}$	$5.7208696X10^{-6}$
400	0.98	0.2448	$4.5581396X10^{-3}$	$5.3706121X10^{-6}$
500	1.23	0.03060	$5.7209302X10^{-3}$	$5.3487805X10^{-6}$
600	1.45	0.0368	$6.744187X10^{-3}$	$5.4565509X10^{-6}$
700	1.8	0.0428	$8.372094X10^{-3}$	$5.1122216X10^{-6}$
800	2.1	0.04896	$9.7674418X10^{-3}$	$5.0125714X10^{-6}$
900	2.6	0.05508	0.012093024	4.554692027
1000	3.0	0.06119	0.0139535	4.385279679
1100	3.2	0.06732	0.0148838	4.523038471
1200	3.4	0.073440	0.01581395	4.643998088
1300	3.4	0.07956	0.01581396	5.030997928





4.2 Bending Test

The bend test is a simple and inexpensive qualitative test that can be used to evaluate both the ductility and soundness of a material. . We placed our prepared specimen between the machine by which we did the tensile test we prepared two specimens for tensile test. Followings are the results of bending tests;

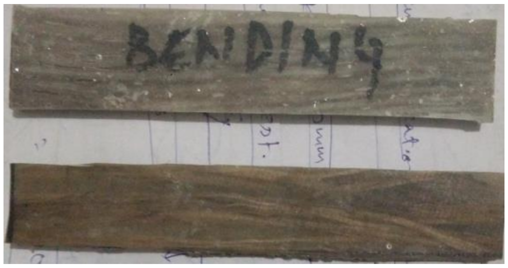


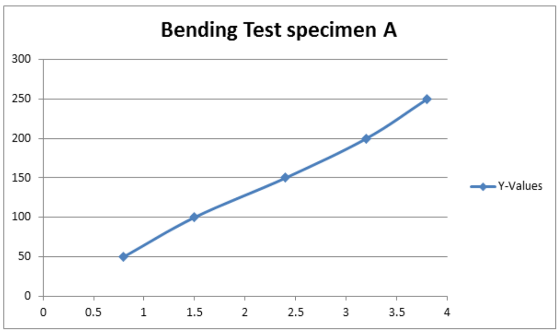
Figure 4.2 Bending test specimens

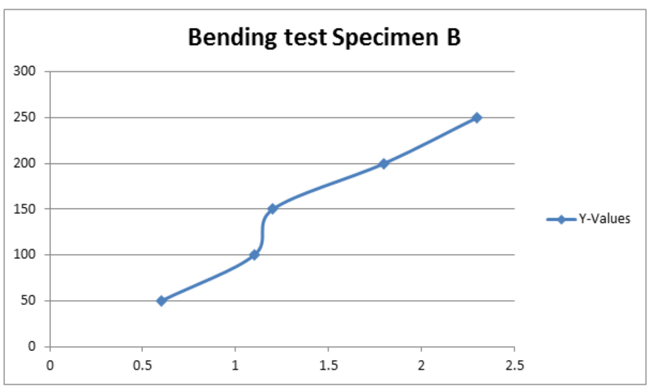
Table 4.3 Bending Test Specimen A

Load F in N	Displacement Δl in mm	Stress σ in Mpa	Strain ε	Tensile Modulus E Mpa
50	0.8	$2.5641026X10^{-3}$	$6.1538482X10^{-3}$	$4.1666666X10^{-7}$
100	1.5	$5.1282052X10^{-3}$	0.01153847	0.4444249
150	2.4	$7.6923077X10^{-3}$	0.01846154	0.4166666324
200	3.2	0.0102565	0.02461539	0.04166703
250	3.8	0.0128206	0.0292308	0.418599012
300	4.1	0.0153847	0.0315385	0.48780697
350	4.5	0.0179488	0.0346154	0.51852066
400	4.56	0.0205129	0.0350769	0.58479798
300	4.8	0.0153847	0.0369230	0.4166699

Table 4.4 Bending Test Specimen B

Load F in N	Displacement Δl in mm	Stress σ in Mpa	Strain ε	Tensile Modulus E Mpa
50	0.6	2.5641026X10-3	4.6153847X10-3	5.555555531X10-7
100	1.1	5.1282052X10-3	8.46153847X10-3	6.060606139X10-7
150	1.2	7.6923077X10-3	9.2307693X10-3	8.333333279X10-7
200	1.8	0.0102565	0.0138462	0.7407447531
250	2.3	0.0128206	0.0176934	0.7245978727
300	2.7	0.0153847	0.0207693	0.74074235
250	3.1	0.0128206	0.0238462	0.537637239





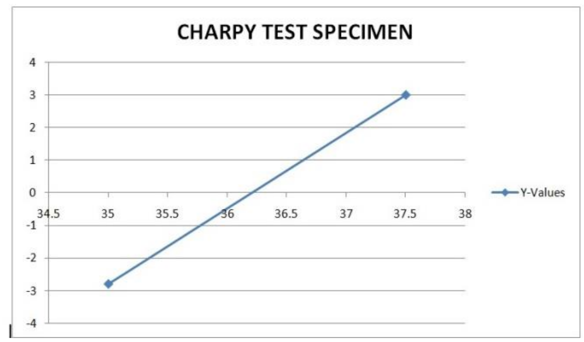
4.3 Chary Impact Test

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. We placed our prepared specimen between the machine by which we did the tensile test we prepared two specimens for tensile test. Followings are the results of Impact test:

Figure 4.3 Impact test specimens

Table 4.5 Charpy Impact Test

Specimen	Impact energy	Impact strength in Kg/m²
Specimen 1	-2.8	35
Specimen 2	3	37.5



V. CONCLUSION

- The successful fabrications of a new class of epoxy based hybrid composites reinforced with okra and glass fiber have been done.
- The maximum hardness, flexural strength is obtained for composites reinforced.
- Better flexural strength and minimal water absorption was obtained at 5 wt % of NaOH alkali treatment concentration.
- Fiber treatment greatly improves the properties of natural fibers by creating a rougher surface for good adhesion between the cellulosic fibers and the polymeric matrices.

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