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Tensile and Flexural Properties of Glass and Kenaf (GKG) Mat Reinforced Epoxy Hybrid Composite

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ABSTRACT

Hybrid composite materials are the great potential for engineering material in many applications. Hybrid polymer composite material offers the designer to obtain the required properties in a controlled considerable extent by the choice of fibers and matrix. The properties are tailored in the material by selecting different kinds of fiber incorporated in the same resin matrix. In the present investigation, the mechanical properties of Kenaf and Glass mat reinforced epoxy hybrid composite were studied. The hand lay-up technique was adopted for the fabrication of hybrid composite materials. The mechanical properties such as Tensile strength, Tensile modulus, Flexural Strength of the hybrid composites were determined as per ASTM standards. The tensile and flexural properties were improved as the fibers reinforcement content increased in the matrix material.

Keywords - Hybrid composite, Hand layup technique, ASTM standards.

I. INTRODUCTION

In ancient history of composite, it was first time used by Mesopotamian and Egyptians which were made strong and stable buildings with mixture of straw and mud about 1500s B.C. Later Mongols invented first bow which was made by mixture of bone, animal and wood glue .But according "Mar-ball" incorporation history was composite around 3400 BC which was used by ancient Mesopotamians in ancient time. They originated plywood using the glue and wood strips at different angles. Egyptians formed death masks with composite about to 2181-2055 BC. In about 1200 AD Mongols invented first composite bow. The bow was small and accurate and had extremely strength [1]. In 1800's there was great revolution in the chemistry in which polymerization produces synthetic resins. In early 1900's different type of plastics such as polyester, vinyl and phenolic was developed. First glass reinforced polymer composite was prepared in thirties. Unsaturated polyester was patented and epoxy was introduced in thirties. During the World War II composites were produced from the research.[2] In 1947 a fully composite automobile was prepared and tested. In 1950 there was revolution of manufacturing methods of composite such as pultrusion, resin moulding transfer and vacuum bag moulding etc. The carbon fibre composites were available commercially before but carbon fibre as patented in 1961. Carbon was improved the stiffness of the thermoset hence sports, marine, automobile product manufactured by the carbon reinforced composites[3]. Polyethylene come into existence around late 1960's. In the middle of 1990's there was mainstream of composite manufacturing and construction. It was the cost effective and light weight and good replacement of traditional materials like metals and engineered plastics [4] Hybrid composites with different stacking sequences of glass/carbon , carbon/basalt , jute/glass on the mechanical loadings significantly affected the properties of the laminates[5].However, glass-reinforced plastics exhibit shortcomings such as their relatively high fiber density (approximately 40% higher than natural fibers), difficulty onto machine, and poor recycling properties, not to mention the potential health hazards posed by glass-fiber particulate.[6] An ecological evaluation, or eco-balance, of natural-fiber mat as compared to glass-fiber mat offers another perspective. The energy consumption to produce a flax-fiber mat (9.55 MJ/kg), including cultivation, harvesting, and fiber separation, amounts to approximately 17% of the energy to produce a glass-fiber mat (54.7 MJ/kg) [7].Natural fibers such as flax, hemp, and jute can be used as reinforcement for thermoset or thermoplastic polymers instead of synthetic fibers[8]. Thermoplastic material currently dominates as matrixes for natural fibers are polypropylene and polyethylene, while thermosets, such as phenolicand polyesters, are common matrixes[9]. Both thermosets and thermoplastics are attractive as matrix materials for composites as a result of large numbers of components being involved such as base resin, curing agents, catalysts, flowing agents, and hardeners that make the formulation complicated in thermoset composites[10].

Natural Fibre and Matrix

Kenaf and Glass mat were supplied by Compact Buying Services, Faridabad, Haryana. Bi-directional mats of these fibers have been used for fabrication of bio- composites. Epoxy resin and hardener was supplied by Excellence Resins, Meerut, UP.

Kenaf Mat

Kenaf has a unique combination of long bast and short core fibers which makes it suitable for a range of paper and cardboard products. Scientists at the ARS have tested several kenaf pulping techniques, with the pulps being used to make several grades of paper including newsprint, bond, coating raw stock and surfaced sized. Results have been positive, particularly in terms of paper quality, durability, print quality and ink absorption.The bast contains average cross and bevan cellulose between 47% to 57%, alpha cellulose between 31% to 39%, lignin between 15% to 18%, pentosans between 21% to 23% and ash between 2% to 5%. The fiber has an average length of 2740μm which is superior to wood (840μm) and an average diameter of 20μ. As for the core, they contain average 34% alpha cellulose, 17.5% lignin, 19.3% pentosans and 2.5% ash. The average fiber length of the core is 600μ . However, these information are vary based upon where, when and how a Kenaf is grown and harvested . According to the fiber length increases with the increase of kenaf height. However, it wasfound that the fiber length decreases as the plant matured [30]. Different view on the fiber length was shared by . Their research found that, the fiber length increases with kenaf age, but at three different phases i.e. increase in the initial stage of growth, decrease in the middle stage and then increase again at the end stage. It was also discovered from the same study by that, kenaf bast fibers grow much more active than kenaf core fibers. This is the possible reason why kenaf bast fibers are longer and relatively stronger than kenaf core fibers. The growth process may be related to several factors such as the development of protein, extractives, cellulose and cell wall of the fibers.

Fig 1 – Kenaf Mat

Glass Mat

These fiber mesh Roll is non-adhesive coated and ideal for minimizing the risk of cracks between column and bricks wall joint ,this mesh roll is used before plaster on the wall . which give protection to the wall and the joint and minimizes the risk of crack on the wall and give strength to the wall . very easy to use & replaces the traditional iron mesh which was used for this purpose. Fiberglass mesh is woven by fiberglass yarn and then coated by alkaline resistant latex. It has alkaline resistance, high strength, etc. It is an ideal engineering material in construction. It is mainly used to reinforce cement, stone, wall materials, roofing and so on. Plastering fiber glass mesh is used for reinforcement surfaces during plastering, installation leveling floors, waterproofing, and restoration of cracked plaster in order to prevent cracking or fraying of the plaster. Fiberglass mesh is cheap material that does not burn and is characterized by both low weight and high strength. These properties allow it to be successfully used in the formation of plaster facades, as well as use on internal wall and ceiling surfaces. This material is widely used for fastening the surface layer at the corners of the room. Most widely used standard fiberglass is S-Glass having density of 145 GSM

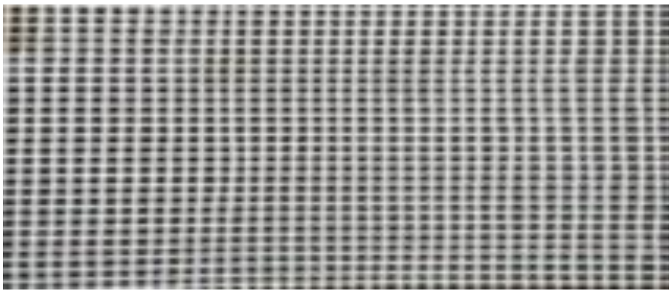

Fig 2 – Glass Mat

Epoxy Resin

Araldite LY 556 is manufactured by Huntsman Advanced Materials having the following outstanding properties has been used as the matrix material. Epoxy Resin was purchased from Excellence Resins, Meerut, UP.

Hardener

Hardener is a curing agent for epoxy resin. Epoxy resins require a hardener to initiate curing. It is also called the catalyst, the substance that hardens the adhesive when mixed with resin. It is the specific selection and combination of the epoxy and hardener components that determine the final characteristics and suitability of the epoxy coating for a given environment. Optimum levels of a hardener are used to formulate epoxy coatings. The ratio differs from product to product. The use of an improper hardener may result in an undercatalyzed or overcatalyzed product. In the present work hardener (HY951) is used. This has a viscosity of 10-20MPa at25ºc.

Fig 3 - Epoxy Resin (Araldite LY 556) and Hardener (HY 956)

Processing

Hybrid composites were fabricated with the help of detachable closed mold of mild steel using hand lay-up technique. The silica gel was applied to the inner surface of mold plates to avoid sticking of polymer with the steel plates during curing.

Fig 4 - Mould

Fig 5 - Roller

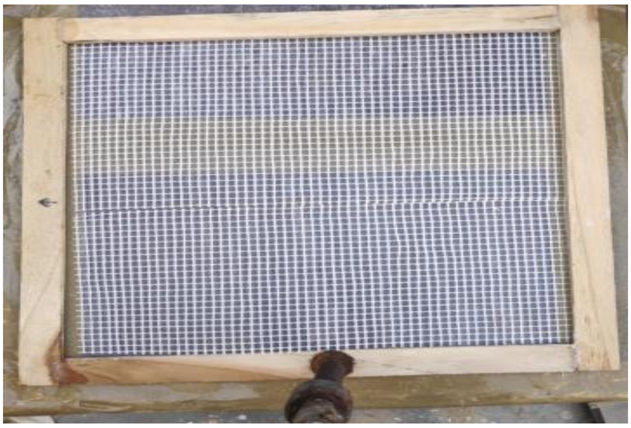

Fig 6 - Wooden Frame

Fig. 7 - Composite Processing

Hybrid composites were fabricated with the help of detachable closed mold of mild steel (450mm x 400 mm) using hand lay-up technique. Wax was applied to the inner surface of mold plates to avoid sticking of polymer with the steel plates during curing. The matrix was prepared by proper mixing of epoxy resin of Araldite LY556 grade and hardener HY951in proportion of 10:1 as per manufacturer (Huntsman). Epoxy resin and hardener were properly mixed to reduce the air bubbles present in the liquid of resin and hardener. A wooden frame of dimension (250*260*6) was prepared. The liquid matrix was then uniformly spread on the inner surface of the mold and the resin was rolled by the steel roller to achieve the equal thickness of resin layer over the surface of the mold. Fibre mats were cut in equal size as of Frame cavity and placed over the layer of resin. Roller was again rolled over to remove any air bubble trapped within the layer. This process was repeated again and again till the pre-decided specifications. For each type of developed composite, the weight fraction of fibre was 28%. Load is applied with the help of C-Clamp . Composite is left for curing for 48 hours at room temp with humidity 55%. Composite is left for curing for 48 hours at room temp with humidity 55%.

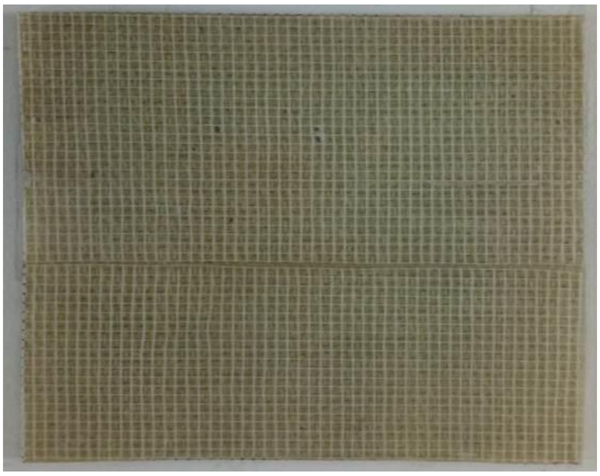

Fig 8 - Final Sheet (Top View)

Fig 9- Final Sheet (Side View)

Epoxy Resin + Hardener
Glass Mat
Epoxy Resin + Hardener
Kenaf Mat
Epoxy Resin + Hardener
Glass Mat
Epoxy Resin + Hardener

Fig 10 - Systemic View of Hybrid Composite

II. TESTING AND RESULTS

(1) Tensile Test

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to a controlled tension until failure. In general, the tensile tests are done on coupons with 0^0 laminae/laminate for corresponding axial properties and coupons with 90^0 laminae/laminate for corresponding transverse properties. **ASTM D 638** 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. The data is often used to specify a material, to design parts to withstand application force and as a quality control check of materials. Tensile test was performed on UTM manufactured by A.S.I Sales Private Limited , Working range : max. 100 kN ,accuracy: +_ 0.66%.

Fig 11-Universal Testing Machine

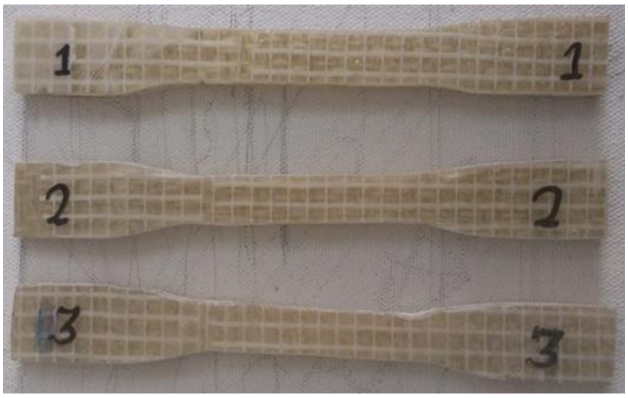

Fig.12(a)-Tensile Specimen before Fracture

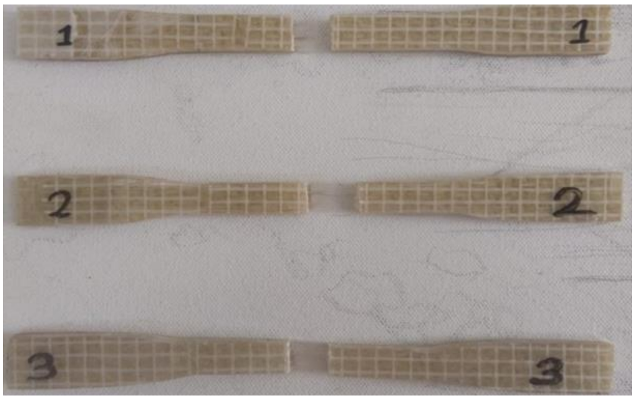

Fig.12(b)-Tensile Specimen after Fracture

Average value obtained of tensile Stress-strain curve are shown in Fig 12c.

- Young modulus=2.24GPa,
- Elongation=1.35,
- Ultimate stress=56MPa.

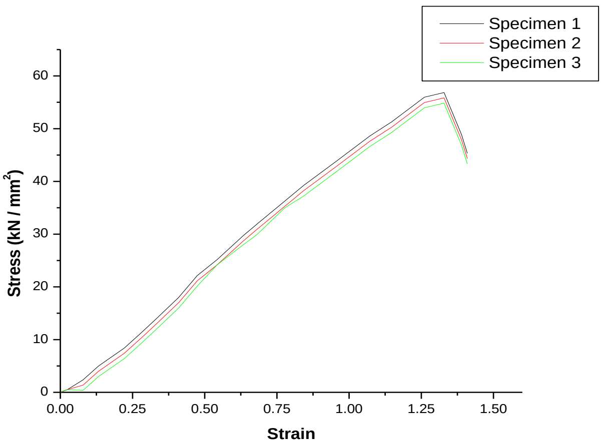

Fig.12(c) - Tensile stress-Strain curve

(2) Flexural Test

The flexural test **ASTM D790** measures the force required to bend a beam under three point loading conditions. The data is often used to select materials for parts that will support loads without flexing. Flexural modulus is used as an indication of a material's stiffness when flexed. Since the physical properties of many materials (especially thermoplastics) can vary depending on ambient temperature, it is sometimes appropriate to test materials at temperatures that simulate the intended end use environment. It is used for mechanical property. The Flexural test is carried out in a UMT no samples cut in accordance with ASTM D-790 standard the testing procedure is as per the three-point bending test by placing the specimen on the Universal Testing Machine and applying load till the specimen fracture and break. Result is compared and flexural strength of the material is identified.

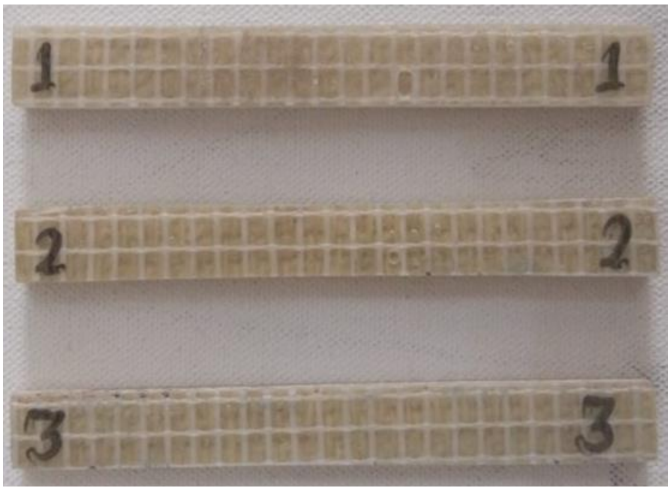

Fig. 13-Flexural Specimen Before Fracture

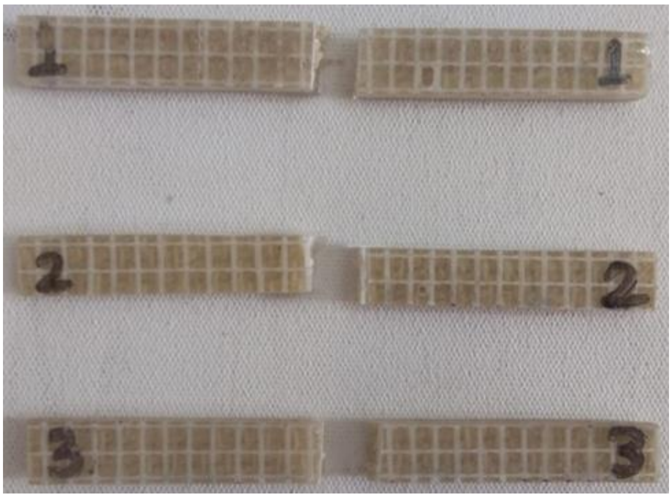

Fig. 14- Flexural Specimen After Fracture

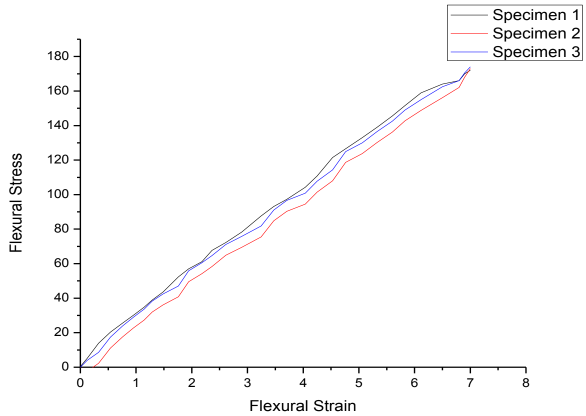

Fig. 15-Flexural Strength vs Strain

Mean Flexural Strength -171.20 MPa

III. CONCLUSION

1. There is improvement in tensile strength of hybrid composite by reinforcing Glass mat and Kenaf mat in epoxy. Tensile Strength increases of GKG hybrid composite (56 MPa) which is higher as compared to Composites of Kenaf (40MPa) and Glass (44 MPa) with epoxy and hybrid composite of Flax And Glass with Epoxy (30 MPa)
2. Flexural Strength increases of GKG hybrid composite (171.2 MPa) which is higher as compared to glass reinforced with Epoxy(110.49 MPa) and plain epoxy.

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