EXPERIMENTAL EVALUATION OF GLASS FIBER REINFORCED COMPOSITES SUBJECTED TO DIFFERENT LOADS

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Abstract:- *Fibre reinforced composites are replacing the traditional material because of its superior properties such as high tensile strength, low thermal expansion, high strength and less weight which can be used in aerospace, air craft, marine and defense applications. The development of new materials is on the anvil and growing day by day. To study the mechanical properties, the tensile, compression, flexural, impact, shear test has been conducted for glass fibre reinforced laminate. These laminates are manufactured by hand layup technique as per ASTM standards are D638, D695, D790, D256, D2344, D2240 respectively. Laminate consists of ten layers of glass fibre with the help of epoxy resin. Finally, the glass fibre reinforced composites are dried in sunlight to remove the moistures. The experimental evaluation was carried out to find the mechanical properties of a glass fibre reinforced composites and also the strength characteristics were determined*.

Key Words: Glass fibre, Epoxy resin, Hardener, Wax.

1. 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. Most composites are made of just two materials. One is the matrix or binder. It surrounds and binds together fibres or fragments of the other material, which is called the reinforcement. The first modern composite material was fibre glass. It is still widely used today for boat hulls, sports equipment, building panels and many car bodies. The matrix is a plastic whereas reinforcement is glass that has been made into fine threads and often woven into a sort of cloth.

On its own the glass is very strong but brittle and it will break if bent sharply. The plastic matrix holds the glass fibres together and also protects them from damage by sharing out the forces acting on them. The biggest advantage of modern composite materials is that they are light as well as strong. By choosing an appropriate combination of matrix and reinforcement material, a new material can be made that exactly meets the requirements of a particular application. Composites also provide design flexibility because many of them can be moulded into complex shapes. The downside is often the cost. Although the resulting product is more efficient, the raw materials are often expensive. 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. Particulate composites have dimensions that are approximately equal in all directions.

The major composite classes include Organic Matrix Composites (OMCs), Metal Matrix Composites (MMCs) and Ceramic Matrix Composites (CMCs). The term organic matrix composite is generally assumed to include two classes of composites, namely Polymer Matrix Composites (PMCs) and Carbon Matrix Composites commonly referred to as carbon composites.

Fibre Reinforced composites (FRP) can be further divided into those containing discontinuous or continuous fibres. Fibre Reinforced Composites are composed of fibres embedded in matrix material. Such a composite is considered to be a discontinuous fibre or short fibre composite if its properties vary with fibre length. On the other hand, when the length of the fibre is such that any further increase in length does not further increase, the elastic modulus of the composite, the composite is considered to be continuous fibre reinforced.

Laminar Composites are composed of layers of materials held together by matrix. Sandwich structures fall under this category. When there is a single ply or a lay-up in which all of the layers or plies are stacked in the same orientation, the lay-up is called a lamina. When the plies are stacked at various angles, the lay-up is called laminate normally laminated materials in which the individual layers, plies, or laminae are oriented in directions that will enhance the strength in the primary load direction. Laminae are extremely strong and stiff in the 0° direction.

Particulate Composites are composed of particles distributed or embedded in a matrix body. The particles may be flakes or in powder form. Concrete and wood particle boards are examples of this category Because the fiber orientation directly impacts mechanical properties, it seems logical to orient as many of the layers as possible in the main load-carrying direction. While this approach may work for some structures, it is usually necessary to balance the load-carrying capability in a number of different directions, such as the 0°, +45°, -45°, and 90° directions shows a photomicrograph of a cross-plied continuous carbon fiber/epoxy laminate. A balanced laminate having equal numbers of plies in the 0°, +45°, –45°, and 90° degrees directions is called a quasi-isotropic laminate, because it carries equal loads in all four directions. Composites are not always the best solution.

This part was machined from a single block of aluminum in about 8.5 hours and assembled into the final component in five hours. Such a part made of composites would probably not be cost competitive. Advanced composites are a diversified and growing industry due to their distinct advantages over competing metallics, including lighter weight, higher performance, and corrosion resistance. They are used in aerospace, automotive, marine, sporting goods, and, more recently, infrastructure applications. The major disadvantageof composites is their high cost.

Glass fibres (GSM-450) are manufactured by drawing molten glass into very fine threads and then immediately protecting them from contact with the atmosphere or with are surfaces in order to preserve the defect free structure that it is created by the drawing process. The glass fibres are as strong as any of the newer inorganic fibres but they lack rigidity on account of their molecular structure.

The properties of glasses can be modified to a limited extend by changing the composition of the glasses, but the only glass used to any great extend in composite materials is ordinary borosilicate glass, known as E-glass. The largest volume usage of composite materials involves E-glass as the reinforcement. These are used to investigate interfacial shear strength mainly and methods of investigating interfacial tensile strength are not well established. The simplest way to evaluate the interfacial tensile strength is to use a tensile specimen with parallel straight edges in which although-the-width embedded fiber whose direction is perpendicular to the loading direction. However, if the fiber end appears on the free surface, stress singularity arises because the bimaterial interface is on the free surface. Even if the fiber is embedded in the matrix, the fiber end serves as the corner bimaterial interface which results in stress singularity.

Therefore, it may be very difficult to evaluate the interfacial tensile strength accurately using this type of specimen configuration because debonding initiation is influenced by the stress singularity. In this study, a glass fiber (13μm in diameter) actually used as composite materials was used for the experiment, and the single fiber reinforced model composite materials whose matrix was the epoxy were made composites but they are usually much less expensive. Particulate reinforced composites usually contain less reinforcement (up to 40 to 50 volume percent) due to processing difficulties and brittleness.

2. LITERATURE REVIEW

In fiber reinforced composite materials, the interface between the fiber and the matrix plays a key role in mechanical properties of composite materials. Therefore, a more accurate evaluation method of the interface is necessary to develop better fiber reinforced composite materials. The simplest way to evaluate the interfacial tensile strength is to use a tensile specimen with parallel straight edges in which a through-the-width embedded fiber whose direction is perpendicular to the loading direction. A specimen has an embedded single fiber perpendicular to the loading direction at the center. It shows a schematic of a parallel straight edged specimen (straight specimen) and shows a cruciform specimen, respectively. Epoxy resin (Epikote 828) was used for the matrix material with TETA (Triethylenetetramine) as a hardener. The glass fiber was washed with acetone and the fiber was embedded in the resin [1].

When the glass fibres are impregnated with a resin and shaped into the required form. The surface treatment can be different for each supplier. It can be for example a roughening of the surface, forming a continuous thread on the whole surface or also sand coating the specimen [2].

Glass Fiber Reinforced Polymers (GFRPs) is a fiber reinforced polymer made of a plastic matrix reinforced by fine fibers of glass. Fiber glass is a lightweight, strong, and robust material used in different industries due to their excellent properties. Its bulk strength and weight properties are very favorable when compared to metals, and it can be easily formed using molding processes. The use of is improved remarkably due to the fact that the field of application is improved day by day especially in automotive industries. Several researches have been taken place in this direction. Most of the studies on are concerned with single reinforcement. The addition of natural fiber to the glass fiber can make the composite hybrid which is comparatively cheaper and easy to use. The manufacturing process for glass fibers suitable for reinforcement uses large furnaces to gradually melt the silica sand, limestone, kaolin clay, fluorspar, colemanite, dolomite and other minerals to liquid form. Glass-fiber reinforced plastic, or GFRP is a fiber reinforced polymer made of a plastic matrix reinforced by fine fibers of glass. Fiberglass is a lightweight, extremely strong, and robust material. The material is typically far less brittle, and 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 [3].

Composite materials are subjected to low temperatures in service and this as induced the need for proper knowledge of low temperature behavior composites. Most of the research in this field is focused on applying different type of loading and laminate composites [4].

Fibre loading enhances the strength of polymer composite and this property also determines the mechanical and corrosion wear behavior of any reinforced composites. Increasing competition and innovation in automobile sector tends to modify the existing products by new and advanced material products This paper presents development and manufacturing of two-wheeler axle by using epoxy resin and glass fiber composite material Glass fibers are used to increase the mechanical and physical properties of the material. Pultrusion is a continuous, automated process that is cost effective for high volume production of parts with uniform cross section so this process is used to manufacture the component which creates continuous composite profile Epoxy resin is one of the excellent thermosetting polymer resins. The cost-to-performance ratio of epoxy resin is outstanding. Epoxy resins possess characteristics such as high strength, low creep, and good adhesion to most of the substrate materials, low shrinkage during curing and low viscosity a chemical widely used to make epoxy resin this resin uses a 2:1 hardener. Mixing 2 parts epoxy to 1part hardener will give you the appropriate final mixture. The 2:1 hardener has a pot life of 35-40 minutes at 80 0 F, set time of 5-6 hours and a drying time of 24-48 hours [6].

3. PROBLEM IDENTIFICAION:

Our day to day life vehicles and automobile parts used the different type of composite fibres such as synthetic fibre and natural fibres. So, we are improving the properties of composite fibre and the same time with low cost. And its possible by the different preparation methods like as various load, constant temperature (room temperature). In this homogenous layer easily mixed with epoxy resin between one layer to another layer. Sometimes epoxy resin did not fully spread over the glass fibre layers so put another layer with load possible to increasing the bonding over the glass fibre layers.

4. METHODOLOGY

From the flow chart above, this project started with discussion with supervisor about materials. This discussion covering project overview supervisor and throw out opinion that related about title and supervisor instruct to proposed a certain design and concept before go up to next step.

Then start to make and decide the best idea about the title. Before that, literature review and research about title is the important point to get the best idea. This includes a study about concept of layup process to fabricate, and material. These tasks have been done through study on the internet, books, and others information. After gather and collect all related information and obtain new idea and knowledge about the title, the project would continue with the testing process.

This process covering purchased material, measuring material and cutting off based on requirement. Here, this process is important because the material would determine whether our product in way to failure or otherwise. After all the drawing and material preparation done the next process is a fabrication process.

There is some specialized process available for processing of composite materials, but only the most commonly usedcommercial process is hand lay-up process. Before lay-up the fibres, the mould is prepared with a wax-coated base sheet to ensure that the sample does not stick to the mould. The reinforcing fibres are cut into the required length and they are laid in the mould. The resin is mixed with hardener for quick setting and then it is applied on the fibre surface.

A roller is used to impregnate the fibres with the resin and to distribute the resin throughout the fibre surface. The fabrication procedure of composite sample in this experimental study is explained in three simple steps, the rust in the mould is cleaned by scrubbing with an abrasive paper. Then, the surface is allowed to dry, after cleaning it with a thinner solution. After drying, the surface is coated with wax, Place the glass fibre over the base plate in the mould and apply resin. Roller is used for proper bonding of resin with fibre. Place the glass fibre and apply resin, Repeat the process up to 10 layers. In this experiment, the glass fibre reinforced composites are prepared at the room temperature and an average relative humidity of 65%. Finally, the glass fibers polymer, are dried in sun light to remove the moisture.

The evaluation is by considering the strength, portable, durability, safety and others. After all process above done on schedule without any problem such as product defect all material for report writing is gathered. The report writing process covering and including all manners from week until finished. This process also included the presentation for final presentation of the project

The aim of this experimental program is to develop high strength Fibre Reinforced Composite containing Glass Fibre on strength parameter of composite. The detailed objectives of this study are as Conduct the experimental investigation to study the effect on mechanical properties. To determine the optimum percent of Glass Fibre on maximum compressive strength. To acquire a relative review on the quality of composite with addition of Glass Fiber at their ideal extents.

SONAR dome is a protective cover to sonar array in warships. It is fitted in the bow (front) of the ships and is always submerged when the ships sails. The dome is required to have acoustic transparency; at the same time, it must be structurally rigid to withstand slamming loads. Earlier domes were manufactured using titanium. Because of superior properties of composites, composite domes have replaced metallic domes, of late. R & DE (E) has designed and developed the first indigenous glass fibre reinforced plastic dome for P15 class of ships of the Indian navy. The dome is 10.5 m in length, 3.1 m in width at the bulbous section and its height is 3m. the acoustic window is the front portion of the dome, about 6 m in length. This region has a sandwich constructed in manufactured and as fitted on ins kolkatta with a glass and epoxy.

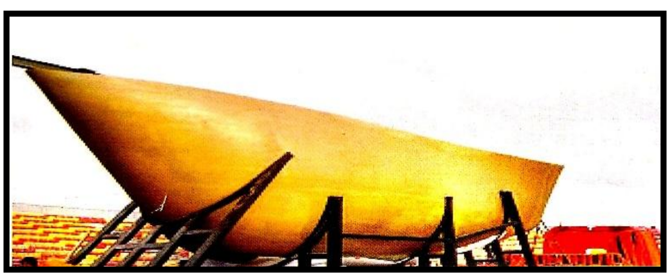

Fig-1: GFRP Sonar Dome

Glass fibre such as reinforced and matrix is used. Then select the reinforced homogenous fibre is used. Because, High mechanical strength, Good electrical insulator, Low thickness, Low thermal expansion, Low coefficient of linear expansion.

Fig-2: Laminate of Glass Fibre

5. EXPERIMENTAL WORK

5.1 TENSILE TEST:

Tensile testing, also known as tension testing, is a fundamental materials science and engineering test in which a sample is subjected to a controlled tension until failure. Properties that are directly measured via a tensile test are ultimate tensile strength, breaking strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined, such as Young's modulus, Poisson's ratio, yieldstrength, and strain-hardening characteristics. In various m/c and structure components are subjected to tensile loading in numerous applications. For safe design of these components, there ultimate tensile strength and ductility one to be determine before actual use. Tensile test can be conducted on UTM

The specimen ASTM standard size for the specimen is (80x24x5mm) respectively. After the specimen loaded at UTM-40 machine Tensile test can be conducted on UTM-40. A material when subjected to a tensile load resists the applied load by developing internal resisting force. The resisting force for unit normal cross-section area is known as stress. The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength.

Fig-3: Specimen before Tensile Testing

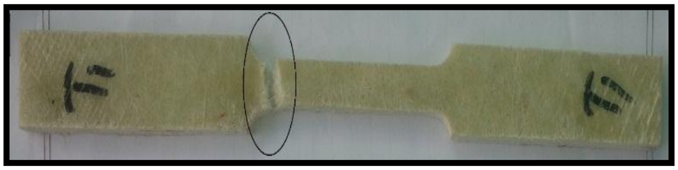

Fig-4: Specimen after Tensile Testing

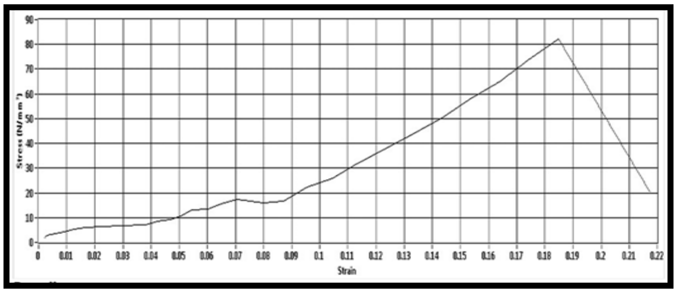

Fig-5: Result of Tensile Test

When the stress strain relationship for shear test where x axis represent has strain and y axis represent has stress. A material when subjected to a tensile load resists the applied load by developing internal resisting force. The resisting force for unit normal cross-section area is known as stress. The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be seen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area goes on decreasing and finally reduces to its minimum value.

5.2 COMPRESSION TEST:

Compression testing is a very common testing method that is used to establish the compressive force or crush resistance of a material and the ability of the material to recover after a specified compressive force is applied and even held over a defined period of time.

It is seen that a compression test is more difficult to be conducted than standard tensile test due to specimen must have larger cross-sectional area to resist any buckling due to bending, the specimen undergoing strain hardening as deformation proceeds, and cross-section of the specimen increases with deformation, thereby requiring substantial increase in the required load. The lateral instability due to buckling action can be avoided by keeping the ratio of height to diameter of the specimen less than 2. The compressive strength essentially depends open '*h*' to'd' ratio. Hence, higher is '*h*' to'd' ratio, lower is the compressive strength.

Testing can be performed at ASTM standard size for the specimen is (50x50x5mm), sub ambient and elevated temperatures. During the test, the specimen is compressed, and deformation versus the applied load is recorded. The compression test is used to determine elastic limit, proportional limit, yield point, yield strength, and (for some materials) compressive strength.

Fig-6: Specimen before Compression Testing

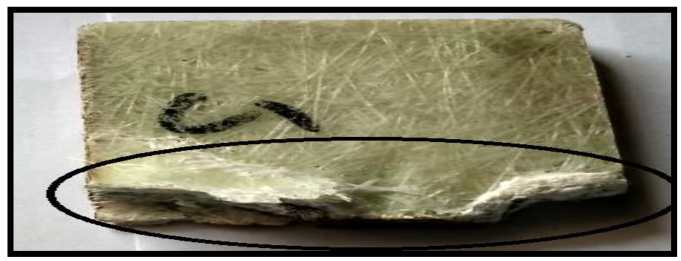

Fig-7: Specimen after Compression Testing

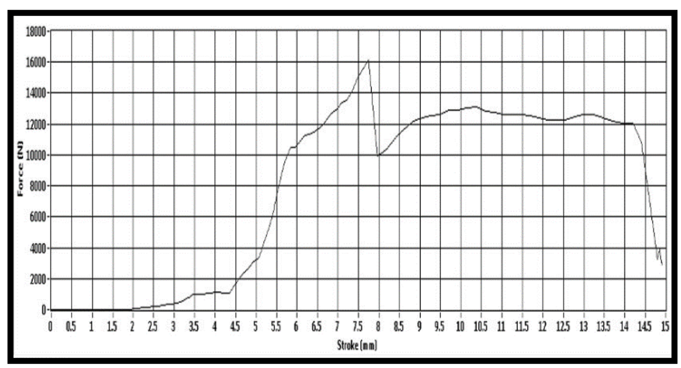

Fig-8: Result of Compression Test

The compression test when x axis represent has stroke and y axis represent has load or force then specimen applying load at vertical position. then slightly increased the load after few minutes certain load the specimen is braked. So, we found the force increasing or decreasing the stroke value definitely increasing due to the given load.

5.3 FLEXURAL TEST:

Flexural strength, also known as modulus of rupture or bend strength, is a mechanical parameter for brittle material and is defined as a material's ability to resist deformation under load. The main advantage of a three-point flexural test is the ease of the specimen preparation and testing.

The bending test (flexural testing) is commonly performed to measure the flexural strength and modulus of Elasticity (E) for different types of materials and products. This test is performed on Universal Testing machine (tensile testingmachine or tensile tester) with a 2 point or 3 point flexural fixture. The most common method for product testing is 3-point test by ASTM standard size for the specimen is (260x26x5mm).

Fig-9: Specimen before Flexural Testing

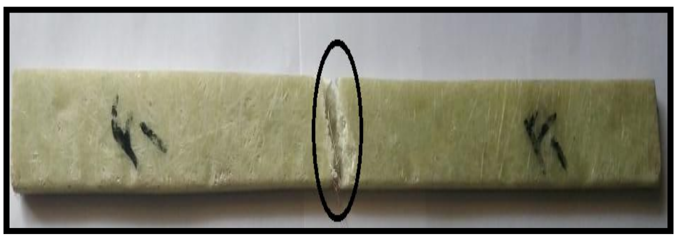

Fig-10: Specimen after Flexural Testing

The flexural test when x axis represent has stroke and y axis represent has load or force then specimen applying load three-point flexural test. Then slightly increased the load after few minutes certain load the specimen is braked. So, we found the force increasing or decreasing the stroke value definitely increasing due to the given load.

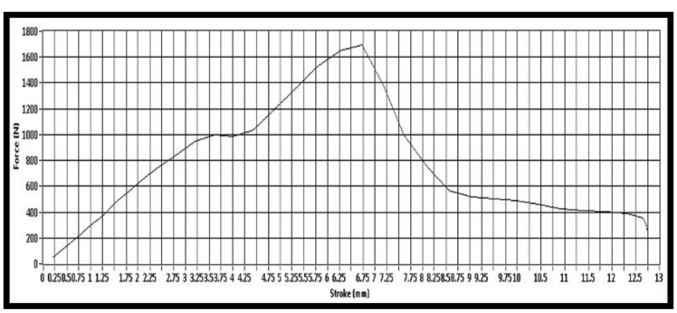

Fig-11: Result of Flexural Test

5.4 IMPACT TEST:

The impact test is a method for evaluating the toughness and notch sensitivity of engineering materials. The notched test specimen is broken by the impact of a heavy pendulum or hammer, falling at a predetermined velocity through a fixed distance. The test measures the energy absorbed by the fractured specimen.

The impact test specimens are prepared according to the required dimension following the ASTM standard size for the specimen is (65x13x5mm). During the testing process, the specimen must be loaded in the testing machine and allows the pendulum until it fractures or breaks. Using the impact test, the energy needed to break the material can be measured easily and can be used to measure the toughness of the material and the yield strength.

Fig-12: Specimen before Impact Testing

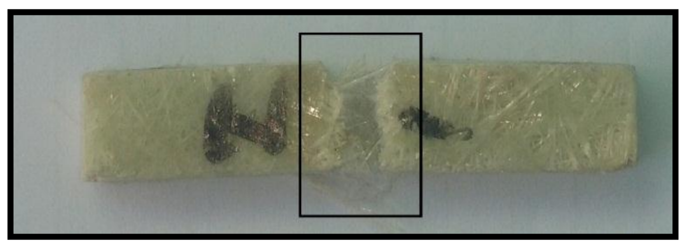

Fig-13: Specimen after Impact Testing

5.5 SHEAR TEST:

In engineering, shear strength is the strength of a material or component against the type of yield or structural failure when the material or component fails in shear. In a reinforced concrete beam, the main purpose of reinforcing bar (rebar) stirrups is to increase the shear strength.

This test method measures the shear stress/strain, the ultimate strength and the ultimate strain, as well as the shear chord modulus of elasticity. The test utilizes a standard universal testing machine and a specially-designed fixture with wedge grip interfaces that clamp one half of the test specimen across its width and support it on its back face as described in the specification. The lower fixture should be mounted on a base plate that supports a linear bearing shaft. The upper fixture should contain a linear bearing which mounts over the shaft on the base.

Fig-14: Specimen before Shear Testing

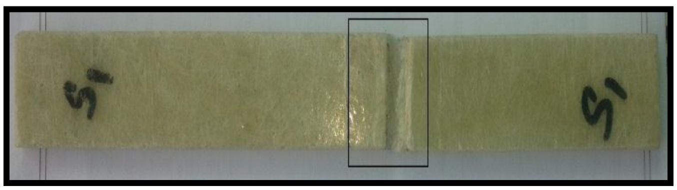

Fig-15: Specimen after Shear Testing

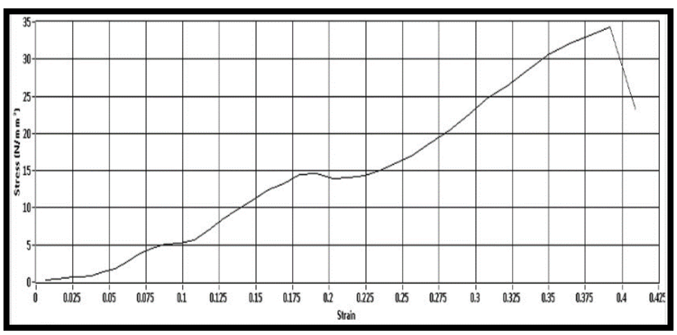

Fig-16: Result of Shear Test

When the stress strain relationship for shear test where x axis represent has strain and y axis represent has stress. A material when subjected to a tensile load resists the applied load by developing internal resisting force. The resisting force for unit normal cross-section area is known as stress. The value of stress in material goes on increasing with an increase in applied tensile load, but it has a certain maximum (finite) limit too. The minimum stress, at which a material fails, is called ultimate tensile strength. The end of elastic limit is indicated by the yield point (load). This can be seen during experiment as explained later in procedure with increase in loading beyond elastic limit original cross-section area goes on decreasing and finally reduces to its minimum value.

5.6 SHORE HARDNESS TEST:

Hardness is defined at the resistance to elastic deformation of the surface. The term can apply to deformation from indentation, scratching, cutting or bending. There are a large variety of methods used for determining the hardness of a substance. A few of the more common methods are the Durometer Hardness Test. The test is carried out as per ASTM D-224011. The specimen is placed on a hard-flat surface. The indentor of the instrument is pressed onto the specimen. The hardness is taken within a specified time.

6. RESULTS AND DISCUSSION

S. NO.	TYPE OF TEST	RESULT
1	Shore hardness test	48,49,48

S. NO.	TYPE OF TEST	LOAD
1	Tensile test	7.77kN
2	Flexural test	1.69kN
3	Compression test	16.15kN
4	Impact test	2 J
5	Shear test	6.49kN

7. CONCLUSION

Thus, the glass fibres reinforced composites samples are fabricated and tested. The composites are subjected to mechanical testing such as tensile, compression, flexural, shear, shore hardness and impact test. Based on the results, the following conclusions are drawn. In this experimental study, the glass fibres reinforced composites have been fabricated with same fibre orientations of 0◦. The mechanical properties of these composites such as tensile strength, impact strength and flexural strength, compression strength, shear strength and shore hardness test have been evaluated. From the experiment, it has been observed that, the composites with the 0◦fibre orientation withstand the results indicated that Glass fibre reinforced composites(homogeneous) specimen gives tensile strength is low The Maximum tensile force (MTF) of the Glass fibre reinforced composites(homogeneous) in the range of 82.26mpa, flexural test in the Glass fibre reinforced composites(homogeneous) is high. The maximum load is with stand 1.69kN, compression test the result indicates that very high strength 16.15kN and the respectively displacement is 1mm, impact strength is obtained for the

Glass fibre reinforced composites(homogeneous) and has the value of 2Joules, shear test indicates high strength with stand maximum load 6.49kN, shore hardness tests the strength obtain 48,49,48 HRB.

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