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Topic :- Mechanical fastening analysis of the Polymer Composites

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PREFACE

This final year major project report on **Mechanical fastening analysis of the Polymer Composites** explains brief details regarding composites, consists of introduction to composite, fiber reinforced composites, natural fiber reinforced composites, natural resins, polymers , types of polymers, etc., literature review, Methodology, results and discussion, conclusion,etc. This major project report have good diagrams, pictures of specimen, specimen preparation and equipments used , table and graphs of experiments data. This major project report is true to its goal of offering more coverages to details regarding composites, natural composites, it’s application and study and preparation of specimens of natural fiber reinforced composite material . It consists of practical research oriented instructions and provides abundance guidance in the experiment procedures. This report consists of appealing and helpful visuals, comprehensive coverage of research and documentation and attention to experiment results. This report consists of good visual texts such as graphs and pictures , and references in APA formats.

ACKNOWLEDGEMENT

This final year major project report is prepared with the help of a number of peoples including respected supervisors, faculty members, classmates and friends. We would like to express our gratitude to our respected supervisors, faculty members , classmates and friends. They provided detailed, valuable comments and suggestions about the major project report document. We are indented to valuable research and experiments conducted by our team member with the help of supervisors, faculty members and teaching assistant or staffs.

We benefited from the experience of our supervisors, faculty members and teaching assistant or staffs and we are grateful for their thoughtful comments and helpful advices.

We are grateful to the researchers whose work references we have taken in our work and major project report.

We express our largest debt of gratitude to supervisors and faculty members for their valuable guidance and assistance in experimentation, research and preparing this final year major project report. Their guidance have strengthened our work. Finally, we thank all the people who inspired us in preparing this final year major project report.

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1. INTRODUCTION

These days, aerospace engineering is all about the light stuff: building airplanes with lighter wings, fuselage and landing gear in an effort to reduce fuel costs.

Advanced carbon-fiber composites have been used in recent years to lighten planes' loads. These materials can match aluminum and titanium in strength but at a fraction of the weight, and can be found in aircraft like the Boeing 787 and Airbus A380, reducing such jets' weight by 20 percent.

Composite materials have a high specific stiffness (stiffness-to-density ratio). Composites offer the stiffness of steel at one fifth the weight and equal the stiffness of aluminum at one half the weight. The specific strength (strength-to-density ratio) of a composite material is very high. Due to this, airplanes and automobiles move faster and with better fuel efficiency. The specific strength is typically in the range of 3 to 5 times that of steel and aluminum alloys. Net-shape or near-net-shape parts can be produced with composite materials. This feature eliminates several machining operations and thus reduces process cycle time and cost. Composite materials provide capabilities for part integration. Several metallic components can be replaced by a single composite component. Composite structures provide in-service monitoring or online process monitoring with the help of embedded sensors . Materials known as "smart" materials. Many defense applications now rely on unique properties delivered by modern composite materials. PRF develops, manufactures and supplies composites that support defense application. Matrix materials can be polymeric, metallic, or ceramic. The terms plastics and resins are often used to refer to polymer matrices. The term polymer means "many units" and refers to the way in which individual molecular units are joined together into a chain-like structure where each unit is like a link in the chain.

Common fiber reinforced composites are composed of fibers and a matrix. Fibers are the reinforcement and the main source of strength while the matrix 'glues' all the fibers together in shape and transfers stresses between the reinforcing fibers. Sometimes, fillers or modifiers might be added to smooth manufacturing process, impart special properties, and/or reduce product cost.

The primary function of the fibers is to carry the loads along their longitudinal directions.

Common fiber reinforcing agents are as follows:

- Aluminum, Aluminum oxide, Aluminum silica • Asbestos
- Beryllium, Beryllium carbide, Beryllium oxide
- Carbon (Graphite)
- Glass (E-glass, S-glass, D-glass)
- Molybdenum

• Polyamide (Aromatic polyamide, Aramid), e.g., Kevlar 29 and Kevlar 49

• Polyester

• Quartz (Fused silica)

• Steel

• Tantalum

• Titanium

• Tungsten, Tungsten monocarbide

FRP Composite Constituents are as follows :-

1. Resins (POLYMERS)
2. Fibers
3. Fiber Reinforcement
4. Fillers
5. Additives
6. Sandwich Panels
7. Adhesives
8. Composite Designs

Different Fiber Types are as follows :-

I. Natural
II. Man-Made
III. Many Varieties Commercially Available Different types of Natural Fibers are as follows:- o Cellulose o Sisal

Different types of Reinforcement are as follows : -

1. Roving (Continuous)
2. Chopped strand
3. Mat

a. Chopped strand

b. Continuous strand

4. Woven roving
5. Stitched
6. Braided
7. Unidirectional
8. Veil

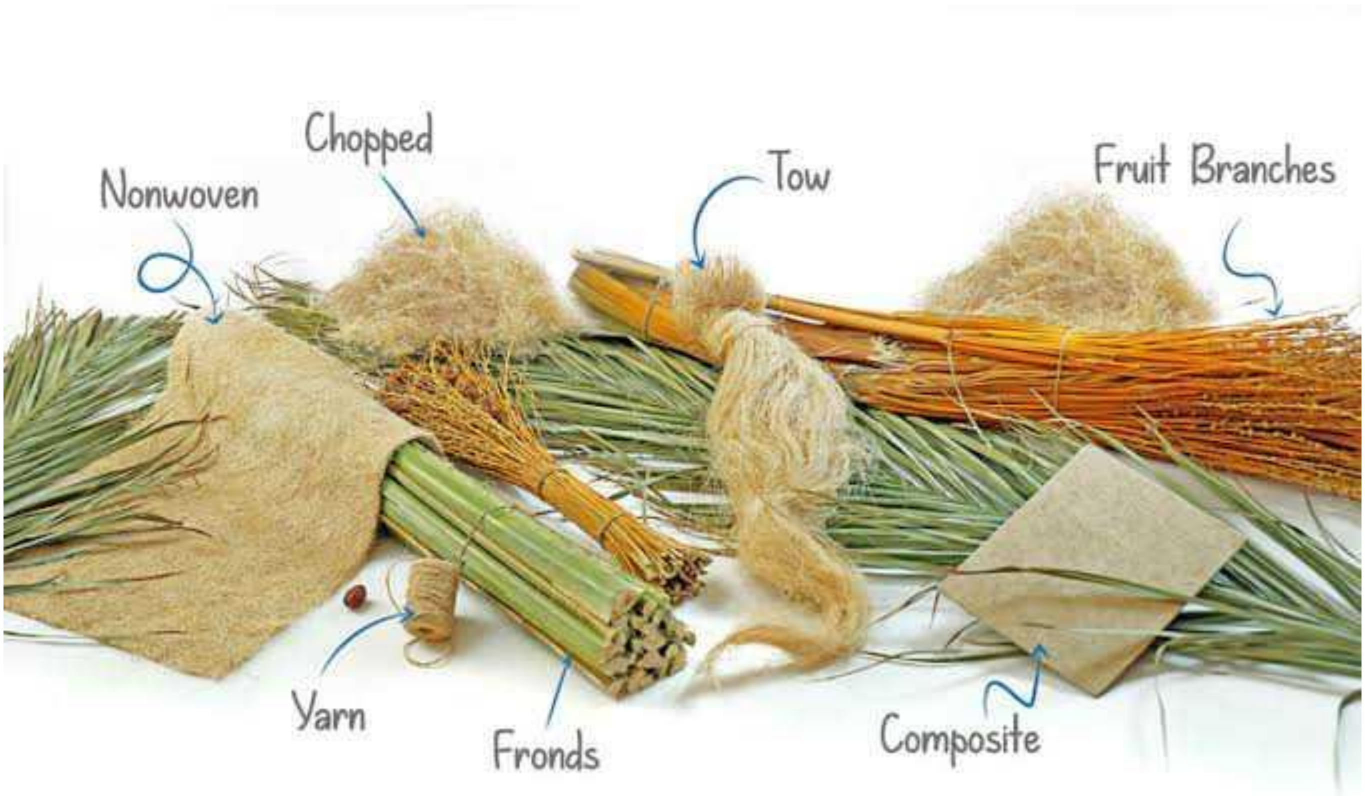


Figure : The different use of fibers are shown here.

A composite is considered to be any multiphase material that exhibits a significant proportion of the properties of both constituent phases such that a better combination of properties is realized.

Principle of combined action states that the better property combinations are fashioned by the judicious combination of two or more distinct materials. Composites of sorts include multiphase metal alloys, ceramics, and polymers. A composite, in the present context, is a multiphase material that is artificially made, as opposed to one that occurs or forms naturally. In addition, the constituent phases must be chemically dissimilar and separated by a distinct interface. Most composites have been created to improve combinations of mechanical characteristics such as stiffness, toughness, and ambient and high-temperature strength. Many composite materials are composed of just two phases; one is termed the matrix, which is continuous and surrounds the other phase, often called the dispersed phase. The properties of composites are a function of the properties of the constituent phases, their relative amounts, and the geometry of the dispersed phase.

Dispersed phase geometry in this context means the shape of the particles and the particle size, distribution, and orientation.

A composite material is a material system composed of two or more physically distinct phases whose combination produces aggregate properties that are different from those of its constituents. The term phase indicates a homogeneous material, such as a metal or ceramic in which all of the grains have the same crystal structure, or a polymer with no fillers.

Future development in the field of composites are possible in following aspects :-

- Composites can be designed that are very strong and stiff, yet very light in weight, giving them strength-to-weight and stiffness-to-weight ratios several times greater than steel or aluminum.
- These strength-to-weight ratio and stiffness-to-weight ratios properties of composites have great applications ranging from aircraft to sports equipment.
- These have a better fatigue property than common engineering metals with a greater toughness.
- Composites with non-corrosive property is applicable in automotive.
- Combinations of properties is achievable in composite material.
- Certain composite material provide better appearance and surface smoothness properties.

Disadvantage and limitations of composite materials are as follows :-

- Many important composites have anisotropic properties, which means they differ depending on the direction in which they are measured.
- As the polymers are reactive to chemicals in the same way polymer based composites are reactive.
- In spite of that the price of composites decreases with the increase in volume of composites, the prices are still high.
- Manufacturing methods used for shaping composite materials are costly and slow.

Examples of composite materials are as follows :-

- Cemented carbides (tungsten carbides with cobalt binder)
- Plastic molding compounds that contain fillers(cellulose fibers, wood flours)
- Rubber mixed with carbon black
- Two phase metal alloy (ferrous + ferric carbide)

Composites can be classified in two different types on the basis of its availability , which are as follows :-

1) **Traditional composites**
2) **Synthetic composites**

Traditional composites :-

The composites that occur in nature or have been produced by civilization for many years.

Synthetic composites :-

These are modern material systems normally associated with the manufacturing industries, in which the components are first produced separately and then combined in a controlled way to achieve the desired structure , properties and part geometry.

Types of Composites on the basis of kind of matrices used :-

- **Polymer matrix composites**

- **Metal matrix composites**
- **Ceramic matrix composites**

Polymer matrix composites :-

It consist of a polymer resin as the matrix, with fibers as the reinforcement medium. These materials are used in the greatest diversity of composite applications, as well as in the largest quantities, in light of their room-temperature properties, ease of fabrication, and cost.

Metal Matrix Composites :-

These consists of metal as matrix of the composites with other material as reinforcement. The matrix is mostly ductile. These materials may be used at higher service temperatures than their base-metal counterparts; furthermore, the reinforcement may improve specific stiffness, specific strength, abrasion resistance, creep resistance, thermal conductivity, and dimensional stability. Some of the advantages of these materials over the polymer-matrix composites include higher operating temperatures, non-flammability, and greater resistance to degradation by organic fluids.

Ceramic-matrix composites :-

These consists of ceramic material as matrix of the composites. The fracture toughness of ceramics have been improved significantly by the development of a new generation of ceramic-matrix composites (CMCs)—particulates, fibers, or whiskers of one ceramic material that have been embedded into a matrix of another ceramic.

Types of composites on the basis of reinforcement :-

There are three types of composites on the basis of reinforcement used are as follows :-

A) **Particle reinforced composites**
B) **Fiber reinforced composites**
C) **Sheet reinforced composites**

A) **Particle reinforced composites**

   For most of these composites, the particulate phase is harder and stiffer than the matrix. These reinforcing particles tend to restrain movement of the matrix phase in the vicinity of each particle.

   Another familiar large-particle composite is concrete, which is composed of cement (the matrix) and sand and gravel (the particulates). Concrete is the discussion topic of a succeeding section.
   Large-particle composites are used with all three material types (metals, polymers, and ceramics).

   Dispersion strengthened composites :-

   Metals and metal alloys may be strengthened and hardened by the uniform dispersion of several volume percent of fine particles of a very hard and inert material.

B) **Fiber-reinforced composites :-**

   These composites have dispersed phase in the form of fiber. This is the most important composite. Its advantages are as follows :-

   A) High strength on weight basis (high specific strength)
   B) High stiffness in weight basis (high specific modulus)

Some examples of fiber composites are as follows :-

a) Glass fiber reinforced- polymer composites

b) Carbon fiber reinforced polymer composites
c) Aramid fiber reinforced Polymer composites

C) **Structural composites**

A structural composite is normally composed of both homogeneous and composite materials, the properties of which depend not only on the properties of the constituent materials but also on the geometrical design of the various structural elements.

The two types of composites are as follows :-

a) Laminar composites
b) Sandwich panel

Components in a composite material :-

The simplest composite material consist of two phase :-

1. A primary phase , and
2. A secondary phase

The primary phase is the **matrix** within which the secondary phase is embedded.

The imbedded phase or also known as reinforcing phase usually strengthen the composites. The reinforcing phase may be in fiber, particle or various other geometries.

The phases are generally insoluble in each other but have very strong adhesion at their surfaces.

The matrix and reinforcing phase can be of any three types :-

1. Metal
2. Ceramics, and
3. Polymer

Reinforcing Phase :-

The main role of the secondary phase is to reinforce the primary phase. The secondary phase can take form of the infiltrated phase in a skeletal or porous matrix.

There are three types of imbedded phase or secondary phase :-

A) Fibers ,
B) Particles, and
C) Flakes

Fibers :-

These are filaments of reinforcing material, generally circular in cross section. These are found in alternative shapes also such as tubular, rectangular and hexagonal. There diameter ranges from 0.0025 mm to 0.13 mm diameter depending on the materials. These are either polycrystalline or amorphous . Fibrous materials are generally either Polymer or ceramics.

Fine wires having relatively large diameters are made of metals such as steel , molybdenum and tungsten. Some application of metal wire reinforce composites are as follows :-

a) Automobile tyres
b) Filament – wound rocket casings
c) Wire – wound high pressure hoses

Natural Fiber Composite Materials :-

Natural fibers such as plant fibers and cellulose based fibers are the most commonly used bio-fillers which are available worldwide for reinforcing various types of polymer matrices. bio-fillers obtained from agricultural waste such as sugarcane bagasse, soy protein, wheat straw and rice husk, groundnut shell, coconut husk and cotton stalk are also used to reinforce polymers because of their abundance and as an economical solution for waste management.

Benefits of natural fiber composite materials :-

1) Biodegradability
2) Low cost and density
3) Renewability
4) Negligible carbon dioxide emission
5) High specific strength
6) Cheaper than synthetic fiber
7) Low environment and health hazard during production when compared to glass fibers
8) Can be used for developing acoustic and thermal insulator nonwoven material because of their hollow and lignocellulosic nature
9) Natural fibers contains 40- 90 % cellulose.
10) Extracted cellulose can be used to reinforce polymer matrices to give good tensile strength.

Examples of lignocellulosic fibers are as follows :-

1) Banana
2) Sugarcane baggase
3) Curaua
4) Flax
5) Jute
6) Hemp
7) Sisal
8) Kenaf

Examples of Woven lignocellulosic fabrics used for polymer composites are as follows :-

1) Jute fabrics
2) Ramie-cotton fabrics
3) Jute-cotton fabrics

Findings:-

- The hydrophilic hydroxyl group from the fiber surface is modified by means of different chemical treatments such as benzoylation; acetylation; alkali; silane; maleated coupling agents; isocyanates;

acrylation, permanganates, and many more have been reported (John & Anandjiwala, 2008b; Kumar et al., 2011; Saw et al., 2013; Zhu et al., 2013).

- the chemical modification does not only modify the fibers but also improves their strength and in composite materials increases their mechanical properties (Satyanarayana et al., 2009; Saw et al., 2013).
- the main disadvantages of bio-based fillers in composite materials are their poor compatibility with polymer matrices and their hydrophilic nature, which result in relative high tendency of moisture sorption (Deka et al., 2013; Majeed et al., 2013; Satyanarayana et al., 2009; Tanobe et al., 2014).
- Application of chemical treatment is found to activate hydroxyl groups (OH) or introduce new moieties that can effectively interconnect with the matrix (Brígida et al., 2010; Li et al., 2007; Mwaikambo & Ansell, 2002; Razak et al., 2014; Thakur & Singha, 2010; Van de Weyenberg et al., 2006).
- FTIR studies on kenaf fiber surface modification using hydrogen peroxide, before and after bleaching treatment were investigated by Razak et al., (2014).
- Diverse methods such as chemical treatment, chemo-mechanical and mechanical treatment are utilized for the extraction of cellulose from lignocellulosic fibers (Hoeger et al., 2013; Kumar et al., 2014; Motaung & Mokhena, 2015; Nair et al., 2014; Rezende et al., 2011; Sun et al., 2004; Wang et al., 2012).
- The chemical extraction of cellulose is mostly done by acid hydrolysis followed by alkaline pulping process (Battegazzore et al., 2014; Pereira et al., 2011) while in other cases alkaline hydrolysis followed by acid hydrolysis (Gbenga & Fatimah, 2014).

Application of Palm leaf fiber are as follows :-

1) Injection molded product using different matrices
2) Heavy duty carrying handle using PALF-PP.
3) General plastic utensils and makeup brush handle using NFP-PP composites.
4) The utilization of bio-based composites in industrial application includes food packaging, automotive, construction, cosmetics, aerospace as well as electrical and electronics (Saba et al., 2014).
5) Fiber reinforced polymer composites are utilized in construction as structural panels and building sections; further, the use of fiber reinforced composites has also developed into economically and sustainable feasible construction materials for load bearing elements in bridges and buildings over the past decades.
6) On the other hand, several studies have investigated the application of natural fibers such as coir (Saravanan & Sivaraja, 2012), hemp (Jarabo et al., 2012), flax (Yan & Chouw, 2013) and jute (Chakraborty et al., 2013) as reinforcement in cement based material for building applications.
7) Natural fiber reinforced composites can be used in aerospace over traditionally used components such as carbon fiber, metal alloys and hybrid laminates because natural fibers offer high specific strength and stiffness.
8) Major car manufacturing industries all over the world now use bio-based filler reinforced composites in miscellaneous applications (Faruk et al., 2014).
9) This fiber has great potential and high quality due to its strength, softness and reduced specific weight and can be used in automotive companies and construction (Spinacé et al., 2011).
10) Among the possible difficulties in the manufacture of wood, cement composite panels can be mentioned phenolic compounds, acids, soluble sugars, resins and extractives of lignocellulosic fibers that may be responsible for delayed or even total prevention of the handle, as when entering contact the alkaline environment generated by cement, solubilize and react with this, preventing crystallization and hardening (Iwakiri and Prata, 2008; Hofstrand et al., 1985).

Application of Coconut husk fiber composite :-

1) Coconut fiber is used in substituting the portion of sand in production of cement composite (Alida et al. , 2011) .

Application of banana fiber polymer composite :-

1) Banana woven fabric reinforcement polymer composites can be used in a wide range of applications
2) reinforce the body of the vehicles in automotive.
3) automotive, building, furniture and packaging industries, etc.

Application of Sisal fiber reinforced polymer composite :-

1) Sisal fiber reinforced polymer composite can be used in building and construction purpose packaging, automobile and railway coach interiors (. Rajesh et al., 2018).

Application of Hemp fiber reinforced polymer composite :-

1. The car uses hemp, sisal, and wool fibers in the manufacture of interior trim, roof, seat covers, and hard top.
2. Hemp fiber reinforced polymer composite are used to make window frame and floor coverings.
3. Mushroom shaped guide posts for bicycle path
4. Housing of radar units(glass fiber disturbs the radar rays)
5. Boats
6. Furniture, and
7. Loudspeakers

Application of Cassava fiber reinforced polymer composite :-

Cassava starch was used as the main chain in the copolymerization of a superabsorbent polymer composite (SAPC) based on acrylic acid and bentonite (Akhmad et al. , 2014).

Figure : Palm leaf fiber being studied for experimentation and project work.

Figure : Banana fiber being studied for experimentation and project work.

Figure : Sisal fiber being studied for experimentation and project work.

Figure : Jute fiber being studied for experimentation and project work.

Figure : Hemp fiber being studied for experimentation and project work.

Figure : Kenaf fiber being studied for experimentation and project work.

Figure : Bast (the most green part in tree trunk cross-sections) being used for making fiber , which is studied in our experimentation and project work.

Advantages of Natural Fibers:-

1. For PLA, the use of natural fibers as reinforcement can overcome some disadvantages such as thermal and mechanical instability at higher temperature due to its low softening point of around 60 °C which it is not suitable for high performance applications (Baheti et al., 2013) and reduction of the brittle behavior of the composites (Pappu et al., 2015).
2. Meet minimum recycle content requirements
3. Non-brittle fracture on impact

4. Lower processing energy requirements
5. Same performance for lower weight
6. Low cost less than the base resin
7. Stronger (25-30%) for the same weight
8. Reducing molding cycle time-up to 30%
9. Fully and easily recyclable
10. High notched impact-up to 2× base resin
11. High flex modulus-up to 5× base resin
12. High tensile modulus-up to 5× base resin
13. Low mold shrinkage
14. Easily colored
15. Good sound abatement capability
16. Better energy management characteristics
17. More shatter resistant
18. Low thermal expansion coefficient
19. Natural appearance
20. Non-abrasive to machinery
21. Natural fibers offers efficient design of complex shapes that are aerodynamic than metal, reduction in fuel consumption and emission due to lower weight, renewable because they are biodegradable in nature and have no corrosion problem, which can reduce airline maintenance cost.

Polymer :-

A polymer is a compound consisting of long-chain molecules, where each molecule is made up of repeating units connected together. There may be thousands, even millions of units in a single polymer molecule. The word *poly* , means many and *mer* , derived from Greek word meros , meaning parts. Polymers are synthesized by joining many small molecules together to form very large molecules, called macromolecules, that possess a chain-like structure.

Polymers can be separated into plastics and rubbers. For the purpose of covering polymers as a technical subject, it is appropriate to divide them into three categories, where (1) and (2) are plastics and (3) is the rubber category:

1) **Thermosetting polymers**
2) **Thermoplastics polymers**
3) **Elastomers**

1) **Thermosetting polymers :-**
   Thermosetting polymers, or thermosets (TS), cannot tolerate repeated heating cycles as thermoplastics can.
   Some examples of thermosetting polymers are as follows :-
   A) Amino resins
   B) Epoxies
   C) Phenolics
   D) Polyesters
   E) Polyimides

F) Polyurethane
G) Silicones

2) **Thermoplastics polymers :-**
Thermoplastic polymers, also called thermoplastics (TP), are solid materials at room temperature, but they become viscous liquids when heated to temperatures of only a few hundred degrees.
Examples of thermoplastic polymers are as follows :-
H) Acetals
I) Acrylonitrile- butadiene-styrene
J) Acrylics
K) Cellulosics
L) Fluropolymers
M) Polyamides
N) Polycarbonates
O) Polyesters
P) Polyethylene
Q) Polypropylene
R) Polystyrene
S) Polyvinyl chloride

3) **Elastomers :-**
Elastomers are the rubbers. Elastomers (E) are polymers that exhibit extreme elastic extensibility when subjected to relatively low mechanical stress. Some examples of elastomers are as follows :-
A) Natural rubbers
B) Synthetic rubbers

Some examples of synthetic rubbers are as follows :-

a) Butadiene rubber
b) Butyl rubber
c) Chloroprene rubber
d) Ethylene- propylene rubber
e) Isoprene rubber
f) Nitrile rubber
g) Polyurethanes
h) Silicones
i) Styrene-butadiene rubber
j) Thermoplastic elastomers

Bio-polymer :-

Biopolymers, bio-based and biodegradable are the words that are becoming more important in the world of industrial plastics. There are two types of bio-polymer , which are as follows :-

1) **Bio-based Polymer :-**

These are produced by biological systems such as micro-organism, plants and animals. These are also called polymeric biomolecules, biological polymer or bio-polymer.

2) **Bio-derived Polymer :-**
These are chemically synthesized , but their building blocks are derived from biological monomers such as amino acids.

Bio-polymer :-

Polymers that are produced by biological systems such as microbial organisms, plants and/or animals through metabolic-based engineering reactions are called biopolymers or simply natural polymers. Polymeric materials come from a variety of sources, ranging from familiar synthetic ones (petroleum-based) such as polystyrene to natural biopolymers such as cellulose, proteins, and microbial-based polyesters that are fundamental to biological structure and function (Wollerdorfer & Bader, 1998; Pandey et al., 2010).Some examples of bio-polymer are as follows :-

1) Carbohydrates,
2) Keratin, and
3) Polyhydroxyalkanoates

Polymeric materials are categorized into three category based on their derivation :-

1) **Category 1 :-**
Polymers that are isolated from the biomass, for example, cellulose and keratin.
2) **Category 2 :-**
Polymers that are chemically synthesised using renewable biobased monomers, for example, poly lactic acid (PLA).
3) **Category 3 :-**
Polymers that are produced by genetically modified species, for example, PHAs.

Chitosan :-

Chitosan (CS) is a kind of marine polymer that can be extracted from the shells of various shellfish including crabs and prawns. Chitosan is a linear copolymer comprised of two monomeric units namely N-acetyl-2-amino-2-deoxy-d-glucose (N-acetylated groups) and 2-amino-2-deoxy-d glucose residues (N-deacetylated groups, amino groups). It is obtained by deacetylation of chitin, a polysaccharide widely distributed in the exoskeleton of insects, crustaceans and fungi. Chitosan polymers are renewable semi-synthetically derived amino-polysaccharides that have unique structures, highly sophisticated functionality, multidimensional properties and a wide range of applications in biomedical and other industrial areas (Dash et al., 2011). Chitosan is a natural polymer with numerous reactive groups for chemical activation, gel-formingcapability, high adsorption capacity, chelating and complexing properties, biodegradability, adsorbable bioactivity and ecological safety.

The advantages of chitosan are as follows :-

1) Biodegradability,
2) Biocompatibility,
3) Homeostatic behavior, and
4) Promotion of wound healing

Application of chitosan are as follows :-

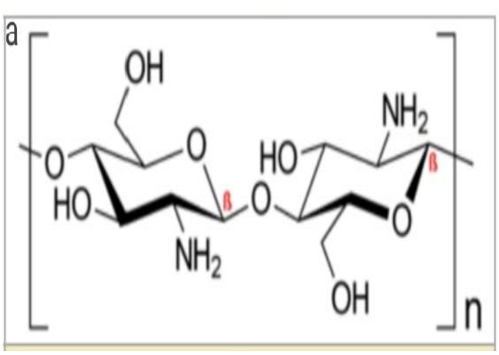
1) Drug delivery
2) Tissue engineering
3) Wound healing
4) Gene therapy
5) Agriculture
6) Environmental protection
7) Chemical detection
8) Biosensors, etc. (Anitha et al., 2014; Younes & Rinaudo, 2015).

Examples of chitosan are as follows :-

1) Composites from chitosan and natural polymers
2) Composites from chitosan and collagen
3) Composites from chitosan and gelatin
4) Composites from chitosan and hyaluronic acids
5) Composites from chitosan and heparin
6) Composites from chitosan and glucomannan
7) Composites from chitosan and synthetic polymer
8) Composites from chitosan and polyurethane
9) Composites from chitosan and polylactic acids
10) Composites from chitosan and polyvinyl alcohol
11) Composites from chitosan and Poly(γ-Glutamic Acid)
12) Composites from chitosan and biomacromolecules
13) Composites from chitosan and inorganic components(calcium carbonate, hydroxyapatite, silicon dioxide, bioactive glasses, ferric tetraoxide, silver nanoparticles)
14) Composites from chitosan and carbon materials

Acrylated Epoxidized Soybean Oil (AESO)

Soybean oil typically comprises averagely 54% linoleic, 23% oleic, 11% palmitic, 4% stearic, and 8% linolenic acids. Soybean oil contains fatty acids from eight different varieties, the chain lengths of which range between 16–22 carbons. Due to the presence of different fatty acid types, soybean oil is composed of various triglyceride types with different double bond numbers on a molecular basis (Khot et al., 2001). It is an acrylic polyester



resin based on soybean oil. AESO is produced from soybean oil in two process steps. The initial step is epoxidation of soybean triglyceride and the second step is acrylization of ESO (López & Santiago, 2013). AESO has found commercial use in surface coatings (Khot et al., 2001).

Figure : (a) Chemical formula of Chitosan resin being studied for experimentation and project work and **(b)** shell shrimp being used to commercially derive chitosan resin**.**

(a)

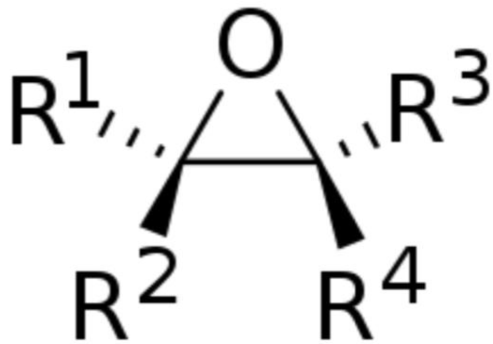


Figure : (a) Chemical formula of Epoxy resin being used for our research and experimentation in project and (**b)** epoxy and hardener being used in project work.

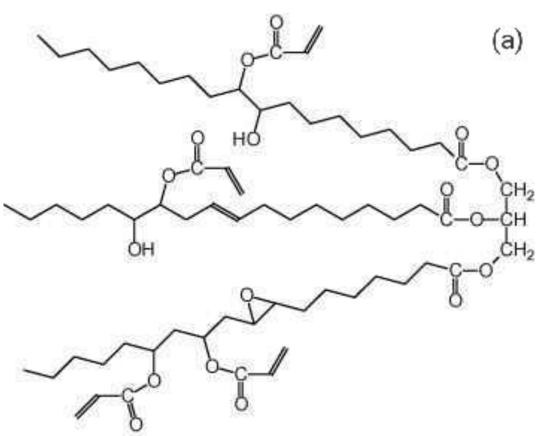


Figure : (a) Chemical formula of acrylated epoxidized soybean oil being used for study in experimentation and project, and **(b)** acrylated epoxidized soybean oil being studied in experimentation and project work.

2. OBJECTIVE

Nowadays composites are widely used in aerospace, automobile and building construction and sports industry. Composites are preferred because it has various profits like lightweight, high mechanical properties and physical properties. Ease, lightweights, particular high modulus, inexhaustibility and biodegradability are the most essential and basic appealing highlights of composites that make them helpful for modern applications. Apart from the above Mechanical fastening commonly necessitates that specimens must have holes over which the fasteners are injected, these types of joints are subjected to both shear, and also the tensile stresses and would be able to resist such type of forces.

3. LITERATURE REVIEW

Kayode F. Adekunle et al. , 2015,[1] have studied surface treatment of natural fibers. It have very high technical applications. They have studied thermal drawbacks of natural fibers.

Johansson et al. ,2012, [2] described products related to packaging industries whose raw materials are derived from forest sectors. They have shown some of innovative approaches for successful introduction of renewable material for packaging industries. They have used renewable fiber and bio-based polymers for use in bioplastic or as coating for paper-based packaging materials. They have worked on different mechanical properties needed for sustainable utilization of renewable materials.

A.K.Mohanty et al. ,2001,[3] have reviewed biocomposite consisting of bio-polymers, natural fibers and various surface modifications of natural fibers. They have studied the relation between the quality of the fiber- matrix interface and final performance of the composite material.

Brijesh Gangil et al. ,2020 ,[4] have studied and worked on natural fiber reinforced polymer (NFRPs), its properties and application in recent times. They have worked on hybrid composites, it's good properties and its limitations. The hybridization process combines both natural and synthetic fiber properties. They have worked on physical and mechanical properties of the hybrid time-based polymer composites.

Manwar Hussain et al. ,1996, [5] have worked on carbon fiber reinforced composites. They have also worked on aluminate dispersed carbon fiber reinforced composites. They have shown in their work that nano or micro-sized aluminate particles into the epoxy matrix improves mechanical properties. They have also discussed hybrid carbon fiber reinforced epoxy composites with nano or micro sized aluminate particles.

Hua Wang et al. ,2019, [6] have worked on chemical treatment including acid pretreatment , alkali pretreatment, and scouring of jute fibers to modify them. They have prepared jute fiber/epoxy composition with a unidirectional jute fiber organization. They have studied basic properties of the composite such as void fraction, tensile stress, initial modulus, and elongation to break. They have found that chemical treatment of jute fiber has significant impact on the formation of void in the composite as shown by better interfacial adhesion. They have found that chemical treatment has a better impact on the mechanical properties of the fiber composites. Altogether , they have studied impact of chemical treatment on jute fiber. Sandeep Kumar, Brijesh Gangil, Manoj Kumar Gupta, et al. ,2020 , [7] have worked on bast fiber reinforced polymer composite. They have worked on chemical treatment of bast fiber to decrease its limitations or drawbacks such as water absorbing capacity, possibility of degradability, etc. They have worked on various bast fibers such as flax, grewia, optical hemp, nettle , jute, etc. They have explained the effect of chemical treatment on bast fiber physio mechanical behavior.

C.Taylor et al. ,2016, [8] have discussed advanced bio-composite material being developed using soybean oil based thermo setting resins and flax fibers. They have given an overview of material developed using soybean oil based resin and flax fiber. They have developed and explained about durability of these types of material when exposed to accelerated weather conditions.

Christopher Taylor et al. , 2019 [9] , have studied weatherability of bio based composites. They have used a newly developed bio-based rein epoxidised sucrose soyate(ESS) .It overcomes poor resin quality and improves the incorporation of additives.

Yipro Danyo et al. ,2019, [10] have presented the mechanical properties of the polymer based composites reinforced with banana fibers which are chemically modified. They have studied that fiber weight fraction has a great effect on composites Mechanical properties. The have found that the young modulus of stiff composites obtained at 6 wt% has 254.00+-12.70 MPa.

The yield strength was found to be 35.70 +-1.79 MPa. The UTS and toughness was obtained at 5 wt %. Statiscal analysis is used to study mechanical properties of the fibers and composites. M.K. Marichelvam et al. , 2020, [11] have developed novel hybrid composites from natural fibers and investigated its mechanical properties. They have used sugarcane baggase and palm sheath in making natural fibers and used epoxy resin for making matrix. They have used compression moulding machines for making samples. They have investigated the performance of fibers and evaluated its tensile properties, yield properties, hardness properties , impact properties and flexural properties. They have developed an automobile dashboard using the best sample.

Sudipta Goswami et al. , 2020, [12] have studied vinyl ester resin and polyurethane interpenetrating polymer networks. They have used blend ratio of 93:7. The have prepared biocomposites using kenaf treated with vinyl silane and fibre content. They have prepared hybrid composites consisting of nano filler and kenaf fibre in VE/PU IPN matrix.

Y. Malekzadeh et al. , 2016, [13] have produced surface treated carbon fibers using HSCF and different proportion of calcium carbonate nanoparticles. The have found that a high quality adhesion between nitric acid - surface treated carbon fibers with PA6/ ABS polymer matrix.

T.Gurunathan et al. , 2015 ,[14] have studied bio composites, biodegradable polymers , natural fibers and their manufacturing techniques. They have improved the fibre-matrix adhesion using various surface modification methods. They have observed enhancement in bio-composites' mechanical properties. They have reviewed an economical impact and future use of these materials.

S.K. Ramamoorthy et al. ,2012,[15] have studied the outdoor qualities of natural fiber based composites. These properties include moisture absorption , etc. The natural fiber composites absorb more moisture than glass or carbon fiber reinforce composites. The have made hybrid of these natural fibers and observed their properties and found that these are lowered in the hybrid natural fiber composites than the natural fiber composites. They have also studied the data of water absorption in both types of composites.

Kayode Feyisetan Adekunle et al. , 2014, [16] have studied plant seed triglyceride oil with further modification techniques to make natural fibers.

Shah et al., 2017, [17] ,have studied the properties of composites. They have described natural fibers and bio-based composites as an alternative and competitive to conventional materials in transportation and construction sector. They have studied the fire retardant natural fibers band bio-based composites. They have summarized fire retardant method, fillers, and factor affecting the flammability of such composites.

Nina Graupner et al. , 2015, [18] have studied natural solutions of technical composites, advantages of composites having different reinforcement fibers, mechanical properties of bast fibres reinforced PLA composites , cellulose reinforced PLA composites and mixture of both. They have studied these composites by using natural solutions. They have studied use of symmetrical and asymmetrical layer in optimizing stress and impact. They have used the symmetrical and asymmetrical layer as an inspiration for biomimetic fibre composites production. They have studied morphology of ceramic structures using SEM. They have also studied compression strength of ceramic structures. They have done TG / DSC analysis of ceramic structure's creation. They have found an enhancement in mechanical properties due to addition of carbon fibers in ceramic structures regardless of heat treatment conditions.

M.Imelia et al. , 2015,[19] have studied ceramizable (ceramifiable) silicone composites ,their elasticity, their flame retardancy property and its applications. They have tested carbon fiber reinforced ceramizable silicone composites. They have studied thermal properties, heat treatment and characterization of the ceramic structure of the composites.

Kayode F. Adekunle , 2015 ,[20] have studied renewable polymers. They have studied their environmental attributes. They have studied the composition of the fatty acids in plants and degree of unsaturation. They have studied the values of fatty acids components presents in the oils. They have also discussed the application of thermosetting polymers obtained from plant seed oils.

K.F. Adekunle et al. , 2009, [21], have studied bio-based composites , its manufacturing methods, formation of resins such as thermosett resins , and different methodologies pertaining to it.

Schmidt et al. , 2004, [24] have studied the macroscopic physical properties of biopolymers like keratin are due both to molecular level structure and microcrystallinity , the self consistent packaging arrangement of molecular order within adefined space. They have processed fiber into end products that can retain the microcrystalline properties of the starting materials.

B.R. George et al. , 2004, [25] have created biodegradable nonwoven fabrics with biodegradable finders such that it can be fabricated in various basis from feather fibers. They have created fabrics such that they were characterized in machine and cross-directions for maximum load and elongation.

G.T. Pott, 2004, [26] have studied moisture sensitivity of natural fibers such as bast fibers which are used to reinforce polymer composites. The fibers swells and rot through fungal attack. They have studied traditional dew retting technique and Duralin® technique. The traditional dew retting technique is the process where the freshly harvested natural fiber stems lie on the field for about four weeks. The recently developed Duralin® process that involves three steps , hydrothermolysis drying and curing , which eliminates the need for traditional dew retting. They have studied the commercial evaluation and development of this new process , which is underway. They have studied the commercial evaluation and development of this new process, which is underway. They have studied the molecular aspects of Duralin® process. They have studied the relative fiber yield due to Duralin® versus dew retted process using decoration runs , discussed Duralin® fiber and Duralin® flax shives , explained method of reducing moisture sensitivity of fibers.

K.C. Schuster et al. , 2004,[27] have studied regenerated cellulosic fibers , such as vicose, modal and lyocell , combine the advantages of natural and synthetic fibers , studied it's advantages in textile and non-woven applications. The production of made cellulosic fibers was shown to be a technological route to obtain fibers with properties similar to natural cellulosic fibers grown from plants. They have described the methodology of production of cellulosic fiber which are wood growing, wood harvesting, wood pulping , then either viscose process or lyocell process.

K. Oksman, et al. , 2004, [28] have studied flax reinforced PLA composites, which readily extrusioned or compression molded , were found to have 50% higher strength than other flax reinforced thermoplastic composites which are already been used in automotive panels. They have described the possibility of using conventional manufacturing process is very important factor for industrial use of renewable materials . They can be processed in a way similar to PP based composites.

Z.S. Petrović et al. , 2004, [29] have studied polyurethane matrix resins, which are a viable alternative to epoxy and polyesters matrix resin and they are already being used commercial in selected farm combine and automotive applications. They have find that vegetable oil based polyurethane are good matrix resin s for composites but their cross linking density must be optimized to obtain the desired property level. They have find that composites based on soy-polyurethane resins and carbon fabrics show the best mechanical properties. They have find that glass fiber reinforced SOY-PU composites have quite good mechanical properties. They have find that natural fiber and polymer fiber reinforced SOY-PU composites have lower density and lower level of mechanical properties and soy- based polyurethane showed good mechanical properties than polyester glass reinforced and epoxy glass reinforced composites. They have find good hydrolytic stability in doy based polyurethane than epoxy and polyester composites.

E. Frollini et al. , 2004, [30] have studied alkali and ionized air treated and untreated lignocellulosic fibers, such as sisal , jute and curauá , were used to reinforce phenolics and lignophenolics matrix materials. They have studied the use of lignin as a partial substitute for phenols in phenolics resins application different from the traditional ones (adhesives) is feasible as demonstrated by the results obtained with lignophenolics foam of closed cells and lignophenolic matrix composites.

W.M. Risen et al. ,2004, [31] have studied about aerogel containing biopolymers or bio-derived polymer and silica. They have studied the preparation and characterization of chitosan – silica aerogels , both with and without metal ions. They have studied the reaction of aerogel materials to form modified aerogels and new hybrid phases.

R. Kozlowski et al. , 2004, [32] have studied natural fibers from lignocellulsic fibers plant and it's application in different fields and object by making composites reinforced with these fibers. They have studied different modification of these fibers to decrease its limitation. They have studied fiber plants such as flax , hemp , ramie, kenaf , jute , abaca , sisal , coir and curauá .

T.P. Schlöesser et al. , 2004, [33] have studied natural fiber reinforced composites, which can be used in automotive. They have studied flax fiber reinforced composites which are used in automotive engine and drive train.

S.J. Eichhorn , 2004, [34] have studied natural and regenerated cellulosic fibers reinforced composites , which have lower fracture toughness than conventional glass reinforced composites. They have done Raman spectroscopy of composites and studied it's different uses . They have done study of biomimetic approaches to the design and implementation of natural fiber composites .

H. Yamaguchi et al. , 2004, [35] have studied bamboo reinforced composites and its commercial application in fabrication of some industrial materials. They have studied bamboo fibers as reinforced material for thermoset plastics and have studied the rheological behavior of bamboo fibers. They have studied properties and limitation of NPMC.

A.N. Netravali , 2004, [36] have studied the application of short and long ramie fiber composites. They have studied the availability and procurement of ramie fibers for use in many different parts of the world . They have studied application if unidirectional ramie fiber reinforced composites.

R. Siakeng et al., 2019, [51] have studied PLA- based natural fiber composites are entirely bio-based material with promising biodegradability and mechanical properties. They have highlighted trends in research and development of PLA and PLA-based natural fiber composites over the past few years. They have studied the research efforts on the synthesis and biodegradation of PLA , its properties, trends, challenges and prospects in the field of PLA and its composites. They have studied properties and application of PLA composites , highlighted future applications of natural fibers reinforced composites and fiber modification techniques such as surface treatment with chemical including alkali, silane, coupling agents, and so forth to improve the fiber surface properties and fiber /matrix interface , which can provide better biocomposites to match various requirements.

K. Oksman et al. , 2003, [52] have studied flax reinforcement PLA composites and methods to improve the mechanical properties of PLA / flax composites such as interfacial adhesion. They have studied the extrusion and compression moulded process for fiber reinforce PLA composites. They have find that conventional manufacturing process is very important factor for industrial use of renewable material. They have done GPC analysis of PLA composites.

S. Jayanthi et al. , 2014, [53] have studied the use of natural fibers in automotive exterior and interior components to recover eco-efficiency and renewability. They have studied the useful properties and way of processing partially eco-friendly injection molded hybrid long fiber reinforced thermoplastics with natural kenaf fiber by impregnation process to improve the desired mechanical properties , thermal properties and recycling of the automotive components. They have also studied the properties and advantages of hybrid composites. They have highlighted the mechanical, thermal and recycling properties of a kenaf natural reinforced composites for consumption in automotive components.

A. Arif et al. ,[54] have done experimental analysis of a polmeric composites fabricated with epoxy resin (Araldite AY105 with hardener HY 951) and banana fiber . They have studied different fiber volume fraction and fiber ratio on the properties of the composites like storage modulus, loss modulus, tensile, fatigue strength was investigated.

K.M. Pillai, et al. , 2011, [55] have studied natural fibers being substituted by artificial glass and carbon fibers in polymer composites. They have studied liquid composite molding (LCM) processes as an important set of “liquid molding technology to manufactured net shaped composite parts that involve filling a dry, fiber-packed mold with a thermosetting resin.

M. Al-Waily , et al. ,2017, [56] have studied buckling behavior of composite plate made from the natural sisal fiber reinforcement. They have examined composite plate specimen reinforced with various volume fraction of natural sisal fibers.

T. Jamnongkan, et al. ,2018, [57] have studied and improved mechanical properties of Polylactic acid composites reinforced with cellulose from recycled newspapers. They have studied the tensile mechanical properties and swelling behavior of biocomposite films were investigated. They have used PLA and PLA / CF films for investigation.

E. Jayamani ,et al. ,2018, [58] have studied the sound absorption application of composites of polymer matrix reinforced with synthetic fiber and natural fibre. It depends on fibre size , porosity, glow sensitivity, thickness, tortuosity and density.

Kengkhetkit et al. , 2018 , [59] have studied lots of natural plant fibers. They have studied and researched over pineapple fiber as it has high mechanical properties.

Abdellaoui et al. , 2018, [60] have studied thermoset composites reinforced with lignocellulosic fiber and its sustainable and renewable aspects.

Ibrahim et al. ,2017 , [61] have studied specialized polysaccharide based composite material prepared from chitosan, a polysaccharide bio-polymer which has property of biodegradability, Biocompatibility, non-toxicity, chemical reactivity, susceptibility to modification and cost effectiveness. They have studied the functional properties of these composites.

Sarasini et al. , 2018, [62] have studied lots of natural plant fibers such as Okra , Borassus, Aruna Donax , Napier grass fibers and and Cissus Quadrangularis. They have studied the introduction of these less common natural fiber in thermoplastic and thermosetting matrices.

Orue et al, 2018, [63] have studied the pretreatment of natural fibers to reduce the hydrophilic character of fiber and improve the fiber / matrix adhesion. They have studied the hydrophilic character of lignocellulosic fiber which reduced the compatibility with the hydrophobic matrices resulting in composites with poor mechanical properties. They have studied different lignocellulosic fiber treatments and the effect of the treatments and the effect of the treatments on fiber properties as well as on composite mechanical performance. They have studied chemical treatment methods such as alkali, silane, esterification, etherification, benzoylation, isocyanate, oxidation, peroxide,etc. , physical treatments methods such as plasma , Corona, thermo-mechanical ,etc. and biological treatments such as fungal, enzymatic, etc.

Sisti et al. ,2018 , [64] have studied the retting procedure that have been developed during years and are applied to extract mainly bast fiber as treatment process largely determine the properties of fiber. They have studied lots of retting process such as microbiological retting process , enzymatic retting process, mechanical retting process, physical retting process, chemical retting process, etc. They have also studied lots of fibers such as flax, hemp, kenaf, jute, etc.

Bismarck et al., 2005, [65] have studied the plant fibers and their properties over synthetic fibers which are low cost, low density, have high specific strength and Young's modulus and easy of formability. They have studied plant fibers composites advantages also.

Minder et al. , 2005, [66] have studied bast fibers composites such as flax, hemp, jute, sisal, kenaf, yucas, abaca, or ramie, which have outstanding mechanical properties such that the tensile strength of the natural fibers, for example is comparable to the strength of high -tensile steel. They have studied the process flow sheet of fiber processing.

Talla et al. , 2017, [67] have studied hemp fiber reinforced polyethylene terephthalate as it shows high potential because of the property of matrices and long fiber of reinforcement.

Yilmaz et al. , 2017, [68] have studied composites made up of soybean oil and the triglyceride structure of soybean oil, which allow conversion to various promising monomers including acrylated epoxidized soybean oil (AESO). They have studied that the AESO-based polymers show viscoelastic behavior with a broad transition region from glassy to rubbery behaviors. They have studied that the properties of AESO-based polymers can be further enhanced by reinforcement with natural fibers and even more with glass fiber.

Armioun et al., 2017, [69] have studied biocomposite composed of engineered biopolymers reinforced with natural fibers and its Industrial application. They have studied the application of polyamides in it because of its wide application and high performance.

Prajer et al. ,2017, [70] have studied the natural fiber reinforced thermoplastics matrix with the emphasis on micromechanics of matrix-and – fiber interface.

Ramamoorthy et al. ,2017, [71] have studied physiochemical and mechanical properties of renewable material with the emphasis on natural fibers such as starch and matrix such as vegetable oils.

4. EXPERIMENTAL DETAILS

The materials are comprised of *Grewia optiva* (density: 0.45g/cm^3; areal weight: 235 g/m^2)*, basalt fiber* (2.67 g/cm^3; areal weight: 262 g/m^2) fibers ,pinapple fiber (1.5 g/cm3), and Epoxy (density: 1.25g/cm^3) LY 556 (procured from Amtech Pvt. Ltd., India). Both the fiber; *basalt fibe* and *grewia optiva* are collected from local market of Roorkee, Uttarakhand, India. From the literature survey, it is evaluated that mechanical properties of natural fiber can be improved by the alkali treatment by reducing the hydrophilic nature. Jute fiber were subjected to alkali treatment containing (5 % sodium hydroxide) give optimum flexural and tensile strength as compared to untreated jute [27]. Recognizing the above facts, the surface modification of *grewia optiva, pinapple fiber and basalt* fibers are treated with 5% sodium hydroxide in the water for a period of 6 hours at room temperature. The chemical reaction between fiber and concentration as follow the Eq. 1 as suggested by Kumar et al. [22]. After chemical treatment, hand-made bi-directional mats were prepared from the surface modified fibers. The pictorial view of *grewia optiva* and *basalt fiber* and fabricated as represented in Fig. 1.

$$\sum \begin{matrix} Grewia\ optiva/ \\ Basalt \\ fibre \end{matrix} - OH + NaOH \rightarrow \sum \begin{matrix} Grewia\ optiva/ \\ Basalt\ \text{-Pineapple} \\ fibre \end{matrix} - O^{-}Na^{+} + H_2O \qquad (1)$$

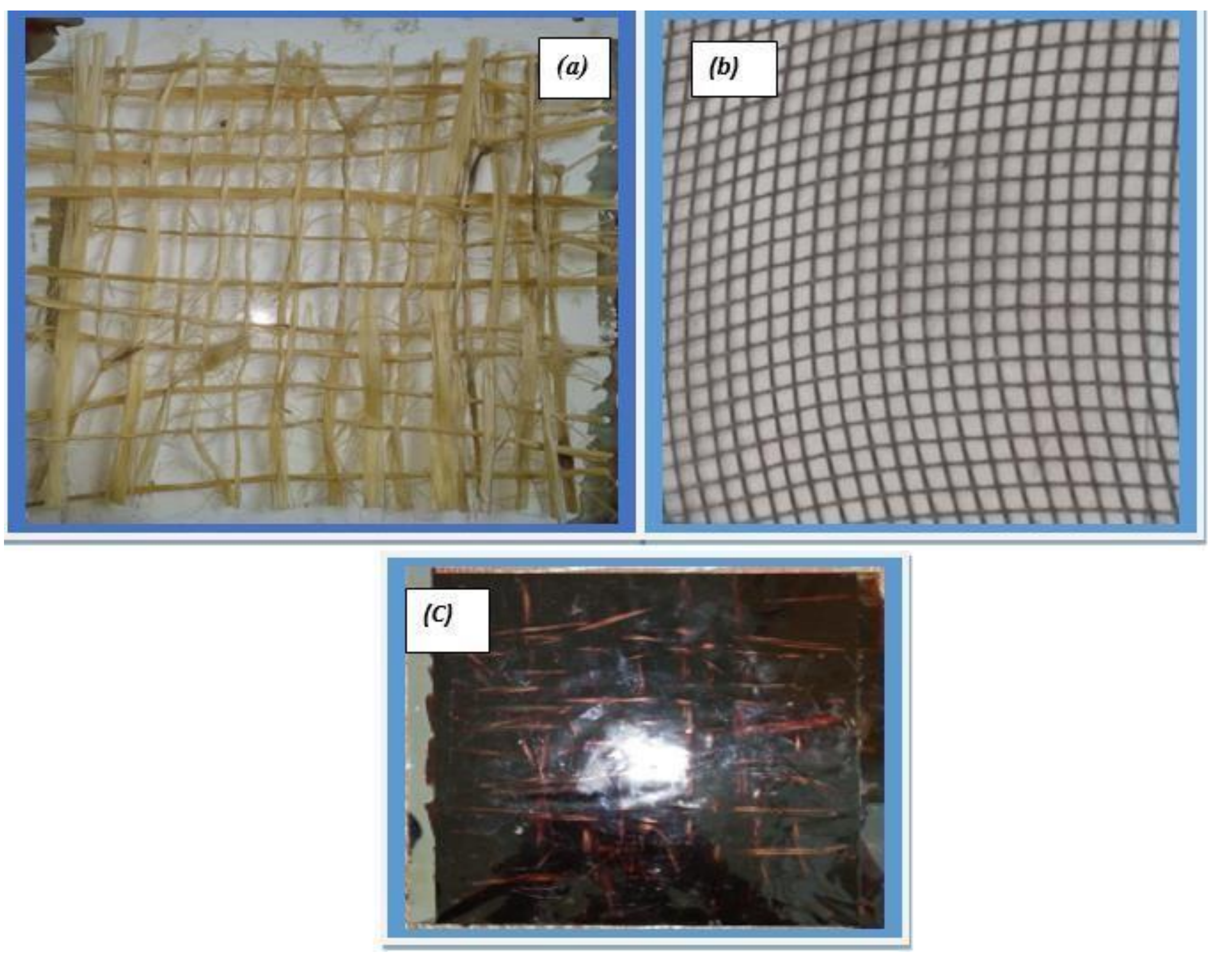
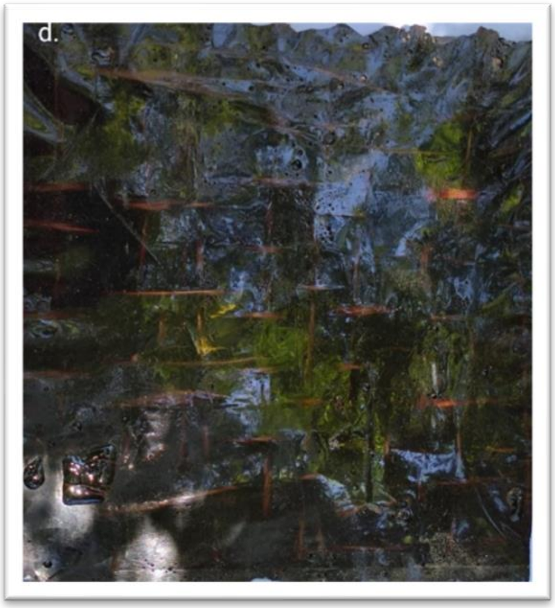


Figure 1. Pictorial view of (a) grewia optiva fiber, (b) Basalt fiber (c) Pineapple fiber and (d) Fabricated composites


d.


e.


g.

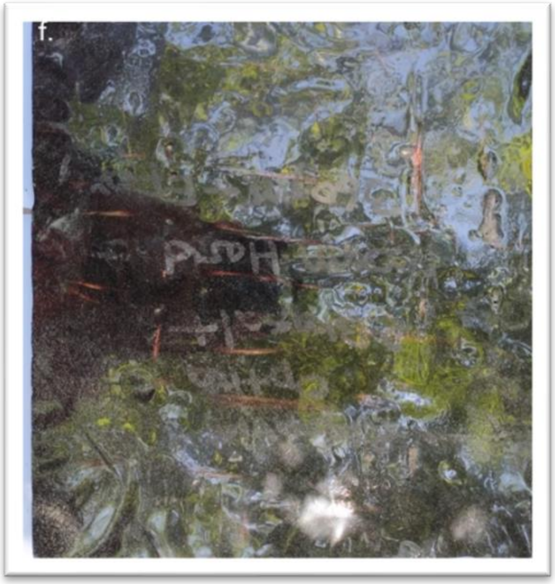


Figure : The given figure (d.), (e.), (f.) and (g.) shows polymer composite samples reinforced with Grewia optiva and pineapple fiber with the number of mat of Grewia optiva being constant to two and number of mat of pineapple fiber varying from zero to three.

Figure : The given figure (h.), (I.), (j.) and (k.) shows second samples of polymer composite samples reinforced with Grewia optiva and pineapple fiber with the number of mat of Grewia optiva being constant to two and number of mat of pineapple fiber varying from zero to three.

Figure : The given figure (l.) shows mat of pineapple fiber used for reinforcing polymer composites along with Grewia optiva.

EQUIPMENTS REQUIRED :-

We have used a lot of equipments in completing the experiment and studying of this research topic. These equipments are as follows :-

- Computer
- Plotter
- Tribometer
- UTM
- Charpy Impact tester

We have used computer for recording the chart of tribological study through tribometer, tribometer for tribological study of specimen,UTM for strength testing and Charpy impact tester for determing impact energy.

Computer :-

A computer can carry out sequences of arithmetic and logic operation automatically. Modern computers can perform generic sets of operation known as program. A computer is a computer computer including hardware, operating system and peripheral equipment needed and used for full operation. A computer consist of at least one processing element CPU having microprocessor, memory, etc.

Control Unit :-

The control unit manages the computer's various components, reads and interpret program signal to transform them into control signals that activates other parts of the computer. It can change the order of execution of some instructions of to improve performance.

CPU :-

The control unit, ALU, and registers are collectively known as a central processing unit. The CPU performs basic arithmetic , logic, controlling, and input/output operation (I/O) operation specified by the instruction in the program.

Components of CPU are as follows :-

1. Arithmetic logic unit (ALU)
2. Control Unit
3. Processor Register

ALU :- It performs arithmetic and logic operation.

Processor register :- It supply operand to the ALU and store the result of ALU operation.

Control Unit :- it performs fetching, decoding and execution of instructions by directing the coordinated operation of the ALU , register and other components.

Microcontroller or systems on a chip :- Integrated circuitry consisting of VPUs, memory, peripheral interfaces and other components of computer are known

Intel Core i7 :-

Intel Core are streamlined mid-range consumer, workstation and enthusiast computer's central processing unit (CPU) marketed by Intel Corporation.

- Core : 6
- Thread : 12
- Base CPU clock rate : 2.6 GHz
- Single Core Turbo clock rate : 4.5-4.6 GHz
- GPU : HD630
- Max GPU Clock rate : 1.15GHz
- L3 Cache : 12MB
- TDP : 45 W
- Memory Support : DDR4-2666

Charpy Impact tester :-

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. The material's notch toughness is measured by the absorbed energy by the sample. Its one of the disadvantage is that some results are comparative. The apparatus consists of a pendulum of known mass and length that is dropped from a known height to impact a notched specimen of material. The energy transferred to the material can be inferred by comparing the difference in the height of the hammer before and after the fracture.

UTM :-

A universal testing machine (UTM), also known as a universal tester, materials testing machine or materials test frame, is used to test the tensile strength and compressive strength of materials.

Common components include:

Load frame – It usually consist of two strong supports for the machine. Some small machines have a single support.

Load cell – It consists of a force transducer or other means of measuring the load . User should provide periodic calliberation by governing regulations or quality system.

Cross head – It consists of a movable cross head (crosshead) which move up or down. Usually this is at a constant speed: sometimes called a constant rate of extension (CRE) machine. Some machines can program the crosshead speed or conduct cyclical testing, testing at constant force, testing at constant deformation, etc.

It consists of an electromechanical, servo-hydraulic, linear drive, and resonance drive.

Means of measuring extension or deformation - Extensometers are used to measure the response of the test specimen to the movement of cross head.

Output device - A means of providing the test result is needed. Some older machines have dial or digital displays and chart recorders. Many newer machines have a computer interface for analysis and printing.

Conditioning - Controlled conditioning (temperature, humidity, pressure, etc.) is needed in some testing of specimen. The machine can be in a controlled room or a special environmental chamber can be placed around the test specimen for the test. Test fixtures, specimen holding jaws, and related sample making equipment are called for in many test methods.

PLOTTER :-

A plotter produces vector graphics drawings. Plotters draw lines on paper using a pen, or in some applications, use a knife to cut a material like vinyl or leather. In the latter case, they are sometimes known as a cutting plotter.

Types of plotters are as follows :-

- Label plotter
- Ink-jet plotter
- Drag-knife cutting plotter
- Static cutting table

Ink-jet plotter :-

Plotters are used primarily in technical drawing and CAD applications, where they have the advantage of working on very large paper sizes while maintaining high resolution. We have used ink-jet plotter to print out the tribology reading chart for study of experiments.

Tribometer :-

A tribometer is an instrument that measures tribological quantities such as coefficient of friction, frictional force, and wear volume between two surfaces in contact. It was invented in 18th century by Dutch Scientist Musschenbroek.

It is also known as tribotester as it performs test and simulation of wear, friction and lubrication which are the subject of tribology.

Theory :-

A simple tribometer is defined by a hanging Mass and a mass resting on a horizontal surface, connected to each other via an string and pulley.

Types of tribometer are as follows :-

- Four ball
- Pin on disc
- Ball on disc
- Ring on ring
- Ball on three plates
- Reciprocating pin
- Block on ring
- Bouncing ball
- Fretting test machine
- Twin disc

Pin on Disc :-

It consist of an stationary pin that is normally loaded against rotating disc. The pin can have any shape to stimulate a specific contact but cylindrical tips are often used to simplify the contact geometry. It is useful to determine a simple wear and friction test for low friction coatings such as diamond like coating on valve train components in internal combustion engines.

Figure : Computer used for recording chart of experiments data as the tribometer is used to provide data to computer.

It had replaced chart record.

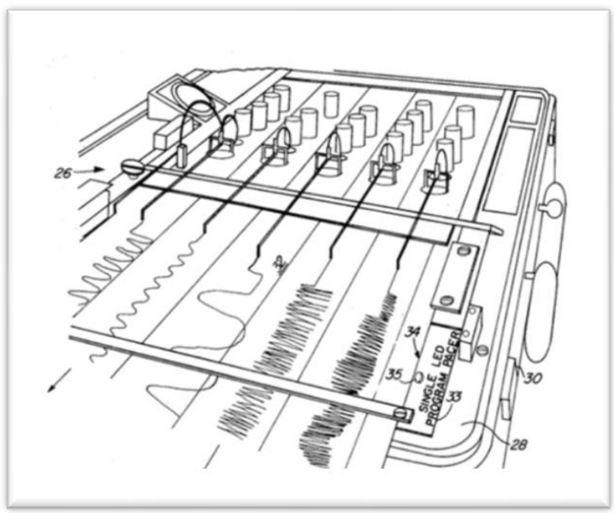


Figure : Chart recorder being used to record the data of processing of the machines. The computer have replaced the chart recorder in this chart recording.

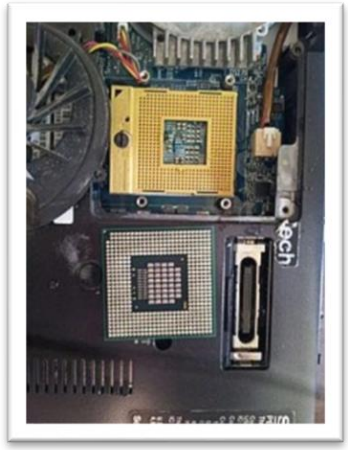


Figure : CPU being used in research and experimentation to record data.

Figure : Intel Core being used in processing the data.

Figure : Impact Charpy machine being used in testing .

Figure : Tribometer being used in collecting tribological data.

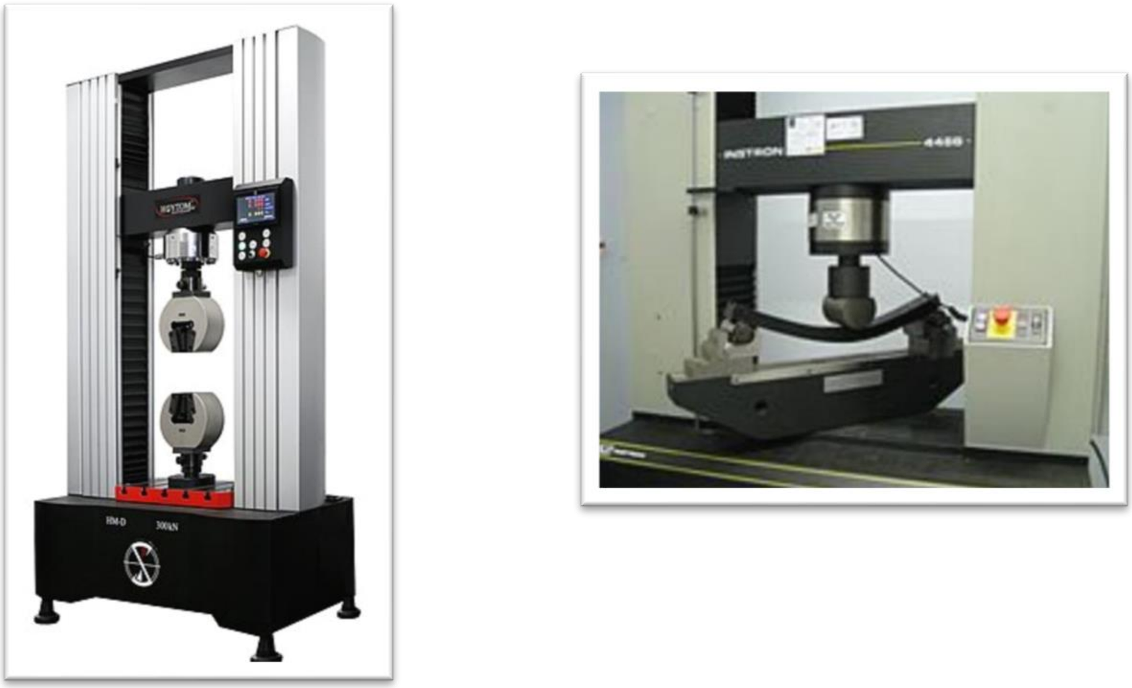


Figure : UTM being used in collecting tensile data.

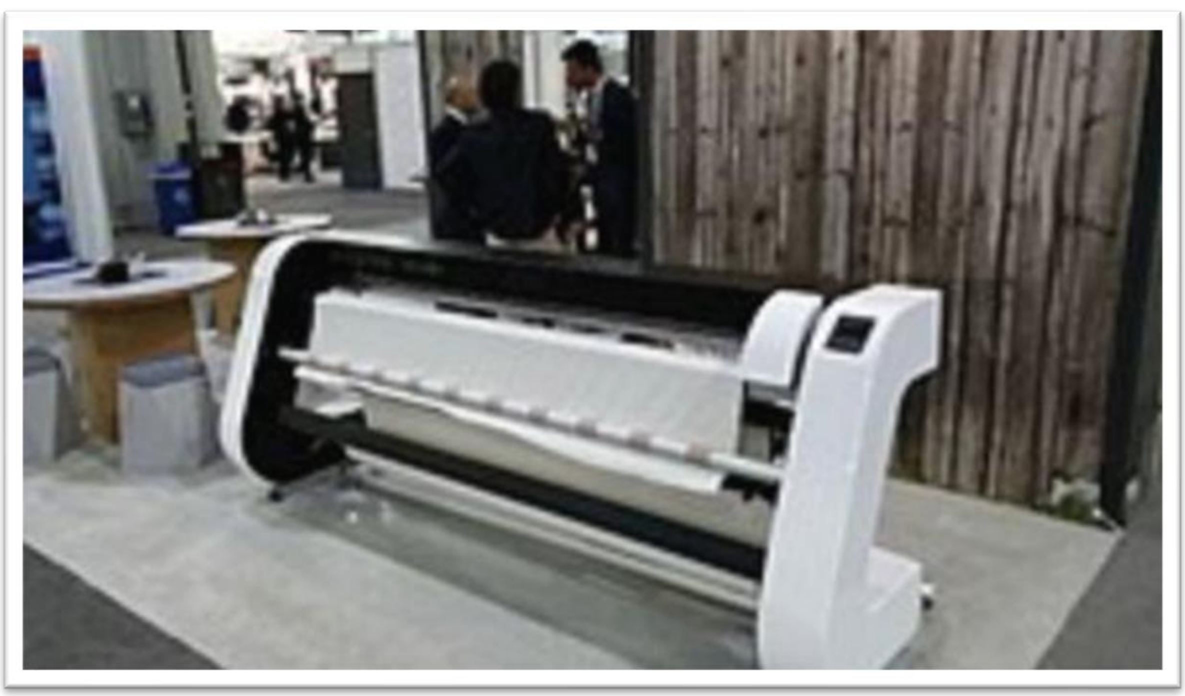


Figure : Plotter being used in printing chart for experimental study.

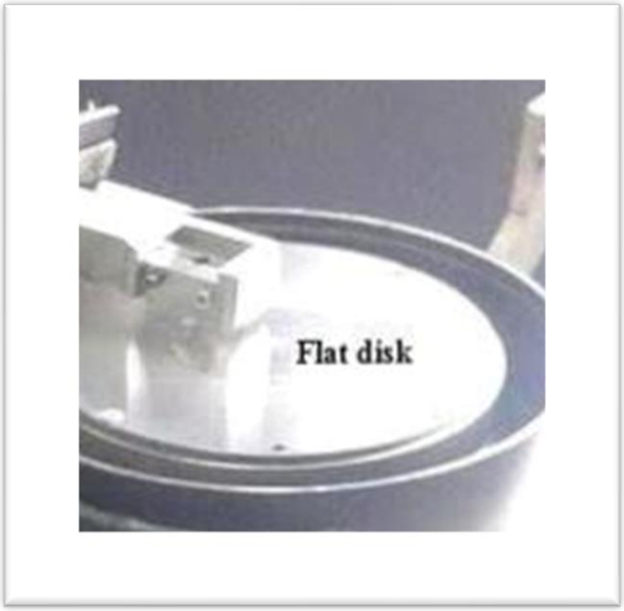


Figure : Pin on disc Tribometer being used in tribological testing of samples in this experimentation and project work.

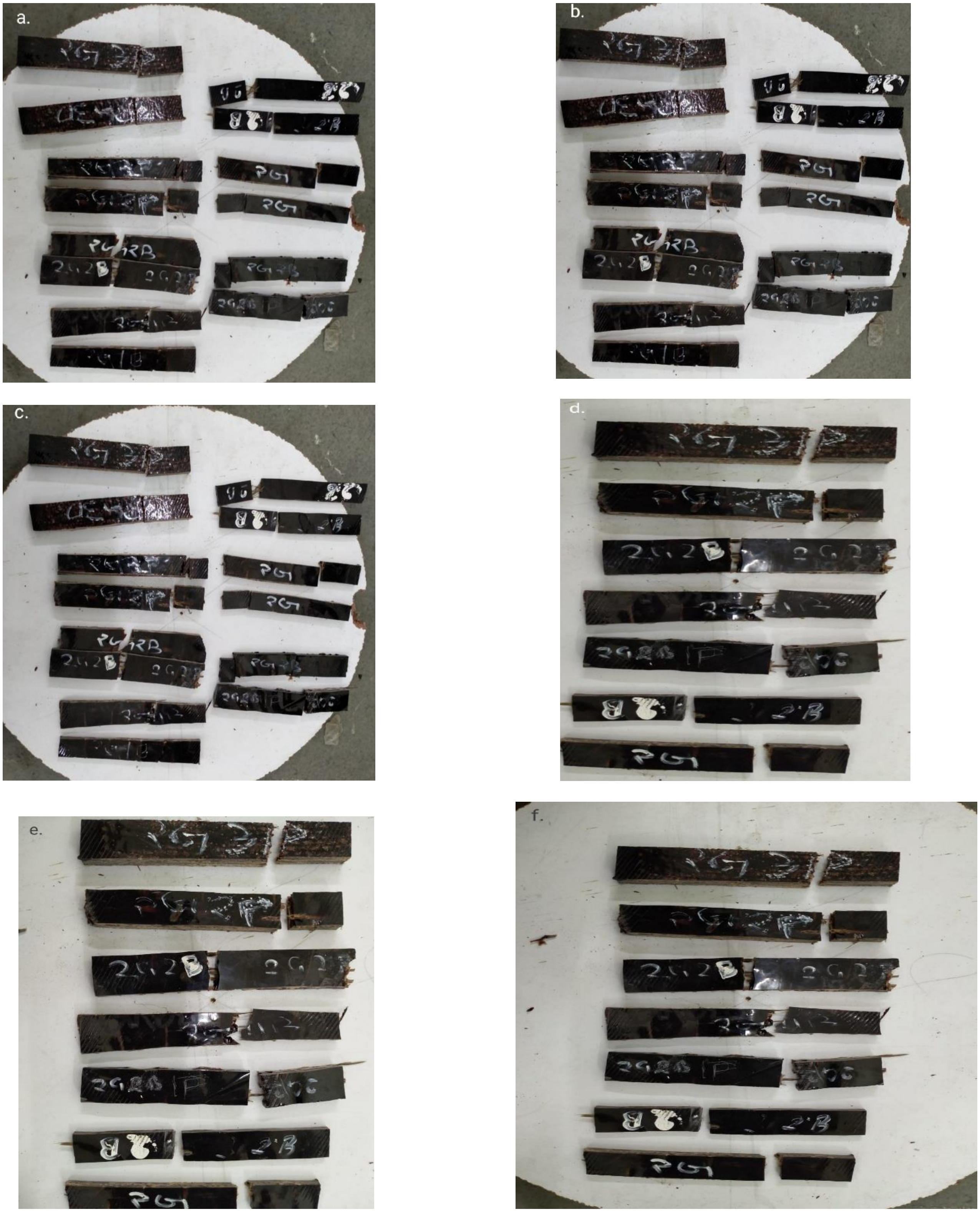


Figure : These figures (a.) , (b.) , (c.), (d.), (e.) and (f.) shows the samples after ultimate tensile strength testing of polymer composites samples prepared during the experimentation and project work.

Figure : The given figure (a.), (b.) and (c.) shows the samples after impact testing over it.

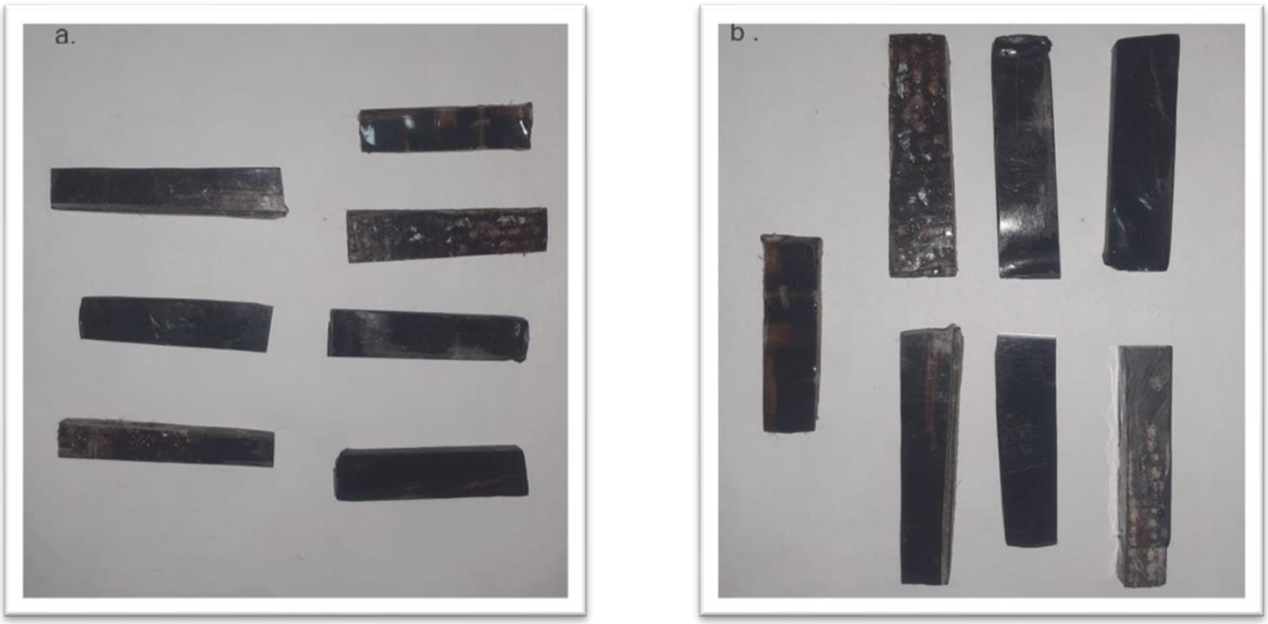


Figure : The given figures (a.) and (b.) shows wear tested samples on pin on disc tribometer.

5. FABRICATION METHOD

In present research, the composites are fabricated by adopted hand lay-up technique. The layup of composite laminates was done by using a glass mold of dimensions 240×240× 10 mm^3. The miller film was used to cover the glass mold for easy removal of cured composites from the glass. Epoxy and hardener were mixed in the proportion of 10/1 at room temperature and then poured in to the mold before applying the bi-directional *grewia optiva/basalt* fiber and *grewia optiva / pineapple fiber* mats. When the first *grewia* optiva mat settles down in to the mold, another layer of resin and hardener of mixtures were applied. Afterward, the cast materials were allowed to cure at room temperature under a load of 12 kg for one day. Table 1 illustrates the designation, weight percentage, and number of mats of the composites.

Table 1Designation, weight percentage, and number of mat of the composites.

Designation	**Weight percentage ratio (Epoxy/GO/BF)**	**Bi-direction mat number (GO/BF)**
GOB-0	98/2/0	2/0
GOB-1	97/2/1	2/1
GOB-2	96/2/2	2/2
GOP-0	98/2/0	2/0
GOP-1	97/2/1	2/1
GOP-2	97/2/2	2/2
GOP-3	97/2/3	2/3
GOB-0	98/0/2	0/2

GOB- *Grewia optiva/Basalt fiber reinforced composites*, GO- *Grewia optvia fiber*, BF- *Basalt fiber*

GPO-Grawia optiva/Pineapple fiber reinforced composite ,GO- Gravia optiva fiber , PF – Pineapple fiber

6. RESULTS & DISCUSSIONS

The mechanical properties of reinforced polymer composites basically depend upon three parameters; (a) reinforcing fibers, (b) matrix, and (c) adhesion between fiber and matrix. In the literature it is pointed out that the chemical treatment of fiber increase the tensile and flexural strength due to reaction between cellulosic fiber hydroxyl groups and anhydride parts which causes a reduction in interfacial tension, better stress transfer between fibers and matrix and resulting in improved surface adhesion between fiber/matrix. Additionally the involvement of basalt and pineapple both wt% is effects the mechanical properties of GOB and GOP composites. From Fig. 2 and 3, it is evident that the mechanical property of fabricated composites increases with increase in the fiber contents. The maximum value of tensile strength of GOB-2 composites are observed to be 40 MPa and GOP-3 composites are observed to be around 45mPa, respectively which are 36.73% and 20.59 % more than GOB-0 and GOP-0 composites.

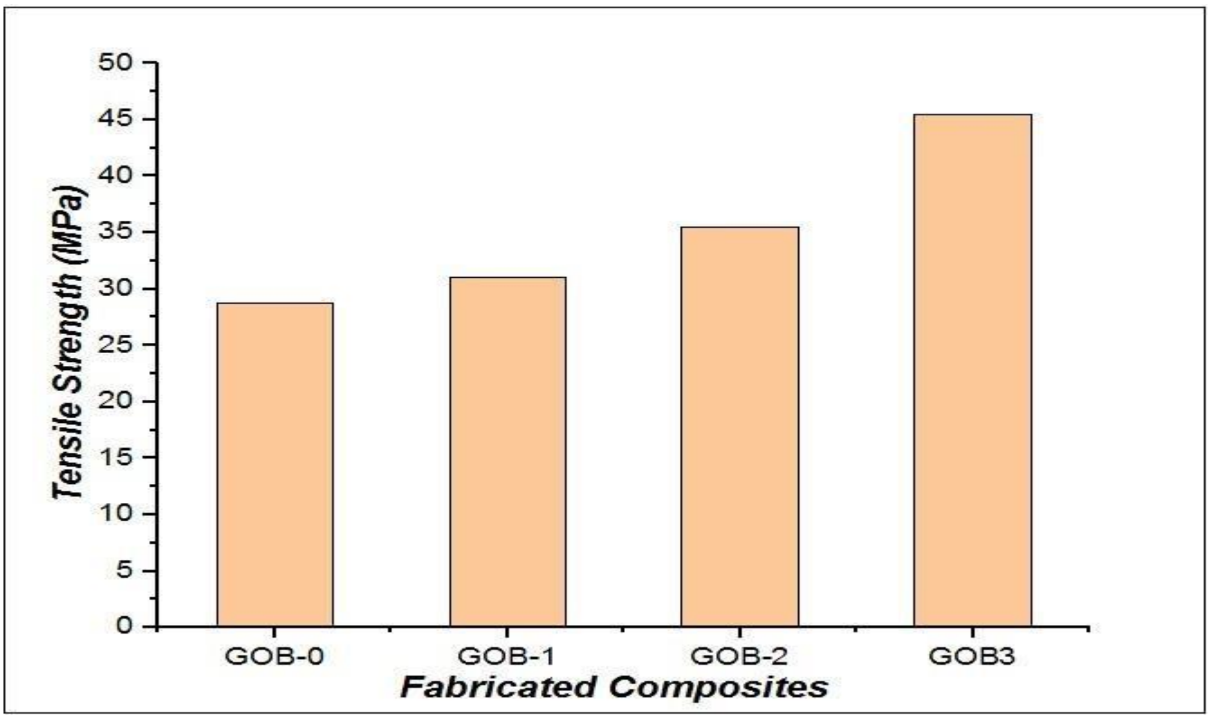


Figure 2. Variation of tensile strength with fabricated composites

However, the tensile strength of GOB-0 and GOP-0 composites showed better performance than monoGOB-0 and GOP-0 composites. This may be due to the fact that, *basalt fiber and pineapple fiber* at the outer surface in case of GOB composites would give rise to resistance to the compressive force, which growing on the specimen surface when load is applied perpendicular to the fabricated specimens. Similar finding was done by Kumar et al [23], they revealed that the incorporation of *bauhinia vahlii* fiber in sisal fiber reinforced epoxy composites attained higher tensile trength and also attained approximately 11% more than its tensile property. Likewise, progressively enhancement has been seen in hardness properties (Fig. 4) and represented the GOB-2 composites show 39.01% in hardness as compared to GOB-0 composites and GOP-3 composite also show 35% as compare to GOP-0 composite .This may be due to sharing of the test load on the *basalt fiber* and *pineapple fiber* which reduced the penetration of the indenter to the surface of fabricated composites and as a result of increasing the hardness of the fabricating material. Afterward, the GOB-2 and GOP-3 composites exhibited superior mechanical properties and also the function of weight percentages of basalt fiber and pineapple fiber.The mechanical properties of GOB composites are in the following order: GOB-2> GOB-1> GOB-0 and same as GOP Copcomposite GOP-3>GOP-2>GOP-1>GOP-0.The fabricated composite is achieved higher mechanical properties at higher fiber loading were due to the enhancement in the fibers amount with respect to area reinforced.

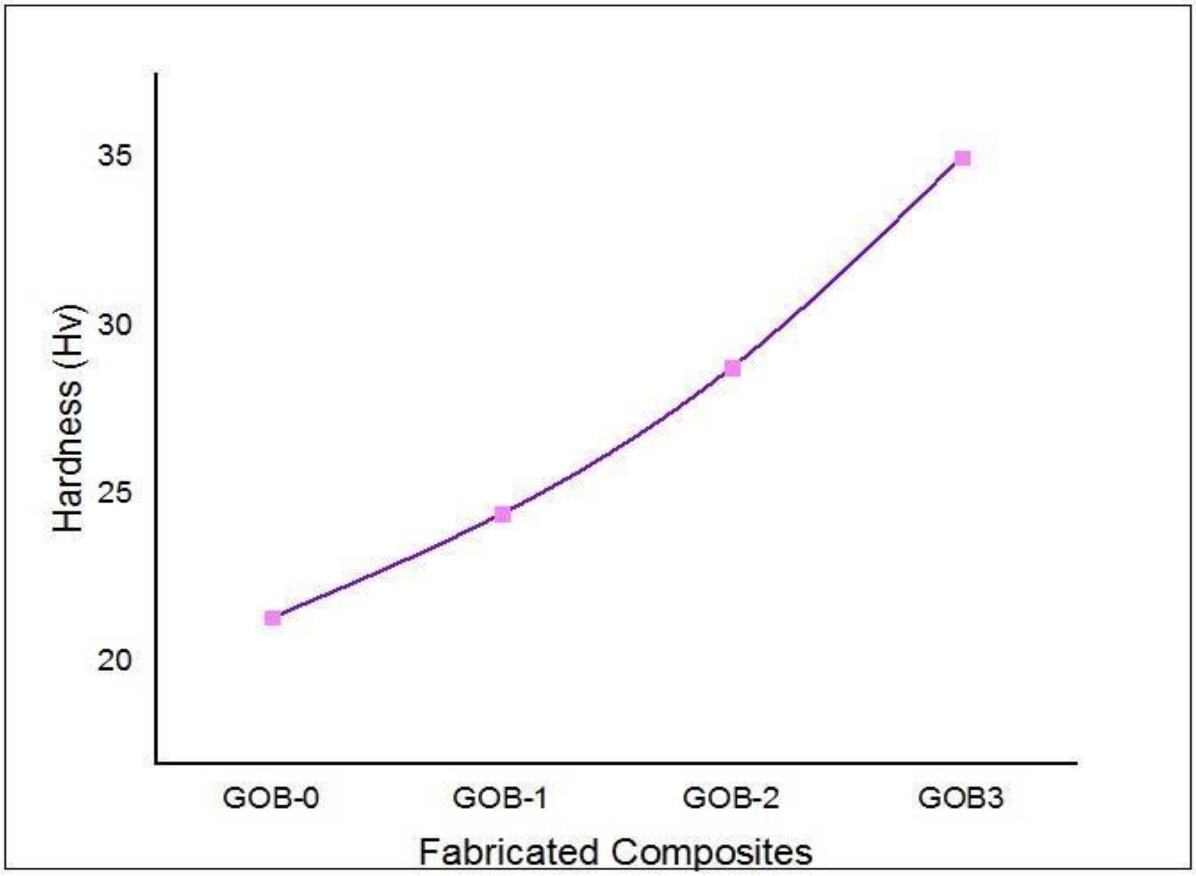


Figure 2. Variation of hardness with fabricated composites

Impact Testing Data-

Table : Impact test of Sample 1 (2G/0B)

Strength	**ENERGY**

0J/cm2	1.1 J

Table : Impact test of Sample 2(2G/1B)

STRENGTH	ENERGY
2.4 J/cm2	1.9 J
5.6 J/cm2	4.5 J

Table : Impact test of Sample 3(2G/2B)

STRENGTH	ENERGY
0 J/cm2	1.3 J
55.9 J/cm2	44.7 J

Table : Impact test of Sample 4(0G/2B)

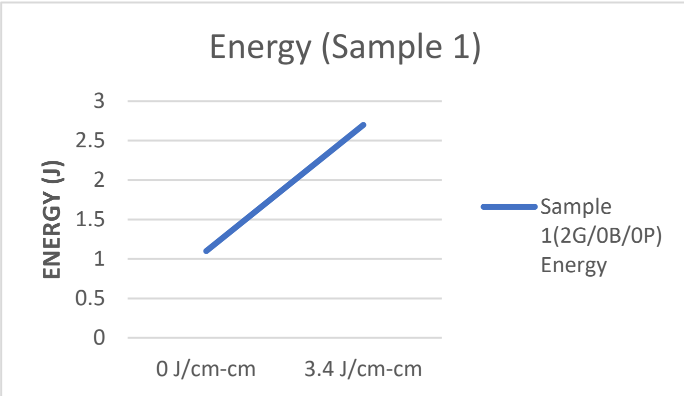
STRENGTH	ENERGY
3.4J/cm2	2.7 J
3.4 J/cm2	2.7 J

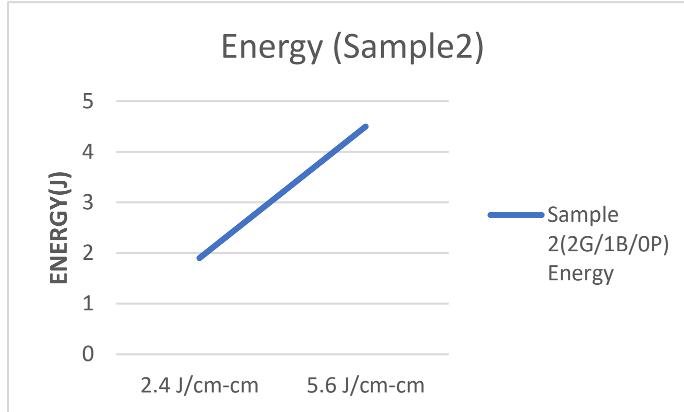
Table : Impact test of Sample 5(2G/2P)

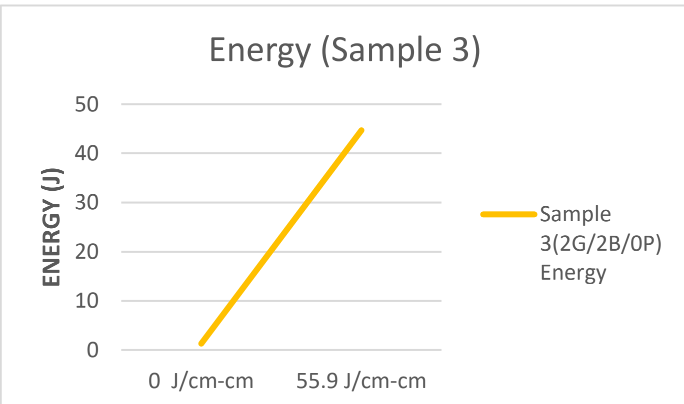
STRENGTH	ENERGY
14.5 J/cm2	19.6 J
27.9 J/cm2	22.3 J

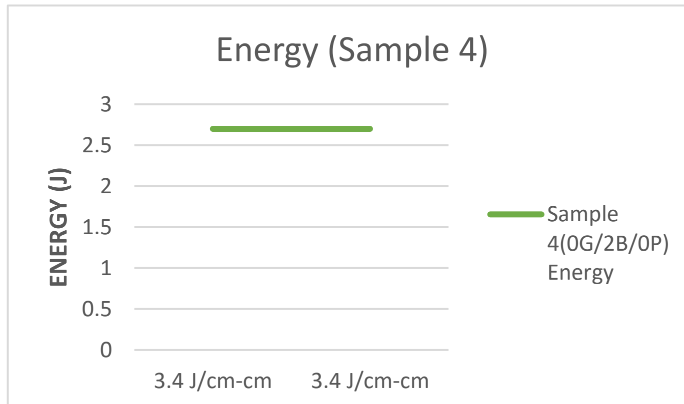
Table : Impact test of Sample 6(2G/3P)

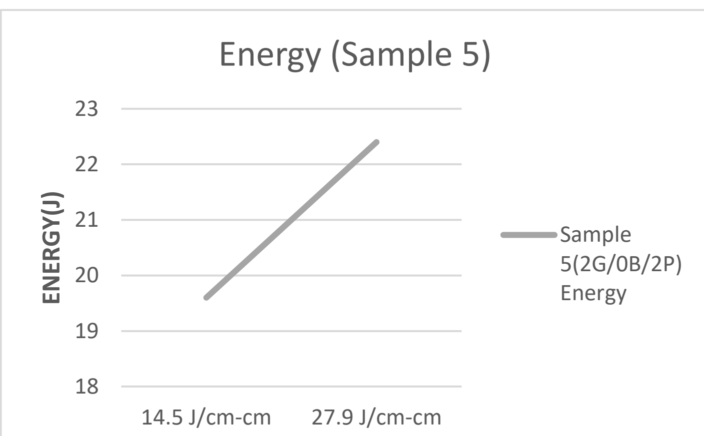
STRENGTH	ENERGY
32.2 J/cm2	24.2 J
48 J/cm2	38.9 J

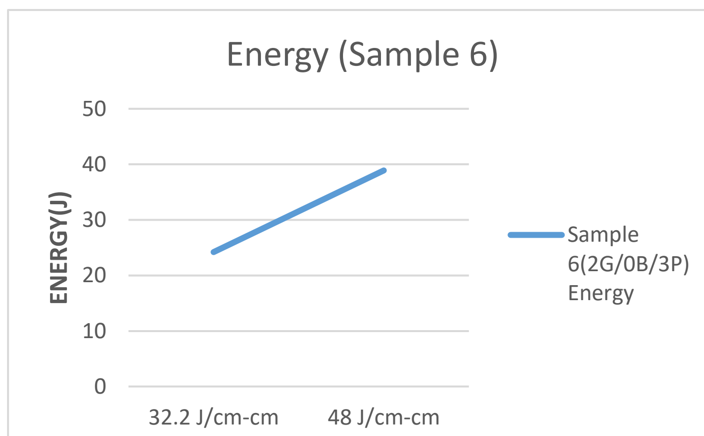

Energy (Sample 1)
ENERGY (J)
3
2.5
2
1.5
1
0.5
0
0 J/cm-cm
3.4 J/cm-cm
Sample 1(2G/0B/0P) Energy


Energy (Sample2)
ENERGY(J)
5
4
3
2
1
0
2.4 J/cm-cm
5.6 J/cm-cm
Sample 2(2G/1B/0P) Energy


Energy (Sample 3)
ENERGY (J)
50
40
30
20
10
0
0 J/cm-cm
55.9 J/cm-cm
Sample 3(2G/2B/0P) Energy


Energy (Sample 4)
ENERGY (J)
3
2.5
2
1.5
1
0.5
0
3.4 J/cm-cm
3.4 J/cm-cm
Sample 4(0G/2B/0P) Energy


Energy (Sample 5)
ENERGY(J)
23
22
21
20
19
18
14.5 J/cm-cm
27.9 J/cm-cm
Sample 5(2G/0B/2P) Energy


Energy (Sample 6)
ENERGY(J)
50
40
30
20
10
0
32.2 J/cm-cm
48 J/cm-cm
Sample 6(2G/0B/3P) Energy

WEAR TESTING DATA :-

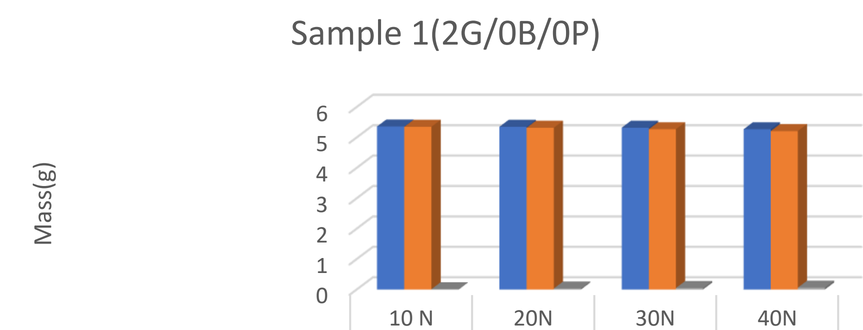
Sample 1(2G/0B/0P)

LOAD	**Mass 1**	**Mass 2**	**Δm = m1 - m2**
10 N	5.360g	5.350g	0.01g
20N	5.350g	5.318g	0.032g
30N	5.318g	5.270g	0.048g
40N	5.270g	5.208g	0.062g
Sample 2(0G/2B/0P)			
LOAD	**Mass 1**	**Mass 2**	**Δm = m1-m2**
10N	3.804g	3.778g	0.026g
20N	3.778g	3.700g	0.078g
30N	3.700g	3.605g	0.095g
40N	3.605g	3.497g	0.108g
Sample 3(2G/1B/0P)			
LOAD	**Mass 1**	**Mass 2**	**Δm = m1- m2**
10 N	4.016g	3.990g	0.026g
20N	3.990g	3.973g	0.017g
30N	3.973g	3.451g	0.522g
40N	3.451g	3.330g	0.121g
Sample 4(2G/0B/3P)			
LOAD	**Mass 1**	**Mass 2**	**Δm = m1-m2**
10N	7.035g	7.015g	0.02g
20N	7.015g	7.013g	0.002g
30N	7013g	7.003g	0.01g
40N	7.003g	6.960g	0.053g
Sample 5 (2G/2B/0P)			
LOAD	**Mass 1**	**Mass 2**	**Δm = m1-m2**
10N	7.851g	7.846g	0.005g
20N	7.846g	7.812g	0.034g
30N	7.812g	7.771g	0.041g
40N	7.771g	7.650g	0.121g
Sample 6 (2G/0B/2P)			
LOAD	**Mass 1**	**Mass 2**	**Δm =m1-m2**
10N	5.986g	5.980g	0.006g
20N	5.980g	5.972g	0.008g
30N	5.972g	5.960g	0.012g
40N	5.960g	5.948g	0.012g
Sample 7(2G/0B/1P)			
LOAD	**Mass 1**	**Mass 2**	**Δm = m1-m2**
10N	5.211g	5.197g	0.014g
20N	5.197g	5.149g	0.048g
30N	5.149g	5.077g	0.072g

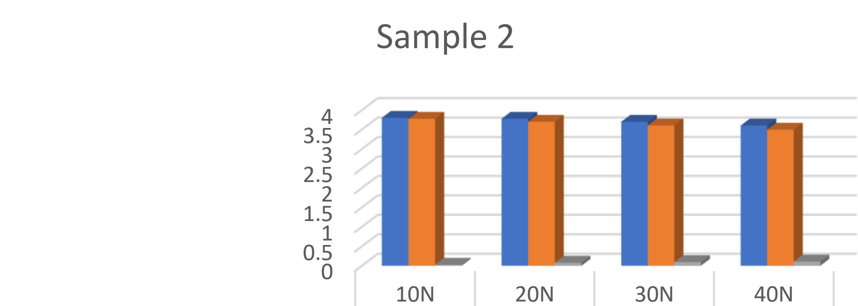
40N	5.077g	4.986g	0.091g

FORCE	2G/0B/0P	0G/2B/0P	2G/1B/0P	2G/0B/3P	2G/2B/0P	2G/0P/2P	2G/0B/1P
10N	0.01g	0.026g	0.026g	0.02g	0.005g	0.006g	0.014g
20N	0.032g	0.078g	0.017g	0.002g	0.034g	0.008g	0.048g
30N	0.048g	0.095g	0.522g	0.01g	0.041g	0.012g	0.072g
40N	0.062g	0.108g	0.121g	0.053g	0.121g	0.012g	0.09g

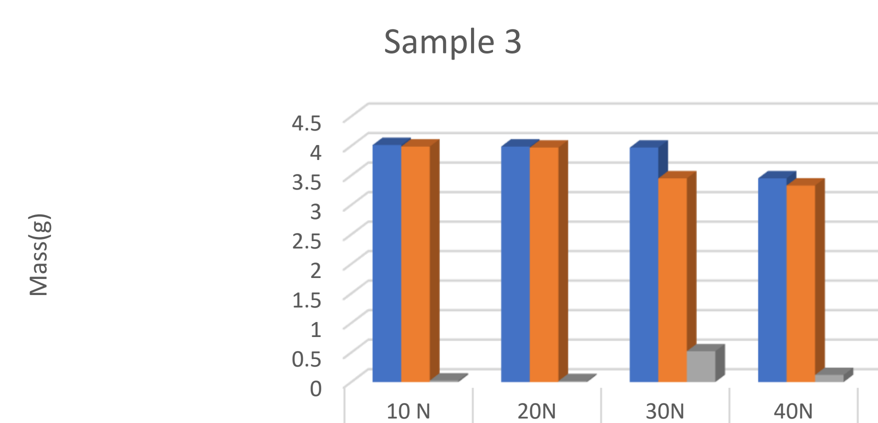
Table : Wear testing data of all samples.



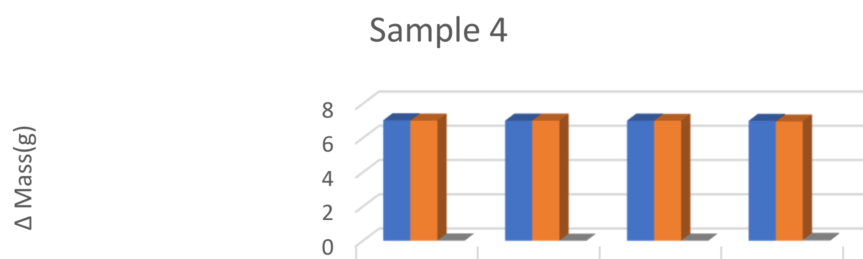
	10 N	20N	30N	40N
Sample 1(2G/0B/0P) Mass 1	5.36	5.35	5.318	5.27
Sample 1(2G/0B/0P) Mass 2	5.35	5.318	5.27	5.208
Sample 1(2G/0B/0P) Δm = m1 - m2	0.01	0.032	0.048	0.062



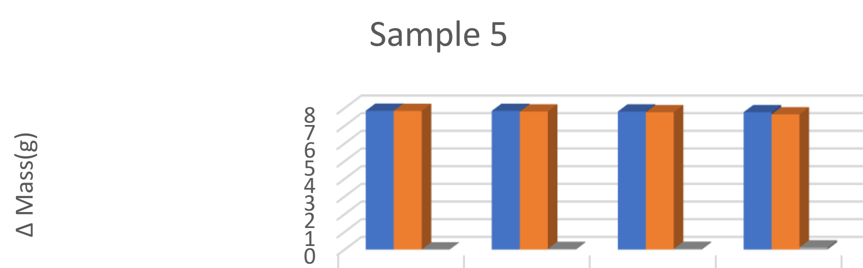
	10N	20N	30N	40N
Sample 2(0G/2B/0P) Mass 1	3.804	3.778	3.7	3.605
Sample 2(0G/2B/0P) Mass 2	3.778	3.7	3.605	3.497
Sample 2(0G/2B/0P) Δm = m1-m2	0.026	0.078	0.095	0.108



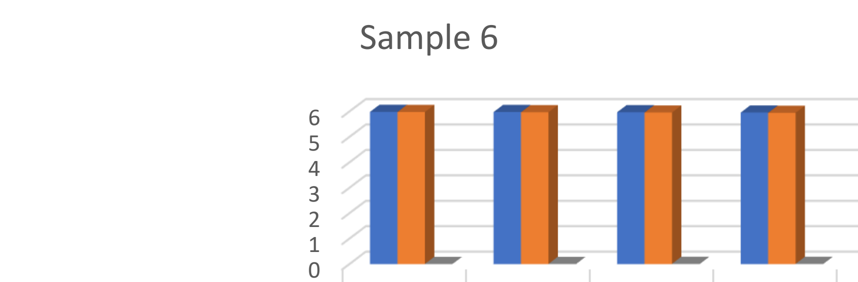
	10 N	20N	30N	40N
Sample 3(2G/1B/0P) Mass 1	4.016	3.99	3.973	3.451
Sample 3(2G/1B/0P) Mass 2	3.99	3.973	3.451	3.33
Sample 3(2G/1B/0P) Δm = m1- m2	0.026	0.017	0.522	0.121



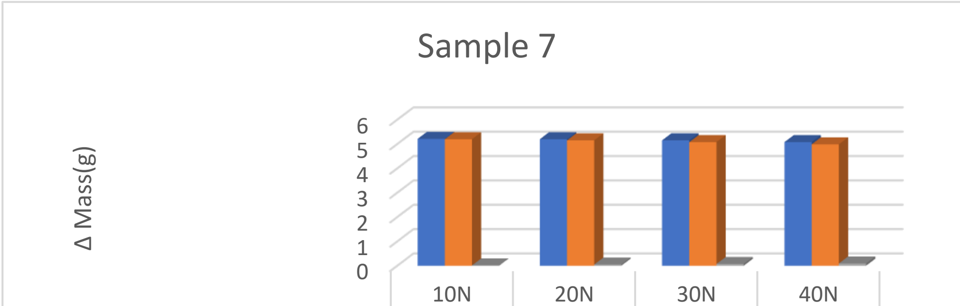
	10N	20N	30N	40N
Sample 4(2G/0B/3P) Mass 1	7.035	7.015	7.013	7.003
Sample 4(2G/0B/3P) Mass 2	7.015	7.013	7.003	6.96
Sample 4(2G/0B/3P) Δm = m1-m2	0.02	0.002	0.01	0.053



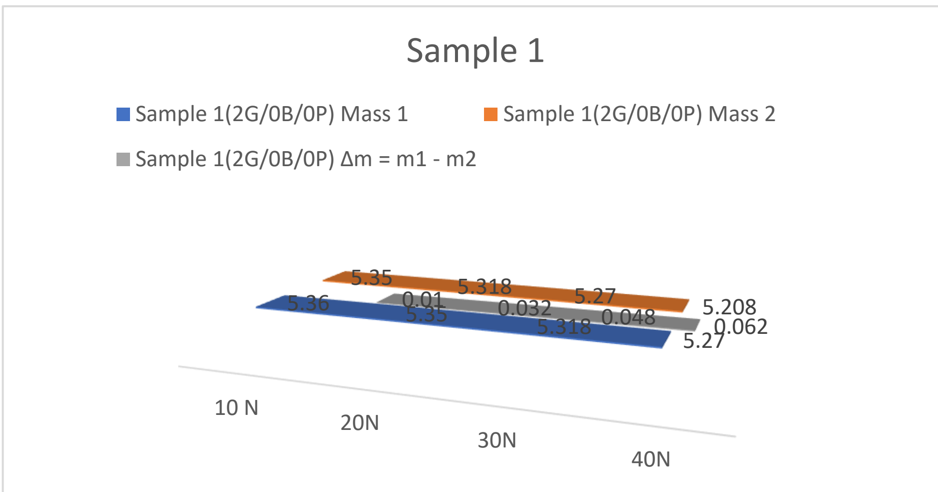
	10N	20N	30N	40N
Sample 5 (2G/2B/0P) Mass 1	7.851	7.846	7.812	7.771
Sample 5 (2G/2B/0P) Mass 2	7.846	7.812	7.771	7.65
Sample 5 (2G/2B/0P) Δm = m1-m2	0.005	0.034	0.041	0.121

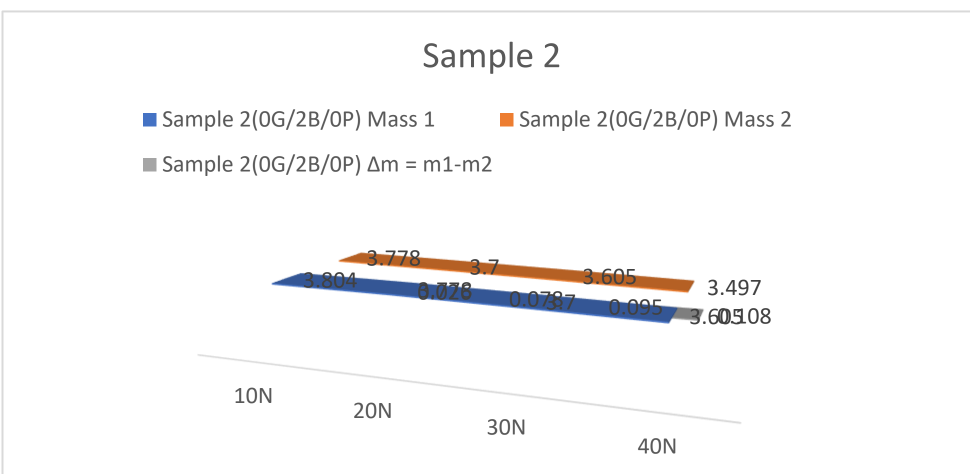


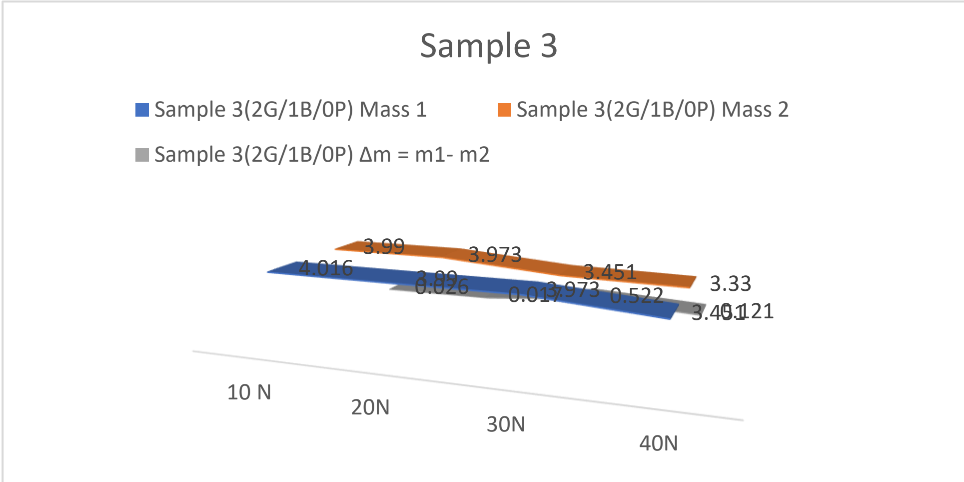
	10N	20N	30N	40N
Sample 6 (2G/0B/2P) Mass 1	5.986	5.98	5.972	5.96
Sample 6 (2G/0B/2P) Mass 2	5.98	5.972	5.96	5.948
Sample 6 (2G/0B/2P) Δm =m1-m2	0.006	0.008	0.012	0.012

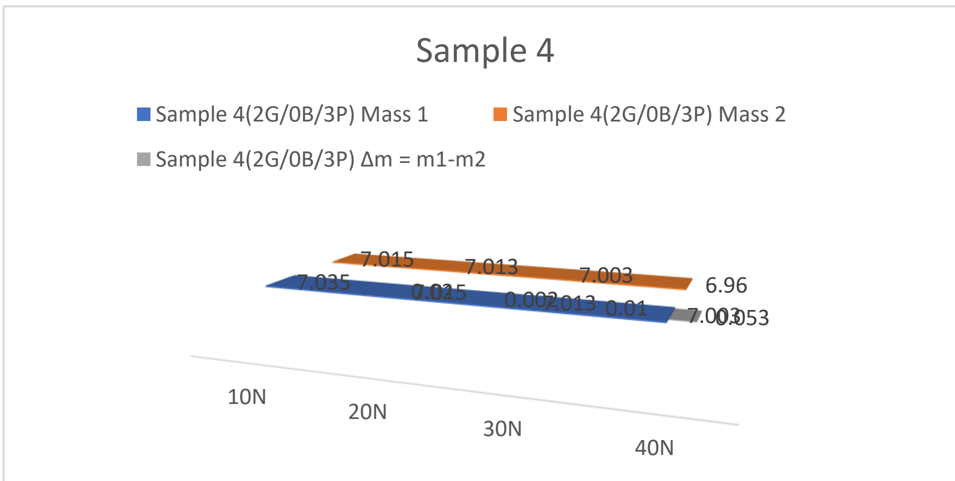


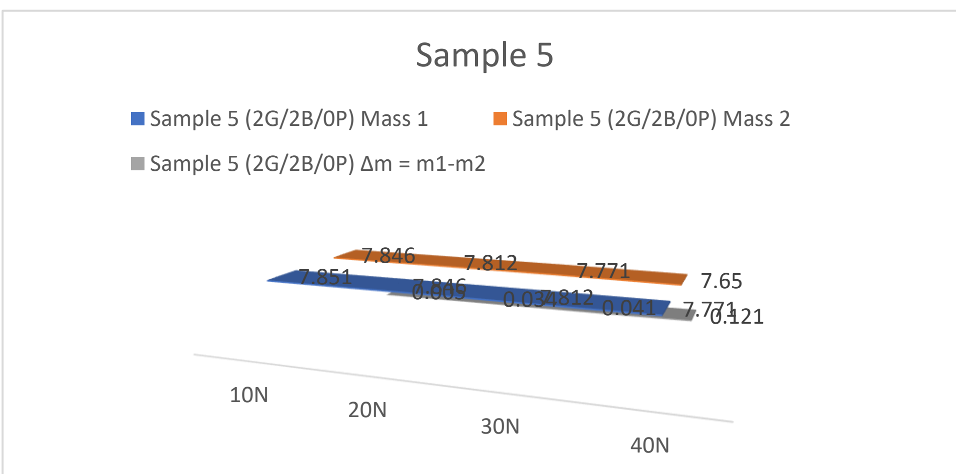
	10N	20N	30N	40N
Sample 7(2G/0B/1P) Mass 1	5.211	5.197	5.149	5.077
Sample 7(2G/0B/1P) Mass 2	5.197	5.149	5.077	4.986
Sample 7(2G/0B/1P) Δm = m1-m2	0.014	0.048	0.072	0.091

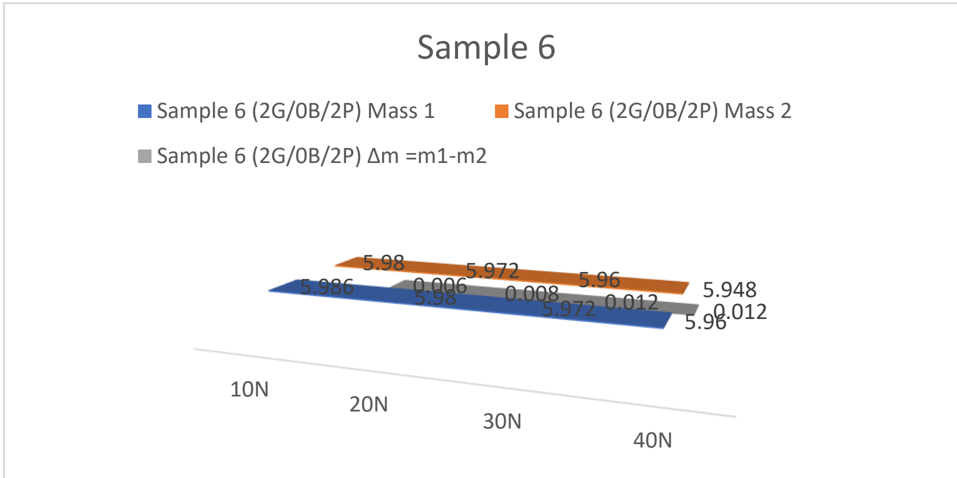





Sample 3
Sample 3(2G/1B/0P) Mass 1
Sample 3(2G/1B/0P) Mass 2
Sample 3(2G/1B/0P) Δm = m1- m2
3.99
3.973
3.451
3.33
4.016
0.026
0.017
0.522
0.121
10 N
20N
30N
40N


Sample 4
Sample 4(2G/0B/3P) Mass 1
Sample 4(2G/0B/3P) Mass 2
Sample 4(2G/0B/3P) Δm = m1-m2
7.015
7.013
7.003
6.96
7.035
0.01
0.053
10N
20N
30N
40N


Sample 5
Sample 5 (2G/2B/0P) Mass 1
Sample 5 (2G/2B/0P) Mass 2
Sample 5 (2G/2B/0P) Δm = m1-m2
7.846
7.812
7.771
7.65
7.851
0.041
0.121
10N
20N
30N
40N


Sample 6
Sample 6 (2G/0B/2P) Mass 1
Sample 6 (2G/0B/2P) Mass 2
Sample 6 (2G/0B/2P) Δm =m1-m2
5.98
5.972
5.96
5.948
5.986
0.006
5.98
0.008
5.972
0.012
5.96
0.012
10N
20N
30N
40N

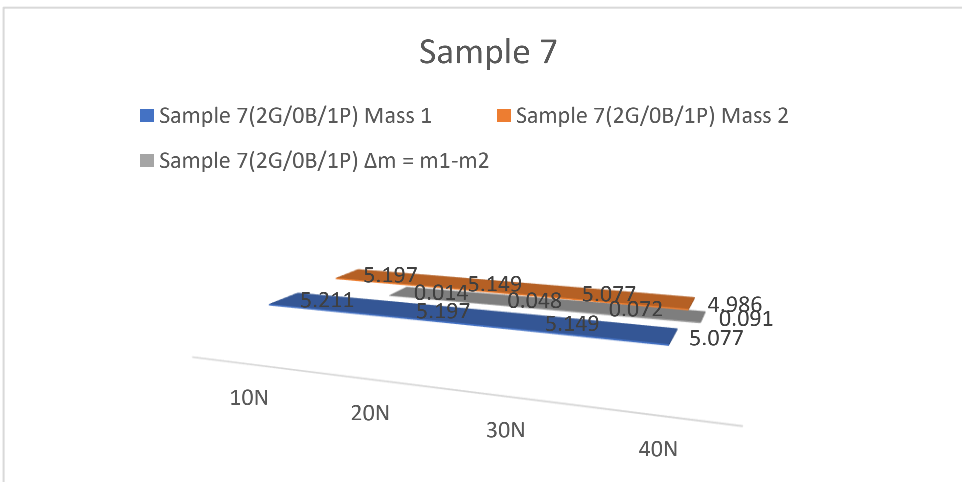
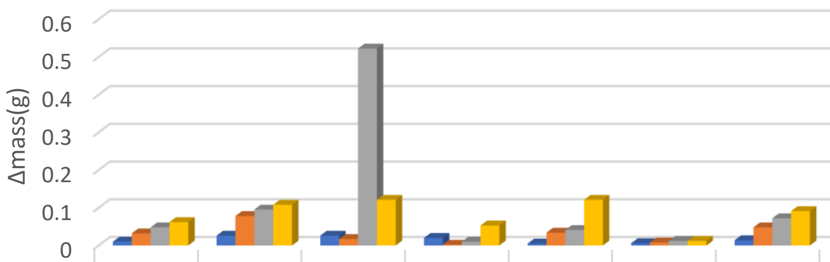
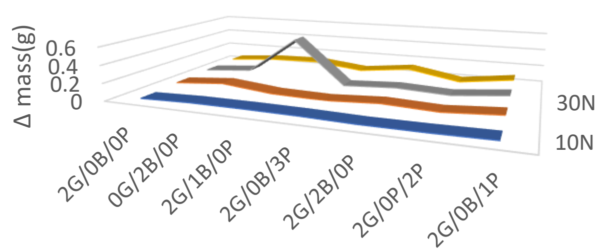

Sample 7
Sample 7(2G/0B/1P) Mass 1
Sample 7(2G/0B/1P) Mass 2
Sample 7(2G/0B/1P) Δm = m1-m2
5.197
5.149
5.077
4.986
5.211
0.014
5.197
0.048
5.149
0.072
0.091
5.077
10N
20N
30N
40N

Chart Title

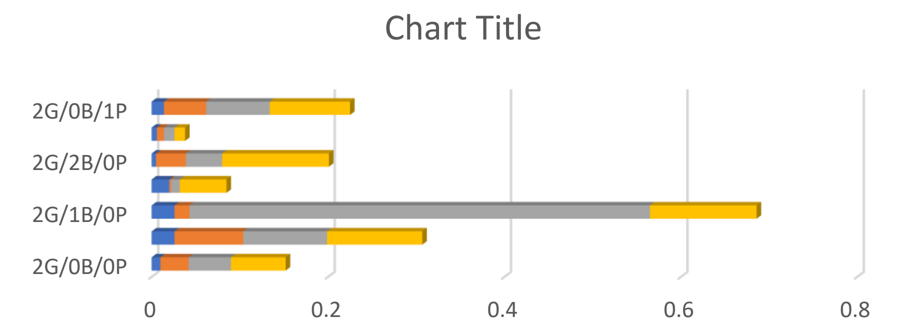


	2G/0B/0P	0G/2B/0P	2G/1B/0P	2G/0B/3P	2G/2B/0P	2G/0P/2P	2G/0B/1P
10N	0.01	0.026	0.026	0.02	0.005	0.006	0.014
20N	0.032	0.078	0.017	0.002	0.034	0.008	0.048
30N	0.048	0.095	0.522	0.01	0.041	0.012	0.072
40N	0.062	0.108	0.121	0.053	0.121	0.012	0.091

Chart Title



	2G/0B/0P	0G/2B/0P	2G/1B/0P	2G/0B/3P	2G/2B/0P	2G/0P/2P	2G/0B/1P
10N	0.01	0.026	0.026	0.02	0.005	0.006	0.014
20N	0.032	0.078	0.017	0.002	0.034	0.008	0.048
30N	0.048	0.095	0.522	0.01	0.041	0.012	0.072
40N	0.062	0.108	0.121	0.053	0.121	0.012	0.091



	2G/0B/0P	0G/2B/0P	2G/1B/0P	2G/0B/3P	2G/2B/0P	2G/0P/2P	2G/0B/1P
10N	0.01	0.026	0.026	0.02	0.005	0.006	0.014
20N	0.032	0.078	0.017	0.002	0.034	0.008	0.048
30N	0.048	0.095	0.522	0.01	0.041	0.012	0.072
40N	0.062	0.108	0.121	0.053	0.121	0.012	0.091

TENSILE TESTING DATA :-

1) **2G**

Input Data :-

Width = 20mm

Thickness = 5mm

Gauge length = 40mm

1. **Sample 1 :**

   Result of tension tests :-

   Maximum force = 3125 N

   Tensile strength = 31.25 MPa

   Elongation = 4.750 %

2. **Sample 2 :**

   Result of tension tests :-

   Maximum force = 3260 N

   Tensile strength = 32.60 MPa

   Elongation = 5.075 %

2) **2G/1B**

Input Data :-

Width = 20mm

Thickness = 10mm

Gauge Length = 40mm

1. **Sample 1:**

   Result of tension tests :-

   Maximum force = 5060 N

   Tensile strength = 25.300 MPa

   Elongation = 9.075%

2. **Sample 2 :**
   Result of tension test :-
   Maximum force = 2245.0 N
   Tensile strength = 22.450 MPa
   Elongation = 3.125%

3) 2G/2B

Input Data :-

Width = 20 mm
Thickness = 10 mm
Elongation = 40 mm

1. **Sample 1 :**
   Result of tension tests :-
   Maximum force = 7480 N
   Tensile strength = 37.4 MPa
   Elongation = 9.875 %
2. **Sample 2 :**
   Result of tension tests :-
   Maximum force = 4665 N
   Tensile strength = 23.325 MPa
   Elongation = 10.55%

<u>Grewia optima and pine fiber reinforcement polymer composite sample test</u>

1) **2G/1P :-**
   Input Data :-
   Width = 20 mm
   Thickness =10 mm
   Gauge Length = 40 mm

1. **Sample 1 :-**
   Result of tensile tests :-
   Maximum force = 6885 N
   Tensile strength = 34.425 MPa
   Elongation = 2.8 %
2. **Sample 2 :-**
   Result of tensile tests :-
   Maximum force = 1940 N
   Tensile strength = 19.4 MPa
   Elongation = 2.8 %

2) **2G/2P :-**
   Input Data:-
   Width = 20 mm
   Thickness = 10 mm
   Gauge Length = 40 mm

   1. **Sample 1:-**

Result of tensile tests :-
Maximum force = 4485 N
Tensile strength = 22.425 MPa
Elongation = 5.4%

2. **Sample 2:-**
   Result of tensile tests :-
   Maximum force = 4500 N
   Tensile Strength = 23.625 MPa
   Elongation = 5.6 %

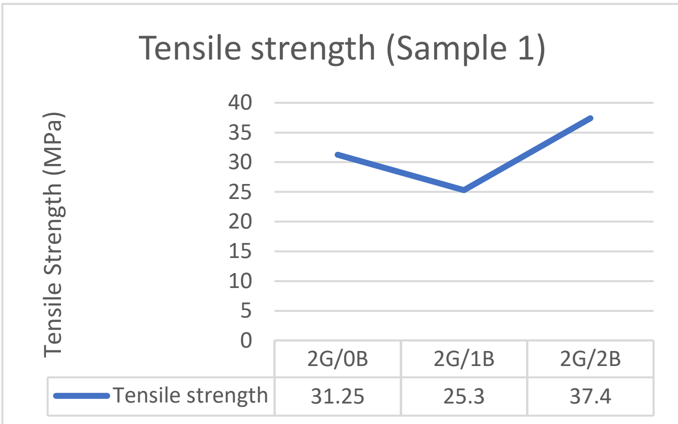
3) **2G/3P :-**
   Input Data :-
   Width = 20 mm
   Thickness = 10 mm
   Gauge Length = 40 mm

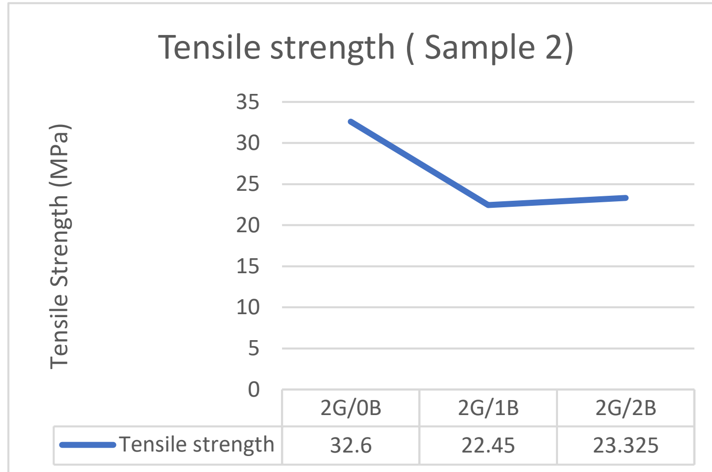
1. **Sample 1 :-**
   Result of tensile tests:-
   Maximum force = 8150 N
   Tensile strength = 40.75 MPa
   Elongation = 6.025 %
2. **Sample 2 :-**
   Result of tensile tests :-
   Maximum force = 8465 N
   Tensile strength = 42.325 MPa
   Elongation = 2.4 %

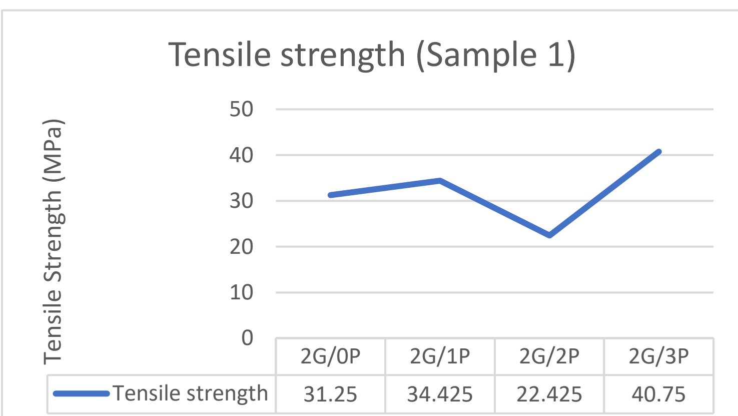
Basalt fiber composites tensile tests :-

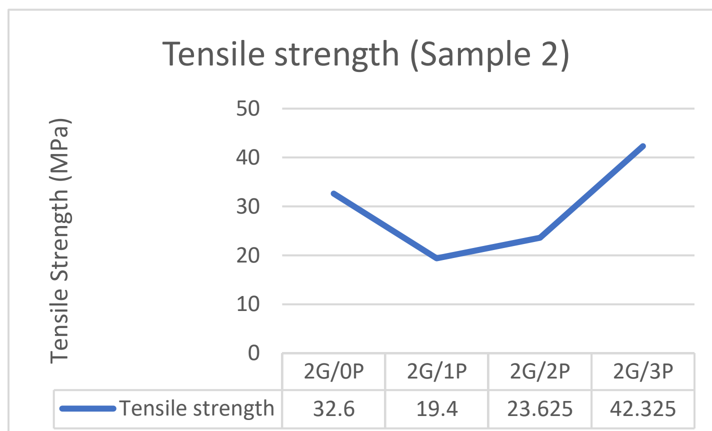
1) **2B :-**
   Input Data :-
   Width = 20 mm
   Thickness = 5 mm
   Gauge Length = 40 mm

1. **Sample 1:-**
   Result of tensile tests:-
   Maximum force = 4005 N
   Tensile Strength = 40.05 MPa
   Elongation = 4.925 %
2. **Sample 2:-**
   Result of tensile tests:-
   Maximum force = 3420 N
   Tensile strength = 34.2MPa
   Elongation = 4.85 %


Tensile strength (Sample 1)
Tensile Strength (MPa)
40
35
30
25
20
15
10
5
0
2G/0B
2G/1B
2G/2B
Tensile strength
31.25
25.3
37.4


Tensile strength (Sample 2)
Tensile Strength (MPa)
35
30
25
20
15
10
5
0
2G/0B
2G/1B
2G/2B
Tensile strength
32.6
22.45
23.325


Tensile strength (Sample 1)
Tensile Strength (MPa)
50
40
30
20
10
0
2G/0P
2G/1P
2G/2P
2G/3P
Tensile strength
31.25
34.425
22.425
40.75


Tensile strength (Sample 2)
Tensile Strength (MPa)
50
40
30
20
10
0
2G/0P
2G/1P
2G/2P
2G/3P
Tensile strength
32.6
19.4
23.625
42.325

CONCLUSIONS

In this paper we have reviewed works on mechanical properties of the polymer-based composites. These include jute fiber, banana fibre and bast fibre . We have explained their mechanical properties and methodologies for making such a composite material. We have reviewed works on the development of novel hybrid composites from natural fibers and investigated its mechanical properties. We have reviewed works on making natural fibers using sugarcane baggage and palm sheath and investigated their performance and properties. We have reviewed works on vinyl ester resin and polyurethane inter penetrating polymer networks. We have reviewed works on surface treated carbon fiber consisting of HSCF and differential proportions of calcium carbonate particles. We have reviewed works on bio-composites, biodegradable polymers, natural fibers and their manufacturing techniques using various surface modeling procedures. We have reviewed the work on outdoor qualities of natural fibers based composites with methods of decreasing outdoor limitations. We have reviewed works on making natural fibers using plant seed oil through its triglyceride content. We have studied the properties of composites made from natural fibers and bio-based material and its application in transportation and structure application. We have made natural fiber reinforced composites material using basalt fiber and grewia optiva fiber using mixture of epoxy and hardener for mechanical properties testing. The influence of natural bast fiber (*grewia optiva* and *Basalt*) on mechanical properties of GOB composites is systematically examined. The optimum values of mechanical properties such as tensile strength, flexural strength, and hardness are achieved for GOB-3 composites. We have also made natural fiber composite material using pineapple fiber and Grewia optiva fiber using mixture of epoxy and hardener for mechanical properties testing and systematically examining their mechanical properties. We have achieved their mechanical properties upto GOP-3 composites.

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