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Analysis of Mechanical Properties of Coir/Portland Pozzolana Reinforced Polymer Matrix Composites

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ABSTRACT

The current analysis deals with the fabrication of the composite sheets with the epoxy reinforced with natural fiber, Coir and the Portland pozzolana. In today's time composite material plays a very important role in engineering application. we can replace the wood with the composite, even the composite is a recyclable. Fields like the aerospace and automobiles sectors always need the lighter weight material with good strength. Many of the parts are complex which can be made by the forming process. A matrix is prepared by using epoxy resin and when it comes to the reinforcement material it could be the natural or artificial fibers. In this we have used the coir (coconut husk) and Portland pozzolana particles. To make the composite traditional hand lay-up process method was used. After that mechanical performance was analyzed by testing the flexural strength and impact strength of samples. Polymer matrix composite is light weight with the good strength and have various mechanical abilities. It is found that coir/epoxy composite sample plates have the higher flexural strength and impact strength, and Portland pozzolana have the highest flexural modulus which proved that abovesaid composites are great alternatives to wood and plastics and over other metals.

Keywords - Fibre Coir, matrix, reinforcement, Portland pozzolana, epoxy, flexural strength, impact strength

1. Introduction

Natural fiber-reinforced composite materials have drawn attention on a regular basis because of its potential for industrial use. Natural fibers are relatively inexpensive, renewable, fully/partially recyclable, biodegradable, and environmentally benign, while synthetic materials lack these qualities [1-2]. The insertion of reinforcements of good tensile strength, of very high modules in a polymer matrix, makes it possible to improve the mechanical and thermal qualities [3-4]. The main sources of filler materials for bio composite products are lignocellulosic fibers like flax, hemp, ramie, kenaf, jute, coir, hard and softwood materials, and rice husk [5-6]. In comparison to synthetic fibers like glass, carbon, nylon, and aramid, their affordability, lower density, and general convenient mechanical properties have made them appealing ecological materials. Natural fibers have a long history of use in a variety of products, including clothing, building materials, and dwellings [7]. Natural fiber-reinforced composites have become extremely popular for many uses in recent years, due to their good characteristics. Natural fiber-reinforced composites are employed in a variety of industries, including the automotive, aerospace, building and construction, consumer goods, packaging, and bio medicine. Animal, vegetable, and mineral fibers are just a few of the various groups that natural fibers fall under. There are also subcategories for seed, bast, stalk, grass/reeds, wood (hard and soft), and leaf fibers [8]. According to research, over 50 million coconuts are produced worldwide each year, producing enormous amounts of coir [9]. Pozzolanic minerals are added to regular Portland Cement to create Portland Pozzolana Cement (PPC). The synthetic pozzolana materials utilized in the production of PPC, including as fly ash, silica fume, rice husk and blast furnace slag, are actually industrial waste that is generated in significant quantities. When used in concrete, these synthetic pozzolana materials can reduce the demand on natural resources, lessen the impact of pollutants on the environment, and they are both dependable and affordable. Natural fibers have low density, high specific strength and provide good thermal and acoustical insulation. The natural fiber is derived either from plants or animals [21]. By incorporating pozzolanic elements into regular Portland Cement, Portland Pozzolana Cement (PPC) is created. Fly ash, silica fume, rice husk and blast furnace slag are examples of artificial pozzolana materials used in the production of PPC. These materials are essentially industrial waste that is produced in vast quantities [10]. A composite usually consists of three parts: (i) the matrix as the continuous phase; (ii) the reinforcements as the irregular or dispersed phase, which includes fiber and particles; and (iii) the fine interphase area, often known as the interface [11-12]. Engineers can modify the qualities to satisfy particular requirements by carefully selecting the matrix, the reinforcement, and the manufacturing method that unites them [13]. Structure-wise, polymers are more complicated than metals or ceramics. However, the strength, modulus, and temperature limitations of polymers are lower. Polymer characteristics deteriorate due to prolonged UV exposure and certain chemicals. Polymers perform poorly as heat and electricity conductors because they primarily rely covalent bonding. Metals are less resistant to chemicals than polymers, though. Macromolecules are huge, chain-like molecules known as polymers. Polymerization, or the uniting of many monomers to form polymers, is the process by which big molecules are created from tiny ones. The thermoset and thermoplastic resins are the two types of polymers used to make advanced PMCs.

To make the composite material we have used LY-556(Resin), HY-951(Hardener) and reinforcement as the coir and black cement. There are two types of the reinforcement material natural and artificial. Natural materials include coir, husk, bamboo etc. and whereas the artificial are carbon fiber, glass fiber, silica etc.

The properties of composite materials are different from the base material which makes the composites more useful and due these properties there is a wide application of composite materials such as in aerospace, marine, IC engine, automobile, machine components, train, etc.There are several other applications of composites in the areas such as air-foil surfaces, antenna structures, compressor blades, engine bay doors, fan blades, flywheels, helicopter transmission structures, jet engines, radar, rocket engines, solar reflectors, satellite structures, turbine blades, turbine shafts, rotor shafts in helicopters, wing box [22-22].
The composite plates which are made of coir and Portland pozzolana we have done the testing of flexural strength and impact strength so that we can get to know which strength holds better on our composite plates.

1.1 Significance of flexural strength

The flexure test method evaluates the response of materials under straightforward beam loading. In the case of particular materials, it is also known as a transverse beam test [14]. For each increase of load, the maximum fiber stress and strain are determined. A stress-strain diagram displays the results. Maximum tension in the outermost fiber is what is meant by "flexural strength." This is computed at the specimen's surface on the concave or tension side. Flexural or compressive strength is a mechanical measurement of a material's highest load bearing capacity without suffering any long-term degradation [15]. The flexural testing machine is shown in fig (1).

Fig (1) Flexural Testing Machine

Fig (2) Impact testing Machine

1.2 Significance of impact strength

To create a dependable and cost-efficient design, it is essential to comprehend the damage and failures of composite materials. The degree of structural deterioration and the kind of damage are often influenced by the impact response's properties [16]. Understanding the characteristics and physical factors that affect impact response is crucial. We must find, define, quantify, and localize the impact harm. The sorts of damages in composite materials, as well as impact damage's classification in composite materials, are presented in this paper. The impact testing machine is in above fig (2).

2. Materials and Methods

2.1 Materials

For fabrication of component, diglyceryl-ether of bisphenol an epoxy (DGEBA, LY556, specific gravity of 1.16) and triethylenetetramine hardener (TETA, HY951, specific gravity of 0.95) was used as a curing agent. Epoxy resin and hardener both were mixed in the beaker with the help of stir in 10:1 by volume. For the reinforcement we have used coir (coconut husk) and Portland pozzolana both of the reinforcement is purchased from the local shop.

2.2 Fabrication of composite

Hand lay-up method is used for the fabrication of Composite material [17]. Initially we made a square mold of steel with the dimension of 150mm*150mm, and applied grease so that we can easily and quickly remove the composite plate from the mold, as grease doesn't allow the composite to stick to the mold. Epoxy (LY554/6 and Hardener (HY951) taken in the ratio of 10 :1 and mixed in a beaker by using stir, till when realize that it becomes a solution. Then first layer of epoxy resin is poured on the mold and above it a layer of coir /black cement which we used as reinforcement is applied uniformly, after then second layer of epoxy resin is poured on it, and wait till the bubbles comes out, the bubbles are removed by using needle, the concept of removing bubbles is that, it protects the composite from holes, irregularities and cracks. The mold is enclosed with a plate before covering with the plate we have to apply the grease on the side of the plate so that when the plate is formed it would be easy to remove the plate from the composite plate and a weight is laid on it to compress the mold. To get hold of around 48 to 72 hours to cure. The composite material part is then cured, cooled and removed from the mold. [18-19]

When the composites plates are cured, the plates are cut into the standard sizes according to ASTM standards and tested. There are some figures which are made by the coir and the port -land pozzolana.

(a) Primary Composite (b) Coir Composite (c)Portland pozzolana Composite

Fig 3. Final fabricated composite plates

3. Testing of Composites

Three samples were prepared with different fibers:

a. Sample 1: Epoxy resin composite

b. Sample 2: Coir and epoxy composite

c. Sample 3: Portland pozzolana composite

Tests conducted on the above prepared composite plates are flexural strength, flexural modulus and impact strength.

Table 1. Type of tests as per ASTM standards:

S. No.	Type of tests	ASTM standards
1.	Flexural Strength	ASTM 790 D
2.	Flexural Modulus	ASTM 790 D
3.	Impact Strength	ASTM 256 D

Table 2. Test results of composite samples:

Material	Flexural strength (MPa)	Flexural Modulus (MPa)	Impact Strength (Izod) (kJ/m^2)
Sample 1 (epoxy and hardener)	23.32	3091.1	1.64
Sample 2 (coir and epoxy)	88.01	3814.9	3.28
Sample 3 (Portland pozzolana and epoxy)	35.74	5344.8	1.48

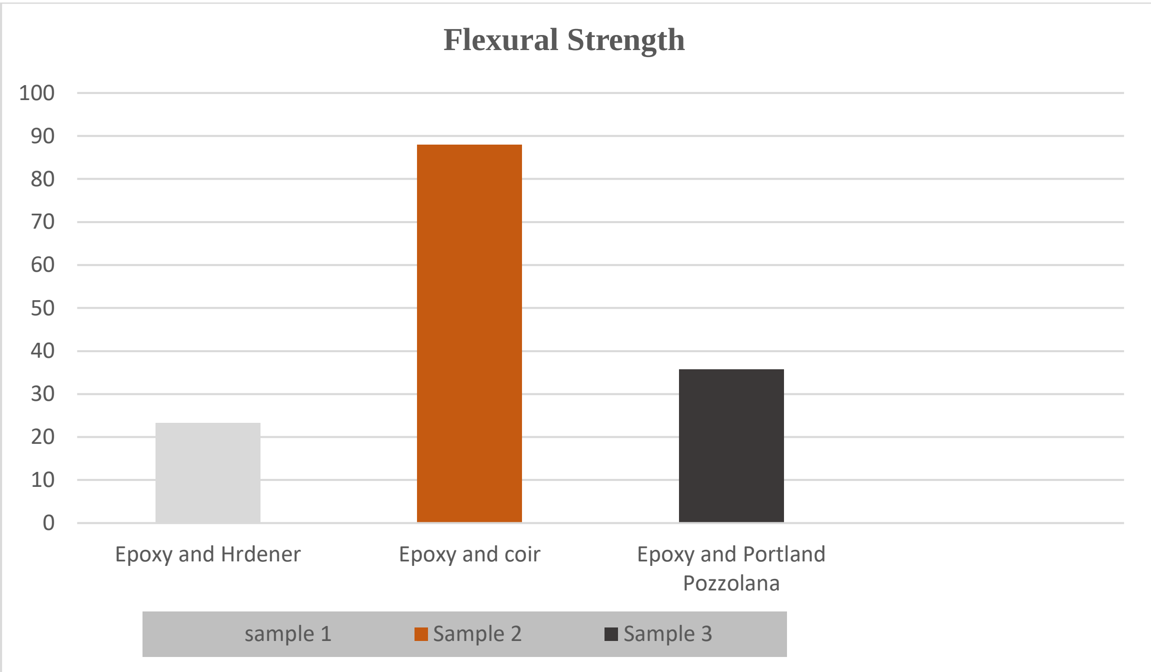

Fig 2. Flexural Strength of Sample 1,2 and 3

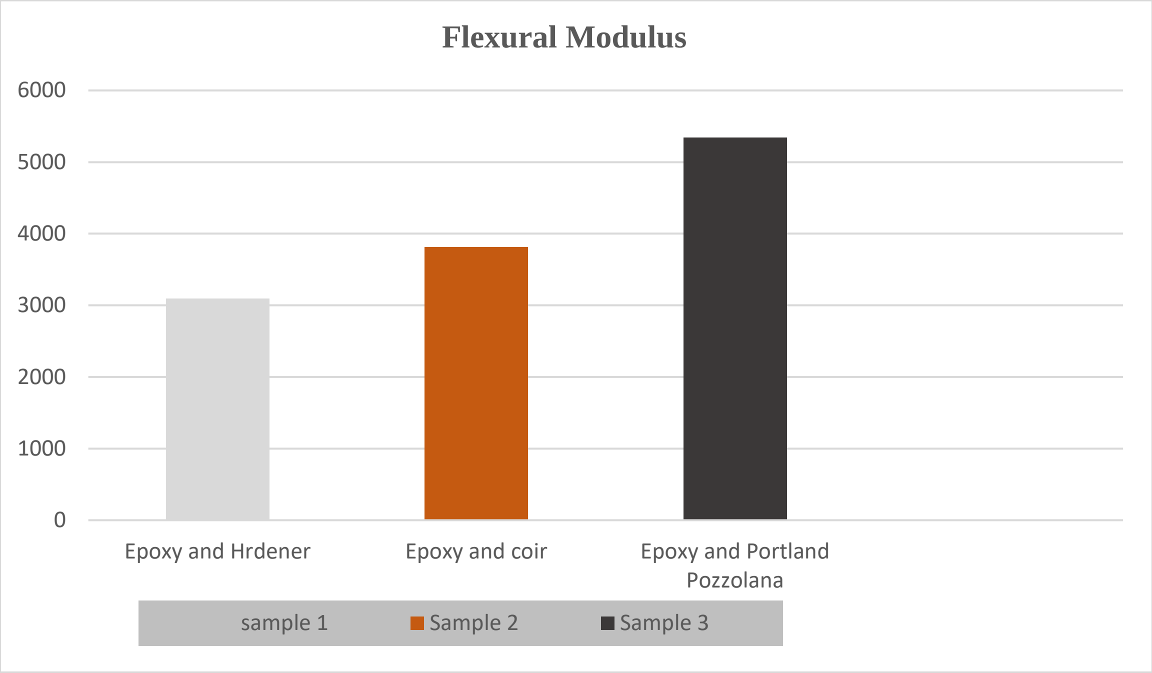

Fig 3. Flexural Modulus of Sample 1,2 and 3

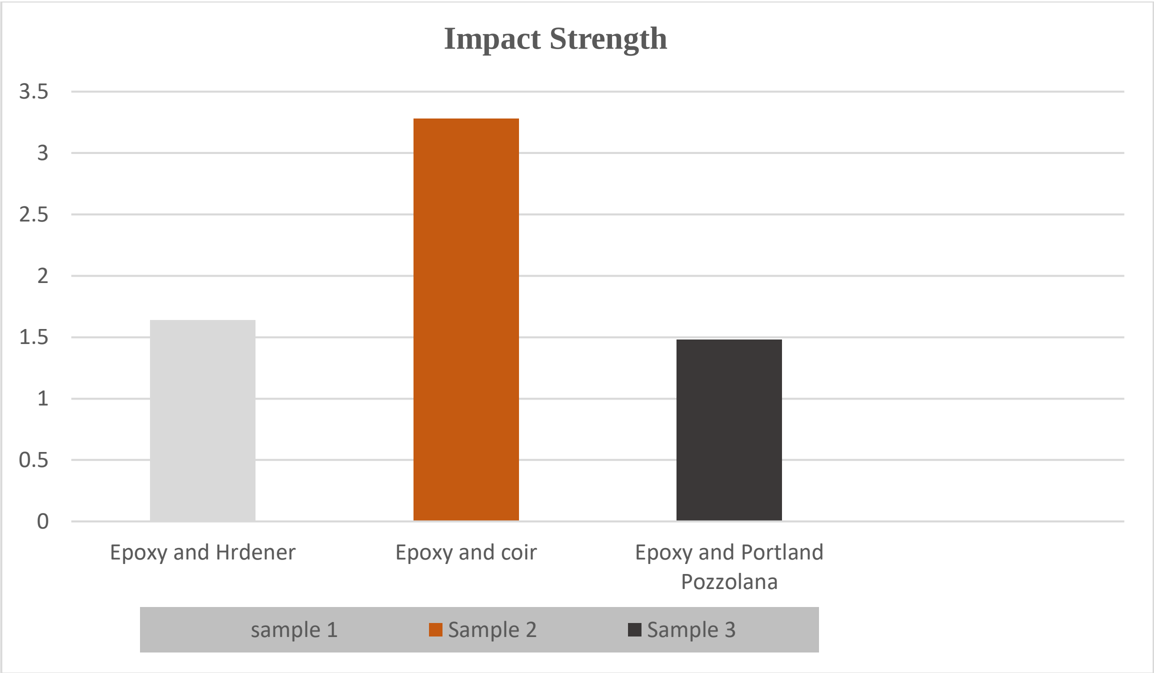

Fig 4. Impact Strength of Sample 1,2 and 3

4. Result and discussion

All the three composite samples are tested as per the above given table 1. All the tests were done in the ASTM standards in the laboratory. **Table 2** shows the summarized results of the tests. The test results are also showed with the help of bar graph fig **[2-4]**. The test results shows that the coir composite polymer specimen (sample 1) is stronger than the other composites.

From **fig. 2.** We get to know that the flexural strength of coir composite is more than the other two composites i.e. 88.01MPa. The coir fiber contains cellulose, hemi cellulose and lignin (the fiber contains 30 to 300 or more cells in its total cross-section) and its cross-section is polygonal or round [22].

From **fig. 3.** It was observed that the flexural modulus of coir and Portland pozzolana composites is higher than primary epoxy composite (sample 1), it indicates that Coir (sample 2) and Portland Pozzolana (sample 3) composites have higher tendency to bend when a given amount of bending stress is applied.

From **fig. 4.** we have got that the impact strength of coir composite (sample 2) is higher than the other two composites. The impact strength of Coir Composite is found to be 3.28kj/m^2 which is the highest among the three samples.

Conclusion

Coir/epoxy resin and Portland Pozzolana/epoxy resin, based composites were fabricated by hand lay-up method by mixing 30% coir and 30% Portland Pozzolana as a reinforcement, we found that the coir, which is a natural reinforcement has higher mechanical properties than synthetic reinforcement like Portland Pozzolana which resulted in higher flexural and impact strength of coir composite. The value obtained from the test of flexural strength is 88.01 MPa, and the impact strength value is 3.28KJ/m^2 of the coir composite. Coir/epoxy may perform better than Portland Pozzolana when choosing a material having high flexural and impact strengths, compared to Portland pozzolana composites coir composite would make an effective reinforcement for creating composites. The desire for bio composites in various applications due to the need for green composites in automobile, packaging, electronics, health, and structural industries has further increased the interest of researchers in the use of bio fibres.

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