

# Investigation on Mechanical Properties of Coir Fiber Reinforced Polymer Resin Composites Saturated with Different Filling Agents

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**Abstract:** The main objective of this research article is to assess the mechanical properties and fracture analysis of bone and sea shell powders independently integrated with coir fiber polymer composites. The specimen was fabricated with coir fiber at various dimensions of coir fiber like diameter, length, content and mesh size of the powder. Tensile, compressive, flexural and impact tests were conducted in the prepared composite materials as per the techniques of ASTM standard. The fracture faces were explored with the help of SEM images. From the final results it was concluded that the sea shell powder composite provides good tensile and flexural strength than bone powder composite, while bone powder composite material gives good compressive and impact strength than sea shell powder composite material.

**Keywords:** Composite, Mechanical Properties, Coir Fiber, Bone and Sea Shell Powder, SEM

## 1. INTRODUCTION

Composite materials play an vital role in the area of engineering applications due to the ease in making multifaceted shape of materials and their high tensile and compressive strength [1]-[3]. A mixture of more than two materials differing in form or composition on a macro scale is called as composite materials, which exhibits better characteristics than that of the individual material [4]-[6]. In general, there are two phases in a composite such as reinforcing phase and matrix phase. Reinforcing materials are used to carry the loads and material matrix is used to join and transmit the load to fibers. In recent days the composites based on polymer are mostly utilized because of their superior mechanical properties as compared with other composites [7], [8]. Due to extensive appliances of polymer composites, it is very much encouraging to study on the deployment of local cheap renewable sources of fiber and fillers available for polymer matrix composite (PMC) manufacturing [9]-[11]. Fillers are simply increase the bulk volume which results in reduction of price are called as extender fillers at the same time as those which enhance the mechanical properties, mainly tensile strength are termed as reinforcing fillers. Several million metric tons of fillers and reinforcements are used annually by the plastic industry. In plastics the usage of these additives is likely to rise with the introduction of improved compounding agents that permit the



use of high filler/ reinforcement content [12], [13]. An experimental analysis was carried out on the heat transfer of nanofluids using carbon nanotubes and the results reveals that the addition of carbon nanotube to the E- Glass fiber composites increased the flexural properties [14]. An analysis was carried on erosion in fibre and particulate filled PMCs with the new concepts of strength improvement [15]. In general, particles have more strength which acts as a reinforcement in PMCs. In these laminations, 75 $\mu$ m sized composite gives better results when compared to other size of particles content composites [16]-[18]. Based on the above mentioned factors this work was taken up to develop a coir fiber based hybrid composite using sea shell powder (SSP) and bone powder (BP) as filling agent. The composites were prepared with different layers and the mechanical properties of the BP mixed composite and SSP added coir fiber composite were studied with ASTM standards and SEM.

## 2. MATERIALS AND METHODS

The bone acquired from animals can be crushed up to 425 $\mu$ , the collective usage of BP particles controls crack development in plastic shrinkage at an early age. BP is very much attractive product since it has low thermal conductivity and bulk density. The addition of BP increases the thermal capacity of the composite specimens and yielded a light weight product. Here 100 $\mu$ m particle sized BP was used to fabricate the composite. SSP is a strong material available in sea shore. The sea shell was crushed and pulverized using ball mill and the powder was sieved and 100 $\mu$ m particle sized SSP was used for the development of the composite laminates. Coir fiber is a reinforced material, a natural product available from coconut. It is generally differentiable by its length and its diameter. The available length of the coir is normally between 10mm to 150mm and for our experimental specimen fabrication 50mm length was chosen. Similarly, the obtainable diameter of coir fiber is between 0.1mm to 3mm and we have selected 0.5mm diameter for fabrication of the composite laminates. Orthothlic polyester resin was used as a matrix, cobalt naphthanate acts as an accelerator and methyl ethyl ketone peroxide (MEKTP) acts as a catalyst. Accelerator and catalyst were mixed with the resin, and were used to start and finish the curing process. Polyester is widely used as matrix for fiber reinforced PMCs and also as structural adhesives. Fiber-reinforced orthothlic polyester resin matrix composite is preferred in load bearing frame works such as aircrafts, automotive, buildings and ships comparative to conventional massive and uniform materials such as wood and metals because of their greater chemical and mechanical properties and also due to their high strength to weight ratios.

Hand lay-up method was used to fabricate the composite material which is one of the well known processes of open molding and simplest technique for fabrication of the PMCs. It is a slow, manual and labour consuming method. The resin and the powder contents were mixed in the % of weight ratio 70:30. The anti adhesive agent was coated on the mould to avoid sticking of the constituent on the surface of the mould. The prime surface coating of the component was formed when the gel coating was applied. The accelerator and catalyst were mixed with polyester resin in proper ratio, this proportion works to bind the materials. Then the prepared powder content was mixed with the binding materials. Coir fiber was spread over the mould. Then the mixture of resin and powder was poured into the mould without any space. The roller was rotated in the mould cavity. The lid was placed on the top of the mould frame which helps to distribute the binding material in the full area of the frame and the load was uniformly applied on the

mould. The set of connections was kept in the dry place for 24 hours. The curing product was taken away from the mould after 24 hours. At last, the PMC was fabricated. Two types of laminates were prepared with the below mentioned % of weight, BP and coir fiber with 15% of weight each and polyester resin composite with 70% of weight. Similarly coir fiber and coconut shell powder with 15% of weight each and polyester resin composite with 70% of weight were prepared. Finally, the laminate was cut by the cutter machine in various shapes and sizes according to the test standards.

### 3. RESULTS AND DISCUSSION

All the five fabricated specimens were tested individually and the results with various mechanical properties results were obtained. The observed results of BP fiber reinforced polymer composite (FRPC) are given in Table I. Similarly the results of SSP FRPC are given in Table II. The average values were taken for the analysis.

#### 3.1 Tensile Strength and Compressive Strength

The tensile strength of BP and SSP composites were compared and the results are given in Fig. 1. The average tensile strength value of BP based composite and SSP based composite was 27.464Mpa and 31.004MPa respectively and it was found that the tensile strength of the SSP composite was better than BP composite. Similarly the compressive strength of BP and SSP composites were calculated and the comparison results are given in Fig. 2. It was found that the average compressive strength value of BP based composite and SSP based composite was 59.228Mpa and 55.440MPa respectively and it was found that the compressive strength of the BP composite was better than SSP composite.

Table I. Mechanical Properties of BP FRPC

Specimen	Tensile Strength (MPa)	Compressive Strength (MPa)	Flexural Strength (MPa)	Impact Strength (MPa)
BP1	26.43	58.23	52.56	70.11
BP2	28.28	61.11	54.67	68.01
BP3	27.08	57.63	53.36	68.45
BP4	27.16	59.41	51.23	65.89
BP5	28.37	59.76	51.05	67.55
<b>Average</b>	<b>27.464</b>	<b>59.228</b>	<b>52.574</b>	<b>68.002</b>

Table II. Mechanical Properties of SSP FRPC

Specimen	Tensile Strength (MPa)	Compressive Strength (MPa)	Flexural Strength (MPa)	Impact Strength (MPa)
SSP1	31.32	54.37	54.34	61.12
SSP2	30.71	55.63	56.11	61.45
SSP3	32.06	53.86	55.76	62.37
SSP4	31.04	57.45	58.63	60.38
SSP5	29.89	55.89	56.03	60.45
<b>Average</b>	<b>31.004</b>	<b>55.44</b>	<b>56.174</b>	<b>61.154</b>

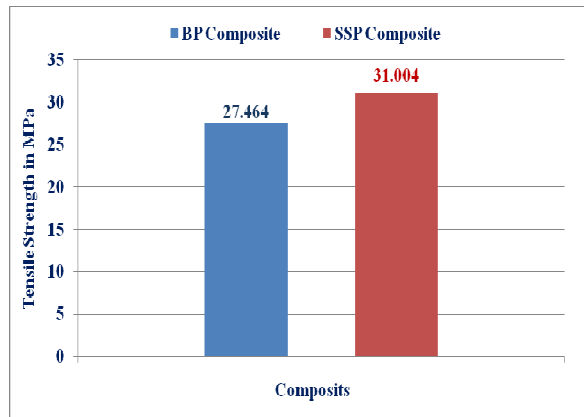


Fig. 1 Average Values of Tensile Strength

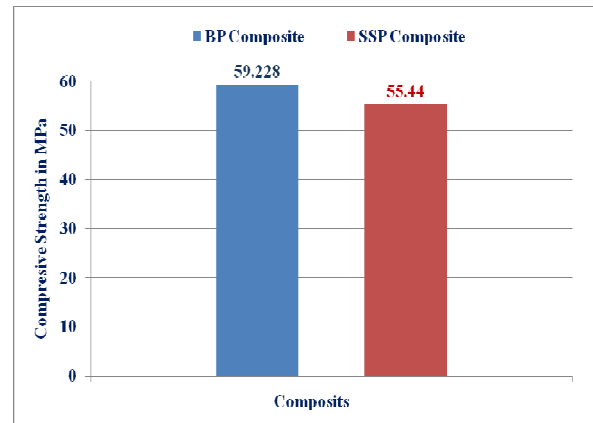


Fig. 2 Average Values of Compressive

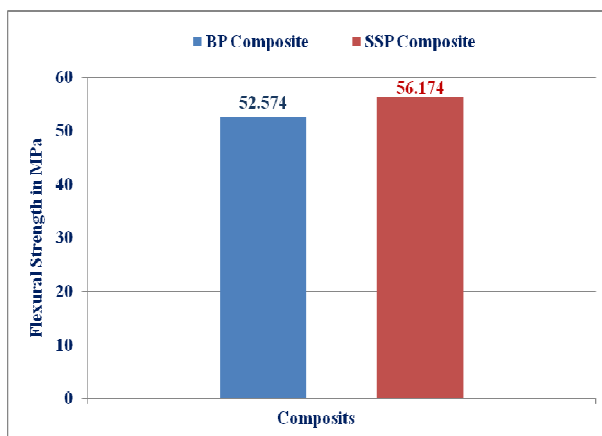


Fig. 3 Average Values of Flexural Strength

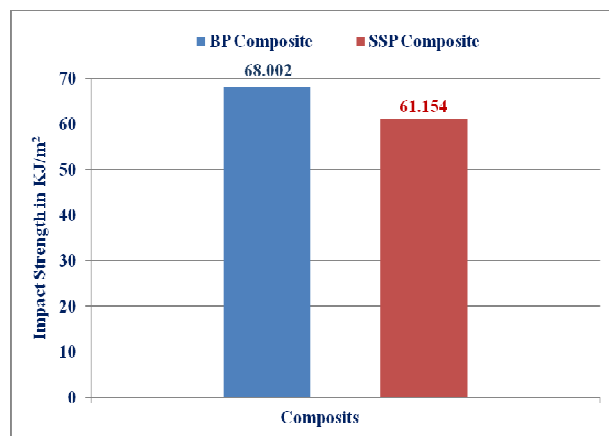


Fig. 4 Average Values of Impact Strength

### 3.2 Flexural Strength and Impact Strength

The flexural strength of BP and SSP composites were calculated and the comparison results are given in Fig. 3. From the figure, it was observed that the average flexural strength value of BP based and SSP based composites was 52.574Mpa and 56.174MPa respectively and it was found that the flexural strength of the SSP composite was better than BP composite. Similarly the impact strength of BP and SSP composites were calculated and shown in Fig. 4. It was found that the average impact strength of BP based and SSP based composites was 68.002kJ/m<sup>2</sup> and 61.154kJ/m<sup>2</sup> respectively and it was observed that the impact strength of the BP composite was better than SSP composite.

### 3.3 Characterization of Composites

The microstructure compositions of the phases present in the SSP based composite was studied using Scanning Electron Microscope equipment. The analyzing specimen was placed over the sample holder and the images were captured under a variety of magnifications. Microscopic layer is composed of parallel rows of first-order lamellae and the first order lamellae in the middle

layer are oriented  $90^\circ$  to the first order lamellae in the inner and outer layers. Each first-order lamella in turn is composed of parallel rows of second-order lamellae, which are oriented  $45^\circ$  to the first-order lamellae. The second-order lamellae are further subdivided into third-order lamellae. The basic building blocks are the third order lath-shaped aragonite crystals with internal twins. In particular, in the middle layer the second-order lamellae are alternating the first-order lamellae by  $90^\circ$  rotation. As far as the field stress is increased on the fracture specimen, a white region appears and progressively increases in size. This whitening is an indication of tablet sliding and inelastic deformations, with the voids left by tablet separation scattering light (this phenomenon is similar to stress whitening associated with crazing in polymers). In the literature dealing with fracture mechanics, such as inelastic region is referred to as the process zone. Fig. 5 to Fig. 12 shows the Scanning Electron Microscope (SEM) images of fractured surfaces of BP based composite as well as SSP based composite after the mechanical testing.

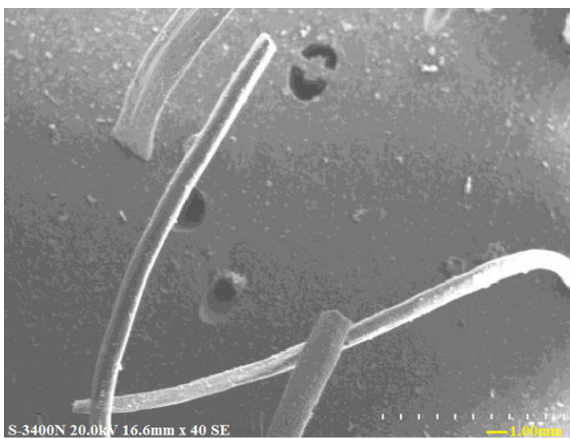


Fig. 5 SEM Image of BP Based Composite



Fig. 6 SEM Image of SSP Based Composite

After the tensile test was carried out the SEM image of BP based composite was clearly identified and shown in Fig. 5. Similarly for SSP based composite the SEM image after tensile test was carried out and given in Fig. 6. From the SEM images it was clearly noticed that the composite particles and coir fiber were integrated with the PMC material. When these two composite materials were compared, the coir fiber was pulled out in more amounts from the BP based composite material during the tensile test hence there was a decrease in tensile strength of the BP based composite. Fig. 7 and Fig. 8 shows the SEM images of BP and SSP based composites after compressive test respectively. In general, bone material has more strength when compared with sea shell. Consequently BP based composite material offers good strength in compressive than the SSP based composite material.





Fig. 7 SEM Image of BP Based Composite

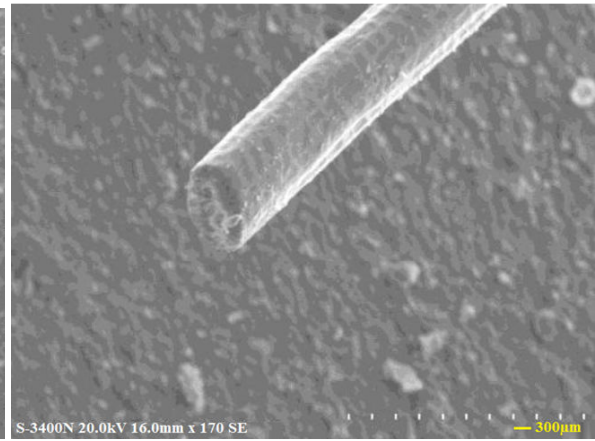


Fig. 8 SEM Image of SSP Based Composite

Flexural test SEM images of BP and SSP based composite materials are illustrated in Fig. 9 and Fig. 10 respectively. It was found that the coir fiber was pulled out from the composite material in BP based composite after the flexural test was done, but in the composite with SSP no blow holes were identified. Hence it was concluded that the composite with SSP provides better results over the composite material with BP during the flexural testing.



Fig. 9 SEM Image of BP Based Composite



Fig. 10 SEM Image of SSP Based Composite

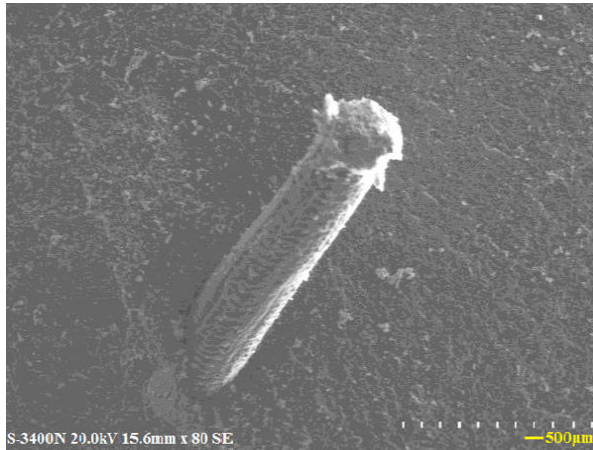


Fig. 11 SEM Image of BP Based Composite

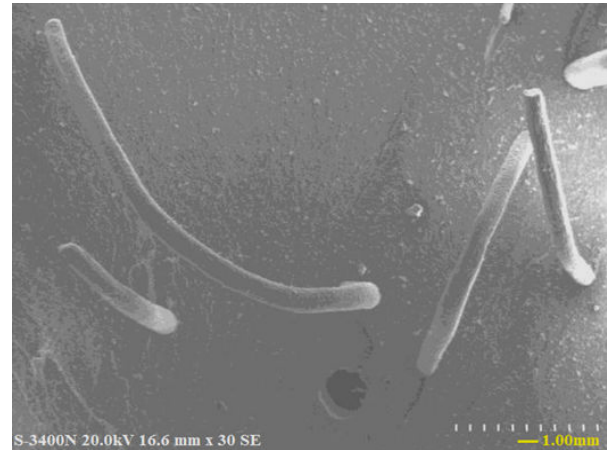


Fig. 12 SEM Image of SSP Based Composite

Similarly SEM images of BP based composite material and SSP based composite material after impact test is illustrated in Fig. 11 and Fig. 12 respectively. It was observed that the coir fiber was pulled out from the matrix material in the SSP based composites after the impact test. In the BP based composites, there was no pull out of fiber from the matrix and hence, fibers get expanded and rupture. So the impact strength was high in BP based composite material compared with SSP composite material.

#### 4. CONCLUSION

Based on the above experimental analysis of BP and SSP added coir fiber composite material, the following conclusions were made.

- From the results it was found that the SSP filled coir fiber composite provides better results when compared to BP filled coir fiber polyester composite when subjected to tensile and flexural test.
- Similarly it was observed that the BP filled coir fiber polyester composite provides better results when compared to SSP filled coir fiber composite when subjected to compressive and impact test.
- The fracture surfaces were analyzed through SEM images and the same results obtained through mechanical properties were observed.

The research may be extended through similar characteristics related to performance evaluation of composite materials with appropriate techniques.

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