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Water Absorption Behaviour of Tamarind Shell Powder and Marble Dust Particles Reinforced Hybrid Bio-Composites

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Abstract

A great gain has been made in recent years in the creation of hybrid bio-composites by combining different natural resources as reinforcement and filler elements. Experiments were conducted to investigate the impact of fine marble dust and tamarind shell powder on the epoxy resin matrix's water absorption capabilities. Marble dust and tamarind shell powder are utilised as reinforcing materials. To create hybrid bio-composite specimens, researchers varied the reinforcement material weight percentages while maintaining the epoxy resin weight percentage as-fixed. Conventional hand layup was used to create hybrid bio-composite boards. Due to the ASTM regulations, hybrid bio-composite specimens used for water absorption testing are sliced away using water jet machining. Hybrid bio-composites with 20 percent fine marble dust and 15 percent tamarind shell powder have improved water absorption characteristics significantly, according to experimental data.

Keywords: Coconut shell powder, marble dust powder,hybrid composites, water absorption behaviour, experimental study.

1. Introduction

Composites have been increasingly popular as a designer's material in recent years. A important factor in the development of light-weight, high-strength materials in the last 50 years has been the rise of polymer composites2. Biodegradable composites with improved mechanical qualities and reduced costs have been the goal of numerous researchers who have worked to define plentiful combinations of biodegradable matrix and natural fillers. Fillers are among the most important natural fibres studied in this field [1]. Many environmental benefits can be gained by using Natural Fillers (NF) reinforced products, reduced pollutants and greenhouse gas emissions as a result of less reliance on non-renewable materials. Organic lignocellulose fillers (such as flax, jute, hemp, and others) can replace synthetic reinforcing fibres in a way that is less harmful to the environment (glass, carbon). To put it simply, natural fillers are more cost-effective than standard ones since they have a higher toughness and corrosion resistance, as well as lower density. Fillers made from natural materials have a number of drawbacks, including surface defects conformance to hydrocolloids, varying fillers sizes, and deterioration by moisture. They also have a low tensile strength and heat dissipation, making them inappropriate for use in requiring high temperatures and degradable in the presence of water. The fibre surface qualities are therefore modified via chemical treatments [2]. There are two types of composites: those that can be dissolvable in water and those that can't be dissolvable at all. It is important to understand that composites consist of two phases: a propagation stage and a composite. The reinforcing phase is one component, while the matrix is the one in which it is embedded. Fiber and all the properties of the mixture are preserved in a composite, but the result is a unique amalgamation of traits that can't be attained by moreover constituent alone. Load-bearing fibres are the most common type of fibre. Load bearing capacity and protection of the fibres from external elements like contaminants, temperature or wetness are provided by the matrix.Fiber reinforced plastics (FRP) are generally acknowledged as materials for both structural and non-structural applications because of the usage of man-made fibres consisting of glass, carbon, boron, etc. Because of its excellent rigidity and strength to weight ratio, FRP has sparked a lot of interest because of its particular modulus. Because of their high cost, these materials cannot be used for other purposes and applications. Current research is focused on the utilisation of natural fibre materials such as banana and cotton in packing and less-cost housing. These natural fibre composites have been proved to be superior in case of electrical resilience, thermally and acoustical isolating characteristics, and fracture resistance [3, 4, and 5]. It was necessary to design new sample and procedures since advanced composite materials are anisotropic. Reinforcement fibres, matrix components, and mechanical performance have to be evaluated in a novel test. Test methods that have been designed to characterise the mechanical characteristics of various mechanical qualities are examined in this review of literature. Because of its less water absorption < 3% and lessdensity swelling rates<1%, Alok Singh and his colleagues discovered the bio composite material to be extremely stable. [1] Using plant-based fibres as a structural component in a composite shows that polymer matrix resins can benefit. As soon as Hayder Abbas Sallal reached a maximum weight proportion of nanofillers, the fracture toughness was maximised. In addition, the declining features of the constructed system were shown as the weight fraction increased. With increasing load proportions (coconut shell powder) up to 6% wt., compressive strength and impact energy were shown to increase. J. Olumuyiwa Agunsoye, et al. [7] found a decrease in porosity as the proportion of coconut shell powder increased. As a result of its hydrophobic properties, this composite can be used in the interior of an automobile. Tamarind shell powder and epoxy were tested for varied mechanical qualities by Srinivas K. R. [8] et al. [8] the best tensile strength was achieved in this experiment when the tamarind shell power and epoxy composition was 80 percent and 20 percent, respectively. An epoxy resin-based bio composite including peanuts shell powder was studied for its material properties [9]. Peanut shell powder was shown to greatly improve the mechanical characteristics of epoxy resin/banana fibre composites. Jute fiber-reinforced, eggshell-powdered epoxy resin bio composite materials were tested for mechanical properties [10]. The mechanical characteristics of epoxy resin/jute fibre composites were dramatically improved when egg shell powder was added to the mixture. Banana fibre reinforced, camellia sinensis particle-filled epoxy resin matrix bio composites were tested for impact and hardness. [11]The mechanical characteristics of epoxy resin/banana fibre composites are greatly improved when camellia sinensis particles are added. [12] The water absorption characteristics of treated and untreated hybrid bio-composites was studied experimentally. [13] The tensile characteristics of hybrid polymer composites was studied practically. [14] The flexural performance of epoxy matrix composites enhanced with chemically modified and unmodified banana fiber/used camellia sinensis particles was studied experimentally. [15] The effect of stacked double hydroxide on polymer Nanocomposites has been examined. The mechanical characteristics of jute fiber-reinforced epoxy resin matrix biocomposites packed with coconut shell particles were studied experimentally [16-21].Combining marble dust powder with tamarind shell ash with epoxy resin composites appears to be scarce in the literature review. The preparation and experimental testing of the water absorption capabilities of epoxy resin composites reinforced with marble dust powder particles and tamarind shell powder have been attempted as a result.

2. Materials and Methods

Local polymer product manufacturers in the Coimbatore region, TN, India, supplied the epoxy resin and hardener used as matrix ingredients. Using a mechanical stirring machine, epoxy resin and hardener were combined at a proportion of 12:01 in directive to achieve a strong bond with filler materials. Granite businesses provide the necessary quantity of marble dust powder. It has been obtained from oil mills in the Dharapuram district of TN, India, that employ tamarind shell powder as filler materials. The collected waste tamarind shells were first washed in In regular water, and then once again in boiling water to eliminate any remaining dust particles. It was allowed to dry in an open area at atmospheric temperature for seven hours after the washing procedure. After the drying process, the tamarind shell powder particles were ground in a flourmill. It has been used to grind the tamarind shell into a powder form by using a flourmill. Manual screening has resulted in the separation of tamarind shell powder into 85 micron-sized particles following the grinding process. All of the six composites' composition information were listed in table 1.

Table 1. Composition details of the composites in weight percentage basis

Sl.No.	Composite Description	Epoxy Resin	Marble Dust Powder	Tamarind Shell Powder
1	Composite - 1	65	35	0
2	Composite - 2	65	0	35
3	Composite - 3	65	17.5	17.5
4	Composite - 4	65	20	15
5	Composite - 5	65	22.5	12.5
6	Composite - 6	65	25	10

This method has yielded the necessary amount of fine tamarind shell particles. Marble powder, epoxy resin, and fine tamarind shell particles were combined with a compression moulding machine to create the composite plates in this study. In the first step of making composite plates, marble dust powder is placed in a machine that compresses it. On the compression-molding machine's surface table are powdered marble dust particles. Tamarind shell powders have totally diffused on the marble dust powder plates after this arrangement. The tamarind shell particles dispersed surface has been coated with an epoxy resin/hardener solution for a specific thickness. Marble dust powder and tamarind shell powders were applied to the epoxy resin/hardener solution and then deposited on the same tamarind shell powder-dispersed surface. The compression-moulding machine was allowed to heat the mate form of marble dust powder, epoxy resin, hardener, and tamarind shell to 145°C for 45 minutes under the specific hydraulic pressure. 120 minutes of processing produced the appropriate composite plates, which were then allowed to cool to room temperature for subsequent use. Upon completion of the cooling process, waterjet cutting has been used to remove the necessary composite specimens from the composite plate in accordance with the ASTM criteria. Five more pieces followed the same pattern. Using the hot injection moulding equipment, six distinct composite boards were depicted in figure 1 (A) to 1 (F) accordingly. Figure 2 shows the well-prepared composite specimens for the water absorption test according to ASTM standards. Tests on the water absorption behaviour of composites have been carried out because of well-prepared specimens. This is a picture of the composite specimens after they've been tested for water absorption in figure 3.

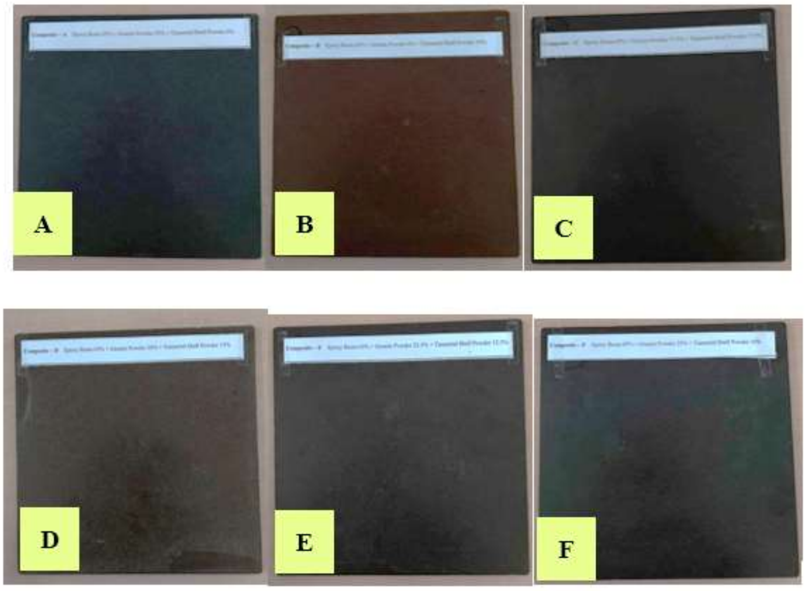

Figure 1Hybrid Bio-Composite Boards of (A) Composite-1 (B) Composite-2 (C) Composite-3 (D) Composite-4 (E) Composite-5 (F) Composite-6

Figure 2 Water absorption test specimens before test

Figure 3 Water absorption test specimens after test

3. Results and Discussions

In order to evaluate the water absorption capabilities of six distinct bio-composites specimens, an experimental investigation was conducted. Each composite specimen's pre-test average weight is shown in figure 4 appropriately, as shown below. For each composite specimen, before testing, an average weight of 4.58 grammes was reported for C1, C2, C3, C4, C5, and C6, respectively. Before the water absorption test, the C1 and C4 composite specimens had a maximum and minimum weight of 4.58 and 3.20 grams, respectively.

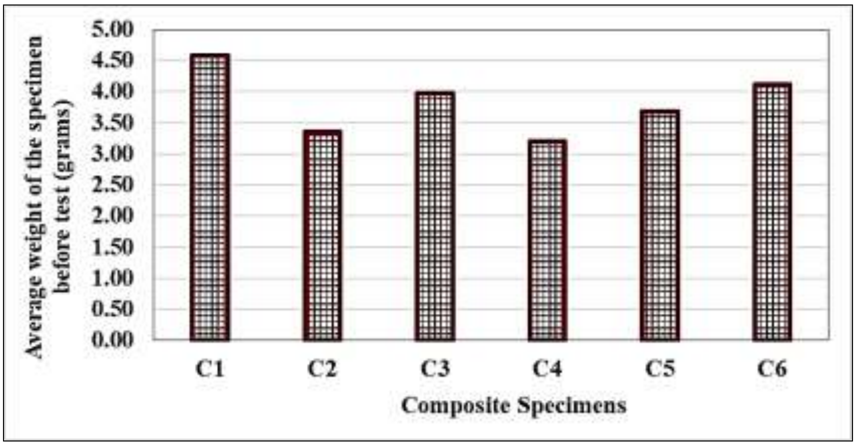

Figure 4Average weight of the composite specimens before test

Figure 5 shows the final average weight of the C1, C2, C3, C4, C5, and C6 composite specimens. Following testing in C1, C2, C3, C4, and C6, the average weight of the composite specimens after the tests was 5.21, 3.98 Kgs for C1 and 3.60 Kgs for C2 respectively. After the water absorption test, the C1 and C4 composite specimens weighed 5.21 and 3.60 grammes, respectively.

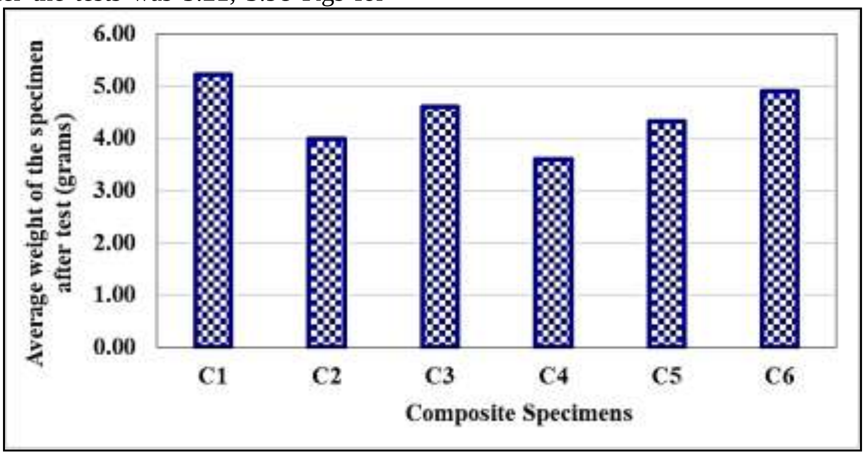

Figure 5 Average weight of the composite specimens after test

As depicted in figure 6, the average weight gain of the composite specimens following the test is shown. Using the figure 6, it was noted that the average weight obtained by the composite specimens in C1 through C6 was 0.63, 0.62, 0.63, 0.4, 0.64 and 0.79 grammes respectively. For C1 and C4 composite specimens, a weight gain of no more than 0.63 grammes and no more than 0.4 grams was seen when the water absorption test was performed.

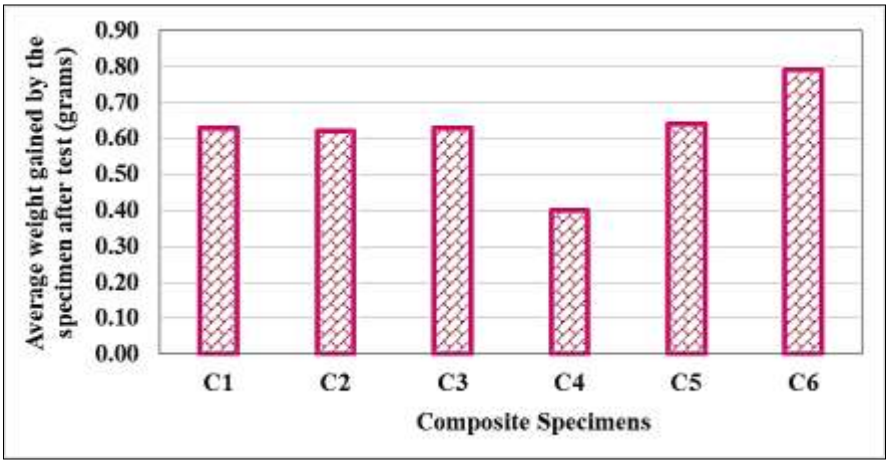

Figure 6 Average weight gained by the composite specimens after test

FIGURE 7 depicts, after testing, the change in water absorption percentage of the composite (C1/C2/3/4/5/C6 sample) specimens. From Figure 7, it was alleged that the composite specimens' water absorption percentages following testing in C1,C2,C3.C4,C5and C6. Water absorption percentages of 19.17 and 12.5 were recorded in C6 and C4 composite specimens before the test.

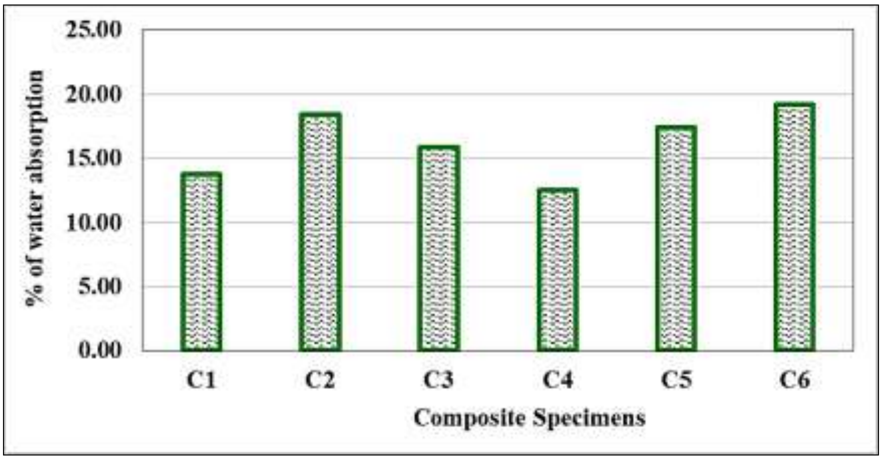

Figure 7 Variation on water absorption percentage by the composite specimens after test

4. Conclusions

Based on water absorption testing on six hybrid-bio composite specimens, the following results were drawn: Before the test, the C1 and C4 composite specimens had been observed to have a minimum and maximum weight of 4.58 and 3.20 grams, respectively. The C1 and C4 composite specimens had the lowest and highest weights of 5.21 and 3.60 g, respectively, following the test. A total of 0.63 and 0.4 g of weight gain were seen in C1 and C4 composite specimens following the test, respectively. Adding fine marble dust and tamarind shell powder to the epoxy resin matrix resulted in C6 and C4 composite specimens with water absorption percentages of 19.17 and 12.5, respectively, prior to the water absorption test.

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