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Improvement on Compressive Properties of Epoxy Resin Matrix Sugarcane Fiber and Coconut Shell Powder Reinforced Hybrid Bio-Composites

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Abstract

Hybrid bio-composites are now being developed by integrating several natural resources as reinforcement and filler components, drastically increasing the required characteristics. This research focused on sugarcane fibre and coconut shell powder granulescombined to an epoxy resin matrix to test the material's compressive strength. Sugarcane fibre is used as a reinforcing material; while coconut shells powder particles are used as filler. The epoxy resin weight percentage was kept constant while different reinforcing and filler components were utilized to construct hybrid bio-composite specimens. Hybrid bio-composite boards were created from start to finish using hot press compression moulding technology. Water jet machining is used to extract hybrid bio-composite specimens from hybrid bio-composite boards for compression tests in compliance with ASTM requirements. Experiments have revealed that adding coconut shell powder particles to a sugarcane fiber/epoxy resin matrix significantly improves the compressive properties of hybrid bio-composites.

Keywords: Bio-composites, sugarcane fiber, coconut shell powder, compressive properties, experimental study.

1. Introduction

The coconut shell that is among the solid agricultural wastes is the non-food component of the coconut. Coconut shell has a lot of potential because of its excellent mechanical properties. Coconut shell powder has many advantages over other materials, including minimal price, recyclable, relatively high stiffness, light weight, low equipment erosion, and renewability. When coconut shell particles are combined with epoxy matrix, the resin's properties are enhanced, and a larger range of applications is generated [1]. Fiber-reinforced polymer (FRP) composite materials are gradually displacing standard metallic components because of their superior toughness ratio and capacity to be tailored to the specific needs of the designs. . Composite materials have found widespread use in the aerospace, automotive, and marine industries as a result of their appealing properties [2]. Because of their inexpensive cost and wide range of applications, particulate packed polymer composites are gaining popularity. In order to evaluate if organic wastes may be used as composite materials in thermoplastic polymers composite materials, the effects of coconut shell ash (CSA) content were examined [3]. More than a dozen research papers have been published on the use of organic materials and additives as reinforcement in polymer. Some examples of these materials include: pineapple sisal jute palm cotton rice husk bamboo wood. The tensile strength and elongation of green composites with varied pineapple fibre contents to virgin resin [4] were examined by Luo and Netravali [13]. The coconut shell powder strengthened epoxy matrix composite is made of coconut shell powder, epoxy resin, and hardener. Three different volume % of coconut shell particles were used to conduct tensile and compression tests on the composites. Experiments have shown that the composites' tensile strength increased as the amount of coconut shell powder

decreased, but their compressive strength grew in the opposite direction [5]. The shape and mechanical characteristics of a coconut shell strengthened polyethylene materials were investigated in terms to determine whether it might be used as fresh samples in manufacturing applications. The influence of the granules on the mechanical behaviour of the specimens formed was explored [6]. Coconut shell strengthened sample was organized by compressing lesscompactness polyethylene matrix with 6 percent – 25% capacity% coconut shell granules. This paper examines the impact of coconut shell powder on the mechanical behaviour of coconut fibre reinforced materials. The epoxy mixtures werecoated with varied quantities of coconut shell powder (filler) (4, 8, 12, and 16 percent volume basis) and coconut fibre (reinforcement) (8, 12, 16, and 20 percent volume basis). The mechanical properties of banana fibre strengthened, peanut shell granules filled epoxy resin matrix bio composites were examined in [8]. The addition of groundnut shell powder to epoxy resin/banana fibre specimen greatly improves the mechanical characteristics. [9] Looked at the mechanical properties of egg shell ash filled epoxy resin matrix bio composites reinforced with jute fibre. The addition of egg shell powder to epoxy resin/jute fibre composites greatly improves their mechanical characteristics. [10] The effect and toughness of adhesives matrix biological specimens strengthened with banana fibers and filled with camellia sinensis granules were quantitatively investigated. Epoxy resin/banana composite materials with camellia sinensis particles added improve mechanical properties significantly. [11] The water absorption characteristics of treated and untreated hybridized organic samples were examined in an experiment. [12] The tensile behaviour of hybrid polymer composites was studied experimentally. [13] The flexural characteristics of adhesive samples reinforced with camellia sinensis fibre and banana fibre that has undergone chemical modification was examined experimentally. [14] The impact of layered double hydroxide in polymer Nano-composites was examined. [15] The mechanical characteristics of jute fibre strengthened coconut shell granules filled epoxy matrix bio-composites were examined experimentally. The literature analysis shows that combining sugarcane powder with coconut shell ash with epoxy resin composites is uncommon [16-20]. As a result, attempts have been made to prepare and test the compaction behaviour of epoxy resin samples strengthened with sugarcane fibre and coconut shell powder.

2. Materials and Methods

The matrix components were adhesive and toughness, which were purchased from the resident polymer market. To achieve good bonding with filler materials, the adhesive and toughness were mixed in the proportion of 15:03 using a mechanical stirring machine. Sugarcane fibre was obtained in the required quantity from the local sugarcane industries. Waste coconut shell powder was collected from oil mills in Erode area of Tamilnadu, India, to be utilized as filler materials. The collected trash coconut shells were first cleaned with regular water then splashedyet again with warm water to totally eliminate any dirt granules. Further cleaning, it was allowable to air dry for 7 hours at room temperature in an open environment. After drying, the well-dried coconut shell is ground into coconut shell powder particles in a flourmill. The flourmill was used to turn the irregularly shaped coconut shell into coconut shell powder. The ash form of coconut shell with variantdimensionsgranules was separated as 105 microns size by hand sifting after the grinding process.

Table 1 shows the configuration details for each of the six composites.

Sl.No.	Composite Description	Matrix wt. %	Sugarcane Fiber wt. %	Coconut Shell Powder wt. %
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 procedure yielded the required amount of tiny coconut shell particles. The composite plates were made from sugarcane fibre, epoxy resin, and fine coconut shell particles using a compression moulding machine in this study. The arrangement of sugarcane fibre particles inside the compression-molding machine is the first step in the production of composite plates. Sugarcane fibre particles have been located on the compaction-molding appliance's surface table. As a result of the aforementioned configuration, the coconut shell powders have entirely scattered on the sugarcane fibre plates' surface. Over the distributed surface of coconut shell particles, an epoxy resin/hardener solution was applied for a specific thickness. Sugarcane fibre was located on the similar coconut shell ash dispersion surface after the adhesive/toughness solution was applied to the sugarcane fibre and coconut shell powders. The mutual mate form of sugarcane fibre, adhesive, and coconut shell permitted the compression-molding machine to heat up to 140°C for 120 min under precise hydraulic pressure. The requisite composite plates were obtained after a 60-minute processing time and allowed to cool at ambient temperature. Following the cooling process, the composite plate was subjected to aquatic jet machining, and the requisite compound samples were taken away from the specimens mate in accordance with ASTM requirements. For the remaining five compositions, the same procedure was followed. Figure 1 (a) and (b) show well-prepared composite specimens for compression testing in accordance with ASTM standards (before and after). Compression trials were conducted on the well-prepared materials samples to control the composites' compression behaviour. The

compression test of the composites was carried out with computerized universal testing equipment with a volume of 400 KN and a load rate of 1 mm/min.

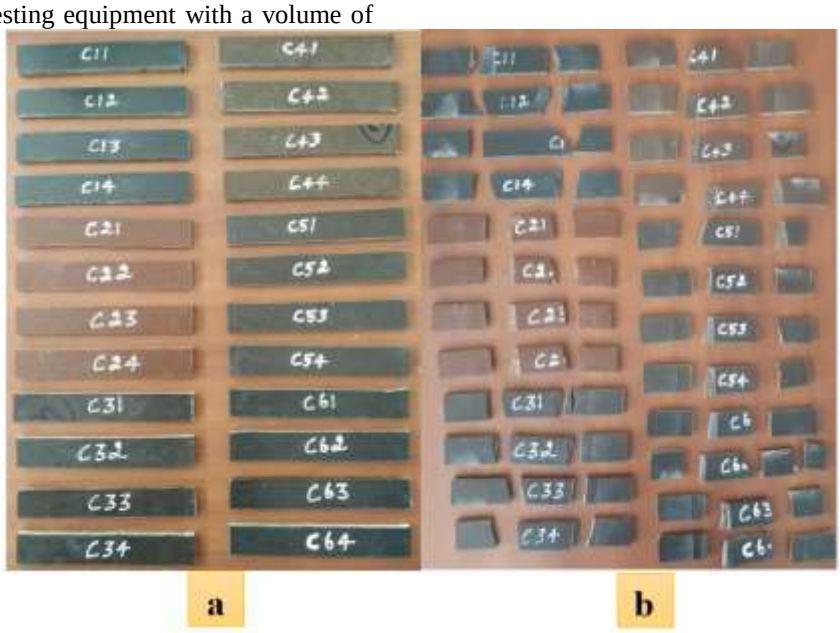

Figure 1 Compression Test Specimens (a) Before Test (b) After Test

Peak Compressive Load for C1 Bio-Composites

The variation on peak compressive load for C11, C12, C13 and C14 bio-composite samples were demonstrated in figure 2. During the compression test on the C11, C12, C13, and C14 bio-composite specimens, peak compressive loads of 6419, 5886, 2196, and 2432 N were observed, respectively. An average peak compressive load of 4233 N was noticed in C1 bio-composite specimens.

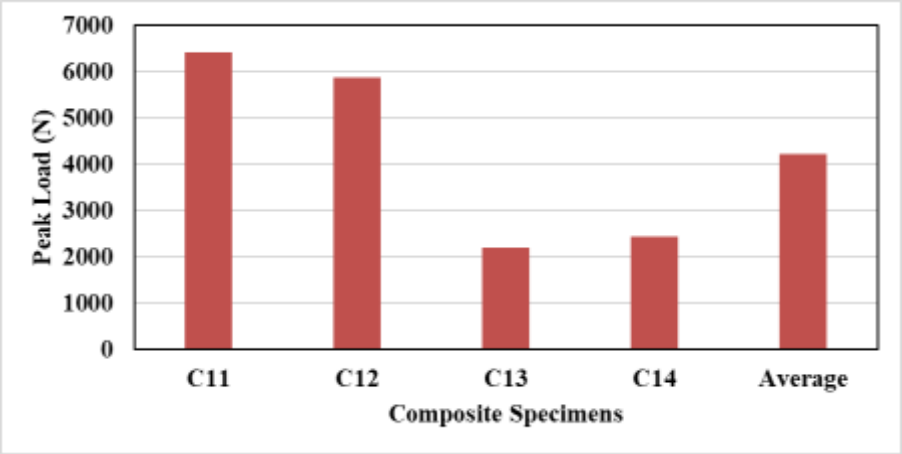

Figure 2 Variation on peak compressive load for composite specimen-01

Compressive Strength for C1 Bio-Composites

The variation on compressive strength for C11, C12, C13 and C14 specimens made of bio-composites were established in figure 3. The strength of compaction of 43, 39, 15 and 16 MPa were detected through the compaction test on the C11, C12, C13 and C14 bio-composite specimens respectively. An average compressive strength of 28 MPa was noticed in C1 bio-composite specimens.

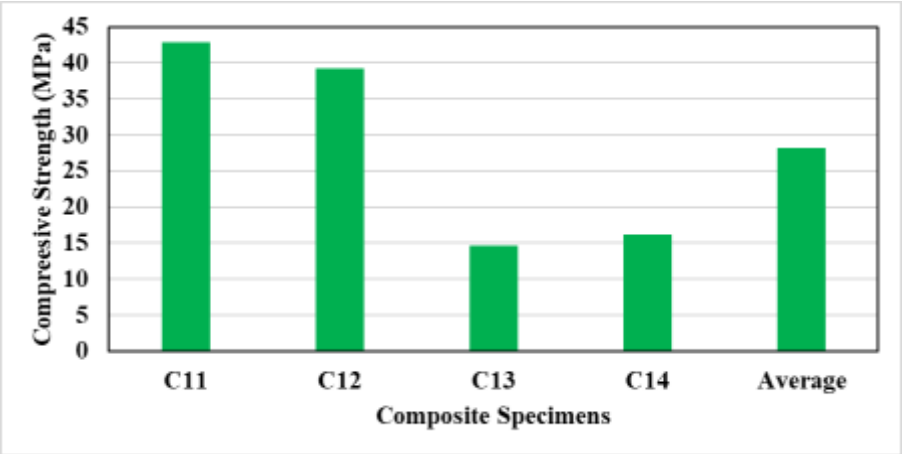

Figure 3Variation on compressive strength for composite specimen-01

Peak Compressive Load for C2 Bio-Composites

The variation on peak compressive load for C21, C22, C23 and C24 organic samples were demonstrated in fig 4. The high compressive load of 4649, 4524, 4847 and 4808 N were detected through the compaction test on the C21, C22, C23 and C24 bio-composite specimens respectively. An average peak compressive load of 4707 N was noticed in C2 bio-composite specimens.

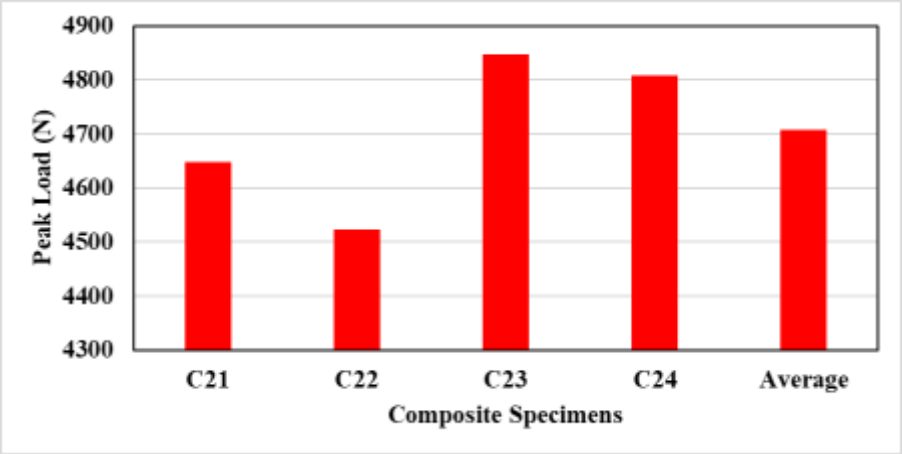

Figure 4Variation on peak compressive load for composite specimen-02

Compressive Strength for C2 Bio-Composites

The variation on compressive strength for C21, C22, C23 and C24 bio-composite specimens were demonstrated in figure 5. The compaction strength of 31, 30, 32 and 32 MPa were experimental during the compaction trials on the C21, C22, C23 and C24 bio-composite specimens respectively. An average compressive strength of 31 MPa was noticed in C2 bio-composite specimens.

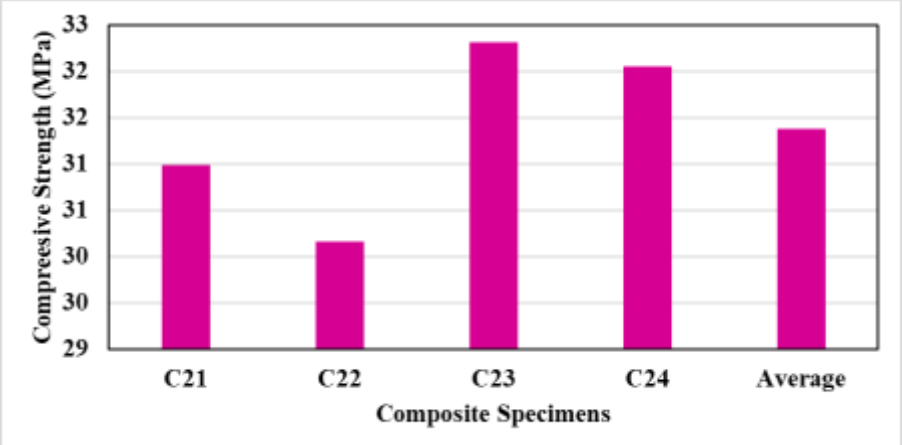

Figure 5 Variation on compressive strength for composite specimen-02

Peak Compressive Load for C3 Bio-Composites

The variation on peak compressive load for C31, C32, C33 and C34 hybridized organicsamples were demonstrated in fig 6. The high compressive load of 5118, 5507, 4775 and 5087 N were evaluatedthrough the compaction trial on the C31, C32, C33 and C34 hybrid bio-composite specimens respectively. An average peak compressive load of 5122 N was noticed in C3 hybrid bio-composite specimens.

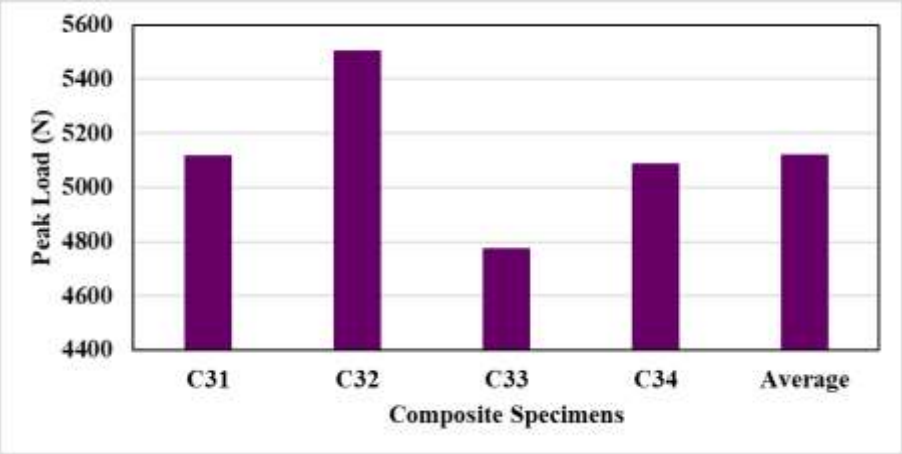

Figure 6 Variation on peak compressive load for composite specimen-03

Compressive Strengthfor C3 Bio-Composites

The variation on compressive strength for C31, C32, C33 and C34 hybrid-bio-composite specimens were demonstrated in figure 7. The compressive strength of 34, 37, 32 and 34 MPa were observed during the compression test on the C31, C32, C33 and C34 hybrid bio-composite specimens respectively. An average compressive strength of 34 MPa was noticed in C3 hybrid bio-composite specimens.

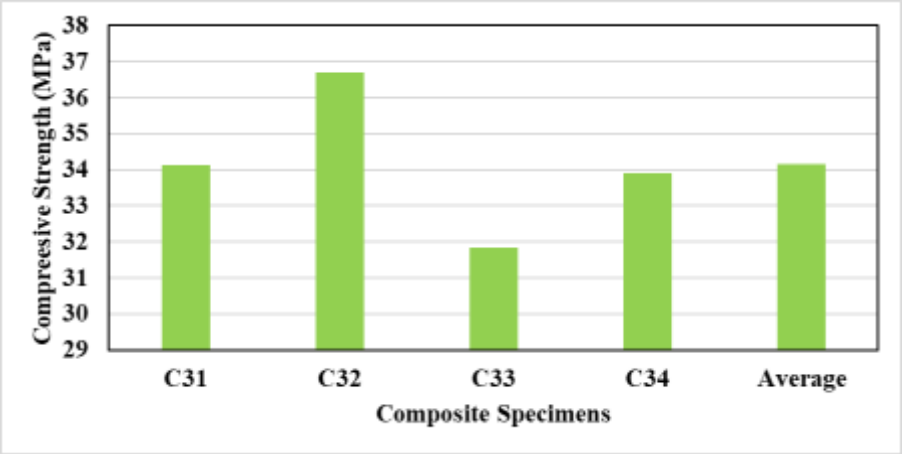

Figure 7 Variation on compressive strength for composite specimen-03

Peak Compressive Loadfor C4 Bio-Composites

The variation on peak compressive load for C41, C42, C43 and C44 hybrid-bio-composite samples were showed in figure 8. The high compressive load of 4925, 5834, 4387 and 4760 N were evaluatedthrough the compaction trials on the C41, C42, C43 and C44 hybrid bio-composite specimens respectively. An average peak compressive load of 4976 N was noticed in C4 hybrid bio-composite specimens.

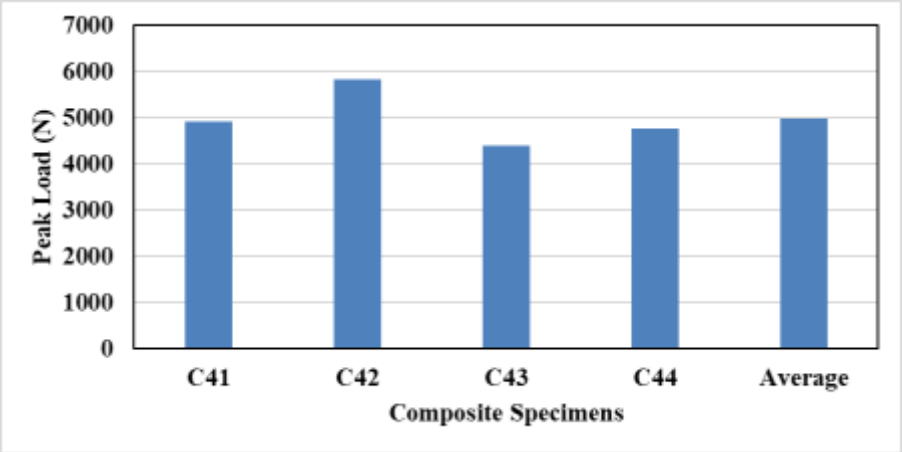

Figure 8 Variation on peak compressive load for composite specimen-04

Compressive Strengthfor C4 Bio-Composites

The variation on compressive strength for C41, C42, C43 and C44 hybrid-bio-composite samples were showed in figure 9. The compressive strength of 33, 39, 29 and 32 MPa were observed during the compression test on the C41, C42, C43 and C44 hybrid bio-composite specimens respectively. An average compressive strength of 33 MPa was noticed in C4 hybrid bio-composite specimens.

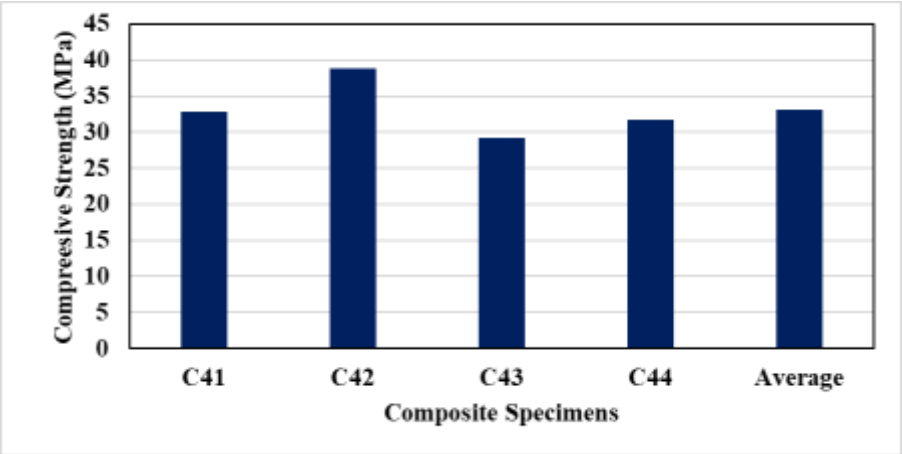

Figure 9 Variation on compressive strength for composite specimen-04

Peak Compressive Loadfor C5 Bio-Composites

The variation on peak compressive load for C51, C52, C53 and C54 hybridized-bio-compositessamples were demonstrated in fig 10. The high compressive load of 4855, 4733, 4539 and 4806 N were analyzed through the compaction test on the C51, C52, C53 and C54 hybrid bio-composite specimens respectively. An average peak compressive load of 4733 N was noticed in C5 hybrid bio-composite specimens.

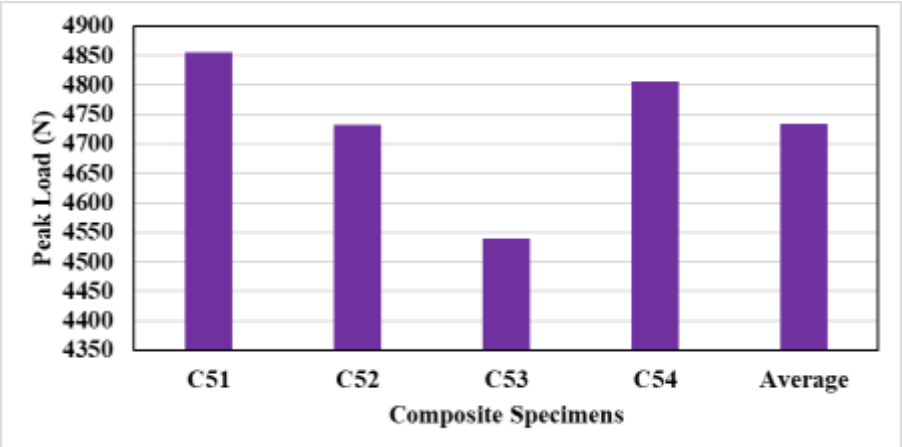

Figure 10 Variation on peak compressive load for composite specimen-05

Compressive Strengthfor C5 Bio-Composites

The variation on compressive strength for C51, C52, C53 and C54 hybrid-bio-composite specimens were demonstrated in figure 11. The compressive strength of 32, 32, 30 and 32 MPa were observed during the compression test on the C51, C52, C53 and C54 hybrid bio-composite specimens respectively. An average compressive strength of 32 MPa was noticed in C5 hybrid bio-composite specimens.

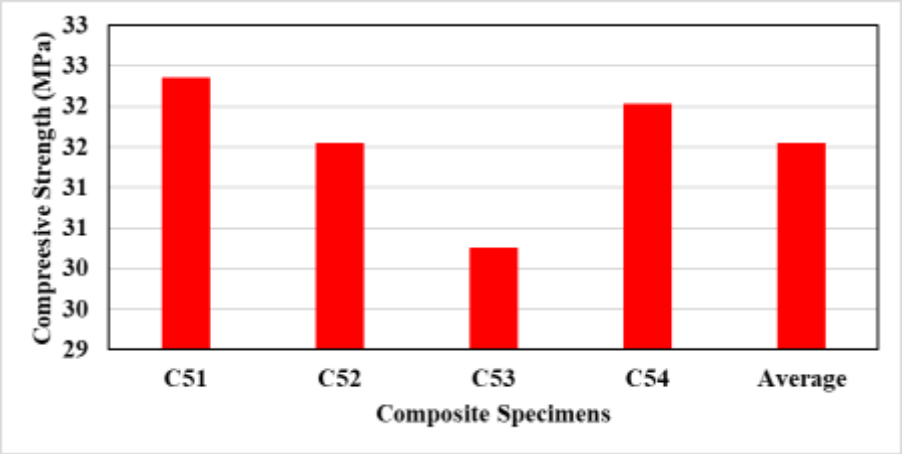

Figure 11 Variation on compressive strength for composite specimen-05

Peak Compressive Loadfor C6 Bio-Composites

The variation on peak compressive load for C61, C62, C63 and C64 hybrid-bio-compositessamples were demonstrated in fig 12. The high compressive load of 4851, 5046, 4973 and 4980 N were analyzed through the compaction test on the C61, C62, C63 and C64 hybrid bio-composite specimens respectively. An average peak compressive load of 4962 N was noticed in C6 hybrid bio-composite specimens.

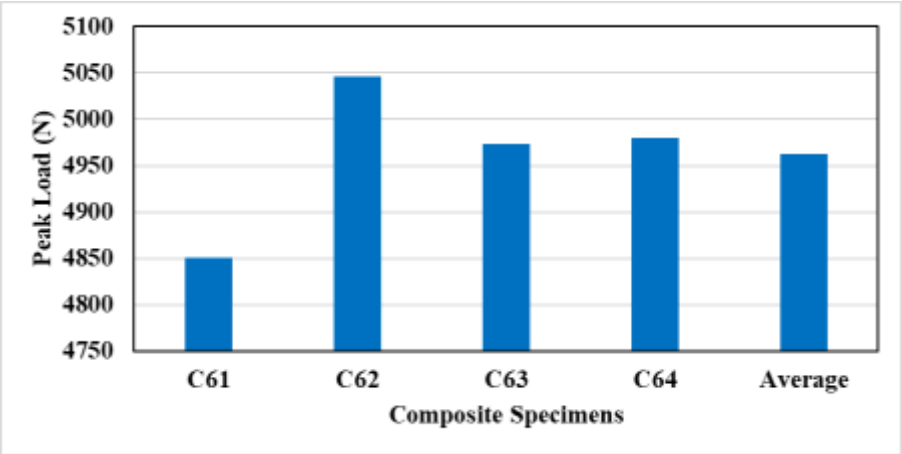

Figure 12 Variation on peak compressive load for composite specimen-06

Compressive Strengthfor C6 Bio-Composites

The variation on compressive strength for C61, C62, C63 and C64 hybrid-bio-composite specimens were demonstrated in figure 13. The compressive strength of 32, 34, 33 and 33 MPa were observed during the compression test on the C61, C62, C63 and C64 hybrid bio-composite specimens respectively. An average compressive strength of 33 MPa was noticed in C6 hybrid bio-composite specimens.

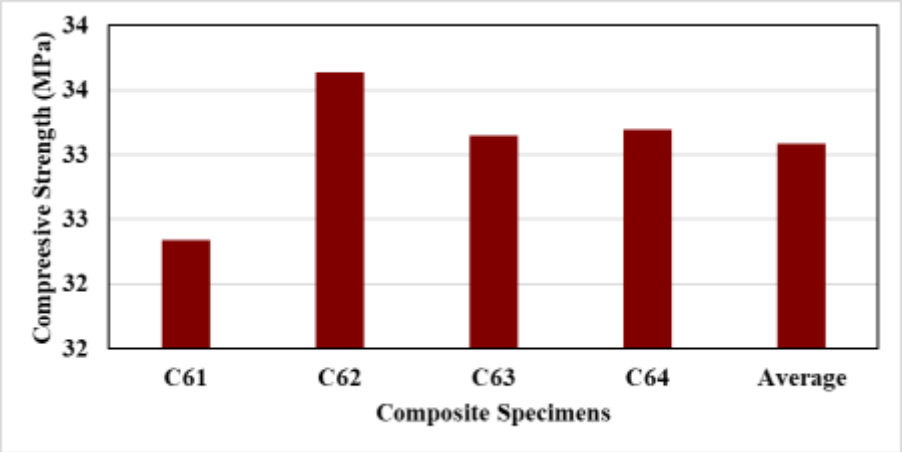

Figure 13 Variation on compressive strength for composite specimen-06

Average Peak Compressive Load for All Bio-Composites
The variation on average peak compressive load for C1, C2, C3, C4, C5 and C6 bio-composite specimens were illustrated in figure 14. The averagepeak compressive load of 4233, 4706, 5121, 4976, 4733 and 4962 N were analyzed through the compaction trials on the C1, C2, C3, C4, C5, and C6 bio-composite specimens respectively.

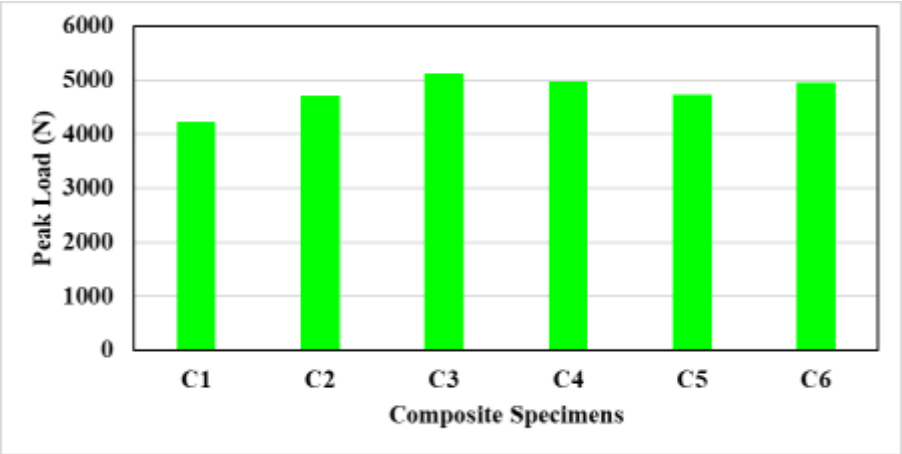

Figure 14 Variation on average peak compressive load for all composite specimens

AverageCompressive Strengthfor All Bio-Composites
The changes on meancompressive strength for C1, C2, C3, C4, C5 and C6 bio-composite specimens were demonstrated in figure 15. The average compressive strength of 28.221, 31.377, 34.144, 33.178, 31.554 and 33.082 MPa were analyzed through the compaction test on the C1, C2, C3, C4, C5 and C6 bio-composite specimens respectively.

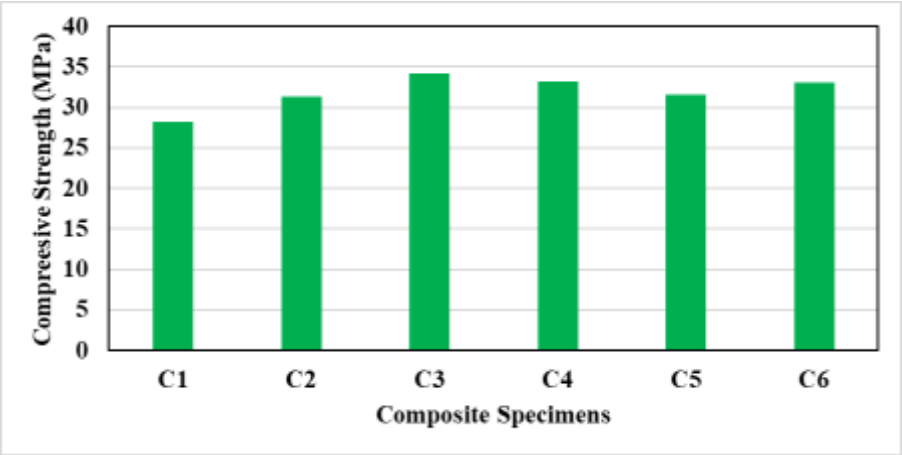

Figure 15 Variation on average compressive strength for all composite specimens

Conclusions

The compressive characteristics of an epoxy resin matrix-sugarcane fibre reinforced organic materials were examined using varying weight % of coconut shell powder particles as a filler material. When compared to various weight % of coconut shell powder and sugarcane fibre particles, composites having 17.5 wt. percent coconut shell powder and 17.5 wt. percent sugarcane fibers demonstrated enhanced compressive load and compaction strength. The presence of tiny coconut shell powder particles and strong interfacial interaction between the matrix and sugarcane fibre gave the composites improved compressive characteristics. Because of improper bonding between the fibre, matrix, and filler materials, adding more than 17.5 wt. percent fine coconut shell powder particles into the fiber/matrix decreases the compressive load and compressive strength of bio-composites.

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