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RESEARCH ARTICLE

Mechanical Responses of Recycled Core Sandwich Structures With Hybrid Composite Facings: A Study of Quasi-Static and Dynamic Behavior

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Received: 20 September 2025 | **Revised:** 22 November 2025 | **Accepted:** 4 December 2025

Keywords: corrugated core | energy absorptions | hybrid composites | mechanical performance | recycled polymers | sandwich structures

ABSTRACT

In this study, a sandwich composite structure was developed by combining a recycled, self-skinned corrugated polypropylene (PP) core with face sheets made from woven hybrid composites of glass, carbon, and aramid fibers. The face sheets were fabricated using the Vacuum-Assisted Resin Transfer Molding (VARTM) process following an optimized stacking sequence, and subsequently integrated with the core using an EVA-based thermoplastic adhesive. The performance of the produced structures was evaluated through quasi-static and dynamic three-point bending tests, as well as edge compression tests. The findings indicate that the interaction among the different fiber layers enhances interfacial integrity and improves structural stability. The obtained results reveal that integrating the hybrid face sheets with the core enhances the structural durability and positively influences the energy absorption and deformation behavior of the material. The structure developed in this context aims to be evaluated as a potential alternative for producing recyclable, environmentally sustainable, and functional components in the automotive industry, particularly in structures such as electric vehicle battery boxes. Additionally, the study presents a novel approach to the reuse of recycled thermoplastic cores in advanced engineering applications.

1 | Introduction

In modern automotive design, two primary requirements stand out: lightness and durability. In this context, composite materials offer significant advantages compared to traditional metal structures. Composite surface plates, with their high strength-to-weight ratio and energy absorption capacity, enhance the overall performance of vehicles while also positively impacting fuel efficiency [1]. Sandwich structures are composite structures designed to provide lightness, strength, and thermal efficiency in the field of engineering and architecture. These structures are characterized by a core material layer positioned between two face sheets. Although the face sheets are typically made of high-strength materials, the core layer is generally selected to be a lightweight yet durable material. This combination of structures offers maximum strength and minimum weight, exhibiting excellent performance under both quasi-static and dynamic loads. Honeycomb, corrugated, lattice structures, and metal foams are often used as cores in sandwich structures. Among these structures, corrugated core structures are a fundamental component of sandwich structures, with a wide range of applications in the automotive industry and other engineering fields. These structures stand out with their lightness and high durability, offering significant advantages in terms of performance and efficiency. First, corrugated core structures offer a high strength-to-weight ratio and can also

Summary

- Stacking sequences of different fabrics influence application suitability.
- Only the first layer was damaged.
- Surface plates remained bonded to the core with excellent adhesion.
- Plates enhance specific energy absorption, improving structural performance.

provide similar or higher structural durability using less material compared to traditional filling materials. Corrugated core sandwich structures have high bending, shear, torsional performance, and loading efficiency compared to honeycomb, foam, and lattice core sandwich structures [1–5]. Additionally, the space in the core of corrugated core sandwich structures allows for the incorporation of other functions, such as energy storage, sensors, and actuators, into the structure. These possibilities of corrugated core sandwich structures enable the structure to be utilized in innovative application areas, such as aerospace, military, automotive, and construction [6].

The physical (additive ratio, secondary material determination, density) and mechanical (hardness, quasi-static surface and edge pressure, and 3-point bending tests) properties of the recycled self-surface plate corrugated polypropylene core used in this study, as well as the dynamic pressure and dynamic 3-point bending tests to measure the impact strength and energy absorption capacity, were investigated in our previous studies. In addition to these, impedance tube tests were performed for acoustic characterization, and the sound transmission loss (STL) and sound absorption coefficient (SAC) values of the structure were determined [7]. Hybrid composite plates were produced as surface plate supports for this previously examined structure and added to the sandwich structures.

Hybrid composite materials can be defined as versatile structures derived from the synergistic combination of different material types. These materials are generally preferred in industries with high performance requirements and are designed to optimize specific properties (mechanical, physical, or financial) [8, 9]. Studies have reported that the stacking order of different types of fabrics has a significant impact on the mechanical properties of hybrid composites, particularly in determining their impact behavior [10, 11]. In this study, the stacking order of glass, carbon, and aramid fiber fabrics was determined by considering the strength, cost, working environment, and conditions of the hybrid surface in the automotive industry.

Carbon (CF) and Aramid (AF) fibers are more expensive than Glass fiber (GF). However, the tensile properties of GF, CF, and AF are similar [12]. Compared with glass fiber and carbon fiber, which are the two most common types of fibers used as reinforcing fibers for composite materials, the modulus of elasticity of Kevlar fiber is higher than that of glass fiber but lower than that of carbon fiber [13–15]. The key properties of carbon fibers include a high stiffness-to-weight ratio, a high strength-to-weight ratio, good corrosion resistance, electrical conductivity, and a high melting temperature [16–20]. CF has the highest specific modulus and strength among GF and AF fabrics [12]. Compared to other synthetic fibers such as glass, aramid, and nylon, carbon fibers have numerous advantages such as high modulus of elasticity, superior tensile strength, low density, high chemical resistance, excellent thermal stability, and low coefficient of thermal expansion, as well as being used as an essential reinforcement phase in composite materials, providing superior performance due to their high stiffness and specific strength despite their relatively high cost [21]. Carbon fibers are also chemically inert and have low thermal expansion coefficients. However, they offer high electrical and thermal conductivity [22, 23]. AF has higher fatigue strength compared to GF and CF. Additionally, AF has strong abrasion resistance, making it difficult to cut [12, 21]. Kevlar fibers, which have high impact resistance, are known for their ability to absorb large amounts of energy at the time of impact [21]. However, AF is sensitive to strong acids, bases, and some oxidants such as chlorine bleach [12]. Additionally, AF exhibits a high moisture absorption property [21]. Using this information, the stacking order of GF, CF, and AF for the hybrid surface, the high electrical conductivity of CF, and the high moisture absorption property of AF led to the use of GF in the first layer and the use of CF fabric in the second place due to its high specific modulus and strength and chemical inertness. AF fabrics have been used in the middle row due to their high fatigue strength and strong abrasion resistance, as well as their extreme sensitivity to acids, bases, and bleaches. Thus, the stacking order of fiber fabrics to produce hybrid composite surfaces has been determined not only by their positive properties but also by their negative properties according to the desired conditions. In addition, the literature has studied the stacking order of hybrid composite surfaces, which changes not only with the properties of individual fibers but also with the effects of fiber fabric arrays on each other in binary shapes.

In one of the studies conducted about face sheets of sandwich materials with dual fiber fabric, it was reported that hybridization of 50% GF and 50% CF in surface sheets had a specific bending strength equivalent to that of surface sheets made entirely of CF composites. In addition, when 50% CF and 50% GF reinforcements were used, the tensile properties were equivalent to using only CF [6]. Thus, the CF and GF fabrics ratio in our study was determined to be equal. In a study investigating the effect of the stacking order of GF and AF in hybrid composites on impact behavior, it was reported that adding a GF layer to the AF layer reduced the impact strength of the hybrid composite due to the restriction of deformation in the AF layer [24]. For that reason, AF and GF fabrics were not placed in a back-to-back arrangement in our study. In another study conducted to investigate the effect of the stacking order on the impact properties of the composite in a GF-CF hybrid composite, it was observed that the inclusion of GF in CF-reinforced structures improved the impact properties and increased the strain against fracture [9]. Additionally, another study found that hybridizing carbon fiber with Kevlar fiber enhances the mechanical behavior of these hybrid composite materials under impact loading and reduces post-impact strength losses compared to carbon/epoxy composites [25]. Using this information, in the developed composite face sheets of this study, GF and CF are stacked in a sequenced manner on the hybrid composite surface. As a result of the above-presented literature research, a composite surface consisting of 10 layers in total was produced, with two layers each of unidirectional GF, CF, AF, and again, CF and GF fabric.

The failure modes and corresponding failure loads in sandwich structures are closely dependent on the material properties, structural configuration, load distribution, and bonding status of the surface-core interface. In sandwich composite structures, there are two interfaces between the core and the surface sheets: the bottom surface and the core, and the top surface and the core. Core-surface bonding is a crucial issue for the structural integrity and load-carrying capacity of sandwich composite structures, and for the complete mechanical potential of these structures to be realized [26–28]. It is also known that the sandwich composite exhibits a more durable structural integrity due to the increased bonding area between the core and surface sheets, which increases the bonding surface.

Although lightness is at the forefront of increasing fuel efficiency and reducing environmental pollution in the automotive sector, reducing material costs is also a crucial issue. However, in addition to reducing vehicle weight and price, the strength of structures that are crucial for human life and used to withstand crash loads in the event of an accident should not be compromised. Therefore, the parts produced should primarily provide life and property safety, and then be structures that are lightweight, low-cost, and offer comfortable features [6, 7].

The present study was conducted to contribute to the improvement of the recycled self-surface plate corrugated polypropylene core structure, whose physical, mechanical, and acoustic properties have been previously investigated experimentally in terms of its use in sectors such as automotive, where lightness and impact properties of the part are essential. The original part of the study involves the production and coating of hybrid composite plates on self-surface plates, increasing in strength and usage areas accordingly. The produced hybrid composite surface was utilized because the plate surfaces of the recycled self-surface plate corrugated polypropylene core part have a wider adhesion surface, and they were bonded together with a thermoplastic adhesive to contribute to recycling. The mechanical properties of the new sandwich structure obtained were also examined, and its usability in other application areas, as well as in the automotive industry, was investigated. It is designed for use in creating lightweight and high-strength parts suitable for electric vehicle battery boxes.

2 | Materials and Fabrication

2.1 | Materials

In this study, hybrid sandwich composite structures were produced by combining different types of fiber-reinforced composite surface sheets with recycled corrugated polypropylene (PP) core structures. Face sheets were obtained by GF, CF, and AF fabrics reinforced epoxy matrix laminated composites. These surfaces were bonded using a recycled self-surface sheet with a corrugated PP core structure, bonded with a thermoplastic EVA-based adhesive.

Fiber fabrics used on composite surface plates are:

- Carbon fiber fabric: 3 K 200 g/m^2, plain weave type (Code: 02C200L),
- Aramid (Twaron) fiber fabric: 170 g/m^2, satin (twill) weave, 1210 DTex density (Code: TK170T),
- Glass (E-glass) fiber fabric: 201 g/m^2, plain weave (Code: 03G201L).

The hybrid composite surface plates are measured to have an average thickness of 2.35 mm, and the recycled propylene self-surface plate corrugated structure used as the core structure is estimated to have an average thickness of 17.25 mm. Some of the fundamental properties of this recycled propylene self-surface plate core structure are presented in Table 1.

The recycled PP core structure was produced by the co-extrusion method. In this method, the core structure, shaped in a prismatic form, is simultaneously brought together with the hot plates located on the upper and lower surfaces, and thermal bonding is achieved by providing constant thickness as it progresses between the cylinders, thus eliminating the need for the use of adhesives, as shown in Figure 1.

The self-surface plate core structure significantly increases the contact area with the surface compared to conventional corrugated core structures, thus strengthening the structural stability. As shown in Figure 2, this structure provides 100% contact with the surface plate, creating an effective adhesion mechanism.

Ethylene Vinyl Acetate (EVA) based hot melt glue, used as an adhesive, is a commercial product with the code “Bosch glue sticks Black 2607001178”. The physical and mechanical properties of other materials used in the production of composite sandwich structures are summarized in Table 2.

2.2 | Production of Hybrid Composite Surface Plates

GF, CF, and AF fabrics were used in the production of hybrid composite face sheets. The layers were arranged in the order of $[(0/90)_2^{GF}/(0/90)_2^{CF}/(0/90)_2^{AF}]_s$, thereby obtaining a total of 10 layers of woven fabrics, which means that produced face sheets can be acceptable as 20 plies. Production was performed using the Vacuum Assisted Resin Transfer Molding (VARTM) method. As a binder system, F-1564 coded epoxy resin and F-3486 coded hardener were mixed in a 100:34 weight ratio to prepare the mixture. After resin infusion, the composites were cured at 80°C for 2 h.

TABLE 1 | Properties of the recycled self-surface plate corrugated polypropylene core sandwich structure.

Density of material	0.99 g/cm^3
Additive content analysis	Talc (%14)—trace amounts PE
Glass transition temperature	About 15.7°C–15.3°C
Hardness	65–66 Shore D

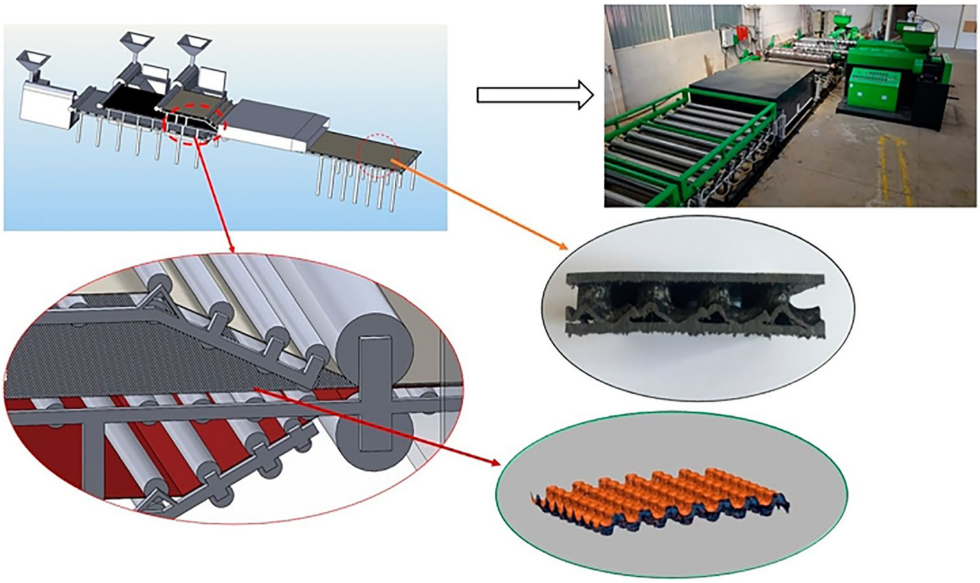

FIGURE 1 | Production of bidirectional sinusoidal corrugated core sandwich structure by the co-extrusion method [7].

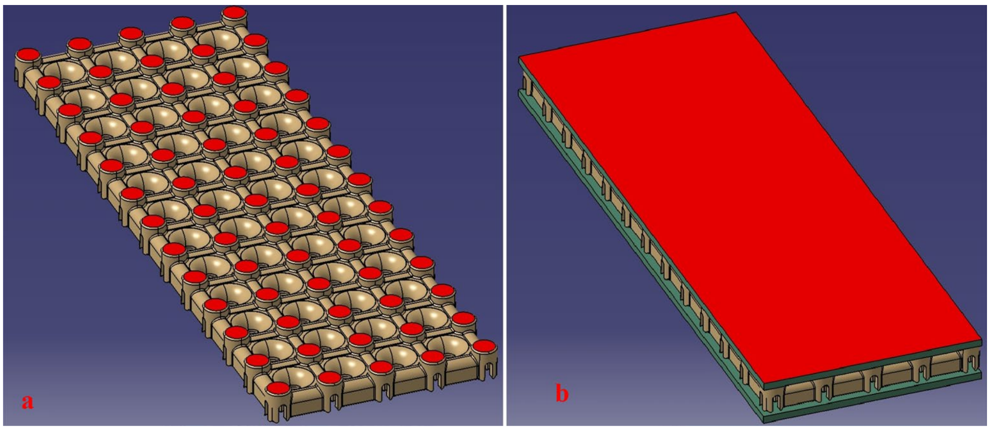

FIGURE 2 | (a) Limited adhesion area of the core structure without a surface plate. (b) Full contact adhesion area of the core structure with its surface plate.

TABLE 2 | Properties of materials used in composite sandwich structures.

Materials	Density (gr/cm^3)	Tensile strength	Modulus of elasticity
Hybrid composite plate	1.44	537.47 MPa	12.6 GPa
Recycled PP core	0.99	20.83 MPa	1.76 GPa
EVA adhesive	0.78	4.52 MPa	11.26 MPa

3 | Experimental Methods

3.1 | Tensile Test of Hybrid Composite Surface Plates

Tensile tests were performed following the ASTM D3039/D3039M-17 standard. Test samples were 25 mm wide, 250 mm long, and 150 mm gauge length. Tests were conducted at a speed of 2 mm/min.

3.2 | 3-Point Bending Test Applied to Hybrid Surface Plate

Three-point bending tests were conducted on hybrid composite surface samples under ASTM D7264/D7264M-21. These tests are performed to determine the behavior of structures under bending loads and to calculate the amount of energy absorbed during deformation under this load, as specified in the standard. In the 3-point bending test, the mid-span of the supports on which the hybrid surface was placed was determined as 100 mm.

3.3 | Production of Sandwich Composite Structures

Before the production of sandwich structures, hybrid surface plates and core structures were sanded unidirectionally with

P100 QI1 DA123X sandpaper to increase surface roughness. Then, particles on the surface were cleaned with 99.5% pure acetone (C_3H_6O). In this way, it is aimed to increase the surface area of both components, which is crucial for a more effective bond. All components were preheated at 80°C for 5 min before applying the adhesive. After the hot EVA adhesive was applied to the surfaces, the parts were quickly joined, and adhesion was achieved by applying pressure with a load of approximately 2.5 kg for 70–80 s, until the adhesive hardened and adhesion occurred (Figure 3).

FIGURE 3 | Isometric view of the produced sandwich composite structures.

3.4 | Quasi-Static Mechanical Tests of Sandwich Structure

Quasi-static edgewise compression loading and three-point bending tests were applied to sandwich structures. With these tests, the carrying capacity and energy absorption behavior of the material under static load were evaluated. Samples, prepared following ASTM C364/C364 M–16 and ASTM C365/C365 M–2 standards, were tested with a Shimadzu AGS-X 50 kN testing machine at a loading rate of 10 mm/min

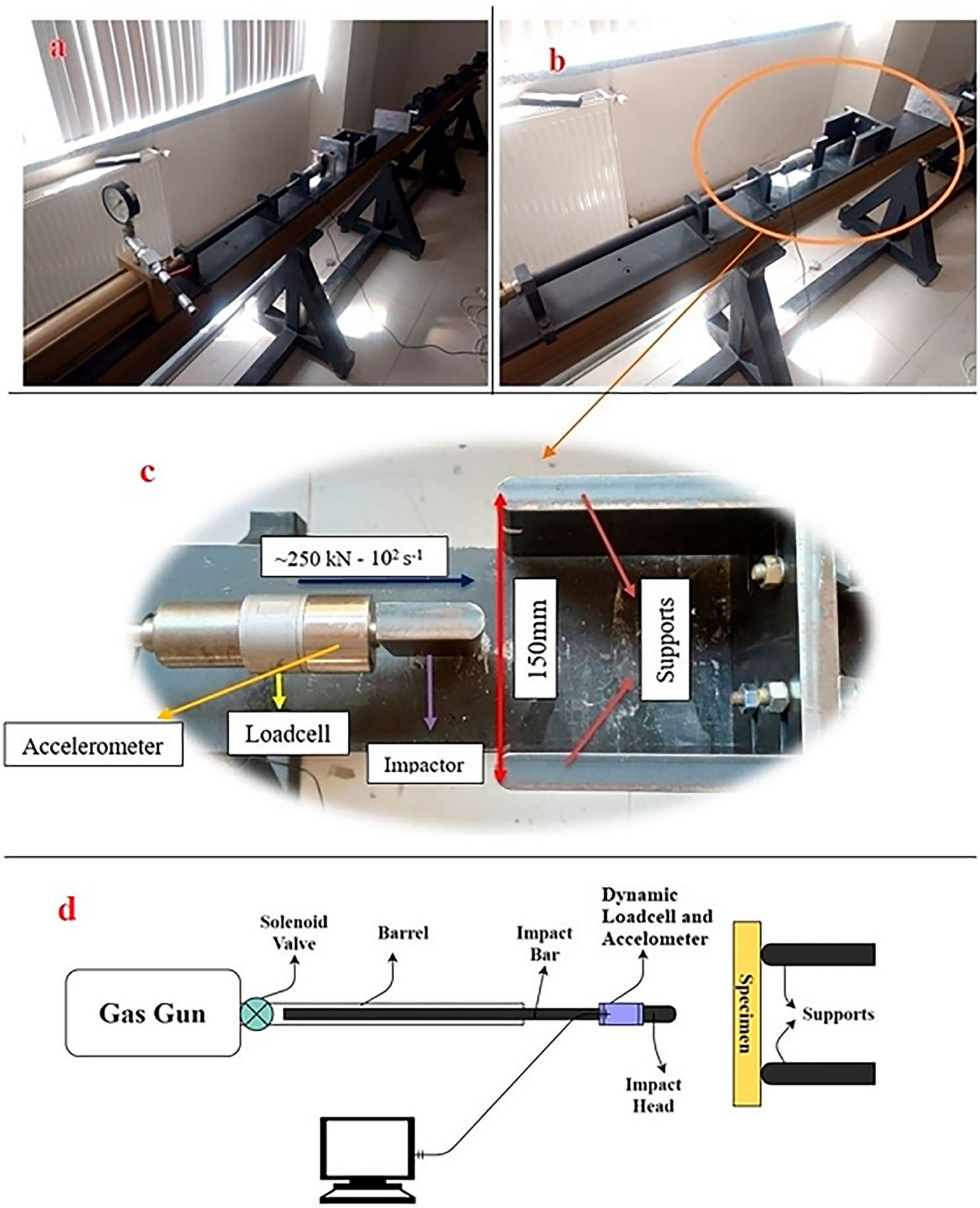

FIGURE 4 | Dynamic three-point bending test setup: (a) Gas gun and load bar, (b) three-point bending apparatus, (c) loading system and supports, (d) schematic representation.

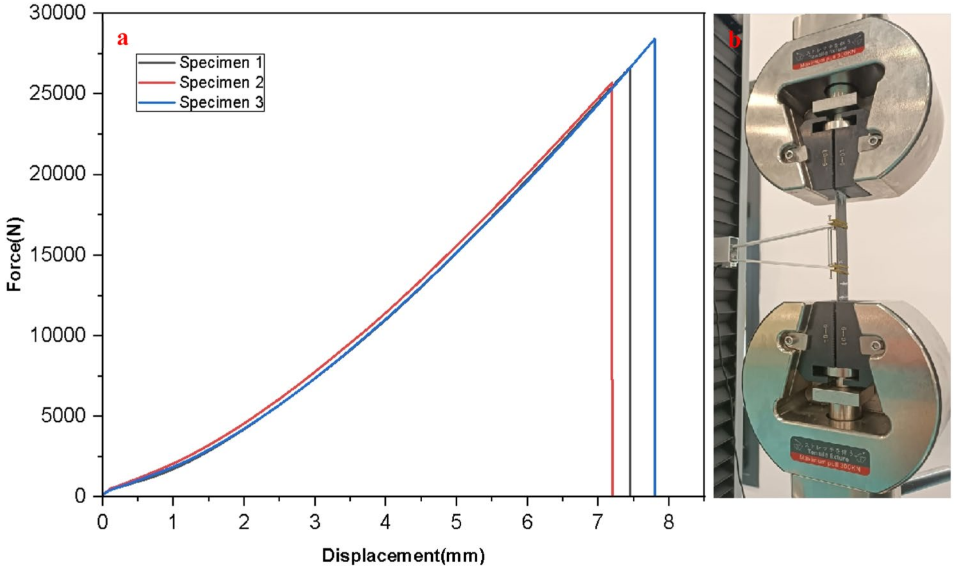

FIGURE 5 | (a) Hybrid composite surface plate tensile test graph. (b) Tensile test device and sample image.

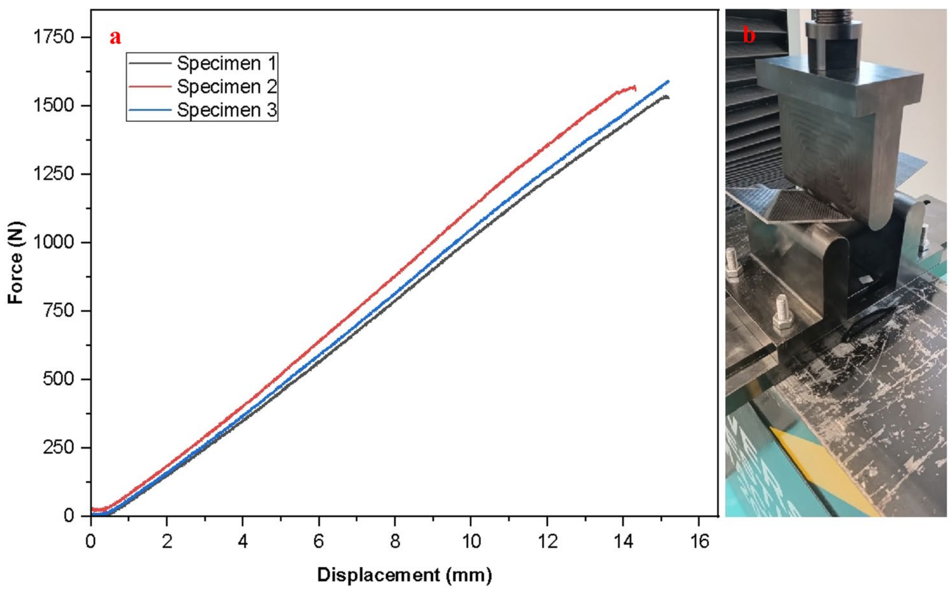

FIGURE 6 | (a) Hybrid composite surface plate 3-point bending test graph. (b) Hybrid composite surface plate 3-point bending device and sample image.

and an ambient temperature of 23°C. The support span length was determined as 150 mm in the three-point bending test.

3.5 | Dynamic Three-Point Bending Test of Sandwich Structure

The behavior of composite sandwich structures under dynamic loading was evaluated using a dynamic three-point bending test, following ASTM C365/C365M–22. The test setup consists of a gas gun filled to a pressure of 10 bars and a load bar connected to it. Approximately 250 kN of instantaneous force can be applied to the samples via the loading head mounted on the end of the bar. Deformation and energy absorption values were recorded with the help of a load cell and accelerometer. Dynamic bending tests measure the mechanical properties and energy absorption capacity of a composite sandwich structure under dynamic loading conditions. This test measures the mechanical and energy absorption capacity of the composite structure, which cannot be determined under quasi-static loading, such as in impact situations. The test setup is shown in Figure 4.

4 | Results and Discussion

4.1 | Test Results of the Hybrid Composite Surface Plate

4.1.1 | Tensile Test Results

Figure 5 shows the force-displacement graphs from the tensile tests of the hybrid composite surface sheets and an image of the sample at the time of testing. According to the test results, the

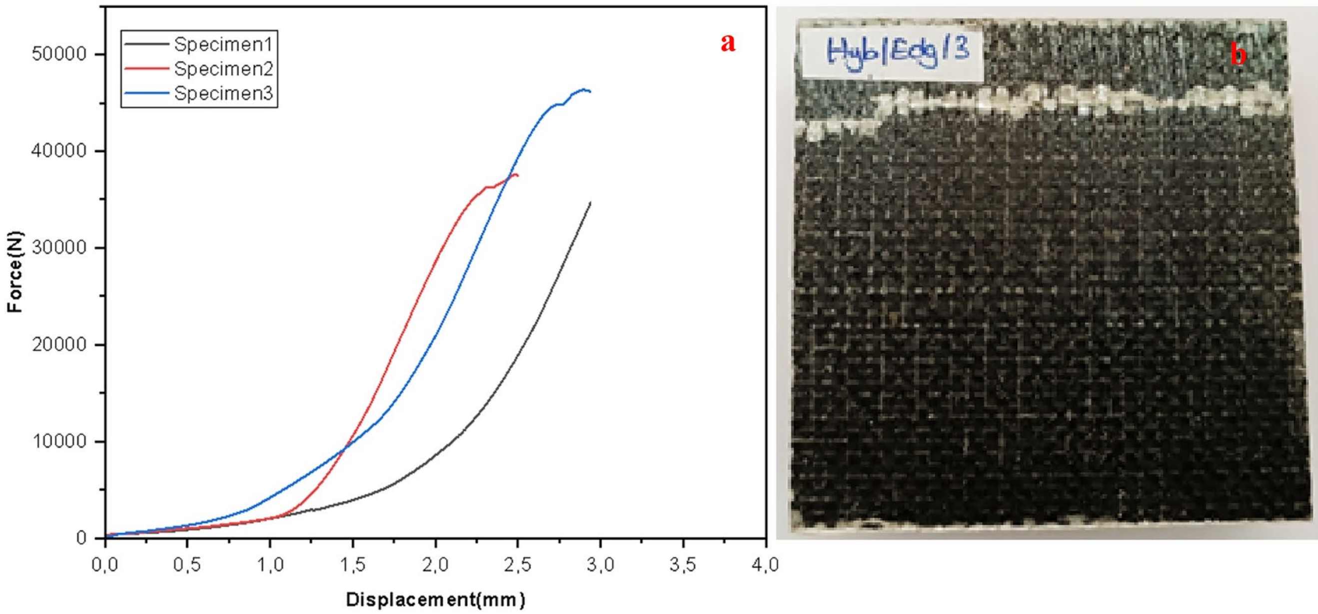

FIGURE 7 | (a) Sandwich structure quasi-static edgewise compression test graphs. (b) Sample image after quasi-static edge compression test.

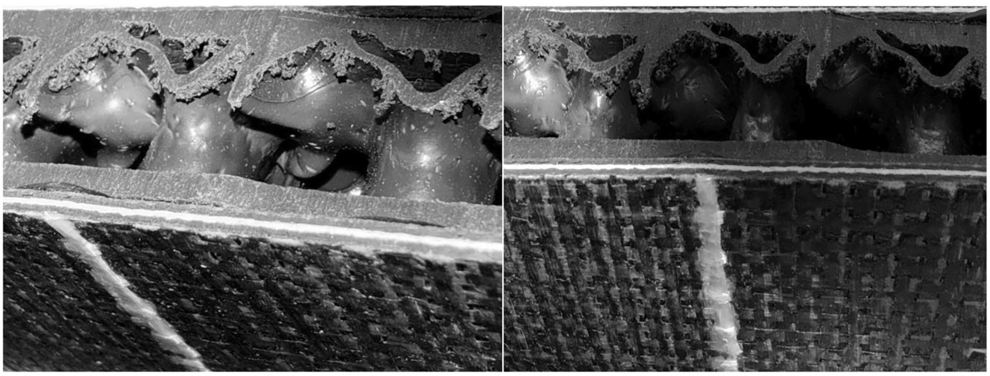

FIGURE 8 | A high-resolution image of the fiber-matrix debonding observed in the topmost glass fiber fabric layer of the hybrid face sheet.

TABLE 3 | Comparison of quasi-static edge compression test results of unskinned core and hybrid composite skinned core sandwich structures.

	Weight (gr)	Max. force (*N*)	Specific max. force (N/g)	Absorbed energy (J)	Specific absorbed energy (J/g)
Hybrid composite surface sandwich	75.24	39,600	526.32	46736.2	621.16
Bare sandwich core	35.30	7408.90	209.88	8922.17	257.75

average maximum stress was 479.05 MPa, and the Modulus of Elasticity was 11.5 GPa. Figure 5 demonstrates that the maximum tensile stress of the hybrid composite reaches 479.05 MPa and that damage initiates in the glass fiber (GF) layer, primarily because the GF layer possesses inherently lower tensile strength than the CF and AF layers, making it the natural initiation site for failure under uniaxial loading [29]. In addition, the relatively lower interfacial shear strength between GF and the epoxy matrix facilitates early fiber-matrix debonding, thereby promoting the subsequent propagation of tensile damage through the laminate [30, 31]. Five samples were used in the tests, and the best and worst results were excluded from the calculations. A review of the data obtained reveals results consistent with those in the literature studies. These results were determined graphically using the following equations. Tensile damage in the samples occurred starting from the center of the test sample and the glass layers, progressing toward the lower layers.

$$\sigma = \frac{F}{A} \tag{1}$$

$$E = \frac{\Delta\sigma}{\Delta\varepsilon} \tag{2}$$

Here, σ is the stress, F is the force, and A is the area of the sample. Furthermore, E is the modulus of elasticity, and ε is the strain.

4.1.2 | 3-Point Bending Test Results

Figure 6 shows the force-displacement graph obtained from the 3-point bending test of the hybrid composite surface plates and the image of the sample at the time of the test. According to the hybrid surface 3-point bending graph, the average maximum load was found to be 1564.99 N, the tensile strength was 500.79 MPa, and the modulus of elasticity was 22.48 GPa. These results were determined graphically using the equations below.

$$\sigma = \frac{3FL}{2bh^2} \tag{3}$$

$$E = \frac{FL^3}{4bd^3y} \tag{4}$$

Here, σ is the bending stress, F is the load at the center of the beam, L is the span length of the test setup, b is the width of the specimen, d is the thickness of the specimen, and y is the deflection.

After reaching the maximum force in all samples, the top glass fiber layers began to separate from the matrix at the level where the load was applied but did not continue to the lower surfaces.

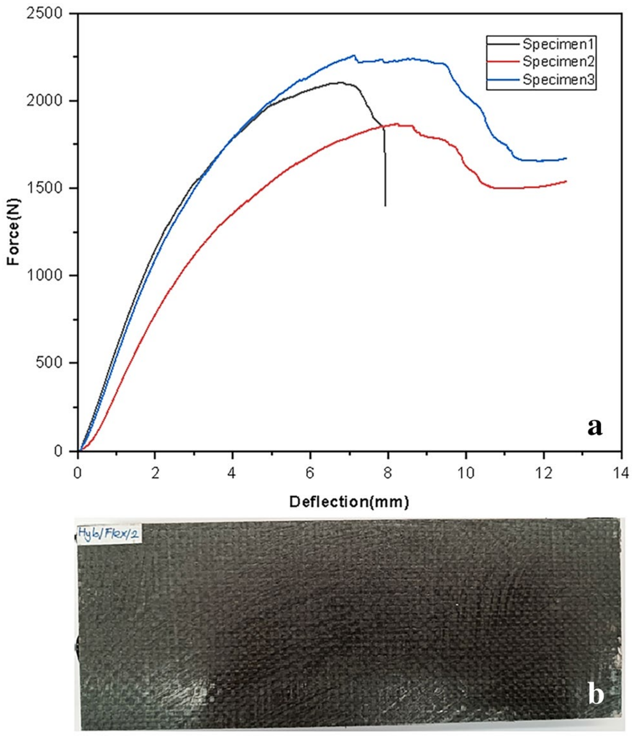

FIGURE 9 | (a) Sandwich structure quasi-static 3-point bending test graphs. (b) Sample image after quasi-static 3-point bending test.

4.2 | Test Results of Sandwich Structure

4.2.1 | Sandwich Structure Quasi-Static Edge Compression Test Results

Figure 7 shows the results of the quasi-static edge compression test on the sandwich structure and the post-test specimen image. Accordingly, the maximum force the specimens could carry was an average of 39.6 kN; no fracture was observed in the hybrid composite surface plates; only fiber-matrix separation occurred in the uppermost glass fiber fabric of the hybrid surface, perpendicular to the load. No core damage was observed in the sandwich core.

The fiber-matrix debonding observed in the topmost glass fiber fabric layer of the hybrid face sheet is illustrated in high-resolution in Figure 8.

A table comparing the edge compression test results of sandwich structures with hybrid composite surface plates to those of sandwich structures without composite surface plates, as experimentally examined in a previous study, is presented in Table 3 below.

4.2.2 | Sandwich Structure Quasi-Static 3-Point Bending Test Results

Figure 9 shows the results of the quasi-static 3-point bending test and the post-test specimen image. Accordingly, the average maximum force was 2076.79 N. When examining the damage of the sandwich structures, the post-test damaged specimen image showed no fracture or cracking damage on the front and back face plates of the sandwich. All cores exhibited only slight cracks and the beginnings of slight crushing, but no fracture was observed. This demonstrated that the hybrid surface distributed the load.

A table comparing the 3-point bending test results of sandwich structures with hybrid composite surface plates to those of sandwich structures without composite surface plates, as experimentally examined in a previous study, is presented in Table 4 below.

4.2.3 | Sandwich Structure Dynamic 3-Point Bending Test Results

Figure 10a–c show the dynamic 3-point bending test graphs applied to the sandwich structure, while Figure 10d shows an image of the sample during the test. This test is performed to determine the impact resistance of the materials used under dynamic loads. The test results showed no damage to the hybrid surfaces of the samples, while the cores exhibited slight crushing and initiation of cracks.

TABLE 4 | Comparison of quasi-static 3-point bending test results of unskinned core and hybrid composite skinned core sandwich structures.

	Weight (gr)	Max. force (N)	Specific max. force (N/g)	Absorbed energy (J)	Specific absorbed energy (J/g)
Hybrid composite surface sandwich	192.23	2076.79	10.80	21372.08	111.18
Bare sandwich core	97.35	1038.30	10.67	17928.45	184.16

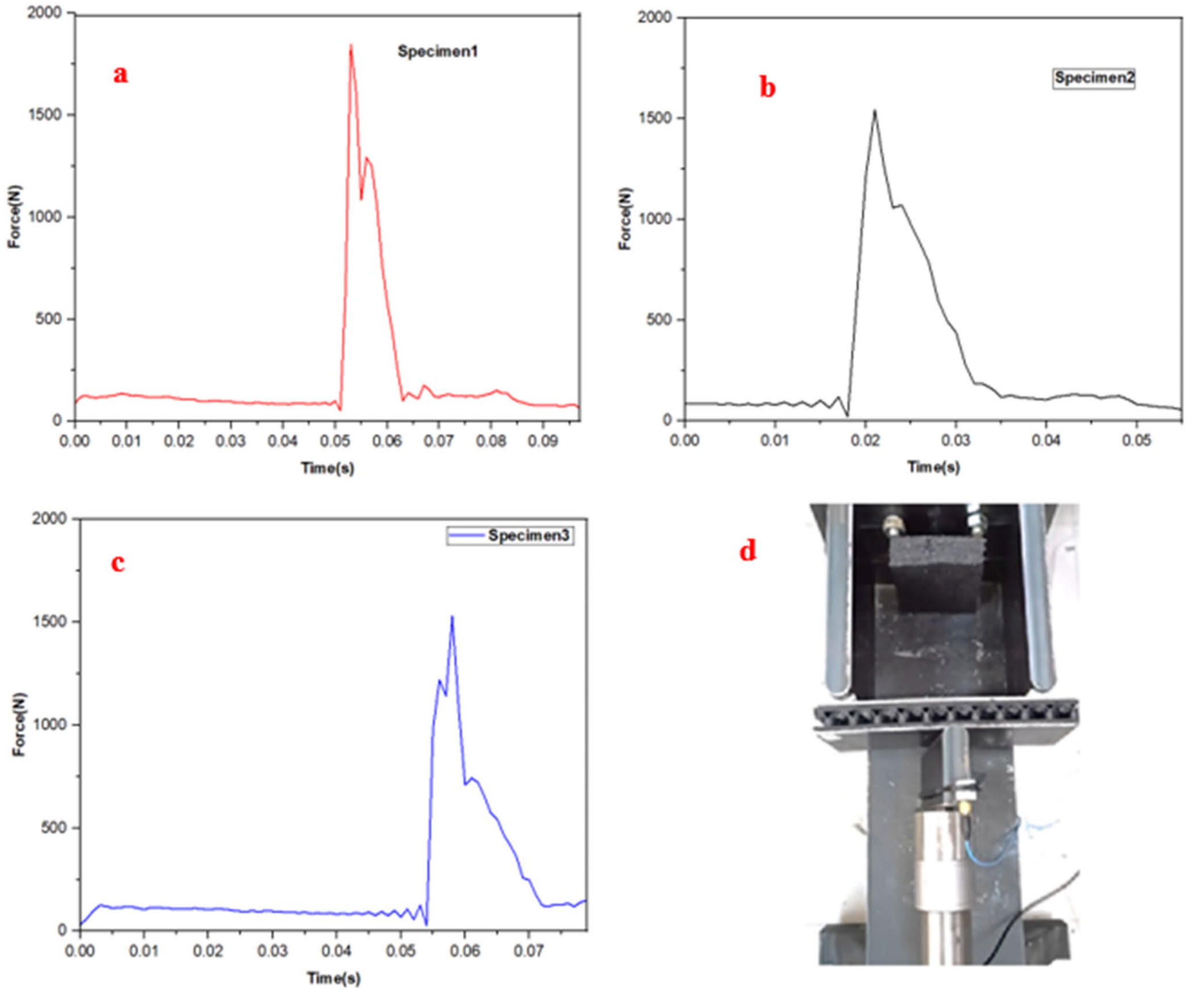

FIGURE 10 | Sandwich structure dynamic three-point bending test graphs: (a) Test graph of Specimen 1. (b) Test graph of Specimen 2. (c) Test graph of Specimen 3. (d) Sample image during dynamic 3-point bending test.

After examining all test results and sample images, it was observed that the hybrid composite surface plates and core suffered minimal damage, with none of this damage attributed to the adhesive. In other words, the compatibility between the adhesive, core, and hybrid surface was optimized, resulting in strong interface adhesion.

4.3 | Discussion

The results from the mechanical tests conducted on the hybrid composite surface plates and the sandwich structure demonstrate promising performance characteristics, indicating their effectiveness in load-bearing applications. The tensile and three-point bending tests revealed that the hybrid composite surface plates exhibit an impressive maximum tensile strength of 479.05 MPa and a modulus of elasticity of 11.5 GPa. Additionally, they show a significant bending strength of 500.79 MPa and a modulus of elasticity of 22.48 GPa. These values align well with existing literature, confirming the reliability of the tested materials.

Interestingly, the observed damage patterns suggest a progressive failure mechanism that begins at the glass fibers and progresses toward the lower layers. This indicates that the material's structural integrity is maintained under load until a critical point is reached. Furthermore, results from the sandwich structure tests indicate that incorporating hybrid composite surface plates enhances overall performance. This is evidenced by their capacity to withstand an average maximum force of 39.6 kN in edge compression tests without fracturing. The absence of core damage and minimal fiber-matrix separation underlines the effectiveness of the hybrid composite in load distribution.

Additionally, the quasi-static three-point bending test demonstrated well-distributed loads, with only slight cracks in the core, further validating the benefits of this hybrid surface. These findings not only highlight the mechanical robustness of the hybrid composite materials but also underscore their potential for applications that demand high strength-to-weight ratios and durability.

5 | Conclusions

This study aimed to strengthen the core by bonding hybrid composite face sheets to a recycled corrugated polypropylene core structure, the properties of which have been experimentally investigated, and to analyze the strength and energy absorption properties of the resulting new structure. To this end, hybrid composite face sheets were produced using an epoxy matrix, with a focus on aligning the Glass/Carbon/Aramid fiber fabrics and controlling the laminate thickness. The produced hybrid composite face sheets were bonded to a recycled, self-coating corrugated polypropylene core structure, the properties of which have been previously investigated. The mechanical properties of the structure were then examined using edge compression, quasi-static, and dynamic three-point bending tests. The results experimentally demonstrated that the hybrid face bonded to the core helped increase the sandwich's bending capacity and the amount of energy it absorbed.

The innovative aspect of this study is that it helps develop new products using recycled materials, contributing to sustainability in industrial sectors where durability, lightness, and reliability are paramount, such as the automotive, aerospace, marine transportation, and architectural construction industries. We believe this study yields significant results, especially in today's world where recycling existing materials is increasingly more important than using new ones. It also demonstrates that the loss of durability in structures built with recycled materials can be more than offset by strengthening them with composite panels, which can be tailored to their intended use and location.

Author Contributions

Büşra Tansu Ceylan: investigation, writing – original draft, methodology. **Kürşad Türkoğlu:** investigation, writing – original draft, writing – review and editing, methodology. **Murat Yazıcı:** supervision, conceptualization, project administration. **Rukiye Ertan:** supervision, project administration.

Acknowledgments

This study was conducted within the scope of the TÜBİTAK-TEYDEB 1505 program (project no. 5220143). The authors sincerely thank TÜBİTAK for their support and would also like to thank POLYTEKS Co. Inc. (Turkey) for their collaboration and project support. Among the authors, Büşra Tansu Ceylan is a scholarship recipient of the TÜBİTAK-BİDEB Industrial Doctorate Program (project no. 118C048), and Murat Yazıcı serves as the manager of the project. BPLAS Co. Inc. is the partner of the 118C048 project. Therefore, Murat Yazıcı and Büşra Tansu Ceylan would also like to present their thanks to BPLAS Co. Inc. BATEG, and Sirena Marine Shipping Industry laboratories were used for the experiments conducted in this study. I want to thank them for their contributions.

Funding

TÜBİTAK-TEYDEB 1505 program (project no. 5220143), POLYTEKS Co., TÜBİTAK-BİDEB Industrial Doctorate Program (project no. 118C048), and BPLAS Co.

Ethics Statement

The authors have nothing to report.

Consent

The authors give their consent for the publication of identifiable details, which can include photographs and details within the text, to be published in the *Journal of Polymer Composites*.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The authors confirm that the data supporting the findings of this study is available within the article.

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