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Material Development and Properties of Medium-Density Board from Low and High-Density Polyethylene

Angeline Baldapan Elegio*

College of Engineering, Architecture and Industrial Design, Bohol Island State University, Bohol, Philippines

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Abstract

This study aims to develop a material from waste low-density polyethylene (LDPE) and high-density polyethylene (HDPE) into a medium-density board and assess its mechanical and physical properties. The development starts with degreasing the upcycled plastic sheets, stacking using premixed polyester resin as an adhesive, pressing, and laminating. The specimens are sent to the Department of Science and Technology Industrial Technology Development Institute (DOST-ITDI) standards and testing division to determine the material's mechanical and physical properties. The findings reveal that the medium-density board successfully combines LDPE and HDPE waste, achieving tensile, flexural, and compressive strengths of 12.1 MPa, 24.2 MPa, and 14.5 MPa, respectively. The board is suitable for shaded outdoor use but not for continuous immersion as it shows a heat deflection temperature of 57.8 °C and 1.27% water absorption after 24 hours. Therefore, it is a potential substitute for furniture, home decor, and light construction materials.

Keywords: polymers, material development, properties, medium-density

1. Introduction

Polymers (plastics) have been central to creating the modern world. Indeed, due to their exceptional material properties and cost-effectiveness, they have been utilized in various sectors, including packaging, construction, electronics, and agriculture, among others [1]. While plastics offer significant benefits and serve as valuable resources for society, such as comfort, hygiene, and safety, leading to the well-being of society, their single-use nature and disposal outweigh the benefits unless used and disposed of appropriately [2]. Globally, more than 300 million tons of plastic waste are produced each year, with only 9% being recycled, while the rest is either incinerated or discarded, primarily accumulating in landfills [3]. It is estimated that there will be 12,000 million metric tonnes of plastic waste on Earth by 2050 if current trends in plastic consumption persist [4].

Unfortunately, artificial petrochemical compounds from oil, such as plastic, will not biodegrade because plastic combines elements extracted from crude oil. Thus, these combinations are synthetic, unknown to nature, and indestructible in a biodegradable sense. Though beneficial in most uses, plastics' chemical inertness and longevity represent major problems when these products are released into the environment [5]. This persistence leads to a range of environmental issues, including the pollution of terrestrial and aquatic ecosystems, harm to wildlife, and the aesthetic degradation of natural landscapes [6]. Synthetic polymers emerged in the late 19th century, during the 1860s, but it was not until following World War II that the "plastics boom" commenced [7]. Fifty percent of the plastic produced is single-use, intended to be thrown away immediately after serving their purpose, such as straws, plastic carrier bags, and water bottles.

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* Corresponding author. E-mail address: angeline.baldapan@bisu.edu.ph

The non-degradable nature of petroleum-based polymers, commonly used in packaging, exacerbates landfill overflow and releases harmful gases during decomposition, posing significant environmental threats [8]. Current research has insufficiently addressed marine pollution arising from single-use plastic bags. Polyethylene is a standard shopping bag material, usually observed in environments (e.g., coastal zones, global ocean, terrestrial ecosystems) with various ecological consequences [9]. Although market-based policies and bans on single-use plastics can reduce waste generation and littering, they cannot fully resolve the plastic pollution crisis [10]. In this case, there will be more plastics in the coming years, thus causing more environmental pollution if not properly reused.

Recycling these resources is one of the ways to help the government address this problem. Thermoplastic softens and becomes flexible when exposed to heat. The long polymer molecules are joined to one another by very weak bonds, which easily break apart when heated and quickly reform when taken away from them. That is why thermoplastics are easy to melt and recycle. In addition, a growing body of scientific evidence suggests that microplastic pollution is ubiquitous, with microplastics found in terrestrial and aquatic environments worldwide [11]. Microplastics are defined as plastic particles smaller than 5 millimeters, including both primary microplastics (e.g., microbeads) and secondary microplastics (e.g., fibers from clothing, fragments from larger plastic items). Primary microplastics are intentionally produced for commercial use, such as in cosmetics, whereas secondary microplastics are formed through the breakdown of larger plastic items.

Fortunately, in partnership with the Japan International Cooperating Agency (JICA) and the Fabrication Laboratory (FABLAB) Bohol, the City of Tagbilaran is adapting the Plastic Recycling Project for Improving Women's Income (PRP4IWI), in which waste plastic shopping bags are heated and cooled to produce upcycled plastic sheets that are then used as the primary material for fashion accessories and souvenir items. The "Kalipunan ng Liping Pilipina" (KALIPI), a women's organized group founded by the Department of Social Welfare and Development (DSWD), produced these recycled plastic sheets, aiming to eliminate the pervasive plastic waste while simultaneously creating an inclusive business opportunity that can employ nearby communities [12]. Thus, plastic sheet upcycling maximizes the use of waste plastic shopping bags and turns them into something more useful.

PRP4IWI developed various products through the workshops, from simple placemats, wallets, ecobags, accessories such as earrings, and uniquely designed flower vases [13]. However, these sheets are only applied to smaller items. Previous work has explored the integration of waste low-density polyethylene (LDPE) and high-density polyethylene (HDPE) composites; for instance, one strategy is to use them in the construction industry, particularly in asphaltic pavements [14]. It further investigated the statistical characteristics of blends.

Another recent approach has demonstrated the potential of recycling LDPE and HDPE by modifying asphalt mixtures and reported an improved deformation resistance and dynamic modulus in LDPE- and HDPE-modified asphalt mixtures, confirmed both experimentally and through machine learning models [15]. Building on this knowledge, this study focuses on developing a laminated medium-density board from recycled LDPE and HDPE, evaluating mechanical and physical properties and aesthetic and structural integrity for light-duty applications.

2. Materials and Methods

This study employed an experimental approach to develop medium-density boards using recycled plastic waste. The methodology comprised three stages: (1) preparation of plastic sheets from collected waste, (2) fabrication of standardized test specimens, and (3) evaluation of their mechanical and physical properties. Each procedure was conducted under controlled conditions and aligned with American Society for Testing and Materials (ASTM) and International Organization for Standardization (ISO) testing standards to ensure reliability and reproducibility.

2.1. *Material preparation*

The application of recycled plastic waste as a raw material for manufacturing green construction panels has been studied in recent years, focusing on its capabilities to help decrease environmental footprint and support circular economy principles. In this research, the research team collected used plastic bags from households, colleagues, institutions, and nearby laundry shops, reflecting a community-focused method of waste collection. The research team transported the collected materials to the PRP4IWI, where the facility upcycled them into plastic sheets. This process was conducted under the close supervision of the management to ensure quality control and adherence to technical standards. The resulting upcycled sheets were intended for use as the core substance in producing medium-density boards to achieve structural integrity.

The gathered waste plastic bags are washed and cut into pieces, as shown in Fig. 1. Removing dirt and dust from the plastic surface is crucial in obtaining a quality sheet. This would affect the binding of the plastic pieces during the heating and compression process. Clean plastic ensures better adhesion between layers, making a stronger and more durable sheet.

Fig. 1 Plastic bags cut into pieces

Fig. 2 shows the use of heat and cold press. The plastic pieces are placed in a heat press below 150 °C and a cold press below 60 °C, as presented in Figs. 2(a) and 2(b), to make upcycled plastic sheets. The controlled temperature ensures that melting is enough to bond without reaching decomposition levels that could emit harmful fumes. Then, applying cold press to harden the sheet consistently, improving its strength and minimizing internal stresses.

(a) Using a heat press at 140 °C (b) Using a cold press at 55 °C

Fig. 2 Using heat and cold press

This technique reduces health hazards and encourages environmentally friendly practices by recycling plastic waste into long-lasting materials without causing air pollution. Appropriate personal protective gear, including gloves and masks, should still be worn when working with hot materials. Still, controlled heating and cooling mitigate the risks associated with traditional plastic recycling techniques that often involve higher temperatures. To support the material preparation process, the researcher organized the necessary tools and equipment in advance. These included a grinder for refining plastic pieces, a compressor and spray gun for finishing applications, and a welding machine for assembly tasks. Additional hand tools such as f-clamps, scissors, wrenches, and screwdrivers were also prepared to facilitate handling and fabrication.

2.2. Fabrication of specimen

The research team prepared specimens according to the sizes required for standard testing, as shown in Table 1. A total of 11 films were used for the tensile strength test, and 7 specimens with a smooth and flat finish were prepared for each of the flexural, compressive, heat deflection temperature, and water absorption tests. These films are laboratory-prepared samples with standardized mechanical and physical testing dimensions.

Table 1 Specimen specifications for testing

Sample	Test	Size in mm (L = length; W = width; T = thickness)	No. of specimens
Plastic product	Tensile properties	L = 200-250; W = 15	11 films
	Flexural properties	L = 100; W = 10; T = 4	7 pieces, smooth and flat
	Compressive properties	L = 50.8; W = 12.7; T = 12.7	7 pieces, smooth and flat
	Heat deflection temperature	L = 127; W = 13; T = 3-13	7 pieces, smooth and flat
	Water absorption	L = 76.20; W = 25.4	7 pieces, smooth and flat

The prepared specimens, each distinctly labeled as illustrated in Fig. 3, were submitted to the Standards and Testing Division of the Department of Science and Technology Industrial Technology Development Institute (DOST-ITDI), a nationally accredited testing laboratory.

Fig. 3 Specimens for laboratory testing

The institute released the results as official summary reports in tabular format, including mean values and standard deviations. Raw datasets, graphical outputs of individual stress–strain curves, and post-test images of fractured specimens for tensile, flexural, and compressive tests were not provided, as these are retained internally. Although this ensured standardized and reliable reporting, it limited the depth of analysis that the research team could perform. Nevertheless, the summarized results provided by the accredited laboratory—derived from ASTM and ISO testing procedures—were sufficient to evaluate the mechanical performance and potential applications of the developed boards. The institute conducted standardized tests to assess key performance indicators such as strength, durability, density, and overall structural integrity.

2.3. Mechanical and physical property testing parameters

The experimental parameters utilized to determine the mechanical and physical properties of the fabricated medium-density board are summarized in Table 2. To evaluate tensile, flexural, and compressive properties, heat deflection temperature, and water absorption characteristics, ASTM and ISO methodologies were conducted under controlled laboratory conditions, with specified test speeds, gauge lengths, and replication numbers to ensure data reliability and reproducibility. The instrumentation included a Shimadzu Universal Testing Machine (Model AGS-50kNXD) for mechanical tests, a Dynisco HDV3 Viact/DTUL machine for thermal performance assessment, and an analytical balance for physical measurements. Environmental factors such as temperature and relative humidity were maintained at 23±2 °C and 50±5%, respectively, to minimize external variability.

Table 2 Test parameters

Test parameter	Tensile properties	Flexural properties	Compressive properties	Heat deflection temperature	Water absorption
Test method	ASTM D638 adapted	ASTM D790/ISO 178 adapted	ASTM D695 adapted	ASTM D648 adapted	ASTM D570 adapted
Speed of test, mm/min	5	-	1.30	-	-
Gage length, mm	50	-	-	-	-
No. of replicate tests	5	-	7	2	3
Instrument used	Shimadzu UTM, model: AGS-50kNXD			Dynisco HDV3 Viact/DTUL machine	Analytical balance
Type of procedure used	-	B	-	-	-
Support span-to-depth ratio	-	16:1	-	-	-
Radius of support/loading noses, mm	-	5	-	-	-
Fiber stress used	-	-	-	0.455 MPa	-
Heating rate	-	-	-	2±0.2 °C	-
Heat transfer media	-	-	-	Silicon oil	-
Type of immersion	-	-	-	-	24h-immersion
Temperature, °C	23±2			-	23±2
Relative humidity, %	50±5			-	50±5

3. Results and Discussion

This section presents the outcomes of fabricating medium-density boards using recycled LDPE and HDPE waste. The results highlight both the technical feasibility and the aesthetic versatility of the developed boards. The fabrication process was evaluated in terms of resin bonding and visual patterns, while mechanical tests assessed tensile, flexural, compressive, heat deflection, and water absorption properties. These findings provide insights into the material’s strengths, limitations, and potential applications in sustainable construction and furniture design.

3.1. Fabrication of the medium-density board

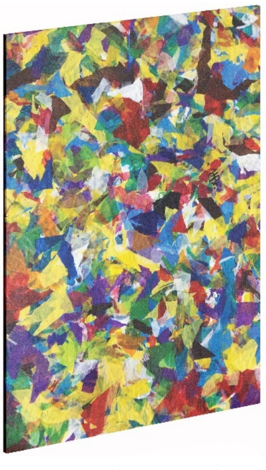

Fig. 4 The medium-density board

The fabrication of medium-density boards using upcycled plastic sheets is a sustainable method of managing plastic waste with the added benefit of making functional composite materials. As a precursor to performance tests, a reproducible and standardized production process must be created to achieve uniformity in structural and physical attributes. This subsection describes the methodology for producing the boards: cleaning plastic sheets, applying premixed polyester resin, pressing, and lamination. These processes were intended to promote interfacial adhesion and material strength. Fig. 4 shows the medium-density board produced from upcycled plastic sheets. The process involved degreasing the sheets, applying premixed polyester resin as an adhesive, stacking, pressing, and laminating. These steps ensured proper bonding and improved the board's structural quality.

One potential challenge was the improper degreasing. The residual contaminants could weaken interlayer adhesion, which would affect the mechanical properties. In this study, this was minimized through careful surface preparation of the plastics before pressing to ensure that the premixed polyester resin can uniformly and securely adhere between the layers, enhancing the resulting composite material's structural integrity and cohesion. The degreasing process ensures surface cleanliness, directly improving resin adhesion.

After degreasing, the research team combined the premixed polyester resin with its hardener. The mixing ratio followed the manufacturer's instructions: 10 mL of hardener per kilogram of resin for a 1% concentration, and 20 mL per kilogram for 2% concentration. The mixture was uniformly applied to the surface of the cleaned plastic sheets, serving as the primary adhesive to bond the layers together. The resin application is carried out using a brushing technique to ensure consistent coverage and sufficient penetration into the surface texture of the sheets. Then, the sheets are carefully stacked and subjected to pressing and wait for a five-hour curing time at room temperature.

This step is critical to promote uniform bonding across the interfacial layers and to eliminate the formation of air pockets within the composite. Entrapped air can compromise the structural integrity of the medium-density board, leading to internal voids that may propagate under mechanical stress and ultimately result in material failure. In addition, the premixed polyester resin used in this study is commercially available and widely used in industry, which supports scalability. Laminating follows, using fine finishing to provide a smooth finish and additional strength to the board.

Fig. 5 presents three patterns in medium-density boards fabricated using LDPE and HDPE waste materials. These patterns are differentiated based on the constituent pieces' geometric characteristics and color schemes, which were manually arranged before the heat-pressing process.

(a) Random shapes, sizes, and colors

(b) Squares with controlled red, yellow, and green colors

(c) Squares and strips in blue, black, and white

Fig. 5 Different patterns produced under different shapes, sizes, and colors

Fig. 5(a) illustrates a composition generated using randomly selected shapes, sizes, and colors. This random distribution produces a highly heterogeneous visual texture that enhances uniqueness and creativity. The unpredictable design provides a distinct aesthetic character, offering versatility for different applications suitable for accent panels or decorative wall features.

Fig. 5(b) demonstrates a pattern created with a more controlled approach, utilizing uniformly shaped squares in a defined color palette of red, yellow, and green. This method introduces a structured and consistent pattern, making it appropriate for tabletops or modular furniture designs where uniformity and vibrancy are desired. Fig. 5(c) exhibits a design composed of square shapes and elongated strips, limited to a color scheme of blue, black, and white. The combination of geometric regularity and a restricted palette generates a visually striking contrast and directional flow that could be applied in modern interior design elements such as cabinets or decorative panels.

These visual outcomes highlight the aesthetic flexibility that can be achieved by varying the recycled polymer components' shape, size, and color. The ratio of LDPE to HDPE was not predetermined, as the study aimed to reflect the variable availability of collected plastic waste and assess the robustness of the upcycling process under such variability. While this approach provided insights into the feasibility of producing functional and aesthetically appealing board products without strict segregation, it also represents one of the study's limitations, since variations in input ratios may influence the reproducibility and consistency of material properties.

The laboratory equipment constraints limited board dimensions to 210 × 297 mm, which restricted scaling in this phase; however, the successful outcomes suggest that larger-scale production is feasible with industrial-grade facilities. In this study, the size was extended by joining the upcycled plastic sheets using mesh tape during the stacking and pressing process, as shown in Fig. 6. The mesh tape acts as a reinforcing material, providing additional structural integrity to the joined sheets and preventing separation. During stacking, the mesh tape is strategically placed between the sheets at the joints, allowing the premixed polyester resin to seep through and bond the layers firmly. When pressed and laminated, the mesh integrates seamlessly into the composite, resulting in a larger and thicker board without compromising strength or durability.

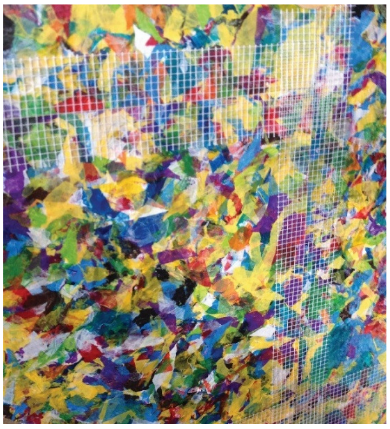

Fig. 6 Joining of two sheets using mesh tape

3.2. Results of the mechanical and physical properties of the medium-density board

This section presents the mechanical and physical performance of the medium-density board developed from a blend of LDPE and HDPE waste. The tests include tensile, flexural, compressive, heat deflection, and water absorption analyses to evaluate strength and durability. Results are compared with values from similar polymer-based composites to assess competitiveness. The tensile properties obtained from the tests are summarized in Table 3.

Table 3 Tensile properties

Sample	Tensile strength (MPa)		Tensile stress at break (MPa)		Tensile stress at yield (MPa)	
	M	SD	M	SD	M	SD
Medium-density board	12.1	3.29	12.1	3.29	-	-
	Tensile strain (elongation) at break (%)		Modulus of elasticity (GPa)		Mean dimension (mm)	
	M	SD	M	SD	W	T
	2.25	0.921	0.742	0.181	14.9	7.79

The material did not show a distinct yield point (no tensile stress/strain at yield), suggesting brittle or non-ductile behavior. The modest tensile strength of 12.1 MPa and low strain at break of 2.25% support the idea of a relatively stiff and brittle material. This is expected due to the blend of flexible LDPE and rigid HDPE polymers. The strength suggests the board can handle reasonable loads, but may not be suitable for applications requiring high tensile resistance. The modulus of elasticity of 0.742 GPa is typical for lower-end polymers, indicating some flexibility but still more rigid than elastomers. This value falls between the typical moduli of LDPE, which is 0.11–0.45 GPa, and HDPE, which is 0.8 GPa, indicating a successful combination of the two materials. Blending HDPE and LDPE can lead to a material with a balance of properties, leveraging the flexibility of LDPE and the strength of HDPE [16]. The standard deviations are relatively high, 3.29 MPa for tensile strength, indicating moderate variation in test results. This is due to sample inconsistencies or experimental variability.

Table 4 presents the flexural performance of the medium-density board as determined through a three-point bending test. The mean flexural strength was 24.2 MPa, with a standard deviation of 3.51 MPa, indicating relatively consistent strength performance among the tested specimens. The material exhibited flexural stress values of 21.5 MPa at 3.5% strain and 22.0 MPa at 5% strain, with standard deviations of 3.25 MPa and 3.22 MPa, respectively. These results suggest a minimal increase in stress between the two strain levels, reflecting the board's moderate ductility under bending stress.

Table 4 Flexural properties

Sample	Flexural strength (MPa)		Flexural stress at given strain (MPa)				Flexural stress at break (MPa)		Flexural modulus (GPa)	
			3.5%		5%					
	M	SD	M	SD	M	SD	M	SD	M	SD
Medium-density board	24.2	3.51	21.5	3.25	22.0	3.22	-	-	0.815	0.134
	Mean dimension (mm)		No. of specimens failed at		No. of Replicate tests		Rate of cross head motion (mm/min)		Support span length (mm)	
	W	T	Y	R						
	11.2	4.44	5	0	5		21.0		76.0	

These results are comparable to those reported in related literature. Recycled HDPE composites have been reported to achieve flexural strengths around 32.6 MPa [17], while LDPE-based composites show lower flexural strengths near 7.61 MPa [18]. The flexural modulus, representing the board's stiffness, was measured at 0.815 GPa with a standard deviation of 0.134 GPa, indicating a moderately rigid behavior appropriate for structural applications requiring bending resistance. Specimen dimensions averaged 11.2 mm in width and 4.44 mm in thickness, with a support span of 76.0 mm during testing. All five replicate tests were completed, with five specimens failing as expected under flexural loading and no failures attributed to testing anomalies. The crosshead motion rate was maintained at 21.0 mm/min, following standard test protocols for reliable comparison of results.

Table 5 shows the results of the compressive testing conducted on medium-density board specimens. The average compressive strength was 14.5 MPa, with a standard deviation of 2.70 MPa, reflecting moderate resistance to axial compressive loading and some variability among the test samples. No data were recorded for compressive stress at yield, suggesting either that yielding was not clearly defined or that failure occurred in a brittle manner without a distinct yield point.

Table 5 Compressive properties

Sample	Compressive strength (MPa)		Compressive stress at yield (MPa)		Compressive modulus (GPa)		Mean dimension (mm)		
	Mean	SD	Mean	SD	Mean	SD	L	W	T
Medium-density board	14.5	2.70	-	-	0.482	0.067	51.4	13.3	13.8

These results are comparable to those reported in related studies. Comparable research on recycled HDPE and wood-plastic composites has documented compressive strengths of approximately 10–28 MPa, depending on material formulation, filler content, and processing techniques [19]. These findings indicate that the developed boards exhibit compressive properties consistent with those of similar polymer-based composites, supporting their potential applicability in structural uses requiring moderate compressive performance. The compressive modulus, representing the material's stiffness under compressive loading, was measured at 0.482 GPa, with a standard deviation of 0.067 GPa. This value indicates a relatively lower stiffness than the flexural modulus, consistent with the structural behavior of composite board materials under different loading conditions. Specimens used in the test had an average dimension of 51.4 mm in length, 13.3 mm in width, and 13.8 mm in thickness, providing a standardized basis for comparison across studies.

As shown in Table 6, the mean heat deflection temperature of the samples was recorded at 57.8 °C, which reflects the material's ability to retain its structural integrity at moderately elevated temperatures. The test was conducted using specimens with the following average dimensions: L = 12.8 mm, W = 14.5 mm, and T = 12.7 mm. The resulting value suggests that the material can be employed in applications where moderate heat resistance is essential and dimensional stability at elevated temperatures is required.

Table 6 Heat deflection temperature

Sample	Heat deflection temperature (°C)	Mean dimension (mm)		
	Mean	L	W	T
Medium-density board	57.8	12.8	14.5	12.7

The board can be used outdoors since, based on the average of all weather stations in the Philippines, excluding Baguio, the mean annual temperature is 26.6 °C [20]. However, in extreme conditions, such as prolonged direct sunlight or near heat sources where surface temperatures can exceed 50 °C, the material may approach its deflection limit, potentially leading to warping or loss of mechanical integrity. Additional treatments like ultraviolet (UV) stabilization or heat-resistant coatings might be considered to enhance thermal performance.

Table 7 suggests that the material absorbs water and increases by 1.27% in weight if immersed in water for 24 hours. This could lead to swelling, dimensional instability, and potential mechanical property degradation over time, especially if the material is consistently exposed to water. Discoloration was also observed on the three replicated specimens. It may not directly affect mechanical strength, but it compromises the aesthetic quality, which is critical for applications where appearance matters, such as outdoor decorative panels and furniture. Thus, the board could be used outdoors, but it is not designed to be submerged in pools and on beaches.

Table 7 Water absorption

Sample code	% Water absorption (Increase in weight)	Mean dimension (mm)			Observation
		L	W	T	
Medium-density board	1.27	77.3	25.8	15.6	Discoloration was observed on the specimens

Compared to Junaid et al. [14], who primarily conducted statistical analyses on LDPE/HDPE blends, the medium-density board demonstrated notable tensile, flexural, and compressive strengths and aesthetic versatility through patterning. This underscores the functional and decorative potential of the material for applications in furniture and light building components. Reducing plastic usage, reusing, recycling, and energy recovery can mitigate environmental impacts [21], and upcycling waste LDPE and HDPE shopping bags into light construction materials offers a better alternative than incineration. The post-consumer LDPE and HDPE shopping bags are low-cost, requiring only collection and minimal pre-processing. Energy use was limited to shredding, pressing, and heating, which are scalable processes adaptable to existing manufacturing setups.

Compared to conventional medium-density fiberboards, the production of the upcycled plastic boards reduces dependence on virgin raw materials and avoids additional deforestation-related impacts. While a full cost–benefit and life cycle assessment are beyond the scope of this study, these initial considerations indicate that the approach is economically viable and environmentally advantageous when implemented at larger scales. Although the developed boards exhibited favorable structural and aesthetic qualities, they may be prone to deformation under sustained loading and potentially degrade when subjected to prolonged UV exposure or fluctuating temperatures. Additionally, while the boards exhibit good bonding from thermal fusion of plastics, the uneven distribution of plastic pieces could serve as starting sites for cracking or delamination.

4. Conclusions

The study successfully demonstrated the feasibility of transforming waste LDPE and HDPE plastic shopping bags into medium-density boards with both aesthetic and functional properties suitable for light construction and decorative applications. The key outcomes are summarized below:

(1) The random coloration and distribution of the plastic fragments enhanced the board's visual appeal and enabled user customization. Although fabrication was limited to an A4-sized (210 × 297 mm) board due to laboratory constraints, the board scaling up is considered feasible through the use of mesh tape reinforcement and lamination techniques for larger, structurally sound panels.

(2) Mechanical testing showed a tensile strength of 12.1 MPa and a low strain at break of 2.25%, indicating a relatively stiff and brittle material, which aligns with the properties of the blended polymers. The modulus of elasticity of 0.742 GPa and flexural modulus of 0.815 GPa suggest that the material exhibits moderate rigidity appropriate for non-load-bearing structural applications. Additionally, the mean flexural strength of 24.2 MPa and compressive strength of 14.5 MPa confirm its capacity to resist moderate flexural and compressive loads.

(3) The heat deflection temperature of 57.8 °C confirms the board's suitability for typical tropical outdoor conditions, such as those in the Philippines. However, exposure to extreme heat may cause deformation. This may warrant using UV- or heat-resistant coatings to extend the material's durability.

(4) Water absorption testing showed a 1.27% weight increase after 24 hours. This suggests a potential dimensional and aesthetic change over time. Despite minor discoloration, the material maintained structural integrity, making it suitable for shaded or semi-exposed outdoor use but not for continuous water immersion.

The results of this study contribute to advancing sustainable material development by showing how plastic waste can be engineered into functional composites. While the developed boards exhibited good performance in mechanical, thermal, and aesthetic aspects, further refinement is needed to improve durability and long-term reliability. Future studies should include detailed stress–strain analyses, controlled LDPE-to-HDPE ratio testing, and weathering or repeated loading assessments. These efforts will help optimize the material and expand its potential use in sustainable furniture, interior design, and light construction applications.

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Conflicts of Interest

The authors declare no conflict of interest.

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