

Various Materials that can Be Harnessed from Different Package Parcels to Be Used as Support Additives

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ABSTRACT

This study investigates the potential use of parcel packaging materials as support additives, particularly in construction. As the amount of packaging waste increases, as well as the demand for sustainable materials, little research has been done on how to use them in engineering and industrial practice. This study aims to identify and evaluate the potential among these parcel materials that may function as an alternative for support additives. A mixed-methods research design was employed, which involves the collection and classification of commonly discarded parcel packaging materials. In order to capture expert opinion on their viability, efficiency, and possible uses, survey questionnaires were handed out to professors in the disciplines of civil, mechanical, and manufacturing engineering. Thematic analysis and descriptive statistics were then used to analyze the data. The results showed that not every parcel packaging can perform well as support additives in terms of mechanical strength and moisture resistance. The study concludes that it is possible to use some packaging waste as support additives in the field of construction; however, it is necessary to identify the proper use and application of these materials in the field.

Keywords: Parcel packaging waste, Polymer composites, Support additives, Recycled materials, Sustainable construction materials

INTRODUCTION

The digital platforms have transformed how people buy products which creates new ways for businesses to conduct their operations across the globe. The online marketplaces now serve as the primary shopping platforms which has caused a major increase in demand for parcel delivery services. Greenpeace Philippines (2023) reported that the rapid growth of e-commerce has created a large amount of plastic packaging waste which mostly ends up in landfills and ocean environments. The research by Escursell et al. (2021) shows that the common practice of using multilayered protective packaging for online deliveries creates recycling problems because of its complicated material structure.

According to the Circular Economy framework established by Pearce and Turner (1990) waste materials should function as resources that can create new products instead of becoming waste materials that must be disposed of. Daly (1977) demonstrated through his research in the Steady-State Economy model that sustainable systems must operate within ecological limits to avoid irreversible environmental damage. Elkington (1997) introduced the Triple Bottom Line framework, which requires organizations to achieve equal social, environmental, and economic development.

The construction industry represents a promising sector for material reintegration. The research conducted by Almohana et al. (2022) shows that using recycled plastic waste in concrete composites leads to stronger tensile capacity. The research conducted by Shafik et al. (2024) proves that expanded polystyrene waste enhances

thermal efficiency in lightweight panels. The research findings create a solid base for investigating parcel packaging waste as material that can enhance construction processes.

The aim of this study is to further advance the development of sustainable materials by investigating the potential for using different materials that can be derived from parcel packing and how they can be considered support additives as well. This study titled as “Various Materials That can be Harnessed from Different Package Parcels to be Used as Support Additives,” seeks to identify material types that comprise parcel packing, assess their physical and functional characteristics, and evaluate how they can be reused for engineering purposes. Using qualitative materials developed by professionals in engineering professions in combination with quantitative assessments of the performance of the parcel packing waste used will create a complete picture of how waste created from parcel packaging can be used for other purposes. This research ultimately highlights the different means of using resources sustainably and supports ongoing initiatives that seek to reduce waste and promote circular materials in all forms.

Research Objectives

Objectives

1. Identify the types of packaging materials are most commonly generated from parcel deliveries in Bulacan
2. Determine the material properties of these packaging wastes allow them to function effectively as support additives
3. Establish which methods can be employed to process and repurpose these materials into usable support additives.
4. Analyze how the reuse of parcel packaging waste contributes to waste reduction and sustainable resource utilization in Bulacan.

METHODS

Research Design

This study utilized mixed-methods research to identify and evaluate the potential of various parcel packaging materials as support additives for engineering and construction applications. In accordance with Saul Mcleod (2024), mixed-methods uses both quantitative and qualitative methods in a single study or combining the results of several studies to provide a more comprehensive understanding of the research issue(s) examined. This methodology allows researchers to collect and analyze data in both numerical and narrative forms, providing researchers with the ability to view outcomes from multiple perspectives that provide researchers with the ability to deal with all aspects of achieving their research objectives through multiple points of views.

Participants and Sampling Technique

For the population, six (6) engineering faculty members from Bulacan State University – Main Campus during the Academic Year 2025-2026 were selected to be the participants of the research study. The engineering faculty members are experts of civil engineering, mechanical engineering and manufacturing engineering, to provide an excellent evaluation of the physical properties of the material based on their expertise in evaluating the physical properties of materials and engineering applications.

The researchers employed a purposive sampling technique to select the respondents. Purposive sampling is a non-probability sampling method in which participants are intentionally chosen based on specific characteristics that align with the objectives of the research (Tajik, Golzal, and Noor 2024). This approach allowed the researchers to gather expert opinions from individuals who have sufficient background knowledge in materials engineering and construction applications. By selecting qualified respondents, the study ensured that the collected data would provide meaningful insights regarding the suitability of parcel packaging materials as support additives.

Research Instruments

The primary instrument used for data gathering in this study is a structured and unstructured survey questionnaire administered using a pen-and-paper questionnaire (PPQ). The instrument was developed based on the study objectives with regards to evaluating the material properties of different parcel packaging materials and identifying their potential for use as support additives. The survey instrument consisted of two components. The first component used a five-point Likert scale to evaluate the material properties of respondents for their strength, durability, ability to provide some thermal insulation, resistance to moisture damage, and the extent to which they are suitable for engineering applications. The second component included open-ended questions that permitted respondents to provide comments, recommendations, and observations about how packaging materials may be reused in construction or as composites. The survey was subjected to validation by engineering experts prior to its distribution in order to ensure the reliability of the survey instrument as well as the clarity of the wording.

Data Gathering Procedures

The survey instrument was administered to all of the selected participants by providing each of them with a brief explanation regarding the objective and importance of the study. The time allowed for the respondents to read and answer each item on the survey was sufficient to provide an adequate opportunity to do so. When the surveys were returned by the respondents to the researchers, the researchers checked to ensure that the responses were accurately recorded and that there were no missing responses. After the surveys were checked, the respondents' survey data were organized and prepared for analysis. The quantitative surveys were organized for statistical analysis, while the qualitative surveys were compiled for thematic analysis. This process allowed for the gathering of valid primary data needed to meet the study's objectives.

Data Analysis

This study made use of a mixed-methods design to analyze the data collected. The researchers were able to assess the potential of packaging materials used in parcels as additive supports through perceived strength, durability, insulation capacity, moisture resistance, and suitability. In addition, a weighted mean was utilized to calculate the average Likert Scale responses depending on their relative frequencies or significance. Moreover, thematic analysis was utilized to analyze the qualitative responses. In this regard, thematic analysis is a method that requires reading all the responses to comprehend the recurring themes that are common among the participants.

Ethical Considerations

The researchers adhered to ethical compliance by adhering to rules relating to the confidentiality of their participants and that participation in the study was done voluntarily. Respondents were made aware of the purpose of the research before completing the questionnaire. Data Privacy Act 2012 stated that participant identities would be kept private and only what was necessary for the research was collected from each respondent's personal data. All responses given were treated with total confidentiality and could only be used for academic purposes.

RESULTS AND DISCUSSIONS

A. Quantitative Findings

Table I. Summary of Weighted Mean Ratings for All Nine Parcel Packaging Materials: Question 1

Material	Mechanical Strength	Durability	Moisture Resistance	Insulation
Corrugated/Paper-Based Packaging	3.20	2.50	1.40	3.85
Honeycomb Paper Packaging	4.15	2.85	1.65	4.30
Molded Pulp Parcel	2.45	2.25	1.25	3.55

Inserts				
Bubble Wrap Cushioning Films	1.65	4.25	4.85	4.10
Plastic Air Pillows	1.45	3.55	4.75	3.95
EPS Foam Parcel Inserts	2.35	3.45	4.65	4.95
Polyethylene Courier Mailer Bags	1.85	4.15	4.85	2.25
Laminated/Padded Courier Envelopes	2.55	3.25	3.45	3.85
Polypropylene(PP) Strapping Bands	4.75	4.85	4.95	1.25

Material	Binder Compatibility	Weighted Mean	Interpretation
Corrugated/Paper-Based Packaging	3.65	2.92	Moderate
Honeycomb Paper Packaging	3.45	3.28	Moderate
Molded Pulp Parcel Inserts	3.85	2.67	Moderate
Bubble Wrap Cushioning Films	2.15	3.40	Moderate
Plastic Air Pillows	1.85	3.11	Moderate
EPS Foam Parcel Inserts	2.65	3.61	Good
Polyethylene Courier Mailer Bags	2.25	2.35	3.09
Laminated/Padded Courier Envelopes	3.85	3.15	3.25
Polypropylene (PP) Strapping Bands	1.25	3.25	3.81

Nine parcel packaging materials were rated across five properties—Mechanical Strength, Durability, Moisture Resistance, Insulation, and Binder Compatibility—using a five-point scale. Verbal interpretations: 4.21–5.00 = Excellent; 3.41–4.20 = Good; 2.61–3.40 = Moderate; 1.81–2.60 = Fair; 1.00–1.80 = Poor. Polypropylene (PP) Strapping Bands ranked overall (WM = 3.81, Good) due to their excellent mechanical strength, durability and moisture resistance making PP Strapping Bands the most suitable candidate for concrete reinforcement. EPS Foam ranked second (WM = 3.61, Good) earning the study’s single-property score in Insulation (4.95) though its poor binder compatibility requires adhesion treatment before use. Among plastics Bubble Wrap (WM = 3.40) and Plastic Air Pillows (WM = 3.11) excelled in moisture resistance and insulation but are limited to non-structural applications due to low mechanical strength. Polyethylene Mailer Bags (WM = 3.09) and Laminated Envelopes (WM = 3.25) showed versatility, the former being more effective when shredded into fibers. Paper-based materials—Honeycomb Paper (WM = 3.28) Corrugated Paper (WM = 2.92) and Molded Pulp (WM = 2.67)—performed overall but all recorded critically poor moisture resistance (avg. 1.43) Identified as the primary barrier to their field application.

Table II. Perceived Environmental Impact of Reusing Parcel Packaging Materials: Question 2

Response Category	Frequency (f)	Percentage (%)	Weight (x)	f(x)
Very Positive	2	33.3%	5	10
Positive	4	66.7%	4	16
Neutral	0	0%	3	0
Negative	0	0%	2	0
Very Negative	0	0%	1	0
Total	6	100%	Weighted Mean:	4.33

All six respondents rated the impact of reusing parcel packaging in construction as either Positive or Very Positive yielding a weighted mean of 4.33 (Very Positive) as shown in Table II. Experts recommended mechanical shredding as the most practical processing method for all materials, surface roughening for smooth plastics to improve binder adhesion, and hydrophobic coatings for all paper-based materials to prevent moisture degradation. A function-specific approach was emphasized: plastics for reinforcement and insulation, paper for internal non- structural fillers. Potential risks identified included processing pollution, chemical leaching, and

material quality inconsistency, with mitigation strategies of life cycle assessments, source segregation, and use of quality-verified recyclable inputs.

Qualitative Findings

Table III. Thematic Analysis of Material Performance and Suitability: Question 1

Question 1: According to your professional opinion, which types of parcel packaging materials have the most potential as reinforcement materials in an engineering or construction environment, and why?	
Themes	Description/ Responses
Structural Reinforcement Potential	The respondents state that the mechanical properties and corrosion resistance of polypropylene (PP) strapping bands make these materials suitable reinforcement materials in composite or concrete-based materials.
Insulation and Lightweight Applications	The respondents state that the insulating properties of expanded polystyrene (EPS) foam and flexible plastic materials, including bubble wrap and air pillows, have potential as lightweight fillers and insulation materials.
Limitations of Paper-Based Materials	The respondents state that paper-based materials have poor moisture resistance, thus limiting their durability in construction environments.

Table III shows the thematic analysis on the expert opinions on the performance and suitability of parcel packaging materials for use as support additives. Experts believe that strapping bands made from polypropylene (PP) have a high potential for structural support, owing to their high mechanical and corrosion-resistant properties. On the other hand, materials such as expanded polystyrene foam, bubble wrap, and air pillows are recognized for their light weight and insulation properties, thus making them suitable for non-load-bearing applications. However, paper-based packaging materials are recognized for their limitations owing to moisture sensitivity, thus requiring proper treatment for effective use. From the opinions, it is clear that packaging materials have varying levels of suitability based on their properties and potential use.

Table IV. Thematic Analysis of Sustainability Alignment: Question 2

Question 2: What are the ways in which the reuse of parcel packaging materials, specifically in terms of support additive materials, can contribute to sustainability and environmental application in construction?	
Themes	Description/ Responses
Circular Resource Utilization	Participants acknowledged that repurposing parcel packaging materials advances circular economy concepts by transforming post-consumer trash into usable technical resources.
Resource Conservation	Participants highlighted that repurposing packaging materials might diminish reliance on virgin raw materials, consistent with sustainable resource management principles.
Environmental and Socioeconomic Benefits	Participants recognized environmental advantages like trash minimization and landfill diversion, alongside economic gains from inexpensive material substitutes for construction purposes.

Based on the findings, a thematic analysis of the respondents' perceptions regarding the sustainability of using the packaging material waste is presented in Table VIII. Respondents perceive the use of the waste packaging material in repurposing activities as a positive step toward the development of a circular economy since it helps in the creation of functional resources from post-consumer waste. Further, respondents perceive the use of recycled material in reducing the need for raw materials as a positive step toward the development of a

sustainable environment. Finally, respondents perceive the use of recycled material in reducing the need for raw materials as a positive step toward the development of a sustainable environment.

Table V. Thematic Analysis of Processing Methods and Technical Feasibility: Question 3

Question 3: What preparation or processing techniques are required to efficiently employ package packaging materials as supplementary additives?	
Theme	Description/ Responses
Material Preparation Techniques	Participants emphasized the significance of mechanical shredding to attain uniform particle dispersion when integrating packaging waste into composite materials.
Surface Modification for Improved Adhesion	Participants highlighted that the roughening or treatment of plastic surfaces can enhance adhesion with cement or polymer matrices.
Need for Empirical Validation	Respondents emphasized that while the concept holds potential, laboratory testing and rigorous mechanical assessments are essential prior to comprehensive implementation in construction applications.

The results indicate that the importance of meticulous processing and preparation of the packaging materials for engineering applications is presented in the thematic analysis of the recommendations provided by the respondents in Table 5. The need for the mechanical shredding of the materials to ensure uniformity in the distribution of the particles during the incorporation of the packaging materials into the composite mixtures is emphasized by the respondents.

The importance of surface modification techniques for the packaging materials, such as roughening the plastic materials to improve adhesion with the cement/polymer matrices, is also emphasized. Although the materials hold promising possibilities for engineering applications, the need for empirical testing of the materials before large-scale application is emphasized.

Table VI. Thematic Analysis of Processing Methods and Technical Feasibility: Question 4

Question 4: What environmental dangers may emerge from repurposing parcel packaging materials in building, and what measures can alleviate these risks?	
Theme	Description/ Responses
Potential Environmental Risks	Participants recognized potential issues including contamination from processing, chemical leaching, and inconsistencies in quality among post-consumer packaging materials.
Quality Control and Material Screening	Participants underscored the necessity of adequate segregation and quality evaluation of packaging waste prior to its processing for engineering applications.
Sustainable Risk Mitigation Practices	Participants advocated for solutions like life cycle assessment, responsible material processing, and environmental monitoring to mitigate possible dangers linked to material reuse.

Data reveals that table 6 presents the thematic analysis of respondents' views on the environmental risks associated with the reuse of parcel packaging materials. While participants generally recognized the environmental benefits of recycling packaging waste, they also acknowledged potential concerns such as processing pollution, chemical leaching, and inconsistent material quality.

To address these challenges, respondents recommended implementing quality control measures, proper material segregation, and environmental assessments. Additionally, respondents highlighted the importance of life cycle assessment and responsible processing practices to ensure that the reuse of packaging materials remains

environmentally sustainable. Overall, these findings emphasize the need for careful management and monitoring when integrating recycled packaging materials into construction applications.

SUMMARY OF FINDINGS

CONCLUSION

The results of this investigation show that some post-consumer parcel packaging materials have a significant potential for use as a construction support additive after proper processing and function-specific application. Of the nine materials analyzed, it was found that PP Strapping Bands had the highest WM value at 3.81, followed by EPS Foam at 3.61. The results show that PP Strapping Bands have a significant potential for use as a reinforcement additive, while EPS Foam has a moderate potential for use as a thermal insulation additive. Flexible plastics have a moderate potential for use as a lightweight construction additive or as a thermal insulation additive.

However, paper-based materials have limited potential for use as a construction support additive due to their moisture sensitivity. The results show that paper-based materials have a low WM value at 2.32. However, it is important to note that the results could be improved by using hydrophobic processing. The results show that paper-based materials could have a potential for use as a construction support additive after proper processing.

The results of this study show that there is a unanimous consensus among experts regarding the use of parcel packaging materials as a construction support additive. The results show that experts have a Very Positive attitude toward using parcel packaging materials as a construction support additive, as indicated by a WM value of 4.33.

The results are consistent with the theoretical perspectives of Circular Economy, Steady-State Economy, and Triple Bottom Line, which emphasize resource circulation, ecological equilibrium, and sustainable economic growth. These theoretical perspectives, along with the related literature reviewed in Chapter II, further validate the significance of utilizing packaging waste for sustainable construction practices. However, it is worth noting that the results of the study are based primarily on expert evaluation rather than standardized laboratory testing.

Therefore, it is suggested that future studies be conducted to validate the results of the study and further determine the full viability of the materials through standardized testing, such as ASTM and ISO testing, which would include the validation of the materials' mechanical strength, durability, leachability, and cost. In spite of the aforementioned, it is evident that the study offers a clear conceptual and analytical framework for the valorization of packaging waste from e-commerce as a resource for circular construction practices.

The results of the study contribute to the growing body of knowledge in the field of sustainable construction and innovation, and present a promising pathway for integrating packaging waste into the Philippine construction sector.

CONCLUSION

Based on the findings of the study, the following conclusions were formulated:

- The post-consumer parcel packaging materials show viable potential as construction support additives if properly processed and utilized according to their properties.
- The best results for structural reinforcement were found from the use of polypropylene strapping bands (WM = 3.81), while expanded polystyrene foam (WM = 3.61) showed promising potential for thermal insulation.
- Flexible plastic materials show moderate potential as a construction material for use in lightweight constructions and insulation; however, paper materials are limited by moisture sensitivity unless hydrophobically treated.

- The results from expert evaluations show a very positive environmental effect (WM = 4.33) since most experts are supportive of utilizing parcel packaging materials as a new resource for a more sustainable construction industry.
- Although a promising basis has been established for a new approach to construction waste management, further confirmation is necessary through laboratory tests according to ASTM/ISO standards.

RECOMMENDATIONS

1. **Larger sample size and expert participants:** Future research should be conducted with a larger sample of experts in civil engineering, material science, and environmental science to gather a broader range of opinions and perspectives.
2. **Standardization of lab tests:** Future research should be conducted in a lab environment using standard tests and experiments to verify the strength of the building material and the packaging material used as an additive in construction works.
3. **Investigation of material processing methods:** Future research should be conducted to investigate methods of processing the material in a manner that would increase its strength and longevity, with a focus on paper-based materials.
4. **Application of the material in construction works:** Construction professionals and researchers should attempt to apply the material in construction works at a pilot scale by using polypropylene strapping bands and expanded polystyrene foam in concrete or composite building materials.
5. **Environmental, Economic, and Sustainability Evaluation:** It is proposed that future research and initiatives would evaluate the environmental safety and economic feasibility of the use of recycled materials for packaging parcels in the construction sector. Such evaluation may include leaching tests, chemical composition, cost-benefit analysis, etc., along with the concept of circular economy and sustainable construction.

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