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Recycled Plastic Core Panels

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Abstract

The increasing demand for resource-efficient construction materials has encouraged the development of wall systems that can divert waste from disposal while remaining technically and economically workable. This preliminary feasibility study developed a composite panel consisting of a compressed post-consumer flexible-plastic core held by galvanized wire mesh and covered on both faces with cement mortar. Three independently fabricated recycled-plastic-core panels were compared with three independently fabricated Styrofoam-core panels in normal compression, post-fire compression, 24-hour water absorption, temperature response during direct heat exposure, and observed fire behavior. The recycled-plastic panels had a higher mean compressive strength under normal loading (207.03 psi) than the Styrofoam panels (175.17 psi) and a higher post-fire mean (192.60 psi versus 151.43 psi); recomputed independent-samples tests did not detect statistically significant differences for either outcome. Mean water absorption was nearly identical (30.05% and 30.09%) and was likewise not significantly different. The recorded temperature and fire observations showed only small descriptive differences between panel types; complete numerical outputs were unavailable for independent verification, so these outcomes are reported descriptively. The estimated installed cost was ₱6,350.00 per square meter for the recycled-plastic system, compared with ₱7,000.00 for concrete hollow-block construction and ₱10,100.00 for the Styrofoam-core system; these estimates do not constitute a lifecycle-cost analysis. A purposively selected sample of 150 stakeholders reported favorable awareness, perception, and acceptability ratings using a researcher-developed, validated questionnaire with excellent internal consistency (Cronbach's α = .922). The findings support continued development of the panel for possible non-load-bearing enclosure, partition, or infill applications, subject to larger replicated testing, fully documented procedures, full-scale assembly evaluation, and code review.

Keywords: recycled plastic; composite panels; non-load-bearing walls; sustainable construction; preliminary feasibility

Introduction

The construction sector faces the linked pressures of increasing material demand, waste generation, and the need for building systems that use resources more efficiently. Prefabricated wall panels can reduce on-site work and provide controlled assembly, but their value depends on the performance of the complete system rather than on light weight or novelty alone. Mechanical resistance, moisture behavior, response to heat and fire, manufacturability, cost, and long-term durability must be considered together. A material that performs well in one respect may remain unsuitable if weaknesses in another property compromise safety or serviceability. This systems perspective is particularly important for composite panels because the core, reinforcement, mortar coating, joints, and installation details interact under use conditions.

Recycled plastics have been investigated as aggregates, binders, fillers, and discrete components in construction materials. Reviews by Saikia and de Brito (2012), Babafemi et al. (2018), Awoyera and Adesina (2020), and Nyika and Dinka (2022) document a wide range of plastic-waste applications while consistently showing that performance depends on polymer type, processing, proportion, and the surrounding matrix. Kumi-Larbi Jnr et al. (2022) further showed that the composition and processing of plastic-bonded sand substantially affect strength, stiffness, thermal behavior, and appropriate end use. Related experimental work demonstrates that recycled thermoplastic composites can also be engineered for acoustic applications (Kucukali-Ozturk et al., 2022). This evidence supports continued material development, but it also cautions against transferring results from one polymer, geometry, or fabrication process to another without direct testing. The behavior of a crumpled flexible-plastic core encased in mesh and mortar cannot be inferred automatically from melted plastic-sand blocks, polymer boards, or conventional concrete.

In the Philippine setting, the possible recovery of low-value plastic bags, wrappers, and multilayer packaging is relevant because these materials are difficult to recycle through conventional streams. Incorporating them into a durable building component could reduce disposal while creating a locally producible construction material. That environmental rationale, however, must remain separate from claims of technical compliance. Diverting waste does

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not by itself establish that a panel is safe, durable, fire resistant, or suitable for structural use. The present investigation therefore treats the recycled-plastic-core panel as an early-stage composite prototype whose measured performance must be interpreted within the exact specimen scale and test conditions used.

The study addressed both technical feasibility and stakeholder response. Adoption of an unfamiliar material is shaped by perceived usefulness, perceived ease of use, and the diffusion of information within a social system (Davis, 1989; Rogers, 2003). Favorable attitudes can justify further demonstration and communication, but they cannot replace laboratory validation or regulatory review. Conversely, technical promise may not lead to implementation if intended users do not understand or trust the material. The technical and social components were therefore considered complementary rather than interchangeable forms of evidence.

The study developed a recycled-plastic-core composite panel and compared it with a Styrofoam-core panel in terms of compressive strength before and after fire exposure, 24-hour water absorption, temperature response during direct heat exposure, observed fire behavior, and estimated installed cost. It also described stakeholder awareness, perception, and acceptability. The comparative null hypotheses were that the mean results for the recycled-plastic and Styrofoam-core panels did not differ for each laboratory outcome. Each hypothesis was examined through a separate two-tailed independent-samples comparison using three independently fabricated panels per group. The study did not test multiple recycled-plastic proportions, flexural strength, acoustic performance, formal thermal conductivity, long-term durability, full-scale wall behavior, connections, or code compliance, and no claim of optimal composition or structural-wall suitability is made.

The prototype panel measured approximately 60 cm × 60 cm × 10 cm. Smaller specimens measuring approximately 24 cm × 24 cm × 10 cm were obtained for the reported laboratory comparisons. This distinction between the fabricated prototype and the test specimen is essential because small cut specimens do not reproduce the boundary conditions, joints, openings, connections, or workmanship effects of an installed wall. The findings are thus limited to preliminary material and specimen behavior. They may inform further research and product development for possible non-load-bearing enclosure, partition, or infill applications, but they do not authorize use in a building project.

The study may assist architects, engineers, builders, material developers, local governments, and researchers by identifying both the promise and the unresolved requirements of a recycled-plastic-core composite panel. For practitioners, the results provide preliminary measurements that can guide the design of a more rigorous validation program. For waste-management and community stakeholders, the work illustrates a potential route for retaining low-value plastics in productive use. For entrepreneurs and researchers, it identifies fabrication consistency, moisture control, fire behavior, full-scale testing, lifecycle cost, and regulatory assessment as necessary areas of development. These contributions concern the composite panel investigated in this study and should not be generalized to conventional lightweight-concrete wall systems.

Accordingly, the study positioned the recycled-plastic-core panel as a preliminary prototype rather than a construction-ready product. The small-specimen evaluations were intended to generate initial evidence on compressive strength, water absorption, temperature response, observed fire behavior, and estimated cost, while the stakeholder survey examined awareness, perception, and acceptability. The findings provide a basis for refining the fabrication process and identifying the standardized, full-scale, and regulatory evaluations required before the panel can be considered for practical building applications.

Review of Related Literature

The study is anchored in the interconnected concepts of sustainable construction, circular economy, materials science, and building-performance evaluation. Sustainable construction emphasizes reducing resource consumption and environmental burdens while maintaining the safety, durability, and service performance of buildings. Circular-economy principles support retaining waste materials in productive use and reducing dependence on virgin resources, although the environmental value of such applications depends on processing, service life, and end-of-life management (da Silva et al., 2021; Nyika & Dinka, 2022). Materials science explains how composition, internal structure, interfaces, and fabrication processes influence the resulting properties of a composite material (Callister & Rethwisch, 2018). Applied to the present study, these concepts provide a basis for examining whether post-consumer flexible plastics can be incorporated into a repeatable composite panel whose measured performance, practical cost, and potential application remain consistent with the available evidence.

The literature shows that plastic waste can be incorporated into construction materials through markedly different mechanisms (da Silva et al., 2021; Zulkernain et al., 2021). In wood-crete, treated sawdust changes the density and

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mechanical behavior of a cementitious matrix, illustrating how a low-density inclusion and its interface affect composite performance (Aigbomian & Fan, 2014). In plastic-bonded sand, the polymer acts as the binder, and processing temperature, sand proportion, and particle size determine compressive and flexural behavior (Kumi-Larbi Jnr et al., 2022). In recycled-PET concrete, plastic is used as an aggregate replacement and influences density, strength, and water absorption (Resende et al., 2024). These systems are not direct equivalents of the present panel, in which flexible post-consumer plastic serves as a compressed core protected by mesh and mortar. Their relevance lies in demonstrating the sensitivity of recycled-plastic composites to material identity, proportions, voids, interfaces, and fabrication control.

Moisture behavior requires similarly cautious interpretation. A hydrophobic polymer does not necessarily make a composite panel resistant to water because absorption may occur through the mortar skins, cracks, interfaces, and connected voids. Water absorption must therefore be reported for the tested assembly and should not be compared with a percentage benchmark for concrete masonry unless the applicable standard, unit basis, density classification, and specimen-conditioning procedure are identified. The present study reports the observed 24-hour mass changes without asserting compliance with an unverified 15% threshold.

Heat transfer and fire resistance are also distinct properties. A temperature difference observed during direct flame exposure is not a thermal-conductivity measurement and should not be described as ASTM C518 testing unless a calibrated heat-flow-meter apparatus and the required specimen conditioning were actually used (ASTM International, 2021). Likewise, the time to visible coating damage or core deformation in an exploratory flame test is not automatically a rated fire-resistance period. Fire ratings apply to tested assemblies under prescribed furnaces, temperature-time curves, loading conditions, integrity criteria, and insulation criteria. The present measurements are accordingly described as direct-heat temperature response and observed behavior during the researcher's fire-exposure procedure, pending full documentation of that procedure.

The literature also supports careful distinction between statistical non-significance and equivalence. With very small groups, inferential tests have low power and unstable assumption checks. Failure to reject a null hypothesis means only that the study did not detect a difference under its design and sample; it does not prove that two materials are identical or interchangeable. Formal equivalence or non-inferiority requires a pre-specified practical margin and an analysis designed for that purpose. For an early prototype, descriptive values, variability, failure modes, and reproducibility are at least as important as a single probability value.

The social component is interpreted through technology-acceptance and diffusion concepts. Davis (1989) established perceived usefulness and perceived ease of use as central determinants of acceptance, while Rogers (2003) explained how perceived attributes, communication, and social systems influence diffusion. These perspectives justify measuring awareness, perception, and acceptability, but they do not permit high mean ratings to be treated as evidence of actual adoption. Readiness for implementation would require a defined sampling frame, a validated instrument, information about respondents' prior exposure, and behavioral or decision evidence in addition to favorable attitudes.

The composite action of the proposed panel also requires attention to interfaces. The plastic core, wire mesh, and mortar faces differ in stiffness, thermal expansion, surface texture, and response to moisture and heat. Under load, the mesh and mortar skins may carry much of the force while the core maintains separation and influences local stability. Under heating, differential movement can initiate cracking or loss of bond even if the coating remains visually intact. Under immersion, cut edges and imperfect interfaces may admit water that later affects mass, adhesion, and durability. Materials-science analysis therefore focuses not only on the nominal ingredients but also on their geometry, continuity, adhesion, void distribution, and processing history (Callister & Rethwisch, 2018).

Evidence from other waste-derived composites reinforces this point. Aigbomian and Fan (2014) found that treating sawdust influenced the behavior of wood-crete, showing that preparation of a low-density inclusion changes its interaction with a cementitious matrix. Jantarachot et al. (2023) likewise demonstrated that plastic-waste incorporation in recycled-aggregate concrete must be evaluated through a defined mixture and testing program. These studies do not validate the present panel directly; instead, they show why the exact waste stream, preparation, proportion, curing, and specimen configuration must be reproducible. An unspecified category such as recycled plastic is too broad to predict performance because flexible films, PET, HDPE, expanded polystyrene, and mixed multilayer packaging have different physical and thermal behavior.

Circularity claims also require a system boundary. Using waste as an input can reduce disposal, yet the net environmental outcome depends on collection, cleaning, transport, auxiliary materials, fabrication energy, service

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life, repairability, and end-of-life options (da Silva et al., 2021). A panel that locks low-value plastic into a durable, maintainable component may retain material value, but premature failure or difficult separation may shift burdens rather than eliminate them. The present study does not conduct a lifecycle assessment; its defensible sustainability claim is narrower. It demonstrates a proposed route for incorporating post-consumer flexible plastic into a composite prototype and identifies the testing needed to determine whether that route can deliver a durable construction component. Nyika and Dinka's (2022) review similarly shows that plastic-waste applications in construction vary widely and must be judged according to the performance and processing of each material system.

The choice of comparator affects interpretation. Styrofoam-core panels provide a useful lightweight reference because both systems use a protected polymer-based core, but they are not necessarily identical in facing composition, density, manufacturing quality, or intended specification. Concrete hollow-block construction, meanwhile, is relevant to cost and common practice but differs fundamentally in geometry, load path, thermal mass, workmanship, and standard classification. The present study therefore uses the Styrofoam specimens for limited side-by-side laboratory description and the hollow-block system for a reported cost comparison. It does not claim that one small composite specimen can be converted directly into an equivalent masonry unit or full wall.

Scale effects provide another reason for restraint. Cutting a panel into a 24 cm specimen changes the edge-to-area ratio and can expose the core or interrupt the mesh. In a full assembly, continuous reinforcement, supports, joints, and adjacent panels may redistribute forces; in a small piece, platen contact and cut edges may dominate. The same problem applies to moisture and heat because penetration paths are shorter and the proportion of exposed edge is larger. Small-specimen tests remain useful for screening materials and improving fabrication, but component-level claims require specimens and boundary conditions that represent the proposed use. The most informative research sequence would use small pieces to refine the core and coating, intermediate panels to examine repeatability and failure modes, and full assemblies to assess joints, openings, connections, and service conditions.

Durability is not a single property but the capacity to retain required performance throughout the intended exposure and service period. For this panel, potential mechanisms include mortar cracking and shrinkage, corrosion of mesh at defects, loss of adhesion at dissimilar-material interfaces, ultraviolet or thermal degradation of exposed plastic, moisture accumulation in voids, biological contamination of retained debris, and damage during transport or installation. The original experiment did not measure these processes. A durability program should begin by defining whether the intended panel is for dry interior, protected exterior, or exposed envelope use, because each category carries different hazards and acceptance criteria. Accelerated tests should then be linked to plausible field conditions and followed by residual mechanical and dimensional measurements.

Safety and environmental performance also depend on feedstock control. Flexible post-consumer packaging may include polyethylene, polypropylene, metallized films, inks, adhesives, food residues, and multilayer laminates. Visual sorting alone may not produce a consistent polymer stream, and contaminants can affect odor, adhesion, smoke, and long-term behavior. A scalable process would need acceptance criteria for incoming plastic, cleaning and drying requirements, prohibited materials, traceability of batches, and procedures for rejected waste. These controls are not merely manufacturing details; they define whether future panels reproduce the material tested in the laboratory and whether environmental benefits are obtained without introducing new indoor-air, fire, or occupational hazards.

Methodology

The study used a quantitative preliminary experimental design to fabricate recycled-plastic-core composite panels and compare selected outcomes with Styrofoam-core panels. The prefabricated wall panel was the experimental unit. Three independent recycled-plastic-core panels and three independent Styrofoam-core panels were fabricated separately using the same dimensions and procedures. Each panel was tested once for its assigned evaluation; consequently, the three observations reported for each panel type represented independent panels rather than subsamples cut from one parent panel.

Post-consumer flexible plastic waste, including bags, wrappers, sachets, and packaging, was sorted, cleaned, and air-dried. The material was manually crumpled and compressed to form an approximately 2-inch core. No multiple plastic-content treatment levels were reported; the investigation evaluated one recycled-plastic formulation. Each recycled-plastic-core panel used 10 kg of post-consumer plastic and two bags of Portland cement. Sand was incorporated at a 1:2 cement-to-sand mortar proportion, with 10 gallons (approximately 37.85 liters) of water used in the mixing process. Galvanized wire mesh with an approximately 2-inch × 2-inch grid was positioned on both faces, and the assembly was covered with an approximately 1-inch mortar layer on each side. The completed panels were moist-cured for 28 days before testing.

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The full panel was approximately 60 cm × 60 cm × 10 cm, while the specimens used in the reported evaluations measured approximately 24 cm × 24 cm × 10 cm. Compression testing was conducted at the University of San Agustin Civil Engineering Laboratory on December 12, 2025, using a Universal Testing Machine that generated computerized graphical output. Three recycled-plastic-core specimens and three Styrofoam-core specimens were allocated to the compression evaluation. The fire and direct-heat evaluations were conducted at the Santa Barbara Fire Station on December 2, 2025, under the supervision of authorized personnel from the Bureau of Fire Protection, who manually recorded the observations. The 24-hour water-absorption evaluation was conducted by the researcher under controlled conditions at the research site. The computerized compression output and handwritten fire-test records were retained as supporting documentation..

The reported outcomes were normal compressive strength, compressive strength after fire exposure, 24-hour water absorption, temperature response during direct heat exposure, observed time to coating damage or core deformation during fire exposure, and estimated installed cost. Compression was described with reference to ASTM C39/C39M, although that standard applies to cylindrical concrete specimens and does not directly match the geometry of the composite pieces tested here (ASTM International, 2024). The procedure is therefore treated as an adapted compression evaluation; the available record does not fully specify loading orientation, bearing area, loading rate, endpoint, and calculation. Water absorption was described with reference to ASTM C140, but the available record does not identify the edition, applicable clause, or complete specimen-conditioning procedure. Flexural strength, formal thermal conductivity, acoustic performance, and density were not analyzed because corresponding measurements were unavailable.

Two distinct exploratory fire-related evaluations were conducted at the Santa Barbara Fire Station. The first exposed the panels directly to flame for five minutes to observe interior and exterior surface temperatures as an indication of temperature response. A separate continuous-exposure observation recorded the time during which the concrete facing remained intact and the time at which core deformation was first observed. The reported hour-based values belong to this second evaluation and are not the duration of the five-minute temperature-response procedure. No ASTM, ISO, or Philippine National Standard fire-resistance protocol was followed; therefore, the observations are not certified fire-resistance ratings. The available procedural record does not specify the heat source, source-to-specimen distance, temperature-time record, specimen orientation, sensor locations, or operational endpoint definitions, so interpretation remains confined to the observed setup.

The cost comparison summed the reported material, roughing, and installation amounts per square meter for the recycled-plastic-core system and compared the resulting estimate with reported prices for Styrofoam-core and concrete hollow-block systems. The comparison was a project-cost estimate at the time and place of the study. It did not include lifecycle maintenance, replacement, financing, external environmental benefits, uncertainty, or statistical testing; accordingly, it cannot establish a significant or lifecycle economic advantage.

A quantitative survey summarized awareness, perception, and acceptability among 150 stakeholders in Iloilo City: 50 homeowners, 50 local builders, and 50 construction professionals. Respondents were selected purposively based on knowledge and experience relevant to the study. The researcher-developed questionnaire measured awareness, perception, and acceptability using a four-point Likert scale (4 = Strongly Agree, 3 = Agree, 2 = Disagree, and 1 = Strongly Disagree). Fifteen faculty members from the College of Technology reviewed the instrument for content validity using criteria adapted from Carter V. Good and Douglas B. Scates. The questionnaire demonstrated excellent internal consistency (Cronbach's α = .922). The researcher administered it personally after obtaining informed consent. Participation was voluntary, and respondents were informed of the study's purpose, confidentiality protections, and their right to decline or withdraw.

Laboratory outcomes were summarized using means and sample standard deviations. After confirmation that the experimental unit was the independently fabricated panel, two-tailed independent-samples Student's t tests were used to compare the recycled-plastic-core and Styrofoam-core groups, with $n = 3$ per group and $\alpha = .05$. The analyses were recomputed in jamovi Version 2.4 after considering independence, approximate normality, and homogeneity of variance. From the raw observations available for normal compression, post-fire compression, and water absorption, the comparisons were recomputed with four degrees of freedom; pooled-standard-deviation Cohen's d and 95% confidence intervals for the mean difference were also calculated. Complete panel-level observations and numerical outputs were unavailable for the temperature and fire-observation outcomes; consequently, those outcomes are presented descriptively rather than as independently verified inferential comparisons. Given the very small groups, descriptive estimates and uncertainty receive greater weight than null-hypothesis decisions. The survey component was summarized using the mean and standard deviation; no qualitative focus-group analysis, ANOVA, or regression is claimed.

The research proposal was evaluated and approved by the panel of evaluators of the Graduate School as part of the institution's academic thesis-approval process. This approval should not be interpreted as equivalent to independent ethics-board clearance. The researcher observed appropriate safeguards for the survey component, including voluntary participation, informed consent, the right to decline or withdraw, and protection of privacy and confidentiality. Research records were handled in accordance with Republic Act No. 10173, or the Data Privacy Act of 2012. The researcher declared no conflict of interest and reported the findings without identifying individual participants or their affiliated establishments.

Results

Under normal loading, recycled-plastic-core panels recorded compressive strengths of 222.50, 159.60, and 239.00 psi, yielding a mean of 207.03 psi (SD = 41.90). Styrofoam-core panels recorded 170.40, 182.80, and 172.30 psi, yielding a mean of 175.17 psi (SD = 6.68). The recycled-plastic group therefore had the higher descriptive mean by 31.87 psi. A recomputed two-tailed independent-samples Student's t test did not detect a statistically significant difference, $t(4) = 1.30$, $p = .263$, Cohen's $d = 1.06$, 95% CI for the mean difference [−36.14, 99.88]. The wide interval reflects the uncertainty produced by only three independent panels per group; accordingly, no claim of superiority or compliance with a concrete-masonry strength requirement is made.

After fire exposure, the recycled-plastic panels recorded compressive strengths of 225.30, 201.40, and 151.10 psi (M = 192.60, SD = 37.87), whereas the Styrofoam panels recorded 131.80, 178.20, and 144.30 psi (M = 151.43, SD = 24.01). The descriptive mean difference was 41.17 psi in favor of the recycled-plastic panels. A recomputed two-tailed independent-samples Student's t test did not detect a statistically significant difference, $t(4) = 1.59$, $p = .187$, Cohen's $d = 1.30$, 95% CI for the mean difference [−30.72, 113.05]. The interval remains wide, and the result does not establish superior post-fire strength.

After 24 hours of water immersion, the recycled-plastic panels recorded absorption values of 30.67%, 28.37%, and 31.11% (M = 30.05%, SD = 1.47), while the Styrofoam panels recorded 30.12%, 28.95%, and 31.20% (M = 30.09%, SD = 1.13). The difference between the means was −0.04 percentage point. A recomputed two-tailed independent-samples Student's t test did not detect a statistically significant difference, $t(4) = -0.04$, $p = .972$, Cohen's $d = -0.03$, 95% CI for the mean difference [−3.01, 2.93]. No compliance judgment is made because an applicable benchmark, density classification, and basis of calculation were not established; the values are therefore presented as observed absorption for the tested composite panels.

During the five-minute direct-flame temperature-response evaluation, the recycled-plastic-core panels had a mean interior temperature of 36.89 °C and a mean exterior temperature of 77.80 °C. The Styrofoam-core panels had corresponding means of 37.58 °C and 77.37 °C. Complete panel-level observations, group standard deviations, test statistics, confidence intervals, effect sizes, and software output were unavailable for independent verification; the temperature outcomes are therefore reported descriptively. These measurements describe temperatures at the reported locations during the exploratory exposure; they are not thermal-conductivity values and do not establish an ASTM C518 result.

In the separate continuous fire-exposure observation, the concrete coating of the recycled-plastic panels remained intact for a mean of 1.42 hours and deformation of the recycled-plastic core was first recorded at a mean of 2.16 hours. The corresponding values for the Styrofoam panels were 1.50 and 2.21 hours. Complete panel-level observations, group standard deviations, test statistics, confidence intervals, effect sizes, and software output were unavailable for independent verification; these outcomes are therefore reported descriptively. Because no recognized fire-resistance standard was followed and essential exposure details remain undocumented, the values are exploratory observations and must not be represented as certified fire-resistance ratings.

The estimated installed cost was ₱6,350.00 per square meter for the recycled-plastic-core panel system, consisting of ₱1,950.00 for the precast wall, ₱3,900.00 for roughing on both sides, and ₱500.00 for installation. The corresponding reported estimates were ₱7,000.00 per square meter for concrete hollow-block construction and ₱10,100.00 per square meter for the commercial Styrofoam-core panel. Thus, the recycled-plastic system had the lowest estimated cost in this project comparison, by ₱650.00 relative to the hollow-block estimate and ₱3,750.00 relative to the Styrofoam-core estimate. No statistical or lifecycle economic comparison was performed.

Among the 150 purposively selected stakeholders, the mean awareness score was 3.25 (SD = 0.76), the mean perception score was 3.24 (SD = 0.71), and the mean acceptability score was 3.25 (SD = 0.72). Under the four-point response scale, these results indicated favorable reported views. The instrument had undergone content review

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by 15 College of Technology faculty members and demonstrated excellent internal consistency (Cronbach's α = .922). Nevertheless, the ratings do not identify why respondents viewed the material favorably or establish actual willingness to adopt it, and the purposive sample limits generalization beyond the respondents.

Discussion and Analysis

The normal-compression results show a higher descriptive mean for the recycled-plastic-core panels, but the recomputed independent-samples test did not detect a statistically significant difference. The estimated effect was large in standardized terms, yet its confidence interval was wide and crossed zero because only three independently fabricated panels were tested per group. The result is best interpreted as preliminary evidence that the fabricated recycled-plastic core did not prevent the small composite specimens from carrying compressive load. It does not demonstrate structural-wall capacity. Materials-science principles explain why compaction, void distribution, mortar–mesh interaction, core confinement, and loading orientation may influence the observed values (Callister & Rethwisch, 2018). Because these factors were not independently controlled or quantified, attributing the mean difference solely to the recycled plastic would go beyond the design.

The post-fire compression values follow the same pattern: the recycled-plastic panels had the higher mean, but the recomputed analysis did not detect a statistically significant difference and produced a wide confidence interval. The values also cannot be interpreted independently of the exposure procedure. Polymer cores may soften, shrink, char, or deform under heat, while the mortar skin may delay direct exposure. Consequently, post-fire residual strength reflects the complete assembly and its prior thermal history. The result suggests a question for further controlled testing rather than proof of improved fire performance. A valid comparison should expose larger numbers of independently fabricated assemblies to the same documented temperature-time regime, measure failure against defined criteria, and then test residual mechanical properties using a geometry-appropriate method.

The nearly identical mean water-absorption values indicate that the mortar coating and connected void structure dominated the 24-hour mass change more than the choice between the two tested cores. This is plausible because water can enter through cracks, edges, interfaces, and pores even when the polymer itself is hydrophobic. The relatively high observed percentages underline the need to improve edge sealing, coating consistency, curing, and surface protection before exterior or moisture-exposed use is considered. The study cannot classify either panel as compliant or noncompliant without an applicable standard and the density- and unit-based criteria required by that standard.

The direct-heat temperature observations show small differences between panel types. These values should be read as an exploratory description of the tested configuration rather than as thermal resistance, thermal mass, or conductivity. Proper thermal characterization requires controlled boundary temperatures, heat flux, steady-state or transient methodology, calibrated sensors, specimen conditioning, and reporting in recognized units. The present measurements nevertheless identify the protective coating, core voids, and internal geometry as variables for future investigation. Recycled thermoplastic composites have been developed for insulation-related applications, but their performance depends on composition and fabrication and cannot be transferred directly to this panel (Kucukali-Ozturk et al., 2022).

The five-minute temperature-response evaluation and the hour-based continuous fire observation were separate procedures. The former recorded interior and exterior surface temperatures during direct-flame exposure, whereas the latter recorded the time during which the concrete facing remained intact and the time at which core deformation was first observed. This distinction resolves the apparent conflict in duration but does not convert either procedure into a certified fire-resistance test. No recognized fire-test standard was followed, and the available procedural record does not specify the heat source, distance, temperature-time record, specimen orientation, sensor locations, or operational endpoint definitions. The findings therefore remain exploratory. Future work should evaluate coating thickness, cracking, joints, penetrations, anchors, and full-wall continuity under a recognized method.

The recycled-plastic-core system had the lowest estimated installed cost in the reported project comparison. This is potentially important for further development, but the result is sensitive to local prices, the assumed system boundary, fabrication scale, labor productivity, transport, waste preparation, quality control, finishes, maintenance, and service life. The analysis did not monetize waste-diversion benefits or evaluate lifecycle costs. It therefore supports only the statement that the proposed system had a lower estimated cost per square meter under the assumptions used, not that it possesses a statistically significant or enduring economic advantage.

The stakeholder ratings show favorable awareness, perception, and acceptability among 150 purposively selected respondents. The researcher-developed four-point questionnaire underwent content review and demonstrated excellent internal consistency (Cronbach's $\alpha = .922$). Technology-acceptance and diffusion theory indicate why these dimensions matter (Davis, 1989; Rogers, 2003), but favorable means alone do not show market readiness, code acceptance, purchase intention, or actual adoption. The purposive design also limits generalization. A stronger follow-up could use a defined probability-based sampling frame, distinguish informed evaluation from general support for recycling, and examine whether acceptability changes after respondents receive verified performance and cost information.

Across the study, nonsignificant comparisons must not be described as equivalence. The confirmed use of three independently fabricated panels per group supports treating the reported observations as independent replicates, but the sample remains too small for precise estimation. For the three outcomes with printed raw observations, the recomputed confidence intervals were wide; complete numerical outputs for the temperature and fire outcomes remain necessary. The appropriate conclusion is that the descriptive outcomes justify additional development but do not establish superiority, interchangeability, code compliance, or unrestricted viability. Replication with larger numbers of independently fabricated panels, preregistered hypotheses, appropriate effect estimates, and full-scale assembly tests is necessary before the material can move from prototype feasibility to a construction product.

The confirmation that three separately fabricated panels represented each group resolves the earlier uncertainty between specimen variation and production variation. Nevertheless, three panels per formulation provide only a limited view of manufacturing repeatability. Panel-to-panel variation may arise from plastic cleaning, compaction, wrapper distribution, mesh placement, mortar mixing, coating thickness, curing, and specimen preparation. A future design should retain the fabricated panel or batch as the experimental unit, increase the number of independent batches, and use any subsamples only to characterize within-panel variation. This hierarchical structure would permit more precise uncertainty estimates and help determine whether process control, rather than nominal core material, is the principal determinant of performance.

The reported compression values should also be interpreted in relation to the actual load path. ASTM C39/C39M-24 is intended for cylindrical concrete specimens and assumes a defined geometry and bearing condition (ASTM International, 2024). A composite square piece with mortar skins, mesh, a compressible core, and cut edges may fail through local crushing, skin buckling, interface separation, mesh deformation, or end effects. Converting the applied load to a nominal psi value does not ensure comparability with a concrete cylinder or masonry unit. A fit-for-purpose test program should document loading direction, loaded area, platen contact, edge preparation, displacement, failure mode, and whether force is applied through the full thickness or mainly through the skins. Photographs and load–displacement curves would add information that a peak strength alone cannot provide.

The moisture findings have implications beyond the single immersion interval. Water uptake can alter weight, thermal behavior, adhesion, corrosion risk at exposed steel, and susceptibility to freeze–thaw or biological growth where relevant. Although plastic wrappers do not absorb water in the same way as porous mineral materials, gaps around the compressed core may store water and prolong drying. Future tests should separate absorption by the mortar faces, edges, and interfaces; record dry density and specimen conditioning; and include drying behavior, repeated wetting, capillary uptake, and exposure after cracking. If the intended use is interior partitioning, moisture criteria should reflect that exposure category rather than an exterior-wall claim.

The recorded coating condition and core-deformation times provide only an exploratory description of the panels' behavior under the reported exposure. They do not establish either reaction-to-fire performance, which concerns properties such as ignition, flame spread, heat release, smoke, and burning droplets, or fire resistance, which concerns the capacity of an assembly to maintain integrity, insulation, and, where applicable, load-bearing performance under standardized exposure. The protective mortar coating may have delayed the direct exposure of the core; however, the absence of a standardized temperature–time regime, defined endpoints, and complete exposure documentation prevents the observations from being interpreted as a certified fire rating. The mixed-plastic composition also limits generalization because different polymers and additives may respond differently to heat and combustion.

Integration of the technical, economic, and social findings does not mean averaging them into a single declaration of viability. Each evidence stream answers a different question. Laboratory observations describe how the small panels behaved; the cost estimate describes the assumed project expenditure; and the purposive survey describes the respondents' reported views. A responsible feasibility judgment requires all three to be adequate and transparent, but weakness in one stream cannot be compensated for by strength in another. High acceptability cannot substitute for a standardized fire procedure, and a favorable mean strength cannot establish market adoption. The integrated conclusion is therefore conditional: continued development is warranted, while subsequent testing must strengthen procedural documentation, sample size, and full-scale validation.

Conclusion

The study produced a recycled-plastic-core composite panel and generated preliminary evidence from comparisons of three independently fabricated panels per group. The recycled-plastic panels had higher descriptive mean compressive strengths before and after fire exposure, but recomputed two-tailed independent-samples tests did not detect statistically significant differences and produced wide confidence intervals. Water absorption was nearly identical and was likewise not significantly different. The five-minute temperature-response evaluation and the hour-based fire observation were confirmed as separate procedures. Complete numerical outputs for these two outcomes were unavailable for independent verification, and neither procedure followed a recognized fire-rating standard. No conclusion is made about flexural strength, acoustic performance, density, formal thermal conductivity, or compliance because corresponding measurements were not reported.

The recycled-plastic-core system had a lower estimated installed cost per square meter than the two reported alternatives in this project comparison. This finding suggests a possible economic advantage for further investigation but is not a lifecycle-cost result. The 150 purposively selected stakeholders also reported favorable awareness, perception, and acceptability through a researcher-developed questionnaire with excellent internal consistency. These ratings, however, do not establish readiness for adoption or permit broad population generalization. Taken together, the evidence suggests potential feasibility for continued development as a non-load-bearing enclosure, partition, or infill system. It does not certify the panel for structural use, fire rating, exterior exposure, or code-compliant installation.

The study's principal contribution is the definition of a development pathway rather than proof of a finished product. Its documented fabrication record now specifies the principal material quantities, including 10 gallons (approximately 37.85 liters) of mixing water, the 28-day curing period, independent-panel replication, testing locations, the distinction between the two fire-related evaluations, and the survey methodology. A defensible next stage requires complete fire-exposure parameters, complete numerical outputs for all comparisons, larger replicated testing, validated methods, moisture-control improvements, full-scale wall and connection tests, lifecycle costing, and regulatory review.

Recommendations

Future research should build on the clarified fabrication and testing record by documenting the heat source, exposure geometry, temperature-time history, measurement locations, and endpoint definitions used in the exploratory fire evaluations. The available computerized compression output and handwritten fire records should be retained with the data archive. Complete numerical outputs for all comparisons should report group standard deviations, effect sizes, confidence intervals, degrees of freedom, and exact probability values. Larger samples of independently fabricated panels are necessary to improve precision and permit more credible assumption checks.

Quality control should be documented at each fabrication stage. Incoming plastics should be weighed after cleaning and drying; core thickness and compaction should be measured at predefined locations; mesh spacing and cover should be checked before coating; mortar batches should record constituent masses and water addition; and coating thickness should be verified after curing. Specimens should receive unique identifiers connecting them to a panel, batch, fabrication date, curing history, and test assignment. These records would allow an investigator to distinguish material effects from fabrication errors and would make future replication possible. Without them, even accurate laboratory measurements cannot establish that another panel made by the same nominal method will behave similarly.

A stronger analytical plan should be established before new specimens are fabricated. Each outcome should have an operational definition, applicable test method, unit, primary comparison, and practical decision threshold. Sample size should be based on a meaningful effect or precision target rather than on equipment convenience alone. Random allocation and blinded measurement should be used where feasible, and all exclusions or failed specimens should be documented. Because multiple outcomes are evaluated, interpretation should consider the family of evidence rather than selecting isolated favorable means. Raw measurements, calculation sheets, photographs of failure, and laboratory reports should be retained in an auditable data package.

Subsequent experiments should fabricate multiple independent panels per formulation and examine deliberately specified plastic types, densities, preparation methods, and core proportions. Flexural behavior, density, acoustic performance, and thermal conductivity should be included only when tested using suitable specimen geometries and fully documented standards. Water absorption should be evaluated with attention to edges, joints, coating cracks, and protective finishes. Fire performance should be assessed by a qualified laboratory using an applicable assembly method and defined integrity, insulation, and structural criteria.

Full-scale non-load-bearing wall assemblies should then be tested for handling, transport, installation, impact, racking, connections, openings, service penetrations, moisture exposure, weathering, ultraviolet exposure, dimensional stability, and long-term durability. Demonstration use should proceed only after technical review and required regulatory approvals. Recommendations for structural wall applications should be withheld unless future full-scale structural and code-compliance testing supports them.

The economic analysis should be expanded to include waste collection and cleaning, fabrication yield, quality control, transport, installation productivity, finishes, maintenance, replacement, and end-of-life management. A subsequent stakeholder study should use a clearly defined sampling frame and, where the objective requires population-level inference, a probability-based procedure. The validated questionnaire and its reliability evidence should be retained and reported, while demonstrations and information campaigns may be considered after verified technical data are available so that acceptability is based on transparent evidence rather than on the general appeal of recycling.

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