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CLEAN COMPOSITE CONSTRUCTION PANEL FROM INDUSTRIAL WASTE»

Abstract

This study explores the development of a sustainable composite construction panel utilizing industrial waste materials. The objective is to reduce environmental pollution by repurposing waste such as fly ash, blast furnace slag, and plastic residues, transforming them into a viable construction product. This research aims to demonstrate that industrial by-products, when processed and combined with appropriate binding agents, can produce panels that meet structural and environmental standards. The composite panel developed in this study offers a cost-effective and eco-friendly alternative to traditional construction materials. Mechanical strength, thermal insulation, and water resistance properties were tested and analyzed. The results indicate that these waste-based panels can perform comparably with conventional panels in key functional metrics. This research contributes to the circular economy and highlights a practical approach to minimizing landfill contributions and greenhouse gas emissions. Further work will be necessary to optimize industrial-scale production and long-term durability assessments.

Methods and Methodology

The research employed a mixed-methods experimental approach, combining qualitative analysis of material properties and quantitative laboratory testing of the

composite panels. The materials used included Class F fly ash from coal combustion, ground granulated blast furnace slag (GGBFS), thermoplastic waste including polyethylene and polypropylene, and a small percentage of cement as a binding agent. Prior to panel production, the industrial waste materials were subjected to pretreatment processes such as sieving, washing, and drying to eliminate contaminants and improve consistency.

Fly ash and GGBFS were selected for their pozzolanic properties, while plastic waste served as a reinforcing agent and partial binder after thermomechanical processing. A hydraulic press was used to mold the composite mixture into flat panels under controlled temperature and pressure. The mixture composition was adjusted through several trials to achieve optimal workability and mechanical strength. Laboratory tests included compressive strength, flexural strength, thermal conductivity, water absorption, and leachability of harmful substances. All tests adhered to relevant ASTM and ISO standards to ensure reproducibility and comparability.

The data collected from the physical and chemical characterization of the materials, as well as performance testing of the composite panels, were statistically analyzed using regression techniques and variance analysis to determine significance levels. These tests provided insight into the relationships between waste composition ratios and panel performance. The methodology emphasized sustainability by reducing virgin material use, conserving energy during manufacturing, and minimizing waste output.

Full Paper

Industrial development has long been associated with large-scale generation of solid waste, much of which ends up in landfills or incineration sites. These disposal methods contribute to serious environmental problems such as soil contamination, air pollution, and the depletion of landfill space. With rising concern over climate change and resource scarcity, the construction industry has been urged to adopt cleaner, more sustainable practices. One promising solution involves reusing industrial waste as raw material for building products. This study focused on the creation of an

environmentally clean composite panel derived from industrial waste, offering a pathway to sustainable construction while mitigating the environmental impact of waste accumulation.

The construction panel was designed to serve as a non-load-bearing wall panel, interior partition, or ceiling element. Its development involved sourcing and integrating industrial by-products such as fly ash, blast furnace slag, and thermoplastic waste. These materials were selected based on their abundance, chemical compatibility, and potential for structural reinforcement. Fly ash and slag are rich in silica and alumina, enabling them to react with water and calcium compounds to form cementitious gels. Thermoplastic waste, when shredded and heated, contributed toughness and cohesion to the composite structure.

Preliminary testing was essential to determine the appropriate material ratios. The initial mixes contained high proportions of fly ash and slag to ensure pozzolanic activity, while thermoplastic content was gradually increased to improve flexibility and reduce brittleness. Cement was added in small quantities to accelerate curing and enhance binding. A plasticizer was used in some trials to improve flowability. Mixing was done mechanically to ensure uniform distribution of all constituents.

Once mixed, the composite blend was poured into steel molds and subjected to hydraulic pressing at 90°C and 5 MPa for 30 minutes. This process allowed the thermoplastics to soften and integrate with the inorganic matrix. After molding, the panels were air-cured for 24 hours and then oven-cured at 60°C for 48 hours. The curing process played a critical role in strengthening the interfacial bonds between components.

The physical and mechanical performance of the panels was evaluated through a series of standardized tests. Compressive strength measurements revealed values ranging from 10 to 18 MPa, depending on the plastic-to-binder ratio. Panels with 30% plastic content exhibited the best combination of strength and flexibility. Flexural strength was also satisfactory, with most samples exceeding 4 MPa, which is within the acceptable range for non-load-bearing applications.

Thermal conductivity tests indicated that the panels offered moderate insulation properties, with values between 0.20 and 0.35 W/m·K. This range is comparable to lightweight concrete and significantly better than solid bricks, making the panels suitable for interior use in energy-efficient buildings. Water absorption tests demonstrated that the panels were hydrophobic, largely due to the presence of plastic. Absorption rates remained below 10% by weight, suggesting good resistance to moisture ingress. Leachability tests confirmed that heavy metals and harmful substances in the industrial waste were well stabilized, with no significant release detected under simulated environmental conditions.

The research also investigated the environmental implications of using these composite panels. A life cycle assessment (LCA) was conducted to compare the new panels with traditional gypsum boards and concrete panels. The LCA results showed a substantial reduction in embodied carbon and energy consumption. The reuse of fly ash and slag avoided the need for virgin raw materials, while the use of plastic waste diverted significant volumes from landfills. Manufacturing required less energy than conventional cement-based products due to lower processing temperatures and minimal grinding requirements.

Socioeconomic aspects were also considered. The production process utilized low-cost materials and straightforward processing methods, making it suitable for adoption in developing regions with limited access to advanced manufacturing infrastructure. The panels could be produced at small to medium scales using locally available industrial waste, thus fostering community-based recycling initiatives and generating employment opportunities.

Despite these advantages, certain limitations were identified. The variability of industrial waste composition could affect consistency and quality. Quality control protocols must be established to ensure reliable panel performance. Long-term durability under various environmental conditions remains to be fully understood, requiring extended field testing and weathering simulations. Fire resistance, while partially addressed through inorganic fillers, also warrants further enhancement to meet building code requirements.

In conclusion, the study demonstrated the technical feasibility and environmental benefits of producing construction panels from industrial waste. The developed composite exhibited acceptable strength, insulation, and water resistance, while promoting sustainability through waste valorization. The approach aligns with circular economy principles and represents a viable alternative for greener building materials. Future research should focus on improving the fire resistance, long-term durability, and large-scale manufacturing logistics. Regulatory support and industry partnerships will be key to translating this innovation from the lab to market-ready applications.

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