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Waste-to-Construction: Converting Plastic, E-Waste and Industrial Waste Into Building Materials: A Review

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ABSTRACT

The rapid growth of urbanization, industrialization, and consumer activities leads to the generation of enormous amounts of plastic wastes, electronic wastes, and industrial by-products. The traditional ways of their disposal, such as landfills and incineration, are associated with environmental and resource management concerns. At the same time, the construction industry is the biggest consumer of natural resources. Therefore, it is possible to use waste materials in the construction field. This review discusses the use of plastic wastes, electronic wastes, and specific industrial wastes in construction. The paper explores the utilization of these wastes in concrete, mortar, bricks, blocks, asphalt, and other construction composites. The review also covers processing techniques, physicochemical properties, mechanical properties, and durability of concrete composites with wastes. Particular attention is paid to environmental benefits and challenges related to the use of various types of waste materials. It is possible to use plastics as a partial replacement of natural aggregates or cement. In turn, industrial wastes, including fly ash, ground granulated blast-furnace slag, steel slag, and other by-products, are suitable for use in mortar or concrete. Electronic wastes can also be used in construction, but specific attention should be paid to their impact on the environment. The review also covers approaches related to the circular economy and modern innovations allowing for obtaining new construction composites. In conclusion, the review highlights the main challenges and opportunities of using waste materials in construction. Thus, although the use of waste materials in the construction industry allows for reducing the impact on landfills, natural resources, and the environment, questions of standardization, durability, and sustainability still require further research.

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KEYWORDS: *Waste-to-construction, plastic waste, e-waste, industrial waste, sustainable construction, recycled materials, circular economy, green concrete.*

INTRODUCTION

The rapid growth of cities and industrial facilities leads to the generation of significant amounts of waste. Products such as plastic packaging, old electronics, various industrial waste, and other products are often placed in landfills, subjected to open dumping, or other forms of recycling. However, such methods may lead to environmental damage and the loss of potential resources. At the same time, the construction industry is in great need of aggregate, cement, sand, and other resources. Thus, the need for recycling arises.

The term refers to the way of recycling which works on a principle of transforming waste into construction products. In other words, the utilization of waste material as a resource is an alternative way of viewing the problem of waste disposal. Such waste recycling fits the modern tendency of the circular-economy to keep materials in use.

Plastic waste is highly attractive by its great amount, low density, and ability to resist against natural decay. A variety of researches have been made to find out whether plastic waste could be used as a substitute for natural aggregates, fibers, or other construction materials by partial replacement. The results showed that appropriate plastic waste could provide beneficial technical properties, such as lightweight and improved durability, while excessive replacement leads to the decreases in mechanical performance.

Industrial wastes are another source of potential resources. Fly ash, blast-furnace slag, steel slag, silica containing residues, foundry sand, and other industrial wastes have been proposed as admixtures or replacements for cementing materials or aggregate. Their use may conserve resources and have beneficial effects on the environment by reducing greenhouse gas emissions and other by-products than traditional cement manufacturing process

Electronic waste is a more complicated opportunity in terms of recycling. Circuit boards, glass, plastics, metals, and other materials that can often be found in electronics can be processed into construction materials. Nevertheless, e-waste contains various toxic chemicals, which makes it necessary to assess how safe and suitable such material is for large-scale construction projects.

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The aim of this study is to evaluate the reuse of plastic waste and e-waste in construction, compare their performance characteristics and shortcomings, and explore the challenges for future research of using such wastes in construction.

REVIEW METHODOLOGY

This review considers the research papers on waste utilization in construction, particularly, on the use of plastic waste, electronic waste, and industrial waste. The search was made in academic databases such as Scopus, Web of Science, ScienceDirect, SpringerLink, ASCE Library, IEEE Xplore, and Google Scholar.

The search terms include: “plastic waste concrete”, “plastic waste construction materials”, “e-waste concrete”, “electronic waste construction materials”, “industrial waste concrete”, “fly ash concrete”, “steel slag aggregate”, “waste-to-construction”, and “circular economy construction”.

The literature was evaluated based on the type of waste used, the process, the application in construction, mechanical properties, sustainability, and scalability. Preference was given to recent studies, including those with pioneering importance, and foundational research, when relevant. Particular emphasis was placed on papers assessing the performance and environmental safety of the construction materials produced rather than simply demonstrating their feasibility.

WASTE MATERIALS FOR CONSTRUCTION APPLICATIONS

Waste materials differ significantly in their physical, chemical, and environmental characteristics. Consequently, the suitability of a waste material depends on its processing method and intended construction application.

1. Plastic Waste

Plastic waste can be converted into flakes, pellets, fibers, or other forms and then incorporated into construction materials. Polyethylene terephthalate (PET), high-density polyethylene (HDPE), polypropylene, and other plastics have been tested for use in concrete and pavement [1], [2].

Plastic particles can be used as a partial replacement of natural aggregate. Plastic fibers can

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improve the cracking and deformation characteristics of concrete. Due to the low specific gravity, the use of plastic can reduce the unit weight of concrete. On the other hand, an increase in the content of plastic particles leads to a decrease in the compressive and tensile strength of concrete due to the poor adhesion between plastic aggregates and cement paste [3].

The surface structure of plastic and its interaction with cement paste is also crucial. Consequently, the method of surface treatment, particle size, and the use of plastic in a mixture with other materials are promising directions for research.

2. Electronic Waste

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E-waste encompasses such items as personal computers, mobile phones, home appliances, circuit boards, cables, displays, batteries, and other metallic and plastic components. Some printed circuit boards may be processed into a substitute for aggregates [4].

The e-waste is fundamentally different from the construction waste due to its potential containing both valuable metals for recycling and dangerous substances. Therefore, the question of material recovery and environmental safety is in focus [5].

Processed e-waste has been studied in concrete and other building materials. Nevertheless, the migration of potentially hazardous elements and compounds under cycles of wetting and drying, and other varying environmental conditions, requires further consideration. As a result, it cannot be used directly in construction materials without going through processing, characterization, and leaching stages [6].

3. Industrial Waste

Industrial waste is probably the most promising source of materials with respect to their chemical or physical similarity with construction materials.

Such wastes are presented by fly ash that can be used as a cementitious material or as an additive to concrete and mortar, and ground granulated blast-furnace slag which can partly replace binder materials (cement) in concrete [7]. Steel slag is another industrial waste that can be used as construction material with some amendments to its expansion properties and chemical composition [8].

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Besides, foundry sand, and some other industrial wastes, e.g. from mining, can be used as a substitute for sand or other mineral admixtures with respect to their particle size and chemical composition, and potential durability.

Table 1: Waste Materials and Potential Construction Applications

Waste Material	Processing	Potential Application	Major Benefit	Major Concern
Plastic	Shredding/pelletizing	Concrete, asphalt, blocks	Reduced plastic disposal	Strength reduction
E-waste	Sorting/crushing	Concrete, blocks	Resource recovery	Toxicity/leaching
Fly ash	Collection/classification	Cement replacement	Reduced cement demand	Quality variability
Blast-furnace slag	Grinding	Cementitious material	Improved durability	Processing requirements
Steel slag	Crushing/aging	Aggregate	Aggregate replacement	Expansion
Foundry sand	Cleaning/sieving	Fine aggregate	Sand conservation	Contamination

PROCESSING AND INCORPORATION METHODS

The transformation of waste into construction material involves the essential stage of preparation. The quality of preparation defines the quality of the end product.

Waste plastic is subjected to collection, sorting, cleaning, shredding, and size determination. Then, it is incorporated into the concrete matrix as aggregate, fibre, or another additive. Its surface may be modified to improve the bond with cement paste.

The processing of e-waste is more complicated; first, collection and segregation are performed. Then, hazardous elements are extracted, followed by disassembly and size reduction. Separate metals may be removed for further utilization; the reduced e-waste fraction is then subjected to various treatments to recover valuable materials.

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Industrial wastes undergo drying, grinding, screening, chemical treatments, aging, and fractionation. For instance, steel slag requires proper aging to reduce its tendency to expansion when turned into aggregate.

The described processing stages are essential because raw waste may contain impurities affecting concrete's properties or requiring special treatment during concrete production. Therefore, when designing concrete, the utilization of waste should not be regarded as a universal solution but as a part of a system, which defines how to prepare concrete mixtures based on waste.

MECHANICAL AND DURABILITY PERFORMANCE

It is common practice to use the mechanical properties of waste-based construction materials, which are characterized by the waste type, particle size, replacement level, processing technology, and interaction with the matrix.

First of all, plastic as an aggregate has significantly lower stiffness and tensile strength compared to mineral aggregates. Thus, the higher the content of plastic, the lower the compressive strength, elastic modulus, and other indicators of normal concrete. However, the use of a certain amount of plastic as an aggregate can allow the production of light concrete with technical properties similar to those of conventional solutions.

On the other hand, the use of industrial wastes as mineral additives usually allows one to obtain improved constructive solutions. For example, fly ash and slag are typical materials that can partially replace cement, as they participate in secondary hydration processes. Therefore, their use level and technological properties of consistency, workability, and others must be selected. Steel slag, in turn, is a promising material for producing heavy concrete aggregate; however, volume instability must be taken into account. Inhomogeneity often deforms the concrete mixture, which is initiated by the improper processing of this waste.

Meanwhile, the use of waste from electronics is complicated by their inconsistency. Thus, some of the processed fractions can be used as aggregate substitutes, while others are contraindicated. The interaction of these materials with concrete components is difficult to predict, as is the effect on strength and other properties. However, the higher the content of e-waste in concrete, the more likely it is to exhibit negative characteristics.

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Finally, the importance of studying the durability of concrete products and structures made of such materials should be emphasized. It is necessary to clarify their resistance to moisture and water, osmotic pressure, freezing and thawing, chemical attack, thermal stresses, abrasiveness, and long-term strength.

Table 2: Effect of Waste Materials on Construction Performance

Waste Type	Strength	Density	Durability Potential	Main Issue
Plastic	Often decreases at high replacement	Decreases	Application dependent	Weak interface
E-waste	Variable	Usually decreases	Requires validation	Leaching
Fly ash	Can improve long-term strength	Similar/lower	Often improved	Early-age strength
Slag	Can improve later-age strength	Similar	Often improved	Processing
Steel slag	Potentially high	Higher	Good when stable	Expansion

VI. ENVIRONMENTAL AND ECONOMIC BENEFITS

The most obvious solution for both problems related to the waste-to-construction is that the use of waste plastic as a partial substitute for aggregate reduces the amount of waste going to dispose of and, at the same time, the consumption of new resources. It happens because industrial by-products, such as fly ash and slag, can, partially replacing Portland cement, decrease greenhouse-gas emissions from cement production.

Furthermore, using waste materials reduces the consumption of sand and stone, which, as it was mentioned before, is a problem because their excessive extraction can lead to environmental damage. Thus, from an environmental perspective, the utilization of waste in construction can be beneficial.

From an economic point of view, the use of waste materials is promising if there is a source of them located near a construction site to minimize transportation costs and if the characteristics of these materials are comparable with traditional aggregates. Nevertheless, such benefits are

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not automatically granted because the processing of waste plastic into construction aggregates requires sorting, cleaning, testing, and other costly procedures. For this reason, it is essential to perform a life cycle assessment (LCA) and analyse costs using life-cycle costing methods rather than focusing only on benefits.

CIRCULAR ECONOMY AND WASTE-TO-CONSTRUCTION

Waste-to-construction represents an important application of circular-economy principles. The conventional linear model follows:

Extract → Manufacture → Use → Dispose

A circular construction model aims to move toward:

Waste Generation → Recovery → Processing → Construction Material → Use → Reuse/Recycling

This approach can reduce dependence on virgin materials and increase resource efficiency.

However, circularity does not necessarily mean using it for concrete recycling. It is essential to assess an entire material life cycle. For instance, if the process of obtaining and transporting waste requires much energy, then using it might not be worth it. Another example might be a hazardous material that needs to be safely contained and isolated. Thus, future construction waste management systems should prioritize material properties and environmental impact.

CHALLENGES AND RESEARCH GAPS

One of the main issues is the complexity of the waste material. Unlike conventional construction materials, waste material can vary greatly depending on the source, collection, and processing.

The use of plastic waste is complicated by the low adhesion of its powder to cement paste and a decrease in the strength characteristics of concrete. It is necessary to study in detail the optimal technology for processing, the particle size of plastic waste, the parameters of destruction, the replacement of one type of plastic with another.

When using e-waste, the importance of determining safe levels of potentially hazardous elements increases, which is complicated by their possible release into the natural environment

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over decades after the use of concrete products made from them. Thus, standard tests for the migration of toxic elements and long-term durability tests are required for such materials.

At the same time, it should be noted that industrial wastes often have a wide range of chemical composition and may contain impurities harmful to the properties of concrete.

In particular, steel slag needs to be subjected to additional processing to reduce its volume instability. In addition, the chemical and phase composition of fly ash and other industrial wastes varies depending on the source.

A critical issue in the use of waste materials in construction is the lack of regulatory technical documentation. Construction standards typically specify requirements for mechanical and durability characteristics, implying extensive testing of materials and their composites to determine their properties.

The environmental behaviour of these materials is relatively poorly studied, and standard short-term strength tests are insufficient to answer questions about their long-term serviceability and safety.

Table 3: Major Challenges and Research Directions

Challenge	Research Gap	Potential Solution
Waste variability	Inconsistent properties	Standardized processing
Plastic–cement bonding	Reduced strength	Surface modification
E-waste toxicity	Long-term leaching data	Encapsulation and leaching tests
Industrial waste variability	Source-dependent properties	Material classification
Durability	Limited long-term data	Accelerated and field testing
Cost	Processing expenses	Local waste-processing systems
Standardization	Limited design codes	Performance-based standards

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FUTURE RESEARCH DIRECTIONS

Future research should shift its emphasis from laboratory-scale demonstrations of concept to include large-scale construction-level applications. An important aspect of future research should be the establishment of standardized waste-processing protocols by which consistent materials can be produced.

The hybrid wastes also offer scope for research, for instance, blends of plastic wastes with industrial supplementary cementing materials not only offer a disposal route but also contribute to cement consumption.

These are areas of major importance, but they all require more systematic approaches such as characterization of hybrid wastes in terms of their chemical and physical attributes or the use of machine learning in order to correlate the wastes' attributes to their performance via mixture design and other variables (e.g., particle size distribution, percentage of replacement, curing).

A critical component of future research on construction materials using waste components should be a life-cycle assessment of their performance. Instead of focusing on their compressive strength, as most previous works have done, emphasis should be placed on carbon footprint, energy consumption, material conservation, toxicity, durability, and recyclability.

An important area of future research should involve the creation of a digital waste-processing platform that would link waste producers with construction material manufacturers, thus enabling it to advise on the type of waste that may be suitable for construction applications and their potential performance.

The future objective should therefore be:
Waste Generation → Smart Sorting → Processing → Material Optimization → Construction Application → Performance Monitoring → Reuse/Recycling

CONCLUSION

Waste-to-construction is a perspective solution to two problems at once: the growing amount of waste and the increasing need for construction resources. The use of plastic waste, e-waste, and industrial wastes for concrete, mortar, bricks, blocks, asphalt concrete, and other purposes is possible.

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The use of plastic wastes diminishes the need for natural aggregates but requires optimization since the properties of concrete and mortar are critical when replacing more than 20% of fine aggregate and more than 10% of coarse aggregate with plastic waste. The application of industrial wastes as a construction material is the best option for future use since several types of industrial wastes have the potential to be used as additives in concrete, thus increasing their strength and quality, and can partially replace natural aggregates. E-waste has the most significant potential for recycling but requires a more profound analysis due to heterogeneity and potential hazards that it might involve.

Overall, the implementation of methods that utilise waste materials in construction will require standardisation of processing techniques, mechanical and durability tests, and life-cycle and environmental safety assessments, as well as the development of performance-based design standards. With further research into combined waste technologies and materials, it will be possible to make a significant contribution to the transition to a circular economy and reduce the use of virgin resources in construction, as well as decrease the amount of waste sent to landfills.

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REFERENCES

1. "Waste plastic as partial replacement for aggregates - a review," IOP Conf. Ser.: Earth Environ. Sci., vol. 357, p. 012018, 2019.
2. "Comprehensive review on the use of plastic waste in sustainable concrete construction," Discover Materials, Springer Nature, 2024.
3. "Use of plastic waste as aggregate in cement mortar and concrete preparation: A review," Construction and Building Materials, ScienceDirect, 2012.
4. "Utilization of E-waste in Concrete and its Environmental Impact - A Review," IEEE Conference Publication, IEEE Xplore, 2018.
5. "Review on electronic waste used as construction materials - a scientometric analysis," Cogent Engineering, Taylor & Francis, 2023.

Page 72-83 © MANTECH PUBLICATIONS 2026. All Rights Reserved

6. "E-Waste Utilization in Concrete: A Systematic Literature Review and Metadata Analysis," Engineering Archive (engrXiv), 2025.
7. "Incorporating Ground Granulated Blast Furnace Slag & Fly Ash in Concrete Production for Sustainable Construction: A Review," Engineering Future Sustainability, 2025.
8. "Adverse Effects of Using Metallurgical Slags as Supplementary Cementitious Materials and Aggregate: A Review," National Center for Biotechnology Information (NCBI/PMC).

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